34th Congress, 1st Session. SENATE. Ex. Doc. No. 22.

REPORT

OF

THE SUPERINTENDENT

OF THE

COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1855.

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

FROM THE

SECRETARY OF THE TREASURY,

COMMUNICATING

A Report of the Superintendent of the Coast Survey, showing the progress of that work during the year ending November 1, 1855.

FEBRUARY 14, 1856.—Read and ordered to be printed.

MARCH 6, 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 1855, 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,
February 6, 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, 1855, and the accompanying map, prepared at the Coast Survey Office, in accordance with the provision of the 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 Senate.

ABSTRACT OF CONTENTS OF REPORT.

CONTENTS OF APPENDIX.

I. GENERAL LISTS.

II. COAST SURVEY REPORTS AND CORRESPONDENCE.

A.—DEVELOPMENTS AND DISCOVERIES.

B.—SPECIAL SURVEYS AND RECONNAISSANCE.

C.—COMMERCE AND COMMERCIAL FACILITIES.

D.—TIDAL AND MAGNETIC OBSERVATIONS.

E.—OFFICE.

III. SPECIAL SCIENTIFIC MATTERS.

A.—GEODETIC AND ASTRONOMICAL.

B.—MAGNETIC.

C.—TIDAL AND CURRENT.

D.—MISCELLANEOUS.

IV. MISCELLANEOUS CORRESPONDENCE.

V. LIGHT-HOUSE MATTERS.

ALPHABETICAL INDEX.

C.

D.

E.

F.

G.

H.

I.

J.

K.

L.

P.

Q.

R.

S.

T.

ERRATA.

In Coast Survey report for 1855.

Page 5, line 1, strike out "*of*."
Page 6, line 20 from bottom, for 259°, read 25°.
Page 21, line 16 from top, for "seventy," read *seventy-five.*
Page 41, line 18 from bottom, read *With three buoys to mark its outline, this channel, etc.*
Page 268, line 22, for +, read —.
Page 268, at bottom insert — before numerator of fraction.
Page 269, in first and second equations, for K, read k.
Page 269, for line 21, read δx_m, the correction of the moon's co-ordinate in right ascension for the instant devoted by ε.
Page 269, for line 23, read δx_s, the correction of the star's co-ordinate in right ascension for the year 1840.
Page 269, line 6 from below, for δp, read δb.
Pages 270–272, the fomulæ of these pages are affected with errors, which will require that they be reprinted in the next report of the survey.
Page 273, line 9 of table, (column y_s ,) read 1861.69.
Page 273, line 24 from bottom of table, (column β',) read 24° 9′ 22″.06.
Page 273, line 17 from bottom of table, (column x_s,) read 596.85.
Page 273, line 19 from bottom of table, (column x_s,) read + 127.46.
Page 273, line 3 from bottom of table, (column y_s,) read — 889.60.
Page 275, line 21 from bottom, for "was," read *were.*
Page 288, lines 21 and 22 of table, insert ζ and α at beginning; and of last four lines ι, α, κ and μ.
Page 314, line 4 from bottom, insert ϵ_Y in middle of heading.
Page 335, second table, insert d in heading of fifth column.
Page 342, line 9 of Appendix No. 51, for "has," read *had.*
Page 345, line 5 from bottom, for "9h. 42m.," read 7*h.* 49*m.*

In the list of geographical positions, annual report of the Coast Survey for 1851.

Page 192, line 21 from top, for "Lat. 42 03 02. 10," read Lat. 42 03 02. 01.
Page 225, line 21 from top, for "Long. 71 35 49. 74," read Long. 71 35 09. 74.
Page 340, line 11 from top, for "16 52 54, Harrison, 196 52 32," read 337 37 30, Harrison, 157 37 46.
Page 340, line 12 from top, for "337 37 30, Wilmer, 157 37 46," read 16 52 54, Wilmer, 196 52 32.
Page 341, line 19 from top, for "Long. 75 57 42.47," read Long. 75 57 52.47.
Page 342, line 3 from top, for "Long. 75 36 32.11," read Long. 75 56 32.11.
Page 344, line 4 from top, for "2479.3, 2711.1, 1.54," read 1969.4, 2153.7, 1.22.
Page 346, line 12 from top, for "Azim. 93 34 20," read Azim. 93 34 00.
Page 411, lines 5 and 6 from top to be struck out.

In the list of geographical positions, annual report of the Coast Survey for 1853.

Page *19, line 8 from top, for "6608.5, 7226.9, 4.10," read 6808.5, 7445.6, 4.23.
Page *20, line 27 from top, for "15721.9, 17196.0, 9.77," read 15771.9, 17247.7, 9.80.

In the annual report of the Coast Survey for 1854.

Page 40, line 9 from top, for "sites," read *sights.*
Page 40, last line, for "6280," read 6293.
Page 41, line 2 from top, for "improves," read *impairs.*
Page *12, line 13 from bottom, for "Sanquel," read *Sauquel.*

Page *19, with lines 12, 13, 14 from top, read *at very low water of spring tides.*
Page *51, (List No. 2,) No. 56, "1–10,000" should read 1–80,000.
Page *52, (List No. 3,) No. 21, "1–30,000" should read 1–20,000.
Page *53, (List No. 5,) No. 15, "1–30,000" should read 1–20,000.
Page *65, line 6 from top, for "Sin C. Agamenticus," read *m.*
Page *65, line 7 from top, for "Ag.," read *Unk.*
Page *65, line 8 from top, for "Unkonoonuc," read *Thompson.*
Page *65, line 9 from top, for "m," read *Sin C. Thompson.*
Page *70, line 6 from top, for "9. 905," read 9. 925.
Page *70, line 22 from bottom, for "are equally," read *are nearly equally.*
Page *72, line 10 from top, for "x, B," read $x, - B$.
Page *72, line 16 from bottom, for "$\mathrm{p}^{\prime\prime\prime}_{\prime\prime\prime}$ $\mathrm{m}^{\prime\prime\prime}_{\prime\prime\prime}$," read $p^{\prime\prime\prime}_{\prime\prime}$ $m^{\prime\prime\prime}_{\prime\prime}$.
Page *75, line 17 from top, for "$= +$ [x n,]" read $= -$ [x n.]
Page *78, line 4 from top, for "5," read $+ 5$.
Page *79, last line, for "but may," read *but the accuracy may.*
Page *91, line 4 from bottom of 3d column, for "0. 9," read 0. 0.
Page *94, line 23 from top, for "0. 667," read 0. 067.
Page *102, line 4 from bottom, for "+102. 0," read +105. 0.
Page *112, line 4 from top, for "0″.061, 0″.105," read 0*s*.061, 0*s*.105.
Page *112, line 12 from top, for "0″. 104," read 0*s*. 104.
Page *112, line 22 from top, for "0″. 139," read 0*s*. 139.
Page *112, line 24 from bottom, for "2″. 734," read 2*s*. 734.
Page *113, line 5 from top, for "observations," read *observation.*
Page *114, line 12 from top, for "according," read *recording.*
Page *115, line 24 from top, for "5h. 8m. 29s.," read 5*h*. 8*m*. 11*s*.
Page *117, line 10 from top, for "L," read "L^1."
Page *134, line 12 from bottom, for "1. 015," read "1. 007."
Page *140, line 2 from top, for "$a = \frac{u_4 - u_3}{t''} - \frac{1}{2} b\,(t'' + t')$," read $a = \frac{u_4 - u_3}{t''} - \frac{1}{2} b\,(t'' + t')$
Page *144, line 20 from bottom, for "7 36. 7," read 1 36. 7.
Page *144, line 19 from bottom, for "7 39. 6," read 1 39. 6.
Page *144, line 18 from bottom, for "2 05. 9," read 2 01. 9.
Page *145, line 6 from top, for "2 11. 3," read 1 11. 3.
Page *145, line 16 from top, for "35 51. 8," read 35 47. 5
Page *145, line 16 from top, for "75 34. 2," read 75 31. 6.
Page *145, line 21 from top, for "Drum's," read *Drane's.*
Page *145, line 45 from bottom, for "84 10. 6," read 84 12. 5.
Page *145, line 38 from bottom, for "89 54. 5," read 89 48. 5.
Page *151, line 3, after "Fourchue," insert *island.*
Page *151, table 3, in heading of column 7, after "geographical," insert *miles;* and for "o z," read *of z.*
Page *153, large table, column 8, line 2, for "1 63," read 1 03.
Page *153, same table, column 1, 2d argument of moon's declination, zero ought to be lowered one line.
Page *158, line 26, for "colors," read *lines.*
Page *159, table No. 1, under second maximum for Sandy Hook, for "1. 00," read 0. 00.
Page *159, table No. 1, under fourth maximum for Cape Henry, for "4. 42," read 3. 42.
Page *159, table No. 1, under second maximum for final value, for "4. 01," read 4. 00.
Page *160, line 51, for "full line," read *shade.*
Page *160, line 52, for "lines," read *shades.*
Page *165, line 28 from bottom, read *wind light and variable.*
Page *165, line 24 from bottom, read *moderate wind from SW.*
Page *165, line 3 from bottom, for "$\times$," read $+$.
Page *166, line 1 from top, for "66," read 166.
Page *167, line 11 from bottom, for "7° S. (7° W.)," read 7° (S. 7° W.)
Page *168, line 7 from top, for "par-tide," read *particle.*
Page *172, line 3 from top, for "depth," read *breadth.*
Page *174, line 6 from bottom, for "N. 35," read N. 35 E.
Page *181, line 14, strike out commas after the two words "transits," and insert after "declinations."
Page *182, line 6, column 4, for "22," read 27.
Page *182, line 6, column 9, for "16," read 13.
Page *182, line 6, column 10, for "18," read 13.
Page *183, in heading of table II, for "Smithville, S. C.," read *Smithville, N. C.*

Page *185, upper table, last line, column 3, for "5. 3," read 5. 8.
Page *185, same table, column 5, line 2 from bottom, for "0. 0," read 0. 3.
Page *190, line 14, for "1854," read 1853.
Page *192, line 12, for "D," read *L*.
Page *192, line 15, for "E," read *D*.
Page *194, line 27 from top, for "bars," read *burs*.
Page *198, line 32 from top, for "investigated," read *invested*.
Page *198, line 35 from top, for "quoted," read *coated*.
In Index, for Lieut., read Capt. W. R. Palmer, U S. A.

REPORT.

MOUNT HARRIS STATION, NEAR DIXMONT, PENOBSCOT COUNTY, MAINE,
October 23, 1855.

SIR: As required by law and the regulations of the Treasury Department, I have the honor to submit a report of the progress of the coast survey under my superintendence for the past year.

The work has been in progress, as for the last three years, in all the States where it is not essentially completed.

My report of progress is divided into three parts: the introduction, containing general statements and references to the more detailed notices of the other parts of the report; the description of all the operations classed geographically, according to sections; and the appendix, containing lists, reports, memoirs, and papers relating to the survey immediately or growing out of its operations.

I. The introduction gives: 1st. Some general statements and notices of the principal subjects which are found in detail in the other portions of the report and remarks. 2d. A condensed statement of the progress during the past year, arranged geographically. 3d. The estimated progress for the next fiscal year, with the estimates of means necessary to secure that progress.

II. The next division contains a detailed account of the work in the field and afloat generally to the 1st of November, 1855, classed geographically by sections, and arranged in each section under the heads of reconnaissance, astronomical work, triangulation, topography, and hydrography. The labors of each officer are then stated, and the statistics reported by him. A very brief summary of the operations precedes the details to facilitate reference to them, and the office-work of the section is noticed in a very general way. Each section forms, as it were, a chapter, and can be referred to easily, being numbered in order from one to eleven. After the work in the field and afloat is a separate chapter of office-work, which closes this part of the report.

III. The papers in the appendix are classified under the following general heads: 1. General lists. 2. Coast Survey reports and correspondence, subdivided into—A, developments and discoveries; B, special surveys and reconnaissances; C, commerce and commercial facilities; D, tides and magnetic results; E, office-work. 3. Special scientific matters, classed as—A, geodetic and astronomical; B, magnetic; C, tidal and current; D, miscellaneous. 4. Miscellaneous correspondence. 5. Light-house matters. 6. List of sketches accompanying the report, and sketches, maps, and diagrams.

An abstract of the contents of the report and appendix, with reference to the pages, and an alphabetical index, precede the report.

The object of this mode of treating the subject, and of the several divisions, were fully explained in my report of last year.

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, 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.

SECTIONS X AND XI. Coast of California and of Oregon and Washington Territories.

Taking in hand the small sketch of the coast which accompanies the chart of magnetic lines, the progress of the survey may be traced in a general way. The triangulation extends with two breaks only, one of ten and one of fifty miles, from Penobscot bay, Maine, to a point ten miles below the Cape Fear, in North Carolina, taking in the sounds and the greater number of bays and rivers to the head of navigation: from thence onward it has included Winyah bay and Georgetown harbor; Charleston harbor, and thence to St. Helena sound; Tybee entrance and its vicinity; the Savannah river to the head of Argyle island; St. Simon's entrance and Brunswick harbor; Cumberland entrance (St. Mary's) and Fernandina; the St. John's to Jacksonville; the Florida reefs and keys from Virginia key to Key Rodriguez, and from Loggerhead key to the Marquesas; the coast of South Florida; from the Miami to the head of the Gulf of Florida; Crystal river offing to Cedar keys; Ocilla river entrance; St. Andrew's bay and its dependencies; Mobile bay and Mississippi sound; Chandeleur sound, connecting Mobile and New Orleans through Lake Borgne and Pontchartrain; Atchafalaya bay, from Point au Fer to Côte Blanche bay; Galveston lower and upper bays, and east and west bays; the coast of Texas, from Galveston entrance to Palacios bay, and the entrance to the Rio Bravo del Norte. This triangulation rests upon eight final and many preliminary bases; the main bases are in Massachusetts, New York, Maryland, North Carolina, South Carolina, Florida, and Mississippi. On the western coast the main triangulation extends from Sonoma mountain, north of San Francisco, to below Monterey; and other triangulations have been made of Rosario straits, the Canal de Haro, and the islands between; of harbors in Puget's sound and its dependencies, and of part of the sound itself; of Columbia river entrance, and up to Astoria; of Humboldt bay; of Ballenas bay; of Monterey; of San Pedro, and of San Diego bay, and includes in preliminary surveys all the ports of California and Oregon, and part of those of Washington. A general hydrographic reconnaissance has been made of the whole western coast, with accurately determined geographical positions of the principal capes, headlands, and ports.

The topography, which, based upon the triangulation, gives the details of the shore and of the interior as far as is necessary for the purposes of the navigator in enabling him to recognise the land, or for a land communication, follows it closely. Besides detached work in Casco bay, it extends with few breaks, except those of the coast line, from Great Boar's Head, north of Portsmouth, New Hampshire, to the head of Bogue sound, North Carolina. It has accompanied all the rest of the work mentioned in tracing the triangulation, being generally about one season only behind the most advanced parts of it, on the Atlantic, the Gulf of Mexico, and the Pacific, so that where the progress belongs to any year previous to the last, the topography has generally been executed.

The hydrography follows in its turn, requiring for its complete development the topography; but in special cases substituting reconnaissance for survey. Detached hydrographic work has been done in Maine, east of the Penobscot; in Casco bay, and in its vicinity; at Portsmouth, Newburyport, Ipswich, and Annisquam. Massachusetts bay is nearly complete, and from Cape Cod to the North Carolina line, including that extremely difficult work of the Nantucket shoals, and the broken ground east, north, and south of them, the bay of the five States, the Vineyard and Long Island sounds, New York bay, and its dependencies, Delaware bay and river, the Chesapeake, and several of its rivers. South of this the hydrography includes Albemarle sound, N. C., the Wimble and Hatteras shoals, Hatteras cove, Hatteras inlet, Ocracoke inlet, Core sound, Cape Lookout shoals, the Fryingpan shoals, Beaufort entrance and harbor, and dependencies, Cape Fear shoals, entrances and river, Winyah bay and Georgetown harbor, S. C., Cape Roman shoals, Bull's bay, Rattlesnake shoals, Charleston entrance and harbor, and approaches, the seacoast from Charleston bar to North Edisto river, North Edisto entrance, Port Royal entrance, and Beaufort river and harbor, Martin's Industry shoal, Gaskin banks, Tybee entrance, Georgia, and Savannah river, to the head of Argyle island, the passes through the Romerly marshes, Doboy inlet, St. Simon's entrance, St. Mary's entrance and Fernandina harbor, Florida, St. John's entrance and river to Jacksonville, the Florida reef from Cape Florida to Key Rodriguez, Key Biscayne bay, Legaré and Turtle harbors, Key West entrances and harbor, Rebecca and Isaac shoals, the Tortugas, Tampa bay, (reconnaissance,) Cedar Keys harbor and approaches, Ocilla river entrance, Apalachicola bay and harbor, and St. Mark's, (reconnaissance,) St. Andrew's bay and dependencies, Mobile entrance and bay to the head of Mobile river, Alabama, Mississippi sound from Giant's pass, Mississippi, nearly to Lake Borgne, Louisiana, the outer coast from Dauphine island, Mississippi, to Ship and Cat islands, part of Chandeleur bay, Louisiana, the passes of the Mississippi, Pass Fourchon, (reconnaissance,) part of Atchafalaya bay, Vermilion bay and Calcasieu entrance, (reconnaissance,) Sabine entrance and river, (reconnaissance,) Galveston entrance and lower and upper bays, the seacoast from Galveston bar to opposite Cedar lake, Aransas pass, (reconnaissance,) the Rio Grande entrance.

The developments useful to commerce and navigation, made in the course of a very large extent of work, are of course numerous, and a full statement of them, continued from my report of last year, is given in the Appendix No. 9. The calls for information from the archives, and the numerous applications for reports, maps and charts, show that these are not the only claims of the coast survey to usefulness. The calls are made notwithstanding the very large distribution of the annual reports of the survey by Congress, amounting, during the past two years, to nearly twenty thousand copies, showing that the demand for the reports, and for the maps and sketches which accompany them, exists in quarters not reached even by this large distribution.

The pressure which increased prices of labor and supplies of all kinds had brought upon us, threatened so seriously to impede our progress, that last year I asked for an increase of the appropriations to meet this increase. This was recommended by the Secretary of the Treasury and granted by Congress, so that I have this year been able to keep up the scale of the survey, which otherwise must have been contracted to meet the increased expenditures of the work in the field, afloat, and in the office. Unforeseen expenses have come upon us for injuries to our small vessels, by storms, which have been necessarily met from means that otherwise would have been devoted to additional work. One of the disasters which will involve us in the most considerable of the unforeseen expenses of the present year, is the explosion of the boiler of the steamer Hetzel. This occurred while the vessel was moving and under apparently no extraordinary pressure of steam. The reports of the commander of the vessel and of an officer of the army who was on board, on coast survey duty at the time, are given in Appendix No. 66. By request of the Navy Department, an investigation into the circumstances of the explosion has been directed.

The best idea of the progress of the work during the past year is to be had, in the least time, by examining the list, Appendix No. 1, which shows the distribution of the field parties and of those afloat during the year, the officers in charge of them, the localities of work, and the progress made by each party; then by passing to Appendix No. 36, in which the office lists show the progress in the several divisions there. The summary, I am convinced, will be deemed entirely satisfactory. It shows a very large amount of labor, physical and mental, on the part of the officers of the survey, and of bodily labor of the men under their charge.

Since the date of my last report five officers of the army, who had considerable experience in the work, have been relieved from service upon it, viz: Captain T. J. Cram, of the topographical engineers, and Brevet Major Henry Prince, Captain E. O. C. Ord, Lieutenant D. T. Van Buren, and Lieutenant James Totten, of the line of the army—the fourth named officer at his own request. Arrangements were made to supply the places of these officers and to detail the additional officers provided for under the rules of the Secretary of War, but the exigencies of the War Department have not permitted them thus far to be carried out. I have no doubt that when these exigencies shall be less pressing, the vacant places will be filled. The loss of the varied scientific ability of Captain Cram has been felt in our operations. No officer or civilian has come under my notice who has superior powers to Major Prince in reconnaissance, including the execution in the field, and the power of communicating the information obtained. Personal inconveniences were only regarded by him in the light of incidents varying the routine of the work, and his outfit and appliances were always on the most economical scale consistent with efficiency. Wherever he went, all persons with whom he came in contact were interested in assisting him in attaining objects which so much interested him. His combinations were happy, his *coup d'œil* perfect, his sketches with pencil and pen characteristic and rapid. I feel it due to this officer, who has devoted so much time and energy and talent to the coast survey, to speak out in regard to his services. I would also refer to the Appendix No. 68 for an expression of my views on this same subject, transmitted to the honorable Secretary of War, with the request from the Treasury that they might be placed on the files of the War Department.

The number of officers of the army at present attached to the survey is eleven, (Appendix No. 2,) viz: Three from the corps of engineers, one from the corps of topographical engineers, four from the artillery, and three from the infantry. Nine additional officers are required to fill the number authorized by the Secretary of War.

The number of officers of the navy attached to the coast survey on hydrographic duty were, on the first of September, fifty-nine, being an increase of four upon the details of the previous year, and a decrease of two from 1853. Of the fifty-five sea officers thus attached, (see list in Appendix No. 3 *bis*,) twenty-seven only were connected with the survey a year ago, so that the rotation of forty-four per cent. to which I referred last year as crippling the parties by its rapidity, has been exceeded during the past year. Allowance should be made for this in considering the hydrographic results of the survey. Were it not that the present enlightened head of the Navy Department has made it a point to permit the survey to retain the chiefs of parties, and thus to have the advantage of experience in the directing mind, the results would have been disastrous. It is true that some of the officers detailed have previously been connected with the survey; but it is equally true that even these must, in the progress of the work, require new training under the new circumstances in which they are placed. The very favorable consideration which the Secretary of the Navy shows towards this work has remedied some of the minor evils to which I felt it my duty to refer in my last report. The new laws relating to seamen have secured to us, also, a better class of men, as a general rule, than we had before their passage. In the details of naval engineers there has also been an improvement in the increased number of more experienced engineers allowed to us. Some of the facts relating to this branch of service in former years were quite of a startling character in reference to the want of experience of the engineers sent to us. On the first of September there were three first assistant engineers on coast survey service, the lowest grade of which, in my judgment, should be sent to have the control of the engine and boilers of a vessel, containing so many officers and men whose lives are valuable to the country and engaged in a work the expenditure for which may be so much increased or diminished, according to the skill and knowledge of the engineers. The number of first, second, and third assistant engineers connected with the survey on the first of September was fourteen ; of these eight were third assistants. I am aware that there are cases of distinguished ability and knowlege in the junior grades of assistants ; but I speak of the rule, and not of the exceptions, and consider the lives and property at stake to require all the experience for their case which can possibly be allotted to them.

The list of naval officers being, according to usage, made up to the first of March and first of September, near the periods when the changes are made from north to south in surveying, or from the office to afloat, none of the results of the action of the Naval Efficiency Board appear upon them, nor have the results of this action been fully developed so as to make it desirable to speak of them up to the date of this report.

The developments and discoveries of the past year have been numerous, although not any one ranking probably so high in importance as the discovery of Stellwagen's bank, made last year. I have placed with the developments the examinations made of the entrances to some harbors which are just now attracting a good deal of attention, and which will be carefully surveyed before the next year closes. A list of developments and discoveries by the Coast Survey, from the beginning of the work to the close of 1854, is contained in Appendix No. 9.

1. Extension of Stellwagen's bank to the southward and eastward, some sixteen or seventeen square miles, enclosed by the twenty-fathom curve.

2. Determinations of rocks off Marblehead and Nahant.

3. Probable connexion of George's bank and the deep-sea banks north and east of Nantucket.

4. Discovery of a shoal lying north and south, one mile and a half southward of Nantucket light-boat.

5. Examination of the interference tides of Nantucket and Martha's Vineyard sounds.

6. The currents of the great bay between Massachusetts, Rhode Island, Connecticut, New York, and New Jersey.

7. Changes in New York bay and harbor.

8. Shoal in the main ship-channel of New York harbor.

9. Re-examination of York spit, Chesapeake bay, and least water determined, (nine feet.)

10. The bars in Rappahannock river.

11. Sub-marine range of hills beyond the Gulf Stream, tracked from Cape Florida to Cape Lookout.

12. Changes in the main, western, and New Inlet channels into the Cape Fear.

13. Changes in the main ship-channel, and in Maffitt's channel, Charleston harbor.

14. Examination of Doboy, St. Simon's, and Cumberland entrances.

15. Temperature of 34° beneath the Gulf Stream, forty miles east of Cape Florida, at a depth of three hundred and twenty-five fathoms.

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

17. Tidal phenomena of the Gulf.

18. Determination of Cortez rock, southern coast of California.

19. Determination of Uncle Sam rock.

20. Reddish sand marking the inner entrance to the Golden Gate.

21. Channel sounded out between Yuba Buena and the Contra Costa, San Francisco bay.

22. Co-tidal lines of the Pacific coast.

A new sketch has been prepared of Stellwagen's bank, representing the additional facts developed in regard to it this year. A bank was looked for to the northward and eastward of this and towards Fippennies, but thus far without success. Under the head of hydrography in Section I, will be found full notices of the other developments in the Section, except those relating to the tides. Last year quite an elaborate series of observations was planned and executed, and the discussion of them made under my immediate direction, and while it showed important progress made, also proved that some additional data were necessary to fully comprehend the subject, the interest of which to the navigation of these sounds cannot be over-estimated. These new observations are noticed briefly in Section I, and more fully in Appendix No. 33. They will undergo immediate discussion. These investigations will reduce to rule some observations of tides and tidal currents, which apparently were quite without regularity.

To test the idea of a current setting on the shore of Long Island, in the great bay between Gay Head and Cape May, which may be called the bay of the five States, (as the term New York bay has been appropriated to a much smaller, though exceedingly important sheet of water,) the experiments described in the hydrography of Section II were made, and with the negative result that of all the bottles thrown in between Nantucket and New York entrance, but one was reported, though the south side of Nantucket and the Vineyard were specially searched, and notices were circulated in all the local papers of Long Island and the vicinity. That one of these bottles should be picked up on the bar at the island of Santa Cruz, one of the Azores, is a fact full of interest and instruction, and suggestive of an important field of research, which I propose at once to occupy.

The maps of an important locality, made at intervals of a few years, give the means of knowing the direction and amount of change taking place, of studying the causes, and of applying the principles of engineering to controlling and modifying them. Such has already proved true in reference to parts of New York harbor, surveyed thoroughly in 1836, and re-surveyed within a few years. The changes developed are of great importance in the commercial development of that great sea-port, and the facility with which they are generalized will appear from the notice of them given in the Appendix No. 24. The new survey making for the Commissioners will do for the whole harbor what the partial surveys have done for limited portions of it.

The fact established by Lieut. Comg. Craven, that the straits of Florida, between Cape Florida and Bemini, are but three hundred and seventy fathoms deep (about four tenths of a mile) in their deepest part, overturns much of the speculation which has in former times been rife upon this matter. The existence of the waters of the polar current below those of the Gulf Stream, even as far south as latitude 259° 36′ N., established by the same observer, is a fact of great interest; the temperature of the surface-water being eighty degrees Fahrenheit. Lieut. Comg. Craven found the water at the depth just named to be but two degrees of Fahrenheit's scale above the freezing-point of fresh water. The mean temperature of the sea on this section, if the waters could be mingled from top to bottom, would at the time of exploration have been 64° Fahrenheit, while that of the air was probably not less than 75° Fahrenheit. The great pressures and low temperatures thus afforded by the ocean must find application in scientific experiment or in useful art.

The following up of the range of hills beyond the Gulf Stream, first discovered in 1853, and extending in the same general direction with the curve of the stream, from the Florida channel nearly to Cape Lookout, is one of those happy results of combined perseverance, skill, and intelligence which cannot be too highly praised. Using the coast survey chart of the Gulf Stream as a basis, the accomplished hydrographer who made this exploration seems to have been at no loss to place his sounding-line just where the bottom would be reached at about the expected depth. I have given notice of these observations in some detail under the head of "Gulf Stream," between Sections III and IV of this report.

The existence at the bottom of the ocean beneath the Gulf Stream, from the latitude of 38° to Cape Florida, of cold water, much colder than belongs to the latitude, has been proved by direct observation in different years.

The destiny of the Cape Fear country, with all its resources and enterprise, hangs in a great degree upon the facility of entrance to this admirable river. Surveys can and will show the progress of changes there, and are the only means by which improvement can be guided. The officer who, regardless of his own personal comfort, has volunteered, while passing from one section of the survey to another, to take up the difficult work of re-examining the Cape Fear entrances, deserves the gratitude of all who have an interest in the resources, and share in the enterprise to which I have alluded. The results as given under the head of hydrography of Section IV, will be found of decided interest.

The favorable changes in the main ship-channel into Charleston harbor, and in the bulkhead which closes Maffitt's channel towards the harbor, have been chronicled by the same officer (Appendix No. 15) whose name has been given to the channel by the citizens of Charleston in token of their appreciation of his services in regard to it. That nature is at this time struggling to open a channel here, and requiring only assistance from art, is quite certain, and now is the time, while the play of forces is tending to do the work, to give the necessary help to confirm the beneficial action. Circumstances may change.

By occasional effort—directed, however, in a systematic way—we are gradually arriving at a knowledge of the depth of the Gulf of Mexico without specially employing a party for the deep-sea work. The lines run this year are of interest, though the depths being obtained with the lead-line, can only be considered as rough approximations.

The entire series of tidal observations necessary to the study of the general motion of the tide-wave in the Gulf of Mexico, and of the principal tidal phenomena of its ports and harbors, have been completed, requiring merely, when more minute investigations succeed these general ones, filling up between principal stations. We have now reliable results for fourteen tidal stations, each occupied for more than two lunations, and four for a year or more. The tidal movement in the Florida channel is traced by four stations from Cape Florida to the Tortugas; that along the western coast of the peninsula by four stations; that along the north shore of the Gulf, between Cape San Blas and the mouths of the Mississippi, by five stations; that between the Mississippi and the Sabine by three stations; and that on the western side of the Gulf, between Galveston and the Rio Grande, by four stations. The observations at these points have been reduced according to methods introduced by myself and modified in the tidal division, and when they admitted of it, according, also, to those of Mr. Lubbock.

The observed tide-wave has been decomposed into its two chief constituents, the diurnal and semi-diurnal waves, and these have been followed in their changes. There is yet much to be done in the study of these results, but they have already, while furnishing all the data required for practical purposes for tide-tables for our useful charts, yielded much richer fruit, and will ultimately give the clue to the somewhat complex system of tides of the Gulf of Mexico. The simple result, that the tide-wave passes across from the Tortugas to the mouth of the Mississippi, there being a difference of but about an hour in the occurrence of the high waters at those two points, is of itself sufficient to stimulate curiosity, and to show that there is much to be unravelled. To state this in another point of view, the semi-diurnal tide at the mouth of the Mississippi is earlier than it is to the east of the Delta or to the west, though this point is deep up the Gulf, as it were, and the question might suggest itself how the tide gets there without touching either of the shores. The curves which represent the law of rise and fall, and time of the compound tide of each of the principal ports, and the two chief components or type curves of the tides of the Gulf, as they may be called, have been satisfactorily determined. They are very characteristic at the periods when the diurnal tide is the greatest and least, namely, when the moon is farthest from the equator, and when crossing it. These tides are especially a coast survey development, for I am not aware that even the phenomena were known, much less the laws of them understood, until the Coast Survey observations and investigations were made. The curious circumstance, that in many of the ports the tide ebbed and flowed as a rule but once a day, and that to this rule there were exceptions, while in others it rose and fell regularly twice in twenty-four (lunar) hours, was of itself known to but few persons. Navigators, generally, attributed the rise and fall of the waters of the Gulf to the winds, and their apparent regularity for days together and then sudden irregularity, to the general trade-wind, character of the winds, and to their exceptional changes.

The determination of the position of a rock so far at sea as the Cortez rock is a matter of great difficulty, and I am less surprised that it was missed in the first reconnaissance of the Cortez bank, than that it was found in the recent examination. The Uncle Sam rock is nearer the coast, and no difficulty existed in finding it when the position was approximately known. Rocks along coasts and in harbors are extremely difficult to find unless where the sea breaks upon them, and no reasonable expenditure of time and means would suffice to make the hydrographer sure that he had found, even by sweeping with deep-sea lines, all such dangers to navigation. A remarkably low tide, with a heavy swell, often reveals these hidden dangers in places where they have been unsuspected, and after a channel has been used by thousands of vessels, day after day and year after year, a point of rock is found by bringing up some unlucky craft. The hydrographer does his best with the sounding-line, obtains all the information he can from pilots and fishermen, and then often must incur the blame, but ill-deserved, of having omitted some pinnacle of rock from his chart.

The discovery of so characteristic a mark as the reddish sand within the bar at San Francisco entrance, cannot fail to be of great importance to navigators. It appears to have been carefully ascertained that it was not owing to some special condition of the rivers that this sand was found, but that it is always there, marking the inner limit of the bar of the Golden Gate. The officer who made this discovery will verify the facts relating to it from time to time. The development of the channel between Yerba Buena and the Contra Costa was a necessary result of the surveys, but not the less useful on that account. The importance now attaching to San Francisco rendered it essential that soundings should be multiplied where a noble city had taken the place of a ranch for the sale of hides, the sole occupant of this splendid bay when even recent charts were made.

The tidal observations on the western coast have furnished materials for a chart showing the places where it is high water at the same instant, or chart of co-tidal lines. An approximate chart has been constructed by me from the discussions of these observations made for me under special instructions, by the tidal division. This chart, and a memoir accompanying it, explanatory of the considerations upon which it was made, was presented, by authority of the Treasury Department, to the American Association for the Advancement of Science, at their recent meeting in Providence, and will be found in Appendix No. 50. The conclusion which I draw from this series of lines is the same as that already deduced from those on the Atlantic coast, namely, that the tides thus observed are essentially littoral, or shore-tides, in their character, and give but little information as to the general progress of the great ocean tide-wave.

I could not properly include, in the table of developments, one of the most useful results of the Coast Survey—the marking of the Florida reef by signals at intervals along it. This has been done by an officer of the survey, under the general instructions of the Light-house Board, and with means furnished by the special appropriation recommended by them for the purpose. The Coast Survey signals along the reef were necessarily of perishable materials. They served, however, to mark the spots where permanent beacons should be placed, and it was only necessary to substitute iron for wood in the construction to furnish the most valuable aids to the day navigation of the Florida channel which have yet been devised.

Fourteen signals or beacons have been thus placed, by request of the Light-house Board, on projecting and dangerous points of the Florida reef. These are so distinguished from each other, by colors and letter-vanes, that the navigator on making one of them can hardly fail to know his position. Plain descriptions are given of each beacon (Appendix No. 16) by the officer who placed them, and such details in regard to them, and remarks, as to make them of the highest value for the day navigation of the reef. In fact, by picking them up in succession and keeping them at a safe distance, the master of a vessel may run along the reef with entire confidence.

The Gulf Stream soundings off Key Biscayne have been examined by Professor Bailey, of West Point, with very interesting results. He states that these soundings, which are from depths varying from one hundred and forty-seven to two hundred and five fathoms, agree in their general characters as well as their organic contents; they are light greenish-grey mud, composed chiefly of organisms, which he names, in a profusion hitherto unrivalled in any known deposite of the present ocean, and only surpassed in fossil state by certain strata of the island of Barbadoes. The interesting remarks of Professor Bailey are given entire in Appendix No. 55.

The following notices to mariners have been communicated to the Treasury Department:

The development of a shoal one mile and a half south of Nantucket light-boat. (Appendix No. 11)

The existence of a knoll in the main ship channel, entrance to New York harbor. (Appendix No. 12.)

The existence of a shoal spot, with but nine feet water, near the end of York spit, Chesapeake bay. (Appendix No. 13.)

Determination of the position of a dangerous rock (lat. 32° 29′ N., long. 119° 04½′ W., approximate) on Cortez bank, off the southern boundary of California. (Appendix No. 18.)

The location of a rock upon which the steamer "*Uncle Sam*" struck, south of Point San Pedro, California. (Appendix No. 19.)

The existence of a deposite of reddish sand inside, and extending from, the bar at the entrance of San Francisco bay, as far up as the "Heads." (Appendix No. 20.)

The beginning is made this year of a compilation, from Coast Survey data, of sailing directions, lists of dangers, latitudes and longitudes, magnetic variations, light-houses, tides and currents, and other hydrographic information, for the coast and ports of the United States which have been surveyed or examined in the progress of the coast survey. This will be added to from year to year as the work advances. The arrangement of the article is described in the preface to it. In every case reference is made to the map, chart, or report, in which the information is found. This list includes nautical information in regard to numerous localities from Maine to Texas, both inclusive, and from southern California to Washington Territory.*

The list of localities surveyed on the western coast (Appendix No. 6) contains sixty-eight, of which the geographical positions have been determined and preliminary surveys have been made. Of these fifteen are bays, sounds, inlets, or straits, of ten of which preliminary surveys have been made, either in the whole or part; of four the topography of the shores only has been executed, and of one the geographical position determined; of ten of these bays, &c., sketches have been published. Nineteen of the localities are harbors or ports, of which preliminary surveys have been made of fourteen, topographical surveys of the rest, and sketches or preliminary charts of all but one published. Twenty-four of the localities are capes, points, headlands, or islands, chiefly surveyed for light-house purposes, of nineteen of which sketches have been published. The remainder include entrances to rivers or to harbors, anchorages, reefs, banks, and the city of San Francisco.

The present list presents twenty localities not on the former, representing nearly the progress during the past year, and for the time previous, the results of which had not reached the office at the date of my last report.

It will be seen that all these surveys, which are deemed of interest, are engraved and published as soon as practicable after their receipt, and that we are up to the last season's field-work with the sketches for this report.

* It was intended to append these sailing directions, &c., to this report, but they are too voluminous for the purpose, and must be published separately. Appendix No. 30 gives a list of them.

Among the matters relating to the western coast contained in my report of this year, is a memoir (Appendix No. 26) descriptive of the coast generally, by Assistant George Davidson. This is valuable, as embodying the experience of an intelligent observer who has gone frequently along the coast, between its two boundaries of Frazer's river and San Diego, in various ways, has visited its principal ports, islands, capes, and headlands, and has navigated many of its waters. It is the beginning of what must grow up into one of the most useful documents resulting from the survey. By a coincidence which is one of its best recommendations, the necessity for such a paper is strongly insisted upon by the intelligent and learned traveller, whose contribution to our work I proceed next to refer to. The memoir will be found in the Appendix No. 64.

Few of the practical details relating to the Coast Survey have given more trouble than the ascertaining of the proper names of localities and their orthography. Even upon the Atlantic coast, and where the settlements have been made by those speaking the English language, the case is difficult; and where, as upon parts of the Atlantic and Gulf coasts, and upon the western coast, the settlements have been ade by the French, Spanish, and other nations, or where the names given by the aborigines of the country, or by the first discoverers, are intended to be preserved, the difficulty is greatly increased. Our population is so changeable, that names are very readily lost, changed, or corrupted. The land parties consult the residents of places on shore; the hydrographic parties the pilots, fishermen, and sea-faring men. Two sets of names are frequently presented, neither of which may be correct. When about to publish the first Coast Survey map of New York bay and harbor, by the advice of the Hon. John C. Spencer, then Secretary of the Treasury, I sent the sheets to the members of Congress from the several districts, asking that they would furnish the names of residents in the districts who might most advantageously be consulted in regard to the proper designation and orthography of the localities embraced within their districts severally. In some cases the names of several residents of the same district were furnished, and the information differed so considerably as to increase rather than remove the doubts resting upon the subject. The information, when classified, led to important suggestions as to a better plan of proceeding. It was plain that if, in such a region as the vicinity of New York, there was difficulty in establishing the names of places and their orthography, there must be much greater difficulty elsewhere. By the advice of the Hon. George P. Marsh and the Hon. Edward Everett, I consulted, for the orthography of names in New York, New Jersey, and Connecticut, the Hon. H. C. Murphy, a ripe scholar, who had made these subjects his especial study. His reports have embodied a fund of information on this subject for our archives, and have afforded a basis, in some cases, for restoring aboriginal names or rescuing them from corruptions; in others, for establishing orthographies beyond a doubt; and in others, have shown that doubts must always rest upon the received orthographies.

This system has been followed up as the finished charts of other portions of the coast have been furnished. On the western coast the case was one of extreme difficulty. Different names had been given by successive discoverers or explorers to the same points, and the same indentations, the same bays and sounds. These had frequently replaced aboriginal names which were preserved by the inhabitants, or names given by the early explorers on land, or by the missionaries, which had been retained in their pure or in a corrupted form. The mistakes and various titles and orthographies were exceedingly perplexing, and in some instances names were altered more than once, modes of spelling were changed and restored, and the whole subject seemed one of perplexing uncertainty. It was of the first importance, then, to trace the history of discovery on that coast; to ascertain the original names and the successive ones; to restore those which were corrupted, and to fix those uncorrupted beyond the power of change; to go back to the earlier names, when the later had not become so permanently attached to the localities as to make it too difficult; and, in short, to make the Coast Survey maps and charts the standard for names and their spelling, as for the geography of the country. To effect this I availed myself of the visit to our country of a distinguished ethnographer, Doctor J. G. Kohl, who had made the most admirable collection of maps of discovery on the Western continent, compiled from various sources, and presenting the subject in the most systematic manner, with a series of his own, showing, by striking and original methods, the results of successive voyages, travels, and expeditions by sea and land. From him I have received a report of the most interesting character, which will be published in connexion with the archives of the survey, and of which an abstract showing the nature of its contents is appended to the present report. (Appendix No. 64.)

The points to which I called the attention of Dr. Kohl are thus briefly summed up in a memorandum which I handed to him for his guidance:

"To trace the succession of discoveries and explorations from Cortez to those of Wilkes and De Mofras, giving their dates and localities. The localities to include the immediate coast and the interior to the coast range of mountains, inclusive. The explorations to be those by sea and by land. To give the maps resulting from these explorations, or notes of where access may be had, if they have been published, and copies of manuscript maps, when they exist only as such. To give the titles of books, maps, and charts relating to these discoveries, and information where they may be found. To give a general notice of each exploration or voyage, with reference to maps, and a general historical map on the plan of Dr. Kohl. To give the best authorities for the names of localities, showing how the names have been given, and thus to establish their orthography as a basis for the geography and hydrography of the western coast of the United States. To furnish a catalogue of the names of headlands, capes, sounds, bays, and harbors, with the authorities."

The impossibility of compressing this work into a small compass forbids its publication as an appendix to this report; though great pains have been taken by Dr. Kohl to reduce it to the smallest possible limit. In consequence of this limitation, and of the nature of the work itself, he has found it desirable to explain exactly how far this work may be considered merely a fragment. (Appendix No. 64.)

The report of Doctor Kohl includes—

"1. A complete historical account of the progress of discovery, as connected with the hydrography of the western coast from Coronados island to Cape Scott, the northern point of Vancouver's island.

"2. A map to illustrate the historical account, showing in colors the range and limits appertaining to each discoverer and explorer.

"3. A collection of maps, reduced copies of originals or duplicates of ancient and modern maps, in further illustration of the history.

"4. A list of names of bays, capes, harbors, &c., on the western coast, with critical and historical remarks, settling the orthography of the names.

"5. A catalogue of books, maps, manuscripts, &c., relative to discoveries on the western coast."

The map illustrative of the memoir just noticed, exhibits in colors the extent of coast included in the discoveries of each navigator and traveller, with names, dates, &c.

A brief description which accompanies it explains the plan adopted in its preparation.

The collection of historical maps shows the tracks and routes pursued by successive explorers, and many of them are copies from manuscripts or from rare printed maps.

The list of geographical names includes the history of nearly three hundred localities, capes, inlets, harbors, &c., on the western coast, with a separate discussion of the name of each and the authorities relating to it.

A geographical description of the coast suggested by Dr. Kohl will be prepared, his views falling in exactly with those which I had commenced to execute for the Atlantic and Gulf coasts.

In fact, the report of William P. Blake, Esq., (Appendix No. 65,) opens with a general description of the sort for a part of the coast of California. The bearing of such a description, drawn from the Coast Survey maps and other authentic sources, upon the historical questions relating to names of localities, is thus stated by Doctor Kohl:

"In many cases, while engaged on the work just completed, I was enabled to decide in regard to certain historical doubts only by following your reports in connexion with letters and views, and the descriptions given by officers engaged in the work under your superintendence. To give but one instance from many which occurred—I could make out that the old '*Cabo Galera*' of the Spaniards was our *Point Conception*, only by comparing the old descriptions of it with the Coast Survey views and delineations of that cape."

The first portion of the memoir by Mr. Blake (Appendix No. 65) is devoted to a general description of the ranges of mountains bordering the California coast. They are shown to consist of a series of parallel ranges, enclosing longitudinal valleys. The general trend of all these ranges is also considered with special reference to the determination of the hydrography of the neighboring coast. The existence of sub-marine mountain ranges parallel with the coast is declared from the indications presented by the features of the land, and by the groups of islands disposed in straight lines. Mr. Blake considers that there are two or more parallel ranges of this kind south of Point Conception, and their probable position and trend is noted. He also considers it highly probable that submerged ranges will be found parallel with the coast north of Point Conception, and suggests that a series of soundings be made on lines perpendicular to the general trend of the coast mountains, and also in the direction of the trend of the islands. The second division of the memoir includes a brief general description of the important geological features of the principal ports and bays from Bodega to San Diego. The nature of the rocks at the several magnetic stations between these points is given, and the descriptions are accompanied and illustrated by small maps and sections.

Lieut. Comg. Alden, chief of the hydrographic party on the Pacific coast, in the steamer Active, has, on various occasions, rendered service to vessels in distress, which I have heartily approved. This year, on her voyage to Washington Territory, he fell in at Crescent City with a body of recruits of the United States army, who had been cast ashore by the burning of their transport, and were in distress, and immediately took the officers and men on board and transported them to Fort Steilacoom, to which they were bound. (See Appendix No. 69.) By a curious coincidence, this timely relief by a Coast Survey vessel was afforded to a detachment under the command of Brevet Major Henry Prince, who had just been relieved from the coast survey, and whose services in the work I have had occasion to acknowledge in the warmest terms.

Every two years the list of geographical positions determined during that period, in the survey, is published in the appendix to my report. The last publication brought the list up to 1853, and it is now completed to 1855 by giving the results for the past two years. (Appendix No. 8.)

A full discussion has been made of the observations of magnetic declination or variation hitherto collected in the coast survey by Assistant Hilgard, Mr. Schott, and myself, and has resulted in the chart given with this report. The mode of discussing the observations to arrive at this chart is rather too technical for statement here, but will be found in the Appendix No. 47. The observations were all reduced to one epoch by the results of Mr. Schott's investigations. (Appendix No. 48.) Some observations were introduced from other sources than the Coast Survey, and due credit will be given in the complete publication for them. The observations on the coast of the Gulf of Mexico and on the Atlantic were separately discussed, and when brought together required but little shifting of the lines to produce agreement. Six groups were formed of the Gulf results, and they were discussed in conditional equations, involving second differences. The stations on the Atlantic were referred to a great circle, passing through a point near Portland and Cedar keys; thirty-one groups were formed, and a complete equation of the second degree applied to them. The thirty-one conditional equations, involving six unknown quantities, were discussed by least squares. By a small change in the coefficient of the square of the abscissa, these two sets were brought quite near together, giving a continuous representation as shown on the chart.

The memoir, or report, of Charles A. Schott, Esq., chief of the computing division of the Coast Survey office, (Appendix No. 48,) is one of great importance, not only to the survey directly, but to all who use the compass, whether navigators, land surveyors, or engineers. The investigation will enable them to reduce observations of the magnetic variation from one date to their equivalents at another, whether before or after the date of observation. It is based on one hundred and eighty observations at stations distributed over the coast of the Atlantic and Gulf of Mexico. The heads of the report will give the best general idea of it. The first contains the discussion of the secular change of the variation at stations presenting reliable observations, prior to about the year 1740; the second, subsequent to that time; the third, results from comparatively recent observations; the fourth, the investigation of formulæ which represent the secular changes of the variation at the several localities, with a general synopsis of results and remarks. The discussions are very ingenious and thorough, are conducted by the methods of the modern mathematics, and will well repay a careful examination. The principal results are represented in curves (Plate No. 51,) and the comparisons are made graphically between the numbers given by the formulæ and by the observations. An interesting fact connected with these discussions is, that a series of observations made with great labor, and apparently with great care, by E. W. Bean, Esq., of Hatboro', Pennsylvania, and kindly communicated to me, proved so discordant with the results which Professor Hansteen had reached, that we felt compelled to reject them, and I was obliged so to inform this indefatigable observer. His reply was a very characteristic one, expressing his conviction of the accuracy of the observations. It has proved not only that these results are in harmony with the law deduced from other authentic observations, but that they afford us one of the best sets of data yet obtained in our country for the discussion of the secular change.

An additional list of magnetic variations determined during the past season will be found in Appendix No. 49.

The tidal observations have been continued during the year on both the eastern and western coasts. The details in the Atlantic and Gulf of Mexico, under my more immediate direction, have been in charge of Assistant L. F. Pourtales, and those on the western coast have been continued with Lieutenant W. P. Trowbridge, of the Corps of Engineers, assistant in the Coast Survey. Those on the Gulf of Mexico have been, as far as the general phenomena are concerned, brought to a close, requiring the occupation of one or two permanent stations to keep up the series, and of some temporary ones at points to be hereafter determined from the discussion of the observations now collected. Of the temporary stations on the Atlantic the same remark may be made. The tidal observations on the western coast have made good progress by Lieut. Trowbridge's exertions, the permanent stations being well kept up, and the temporary ones having been extended north into a difficult portion of the survey and to difficult points on the coast.

In my report of last year, I gave (Appendix No. 51) tide-tables for some of the principal points of the United States, derived from the observations and reductions in the Coast Survey. I have substituted for these, in the present report, (Appendix No. 53,) an article of a more popular cast, prepared from the Coast Survey data, and communicated by authority of the Treasury Department to Messrs. E. & G. W. Blunt. I consider that the services of these gentlemen, in reference to the hydrography of our coast and to navigation generally, entitle them to the highest consideration from any one engaged in similar pursuits, and therefore most cheerfully afford the time necessary to recast scientific matters into a popular form for them. I feel it a compliment to be asked to assist men of their order of usefulness. They sow their seed broadcast, and access is had to soils which otherwise it might never reach, if confined to official reports and scientific memoirs. Nor is this done in any spirit of exclusiveness; for to others, with the same object, I would gladly afford the same aid, if they considered it desirable to have it. It has been said by one of the highest scientific authorities in matters relating to the applications of mathematics to physical astronomy, that until he prepared a popular treatise on perturbations, in which, casting aside all formulæ, he labored to bring the result within the mind's grasp, logically arranged in words, the subject had not the same clearness in the mind which it assumed under the process necessary to popularize it. In our American association we have seen one of the greatest mathematicians of the day explaining the most abstruse problems of this same physical astronomy by a logical analysis of the most convincing sort, and treating the formulæ, in which he afterwards clothed the analysis, as a dress which any one could put on at will. These high authorities sustain me in saying that efforts thus to popularize the Coast Survey results are not lost, even to the highest scientific discussions of them, and that clearness of conception of the phenomena results from attempts thus to set them in order for a ready understanding of them.

Before giving a short account of these tide-tables, I must be permitted a word as to the mode of preparation of them, and similar articles defining my own connexion and that of others with them. I am not willing to take from others, because having officially certain power to do so, and because usage has in some cases sanctioned it from time immemorial, results of their labors, nor am I willing to give up my just right over my own studies. In organizing the tidal division, I of course availed myself of the labors of the officers who had been engaged in the subject from the first beginnings, and especially I studied what was written in regard to it. The processes then established under my direction were the best that I could find, or thought them so. These have been in part continued, in part modified, by myself and by others, and in part changed. Mr. W. W. Gordon, Sub-Assistant Henry Mitchell, and Assistant L. F. Pourtales, have in turn been very useful in this respect. The routine of the tidal division is now established in a great degree, and kept steadily onward, by the care of Assistant Pourtales, in charge of it, and the industry and skill of the computers under him. In the course of this routine results are furnished for the maps and charts of the survey according to prescribed forms, which have originated in precisely the same way with the routine of computations. When a special subject comes up for discussion, I collect from the tidal division all the data bearing upon it, and for furnishing these the chief of the division and computers are entitled to credit. If, upon study, more information is necessary, I call for it, prescribing generally its form. The ideas which occur to me as to modes of working, I communicate; the hypotheses which arise in the course of the investigation I cause to be tested. In all this the computer who acts deserves merely the credit of accuracy of computation, which I do not claim. If he finds opportunity for improving my processes, I give him credit for this; and so if he points out some relation which I had not observed, but he in no sense prepares my paper, he is entitled to more credit than the copyist who writes it out, but it is of the same order. In preparing, for example, my paper on the co-tidal lines of the Atlantic coast, I called for the data of the establishments, put them roughly in order, had them arranged properly, the co-tidal hours deduced by referring to Mr. Whewell's paper as a guide, and the establishments carried out to deep water by referring to the charts and to Mr. Airy's tables. The results being returned to me, I grouped them by Lloyd's method; and finding that various groups should be tried, directed this. These results were examined and returned, over and over again, for new discussions in the division. In this I, of course, computed many of the tables roughly, so as to see whether the hypothesis were likely to yield fruit, and sometimes more and sometimes less thoroughly, according to the time at my disposal from pressing avocations. The subject at last began to assume a definite shape; I drew up the text, leaving such numbers as required examination blank, to be filled in the tidal division, and the tables to be filled in from revised computations; the chart roughly drawn to be done carefully. In all this I give great credit to Mr. Pourtales as assisting me, and in my paper have given the names of the computers by whom the results were reduced. This is the credit to which Mr. Pourtales and Messrs. Heaton, Mitchell, and Hawley are entitled, and I would be the last one to deprive them of a particle of it. So in the case of the tide-tables which are under consideration ; the data came from the office, and were often returned for re-arrangement and revision. The routine tables were presented by the division. The roughly prepared tables, original with me, were returned to them to be completed. The examples roughly worked out were sent to them for revision, and in many cases others were substituted for them which I had at first fixed upon. In all this, credit is due to Mr. Pourtales for entire and thorough co-operation with me, and to the computers generally for their faithful work. The article, however, is mine. I am alone responsible for its faults and imperfections. If it renders service to navigators, I shall be happy in sharing the pleasure from this source with those who have contributed to enable me to receive it.

These tide-tables (Appendix No. 53) give only approximate results, but such as may safely be used in a general way, before more complete prediction tables can be furnished, or when these are not at hand. The first part of the paper gives the mode of determining roughly the time and height of high water at the ports of the United States named, by referring to the Nautical Almanac for the time of moon's transit, and to the tables for the other quantities. Examples show how to apply the rule. The second part gives the means of a nearer approximation to the time and height of high and low water, by taking into consideration some changes which are not allowed for in the first part. Tables are again given which are less compact than those in the first part, but are, however, quite simple, and require the use only of the Nautical Almanac in conjunction with them to give the second approximation sought. Rules are again given, and examples follow the rules. Next, the attempt is made to give an idea of how to work tides having a large daily inequality, as those on the Pacific and in certain parts of the Gulf of Mexico, where the morning and afternoon tides differ greatly in height and time. Tables are again given, in which, by the use of the Nautical Almanac in determining the moon's declination, the time and height of these apparently irregular tides can be predicted within moderate limits. The rules and tables are not so simple as those of the second part, but I trust will be found not difficult to use. Some brief notes are added on the tides of the Gulf of Mexico, which are, however, confined to the limited object of showing the height at the different ports.

Last year I directed a series of observations on the interference tides of Nantucket and the Vineyard sounds, and gave my personal attention to the observations until in operation, when I left them under the charge of Sub-Assistant Henry Mitchell, who carried out my design with signal ability. This year we have taken up the results where the computations of the last year's work showed we had arrived, and have sought, by additional observations, to unravel some of the still tangled skein of these tides. The objects attained last year, and sought this, are stated in a general way in Appendix No. 33. I must not here omit to state that the powerful analysis of Professor Peirce has been directed to this subject in consequence of the interest which he found in some of the results of last year, and that I have great hope of assistance in reducing this complex system to order, from his mature study of the problem which it presents.

I have already noticed under the head of developments the description and chart of the co-tidal lines of the western coast, (Appendix No. 50 and Sketch No. 49,) which have been added to our results of this year.

In connexion with the subjects relating to the western coast tides, I may here refer to Appendix No. 51, as containing the results of observations upon earthquake waves, recorded upon the self-registering tide-gauges at San Francisco and San Diego, on the 23d of December, 1854. The connexion of the observationsat the two ports with each other is carefully traced out, and both are referred to the earthquake waves of the date mentioned which caused such extraordinary disasters in Japan, and especially in the harbor and city of Simoda. The character of these waves being ascertained, and the time of their transmission, the average depth of the ocean in their path becomes known.

A valuable paper by Charles A. Schott, Esq., chief of the computing division, on the solution of normal equations by indirect elimination, is given in Appendix No. 40. It is too technical in its character to be understood by such a notice as is appropriate in this place, and I therefore merely refer to it by its title, that those whom its details will interest may refer immediately to it.

The point to which, in the several chronometric expeditions of the Coast Survey, we had brought the determinations of longitude between Cambridge and Liverpool, was stated in my last report. The outstanding differences of results pointing to temperature as their source, a new expedition has been undertaken and just brought to a close, in which the greatest care has been taken to secure as equal a temperature as possible. The temperatures of the chronometers while at sea and ashore have been ascertained, and the several chronometers had been specially examined before the expedition commenced, for the effect of temperature. We have also taken pains to eliminate personal equation, as far as it can be done by using the same observers, both at Cambridge and Liverpool. As heretofore, the distinguished director of the Harvard Observatory, William C. Bond, Esq., has had immediate charge of this expedition, and the full and creditable co-operation of Mr. Hartnup, the director of the Liverpool Observatory, has been given. The computation of the results of this expedition has already been commenced by George P. Bond, Esq., of the Harvard Observatory. (Appendix No. 43.)

Director W. C. Bond has continued to furnish us the observations of moon culminations, and has added to them observations on the lunar spots. Interesting remarks upon this subject are contained in his report. (Appendix No. 43.)

The volume containing the results of the Coast Survey chronometer expeditions of 1849, 1850, and 1851 has been prepared by George P. Bond, Esq., and is now reported as ready for the press.

The telegraph operations for longitude have been extended during the past year as far as Macon, Georgia, and arrangements have been made for continuing the work to Montgomery and Mobile, and thus reaching New Orleans as speedily as is consistent with due care and precision in the operation. A full report of the work is given under the head of Section V, where the stations of last year were established, and in the Appendix No. 46. The entire report is printed of the accomplished astronomer who directed the observations. A catalogue of the places of circumpolar stars, and of zenith stars, derived from the best authorities and brought up to January, 1855, is given with this report, and is printed, as being useful for reference by our parties and by astronomers generally. The programme of the longitude operations, together with the modes of reduction of the observations, give an excellent idea of the method of applying the telegraph to this purpose. The report contains, also, memoranda in regard to the instruments employed. The suggestion with which it closes, of a series of observations between Wilmington and Columbia, upon the new line just put up, is in the course of execution. This will connect Wilmington and Columbia directly, each of these stations having already been connected with Washington by an intermediate station. Thus a most important verification will be obtained.

Mr. Mathiot has presented to me a paper which, as bearing upon our interpretation of the experiments on wave time in transmitting galvanic signals, for telegraphic differences of longitude, appropriately finds a place in the appendix to my report, (No. 61.) It is the description of an experiment designed to show that a sensible interval of time is required to raise a galvanic current to its maximum, under certain fixed circumstances, or that before the action of a battery can affect a conductor, a sensible period of time is required to generate the electricity necessary to produce the maximum intensity of current due to the battery with this conductor.

Having arrived at conclusions fatal to the accuracy of the present mode of observing and computing moon culminations for longitude, Professor Peirce has been engaged in investigations intended to rescue this branch of astronomy from the position in which he finds it. A proposition for determining minutely the figure of the moon's disk is one of the points of these investigations. This, as will be seen in his able memoir, (Appendix No. 42,) depends upon the use to be made of occultations of the Pleiades. The subject of occultations, which were favorite themes with Bessel and Walker, Professor Peirce proposes to take up again and to apply thoroughly by means of a new minute triangulation of the Pleiades. This work is imperiously demanded of the Coast Survey. The project has found favor with the men of science of our country, who thoroughly understand its bearings, and the results to be expected from it. It requires, however, the use of very expensive instruments, quite beyond the means of the Coast Survey to procure. From this dilemma we have been relieved by the liberality of citizens of New York State—of the city of Albany—who have offered us the use of instruments exactly adapted to this purpose, which they have undertaken to supply, under the direction of the authorities of the survey; the sole condition being that they shall be worthy of the work, of the state of science of the day, and exceed in magnitude and value any heretofore provided for a similar purpose. I cannot refrain from mentioning Mrs. Blandina Dudley as the liberal and enlightened donor of a heliometer, which is to be used at Albany for the execution of this work. Other necessary instruments will be provided by the public-spirited citizens of Albany, who have charged Dr. B. A. Gould, jr.—whose astronomical labors are already so well known to the country—to procure the first-class instruments needed for these investigations. Professor Peirce's lucid report on the method of determining longitude by the occultation of the Pleiades will be found in Appendix No. 42.

Dr. Peters has urged upon me the use of transits of some of the best defined of the lunar spots, instead of the moon's limb, for longitude purposes, and has made some interesting comparisons at the Cloverden station with the Harvard Observatory, the differences of longitude of the two stations being known from geodetic observations.

The accuracy of our latitude determinations depending, of course, on those of the declinations of the stars employed in them, it is of great importance to us to ascertain the value to be attached to different catalogues embracing the stars used in our observations. This subject has occupied the attention of different officers of the survey; and recently Mr. Charles A. Schott, in charge of the computing division, has made a useful comparison of the Greenwich Twelve Year Catalogue—deservedly a favorite from its accuracy—and of Rümker's Hamburg Catalogue, including right ascensions as well as declinations, (Appendix No. 45.) This catalogue stands the test of the comparison better than that of the British Association. On the average, the north polar distances are three-tenths of a second less than those of the Twelve Year Catalogue; the average difference, without regard to sign, is one second and two-tenths, and the greatest difference eight seconds and three-tenths. The number of observations for determining a star's place is less in the Hamburg Catalogue than in the Greenwich, in the proportion of two to three, the average number being nine in the former.

With a view to secure steady progress in the publication of the records and results of the survey for which appropriation has been made by Congress, I have relieved Assistant J. E. Hilgard from the charge of the computing division of the office, and have assigned to him, in conjunction with the assistant in charge of the office where the work touches upon the office ground, under my immediate direction, and with instructions in regard to the general plan of the publication, the arrangement of the details of its execution, of the forms for the different varieties of work which it embraces, of the descriptions which it requires, of the copyings from the archives, the printing, and the like. Many of these details have been already matured, and are in the course of execution. The astronomical observations with Airy's zenith sector, with the zenith telescope at certain stations, and portions of the geodetic work, are preparing for the printer.

A volume containing the Gulf Stream results has made considerable progress, the whole of the diagrams having been revised by Professor Pendleton and prepared for engraving under my immediate direction, and some portions of the text being ready.

The magnetic observations have undergone a thorough examination by Assistant Hilgard and myself, preparatory to collecting them in a volume of records and results. Mr. Schott has also been engaged in labors bearing on this same subject.

The sailing directions and other items of nautical information collected in the course of the survey are preparing for these volumes. In connexion with this, a general coast description, to follow the coast as surveyed, is in progress.

In addition to the volumes thus preparing for the press, from what may be called the regular work of the survey, a volume of results of the chronometer expeditions has been prepared by George P. Bond, Esq.; an elaborate report of investigations on the Florida reefs has been nearly completed by Professor Agassiz, and the requisite plates have been nearly finished, in a style which will do credit to the state of the art of lithography in our country; a valuable memoir by J. G. Kohl, Esq., on the history of maritime discovery on the western coast, has been prepared.

The publications from the archives, while they insure that no part of the work shall be lost by accident, and that all of it shall be made useful as rapidly as executed, gives the very great further advantage that its revision may be made while those who did the work in the field are still connected with the survey. It will avoid the drawing out to a great length of publications after the work has closed—a thing which has been the reproach of many surveys. It will prevent the necessity for expensive arrangements for the care and preservation of the archives, accumulating from year to year in an increasing ratio. These are but a few of the advantages which will flow directly or indirectly from these publications. It is obvious to the least reflection that the first step in such a work is the most difficult, and that when we have once commenced to publish, the volumes will follow each other in succession as rapidly as the means appropriated will allow, when the work of preparation and printing has become one of routine, or in a great degree mechanical. The publication of the special reports referred to, which contain investigations that advance the science of the day, instead of sealing them up in the archives and using merely the results, will be hailed with satisfaction by the men of science of the country. The volumes relating to our harbors and coast, and embodying the varied information collected in the progress of the survey, will have nearly the same interest for commercial men and navigators. It has become already apparent from the great number of ways in which the coast survey results are worked up in the publications of the day, in maps, gazetteers, manuals, and the like, that such publications are much sought for as of general public interest.

Considerable progress has been made by Lieutenant E. B. Hunt, of the corps of engineers, in the preparation of a descriptive index of papers relating to astronomy, geodesy, topography, hydrography, drawing, engraving, printing, electrotyping, and the like, including in fact all subjects of mathematics, physics, chemistry, and their applications to science and the arts, which are used in the various branches or departments of the survey. Such an index will constitute for this special work what the celebrated index of Doctor Young did for natural philosophy generally, up to the date of its execution. Such an index of reference to works accessible to the officers of the survey, and to those interested in similar pursuits, will be of the greatest value in directing research and in preventing loss of time and study in reproducing that which has already been done. This index would have been prepared for the present year's report, but the pressure of engineering and light-house duties assigned to Lieutenant Hunt, under an arrangement between the Engineer department and the Coast Survey, has been more severely felt than was expected, and this work could not be completed, without too much haste, in time to be incorporated in the appendix of this report.

The ten years' general index of the Coast Survey reports, prepared last year by Lieutenant Hunt, has already proved of the greatest convenience to the officers of the work. In many cases known to me it has saved a great deal of time in referring to special matters embraced in those reports.

The officers of the survey contribute, from time to time, ingenious practical devices in the way of their work, descriptions of which are published with my report. During the past year reports upon the following have been received, (Appendix, Nos. 41, 56, to 60 and 63):

1. Description of an apparatus for measuring preliminary bases, by Assistant C. O. Boutelle, (Appendix No. 41, Sketch 53); 2, of a tripod and scaffold for primary stations, (Appendix No. 57); 3, of a signal for secondary triangulation, by Assistant John Farley, (Appendix No. 58, Sketch 52); 4, of a signal for hydrographic purposes, by Lieut. Comg. B. F. Sands, U. S. N., assistant, (Appendix No. 60, Sketch 54); 5, of an instrument for obtaining specimens of the bottom of the sea, by the same officer, (Appendix No. 56, Sketch 55); 6, of a branch circuit galvanometer for measuring galvanic currents of great quantity, by George Mathiot, Esq., (Appendix No. 63.)

The devices for measuring preliminary bases are not only of value in themselves, but suggestive by their combinations; and in working, various modes occur as suitable in different cases, or to different persons. The secondary signal, though simple, is exceedingly useful; for in small triangulations, unless the signals are very straight, small, well centred, and truly vertical, the work cannot close, and faults are sometimes attributed to instruments and atmospheric circumstances, when the character and placing of the signals should bear the blame. Lieut. Comg. Sands' ingenious tripod and signal admits of many applications; the revolving signal itself, made of metal, may in many positions replace a heliotrope. He has devised also a revolving heliotrope, which is admirably adapted to geodetic purposes. One of the instruments now referred to was used during the present season by my party, in Section I, at a subsidiary station, and answered all the purposes for which it was intended. A description of this form of heliotrope is given in Appendix No. 59, and the form of the instrument is presented in Sketch No. 54. The instrument for obtaining specimens of the bottom is on a plan quite different from any we have hitherto tried in the survey. Mr. Mathiot's branch circuit galvanometer has been in use for some time in his department, with important practical results in electrotyping.

In my last report I mentioned a portable transit by William Würdemann, Esq., which had given excellent results, and this year have had a similar one under trial in my party, with entire satisfaction to the observers. We have also used a new zenith telescope by Mr. Würdemann, which for admirable workmanship surpasses any instrument I have before seen, from his establishment. The design, too, is excellent, and well deserves the praise bestowed by Assistant Dean, in his description, Appendix No. 44. Where great portability is not desired, this instrument leaves almost nothing to be desired.

Each field-party of the Coast Survey, as a general rule, works up its own observations, the topographical parties return their sheets in a finished form, and the hydrographers reduce their soundings and plot them upon charts. The office-work executed by each party is reported to the Superintendent, and, with special exceptions only, turned into the office at Washington, before resuming operations, in the field or afloat. Duplicate computations and verifications are made in the office, and the comparison is required to be reported to the Superintendent. In the office the work is combined so as to furnish maps, charts and sketches, and these are drawn, engraved and published. The labors of the office thus increase with the increase of the field-work, and its organization must develope with that of the rest of the work. The present arrangements are due in a great degree to Captain Humphreys, Major Stevens, and Captain Benham, who have been successively in charge of the office, and to myself, and any one who has watched the progress of change will see that it has been gradual, and has combined the experience of many minds desirous of progress and not fearful of change. The labors of Captain Humphreys, who was the first assistant in charge under my superintendency, and under whom the survey assumed the general form which it has now, have indelibly impressed themselves, as

I see and know, upon the office arrangements; and, after mature consideration and the experience of the present, I have not a word to withdraw of the commendation which I have bestowed in former years upon his abilities, zeal, industry, and success. In reiterating this, I give the best possible pledge to his successors that their just claims will neither be overlooked nor forgotten when they in turn shall have sought other fields of usefulness. Administration has in many cases taken the place of personal execution of details; but this is admitted as a consequence of the expansion of the work, or, in other words, a necessity. The organization of the office now presents the following divisions, each under a chief immediately responsible to the assistant in charge of the office, and to whom, in turn, the employés in his division are responsible: 1, the computing division; 2, the tidal division; 3, the drawing division; 4, the engraving division; 5, the electrotyping division; 6, the printing and publishing; 7, the distribution and sale; 8, the instrument-making and carpentry; and 9, the archives and library. The instruments are under the immediate charge of the general disbursing agent; the clerks generally, messengers and laborers, are under the immediate supervision of the clerk of the assistant in charge of the office.

The assistant in charge had formerly a general assistant, whose duties were of importance, and the necessity for replacing whom has been fully recognised, but so far without result. Attention is again called to the filling of this important position, by the assistant in charge of the office, in whose remarks I fully concur. Officers of the army are liable to be frequently changed. Being in charge of most of the divisions, it has been rendered especially necessary that a permanent aid or clerk should be allowed to each, to avoid the loss of the office experience. This arrangement secures the progress which new mind applied to the details of the division generally brings, and at the same time steady and matured action.

A hydrographic officer is also attached to the office, whose duties in the revision of work and in advising in regard to details of office hydrography are of the first importance.

The lists presented by the several divisions of the office, (Appendix No. 36,) and the notices of their labors in a subsequent part of this report, will show that the office has fully maintained its efficiency during the past year under the charge of Captain H. W. Benham, of the corps of engineers. The results of the computing and tidal divisions have already been referred to in a general way, and some of them quite at length.

The action of all the divisions according to a regular plan, the parts of which fit with each other, is secured by a project of work submitted in advance by the assistant in charge to the examination of the Superintendent; the details, of course, to be varied from more or less in the course of the year, but unity of purpose is secured, and general conformity to a system arranged beforehand prevents desultory and irregular effect.

Under the authority of the Treasury Department, nearly eight thousand sheets of charts and maps have been, during the past year, distributed or deposited for sale. Two-thirds of the number have been distributed gratuitously, and the remainder, with the exception of a few used in the office, have been sent by the disbursing agent to the sale agents, as heretofore.

At the suggestion of the assistant in charge, thirty-two sets, selected from the published maps, were bound into volumes and distributed to universities, naval stations, and vessels, and to persons specially interested in the progress of commerce and navigation in various parts of the Union.

It may in part be anticipated from the previous remarks that the tidal division bears, at present, a less simple relation to the organization of the survey than others. It is, in fact, in reference to the execution of the Superintendent's instructions for observations, and seeing to the faithful and continuous execution of their duties by the tidal observers, analogous to a field party, with many scattered observers, such as is controlled by Lieutenant Trowbridge. In reference to carrying on discussions of the observations, it is under the immediate direction of the Superintendent, who is, for all such discussions, effectively the chief of the party, though, as his attention is necessarily of an intermitting sort, he finds it necessary to steadiness of execution to devolve this charge upon an assistant. The chief of the tidal division is also chief of a party, and directly and solely responsible, in the discharge of this duty, to the Superintendent, with whom all correspondence should be held, and to whom all reports should be addressed. The tidal records go into the general archives of the survey, and are drawn from them from time to time, as their discussion requires. The results of the tidal party's discussions are furnished to the office for the maps and charts in prescribed forms. In this, and for all purposes of regulation in regard to attendance, receipt of pay, and the like, the tidal division forms part of the office, and should correspond with the assistant in charge and report to him.

These remarks will explain why a report of Assistant Pourtales finds notice in this introduction, and is given in the Appendix No. 32, while another is noticed under the head of the office, and placed with other reports in Appendix No. 36. The report in Appendix No. 32 shows the tidal observations made during the year, and the discussions in progress or made in relation to them.

In the drawing division, the list of maps, charts and sketches (Appendix No. 36) shows seventy in hand, of which twenty-seven are finished maps, and forty-eight preliminary charts and sketches; of these, thirty-six have been completed and thirty-nine are in progress. Besides these there are ten diagrams, illustrating matters described in the report and appendix. These numbers are about the same as those of last year.

The list of maps and preliminary charts and sketches (Appendix No. 36) which have been engraved up to this time shows two hundred and twenty-six, including some in every part of our extended coast. One hundred and fifty-seven are of localities on the Atlantic and Gulf coast, forty-four on the Pacific, and twenty-five are sketches showing the progress of the survey. The list includes, in some cases, different editions of the same map or chart. Forty-five of the sheets are of finished maps and charts. The list of maps and charts engraving includes twenty-eight plates. There were unfinished at the date of the last report on the engraving, thirty-one plates; forty-six have been commenced during the past year, and seventy-one, including nineteen progress sketches, having been completed during the year. All these numbers, which represent work finished or in progress, are an increase of those of the previous year, and attest the progress of this division of the office in its useful labors.

The greater part of this is work of the inferior grades. The first-class engraving does not keep up with the field-work, notwithstanding all our efforts. We have tried at home everywhere, and abroad by correspondence, to increase our force of first-class engravers, but with very limited success; and my impression of the necessities of the case has become so strong, from observation year after year, of the increasing wants of this branch of the Coast Survey, that I have finally addressed the Department on the subject, (Appendix No. 37,) and have presented the case for its decisive action. The views of the assistant in charge of the office have been strongly presented to me, and I place them with my own in the Appendix No. 38. I doubt not that we shall realize important results from the action taken in this case, to which the zeal and energy of Captain Benham will be entirely devoted. Map engraving of the first class as a branch of art, especially topographical engraving, has been neglected in our country, and hence, when a demand occurs for finished maps, it cannot be met. Other branches of this admirable art have taken precedence, in point of public estimation and profit, of this one; and we feel sensibly the consequences. To raise up a school of topographical engraving might be possible in a long series of years, but it would require a work on a much larger scale than ours, and of a more permanent character, and a community more patient in its demands for results, to make this a mode for us to apply exclusively. We hope, among the young men who devote themselves to the engraving art in our office, that some will become first-class engravers; but a few, however, of many who enter, can hope to do so. We want immediately, not in the remote future, first-class results. The young men themselves who are to be taught want more first-class instructors.

We have heretofore derived great assistance in altering maps and enlarging them from the electrotype process. The entrance plate of Delaware bay having been some years ago irreparably injured, and the publication of the whole series being thus delayed, it was determined to expedite its re-engraving by dividing the plate between several engravers, trusting to re-uniting the parts by electrotyping. This was successfully done by the accomplished electrotypist of the Survey. Intent, however, always upon improving his art, he had become dissatisfied with the slow operation of making very nice joints between the plates to be combined, and with the injury which finely engraved plates suffered in the operations of making these joints, requiring much re-engraving after the combination was effected. He has hit upon a process by which the whole operation becomes extremely simple and perfect, and in which hours replace weeks formerly given to it. A thin electrotype cast of the plate to be remodeled is taken, which, while it has all the engraving perfectly upon it, is thin enough to be cut readily with the shears. The pieces cut to the requisite shapes are cemented, in the new form required, upon a blank plate, and an electrotype copy of this is made. A beautiful application of this process has lately been made to the map of Mobile bay. The entrance of this bay occurs both on the map of the Mississippi sound and of Mobile bay. Being engraved with the former map, it was copied by the electrotype, cut from it, joined to a similar cast of the upper bay, and now forms a map on one sheet of Mobile bay, in which scarcely any re-engraving is necessary. A description of the process devised by Mr. Mathiot will be found in Appendix No. 62.

Besides the general maps resulting from the surveys, special ones have been in progress in the office during the year. The Congress map has been brought up to date; the Commissioners' map of the harbor of New York has been kept as closely up with the field-work as circumstances allowed; and the Light-house map for the Board has been studied and is in progress. A revised description of the Congress map will be found in Appendix No. 39. The map, as directed by law, exhibits in colors the principal results of the survey, and the statistics connected with it show the progress of the work and some of the more important details of methods.

The number of items of information communicated from the archives again presents (Appendix No. 5) an increase within the past year, now numbering *eighty-three*, of which twenty-two were for departments of the government, fifty-eight for individuals or associations, and three for local authorities. An application to the Superintendent for such information is forwarded to the Treasury Department, and in no case, thus far, has its assent to the communication been refused. The conditions which it makes are the liberal ones, that if the information is published, credit shall be given to the Coast Survey for it, and that the cost of copying the record, or map, or chart, shall be borne by the person to whom it is sent. The list does not include the copies of proof-sheets of maps and of published ones sent upon special application, under the authority of the Treasury Department. It will be seen that the localities embraced in the list extend over the entire coast of the United States, one of the early ones being Eggemoggin reach, east of Penobscot bay, in Maine, and one of those near the end being Matagorda bay, in Texas. The western coast localities occur frequently on the list.

The following list of maps, sketches, and diagrams, to accompany this report, contains sixty titles, several small sketches or diagrams being in some cases placed upon the same plate. The maps and sketches of localities are arranged geographically in the separate sections of the survey. All those belonging to the first section are lettered A, to the second B, and so onward. They are numbered also in the order in which they occur in the section, as A No. 1, A No. 2, and so on. The first sketch in each section is the one showing the progress of the work in the section generally, and the sub-sketches of progress in different parts of the section come next in order. For general reference, a number will be found on the upper part of the sheet of each plate. These numbers run through the whole series of plates in the volume. A list of the plates immediately precedes them, after the last page of the appendix. The diagrams not referring to localities, and classed as miscellaneous, are lettered:

1. A. Progress sketch, Section I.
2. A *bis*. Progress sketch, Section I.
3. Portland harbor, showing the Commissioners' wharf-line, (preliminary chart.)
4. Ipswich and Annisquam harbors, (preliminary chart.)
5. Stellwagen's bank, entrance to Massachusetts bay, (sketch.)
6. Muskeget channel, (preliminary chart.)
7. B. Progress sketch, Section II.
8. Hudson river, lower sheet, (preliminary chart.)
9. Sketch, showing changes in Sandy Hook, from 1779 to 1855.
10. C. Progress sketch, Section III.
11. Seacoast of Virginia, No. 2, from Gargathy inlet to the southern boundary line, (preliminary chart.)
12. Chesapeake bay, (preliminary chart.)
13. James river, from Richmond to Harrison's bar, (preliminary chart.)
14. D. Progress sketch, Section IV.
15. Albemarle sound, (preliminary chart.)
16. Cape Fear river, lower part, (preliminary chart.)
17. Chart of Gulf Stream explorations.
18. E. Progress sketch, Section V.
19. Winyah bay and Georgetown harbor, (preliminary chart.)
20. Comparative chart of Maffitt's channel, Charleston harbor, from 1850 to 1855.
21. Comparative chart of Charleston bar.
22. Port Royal entrance and Beaufort river, (reconnaissance.)
23. Savannah river to the head of Argyle island, (preliminary chart.)
24. Romerly marshes, (reconnaissance.)
25. Doboy bar and inlet, (reconnaissance.)
26. F. Progress sketch, Section VI.
27. F No. 2. Progress sketch, Florida reefs, with Key Biscayne and Cape Sable bases.
28. Legaré anchorage.
29. Florida reefs, from Key Biscayne to Carysfort Reef light, (preliminary chart.)
30. Positions of beacons on Florida reefs, (sketch.)
31. Tampa bay, (reconnaissance.)
32. G. Progress sketch, Section VII.
33. Cedar keys.
34. Ocilla river, (preliminary chart.)
35. St. Andrew's bay, (preliminary chart.)
36. H. Progress sketch, Section VIII.
37. Biloxi bay, (preliminary chart.)
38. Profiles of deep-sea soundings in the Gulf of Mexico, (sketch.)
39. I. Progress sketch, Section IX.
40. Entrances to Vermilion bay and Calcasieu river, (reconnaissance.)
41. Galveston bay, (preliminary chart.)
42. J. Progress sketch, western coast.
43. J No. 2. Progress sketch, Sections X and XI.
44. J No. 3. Progress sketch, Rosario straits and vicinity.
45. San Pedro and Santa Barbara anchorages, (preliminary charts.
46. South Farrallon island.
47. Point Reyes and Drake's bay, (preliminary chart.)
48. Alden's reconnaissance, western coast, No. 3, from Umpquah river to the northern boundary.

49. J. Co-tidal lines of the Pacific coast.
50. Diagrams, illustrating earthquake waves at San Diego, San Francisco, and Astoria.
51. Diagrams of secular variation of magnetic declinations.
52. Boutelle's signal and scaffold for primary stations, and Farley's signal for secondary stations.
53. Boutelle's apparatus for measuring preliminary bases.
54. Sands' gas-pipe tripod and revolving heliotrope.
55. Sands' specimen box for deep-sea soundings.
56. Isogonic lines of the eastern and western coasts of the United States.
57. Geological map and section of Point Reyes.
58. Geological map of the entrance to San Francisco bay.
59. Geological map of Point Pinos and Monterey bay.
60. Geological map of San Diego.

The list includes maps, besides the progress sketches, of localities in every section of the Coast Survey.

The following shows the reports made within the past year by request of the Light-house Board, and under the laws of 1851, 1852, and 1854, of examinations for sites of light-houses. The reports themselves will be found in the Appendix, No. 78 to No. 86. The greater number of examinations have been made upon the Pacific coast:

Wood island, entrance to Small Point harbor, Maine.
Pier-head at Kennebunk harbor, Maine.
Absecom bar, coast of New Jersey.
Entrance to Vermilion bay, Louisiana.
Mouth of Calcasieu river, Louisiana.
Gallinipper Point, Texas.
Santa Cruz island, California.
Harbor of San Pedro, California.
Harbor of Santa Barbara, California.
Harbor of Santa Cruz, California.
Point Lobos, California.
Point Reyes, California.
Trinidad bay, California.
Crescent City harbor, California.
Umpquah, Oregon Territory.
Cape Shoalwater, Washington Territory.
New Dungeness, Washington Territory.
Smith's or Blunt's island, Washington Territory.

Progress has been reported (Appendix No. 84) in reference to the re-examination of Santa Cruz island, California.

A general table of these examinations, with the results, is given in Appendix No. 77.

The following additional aids to navigation have been recommended by officers of the Coast Survey; their experience, or the authentic information which they have received, indicating the necessity for them. (See Appendix, No. 70 to No. 76.)

Buoy to mark an eighteen-feet shoal in the main ship-channel entrance to New York harbor.

Light-house or day-beacon on York spit, Virginia.

Beacon between St. Augustine and Cape Canaveral, Florida.

Beacon-light at Mosquito inlet, Florida.

Beacon-light at Indian River inlet, Florida.

Beacon at Hillsboro', Florida.
Buoy on Margot Fish shoal, Florida.
Buoy on "Hen and Chickens," Florida.
Buoy on Seven-feet shoal, abreast of Key Vacas, Florida.
Light-house on Half-Moon reef, (Matagorda bay,) Texas.
Light-house or light-boat on Alligator Head, Texas.
Light on Sand Point, (entrance of Lavacca bay,) Texas.
Light on San Miguel, California.
Light-house at Pigeon Point, California.
Buoys outside of the bar at Golden Gate, California.
Light-house at Point Arena, California.
Light-house on Red Bluff, (Humboldt bay,) California.
Light-house on Point Adams, Oregon Territory.
Light-house on Tatoosh island, Washington Territory.
Buoys on New Dungeness spit, Washington Territory.
Buoys at Ediz Point, Washington Territory.
Light-house on Smith's island, Washington Territory.
Light-house on Point Wilson, Washington Territory.

These recommendations have been transmitted to the Light-house Board for their consideration through the Secretary of the Treasury. (Appendix No. 70.)

The watchful consideration of the wants of navigation, and the recommendations for supplying them to the proper authorities, are among the most useful services which can be rendered by the officers of the Coast Survey.

Special surveys have been made for the Land Office of the Florida Keys, under the act of Congress of June 28, 1848; and of the islands of the western coast, under the act of August 31, 1852; for the Engineer Department, of the Rappahannock river, Virginia, and of the St. John's, Florida.

The work on the Florida keys, for the Land Office, included the connection of the Keys with each other, and ultimately with the main, and their division into sections and quarter sections by meridians and parallels, referring to a determinate point on Key West, and to the difference of latitude and longitude from that point. The progress made has been duly reported to the Commissioner of the Land Office, consisting of extracts from the reports of the five assistants of the Coast Survey who have been employed in that region, embodying not only an account of the progress of the work, but also of the nature of the surface of the keys. Topographical maps representing the surveys accompanied the report, with descriptive notes relating to the positions of the marking-posts of the quarter sections. An inspection of this work was made by one of the senior assistants of the survey, and I visited, myself, the parties and examined the surveys executed. The report to the Commissioner is published in Appendix No. 25.

We have met with many obstacles in the survey of the islands off the coast of California, but at the latest reports the parties were at work there, and from the character of the assistants engaged in the matter, they will, I doubt not, present as good an account of work as the season will permit. The schooner Humboldt, built by the Coast Survey for this work, and sent to the western coast, had, after a passage which was at first disastrous, requiring her to put into Rio to refit, reached San Francisco, where the assistant who was to employ her had long before arrived, and waited the means furnished by the new appropriation and the arrival of his vessel to join the other parties at work near the islands. I am expecting reports from these parties by every California mail, having provided for the anticipation of the reports usually made at the end of the season.

The survey of the Rappahannock has been steadily prosecuted; the triangulation is now complete from above Fredericksburg to the mouth of the river; the topography is following it closely, and the hydrography has reached a point below Tappahannock. The topographical party is now engaged there, and the hydrographic party will return as soon as their labors in New York bay can be brought to a close. Full details in regard to this survey will be found under the head of Section III, and in the Appendix No. 14, a letter relating to the river. The maps of the river are making in the office from the results already obtained, combining, together, the topography and hydrography of which maps already exist, as far as the survey has been carried.

The survey of the St. John's river, from Mayport Mills to above Jacksonville, has been nearly completed. There is yet required the measurement of a local base of verification, and a portion of topography. The maps for the Engineer Department are in progress. The details of the work are given in Section VI of my report, under the heads of the several operations. Much difficulty was experienced in procuring the current observations recommended by the commission on the river and requested by the Engineer Department. These, and the tidal observations, I have not yet investigated. I visited the parties during the surveying season, and looked into their plans of working and their results.

Last year, by invitation of the city authorities of Portland, I took part in a commission for recommending a proper shore-line for the harbor, consisting of General Totten, United States Chief Engineer, Commander Charles H. Davis, U. S. Navy, and myself. The object of fixing a shore-line, beyond which parties should not be allowed to encroach upon the water, was to prevent, by timely action, injury to the noble harbor in question. The report of this commission has been published by the city authorities, but will probably not find its way into a public document, where it should, for reference, unless I place it in this report. (Appendix No. 31.) By so doing, I do not intend to imply authorship of the report, which will be readily recognised as that of one of my accomplished colleagues. The valuable statistics appended to this report of the commissioners by John A. Poor, Esq., of Portland, I have, by his permission, presented in abstract with the report. The notice of Portland harbor will, I think, be found of interest to nautical men, as well as to engineers.

I proceed next to give a condensed statement of the operations of the past surveying season, to October 1, 1855, and to follow this by the estimates for the fiscal year ending July, 1857, adapted to the same scale of progress.

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.—(Sketches A Nos.* 1 *and* 2.)—Mount Harris, Dixmont, Maine, between the Kennebec and Penobscot, has been occupied as a geodetic and astronomical station, magnetic observations having been also made in connexion with the others. The minute reconnaissance of some doubtful lines in advance of the triangulation and for a base of verification, has been in progress. The secondary triangulation of the Kennebec from its entrance, to Bath, Maine, has been in progress. The topography of the islands and main shore of Casco bay has been in progress. That of the sea-shore of New Hampshire, from the mouth of the Merrimac river to that of Hampton river and Great Boar's Head, and of the coast of Massachusetts, near Ipswich and Annisquam, has been completed. Some deficiencies near Hyannis, on the south shore of Cape Cod, have been supplied. A section of the Gulf Stream off Cape Cod and Nantucket has been attempted. The hydrography of Massachusetts bay has been continued. Stellwagen's bank has been further examined, and the off-shore work broad off from Cape Cod peninsula to deep water has been in part executed. Deep-sea soundings have been made off the entrance to Massachusetts bay. The hydrography of the Vineyard and Nantucket sounds has been nearly completed. Additional tidal observations have been made at stations upon Nantucket and the Vineyard sounds, and upon Block Island sound. The permanent tide-gauge at Boston has been kept up. The magnetic elements have been redetermined for changes at Burlington, Vermont; Salem, Boston, and Nantucket, Massachusetts; and Providence, Rhode Island. A new chronometer expedition for the longitude of a central point of the survey has been completed. The computations and reductions of the season's work have been made.

The following maps, charts, and sketches, belonging to this section, have been drawn: Portland harbor, scale $\frac{1}{10000}$, for Commissioners; ditto, $\frac{1}{2000}$, for Commissioners; Muskeget channel, $\frac{1}{600000}$; Nantucket shoals, $\frac{1}{200000}$; and Gloucester harbor, $\frac{1}{20000}$, The following drawings are in progress: Portland harbor, $\frac{1}{20000}$; Plymouth harbor, $\frac{1}{20000}$; Ipswich and Annisquam harbors, $\frac{1}{20000}$; Bass River harbor, $\frac{1}{40000}$; Monomoy shoals, $\frac{1}{40000}$; Eastern series, sheets Nos. 2 and 3, $\frac{1}{80000}$; and Massachusetts bay, $\frac{1}{80000}$. The engraving of the following plates has been completed during the year: Eggemoggin reach, Portland harbor, as preliminary; York River harbor, Portsmouth harbor, as preliminary; Newburyport harbor, Salem harbor, Gloucester harbor, as preliminary; Stellwagen's bank, Plymouth harbor, as preliminary; Monomoy shoals, as preliminary; Bass River harbor, as preliminary; Nantucket shoals, (new edition.) Tidal currents of Nantucket shoals, and Muskeget channel, as preliminary; and the following are in progress: Portland harbor, as finished; Gloucester harbor, as finished; Annisquam and Ipswich harbors, Boston harbor, Plymouth harbor, as finished; Monomoy shoals, as finished; Bass River harbor, as finished; Muskeget channel, as finished; and Eastern series No. 1.

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and of part of Delaware.*—(*Sketch B.*)—A complete re-survey, including triangulation, topography, and hydrography of New York bay and harbor, and of the approaches, has been in progress, to furnish a map of the present date for the Commissioners on encroachments on New York harbor. This work includes the Hudson to above Yonkers, the East river to Throg's neck, Harlem river, Newark bay, Arthur Kull sound, the Kills, and Raritan bay. The Coast Survey triangulation has been connected with the High School Observatory at Philadelphia. The magnetic elements have been determined at New Haven, Connecticut; Greenbush, Cold Spring, New York city, and Bedloe's island, New York; Sandy Hook and Cape May, New Jersey; and Philadelphia, Pennsylvania. The tidal observations at Governor's island have been continued. Examinations of light-house sites have been made at Absecom bar, Bowers' beach, and the entrance of Dona river. The following drawings have been made or are in progress: A comparative chart of New York bay and harbor, scale $\frac{1}{10000}$; and a finished map of the bay and harbor, $\frac{1}{20000}$; (both for the Commissioners on harbor encroachments;) also a comparative map, $\frac{1}{10000}$, showing changes at the south end of Manhattan island. The engraving is in progress, or completed, of Long Island sound, Eastern, Middle, and Western sheets, and south side of Long Island, Nos. 2 and 3.

SECTION III. *Coast of Delaware, Maryland, and part of Virginia.*—(*Sketch C.*)—The secondary triangulation of the James river has been extended from City Point to Upper Brandon; that of the Rappahannock from near Tappahannock to the mouth of the river; and a base of verification has been measured for the work of the upper part of the river. The topography of the sea-coast of Virginia has been completed from Gargathy to Chincoteague inlet. Verifications have been made of the topography of Bodkin Point, Sassafras river entrance, of South river, and the entrance to the Magothy. The topography of the western shore of the Chesapeake has been completed from Back river to the mouth of York river. The hydrography has been completed of the entrance to Chesapeake bay, of Pocomoke sound, Chesapeake bay, of the Rappahannock river to a point below Tappahannock, of the James river from Deep-water Point to Hog island, opposite Jamestown island. The magnetic declination, dip and intensity have been observed at Washington and Causten's station, near Georgetown, D. C. The tidal observations have been continued at Old Point Comfort, and others made in the Rappahannock and James rivers. Drawings have been made, or are in progress, of Chesapeake bay, sheets Nos. 1, 2, 3, 4, 5, and 6, of a preliminary chart of Chesapeake bay, and of the sea-coast of Virginia, No. 2. The sea-coast of Virginia No. 2 (lower part) has been engraved, and the sea-coast of Virginia and entrance to Chesapeake bay; Chesapeake bay, $\frac{1}{400000}$, Chesapeake bay Nos. 1 and 2, $\frac{1}{80000}$, and Patapsco river, are in progress.

SECTION IV. *Coast of part of Virginia and of part of North Carolina.*—(*Sketch D.*)—The triangulation of the ocean-coast has been extended from the upper part of Currituck sound to within eleven miles of Cape Henry, and from the southern part of Bogue sound to New River inlet. The triangulation and topography of the south side of the Cape Fear has been completed. The ocean hydrography has been extended from Cape Henry to the Virginia and North Carolina line, connecting with the work off Chesapeake entrance; the positions of the beacons at Beaufort, North Carolina, have been determined; the entrances to Cape Fear have been re-examined for changes. A chart of the Gulf Stream and a preliminary chart of Albemarle sound have been drawn, and a map of Cape Fear river, upper and lower sheets, is in progress. The engraving of Wimble shoals, Beaufort harbor, North Carolina, on steel, as preliminary, and Gulf Stream explorations, 1854, has been completed; and Albemarle sound, $\frac{1}{200000}$, Albemarle sound Nos. 1 and 2, $\frac{1}{80000}$, and Beaufort harbor, North Carolina, on steel, as finished, are in progress.

SECTION V. *Coast of part of North Carolina, of South Carolina, and of Georgia.—(Sketch E.)*—The difference of longitude has been found by telegraphic signals between Columbia, South Carolina, and Macon, Georgia, and observations for latitude and magnetic elements made at Macon, on the line from Washington to New Orleans. A reconnaissance for the primary triangulation has been made from Cape Fear southward. The connection of the Edisto base and Charleston has been completed and hydrographic signals determined on the ocean coast. The secondary triangulation has been carried from the Cape Fear to Lockwood's Folly, and the topography in connection with it has been executed. The triangulation and topography of the Romerly marshes, near Tybee, have been completed. The triangulation of St. Simon's sound and Brunswick harbor has been commenced. The topography of the southern part of Edisto and the north shore of South Edisto river to Raccoon island has been completed. The main ship and Maffitt's channels, Charleston harbor, have been sounded out anew. The ocean work in-shore from Charleston bar to North Edisto has been completed. The Savannah bar, Gaskin banks, Martin's Industry, Port Royal bar and sound, and Beaufort river, South Carolina, to the city of Beaufort, have been sounded out. The channels through the Romerly marshes have been closely sounded out. The hydrography of Doboy bar and sound has been executed. An examination of St. Simon's bar and Brunswick harbor has been made. Tidal observations have been kept up in Charleston harbor, and stations made at Charleston light and St. Simon's, Georgia. The exploration of the Gulf Stream in this section has been continued. Drawings of Winyah bay and Georgetown harbor, $\frac{1}{40000}$; Winyah bay, Roman shoals, $\frac{1}{100000}$; Maffitt's channel in 1852 and 1854, and Doboy bar and sound, have been completed during the year, and Charleston harbor and Savannah river, to the head of Argyle island, are in progress. The engraving of Winyah bay and Cape Roman shoals, comparative map of Maffitt's channel, Charleston harbor, Doboy bar and inlet, has been finished, and that of Winyah bay and Georgetown harbor is in progress.

SECTION VI. *Coast, reefs, and keys of Florida.—(Sketch F.)*—Two bases for the triangulation of the Florida keys and reef have been measured, one at Key Biscayne and one at Cape Sable. The reconnaissance for connecting these bases with the triangulation of the main and keys has been made, and the Key Biscayne base has been completed. A preliminary triangulation of St. Mary's entrance and Fernandina harbor has been made. The triangulation of the St. John's has been carried from Mayport Mills to above Jacksonville. The triangulation of the Florida reef and keys has been extended eastward to Loggerhead key; that of Barnes' sound has made some progress. The topography of the shores of the St. John's has been extended from Mayport Mills to Jacksonville. Verification has been made of the topography of the Florida keys. The topography of the keys has been extended eastward to include Mud keys, Snipe keys, Saddle Bunch, and several detached keys; and westward towards the western end of Key Largo. The reef has been sounded out from Carysfort to Grecian shoal, and permanent signals have been placed. The hydrography of the St. John's has been completed to above Jacksonville. A hydrographic reconnaissance has been made of St. Mary's entrance and Fernandina harbor; also of Tampa bay, on the western side of the Florida peninsula. A section of the Gulf Stream has been run from Cape Florida across to Bemini, and the hill range on the outer side of the Gulf Stream has been tracked along this section. The work of the field parties has been inspected. Tidal observations have been made at Indian river, Indian key, and the Tortugas. The first sheet of the chart of Florida reefs, and a comparative map of the northwest channel of Key West, (1846 and 1851,) have been drawn during the year, and sketches of Key Biscayne and Cape Sable bases, and positions of signals on the reefs of Florida, to accompany this report. Plates of Turtle harbor, Florida reefs, Coffin's Patches, and Key West harbor and its approaches, have been engraved.

SECTION VII. *Part of the coast of Florida.*—(*Sketch G.*)—A preliminary base has been measured and a triangulation made of St. Andrew's bay; the topography and hydrography have also been completed, and the difference of longitude from Pascagoula determined. The hydrography of Ocilla river entrance has been executed, making the survey complete. The hydrography of Cedar keys has been continued. Deep-sea soundings have been run between the Tortugas and Pensacola, across the section from Mobile and from Pensacola westward. A preliminary chart of Cedar keys, and sketch of Ocilla river, have been drawn, and St. Andrew's bay has been nearly completed. Cedar keys and its approaches, as preliminary, and Ocilla river, have been engraved, and Cedar keys and its approaches, as finished, is in progress.

SECTION VIII. *Coast of Alabama, of Mississippi, and part of Louisiana.*—(*Sketch H.*)—The primary triangulation of Mississippi sound has been nearly completed, and astronomical and magnetic observations have been made at Cat island. Astronomical observations have been made at Pascagoula for chronometer difference of longitude between that station and St. Andrew's and Atchafalaya bays. The secondary triangulation of the Chandeleur islands and sound has been in progress. A preliminary base has been measured, and the triangulation of Atchafalaya bay has been made. The topography between Lake Borgne and Lake Pontchartrain, of the Chandeleur islands, and of the eastern coast of Atchafalaya bay, has been executed. The hydrography of Mississippi sound has been nearly completed; the passage between Pelican and Dauphine islands has been re-examined; deep-sea soundings in the Gulf off the coast of Florida, Alabama, and Mississippi, and off the delta of the Mississippi river, have been made. Reconnaissances of the entrances to Vermilion bay and Calcasieu river, Louisiana, have been made for light-house purposes. A drawing of Mississippi sound, sheet No. 1, and sketches of the entrances to Vermilion bay and Calcasieu river, have been finished; and Mississippi sound, sheet No. 2, sketch of the Gulf of Mexico for profiles of deep-sea soundings, and map of Biloxi bay, are in progress. Pass Fourchon, and entrances to Vermilion bay and Calcasieu river, have been engraved, and Mobile bay and Mississippi sound, No. 1, are in progress.

SECTION IX. *Coast of part of Louisiana, and coast of Texas.*—(*Sketch I.*)—The secondary triangulation has been extended from the head of Matagorda bay southward and westward, and the topography has followed it. The hydrography of Galveston upper bay and Turtle bay has been completed, and the soundings made on the Gulf coast, outside from Galveston bay, to a position off Cedar lake. An examination for light-house purposes has been made at Lavacca bay. The engraving of the entrance to the Rio Grande has been completed.

SECTIONS X AND XI. *Coast of California, Oregon, and Washington.*—(*Sketches J and K Nos. 1, 2, and 3.*)—The primary triangulation of the coast has been extended southward and northward of San Francisco; the secondary triangulation of the coast near Point Duma and of the Santa Bartara islands has been in progress. A preliminary base has been measured, and the triangulation made of Port Townsend, of Admiralty inlet, and of part of Puget's sound. The topography of the coast between Monterey and San Francisco has been nearly completed, and that near Point Duma and of part of the western islands, including part of Santa Cruz and Anacapa, has been executed. The topography of San Francisco and San Pablo bays has been in great part completed. The hydrography of Admiralty inlet has made good progress. The harbors of Steilacoom and Olympia have been examined. A preliminary survey of Gray's harbor has been made, and off-shore soundings taken off the coast of Oregon. Examinations for light-house purposes have been made of New Dungeness and Cape Shoalwater, Washington Territory; of Umpquah, Oregon; of Crescent City harbor, Trinidad bay, and Point Lobos, California; and re-examinations of Santa Cruz and Anacapa islands, and the main shore on Santa Barbara channel. The hydrography of San Francisco entrance and bay has been completed; that of Monterey bay and near Point Año Nuevo has been continued; that of the Santa Barbara islands and of the coast opposite them has been in progress. Tidal stations have been established at Cape Flattery, Gray's harbor, the South Farrallon, and Point Conception; and the observations have been continued at San Diego, San Francisco, and Astoria. The following drawings have been completed during the year: San Pedro bay, Santa Barbara, Anacapa island, Point Reyes, and Drake's bay, Columbia river, Alden's reconnaissance No. 3, Rosario straits and Canal de Haro, Port Townsend, Duwamish bay, South Farrallon island, Grenville harbor and Smith's or Blunt's island, and a map of San Francisco entrance ($\frac{1}{50000}$) is in progress. The engraving of San Pedro anchorage and vicinity of Santa Barbara; Anacapa island; Santa Cruz and Año Nuevo harbors; Alden's reconnaissance (middle sheet,) Point Reyes, and Drake's bay; Port Orford and other harbors; entrance to Umpquah river; entrance to Columbia river; Grenville harbor; Canal de Haro, and Strait of Rosario and approaches; Port Townsend; Duwamish bay, and Seattle harbor, and Smith's or Blunt's island, has been completed, and that of South Farrallon island, and Alden's reconnaissance, northern sheet, to accompany this report.

The observations of the field parties, as they have been turned into the office, have been computed, and when approved passed into the archives. The topographical maps and hydrographic charts, with the computed results, have furnished the data from which the new maps and sketches referred to have been drawn and engraved. Some plates have been prepared for the annual report, not coming under the head of any of the sections. The engraved maps have been electrotyped, and from these plates impressions taken for publication. The numerous sketches of progress, and others accompanying the report, are in part from these data.

The estimates for the next fiscal year are generally the same as those for the past. These suppose the same aid which is now furnished under the law from the Navy and War Departments by the detail of officers for the hydrography and land work 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 1856-'57.	Approriated for fiscal year 1855-'56.
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	----------
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 and alterations of steamers Hetzel and Vixen, and of sailing-vessels employed in the Coast Survey, per act of March 2, 1853	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

ESTIMATE IN DETAIL FOR THE FISCAL YEAR 1856-'57.

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 *Saunders* and *Mount Desert,* and the astronomical and magnetic observations connected with it; to complete the minute reconnaissance and the selection of a site for the base of verification; to complete the secondary triangulation of the *Kennebec* to *Bath,* and to extend it eastward towards the *Penobscot*; to continue the topography of *Casco bay,* east of *Portland,* and of the islands and main; to continue the hydrography of *Casco bay,* and of the entrance to the *Kennebec,* and to commence that of *Penobscot bay;* to complete the hydrography of *Massachusetts bay* and approaches, with the off-shore hydrography, and of the coast of *Cape Ann,* and that 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 commence the drawing of the coast chart of *Maine and New Hampshire;* to continue that from *Portsmouth to Cape Ann;* to complete the general coast chart from *Cape Ann to Point Judith, Massachusetts bay,* No. 2, and sketches of the section; to continue the engraving of Eastern series, Nos. 2 and 3, and to complete the engraving of the charts of *Portland harbor, Annisquam and Ipswich harbors, Boston harbor, and Plymouth harbor,* Eastern series, No. 1, and the preliminary sketches of the section,—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 commence the drawing and engraving of the *Hudson river* sheets, and to complete the engraving of the middle and continue that of the eastern sheet, south side of *Long Island,* 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 *James and York rivers,* and to commence that of the *Potomac;* to complete the topography of the lower part of *Chesapeake bay,* and to continue that of the *James and Rappahannock rivers,* and of the outer coast of *Maryland and Virginia;* to continue the off-shore hydrography of the section, the hydrography of approaches to *Chesapeake bay,* and to continue that of the *James,* and complete that of the *Rappahannock river.* OFFICE-WORK.—To make the requisite reductions and computations; to continue the drawing of the lower series of coast charts of *Chesapeake bay,* and sheets of *Rappahannock river,* and to complete that of the preliminary chart of *James river* and sketches of the section; to complete the engraving of *Chesapeake bay,* No. 1, $\frac{1}{80000}$, and Patapsco river, and continue that of *Chesapeake bay,* No. 2, $\frac{1}{80000}$, *Chesapeake bay,* $\frac{1}{400000}$, *Rappahannock river, James river, York river,* and *York harbor,*—will require..........	25,000
SECTION IV. *Coast of Virginia and North Carolina.* FIELD-WORK.—To make astronomical and magnetic observations at *Cape Fear entrance;* to continue the primary triangulation of *Pamplico sound,* and complete the approximate connection with the	

Chesapeake triangulation; to complete the triangulation of the coast from *New river* to *Cape Fear*, and to extend it from *Cape Fear and Lockwood's Folly* southward; to follow with the topography of *Currituck sound* north, of *Bogue sound* south, and south of *Cape Fear;* to complete the hydrography of *Wimble shoals*, and to continue that of the outer coast south to *Hatteras*, and south of *Cape Lookout;* to continue observations of currents in the *Gulf Stream.* OFFICE-WORK.—To make the computations and reductions; to commence the drawing of the chart of seacoast of *North Carolina*, and to draw the sketches of the section; to complete the engraving of seacoast of *North Carolina*, and of *Albemarle sound*, No. 2, $\frac{1}{80000}$, and *Beaufort harbor, N. C.*, on steel, and to continue that of *Albemarle sound*, No. 1, $\frac{1}{80000}$, and sheets Nos. 1 and 2, *Cape Fear river and entrance*,—will require.......... $30,000

SECTION V. *Coast of South Carolina and Georgia.* FIELD-WORK.—To continue the primary triangulation, and the secondary connected with it, eastward between *Charleston and Bull's bay*, and to make the necessary astronomical and magnetic observations; to extend the secondary triangulation south of *St. Helena sound;* to continue the secondary triangulation south of *Tybee entrance*, including *Ossabaw and Warsaw sounds;* to complete that of *Doboy inlet* to *Darien*, of *St. Simon's sound* and *Turtle river* to *Brunswick*, and of *Cumberland sound* and *St. Mary's river;* to commence that of *Sapelo* and *St. Catherine's sounds;* to extend the topography east from *Charleston harbor*, and south from *Tybee*, and on the *sounds* named in the triangulation following it; to continue the hydrography of the ocean coast between *Charleston and Savannah entrances*, and from *Georgetown entrance* south, to include *Roman shoals;* to complete the hydrography of *St. Helena sound, Port Royal entrance, and Martin's Industry, Doboy inlet, St. Simon's sound, and Cumberland sound*, and the *St. Mary's*, and if practicable of *Sapelo sound*, and extend it southward; to continue tidal observations along the coast of the section, and the exploration of currents in the *Gulf Stream.* OFFICE-WORK.—To make the computations and reductions of the work of the section; to continue the drawing of the general coast chart south of *Charleston*, and preliminary chart of the coast of *South Carolina*, No. 2; to draw the sketches of the section; to complete the engraving of *Charleston harbor*, second edition, seacoast of *South Carolina, Port Royal entrance, Savannah river entrance*, and the preliminary sketches of the section,—will require.......... 33,000

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

SECTION VII. *Coast of Florida.* FIELD-WORK.—To make the necessary astronomical and magnetic observations, and complete the triangulation of *St. Mark's and Apalachicola harbors*, and *St. Joseph's bay;* to continue the triangulation of *Pensacola harbor*, and of the coast south of *Cedar keys;* to continue the topography of *St. Joseph's bay*, and of the coast south of *Cedar keys*, and to commence that of *St. Mark's and Apalachicola harbors*, and of *Pensacola harbor;* to complete the hydrography of *Crystal river offing* and southward, and *St. Joseph's bay*, of *St. Mark's and Apalachicola harbors*, and to commence that of *Pensacola harbor*, and to continue tidal observations at stations in the section. OFFICE-WORK.—To make the requisite computations and reductions; to commence the chart of approaches to *Cedar keys*, south of *Crystal river*, and to draw the sketches of the section; to complete the engraving of *St. Andrew's bay*, and commence that of *St. Mark's and Apalachicola*, and to engrave the sketches of the section,—will require.......... 35,000

SECTION VIII. *Coast of Alabama, Mississippi, and Louisiana.* FIELD-WORK.—To complete the primary triangulation, and secondary triangulation in connexion with it, outside of the *Chandeleur islands*, across to the mouths of the *Mississippi;* and the secondary triangulation of *Vermilion bay;* to continue the topography of the shores of *Lake Pontchartrain*, and of the neck between the *lake* and the *Mississippi;* to commence the topography of *Atchafalaya bay*, and continue that of *Calcasieu bay;* to complete the hydrography of *Louisiana sound*, and to continue the off-shore work of the coast of *Alabama, Mississippi and Louisiana*, to the mouth of the *Mississippi;* and to continue observations of tides and currents, and observations for temperature, along the *Gulf coast* of the section. OFFICE-WORK.—To make the necessary reductions and computations for the work of the section; to complete the drawing of coast chart No. 3, and preliminary chart No. 2, of *Mississippi sound;* to commence that of the preliminary chart of approaches to the delta of the *Mississippi*, and to draw the sketches of the section; to complete the engraving of *Mobile bay*, $\frac{1}{80000}$, and *Mississippi sound* No. 1; to commence that of *Mississippi sound* No. 2, and continue the engraving of *Biloxi bay*, and sketches of the section,—will require.................................... $33,000

SECTION IX. *Coast of Louisiana and Texas.* FIELD-WORK.—To extend the main triangulation southward and westward, and to make the astronomical and magnetic observations connected with it; to complete the secondary triangulation and topography of *Matagorda and Lavacca bays;* to complete the hydrography, in-shore and off-shore, from *Pass Cavallo*, southward and westward, and to commence that of *Matagorda and Lavacca bays.* OFFICE-WORK.—To make the required reductions and computations; to complete the drawing of the coast chart and continue that of the preliminary chart of *Galveston bay*, and to draw the sketches of the section; to complete the engraving of the chart of *Galveston bay*, and *East and West bays*, and preliminary sketches of the section,—will require................ 26,000

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

Total, exclusive of *Florida reefs and keys*, and of *western coast*........................ 250,000

The estimate for the *Florida coast, reefs, and keys*, and for the *western coast*, is intended to accomplish the following results, namely:

SECTION VI. *Reefs, keys, and coast of Florida.* FIELD-WORK.—To complete the general reconnaissance of the coast, and continue the triangulation of *reefs*, &c., outside, and of the keys from *Key Largo* towards *Key West*, and from *Bahia Honda* eastward; that between the outer keys and main, and of the inner keys; to continue the triangulation of *Barnes' sound*, and that of *Florida bay*, including the connection with the *Cape Sable base;* to continue the topography of the keys, from the shores of *Key Largo*, westward, and that of the *Pine islands* and *Bahia Honda*, eastward. OFFICE-WORK.—To make reductions and computations; to complete the drawing of entrance to *St. Mary's river;* to continue that of the coast charts of *Florida reef*, and sketches of the section; to complete the engraving of sheet No. 1, *Florida reefs and keys*, of the reconnaissance of *Tampa bay*, of the survey 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 primary triangulation south of *Monterey* and north of *San Francisco bay*, and the secondary triangulation in connexion with it; to continue the secondary triangulation of *San Francisco bay* and of its approaches; to continue the triangulation of harbors as the developments of the survey may require, and of islands in the *Gulf of Georgia*, of the *Straits of Rosario*, and of parts of *Puget's sound* and its harbors; to follow the triangulation with the topography of the dependencies of *San Francisco bay;* thence northward of *Ballenas bay* and southward of *Monterey*, and to make the topography corresponding to the triangulation in *Wash-*

ington Territory; to continue the hydrography of *San Francisco bay* and its dependencies, that of the coast of the *Bay of Monterey,* and of the *Gulf of Georgia,* (*Washington Territory,*) and its approaches; to continue the hydrography of *Puget's sound*; to complete some of its most important harbors, and to continue certain tidal stations along the western coast. OFFICE-WORK.—To make the requisite reductions and computations; to complete the drawing of chart of *San Francisco bay,* and commence the coast chart north of *San Francisco;* to complete the drawing of preliminary surveys and reconnaissances of harbors and the sketches of the sections; to continue the engraving of chart of *San Francisco entrance;* to commence that of the *Gulf of Georgia,* and to engrave the reconnaissances of harbors, and the sketches of the sections,—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 and alterations of steamers "Hetzel" and "Vixen," and of sailing-vessels employed in the Coast Survey, per act of March 2, 1853........................ 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

I proceed next to the detailed account of the work, according to geographical sections, and followed by a statement of the work at the office in Washington.

SECTION I.—FROM PASSAMAQUODDY BAY TO POINT JUDITH, INCLUDING THE COAST OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND. (SKETCH A.)

The survey has made its usual progress in this section. An additional station of the primary triangulation has been occupied between the Kennebec and Penobscot, its lines extending forward to Mount Desert and Isle au Haut, and the work being still quite in advance of the secondary. Astronomical and magnetic observations have been made at the same station, and additional magnetic observations at several others. The reconnaissance for a base of verification, and for some of the doubtful lines towards the boundary, has been completed. The secondary triangulation has been extended over the entrance to the Kennebec, and up the river to beyond Bath. The topography of Casco bay, its islands and main, has made progress; and that of the coast has been executed from near Newburyport to Hampton river entrance, besides work of filling-in on Cape Ann and Cape Cod.

The hydrography of Massachusetts bay has made very good progress inside, and the approaches. Additional investigations of Stellwagen's bank have been made; several rocks have been determined. The difficult in and off-shore work on the outside of Cape Cod peninsula has advanced well; and off-shore lines have been run west of Nantucket shoals, and between Cape Cod and George's bank. The hydrography of Nantucket and the Vineyard sounds has been nearly completed, and work of verification has been executed.

A section of the Gulf Stream, southeast from Nantucket, has been partly explored. The tidal observations at Boston have been kept up. Additional observations for the tides of the Vineyard and Nantucket sounds have been made.

A new chronometer expedition for examining the effects of temperature, supposed to produce the differences in former results of outward and inward voyages, has been made, and the observations are already under discussion. This included an elaborate examination of the effects of temperature on the chronometers employed in the expedition. The usual observations for culminations have been procured, and observations on transits of lunar spots for longitude have been in the course of examination. The preparations made to carry out the suggestions of Professor Peirce in regard to the triangulation of the Pleiades, and their uses in conjunction with the moon, for longitudes, at the next period of their occultations, are noticed in the introduction to my report.

The following maps, charts, and sketches, have been drawn within the year: Portland harbor, $\frac{1}{10000}$ and $\frac{1}{2500}$, (for Commissioners,) Nantucket shoals, Gloucester harbor, Plymouth harbor, Ipswich and Annisquam harbors, Bass River harbor, Monomoy shoals, Eastern series Nos. 2 and 3, and the chart of Massachusetts bay is in progress.

The engraving of the following plates has been in progress during the year: Portland harbor, Annisquam and Ipswich harbors, Boston harbor, Plymouth harbor, Monomoy shoals, Bass River harbor, Muskeget channel, and Eastern series No. 1. The engraving of Salem, Newburyport, and Gloucester harbors has been completed.

Reconnaissance.—The reconnaissance for a base of verification for the primary triangulation, and for some of the projected lines, in Maine, considered doubtful from examinations of previous years, has been continued by Assistant Charles O. Boutelle, aided by Sub-Assistant J. A. Sullivan, and by Mr. F. P. Webber. In the month of October, Mr. Boutelle examined the intervening ridge found by Major Prince to exist upon the line *Moose-a-bec — Cooper;* but, owing to the prevalence of fogs and rains, was not able to complete the reconnaissance before the time proper for his return to the work in Section V. It will be resumed early in the next summer.

A topographical survey was made, under the direction of Mr. Boutelle, by Sub-Assistant J. A. Sullivan and Mr. F. P. Webber, of the site for a base of verification found last year by Major Prince upon Epping plains. A plan and profile of this line, and its connexion with the primary triangulation, has been submitted by Mr. Boutelle. The site is represented on Sketch A.

The connections of the base site with the stations in the quadrilateral in which it is situated, are all that could be desired as means for verifying the primary triangulation in Section I.

Primary triangulation and astronomical observations.—After the measurement of the Florida bases in April and May, the party under my immediate charge returned to Washington, and comparisons of the base apparatus with the standard bar were carefully made. The party next proceeded to this section, where Mount Harris, Dixmont, was occupied between the 25th of July and 22d of October. Horizontal angles were measured for the primary triangulation, azimuths, latitude, and magnetic elements determined, and vertical angles measured for heights. The season and locality were very unfavorable for the geodetic observations; frequent haze and storms, and the fogs of the Penobscot and Kennebec, interrupting them. The nights were, until late in the season, favorable for astronomical work, especially near the zenith, to which our modes of observing refer. There were eight heliotrope points to be observed upon, and three secondary signals, the shortest of the primary lines being 26.5 miles, and the longest 60. It was necessary to raise the heliotrope on Mount Desert some fifty-six feet above the ground, in order that the line from Mount Harris should pass above Mount Waldo. The station point at Mount Harris had been elevated twenty feet above the ground by a substantial structure of mason work, prepared last season. I was assisted in the observations generally by Assistant G. W. Dean, who had entire charge of the transit observations for time, and of the latitude and magnetic observations, and measured the vertical angles for heights. Mr. S. J. Hough was the recorder of the geodetic work, Messrs. F. M. McIver and McLane Tilton of the astronomical. Sub-Assistant Edward Goodfellow also observed for latitude, in order to test the question of personal equation with the zenith telescope, and was engaged under my immediate direction in discussing the observations and bringing up the records of the measurement of the Florida bases, in which he had assisted. I was indebted to Assistant A. S. Wadsworth for aid in posting heliotropers, and to Lieutenant James Totten, U. S. A., for the erection of a high station and scaffold at Mount Desert. The necessity for great steadiness in the structure, and for great strength to make it resist the high winds of this region and season of the year, made this work one of no small practical difficulty. Lieutenant Totten also assisted, from time to time, in the observations of horizontal angles.

Two zenith telescopes were used by Assistant Dean in order to examine, in a point of view which had suggested itself to him, the subject of personal equation differing from that to which I have above referred, namely, the use of different instruments by the same observer, determining the latitude by the same stars. The number of measures taken for the primary angles was 1,025 upon eight points, and for the secondary 150 upon three points, with the thirty-inch theodolite by Troughton & Simms, (C. S. No. 1.) The number of measures of vertical angles for heights was 180 upon four stations, with the eight-inch Gambey, (C. S. No. 57,) and 104 upon eleven stations with the micrometer of the thirty-inch theodolite.

The station at Thomas' Hill, Bangor, which had been used by the late Assistant S. C. Walker in determining, by telegraph, the difference of longitude between Cambridge and Bangor, and Bangor and Halifax, was observed in turn with the primary stations. A mark at the distance of about two and a half miles was connected with the primary station, and its azimuth determined by eleven sets of observations on Polaris at its eastern elongation, and by five on Lamda Ursæ Minoris at upper culmination. Each set of observations consisted of five pointings on the star, telescope direct, and as many telescope reversed, and of twelve pointings on the mark, telescope direct and reversed. These numbers have been derived from previous examinations of the probable errors of observation.

The latitude observations by Mr. Dean consisted of 264 sets on 49 pairs of stars, with a new zenith telescope by William Würdemann, loaned by that artist, and of 179 sets on 39 pairs with a Troughton & Simms zenith telescope, (C. S. No. 2.) The number of observations on each pair of stars was five. Of the pairs 16 were selected from the Greenwich Twelve Year Catalogue, and 33 from the British Association Catalogue. The values of the micrometers were determined by 480 observations on Polaris at elongation, and of the levels by forty measurements with the micrometer screw, the pointings being made upon a collimator adjusted to a siderial focus. The observations made by Mr. Goodfellow consisted of 224 sets on 38 pairs of stars with a Würdemann zenith telescope, and of 220 observations for micrometer value, the same pairs being used, as far as practicable, as in Mr. Dean's observations, and the micrometer value being determined in the same way.

Too much praise cannot be awarded to the new zenith telescope made by Mr. Würdemann. In his report (Appendix No. 44) Mr. Dean says: "This instrument is the largest, and, in point of nice mechanical construction and style of finish, far excels all others of a similar kind which have fallen within my notice. The telescope is fifty-one inches in focal length, with an aperture of three and three-fourths inches. The diaphragm consists of five vertical threads, adjusted at convenient intervals for transit observations, and provided with an adjusting screw for collimation. The limits of the field are equal to fifty revolutions of the micrometer, or more than thirty minutes of arc, and the arrangement for its illumination is most complete. The lamp is small, but so constructed that it gives a strong, steady light from seven to eight hours without any attention, and without affecting the instrument by heat. The eye-piece is provided with a parallactic movement, and the levels attached to the telescope are of the most perfect construction. The weight of the telescope and its appendages upon its horizontal axis is almost entirely removed by an ingenious contrivance for attaching the counterpoise weight, devised by Mr. Würdemann, by which the bearing is transferred to the outside of the steel cylinder, enclosing the horizontal axis, by means of a steel-bar lever which is attached to the telescope, and a ring moving freely upon friction rollers around the steel cylinder and directly over the vertical axis."

* * * * * * * * * * *

"The design, construction, and finish of this instrument are highly creditable to the artistic taste and workmanship of Mr. Würdemann."

The time for the latitude and azimuth observations was determined by 129 transits of high and low stars with the Würdemann portable transit, (C. S. No. 10.) This small instrument fully sustained the reputation given to its class by the observations made by Assistant Davidson on the western coast, detailed in my report of last year.

Magnetic observations.—The magnetic declination was determined at a point just southwest of the station, by 188 observations on four days with a portable declinometer by Jones, (C. S. No. 1.) A magnetic disturbance accompanying an Aurora interrupted the observations on one day, but the results accepted appeared quite free from disturbing action. The horizontal intensity was obtained from two sets of observations on two days. The dip was measured by four sets on four days with a ten-inch dip-circle by Barrow, (C. S. No. 4,) the place of observation being near that for the declination. The geological formation of Mount Harris is called by Dr. Jackson *talcose slate.* Gneiss appears in parts of the hill, but not at the summit.

Meteorological observations.—The usual meteorological journal was kept by Mr. S. J. Hough, and 333 observations for temperature, 270 for the evaporating point, and 356 of the barometer, (Green, No. 613, and aneroid by Dent, No. 8580,) wind, &c., were recorded.

The heliotropers kept journals of the weather at each station, and forwarded them weekly. A comparison of these journals enables us to form conclusions in regard to the general direction and velocity of passing storms, and assist in fixing their geographical limits.

The climate in this part of the section presents a strong contrast to that further south—in Massachusetts, for example—in relation to geodetic work. The sudden change from a comparatively high to a low temperature is accompanied by frequent storms of wind and rain, by great cloudiness, and by almost constant haze. The water retaining its comparatively high temperature, sea-fogs are very frequent. The powerful radiation which goes on at night when the sky is clear, covers the numerous ponds and valleys with fog, which, on the rising of the sun, is set in motion, and entirely destroys the transparency of the air. The abrupt change of temperature in the air by cooling, when the ground is comparatively warm, causes extraordinary lateral as well as vertical refraction. The cloudy days of autumn, of which we usually had two or three while working in Massachusetts, when the air was so transparent that very distant signals were perfectly seen, have not been met in our experience at this station. This summer I considered the propriety of changing the day observations with heliotropes for night ones with lamps and lenses; but the observations in regard to the fogs showed that it was not advisable to make the change. At present, with our long lines, we keep fully ahead of the secondary triangulation, even while working only a part of a season in this section; and as the number of points to be observed diminish on approaching the boundary, and the length of the lines diminish, the work can, at any time after the occupation of Mount Desert, be pushed, if at all necessary.

Magnetic observations.—During the month of August, observations for the determination of magnetic declination, dip, and horizontal intensity were made by Charles A. Schott, Esq., of the computing division, Coast Survey office, at the following named stations in the section: Salem, Boston, and Nantucket, Mass., and Providence, R. I.

The results obtained at these several places, and at other stations, as noticed under Sections II and III, are given in Appendix No. 49.

Mr. Schott was aided in the operations here mentioned by Mr. J. Main, of the computing division.

As Mr. Schott's labors spread over several sections, I give his report in the appendix (No. 49) as presenting a view of the whole series. The expenditure on these observations is the smallest, considering the results obtained, ever incurred for such a purpose in the survey.

Secondary triangulation.—Assistant C. O. Boutelle has presented, in a very complete shape, the results of secondary triangulation of the coast of Maine from Saco river to the mouth of the Kennebec, executed by him in 1850, 1852, and 1854. In this report he says:

"I beg to call your attention to the marked contrast presented between the statistics of work shown in the preface to Vol. I, and in my report of work in Section V, lately sent you. Six months' work in Section I has sufficed to occupy four-tenths as many stations, to measure as many angles, on nearly as many objects, by six-tenths as many observations as have required all the time spent in triangulation in Section V, from 1850 to the present time, viz:

	Whole time.	Stations occupied.	Angles observed.	Objects observed.	No. of observations.
Section I	5.8 months	48	1,222	1,089	10,359
Section V	19.2 months	121	1,234	1,133	16,585

"I throw out the time occupied in astronomical observations.

"If the *cost* of each work were similarly contrasted, it would show the difference still more strongly marked."

The continuation of the secondary triangulation of the coast of Maine has been under charge of Lieutenant A. W. Evans, U. S. A., assistant in the Coast Survey, assisted by Sub-Assistant Benjamin Huger, jr. The work has been confined to the Kennebec river, extending from the mouth, which it connects with Mr. Boutelle's triangulation to Merrymeeting bay. The wooded character of the shores of the river has made the work tedious.

Lieutenant Evans made a reconnaissance in Merrymeeting bay in the month of August, and during the progress of the work connected two stations, viz: *Sebattis* and *Manhegan*, of the primary triangulation, with a new point in the secondary series upon the Damariscotta river. Connections were also made with points in the secondary work of the previous year, to the westward. The triangulation of this season includes the city of Bath and the towns of Phipsburg, Arrowsic, and Georgetown. Points were also established in Woolwich, Westport, Wiscasset, Edgecombe, and Boothbay. Twenty-nine stations in all were established, of which twelve were occupied. One hundred and ninety-one angles were measured upon seventy-two objects, by fifteen hundred and forty-five observations. Four hundred and sixty measurements were made for vertical angles at four stations.

The work was discontinued in the middle of November, at which time Lieutenant Evans prepared the schooner "Hassler," which had been employed in the service of his party for resuming duty in Section V. He expresses his obligations for the essential assistance rendered by Sub-Assistant Huger, who has been assigned to the charge of a party to be engaged on the western coast of Florida.

Topography.—Assistant A. W. Longfellow has continued the topography of islands in Casco bay, east of Portland, in connection with the determination of the shore-line of the main land, from a point opposite Mackworth's island northward, and eastward beyond Clapboard island. The islands embraced in his sheet of this season are, Long, Marsh, Jewett's, Green Crotch, Hope, Little Jebeig, Great Jebeig, Crow, Sand, Little Bangs, Stave, Ministerial, Bates', Cousins', Little John's, Great Moges, Stockman's, Sturdevant's, and Basket island.

The shore-line of all at high and low-water mark, and the topography of several of those named, has been completed.

This work was commenced on the first of August, and terminated on the arrival of the period for the return of Assistant Longfellow to Section V, where he had been engaged in the former part of the present surveying season. Mr. N. S. Finney has been attached to the party as aid.

The schooner Meredith was employed in furnishing transportation, and was also used in the early part of the season in posting the heliotropers for the primary triangulation.

It was intended to use this work immediately for the hydrography of Casco bay, and Mr. Longfellow was directed accordingly to work up the shore-lines. The steamer Walker, Lieut. Comg. Sands, was directed to this point, but her repairs occupied so much more time than had been reported as neccessary for the purpose, that the proper season passed before she could reach the station, and the stormy character of the weather here, entirely broke in upon my plans.

After completing the work of verification assigned to him in Chesapeake bay, (see Section III,) Assistant H. L. Whiting was occupied in office-work until the season was favorable for topography in Section I. He then commenced filling up the space between the plane-table sheets of Assistants Boyce and Glück near Falmouth, between Essex and Annisquam, on his own sheets, and extending the coast topography from the limits of Assistant Longfellow's sheet near Newburyport, and to the mouth of Hampton river. The sheet from north of Newburyport, Massachusetts, to Great Boar's Head, New Hampshire, (see Sketch A *bis*,) was chiefly executed by Sub-Assistant C. T. Iardella, and verified by Mr. Whiting. "The work is carried back to the Eastern railroad, which has been the boundary, inland, for the last two seasons. The work is much in detail, with the sand-hills of Salisbury and part of Hampton Beach, the marshes back of them, with Hampton river, and numerous creeks winding through them in all directions. The necks and fast land are pretty thickly settled with farms and irregular portions of cleared and wooded land."

"The character of the country slightly changes from that further south; the high rolling hills peculiar to the country between Ipswich and Newburyport seem to recede further from the shore, and the land is generally lower, more rocky, and apparently not so fertile, and the pine and cedar seem to be a more characteristic growth. There are some rocks and ledges off Hampton river and Great Boar's Head, which stretch out towards the Isle of Shoals, and seem to indicate a gradual return of the rocky and broken character of our northern coast, which was for some distance quite lost in the 'Cove' or interval between the promontory of Cape Ann and the more rugged country we are again approaching. The shore still continues quite low, however, to the northward, Great Boar's Head being the only bluff or headland in the vicinity which is directly on the shore."

The following are the statistics of Mr. Whiting's work:

Shore-line	$27\frac{1}{2}$	miles.
Length of creeks	44	"
Length of roads	32	"
Outline of marsh	25	"
Length of railroad	$5\frac{3}{4}$	"
Area in square miles	14	

The topography north of Thompson's station, Cape Ann—above referred to as near Annisquam—was executed by Mr. Whiting, assisted by Sub-Assistant J. A. Sullivan.

"This work (Sketch A *bis*,) comprised the high broken land of 'West Parish,' directly north of your station of 'Thompson's,' and lying between Squam and Essex rivers. I was able to resume the work without trouble or delay, and made a very satisfactory closing of this sheet. The weather during this time was very favorable.

"The character of the country is that peculiar to this ridge of Cape Ann, wonderfully broken, with abrupt hills, rocks, valleys, &c. The height of the country ranges from 150 to 200 feet; all minor and artificial details, as buildings, woods, fences, &c., seem lost in the general character of huge rocks and boulders, sometimes absorbing nearly three curves."

"The amount of detail, as generally given, does not cover the work, which is one mass of curves of contour and elevation. The area surveyed is about five square miles, with some ten miles of road."

The survey near Hyannis was made by Sub-Assistant Sullivan, and verified by Mr. Whiting. It covered an area of about six square miles of wooded country.

Mr. Whiting speaks very favorably of the work of both of his assistants.

The season here having closed, Assistant Whiting has been instructed to resume the work of verification in Section III, Sub-Assistant C. T. Iardella to take up the topography of the Florida keys (Section VI,) and Sub-Assistant J. A. Sullivan has been assigned the charge of a topographical party in Texas (Section IX) with Assistant Gilbert.

Hydrography.—Two parties have been engaged in the regular hydrography of this section—that of Lieut. Comg. H. S. Stellwagen in the steamer "Bibb," with the schooner "Petrel" as a tender, and that of Lieut. Comg. C. R. P. Rodgers in the schooner "Gallatin." A third party, that of Lieut. Comg. B. F. Sands, commanding the steamer "Walker," was assigned to work in the part of the Gulf Stream more immediately connected with this section, and in Casco bay; but the repairs to the steamer occupied so much more time than was anticipated, that the very boisterous autumn weather of this year commenced before the vessel was ready for sea, and rendered impracticable the completion of more than a part of the Gulf Stream work.

The hydrography of Lieut. Comg. H. S. Stellwagen, U. S. N., assistant in the Coast Survey, has consisted of several lines eastward from Nantucket, some one hundred and fifty miles and back, to Nausett, Cape Cod.

Lieut. Comg. Stellwagen made search for a bank north and east of Stellwagen's bank, indicated by Lieut. Comg. Almy, from soundings which he had made on approaching this point of the coast in the "Independence," but without success.

This party determined the position of the rock and flat ground in Gloucester harbor, pointed out by Mr. Webber, one of the pilots. The rock is "on Eastern Point ledge. The flat ground is a continuation of Dog bar."

Lieut. Comg. Stellwagen further says: "Webber's rock lies S. S. W., true, from Eastern Point light, distant three hundred and sixty-three yards, and has but seven feet water at ordinary low tides; its top is not more than three or four feet in diameter, and could be easily removed by powder. The '*flat ground*' spoken of by Mr. Webber is part of the 'Dog Bar ledges;' shoalest water sixteen feet at ordinary low tide. We found a space with but thirteen feet at Round rock, and a small ledge extending a little north of it, with fifteen and seventeen feet."

A syphon tide-gauge, invented by Lieut. Comg. Stellwagen, was tried by him near Highland light, Cape Cod, and with good results.

Additional soundings upon the southern extremity of Stellwagen's bank showed that the twenty-fathom curve extended further south and east than was previously supposed. The new edition of the chart (see Sketch No. 5) shows this extension.

The party also located "Sammy's" rock, between Nahant and Marblehead, and a small rock near Nahant.

The following office-work was completed by the party before resuming work afloat this season:

"1. Sheet of off-shore soundings, extending from Nantucket shoals S. E., E., and N. E.; scale $\frac{1}{300000}$.

"2. New plotting and completing chart of the south side of Nantucket island, connecting work on the Nantucket shoals with that of Muskeget channel; scale $\frac{1}{40000}$.

"3. Completion of work between Marblehead and Boston harbor; scale $\frac{1}{20000}$.

"4. Plotting, completion, and reduction of the chart of Massachusetts bay, including Stellwagen's bank; scale $\frac{1}{100000}$, reduction $\frac{1}{400000}$.

"5. Plotting one line of soundings between Chatham and Cape Cod, $\frac{1}{40000}$.

"The copying of soundings and tide-books, &c., and labelling and recording specimens, have also been finished."

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

"Deep-sea lines, from South shoal to eastward and return, number of angles, 12; soundings, 248; miles, 330.

"Atlantic coast, Cape Cod peninsula, number of angles, 505; soundings, 2,484; miles, 351—computed in round numbers, as some lines extend from Cape Cod to Massachusetts bay. Massachusetts bay, Stellwagen's bank, &c., number of angles, 1,126; soundings, 5,738; miles run in sounding, 1,025.

"Total angles, 1,643; soundings, 8,470; miles, 1,706."

From the lines run, we obtain a glimpse of the form of bottom in this region of complexity; but it will require many more, fully to explore it. The most instructive line is that due east from the Nantucket light-vessel, on which we have in succession, beginning fifteen nautical miles from the vessel, twenty-eight fathoms; forty-five, forty, twenty-four fathoms; at fifty-five miles, thirty, thirty, twenty-five, twenty-nine or thirty, twenty-nine, twenty-one fathoms; at ninety miles, thirty-six, thirty-eight, forty-five, forty-four, forty-four, forty-nine, fifty, sixty-two; and one hundred and thirty fathoms, at one hundred and fifty-two miles; showing between fifty-five and ninety miles a space with from twenty-one to thirty fathoms. South of the twenty-one to thirty fathoms' space, a line run at about fifteen to twenty miles' distance shows deeper water; while north of it, and between this space and George's bank, three lines show respectively eighteen and twenty-five fathoms; twenty-nine, twenty-five, seventeen, twenty, twenty-two, twenty-two fathoms; and twenty, twenty-five, twenty-five, fifteen, twenty-five fathoms. This indicates that the shoal space is related to George's bank and the shoal ground on the north. The steep pitch which characterizes these under-water slopes, as far as we have examined the coast, appears on the line first referred to at about one hundred and fifty miles from land. The same occurs at about one hundred and thirty-five miles on a line nearly east by south from the southeastern point of Nantucket, and about one hundred miles on a line southeast from the same point.

The party of Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, in the schooner Gallatin, commenced operations on the first of August. "The first work was the survey of the shoals near Stage harbor and Chatham lights. Thence we proceeded to survey the mid-passage between Great Point and Monomoy, including a minute examination of Great Round shoal, where we found in one place but two feet of water. We then filled the deficiencies on the southeast side of Martha's Vineyard, and those between West Chop and the Nantucket light-boat. After this we devoted ourselves to a patient and very minute examination of the numerous shoals north of Muskeget and Tuckernuck islands—a most difficult field, covered with sand-rips, over which the tide rushes with great velocity. The wind in this locality is rarely moderate; when there is not a flat calm, the breeze is usually fresh enough to baffle or impede the hydrographer, while in the frequent fogs he also finds a formidable enemy. We have very carefully surveyed a clear, beating, ship channel, with not less than seventeen feet at low water, passing between the Tuckernuck, the Shovelful, and the Muskeget shoals, towards the harbor of Nantucket, with three buoys to mark its outline. This channel cannot fail to be much used by vessels bound to Nantucket from the westward. In fresh northerly winds it will save much exposure to a rough sea, shorten the distance, and perhaps obviate the necessity of beating to windward. It will at all times be very advantageous to the steamers on the route between New Bedford and Nantucket, and to the Nantucket whale-ships, which are usually, during six months of the year, towed by steam to Edgartown, where, during the winter months, they load and refit."

Lieut. Comg. Rodgers acknowledges the efficient services of the officers in his command, and also specially mentions the valuable aid kindly afforded by the collector at Nantucket, E. W. Allen, Esq., and by the collector at New Bedford, C. B. H. Fessenden, Esq., in placing boats at his disposal for the use of the hydrographic party.

The work, terminating on the 10th of October, presented the following statistics:

Number of miles run in sounding	894
Number of theodolite angles	1,47
Number of sextant angles	1,042
Number of soundings recorded	16,200

The existence of the channel referred to in the report of Lieut. Comg. Rodgers is indicated upon a local chart recently published, but its capacity and importance, as developed in the progress of his work, seem to have remained, until the period of his thorough examination, entirely unknown.

The shoal discovered by Lieut. Comg. Rodgers, a mile and a half to the southward of Nantucket light-boat, (see Appendix No. 11,) though determined in position and general limits, notwithstanding the lateness of the season, will be more precisely defined in the course of the ensuing surveying year.

Tides.—The regular observations of tides at Boston have been kept up, and those already collected have been under discussion. This, in fact, is one of our most reliable and continuous series on the Atlantic coast. I have already noticed the discussion of the results in the introductory part of the report.

The study of the curious interference tides in Martha's Vineyard and Nantucket sounds, and in the passages between them and the ocean, and in the ocean near the shores of the islands of the same names, was commenced last year, and the limits of the variable tides, the characteristic forms of the interference waves, and the general facts in regard to the tides, were obtained by observation. This year observations based upon the conclusions of the former season have been made for the more minute determination of the curious tidal phenomena of this region. Observations have also been made upon the laws of the tides in basins communicating by narrow entrances with the sea.

SECTION II.—FROM POINT JUDITH TO CAPE HENLOPEN, INCLUDING THE COAST OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE. (SKETCH B.)

In the spring of this year, the Commissioners appointed by the governor, under authority of an act of the legislature of the State of New York, to restrain the encroachments on the harbor of New York, and to report in relation to them, called upon the President of the United States for the services of engineers and surveyors to assist them in labors which they deemed not only of local but of national importance. They were referred by the President to the Coast Survey office, and, during my absence in Florida, conferred with the assistant in charge, Captain Benham, of the corps of engineers, and explained their views and wishes. Under the sanction of the President and Secretary of the Treasury, and by request of the Commissioners, I subsequently went to New York and arranged for them a re-survey of New York bay and harbor, which should present at once the outline and topography of the immediate shores, and the hydrography of the harbor, the outer bay, and adjacent bays, and the East and North rivers, and subsequently give the whole topography and hydrography of the bay and dependencies, as required by the State law, the Commissioners bearing the expense of the work, and having the services of the Coast Survey officers as volunteers in it, and the use of the vessels, instruments, equipments, and the like.

With these arrangements for the field-work were others, connected with the preparation of a map of the survey; first in a preliminary form, with shore-line, characteristic topography of the immediate shores and hydrography, and finally in a complete form, to show the city and wharves, the adjacent cities, and to extend eastward to the meridian of Throg's Point; westward to that of Perth Amboy, New Jersey; on the north to about a mile above Spuyten-dyvil creek on the Hudson; and to the south to about the old entrance of Shrewsbury river, which would include the seaward approaches of the bay. A comparative map was prepared of the previous surveys of the Coast Survey executed in parts of the harbor and approaches in 1836, 1848, and 1853, and the interest attaching to its results determined the Commissioners to have the new surveys added to the comparison in a similar map. A comparative map of New York city and the south end of Manhattan island was also directed to be prepared for various periods characteristic in the growth of the city, and from authentic materials accessible to the Commissioners in the State and city offices, and in private collections.

The arrangements for the field and office work were submitted by me to the Commissioners and approved, and I have kept the operations steadily in view by weekly reports from the field and half-monthly from the office, so as to supply additional facilities or parties to meet the contingencies of the weather and other circumstances. The assistants who have engaged in this survey, whose names will be stated in the notices which follow, have all entered upon it with a heartiness which does them very great credit; and each one has obviously made it a study, that so far as he was concerned, the work should succeed, and that the difficult conditions of coming up to time, without sacrificing accuracy, should be fulfilled. I supposed at first that but little triangulation would be necessary, and transferred the party of Assistant Edmund Blunt from the upper part of the Hudson to this work in consequence of his knowledge of the localities of the signals formerly established by the Coast Survey, but I soon found that all his ability and skill would be required to keep the parties depending upon him for points, at work. The changes in the neighborhood of the city were such, that not only most of the station points were lost by occupation by buildings and the like, but the lines were interrupted in the same way or by ornamental trees; hills had been cut down, and radical changes of all sorts had been made, so as to render almost an entirely new triangulation indispensable. This was readily made upon the basis of the lines of the old work which could be recovered; but the question being one of time, and the topographical and hydrographic parties not being able to begin their work effectively until numerous new points were determined, Mr. Blunt's powers were severely taxed. In addition to his former assistant, Lieutenant A. H. Seward, U. S. Army, I detailed Assistant C. P. Bolles to join Mr. Blunt, expecting that he would serve but a few weeks, but instead of this he was obliged to remain in New York from early in July until the beginning of October. Further aid being necessary, Sub-Assistant John Rockwell was next instructed to join Mr. Blunt, and remained with him until the close of the season. The services of these gentlemen will be stated in a more detailed notice of the work from Mr. Blunt's report.

Assistant F. H. Gerdes had already, last year, commenced, and in great part completed, a map of the wharves of the city of New York. This work he was instructed to complete, and to add the city, and the cities of Brooklyn, Jersey City, and Hoboken, and then the topography of the shores of the East river and Hell Gate to Throg's Point; of Harlem river, and of the Hudson to the limits of his former survey of its banks.

Assistant R. D. Cutts was instructed to take up the topography of Staten Island and its vicinity up to Jersey City, and on his being relieved, to join the Commissioners under the treaty relating to the fisheries of the coast, Assistant A. S. Wadsworth was ordered from my party for this duty.

Assistant A. M. Harrison took up the topography of Sandy Hook, and of the shores of Shrewsbury river, of Sandy Hook bay, and of Raritan bay.

Subsequently, Assistant S. A. Gilbert was instructed to execute the topography from Brooklyn round the shores of the inner and outer bay, of Coney island and Long Island to beyond Rockaway inlet.

To Lieut. Comg. T. A. Craven, U. S. Navy, assistant in the Coast Survey, in the steamer Corwin, and schooner Madison, Lieutenant Truxton, was intrusted the hydrography of the East river, Hell Gate, and the sound; of Throg's Point, of the upper and lower bays, and the approaches from sea, and of Raritan bay.

To Lieut. Comg. Richard Wainwright, in the schooner Nautilus, was assigned the hydrography of the Hudson from above Yonkers to the mouth; and on his being furnished by the Commissioners with a small steamboat, which very much facilitated his work, that of Newark bay, of Kill van Kull, and of Arthur Kull sound.

The computations of his work were made by Assistant Blunt as fast as the observations were turned in, and the results furnished to the other parties and to the office at Washington.

The topographers, as they determined shore-line from time to time, traced it and furnished it to the hydrographic parties, and sent it also to the office.

The hydrographic work was plotted, as it came in, by Mr. Balbach, the draughtsman of Lieut. Comg. Craven's party, and by Mr. Strausz, the draughtsman of Lieut. Comg. Wainwright's party. Tracings were sent, as the work advanced, to the office at Washington.

At the office a projection was made for the map by Mr. Boschke, and the results worked in as fast as they were furnished, by him and by Mr. Key.

The assistant in charge did his best, also, by communicating the wants of the office to the field parties and to me, to obtain the necessary materials in time.

The various information which had been determined to be placed on the map was collected, as far as practicable, before the com letion of the survey. I was indebted to Captain A. A. Gibson, U. S. Army, for the interest which he showed in this matter, and for the various suggestions which he made to improve the value of the map. The scale of this map has been agreed upon with the Commissioners as $\frac{1}{20000}$; and besides this, a map of the city wharves and of Brooklyn was to be made upon a scale of $\frac{1}{5000}$. On the scale of $\frac{1}{20000}$ the Commissioner's map will consist of twelve sheets, each 44 inches long by 28 inches wide, and forming, when united, a large sheet, 11 feet in length and $9\frac{1}{3}$ feet in width. The comparative map of different surveys will be on a scale of $\frac{1}{20000}$, and in two large sheets, 4 feet by 4 feet. This study is in charge of Mr. Boschke.

In August last I repaired to New York to meet the officers who had been selected to act as advisers in regard to the engineering and other questions involved in the encroachments on the harbor, and while there communicated with the Coast Survey parties, giving supplementary instructions, and carefully informing myself of the degree of progress of the several parts of he survey.

I proceed to notice the several operations of the parties, drawn from the reports to the first of November.

Triangulation.—This embraces an area of four hundred and thirty-four miles, extending over the space already described as included in the limits of the Commissioner's map. It has been executed by Assistant Edmund Blunt, with the aid of Assistant A. H. Seward, U. S. Army, and Assistants C. P. Bolles, and John Rockwell. Between the 20th of June and the 30th of October, one hundred and thirty-eight stations were occupied, and 1,589 series of observations made, consisting of 10,397 observations. This presents an amount of work almost unprecedented. With great practical skill, it has been made of the character exactly required, so as to lose no time by aiming at arrangement of triangles inappropriate to the circumstances of the case.

Topography.—The limits of the topographical sheets executed by Assistant F. H. Gerdes are stated in his report, Appendix No. 21. They consist of two sheets of the East river, two of the North (Hudson) river, and one of Manhattan island. The statistics of the details are as follows:

	Shore-line.	Shore-line of wharves.	Area.
	Miles.	*Miles.*	*Sq. miles.*
Sheet No. I	19	4	6
Sheet No. II	10	2	10
Sheet No. III	$7\frac{1}{2}$	----------	8
Sheet No. IV	33	1	18
Sheet No. V	46	12	23
Sheet No. VI	$1\frac{1}{2}$	1	$\frac{1}{2}$
Total	117	20	$65\frac{1}{2}$

The limits of the sheets of Assistant A. M. Harrison are also given in detail in his report, (Appendix No. 23,) and the general limits of his entire work have been already stated. The areas and extent of shore-line are as follows:

	Miles of shore-line.	Roads.	Area.
Sheet No. 1	23½	3½	1½
Sheet No. 2	10¼	1	¼
Sheet No. 3	15¼	2¼	¼
Total	49	6¾	2

Interesting particulars in regard to the amount of washing away of the south shore of Raritan bay are given in Mr. Harrison's report. Mr. Harrison was assisted by Mr. P. R. Hawley, and had the use of the Coast Survey schooner "John Y. Mason" for transportation.

The report of Assistant S. A. Gilbert (Appendix No. 22) shows the following amount of work executed on Long Island, between Gowanus and Hog Island inlet. The amount of details thus far surveyed is as follows:

Shore-line	178 miles.
Roads	67 "
Area	46 square miles.

Mr. Gilbert acknowledges the assistance derived from the services of Mr. Malcolm Seaton, aid in his party.

The plane-table work of Assistant A. S. Wadsworth, executed between the 10th of August and 1st of November, extended on the Jersey shore from Jersey City to Constable's Point, on Staten Island; on Staten Island, from the quarantine to Newark bay, and including also the shores of Newark bay to the mouths of the Passaic and Hackensack rivers. Fifty miles of shore-line are comprised in it. The party is still at work completing the shores of the Great Kills.

Hydrography.—In the execution of the hydrography of the East river, and of the inner and outer harbors, Lieut. Comg. T. A. Craven reports the following work done up to November 1st:

Area surveyed, (square miles)	40
Miles of soundings	1,967
Number of angles measured	5,132
Number of soundings	74,050
Greatest depth of water, (fathoms)	20
Least depth of water, (fathom)	1
Tides observed, (stations)	5
Operations commenced	July 1.
Operations discontinued	Nov. 10.

Twenty-five current stations were occupied, and full sets of observations made at them. The discovery or development of a shoal in the main ship-channel, south of the Narrows and near West bank, is one of the important results of this re-survey. Official information of this is expected at an early date, and will be published at once.

Lieut. Comg. Craven made some very interesting experiments, at my suggestion, to test his views of the source of increase of the point of Sandy Hook; these, however, require repetition before drawing positive conclusions from them.

Up to the 1st of November, Lieut. Comg. Wainwright had completed the part of the Hudson river between Glenwood and Castle Garden, Newark bay, and Kill van Kull and Arthur Kull, or Staten Island sound, to Elizabethport, and expected to complete the work assigned to him before the close of the season.

The statistics of his work are as follows:

Number of miles of soundings run	388
" angles observed	4,311
" casts of the lead	28,259
" current stations occupied	12
" tidal stations occupied	5

A small steamboat was employed for Lieut. Comg. Wainwright by the Commissioners, and served greatly to advance the progress of the hydrography.

Assistant H. L. Whiting, on his return from Section I, made an examination and re-survey of Sandy Point, near Stonington, Connecticut, and found that a material change had taken place since the survey in 1839, along the beach and point north from Napatree, (the bluff at the southwest angle of the beach, extending from Watch Hill to Sandy Point.) He reports that, since the period of the former survey, the point has extended northward about a thousand feet, and that it has also changed in shape since 1839. "The greatest and most important change, however, is in the bay or harbor. The encroachments of the beach, and deposites of sand beyond, have entirely changed the condition of the channel."

A hydrographic examination of this locality, and re-survey if necessary, will be included in the instructions of the ensuing season.

In addition to the foregoing, the following work has been done in this section:

Magnetic observations.—An elaborate discussion of observations in the United States, with a view to determine the changes of variation, has been made during the past two years by Charles A. Schott, Esq., of the computing division of the Coast Survey office. The importance of the results must be obvious when it is stated that, without them, the variations upon our published charts become in a few years obsolete; and that, with them, they may be supplied without sensible error for many years.

In the course of this discussion it became apparent that, at certain localities, the magnetic elements must be re-determined, to test the amount of their change. This has been done in the course of the past summer by Mr. Schott, assisted by Mr. Main, of the computing division, the stations having been selected in reference to their immediate usefulness for the purposes referred to. In New York harbor an examination of the local variations was made by occupying, in succession, a station on Manhattan, Governor's and Bedloe's islands, and at Sandy Hook. The other stations occupied in this section were at Albany, Greenbush, and New York city; at Cold Spring, opposite West Point; at Philadelphia; and at Cape May, New Jersey.

Secondary triangulation.—For the purpose of making use of the moon culminations and occultations observed at Philadelphia for longitude, the Old and New High School Observatories have been connected with the Coast Survey triangulation points in their vicinity, (Sketch B.) The completion of this work in the early part of March devolved on Captain W. R. Palmer, U. S. Topographical Engineers, by the detachment of Captain T. J. Cram from Coast Survey service, and the results show that the measurements necessary in the connexion were made with great care.

Captain Palmer refers, in his report on the completion of this work, to the acceptable services volunteered by Assistant George Davidson, then incidentally engaged in other duty at Philadelphia. The original and duplicate records of the work of connexion have been deposited in the office.

In consequence of a change of location in the High School Observatory, involving the transfer and re-adjustment of the instruments employed, only a few moon culminations were observed during the present year. In this department the survey has lost the valuable services of Professor E. Otis Kendall, by his attachment to the chair of mathematics in the University of Pennsylvania, which takes him from the High School.

At the close of last season, Lieut. Comg. Maxwell Woodhull, U. S. N., assistant in the Coast Survey, made an interesting experiment on currents in the bay between Nantucket and

Cape May, which I have elsewhere called the Bay of the five States. It had been alleged that a current set inwards in this bay towards some part of Long Island. To test this crossing from Nantucket to New York, current-bottles were thrown over from the schooner Gallatin, with requests on the labels contained within them that their finding should be reported to the Coast Survey office. The information was circulated through the medium of the press as widely as was practicable. The bottles were thrown overboard between latitude 40° 59′ N. and longitude 71° 03′ W., and latitude 40° 26½′ N. and longitude 73° 50½′ W., in the latter part of the month of October, 1854. None of them being heard of, I employed a careful person to search the south shore of Nantucket, and also had some search made on that of Martha's Vineyard, but the current-bottles were not found. It was concluded, therefore, as probable that the current was setting outward, and not inward, at that time, and that it had carried them into one of the branches of the Gulf Stream.

Quite recently I received from Charles Bowen Jones, Esq., H. B. M. consul at the Azores, the only card which has yet been returned. This was picked up while floating on the bar at *Santa Cruz*, (Azores,) on the 13th of last June, and has been courteously forwarded to me through the United States consul at the Western islands, Charles W. Dabney, Esq.

The bottle containing it was put over from the *Gallatin*, about four miles southeast of Sandy Hook, on the 30th of October, 1854. A copy of the card, as filled up and returned by Mr. Jones, will be found in the Appendix No. 54.

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

This is one of the sections of the survey which, from its early beginning and the manner in which it has been pushed, is the most forward. The primary triangulation is entirely complete, and the secondary on the ocean shore. The main body of the topography of the Chesapeake and the outer coast is done, and the remainder will be finished, with the present force applied, before the office can be ready for engraving it. There remains about thirteen months' work for one party near the lower part of the Chesapeake, and some eighteen months' on the outer coast of Maryland and Virginia. The triangulation of the rivers of Maryland, and of the Rappahannock, in Virginia, is done; that of the James river nearly done. The topography of rivers in Maryland is in general completed, and part of those in Virginia. The in-shore hydrography of the outer coast, and of the Chesapeake bay proper, is finished. There remains the off-shore work and parts of the rivers. In fact, this section has made greater proportionate progress than if the present plan of the survey had been earlier adopted, attempting to bring all the sections, as far as practicable, on the same line. Maps and charts have been drawn of Chesapeake bay, sheets Nos. 1, 2, 3, 4, 5, and 6, and seacoast of Virginia, No. 2. The last mentioned has been engraved, and the chart of the seacoast of Virginia and entrance to Chesapeake bay, with those of Chesapeake bay, $\frac{1}{400000}$, and sheets Nos. 1 and 2, $\frac{1}{80000}$, are in progress.

During the past year the following operations have been in progress, of which a detailed account will be found under the separate heads of the section:

1. Magnetic observations in connexion with those on the coast, or to determine the changes of the magnetic elements necessary to our charts.
2. The triangulation of the Rappahannock river has been completed.
3. That of the James river has been so nearly finished, that this winter or next spring, at furthest, it will be carried to the mouth of the river.
4. The verification of the topography on the shores of the Chesapeake has been in progress.
5. The topography of the lower part of the Chesapeake has been nearly completed.
6. The topography of the outer or ocean shore of the section has been also in progress.
7. The topography of Rappahannock river has been carried forward with the hydrography.
8. Hydrography of verification has been executed in the lower part of Chesapeake bay, and sailing directions and lists of dangers prepared.

9. The hydrography of Pocomoke sound, Chesapeake bay, has been completed.

10. The hydrography of James river has been in progress from near the mouth up the river.

11. The hydrography of the Rappahannock is well advanced towards completion.

12. The regular tidal observations have been kept up at Old Point Comfort, and others have been made for river-tides in the Rappahannock and James rivers.

13. Views have been taken for the charts of the outer coast.

Magnetic observations.—In connexion with a series of stations in Sections I and II, observations were made during the present season for declination dip and horizontal intensity, at the magnetic observatory in the Smithsonian grounds, and also on Capitol hill, in Washington city, and at Causten station, Georgetown. These were conducted by Charles A. Schott, Esq., of the computing division, Coast Survey office, aided by Mr. J. Main, and the results obtained are presented in Appendix No. 49.

Secondary triangulation.—After making a careful reconnaissance in the early part of November of last year, the party of Captain W. R. Palmer, U. S. Topographical Engineers, assistant in the Coast Survey, proceeded to measure a base of verification on the south side of the Rappahannock river, Virginia, (Sketch C.) The site selected is about five miles below Tappahannock, and opposite to Accaceek Point.

"The apparatus used in the measurement consisted of two four-metre rods of iron wire of the diameter of those employed in the measurement of the original base in April, 1853, about ten miles below Fredericksburg. The temperature of the rods was ascertained by means of two thermometers, one being attached to each rod during the progress of the measurement. The rods were supported by four tripods, made of pine wood, and the deviations from a level were carefully determined by means of the sector."

Captain Palmer completed the measurement on the 17th of November, and forwarded to the Coast Survey office the note-books containing the details of the operations, and a sketch of the vicinity.

The length of the base, as determined in the computing division, is found to be 1639.8808 metres, or 1.019 statute miles.

His report continues as follows:

"The triangulation founded upon this base was, by the 6th of December, carried, by a series of five well-shaped triangles, to the line "Bowler — Folly" below, and up the Rappahannock to station "Jones — Carter," the termination of the work in the previous season, (see Sketch C.) This line, as determined in June, 1854, by the triangulation from the original base, measured 4069.69 metres, and by the triangulation founded on the base of verification, 4069.64." The difference, 0.05 of a metre, or less than two English inches, presents a highly satisfactory result, and is strong evidence of the care taken in erecting proper secondary signals, and securing their verticality, in placing the theodolite accurately on the station points, and in the angular measures made in a series of sixty-nine triangles, of the correctness of which it furnishes a direct test. Captain Palmer resumed operations on the Rappahannock on the 22d of April, and by the 25th of June completed the triangulation of the river to its entrance into Chesapeake bay.

The progress of the work during the season, as shown by the statistics, has been marked by the characteristic zeal, ability, and energy of that officer. Of the fifty stations established by him since the date of my last report, thirty-five were occupied; and on fifty-five objects, one hundred and fifty-eight angles were measured by two thousand three hundred and eight observations, with the six-inch Brunner theodolite, No. 60. The length of river-course included in the work of the season is about forty miles, and the area covered by the triangulation, eighty-eight square miles. The whole length of the river, from Fredericksburg to the mouth, is about 108 miles. This distance was estimated by pilots and others, who accompanied Captain Palmer in his reconnaissance, at one hundred and fifty-five miles, which Colonel Mansfield and himself, by estimate, reduced to one hundred and thirty. The erroneous estimates of distances, where there are no good maps, have entered into the estimates of the speed of vessels and so forth, mingling thus with many of the transactions of ordinary life, the scale of which they exaggerate.

Lieutenant J. P. Roy, U. S. Army, assistant, was attached to this party, and his efficiency is properly commended by Captain Palmer, who acknowledges also the services of Mr. P. C. F. West, temporarily attached to the party as aid.

The party had the use of the schooner Bancroft for transportation.

Having secured and marked the numerous station points used in the season, Captain Palmer returned to the office, and has deposited there the records of the work, original and duplicate, together with sketches and descriptions of the signals. Captain Palmer takes occasion to rectify an omission in his reconnaissance report of 1853, which, though he had almost immediately corrected in a letter, had escaped my attention until it was recalled by A. G. Grinnon, Esq., of Madison C. H., Virginia. The fact as it should stand is, that on the Rappahannock rock occurs, (a secondary sandstone overlying the granite at Falmouth,) and extends several miles down the river to the clays. This fact may be a very important one in reference to the improvement of the river.

Captain Palmer is at present engaged in charge of the Coast Survey office, during the temporary absence of Captain Benham, of the corps of engineers. I had intended to assign to him the execution of a large triangulation as a mark of my appreciation of his merit and capacity, as shown on the Rappahannock, but the duty in which he is now engaged claimed precedence of the other. While in Philadelphia, engaged in completing his work of the autumn, Captain Palmer completed, in March last, the work of connecting the old High School Observatory with the new one, and with the general triangulation of the survey, which had been commenced by Captain Cram, U. S. Topographical Engineers, just before he was relieved from the Coast Survey.

The triangulation of the James river, Virginia, below City Point, in charge of Assistant John Farley, was in progress at the date of my last annual report, and has been prosecuted in the usual manner, the work being suspended during winter only in consequence of the frequent impediments from ice and bad weather, and after midsummer and in the early part of the autumn by reason of the unfavorable nature of the season for field duty.

Beginning on the 15th of October at City Point, the junction of the triangulation of the Appomattox river from Petersburg, and that of the James river from Richmond, the work of the main stream was advanced as far west as Westover west base by the 25th of December.

The intervening time, previous to resuming the triangulation in the middle of April, was employed by Assistant Farley in revising the computations of his work of last season, including those requisite for the comparison of the two bases at Richmond and Petersburg, the results of which show a very close agreement between their measured and computed lengths.

Field operations were continued until the 3d of July, at which time the work had reached a station twenty-two miles below City Point. (Sketch C.) Twenty-two stations were occupied in a series of twenty-six triangles, all the angles of which were measured by two thousand two hundred and twenty-two observations with the six-inch Brunner theodolite, No. 66. The area comprised in the triangulation below City Point is about twenty-three square miles.

The difficulties presented by the sinuous character of the James river have been successfully met by the experience and resources of Assistant Farley; and, under favorable circumstances, it is probable that the triangulation may be extended, during the present autumn, or certainly in the early part of the spring and summer, to the mouth of the river, so as to form a connection with the main work on Chesapeake bay. In this duty he is now engaged, having been employed during the summer in the computations of his work of the present season.

One of the essential conditions of a successful tertiary, or of a secondary triangulation with small sides, is that the signal-poles shall be straight, of proper shape, and truly vertical—the neglect of which frequently involves much expense and labor. A very neat arrangement for a secondary signal, stand, and pole, has been made by Assistant Farley, and his description and drawing are given in the Appendix No. 58, and on Plate No. 52.

Topography.—Assistant H. L. Whiting was engaged, at the date of my last annual report, in the revision and verification of topography at Bodkin Point, and on the north and south shore of the mouth of Sassafras river, Chesapeake bay, (Sketch C.) This duty was completed on the 18th of December. Succeeding operations of a similar character will be referred to under Section VI. On his return from Florida, at the close of April, Assistant Whiting resumed and continued the work of verification on South river, and at the mouth of Magothy river, Chesapeake bay, (Sketch C,) until the beginning of June, and was subsequently engaged in topographical surveys in Massachusetts and New Hampshire, as mentioned under Section I. His topographical sheet of Sassafras River entrance, Maryland, ($\frac{1}{20000}$,) has been received at the office.

The topography of the western shore of Chesapeake bay, from Back river northward, and including part of York river, has been executed by the party of Assistant John Seib. This work is embraced in plane-table sheets No. 62 and No. 63, which are now complete.—(Sketch C.)

The survey of the present year includes Bennet's creek, Pocosin river, Cheesman's creek, Back creek, part of York river, and several small creeks and water-courses, (Sketch C.) On the southern shore of York river, the topography has been carried from the main shore of Chesapeake bay to within three and a half miles of Yorktown.

Assistant Seib commenced work on the 22d of June, (after his return from Section V,) and closed operations on the 4th of August. The Coast Survey schooner Wave was in the service of his party.

The completed topographical sheets present the following statistics for the present season:

Shore-line surveyed	58	miles.
Roads surveyed	23½	"
Area surveyed	21½	"

The country over which these sheets extend is thus described by Mr. Seib:

"The land is low and almost level; it rises a little, and gradually as it recedes from the shore of the Chesapeake bay. Along the latter are extensive marshes, and in and beyond them patches of pine woods, with a few small farms. Along the rivers, creeks, and roads, it is thickly settled, and between them are large bodies of woods, mostly of pine; at some distance from the bay there are fine oaks, gum, chestnut, &c."

This party resumed the topography of the Rappahannock river, and continued it until the progress of the season rendered it advisable to return to Section V.

Between the 10th and 26th of October he was engaged in the revision of shore-line of the Rappahannock river, furnished by the hydrographic party, and joining his own previous work, and from that time until the 16th of November pursued the regular topographical survey of the shores of that river below Accaceek Point, (Sketch C,) carrying the work as far as stations "*Punch Bowl — Downman.*" The length of river course included in his two sheets is twelve miles and a half. One of the sheets has been completed, and the other is very nearly so. Together they include about thirty-three miles of shore-line.

The devotion of this able topographer to his work is shown by his constant presence in the field, changing the locality and section to suit the season for working.

The topography of the sea-coast of Virginia from Watson station, on Metomkin bay, to a point opposite to the east end of Wallop's island and mouth of Chincoteague inlet, was executed between the middle of July and the 26th of August by the party of Assistant George D. Wise, subsequent to his return from duty in Section VII. The details furnished by the survey of the present season complete the sheet of that vicinity commenced by Sub-Assistant W. M. Johnson, (Sketch C.) These include thirteen miles of shore-line and thirty-one miles of road within an area of fifteen square miles.

Sub-Assistant Spencer C. McCorkle was engaged during the progress of this work in the party of Assistant Wise.

The topographical sheet extending from Gargathy station to Wachapreague inlet was received at the office in December, and Assistant Wise reports the probable completion of another before his return to duty in Section VII, for which he is now under instructions.

Hydrography.—Lieut. Comg. Richard Wainwright, U. S. Navy, assistant in the Coast Survey, in command of the surveying schooner Nautilus, has continued the finished hydrography of Rappahannock river from Green's bay, the limit of the previous season, to a point five miles below Tappahannock, the termination of the triangulation of last year, (Sketch C.) The extent of river course embraced in the soundings of the present season is about thirty-six miles.

This work, as heretofore mentioned, was undertaken and is prosecuted at the request of the Engineer Department.

Lieut. Comg. Wainwright makes special mention of the services of Mr. A. Strausz, attached to his party as draughtsman, in the prompt and accurate determination of the shore-line requisite in the hydrographic work.

The details of the season are as follows:

Miles of sounding run	298
Casts of the lead	32,569
Angles observed (in hydrography)	2,096
Stations occupied with theodolite	50
Miles of shore-line surveyed	65

Six tidal stations were occupied below Leedstown in April and May, at which over three thousand observations were recorded.

At the end of March Lieut. Comg. Wainwright turned into the office his hydrographic sheets Nos. 4, 5, 6, ($\frac{1}{5000}$) and sheets Nos. 7, 8, ($\frac{1}{10000}$) of Rappahannock river.

During the summer and autumn he was engaged in the hydrography of the Hudson river and the dependencies of New York bay, as noticed under Section II, and will shortly resume work on the Rappahannock. Some particulars of interest in regard to the *bars* of that river are contained in a list given by Lieut. Comg. Wainwright. (Appendix No. 14.)

The hydrography of the James river, Virginia, from Deep Water Point light-house to a point opposite to Jamestown island, has been executed by the party of Lieut. Comg. J. N. Maffitt, U. S. Navy, assistant in the Coast Survey, (Sketch C.) This work was prosecuted with great energy after the return of the hydrographic party from the Atlantic coast, south of Charleston, the necessary preliminary triangulation of the river being executed personally by Lieutenant Maffitt. The shore-line was also determined by the party throughout an extent of twenty-eight miles, embraced in the hydrography. The number of angles observed was eighteen hundred, and the number determined two hundred and seventy-seven. Work was discontinued at the end of August in consequence of sickness on board the schooner Crawford, employed in the operations.

The statistics of this survey are—

Number of miles run in sounding	1,081.5
Whole number of soundings	39,464

Observations were made at two tidal and at five current stations within the limits before mentioned. The chart of James river on scale $\frac{1}{20000}$, in two parts, has been drawn and sent to the office by Lieut. Comg. Maffitt.

The hydrography of the outer coast of this section, and of the Chesapeake bay proper, was completed last year by the party of Lieut. Comg. Almy, whose work in continuation lies in Section IV, where the details will be found. At the opening of the present season, he revised and verified the soundings upon important sheets of work executed in the lower part of the bay, and prepared sailing directions, lists of dangers, &c., for the charts of this part of the bay and of its entrance.

The boiler of the steamer Hetzel, assigned to this party, exploded on the 24th of August, causing the death of several of the party, and seriously injuring the vessel. The steamer was employed, at the time, to furnish transportation to Captain Gibson, U. S. Army, assistant in the Coast Survey, who was to take the views required of the chart for the sea-coast of Maryland and Virginia north of the Chesapeake entrance. She was at Sand Shoal inlet, under what was supposed to be easy steam, when the port boiler burst. Third Assistant Engineer Samuel C. Latimer, U. S. Navy, William Bulger, first-class fireman, and Bernard Moran, seaman, were killed on the spot; and William Gardner, first-class fireman, John T. Knight, second-class fireman, and Michael Scanlan, ordinary seaman, were fatally injured, so that they died in spite of the care and attention of Assistant Surgeon Williamson, U. S. Navy, who was in attendance upon them. Benjamin Van Horn, second-class fireman, David E. Marshall, quartermaster, and Coleman Welsh, ordinary seaman, were seriously injured. The report of this melancholy disaster, as given by Lieut. Comg. Almy, is in the Appendix No. 66.

The vessel took fire and was thought to be sinking; but the fire was checked, the leak stopped, and she was finally towed to Hampton roads, and thence to Baltimore. An inquiry into the cause of the explosion has been made, and a report is soon expected of the extent of injury to the vessel and machinery, and the cost of repairs, should it be deemed expedient to put her again in commission. The Hetzel is a serviceable vessel, being of light draught; and though her power is but moderate, it has been adequate to the work in and near Chesapeake bay, in which she has been employed. In order to enable Lieut. Comg. Almy to execute the hydrography of Pocomoke sound, Chesapeake bay, which formed a part of his instructions for the season, the party was transferred to the Coast Survey schooner Varina, which had just returned from the Florida coast, under command of Lieut. Comg. O. H. Berryman. This officer promptly made the arrangements necessary to give to Lieut. Comg. Almy the use of the Varina, occupying himself the wreck of the Hetzel as an office to bring up his work.

The work in Pocomoke sound was completed by Lieut. Comg. Almy, notwithstanding the disadvantages arising from the necessity of transferring his party to another vessel, and the unusually boisterous character of the latter part of the season. The limits of the work on the westward extend to a line passing southward from Fog island to Watt's island, and thence to Scott's Hall, on the Virginia shore of Chesapeake bay, (Sketch C.) "The configuration of the bottom of this sound is such, having a river channel with several creek branches and flats, that the lines of soundings required to be run closely. In executing this part of the season's work, 407 nautical miles were run in sounding, and the whole number of soundings made was 16,330. Nine hundred and twenty-one angles were taken by the theodolite, and eight hundred and two by sextants, for hydrographic positions. Nineteen high tides, and twenty-one low tides, were observed. The whole number of tidal observations recorded was seven hundred and three."

The hydrography of Tangier sound, included in the instructions for the present year, was unavoidably postponed in consequence of delay arising from the disaster to the steamer Hetzel, already referred to.

Lieut. Comg. Almy has turned into the office during the past year the following charts:

Mobjack bay to Cape Henry, Virginia	$\frac{1}{40000}$
Hampton Roads and part of Elizabeth river to Fort Norfolk	$\frac{1}{20000}$
Norfolk harbor, Virginia	$\frac{1}{10000}$
Lynn Haven Roads, Virginia	....

As referred to in previous reports, the continued operations of this party in the vicinity of numerous shoals and dangers has afforded occasion to render important incidental services to vessels navigating the lower part of Chesapeake bay. Three instances of this kind have occurred within the present season. The schooners *Jane Brindle* and *David Cox* having grounded on Hampton bar, and the schooner *Arno* on Willoughby's bank, were worked off by parties of officers and men from the *Hetzel*. The Arno had hoisted signals of distress, and was relieved with considerable difficulty and some delay. Lieut. Comg. Almy remarks in reference to these and other cases:

"It is often in my power, and I deem it my duty, to go to the relief of vessels in danger when I can do so consistently with the discharge of other duties devolved upon me."

A report from Lieut. Comg. Almy relating to a light-house on "York Spit," Chesapeake bay, will be found in the Appendix No. 71.

Tides.—The usual tide observations, with the Saxton self-registering gauge, have been made at Old Point Comfort. These are returned monthly to the office, read off there from the autographic sheets, and reduced by the tidal party under charge of L. F. Pourtales, Esq.

Observations for river tides have been made by the parties of Lieut. Comg. Wainwright in the Rappahannock river, and Lieut. Comg. Maffitt in the James river; *six* stations having been occupied by the former, and *two* by the latter party.

The attempts hitherto made to erect a gauge near Cape Henry, for comparison with that at Old Point Comfort, and for testing the correctness of the reduction by depth from one point to the other, have not been successful.

The tides of the Chesapeake, which present very interesting problems, will be investigated.

Views.—Captain A. A. Gibson, U. S. A., was instructed to join Lieut. Comg. Almy in August, and to go with him to such points as were suitable for taking the views required for the charts of the ocean shores of this section, and had in fact accomplished this duty, having taken the sketches, when the steamer Hetzel, which had conveyed him to the localities, was disabled by the bursting of one of her boilers, as already narrated. The letter of Captain Gibson, announcing this disaster, and written at the request of Lieut. Comg. Almy, is given in the Appendix No. 66.

GULF STREAM.

My instructions of last year had provided for quite a considerable amount of incidental work to be done in the Gulf Stream by our hydrographic vessels in passing south and north, to and from the southern sections; but storms and other circumstances prevented their execution. The information which has now been collected, and which has resulted in the chart of the Gulf Stream already published, should serve as the basis for new inquiries. The tracing of the range of hills beyond the axis of the Gulf Stream by Lieut. Comg. Sands, in the steamer Walker, is an example of the successful application of this knowledge to work out a result, and the zeal shown by him in the prosecution of the work, seconded by his skill in selecting his positions, has been amply rewarded by the most interesting results.

Direct observations in the continuation of the plan of making sections across the stream have also been made by Lieut. Comg. Craven, near Cape Florida, and by Lieut. Comg. Sands, southeast from Nantucket.

1. In passing from the Gulf of Mexico northward, Lieut. Comg. Sands, U. S. N., assistant in the Coast Survey, ran a line of deep-sea soundings, and for temperatures through the Florida channel, and as far north as Hatteras, (Sketch No. 17.)

In a general way, the results may be stated as follows, though, when we come to analyze them, it will be found that the general statement requires some limitations, that, *following nearly the course of the Gulf Stream* (see Sketch No. 15, Coast Survey Report, 1853, or No. 24, Coast Survey Report, 1854) *from a point southward of the Pine islands*, (Florida keys,) in latitude 24° 23′ N. and longitude 81° 23′ W., *he kept soundings until off Cape Lookout*, in latitude 33° 57′ N. and longitude 75° 36′ W. No measured depth exceeded five hundred and seventy fathoms, which probably corresponds to about four hundred fathoms of actual depth. The nearest approach to the land off the Florida peninsula was about twenty-two miles, south of Jupiter inlet; and the distance off Cape Lookout was about sixty miles (nautical.)

If we trace the stations as they follow each other by the Gulf Stream chart of 1854, we shall find, beginning off Cape Canaveral, (Position 8,) that Lieut. Comg. Sands was on the outer edge of the axis band of the Gulf Stream, where he found the depth four hundred and ten fathoms, the position corresponding with the range of hills discovered by Lieuts. Craven and Maffitt; that Positions 9 and 10 followed the same edge, (giving the same depth, four hundred and ten fathoms,) and 11 inclined more to the westward, or towards the axis of the stream, (giving five hundred and fifteen fathoms for the depth.) The Positions 12, 13, 14, and 15 are nearly in the axis of the Gulf Stream, the depths measured being five hundred and thirty, five hundred and ten, no bottom at four hundred and forty, and five hundred and sixty fathoms. Position 15 is just north of the St. Simon's section, and corresponds nearly with one of Lieut. Comg. Craven's positions of 1854. Lieut. Craven determined the depth, with the Massey log, to be four hundred fathoms; Lieut. Comg. Sands, with the ordinary line, five hundred and sixty fathoms, giving about the same proportion which Lieut. Comg. Craven had previously found, under corresponding circumstances of depth and current, for the two methods. Position 16 is off the axis of the stream, and to the east of it; the depth is five hundred and seventy fathoms. This is on the Charleston section, as run by Lieut. Comg. Maffitt, in 1853, and falls near two of his stations, at one of which the depth was determined by the sounding-line, as between three hundred and four hundred fathoms, and the other, where no bottom was found, at six hundred fathoms. This position is not far enough east for the top of the hill-range struck by Lieut. Comg. Maffitt. Position 17 is nearly on Lieut. Comg. Craven's Charleston section of 1853, and lies near one position at which he found bottom at four hundred and eighty fathoms, and another no bottom at five hundred fathoms. Lieut. Comg. Sands found no bottom at five hundred and seventy fathoms, the line parting. Position 18 is near the inner or western edge of the hottest or axis band of the stream. The depth found was five hundred fathoms, falling on the Cape Fear section, between two stations of Lieut. Comg. Maffitt, at one of which the depth was seventy fathoms, and at the other no bottom was found in six hundred fathoms. Between 16 and 18 the axis of the Gulf Stream had been crossed, 19 is on the edge of the cold-wall band, 20 is in that band, and 21 in the cold water near the shore. The depths measured were respectively four hundred, four hundred and thirty, (uncertain,) and twenty-three fathoms.

To resume, the Gulf Stream chart indicates that soundings were struck on the outer edge of the hottest band of the Gulf Stream; that they were carried along that edge, inclining to the westward or towards the axis; then nearly along the axis, inclining from it; then crossing it to the westward into the cold-wall band, and crossing this to the cold water near the shore. This supposes the chart to represent correctly the course and division of the Gulf Stream, requiring that these phenomena should be the same as in former years, and that the chart should correctly represent the former observations.

The soundings for temperature having been taken at different depths, we are enabled, from former deductions, to know to what parts of the stream the curves representing the changes of temperature with depth apply. From these comparisons, independently, I would infer that Position 8 was outside of the axis; 9 and 10 outside, but near it; 12 outside, and 13 inside; 15 and 16 on it; 18, 19, and 20 inside of it, near the cold wall, 19 being nearer than the other to the middle of that band. The deepest temperatures not being numerous, and being sometimes quite discrepant, makes this comparison less valuable that it would otherwise be. The difficulty referred to, arises from the liability of jarring the lower thermometer when the lead strikes the bottom; in which case the indication of the instrument is sometimes affected, even when, as will sometimes happen, the thermometer itself does not also strike. I have omitted the positions when there were not deep-sea temperatures to check those nearer the surface. These deductions would require no change in the axis, as represented on the diagram of 1854, between Canaveral and Charleston. Either of the diagrams represents the case within the probable limits of error of position and observation.

The question of the limit of this range of hills still remains undetermined from these observations, for the line broke at Position 17, which is the last limit heretofore established of the range; and the next position is so much inshore, as to make it doubtful whether it is not on the inner slope towards the land.

The surface temperatures, and those at fifteen fathoms, agree with the deductions which have just been made. That these were in part affected by the temperature of the air is obvious; but that the greater part of their change is not due to this, but to different positions with respect to the axis, is all plain from examination.

The surface temperatures taken in the hot band were from 83° to 81½° Fahrenheit; those at fifteen fathoms, from 82° to 78½°. The lowest temperature, twenty fathoms from the bottom, observed beneath the warm band, was at Position 6, off Cape Florida; at five hundred fathoms, 49° Fahrenheit. From this point the temperatures increased in passing northward, to 60°, 59°, and 54°, at the depths of five hundred and ten, five hundred and forty, and five hundred and fifty fathoms, in Positions 12, 15, and 16, from the latitude of St. Augustine to that of Tybee.

The surface temperatures of those observations taken in June, 1855, are some two degrees higher than in corresponding localities in the same month of 1853.

2. A very interesting section of the Gulf Stream was made by Lieut. Comg. T. A. Craven, U. S. Navy, assistant in the Coast Survey, across from Cape Florida light, eastward, to Bemini, (Sketch No. 17,) carrying soundings with a depth not exceeding three hundred and seventy fathoms the whole way across. The section was run in the month of April. The highest surface temperature was 80° Fahrenheit, and the lowest temperature observed, corresponding to the greatest depth, 34° Fahrenheit, or within two degrees of the freezing-point of fresh water.

The curves of temperature with depth in this comparatively shallow pass, present quite a new feature, or rather an exaggeration of the former curve, representing a movement and not an equilibrium of temperature.

The following statistics of his Gulf Stream work are reported by Lieut. Comg. Craven:

Positions made	12	
Greatest depth on section	370	fathoms.
Lowest temperature observed	34°	Fahrenheit.
Surface temperature	80°	"
Aggregate fathoms of line used	8,337	

The section of the Gulf Stream off Nantucket is a peculiarly difficult one, and has been attempted several times without success. Is length is such (see chart in report of 1854) that bad weather, or accident to the vessel or instruments, is very liable to occur before the section is crossed. It was attempted last year by Lieut. Comg. Craven, and this year by Lieut. Comg. Sands, who, in October, reached some forty miles east of the position of Lieut. Comg. Craven, marked on the chart of 1854. I have still the hope that a second attempt by this officer may be more successful than the first, in which the stormy weather, and expenditure of fuel carried, prevented progress across the stream.

Professor Bailey, of the Military Academy, West Point, has devoted such time as he could spare from the arduous labors of his professorship, to the examination of the organisms to be found in the soundings along the coast. An interesting communication from him relative to a cursory examination made of specimens from the Florida section will be found in Appendix No. 55.

SECTION IV.—FROM CAPE HENRY TO CAPE FEAR, INCLUDING PART OF VIRGINIA AND NORTH CAROLINA. (SKETCH D.)

This section is one which has in past years made comparatively considerable progress, and which, therefore, had not needed pressing. The peculiarities of the survey in it are many, but well understood, and will gradually be provided for. The small ocean-shore triangulation now extends from within eleven miles of Cape Henry, where it will join the Chesapeake work, to within forty miles of New inlet, where it will meet that of the Cape Fear. It serves as a reconnaissance for the main work, determining, from the minute knowledge acquired in the course of its execution, and of that of the hydrography which follows it, the character and circumstances of the larger triangulation. Meanwhile it furnishes hydrographic points and shore-line, which have been used for the survey of the shoals, inlets, and harbors, of this most dangerous portion of our coast, which have in turn been taken up, and, with a few exceptions, disposed of for the present. The Wimble shoals, Hatteras shoals, the Frying Pan and Cape Fear shoals, have been surveyed; Hatteras and Ocracoke inlets, Hatteras cove, Beaufort and Cape Fear harbors, have been thoroughly surveyed, and their changes carefully watched. The whole of Albemarle sound has been covered by a primary and secondary triangulation, and its topography and hydrography have been executed. The sounds from Pamplico southward have been covered by triangulation and topography, including Core sound, Beaufort harbor, Bogue sound, and others south of it, to below New river. A reconnaissance of Pamplico sound and its tributary rivers has been made, by which we know exactly the nature of the work necessary there, and as soon as a main triangulation party is disposable it will be ordered; the expense of the small work ceasing in one to two years more. Great care has been taken to preserve all the station points not absolutely in movable sands, and to provide means for the recovery of those which may be lost from causes only controllable at too great expense. The steady prosecution of the plan of work in this section is all that is necessary to bring its results out even earlier than that of the other sections, as it was begun early, and more than half of it presents but moderate difficulties of execution. The steam-vessel which has heretofore been devoted to Section III is available for this section, and should be repaired for the purpose, or another be furnished in her place, so that the regular coast hydrography may keep onward. This year it has advanced from Cape Henry to the North Carolina line, a distance of thirty-six miles, in part of a season. The explosion which crippled the Hetzel towards the close of the season is noticed under the head of Section III. It may be proper to remark here, that when the land-work of a coast like this is once completed, the hydrography may be repeated at intervals at a very slight expense. The points becoming known when the sands shift, re-surveys are not only useful in determining the actual condition of things, but in furnishing data to the engineer for tracing effects to causes, and thus for engineering knowledge necessary to enable him to control and modify the forces of nature. I have already pointed out, in previous reports, that this coast is in a dangerous condition of destruction by the ocean; the sands which protect Albemarle and Pamplico sounds from the invasion of the ocean, being carried away year by year and deposited on the shoals.

The small triangulation at the northern end of this section will require one, and perhaps two, seasons to reach Cape Henry, and that at the south end one and a part of another to reach the Cape Fear. The work will then be continuous along the whole ocean-shore of the section. Meanwhile, the other operations necessary to complete the land-work will be in progress, and the regular outside hydrography will be advancing. I expect, also, that the appropriation may permit work in Pamplico sound, and the rivers emptying into it. Preparations have been made to avail ourselves of the new telegraph line between Wilmington, N. C., and Charleston, S. C., to connect those two points for difference of longitude directly, which have heretofore been connected through Raleigh, thus checking the former work between Washington and Columbia. De Rosset station, at Wilmington, and the State-House station at Columbia, which have been kept standing, will afford ready means for this purpose.

The following charts relating to this section have been published:

Pasquotank river $\frac{1}{60000}$, 1850; Beaufort harbor $\frac{1}{20000}$, 1851; Frying-Pan shoals $\frac{1}{120000}$, 1851; New river and bar $\frac{1}{15000}$, 1852; Ocracoke inlet $\frac{1}{40000}$, 1853; and Beaufort harbor, preliminary chart, 1854.

The following have been prepared during the year, or are in progress, in the drawing and engraving division:

Preliminary chart of Albemarle sound ; map of Cape Fear river, upper and lower sheets; and Beaufort harbor, on steel, as a finished chart.

Triangulation.—The triangulation joining the Chesapeake and Currituck sound has baffled all calculations as to the time of its execution, partly from the difficulties of the work, and partly from the loss of station-points and the necessity for remeasuring angles, and other causes. It is not certain that even another season may not be required to complete it. In the mean time, points have been determined approximately on the ocean shore for the use of the hydrographic party. Assistant J. J. S. Hassler, under whose charge this work has been, reports for the last season's work ten stations determined and five re-determined, eighteen hydrographic signals placed, two thousand and sixteen observations made, and an extent of ocean coast of fourteen miles, bordering the area of twenty-eight miles included. The part of the sound in which they were at work being too shoal to use the schooner Vanderbilt for transportation, the party suffered a good deal from exposure to the inclemency of the winter in open boats and flats. The northern limit of the work is at Bonny Signal, (see Sketch D,) about eleven miles only south of Cape Henry.

On completing the inking of his topographical work in Section I, Assistant A. S. Wadsworth resumed the triangulation of the outer coast of North Carolina, between Bogue sound and Stump sound, (see Sketch D,) commencing at the line Pickett — Plum-Orchard in the former sound, and reaching the line Skeleton — Macawber in the latter, about three miles south of New river, at the close of the season, extending twenty-five miles along the coast, and covering thirty square miles. Forty-five stations were occupied, forty-nine points observed upon, and one hundred and forty angles measured, by 5,022 observations with a six-inch Gambey theodolite, (C. S. No. 27.)

The points along the beach of this triangulation are all available for the hydrography, and are quite numerous.

Mr. Wadsworth reports, that should it be necessary to resort to a small main triangulation in this region, there will be no difficulty in measuring short bases at any desirable points ; that along the beach there will be no cutting required ; that signals may be placed where most convenient for the work ; and that the wood, within such limits as the triangulation would be likely to cover, is of little value.

The winter season is reported by the parties on this part of the coast to have been unusually severe ; and this, together with the difficulties of transportation, retarded the work.

Mr. H. S. Duval served as aid in this party, assisting in part in measuring the angles.

Assistant Wadsworth, after his return, was on duty in my party in Section I, and subsequently engaged in topographical work for the Commissioners on New York harbor, as mentioned under Section II.

The topography, which has usually been combined with the triangulation by Mr. Wadsworth, was omitted this year and the last, with a view earlier to close upon the Cape Fear triangulation. It will be resumed by a second party in the coming season.

The work of Assistant Bolles, south of the Cape Fear, belongs properly to Section V, in which it will be found detailed.

Hydrography.—The regular hydrography of the section has been executed by the party of Lieut. Comg. J. J. Almy. U. S. N., assistant in the Coast Survey, in the steamer Hetzel. The Sketch D shows the limits of the work, which are Cape Henry on the north, and the boundary between the States of Virginia and North Carolina (in latitude 36° 31′ N.) on the south—"a sea-coast extent of twenty-six miles, and extending seaward from sixteen to twenty miles. This comprises an area of three hundred and fifty square miles.

"In executing this, six hundred and nineteen nautical miles have been run in sounding ; five thousand four hundred and ninety-one soundings have been taken in from three to thirteen fathoms water. The number of angles taken by theodolites for hydrographic positions is one thousand and forty-nine, and the number taken by sextants for the same purpose is seven hundred and seventy-five. The number of tides observed is twenty-six high tides and thirty-four low tides, and the number of tidal observations is five hundred and seventy."

By referring to Sketches C and D, it will be seen that the hydrography of the entire sea-coast of Virginia, about one hundred and five statute miles in extent in chord lines, is completed. This was commenced by Lieut. Comg. Almy in 1851, and has been carried forward with steady perseverance. During the same period he has done a very large share of hydrography in the Chesapeake bay, selecting, generally, for its execution those portions of the seasons unfit for outside work.

The work of this party in the Chesapeake and outside, in Section III, will be found mentioned under the head of that section.

On his way from the coast of South Carolina to the James river, Lieut. Comg. Maffitt examined the channels at the main entrance to the Cape Fear, and also New inlet, (see Sketch D.) It is known that the shifting sands of the Cape Fear and New inlet bars cause frequent variations in the depths, according to the prevalence of particular winds and their degree of violence, so that at different seasons of the year and in different years the channels change their comparative depths. When Lieut. Comg. Maffitt made his examination, in June, the main ship-channel had two feet and three-tenths less water in it than when surveyed by him in 1853, while the western channel had become the main entrance, having two feet more water in it than in October, 1853. New Inlet bar, in like manner, had shoaled nearly two feet.

The positions of the new channel beacons at Beaufort, N. C., were determined by the same party. Sketches of these different determinations have been furnished to the office.

In these detached works there were:

For the Cape Fear.

Number of soundings	2,188
Number of angles	137
Number of miles of soundings	67

For Beaufort.

Number of soundings	459
Number of angles	46
Number of miles of soundings	14

SECTION V.—FROM CAPE FEAR TO THE ST. MARY'S RIVER, INCLUDING THE COAST OF THE STATES OF SOUTH CAROLINA AND GEORGIA. (SKETCH E.)

Along the coast of this section we have made good advances since the survey was commenced in 1848, on a scale so small that at first it appeared to make almost no progress. We have gained, too, much experience, and know how to appreciate better both the difficulties and facilities. While the harbors and shoals have received our first attention, and have been examined without waiting for the regular progress of the work from end to end of the section, that regular progress has been kept steadily in view. While some of the easier portions of the work have been done, we have not avoided the difficult parts, but have plodded slowly through them, studying meanwhile how such work may be better and more rapidly done hereafter. As the appropriations have been increased, and the sections begun before this have not required so much, additional resources have been laid out upon this section. Many special surveys have also been made for the Engineer Department, which will ultimately be woven into the general survey of the coast. I will rapidly pass in review the work done. Charleston harbor and its approaches has been carefully surveyed, the bar sounded out twice, and Maffitt's channel three several times. These surveys were at once made the bases of the proposed improvement of the harbor by the city of Charleston and by the United States. A preliminary chart has been published, and the finished map is in progress of engraving. Several comparative sketches of Maffitt's channel have been published. Tybee entrance and approaches and the Savannah river have been surveyed above the city to the head of Argyle island. The maps of these surveys were used by the Commission on the improvement of the river. A preliminary sketch has been published, and the finished map is in progress. A base line has been measured on Edisto island, and the triangulation carried from it northward and eastward to Long island, S. C., and southward and westward to the Hunting islands. In connection with this, the topography has covered about two-thirds of the same space, and the hydrography of the ocean coast has been nearly completed between Charleston and North Edisto. Two harbors of refuge, Bull's bay on the north, and North Edisto on the south, have been surveyed, and charts of them published. The information thus obtained has also induced appropriations for lighting them, so as to enable vessels driven either to the eastward or westward of Charleston to find a refuge either by night or day. Port Royal entrance, and the shoal off it, known as Martin's Industry, have been examined, and a sketch of the reconnaissance, extending to Beaufort harbor, is in progress. The approaches to Tybee entrance—namely, Calibogue sound on the north, and the opposite shore of Savannah river to the south—have been triangulated, and the survey of Romerly marshes made complete in reference to a cut proposed through them. Winyah bay and Georgetown harbor have been surveyed, and the Roman shoals to the south of it. A general reconnaissance has been carried along the coast of the section, including a recent one from the Cape Fear to Charleston, and the triangulation and topography have made progress over the reconnaissance from the Cape Fear south to Lockwood's Folly. A hydrographic reconnaissance of Doboy inlet, and of Altamaha river to Darien, has been made. The triangulation of St. Simon's sound and Brunswick river is in progress. A hydrographic reconnaissance of St. Andrew's sound has been made. A triangulation of Cumberland sound is in progress, upon which a hydrographic reconnaissance has been based. These detached pieces of work embrace more than three-fourths of the most important points on the coast, and attention has been directed to them in their intrinsic order of importance, or that which circumstances gave to them. The preliminary bases upon which these surveys rest have been measured by rods duly compared at the Coast Survey office, and the work forms part of the general coast series, each fragment falling into its appropriate place in the whole survey. The tides have been investigated by numerous stations along this reach of coast, and the results have been worked up and published in tide-tables, and in the form of co-tidal lines on a chart. The magnetic elements have been determined at various points, including the stations of the primary triangulation and points in the harbors. The latitudes and azimuths necessary to constitute a geodetic work have been attended to, and the differences of longitude, for which the telegraph has afforded such admirable means, have been determined for the long reaches over which the lines extend. In this way Charleston and Savannah have been connected with Washington city, and thus with the central longitude station of the Coast Survey, and with each other.

During the past year the survey of this section has made even more than usual advance, in all its branches, as the detailed account of the operations under the several heads of longitude determination, primary and secondary triangulation, topography, hydrography, and tides, will fully show.

The hurricane of September, 1854, which raged so fearfully along the coast of South Carolina and Georgia, made, no doubt, many changes in it. The destructive action on Sullivan's island, Charleston harbor, led to the not unreasonable supposition that Maffitt's channel might also have been affected by it. In 1851 the Moultrie house stood about one hundred and twenty-seven yards from high-water mark, and in March, 1855, but thirty-six yards. Such a remarkable change attracted attention immediately after the storm, and I directed Lieut. Comg. Maffitt to make as early a re-examination of the channel as practicable. This was done in March, 1855, giving the gratifying evidence of an improvement on the bulk-head of the channel. (See Sketch No. 20.) In a recent letter (see Appendix No. 15) on the comparative map, showing the results of different surveys of this channel between 1851 and 1855, Lieut. Comg. Maffitt remarks:

"The chart of 1855 shows a general increase of depth upon the bulk-head, and a contraction of eighteen yards in the general width of the channel. Bowman's jettee has settled about one foot and fifty-six hundredths, the result of which has been to increase, by twenty-eight minutes, the duration of the flow of ebb-tide over the jettee, with an increased velocity of half a knot per hour directly through the channel. The benefit of this is, no doubt, made manifest by the general increase of water over the bulk-head. The high-water mark along the shore of Sullivan's island is now three hundred and twenty yards more to the northward than in 1852. The necessity for small jettees along this shore, for its general protection, is a subject for consideration."

"*Distance in direct line of channel-way, from twelve-feet curve to twelve-feet curve, or breadth of bulk-head.*

1850	2,660 yards.
1852	3,200 "
1854	1,100 "
1855	1,000 "

"*Length of shoals fringing the southern edge of Maffitt's or Sullivan's Island channel.*

	Yards long.	Yards wide.
1850	2,600	700
1852	5,700	260
1854	700	200, broken and scattered.
1855	680	200

"The general increase of depth on bulk-head, from 1852 to 1855, is four and a half feet.

"The above table gives striking evidence in favor of the adaptation of this channel for improvement. It will be observed that there is an improved condition of the channel, from chart to chart, and that the scrutiny of five years has, as yet, developed nothing but a flattering progression, encouraging the laudable enterprise."

A re-examination of the main ship-channel of Charleston harbor was made in March, in consequence of alleged changes. Upon this subject I give an extract from Lieut. Comg. Maffitt's report:

"A re-examination of the main ship-channel of Charleston bar gave evidence of some considerable change since the survey of 1851. The channel has made to the southward, since that time, some forty yards; and also, at the period of this last investigation, (March 8th and 9th, 1855,) had deepened in the *general channel-way* about .95, or nearly one foot.

"I question the continued improvement or present permanency of this bettered condition of the main ship-channel. Its position, in reference to the dredging influence of the tidal-currents, of ebb and flood, is such as to insure a certain normal depth, influenced, at times, by heavy gales—some deepening it, and others having the reverse influence. The Coast Survey chart probably presents the normal depth that will, as a rule, be found in this channel at mean low water, as the original soundings of 1849 do not differ materially from those of 1850 and 1851."

At the time of this survey the buoys were found to be placed in the best water.

The survey of Romerly marshes, for the Savannah Chamber of Commerce, was made upon an unusually large scale, that it might afford data for their discussions in regard to the possibility of improving the intricate interior navigation now passing through them. A copy of the survey has been furnished to the president of the Chamber.

The drawings of the following maps, charts, and sketches have been in progress, or have been completed within the year: Winyah bay and Georgetown harbor; Winyah bay and Roman shoals; comparative chart of Maffitt's channel, 1852 to 1854; Charleston harbor, and Savannah river; and these have likewise been engraved, with the exception of the first and last. The chart of Winyah bay and Georgetown harbor is now in progress in the engraving division.

Longitude determinations.—Another link in the chain of longitudes between Washington and New Orleans, as determined by telegraph, has been completed this season, by connecting Columbia, South Carolina, with Macon, Georgia. To make the determinations at these points complete, the latitudes and magnetic elements have at the same time been observed.

Near the close of December, Dr. Gould took charge of the Columbia station, and the station at Macon was assigned to Assistant G. W. Dean. On the 1st of January the instruments were in position, and the observations for latitude at Macon were commenced. The usual delays from accidents to the telegraph lines, and other causes over which the observers had no control, formed no exception to former experience in this branch of the Coast Survey operations; and, before the observations were fairly commenced, the services of Dr. Gould were required in another section, and the charge of the Columbia station was transferred to Sub-Assistant Edward Goodfellow.

Between the 16th of January and the 10th of March, one hundred and twenty-seven star signals were successfully exchanged, on seven different nights; the observers exchanging places after three successful nights' observations, for the purpose of eliminating the effect of personal equation.

At the Columbia station, four hundred and two observations were made upon eighty-seven stars, with transit No. 8, C. S., for determining the clock error, azimuth, and collimation corrections to the transit instrument. Fifty-five observations were made upon eleven well determined circumpolar stars for thread intervals. The inequalities of the transit pivots were determined with the riding-level, attached to the instrument by the usual method.

At Macon, three hundred and thirty observations were made upon seventy-one stars, with transit No. 6, C. S., for the determination of the clock and instrumental corrections. Thirty-five observations were made upon ten circumpolar stars, at upper and lower culmination, for thread intervals, and the inequalities of the pivots of the transit were determined by the method adopted at Columbia. Observations were also made for determining the personal equation between Mr. Dean and Mr. Goodfellow.

The latitude of the station was determined by Assistant G. W. Dean, from one hundred and sixty-three observations upon thirty-four pairs of stars, with zenith telescope No. 5, C. S. The value of the micrometer was obtained from two hundred and eighteen observations upon Polaris near its western elongation, and the necessary observations for the value of the level divisions were also made.

The magnetic determinations were made near the southeastern part of the Academy square. They consisted of one hundred and sixty-five observations for variation on four different days, with declinometer No. 22, Jones, (C. S. No. 1,) two sets for horizontal intensity and moment of inertia on two days, and three sets for dip with the ten-inch Barrow dip-circle (C. S. No. 4) on three days.

A meridian line was established and permanently marked in the Academy square at Macon, by Mr. Dean.

The ready co-operation of the officers connected with the telegraph lines, and particularly Messrs. Butler and Heiss, superintendents of the lines over which the experiments were made the past season, are appropriately acknowledged in the reports of the officers who had charge of the respective stations.

The report of Dr. Gould, which contains many important details in regard to the telegraphic method of longitudes, is given in the Appendix No. 46.

Triangulation.—The party of Assistant C. O. Boutelle has been engaged during the season in the triangulation of the Stono river, which, when completed, makes a continuous system of secondary work extending from St. Helena sound to Long island, east of Charleston, S. C.

He has also restored the hydrographic signals on the ocean shore, destroyed by storms and the encroachments of the sea, between Charleston and North Edisto river, and executed miscellaneous work connected with the primary triangulation. The following are the statistics of the work done:

Number of stations occupied	13
" angles measured	63
" objects observed upon	70
" observations made	542

The angles were measured with the ten-inch Gambey repeating theodolite, C. S. No. 43.

Mr. Boutelle was assisted during part of the season by Assistant Fairfield and Sub-Assistant Huger, and by Mr. J. A. Sullivan, aid. The party had the use of the schooner Guthrie for transportation.

Upon the secondary triangulation Mr. Boutelle remarks:

"This work unites with the secondary triangulation of Wadmelaw sound, (Sketch E,) upon the line Bailey (2) to Chrisholm (2,) and completes a chain of secondary triangles extending from St. Helena sound to the northeast end of Long island, S. C. You will see, by the sketch, that the chain is a double one from Edisto to Charleston. Separating at Rockville church, one chain of triangles proceeds along the sea-shore by the way of Bohicket creek, Kiawah and Folly Island rivers, to Charleston harbor, where it unites with that work upon the line Charleston light to Circular church. The other chain proceeds up North Edisto river and Wadmelaw sound to Church flats, thence down the Stono and across James island to Charleston harbor, uniting upon the same line as the first set. In crossing James island, the station 'Royal' was made in the primary line Elliott's cut to Charleston light. Two secondary triangles are formed with this station upon Circular church, Elliott's cut to Royal, and Royal to Charleston light, the sum of the two secondary sides; Elliott's cut to Royal, and Royal to Charleston light, being equal to the primary side. They stand this test very well."

"In these two series of triangles, there are fifty-nine points, of which fifty-eight have been occupied—several of them three times, and many of them twice. Twenty-one stations are upon houses, or buildings near houses; two are in church towers; one on Charleston light, and one on Fort Sumpter. Five are upon primary tripods forty-five feet above the ground. Forty-nine sides are through avenues. In connection with the secondary triangulation, sixty-two other points of third order have been determined for the use of the topographical and hydrographic parties. One of the most difficult tasks for the triangulation party in this section is to furnish points directly upon the sea-coast for the use of the hydrographic parties. A belt of sand-hills, varying in height from ten to thirty-five feet, intervenes between the interior marshes, along which the secondary triangulation is carried, and the sea-beach. These sand-hills are nearly everywhere covered with pine forest-trees from fifty to one hundred and twenty feet in height, while the ground between the trees is covered with a dense and tangled undergrowth, sorely impeding our progress in opening avenues. Thus far along the coast, we have succeeded in furnishing points by taking advantage of openings in the wood, putting flags on tall trees visible from the top of some house in the interior on which we have a station, and the line from which we cross from secondary stations like 'Townsend,' on Botany bay, or Big Sandy Point, near the mouth of the Stono, which are situated upon points commanding the coast in either direction, and making good intersections upon all shore-points seen from one interior station. But occasional cases will arise, as at Long island, near the upper end, where an avenue seems the only available resource. I think, however, that by careful reconnaissance and judgment in establishing secondary stations, points may be furnished along the entire sea-coast of South Carolina as fast as they are required by the hydrography."

"The use of *houses* as secondary stations has been eminently successful. From the statistics here given, you will see that at best many avenues are required. Had all our stations been upon the ground, we must either have multiplied enormously the number of avenues, or built high signals and observing tripods, or have made smaller, more numerous and less symmetrical triangles along the edges of the marsh. I have so often mentioned in my reports the considerate kindness with which we have been allowed thus to occupy nearly every house along our routes, that it is unnecessary to enlarge upon it here. The character of our work along the seacoast of South Carolina is such that we are necessarily thrown much upon the courtesy of the planters who occupy it for facilities in prosecuting our labor, and in many cases we cause them both trouble and inconvenience. These have not only been cheerfully borne, but in addition thereto, an amount of personal kindness and consideration, combined with interest and aid to our work, has been everywhere manifested far beyond our expectations or deserts."

An important suggestion in regard to the employment of night-signals, under the circumstances of the southern sections of the survey, is made as follows: "I carried out last season four 'Fresnel signal-lanterns' to use at night; but the delays in beginning work, described in this report, prevented me from using them. I have great faith that they may be rendered useful, and that night observations through avenues will be found more accurate than those by day. If lateral refraction in avenues is increased by the heat of the sun upon one side of the avenue, while the other side is in shadow, we will be more likely to have uniform density during the night. The nights, too, are generally *calmer* than the day, and our tripods will be more steady. I was sorely pained at the necessity for leaving the question unsettled last season, and hope it will be fully tested next winter.

"The amount of light cut off by the avenues is very great. The side, east base, to Mathews' and Elliott's Cut, to New Cut, are each about twelve miles long. At no one of these stations have I ever seen the signal-pole at the other, and upon the last named side, where there is an avenue 4.8 miles long and thirty feet wide, I have never seen the outline of the large tripod and scaffold at each end, although both were freshly whitewashed, and could be seen at five miles distance with the naked eye when the country was open. But in the latter case, branches projecting across the line more than forty-five feet were not cut, and thus the avenue formed a kind of tube five miles in length, and with an average diameter of thirty feet—the eye at Elliot's Cut being 3.5 miles, and at New Cut 4.2 miles, from the nearest end of the tube."

The form of tripod used at the primary stations for elevating the instrument described in Assistant Boutelle's report of 1853, and a model of which is deposited in the Coast Survey office at Washington, appears to have been very successful, as will be seen by the following remarks extracted from Mr. Boutelle's report of the past season: "A long-continued series of observations at the Elliott's Cut tripod showed its usefulness, and the great storm of last September tested its steadiness. On examining it with the sectors in December last, the station-point marked upon the top of the tripod was found to be exactly over the mark in the ground beneath it."

On the tenth of March operations were closed in this section, the means provided having already been exhausted, and Assistant Boutelle, with Mr. Sullivan, proceeded to the St. John's, and thence in the schooner Graham to Key Biscayne, to prepare for the measurement of the base line there, (see Section VI.) Sub-Assistant Huger was attached to the party of Lieutenant Evans, engaged in the triangulation of the St. John's, and when this work closed, proceeded with the same party to Casco bay, (see Section I).

When Assistant Boutelle was instructed to resume work in this section, it was expected that he would replace Assistant Cutts, the period of whose detail for the western coast had expired, in the California section. His operations were directed accordingly, especially to the closing up of what he had undertaken. Since that time, Mr. Cutts has been detailed as surveyor to the commission on fisheries, and Mr. Boutelle will return to this field of labor, in which he has acquired so much experience.

The reconnaissance made two years ago by Major Henry Prince (Report of Superintendent Coast Survey, 1853, p. 55, Sketch E,) showed that a peculiar system of working must be adopted between the Cape Fear and Winyah bay. Accordingly, Assistant C. P. Bolles was instructed to make a small triangulation over the narrow sounds, and the small belt comparatively clear of wood, near the ocean, carrying forward the topography at the same time, and making a reconnaissance for a main triangulation. Mr. Bolles was assisted by Sub-Assistant G. H. Bagwell.

During the season he carried this combined work nearly to Lockwood's Folly, (Sketch E,) and has arrived at some quite satisfactory results as to the mode of progress with the main triangulation in this region. By this plan of working, the lines for the main work can be selected so as to secure the least possible cutting, and other advantages, and their directions being known with reference to the sides of the small triangles, they can be run with certainty, and therefore at a moderate expense, when compared with the plan of random lines.

A triangulation of Romerly marshes, south of Tybee entrance, was completed, and of St. Simon's sound and Turtle river in part, executed by Assistant A. W. Longfellow, in the months of March and April last. The Romerly marshes lie between Skiddoway island on the west, and Great Warsaw island on the east, (see Sketch E,) and are bounded on the north by Wilmington river and Warsaw sound, and on the south by Odingsell's creek. My attention had been directed to their survey by the Chamber of Commerce of Savannah, in reference especially to the channel through them used by the inland steamboats and coasting vessels. A local base was measured, and provision made for connecting it with the triangulation of the coast south of Tybee. Mr. Longfellow remarks: "Much delay and loss of time occurred here from the difficulty of seeing the points and signals, the ordinary obstacles to observing over the southern marshes being rendered almost insuperable by the smoke from the extensive fires which were raging in the interior of Georgia. Repeatedly, for eight or ten days in succession, objects within half a mile could not be identified. The mornings were usually foggy, and the smoke and haze so dense during the day, that the only tolerable seeing was had for a few moments before and after sunset. This annoying delay much curtailed my subsequent operations in Section V, as after getting up the signals I was unable to commence the measurements of angles till March 4, and concluded them March 23.

"In this interval seven (7) stations and twenty (20) topographical points were put up, five (5) stations were occupied, and seventy-three (73) angles were measured, by 1,483 repetitions, with the six-inch Brunner theodolite, No. 67, belonging to the Coast Survey."

These points having been furnished to the hydrographic party of Lieut. Comg. Maffitt, Assistant Longfellow took up the triangulation of St. Simon's sound and Brunswick harbor. (Sketch E.)

A base line was measured with the chain upon the sand beach at the south end of St. Simon's island, in front of the plantation of the Hon. T. Butler King. From this base the work was carried southwardly to Jekyl island, on the outer shore of which, as on St. Simon's, points were established for the use of the sounding party in surveying the bar. From Jekyl the triangles were carried to within a mile of Brunswick, and also started northwardly towards Frederica, Darien, and Doboy sound. Fourteen (14) stations were erected, and seven (7) occupied. Thirty-two (32) angles were measured by 1,496 repetitions.

Copies of the field-notes, and the computations of the work, have been made and forwarded to the office.

On closing this work, Mr. Longfellow returned to Section I, where he has been employed in the topography of Casco bay. (See Section I.)

A reconnaissance for the triangulation of Cumberland sound and the entrance to St. Mary's river, will be found included in the notice of Section VI.

Topography.—The topography of Edisto island has been continued by Assistant John Seib, and that south of the Cape Fear, in connection with the work of secondary triangulation, by Assistant Charles P. Bolles.

Assistant Seib commenced the topography near Edingsville, (see Sketch E,) on the ocean shore of Edisto, at the point where it had been left by Assistant George D. Wise, about the middle of January, and between that period and the 8th of May, had completed the shore-line and interior to the South Edisto river, and up the river nearly to Raccoon island, and on the northeast to the public road, joining Assistant Wise's work there. The shore-line surveyed was eleven miles and a quarter, ($11\frac{1}{4}$,) the area thirty-four (34) miles, the shore-line of creeks and water-courses navigable by small vessels seventy (70) miles. This is one of the most highly cultivated regions of the sea islands of South Carolina, and being intersected in every direction by water-courses, is difficult to survey. Mr. Seib acknowledges his obligations to the gentlemen on whose plantations he surveyed for their kindness in facilitating his work. On completing the inking of his maps, Assistant Seib resumed the topography of the Chesapeake above its entrance. (See Section III.)

The topographical work from Cape Fear entrance to Lockwood's Folly (Sketch E) has already been referred to under the head of the triangulation with which it was combined.

Hydrography.—The regular hydrography of this section has, as heretofore, been under the charge of Lieut. Comg. J. N. Maffitt, U. S. N., assistant in the Coast Survey, having this year the services of three sailing vessels, the schooners Crawford and Madison, and the tender Bouncer. This party commenced work with the resurvey of Maffitt's channel, in Charleston harbor, apprehensions in regard to its deterioration having been caused by the very great changes of shore-line of Sullivan's island beach, near the channel, made by the severe gale of September 11, 1854. Happily these fears were groundless, the depth of water on the bulk-head closing the channel having actually improved. (See Comparative Chart, Sketch No. 20.)

About the same time Lieutenant Simpson, in the Madison, commenced the outside hydrography from Charleston bar to North Edisto, (Sketch E,) completing the whole within two miles in the course of the season, thus furnishing materials for a coast chart of the section. The unusually boisterous character of the season told much upon the progress of the work.

After completing the re-examination of Maffitt's channel, the survey of the Romerly marshes (Sketch No. 24) near Tybee entrance, Georgia, and their approaches, was made upon the basis of Mr. Longfellow's triangulation, and a chart at once furnished for the Chamber of Commerce of Savannah.

Changes having been reported in the depth and position of the main ship-channel of Charleston, Lieut. Comg. Maffitt next made a re-survey there with results which will be referred to hereafter.

The last work of the season was a survey of the northern approaches to Tybee, and an elaborate hydrographic reconnaissance of Martin's Industry shoal, Port Royal bar, Port Royal bay, and Beaufort river, S. C., to the city of Beaufort. On the 4th of June the work was closed in this section and the party transferred to the James river, (see hydrogrrphy Section III,) having in the last mentioned work accomplished one of the most difficult pieces of hydrography yet undertaken in the course of the survey of the coast.

In a severe gale on the 23d of April the schooner Bouncer, used as a tender by the vessels of this party, was wrecked off Port Royal bay. The vessel was at anchor when the gale came up but could not be got under weigh, and both cables parting, she went ashore and was dashed to pieces. All hands were happily saved, but the property contained in the vessel, public and private, was lost or much injured.

In passing northward Lieut. Comg. Maffitt re-examined the Cape Fear entrance and New Inlet, and also determined the positions of the new beacons at Beaufort, N. C. (See hydrography of Section IV.)

The statistics of the season's work in this section (Section V) are as follows:

Supplementary work on Charleston Bar.

Number of angles observed	410
Number of soundings made	4,060
Number of miles of soundings	72

Off-shore work between Charleston Light and North Edisto.

Number of angles observed	672
Number of soundings	6,698
Number of miles of soundings	460
Number of specimens	22
Number of current observations	8

Romerly Marshes.

Number of angles observed	490
Number of angles of determination	98
Number of current observations	5
Number of miles of soundings	209
Number of miles of shore-line	39
Number of soundings	7,031

Martin's Industry, Port Royal, and Beaufort river, S. C.

Number of angles observed	2,497
Number of angles of determination	1,084
Number of soundings	40,106
Number of miles of soundings	842.5
Number of specimens	18
Number of current observations	6
Number of miles of shore-line	63

This work, with that off the Cape Fear and Beaufort, North Carolina, and in the James river, makes the following remarkable aggregate of the year. The officers of the party were Lieutenant Simpson and Acting Masters Davidson and Luce, of whose services Lieut. Comg. Maffitt makes full acknowledgment in his report.

Recapitulation of work in Sections III, IV, and V, by the party of Lieut. Comg. Maffitt.

Miles of soundings run	2,746
Soundings taken	100,006
Angles observed	7,374
Specimens	40
Current observations	24
Miles of shore line	130
Tidal stations	7

The following charts and sketches of this hydrography have been sent to the office: Chart of re-survey of Maffitt's or Sullivan's island channel, $\frac{1}{5000}$; chart of Romerly marshes, $\frac{1}{5000}$; sketch of Charleston main ship-channel, $\frac{1}{20000}$; that of Martin's Industry and Port Royal bar is in preparation. The recent results of the survey of Maffitt's channel have been placed on the comparation map, (Sketch No. 20,) and a new edition of it issued with this report.

A complete hydrographic reconnaissance of Doboy bar and sound, leading to Darien, Georgia, was made by Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, in the steamer Corwin, in February last. Lieut. Comg. Craven states in his report: "I have to observe that the winter season at the South was particularly unfavorable for my operations, the atmosphere being filled with smoke from the extensive fires raging in the woods; during a delay of six weeks at Doboy, I had, in the aggregate, only ten working days."

The following are the statistics of the work:

Miles of soundings	213
Angles taken	539
Soundings	12,800
Area surveyed, (square miles)	21½
Miles of shore-line surveyed	14

Lieut. Comg. Craven also made a hydrographic examination of St. Simon's sound and Turtle river, to Brunswick, Ga., in compliance with the request made to me by the Secretary of the Navy, and a sketch founded upon it was sent to the Department. It is proposed, during the coming season, to replace this by a complete survey, based on the triangulation of Mr. Longfellow, heretofore noticed.

The hydrographic reconnaissance of Cumberland sound, and the harbor of Fernandina, by Lieut. Trenchard, will be found under the head of hydrography of section VI.

Tides.—Tidal observations were made at St. Simon's island, near the light-house, with a Saxton self-registering gauge, by Gustavus Würdemann, Esq., for two lunations, and the records have been reduced at the office.

Charleston has been one of the permanent tidal stations of the survey; but on the change of occupancy of Castle Pinckney from the military authorities to the civil, the observations were interrupted, and the tide gauge, and wharf where it was placed, were much injured. Great pains have been taken, but with indifferent success, to restore this station to its former efficiency. As soon as Mr. Würdemann is disposable he will be sent there and the observations be resumed. Few persons are aware of the importance of not breaking in upon a series of observations like these, where the circumstances varying in a cycle, a break deranges by so much the whole series, and hence it is difficult to secure continuity of observation. In this case, the efforts made by the chief of the tidal party at the office were without success.

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.)

The work of this section has made excellent progress during the past season, and has been pushed even beyond the limit permitted by the appropriation of the past fiscal year, by anticipating in a degree the increased resources of the present. The operations have been as follows:

1. Two base lines have been measured; one on Key Biscayne, the other on Cape Sable prairie.
2. The triangulation of the Keys has been extended eastward to Loggerhead Key.
3. The triangulation of the Keys within the sounds has been extended westward towards Florida bay.
4. The triangulation of the St. John's river has been carried from Mayport Mills, near the entrance, to above Jacksonville.
5. The triangulation of the entrance to Cumberland sound, and of the St. Mary's river, and of Fernandina harbor, has been commenced.
6. The topography of Mud Keys, Snipe Keys, Saddle Bunch Keys, Crane Keys, Whiting Key, Marvin Key, Mallory Key, Blake Key, and Wells Key, has been completed, and the marking for the Land Office has been executed.
7. The topography of Key Largo has been in progress.
8. The topography of reefs and keys of previous years, including that of Key Biscayne bay, of the Marquesas, of Boca Chica, and the keys northeast of it, and of Key Largo, has been verified.
9. The topography of the St. John's has been carried from Mayport Mills to Jacksonville, requiring but little additional work to carry it to the limit of the triangulation.
10. The hydrography of the reef has been carried from Carysfort reef to Grecian shoal.
11. A hydrographic reconnaissance of Tampa bay has been made.

12. The hydrography of the St. John's river has been executed from the entrance to above Jacksonville, and elaborate tidal and current observations have been recorded.

13. A hydrographic reconnaissance of St. Mary's entrance and Fernandina harbor has been made.

14. Tidal observations have been made for not less than two lunations, by self-registering gauges, at Indian River inlet, Indian Key, and the Tortugas.

15. Fourteen beacons or signals have been placed upon the Florida reef.

An account of these various operations will be found under separate heads in the following pages. They have employed the time, in part, of one party for the measurement of bases; of three triangulation parties; of four topographical parties; and of three hydrographic parties; one having a steamer and sailing vessel, and the others, each, a sailing vessel.

The office-work of the several parties which had been in the field or afloat during the previous season in this section, was brought up before recommencing operations.

The drawing of the first sheet of the chart of Florida reefs, $\frac{1}{80000}$, has been completed, as also a comparative map of the northwest channel to Key West, between 1846 and 1851.

The engraving of the chart of Key West harbor, and its approaches, has been completed within the year.

The work which is directly available for the purposes of the Land Office, is that executed by one of the triangulation parties, two of the topographical parties, and the measurement of the base at Cape Sable, by means of which the prairie may at once be divided.

At the request of the Engineer Department, and in conformity with arrangements made, by the approval of the Chief Engineer, General Joseph G. Totten, with Lieutenant John Newton and Captain J. F. Gilmer, of the corps of engineers, the survey of the St. John's river was carried from Mayport mills, near the entrance, at which it was left in 1853, to a point beyond Jacksonville.

The triangulation was completed in May last, and the topography and hydrography followed it closely. There yet remains a base of verification to be measured, and a small portion of topography above Jacksonville to be executed. In connection with the hydrography, special observations of tides and currents were called for by the Commission on the improvement of the St. John's, a part of which near the bar at the entrance were of very difficult execution. The work has not yet been discussed, but, as far as present indications go, will be satisfactory. I inspected the parties engaged in it in March last, while on the way to measure the south Florida bases, and found the arrangements and progress quite satisfactory.

One of the most valuable labors of the season in this section has been the placing, for the Light-House Board, the beacons forming a nearly continuous series along the whole Florida reef, from the Fowey Rocks, at the eastern extremity, to Eastern Sambo, on the western end of the reef. They are placed at suitable distances and appropriately marked, so as to enable the navigator, in the day-time, precisely to know his position when he makes any one of them, and to follow them in succession along the reef, after he has fallen in with and recognised one. These have replaced Coast Survey signals, so that their positions are determined where the survey has reached. Generally, these signals were made use of in placing the new ones, and thus it has been found that the materials used are likely to stand the action of the sea for many years. The places, construction, and all other matters relating to these signals, were approved by the Light-House Board before acting in replacing them.

The tidal stations established between Cape Florida on the east, and the Tortugas on the west, have given very satisfactory information in regard to the progress of the tide-wave through the Florida channel.

The difference in the time of semi-diurnal high-water between Cape Florida and Indian Key, is thirty-one minutes; between Indian Key and Key West, thirty-six minutes; and between Key West and the Tortugas, twenty-nine minutes.

The corresponding distances are about fifty-eight, fifty-five, and forty-nine nautical miles.

Key Biscayne and Cape Sable bases.—These bases, for the triangulation of south Florida, and of the keys and reef, were selected after a reconnaissance by Assistant F. H. Gerdes had determined the probable character of the main triangulation, and the facilities afforded for the measurement of the base or bases upon which it must rest. The sites selected were subsequently surveyed by the plane-table, and their connection with the triangulation studied. (Sketch F No. 2.) Bases of about four miles in length it was found could be readily measured on Key Biscayne and at Cape Sable, the length being in good relation to that of the sides of the triangles, and their connection with the triangulation easy. A preliminary base measured at Key Biscayne would serve the immediate purposes of the triangulation of the eastern keys and eastern part of the reef, while the final base there would verify the lengths coming from Cape Sable, and give a base for passing northward on the Atlantic side of the Peninsula. The Cape Sable base comes by an easy triangulation across Florida Bay, to above the middle of the keys, between the Marquesas on the west, and Virginia Key on the east. Considered as the bases upon which the triangulation of the main land and adjacent keys was to rest, they were at the opposite side of the peninsula—the one on the Atlantic, and the other on the Gulf side.

The site of the Key Biscayne base presented very moderate undulations of surface, (Sketch F No. 2,) and but few obstacles from wood or from marshy ground.

That at Cape Sable (Sketch F No. 2) was admirable, being almost a perfect level on a prairie, with the single drawback, that dry weather was indispensable to the measurement, the site becoming rapidly soft and tremulous after rains.

The Key Biscayne site required considerable preparation, by clearing and grading, which was executed, first by Assistant Gerdes, and next by Lieutenant Totten, U. S. A., and by Assistant C. O. Boutelle, and others of my party, just before and during the measurement. The lowest parts of the Cape Sable base were ditched on either side by Mr. Gerdes, and in some places embanked. At the western end a cut was made through a mangrove wood, and a slight embankment raised by Messrs. Boutelle snd Dean just before the measurement; but generally, firing or cutting the grass, and removing the roots where the measuring apparatus stood, were the only preparations necessary.

The preparation of the monuments and screw-piles for the ends of the bases, the stones and screw-piles for marking the intermediate miles, and of the equipments generally, were made during the winter, under my direction, by Thomas McDonnell, Esq. The preparations for measurement were made by Assistant C. O. Boutelle and Mr. J. A. Sullivan, aid. The party had the use of the schooner Graham for transportation, and, during part of the time, the schooner Bowditch; and were also aided, by transportation and towage, by the steamer Corwin, Lieut. Comg. Craven. The base apparatus, retained at the office until the latest moment for comparisons, was sent by steam from Washington, and shipped on board the Graham at the St. John's river.

Comparisons were made by the measuring bars Nos. 1 and 2 with the standard iron-bar before the measurement at Key Biscayne; during it, on the occurrence of an injury to one of the measuring bars, and at the close, and on closing the Cape Sable measurement.

The apparatus for comparison of the measuring bars with the standard was the same as that in use at previous bases, the Saxton pyrometer. It consisted, essentially, of two granite or heavy wooden posts, sunk about two feet in the ground, at a distance from each other equal to the length of the standard-bar. The pressure of the earth around the posts was prevented by a box filled with sand, which produced a remarkable steadiness in the apparatus. A sunken box, loosely fitting around the posts, protected them from the direct action of the sun, wind, and rains. One of these posts supported an immovable abutting screw, the other a mirror with abutting screw attached, placed in a vertical position, and turning upon an axis. Opposite the mirror, at a distance of twenty feet, and at right angles to the direction of the posts, a wooden pillar supported a graduated scale and reading telescope. The abutting screw, mirror, and scale, were in the same horizontal plane. In making a comparison, the standard-bar, enclosed in a wooden case with openings at the ends for the extremities of the bar, was placed on trestles between the granite posts, one end of the bar being in contact with the fixed abutting screw, the other resting against the screw of the mirror. The reading of the scale, as reflected in the mirror, and the indications of the thermometers attached to the bar were then noted, the standard removed, and one of the measuring bars made to occupy its place. If the length of the bar fell short of that of the standard, so that the reading came off the scale, the deficiency was made up by turns of the mirror screw, the number of turns being carefully noted. In the comparisons after the measurement, however, a larger scale was used, and the necessity of turning the screw was done away with.

In all, seventeen sets of comparisons, each set consisting of three readings of the standard, and three of each of the measuring bars were taken, both before and after the measurement, and upon eight different days, at temperatures ranging from 57° to 86° Fahrenheit.

The measurement at Key Biscayne was commenced from North Base on the 9th of April, and nine working days, of seven and one-third hours each, were occupied in the measurement, the average progress in a day being 107.2 tubes, or one-fourth of a mile. The chief obstacles to rapid progress were the interwoven palmetto roots, which it was impossible entirely to extirpate, obliging the bearers to move with great caution; the irregularity and frequent changes of grade in the surface; and the high temperature at which the work was carried on. The whole number of tubes measured was 965, (corresponding to a length of about 3.601 miles,) uncorrected from inclination, of which 492, or more than one-half, required an adjustment for rising on falling grades. The average of greatest plus inclinations on the several days was 58′, of greatest minus 54′. The average temperature of the thermometer at the contact end of each tube, was 82″.9 Fahrenheit.

The party left camp, generally, before daylight, so as to reach the part of the line where the measurement was going on by sunrise at latest, and the work was continued until sunset, with an interruption of an hour at breakfast-time, and of two hours during the hottest part of the day.

The following table contains some of the statistics of the measurement which are of interest.

Abstract of the measurement of Key Biscayne base.

Date.	Hours.	Number of tubes.			Average time of one tube.	Average inclination.	Greatest inclination.	Number of tubes.		General character of surface.	Average temperature N. thermometer.
		In day.	In day of nine hours.	Per hour.				Level.	Inclined.		
1855.	h. m.				min.	+ −	+ −				°
April 9	7 10	69	87.3	9.7	6.23	19 14	35 35	38	31	Sand and moderately soft marsh ..	87.5
10	7 50	81	94.5	10.5	5.80	25 21	60 70	24	57	Hard sand—then marshy ground..	82.0
11	8 40	113	111.6	12.4	4.60	31 35	60 60	49	64	Sand and soft marsh............	85.9
12	7 17	99	124.2	13.8	4.41	38 29	80 50	40	59	Sand and hard marsh	75.2
13	2 20	36	139.5	15.5	3.89	24 26	35 60	17	19	Sand..............................	77.9
14	9 23	166	156.6	17.4	3.39	27 18	65 30	103	63	..do..............................	80.7
16	5 41	108	165.6	18.4	3.16	30 31	50 60	63	45	..do..............................	86.0
17	9 03	147	145.8	16.2	3.70	41 23	65 45	75	72	..do..............................	85.3
18	9 07	146	144.9	16.1	3.74	41 38	75 75	64	82	..do..............................	85.3
Average for whole base.	7 23	107.2	130	14.4	4.33	31′ 26′	58′ 54′	53	55		82.9

The measurement of the base at Cape Sable was commenced on the 4th of May and completed on the 11th, occupying eight days of about six hours each.

The whole number of tubes measured was 1,072; the average number per day 134, or one half mile in length; and the greatest number in any one day was 192 in six hours twenty-four minutes—an average of two minutes to each tube. For the whole base the average number of tubes per day of nine hours was 200. This rapidity was attained at a mean temperature of 87°.9. The level character of the ground is shown by the fact, that of the whole number of tubes measured, only 78, or a little over seven-hundredths of the whole, were inclined, while the greatest inclination did not exceed 25′.

The nature of the ground rendered it advisable to mark the ends of this base with screw-piles, which had accordingly been prepared for the purpose—a large one, the centre of which marked the end, and four smaller ones—two in the line of the base, and two in a line at right angles to it, at suitable distances from the central pile. It is not necessary here to enter into the details of inserting these piles and making the points with precision; they gave, however, no especial trouble. Two of the mile-points were marked by similar piles.

The statistics of the Cape Sable base are given in the annexed table.

Abstract of the measurement of Cape Sable base.

Date.	Hours.	Number of tubes.			Average time of one tube.	Average inclination.	Greatest inclination.	Number of tubes.		General character of surface.	Average temperature W. thermometer.
		In day.	In day of nine hours.	Per hour.				Level.	Inclined.		
1855.	h. m.				min.	+ −	+ −				°
May 3	2 58	39	119.7	13.3	4.56	20 0	20 0	38	1	Hard marsh, with growth of samphire.	91.8
4	7 04	150	189.0	21.0	2.83	15 0	15 0	147	3	Hard marsh, with growth of samphire.	92.6
5	6 07	130	187.2	20.8	3.28	15 20	20 25	117	13	Hard marsh, with growth of samphire.	87.8
7	7 13	169	202.5	23.5	2.56	20 16	25 15	145	24	Hard prairie—grass and samphire.	86.0
8	6 07	138	202.5	22.5	2.66	0 15	0 15	131	7	......do............do..........	89.7
9	7 36	179	201.6	2304	2.55	12 14	15 15	165	14	Hard prairie—grass burned off....	89.3
10	6 24	192	269.1	29.9	2.00	14 0	20 0	179	13	......do............do..........	88.4
11	2 57	75	228.6	25.4	2.36	0 13	0 15	72	3	Hard prairie—long and spire grass.	77.9
Average for whole base.	5 48.3	134	200.0	22.47	2.85	′ ′ 12 10	′ ′ 14 11	124	10		87.9

I have already stated that the immediate preparations for measurement were made by Assistant C. O. Boutelle and Mr. J. A. Sullivan, aid. In the measurement I was assisted by Assistant G. W. Dean, Sub-Assistant Edward Goodfellow, Mr. Fairman Rogers, volunteer aid, and Mr. Thomas McDonnell. Mr. Prenot, of the office of Weights and Measures, accompanied us to keep the apparatus in its best working order, and on the occasion of an injury to it at Key Biscayne, rendered especially valuable service by his mechanical skill and ingenuity and his promptness. Mr. C. B. Baker, aid, rendered occasional service on the two lines. Mr. Rogers and Mr. McDonnell took part with me in the comparisons of the apparatus with the standard-bar. Mr. Dean placed the monuments and mile-stones, assisted by Mr. Goodfellow. The records were kept by Mr. Goodfellow.

This service being especially severe, I must transgress my usual rule by making a sincere acknowledgment to every member of the party of my high appreciation of their labors, so cheerfully rendered under circumstances often of considerable trial.

To Fairman Rogers, Esq., of Philadelphia, civil engineer, who volunteered to accompany me for the sake of seeing the modes of working in the Coast Survey parties, and was always ready for work of any description, even the hardest, skilful, energetic, and untiring in its execution, my thanks are especially due and especially paid.

During the measurement at Cape Sable, Assistant C. O. Boutelle and Lieut. James Totten, U. S. A., made a minute reconnaissance for the connection of the base with the keys to the southward and on the main to the northward.

Lieut. Watkins, U. S. N., light-house inspector of the district, gave us every facility which his duty permitted, accompanying the party in the light-house schooner "Florida" to Cape Sable, and assisting in the reconnaissance just referred to personally, and by the aid of his vessel, boats, and men.

The comparisons of the measuring apparatus with the standard-bar at Cape Sable were completed between the 12th and 18th of May, and the party left the base. Similar comparisons, in which I was assisted by Mr. Hilgard, Mr. Dean, Mr. McDonnell, and Mr. Prenot, were made after the return of the apparatus to Washington—an arrangement as nearly similar in all respects to that used in the field as it could be made, having been adopted for the experiments. It is worthy of note, that the results thus obtained are the best which the office comparisons have yielded, owing to difficulties heretofore found insuperable in the change of distance of the two points connected with the ground, between which the apparatus is measured, and other causes, some of which, though obvious, could not be remedied, and others which baffled our investigations.

It may be of interest to compare the statistics of the different measurements made with this base apparatus since it has received its present approved form. The bases which I have measured since that time have been those at Bodie's island, N. C., Edisto island, S. C., Key Biscayne, and Cape Sable, Florida. The following table shows the comparison:

Comparative table.—Time of occupation, rate of progress, &c.—Bodie's island, Edisto island, Key Biscayne, and Cape Sable.

	Bodie's island.	Edisto island.	Key Biscayne.	Cape Sable.
Whole number of tubes measured	1,807	1,787	965	1,072
days employed	10	13	9	8
hours employed	81*h* 8*m.*	97*h.* 28*m.*	66*h.* 31*m.*	46*h.* 26*m.*
tubes level	1,496	862	473	994
tubes inclined	311	925	492	78
Average length of working day	8*h.* 7*m.*	7*h.* 30*m.*	7*h.* 23*m.*	5*h.* 48.3*m.*
time of one tube	2.90*m.*	3.37*m.*	4.33*m.*	2.85*m.*
number of tubes per day	180.7	137.5	107.2	134
number of tubes per day of nine hours	197.9	165.9	130	200
number of tubes per hour	21.98	18.4	14.4	22.47
plus inclination	16′.2	24′.5	31′	12′
minus inclination	19′.6	23′.0	26′	10′
of greatest plus inclination	23′.7	55′.4	58′	14′
of greatest minus inclination	29′.5	48′.4	54′	11′
number of tubes level per day	149.6	66.3	53	124
number of tubes inclined per day	31.1	71.1	55	10
temperature of thermometer at contact end	52.0	59.5	82.9	87.9

The base at Bodie's island was measured upon a sand-beach, and in part on perfectly level sand-flats; that at Edisto over a remarkably level piece of cultivated ground; that at Key Biscayne over an undulating surface of sand; that at Cape Sable over an almost level prairie covered with grass. At Edisto considerable pains were taken in grading. At Key Biscayne more grading was desirable than we had time to make. At Bodie's island and Cape Sable scarcely any grading was necessary. The surface at Bodie's island was a sharp silicious sand, on which it was easy to move the iron plates supporting the trestles of the measuring tubes. At Cape Sable the earth, when the roots of the grass were removed, was a loam of mixed vegetable and calcareous matter, the latter being in the form of an impalpable powder, and forming, when wet, a sticky mass like clay.

The base measured during the present season at Key Biscayne was connected with the triangulation of the Florida Reef by Lieut. James Totten, U. S. A., assistant in the Coast Survey.

Arriving at the end of May from Key West, in the schooner Bowditch, Lieutenant Totten commenced at once the erection of signals at North base, South base, the station Key Biscayne, and at Elliott's Beach. The works at the last-named station being found nearly obliterated, a new centre was established, and marked by five granite blocks sunk into the earth; four being placed at the cardinal points, six feet distant respectively, from that on which the centre was marked by the intersection of lines cut on the stone. A record of the station-marks at each end of the newly measured base has been placed on file in the office. Lieutenant Totten commenced observations at Elliott's Beach on the 1st of June, and successively occupied South Base, Key Biscayne, and North Base. The signals used at these stations were from fifty to sixty feet in height, and the utmost care was taken in their adjustment in vertical positions.

The connection was completed within a month, (see Sketch F,) and the results include the following statistics:

Number of stations occupied	4
" angles measured	6
" sets of observations (six direct and six reverse)	40
" single observations	480
Length of line, South Base to Elliott's Beach	9786.7 metres.
" " North Base to Key Biscayne	960.7 metres.
Area included in the triangles	11.1 sq. miles.

After concluding this work, Lieutenant Totten laid up the schooner Bowditch at Key West, and returned to the North, where he was subsequently engaged with my party, as mentioned under Section I.

Triangulation.—The triangulation of the Florida reefs and keys has been continued by the parties of Lieutenant James Totten, U. S. Army, and of Lieutenant A. H. Seward, U. S. Army, assistants in the Coast Survey—the former having charge of the work outside of the sounds, and the latter of that within them. The services of Lieutenant James Totten having been required in connection with the preparations for measuring the base lines before referred to, and the erection of beacons for the light-house establishment, the party was placed in charge of Sub-Assistant John Rockwell, an extract from whose report will show the limits and general character of the work done.

"The space embraced by the triangulation (see Sketch F) extends from the line Rock Point—Eastern Sambo, eastward as far as the line Loggerhead key—Palmetto, the last named station being near Newfound harbor, and northward as far as the line Douglas key—Point Dora, where it joins previous work of Lieutenant Totten. The southern boundary is the line of the Florida reef. This is independent of the small piece of detached work for the determination of the position of the northwest light-house in Key West harbor, which was also accomplished by the party."

The Saddle Bunch Group, besides numerous detached keys, are included in the limits just stated, and the results of the season may be summed up as follows:

Number of stations occupied	23
" observations made	5,341
Area of triangulation, in square miles	125
Length of longest side, in miles	9.335.

The instrument used in making the observations were the ten-inch, No. 73, and six-inch, No. 19, Gambey theodolites of the Coast Survey.

The schooner Petrel was employed in this and other duties of the party of Lieutenant Totten.

I visited this party in the latter part of April, and was entirely satisfied with all the arrangements for working. Before the close of the season a sufficient number of points was determined to occupy a topographical party in its appropriate duty during the next season.

Mr. Rockwell gives the following particulars relative to the peculiar character of the keys embraced in the survey of the present year.

"The keys over which the work was extended may safely be characterized as among the least valuable of all the keys. The foundation of coral rock is covered but scantily with soil. In some places the mangrove and buttonwood trees will grow, in others only the bush mangrove. The solid land forms only a small proportion of the whole. A large part of the area is covered by an intricate system of shallow creeks and lagoons, which cut up and separate the keys, and another part by swamps, where the mangrove grows to a considerable size and with wonderful density. Within this region there are a few settlements of single houses on spots where sufficient soil has been found to cultivate vegetables and fruits. The quality of the soil appears to be good enough to produce all that is elsewhere raised in similar climates, and such trees or plants as require no great depth of earth, flourish well; but the supply of soil is quite deficient. There is, however, an opportunity to effect a good deal more than has been done in the way of cultivation of the soil. There is available land enough in these keys, within a reasonable distance from Key West, to supply that market with such articles as can be raised, but the town is at present dependent for its supplies upon importation from the main land of Florida and the Northern States.

"Sponges are obtained in the shallow waters among the keys to a considerable extent, and form one of the articles of export from Key West, though not a very important one." (Appendix No. 25.)

The party of Lieutenant A. H. Seward, U. S. A., was engaged during part of the season in extending southward from last year's limits the triangulation in Barnes' sound. (See Sketch F.)

In consequence, however, of the increasing shoalness of the water in the lower part of the sound, the schooner Bowditch, employed by the party for transportation, was necessarily left at the anchorage of the preceding year—the triangulation being carried on from thence with small boats until the distance from the vessel rendered further operations by this method impracticable. Six stations were occupied by the party, at which a hundred and thirty-three angular measures were made by eight hundred observations. The work of the season terminated at Duck key, (Sketch F,) on the 20th of February; at which time the schooner Bowditch was assigned to Assistant Whiting, and was subsequently employed in the operations of my own party in the section.

The following extract from the report of Lieutenant Seward shows the nature of the obstacles met in the progress of the work in Barnes' sound:

"While employed in carrying on the triangulation, I took advantage of favorable opportunities to reconnoitre that portion of the sound between Key Largo and the main shore, but was unable in many places to get more than half way across with the small boat, on account of the bars which connect the different keys having no channels as heretofore."

After consultation with Lieutenant Seward, and a personal examination of portions of this intricate region, a plan of transportation and working has been adopted which I believe will remedy in a great degree the obstacles heretofore found. By coming off the base at Cape Sable, and carrying the triangulation eastward to meet the former work, a satisfactory solution will be found of the problem regarding the continuance of the triangulation.

Lieutenant Seward joined the party of Assistant Blunt in the summer, and has since been engaged in operations connected with the work of the New York Harbor Commission, as noticed under Section II.

The triangulation of the St. John's, by Lieutenant A. W. Evans, U. S. A., assistant in the Coast Survey, is connected with that formerly executed at and near the entrance by Assistant G. A. Fairfield, by the common stations Sand-hill, (3,) Round Pond, and Horse-shoe, (See Sketch F,) and, from the side between the last two, the work was carried on up the river, and points given to a topographical party, under the charge of Assistant A. M. Harrison. "The observations for continuing and completing the work were carried steadily onward, with occasional delays in reconnoitering for new intermediate stations, and the erection of signals. The St. John's, from its mouth to Dames' Point, presents a series of extensive marshes, intersected by large streams, affording opportunity, which was used as much as possible, for a comparatively large order of triangles. At Reddie's Point, four miles above Dames' Point, the river is suddenly contracted to about a mile in width, and it maintains this width, with slight variation, to Jacksonville. The heavily wooded nature of the banks prevented any selection of stations, except at points comparatively near the water's edge, and therefore rendered necessary an increased number of them. An object kept in view from the beginning was the avoidance, as much as possible, of heavy cutting of timber, unavoidable in many cases."

Mr. John B. Harvie acted as aid to Lieutenant Evans during part of the season, and Mr. F. M. McIver during the rest. The instrument used was a six-inch theodolite, by Brunner, C. S. No. 58, with which all the observations were made.

"The plan adopted in the triangulation of Casco bay, in the summer of 1854, was continued here—of taking, for every set of measures reading *forward* upon the instrument, a corresponding set *backward*, to correct any possible drag of the lower limb. The work was finished only in May, the measurement of a base of verification being unavoidably postponed."

The work executed upon the St. John's may be summed up as follows: "The triangulation extended from Mayport Mills to Winter's Point, about two miles above Jacksonville; thirty-one (31) stations of 2d order were occupied, and four (4) of 3d order; and three hundred and ninety-three angles were measured upon one hundred and ten points, by five thousand six hundred and fifty-four (5,654) observations. Three stations of Mr. Fairfield were occupied, and twenty-eight new ones."

"The St. Mary's work occupied about a month's time, and consisted in the measurement of a base and in a reconnaissance, having for its object ultimately the selection of stations for a triangulation, and immediately the furnishing of points to the hydrographic party which commenced operations in June. My operations embraced Cumberland sound, northward as far as Dungenness House, Amelia river to Yellow Bluff, the proposed terminus of the Atlantic and Gulf railroad, and the *entrance* and bar. A rough reconnaissance was first made with a telescope having a circle reading to three minutes. Points upon the shore of the sound and the sea, selected with a view to intervisibility, were occupied with theodolite No. 58, and angles measured by sweeping round upon all signals in sight. These signals were generally flags, and a numerical nomenclature was adopted for them; commencing on the inside of each island, and running outward, in order, to the sea-shore. These points were thus all determined by intersection, but not, of course, with the accuracy of a triangulation. A base of a mile in length was selected upon Tiger island, near the sound, from which it was separated by a strip of wooded sand-hills. The ground, of sand and marsh, was very level and unobstructed. Four hundred and four bars in all were measured, (1,616 metres, or 1.005 miles,) and the temperatures of each noted. The extremities of the base were marked by stones set in the ground, and were then connected by observations with the points of the reconnaissance. These points were then plotted, and a sketch, including a tolerably accurate shore-line, was furnished to Lieutenant S. D. Trenchard, U. S. Navy, in charge of the hydrographic party."

Topography.—Two parties, as in the previous season, have been employed in the special survey of the Florida keys for the General Land Office.

The topography of several groups lying northeast of Key West, and of detached keys in their immediate vicinity, has been executed by the party of Assistant J. Hull Adams, and the included area divided into quarter sections by posts numbered and properly secured to resist the action of the tides for their displacement.

Assistant Adams arrived at Key West in December, but owing to the detention of the schooner *Agassiz* for repairs, rendered necessary by the damage sustained by being run upon the rocks near Cruz del Padre, on the coast of Cuba, operations were not commenced until the close of the following month. From that time until near the end of May the survey was prosecuted without interruption; and regarding the difficulties presented by the peculiar character of the localities, as falling within my own personal observation, the results are highly creditable to the party entrusted with its execution. The work includes the topography and marking of the Mud keys, Snipe keys, Saddle Bunch keys, Crane keys, Whiting key, Marvin key, Mallory key, Blake key, and Wells' key, (Sketch F.) Favorable weather, and the diligent employment of facilities thus afforded, show a considerable aggregate in the work executed during the season. The statistics are as follows

Shore-line of keys surveyed	142 miles.
Area	63 square miles.

Special mention is made in the season's report of the untiring application to duty of Sub-Assistant C. T. Iardella, attached to this party.

Tracings from the maps drawn by Assistant Adams during the summer have been furnished to the Commissioner of the General Land Office, reference to which, and extracts from the report of the season, will be found in Appendix No. 25.

The work of this party was inspected and verified by actually repeating portions of it independently by Assistant H. L. Whiting, one of the most experienced and accomplished topographers of the Coast Survey, whose report was very favorable to its accuracy, thoroughness, and neatness.

Assistant Whiting examined also the work of previous years by Mr. Adams, from Soldier key to Key Largo, and also near Boca Chica, at the western end of the reef. In his report, Mr. Whiting says:

"Mr. Adams' work appears to be very carefully and faithfully executed, even to the minor details, and the representations are natural and characteristic. I consider it as work of the first class."

"With regard to the amount of work done in a season, I should consider it fair. The survey is simple; that is, it has but one feature—the determining of the outline of a generally wooded shore; but the difficulties of getting at this shore, with accurate points and stations for detail, are sometimes almost insurmountable. The outside shore is generally accessible, but on the inside, and on the shore of the creeks and passages between the keys, the mangrove often grows quite out into deep water; and where this is not the case, the mud is so deep and soft that it is almost impossible to approach or make stations along the shore."

"These are characteristics peculiar to this work and coast, and materially affect a comparison or estimate as to the amount of work which might be done in any given length of time.

"Of the two sheets of Mr. Adams' work, where the Land Office sections were marked, I found all the posts in place, as far as I examined; and it is worthy of remark, that every *corner section*, falling upon any of the keys, has been marked throughout the whole of his work of last season. This season the marking has been omitted on the overflowed lands, &c., according to instructions."

The work of the second party, which was under the charge of Sub-Assistant S. A. Wainwright, has furnished the outside shore-line between Point Perry and Excelsior, and three square miles of the interior of Key Largo North. (Sketch F.) The length of shore-line surveyed is about thirty-three miles.

Various expedients, tried by Sub-Assistant Wainwright, for inserting posts to mark the intersections of land section-lines with the shore, were found impracticable, the coast being composed of continuous coral rock. Signals were, however, placed at all the points determined, and adequate means will be provided, when the time for final marking arrives, to overcome the difficulty referred to.

The progress of the work at Key Largo North during the season was much hindered by bad weather and by the cutting of lines.

The schooner Joseph Henry was employed in the operations of this party.

Mr. Wainwright reports that, besides the stormy character of the early part of the season, the great distance of safe harbors in which his vessel could lie, outside, impeded sensibly his progress.

Since the date of my last annual report, the topographical sheet of Bahia Honda, or Spanish harbor, has been turned into the office by Mr. Wainwright. He is now about to resume work on the inside shore of Key Largo North.

The topography executed by Mr. Wainwright and by his assistant, Mr. H. S. Duval, in the season of 1854, was examined by Assistant H. L. Whiting, who reports with moderate favor of its character, and with less of its amount. That of this year is, considering the nature of the season, more satisfactory, as I ascertained by personal examination, near the close of the season.

Topographical verification.—A careful examination or verification of the topography executed in the southern part of this section during previous years, and during the early part of this season, was made by Assistant H. L. Whiting during part of the months of March and April. This consisted of three topographical sheets by Sub-Assistant J. H. Adams, in Key Biscayne bay; one sheet by Sub-Assistant S. A. Wainwright, comprising the north end of Key Largo; two sheets by Sub-Assistant Adams, northeast from Boca Chica; and one sheet of Sub-Assistant R. M. Bache, containing Boca Chica itself. The object of this examination was not only to verify the work, but to have the suggestions, in regard to the Land Office survey, of one of the most experienced and accomplished topographers in the Coast Survey. The verification was found quite satisfactory, as might have been expected, and the details of this and Mr. Whiting's suggestions will form a basis for future action.

After speaking of the great difficulty and expenses of cutting the lines of quarter-sections through the mangrove growth, Mr. Whiting observes: "If the object of the Land Office survey is to define and locate the particular sections and quarter-sections sufficiently to enable those who take up the land to identify them, this is accomplished, it appears to me, beyond all question, by the marking as now done. The fact of the section-lines terminating and intersecting with the *shore-line* on all sides of the keys, makes a positive and definite point, and a mathematical determination of the sections."

On presenting this subject to the Commissioner of the Land Office, I was authorized to omit the cutting through of their lines, the expense of which is certainly, under the circumstances, not warranted. Mr. Whiting had the use of the schooner Bowditch for the greater portion of the work.

The plane-table survey of the banks of St. John's river, Florida, for the Engineer Department, has been nearly completed by the party of Assistant A. M. Harrison, commencing on the 6th of March, at Mayport Mills, and joining with the sheet of Sub-Assistant R. M. Bache, the work was carried along both sides of the river as far up as Jacksonville, where it was stopped on the 14th of May by the illness of Assistant Harrison. His report presents the following statistics:

Miles of shore-line surveyed	65
Miles of creeks, sloughs, &c	58
Area in square miles	13½

The work is embraced in three sheets, and the portion above Jacksonville, yet to be included, will occupy but a small part of the time allotted for work in the coming season.

The schooner J. Y. Mason was employed in transporting the party, instruments, and equipments, required in the work.

Special mention is made, in the report of the season, of the efficient services of Mr. P. R. Hawley, who was engaged as aid to this party.

Assistant Harrison has been occupied since his return from Florida in plane-table surveys, as mentioned under Section II.

Hydrography.—The hydrography of the Florida reef, under the charge of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, in the steamer Corwin, has made good progress, and the quality of the work fully sustains the reputation of that accomplished hydrographer.

It has been extended from Carysfort reef to Grecian shoal, (see Sketch F,) and comprises an area of sixty-five square miles. The number of miles and soundings run was 267; the number of angles measured, 622; and of soundings taken, 16,136.

A section of the Gulf Stream has also been run by the same officer, which brings the explorations south as far as Cape Florida. This party also rendered essential assistance to me in transportation, and other facilities, while preparing for and engaged in measuring the base lines at Key Biscayne and Cape Sable.

The cheerful manner in which all these services were rendered by the chief of the party and the officers of the steamer Corwin greatly enhanced their value, and made them as acceptable to me, individually, as they were useful to the public service.

Besides the hydrography in this section, Lieut. Comg. Craven executed that of Doboy sound, a reconnaissance of St. Simon's, and a re-survey of New York bay and harbor; of which notice has already been taken under their appropriate heads, in sections II and V. Such an amount of varied work of standard excellence has not before been executed by any coast survey party. When the season is sufficiently advanced for the purpose, these indefatigable officers will return to their labors on the Florida reef.

The experience gained by Lieut. Comg. Craven in prosecuting the hydrography of this section, has enabled him to make judicious recommendations in regard to aids to navigation required on the eastern coast of Florida. These, on being communicated to me, were referred to the Light-house Board. The special localities and character of the aids recommended are stated in Appendix No. 72.

A hydrographic reconnaissance of Tampa bay was made in June last by Lieut. Comg. O. H. Berryman, U. S. N., assistant in the Coast Survey, in the schooner Varina.

A base was measured with a chain on Egmont key, (see Sketch F,) from the south side of the light-house towards the end of the key, and points determined by its use on both sides of the bay to Fort Brooke and Old Tampa. The hydrography was commenced at Egmont key, and carried to Gadsden's Point, Fort Brooke, and Old Tampa. In reference to the use of the shores of Tampa bay as a railroad terminus, Lieut. Comg. Berryman says:

"I have found an excellent harbor and site for a railroad depot, but the piers, I think, will be unusually long; yet, if the Company are desirous of making a substantial improvement, the length of the piers ought not to be a serious objection."

"Eighteen feet water may be brought to the anchorage from sea; the anchorage is very spacious and deep, (having from four to five fathoms,) the holding ground excellent. The ground for the depot is perhaps twelve feet above the ordinary high tides, and three above the tide in the great gale of 1846. This is at the landing, and from this point the land rises very gently for five hundred metres, to about twenty feet. Pines and some black-jack are the only timber; the area is about four or five hundred acres, and piers will require to be four or five hundred metres long to reach fifteen feet water. The anchorage is protected on the east by a middle ground several miles wide, having from eight to ten and twelve feet on it; on all other sides by land and banks. This anchorage is on the west side of the bay, and just south of Mount Point."

"The approach to this anchorage is by the main ship-channel, up to Mangrove point; thence, west-northwesterly across the bay, around the north end of the great middle ground, and south, keeping in the deep water." "At high summer tides, perhaps a draught of twenty feet may be brought in."

"This reconnaissance has been very laborious to those employed."

The following statistics of this work are reported:

One base line on Egmont key	2,465 metres.
Stations established	20
Stations occupied	17
Number of soundings	32,121
Number of double angles (sextant)	19
Number of theododite	405
Miles of lines of soundings	790
Area in square miles (statute)	256
Number of tidal stations,	6
Average rise and fall of tide	1.7 feet.

"Vessels drawing eighteen feet may safely trade to this bay, and may keep, at a high-tide reach, the anchorage alluded to in my remarks respecting the terminus for a railroad on the west side of the bay."

"Ballast point may be approached nearer than a mile with ten feet very soft bottom. Old Tampa may be reached with the same depth quite as near."

"The sheet will best exhibit these approaches; it will be furnished very shortly, and a tracing will be forwarded at once." The engraved sketch of this reconnaissance accompanies this report. (Sketch No. 31.)

The instructions of Lieutenant Berryman included an examination of Charlotte harbor, but the season was too far advanced, when the reconnaissance of Tampa was completed, to permit its execution.

The hydrography of Ocilla river and St. Andrew's bay by this party, and the observations made in the Gulf Stream, will be found noticed in their appropriate places.

The special hydrography of the St. John's river, Florida, (Sketch F,) for the Engineer Department, was completed within the present season by the party of Lieut. Comg. Richard Wainwright, U. S. Navy, assistant in the Coast Survey. The services of that officer being required in the continued hydrography of Section III, and subsequently in New York harbor, the completion of the survey of the St. John's was assigned to Lieutenant Trenchard, of his party. With the schooner Guthrie, soundings were commenced on the 10th of April at Mayport Mills, connecting with the hydrographic work of Lieut. Comg. Craven, and lines were carried from thence to the upper limits of the triangulation at Winters' Point about two miles above Jacksonville. The soundings are embraced within about thirty miles of shore line; and nearly thirty thousand casts of the lead were made, over nine hundred angles observed, and about a thousand miles of sounding-line run. The bottom is generally sand and mud. The greatest depth of water found was eighty-two feet at a point off Jacksonville. In connection with the hydrography of the river, observations were made at eight current stations on and outside of the bar, a flood and an ebb being observed at each. Five temporary and seven permanent tidal stations were also occupied. At four of the latter simultaneous hourly observations were made for six days, and results obtained, which are reported to be satisfactory, the object being to trace minutely the passage of the tide-wave along the river. At the three stations, viz: Near Light-house, on the Bar, and at Fort George inlet, observations were made for four days, and full simultaneous tides were made sufficient, it was thought, to insure good results.

"The tide-stations were located, with one exception, at the points marked upon the tracing accompanying the instructions. The exception was at Station B, the water being too shoal for the gauge, and a site upon the opposite side of the river in deeper water was selected as being more suitable." "The greatest rise and fall exhibited by the tidal observations is as follows: At A, Taylor's Mill, near Jacksonville, 1.20 foot; at B, near St. John's Mills, 1.75 foot; C, on Dames' Point, 2.47 feet; D, near St. John's Bluff, 3.83 feet; near the Light-house, 6 feet; on the Bar, 6.20 feet; and at Fort George inlet, 6.60 feet.

"All the current observations on and outside of the bar have been completed. The stations marked upon the tracing accompanying instructions were occupied, as far as practicable, a flood and ebb being observed at each. Observations have been made, in all, at eight stations. The exposed character of the tidal and current stations near the bar caused the failure of the first attempt to procure simultaneous observations at them, and it was finally necessary to hire a steamboat to accomplish the object—thus delaying the completion of the work in the first instance, and, finally, considerably increasing the expenses."

The season not affording time for a complete survey of Cumberland sound and St. Mary's river, a hydrographic reconnaissance was ordered, in connection with the triangulation of Assistant A. W. Evans, before referred to. This was executed by Lieutenant Trenchard, U. S. Navy, assistant in the Coast Survey, detailed from the party of Lieut. Comg. Wainwright. This reconnaissance will be followed up by a complete survey. Its results can only be considered approximate. (Sketch F.) Lieutenant Trenchard says, in his report: "The least water found upon the bar at ordinary low tide was thirteen feet. Eight feet can be carried through the Swash or Cumberland channel. The former ship (now the south) channel is nearly closed, and is used only by steamers of light draught in mild weather."

"Over twenty feet can be carried up Amelia river to Yellow Bluff, and there is good anchorage off the town of Fernandina, in from five to seven fathoms water, soft muddy bottom. Nearly four thousand casts of the lead were made in from one to thirteen fathoms water, and over eighty miles of soundings run. The tide-gauge used for the reduction of soundings was established at Fort Clinch wharf."

"High and low water was observed at Fort Clinch, Fernandina, and the town of St. Mary's, which exhibited no difference in the rise and fall of tide, or any in the time of high and low water at the two former places, the rise and fall being eight feet. The time of high water at Fort Clinch was thirty-five minutes earlier and low water forty-five minutes earlier than at St. Mary's, the rise and fall being 7.35 feet."

Tides.—The attempt to observe the tides at Indian River inlet, on the western coast of the Florida peninsula, having last year failed from circumstances stated in my report, Mr. Gustavus Würdemann was sent there in April to establish a self-registering gauge and to obtain observations for at least two lunations. This duty he satisfactorily performed, and the results have been sent to the office and reduced.

A self-registering gauge was established at Indian Key by Lieutenant James Totten, U. S. Army, and Mr. L. E. Tansill, placed in charge of it. This gives an intermediate point between Cape Florida and Key West for the study of the motion of the tide-wave along the reefs and keys. The gauge was kept working for two lunations, and the results have been returned to the Coast Survey office and reduced.

Corporal Thompson, of the Engineer company, established a self-registering gauge at the Tortugas, and observed during two lunations; this completes the general group of stations for the Florida channel.

The tides at Tortugas resemble very much those at Key West, having the same large diurnal irregularity. Those at Indian Key are intermediate in their character between the tides at Cape Florida and at Key West.

All the observations made in this region have now been reduced by the tidal party at the Coast Survey office, and the results put in the form of tide tables and furnished to me for the discussion of the co-tidal lines of the Gulf of Mexico, now in progress.

Beacons.—Beacons or signals intended to be permanent for the use of navigators were placed upon fourteen points of the Florida Reef, under the direction of Lieutenant James Totten, U. S. Army, assistant in the Coast Survey, and with means furnished by the Light-house Board, by whom also the plans for the work were approved before my instructions were issued. The localities at which the signals were erected are as follows: Beginning at the westward and passing eastward along the reef, (see Sketch No. 30,) 1, Eastern Sambo; 2, American shoals; 3, Alligator reef; 4, Croker's reef; 5, Conch reef; 6, Pickle's reef; 7, French reef; 8, Grecian shoals; 9, Turtle reef; 10, Pacific reef; 11, Ajax reef; 12, Long reef; 13, Triangle reef; 14, Fowey rocks. There yet remains one to be placed at the "Elbow," between Grecian shoals and Turtle reef.

These signals or beacons, placed on the most projecting and dangerous points of the Florida reef, are generally from four to six miles from the keys, and within half a mile of the usual limit of the Gulf Stream. "In the day-time they cannot fail to attract the attention of careful navigators, and to warn them of their proximity to danger." They stand in four feet or less of water. Close to the eastward the water is very deep.

"A vessel approaching from the seaward may sail within a few hundred yards of any of these beacons; but it would always be prudent, and particularly in very light or very heavy weather, to give them a wide berth. In light weather it often happens, especially after long easterly blows, that the force and direction of the Gulf Stream sets across the reef, and then vessels are imperceptibly carried amid the dangers, although the course steered should, if made, carry them outside of all trouble." "When this misfortune befalls the master of a vessel, it frequently occurs that the wind proves too light to draw his ship out of danger, and a few moments' indecision then is fatal. When he finds himself to the west of any one of the signals, or the signal bearing *east* from the vessel, he may be sure that he is between the reef and the keys, and consequently surrounded by shoals and dangerous rocks. In all such cases of danger, as above mentioned, unless perfectly acquainted with his whereabouts, he should lose no time in coming to anchor until he can ascertain which is the safe course to pursue."

The report of Lieutenant Totten (Appendix No. 16) contains a full description with references to a drawing (Sketch No. 30) of the mode of constructing the beacons, of the mode of distinguishing them, and of the localities, with remarks in relation to them of great interest to navigators.

These signals are piles of wrought and cast iron, thirty-six feet high, inserted below in the coral reef, and surmounted by an iron cylinder of lattice work, to render it more readily visible from a distance. "Three colors have been used in painting each signal, so as to make them as striking to the eye as possible. For this purpose *white*, *red*, and *black* have been chosen as the most conspicuous; and in painting the signals, these three colors have been so combined that no two adjacent beacons have the same colors upon the like parts."

"By examination of the colors alone, on approaching any one of these signals, the master of a vessel may ascertain his latitude and longitude with tolerable certainty; and if the letter in the vane can be made out, then there can be no mistake whatever."

The letters by which the beacons are distinguished follow each other in order from the westward, as fully described in Lieut. Totten's report. I am satisfied, after examining these signals, that some mode of distinction other than that by the letter-vane should be used; perhaps a solid made by the rotation of a letter about a vertical axis, such as is described in a note by me to the preliminary Light-House Board, and published in the report of 1852, might answer the purpose as a distinguishing mark.

The whole duty of determining the points for these beacons, of making the plans for them, of superintending their construction, and placing, was executed by Lieut. Totten with care, skill, and economy.

Doubts in regard to the specimens of bottom formerly collected in and near Key Biscayne bay and Cape Florida having arisen from the examinations of Professor Bailey, Lieut. Totten made a well-selected collection from characteristic localities while engaged in the vicinity in connecting the Key Biscayne base with the main triangulation. These, with the descriptive report of localities, &c., accompanying, have been submitted to Professor Bailey.

SECTION VII.—FROM ST. JOSEPH'S BAY TO MOBILE BAY, INCLUDING PART OF THE COAST OF FLORIDA AND ALABAMA. (SKETCH G.)

This is the first year that an appropriation has been granted for this section, which includes a difficult part of the coast, and where progress must necessarily be slow. Three parties have been at work—one in determining the astronomical position of a point in St. Andrew's bay by its latitude and difference of longitude from Pascagoula, in magnetic observations at the same point, in measuring a preliminary base, and in a secondary triangulation of St. Andrew's entrance and bay, and part of its dependencies; a second, in the topography of the same bay; and a third, in the hydrography of Ocilla river and entrance, St. Andrew's bay, and Cedar keys, and in running deep-sea lines in the Gulf. Tidal observations were also made at St. Mark's. A preliminary chart of Cedar keys and sketch of Ocilla river have been drawn, and that of

St. Andrew's bay nearly completed. Cedar keys and approaches, as preliminary, and Ocilla river have been engraved, and Cedar keys and approaches, as finished, is in progress.

Astronomical observations.—Observations for latitude with the zenith telescope on eighty-three pairs of stars, and for azimuth and magnetic declination, were made at St. Andrew's (see Sketch No. 35) by Sub-Assistant J. G. Oltmanns, of the party of Assistant Gerdes, and ninety-five transists were observed for local time and difference of longitude between St. Andrew's and Pascagoula. These were conducted during the progress of the triangulation of St. Andrew's bay. The observations for latitude were made with the zenith telescope (No. 1) of Troughton & Simms; those for azimuth with a twelve-inch Gambey theodolite (C. S. No. 16,) observing direct and by reflection in mercury; those for time, in connection with the foregoing, with the transit, (C. S. No. 9,) by Troughton & Simms; and the declinations, by a Jones declinometer, (C. S. No. 2.)

Triangulation.—The triangulation of St. Andrew's bay (see Sketch G) has been executed by the party of Assistant F. H. Gerdes. Operations were begun on the 17th of December, and by the 17th of the following March the work was completed by a system of triangles extending over the sound, including the various small islands adjacent, and embracing St. Andrew's city, together with East and Northwest bays. A new base was measured with iron wires on the north side of St. Andrew's sound, upon which the secondary triangulation rests. This was connected with the tertiary base measured last year with a chain, and gave the small difference of 0.2 of a metre between the two measurements. This work was executed by Sub-Assistant J. G. Oltmanns, under the instructions of Mr. Gerdes.

The following are the statistics of the work:

Number of signals erected and secured	36
Number of signals occupied as stations	34
Number of signals and objects observed on	67
Number of angles measured	195
Number of observations	1,176
Number of triangles calculated	63
Area of triangulation, in square miles	55

The instrument used was a six-inch Gambey theodolite, (C. S. No. 6.)

On the completion of this work the party proceeded to the execution of duty in Section VIII.

Topography.—A plane-table survey of St. Andrew's bay and sound, including St. Andrew's city, has been executed by the party of Assistant George D. Wise. This work was commenced on the 10th of January, and completed on the 22d of April. Within that period Assistant Wise was also engaged in furnishing shore-line and points for the hydrographic party engaged at St. Andrew's bay. His report of the season in this section contains the following summary of the work accomplished by the topographical party:

Miles of Gulf coast surveyed	27
Miles of road-line surveyed	17½
Miles of shore-line surveyed	130
Area, in square miles	52

"St. Andrew's bay is a very beautiful sheet of water, easy of access, and sheltered from all winds. The vicinity is considered remarkably healthy, having never been visited by the cholera or yellow fever, and is much frequented during the summer months by inhabitants from the interior, who resort to its shores for bathing, hunting, and fishing. The shores are sandy and the water bold. The soil is said to be peculiarly adapted to the culture of the grape."

The map of St Andrew's bay and sound, $\frac{1}{20000}$, drawn by Assistant Wise, is now in the archives of the Coast Survey Office.

Mr. Wise was engaged during the summer in topographical work, noticed under Section III, and will shortly return to resume the plane-table work on the western coast of Florida.

Hydrography.—The hydrography of this section has been in charge of Lieut. Comg. O. H. Berryman, U. S. Navy, assistant in the Coast Survey, commanding the schooner Varina, and has consisted of a survey of St. Andrew's entrance and part of the bay, of Ocilla river and entrance, and of part of Cedar keys. Off-shore soundings have also been made on a line from the Tortugas to Pensacola, and from Cedar keys to Pensacola. The work of the same party in Tampa bay belongs to the preceding section, (Section VI,) and the soundings for temperature in the Gulf Stream, by this party, have been noticed. The limits of the work of St. Andrew's bay are shown in Sketch G; they include the entrance and approaches, and the bay to St. Andrew's City. In his report upon this hydrography, Lieut. Comg. Berryman observes:

"In the survey of St. Andrew's bay, I did not find as much water on the bar of the main entrance as I had been led to expect—sixteen feet being all that can be carried over at low tide; but as the coast is rather bold, and the bottom clean sand, alterations may be expected in the bars and channels."

"St. Andrew's bay is a fine sheet of water, but the draught which can pass the bar cannot be carried more than three or four miles, owing to a shoal which extends from Davis's Point entirely around by Saddle Hills, and then towards the small inlet by the west end of Hurricane island. No more than thirteen feet can be found on this shoal in the deepest part; it is, however, very narrow, and after crossing it three fathoms will be found, and increasing to as much as eight in proceeding to St. Andrew's City. Good anchorage may be found, after getting over the bar and inside the banks, by hauling to the westward under 'Saddle Hills,' which form the east end of the 'Hurricane island,' with good holding ground in three fathoms. All the shoals can be seen very plainly. In windy weather, from S. W., the surf breaks nearly across the bar."

"The entrance by the east channel, around the west end of Crooked island, has a little more water than the main pass, but the communication with the west part of the bay is obstructed by a bulk-head, running in a N. W. direction from the middle ground quite to the shore, of hard white sand; and a passage about forty feet wide, with ten feet water, lies between the middle and the bulk-head."

"Very little commerce is carried on here, there being only one or two saw-mills near the head of the bay."

The statistics for the survey of this bay are as follows:

Number of stations occupied	11
Number of soundings	46,671
Number of double angles	683
Number of theodolite angles	390
Miles of lines of soundings	702
Area, in square miles (statute)	64
Number of tidal stations	3
Number of tidal stations reoccupied	1

At the request of the Hon. Mr. Cabell, a survey of the Ocilla river, much resorted to for procuring live-oak timber, was made last year by Assistants Wise and Offley, but the hydrography could not be executed. (See Sketch No. 34.) This season Lieut. Comg. Berryman, in the schooner Varina, has taken up the hydrography, executing the following work:

Number of soundings	12,240
Miles of lines of soundings	47.6
Area, in square miles	5.5
Number of theodolite angles	118
Double angles (sextant)	122
Tidal stations	1
Stations established	6

The description of the Ocilla, and some interesting particulars in regard to it, are thus given by Lieut. Comg. Berryman:

"The Ocilla river entrance is about ten miles east of St. Mark's light-house, and is fronted by a labyrinth of sand and oyster banks, which extend several miles off seaward, and are bare at low tides. The channel winds among these banks very crooked and narrow towards the mouth of the river, which empties into the Gulf of Mexico, between two extensive marshes, entirely overflowed at high tide."

"Vessels drawing five feet of water may enter this river at high tide, but they cannot swing to or around their anchorage, owing to the very narrow channel. The mouth of the river is about eight hundred metres wide, and grows narrower as you ascend. Some rocks may be found in the channel-way, and about two and a half or three miles from its entrance, a ledge crosses from one side to the other; none but boats can pass it."

"Large quantities of live-oak, ready for shipment, line the shore after getting above the marshes."

"Vessels bound for this river must obtain a pilot at St. Mark's, and then they will have great difficulty in finding their way into the entrance. The whole should be staked out like St. Mark's."

The hydrography of Cedar keys and approaches was continued from that of last year, and occupied the time of the party until it was necessary to proceed to St. Andrew's bay. The work lies west and north of the channel No. 4, (see Sketch No. 33, and Sketch G No. 2, Report 1852,) as far as Derrick key, and east and south from Snake key towards the "Oyster reefs." Lieut. Comg. Berryman states that the hydrography resembles that previously executed by him at this locality, there being a series of flats, with channels between them, leading to the passes in the Oyster reefs. The following statistics of the work are given:

Number of soundings	46,346
" double angles	322
" theodolite angles	207
Miles of lines of soundings	356
Area, in square miles (statute)	39
Number of tidal stations	2
Stations occupied	5
Stations established	5

In passing from the Tortugas to Pensacola, Lieut. Comg. Berryman ran a line of deep-sea soundings, about latitude 26° N., longitude 84° W., to latitude 30° N., longitude 87° W., taking also the temperature at the surface of the sea, at twenty fathoms depth, and at the bottom. The depths varied from ninety fathoms to three hundred and twenty, the greatest depth found, and thence to sixteen fathoms. The figure on the bottom of the line run is a gradually increasing slope from ten fathoms in forty miles to forty fathoms in twenty miles, with finally a sudden steep pitch from two hundred fathoms to three hundred and twenty in depth in twenty miles. A corresponding steep rise on the other side gave three hundred and twenty fathoms to one hundred and sixty fathoms in forty-five miles, and a varying slope, averaging about 1.6 fathoms to the mile. The surface temperatures were quite irregular, varying generally, however, from 68°.4 to 71°.4. These, at twenty fathoms, were quite uniform, varying, omitting one observation, from 67° to 69°, on the whole line. The temperatures at the bottom, allowing for irregular observations, were lower as the bottom was deeper, passing from 66° at forty fathoms depth of bottom, to about 56° at three hundred and twenty fathoms. The observations were made on the 31st of December and the 1st and 2d of January, and the temperature of the air, recorded at the same time with the temperature of the water, varied from 60°.9 to 73°.4. The connection of the deep pocket, which Lieutenant Berryman crossed, with the solution of the curious problems relating to the motion of the tide-wave in the Gulf, will probably hereafter appear.

Tides.—Tidal observations were made at St. Mark's with a Saxton self-registering tide-gauge, by Corporal Thompson, of the engineer company, for two lunations. The tides are similar to those of Cedar keys, being half-day tides, with a large diurnal inequality, or difference between the morning and afternoon tides. This difference amounted, in extreme cases, for high water, to 1.3 foot in height.

There is so great a change in the tidal phenomena between St. George's and Cedar keys, that other stations may yet have to be introduced when the minuter investigations of the motion of the tide-wave are undertaken.

SECTION VIII.—FROM MOBILE POINT TO VERMILION BAY, INCLUDING THE COAST OF MISSISSIPPI AND PART OF LOUISIANA. (SKETCH H.)

The work of this section has made unusually good progress. The primary triangulation, which has been stationary for some years for want of means to supply a party for its execution, has been resumed, and the secondary triangulation and topography of Chandeleur sound and islands has been in vigorous progress. The latitude and longitude of a point in Atchafalaya bay have been determined, and the triangulation of the bay from Point au Fer to Cote Blanche bay has been executed. The topography has followed this closely, and extends from the point just named to include Belle isle, at the mouth of the Atchafalaya river. Magnetic observations have been made at Belle isle. The topography of the neck between Lakes Borgne and Pontchartrain has been executed. The hydrography of Mississippi sound has been carried westward nearly to Pitcher point, including the back bay of Biloxi, and the entrance between Horn and Ship islands. Special deep-sea lines in the Gulf of Mexico have been run; hydrographic reconnaissances of the entrance to Vermilion bay, and that of Calcasieu river, coast of Louisiana, have been made.

The drawing of Sheet No. 1 of Mississippi sound has been finished during the season, and that of Sheet No. 2, and of Biloxi bay, has been in progress.

The engraving of sheets of Mobile bay and Mississippi sound, No. 1, is now in progross.

Triangulation and astronomical observations.—Two triangulation parties have been employed in this section during the greater part of the season; one under charge of Assistant F. H. Gerdes, and the other of Assistant J. E. Hilgard. Sub-Assistants J. G. Oltmanns and Stephen Harris volunteered to remain in this section during the summer, to advance the main triangulation and work of the Chandeleur islands, which had fallen behind the actual wants of the other parts of the work in this locality.

The zeal and devotion to the service of these young gentlemen, and of Messrs. J. S. Harris and R. Halter, aids, who are with them, deserve great commendation. It has exposed them to one of the most violent hurricanes which has occurred on this part of the coast for many years, of which the vicinity of Mississippi City appears to have been the seat of greatest violence. The uneasiness which was felt in regard to the exposure of these officers and their men in the small schooners of the survey has been happily disappointed—intelligence having been received of their safety.

Assistant Gerdes was occupied on the Hudson (Section II) during last summer, and in inking the topographical sheets resulting from the season's survey; Sub-Assistant Oltmanns, in the meanwhile, in the schooner Gerdes, taking up the triangulation of St. Andrew's bay, (Section VII,) as already noticed.

Observations for time having been made at Pascagoula, the chronometers were transported in the schooner Gerdes to Atchafalaya bay, to obtain the difference of longitude, (see Sketches G and H.) An astronomical station was established on Deer island, at the mouth of the Atchafalaya river, at which latitude observations were taken with the zenith telescope, (C. S. No. 1,) and time observations made with the transit, (C. S. No. 9.) The magnetic declination was observed also at the same station.

"One of the difficulties encountered was in the selection of a good site for a base, and it was found impossible to employ in the measurement anything but a chain, as the ground consists entirely of marsh. A line was selected at Point au Fer, and connects with the work, as will be seen by reference to Sketch H.

"A better line can be measured with the rods and trestles on Cote Blanche bay, which will be in the middle of the work."

This base is, therefore, to be considered as altogether preliminary. It has been seen at St. Andrew's that Mr. Gerdes's chaining may be safely relied upon for such purposes.

The triangulation extends from Point au Fer (Sketch H) to Cote Blanche bay, and includes an area of about two hundred and eighty square miles.

"It consists of primary, secondary, and tertiary triangles, of very good shape, fulfilling all the necessary conditions. The primary lines vary from ten to fifteen miles in length, and all of them have been observed on sufficiently for a preliminary survey."

The statistics of this work are reported as follows:

Transit observations for time, at Pascagoula and Deer island	161
Observations for latitude, (pairs of stars)	86
Observations for azimuth on Polaris, at Point au Fer light	60
Observations for magnetic declination	225
Triangulation stations, number of	17

The usual books and records were duly prepared and turned in with this work.

In conjunction with Assistant Hilgard, Mr. Gerdes re-measured a portion of the Dauphine island base, to verify the marks there, which had in part been disturbed in the hurricane of 1852. This work has been satisfactorily accomplished, and a new terminus marked for the west end of the base, derived from the marks of the old measurement. The result of this work has been very gratifying, as but for the care taken during the measurement in 1847, to mark intermediate points along the base, and to retain even the occasional markings undisturbed, the west end of this base might have been lost, the hurricane having obliterated or disturbed the monument, and the marks connected with it.

At the close of this work Mr. Gerdes returned to Section II, where he has been employed in New York bay and harbor for the Commissioners. (See Section II.)

Sub-Assistant Oltmanns, in the schooner Gerdes, took up the triangulation and topography of the Chandeleur islands, and to avoid the necessity of waiting for the connection of the triangulation on the north, measured, in conjunction with Sub-Assistant Stephen Harris, a preliminary base on one of the divisions of Chandeleur island, (see Sketch H,) and has made a secondary triangulation for connecting the islands of the group with each other and with the main. He reports, under date of August 22d: "I have laid out and measured nearly all the angles of a secondary triangulation from the Chandeleur, north end, towards the south some eighteen or twenty miles, and to the westward, embracing those of the Chandeleur islands, generally called the Freemason Keys. From these a connection with the main land may be established."

"The angles were measured with the twelve-inch Gambey theodolite, (C. S. No. 16,) by two or three sets of six repetitions, direct and reversed, and the triangles close very well, $2''.7$ being the largest correction for any single triangle."

"The atmosphere is generally, except very early in the morning, so heated, that observing with any degree of accuracy becomes impossible, and in only two instances have I been able to observe in the afternoon."

Much of the result of the patience and labor of the party was destroyed by the disastrous hurricane of September 16th of the present year. Its effect on the immediate site of his work is thus described by Mr. Oltmanns:

"The beach on which the base was measured is entirely washed away, and at the north end I found, instead of a sand-bank from ten to twelve feet high, *eight feet of water*. Only four or five posts throughout the line remain to show even the situation of the base. Nearly all the stations were disturbed in such a way as to require the re-erection of signals."

Proper measures have been taken for restoring the signals, and for repeating the observations rendered necessary by their displacement.

The party is still engaged in this duty, and satisfactory progress in its accomplishment has been reported.

The continuation of the primary triangulation of this section on Mississippi and Chandeleur sounds was entrusted to Assistant J. E. Hilgard, who also had charge of work connected with the publication of the Coast Survey records and results, which required his presence in Washington.

In his absence the party is in charge of Sub-Assistant Stephen Harris, with Mr. J. S. Harris as aid. Mr. Hilgard, after reporting his preparations for work in December last, says:

"After erecting tripods and scaffolds at all the principal stations, (the weather being too hazy for observation,) I awaited opportunities for measuring angles, but such was the prevalence of fog and smoke, that up to February 12th I succeded in measuring completely the angles at only one station, (East Pascagoula,) and partially at two others. At that time, conceiving that the work could not be carried on to advantage during the ensuing two months, I discharged the hands, and entrusted my aid, Mr. J. S. Harris, to occupy and measure the angles at station 'Mississippi City,' while I proceeded to Washington, to confer with you in regard to the publication of records and results."

"I rejoined my party in Section VIII on the 12th of April, and by May 3d completed the measurement of angles in the quadrilateral *East Pascagoula*, *Horn Island east*, *Horn Island west*, and *Bellefontaine*. Mr. Harris had succeeded in getting a great number of measures of the angles at 'Mississippi City.' At that time I was joined by Mr. Stephen Harris, who was to continue the work after my return to Washington. We proceeded to Lake Borgne and Pontchartrain, examined the condition of the signals, and replaced those that had decayed."

"Observations at Rigolets light were completed, and those at Grand island partially finished by the close of May, and the annexed sketch shows by red lines what remained to be done at that date. I left my party on May 24th, leaving Mr. Stephen Harris in charge, with detailed instructions for the continuation of the work."

Up to October 1st, the date of Mr. Hilgard's report, six primary stations had been occupied, and two hundred and twenty-one angles measured with the 10-inch (No. 74) and 12-inch (No. 37) Gambey theodolites. The progress made is shown on Sketch H.

In the intervals, when observations on long lines were less practicable, the secondary triangulation in Lake Borgne and Lake Pontchartrain was pushed by the party, and hopes are entertained of its completion as far as New Orleans before the close of the present year. Between the middle of May and the end of August, eight stations were occupied, and three hundred and thirty-five angles measured by six repetitions of each, (Sketch H.)

"Much delay and additional work was caused by the loss of some of the station-marks. The instability of the shores in this region makes the preservation of stations a matter of great difficulty, which it is now proposed to meet by the use of iron screw-piles."

Topography.—The three localities where topographical work has been in progress in this section are: Atchafalaya bay, Louisiana; between Lakes Borgne and Pontchartrain; and the Chandeleur islands; the first, by Assistant F. H. Gerdes; the second, by Assistant R. M. Bache; and the third, by Sub-Assistant J. G. Oltmanns, (see Sketch H.)

Mr. Gerdes' survey at Atchafalaya, occupies the four sheets marked on Sketch H, including Point au Fer, and the eastern side of Atchafalaya bay and Belle isle. The sheets give, together, rather more than one hundred miles of shore-line, and embrace an area of about seventy square miles.

Sub-Assistant Oltmanns followed, under the direction of Assistant Hilgard, his own triangulation of the Chandeleur islands by a topographical survey, beginning at port Chandeleur and extending southward, including the Chandeleur islands, to a point half a mile below the south base, and the north of Freemason keys to Point Hope, (Sketch H.) This work comprised one hundred and twenty-six miles of shore-line; but in consequence of changes caused by the recent hurricane, already referred to, a re-examination will be necessary before the return of the topographical sheets. The proper directions have been given for this purpose.

Mr. Oltmanns observes: "The southeast and south wind raised the tide quite over the islands, and, as I actually measured at the time, there was a current of six and a quarter miles per hour. As a natural consequence, the shape and size of the Chandeleur islands have undergone material alteration. The changes are small at the north end, but become more frequent and considerable to the southward."

Mr. Oltmanns is still engaged in the revision rendered necessary by the circumstances just mentioned, and the shore-line will at once be re-surveyed where it has changed, so as to be in proper condition for the execution of the hydrography.

The topography of the neck of land between Lakes Borgne and Pontchartrain (see Sketch H,) has been in part executed by the party of Assistant R. M. Bache. His party was organized in February, but in consequence of delays in the necessary repairs of the vessel employed in the work, operations in the field were not commenced until the end of March.

The sheet of the season embraces the eastern part of the Rigolets and the adjacent shore of Lake Borgne. The party remained in the field until the 12th of June, at which time the survey comprised thirty-four miles of shore-line, within an area of about seven square miles.

Assistant Bache has been engaged in office-work since his return, and will shortly resume the topography of this section.

Hydrography.—The hydrography has been continued by the party of Lieut. Comg. B. F. Sands, U. S. Navy, assistant in the Coast Survey, in the steamer Walker. Before resuming his duties afloat, the office-work of the last season was closed up, consisting of the plotting and inking of his chart of soundings off Horn and Ship islands, from the meridian of Round island nearly to Cat island, scale $\frac{1}{20000}$, and of lines of soundings run between Pensacola and Mississippi delta, and of one run south of the delta in search of a reputed shoal, scale $\frac{1}{600000}$. The hydrographic note-books and journals were also duplicated and verified.

The regular hydrography of the Mississippi sound was advanced from a line between the west end of Horn island and Belfontaine, completing the sound westward to within two miles of Pitcher point, and including the back bay of Biloxi and the entrance between Horn and Ship islands.

Lieut. Comg. Sands remarks:

"We were much interrupted by foggy and hazy weather; but such time was profitably employed in repairing damages sustained in the several gales which we had encountered in the month of January."

After closing this part of the hydrography, an examination was made of the channel between Pelican and Dauphine islands, which a few years ago was used by the steamboats plying between Mobile and New Orleans. This channel was found to have but five feet of water in it, and about thirty yards in width, "entirely impracticable for vessels, and changed by every gale from the southward of east or west."

Lieut. Comg. Sands continues:

"The little bay between Pelican and the east side of Dauphine island was not materially changed, and is still a good anchorage for vessels that can enter the channel at the south end of Pelican island, where twelve feet can be carried in."

A reconnaissance was made of the entrances to Vermilion bay and to Calcasieu river, Louisiana, (Sketch No. 40,) by Lieut. Comg. Sands, and sketches were furnished to the Light-House Board, at whose request the work was executed. These are appended to this report. Of the bar of Vermilion bay, Lieut. Comg. Sands reports, that "none but very light-draught vessels can get over it;" and of that of Calcasieu, that "it has five and a half feet at low water, shoaling gradually to that depth from three fathoms, and deepening on the inside to twelve and fourteen feet in the river."

On his passage out to Section VIII, Lieut. Comg. Sands began a line of deep-sea soundings and temperatures, intending to pass from the northwest passage out of Key West harbor to the delta of the Mississippi (Sketch No. 38,) but was interrupted by a gale, on the abatement of which the line was resumed. Unfortunately the information in regard to depths over two hundred and fifty fathoms is incomplete, and that depth is soon reached from either end of the line. The facts in regard to temperature are, however, interesting, showing that late in December, while the temperature of the air was from 61° to 73° Fahrenheit, surface temperatures in the Gulf were found as high as 77° Fahrenheit; and that at a depth of about two hundred and thirty fathoms, the lowest temperature measured was 50° Fahrenheit.

Other interesting lines of deep-sea soundings were run by Lieut. Comg. Sands: one from Ship Island shoal to the delta of the Mississippi gave no depth greater than thirty fathoms; a second, from the eastern side of the delta to near Pensacola, gave, after finally leaving the delta, no depth less than thirty-seven fathoms, being, in fact, well on the plateau before remarked in this region; a third, from Pensacola southward, shows that the depths increase rapidly at a moderate distance from the shore, compared with the corresponding increase further to the westward.

Sections prepared from this work will be found on Sketch No. 38.

The remarkable work executed by Lieut. Comg. Sands in the Gulf Stream has already been noticed. (See Gulf Stream.)

A fourth line of soundings was run from Mobile entrance towards Key West. (See Sketch No. 38.)

In summing up his season's hydrography, Lieut. Comg. Sands remarks:

"The work of the party, with all the disadvantages of bad weather, as will be seen by the following statistics, is nearly double that of any previous season, which is mainly attributable to being well officered and manned, enabling me to take advantage of every hour of favorable weather with a strong force."

The amount of work of different kinds and in different localities is thus stated:

	Miles of soundings.	Number of casts.	Angles.	Temp. stations.
Mississippi sound, Biloxi bay and entrance, between Horn and Ship islands	1,297	93,050	2,327	
Examination of Pelican sound	20	1,367	46	
Reconnaissance of Vermilion bay	120	8,084	331	
Reconnaissance of Calcasieu river	35	2,770	162	
Line from Key West to Mississippi delta and Ship shoal	235	132	----------	11
Line from Mississippi delta to Pensacola	124¾	62		
Line from Pensacola, south	80¾	50		
Line from Mobile to Key West	406¾	76	----------	4
	2,319¼	105,591	2,866	15

A line of soundings was run across the entrance to the Mississippi delta by Lieut. Comg. E. J. De Haven, carrying depths from nine to forty-two fathoms.

An apparatus for bringing up specimens of the bottoms has been contrived by Lieut. Comg. Sands, a description and figure of which are given in Appendix No. 56, and Sketch No. 55. It is quite different in form from any of those previously used in the survey, and practice alone can decide in regard to the several merits of the plans for different kinds of bottom. In speaking of one of his lines of deep-sea soundings in the Gulf, Lieut. Comg. Sands observes: "These deep-sea soundings have enabled me to test satisfactorily my specimen-tube, a plan of which I have submitted to you. It never failed to bring up a specimen of the bottom except upon one occasion, when the lead and specimen-tube came up so battered and bruised as to prove conclusively that it had struck rock."

We are indebted to Lieutenant Comg. Sands for the arrangement of a gas-pipe tripod for signals on shoals, and for beacons—a description of which is given in Appendix No. 60, and a drawing in Sketch No. 54.

I extract from his report the remarks in relation to the tests to which this tripod has been subjected: "One was placed, in May, 1853, on a shoal off the west end of Horn island, in the entrance between Horn and Ship islands, a situation exposed to heavy seas from the Gulf of Mexico, and upon resuming my work this season I found it unmoved—more firmly fixed even than when first placed, after a lapse of two years."

"The success of the experiment induced me to place it in the midst of the breakers, on Dog Island bar, in the same inlet, as a signal to be used in my hydrographic work, and I left it there to serve as a beacon for vessels navigating Mississippi sound, as the bar is close upon the southern side of the deep channel running along to the northward of Ship and Horn islands."

Light-houses.—The reports of Lieut. Comg. Sands, of reconnaissances made of Vermilion bay and Calcasieu river, at the request of the Light-house Board, are given in the Appendix Nos. 80 and 81. The sketches resulting are shown on Plate No. 40. I have already noticed the work under the head of hydrography in this section. Lieut. Comg. Sands recommends the discontinuance of the light at the entrance of Vermilion bay, and reports against the erection of a light-house at Calcasieu river.

SECTION IX.—FROM VERMILION BAY TO THE BOUNDARY, INCLUDING PART OF THE COAST OF LOUISIANA AHD THAT OF TEXAS. (Sketch I.)

The progress of the survey has been interrupted in this section by causes which could not be foreseen, and which will be referred to in giving an account of the operations. A triangulation and topographical party, and a hydrographic party, with two vessels, have been at work during part of the season just past. The details in this section are so few that progress is rapid in proportion to the time expended, but not in proportion to the means, in consequence, chiefly, of the expense of supplies, and the difficulties in regard to transportation.

Steps have already been taken to secure the early arrival of the parties in this section at their several stations, and a topographical party will be added to those sent there last year.

The engraving of the map of the entrance to the Rio Grande has been completed.

Triangulation.—The triangulation of the coast of Texas, southward and westward from the head of Matagorda bay, has been extended during the season by the party of Assistant S. A. Gilbert. At the close of the last season, Assistant Gilbert made a plane-table survey of part of Cape Small, which is referred to in Section I. In consequence of unavoidable delays in receiving instruments and equipage for the party, operations were not commenced on the coast of Texas until the middle of March. The triangulation covers the upper part of Matagorda bay, from its eastern extremity to stations near Palacios bay, a lineal extent of about twenty-eight miles, (see Sketch I.) Assistant Gilbert selected ten principal stations, eight of which were occupied in the measurement of forty-four angles. The series of triangles comprises an area of about two hundred square miles.

The following description is given by Mr. Gilbert of the character of the country over which his survey has extended: "With the exception of the immediate vicinity of the Colorado river it is prairie; much of it is low and wet, liable to be flooded from the bay during very high water. The woods along the Colorado are very dense, mostly cotton-wood and willow. The river empties into the bay by two mouths, but for several miles back it is a perfect labyrinth of channels, bayous, and islands. There is but little trade in or out of it as yet, but it is being improved so as to be made navigable at all stages of water. The entrance to both mouths is very shoal (about three feet) over a bar of hard sand and shells. Matagorda is a pleasant town of about three hundred inhabitants; it was almost demolished by the September tornado, but has been nearly rebuilt."

Topography.—In connection with the triangulation, the party of Assistant Gilbert executed the topography of the western shore of Matagorda bay from "Seven Mile Station" above Matagorda, southward, to include the town, and the mouth of the Colorado river (Sketch I.) In that extent, about twenty-four miles of shore-line were determined, and eighteen miles of roads. The area embraced in the topography is about eighteen square miles.

Assistant Gilbert mentions, in terms of high praise, the efficient services of Mr. Malcolm Seaton, attached to his party.

On his return from this section, in the middle of June, Mr. Gilbert was engaged in his office-work, but later in the season, on a pressing call for his services, took the field in Section II, where he will be engaged until the usual time of making preparations for return to the southern work.

Hydrography.—The party of Lieut. Comg. E. J. De Haven, U. S. Navy, in the schooners Arago and Belle, has been engaged in continuing the in-shore hydrography of the coast of Texas, southward from the entrance to Galveston bay, and that of the upper part of Galveston and Turtle bay, which is now completed (Sketch I.) Work was commenced on the 21st of January and continued until the 15th of May, at a good rate of progress. At the last mentioned date, while the party was engaged in landing materials for the erection of a signal at San Bernard station, the Arago was set on shore by the force of the current. The damage received and the advance of the season induced Lieut. Comg. De Haven to return to the North, after having temporarily repaired the vessel. The report in detail of the disaster to the Arago is given in Appendix No. 67. The in-shore soundings were carried from above Bolivar Point, southward and westward along the coast, nearly to Bernard station, a distance of about fifty miles (Sketch I.) The soundings in Turtle bay were made in the schooner Belle.

Whole number of soundings	20,865
Miles run in sounding	1,014
Angles observed	1,080

Tides.—Tidal observations were made for correcting the sounding at Bolivar Point, at San Luis, and at Velasco—the establishment of stations outside of the bars being reported as impracticable. The observations for the progress of the tide-wave in the Gulf of Mexico have been completed in this section.

Light-houses.—An examination for a light-house site at Gallinipper Point, Lavacca bay, was made by Lieut. Comg. De Haven, and has been reported. (See Appendix No. 82.) Several aids to navigation in Matagorda bay, recommended by him, are stated in Appendix No. 73.

SECTIONS X AND XI.—COAST OF CALIFORNIA, AND OF OREGON AND WASHINGTON TERRITORIES. (SKETCHES J AND K.)

The regular operations of the survey have been successfully carried forward during the past year in both these sections, as the details in the following pages will serve to show.

The primary triangulation north and south of San Francisco, and the tertiary system along the coast connected with it, has advanced satisfactorily. The triangulation near Santa Barbara, and of the Western islands, has also made progress.

The triangulation of Port Townsend harbor, of Admiralty inlet, and of Puget's sound, has been carried on from a base measured near Port Townsend.

The topography in connection with each one of these triangulations has followed them closely. That of the coast between San Francisco and Monterey has been nearly completed, so as to join the two places. Anacapa, part of Santa Cruz, and the coast between Point Duma and Buenaventura, have been surveyed.

The hydrography of San Francisco entrance, and bay proper, has been completed within the limits necessary for a complete chart of the bay. Some interesting developments have been made in the course of this survey. The hydrography of the coast near Point Duma, and of the

Western islands, has been in progress. A dangerous rock on Cortez bank has been determined in position, as also a rock on the immediate coast near Point San Pedro, upon which the steamer "*Uncle Sam*" struck. (Appendix Nos. 18, 19.)

Light-house examinations have been made at several points.

The investigation of the tides has been continued, and some interesting results in regard to earthquake waves have been observed. The co-tidal lines of the Pacific coast have been approximately established.

The preliminary chart of San Francisco entrance, map of south Farrallon island, and Alden's reconnaissance, northern sheet, have been drawn and engraved to accompany this report. (Sketch No. 48.)

Assistant George Davidson has furnished a valuable article descriptive of the coast, from the northern to the southern boundary.

A complete history of the exploration and discovery, with an analysis of the names of localities, and a historical map, has been furnished by Dr. J. G. Kohl, and an abstract is appended to this report. (Appendix No. 64.)

An able report on the geology of the immediate coast, which has such close relation with its topography and hydrography, has been made by William P. Blake, Esq., geologist of the Exploring Expedition of Lieutenant Williamson, U. S. Topographical Engineers, and is also appended to this report. (Appendix No. 65.)

Primary triangulation.—This work, northward from San Francisco, and on Monterey bay, California, was continued in charge of Assistant R. D. Cutts until the time of his relief in April, by the arrival of Assistant G. A. Fairfield, appointed to that duty.

The party of Assistant Cutts moved from the station "*Santa Cruz,*" (see Sketch J K No. 2,) at the end of November, having in the interval, when observations on the main lines of the series were prevented by unfavorable weather, completed three tertiary stations in the vicinity. On completing the station at the mouth of Pajaro river his efforts were employed in marking, by stone blocks, the primary stations on San Pablo bay for their future security, and in placing stone monuments, with suitable inscriptions, to mark the termini of the Pulgas base.

"Each monument is of the same size and material, and consists of two pieces of Benicia freestone, viz: a square shaft and pedestal."

"The shaft is 5 feet in height, and its top and base 1 foot 10 inches, and 2 feet square, respectively. The diminution from the base upwards is one-twelfth; the shaft weighs a ton and a half. The pedestal is 2 feet 8 inches square, and 1 foot 3 inches in height, including the inch bevel on the top, and upon which the shaft rests. The weight of the pedestal is three-fourths of a ton."

The usual inscription is cut upon the monument at each end of the base.

After completing observations at a third station, connecting with the two on Monterey bay, before mentioned, the party resumed operations on the series extending northward from San Francisco bay. In reference to this work Assistant Cutts remarks:

"This station (Sonoma Mount, see Sketch J K No. 2) will connect with the hills overlooking Bodega bay, and, to the northward, with the mountains lying between Russian river and Clear lake. The character of the country is such, that it is not possible to determine from the primary stations the topographical points necessary for the delineation of the coast. A small tertiary series is indispensable for this purpose, so far as I have reconnoitred."

"Now that the triangulation, both to the northward and southward, has emerged from the confining barriers extending from San Francisco to Mount Bache, the scheme for the primary triangulation in both directions can be much enlarged, should it be deemed advisable. The last line observed from Mount Bache was fifty miles in length, and the base for the continuation of the work southward is forty-seven miles."

A sketch of the triangulation executed and proposed, and the records, abstracts of angles, computations, &c., appertaining to the work up to the period of the departure of Mr. Cutts on the 16th of May, have been received at the office, and duplicates of the results, together with tracings of the topographical sheets, were turned over to Messrs. Fairfield and Rodgers, to form part of the archives of their respective parties.

The statistics of the work executed between the beginning of the present surveying year and May 1st, are as follows:

Primary stations occupied	2
Secondary and tertiary stations occupied	5
Number of angles observed and determined	47
Number of horizontal measurements	1,966
Number of signals erected	16
Number of vertical measurements	274
Number of observations for azimuth	368

The weather, since the arrival of Assistant Fairfield, has much hindered the progress of the triangulation northward from San Francisco.

After a short leave of absence, Assistant Cutts was assigned to duty in New York harbor, (see Section II,) and relieved from that to take the important position of surveyor to the commission under the treaty relating to fisheries on the coast of the United States and the British provinces of America.

At the close of May last, Assistant George Davidson, in the Coast Survey brig *Fauntleroy*, left San Francisco for Washington Territory, where he was to undertake the triangulation of Admiralty inlet. In July a short preliminary base, a mile and three quarters in length, had been measured near Port Townshend for the work of Admiralty inlet, Puget's sound, and Hood's canal; but Mr. Davidson still hoped, in the course of the triangulation, to find a better base than this, especially for the triangulation of the Straits of Fuca. The side on which the triangulation of Port Townshend connects with that of Admiralty inlet being but two miles, and the longest lines of the inlet work about ten to fifteen miles, the length of the base already found would not be objectionable, if the triangles from it were well conditioned.

The unusually hazy character of the weather much hindered the progress of the triangulation, which, however, Mr. Davidson was enabled to carry to the line "Bush—Foulweather," at the entrance of Hood's canal, (see Sketch J No. 3,) erecting signals also as far as "Point No-Point," on the west side, and Useless bay, on the east.

Sub-Assistant J. S. Lawson, under the direction of Mr. Davidson, executed a tertiary triangulation in connection with the topography of New Dungeness. He has also completed topographical surveys of Port Ludlow and Smith's island, at the entrance of the Straits of Rosario.

In the course of the triangulation the number of first-class signals erected by Assistant Davidson was nineteen, with an equal number of the second class. Fourteen stations were occupied, at which one hundred and six angles were measured by two thousand six hundred and twenty-eight repetitions upon one hundred and one objects. The number of secondary objects observed upon to assist in sketching the shore-line was three hundred and six.

Altitudes were observed with the sextant at two stations upon twenty objects.

Sub-Assistant Lawson occupied four stations at New Dungeness, and measured ten angles by one hundred and ninety-two repetitions. His topographical work embraces a total shore-line of thirty-four miles, and an area of about 4.7 square miles.

A change in the position of the bubble of the level of the zenith telescope in use at Humboldt astronomical station was noticed by Assistant Davidson during the prevalence of shocks of an earthquake. Unfortunately, the transit instrument, with its level, was not in use, and the observations on the level of the zenith telescope were not such as to lead to any conclusion beyond that just stated.

On closing their work in October, 1854, Assistant Davidson and Sub-Assistant James S. Lawson, who had been five years on the western coast, were instructed to return to the Atlantic side, and I had begun to make arrangements for substituting other officers in their places, when they applied to return to these Sections.

The experience which they had acquired rendering them so especially competent for duty there, I did not hesitate to comply with their request, and they returned in March last to San Francisco. Assistant Davidson has again been afflicted with rheumatism, but his persevering energy has kept him in the field.

I am indebted to Mr. Davidson, who was one of the pioneers on this coast, and has, from choice, worked there, returning after a short visit to his friends, for a good general description of the western coast from the northern to the southern boundary. He has been frequently up and down the coast in the several vessels of the survey and in almost every mode of conveyance which the country affords, determining geographical positions, making magnetic observations, executing the triangulation and topography of the survey, examining sites for light-houses, and engaging in all the miscellaneous duties which the beginning of a survey necessarily require. His descriptions are, therefore, generally drawn from his own observation; and where he has collected the information, he so states in his report. This memoir (Appendix No. 26) will be found to contain notices of the following localities: Straits of Rosario, Canal de Haro, (islands forming these straits,) Admiralty inlet, Puget's sound, Straits of Juan de Fuca, coast from Cape Flattery to Gray's harbor, Shoalwater bay, Columbia river, coast from thence to Cape Blanco, Rogue river, Crescent City, Klamath river, Trinidad bay, Mad river, Humboldt bay, Eel River valley, Shelter Cove, Mendocino City, Albion river, Point Arena, Haven's Anchorage, Bodega bay, Tomales bay, Point Reyes, the Farrallones, the Golden Gate, San Francisco, the coast from thence to Monterey bay, San Simeon, San Luis Obispo, coast south of Point Conception along Santa Barbara channel, San Pedro bay, Los Angeles, Mission of San Luis Rey, and San Diego. Valuable information is given in reference to the character and modes of execution of the Coast Survey work in California and Oregon and Washington Territories.

Some additional work in the triangulation for connecting the western islands and the coast was executed by Captain E. O. C. Ord, U. S. Army, after the date of my last report, and before the order relieving him from Coast Survey duty reached him. As early as he could be spared from this side, Assistant W. E. Greenwell was instructed to relieve Captain Ord. A vessel suited to the western coast (the schooner Humboldt) was built under the direction of Mr. Greenwell, and sent round Cape Horn, while he proceeded by the most direct route to San Francisco. The appropriation had been so nearly exhausted by the expenditures for the party of Captain Ord, that Mr. Greenwell judged it expedient to await the arrival of his vessel, and of the new fiscal year, before undertaking to organize a party. The schooner Humboldt was injured in a gale and put into Rio for repairs. Proceeding on her voyage, she reached San Francisco, after a tedious passage, at the close of the month of August; and, at the last advices, Assistant Greenwell was at San Pedro, with instruments in place, and ready to take advantage of the first favorable weather which might offer for observing. He had erected signals at Point Duma and Santa Barbara island, and three on Santa Catalina (Sketch J K No. 2.)

The ultimate plan of Captain Ord for the accomplishment of this work, as stated in his supplementary report, was, to proceed from a base measured near Los Angeles, connecting thence with the nearest island, and including all the islands in a series of triangles, joining them at practicable points with the main. Assistant Greenwell expresses strong hopes of being able to find on Santa Cruz island a site for a base which may serve for the triangulation of that and the neighboring islands, and afford at once the preliminaries requisite for their topographical survey.

He commends, in his report, the willingness and energy shown in the service by Mr. P. C. F. West, attached to his party as aid.

Sub-Assistant A. F. Rodgers has continued the topography of San Francisco bay and that of San Pablo bay and its dependencies. Just previous to the date of my last annual report, he had completed a sheet extending from the entrance and embracing the western shore of San Pablo bay as far as Petaluma creek, the shore of which it also includes. He has since completed the topography of the opposite shore of the bay, from the mouth of Karquines strait southward to a point beyond the entrance, and that of the eastern shore of San Francisco bay from San Antonio creek, opposite to the city of San Francisco, and extending southward about nine miles.

The following are the results of his season's work:

Miles of shore-line of land surveyed	$73\frac{1}{2}$
Miles of marshes, creeks, roads, and ponds	245
Total area (square miles)	$62\frac{1}{4}$

Sub-Assistant Rodgers has sent to the office the sheets containing his work of the present season. Mr. Rodgers also re-surveyed the shore of San Francisco entrance near Fort Point, the topography of which had been materially changed in the preparation of the site for the works of fortification there.

In assigning a reason for a recommendation, which has been adopted, that the projected sheet—San Francisco bay and harbor—should be extended to include San Leandro creek, Mr. Rodgers remarks: "Within the limits of this sheet is the topography of the bay of San Leandro, upon the western bank of which is the village of Alameda; between this and the neighboring town of Oakland, upon San Antonio creek, much rivalry exists, each claiming superior advantages as a point of embarcation for the produce of the garden county of the State, (in which they are both situated,) finding a market, as it must do, in San Francisco through one of these channels. A great drawback to the prosperity of Alameda and Oakland has been found in the shallowness of the water at low tide, in approaching them from the main bay, rendering the arrival and departure of ferry-boats so irregular as to prevent their being resorted to by the business men of San Francisco as places of residence, while their milder climate and picturesque beauty of location eminently fit them for such retirement. Should San Francisco fulfil the promises of early days, and attain the importance which, as the commercial emporium of the western coast of our continent, she seems destined to, the towns opposite to and so near as Oakland and Alameda will, of course, participate in her prosperity. Various projects for improving the channels in the San Antonio creek and that of San Leandro have already been discussed, and a bill appropriating thirty thousand dollars for deepening the former channel was brought before the legislature of the State at its last session. I would most respectfully recommend that the bay of San Leandro and adjacent shores be included in the harbor chart of San Francisco bay when published. More than the additional topography necessary for the extension of the project map, as sent from the office to Lieut. Comg. Alden, is furnished upon the plane-table sheet which I forward herewith. A harbor map without this work upon it would appear incomplete, as San Leandro and San Antonio creeks are the only important points upon the bay in the vicinity of San Francisco, and as such attract especial attention."

Sub-Assistant W. M. Johnson has continued the topography of the coast between Point Año Nuevo and Pigeon Point, (Sketch J No. 2,) and executed the surveys necessary for examinations for sites of light-houses at Santa Barbara and San Pedro. (Sketch No. 45.)

Of the country embraced in the first-named survey, Mr. Johnson says: "The country gone over is very broken, being intersected by deep ravines running perpendicular to the general direction of the coast line; several of these contain living streams of pure water, and in this particular it possesses great advantages as a grazing country. The point of greatest elevation embraced within the survey is five hundred feet above high water."

Mr. Johnson gives, in this connection, reasons for preferring Pigeon Point to Point Año Nuevo for the site of a light-house, which have been submitted to the Light-house Board. (See Appendix No. 74.)

The work of the season was interrupted by the illness of Mr. Johnson, but resumed at the earliest moment with his characteristic fidelity. The results of the examinations made by Lieutenant T. H. Stevens, U. S. Navy, assistant in the Coast Survey, near Santa Barbara and San Pedro, based on the surveys of Mr. Johnson, are given in Appendix No. 83.

Returning from this work, that of the coast north of Pigeon Point was resumed, when Mr. Johnson received instructions to co-operate in the survey of Santa Cruz and Anacapa islands, (Santa Barbara islands,) and the adjacent coast, for light-house purposes, (Sketch J.) Of this survey, Mr. Johnson says: "The islands make a double sheet, as we succeeded in connecting them by triangulation, three points on Anacapa having been established from the triangulation on Santa Cruz as a base. This was the only way in which the survey could have been made satisfactory, as, from the formation of Anacapa, it would have been impossible to get a sufficient base to connect the three parts of this island. The west end of Anacapa is a peak nine hundred and thirty feet in height, the base of which is 3,893 yards long and 1,239 yards wide. This is separated from the middle island by a gap ten feet wide, through which the boats usually passed to and from work."

"The middle island is 2,964 yards long and 493 yards wide. East island is 2,088 yards long and 493 yards wide. The gap separating Middle and East islands is two hundred and four yards wide; but, from the great number of rocks, it is impassable even for the small boat of the schooner. The length of Anacapa, on a direct line from point to point, is five miles and forty-five yards."

The party of Sub-Assistant Johnson has since been employed in the topographical survey of the coast of Santa Barbara channel, between Buenaventura and Point Duma, and in furnishing points and shore-line for the hydrographic party now engaged there. The following statistics for the season are reported:

Number of miles of coast-line surveyed	49½
Number of miles of shore-line of rivers, creeks, &c	37½
Number of miles of roads of rivers, creeks, &c	34
Area of country in square miles	30½

Interesting particulars in regard to Santa Cruz island and the valley of San Buenaventura will be found in extracts from the report of Mr. Johnson, (Appendix No. 28.)

Hydrography.—Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey, in the steamer Active, has been engaged in the hydrography in these sections, assisted during part of the season by Lieut. Comg. T. H. Stevens, U. S. N., and during the remainder by Lieut. Comg. Archibald MacRae, in the schooner Ewing.

A summary of the operations of the party under the immediate charge of Lieut. Comg. Alden, from the date of my last report to the close of June, when they proceeded to Washington Territory, is thus given in a report from the chief of the party:

"Soon after our return from the North, the soundings in Sir Francis Drake's bay and about Punto de los Reyes were done, (Sketch No. 47;) then the work on the bar and entrance of San Francisco bay, including some ten miles of the coast on either side, was commenced and steadily continued, with occasional interruptions by the weather, to its completion. This chart, with a report in relation to matters connected with it, was forwarded to you on March 16th, together with some two hundred and thirty specimens of the bottom. The work inside was then resumed, and connected with that previously done and the inside work. The whole is comprised in six sheets, the last five of which were sent to you on the 1st instant, with forty-one additional specimens of the bottom. The accompanying sketch will show the limits, and the following statistics the amount of hydrography done in and about the harbor: Fourteen hundred and sixty-four miles have been run in soundings, and twenty-five thousand six hundred and ninety-three (25,693) soundings taken. The number of angles taken with the theodolites, for hydrographic positions, is six hundred and ninety-one; and the number with the sextants, for the same purpose, is five thousand seven hundred and sixty-seven, (5,767.) The square miles of area sounded out are three hundred and two, and the number of specimens of the bottom taken is two hundred and twenty-seven."

"Sailing directions, and remarks on the bar and entrance, were forwarded to you with the chart on March 15th, and I would now briefly notice all the outlying hidden dangers on the inside of the bay which have come under my observation.

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APPENDIX.

APPENDIX No. 1.

Distribution of the parties of the Coast Survey upon the coast of the United States during the surveying season of 1854–'55.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
I	From Passamaquoddy bay to Point Judith, including the coast of Maine, New Hampshire, Massachusetts, and Rhode Island.	No. 1	Geodetic, astronomical, & magnetic observations.	A. D. Bache, superintendent; G. W. Dean, assistant; E. Goodfellow, sub-assistant.	Harris Mountain, near Dixmont, Penobscot county, Maine; geodetic, astronomical, and magnetic observations. (Part of season. See also Sections V and VI.)
		2	Reconnaissance	C. O. Boutelle, assistant; J. A. Sullivan, sub-assistant; F. P. Webber, aid.	Extension of reconnaisance on coast of Maine, east of line Mt. Desert—Humpback, and selection of site for a base of verification. (See also Sections V and VI.)
		3	Secondary triangulation.	Lieut. A. W. Evans, U. S. Army, assistant; B. Huger, jr., sub-assistant.	Approaches of Kennebec river, extending to Merrymeeting bay, and including Bath, Me. (See also Section VI.)
		4	Topography	A. W. Longfellow, assistant; N. S. Finney, aid.	Islands in Casco bay, east of Portland harbor, from Little Hog island to Eagle island, and shore-line of main from Mackey's Point nearly to Parker's Point. (See also Section V.)
		5	Topography	S. A. Gilbert, assistant	Survey of Wood island and vicinity of Small Point harbor, Maine, for light-house purposes, 1854. (See also sections II and IX.)
		6	Topography	H. L. Whiting, assistant; C. T. Iardella, sub-assistant; J. A. Sullivan, sub-assistant.	Coast of New Hampshire from near the mouth of Merrimac river, northward to Hampton river and Great Boar's Head; interior between Essex and Annis Squam, (Cape Ann,) Mass.; shore and interior between Hyannis and South Dennis, (Cape Cod,) Mass. (See also Sections II, III, and VI.)
		7	Hydrography	Lieutenant Commanding H. S. Stellwagen, U. S. Navy, assistant.	Inside hydrography of Massachusetts bay. Off-shore soundings from Massachusetts bay eastward to deep water, and southward to Nantucket
		8	Hydrography	Lieutenant Commanding C. R. P. Rodgers, U. S. Navy, assistant.	Completion of hydrography in Vineyard and Nantucket sounds.

APPENDIX No. 1—Continued.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
I	From Passamaquoddy bay to Point Judith—Continued.	No. 9	Tidal observations	H. Mitchell, sub-assistant; G. Wurdemann.	Stations on Vineyard sound and south shore of Mass. Observations at Boston dry dock continued.
		10	Magnetic observations.	Charles A. Schott, computing division Coast Survey office; J. Main, assisting.	Determination of magnetic declination, dip, and intensity, at Burlington, Vt.; Salem, Boston, and Nantucket, Mass.; and at Providence, R. I. (See also Sections II and III.)
II	From Point Judith to Cape Henlopen, including the coast of Connecticut, New York, N. Jersey, Pennsylvania, & Delaware.	1	Triangulation	Edmund Blunt, assistant; C. P. Bolles, assistant; Lieut. A. H. Seward, U. S. Army, assistant; J. Rockwell, sub-assistant; C. B. Baker, aid.	Restoring and furnishing points in the vicinity of New York, for parties engaged in the resurvey for Commissioners on harbor encroachments. (See also Sections V and VI.)
		2	Triangulation	Captain W. R. Palmer, U. S. Topographical Engineers, assistant.	Connection of Old and New High School observatories at Philadelphia with Coast Survey triangulation points. (See also Section III.)
		3	Topography	F. H. Gerdes, assistant; C. F. Mayer, jr., aid; C. H. Boyd, aid.	Topography of Manhattan island, including New York city; opposite shore of Hudson river, including Jersey City and Hoboken; opposite shore of East river, including Brooklyn and Williamsburg; eastern shore of Harlem river and shores of East river, from New York city to Throg's Neck, completed, for Commissioners on harbor encroachments. (See also Sections VII and VIII.)
		4	Topography	Richard D. Cutts, assistant, (part of season;) A. S. Wadsworth, assistant; H. S. Duval, aid.	Resurvey of shores of Staten island, for Commissioners on harbor encroachments. (See also Section IV.)
		5	Topography	S. A. Gilbert, assistant; M. Seaton, aid.	Eastern shore-line of New York bay and the Narrows, and topography of Long island from Gowanus to Hog inlet, for Commissioners on harbor encroachments. (See also Sections I and IX.)
		6	Topography	A. M. Harrison, assistant; P. R. Hawley, aid.	Resurvey of southern shores of Raritan and Sandy Hook bays, from South Amboy to Shrewsbury inlet, including topography of Highlands of Navesink and Sandy Hook, for Commissioners on harbor encroachments. (See also Section VI.)
		7	Topography	H. L. Whiting, assistant.	Examination and resurvey of Sandy Point, near Stonington, Conn. (See also Sections I, III, and VI.)
		8	Hydrography	Lieutenant Commanding T. A. Craven, U. S. Navy, assistant.	East river from Throg's Neck to New York city; the harbor, and New York bay and its approaches, resurveyed for Commissioners on harbor encroachments. (See also Section VI and Gulf Stream.)

APPENDIX No. 1—Continued.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
II.	From Point Judith to Cape Henlopen—Continued.	No. 9	Hydrography -----	Lieutenant Commanding Richard Wainwright, U. S. Navy, assistant.	Hudson river from Yonkers to line joining Castle Clinton and Paulus Hook; Harlem river from Spuyten Dyvil creek to East river; Kill Van Kull; Newark bay and dependencies; and Staten island sound, completed; with tidal and current observations, for Commissioners on harbor encroachments. (See also Sections III and VI.)
			Tidal observations.	---------------------	At Governor's island, continued with self-registering tide gauge.
		10	Magnetic observations.	Charles A. Schott, computing division, Coast Survey office.	Determination of magnetic declination, dip, and intensity, at New Haven, Conn.; Greenbush, on Hudson river; at Cold Spring and New York city; Bedloe's island; Sandy Hook; Philadelphia; and at Cape May, N. J. (See also Sections I and III.)
III	From Cape Henlopen to Cape Henry, including the coast of Delaware, Maryland, and Virginia.	1	Secondary triangulation.	Captain W. R. Palmer, U. S. Topographical Engineers, assistant; Lieutenant J. P. Roy, U. S. Army, assistant; P. C. F. West, aid, (part of season.)	Measurement of verification base near Tappahannock, Va.; triangulation of Rappahannock river completed from base to Chesapeake bay. (See also Section II.)
		2	Secondary triangulation.	John Farley, assistant; Charles Ferguson, aid.	James river, Va., from City Point to line Upper Brandon—Trees Point, towards Chesapeake bay.
		3	Topography-------	George D. Wise, assistant; Spencer C. McCorkle, sub-assistant.	Sea coast of Virginia from Gargathy to Chincoteague inlet. (See also Section VII.)
		4	Topography-------	H. L. Whiting, assistant.-	Verification of work at Bodkin Point; mouth of Sassafras river; and on South river; resurvey of shore and interior at mouth of Magothy river, Chesapeake bay. (See also Sections I, II, and VI.)
		5	Topography-------	John Seib, assistant------	Topography of western shore of Chesapeake bay completed from Back river to mouth of York river, including Pocosin river. (See also Section V.)
		6	Topography-------	John Seib, assistant------	Topography of Rappahannock river from Accaceek Point to stations "Punch-bowl—Downman." (See also Section V.)
		7	Hydrography -----	Lieutenant Commanding J. J. Almy, U. S. Navy, assistant.	Hydrography of Pocomoke sound, Chesapeake bay. (See also Section IV.)
		8	Hydrography -----	Lieutenant Commanding R. Wainwright, U. S. Navy, assistant.	Rappahannock river from Green's bay; hydrography carried below Tappahannock; tides observed. (See also Sections II and VI.)
		9	Hydrography -----	Lieutenant Commanding J. N. Maffitt, U. S. Navy, assistant.	Hydrography of James river westward, from Deep-water Point light to above Hog island, opposite Jamestown island. Tides and currents observed. (See also sections IV and V.)
			Magnetic observations.	Charles A. Schott, computing division, Coast Survey office.	Determination of magnetic declination, dip, and intensity, at Washington city and Georgetown, D. C. (See also Sections I and II.)

APPENDIX No. 1—Continued.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
III	From Cape Henlopen to Cape Henry—Continued.	....	Views............	Captain A. A. Gibson, U. S. Army, assistant.	Off-shore views of Cape Henry and Smith's island, entrance to Chesapeake bay.
IV	From Cape Henry to Cape Fear, including part of the coast of Virginia and coast of North Carolina.	No. 1	Secondary triangulation.	J. J. S. Hassler, assistant.	Triangulation continued from Currituck sound, approaching Cape Henry, Virginia. Determination of hydrographic points south of Cape Henry.
		2	Secondary and tertiary triangulation.	A. S. Wadsworth, assistant; H. S. Duval, aid.	Coast of North Carolina from southern part of Bogue sound to New River inlet. (See also Section II.)
		3	Hydrography	Lieutenant Commanding J. J. Almy, U. S. Navy, assistant.	Seacoast from Cape Henry to southern boundary of Virginia, completed. (See also Section III.)
		4	Hydrography	Lieutenant Commanding J. N. Maffitt, U. S. Navy, assistant.	Resurvey of the western main ship-channel and New Inlet bars, at the mouth of Cape Fear river, N. C. Determination of the Bug-lights and buoys. Re-examination of sailing-lines, and directions for entering the harbor of Beaufort, N. C. (See also Sections III and V.)
V	From Cape Fear to St. Mary's river, including the coast of South Carolina and Georgia.	1	Astronomical and magnetic observations.	Dr. B. A. Gould, jr., assistant; G. W. Dean, assistant; E. Goodfellow, sub-assistant.	Telegraphic difference of longitude between Columbia, S. C., and Macon, Georgia; observations for latitude and magnetic elements at Macon. (See also Sections I and VI.)
		2	Reconnaissance ...	C. P. Bolles, assistant....	For primary triangulation from Cape Fear entrance to Lockwood's Folly, N. C. (See also Section II.)
		3	Primary and secondary triangulation.	C. O. Boutelle, assistant; G. A. Fairfield, assistant, (part of season;) B. Huger, jr., sub-assistant; J. A. Sullivan, aid; F. M. McIver, aid.	Erection of signals for primary work; secondary triangulation on Stono river; determination of hydrographic signals between Charleston and North Edisto river. (See also Sections I and VI.)
		4	Secondary triangulation and topography.	C. P. Bolles, assistant; G. H. Bagwell, aid.	Coast of North Carolina, from Cape Fear southward, nearly to Lockwood's Folly. (See also Section II.)
		5	Secondary and tertiary triangulation.	A. W. Longfellow, assistant; N. S. Finney, aid.	Romerly marshes; St. Simon's sound, and Brunswick harbor, Georgia. (See also Section I.)
		6	Topography	John Seib, assistant......	Southern part of sea-coast of Edisto island, S. C., and shore of South Edisto river, nearly to Raccoon island. (See also Section III.)
		7	Hydrography	Lieutenant Commanding J. N. Maffitt, U. S. Navy, assistant.	Supplementary work on Charleston bar and in Maffitt's channel. Hydrography of coast from Charleston bar to North Edisto river, and from Savannah bar northward, including Gaskin banks, Martin's Industry, Port Royal bar and sound, and Beaufort river to the city of Beaufort, S. C. Hydrography of Romerly marshes, Georgia. (See also Sections III and IV.)

APPENDIX No. 1—Continued.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
V	From Cape Fear to St. Mary's river—Continued.	No. 8	Hydrography	Lieutenant Commanding T. A. Craven, U. S. Navy, assistant.	Hydrography and shore-line of Doboy bar and sound. Reconnaissance of St. Simon's bar and channel to Brunswick harbor, Georgia. (See also Section II, Gulf Stream, and Section VI.)
		9	Tidal observations	G. Würdemann	At Charleston, S. Carolina, (Castle Pinckney,) regular tidal observations, and at St. Simon's island, Georgia, with self-registering tide gauge. (See also Section VI.)
V & VI	Gulf Stream	1	Hydrography	Lieutenant Commanding T. A. Craven, U. S. Navy, assistant.	Exploration of stream from Cape Florida to Bemini island. (See also Sections II, V, and VI.)
		2	Hydrography	Lieutenant Commanding B. F. Sands, U. S. Navy, assistant.	Temperature observations and soundings in the axis of the stream, between latitude 24° 23′ and 34° 52′ north. (See also Section VIII.)
VI	From St. Mary's river to St. Joseph's bay, including the eastern and part of the western coast of Florida.	1	Geodetic operations	A. D. Bache, superintendent; C. O. Boutelle, assistant; G. W. Dean, assistant; E. Goodfellow, sub-assistant; J. A. Sullivan, aid.	Measurement of bases at Cape Florida (Key Biscayne) and Cape Sable, Florida. (See also Section I.)
		2	Reconnaissance	C. O. Boutelle, assistant; Lieut. James Totten, U. S. Army, assistant.	For connection of base at Cape Sable with triangulation of Florida reefs and keys. (See also Sections I and V.)
		3	Triangulation	Lieut. James Totten, U. S. Army, assistant.	Connection of base at Cape Florida (Key Biscayne) with triangulation of Florida reefs and keys.
		4	Triangulation	Lieut. A. W. Evans, U. S. Army, assistant; F. M. McIver, aid.	Reconnaissance of approaches to St. Mary's river, including the harbor of Fernandina; triangulation of St. John's river, Florida, from Mayport Mills to Jacksonville, for Engineer Department. (See also Section I.)
		5	Secondary triangulation.	Lieut. James Totten, U. S. Army, assistant; John Rockwell, sub-assistant.	Keys on Florida reef westward and southward from Loggerhead Key to Eastern Sambo. Erection of screw-pile signals on Florida reefs, and establishment of tide gauge at Indian Key. (See also Section II.)
		6	Secondary triangulation.	Lieut. A. H. Seward, U. S. Army, assistant; C. B. Baker, aid.	Extension of triangulation in Barnes's sound, from Grassy Point to Duck Key. (See also Section II.)
		7	Topography	A. M. Harrison, assistant; P. R. Hawley, aid.	Topography and shore-line of St. John's river, Florida, from Mayport Mills to Jacksonville, for Engineer Department. (See also Section II.)
		8	Topography	H. L. Whiting, assistant	Verification of work on eastern coast of Florida, including Key Biscayne bay, and southward to Key Largo; part of Pine island keys and Boca Chica. (See also Sections I, II, and III.)
		9	Topography	I. Hull Adams, assistant; C. T. Iardella, sub-assistant.	Mud keys, Snipe keys, Saddle Bunch key, and detached keys on Florida reef, surveyed and marked in sections for General Land Office.

APPENDIX No. 1—Continued.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
VI.	From St. Mary's river to St. Joseph's bay—Continued.	No. 10	Topography	S. A. Wainwright, sub-assistant; C. Fendall, aid.	Shore-line on outer coast of Key Largo north, from Point Perry to Excelsior, for General Land Office.
		11	Hydrography	Lieutenant Commanding T. A. Craven, U. S. Navy, assistant.	Florida reefs from Carysfort reef to Grecian shoal. Examination of the reefs and eastern coast of Florida for location of aids to navigation.—Appendix No. 72. (See also Sections II and V, and Gulf Stream.)
		12	Hydrography	Lieutenant Commanding Richard Wainwright, U. S. Navy, assistant; Lieutenant Stephen D. Trenchard, U. S. Navy, assistant.	Hydrography of St. John's river from entrance to Jacksonville, completed, for Engineer Department: reconnaissance of approaches to St. Mary's river, including the harbor of Fernandina. Tidal and current observations. (See also Sections II and III.)
		13	Hydrography	Lieutenant Commanding O. H. Berryman, U. S. Navy, assistant.	Complete hydrographic reconnaissance of Tampa bay. (See also Section VII.)
		14	Tidal observations	G. Würdemann	Station on Indian river, with self-registering tide gauge; on Indian key, Florida reef; and at Tortugas. (See also Section V.)
			Inspection	A. D. Bache, superintendent.	Triangulation and topographical parties at work on Florida reefs and keys. (See also Section I.)
VII.	From St. Joseph's bay to Mobile bay, including part of the western coast of Florida and Alabama.	1	Triangulation and astronomical and magnetic observations.	F. H. Gerdes, assistant; J. G. Oltmanns, sub-assistant.	Measurement of preliminary base and triangulation of St. Andrew's bay; observations for latitude, azimuth, and magnetic declination, and for difference of longitude between St. Andrew's, Fla., and Pascagoula, Miss. (See also Sections II and VIII.)
		2	Topography	G. D. Wise, assistant	Shores of St. Andrew's bay and sound, including St. Andrew's city, Fla. (See also Sec. III.)
		3	Hydrography	Lieutenant Commanding O. H. Berryman, U. S. Navy, assistant.	Hydrography of Cedar Keys; Ocilla river entrance; and St. Andrew's sound, completed. (See also Section VI.)
VIII.	From Mobile bay to Vermilion bay, including the coast of Alabama, Mississippi, and part of Louisiana.	1	Primary triangulation and astronomical observations.	J. E. Hilgard, assistant; Stephen Harris, sub-assistant.	Mississippi sound, completion of primary triangulation; astronomical observations at Cat island.
		2	Astronomical observations.	F. H. Gerdes, assistant; J. G. Oltmanns, sub-assistant.	At Pascagoula, Miss., for difference of longitude between that point and St. Andrew's, eastward, and Belle Isle, La., westward; observations at Deer island, La. (See also Sections II and VII.)
		3	Secondary triangulation and topography.	J. E. Hilgard, assistant; J. G. Oltmanns, sub-assistant; Stephen Harris, sub-assistant; J. S. Harris, aid; R. Halter, aid.	Completion of secondary triangulation of Lake Borgne; measurement of preliminary base, and commencement of primary and secondary triangulation of Chandeleur sound; determinations of azimuth, and topography of islands in Chandeleur sound.

APPENDIX No. 1—Continued.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
VIII	From Mobile bay to Vermilion bay—Continued.	No. 4	Secondary triangulation and topography.	F. H. Gerdes, assistant; J. G. Oltmanns, sub-assistant.	Atchafalaya bay, coast of Louisiana, from Point au Fer to Cote Blanche bay. (See also Sections II and VII.)
		5	Topography	R. M. Bache, assistant	Shore-line and topography of eastern part of the Rigolets, Louisiana.
		6	Hydrography	Lieutenant Commanding B. F. Sands, U. S. Navy, assistant.	Biloxi bay and entrance; Mississippi sound, between Horn and Ship islands; examination of Pelican island channel. Lines of soundings from Mobile to Key West; thence to Ship shoal and Mississippi delta; thence to Pensacola and southward. Reconnaissance of entrances to Vermilion bay and Calcasieu river (Section IX) for light-house purposes. (See also Section I and Gulf Stream.)
IX	From Vermilion bay to southeastern boundary, including part of Louisiana and the coast of Texas.	1	Secondary triangulation and topography.	S. A. Gilbert, assistant; M. Seaton, aid.	Extension of secondary triangulation from eastern end of Matagorda bay, Texas, to near Palacios bay; topographical surveys in the vicinity of Matagorda and the mouth of the Colorado. (See also Sections I and II.)
		2	Hydrography	Lieutenant Commanding E. J. De Haven, U. S. Navy, assistant.	Hydrography of Upper Galveston and Turtle bays completed; in-shore soundings completed between Galveston bar and Cedar lake. Examination of entrance to Lavacca bay for light-house site.
X & XI	Western coast of the U. States; California, and Oregon & Washington Territories.	1	Primary and secondary triangulation.	R. D. Cutts, assistant, (part of season;) G. A. Fairfield, assistant, (part of season.)	Extension of primary, secondary, and tertiary triangulation northward from San Francisco, and southward adjacent to the bay of Monterey, Cal. (See also Sections II and V.)
		2	Triangulation	W. E. Greenwell, assistant; P. C. F. West, aid.	Triangulation of islands in Santa Barbara channel; determination of points for topographical survey between Point Duma and Buenaventura.
		3	Triangulation	George Davidson, assistant.	Preliminary base measured near Port Townshend, Washington Territory, for triangulation of Admiralty inlet, Puget's sound, and Hood's canal. Extension of triangulation to line "Bush--Foulweather," entrance of Hood's canal.
		4	Tertiary triangulation and topography.	James S. Lawson, sub-assistant.	Tertiary triangulation and topography of New Dungeness, and topography of Port Ludlow and Smith's island, Washington Territory.
		5	Topography	Lieut. W. P. Trowbridge, U. S. Eng., assistant.	Preliminary survey of South Farallon island, California.
		6	Topography	Aug. F. Rodgers, sub-assistant.	Western shore of San Pablo bay, from Petaluma creek southward to San Pedro Point; opposite shores from entrance of Karquines strait to Molate island; and eastern shore of San Francisco bay from Middle Point southward to a station opposite Point San Mateo.

APPENDIX No. 1—Continued.

Sections.	Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
X & XI	Western coast of the U. States—Continued.	No. 7	Topography	W. M. Johnson, sub-assistant.	Completion of topography between Point San Pedro and Pigeon Point, California. Survey of Santa Barbara; Anacapa island, eastern part of Santa Cruz island, and main from Buenaventura to Point Duma, for Light-house Board.
		8	Hydrography	Lieutenant Commanding James Alden, U. S. Navy, assistant.	Hydrography of Admiralty inlet, from entrance to Foulweather bluff; examination of harbors of Steilacoom and Olympia; survey of Bellingham bay, New Dungeness, and Cape Shoalwater, Washington Territory; hydrography of Shoalwater bay and connection with Baker's bay, Oregon Territory; examination of entrance to Umpquah river, and resurvey of Crescent City harbor for light-house sites; hydrography of bar and entrance to San Francisco bay completed.
		9	Hydrography	Lieutenant Commanding Arch'd MacRae, U. S. Navy, assistant.	Continuation of survey of Monterey bay and at Point Año Nuevo; hydrography of Santa Barbara channel and re-examination of Santa Cruz and Anacapa islands, for Light-house Board.
		10	Tidal and magnetic observations.	Lieut. W. P. Trowbridge, U. S. Engineers, assistant.	Establishment of tidal stations at Cape Flattery, Gray's harbor, South Farrallon island, and Point Conception; continued observations at San Diego, San Francisco, and Astoria; magnetic observations at Neeah bay, Washington Territory.

APPENDIX No. 2.

List of army officers on Coast Survey duty March 1, 1855.

Name.	Rank.	Date of attachment.
H. W. Benham	Captain engineers	April 1, 1853
W. R. Palmer	Captain topographical engineers	March 2, 1852
Aug. A. Gibson	Captain 2d artillery	January 17, 1851
James Totten	First lieutenant 2d artillery	December 10, 1850
Edward B. Hunt	First lieutenant engineers	May 5, 1851
Joseph C. Clark, jr	First lieutenant 4th artillery	January 7, 1854
John C. Tidball	First lieutenant 2d artillery	September 6, 1854
Aug. H. Seward	First lieutenant 5th infantry	December 8, 1851
Wm. P. Trowbridge	First lieutenant engineers	April 18, 1851
James P. Roy	Second lieutenant 2d infantry	October 7, 1853
Andrew W. Evans	Brevet second lieutenant 7th infantry	November 10, 1852

NOTE.—The same officers were attached to the Coast Survey on September 1, 1855, as on March 1, 1855. The list of names is therefore omitted.

APPENDIX No. 3.

List of navy officers on Coast Survey duty March 1, 1855.

Vessel.	Locality of service.	Officers.	Rank.	Date of attachment.
Schooner Nautilus	Section III	Richard Wainwright	Lieutenant commanding	January 31, 1848
		S. D. Trenchard	Lieutenant	March 1, 1853
		J. B. Stewart	Acting master	November 15, 1852
Schooners Crawford and Madison.	Section V	J. N. Maffitt	Lieutenant commanding	May 9, 1843
		Edward Simpson	Master	January 9, 1855
		Hunter Davidson	Acting master	January 17, 1852
		S. B. Luce	do	May 18, 1854
Steamer Corwin and tender.	Section VI	T. A. Craven	Lieutenant commanding	November 27, 1850
		J. C. Febiger	Lieutenant	December 3, 1851
		Edward Renshaw	Acting master	June 3, 1853
		John L. Davis	do	November 24, 1854
		W. T. Truxtun	Passed midshipman	July 19, 1854
		Thomas C. Eaton	do	July 23, 1852
		T. Le P. Cronmiller	Assistant surgeon	November 28, 1853
Schooner Varina	Section VII	O. H. Berryman	Lieutenant commanding	December 8, 1853
		Earl English	Master	December 21, 1853
		S. Livingston Breese	Passed midshipman	October 11, 1854
		F. Horner, jr	Assistant surgeon	October 3, 1854
Steamer Walker	Section VIII	B. F. Sands	Lieutenant commanding	May 14, 1850
		J. Dorsey Read	Lieutenant	November 28, 1854
		R. C. Duval	Acting master	November 17, 1852
		Charles Gray	Passed midshipman	November 12, 1854
		Joseph A. Seawell	do	December 5, 1853
		Marius Duvall	Passed assistant surgeon	November 1, 1854
Schooners Arago and Belle.	Section IX	E. J. De Haven	Lieutenant commanding	November 12, 1853
		John T. Walker	Acting master	April 7, 1853
		L. H. Lyne	do	September 26, 1852
		Dawson Phenix	Passed midshipman	April 7, 1853
		J. F. Huestis	Assistant surgeon	October 25, 1854
Steamer Active and schooner Ewing.	Sections X and XI	James Alden	Lieutenant commanding	May 18, 1849
		Archibald MacRae	Lieutenant	January 30, 1855
		J. S. Kennard	do	May 6, 1852
		R. M. Cuyler	do	June 20, 1845
		S. S. Bassett	Acting master	March 17, 1849
		Edward E. Stone	do	March 29, 1854
		P. C. Johnson	Passed midshipman	July 20, 1854
		J. Suddards	Assistant surgeon	April 3, 1852
	Office	H. S. Stellwagen	Lieutenant	October 22, 1852
	Office	F. A. Parker	do	March 31, 1853
	Office	E. C. Stout	Master	June 7, 1854
	Office	M. Woodhull	Lieutenant	May 30, 1848
	Office	Joseph B. Smith	Passed midshipman	August 4, 1852
	Office	O. F. Johnston	do	May 18, 1854
	Office	John J. Almy	Lieutenant	March 12, 1851
	Office	M. C. Perry	do	January 15, 1853
	Office	R. L. Law	Master	May 1, 1851
	Office	W. D. Whiting	Passed midshipman	July 30, 1853
	Office	A. G. Pendleton	Professor of mathematics	May 8, 1848

APPENDIX No. 3 *bis*.

List of navy officers on Coast Survey duty September 1, 1855.

Vessel.	Locality of service.	Officers.	Rank.	Date of attachment.
Steamer Bibb	Section I	H. S. Stellwagen	Lieutenant commanding	October 22, 1852
		F. A. Parker	Lieutenant	March 31, 1853
		E. C. Stout	Master	June 7, 1854
		John T. Walker	Acting master	April 7, 1853
		K. R. Breese	Passed midshipman	July 10, 1855
		Geo. F. Morrison	Midshipman	June 19, 1855
		Edward C. Stockton	do	July 31, 1855

APPENDIX No. 3 *bis*—Continued.

Vessel.	Locality of service.	Officers.	Rank.	Date of attachment.
Steamer Walker	Section I	B. F. Sands	Lieutenant commanding	May 14, 1850
		J. K. Duer	Lieutenant	August 1, 1855
		Marius Duvall	Passed assistant surgeon	November 1, 1854
		Horace N. Crabb	Acting master	August 23, 1855
		Charles Gray	Passed midshipman	November 12, 1854
		Joseph A. Seawell	do	December 5, 1853
Schooner Gallatin	Section I	C. R. P. Rodgers	Lieutenant commanding	July 7, 1855
		E. Simpson	Lieutenant	January 9, 1855
		Joseph B. Smith	Acting master	August 4, 1852
		Thos. T. Houston	Passed Midshipman	May 31, 1855
		Geo. W. Young	do	July 27, 1855
Schooner Nautilus	Section II	Richard Wainwright	Lieutenant commanding	January 31, 1848
		W. A. Webb	Lieutenant	July 11, 1855
		J. B. Stewart	Acting master	November 15, 1852
		D. Porter McCorkle	Passed midshipman	March 6, 1855
		C. F. Thomas	Midshipman	March 10, 1855
Steamer Corwin and schooner Madison.	Section II	T. Aug. Craven	Lieutenant commanding	November 27, 1850
		J. C. Febiger	Lieutenant	December 3, 1851
		W. G. Temple	do	June 5, 1855
		T. Le P. Cronmiller	Assistant surgeon	November 28, 1853
		John L. Davis	Acting master	November 24, 1854
		W. T. Truxtun	do	July 19, 1854
		Thos. C. Eaton	Passed midshipman	July 23, 1852
		James H. Rochelle	do	July 11, 1855
Steamer Hetzel	Section III	John J. Almy	Lieutenant commanding	March 12, 1851
		C. H. Williamson	Assistant surgeon	April 5, 1855
		R. D. Minor	Acting master	April 19, 1855
		A. Allmand	Passed midshipman	March 28, 1855
		C. P. McGary	do	July 16, 1855
		James W. Shirk	Midshipman	May 1, 1855
Schooner Crawford	Section III	J. N. Maffitt	Lieutenant commanding	May 9, 1843
		Hunter Davidson	Acting master	January 17, 1852
		S. B. Luce	do	May 18, 1854
		Ralph Chandler	Passed midshipman	July 10, 1855
		C. H. Cushman	do	June 13, 1855
Schooner Varina	Section VII	O. H. Berryman	Lieutenant commanding	December 8, 1853
		S. L. Breese	Passed midshipman	October 11, 1854
Steamer Active and schooner Ewing.	Sections X and XI	James Alden	Lieutenant commanding	May 18, 1849
		Archibald MacRae	Lieutenant	January 30, 1855
		J. S. Kennard	do	May 6, 1852
		R. M. Cuyler	do	June 20, 1845
		J. M. Browne	Assistant surgeon	May 10, 1855
		S. S. Bassett	Acting master	March 17, 1849
		Edward E. Stone	do	March 29, 1854
		P. C. Johnson	Passed midshipman	July 20, 1854
	Office duty	E. J. De Haven	Lieutenant	November 12, 1853
	Do	L. H. Lyne	Passed midshipman	September 26, 1852
	Do	S. D. Trenchard	Lieutenant	March 1, 1853
	Do	J. Dorsey Read	do	November 28, 1854
	Do	R. C. Duvall	Passed midshipman	November 17, 1852
	Do	W. D. Whiting	Master	July 30, 1853
	Do	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, 1855.

Vessel.	Assistant engineers.	Rank.	Date of attachment.
Steamer Corwin	Daniel T. Mapes	Second assistant engineer	June 27, 1854
	James F. Lamdin	Third assistant engineer	June 30, 1854
	R. M. Bartleman	do do	June 8, 1854
Steamer Walker	Andrew Lawton	First assistant engineer	October 22, 1853
	J. M. Harris	Third assistant engineer	October 27, 1854
	W. M. Willett	do do	October 27, 1854
	John Hollins	do do	October 27, 1854

APPENDIX No. 4—Continued.

Vessel.	Assistant engineers.	Rank.	Date of attachment.
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	James M. Adams	First assistant engineer	June 7, 1854
Steamer Hetzel	W. C. Wheeler	Second assistant engineer	September 7, 1853

APPENDIX No. 4 *bis.*

List of assistant engineers United States Navy, on Coast Survey duty September 1, 1855.

Vessel.	Assistant engineers.	Rank.	Date of attachment.
Steamer Bibb	James M. Adams	First assistant engineer	June 7, 1854
	Richard B. Quin	Second assistant engineer	May 28, 1855
	William H. Hunt	Third assistant engineer	June 27, 1855
Steamer Walker	A. Lawton	First assistant engineer	October 22, 1853
	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 Corwin	Thomas A. Jackson	Second assistant engineer	June 30, 1855
	James F. Lamdin	Third assistant engineer	June 30, 1854
	R. M. Bartleman	do do	December 19, 1854
Steamer Hetzel	W. C. Wheeler	Second assistant engineer	September 7, 1853
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

APPENDIX No. 5.

List of information furnished by Coast Survey under authority of the Treasury Department.

Date.	To whom communicated.	Information communicated.
1854.		
Oct. 19	Marshall Parks, Esq	Tracing of Albemarle sound.
21	Hon. S. R. Mallory	Tracing of Turtle harbor, Florida reef.
28	G. W. Blunt, Esq	Tracing of Atchafalaya bay and Ship island shoal, La.
Nov. 10	Light-house Board	Tracing of Eggemoggin reach, Maine.
29	Do	Tracing of Baker's island, Maine.
Dec. 4	G. W. Blunt, Esq	Soundings on Stellwagen's bank, entrance to Massachusetts bay.
5	Hon. D. L. Yulee	Commercial facilities at Cedar keys, Florida.
14	J. Hartnup, Esq., Liverpool	Results of chronometer expeditions, 1849, 1850, and 1851, for difference of longitude.
14	Capt. R. N. Shortland, R. N	Results of chronometer expeditions, 1849, 1850, and 1851, for difference of longitude.
19	Maj. G. D. Ramsay, U. S. A	Tracing of Old Point Comfort and vicinity.
23	E. C. Bogert, Esq	Tracing of Flushing bay, N. Y.
1855.		
Jan. 31	Light-house Board	Tracing of entrance to Vermilion bay, La.
Feb. 2	Do	Tracing of entrance to Calcasieu river, La.
5	Do	Tracing of harbor of Santa Barbara, Cal.
5	Do	Tracing of harbor of San Pedro, Cal.
5	Do	Tracing of Santa Cruz harbor, Cal.
5	Do	Tracing of Point Reyes, Cal.
5	Do	Tracing of Smith's island, Washington Territory.
5	J. E. Willet, Esq	Geographical and magnetic data from observations at Macon, Ga.
6	Navy Department	Depths at entrance of Mississippi river.
12	Light-house Board	Tracing of Absecum inlet, N. J.
13	Prof. James Nooney	Tracing of Monterey bay from Pajaro river southward, Cal.
14	Navy Department	Tracing of St. Simon's inlet, Brunswick harbor, Ga.
16	Light-house Board	Tracing of Gloucester harbor, Mass.
22	Do	Tracing of Wood island and Small Point harbor, Maine.
28	Do	Tracing of Point Wilson, Washington Territory.

APPENDIX No. 5—Continued.

Date.		To whom communicated.	Information communicated.
1855.			
March	2	Hon. S. R. Mallory	Tracing of Boca Chica, Florida reef.
	3	Egbert S. Viele, Esq	Tracing of reconnaissance in New Jersey.
	16	Hon. E. C. Cabell	Tracing and report on hydrographic survey of Ocilla river, Fla.
	17	Samuel H. Dewey, Esq	Magnetic declinations between Patapsco river and Cape Fear.
	17	E. O. Boyle, Esq	Tracing of Prince's and Diamond reefs, New York harbor.
	17	S. M. Harrington, Esq	Report on examination of Doña river, Delaware bay.
	19	G. W. Blunt, Esq	Geographical positions near Cape Fear.
	21	Thomas H. Buckler, Esq	Depths at harbor entrances, Boston and New York.
	31	E. O. Boyle, Esq	Tracing of Quincy's reef, New York harbor.
April	19	City of Portland, Maine	Complete map of Portland harbor.
	27	G. W. Blunt, Esq	Geographical positions at Georgetown, S. C.
	28	W. D. Cooke, Esq	Tracing of coast-line of North Carolina.
	30	Col. John L. Smith, corps of engineers	Tracing of five sheets topography and hydrography of Rappahannock river, Va.
May	1	Commission on harbor encroachments, N. Y	Tracing of Manhattan island.
	7	Husted and Kroehl	Tracing of Diamond reef, New York harbor.
	16	Capt. G. Dutton, corps of engineers	Tracing of Prince's and Diamond reefs, New York harbor.
	17	Lieut. J. M. Gilliss, U. S. N	Longitude of Philadelphia, Charleston, and Presidio, by lunar transits.
	24	Ashbel Welch, Esq	Tracing of Delaware river above and below Crosswick creek.
June	5	Capt. B. H. Hill, U. S. A	Tracing of Key Biscayne bay, Fla.
	9	Charles Copley, Esq	Sketch of shoals north of Nantucket.
	9	Light-house Board	Tracing of topography between Point Año Nuevo and Pigeon Point, Cal.
	13	Lieut. G. G. Meade, topographical engineers	Tracing of Ship John shoal, Delaware bay.
	13	Do do	Tracing of Cross Ledge shoal, Delaware bay.
	21	Commander George S. Blake, U. S. N	Discussion of western coast tidal phenomena caused by an earthquake.
	25	Lieut. John Rodgers, U. S. N	Discussion of western coast tidal phenomena caused by an earthquake.
	25	Light-house Board	Tracing of York Spit and vicinity, Chesapeake bay.
	26	Hon. D. L. Yulee	Hydrographic reconnaissance at Tampa bay, Fla.
	29	Ashbel Welch, Esq	Tracing of hydrography of Raritan river, N. J.
July	2	Prof. A. Guyot	Description of bench-marks on Mount Washington.
	2	A. G. Thompson, Esq	Tracing of part of south side of Long island.
	2	Hon. D. L. Yulee	Tracing of St. Simon's inlet, Brunswick harbor, Ga.
	5	H. Oelrichs, Esq	Tracing of Gunpowder and Saltpetre rivers, Md.
	6	Charles Green, Esq	Tracing of Doboy bar and sound, Ga.
	10	Light-house Board	Tracing of South Farallon island, Cal.
	10	Charles Copley, Esq	Tracing of shore-line from Succonesset to Hyannis, Mass.
	14	Hon. D. L. Yulee	Depths and rise of tide at Boston, Philadelphia, and Baltimore.
	20	Gen. T. Tilghman	Tracing of part of Choptank and Chester rivers, Md.
	23	George P. Elliot, Esq	Depths on bar and in channel to Beaufort, S. C.
Aug.	2	Light-house Board	Tracing of Doboy inlet, Ga.
	10	Astronomical Journal	Comparison of star places as given in the Hamburg and Greenwich catalogues.
	12	D. J. Baldwin, Esq	Tracing of limits of triangulation and topography on Matagorda bay, Texas.
	15	Engineer Department	Tracing of entrance to Mobile bay.
	15	Do	Tracing and report of recent examination of Pelican Island channel, Mobile bay.
	16	Charles Copley, Esq	Tidal data for stations on the coast of Maine.
	18	R. L. Pease, Esq	Tracing of Martha's Vineyard.
	27	C. Bellman, Esq	Tracing of topographic survey at Biloxi bay, Miss.
	30	Light-house Board	Description and sketch of positions of signals on Florida reefs.
Sept.	10	G. W. Blunt, Esq	Tracing of shore-line of Cape Lookout.
	10	Do	Latitude and longitude of Cape Lookout light.
	22	Do	Description and sketch of positions of signals on Florida reefs.
	22	O. S. Hubbell, Esq	Tracing of coast of New Jersey from Brigantine beach to Great Egg harbor.
Oct.	20	G. W. Blunt, Esq	Tracing of deep-sea soundings near Nantucket.
		Do	Tracing of soundings in Gulf of Mexico.
	27	Lieut. W. H. Stevens, corps of engineers	Tracing of west bay of Galveston from San Luis Pass to Brazos river.
	27	S. Thayer Abert, Esq	Projection and triangulation points on New river, N. C.
	27	Chamber of Commerce, Savannah	Tracing and copy of report on late survey of Romerly marshes, Ga.
	29	G. W. Blunt, Esq	Tracing of part of the hydrography south side of Martha's Vineyard.

APPENDIX No. 6.

List of capes, headlands, islands, harbors, and anchorages on the Western coast of the United States, of which either the geographical positions have been determined, topographical surveys made, or charts or sketches issued, to date of report of 1855.

Names, in geographical order.	Character of work.		Published.
Los Coronados islands	Position determined	Topographical survey	Sketch
Cortez bank	do	Preliminary survey	do
San Diego entrance and bay	do	Topographical survey	do
Point Loma	do	do	do
False bay	do	do	
San Clemente harbor	do	Preliminary survey	Sketch
San Nicolas island	do		
Catalina harbor	do	Preliminary survey	Sketch
San Pedro harbor	do	do	do
Point Pedro	do	Topographical survey	do
Point Fermin	do	do	do
Point Duma	do	do	
Anacapa island	do	do	Sketch
Cuyler's harbor, island of San Miguel	do	Preliminary survey	do
Prisoners' harbor, Santa Cruz island	do	do	do
Smugglers' cove, Santa Cruz island	do	Topographical survey	
Buenaventura mission	do	do	
Santa Barbara, anchorage and point	do	do	Sketch
Coxo harbor	do	Preliminary survey	do
Point Conception	do	Topographical survey	do
Harbor of San Luis Obispo	do	Preliminary survey	do
San Simeon harbor	do	do	do
Point Piños	do	Topographical survey	do
Monterey harbor	do	do	Preliminary chart
Bay of Monterey	do	do	Sketch
Salinas river	do	do	
Pajaro river	do	do	
Santa Cruz harbor	do	do	Sketch
Point Año Nuevo	do	do	do
Point San Pedro	do	do	do
South Farallon island	do	do	do
Point Lobos	do	do	
Fort Point	do	do	Sketch
The Golden Gate	do	do	
City of San Francisco and its vicinity	do	do	Preliminary chart
San Francisco bay	do	Preliminary survey	Sketch
San Pablo bay	do	do	do
Point Bonita	do	Topographical survey	
Ballenas bay and bluff	do	do	
Duxbury reef	do	Preliminary survey	
Sir Francis Drake's bay	do	do	
Point Reyes	do	Topographical survey	Sketch
Tomales bay	do	do	
Bodega bay	do		
Haven's anchorage	do	Preliminary survey	
Harbor of Mendocino city	do	do	Sketch
Shelter cove	do	do	do
Humboldt bay	do	do	do
Trinidad bay	do	do	do
Crescent City harbor	do	do	do
Port Orford or Ewing harbor	do	do	do
Entrance to Umpquah river	do	do	do
Point Adams	do	Topographical survey	do
Sand island	do	do	do
Entrance to Columbia river	do	Preliminary survey	Preliminary chart
Cape Hancock or Disappointment	do	Topographical survey	Sketch
Shoalwater bay	do	Preliminary survey	do
Grenville harbor	do	do	do
Cape Flattery	do	Topographical survey	do
Nee-ah harbor	do	Preliminary survey	Preliminary chart
False Dungeness harbor	do	do	Sketch
Port Townshend	do	do	do
Admiralty inlet	do	do	do
Puget sound	do	do	do
Duwamish bay	do	do	do
Smith's or Blunt's island	do	do	do
Canal de Haro and strait of Rosario	do	do	do
Strawberry bay and Cypress island	do	Topographical survey	

APPENDIX No. 7.

Results of the Coast Survey at different periods from 1844 *to* 1855.

	Previous to 1844.	From 1844 to 1854.	For 1854.	Total from beginning of survey.
Reconnaissance:				
Area, in square miles	9,642	33,962	795	44,399
Parties, number of	----------	----------	13	----------
Base-lines:				
Number of	1	7	0	8
Preliminary, number of	2	22	2	26
Length of, in miles	19½	87	3¾	110¼
Triangulation:				
Area, in square miles	9,076	22,086	2,701	33,863
Extent of coast-line, in miles	310	1,354	313	1,977
Extent of shore-line, in miles	3,215	8,215	1,577	13,007
Horizontal angle stations, number of	750	1,607	204	2,561
Points determined, number of	1,183	2,800	388	4,371
Vertical angle stations, number of	15	92	89	196
Heights determined, number of	44	319	127	490
Astronomical stations:				
Azimuth, number of	9	47	5	61
Latitude, number of	9	81	6	96
Longitude, number of	1	66	4	71
Longitude, (permanent,) number of	----------	----------	4	----------
Magnetic stations, number of	----------	137	9	146
Triangulation parties, number of	----------	----------	18	----------
Astronomical parties, number of	----------	----------	7	----------
Magnetic parties, number of	----------	----------	6	----------
Topography:				
Area, in square miles	6,222	5,119	523	11,864
Length of shore-line, in miles	6,100	9,802	1,613	17,515
Topographical parties, number of	----------	----------	15	----------
Hydrography:				
Area, in square miles	9,623	----------	----------	----------
Parties, number of	----------	----------	11	----------
Soundings, number of	808,147	2,445,761	162,454	3,416,362
Soundings in Gulf stream for temperature	----------	1,455	260	1,715
Fathoms of line used in same	----------	143,108	33,649	176,757
Tidal stations, number of	108	330	71	509
Tidal parties, number of	----------	----------	4	----------
Current parties, number of	----------	----------	2	----------
Current stations, number of	----------	431	10	441
Specimens of bottom, number of	1,327	4,702	34	6,063
Topographical maps, (original,) number of	166	250	47	463
Hydrographical maps, (original,) number of	127	246	57	430
Reductions and other maps	326	706	128	1,160
Total number of manuscript maps	619	1,202	232	2,053
Records of triangulation, (original,) number of volumes	97	230	46	373
Records, astronomical, (original,) number of volumes	17	226	88	331
Records, magnetic, (original,) number of volumes	4	55	4	63
Duplicates of the above, number of volumes	27	399	84	510
Computations, number of volumes	78	331	91	500
Hydrographical books, (original,) number of volumes	188	1,379	66	1,633
Sounding and angle observations, (duplicates,) number of volumes	28	112	7	147
Hydrographical books, (original,) number of volumes	127	761	70	958
Tidal and current observations, (duplicates,) number of volumes	----------	845	79	924
Hydrographical books, tidal reductions, number of volumes	----------	252	81	333
Total records, number of volumes	566	4,590	616	5,772
Library, number of volumes	----------	2,117	155	2,272
Engraved plates of maps, number of	5	47	----------	52
Engraved plates electrotyped, number of	----------	125	77	202
Published maps, number of	----------	47	9	56
Printed sheets of maps distributed, number of	----------	29,342	5,195	34,537
Printed sheets of maps, sale agents, number of	----------	39,318	3,232	42,550
Total number of printed sheets	----------	112,895	42,298	155,193
Instruments, cost of	$31,872	$51,300	$5,405	$88,577

APPENDIX No. 8.

List of geographical positions determined by the United States Coast Survey and continued from the reports of 1851 *and* 1853.

The present list is a continuation of that published in the annual reports for 1851 and 1853, and contains the geographical positions of points determined astronomically and trigonometrically since the date of the former, with the repetition of some points previously published for convenience of reference. The following explanations will give all the information requisite for the use of the tables.

For the purposes of the survey, the coast is divided into eleven sections; in all of which the work is carried on simultaneously. The survey being in different stages of progress in the several sections, and new results being added from year to year to those here given, the same divisions have been adopted in this publication:

The several sections are defined as follows:

Section I. From Passamaquoddy bay to Point Judith.
Section II. From Point Judith to Cape Henlopen.
Section III. From Cape Henlopen to Cape Henry.
Section IV. From Cape Henry to Cape Fear.
Section V. From Cape Fear to St. Mary's river.
Section VI. From St. Mary's river to St. Joseph's bay.
Section VII. From St. Joseph's bay to Mobile bay.
Section VIII. From Mobile bay to Vermilion bay.
Section IX. From Vermilion bay to the Rio Grande.
Section X. Coast of California, San Diego bay to 42d parallel.
Section XI. Coast of Oregon, 42d to 49th parallel.

The tables give the latitudes and longitudes of the trigonometrical points in each section, and their relative azimuths, or bearings and distances.

The manner in which these data have been obtained may be briefly explained here.

In each section a base-line of from five to ten miles is measured with all possible accuracy. A series of triangles, deriving the lengths of their sides from this base, is then established along the coast by the measurement of the angles between the intervisible stations. In this primary series the triangles are made as large as the nature of the country will permit, because the liability to error increases with the number of triangles.

On the bases furnished by the sides of the primary triangles a secondary triangulation is next established, extending along the coast, and over the smaller bays and sounds, and determining a large number of points at distances a few miles apart.

The distances between the points thus determined, as given in the tables, are liable to an average error of about one foot in six miles, until a final adjustment between the base-lines shall have been made.

In some parts of the survey the base-lines for the primary triangulation have not yet been measured, in which cases the distances depend on preliminary base-lines, measured with great care; and they are liable to an average error of one foot in three miles. This applies to the positions on Savannah river in Section V, and to those in Sections VI, IX, X, and XI.

As on the completion of the primary triangulation in each section the several series form one connected chain, the different bases afford verification of each other and of the triangulation connecting them. The first three sections are thus connected.

Observations for latitude and azimuth are made at a number of stations of the primary triangulation in each section. The difference of latitude, longitude, and azimuth between these and other stations are then computed, under the supposition that the earth is a spheroid of revolution of the following dimensions, which are those determined by Bessel from all the measurements made to the present time, viz:

Equatorial radius = 6377397.16 metres.
Polar radius = 6356078.96 metres.
Eccentricity = 0.08169683

It has been found that the differences of latitude and longitude, as computed in this manner from the distance and azimuth between two stations, and which are called geodetic, differ from those obtained by astronomical observations. Such disagreements are due to local irregularities in the figure and density of the earth; and the error resulting from them in the determinations of latitude, and of the meridian plane, is designated as station error. It amounts, according to the results obtained at present, to between one and two seconds of arc in the eastern section of the survey, and to about half a second in the sections south of the Delaware.

In order to eliminate the influence of station errors on the general results, observations are made at a number of stations, the results are referred to a central station by means of the geodetic differences, and the mean of all is used for the computation of the positions given in the tables. The geographical positions must therefore be considered as liable to future changes, from the accumulation of new observations, and the final discussion of all the results obtained.

The *differences of longitude* are obtained, as has been stated, by computation from the distances, latitudes, and azimuths of the triangulation. In adding up these differences from station to station, an accumulation of the unavoidable errors is probable. They are checked, however, by differences of longitude, determined by means of the electro-magnetic telegraph, in every section where the introduction of the latter makes it practicable.

SEATON STATION, in Washington city, has been selected as the centre for the telegraphic differences of longitude. The sections at present connected by telegraph are Sections I, II, III, IV, and V. The first three being also connected by triangulation, the check on the geodetic differences of longitude is here obtained, and the agreement is very close.

The longitude from Greenwich in these sections depends upon that of Cambridge Observatory, as determined by chronometric differences between Liverpool and Cambridge, and by occultations, eclipses, and moon culminations, observed at various observatories in the United States, and referred to Cambridge by means of telegraphic differences.

The following statement shows the result up to the present time:

Longitude of Cambridge from Greenwich.

	h. m. s.
By moon culminations observed at Cambridge, Hudson, O., U. S. Expl. Ex. Observatory, and National Observatory..................	4 44 28.4
By eclipses and occultations at Cambridge, Brooklyn, Philadelphia, and U. S. Expl. Ex. Observatory..	4 44 29.6
By chronometric differences	4 44 30.1

The longitude adopted for the present is 4*h*. 44*m*. 29.5*s*., or 71° 7′ 22.50″.

In Sections IV, VI, VIII, and IX, the longitudes are counted from central stations in each, for which we have at present the following data, subject to future corrections:

	° ′ ″
Section IV. Stevenson's Point, west of Greenwich..............................	76 10 43.5
Section VI. Cape Florida, west of Greenwich....................................	80 9 24
Sections VIII and IX. Fort Morgan, Mobile Point, west of Greenwich...	88 0 25

The longitudes in Sections X and XI are reckoned from Greenwich. They depend on moon culminations observed at Point Conception, San Diego, Point Pinos, Port Orford, Cape Disappointment, and Cape Flattery, compared with corresponding observations at Greenwich and American observatories, and on chronometric differences between the same and other stations.

Explanation of the tables.

The first column on the left contains the name of the several stations or triangulation points. Their general locality is intimated by the heading at the top of the page, by means of which they will be readily found on the sketches accompanying the tables. Sub-headings in the first column indicate the locality more minutely where it is practicable.

The stations are generally either prominent objects of permanence, such as spires, light-houses, beacons, &c., or they are points on prominent hills, capes, or points of land, where signals have been erected for the purpose of the survey, and which are marked on the ground. In a small number of cases, in the first three sections, but much more frequently in the southern sections, where settlements on the coast are sparse and few permanent objects are to be found, the stations have no other distinguishing mark than the signal erected on the spot, and after its decay, the mark left on the ground to designate the station-point. The latter generally consists of posts or stones set around the point, while the centre of the station is designated by an earthen cone or glass bottle buried under the surface of the ground, and marked on top by a stone or post. Where the station is on a rock, a copper bolt, or a hole filled with lead or sulphur, will be found to designate the exact spot.

The sketches showing the configuration of the land, as well as the relative positions of the stations, no great difficulty will be experienced in finding the latter when desired for local surveys or reference. In any case where minute descriptions of particular points are required, they can be had by application addressed to the Coast Survey office.

The second and third columns contain the latitudes and longitudes of the stations named. The fourth column contains the azimuth of the line joining the station named in the first column to that named in the fifth—that is to say, the angle which that line makes with the meridian of the former station, reckoned from south around by west, through the whole circle. The sixth column gives the back azimuth of the same line, or the angle which it makes with the meridian of the latter station, reckoned as before; the difference between the azimuths in the fourth and those in the sixth column being 180° less the inclination of the meridians at the two stations.

The seventh, eighth, and ninth columns give the distances, in metres, yards, and miles, between the stations named in the first and fifth columns. The relation of the metre to the yard, used in obtaining these results, is, 1 metre = 1.0935696 yards, or 39.368505 United States standard inches.

For each station the azimuths and distances to two other stations are given. In every case the lines so given have actually been observed.

In each section the stations of the primary triangulation are distinguished by being printed in SMALL CAPITALS.

In Section V, near the mouth of the Savannah river, some of the former preliminary positions have been improved from more reliable observations; and in Section VI, the positions in the vicinity of Key West, and to the westward of it, have been repeated, and the longitudes are counted from Greenwich.

16

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Casco Bay, and continuation to Cape Small. Sketch A.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
MOUNT INDEPENDENCE	43 45 32.17	70 18 53.04						
CAPE SMALL	43 46 41.65	69 50 22.71	86 57 21	Mount Independence	266 37 38	38308.3	41892.8	23.80
Bradbury	43 54 06.48	70 10 34.99	296 45 59	Cape Small	116 59 59	30359.0	33199.7	18.86
			35 04 47	Mount Independence	214 59 02	19383.2	21196.9	12.04
Halfway Rock	43 39 20.30	70 01 53.16	228 32 36	Cape Small	48 40 33	20599.3	22526.8	12.80
			156 56 41	Bradbury	336 50 40	29732.4	32514.5	18.47
John's Hill	43 34 45.00	72 12 30.61	239 12 32	Halfway Rock	59 19 52	16625.7	18181.4	10.33
			156 49 10	Mount Independence	336 44 46	21731.1	23764.5	13.50
Harpswell Church	43 47 58.33	69 58 51.42	80 35 08	Mount Independence	260 21 17	27243.4	29792.5	16.93
			125 56 13	Bradbury	305 48 06	19389.9	21204.2	12.05
Jebeig	43 44 13.59	70 06 53.69	164 53 52	Bradbury	344 51 19	18953.1	20726.5	11.78
			98 38 19	Mount Independence	278 30 02	16274.3	17797.1	10.11
Long Island	43 41 59.12	70 08 12.41	23 23 11	John's Hill	203 20 12	14592.8	15958.2	9.07
			114 41 55	Mount Independence	294 34 32	15771.8	17247.6	9.80
York	43 46 41.88	70 10 47.51	338 17 53	Long Island	158 19 39	9390.8	10269.5	5.83
			78 50 25	Mount Independence	258 44 49	11069.2	12104.9	6.88
Haskel	43 42 59.65	70 01 39.31	119 16 02	York	299 09 44	14051.1	15365.9	8.73
			78 03 12	Long Island	257 58 40	8995.8	9837.5	5.59
Seguin Light	43 42 25.25	69 45 10.62	92 50 27	Haskel	272 39 04	22157.4	24230.7	13.77
			75 50 03	Halfway Rock	255 38 30	23167.2	25334.9	14.40
Ragged	43 43 39.18	69 55 54.68	81 02 44	Haskel	260 58 46	7808.9	8539.6	4.85
			45 10 14	Halfway Rock	225 06 07	11325.1	12384.8	7.04
Randall	43 45 55.80	70 00 28.69	16 12 49	Haskel	196 12 00	5660.6	6190.3	3.52
			304 29 28	Ragged	124 32 37	7439.8	8135.9	4.62
Moges	43 47 02.78	70 05 15.23	327 12 23	Haskel	147 14 52	8923.0	9757.9	5.55
			287 51 08	Randall	107 54 26	6732.3	7362.2	4.18
Bald Head	43 42 21.28	69 50 55.38	69 18 07	Halfway Rock	249 10 33	15754.6	17228.8	9.79
			109 46 14	Ragged	289 42 47	7117.2	7783.2	4.42
Yarmouth	43 46 56.63	69 54 27.00	17 51 01	Ragged	197 50 01	6401.1	7000.0	3.99
			330 51 20	Bald Head	150 53 44	9727.2	10637.4	6.04
Morse	43 44 15.94	69 49 13.32	82 50 25	Ragged	262 45 48	9052.5	9899.5	5.62
			125 16 59	Yarmouth	305 13 22	8590.4	9394.2	5.34
Orr	43 51 05.87	69 54 02.53	4 04 13	Yarmouth	184 03 56	7710.7	8432.2	4.79
			10 19 08	Ragged	190 17 51	14010.8	15321.8	8.70
Burnt Ledge	43 47 55.99	69 49 44.73	46 16 09	Ragged	226 11 53	11457.0	12529.0	7.12
			135 31 05	Orr	315 28 07	8216.6	8985.4	5.10
Freeport Church	43 51 26.59	70 05 51.44	37 00 22	York	216 56 57	10998.2	12027.3	6.83
			127 57 59	Bradbury	307 54 44	8025.3	8776.2	4.99
Kellogg	43 49 50.96	69 57 53.24	105 29 24	Freeport Church	285 23 55	11080.9	12117.7	6.88
			62 19 24	Moges	242 14 18	11158.8	12202.9	6.93
Evans	43 52 34.45	70 00 23.90	32 28 44	Moges	212 25 26	12129.9	13264.9	7.54
			326 17 19	Kellogg	146 19 03	6064.2	6631.6	3.77
Tate	43 59 39.87	69.59 22.42	55 36 36	Bradbury	235 28 49	18186.7	19888.4	11.30
			335 44 54	Orr	155 48 36	17393.6	19021.1	10.81
Birch Point	43 45 03.07	70 08 09.56	56 27 55	Moody	236 24 24	8180.5	8946.0	5.08
			0 38 27	Long Island	180 38 25	5676.9	6208.1	3.53
Cow Island	43 41 28.79	70 10 48.29	122 37 38	Moody	302 35 57	3877.6	4240.4	2.41
			254 58 20	Long Island	75 00 08	3613.8	3951.9	2.24
Robinson's Rock	43 45 33.21	69 50 43.42	63 13 23	Ragged	243 09 48	7802.1	8532.1	4.85
			319 46 47	Morse	139 47 49	3122.4	3414.6	1.94
Sherman	43 50 43.16	70 05 09.49	1 04 52	Moges	181 04 48	6802.3	7438.8	4.23
			279 20 37	Kellogg	99 25 43	9876.8	10801.0	6.14
Litchfield	43 51 29.60	70 03 42.43	88 10 09	Freeport Church	268 08 39	2882.2	3151.9	1.79
			53 37 01	Sherman	233 36 01	2415.3	2641.3	1.50
Drinkwater, flag	43 48 32.96	70 08 25.91	303 07 19	Moges	123 09 31	5090.4	5566.7	3.16
			42 43 56	York	222 42 18	4665.4	5101.9	2.90
Ross, point of observation	43 52 36.16	69 59 01.20	292 38 47	Orr	112 42 14	7227.4	7903.6	4.49
			343 24 46	Kellogg	163 25 29	5319.0	5816.7	3.30
Ross' House, chimney	43 52 36.55	69 59 00.96	343 30 30	Kellogg	163 31 17	5329.1	5827.7	3.31
			292 45 03	Orr	112 48 30	7227.3	7903.6	4.49

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Casco Bay, and continuation to Cape Small. Sketch A.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Brunswick, Baptist church..	43 55 02.11	69 57 38.38	1 58 56	Kellogg	181 58 46	8508.9	10507.0	5.97
			326 31 16	Orr	146 33 46	8738.6	9556.3	5.43
Brunswick, north turret of College chapel.	43 54 29.18	69 57 23.89	324 21 45	Orr	144 24 05	7717.6	8439.7	4.79
			4 22 14	Kellogg	184 21 54	8610.4	9416.1	5.35
Brunswick, south turret of College chapel.	43 54 28.80	69 57 23.97	324 18 03	Orr	144 20 23	7711.2	8432.2	4.79
			4 21 21	Kellogg	184 21 01	8600.2	9404.9	5.34
Brunswick, dark spire of Congregational church.	43 54 37.15	69 57 26.94	325 00 09	Orr	145 02 31	7959.4	8704.1	4.94
			3 48 20	Kellogg	183 48 02	8852.7	9681.0	5.50
Sylvester Hill	43 53 39.89	70 04 09.24	289 16 49	Orr	109 23 59	14354.1	15697.2	8.93
			310 02 42	Kellogg	130 07 03	10972.2	11998.9	6.83
Woodside	43 52 12.10	69 59 22.94	285 54 53	Orr	105 58 35	7440.8	8137.0	4.62
			335 17 38	Kellogg	155 18 40	4794.2	5242.8	2.98
Given	43 51 16.88	69 57 46.02	3 28 45	Kellogg	183 28 40	2656.5	2905.1	1.65
			273 52 30	Orr	93 55 05	5002.6	5470.7	3.11
Starwood	43 51 17.23	69 59 07.25	272 55 09	Orr	92 58 40	6814.0	7451.6	4.23
			328 09 22	Kellogg	148 10 13	3133.5	3426.7	1.95
Jebaskadiggin Pine	43 48 38.72	69 55 50.90	51 01 15	Randall	230 58 03	7990.6	8738.3	4.96
			329 13 35	Yarmouth	149 14 33	3668.1	4011.3	2.28
Pine	43 50 21.76	69 53 59.36	177 01 17	Orr	357 01 15	1363.0	1490.5	0.85
			79 42 45	Kellogg	259 40 03	5310.5	5807.4	3.30
Pond Island	43 44 01.62	69 57 57.81	136 15 00	Randall	316 13 15	4879.3	5335.8	3.03
			221 06 10	Yarmouth	41 08 36	7169.5	7840.3	4.45
Ram Island	43 44 49.60	69 57 32.67	29 52 33	Halfway Rock	209 49 31	11716.7	12813.0	7.28
			314 44 08	Ragged	134 45 16	3087.0	3375.8	1.92
Oak Island	43 45 46.52	69 56 36.84	309 37 27	Bald Head	129 41 20	9923.8	10852.4	6.16
			346 29 57	Ragged	166 30 26	4041.2	4419.3	2.51
Elm	43 45 20.87	69 55 42.51	310 45 12	Bald Head	130 48 28	8484.9	9278.8	5.27
			4 57 40	Ragged	184 57 32	3149.7	3444.4	1.96
Clapboard Island	43 42 53.62	70 11 18.76	247 23 18	Jebeig	67 26 21	6424.9	7026.1	3.99
			185 40 01	York	5 40 23	7078.9	7741.3	4.40
Jack	43 44 59.40	69 58 51.26	179 57 52	Harpswell Church	359 57 52	5521.8	6038.5	3.43
			302 02 58	Ragged	122 04 58	4662.3	5098.5	2.90
School-House	43 41 11.59	70 09 03.38	217 53 02	Long Island	37 53 37	1858.5	2032.4	1.15
			327 40 21	Green Island	147 41 42	4894.8	5352.8	3.04
Cleves	43 46 27.48	70 07 24.23	160 24 15	Drinkwater	340 23 31	4109.8	4494.3	2.55
			95 36 15	York	275 33 54	4565.4	4993.7	2.84
White House	43 43 09.67	70 07 38.97	53 43 03	Cow Island	233 40 52	5258.6	5750.6	3.27
			354 40 10	Green Island	174 40 32	7814.4	8545.6	4.85
Basket	43 44 06.43	70 09 38.44	17 49 17	Cow Island	197 48 34	5109.9	5588.0	3.17
			266 33 21	Jebeig	86 35 15	3693.0	4038.5	2.29
Eagle Island, tree	43 42 35.97	70 02 52.26	245 53 02	Haskel	65 53 52	1788.9	1956.3	1.11
			347 37 51	Halfway Rock	167 38 32	6181.7	6760.1	3.84
Minesteral	43 43 05.59	70 04 03.72	337 10 33	Halfway Rock	157 12 04	7542.4	8248.1	4.69
			273 13 57	Haskel	93 15 37	3237.5	3540.4	2.01
Bates	43 42 31.01	70 04 21.45	330 32 55	Halfway Rock	150 34 38	6757.6	7389.9	4.20
			256 17 50	Haskel	76 19 42	3735.5	4085.0	2.32
Jewel's Island	43 41 19.38	70 05 10.17	30 47 13	Green Island	210 45 53	5094.1	5570.7	3.17
			236 44 13	Haskel	56 46 39	5644.6	6172.7	3.51
Stave Island	43 42 54.62	70 04 50.69	226 19 46	Randall	46 22 47	8100.6	8858.6	5.03
			175 53 55	Moges	355 53 45	7677.5	8395.9	4.77
Horse Island, (1)	43 43 59.33	70 02 21.94	215 09 37	Randall	35 10 55	4397.7	4809.2	2.73
			332 36 23	Haskel	152 36 53	2073.3	2267.3	1.29
Upper Flag Island	43 43 25 63	70 02 24.64	209 13 31	Randall	29 14 51	5310.8	5807.7	3.30
			308 18 17	Haskel	128 18 48	1293.0	1414.0	0.80
Broken Cave	43 41 44 24	70 03 59 63	233 27 17	Haskel	53 28 54	3909.3	4275.1	2.43
			327 27 50	Halfway Rock	147 29 17	5268.3	5761.2	3.27
Crotch Island, northeast point	43 42 23.63	70 05 27.35	257 41 26	Haskel	77 44 03	5224.2	5713.0	3.24
			181 48 00	Moges	1 48 08	8618.7	9425.1	5.35
Crotch Island, east point	43 41 37.51	70 05 16.03	242 23 31	Haskel	62 26 01	5474.1	5986.3	3.40
			218 52 00	Randall	38 55 19	10241.5	11199.8	6.36
Sturdivant Island	43 44 29.08	70 10 31.16	275 35 29	Jebeig	95 37 59	4888.9	5346.4	3.04
			174 54 17	York	354 54 03	4114.7	4499.7	2.56

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Casco Bay, and continuation to Cape Small. Sketch A.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Little Jebeig	43 42 48.55	70 08 38.00	158 06 36	York	338 04 06	7761.3	8487.5	4.82
			210 02 08	Moges	30 03 21	9061.9	9909.8	5.63
Little Bangs Island	43 43 24.57	70 05 18.01	234 10 49	Randall	54 14 09	7979.7	8726.3	4.96
			278 54 21	Haskel	98 56 52	4954.8	5418.4	3.08
Birch Island	43 49 12.49	69 59 45.15	332 18 43	Harpswell Church	152 19 20	2584.8	2826.7	1 61
			244 35 46	Kellogg	64 37 03	2767.7	3026.7	1.72
Mark Island, flag in tree	43 43 15.28	69 53 34.70	221 58 46	Robinson's Rock	42 00 41	5727.5	6263.4	3.56
			170 17 10	Yarmouth	350 16 34	6930.6	7579.1	4.31
Horse Island, (2)	43 46 09.15	69 51 55.07	304 41 16	Robinson's Rock	124 42 06	1948.8	2131.1	1.21
			49 13 01	Ragged	229 10 15	7081.7	7744.3	4.40
Green Island, (2)	43 46 13.83	70 04 43.10	96 05 57	York	276 01 45	8194.2	8960.9	5.09
			154 33 21	Moges	334 32 59	1672.4	1828.9	1.04
French's Island	43 46 53.22	70 03 59.53	290 34 45	Randall	110 37 11	5036.7	5508.0	3.13
			336 28 15	Haskel	156 29 52	7860.6	8596.1	4.88
Great Whale Boat Island	43 45 28.20	70 02 33.58	253 02 26	Randall	73 03 53	2918.9	3192.0	1.81
			345 09 25	Haskel	165 10 03	4742.0	5185.7	2.95
Little Whale Boat Island	43 45 59.76	70 03 04.12	271 59 52	Randall	92 01 40	3478.6	3804.1	2.16
			341 08 29	Haskel	161 09 28	5872.8	6422.3	3.65
Eagle Island	43 42 35.98	70 02 52.25	347 37 52	Halfway Rock	167 38 33	6182.0	6760.5	3.84
			119 09 31	Jebeig	299 06 44	6186.3	6765.1	3.84
Hope Island	43 42 14.36	70 06 48.93	75 52 42	Long Island	255 51 44	1927.1	2107.4	1.20
			3 43 19	Green Island	183 43 07	6086.5	6656.0	3.78
Little Birch Island	43 43 54.18	70 02 42.33	64 21 47	Long Island	244 17 58	8196.7	8963.7	5.09
			320 01 34	Haskel	140 02 18	2195.5	2400.9	1.36
Barn on northeast end of Great Jebeig.	43 45 20.92	70 05 31.45	309 58 55	Haskel	130 01 36	6781.4	7415.9	4.21
			260 56 19	Randall	80 59 48	6856.4	7497.9	4.25
Stockman's Island	43 44 04.62	70 04 33.00	297 15 53	Haskel	117 17 53	4373.9	4783.2	2.72
			237 51 25	Randall	57 54 14	6452.6	7056.4	4.01
Bibber's Island	43 47 58.98	70 03 48.26	246 25 34	Kellogg	66 29 40	8653.2	9462.9	5.38
			270 08 39	Harpswell Church	90 12 05	6635.0	7255.8	4.12
Flying Point	43 49 00.88	70 03 15.42	288 05 41	Harpswell Church	108 08 44	6207.5	6788.3	3.86
			36 18 23	Moges	216 17 00	4522.4	4945.6	2.81
Freeport River, flag in tree, Wolf's Neck.	43 49 30.60	70 04 54.30	318 07 29	Randall	138 10 33	8899.0	9731.7	5.53
			5 51 37	Moges	185 51 23	4585.7	5014.8	2.85
Freeport, dark spire	43 51 43.99	70 05 41.93	307 10 29	Harpswell Church	127 15 13	11515.0	12592.5	7.15
			356 04 11	Moges	176 04 29	8697.9	9511.7	5.40
William's Island, red flag on tree.	43 48 44.43	70 02 37.62	252 03 54	Kellogg	72 07 11	6677.4	7302.2	4.15
			285 42 03	Harpswell Church	105 44 39	5251.8	5743.2	3.26
Poplar on Day's Land	43 50 16.49	70 04 14.54	134 59 54	Freeport Church	314 58 47	3059.9	3346.2	1.90
			123 51 24	Sherman	303 50 46	1478.1	1616.4	0.92
Little Crow Island	43 43 43.50	70 05 53.40	240 37 39	Randall	60 41 23	8331.9	9111.5	5.18
			283 21 36	Haskel	103 24 32	5845.4	6392.3	3.63
Parker's Point	43 47 19.87	70 08 16.50	174 40 09	Drinkwater	354 40 02	2265.2	2477.1	1.41
			70 51 56	York	250 50 11	3573.9	3908.3	2.22
Daniel Roduck	43 50 54.97	70 04 29.98	67 35 09	Sherman	247 34 42	954.7	1044.0	0.59
			118 12 51	Freeport Church	298 11 54	2064.4	2257.5	1.28
Crab Island	43 47 43.89	70 05 23.19	75 14 58	York	255 11 06	7498.8	8200.5	4.66
			352 01 31	Moges	172 01 36	1281.1	1401.0	0.79
Staples' Point, poplar	43 48 06.99	70 06 26.22	199 34 16	Sherman	19 35 09	5115.2	5593.8	3.18
			321 18 29	Moges	141 19 18	2538.7	2776.2	1.58
Lane's Island	43 47 31.33	70 07 04.91	289 45 44	Moges	109 47 00	2605.4	2849.1	1.62
			72 58 29	York	252 55 55	5205.2	5692.2	3.23
Yarmouth, academy cupola nearest the church.	43 47 57.84	70 10 41.34	225 07 36	Freeport Church	45 10 56	9134.8	9989.5	5.68
			3 21 46	York	183 21 42	2347.6	2567.2	1.46
Yarmouth, academy cupola farthest from the church.	43 47 58.58	70 10 43.04	2 24 31	York	182 24 28	2368.3	2589.9	1.47
			225 23 39	Freeport Church	45 27 01	9145.2	10000.9	5.68
Yarmouth, yellow spire	43 48 11.13	70 11 25.70	342 46 16	York	162 46 42	2883.5	3153.3	1.79
			284 15 21	Moges	104 19 37	8545.4	9345.0	5.31
Yarmouth, white spire	43 47 56.71	70 10 40.44	3 54 45	York	183 54 40	2314.5	2531.1	1.44
			282 51 56	Moges	102 55 41	7457.8	8155.6	4.63
Hill's Point, flag in tree	43 45 46.61	70 10 09.66	35 09 19	Moody	215 07 11	7173.6	7844.8	4.46
			153 36 56	York	333 36 30	1904.2	2082.4	1.18

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Casco Bay, and continuation to Cape Small. Sketch A.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Walnut Hill	43 45 24.82	70 12 02.00	91 27 11	Mount Independence	271 22 27	9196.6	10957.1	5.71
			215 00 27	York	35 01 19	2903.5	3175.2	1.80
Mare Point	43 49 49.22	70 00 40.31	324 34 30	Harpswell Church	144 35 45	4199.3	4592.2	2.61
			269 09 36	Kellogg	89 11 32	3732.8	4082.1	2.32
Shelter Island	43 47 55.56	70 00 35.13	267 52 44	Harpswell Church	87 53 56	2319 6	2536.6	1.44
			357 45 57	Randall	177 46 01	3698.8	4044.9	2.30
Scrag Island	43 50 14.42	69 58 37.19	4 19 34	Harpswell Church	184 19 24	4212.0	4606.1	2.62
			306 23 33	Kellogg	126 24 03	1219.5	1333.6	0.76
Gosling	43 47 01.69	70 02 25.94	307 47 08	Randall	127 48 29	3318.0	3628.5	2.06
			249 57 17	Harpswell Church	69 59 45	5104.0	5581.6	3.17
Merryman	43 47 38.26	69 58 29.16	40 13 02	Randall	220 11 39	4140.4	4527.8	2.57
			26 20 20	Haskel	206 18 08	9592.3	10489.8	5.96
Allen	43 48 01.91	69 59 20.14	279 46 41	Harpswell Church	99 47 01	651.5	712.4	0.41
			209 58 27	Kellogg	29 59 27	3885.5	4249.1	2.41
Pole Island	43 47 51.39	69 55 01.23	335 38 05	Yarmouth	155 38 29	1854.9	2028.5	1.15
			8 44 13	Ragged	188 43 36	7874.5	8611.3	4.89
Stover	43 45 02.55	70 00 08.60	164 42 25	Randall	344 42 11	1703.5	1862.9	1.06
			28 09 31	Haskel	208 08 28	4301.8	4704.3	2.67
Winslow Morse	43 44 04.36	69 50 42.63	179 37 55	Robinson's Rock	359 37 54	2741.9	2998.4	1.70
			83 40 57	Ragged	263 37 21	7026.0	7683.4	4.36
White Bull	43 43 08.06	69 55 09.40	284 13 03	Bald Head	104 15 59	5866.3	6415.2	3.64
			187 39 20	Yarmouth	7 39 49	7117.5	7783.5	4.42
Byle's Point	43 47 19.07	69 56 36.46	283 26 32	Yarmouth	103 28 02	2976.1	3254.6	1.85
			352 09 14	Ragged	172 09 43	6849.5	7490.4	4.25
Bailey's Island	43 43 10.61	69 59 52.62	171 00 25	Randall	351 00 00	5161.1	5644.0	3.21
			81 57 22	Haskel	261 56 08	2411.8	2637.5	1.50
Orr's Island, north chimney of house.	43 46 09.76	69.57 55.16	82 51 42	Randall	262 49 56	3460.6	3784.4	2.15
			40 32 48	Haskel	220 30 13	7717.7	8439.8	4.79
Bear Island	43 46 45.88	69 52 33.31	97 26 30	Yarmouth	277 25 11	2563.8	2803.7	1.59
			38 02 17	Ragged	217 59 58	7313.4	7997.7	4.54
Rogue Island	43 46 20.57	69 53 28.53	213 16 08	Ragged	33 17 49	5957.7	6515.1	3.70
			291 35 01	Robinson's Rock	111 36 55	3971.3	4342.9	2.47
Jenny	43 45 53.31	69 54 11.20	169 45 05	Yarmouth	349 44 54	1986.0	2171.8	1.23
			29 13 46	Ragged	209 12 34	4742.4	5186.1	2.95
Long Ledge	43 45 30.23	69 53 38 55	41 38 27	Ragged	221 36 53	4584.8	5013.8	2.85
			157 53 15	Yarmouth	337 52 42	2878.0	3147.3	1.79
Flag Island	43 44 52.69	69 53 13.30	156 41 26	Yarmouth	336 40 35	4164.8	4554.5	2.59
			57 52 41	Ragged	237 50 49	4264.3	4663.3	2.65
Wood Island	43 43 57.87	69 51 47.30	338 41 38	Bald Head	158 42 14	3199.3	3498.6	1.99
			84 04 36	Ragged	264 01 45	5565.6	6086.4	3.46
Lowell	43 44 33.50	69 50 17.62	257 26 19	Ragged	77 30 12	7726.0	8448.9	4.80
			162 36 14	Robinson's Rock	342 35 56	1930.9	2111.6	1.20
Cape Small Point	43 42 07.33	69 49 54.91	193 11 42	Morse	13 12 11	4076.3	4457.7	2.53
			107 38 22	Bald Head	287 37 40	1420.6	1553.5	0.88
Fuller's Rock	43 41 43.64	69 49 42.47	187 54 02	Morse	7 54 22	4744.7	5188.6	2.95
			125 26 11	Bald Head	305 25 21	2003.4	2190.8	1.24

Section II.—Hudson River. Sketch B.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Crow's Nest	41 24 28.71	73 58 41.64	....	....	....	....	....	....
Bald Hill	41 30 03.51	73 54 44.21	28 06 08	Crow's Nest	208 03 30	11705.6	12800.9	7.27
Prospect Hill	41 33 19.45	74 01 29.02	346 38 35	Crow's Nest	166 40 26	16826.3	18400.7	10.45
			302 45 01	Bald Hill	122 49 30	11161.9	12206.3	6.93
Bingham	41 35 28.88	73 59 11.93	328 15 15	Bald Hill	148 18 13	11799.8	12903.9	7.33
			38 30 33	Prospect Hill	218 29 02	5101.5	5578.8	3.17

UNITED STATES COAST SURVEY—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River. Sketch B.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Underhill	41 35 45.05	73 51 36.97	87 19 51	Bingham	267 14 49	10517.4	11534.3	6.55
			71 55 12	Prospect Hill	251 48 39	14430.7	15781.0	8.97
Golden Ridge	41 38 42.54	73 58 48.65	5 09 19	Bingham	185 09 04	5998.4	6559.7	3.73
			340 30 06	Bald Hill	160 32 48	16983.0	18572.1	10.55
Vervalin	41 41 19.24	73 50 35.08	7 54 54	Underhill	187 54 13	10408.1	11382.0	6.47
			47 56 42	Bingham	227 50 59	16120.2	17628.6	10.02
New York Latting Observatory.	40 45 15.23	73 58 39.48	286 40 09	Vetts	106 43 06	6626.5	7246.5	4.12
			32 34 46	Howard	212 30 35	16775.9	18345.6	10.42
Cruger	41 14 01.82	73 56 02.10	245 49 43	Dickerson	65 52 34	6623.0	7242.7	4.12
			297 12 22	Colleberg East	117 13 53	3600.1	3937.0	2.24
Washington Hill	41 15 13.98	73 56 55.35	330 52 35	Cruger	150 53 10	2547.5	2785.9	1.58
			35 18 47	Knapp	215 17 48	3558.0	3890.9	2.21
Lower Dunderberg	41 15 31.44	73 58 32.24	283 26 07	Washington Hill	103 27 11	2319.0	2536.0	1.44
			238 43 15	Johnny Lent	58 44 45	3965.1	4336.1	2.46
Cat Hill	41 25 02.27	73 54 47.98	30 35 05	Bear Mount.	210 31 45	13817.0	15109.9	8.58
			44 44 04	Bare Rock	224 41 32	7601.0	8312.2	4.72
Croton	41 12 47.58	73 54 15.65	58 06 46	High Tor	238 04 33	5520.9	6037.5	3.43
			132 44 22	Cruger	312 43 12	3375.1	3690.9	2.10
Teller's Point north	41 11 12.05	73 53 46.02	90 19 38	High Tor	270 17 06	5378.2	5881.4	3.34
			148 49 31	Cruger	328 48 01	6121.4	6694.2	3.80
Robinson	41 29 29.06	74 00 13.00	166 04 52	Prospect Hill	346 04 02	7322.2	8007.3	4.55
			262 02 14	Bald Head	82 05 52	7699.0	8419.4	4.78
Gwinn	41 30 37.39	74 00 47.70	169 09 35	Prospect Hill	349 09 08	5090.1	5566.4	3.16
			339 06 05	Robinson	159 06 28	2256.2	2467.3	1.40
Whortleberry	41 30 57.53	73 58 36.39	137 35 25	Prospect Hill	317 33 30	5931.0	6486.0	3.69
			287 10 39	Bald Hill	107 13 13	5635.6	6162.9	3.50
Verplank	41 32 03.47	73 58 16.16	117 41 34	Prospect Hill	297 39 26	5046.7	5518.9	3.14
			306 57 49	Bald Hill	127 00 09	6151.5	6727.1	3.82
Weed	41 32 54.59	73 59 41.25	107 05 02	Prospect Hill	287 03 50	2612.4	2856.9	1.62
			307 26 25	Bald Hill	127 29 42	8675.6	9487.4	5.39
Railroad 51	41 31 13.27	73 58 47.06	68 25 21	Gwinn	248 24 01	3008.1	3289.6	1.87
			158 06 24	Weed	338 05 48	3368.1	3683.2	2.09
Spy Hill	41 30 09.71	73 58 27.79	62 48 42	Robinson	242 47 32	2743.4	3000.1	1.71
			144 20 55	Prospect Hill	324 18 55	7204.6	7878.7	4.48
Sheafe	41 36 25.41	73 55 38.08	353 56 53	Bald Hill	173 57 29	11846.9	12955.4	7.36
			54 49 07	Prospect Hill	234 45 14	9948.3	10879.2	6.18
Mansion Hill	41 37 45.17	73 57 28.03	294 28 36	Underhill	114 32 29	8932.0	9767.8	5.55
			345 03 45	Bald Hill	165 05 34	14738.4	16117.5	9.16
Mud Hole	41 33 16.16	73 59 04.22	314 34 22	Bald Hill	134 37 14	8464.2	9256.2	5.26
			12 49 48	Robinson	192 49 02	7184.5	7856.8	4.46
Angel	41 34 21.79	73 56 02.25	75 46 39	Prospect Hill	255 43 02	7810.9	8541.8	4.85
			247 17 13	Underhill	67 20 09	6659.3	7282.4	4.14
Old Ferry	41 34 46.51	73 56 30.74	68 47 17	Prospect Hill	248 43 59	7413.7	8107.4	4.61
			109 18 32	Bingham	289 16 45	3955.4	4325.5	2.46
Truesdall	41 33 45.54	73 58 40.23	321 21 44	Bald Hill	141 24 20	8765.9	9586.1	5.45
			167 02 03	Bingham	347 01 42	3271.5	3577.6	2.03
Armstrong	41 34 02.50	73 57 55.73	328 55 48	Bald Hill	148 57 55	8605.7	9410.9	5.35
			20 40 54	Robinson	200 39 23	9015.2	9858.8	5.60
Newburgh Spire	41 30 05.93	74 00 12.05	270 31 55	Bald Hill	90 35 32	7603.0	8314.4	4.72
			267 13 45	Spy Hill	87 14 54	2420.6	2647.1	1.50
Carpenter	41 34 10.52	73 53 19.06	14 31 42	Bald Hill	194 30 46	7871.3	8607.8	4.89
			82 08 37	Prospect Hill	262 03 12	11460.2	12532.5	7.12
Rapalyee	41 30 35.47	73 52 34.40	112 15 15	Prospect Hill	292 09 21	13384.5	14636.9	8.32
			187 55 39	Underhill	7 56 17	9642.1	10544.3	5.99
Fishkill Landing	41 30 09.18	73 58 45.47	58 38 25	Robinson	238 37 27	2377.6	2600.1	1.48
			107 04 41	Gwinn	287 03 20	2965.0	3242.4	1.84

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section III.—Rappahannock River. Sketch C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
SANDY POINT	37 33 38.48	75 56 17.92						
WINDMILL POINT	37 36 41.82	76 16 14.63	280 47 45	Sandy Point	100 59 55	29896.2	32693.6	18.58
Stingray Point	37 33 35.14	76 17 21.72	195 57 12	Windmill Point	15 57 53	5985.6	6545.7	3.72
			269 42 09	Sandy Point	89 54 59	31013.8	33915.8	19.27
Mosquito Point	37 36 27.53	76 21 14.74	266 32 57	Windmill Point	86 36 00	7372.8	8062.7	4.58
			312 53 34	Stingray Point	132 55 56	7805.1	8535.4	4.85
Stiff	37 34 19.15	76 21 47.82	241 41 06	Windmill Point	61 44 29	9281.1	10149.5	5.77
			191 35 01	Mosquito Point	11 35 21	4040.0	4418.0	2.51
Gray's Point	37 36 39.28	76 25 32.04	308 07 36	Stiff	128 09 53	6993.9	7648.3	4.34
			273 15 48	Mosquito Point	93 18 25	6320.6	6912.0	3.93
Cherry Point	37 37 36.21	76 23 55.44	298 13 59	Mosquito Point	118 15 37	4473.2	4891.8	2.78
			53 28 44	Gray's Point	233 27 45	2948.1	3223.9	1.83
Cabell	37 38 52.58	76 26 54.72	298 09 50	Cherry Point	118 11 40	4986.0	5452.5	3.10
			333 44 19	Gray's Point	153 45 10	4582.0	5010.8	2.85
Toll's Point	37 38 31.25	76 30 05.65	297 12 19	Gray's Point	117 15 06	7544.3	8250.2	4.69
			261 59 11	Cabell	82 01 08	4726.1	5168.3	2.94
Whiting	37 36 40.17	76 29 50.27	226 30 14	Cabell	46 32 01	5931.8	6486.8	3.69
			173 43 06	Toll's Point	353 42 57	3445.0	3767.3	2.14
Bailey's Bluff	37 37 57.29	76 33 09.25	256 53 27	Toll's Point	76 55 19	4621.1	5053.5	2.87
			295 57 42	Whiting	115 59 44	5427.3	5935.1	3.37
Beach Point	37 39 51.56	76 31 57.11	332 11 59	Whiting	152 13 16	6669.0	7293.0	4.14
			26 39 50	Bailey's Bluff	206 39 06	3941.4	4310.2	2.45
Spindle	37 40 24.61	76 34 29.22	336 39 01	Bailey's Bluff	156 39 50	4946.2	5409.0	3.07
			285 16 33	Beach Point	105 18 06	3864.1	4225.7	2.40
W. Jones	37 43 09.61	76 33 13.35	342 59 00	Beach Point	162 59 47	6384.6	6982.0	3.97
			20 04 33	Spindle	200 03 47	5415.3	5922.0	3.37
Hundley	37 42 47.65	76 35 31.26	258 39 21	W. Jones	78 40 45	3444.4	3766.7	2.14
			340 58 35	Spindle	160 59 13	4664.2	5100.6	2.90
Carter	37 44 14.65	76 33 56.53	40 52 00	Hundley	220 51 02	3545.9	3877.7	2.20
			332 11 46	W. Jones	152 12 12	2266.6	2478.7	1.41
Punch Bowl	37 44 29.57	76 36 50.47	276 09 08	Carter	96 10 54	4283.1	4683.9	2.66
			328 18 28	Hundley	148 19 17	3692.3	4037.8	2.29
Downman	37 46 19.85	76 35 56.12	21 22 20	Punch Bowl	201 21 47	3650.7	3992.3	2.27
			322 48 48	Carter	142 50 01	4844.3	5297.6	3.01
Sullivan	37 45 18.66	76 34 15.15	127 22 04	Downman	307 21 02	3108.8	3399.7	1.93
			68 18 32	Punch Bowl	248 16 57	4091.9	4474.8	2.54
Garrett	37 44 51.03	76 37 25.74	259 38 17	Sullivan	79 40 14	4742.1	5185.8	2.95
			218 41 16	Downman	38 42 11	3508.2	3836.5	2.18
Yerby	37 47 45.53	76 38 53.68	338 11 23	Garrett	158 12 17	5793.9	6336.0	3.60
			301 17 08	Downman	121 18 57	5084.1	5559.8	3.16
Jessie	37 46 18.94	76 40 39.92	224 13 43	Yerby	44 14 48	3726.0	4074.6	2.32
			299 40 31	Garrett	119 42 30	5470.8	5982.7	3.40
Middleton	37 49 31.14	76 42 04.24	304 55 12	Yerby	124 57 09	5685.3	6217.3	3.53
			340 47 59	Jessie	160 48 51	6274.1	6861.2	3.90
Layton	37 47 05.18	76 41 13.27	164 30 58	Middleton	344 30 27	4669.4	5106.3	2.90
			249 58 13	Yerby	69 59 39	3634.4	3974.5	2.26
Bowler	37 49 18.39	76 44 47.49	308 04 07	Layton	128 06 18	6657.5	7280.4	4.14
			264 21 40	Middleton	84 23 20	4011.2	4386.5	2.49
Barber	37 49 37.32	76 42 14.07	81 10 23	Bowler	261 08 49	3796.8	4152.1	2.36
			342 24 07	Layton	162 24 44	4920.3	5380.7	3.06
Neale	37 50 40.12	76 43 13.93	42 14 42	Bowler	222 13 45	3403.2	3721.6	2.12
			322 54 35	Barber	142 55 12	2427.1	2654.2	1.51
Folly	37 52 08.94	76 44 19.22	7 29 24	Bowler	187 29 07	5302.9	5799.1	3.29
			329 45 25	Neale	149 46 05	3169.3	3465.8	1.97
Eubank	37 50 59.11	76 45 50.63	226 03 17	Folly	46 04 13	3102.6	3392.9	1.93
			333 33 35	Bowler	153 34 14	3467.6	3792.1	2.15
South Base	37 52 08.13	76 46 47.06	269 35 22	Folly	89 36 53	3613.0	3951.1	2.25
			327 02 39	Eubank	147 03 14	2535.6	2772.9	1.58
Accaceek Point	37 52 39.68	76 45 41.46	4 08 00	Eubank	184 07 54	3108.5	3399.4	1.93
			58 45 14	South Base	238 44 34	1874.9	2050.3	1.17

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section III.—Rappahannock River. Sketch C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
North Base	37 52 51.67	76 47 25.61	278 15 18	Accaceek Point	98 16 22	2571.4	2812.0	1.60
			324 56 07	South Base	144 56 31	1639.9	1793.3	1.02
Ellet	37 54 12.60	76 46 08.46	347 01 53	Accaceek Point	167 02 10	2939.5	3214.5	1.83
			37 04 19	North Base	217 03 32	3126.7	3419.3	1.94
Payne Waring	37 53 50.54	76 48 23.01	258 17 53	Ellet	78 19 16	3356.2	3670.2	2.08
			322 18 02	North Base	142 18 37	2293.7	2508.3	1.43
Carter	37 55 21.52	76 47 28.59	25 21 38	Payne Waring	205 21 05	3103.9	3394.3	1.93
			317 20 57	Ellet	137 21 46	2888.6	3158.9	1.80
Alice Jones	37 54 50.20	76 50 10.46	256 15 36	Carter	76 17 16	4069.4	4450.2	2.53
			305 00 49	Payne Waring	125 01 55	3204.9	3504.8	1.99
Mango Rite	37 56 04.20	76 49 57.60	7 50 27	Alice Jones	187 50 19	2302.8	2518.3	1.43
			289 52 00	Carter	109 53 32	3869.1	4231.1	2.40
Tappahannock, Episcopal church steeple.	37 55 35.53	76 51 12.95	312 28 36	Alice Jones	132 29 14	2069.2	2262.8	1.29
			244 20 09	Mango Rite	64 20 55	2041.2	2232.2	1.27
Atkins	37 56 10.89	76 51 30.52	275 11 12	Mango Rite	95 12 09	2278.0	2491.1	1.42
			321 49 48	Alice Jones	141 50 37	3163.7	3459.7	1.97
Ferry Marsh	37 56 58.19	76 50 46.14	36 36 48	Atkins	216 36 21	1816.6	1986.6	1.13
			324 32 43	Mango Rite	144 33 13	2043.3	2234.5	1.27
Brockenbrough	37 56 59.75	76 52 32.58	271 02 52	Ferry Marsh	91 05 57	2598.7	2841.9	1.61
			314 49 27	Atkins	134 50 05	2136.4	2336.3	1.33
Fauntleroy	37 58 50.45	76 51 39.68	20 43 34	Brockenbrough	200 43 01	3648.9	3990.3	2.27
			339 18 37	Ferry Marsh	159 19 10	3699.2	4045.3	2.30
Robinson	37 58 15.12	76 53 56.11	251 52 11	Fauntleroy	71 53 35	3502.9	3830.7	2.18
			318 43 37	Brockenbrough	138 44 28	3091.1	3380.3	1.92
Mulberry	37 59 34.65	76 53 35.08	11 49 04	Robinson	191 48 51	2505.0	2739.4	1.56
			295 48 46	Fauntleroy	115 49 57	3128.2	3420.9	1.94
Beverly	37 59 52.71	76 55 48.58	279 41 22	Mulberry	99 42 44	3304.0	3613.2	2.05
			317 37 17	Robinson	137 38 26	4072.3	4453.3	2.53
Bernard	38 00 53.92	76 53 52.55	56 18 57	Beverly	236 17 46	3401.7	3720.0	2.11
			350 06 34	Mulberry	170 06 45	2480.7	2712.8	1.54
Payne	38 01 59.72	76 55 46.07	306 13 20	Bernard	126 14 30	3432.0	3753.1	2.13
			0 53 47	Beverly	180 53 45	3916.1	4282.5	2.43
Cliff	38 02 29.60	76 54 24.07	65 16 16	Payne	245 15 25	2201.2	2407.2	1.37
			345 23 24	Bernard	165 23 43	3048.1	3333.3	1.89
Lloyd	38 02 59.32	76 55 21.77	303 04 32	Cliff	123 05 08	1678.7	1835.8	1.04
			17 52 11	Payne	197 51 56	1930.4	2111.0	1.20
Smith	38 04 12.97	76 55 06.00	342 12 48	Cliff	162 13 14	3346.7	3659.8	2.08
			9 36 28	Lloyd	189 36 18	2302.8	2518.3	1.43
John Goulman	38 03 52.67	76 56 02.38	245 30 32	Smith	65 31 07	1509.9	1651.2	0.94
			328 57 08	Lloyd	148 57 33	1919.7	2099.3	1.19
Smoot	38 04 58.04	75 56 32.16	340 11 51	John Goulman	160 12 09	2142.1	2342.5	1.33
			303 29 38	Smith	123 30 31	2[illegible]17.8	2753.4	1.56
Robert Waring	38 04 46.13	76 57 35.82	256 40 43	Smoot	76 41 22	1594.2	1743.4	0.99
			305 53 26	John Goulman	125 54 24	2811.1	3074.1	1.75
Bunker Hill	38 05 41.37	76 57 47.99	350 07 37	Robert Waring	170 07 45	1728.6	1890.3	1.07
			305 51 42	Smoot	125 52 29	2279.9	2493.2	1.42
Eliza Waring	38 05 16.41	76 59 12.10	249 24 29	Bunker Hill	69 25 21	2189.2	2394.0	1.36
			291 41 09	Robert Waring	111 42 08	2524.9	2761.2	1.57
Henry Taylor	38 06 48.15	76 59 35.91	348 24 36	Eliza Waring	168 24 51	2887.2	3157.4	1.80
			308 03 11	Bunker Hill	128 04 18	3339.1	3651.5	2.07
Brooke	38 05 37.42	77 00 17.67	205 00 35	Henry Taylor	25 01 01	2406.3	2631.5	1.50
			292 03 44	Eliza Waring	112 04 25	1724.0	1885.3	1.07
James Robb	38 06 45.21	77 01 36.55	317 23 57	Brooke	137 24 46	2839.1	3104.8	1.76
			268 13 26	Henry Taylor	88 14 40	2939.9	3215.0	1.83
Garnett	38 06 12.79	77 02 37.67	236 07 18	James Robb	56 07 56	1793.3	1961.1	1.11
			287 43 09	Brooke	107 44 35	3580.8	3915.9	2.22
Thomas Goulman	38 07 36.09	77 02 33.05	2 30 42	Garnett	182 30 39	2570.4	2810.9	1.60
			318 44 00	James Robb	138 44 35	2086.5	2281.7	1.30
Baylor	38 07 40.31	77 03 47.34	274 06 50	Thomas Goulman	94 07 36	1813.9	1983.6	1.13
			327 49 44	Garnett	147 50 27	3187.5	3485.8	1.98
Silas Gouldin	38 09 04.08	77 02 45.40	30 17 26	Baylor	210 16 48	2990.6	3270.4	1.86
			353 40 18	Thomas Goulman	173 40 26	2729.4	2984.8	1.70

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section III. Rappahannock River. Sketch C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Brick Quarter	38 10 16.53	77 05 32.61	298 46 37	Silas Gouldin	118 46 20	4644.2	5078.8	2.89
			331 59 16	Baylor	152 00 21	5458.2	5968.9	3.39
Seib	38 07 41.32	77 04 36.82	226 44 44	Silas Gouldin	46 45 53	3724.2	4072.7	2.31
			271 27 57	Baylor	91 28 28	1205.3	1318.1	0.75
Wave	38 09 33.14	77 03 54.57	298 01 01	Silas Gouldin	118 01 44	1907.2	2085.7	1.18
			357 06 22	Baylor	177 06 26	3483.0	3808.9	2.16
Liberty Hill	38 07 46.91	77 07 00.72	272 27 20	Baylor	92 29 19	4713.6	5154.7	2.93
			204 55 04	Brick Quarter	24 55 58	5089.9	5566.2	3.16
Nansatico	38 10 19.80	77 06 43.04	5 13 12	Liberty Hill	185 13 01	4733.2	5176.1	2.94
			273 15 24	Brick Quarter	93 16 08	1716.9	1877.6	1.07
Oaken Brow	38 11 08.72	77 07 46.96	314 06 34	Nansatico	134 07 14	2166.6	2369.3	1.35
			349 44 28	Liberty Hill	169 44 57	6322.7	6914.3	3.93
Camden	38 09 40.43	77 09 33.05	223 28 34	Oaken Brow	43 29 40	3751.7	4102.7	2.33
			313 19 37	Liberty Hill	133 21 11	5099.1	5576.2	3.17
Jack's Hill	38 08 43.31	77 08 39.22	195 50 11	Oaken Brow	15 50 43	4659.8	5095.8	2.90
			143 20 58	Camden	323 20 25	2194.9	2400.3	1.36
Woodlawn	38 11 33.06	77 09 06.06	291 17 50	Oaken Brow	111 18 39	2065.8	2259.1	1.28
			10 42 40	Camden	190 42 23	3534.2	3864.9	2.20
Port Royal	38 10 20.27	77 11 06.42	298 23 06	Camden	118 24 04	2583.5	2825.2	1.61
			232 31 45	Woodlawn	52 32 59	3689.9	4035.2	2.29
Walsingham	38 11 06.26	77 10 04.69	343 46 25	Camden	163 46 45	2756.2	3014.1	1.71
			46 39 42	Port Royal	226 39 04	2065.8	2259.1	1.28
Mill Bank	38 12 04.33	77 11 15.76	355 56 57	Port Royal	175 57 03	3216.0	3516.9	2.00
			315 59 09	Walsingham	135 59 53	2488.9	2721.8	1.55
Holland Point	38 11 02.11	77 12 05.33	212 09 31	Mill Bank	32 10 02	2266.0	2478.0	1.41
			311 58 14	Port Royal	131 58 50	1928.4	2108.8	1.20
Lewis	38 12 10.41	77 13 00.53	327 28 15	Holland Point	147 28 49	2497.6	2731.3	1.55
			274 12 08	Mill Bank	94 13 13	2555.7	2794.8	1.59
Port Royal Steeple	38 10 12.47	77 11 02.59	135 04 01	Holland Point	315 03 22	2161.6	2363.9	1.34
			174 41 36	Mill Bank	354 41 28	3463.3	3787.4	2.15
Hazelwood	38 10 32.82	77 13 57.50	204 43 52	Lewis	24 44 27	3312.8	3622.8	2.06
			251 41 11	Holland Point	71 42 20	2875.0	3144.0	1.79
Gouldin	38 12 09.66	77 14 46.18	269 28 33	Lewis	89 29 38	2570.5	2811.0	1.60
			338 21 14	Hazelwood	158 21 44	3212.1	3512.7	1.99
Cherry Point	38 13 40.40	77 13 20.43	36 43 04	Gouldin	216 42 11	3489.5	3816.0	2.17
			350 06 07	Lewis	170 06 19	2816.2	3079.7	1.75
Jones	38 14 04.17	77 15 20.43	284 05 14	Cherry Point	104 06 28	3008.9	3290.4	1.87
			346 43 18	Gouldin	166 43 39	3627.2	3966.6	2.25
Robb	38 15 23.90	77 14 55.11	14 03 45	Jones	194 03 29	2533.9	2771.0	1.57
			324 10 55	Cherry Point	144 11 54	3934.7	4302.9	2.45
Arnold	38 14 59.63	77 16 00.26	330 28 07	Jones	150 28 32	1965.1	2149.0	1.22
			244 42 36	Robb	64 43 16	1751.7	1915.6	1.09
Skinker's Neck	38 14 21.22	77 16 08.12	189 10 10	Arnold	9 10 15	1199.5	1311.7	0.75
			294 22 36	Jones	114 23 06	1273.3	1392.4	0.79
Corbin's Neck	38 14 51.64	77 16 55.82	308 57 26	Skinker's Neck	128 57 56	1491.3	1630.8	0.93
			259 39 10	Arnold	79 39 44	1373.0	1501.5	0.85
Skinker's Granary	38 13 27.14	77 16 19.39	161 13 21	Corbin's Neck	341 12 58	2751.5	3008.9	1.71
			189 19 45	Skinker's Neck	9 19 52	1689.6	1847.7	1.05
Southeast Base	38 14 34.72	77 18 18.27	255 24 29	Corbin's Neck	75 25 20	2071.6	2265.4	1.29
			305 45 59	Skinker's Granary	125 47 13	3563.5	3896.9	2.21
Corbin's Barn	38 13 29.00	78 18 09.93	174 16 41	Southeast Base	354 16 36	2036.2	2226.7	1.27
			215 15 58	Corbin's Neck	35 16 44	3120.6	3412.6	1.94
W. P. Taylor	38 14 00.40	77 18 54.97	220 08 31	Southeast Base	40 08 54	1383.9	1513.4	0.86
			311 28 03	Corbin's Barn	131 28 31	1462.0	1598.8	0.91
Northwest Base	38 14 45.85	77 19 07.30	347 55 25	W. P. Taylor	167 55 33	1432.9	1567.0	0.89
			286 03 42	S.E. Base	106 04 12	1240.4	1356.5	0.77
Gordon (1)	38 14 20.33	77 20 25.49	247 30 52	N.W. Base	67 31 40	2057.6	2250.1	1.28
			285 35 21	W. P. Taylor	105 36 17	2285.3	2499.1	1.42
Sedden	38 15 02.96	77 20 47.31	338 01 14	Gordon (1)	158 01 28	1417.1	1549.7	0.88
			282 13 48	N.W. Base	102 14 50	2487.9	2720.7	1.55
Gordon (2)	38 14 25.18	77 21 30.07	221 45 18	Sedden	41 45 44	1561.3	1707.4	0.97
			275 25 50	Gordon (1)	95 26 30	1577.4	1725.0	0.98

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section III. Rappahannock River. Sketch C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Snowden	38 15 02.13	77 21 46.10	341 06 45 268 58 31	Gordon (2) Sedden	161 06 55 88 59 07	1204.1 1429.7	1316.8 1563.5	0.75 0 89
H. Taylor	38 14 26.13	77 22 55.45	236 38 18 270 48 10	Snowden Gordon (2)	56 39 01 90 49 03	2018.6 2076.1	2207.5 2270.4	1.25 1.29
Fitzhugh	38 15 38.86	77 23 41.60	333 24 59 291 57 21	H. Taylor Snowden	153 25 28 111 58 33	2507.3 3027.4	2741.9 3310.7	1.56 1.88
Alsop	38 14 59.15	77 24 03.09	203 06 16 301 45 14	Fitzhugh H. Taylor	23 06 29 121 45 56	1331.1 1934.0	1455.6 2115.0	0.83 1.20
Pratt	38 15 24.62	77 25 18.41	259 25 15 293 12 09	Fitzhugh Alsop	79 26 15 113 12 56	2393.9 1992.3	2617.9 2178.7	1.49 1.24
Morson	38 16 11.50	77 24 52.24	23 45 22 300 21 47	Pratt Fitzhugh	203 45 06 120 22 31	1579.1 1990.1	1726.9 2176.3	0.98 1.24
Bernard (2)	38 16 06.19	77 26 19.13	265 33 47 310 57 50	Morson Pratt	85 34 41 130 58 28	2118.3 1954.9	2316.5 2137.8	1.32 1.21
Pollock	38 16 45.39	77 25 28.58	45 28 40 319 47 10	Bernard (2) Morson	225 28 09 139 47 32	1723.2 1368.1	1884.4 1496.1	1.07 0.85
Bernard (1)	38 16 50.95	77 26 43.23	275 23 42 337 00 06	Pollock Bernard (2)	95 24 28 157 00 21	1822.1 1499.0	1992.6 1639.3	1.13 0.93
Bray	38 17 33.10	77 26 25.99	17 52 15 316 30 58	Bernard (1) Pollock	197 52 04 136 31 34	1365.4 2027.2	1493.2 2216.9	0.85 1.26
Howison	38 17 58.26	77 28 01.44	288 29 12 317 30 37	Bray Bernard (1)	108 30 11 137 31 25	2445.6 2814.0	2674.4 3077.3	1.52 1.75
Scott	38 19 19.39	77 27 28.02	17 59 19 335 18 04	Howison Bray	197 58 58 155 18 42	2629.8 3606.9	2875.9 3944.4	1.63 2.24
Fredericksburg, Episcopal church steeple.	38 18 05.79	77 27 17.27	173 26 28 77 48 48	Scott Howison	353 26 21 257 48 21	2284.3 1098.0	2498.0 1200.7	1.42 0.68
JAMES RIVER.								
City Point	37 18 59.12	77 16 23.68	....	....	....	....	....	....
Comer	37 18 28.49	77 17 14.54	232 57 59	City Point	52 58 30	1568.3	1715.1	0.97
Lower Hundred	37 19 41.49	77 16 48.09	335 17 34 16 08 18	City Point Comer	155 17 49 196 08 02	1437.5 2342.7	1572.0 2561.9	0.89 1.46
Eppes Island	37 19 36.29	77 15 35.00	46 17 49 95 05 58	City Point Lower Hundred	226 17 19 275 05 14	1657.9 1806.3	1813.0 1975.3	1.03 1.12
Nunley	37 17 59.99	77 15 23.81	141 02 23 174 42 00	City Point Eppes Island	321 01 47 354 41 53	2344.1 2981.0	2563.4 3259.9	1.46 1.85
Pack's Point	37 19 18.87	77 14 04.51	38 46 30 103 33 34	Nunley Eppes Island	218 45 42 283 32 39	3118.3 2291.4	3410.1 2505.8	1.94 1.42
Jordan	37 17 56.91	77 13 20.39	91 48 07 156 44 17	Nunley Pack's Point	271 46 52 336 43 50	3040.8 2750.0	3325.3 3007.3	1.89 1.71
Point Jordan House	37 18 43.77	77 13 08.77	67 55 19 11 12 58	Nunley Jordan	247 53 57 191 12 51	3588.5 6472.3	3924.3 7077.9	2.23 4.02
Berkley	37 18 55.03	77 10 45.64	64 49 59 98 33 14	Jordan Pack's Point	244 48 25 278 31 13	4210.6 4950.9	4604.6 5414.2	2.62 3.08
Bermuda Hundred	37 20 28.29	77 16 15.61	328 03 01 28 59 39	Eppes Island Lower Hundred	148 03 26 208 59 19	1889.1 1649.3	2065.9 1803.6	1.17 1.02
Dogham	37 21 14.19	77 14 49.86	56 09 49 20 12 44	Bermuda Hundred Eppes Island	236 08 57 200 12 17	2540.7 3216.0	2778.4 3516.9	1 58 2.00
Shirley House	37 20 27.99	77 15 24.44	9 15 42 90 26 02	Eppes Island Bermuda Hundred	189 15 36 270 25 31	1614.6 1259.3	1765.7 1377.1	1.00 0.78
Westbrook	37 21 01.25	77 16 57.78	354 27 26 262 45 54	Lower Hundred Dogham	174 27 32 82 47 12	2470.4 3172.8	2701.6 3469.7	1.54 1.97
Watkins	37 21 03.27	77 16 20.21	261 22 43 354 00 25	Dogham Bermuda Hundred	81 23 38 174 00 28	2248.6 1084.1	2459.0 1185.5	1.40 0.67
Presquille	37 21 39.94	77 15 45.55	18 31 01 37 02 14	Bermuda Hundred Watkins	198 30 43 217 01 53	2329.1 1415.9	2547.0 1548.4	1.45 0.88
Bremo	37 22 38.77	77 16 29.74	329 03 18 355 26 41	Presquille Watkins	149 03 45 175 26 47	2114.5 2953.2	2312.4 3229.5	1.31 1.84
Presquille House	37 21 12.41	77 15 51.25	267 54 53 23 47 04	Dogham Bermuda Hundred	87 55 30 203 46 49	1511.7 1499.3	1653.2 1639.6	0.94 0.93

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section III. James River. Sketch C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Watkins House	37 21 11.55	77 15 51.10	352 18 41	Eppes Island	172 18 51	2963.1	3240.4	1.84
			24 20 16	Bermuda Hundred	204 20 01	1463.5	1600.4	0.91
Mount Blanco	37 21 41 46	77 18 18.22	236 29 20	Bremo	56 30 26	3200.6	3500.1	1.99
			292 03 27	Watkins	112 04 39	3133.4	3426.6	1.95
Allen	37 23 54.14	77 17 26.49	328 59 52	Bremo	149 00 25	2710 4	2964.0	1.68
			17 17 12	Mount Blanco	197 16 41	4283.4	4684.2	2.66
Jones	37 22 35.24	77 18 55.96	222 07 51	Allen	42 08 46	3279.8	3586.7	2.04
			268 15 22	Bremo	88 16 51	3598.5	3935.2	2.24
Farrar	37 22 49.61	77 21 09.09	250 00 53	Allen	70 03 08	5825.2	6370.3	3.62
			277 41 27	Jones	97 42 48	3304 9	3614.1	2.05
Sewcocks	37 23 14.35	77 20 44.14	294 21 40	Jones	114 22 46	2921.4	3194.8	1.82
			38 50 06	Farrar	218 49 51	978.9	1077.5	0.61
Janney	37 23 20.10	77 21 20.87	342 52 00	Farrar	162 52 07	983 6	1075.6	0.61
			281 06 16	Sewcocks	101 06 38	920.8	1007.0	0.57
Brick Yard	37 23 39.75	77 20 03.16	320 15 21	Jones	140 16 04	2585.9	2827.9	1.61
			46 22 56	Farrar	226 22 16	2240.2	2449.8	1.39
Old Place	37 23 29.28	77 22 06.48	284 09 06	Janney	104 09 34	1156.9	1265.1	0.72
			310 53 53	Farrar	130 54 27	1867.6	2042.4	1.16
Coxendale	37 22 57.39	77 22 39.78	219 47 48	Old Place	39 48 08	1279.7	1399.4	0.79
			250 09 26	Janney	70 10 14	2063.3	2256.4	1.28
Boler	37 24 04.81	77 22 28.16	334 02 39	Old Place	154 02 52	1218.0	1332.0	0.76
			7 50 09	Coxendale	187 50 02	2097.9	2294.2	1.30
Kingsland	37 24 14.93	77 23 28.15	281 56 07	Boler	101 56 44	1507.9	1649.0	0.94
			333 32 21	Coxendale	153 32 50	2669.9	2919.7	1.66
Hopewell	37 24 34.52	77 23 06.64	314 03 25	Boler	134 03 48	1316.9	1440.1	0.82
			41 13 11	Kingsland	221 12 58	802.7	877.8	0.50
Longfield	37 24 54.90	77 23 25.53	323 31 00	Hopewell	143 [illegible] 12	781.3	854.4	0.49
			2 59 19	Kingsland	182 59 17	1233.7	1349.1	0.77
Auburn Chase	37 24 55.24	77 24 25.76	271 00 21	Longfield	91 00 57	1481.1	1619.7	0.92
			311 36 13	Kingsland	131 36 48	1894.7	2072.0	1.18
Birdsong	37 24 33.79	77 23 06.65	313 20 33	Boler	133 20 56	1301.5	1423.3	0.81
			42 17 10	Kingsland	222 16 57	785.9	859.4	0.49
Maguire	37 22 46.54	77 20 40.36	97 37 17	Farrar	277 37 00	713.0	779.7	0.44
			173 48 08	Sewcocks	353 48 06	862.1	942.8	0.54
Wilton Creek	37 25 49.03	77 24 27.75	317 29 03	Longfield	137 29 41	2263.7	2475.5	1.41
			358 17 39	Auburn Chase	178 17 40	1643.3	1797.1	1.02
Chester Hill	37 26 05.98	77 25 54.72	283 43 27	Wilton Creek	103 44 20	2200.7	2406.6	1.37
			314 42 12	Auburn Chase	134 43 06	3077.3	3365.2	1.91
Brooks	37 26 44.98	77 24 52.14	340 49 54	Wilton Creek	160 50 09	1826.0	1996.9	1.13
			51 59 28	Chester Hill	231 58 50	1952.3	2135.0	1.21
Warwick	37 27 20.18	77 25 29.38	319 51 06	Brooks	139 51 29	1419.4	1552.2	0.88
			15 14 07	Chester Hill	195 13 52	2370.6	2592.4	1.47
Chatsworth	37 28 03.29	77 24 37.69	8 22 11	Brooks	188 22 03	2440.1	2668.4	1.52
			43 42 13	Warwick	223 41 42	1838.4	2010.4	1.14
French	37 28 31.14	77 25 22.84	307 43 34	Chatsworth	127 44 01	1402.6	1533.8	0.87
			4 11 57	Warwick	184 11 53	2193.3	2398.5	1.36
Randolph	37 28 46.61	77 24 57.12	340 19 49	Chatsworth	160 20 01	1418.1	1550.8	0.88
			52 57 25	French	232 57 09	791.8	865.9	0.49
Lyle	37 29 01.87	77 25 28.94	301 01 30	Randolph	121 01 49	912.3	997.7	0.57
			351 00 45	French	171 00 49	959.0	1048.7	0.60
Peyton's Creek	37 29 11.10	77 24 48.43	74 03 02	Lyle	254 02 37	1035.1	1132.0	0.64
			15 47 44	Randolph	195 47 39	784 4	857.8	0.49
South Base	37 29 43.36	77 25 37.62	350 32 33	Lyle	170 32 38	1296.6	1417.9	0.81
			309 27 21	Peyton's Creek	129 27 51	1564.9	1711.3	0.97
Harrison	37 30 01.17	77 24 47.55	0 48 18	Peyton's Creek	180 48 17	1543.7	1688.1	0.96
			65 56 41	South Base	245 56 11	1346.7	1472 7	0.84
North Base	37 30 12.15	77 25 33.96	286 32 19	Harrison	106 32 45	1189.3	1300.6	0.74
			5 45 56	South Base	185 45 54	892.2	975.7	0.55
Priest	37 30 13.85	77 24 20.41	88 20 52	North Base	268 20 07	1807.2	1976.3	1.12
			63 38 18	South Base	243 37 31	2116.4	2314.4	1.31
Rockets	37 31 26.04	77 24 30.75	8 57 34	Harrison	188 57 24	2648.6	2896.4	1.65
			353 29 19	Priest	173 29 25	2 39.8	2449.4	1.39

UNITED STATES COAST SURVEY—GEOGRAPHICAL POSITIONS.

Section III. James River. Sketch C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Hydrographic Signal	37 29 58.92	77 24 58.00	63 45 23	South Base	243 44 59	1085.1	1186.6	0.67
			114 47 03	North Base	294 46 41	973.0	1064.0	0.60
Mayo's House	37 30 31.11	77 24 38.06	66 57 06	North Base	246 56 32	1492.2	1631.8	0.93
			320 49 33	Priest	140 49 44	686.2	750.4	0.43
Hydrographic Signal No. 2	37 29 15.25	77 24 53.84	175 39 40	Hydrographic Signal	355 39 37	1350.0	1476.3	0.84
			128 51 23	South Base	308 50 56	1380.9	1510.1	0.86
Richmond, Presbyterian Ch.	37 32 20.50	77 26 06.36	348 37 51	North Base	168 38 11	4035.7	4413.3	2.51
			305 33 56	Rockets	125 34 54	2885.8	3155.8	1.79
Richmond, Church with arrow.	37 32 20.67	77 25 56.18	352 09 37	North Base	172 09 51	3999.2	4373.4	2.48
			308 45 27	Rockets	128 46 19	2689.7	2941.4	1.67
Richmond, St. Paul's Church	37 32 20.89	77 25 50.91	354 00 52	North Base	174 01 02	3990.3	4363.7	2.48
			330 25 18	Priest	150 26 13	4502.7	4924.0	2.80
Richmond, Capitol	37 32 16.91	77 25 45.75	355 41 46	North Base	175 41 53	3856.7	4217.6	2.40
			331 04 14	Priest	151 05 06	4333.8	4739.3	2.69
Richmond, Penitentiary	37 32 19.79	77 26 36.62	338 38 29	North Base	158 39 07	4224.5	4619.8	2.62
			319 14 45	Priest	139 16 08	5124.1	5603.6	3.18
Gas Chimney	37 30 58.42	77 24 41.19	42 16 06	North Base	222 15 34	1927.0	2107.3	1.20
			339 37 01	Priest	159 37 14	1465.5	1602.6	0.91
Manchester	37 30 58.25	77 26 17.14	295 30 40	Priest	115 31 51	3176.6	3473.8	1.97
			323 16 15	North Base	143 16 41	1772.8	1938.7	1.10
Wreck	37 28 47.22	77 25 14.50	141 50 36	Lyle	321 50 27	574.2	627.9	0.36
			272 30 47	Randolph	92 30 58	427.3	467.3	0.27
Topographic Signal No. 1	37 29 23.23	77 25 08.52	130 58 11	South Base	310 57 53	946.5	1035.1	0.59
			37 18 50	Lyle	217 18 33	897.8	905.2	0.51
Topographic Signal No. 2	37 29 15.62	77 25 08.02	139 38 10	South Base	319 37 53	1122.2	1227.2	0.70
			50 28 51	Lyle	230 28 38	666.1	728.4	0.41
Marsh	37 29 15.23	77 24 53.83	128 52 25	South Base	308 51 58	1381.4	1510.7	0.86
			64 28 09	Lyle	244 27 48	955.9	1045.3	0.59
Bar	37 28 57.51	77 24 58.33	145 40 27	South Base	325 40 03	1711.2	1871.3	1 06
			100 07 17	Lyle	280 06 58	764.0	835.5	0.47
Drury	37 29 04.97	77 25 11.12	151 11 19	South Base	331 11 03	1350.6	1477.0	0.84
			77 41 09	Lyle	257 40 58	448.2	490.1	0.28
Cotton Factory	37 31 33.19	77 25 52.10	349 53 46	North Base	169 53 57	2537.5	2774.9	1.58
			317 21 50	Priest	137 22 46	3324.3	3635.4	2.07
Hydrographic Signal No. 1 (W.)	37 30 07.10	77 25 18.73	296 20 05	Hydrographic Signal	116 20 18	568.3	621.5	0.35
			32 21 44	South Base	212 21 32	866.6	947.7	0.54

Section IV.—Bogue Sound. Sketch D.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Arendell	34 43 10.11	0 30 53.16						
Fort Macon	34 41 43.55	0 29 15.77	137 06 42	Arendell	317 05 47	3640.7	3981.4	2.26
Lueber	34 41 48.50	0 31 14.65	192 15 53	Arendell	12 16 05	2573.2	2814.0	1.60
			272 52 47	Fort Macon	92 53 55	3029.1	3312.5	1.88
Shepard's Point	34 43 03.79	0 31 51.52	262 30 58	Arendell	82 31 31	1497.4	1637.5	0.93
			337 58 35	Lueber	157 58 56	2502.1	2736.2	1.56
Smith's Creek	34 41 57.44	0 33 22.34	228 29 38	Shepard's Point	48 30 30	3085.4	3374.1	1.92
			274 49 49	Lueber	94 51 02	3261.0	3566.1	2.03
Mill at White Hall	34 43 19.77	0 34 08.56	278 01 52	Shepard's Point	98 03 10	3521.0	3850.5	2.19
			335 07 40	Smith's Creek	155 08 06	2796.2	3057.8	1.74
Fish House	34 43 17.37	0 32 51.76	17 31 48	Smith's Creek	197 31 31	2583.0	2824.7	1.61
			317 55 43	Lueber	137 56 38	3688.3	4033.4	2.29
White Hall	34 43 19.82	0 34 12.25	277 50 41	Shepard's Point	97 52 01	3614.3	3952.5	2.25
			333 25 02	Smith's Creek	153 25 30	2838.4	3104.0	1.76
Hoop-pole	34 42 13.73	0 35 28.45	223 35 16	White Hall	43 35 59	2811.7	3074.8	1.75
			278 52 55	Smith's Creek	98 54 07	3248.2	3552.1	2.02

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section IV.—Bogue Sound Sketch D.

Name or station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Spooner's Creek	34 43 29.03	0 36 58.03	273 50 17	White Hall	93 51 51	4226.8	4622.3	2.62
			315 30 23	Hoop-pole	135 31 14	3252.3	3556.6	2.02
McGinnis	34 42 14.55	0 37 52.26	211 00 52	Spooner's Creek	31 01 23	2677.8	2928.4	1.67
			270 23 07	Hoop-pole	90 24 29	3659.5	4001.9	2.27
Jumping Run	34 43 36.72	0 40 19.98	272 37 22	Spooner's Creek	92 39 17	5142.9	5624.1	3.20
			303 57 14	McGinnis	123 58 38	4531.4	4955.4	2.82
Rocky Point	34 41 26.06	0 42 10.59	214 56 52	Jumping Run	34 57 55	4912.1	5371.7	3.05
			257 10 25	McGinnis	77 12 52	6741.5	7372.3	4.19
Shelly Point	34 43 15.38	0 43 10.87	261 23 14	Jumping Run	81 24 51	4396.8	4808.2	2.73
			335 30 49	Rocky Point	155 31 23	3701.3	4047.6	2.30
Broad Creek	34 42 38 13	0 45 16.10	256 30 04	Jumping Run	76 32 53	7747.1	8472.0	4.81
			250 10 41	Shelly Point	70 11 52	3386.7	3703.6	2.10
Flag Staff	34 40 52.09	0 43 21.83	138 20 07	Broad Creek	318 19 02	4373.9	4783.2	2.72
			183 36 47	Shelly Point	3 36 53	4423.7	4837.6	2.75
Bodine's Cove	34 40 40.36	0 46 17.14	203 10 16	Broad Creek	23 10 50	3947.1	4316.4	2.45
			257 20 05	Rocky Point	77 22 25	6431.3	7033.1	4.00
Old Store Point	34 41 21.39	0 48 46.66	248 59 17	Broad Creek	69 01 17	5738.9	6275.9	3.57
			292 26 21	Bodine's Cove	112 27 46	4117.4	4502.7	2.56
Montgomery	34 40 28.09	0 46 08.98	115 56 02	Old Store Point	295 54 32	4462.2	4879.7	2.77
			198 33 36	Broad Creek	18 34 06	4226.7	4622.2	2.63
Bay Pole	34 40 30.14	0 47 55.53	145 25 22	Old Store Point	325 24 53	2292.4	2506.9	1.42
			262 49 23	Bodine's Cove	82 50 19	2524.2	2760.4	1.57
Piney Point	34 40 30.41	0 49 20.67	266 13 51	Bodine's Cove	86 15 36	4681.8	5119.9	2.91
			270 12 57	Bay Pole	90 13 46	2167.3	2370.1	1.35
Oak Point	34 40 29.49	0 49 37.76	214 17 23	Old Store Point	34 17 52	2308.8	2524.8	1.43
			266 13 52	Bodine's Cove	86 15 46	5117.7	5596.6	3.18
Fresh Water	34 40 54.40	0 50 21.46	295 32 04	Piney Point	115 32 39	1714.5	1874.9	1.06
			304 36 42	Oak Point	124 37 07	1351.4	1477.9	0.84
Pickett	34 40 50.67	0 50 31.46	244 47 48	Old Store Point	64 48 48	2947.8	3223.6	1.83
			295 31 05	Oak Point	115 31 36	1514.5	1656.2	0.94
Plum Orchard	34 40 07.95	0 51 03.39	216 42 40	Fresh Water	36 43 04	1785.4	1952.5	1.11
			211 41 48	Pickett	31 42 06	1546.8	1691.5	0.96
Deer Point	34 40 44.04	0 52 15.62	301 09 35	Plum Orchard	121 10 16	2148.7	2349.8	1.34
			265 35 22	Pickett	85 36 21	2659.0	2907.8	1.65
Mud Point	34 39 45.87	0 52 41.67	200 18 13	Deer Point	20 18 28	1911.3	2090.1	1.19
			254 46 35	Plum Orchard	74 47 31	2592.9	2835.5	1.61
Hickory Point	34 40 20.74	0 54 18.10	293 38 04	Mud Point	113 38 59	2679.5	2930.2	1.67
			257 01 20	Deer Point	77 02 30	3199.2	3498.6	1.99
Frazier's Creek	34 39 14.66	0 54 10.54	174 36 22	Hickory Point	354 36 18	2045.1	2236.5	1.27
			246 58 14	Mud Point	66 59 04	2458.4	2688.4	1.53
Huggin's Island	34 40 05.82	0 55 14.80	313 56 03	Frazier's Creek	133 56 39	2271.6	2484.1	1.41
			252 19 38	Hickory Point	72 20 10	1514.8	1656.5	0.94
Pole at fish-house	34 40 28.48	0 54 47.68	292 15 01	Mud Point	112 16 13	3466.1	3790.4	2.15
			337 25 35	Frazier's Creek	157 25 56	2463.2	2693.7	1.53
Jones	34 42 00.67	0 55 22.05	357 00 43	Huggin's Island	177 00 47	3543.6	3875.2	2.20
			332 07 52	Hickory Point	152 08 28	3482.8	3808.7	2.16
Heady	34 38 22.42	0 55 55.92	198 11 17	Huggin's Island	18 11 40	3353.7	3667.5	2.08
			239 01 47	Frazier's Creek	59 02 47	3129.0	3421.8	1.94
Brick Store	34 41 11.23	0 55 39.20	4 40 41	Heady	184 40 31	5218.7	5707.0	3.24
			327 50 54	Frazier's Creek	147 51 44	4241.8	4638.7	2.64
Bogue Inlet	34 38 45.15	0 54 02.65	76 21 39	Heady	256 20 35	2968.0	3245.7	1.84
			143 32 41	Huggin's Island	323 32 00	3090.7	3379.9	1.92
BROWN SOUND.								
Humphreys	34 40 08.84	0 57 12.50	329 15 19	Heady	149 16 02	3815.1	4172.1	2.37
			271 46 11	Huggin's Island	91 47 18	2997.9	3278.4	1.86
Duval	34 37 53.42	0 57 34.56	187 39 48	Humphreys	7 40 01	4210.2	4604.1	2.62
			250 24 52	Heady	70 25 48	2666.2	2915.7	1.66
Hammock	34 38 45.85	0 58 44.33	312 16 30	Duval	132 17 10	2401.4	2626.1	1.49
			222 25 43	Humphreys	42 26 35	3464.6	3788.8	2.15
Bear Inlet	34 36 47.20	1 00 08.11	210 15 49	Hammock	30 16 37	4233.0	4629.1	2.63
			242 26 16	Duval	62 27 43	4411.2	4824.0	2.74

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section IV.—Brown Sound. Sketch D.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Dexter Point	34 37 40.34	1 01 00.98	320 33 28	Bear Inlet	140 33 58	2120.0	2318.4	1.32
			239 52 25	Hammock	59 53 43	4023.0	4399.4	2.50
Simson	34 36 56.52	1 01 45.74	276 34 31	Bear Inlet	96 35 26	2503.7	2738.0	1.56
			220 10 37	Dexter Point	40 11 02	1767.3	1932.7	1.10
Brown's Inlet	34 35 49.34	1 02 04.39	192 55 28	Simson	12 55 39	2123.8	2322.5	1.32
			238 56 58	Bear Inlet	58 58 04	3457.7	3781.2	2.15
Freeman's Landing	34 35 42.37	1 03 24.45	263 59 08	Brown's Inlet	83 59 53	2051.1	2243.0	1.27
			227 44 08	Simson	47 45 04	3397.6	3715.5	2.11
Mean Hill	34 35 01.41	1 03 25.12	180 46 03	Freeman's Landing	0 46 03	1261.9	1380.0	0.78
			234 19 15	Brown's Inlet	54 20 01	2531.9	2768.8	1.57
Hurst's Landing	34 34 59.93	1 04 03.98	267 21 15	Mean Hill	87 21 37	991.4	1084.2	0.62
			217 36 16	Freeman's Landing	37 36 38	1650.5	1804.9	1.03
Ezekiel	34 34 35.01	1 04 06.15	184 06 39	Hurst's Landing	4 06 40	769.7	841.7	0.48
			232 06 45	Mean Hill	52 07 08	1324.8	1448.8	0.82
Horsehead	34 34 37.27	1 04 28.52	276 57 44	Ezekiel	96 57 57	574.4	628.1	0.36
			221 50 55	Hurst's Landing	41 51 09	937.3	1025.0	0.58
Westerly	34 34 15.65	1 04 33.98	191 47 33	Horsehead	11 47 36	680.7	744.4	0.42
			229 55 36	Ezekiel	49 55 52	926.9	1013.6	0.57
Gillet's Creek	34 34 18.29	1 05 01.86	276 32 33	Westerly	96 32 49	715.3	782.2	0.44
			235 27 35	Horsehead	55 27 54	1031.5	1128.0	0.64
Frank	34 33 55.22	1 05 03.54	183 26 27	Gillet's Creek	3 26 28	712.0	778.6	0.44
			230 07 40	Westerly	50 07 57	981.6	1073.5	0.61
Broom	34 33 57.25	1 05 25.19	276 26 34	Frank	96 26 46	555.4	607.4	0.35
			222 31 28	Gillet's Creek	42 31 41	879.9	962.2	0.55
Calf	34 33 34.07	1 05 34.21	197 50 54	Broom	17 50 59	750.2	820.4	0.47
			230 11 16	Frank	50 11 33	1018.0	1113.3	0.63
Cameron	34 33 35.99	1 06 06.82	274 03 20	Calf	94 03 39	833.3	911.3	0.52
			238 18 22	Broom	58 18 46	1247.1	1363.8	0.77
Rubber	34 33 07.08	1 06 15.45	193 52 24	Cameron	13 52 29	917.3	1003.1	0.57
			231 39 01	Calf	51 39 24	1340.4	1465.8	0.83
Fonville	34 33 18.57	1 06 42.00	297 35 58	Rubber	117 36 13	763.7	835.2	0.47
			239 05 41	Cameron	59 06 01	1045.2	1143.0	0.65
Hobby	34 32 44.27	1 06 50.00	190 55 24	Fonville	10 55 29	1076.3	1177.0	0.67
			231 24 10	Rubber	51 24 30	1126.9	1232.3	0.70
Whitfield	34 32 49.27	1 07 25.57	279 38 38	Hobby	99 38 58	919.6	1005.6	0.57
			230 53 26	Fonville	50 53 51	1431.2	1565.1	0.89
Fitzhugh	34 32 12.46	1 07 40.87	198 59 11	Whitfield	18 59 20	1199.4	1311.6	0.74
			232 55 10	Hobby	52 55 39	1625.6	1777.7	1.01
Lighter	34 32 35.78	1 08 57.47	290 11 52	Fitzhugh	110 12 35	2080.9	2275.6	1.29
			259 56 14	Whitfield	79 57 06	2379.5	2602.2	1.48
Cæsar	34 31 41.24	1 08 56.92	179 31 25	Lighter	359 31 25	1680.7	1838.0	1.04
			243 36 30	Fitzhugh	63 37 13	2164.6	2367.1	1.35
Swan Point	34 32 28.89	1 10 17.94	305 23 42	Cæsar	125 24 28	2534.4	2771.5	1.58
			264 04 52	Lighter	84 05 38	2062.6	2255.6	1.28
New River Inlet	34 31 58.62	1 08 11.53	241 23 31	Fitzhugh	61 23 48	890.3	973.6	0.55
			134 21 04	Lighter	314 20 38	1637.9	1791.2	1.02
McMillan	34 33 04.02	1 10 15.00	293 44 52	Lighter	113 45 36	2159.6	2361.7	1.34
			3 57 16	Swan Point	183 57 14	1085.0	1186.5	0.67
Pond	34 33 06.85	1 08 56.54	87 30 32	McMillan	267 29 47	2002.1	2189.4	1.24
			1 24 40	Lighter	181 24 39	957.5	1047.1	0.59
Wilson's Bluff	34 34 12.07	1 10 10.39	3 12 43	McMillan	183 12 40	2100.2	2296.7	1.31
			216 52 11	Pond	136 52 53	2753.5	3011.1	1.71
Hall's Point	34 33 37.19	1 10 55.79	227 06 58	Wilson's Bluff	47 07 24	1579.4	1727.2	0.98
			314 30 28	McMillan	134 30 51	1458.1	1594.5	0.91
Sampson	34 31 07.14	1 10 08.33	174 26 30	Swan Point	354 26 25	2530.5	2767.3	1.57
			240 00 53	Cæsar	60 01 33	2102.2	2298.9	1.31
ustis	34 31 23.33	1 11 04.36	289 13 53	Sampson	109 14 25	1513.4	1655.0	0.94
			30 21 55	Swan Point	30 22 21	2341.2	2560.3	1.45
Sinclair	34 30 40.55	1 10 59.13	174 13 19	Justis	354 13 16	1324.6	1448.5	0.82
			237 41 25	Sampson	57 41 56	1533.0	1676.4	0.95
St. Patrick	34 30 49.41	1 11 39.17	284 57 44	Sinclair	104 58 07	1056.9	1155.8	0.66
			220 20 38	Justis	40 20 58	1371.1	1499.4	0.85

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section IV.—Brown Sound. Sketch D.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Skeleton	34 30 13.17	1 12 02.87	208 25 56	St. Patrick	28 26 09	1269.8	1388.6	0.79
			242 34 08	Sinclair	62 34 44	1831.6	2003.0	1.14
Macawber	34 30 40.20	1 12 27.46	323 01 09	Skeleton	143 01 23	1042.6	1140.2	0.65
			257 01 29	St. Patrick	77 01 56	1263.9	1382.2	0.78
CAPE FEAR RIVER.								
Cape Fear Base. North End	33 54 28.09	77 56 21.47	......	......	......	......	......	......
Cape Fear Base. South End	33 52 27.58	77 56 42.50	188 16 44	North Base	8 16 56	3751.6	4102.6	2.33
Three Cedars	33 53 31.92	77 59 04.50	247 32 15	North Base	67 33 46	4531.7	4955.7	2.82
			298 30 00	South Base	118 31 19	4152.3	4540.8	2.58
McRacken	33 57 01.26	77 58 48.20	321 22 49	North Base	141 24 11	6039.0	6604.1	3.75
			3 42 53	Three Cedars	183 42 44	6463.1	7067.9	4.02
Federal Point	33 57 32.63	77 55 52.23	7 31 31	North Base	187 31 14	5734.6	6271.2	3.56
			77 56 33	McRacken	257 54 55	4619.9	5052.2	2.87
Reeves	33 58 54.90	77 57 10.21	351 20 17	North Base	171 20 44	8314.6	9092.6	5.17
			35 42 15	McRacken	215 41 20	4310.7	4714.1	2.68
Grissom	34 00 11.14	77 54 58.88	15 39 58	Federal Point	195 39 28	5072.0	5546.6	3.15
			55 08 03	Reeves	235 06 50	4108.2	4492.6	2.55
Milinor	34 01 55.04	77 56 25.22	11 45 15	Reeves	191 44 50	5668.9	6199.3	3.52
			325 18 41	Grissom	145 19 29	3892.7	4256.9	2.42
Sugar Loaf	34 02 25.31	77 55 05.56	357 37 23	Grissom	177 37 27	4137.0	4524.1	2.57
			65 28 28	Milinor	245 27 43	2245.7	2455.8	1.40
Doctor Point	34 04 03.19	77 55 18.19	353 52 07	Sugar Loaf	173 52 14	3032.9	3316.7	1.89
			23 31 53	Milinor	203 31 15	4305.9	4708.8	2.67
Holmes	34 03 48.07	77 56 18.94	2 38 50	Milinor	182 38 47	3485.8	3812.0	2.17
			253 20 26	Doctor Point	73 21 00	1625.7	1777.8	1.01
Lane	34 05 33.64	77 55 22.52	357 43 18	Doctor Point	177 43 20	2789.0	3050.0	1.73
			23 58 48	Holmes	203 58 16	3559.7	3892.8	2.21
Kate	34 05 54.98	77 56 38.17	352 48 48	Holmes	172 48 59	3940.9	4309.6	2.45
			288 43 21	Lane	108 44 04	2047.5	2239.1	1.27
Pierce	34 06 57.63	77 55 30.55	355 26 54	Lane	175 26 59	2595.9	2838.8	1.61
			41 55 08	Kate	221 54 30	2594.0	2836.7	1.61
Campbell Island	34 07 15.17	77 56 41.99	286 26 21	Pierce	106 27 01	1908.5	2087.1	1.19
			357 43 50	Kate	177 43 52	2472.5	2703.9	1.54
Cowan	34 08 37.91	77 57 23.09	316 58 22	Pierce	136 59 25	4225.9	4621.3	2.62
			337 33 21	Campbell Island	157 33 44	2758.3	3016.4	1.71
Eliza	34 08 47.98	77 56 21.74	10 17 05	Campbell Island	190 16 54	2906.2	3178.1	1.81
			78 50 30	Cowan	258 49 55	1601.7	1751.6	1.00
Clarendon	34 09 28.12	77 57 46.58	338 44 32	Cowan	158 44 45	1659.9	1815.2	1.03
			299 38 28	Eliza	119 39 16	2500.4	2734.4	1.55
Smith	34 10 18.47	77 57 00 29	340 29 51	Eliza	160 30 13	2957.7	3234.5	1.84
			37 23 38	Clarendon	217 23 12	1952.3	2135.0	1.21
Hawkins	34 10 48.37	77 57 44.13	1 27 22	Clarendon	181 27 21	2473.2	2704.6	1.54
			309 22 11	Smith	129 22 36	1452.1	1588.0	0.90
Dudley	34 11 59.87	77 57 06.49	357 05 32	Smith	177 05 35	3128.0	3420.7	1.94
			23 37 54	Hawkins	203 37 33	2404.4	2629.4	1.50
Eagle	34 11 43.76	77 58 15.76	334 36 36	Hawkins	154 36 54	1888.8	2065.5	1.17
			254 21 15	Dudley	74 21 54	1811.6	1981.1	1.12
Moore	34 13 00.94	77 58 39.23	345 49 10	Eagle	165 49 23	2452.6	2682.1	1.52
			308 23 26	Dudley	128 24 18	3029.0	3312.4	1.88
Nutt	34 14 22.29	77 56 41.78	50 11 06	Moore	230 10 00	3913.6	4279.8	2.43
			8 12 13	Dudley	188 11 59	4433.1	4847.9	2.75
Wilmington, Episcopal ch. tower.	34 14 00.88	77 56 32.60	160 24 21	Nutt	340 24 16	700.1	765.6	0.43
			60 19 49	Moore	240 18 38	3729.9	4078.9	2.32
Bald Head Light-house	33 52 18.41	77 59 49.00	266 36 35	South Base	86 38 19	4801.1	5250.3	2.98
			233 08 27	North Base	53 10 23	6662.9	7286.3	4.14
Fort Johnson, flag-staff	33 54 57.23	78 00 48 17	314 37 02	Three Cedars	134 38 00	3741.6	4091.7	2.33
			277 26 46	North Base	97 29 15	6909.0	7555.5	4.29
Bug Light	33 56 03.64	77 59 10.68	358 03 19	Three Cedars	178 03 22	4676.9	5114.5	2.91
			304 05 54	North Base	124 07 28	5249.0	5740 2	3.26
Cape Fear	33 49 52.37	77 57 11.98	138 07 00	Bald Head Light	318 05 32	6044.2	6609.7	3.76

UNITED STATES COAST SURVEY—GEOGRAPHICAL POSITIONS.

Section IV.—Cape Fear River. Sketch D.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Fort Caswell	33 53 26.18	78 00 48.07	254 25 13	North Base	74 27 42	7109.5	7774.7	4.42
			179 56 52	Fort Johnson, flag-staff	359 56 52	2805.0	3067.5	1.74
Price's Creek Light	33 56 03.71	77 59 13.43	26 36 53	Fort Caswell	206 36 00	5427.9	5935.8	3.37
			303 41 22	North Base	123 42 58	5308.8	5805.5	3.30
Oak Island Tall Light	33 53 23.31	78 01 36.08	256 06 24	North Base	76 09 19	8325.2	9104.2	5.17
			306 00 38	Bald Head Light	126 01 38	3400.3	3718.5	2.11
Oak Island Low Light	33 53 20.83	78 01 38 34	255 41 45	North Base	75 44 42	8400.0	9186.0	5.22
			304 23 35	Bald Head Light	124 24 36	3403.9	3722.4	2.12
Oak Island Lookout Pole	33 53 45.95	78 03 31.89	263 16 18	North Base	83 20 18	11133.1	12174.8	6.92
			295 11 30	Bald Head Light	115 13 34	6331.4	6923.8	3.93
Light Ship, (ebb)	33 56 15.93	77 57 25.17	333 46 36	North Base	153 47 12	3703.5	4050.0	2.30
			123 14 05	McRacken	303 13 19	2548.5	2787.0	1.58
Light Ship, (flood)	33 56 17.24	77 57 27.25	44 23 58	Fort Caswell	224 22 06	7374.1	8064.1	4.58
			81 02 21	Bug Light	261 01 23	2688.3	2939.8	1.67
Middle Base	33 53 32.19	77 56 30.80	65 58 05	Bald Head Light	245 56 15	5576.8	6098.6	3.47
			187 55 28	North Base	7 55 33	1739.0	1901.7	1.08
New Inlet, Pilot's Mark	33 56 12.44	77 56 04.05	86 47 16	Bug Light	266 45 32	4796.4	5245.2	2.98
			7 55 19	North Base	187 55 09	3246.8	3550.6	2.02
Federal Point, Pilot's Mark	33 58 30.92	77 55 20.40	11 50 29	North Base	191 49 55	7643.8	8359.0	4.75
			62 38 25	McRacken	242 36 29	6007.0	6569.1	3.73
Federal Point Light-house	33 58 03.59	77 54 52.57	18 58 56	North Base	198 58 06	7020.5	7677 4	4.36
			161 34 15	Milinor	341 33 23	7516.6	8219.9	4.67
Robbins	34 00 11.30	77 57 11.95	270 04 10	Grissom	90 05 25	3414.5	3734.0	2.12
			358 54 49	Reeves	178 54 50	2354.3	2574.6	1.46
Buoy, in channel	33 58 55.04	77 56 31.29	89 45 00	Reeves	269 44 38	999.0	1092.5	0.62
			225 19 08	Grissom	45 20 00	3334.9	3646 9	2.07
Reeves' House, centre chimney.	33 59 22.81	77 57 18.22	186 08 39	Robbins	6 08 42	1502.7	1643.3	0.93
			247 22 39	Grissom	67 23 57	3873.4	4235.8	2.41
Red House, western chimney.	33 59 39.53	77 57 15.83	354 00 45	Reeves	174 00 48	1382.4	1511.8	0.86
			185 48 08	Robbins	5 48 10	984 8	1076.9	0.61
Robbins's House, eastern white chimney.	34 00 01.10	77 57 15.40	356 15 45	Reeves	176 15 48	2043.8	2235.0	1.27
			195 43 18	Robbins	15 43 20	326.6	357.2	0.20
Two-story House, southern chimney.	34 01 08.44	77 56 51.74	6 34 28	Reeves	186 34 18	4141.5	4529.0	2.57
			16 25 11	Robbins	196 25 00	1835.3	2007.0	1.14
Chimney of house, with one dormer window facing river.	34 00 38.18	77 5[illegible] 43.69	77 43 41	Robbins	257 42 18	3893.4	4257.7	2.42
			132 17 33	Milinor	312 16 36	3520.1	3849.5	2.19
Barrel on post in river	34 00 40.39	77 55 55.12	301 57 54	Grissom	121 58 25	1701.0	1860.2	1.06
			65 33 41	Robbins	245 32 58	2165.6	2368.2	1.35
Shanks' Hydrographic Signal, northern tree.	34 01 27.68	77 56 33.00	11 28 24	Reeves	191 28 03	4802.8	5252 2	2.98
			23 00 47	Robbins	203 00 25	2556.7	2795.9	1.59
Hydrographic Signal Flag, on Sugar Loaf Hill.	34 02 11.06	77 54 53.30	43 57 43	Robbins	223 56 25	5125.1	5604.7	3.18
			78 11 16	Milinor	258 10 25	2408.8	2634.2	1.50
Orton Point Light-house	34 03 21.98	77 56 11.06	7 43 06	Milinor	187 42 58	2702.8	2955.7	1.68
			226 52 12	Doctor Point	46 52 42	1857.3	2031.1	1.15
Hydrographic Signal near Orton Point.	34 03 31.75	77 55 57.50	346 19 18	Grissom	166 19 51	6360.6	6955.8	3.95
			13 25 26	Milinor	193 25 10	3062.9	3349.5	1.90
Hill	34 04 46.94	77 56 30.34	350 50 39	Holmes	170 50 45	1837.1	2009.0	1.14
			230 22 59	Lane	50 23 37	2256.7	2467.9	1.40
Sallie	34 08 09.23	77 55 55.00	344 08 53	Pierce	164 09 07	2293.4	2508.0	1.42
			111 23 36	Cowan	291 22 46	2423.4	2650.2	1.51
Mallory	34 10 27.36	77 57 54.31	353 48 38	Clarendon	173 48 44	1835.8	2007.6	1.14
			322 14 39	Eliza	142 15 31	3872.4	4234.8	2.41
Saunders	34 11 01.65	77 57 03.90	68 20 03	Hawkins	248 19 40	1108.3	1212.0	0.69
			177 53 14	Dudley	357 53 13	1795.0	1963.0	1.12
Campbell Island Light-house.	34 06 56.57	77 56 02.91	337 56 36	Lane	157 56 59	2756.9	3014.9	1.71
			185 10 24	Sallie	5 10 28	2217.9	2425.4	1.38
Guppy	34 09 04.90	77 57 34.30	285 39 46	Eliza	105 40 27	1930.3	2110.9	1.20
			303 58 58	Sallie	123 59 54	3067.8	3354.8	1.91
Pine Tree on Dr. Everett's place.	34 12 30.11	77 58 32.54	292 55 00	Dudley	112 55 48	2391.7	2615.5	1.49
			343 15 16	Eagle	163 15 26	1491.3	1630.8	0.93
Flag 1, in cypress tree	34 12 34.39	77 57 58.02	308 52 14	Dudley	128 52 42	1694.4	1852.9	1.05
			16 13 56	Eagle	196 13 45	1624.7	1776.7	1.01

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section IV.—Cape Fear River. Sketch D.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Flag 2 on Brunswick River..	34 13 59.88	77 58 51.67	259 41 06	Episcopal Church..........	79 42 24	3617.1	3955.6	2.25
			345 08 07	Moore.........	165 08 14	1241.4	1357.5	0.77
Flag 3 on Brunswick River..	34 14 24.78	77 59 07.08	280 32 17	Episcopal Church..........	100 33 44	4020.8	4397.0	2.50
			344 34 18	Moore.	164 34 34	2679.6	2930.3	1.67
Ferry-house	34 13 52.28	77 58 57.83	265 54 35	Episcopal Church..........	85 55 57	3725.8	4074.4	2.31
			343 14 53	Moore	163 15 04	1651.9	1806.5	1.03
Potter's Mill, chimney	34 14 42.25	77 57 19.76	316 38 19	Episcopal Church..........	136 38 45	1757.4	1921.8	1.09
			302 27 47	Nutt	122 28 08	1151.8	1259.6	0.71
Wilmington Baptist Church Tower.	34 13 46.23	77 56 40.57	65 19 45	Moore	245 18 38	3342.1	3654.8	2.08
			204 18 54	Episcopal Church.....	24 18 58	495.1	541.4	0.31
Wilmington Presbyterian Church Spire.	34 13 53.88	77 56 41.60	10 16 43	Dudley.....................	190 16 29	3569.6	3903.6	2.22
			179 41 55	Nutt	359 41 55	875.2	957.1	0.54
Custom-house, flag-staff	34 14 02.62	77 56 47.22	192 56 25	Nutt	12 56 28	621.7	679.9	0.39
			7 25 33	Dudley.....................	187 25 22	3813.9	4170.8	2.37
Pole on Ship Chandler's Store	34 13 57.02	77 56 45.61	187 10 33	Nutt	7 10 35	784.7	858.1	0.49
			8 25 12	Dudley......	188 25 00	3648.4	3989.8	2.27
White flag-staff in Front street.	34 14 02.45	77 56 45.61	8 03 22	Dudley.......	188 03 10	3814.1	4171.0	2.37
			278 15 15	Episcopal Church..........	98 15 22	336.3	367.8	0.21
Upper Methodist Church Spire.	34 13 54.74	77 56 17.32	143 35 38	Nutt	323 35 25	1054.4	1153.1	0.66
			115 48 28	Episcopal Church..........	295 48 20	434.4	475.0	0.27
Lower Windmill Chimney ..	34 13 52.38	77 56 56.38	4 15 43	Dudley.....................	184 15 37	3476.0	3801.3	2.16
			202 04 47	Nutt	22 04 55	994.2	1087.2	0.62

Section V.—Savannah River. Sketch E.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Fort Jackson	32 04 57.87	81 01 59.84	....	....	....	....	....	....
Proctor, 1852	32 06 09.53	81 00 52.47	38 40 32	Fort Jackson	218 39 56	2826.8	3091.3	1.76
Rock Point.................	32 05 35.77	80 59 09.43	75 22 18	Fort Jackson	255 20 48	4617.9	5050.0	2.87
			111 03 37	Proctor, 1852	291 02 42	2894.5	3165.3	1.80
Proctor, 1853	32 06 10.11	81 00 53.29	38 06 38	Fort Jackson	218 06 03	2827.5	3092.1	1.76
			291 13 16	Rock Point.....	111 14 11	2920.9	3194.2	1.81
Cooper	32 03 45.25	81 00 32.13	134 12 24	Fort Jackson	314 11 37	3208.4	3508.6	1.99
			212 29 33	Rock Point.................	32 30 17	4036.0	4413.7	2.51
Norton	32 05 01.93	80 54 59.39	74 52 46	Cooper	254 49 49	9039.6	9885.4	5.62
			99 03 07	Rock Point................	279 00 54	6638.3	7259.5	4.12
McQueen	32 02 54.54	80 57 01.78	146 01 25	Rock Point................	326 00 17	5988.7	6549.1	3.72
			219 16 40	Norton....................	39 17 45	5069.1	5543.4	3.15
Fort Pulaski................	32 01 41.02	80 53 15.78	110 55 11	McQueen	290 53 11	6346.8	6940.7	3.94
			156 17 45	Norton....................	336 16 50	6758.4	7390.8	4.20
Mungen	32 04 52.50	80 52 15.63	93 53 04	Norton....................	273 51 37	4303.9	4706.6	2.67
			64 11 29	McQueen	244 08 57	8337.7	9117.9	5.18
Tybee Light, chimney	32 01 21.37	80 50 33.14	98 05 05	Fort Pulaski...............	278 03 30	4308.6	4711.8	2.68
			157 33 16	Mungen	337 32 22	7035.6	7693.9	4.37
Wooden Beacon, Elba Island.	32 04 29.44	80 58 23.85	98 48 23	Fort Jackson	278 46 28	5730.9	6267.1	3.56
			149 40 35	Rock Point................	329 40 11	2366.9	2588.4	1.47
St. Augustin...	32 04 38.87	80 59 34.14	200 17 19	Rock Point................	20 17 32	1868.4	2043.2	1.16
			143 39 24	Proctor, 1852	323 39 42	3466.0	3790.3	2.15
Magnetic Point.............	32 01 30.62	80 50 35.41	94 22 01	Fort Pulaski...............	274 20 36	4219.7	4614.5	2.62
			157 05 21	Mungen	337 04 28	6750.5	7382.2	4.19
Bug Light..................	32 01 18.61	80 50 07.91	97 59 10	Fort Pulaski...............	277 57 30	4977.4	5443.1	3.09
			153 03 10	Mungen....................	333 02 02	7390.5	8082.0	4.59
Barrel on Long Island, opposite Wreck.	32 03 08.49	80 56 34.24	59 16 08	McQueen	239 15 53	840.6	919.3	0.52
			138 06 42	Rock Point.....	318 05 20	6094.3	6564.5	3.79
Hydrographic Signal, Venus Point.	32 03 28.07	80 57 56.30	58 59 34	McQueen..................	238 58 59	2004.2	2191.7	1.25
			116 02 31	Wooden Beacon, Elba Isl'd.	296 01 13	4306.8	4709.8	2.68

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section V.—Savannah River. Sketch E.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
McKay's Winnowing Shed..	32 05 19.36	81 00 59.91	187 11 54	Proctor, 1852.............	7 11 58	1557.4	1703.1	0.97
			260 05 44	Rock Point...............	80 06 43	2940.4	3215 3	1.83
Maffit's Marsh...	32 06 09.14	81 00 08.55	303 32 52	Rock Point...............	123 33 23	1859.6	2033.6	1.16
			90 35 55	Proctor, 1852..............	270 35 32	1151.5	1259.3	0.72
Maffit's No. 1..............	32 04 58.37	80 58 19.40	131 17 25	Rock Point...............	311 16 58	1745.9	1909.3	1.08
			7 28 10	Wooden Beacon, Elba Isl'd	187 28 08	898.7	982.8	0.56
Mungen's West Chimney...	32 04 52.55	80 52 15.65	14 58 21	Fort Pulaski..............	194 57 49	6106.0	6677.3	3.79
			64 10 48	McQueen	244 08 16	8338.0	9118.2	5.18
Mungen's East Chimney	32 04 52.58	80 52 15.43	15 01 21	Fort Pulaski..............	195 00 49	6108.4	6680.0	3.80
			64 11 29	McQueen	244 08 57	8343.6	9124.3	5.18
Smith's Thrashing Mill, Brick Chimney.	32 05 51.48	81 01 50.28	249 51 01	Proctor, 1852	69 51 32	1614.2	1765 2	1.00
			295 00 37	Wooden Beacon, Elba Isl'd	115 02 27	5973.4	6532.3	3.71
Red Brick Beacon..........	32 02 10.85	80 53 54.46	312 09 08	Fort Pulaski..............	132 09 29	1369.1	1497.2	0.85
			105 19 40	McQueen	285 18 01	5094.9	5571.6	3.17
Square White Beacon with light.	32 02 21.56	80 53 29.90	343 27 55	Fort Pulaski..............	163 28 02	1302 3	1424.2	0.81
			100 22 28	McQueen	280 20 36	5650.2	6178.9	3.51
Large White House, East Chimney.	32 02 45.80	80 59 55.31	216 54 58	Wooden Beacon, Elba Isl'd	36 55 47	3992.7	4366.3	2.48
			266 30 08	McQueen	86 37 40	4559.7	4986.4	2.83
Large White House, West Chimney.	32 02 45.99	80 59 55.81	217 07 03	Wooden Beacon, Elba Isl'd	37 07 52	3996.0	4369.9	2.48
			266 41 05	McQueen	86 42 37	4572.6	5000.5	2.84
CALIBOGUE SOUND.								
Mungen	32 04 52.50	80 52 15.63	....	....	....	....	....	....
Tybee Light, Chimney......	32 01 21.37	80 50 33.14	157 33 16	Mungen	337 32 22	7035.6	7693.9	4.37
Braddock	32 06 59.11	80 47 54.31	21 50 26	Tybee Light..............	201 49 01	11205.3	12253.8	6.96
			60 22 13	Mungen	240 19 54	7863.0	8620.6	4.90
Stoddard..................	32 06 35 61	80 50 37.18	260 22 06	Braddock	80 23 32	4330.0	4735.2	2.69
			359 22 48	Tybee Light..............	179 22 50	9678.9	10584.6	6.01
Pope	32 08 44.07	80 50 00.63	314 18 46	Braddock	134 19 53	4627.1	5060.1	2.87
			13 36 53	Stoddard	193 36 34	4070.8	4451.7	2.53
Baynard..................	32 08 00.31	80 48 51.74	46 39 36	Stoddard	226 38 40	3800.3	4155.9	2.36
			126 45 09	Pope	306 44 32	2252.8	2463.6	1.40
Peninsula	32 09 42.26	80 47 49.42	27 28 51	Baynard..................	207 28 18	3539.1	3870.3	2.20
			62 28 33	Pope	242 27 23	3876.7	4239.5	2.41
Hilton Head...............	32 06 49.58	80 49 00.51	80 22 30	Stoddard	260 21 39	2570.3	2810.8	1.60
			155 55 50	Pope	335 55 18	3862.3	4223.7	2.40
Kirk	32 10 14.68	80 49 25.76	347 50 32	Baynard..................	167 50 50	4233.3	4629.4	2.63
			291 34 41	Peninsula	111 35 32	2714.1	2968.1	1.69
Barataria	32 11 16.27	80 48 23.87	342 41 22	Peninsula	162 41 40	3032.7	3316.5	1.88
			40 31 24	Kirk	220 30 51	2495 3	2728.8	1.55
Spanish Wells.............	32 11 30.99	80 46 45.42	60 46 39	Kirk	240 45 14	4812.7	5263.0	2.99
			80 01 51	Barataria.................	260 00 59	2617.9	2862.9	1.63
Jesse.....................	32 12 57.07	80 48 32.75	313 19 19	Spanish Wells............	133 20 17	3863.6	4225.1	2 40
			355 42 58	Barataria.................	175 43 03	3113.5	3404.8	1.93
Baynard's House, west tall chimney.	32 07 45.43	80 48 39.78	55 03 43	Stoddard	235 02 41	3754.1	4105.4	2.33
			130 27 03	Pope	310 26 20	2784.0	3044.5	1.73
Tall Pine southeast of Pope .	32 08 31.87	80 49 56.47	194 15 16	Kirk	14 15 32	3267.1	3572.8	2.03
			16 35 37	Stoddard	196 35 15	3736.2	4085.8	2.32
Tall Pine near Baynard's House.	32 07 51.78	80 48 48.61	128 14 12	Pope	308 13 30	2602.6	2846.1	1.62
			165 35 44	Kirk	345 35 21	4544.1	4969.3	2.82
Dead Tree at mouth of Broad creek.	32 08 39.34	80 48 19.50	35 06 30	Baynard..................	215 06 23	1469 2	1606.7	0.91
			93 09 28	Pope	273 08 34	2654.0	2902.3	1.65
Chimnies..................	32 09 58.12	80 51 08.76	259 17 31	Kirk	79 18 26	2746.0	3002.9	1.71
			321 56 37	Pope	141 57 13	2896.3	3167.3	1.80
Broad Creek...............	32 08 47.72	80 48 06.50	142 13 04	Kirk	322 12 22	3389.0	3706.1	2.11
			87 51 21	Pope	267 50 20	2292.5	2507.0	1.43
Oaks......................	32 10 15.27	80 47 21.17	138 50 48	Barataria	318 50 15	2495.5	2729 0	1.55
			89 41 20	Kirk	269 40 14	3263.9	3569.3	2.03
WINYAH BAY.								
South Island Base. South End ...	33 12 33.37	79 07 49.03	....	....	....	....	....	....
South Island Base. North End....	33 14 03.33	79 07 48.06	0 32 57	South Base...............	180 32 57	2771.0	3030.3	1.72

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section V—Winyah Bay. Sketch E.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Light-house Point	33 13 14.86	79 06 31.15	57 38 31	South Base	237 37 48	2387.4	2610.8	1.48
			126 53 17	North Base	306 52 35	2487.5	2720.3	1.55
Brown	33 13 38.00	79 09 17.66	310 55 59	South Base	130 56 47	3038.1	3322.4	1.89
			251 24 59	North Base	71 25 48	2448.8	2677.9	1.52
Sin	33 15 53.82	79 06 18.38	3 51 42	Light-house Point	183 51 35	4908.4	5367.7	3.05
			34 16 48	North Base	214 15 59	4119.1	4504.5	2.56
Cat Island	33 15 00.50	79 09 21.61	306 00 13	North Base	126 01 04	2995.4	3275.7	1.86
			357 42 01	Brown	177 42 03	2543.3	2781.3	1.58
Drew	33 18 14.22	79 08 19.19	324 07 59	Sin	144 09 06	5336.1	5835.4	3.32
			15 08 50	Cat Island	195 08 17	6181.8	6760.2	3.84
Eugene	33 16 36.57	79 08 50.59	15 10 42	Cat Island	195 10 25	3066.2	3353.1	1.91
			195 06 32	Drew	15 06 49	3115.9	3407.5	1.94
Dennis	33 17 50.99	79 10 34.88	340 08 45	Cat Island	160 09 26	5583.8	6106.3	3.47
			258 28 10	Drew	78 29 24	3582.0	3917.2	2.23
Hesterville	33 15 47.71	79 11 29.74	268 38 13	Sin	88 41 04	8059.7	8813.8	5.01
			227 30 45	Drew	47 32 30	6683.8	7309.2	4.15
Oak Hill	33 17 03.05	79 12 54.33	252 51 39	Drew	72 54 10	7447.8	8144.7	4.63
			316 40 15	Hesterville	136 41 01	3190.3	3488.8	1.98
Frazer	33 18 01.44	79 11 32.51	328 42 15	Cat Island	148 43 27	6522.4	7132.7	4.05
			359 00 13	Hesterville	179 00 15	4120.3	4505.9	2.56
Mayrant	33 19 03.80	79 13 11.09	353 21 17	Oak Hill	173 21 26	3744.9	4095.3	2.33
			306 59 21	Frazer	127 00 15	3192.4	3491.1	1.98
Totten	33 18 45.87	79 12 07.39	20 58 56	Oak Hill	200 58 30	3392.1	3709.5	2.11
			108 32 42	Mayrant	288 32 07	1737.6	1900.2	1.08
Bay	33 19 59.85	79 11 17.13	29 42 02	Totten	209 41 34	2623.7	2869.2	1.63
			59 38 37	Mayrant	239 37 34	3415.5	3735.1	2.12
Winyah	33 20 11.62	79 12 59.63	8 04 19	Mayrant	188 04 13	2110.2	2307.7	1.31
			332 54 40	Totten	152 55 09	2967.2	3244.8	1.84
Allston	33 21 37.81	79 12 15.00	333 37 17	Bay	153 37 48	3368.2	3683.4	2.09
			23 29 33	Winyah	203 29 08	2894.8	3165.7	1.80
Rice	33 20 54.37	79 10 48.76	68 44 56	Winyah	248 43 44	3630.9	3970.6	2.26
			120 58 52	Allston	300 58 05	2600.4	2843.7	1.6[illegible]
Head	33 21 37.84	79 11 24.18	89 57 41	Allston	269 57 13	1313.7	1436.6	0.82
			325 37 56	Rice	145 38 16	1622.5	1774.3	1.01
Lowndes	33 11 48.11	79 09 27.76	184 24 59	Brown	4 25 04	3395.2	3712.9	2.11
			241 23 15	South Base	61 24 09	2912.4	3184.9	1.81
Abel	33 18 33.09	79 13 15.60	348 46 49	Oak Hill	168 47 01	2827.6	3092.2	1.76
			187 02 29	Mayrant	7 02 31	953.4	1042.6	0.59
Baker, pole with flag and braces.	33 16 16.20	79 07 44.28	1 20 50	North Base	181 20 48	4094.3	4477.4	2.54
			47 12 38	Cat Island	227 11 45	3432.6	3753.8	2.13
Bay Mill, chimney	33 15 51.26	79 11 55.58	279 17 18	Hesterville	99 17 32	677.4	740.8	0.42
			209 30 23	Dennis	29 31 07	4238.3	4634.9	2.63
McConvey	33 10 14.83	79 08 11.33	145 26 23	Lowndes	325 25 41	3489.3	3815.8	2.17
			205 04 01	Light-house Point	25 04 56	6122.6	6695.5	3.80
Cedar Island	33 07 57.72	79 10 37.06	194 11 30	Lowndes	14 12 08	7320.6	8005.6	4.55
			221 47 13	McConvey	41 48 33	5665.5	6195.6	3.52
Craven, (1)	33 10 52.74	79 07 49.85	204 57 37	Light-house Point	24 58 20	4829.8	5281.7	3.00
			180 23 20	South Base	0 23 20	3100.3	3390.4	1.93
Dennis, tripod	33 17 51.70	79 10 29.67	80 52 30	Dennis	260 52 27	136.5	149.3	0.09
			68 11 19	Oak Hill	248 10 00	4031.4	4408.6	2.51
Dobbin	33 16 26.95	79 12 21.95	226 55 39	Dennis	46 56 38	3791.5	4146.3	2.36
			311 49 03	Hesterville	131 49 32	1812.8	1982.4	1.13
Folly	33 21 59.11	89 11 44.51	321 16 40	Head	141 16 51	839.9	918.5	0.52
			324 08 26	Rice	144 08 57	2460.8	2691.1	1.53
Fort, northeast chimney	33 21 17.33	79 12 20.44	192 34 20	Allston	12 34 23	646.3	706.8	0.40
			246 30 56	Head	66 31 27	1585.7	1734.1	0.99
Georgetown Episcop'l Church Spire.	33 22 06.99	79 12 29.84	334 21 35	Bay	154 22 15	4344.6	4751.1	2.70
			310 33 29	Rice	130 34 25	3439.7	3761.6	2.14
Hare	33 20 17.91	79 11 48.32	43 09 34	Mayrant	223 08 49	3129.1	3421.9	1.94
			9 51 59	Totten	189 51 49	2877.8	3147.1	1.79
Mrs. Keith, pole on house	33 14 22.39	79 07 04 70	108 20 16	Cat Island	288 19 01	3733.0	4082.3	2.32
			18 52 10	South Base	198 51 46	3548.8	3880.9	2.21

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section V.—Winyah Bay. Sketch E.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Laurens	33 15 30.44	79 07 29.43	72 22 16	Cat Island	252 21 15	3046.5	3331.6	1.89
			248 35 29	Sin	68 36 08	1975.1	2159.9	1.23
Leighton's Mill, chimney	33 21 40.89	79 12 35.07	272 55 57	Head	92 56 36	1834.9	2006.6	1.14
			297 32 02	Rice	117 33 00	3099.7	3389.7	1.93
Light-house, chimney	33 13 20.61	79 06 44.37	128 37 06	North Base	308 36 31	2108.5	2305.8	1.31
			97 41 52	Brown	277 40 28	4004.9	4379.6	2.49
Maffitt's Tripod, near south base.	33 12 40.91	79 07 48.36	4 15 54	South Base	184 15 54	232.8	254.6	0.14
			180 12 39	North Base	0 12 39	2538.9	2776.5	1.58
Marsh Island, pole and flag	33 19 06.17	79 12 00.97	14 52 02	Totten	194 51 58	646.9	707.4	0.40
			87 42 25	Mayrant	267 41 46	1814.8	1984.6	1.13
Mary	33 20 20.76	79 12 59.28	225 59 20	Head	46 00 12	3418.0	3737.8	2.12
			205 44 32	Allston	25 44 56	2635.2	2881.8	1.64
Totten's North Base	33 14 02.09	79 07 48.02	306 03 55	Light-house Point	126 10 37	2465.3	2696.0	1.53
			0 32 55	South Base	180 32 54	2733.1	2988.8	1.70
Old Tree	33 20 57.38	79 10 50.03	67 11 42	Winyah	247 10 31	3635.1	3975.2	2.26
			119 33 35	Allston	299 32 48	2525.0	2761.3	1.57
Winnowing Mill	33 21 53.26	79 09 53.36	38 17 10	Rice	218 16 40	2311.4	2527.7	1.44
			78 33 56	Head	258 33 06	2395.2	2619.3	1.49
Pine	33 20 08.41	79 12 59.53	332 03 39	Totten	152 04 08	2878.2	3147.5	1.79
			8 32 29	Mayrant	188 32 23	2012.6	2200.9	1.25
Rabbit	33 19 47.95	79 12 13.02	47 50 15	Mayrant	227 49 43	2026.0	2215.6	1.26
			355 38 33	Totten	175 38 36	1918.1	2097.6	1.19
Read	33 20 50.17	79 12 33.85	349 52 02	Totten	169 52 17	3889.9	4253.9	2.42
			29 18 38	Winyah	209 18 24	1361.6	1489.0	0.85
Tarbox	33 15 15.88	79 10 18.38	209 17 49	Drew	29 18 54	6300.1	6889.6	3.91
			174 53 37	Dennis	354 53 28	4797.4	5246.3	2.98
Tripe	33 14 44.55	79 08 20.35	235 55 42	Sin	55 56 49	3810.1	4166.6	2.37
			35 53 20	Brown	215 52 49	2530.5	2767.3	1.57

Section VI.—Barnes' Sound. Sketch F.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Snapper Point	25 19 24.01	W.0 08 04.83	....	....	....	....	....	....
Long Arsenicker Key	25 22 34.43	0 08 38.74	350 48 16	Snapper Point	170 48 31	5935.2	6490.6	3.69
Card's Point, (Seward)	25 19 20.65	0 11 12.56	268 51 33	Snapper Point	88 52 54	5250.9	5742.2	3.26
			215 47 33	Long Arsenicker Key	35 48 39	7351.5	8039.4	4.57
Jew Point	25 17 10.27	0 10 25.87	161 58 11	Card's Point, (Seward)	341 57 51	4218.7	4613.4	2.62
			223 46 54	Snapper Point	43 47 54	5700.3	6233.7	3.54
Mud Point	25 18 21.37	0 13 10.13	240 58 40	Card's Point, (Seward)	60 59 30	3760.1	4111.9	2.34
			257 15 45	Snapper Point	77 17 55	8753.2	9572.2	5.44
Mosquito Creek	25 16 38.76	0 11 59.53	147 58 52	Mud Point	327 58 22	3724.0	4072.5	2.31
			194 46 30	Card's Point, (Seward)	14 46 50	5151.5	5633.5	3.20
Narrow Point	25 17 13.14	0 14 11.80	219 24 09	Mud Point	39 24 35	2716.9	2971.1	1.69
			285 57 05	Mosquito Creek	105 58 01	3848.1	4208.2	2.39
Main Key	25 14 45.68	0 14 25.53	184 50 24	Narrow Point	4 50 30	4553.5	4979.6	2.83
			229 34 03	Mosquito Creek	49 35 05	5365.6	5867.7	3.33
Largo North, (Seward)	25 14 05.18	0 10 51.14	157 57 21	Mosquito Creek	337 56 52	5098.0	5575.0	3.17
			135 51 44	Narrow Point	315 50 18	8060.0	8814.2	5.01
Largo Point	25 11 58.88	0 13 26.91	162 16 33	Main Key	342 16 08	5388.0	5892.2	3.35
			228 16 38	Largo North, (Seward)	48 17 45	5840.4	6386.9	3.63
Clay Point	25 13 08.59	0 16 16.67	226 09 20	Main Key	46 10 07	4313.1	4716.7	2.68
			259 09 37	Largo North, (Seward)	79 11 56	9276.1	10144.1	5.76
Crab Point	25 11 26.92	W.0 14 18.12	133 18 35	Clay Point	313 17 44	4561.0	4987.8	2.83
			178 03 26	Main Key	358 03 23	6119.0	6691.6	3.80

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section VI.—Barnes' Sound. Sketch F.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Shell Key	25 10 39 36	W.0 16 53.82	192 45 10	Clay Point	12 45 26	4707.3	5147.8	2.92
			251 26 20	Crab Point	71 27 26	4598.1	5028.3	2.86
Bush Point	25 08 51.41	0 16 08.02	158 53 31	Shell Key	338 53 11	3560.6	3893.8	2.21
			212 44 30	Crab Point	32 45 16	5688.8	6221.1	3.54
East Point	25 09 36.43	0 14 25.98	183 42 10	Crab Point	3 42 13	3406.5	3725.3	2.12
			115 04 38	Shell Key	295 03 35	4570.2	4997.8	2.84
Snake Point	25 10 17.64	0 14 14.27	98 31 22	Shell Key	278 30 14	4517.0	4939.7	2.81
			177 06 25	Crab Point	357 06 23	2134.4	2334.1	1.33
Neck	25 11 51.95	0 16 44.27	280 39 09	Crab Point	100 40 11	4163 4	4553.0	2.59
			6 49 39	Shell Key	186 49 35	2249.1	2459.5	1.40
Sound Point	25 10 28.12	0 17 37.83	254 18 20	Shell Key	74 18 39	1279.7	1399.4	0.79
			319 47 38	Bush Point	139 48 16	3895.8	4260.3	2.42
Fly Point	25 09 34.19	0 18 03.77	224 19 10	Shell Key	44 19 40	2803.2	3065.5	1 74
			292 05 37	Bush Point	112 06 26	3498.5	3825.9	2.17
Pond Point	25 08 14.80	0 15 04.86	145 33 24	Shell Key	325 32 38	5394.1	5898.8	3.35
			192 28 52	Crab Point	12 29 12	6054.2	6620.7	3.76
Cross Key	25 11 41.54	0 15 38.15	9 04 53	Bush Point	189 04 40	5300.9	5796.9	3.29
			47 55 35	Shell Key	227 55 03	2854.4	3121.5	1 77
Creek	25 10 59.39	0 13 55.13	43 23 20	Bush Point	223 22 23	5417.8	5924.7	3.37
			82 59 29	Shell Key	262 58 13	5040.8	5512.5	3.13
Grass Point	25 09 07.05	0 17 20.85	194 55 02	Shell Key	14 55 13	2939.6	3214.7	1.83
			283 16 13	Bush Point	103 16 44	2095.5	2291.6	1.30
Scorpion	25 13 58 67	0 16 44.34	318 45 20	Crab Point	138 46 22	6209.1	6790.1	3.86
			333 20 05	Clay Point	153 20 17	1724.4	1885.7	1.07
Hawk Point	25 12 24.98	0 17 55.40	332 02 52	Shell Key	152 03 18	3678.3	4022.5	2.29
			244 05 23	Clay Point	64 06 05	3071.4	3358.8	1.91
Channel Point	25 13 20.48	0 17 56.63	277 26 58	Clay Point	97 27 41	2820.8	3084.7	1.75
			340 28 06	Shell Key	160 28 33	5259.7	5751.9	3.27
Spider Point	25 14 01.75	0 18 32.11	293 20 12	Clay Point	113 21 10	4127.8	4514.0	2.56
			336 09 21	Shell Key	156 10 03	6807.6	7444.6	4.23
Lock Point	25 14 15.99	0 14 57.71	328 55 47	Largo Point	148 56 26	4925.0	5385.8	3.06
			46 49 59	Clay Point	226 49 25	3031.0	3314.6	1.88
Grouper Point	25 13 53.94	0 16 28.10	245 05 52	Main Key	65 06 44	3781.3	4135.1	2 35
			347 07 07	Clay Point	167 07 12	1431.6	1565.6	0.89
Flat Point	25 15 25.54	0 15 57.57	295 27 33	Main Key	115 28 12	2852.3	3119.2	1.77
			7 14 30	Clay Point	187 14 22	4247.6	4645 0	2 64
Bay Point	25 14 18.48	0 15 56.15	251 43 50	Main Key	71 44 29	2670.3	2920.2	1.66
			14 58 18	Clay Point	194 58 09	2226.0	2434.3	1.38
Sponge Point	25 14 39.63	0 16 31.23	219 32 46	Narrow Point	39 33 46	6126.0	6699.2	3.81
			266 57 59	Main Key	86 58 53	3522.3	3851.9	2.19
Jew Fish Creek	25 15 54.71	0 11 10.86	350 42 01	Largo North, (Seward)	170 42 09	3414.8	3734.3	2.12
			68 42 31	Main Key	248 41 08	5846.3	6393.3	3.63
Sand Beach	25 11 49.63	0 15 33.63	199 22 51	Main Key	19 23 20	5742.1	6279.4	3.57
			242 10 19	Largo North, (Seward)	62 12 19	8939.1	9775.5	5.55
Thursday Point	25 12 20.05	0 12 55.32	191 05 32	Mosquito Creek	11 05 56	8111.4	8870.4	5.04
			227 02 40	Largo North, (Seward)	47 03 33	4748.0	5192.3	2.95
Cove Point	25 12 34.41	0 11 49.48	132 46 20	Main Key	312 45 14	5948.6	6505.2	3.70
			177 51 23	Mosquito Creek	357 51 19	7523.5	8227.5	4.67
Baker Point	25 15 16.35	0 10 36.82	38 05 12	Largo Point	218 04 00	7718.5	8440.7	4.80
			81 37 29	Main Key	261 35 51	6468.7	7074.0	4.02
Middle Key	25 16 44.47	0 14 13.94	310 48 23	Largo North, (Seward)	130 49 50	7497.8	8199.4	4.66
			272 40 10	Mosquito Creek	92 41 07	3763.9	4116.1	2.34
Short Key	25 15 53.43	0 14 36.83	252 24 17	Mosquito Creek	72 25 24	4616.4	5048.4	2.87
			297 47 32	Largo North, (Seward)	117 49 08	7139.6	7807.7	4.44
Division Point	25 13 07.89	0 15 43.73	298 59 49	Largo Point	119 00 47	4379.0	4788.7	2.72
			257 49 58	Largo North, (Seward)	77 52 03	8376.3	9160.1	5.20
Pierce Point	25 18 58.98	0 12 52 23	309 14 35	Jew Point	129 15 38	5286.4	5781.1	3.28
			256 32 39	Card's Point, (Seward)	76 33 22	2865.8	3134.0	1.78
Alligator	25 12 24.50	0 18 26.59	249 31 51	Clay Point	69 32 46	3880 7	4243.8	2.41
			321 13 57	Shell Key	141 14 36	4148.1	4536.2	2.58
Duck Key	25 10 43.90	W.0 19 58.02	219 35 05	Alligator	39 35 44	4016.3	4392.1	2.50
			271 32 19	Shell Key	91 33 37	5159.1	5641.8	3 21

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section VI.—Barnes' Sound. Sketch F.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Snipe Point	25 12 13.58	W.0 20 22.77	264 05 52	Alligator	84 06 41	3269.2	3575 1	2 03
			345 54 17	Duck Key	165 54 28	2844.9	3111.1	1.77
Drum Point	25 10 01.00	0 18 08.39	173 24 59	Alligator	353 24 51	4444.5	4860.4	2.76
			113 16 38	Duck Key	293 15 51	3341.5	3654.2	2.08
Swamp Point	25 10 19.59	W.0 17 56.91	167 48 02	Alligator	347 47 49	3932.0	4299.9	2.44
			102 26 59	Duck Key	282 26 07	3472.6	3797.5	2.16
KEY WEST TO MARQUESAS.				WESTERN PART OF FLORIDA KEYS.				
Sand Key	24 27 09.51	81 52 43.00	....	....	....	....	....	....
West Crawfish Key	24 32 16.16	81 53 05.71	356 07 21	Sand Key	176 07 30	9455.6	10340.4	5.88
Tift's Observatory	24 33 31.13	81 48 36.73	31 10 55	Sand Key	211 09 11	13721.1	15005 0	8.53
			73 25 01	West Crawfish Key	253 23 07	8074.3	8829.8	5.02
East Crawfish Key	24 33 39.95	81 51 44.90	272 49 58	Tift's Observatory	92 51 18	5470.2	5982.1	3.40
			7 45 24	Sand Key	187 45 00	12150.7	13287.7	7.55
Northwest Boca Chica	24 38 24.62	81 46 49.49	17 30 37	Tift's Observatory	197 29.54	9467.9	10353.8	5.88
			43 30 40	East Crawfish Key	223 28.37	12072.7	13202.4	7.50
East Point	24 34 13.72	81 45 45.68	74 15 12	Tift's Observatory	254 14.04	4825.3	5276.8	3.00
			166 54 50	Northwest Boca Chica	346 54.23	7925.2	8666.8	4.92
Flemming's Key	24 34 40.07	81 47 57.43	195 27 25	Northwest Boca Chica	15 27 54	7168.0	7838.7	4.45
			23 50 10	Tift's Observatory	203 49 56	2318.7	2535.7	1.44
U. S. Barracks	24 33 37.93	81 47 38.23	250 49 12	East Point	70 49 59	3352.9	3666.6	2.08
			81 56 24	Tift's Observatory	261 56 03	1491.8	1631.4	0.93
Key West Light	24 32 58.10	81 48 07.13	81 17 13	West Crawfish Key	261 15 09	8500.6	9296.0	5.28
			239 41 01	East Point	59 42 00	4610.3	5041.7	2.86
Old Beacon	24 32 38.01	81 48 19.41	85 14 46	West Crawfish Key	265 12 47	8085.0	8841.5	5.03
			168 57 58	Tift's Observatory	348 57 53	1665.0	1820.8	1.04
Rocky Point	24 33 03.26	81 45 23.78	99 16 01	Tift's Observatory	279 14 43	5329.9	5828.6	3.30
			166 18 02	Northwest Boca Chica	346 17 26	10176.5	11128.7	6.32
Wreck of the Frankford	24 34 58.16	81 49 05.53	53 36 15	North Crawfish Key	233 34 35	8397.1	9182.8	5.22
			211 03 21	Northwest Boca Chica	31 04 19	7415.2	8109.1	4.61
Bank in Northwest Channel	24 35 00.27	81 49 37.48	216 54 54	Northwest Boca Chica	36 56 04	7864.6	8600.5	4.89
			49 15 30	West Crawfish Key	229 14 04	7734.3	8458.0	4.81
Cotteral's Key	24 36 01.19	81 55 21.04	331 10 55	West Crawfish Key	151 11 51	7901.3	8640.6	4.91
			252 55 06	Northwest Boca Chica	72 58 39	15048.4	16456.5	9.35
Major Bache's Station on Cotteral's Key.	24 36 22.20	81 55 26.62	255 27 01	Northwest Boca Chica	75 30 36	15023.2	16428.9	9.33
			294 11 44	Tift's Observatory	114 14 37	12829.2	14029.6	7.97
Mullet Key	24 34 38.38	81 55 05.82	243 28 13	Northwest Boca Chica	63 31 40	15599.1	17058.7	9.69
			280 31 15	Tift's Observatory	100 33 59	11397.1	12365.1	7.02
A	24 33 32.84	81 53 08.22	358 16 56	West Crawfish Key	178 16 56	2360.4	2581.3	1.47
			229 51 31	Northwest Boca Chica	49 54 08	13930.7	15234.2	8.66
B	24 32 39.30	81 54 50.74	261 29 50	Tift's Observatory	81 32 28	10811.4	11823.0	6.72
			340 28 37	Sand Key	160 29 30	10764.5	11771.7	6.69
C	24 32 36.67	81 55 05 87	261 24 30	Tift's Observatory	81 27 14	11244.5	12296.6	6.99
			280 33 40	West Crawfish Key	100 34 30	3439.9	3761.8	2.14
Middle Ground	24 28 52.75	81 53 00.31	221 31 28	Tift's Observatory	41 33 20	11442.0	12512.6	7.11
			178 36 37	West Crawfish Key	358 36 35	6259.5	6845.2	3.89
Rock Key	24 27 18.30	81 51 31.68	203 56 06	Tift's Observatory	23 57 21	12550.2	13724.5	7.80
			82 19 56	Sand Key	262 19 26	2026.8	2216.5	1.26
Eastern Dry Rocks	24 27 37.79	81 50 39.90	75 55 09	Sand Key	255 54 18	3574.0	3908.4	2.22
			198 29 11	Tift's Observatory	18 30 05	11462.6	12535.2	7.12
Western Dry Rocks	24 26 43.70	81 55 39.23	223 52 33	Tift's Observatory	43 55 31	17395.8	19023.5	10.80
			260 54 06	Sand Key	80 55 19	5026.2	5496.5	3.12
Woman Key	24 31 44.70	81 55 05.79	334 35 26	Sand Key	154 36 25	9372.2	10249.2	5.82
			326 15 43	Middle Ground	146 16 36	6360.7	6955.9	3.95
Woman Key West	24 31 29.76	81 55 46.86	99 07 09	Boca Grande	279 05 10	8129.9	8890.6	5.05
			184 58 13	Cotteral's Key	4 58 24	8382.0	9166.3	5.21
Wreck of Brig Moreno (head)	24 31 09.95	81 56 17.64	98 38 30	Man Key	278 37 48	2878.8	3148.2	1.79
			190 04 26	Cotteral's Key	10 04 49	9100.5	9952.0	5.65
Man Key	24 31 24.00	81 57 58.76	256 13 05	Tift's Observatory	76 17 00	16456.8	17996.7	10.23
			258 58 25	W. Crawfish Key	79 00 27	8402.1	9188.3	5.22

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section VI.—Western part of Florida Keys. Sketch F.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Lavina Bank	24 35 09.93	81 59 20.63	256 48 53	Cotteral's Key	76 50 33	6921.5	7569.1	4.30
			341 39 31	Man Key	161 40 05	7322.5	8007.7	4.55
Boca Grande	24 32 11.57	82 00 32.10	231 04 13	Cotteral's Key	51 06 23	11247.1	12299.5	6.99
			200 07 22	Lavina Bank	20 07 52	5844.1	6390.9	3.63
Boca Grande, east	24 31 45.82	81 59 58.79	130 12 27	Boca Grande	310 12 12	1227.2	1342.0	0.76
			189 42 11	Lavina Bank	9 42 27	6370.6	6966.7	3.96
Mule Key	24 34 46.20	81 57 05.98	231 58 59	Cotteral's Key	51 59 43	3746.7	4097.3	2.33
			50 38 56	Boca Grande	230 37 30	7501.3	8203.2	4.66
Marquesas Alpha	24 34 23.87	82 06 04.99	293 28 04	Boca Grande	113 30 23	10213.4	11169.1	6.34
			262 52 40	Lavina Bank	82 55 28	11463.9	12536.6	7.12
Marquesas Beta	24 32 54.59	82 07 03.45	210 54 50	Alpha	30 55 14	3201.8	3501.4	1.99
			252 14 31	Lavina Bank	72 17 44	13671.3	14950.5	8.49
Marquesas Gamma	24 34 11.63	82 09 24.39	300 51 29	Beta	120 52 27	4619.8	5052.1	2.87
			266 08 49	Alpha	86 10 12	5622.7	6148.8	3.49
Marquesas Delta	24 35 13.11	82 08 47.95	345 45 58	Epsilon	165 46 13	4179.0	4570.0	2.60
			288 16 32	Alpha	108 17 39	4828.2	5280.0	3.00
Marquesas Epsilon	24 33 01.44	82 08 11 43	276 16 50	Beta	96 17 18	1924.4	2104.5	1.19
			136 27 17	Gamma	316 26 47	2979.5	3258.3	1.85
Marquesas Theta	24 32 49.41	82 09 36.69	261 13 32	Epsilon	81 14 08	2427.6	2654.8	1.51
			187 47 28	Gamma	7 47 33	2553.2	2792.1	1.59
KEYS TO THE EASTWARD OF KEY WEST.								
Stock Island	24 33 45.28	81 43 40.31	86 57 58	Tift's Observatory	266 55 58	8183.3	8949.0	5.09
			148 14 43	Northwest Boca Chica	328 13 24	10108.1	11053.9	6.28
Channel Key	24 36 09.03	81 43 30.61	60 06 10	Tift's Observatory	240 04 05	9741.1	10652.6	6.05
			3 31 55	Stock Island	183 31 51	4430.9	4845.5	2.75
Raccoon Key	24 35 16.39	81 44 32.79	332 13 04	Stock Island	152 13 25	3168.1	3464.5	1.97
			227 12 04	Channel Key	47 12 30	2383.8	2606.9	1.48
Western Sambo	24 28 47.84	81 43 07.71	133 48 26	Tift's Observatory	313 46 12	12594.4	13772.9	7.83
			174 16 08	Stock Island	354 16 22	9196.7	10057.2	5.71
Sand Key Light-house	24 27 10.00	81 52 43.02	211 11 16	Tift's Observatory	31 13 01	13708.4	14991.1	8.52
			231 26 53	Stock Island	51 30 38	19526.1	21353.2	12.13
Northwest Channel Light-house.	24 37 04.05	81 54 00.84	258 25 32	Northwest Boca Chica	78 28 32	12381.1	13539.6	7.69
			305 10 50	Tift's Observatory	125 13 07	11364.3	12427.6	7.06
Rock Point	24 33 27.48	81 41 12.16	97 29 41	Stock Island	277 28 39	4204.2	4597.6	2.61
			141 55 31	Channel Key	321 54 33	6314.5	6905.4	3.92
Eastern Sambo, 1853	24 29 31.60	81 39 55.24	140 56 53	Stock Island	320 55 20	10051.7	10992.2	6.25
			163 23 25	Rock Point	343 22 53	7572.8	8281 4	4.71
Sandy Point	24 33 20.27	81 43 03 77	265 57 09	Rock Point	85 57 56	3148.0	3442.6	1.96
			322 57 44	Eastern Sambo, 1853	142 59 02	8811.6	9636.1	5.48
Monday Key	24 35 13.49	81 42 59.98	91 57 49	Raccoon Key	271 57 15	2612.5	2857.0	1.62
			153 14 37	Channel Key	333 14 24	1913.8	2092.9	1.19
East Harbor Key	24 38 04.55	81 43 18.56	5 26 51	Channel Key	185 26 46	3570.0	3904.0	2.22
			95 57 24	North West Boca Chica	275 55 56	5963.5	6521 5	3.71
Kayo Agua	24 37 52.14	81 44 30.41	332 04 02	Channel Key	152 04 27	3590.3	3926.3	2.23
			259 17 51	East Harbor Key	79 18 21	2056 0	2248.4	1.28
Long Point	24 36 07.38	81 42 18.37	91 26 28	Channel Key	271 25 58	2032.5	2222.7	1.26
			35 13 17	Monday Key	215 13 00	2029.4	2219.3	1.26
Geigers	24 34 04.71	81 40 13.43	55 16 23	Rock Point	235 15 59	2010.7	2198.8	1.25
			356 30 36	Eastern Sambo, 1853	176 30 44	8417.8	9205.5	5.23
West Harbor Key	24 39 07.75	81 45 16.69	63 03 07	North West Boca Chica	243 02 29	2927.4	3201.3	1.82
			300 20 18	East Harbor Key	120 21 07	3848.9	4209.0	2.39
Mud Key	24 39 59.29	81 41 39.96	71 30 54	North West Boca Chica	251 28 45	9177 2	10035.9	5.70
			23 43 08	Channel Key	203 42 22	7737.4	8461.4	4.81
Tree	24 34 11.41	81 42 08.05	72 47 52	Stock Island	252 47 13	2717.4	2971.7	1.69
			310 40 42	Rock Point	130 41 05	2073.5	2267.5	1.29
Rockland Key	24 35 31.65	81 41 06.47	105 50 36	Channel Key	285 49 36	4214.5	4608.8	2.62
			141 42 23	East Harbor Key	321 41 28	5994.1	6555.0	3.72
Saddle Hills South	24 34 26.77	81 38 39.48	13 13 01	Eastern Sambo, 1853	193 12 30	9327.7	10200.5	5 79
			67 00 09	Rock Point	246 59 05	4667.2	5103.9	2.90
Half-moon Key	24 36 23.12	81 39 47.58	86 03 37	Channel Key	266 02 04	6288.4	6876.8	3.91
			154 35 27	Mud Key	334 34 40	7363.1	8052.1	4.57

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section VI.—Keys to the eastward of Key West. Sketch F.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Eagle Nest Key	24 37 51.42	81 42 04.03	7 11 02	Long Point	187 10 56	3226.2	3528.1	2.00
			100 54 44	East Harbor Key	280 54 13	2134.4	2334.1	1.33
Harbor Bank	24 39 52.87	81 44 02.61	267 09 54	Mud Key	87 10 53	4015.3	4391.0	2.49
			339 36 35	East Harbor Key	159 36 53	3555.0	3887.7	2.21
Wall Key	24 38 38.91	81 39 17.76	11 20 59	Halfmoon Key	191 20 46	4261.0	4659.7	2.65
			121 44 54	Mud Key	301 43 55	4701.0	5140.9	2.92
Sal Bunce, No. 2	24 37 47.34	81 37 41.38	121 11 43	Mud Key	301 10 03	7841.1	8574.8	4.87
			53 52 36	Halfmoon Key	233 51 43	4394.4	4805.6	2.73
O'Hara Key	24 36 58.72	81 38 43.91	58 33 21	Halfmoon Key	238 32 54	2099.1	2295.5	1.30
			162 50 17	Wall Key	342 50 03	3226.4	3528.3	2.00
Snipe Point	24 41 50.86	81 40 34.08	28 21 14	Mud Key	208 20 47	3900.2	4265.1	2.42
			340 01 53	Wall Key	160 02 25	6283.1	6871.0	3.90
Snipe Key, No. 1	24 40 53.92	81 40 09.21	56 37 50	Mud Key	236 37 12	3055.0	3340.9	1.90
			340 47 55	Wall Key	160 48 17	4398.2	4809.7	2.73
Snipe Key, No. 2	24 40 04.05	81 38 44.80	19 29 12	Wall Key	199 28 58	2778.6	3038.6	1.73
			88 18 26	Mud Key	268 17 13	4926.5	5387.5	3.06
The Narrows	24 38 58.65	81 37 04.18	260 48 27	Wall Key	80 49 23	3805.1	4161.2	2.36
			125 25 37	Snipe Key, No. 2	305 24 55	3471.7	3796.5	2.16
Sal Bunce, No. 3	24 38 06.54	81 35 59.79	131 31 40	The Narrows	311 31 13	2418.0	2644.3	1.50
			78 18 59	Sal Bunce, No. 2	258 18 17	2917.3	3190.3	1.81
Mud Bank	24 40 37.58	81 42 08.79	325 28 56	Mud Key	145 29 08	1430.0	1563.8	0.89
			229 44 16	Snipe Point	49 44 55	3488.4	3814.8	2.17
Blake Key	24 40 36.44	81 37 04.81	45 57 24	Wall Key	225 56 28	5201.0	5687.7	3.23
			111 16 37	Snipe Point	291 15 10	6312.0	6902.6	3.92
Marvin Key	24 42 37.76	81 38 40.75	65 38 02	Snipe Point	245 37 14	3496.8	3824.0	2.17
			324 08 47	Blake Key	144 09 27	4604.5	5035.3	2.86
Johnston's Key	24 42 36.44	81 35 38.58	33 17 37	Blake Key	213 17 01	4416.2	4829.4	2.74
			90 27 57	Marvin Key	270 26 41	5119.9	5599.0	3.18
Mallory Key	24 41 14.33	81 38 05.37	105 03 26	Snipe Point	285 02 24	4328.4	4733.4	2.69
			158 49 27	Marvin Key	338 49 12	2752.8	3010.4	1.71
Douglas Key	24 40 20.83	81 34 44.68	96 57 44	Blake Key	276 56 45	3968.7	4340.1	2.47
			160 02 43	Johnston's Key	340 02 20	4438.6	4853.9	2.76
Point Dora	24 41 30.53	81 33 26.17	45 49 50	Douglas Key	225 49 17	3077.0	3364.9	1.91
			118 35 38	Johnston's Key	298 34 43	4238.1	4634.7	2.63
Saddle Hills North	24 35 07.69	81 36 14.65	111 11 26	Halfmoon Key	291 09 57	6423.3	7024.3	3.99
			153 35 35	Sal Bunce, No. 2	333 34 59	5483.8	5996.9	3.41
Sal Bunce, No. 1	24 36 10.86	81 37 50.18	96 31 12	Halfmoon Key	276 30 23	3323.3	3634.3	2.06
			184 46 04	Sal Bunce, No. 2	4 46 08	2977.9	3256.5	1.85
Eastern Sambo, 1855	24 29 31.68	81 39 55.03	163 20 31	Rock Point	343 19 59	7572.5	8281.1	4.71
			193 10 31	Saddle Hills South	13 11 02	9323.9	10196.3	5.79
Kite	24 38 03.50	81 34 47.14	84 12 46	Sal Bunce, No. 2	264 11 33	4925.3	5386.2	3.06
			24 28 23	Saddle Hills North	204 27 47	5943.1	6499.2	3.69
Buzzard	24 36 47.53	81 35 23.62	115 24 34	Sal Bunce, No. 2	295 23 37	4289.1	4690.4	2.67
			203 41 52	Kite	23 42 07	2552.6	2791.5	1.59
Crane	24 37 22.08	81 35 26.12	220 41 57	Kite	40 42 13	1681.1	1838.4	1.04
			356 12 53	Buzzard	176 12 54	1065.2	1164.9	0.66
Hawk	24 37 13.06	81 34 04 44	96 53 08	Crane	276 52 34	2313.9	2530.4	1.44
			142 16 01	Kite	322 15 43	1962.1	2145.7	1.22
Sugarloaf	24 36 09.88	81 33 51.17	64 38 21	Saddle Hills North	244 37 22	4467.1	4885.1	2.78
			114 51 32	Sal Bunce, No. 2	294 49 56	7135.4	7803.1	4.43
Sal Bunce	24 35 06.73	81 37 26.97	175 18 25	Sal Bunce, No. 2	355 18 24	4957.5	5421.4	3.08
			269 10 41	Saddle Hills North	89 11 11	2034.5	2224.9	1.26
Washerwoman	24 32 51.65	81 35 22.70	202 53 17	Sugarloaf	22 53 55	6619.8	7239.2	3.89
			117 51 56	Saddle Hills South	297 50 34	6263.0	6849.0	4.11
Hackley	24 38 32.80	81 31 52 95	37 06 06	Sugarloaf	217 05 17	5512.6	6028.4	3.43
			79 34 54	Kite	259 33 42	4980.7	5446.7	3.09
Martha	24 37 04.44	81 31 11.14	69 33 30	Sugarloaf	249 32 23	4803.8	5253.3	2.98
			156 36 58	Hackley	336 36 41	2961.9	3239.0	1.84
Eliza	24 39 19.73	81 30 37.18	55 53 08	Hackley	235 52 37	2573.8	2814.6	1.60
			130 16 14	Point Dora	310 15 03	6219.0	6800.9	3.86
Buttonwood	24 39 21.55	81 33 21.91	128 05 07	Douglas Key	308 04 33	2956.5	3233.1	1.84
			178 16 03	Point Dora	358 16 01	3969.3	4340.7	2.47

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section VI.—Keys to the eastward of Key West. Sketch F.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Loggerhead	24 36 54.12	81 28 47.94	94 30 49	Martha	274 29 49	4040.1	4418.1	2.51
			145 34 08	Eliza	325 33 23	5431.5	5939.7	3.38
Gopher Key	24 38 27.52	81 29 07.38	122 28 02	Eliza	302 27 24	2992.4	3272.4	1.86
			349 13 55	Loggerhead	169 14 03	2925.0	3198.7	1.82
Palmetto	24 39 36.72	81 27 41.92	20 22 03	Loggerhead	200 21 35	5335.8	5835.1	3.32
			83 57 19	Eliza	263 56 06	4955.1	5418.7	3.08
American Shoal	24 31 24.16	81 31 15.71	180 42 05	Martha	0 42 07	10470.3	11450.0	6.51
			114 14 44	Saddle Hills, South	294 11 40	13692.7	14973.9	8.51

Section VII.—Cedar Keys, Florida. Sketch G.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Cedar Keys Base. North End	29 08 15.45	83 02 33.57	....	....	....	....	....	....
Cedar Keys Base. South End	29 07 58.34	83 03 08.74	241 00 10	North Base	61 00 27	1086.7	1188.4	0.67
Harbor Key	29 07 07.27	83 03 17.51	209 30 14	North Base	29 30 36	2411.6	2637.3	1.50
			188 34 55	South Base	8 34 59	1589.9	1738.7	0.99
South Point	29 07 38.28	83 04 02.13	246 49 45	South Base	66 50 11	1569.7	1716.6	0.97
			308 21 32	Harbor Key	128 21 54	1538.0	1681.9	0.96
Seahorse Key	29 05 50.10	83 04 38.00	222 28 45	Harbor Key	42 29 24	3221.6	3523.0	2.00
			196 13 54	South Point	16 14 12	3468.6	3793.2	2.16
Depot Key	29 07 29.84	83 02 45.00	97 06 22	South Point	277 05 44	2100.9	2297.5	1.31
			44 51 33	Seahorse Key	224 50 38	4331.3	4736.6	2.69
Snake Key	29 05 58.23	83 02 47.61	146 49 01	South Point	326 48 25	3680.4	4024.8	2.29
			181 25 59	Depot Key	1 26 00	2821.3	3085.3	1.75
North Key, South	29 07 14.97	83 06 07.04	257 59 41	South Point	78 00 42	3451.8	3774.8	2.15
			317 20 24	Seahorse Key	137 21 08	3552.7	3885.1	2.21
North Key, North	29 08 06.30	83 06 00.24	285 09 24	South Point	105 10 22	3307.8	3617.3	2.05
			332 04 26	Seahorse Key	152 05 06	4748.4	5192.7	2.95
Lime Point	29 08 55.07	83 04 14.57	6 20 48	Seahorse Key	186 20 37	5729.6	6265.7	3.56
			62 18 58	North Key, North	242 18 06	3225.4	3527.2	2.00
Black Point	29 10 52.95	83 04 38.06	350 04 43	Lime Point	170 04 54	3684.1	4028.8	2.29
			23 25 19	North Key, North	203 24 39	5588.1	6111.0	3.47
Pelican Shoal	29 10 37.71	83 07 00.23	263 01 25	Black Point	83 02 34	3869.4	4231.5	2.40
			340 48 41	North Key, North	160 49 10	4932.5	5394.0	3.06
Bird Key	29 06 52.94	83 05 20.21	236 31 08	South Point	56 31 46	2530.6	2767.4	1.57
			329 27 21	Seahorse Key	149 27 42	2246.1	2456.3	1.40
Middle Key	29 07 59.00	83 05 00.52	98 00 53	North Key, North	278 00 24	1630.2	1782.7	1.01
			215 43 45	Lime Point	35 44 07	2126.3	2325.3	1.32
Way Key	29 08 10.43	83 02 55.17	357 07 28	Snake Key	177 07 32	4075.1	4456.4	2.53
			61 19 46	South Point	241 19 13	2062.9	2255.9	1.28
Depot Key, East	29 07 05.57	83 02 25.66	57 00 29	Seahorse Key	236 59 25	4266.1	4665.3	2.65
			111 07 02	South Point	291 06 15	2795.3	3056.9	1.74
Johnson's House, Cupola	29 05 49.48	83 04 53.76	143 02 05	North Key, South	323 01 29	3294.0	3602.2	2.05
			202 37 19	South Point	22 37 44	3628.4	3967.9	2.25
Oyster Reef, South	29 07 23.96	82 59 36.38	62 58 06	Snake Key	242 56 33	5804.4	6347.5	3.61
			104 55 29	Way Key	284 53 52	5560.4	6080.7	3.46
Seahorse Key, West	29 06 09.02	83 05 23.62	149 58 17	North Key, South	329 57 56	2345.1	2564.5	1.46
			218 42 58	South Point	38 43 38	3521.9	3851.4	2.19
No. 1	29 08 34.26	83 04 43.00	23 34 29	Middle Key	203 34 20	1184.2	1295.0	0.74
			67 39 39	North Key, North	247 39 01	2257.3	2468.5	1.40
No. 3	29 08 46.29	83 05 04.93	355 19 03	Middle Key	175 19 05	1460.6	1597.3	0.91
			50 35 26	North Key, North	230 34 59	1935.0	2116.1	1.20
No. 4	29 08 51.57	83 05 13.27	347 58 16	Middle Key	167 58 22	1654.5	1809.3	1.03
			42 23 17	North Key, North	222 22 54	1883.1	2059.3	1.17
No. 5	29 08 53.59	83 05 27.21	336 46 05	Middle Key	156 46 18	1828.8	1999.9	1.14
			31 34 04	North Key, North	211 33 48	1705.7	1865.3	1.06

UNITED STATES COAST SURVEY—GEOGRAPHICAL POSITIONS.

Section VII.—Cedar Keys, Florida. Sketch G.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
No. 6	29 09 08.99	83 05 39.67	333 50 21 16 05 31	Middle Key North Key, North	153 50 40 196 05 21	2400.4 2006.0	2625.0 2193.7	1.49 1.25
Oyster Reef, A	29 08 26.67	82 59 44.10	47 21 30 84 28 56	Snake Key Way Key	227 20 01 264 27 23	6744.6 5188.0	7375.7 5673.5	4.19 3.22
Oyster Reef, B, No. 2	29 09 24.14	83 00 54.40	55 11 49 330 18 59	Way Key Oyster Reef, South	235 10 50 150 19 37	3975.1 4258.5	4347.1 4657.0	2.47 2.65
Signal No. 4	29 10 13.14	83 02 02.11	309 29 54 20 47 09	Oyster Reef, B, No. 2 Way Key	129 30 27 200 46 43	2371.3 4040.6	2593.2 4418.7	1.47 2.51
Goose Point	29 10 18.12	83 02 51.79	276 30 42 1 19 51	Signal No. 4 Way Key	96 31 06 181 19 49	1350.9 3932.0	1477.3 4299.9	0.84 2.44
Palmetto Island	29 10 21.70	83 03 42.37	275 32 57 342 28 46	Signal No. 4 Way Key	95 33 46 162 29 09	2721.5 4237.7	2976.1 4634.2	1.69 2.63
Cedar Point	29 09 21.69	83 01 38.97	158 27 39 266 24 21	Signal No. 4 Oyster Reef, B, No. 2	338 27 28 86 24 43	1702.9 1206.9	1862.2 1319.8	1.06 0.75

Section X.—Southern part of San Francisco Bay and continuation to Monterey Bay. Sketch J.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Pulgas Base .. { West End..	37 28 45.65	122 14 17.03	....	....	....	....	....	....
Pulgas Base .. { East End...	37 28 33.12	122 07 09.43	92 08 28	West Base	272 04 08	10512.1	11495.7	6.53
Red Hill	37 33 01.62	122 04 42.24	60 50 26 23 36 07	West Base East Base	240 44 36 203 34 37	16169.8 9031.4	17682.8 9876.5	10.05 5.61
Guano Island	37 34 20.56	122 14 44.83	313 43 46 356 12 58	East Base West Base	133 48 24 176 13 15	15482.8 10346.5	16931.5 11314.6	9.62 6.43
Contra Costa, (1)	37 41 41.42	122 10 16.54	332 52 49 25 50 53	Red Hill Guano Island	152 56 13 205 48 09	17998.7 15098.5	19682.8 16511.3	11.18 9.38
Point Avisadera	37 43 30.84	122 20 48.87	332 13 29 282 14 04	Guano Island Contra Costa, (1)	152 17 11 102 20 31	19167.3 15849.2	20960.8 17332.2	11.91 9.85
San Antonio Creek	37 47 27.01	122 13 22.23	336 52 40 56 22 23	Contra Costa, (1) Point Avisadera	156 54 34 236 17 50	11583.1 13134.1	12666.9 14363.1	7.20 8.16
Yerba Buena	37 48 33.78	122 20 56.45	358 51 39 280 27 24	Point Avisadera San Antonio Creek	178 51 44 100 32 02	9340.8 11299.8	10214.8 12357.1	5.80 7.02
Ridge	37 30 42.94	122 21 32.00	219 09 40 260 07 47	Contra Costa, (1) Red Hill	39 16 32 80 18 02	26201.0 25155.1	28652.6 27508.9	16.28 15.63
Rocky Mound	37 52 54.26	122 13 31.82	340 31 32 16 01 58	Red Hill Ridge	160 36 56 195 57 04	38986.4 42693.4	42634.3 46688.2	24.22 26.53
Black Mountain	37 19 06.64	122 07 50.73	136 49 02 190 11 19	Ridge Red Hill	316 40 43 10 13 14	29469.7 26152.9	32227.2 28600.0	18.31 16.25
Master's Hill	37 20 14.82	121 43 14.42	86 48 51 126 51 38	Black Mountain Red Hill	266 33 56 306 38 35	36401.6 39504.2	39807.7 43200.6	22.62 24.57
Mount Bache	37 06 37.73	121 49 37.65	130 40 38 200 31 36	Black Mountain Master's Hill	310 29 37 20 35 28	35483.8 26900.2	38804.0 29417.2	22.05 16.71
Murphy	37 06 40.86	121 30 08.18	89 54 22 142 22 58	Mount Bache Master's Hill	269 42 36 322 15 02	28870.2 31705.1	31571.6 34671.7	17.94 19.70
Gavillan	36 45 17.70	121 30 12.48	143 56 24 180 09 13	Mount Bache Murphy	323 44 44 0 09 16	48866.3 39551.6	53438.7 43252.4	30.36 24.58
Santa Cruz Station	36 58 38.80	122 02 19.98	231 50 58 297 11 25	Mount Bache Gavilan	51 58 37 117 30 41	23931.6 53744.4	26170.9 58773.2	14.87 33.39
Point San Leonardo	37 44 05.63	122 14 02.55	189 01 38 308 45 12	San Antonio Creek Contra Costa, (1)	9 02 03 128 47 30	6286.1 7099.1	6874.3 7763.4	3.91 4.41
Point San Matheo	37 35 23.99	122 18 15.47	165 56 32 290 42 39	Point Avisadera Guano Island	345 55 28 110 44 47	15472.2 5525.3	16919.9 6042.3	9.61 3.43
Sierra Point	37 40 25.57	122 22 35.91	204 38 59 314 12 39	Point Avisadera Guano Island	24 40 04 134 17 27	6284.3 16125.6	6872.3 17634.5	3.90 10.02
Point Bruno	37 39 14.12	122 21 52.12	191 04 24 310 46 45	Point Avisadera Guano Island	11 05 03 130 51 06	8064.3 13845.3	8818.9 15140.[illegible]	5.01 8.6[illegible]

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section X.—Southern part of San Francisco Bay and continuation to Monterey Bay. Sketch J.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Sanchez	37 34 59.41	122 20 25.72	278 07 16	Guano Island	98 10 44	8449.0	9239.6	5.25
			164 54 27	Point Bruno	344 53 34	8132.7	8893.7	5.05
Pise Hill	37 27 40.94	222 19 37.31	245 42 37	Red Hill	65 51 42	24101.1	26356.2	14.98
			264 56 00	East Base	85 03 35	18446.1	20172.1	11.46
Contra Costa, (2)	37 37 19.66	122 08 05.80	327 51 48	Red Hill	147 53 52	9392.0	10270.8	5.84
			60 36 21	Guano Island	240 32 18	11237.1	12288.6	6.98
Goucher	37 30 43.86	122 00 14.30	68 28 07	East Base	248 23 54	10963.7	11989.6	6.81
			122 52 10	Red Hill	302 49 27	7829.4	8562.0	4.86
Punto Potrero	37 30 00.64	122 05 24.93	190 38 08	Red Hill	10 38 34	5676.5	6207.6	3.53
			260 04 02	Goucher	80 07 11	7743.6	8468.2	4.81
Angelo	37 31 06.07	122 14 55.42	182 28 54	Guano Island	2 29 01	6001.0	6562.5	3.73
			256 38 05	Red Hill	76 44 19	15468.2	16915.6	9.61
Marsh Point	37 31 55.22	122 10 39.44	126 40 01	Guano Island	306 37 31	7506.1	8208.4	4.66
			256 49 48	Red Hill	76 53 26	9003.6	9846.1	5.59
Mowry's Creek	37 28 19.80	122 00 28.56	92 25 19	East Base	272 21 15	9857.2	10779.5	6.12
			184 30 24	Goucher	4 30 33	4454.6	4871.4	2.77
San Francisquito Creek	37 27 36.11	122 05 14.69	121 57 03	East Base	301 55 53	3322.2	3633.1	2.06
			184 32 14	Red Hill	4 32 34	10065.9	11007.8	6.25
Long Point	37 27 05.47	122 03 07.49	114 27 51	East Base	294 25 24	6530.1	7141.1	4.06
			168 02 27	Red Hill	348 01 29	11222.8	12272.9	6.97
Light-house S. E. Farrallon	37 41 55.20	122 59 05.09	253 52 00	Rocky Mount	73 19 55	69885.7	76424.9	43.42
			294 11 08	Pise Hill	114 35 12	63779.9	69747.8	39.63
Johnston	37 26 16.85	122 25 28.43	215 17 04	Ridge	35 19 28	10050.7	10991.1	6.24
			253 14 55	Pise Hill	73 18 29	9010.2	9853.3	5.60
Half Moon Bay	37 29 16.24	122 24 54.92	290 36 08	Pise Hill	110 39 21	8337.6	9117.7	5.18
			8 28 21	Johnston	188 28 01	5590.8	6113.9	3.47
Ditch	37 39 06.36	122 08 08.04	335 48 23	Red Hill	155 50 29	12325.0	13478.2	7.66
			51 52 17	Ridge	231 44 07	25096.9	27445.2	15.59
Union Island	37 34 18.59	122 05 13.78	341 55 56	Red Hill	161 56 15	2495.7	2729.2	1.55
			74 36 28	Ridge	254 26 32	38729.4	42353.3	24.06
Union City Mills	37 35 39.92	122 04 25.91	9 21 09	Black Mountain	189 19 04	31030.0	33933.5	19.28
			70 06 30	Ridge	249 56 05	38729.4	42353.3	21.06
Mission Church, San Jose	37 32 00.08	121 54 10.27	40 18 01	Black Mountain	220 09 42	31229.6	34151.7	19.40
			86 45 45	Ridge	266 29 05	40378.4	44156.6	25.09
Calaveras Point	37 27 55.94	112 02 01.46	27 47 45	Black Mountain	207 44 13	18439.4	20164.8	11.46
			157 16 50	Red Hill	337 15 12	10216.8	11172.8	6.35
Alriso Mill	37 25 42.84	121 57 50.41	295 03 55	Master's Hill	115 12 47	23802.2	26029.4	14.79
			50 27 37	Black Mountain	230 21 33	19164.6	20957.8	11.91
Catholic Church, Santa Clara	37 20 55.59	121 55 26.87	79 40 05	Black Mountain	259 32 34	18615.0	20356.8	11.57
			273 55 37	Master's Hill	94 03 01	18070.2	19761.0	11.23
Spire, San Jose	37 20 04.04	121 52 39.79	85 33 48	Black Mountain	265 24 36	22493.8	24598.5	13.98
			268 35 03	Master's Hill	88 40 46	13919.6	15222.1	8.65
Santa Ana	36 54 16.18	121 12 58.79	57 08 31	Gavilan	236 58 11	30519.9	33375.6	18.96
			112 59 28	Mount Bache	292 37 24	58966.2	64483.6	36.64
Pajaro Mouth	36 51 06.27	121 47 35.64	292 28 41	Gavilan	112 39 06	27999.2	30619.1	17.40
			122 35 00	Santa Cruz Station	302 26 09	25954.8	28383.4	16.13
Mount Carmel	36 23 06.90	121 46 16.57	176 28 12	Mount Bache	356 26 12	80626.6	88170.8	50.10
			210 13 12	Gavilan	30 22 46	47506.8	51952.0	29.52
White's Landing	36 54 22.36	121 49 42.13	112 55 21	Santa Cruz Station	292 47 44	20348.3	22252.3	12.64
			180 16 47	Mount Bache	0 16 50	22667.2	24788.2	14 08
Mount Deception	36 27 01.01	121 51 11.94	181 49 12	Mount Bache	1 50 08	73294.1	80152.2	45.54
			222 41 36	Gavilan	42 54 07	46066.8	50377.2	28.62
Two Tree Hill	36 29 30.63	121 53 11.58	184 23 58	Mount Bache	4 26 06	68850.0	75292.3	42.78
			229 27 18	Gavilan	49 41 03	45011.0	49222.7	27.97
Light-house, Point Pinos	36 37 58.09	121 55 00.12	164 07 29	Santa Cruz Station	344 03 05	39765.9	43486.8	24.71
			188 32 27	Mount Bache	8 35 41	53602.8	58618.4	33.31
Santa Cruz Point	36 57 02.34	122 00 33.98	138 36 10	Santa Cruz Station	318 35 06	3964.3	4335.2	2.46
			222 23 19	Mount Bache	42 29 54	24034.0	26282.8	14.93
Soucal Point	36 57 14.50	121 57 34.74	214 08 29	Mount Bache	34 13 16	20985.7	22949.3	13.04
			110 14 33	Santa Cruz Station	290 11 42	7518.3	8221.8	4.67
Warehouse Wharf	36 57 37.26	122 00 30.37	224 01 11	Mount Bache	44 07 44	23188.3	25358.0	14.41
			296 42 00	Gavilan	117 00 10	50467.9	55190.2	31.36

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section X.—Southern part of San Francisco Bay and continuation to Monterey Bay. Sketch J.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ″ ′	*Metres.*	*Yards.*	*Miles.*
Flag-staff, warehouse	36 57 36.92	122 00 29.97	5 18 47	Santa Cruz Point	185 18 45	1070.6	1170.8	0.66
			125 02 26	Santa Cruz Station	305 01 20	3322.9	3633.8	2.06
Moore	36 56 51.77	122 02 55.39	194 51 44	Santa Cruz Station	14 52 06	3413.4	3732.8	2.12
			264 40 03	Santa Cruz Point	84 41 28	3513.5	3842.3	2.18
St. John's Hill	36 58 34.85	122 04 32.74	267 51 43	Santa Cruz Station	87 53 03	3285.4	3592.8	2.04
			322 49 58	Moore	142 50 57	3986.7	4359.7	2.48
Salinas Bend	36 44 22.81	121 47 11.95	177 17 54	Pajaro Mouth	357 17 40	12449.5	13614.4	7.74
			266 05 18	Gavilan	86 15 28	25343.5	27714.9	15.75
Balcraft (1)	36 57 15.13	122 04 31.39	179 13 21	St. John's Hill	359 13 20	2457.4	2687 3	1.53
			286 51 31	Moore	106 52 29	2481.8	2714.0	1.54

APPENDIX No. 9.

General list of Coast Survey discoveries and developments to 1854 *inclusive.*

1. Determination of the dimensions of Alden's Rock, near Cape Elizabeth, Maine—1854.

2. A rock (not on any chart) in the inner harbor of Gloucester, Mass.—discovered 1853.

3. 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.

4. 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.

5. A dangerous sunken ledge (Davis' ledge) to the eastward and in the neighborhood of Minot's ledge—1854.

6. Boston harbor: Broad Sound channel thoroughly surveyed, and marks recommended—1848.

7. Several rocks in the fair channel-way in Boston harbor entrance—1854.

8. Nantucket shoals: Davis' New South shoal, discovered in 1846, six miles south of the old Nantucket South shoals, in the track of all vessels between New York and Europe, or running along the coast from the Eastern to the Southern States, or South America.

9. Ditto: Two new shoals north and east of Nantucket—discovered in 1847.

10. Ditto: Six new shoals near Nantucket; the outermost one, fourteen and a half miles from land, and with only ten feet water—discovered in 1848.

11. Ditto: McBlair's shoals, off Nantucket—discovered in 1849.

12. The tidal currents of Nantucket shoals and the approaches—1854.

13. Nantucket shoals: Davis' Bank—discovered in 1848, and survey finished in 1851.

14. Ditto: Fishing Rip, a large shoal extending north and south about ten miles to the eastward of Davis' Bank and thirty from Nantucket, with four and a half fathoms—surveyed in 1852.

15. Ditto: A ridge connecting Davis' New South shoal and Davis' Bank—found in 1853.

16. Ditto: 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.

17. Contraction of the inlet at the north end of Monomoy island, and opening of new entrance to Chatham harbor—1853.

18. Muskeget channel—surveyed by Lieut. C. H. Davis in 1848, and Lieut. C. H. McBlair in 1850.

19. Numerous rocks in Martha's Vineyard sound, Long Island sound, and the various bays and harbors connected with them.

20. The tidal currents of Long Island sound—1854.

21. Gedney's channel into New York bay, having two feet more water than the old channels. Had the true depth of this channel (which is seen, by comparing old and new charts, to have then probably existed) been known in 1778, the French fleet under Count D'Estang would have passed into the bay and taken the assembled British vessels.

22. The changes in New York harbor, near the city, between 1845 and 1854.

23. Sandy Hook: Its remarkable increase out across the main ship-channel has been traced from the surveys of the topographical engineers and others, and by several successive special surveys.

24. Increase of depth in Buttermilk channel, ascertained and made known in 1848 by survey of Lieut. D. D. Porter.

25. 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.

26. Blunt's channel in Delaware bay.

27. Changes in the Delaware near the Pea Patch.

28. The true extent and position of the dangerous shoals near Chincoteague inlet, Virginia—1852.

29. Metompkin inlet, Virginia, shoaling from eleven to eight feet in the channel during 1852.

30. Two channels into Wachapreague inlet, Virginia—one from the northward and the other from the eastward—both with seven feet water at low tide—1852.

31. A shoal half a mile in extent, not put down on any chart, 5½ miles east from the north end of Paramore's island, Virginia: it has but four fathoms water on it, and has nine fathoms around it—1852.

32. Great Machipungo inlet, Va.; found to have a fine wide channel, with eleven feet water on the bar at low tide and fourteen at high; good anchorage inside in from two to eight fathoms; the best harbor between the Chesapeake and Delaware entrances—1852.

33. 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.

34. 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.

35. 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.

36. A shoal at the mouth of the Great and Little Choptank, in Chesapeake bay—1848.

37. The general permanence of the Bodkin channel, and shoals in its vicinity, at the entrance of the Patapsco river—between 1844 and 1854.

38. 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.

39. A reconnaissance of the Wimble shoals near Nag's Head, coast of North Carolina—1854.

40. Deeper water found on Diamond shoal, and a dangerous nine-feet shoal off Cape Hatteras—1850.

41. A new channel, with fourteen feet water, into Hatteras inlet, formed during the year 1852, which is better and straighter than the old channel.

42. 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.

43. 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 to 8½ 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 on 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.

44. Shoaling of Cape Fear river bar thoroughly examined for purposes of improvement—1852.

45. The general permanence in depth on the bar of Beaufort, N. C., with the change of position of the channel—1854.

46. Changes at the entrance of Winyah bay, Georgetown harbor, and the washing away of Light-house Point, at the same entrance—1853.

47. Maffitt's new channel, Charleston harbor, with the same depth of water as the ship-channel—1850.

48. The changes in Maffitt's channel, Charleston harbor, S. C., from 1852 to 1854.

49. Changes in the channels at the entrance of Charleston harbor—1852.

50. 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.

51. The discovery of cold water at the bottom of the sea below the Gulf Stream, along the coasts of North and South Carolina, Georgia, and Florida—1853.

52. The discovery of the cold wall, alternate warm and cold bands, and various other features of the Gulf Stream, especially such as concern its superficial and deep temperatures or sections, and its distribution relative to the shore and bottom.

53. Various facts relative to the distribution of minute shells on the ocean-bottom, of probable use to navigators for recognising their positions.

54. Hetzel shoal, off Cape Carnaveral, Florida—1850.

55. 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.

56. A new passage, with three fathoms water, through Florida reef to Legaré harbor, under Triumph reef (latitude 25° 30′, longitude 80° 03′ W.,) which, if properly buoyed, will be valuable as a harbor of refuge.

57. A safe rule for crossing the Florida reef near Indian key—1854.

58. A new channel into Key West harbor—1850.

59. Co-tidal lines for the Atlantic coast of the United States—1854.

60. Isaac shoal, near Rebecca shoal, Florida reef; not laid down on any chart—1852.

61. Channel No. 4, a northwest entrance into Cedar Keys bay—1852.

62. Mobile Bay Entrance bar; in 1822 only seventeen feet at low water could be carried over it; in 1841 it was nineteen, and in 1847 it was twenty and three quarters feet, as shown by successive surveys—1847.

63. The diminution, almost closing, of the passage between Dauphine and Pelican islands, at the entrance of Mobile bay—1853.

64. Horn Island channel, on the coast of Mississippi.

65. 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.

66. The accurate determination of Ship shoal, off the coast of Louisiana, in connexion with the site for a light-house—1853.

67. An increase of depth of water on the bar at Pass Fourchon, Louisiana—1854.

68. The changes at Aransas Pass, Texas, as bearing on the question of a light-house site—1853.

69. A shoal inside of Ballast Point, San Diego bay, with twelve and a half feet of water; not laid down on any chart—1852.

70. The determination of the positions and soundings on Cortez Bank, near the island of San Clemente, coast of California—1853.

71. Changes in the channels of entrance of Humboldt bay or harbor, California—1852 and 1853.

72. 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.

73. The depth of water on the bars at the entrance of Rogue river and Umpquah river, Oregon—1853.

74. A shoal at the entrance to the Straits of Rosario, Washington Territory, giving good holding-ground in thirty-three feet—1854.

75. Boulder reef, northwest of Sinclair island, Rosario strait, partly bare at unusually low tides, and surrounded by kelp—1854.

76. Belle Rock, in the middle of Rosario strait, Washington Territory, visible only at extreme low tides—1854.

77. Entrance Rock, at the entrance of Rosario strait—1854.

78. Unit Rock, in the Canal de Haro, Washington Territory—1854.

79. A five-fathom shoal in the Strait of Juan de Fuca, between Canal de Haro and Rosario strait—1854.

80. The non-existence of two islands at northern entrance of Canal de Haro, laid down on charts—1854.

81. The non-existence of San Juan island, usually laid among the Santa Barbara group—1854.

82. Tides of San Diego, San Francisco, and Astoria—1854.

83. 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 very imperfectly known.

Additional list for 1855.

1. Extension of Stellwagen's Bank to the southward and eastward some sixteen or seventeen square miles, enclosed by the twenty-fathom curve.
2. Determination of rocks off Marblehead and Nahant.
3. Probable connexion of George's Bank and the deep-sea banks north and east of Nantucket.
4. Discovery of a shoal lying north and south, one mile and a half southward of Nantucket light-boat.
5. Examination of the interference tides of Nantucket and Martha's Vineyard sounds.
6. The currents of the great bay between Massachusetts, Rhode Island, New York, and New Jersey.
7. Changes in New York bay and harbor.
8. Shoal in the main ship-channel of New York harbor.
9. Re-examination of York Spit, Chesapeake bay, and least water determined, (nine feet.)
10. The bars in Rappahannock river.
11. Submarine range of hills beyond the Gulf Stream, tracked from Cape Florida to Cape Lookout.
12. Changes in the main Western and New Inlet channels into Cape Fear.
13. Changes in the main ship-channel and in Maffitt's channel, Charleston harbor.
14. Examination of Doboy, St. Simon's, and Cumberland entrances.
15. Temperature of $34°$ beneath the Gulf Stream, thirty-five miles east of Cape Florida, at a depth of three hundred and seventy fathoms.

16. Deep-sea soundings in the Gulf of Mexico.
17. Tidal phenomena of the Gulf.
18. Determination of Cortez Rock, southern coast of California.
19. Determination of Uncle Sam Rock.
20. Red sand, marking the inner entrance to the Golden Gate.
21. Channel sounded out between Yerba Buena and the Contra Costa, San Francisco bay.
22. Co-tidal lines of the Pacific coast.

APPENDIX No. 10.

Letter of Commander Charles H. Davis, United States navy, communicating information relative to developments made in Boston harbor.

CAMBRIDGE, MASS., *October* 30, 1855.

DEAR SIR: I have the pleasure to inform you that I have recently determined several important spots in Boston harbor of which I have been some time in search.

A year ago, (October 29, 1854,) I wrote a letter to Mr. Alfred Nash, the very intelligent and skilful pilot, in which I furnished him with memoranda of dangerous places said to exist, and still not actually known. A copy of that letter is transmitted herewith. During the present month Mr. Nash has apprized me of his having verified some of these new dangers, and accordingly I have determined their position with precision.

On the list accompanying this report, I have given not only the angles and depths, but notices of the manner in which the dangers have been first discovered.

In our rarely long-interrupted correspondence upon the hydrography of Boston harbor, and its improvement, there has frequently been occasion to mention to you that several of the most able of the Boston pilots have interested themselves in communicating to the Coast Survey (either through me, or directly to yourself) all *authentic* information—the only information worth having—concerning such discoveries as those now reported.

Owing to the broken, jagged, and uneven form of the rocky bottom of Boston harbor, in which numerous high-spiring points, with scarcely surface enough for the lead to rest on, are known to exist, these discoveries must be occasionally expected. They are made by vessels striking on shoal spots, where only good water had till then been known. These spots are, in fact, often surrounded by the deepest water. They are not likely to be found in any other manner, for there is nothing in the character of the bottom or its form (being, as it is, wholly devoid of any regularity of contour) to indicate the places of these sharp points. The method of tracing the spurs or ridges under water, suggested by Prof. Agassiz, does not apply in the special cases to which these remarks refer. All this is well known to you, and has been said before; but the occasional repetition of it may serve to correct the erroneous impression that the discovery of hitherto unknown rocks shows any defects in the regular hydrographic survey, or affords to an indifferent person, to whom they may happen to be communicated by the pilots, any cause for self-gratulation. So far from showing defects, the fact that these rocks are discovered, as they are, by the most skilful pilots, added to the fact that they lie for the most part in deep water and in the channel-ways, prove that the survey is fully up to the actual state of knowledge, and keeps pace with its advances.

An opposite opinion could only be held by one ignorant of hydrography and of the nature of this ground.

I have heard that some rocks not down on the chart have been found among the Cohasset group. I will inquire into this. In such a vast congeries of rocks, among which there are no channels suited for general use, the only important determination to the seaman is the outer limit of safety. One stone more or less is of no real consequence in a region which is wholly unapproachable. But I shall not fail, on this account, to obtain all the information in my power, in order to insure the minutest accuracy of definition, which is the ultimate aim of the Coast Survey.

Very truly and respectfully yours,

CHARLES HENRY DAVIS,
Comdr., Supt. Nautical Almanac.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 11.

Letter to the Secretary of the Treasury, communicating the discovery, by Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, of a shoal a short distance south of Nantucket light-boat.

NEW YORK, *November* 6, 1855.

SIR: I have the honor to communicate the discovery by Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, of a shoal south of the Cross Rips in Nantucket sound, and to append the following extract from his report relative to its position and dimensions:

"The true bearing of the shoal from Nantucket light-boat is very nearly south, and its distance a mile and two-fifths. The least depth of water upon it is eleven feet, its length in a general north and south direction is nearly three-quarters of a mile, and its breadth varies from fifty yards to a quarter of a mile, the greatest breadth being at the southern extremity."

I would respectfully request authority to publish the foregoing.

Very respectfully, yours,

A. D. BACHE,
Superintendent.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 12.

Letter of the Superintendent to the Secretary of the Treasury, communicating the position of a shoal spot with eighteen feet water, found in the main ship-channel, entrance to New York harbor, by Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey.

COAST SURVEY OFFICE, *November* 21, 1855.

SIR: I have the honor to report that in the progress of the hydrographic work of the present season in the vicinity of the Narrows, entrance to New York harbor, by the party of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, a shoal spot existing in the main ship-channel has been found, and its extent, &c., completely developed by that officer. The following extract from the report of Lieut. Comg. Craven, communicating the position of the shoal, seems conclusive also as regards the slight previous knowledge of its existence:

"Its position is 2,067 yards S. 30° E. (true) from the light-house on Staten island.* It lies north and south, and its length in that direction is 503 yards. The breadth from east to west

* Near Fort Tompkins. The new light-house near the "*Elm Tree*" bears W. 30° S. (true) distant 5,649 yards from the centre of the shoal.

is 164 yards; soundings, 18 feet at low water. This shoal is composed of sand and shells, or, more strictly, is a *shell-bank*, and I recommend placing a buoy on it.

"It may be proper to state that some of the pilots claim to have known of the existence of the shoal, though I have not found any who could give the ranges for it. The steamer *Baltic* struck on it a few months since, and it was reported that she had struck upon a wreck, from which I infer that there was no certain knowledge of its existence."

I concur in the recommendation of Lieut. Comg. Craven, for placing a buoy upon the shoal which he has described, and would respectfully request that a copy of this letter be sent to the Light-house Board.

I would further request authority to publish the information now communicated.

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 13.

Letter from the Superintendent to the Secretary of the Treasury, communicating the existence of a shoal spot near the end of York Spit, Chesapeake bay, reported by Lieut. Comg. J. J. Almy, U. S. N., assistant in the Coast Survey.

COAST SURVEY OFFICE, *June* 4, 1855.

SIR: I have the honor to enclose an extract of a letter just received from Lieut. Comg. J. J. Almy, U. S. N., assistant in the Coast Survey, reporting the existence, near the end of York Spit, Chesapeake bay, of a spot having but nine feet upon it at low-water.

In view of the fact that appropriation has been made for the erection of a light-house on or near the end of York Spit, I would respectfully request that the information communicated by Lieut. Comg. Almy may be transmitted to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

[Extract.]

U. S. COAST SURVEY STEAMER HETZEL,
Old Point Comfort, Va., June 1, 1855.

DEAR SIR: * * * I last year reported to you that near the end of York Spit there was found as little as fourteen feet water. A line of soundings run subsequently, and plotted last winter, gave eleven feet; but having lately proceeded to the spot, I find, after thorough examination, as little as nine feet at low water. This is important, since an appropriation has been made to erect a light-house near or on the end of York Spit. * * * *

I am, sir, very respectfully, your obedient servant,

JOHN J. ALMY,
Lieut. Comg., Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 14.

Letter accompanying the season's report of Lieut. Comg. R. Wainwright, U. S. N., assistant in the Coast Survey, on the execution of hydrography in Rappahannock river, Virginia.

WASHINGTON, *June* 25, 1855.

DEAR SIR: I give below a list of the bars in the Rappahannock river, between Fredericksburg and Tappahannock, with the depth of water on each, the character of the bottom, the extent of each bar, and its distance from the head of navigation, (Railroad bridge above Fredericksburg.) For a mile and a quarter below that point the river is shallow, three feet and a half being the average depth that can be carried. The next shoal place below is marked No. 1 in the following list:

No. of bar.	Average depth of water.	Extent of bars.	Character of the bottom.	Distance from railroad bridge.
1	7½ feet	⅛ of a mile.	Sand	1¼ miles.
2	6½ do	⅛ do	Sand and mud	3½ do
3	4 do	1¼ do	Sand	4⅛ do
4	5 do	½ do	do	7 do
5	7 do	¼ do	Mud	8½ do
6	7 do	¼ do	Sand and mud	9½ do
7	6 do	¼ do	do do	10½ do
8	6 do	¼ do	do do	11½ do
9	7½ do	¼ do	do do	12 do

Between the bars nine feet of water can be carried, and from bar No. 9 to within two miles and a half of Tappahannock twelve feet, with the exception of a bar in Tobago bay, with a depth of water on it of eight feet. It is a quarter of a mile in extent, and is three miles and a quarter below Port Royal. The depths are all given as at low water.

At the lower end of Green's bay the river makes a sudden turn, and the channel is very narrow, which causes many vessels to run ashore.

The most intricate part of the river occurs opposite Tappahannock, the stream being there divided into several channels of little water, but the plotting of my work in that portion of the river is not yet sufficiently advanced to enable me to give a detailed account of it. All the bars, with the exception of the first, second, and fourth, seem to have been formed by creeks which empty into the river opposite to them.

The rise and fall of the tide is about four feet.

Respectfully, yours,

R. WAINWRIGHT,
Lieut. Comg. and Assistant in Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 15.

Letter to the Superintendent from Lieut. Comg. J. N. Maffitt, U. S. Navy, assistant in the Coast Survey, transmitting his comparative chart of Maffitt's channel, Charleston harbor. (Sketch E No. 3.)

U. S. COAST SURVEY, SCHOONER CRAWFORD, *September*, 1855.

DEAR SIR: In handing to you the chart of my recent re-survey of Maffitt's or Sullivan's Island channel, I have made some notes in reference to the changes that have become manifest by my repeated surveys, extending from 1850 to this date, a period of five years, during which time numerous storms have swept the coast, the gale of September, 1854, especially, producing changes of the most marked, and, in many instances, serious character.

I am happy to state that the surges of the sea, though beating on the bar at every assailable position during the prevalence of that terrific blow, has not closed up, as by many was predicted, this channel; but, on the contrary, a marked change for the better is apparent, and the experiment suggested by an anxious desire to benefit the commercial prosperity of the noble city of Charleston, is urged by the friendly overture of nature, inviting, instead of repelling, the opening of this more desirable passage to the ocean.

Those who are familiar with the subject of bar improvements, can fully appreciate the great and various difficulties that are to be battled with, in such a field of operation. The uninitiated look for prompt results, and but too often condemn or intimidate the more sanguine, when there is a slight failure either from contracted means or inappropriate machinery for the tedious and harassing experiment.

The scepticism of many has induced me to give the whole subject-matter a careful revisal. While schemes, unequivocal in their character, for the formation of a new and deeper channel to the ocean are easily arranged, they are so vast, by necessity, that the government exchequer would scarce suffice for such expensive operations.

That a necessity exists for attention to the bar of Charleston, no one doubts; suggestions were anxiously called for, and many were submitted to the unbiassed consideration of the commission called by the city to look into this matter. But one plan was adopted, and that originating with me was offered with extreme hesitation as an *experiment* that involved but a moderate outlay without the possibility of detriment to any existing channel. That the plan is still a hopeful one, my previous study of the subject fully shows. The following table bears me out fully in the deductions which I drew from the record of my surveys.

The chart of 1855 shows a general increase of depth upon the bulk-head, and a contraction of eighteen yards in the general width of the channel. Bowman's jettee has settled about one foot and fifty-six hundredths, the result of which has been to increase by twenty-eight minutes the duration of the flow of ebb-tide over the jettee, with an increased velocity of half a knot per hour, directly through the channel. The benefit of this is, no doubt, made manifest by the increase of water over the bulk-head.

The high-water mark along the shore of Sullivan's island, is now three hundred and twenty yards more to the northward than in 1852, and the necessity for small jettees along the shore for its general protection, is a subject for consideration.

Distance in direct line of channel way from 12 *feet curve to* 12 *feet curve, or breadth of bulk-head.*

	Yards.
1850	2,660
1852	3,200
1854	1,100
1855	1,000

Length of shoals fringing the southern edge of Maffitt's or Sullivan's Island channel.

	Yards in length.	Yards in width.
1850	2,600	700
1852	5,700	260
1854	700	200 (Broken and scattered.)
1855	680	200

The general increase of depth on the bulk-head from 1852 to 1855 is four and a half feet.

The above table gives striking evidence in favor of the adoption of this channel. It will be observed that there is an improvement in the condition of the channel from chart to chart, and that the scrutiny of five years has as yet developed nothing but a flattering progression, encouraging the laudable enterprise.

A reference to the comparative chart will clearly exhibit the changes that have been followed up from year to year under your explicit instructions.

Respectfully, your obedient servant,

J. N. MAFFITT,
Lieutenant U. S. Navy, Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent Coast Survey.

APPENDIX No. 16.

Report made to the Superintendent by Lieutenant James Totten, U. S. Army, assistant in the Coast Survey, on the erection of screw-pile beacons on Florida reefs, with descriptions of the signals. (*See Sketch F No.* 5.)

NEW LONDON, CONNECTICUT, *July* 16, 1855.

DEAR SIR: I have the honor to report, that, in obedience to your instructions of January 20, 1854, enclosing those from the Light-house Board of the 19th of the same month, and by authority of subsequent instructions, I have caused a number of screw-pile signals or beacons to be constructed, and have had them erected along the Florida reef.

The complete signal, as now standing at several points hereinafter named along the reef, is made entirely of cast and wrought iron, and is thirty-six feet in vertical height. Each signal consists of a screw-pile, and a vertical shaft of thirty-six feet above the top of the pile. The shaft for convenience in transportation, &c., is made in three sections, designated, respectively, the first, second, and third sections, counting from the lowest to the highest. The screw-pile and the two lower sections are of cast, and the upper section of wrought-iron. The screw-pile is nine feet long, and nine inches in exterior diameter, and has a cylindrical cavity within it seven and a half inches in diameter, and seven feet in depth. The first or lower section has an extreme length of fourteen feet, of which four feet passes into the cylindrical cavity of the pile, and is there carefully wedged in its place, leaving ten feet in the clear above the pile. On the upper end of this section is cast the lower half of a collar, so arranged, in connection with the other half cast on the foot of the second section, that the two can be firmly bolted together. The second or middle section is ten feet in extreme length, and is provided, at either end, with the respective halves of two collars, so adjusted, in connection with those on the other sections, that the whole shaft may be strongly bolted together. The first and second sections are cast hollow, and the iron in each is seven-eighths of an inch in thickness. The third or upper section (called also the spindle,) of wrought-iron, is sixteen feet in extreme length, and is solid throughout. On the lower end of this is the half of a collar, corresponding to that on the upper end of the second section, and intended for fastening these two sections together. The third section or spindle carries a vane of wrought-iron, and a cylinder or barrel of strong hoop-iron. The vane is supported in its position just above the collar connecting the second section and spindle, by two powerful hinges. The vane represents one of the letters of the alphabet, supported by the hinges, six feet in vertical height, and otherwise in proportion. The cylinder or barrel is six feet in length, by two and a half feet in diameter, and is strongly made after the manner of lattice-work, of hoop-iron, and is firmly secured in its position at the top of the third section. The shaft at the foot of the lower section, where it enters the screw-pile, is seven and a quarter inches in exterior diameter, and decreases uniformly in size to the top of the spindle, where it is only two inches in diameter. Three colors have been used in painting each signal, so as to make them as striking to the eye of the mariner as possible. For this purpose, *white, red*, and *black*, have been chosen as the most conspicuous; and, in painting the signals, these three colors have been so combined that no two adjacent beacons have the same colors upon like parts.

By examination of the colors alone, on approaching any one of these signals, the master of a vessel may ascertain his latitude and longitude with tolerable certainty; and if the letter in the vane can be made out, then there can be no mistake whatever, if reference be had to what follows herein.

The signals above described are located on the most projecting and dangerous points of the Florida reef, and stand generally from four to six miles from the outside shores of the Florida keys, and within half a mile, in every instance, of the Gulf Stream. In the day-time these signals cannot fail to attract the attention of careful navigators, and warn them of their proximity to danger.

The depth of water where the signals stand does not exceed four feet in any case at low tide, and just outside of them to the eastward, in the Gulf Stream, it is of unknown depths. A vessel approaching from the seaward may sail within a few hundred yards of any of these beacons; but it would always be prudent, and particularly in very light or very heavy weather, to give them a wide berth. In light weather it often happens, especially after long easterly blows, that the force and direction of the Gulf Stream sets across the reef, and then vessels are imperceptibly carried amid the dangers, although the course steered should, if made, carry them outside of all trouble. When this misfortune befalls a master of a vessel, it frequently occurs that the wind proves too light to draw his ship out of danger, and a few moments' indecision then, is fatal. When he finds himself to the west of any one of the signals, or the signal bearing *east* from his vessel, he may be sure that he is between the reef and the keys, and, consequently, surrounded by shoals and dangerous rocks. In all such cases of danger the master of a vessel, unless perfectly acquainted with his whereabouts, should lose no time in coming to anchor until he can ascertain which is the safe course to pursue.

The following named reefs, &c., are the localities where the improved signals stand. These points are well known to all the wreckers and pilots who frequent the Florida reef, and each of them has, at some time, proved fatal to one or more valuable vessels and their cargoes. I mention the points in the order in which the signals stand, proceeding from Key West towards Cape Florida and this is also the alphabetical order of their localities.

1. THE EASTERN SAMBO.—The signal on this carries the letter "A" in the vane, and bears S. 3° 29′ 24″ E., (true,) and is distant about 4.5 nautical miles from Geiger's houses; it also bears S. 13° 13′ 01″ W., (true,) and is distant 5.0 miles from south Saddle Hills. It stands in latitude 24° 29′ 32″ N., and longitude 81° 39′ 55″ W. The letter is painted *white*, the cylinder or barrel *black*, and the shaft and vane (all except the letter,) *red*.

2. THE AMERICAN SHOALS.—The signal on this carries the letter "B" in the vane, and bears S. 22° 16′ 35″ W., (true,) and is distant 5.9 nautical miles from Loggerhead key; it also bears N. 76° 38′ 59″ E., (true,) and is distant 8.1 nautical miles from the Eastern Sambo. It stands in latitude 24° 31′ 24″ N., and longitude 81° 31′ 16″ W. The letter is painted *black*, the cylinder or barrel *red*, and the shaft and vane (all except the letter,) *white*.

3. ALLIGATOR REEF.—The signal on this carries the letter "C" in the vane, and bears about S. 66° 30′ E. by compass, and is distant near 5.0 miles from Indian key. It stands in latitude 24° 49′ 08″ N., and longitude 80° 38′ 08″ W. The letter is painted *red*, the cylinder or barrel *white*, and the shaft and vane (all except the letter,) *black*.

4. CROCKER'S REEF.—The signal on this carries the letter "D" in the vane, and bears about S. 39° 15′ E. by compass, and is distant between 4 and 5 miles from Snake Creek Point. It stands in latitude 24° 54′ 21″ N., and longitude 80° 31′ 26″ W. The letter is painted *white*, the cylinder or barrel *black*, and the shaft and vane (all except the letter,) *red*.

5. CONCH REEF.—The signal on this carries the letter "E" in the vane, and bears about S.

4° 30′ W. by compass, from Rodriguez bank, and about S. 43° 30′ E. by compass, from Key Tavernier. It stands in latitude 24° 56′ 36″ N., and longitude 80° 27′ 50″ W. The letter is painted *black,* the cylinder or barrel *red,* and the shaft and vane (all except the letter,) *white.*

6. PICKLE'S REEF.—The signal on this carries the letter "F" in the vane, and bears S. 16° 57′ 43″ E., (true,) and is distant 5.4 nautical miles from Point Charles; it also bears S. 6° 34′ 30″ W., (true,) and is distant 7.0 nautical miles from Lower Sound Point. It stands in latitude 24° 59′ 22″ N., and longitude 80° 24′ 55″ W. The letter is painted *red,* the cylinder or barrel *white,* and the shaft and vane (all except the letter,) *black.*

7. FRENCH REEF.—The signal on this carries the letter "G" in the vane, and bears S. 32° 33′ 53″ E., (true,) and is distant 5.0 nautical miles from Lower Sound Point; it also bears S. 10° 30′ 07″ E., (true,) and is distant 6.2 nautical miles from Point Willie. It stands in latitude 25° 02′ 06″ N., and longitude 80° 21′ 05″ W. The letter is painted *white,* the cylinder or barrel *black,* and the shaft and vane (all except the letter,) *red.*

8. GRECIAN SHOALS.—The signal on this carries the letter "H" in the vane, and bears S. 45° 58′ 23″ E., (true,) and is distant 3.9 nautical miles from Sound Point; it also bears S. 21° 24′ 32″ W., (true,) and is distant 5.3 nautical miles from Basin bank. It stands in latitude 25° 07′ 22″ N., and longitude 80° 17′ 57″ W. The letter is painted *black,* the cylinder or barrel *red,* and the shaft and vane (all except the letter,) *white.*

9. TURTLE REEF.—The signal on this carries the letter "K" in the vane, and bears S. 22° 20′ 47″ E., (true,) and is distant 4.4 nautical miles from Old Rhodes; it also bears S. 6° 28′ 07″ W., (true,) and is distant 6.1 nautical miles from Cæsar's Creek bank. It stands in latitude 25° 16′ 52″ N., and longitude 80° 12′ 34″ W. The letter is painted *white,* the cylinder or barrel *black,* and the shaft and vane (all except the letter,) *red.*

10. PACIFIC REEF.—The signal on this carries the letter "L" in the vane, and bears N. 76° 29′ 51″ E., (true,) and is distant 5.5 nautical miles from Old Rhodes; it also bears S. 15° 48′ 15″ E., (true,) and is distant 7.1 nautical miles from Elliott's key, No. 1. It stands in latitude 25° 22′ 13″ N., and longitude 80° 08′ 30″ W. The letter is painted *black,* the cylinder or barrel *red,* and the shaft and vane (all except the letter,) *white.*

11. AJAX REEF.—The signal on this carries the letter "M" in the vane, and bears S. 79° 35′ 43″ E., (true,) and is distant 3.9 nautical miles from Elliott's key, No. 2; it also bears S. 26° 06′ 05″ E., (true,) and is distant 5.4 nautical miles from Elliott's key, No. 1. It stands in latitude 25° 24′ 09″ N., and longitude 80° 07′ 59″ W. The letter is painted *red,* the cylinder or barrel *white,* and the shaft and vane (all except the letter,) *black.*

12. LONG REEF.—The signal on this carries the letter "N" in the vane, and bears S. 52° 15′ 21″ E., (true,) and is distant 3.8 nautical miles from Elliott's key, No. 1; it also bears S. 13° 53′ 51″ E., (true,) and is distant 8.8 nautical miles from Soldier key. It stands in latitude 25° 26′ 45″ N., and longitude 80° 07′ 21″ W. The letter is painted *white,* the cylinder or barrel *black,* and the shaft and vane (all except the letter,) *red.*

13. TRIUMPH REEF.—The signal on this carries the letter "O" in the vane, and bears S. 82° 30′ 26″ E., (true,) and is distant 3.5 nautical miles from Elliott's key, No. 1; it also bears S. 21° 04′ 14″ E., (true,) and is distant 7.2 nautical miles from Soldier key. It stands in latitude 25° 28′ 37″ N., and longitude 80° 06′ 50″ W. The letter is painted *black,* the cylinder or barrel *red,* and the shaft and vane (all except the letter,) *white.*

14. FOWEY ROCKS.—The signal on this carries the letter "P" in the vane, and bears S. 89° 58′ 16″ E., (true,) and is distant 3.5 nautical miles from Soldier key; it also bears S. 35° 41′ 55″ E., (true,) and is distant 5.5 nautical miles from Cape Florida. It stands in latitude 25° 35′ 23″ N., and longitude 80° 05′ 51″ W. The letter is painted *red,* the cylinder or barrel *white,* and the shaft and vane (all except the letter,) *black.*

The foregoing is an account of the character and localities of all the improved signals which have been erected. There is yet another to be put up on the "Elbow," a point in the alphabetical order between "H" and "K," and is to stand between "the Grecian shoals" and

"Turtle reef." The vane of the signal to be put on the "Elbow" carries the letter J, and is already provided and stored at Key West. The character of pile used for the other signals above mentioned was not suitable, owing to the greater depth of water on the "Elbow" and the nature of the rock there. One of a greater length than those used, of a peculiar pattern, and having a cast-steel bit, must be provided for this position.

I am, very respectfully, your obedient servant,

JAMES TOTTEN,
Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 17.

Report of Lieut. Comg. B. F. Sands, U. S. N., assistant in the Coast Survey, upon the result of an examination of the channel between Pelican island and Dauphine island, west of entrance to Mobile bay.

COTTAGE POST OFFICE, MONTGOMERY COUNTY, MD.,
July 15, 1855.

SIR: The Pelican channel, between Pelican and Dauphine islands, is constantly changing. My examination of it in May last shows a very narrow channel of seven feet near the beach of Dauphine island, which is changed in depth and direction by almost every severe gale that visits the coast.

The north end of Pelican island is sometimes cut away and distributed in shoal-lumps in what was previously the channel, and sometimes thrown upon the beach of Dauphine island, forming a point there as shown in the sketch of my examination in 1853, after the August gale, which also cut a shallow and narrow passage through the narrow part of Pelican island. That passage is now closed.

From these frequent changes I consider the channel impracticable for vessels larger than sail-boats.

The bay between Pelican and the east end of Dauphine island is much the same as when it was surveyed by Lieut. Comg. Patterson, and is a good anchorage for vessels that can enter the channel at the south end of Pelican island, which is marked by a spar-buoy.

The accompanying sketch shows the channel as it was in May last.

Respectfully, your obedient servant,

B. F. SANDS,
Lieut. Comg. U. S. N., assistant in Coast Survey.

Prof. A. D. BACHE, *Superintendent.*

APPENDIX No. 18.

Letter from the Superintendent to the Secretary of the Treasury, communicating the position of a dangerous rock on Cortez Bank, coast of California, determined by Lieut. Comg. Archibald MacRae, U. S. N., assistant in the Coast Survey.

COAST SURVEY STATION, DIXMONT, ME., *October* 10, 1855.

SIR: I have the honor to report that, under the instructions of Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey, a dangerous rock on *Cortez Bank,* off the extreme southern coast of *California*, was sought for by Lieut. Comg. Archibald MacRae, U. S. N., assistant Coast Survey, and determined to be in latitude 32° 29′ N., and longitude 119°.04½ W., (both approximate.) The shoalest water on the rock is reported by Lieut. MacRae to be three and a half fathoms, subject to a possible tidal reduction of six feet, which might reduce it to *two and a half fathoms*, or *fifteen feet*.

Lieut. MacRae placed a buoy, composed of two casks, with a flag-staff between, upon the shoalest part of the ledge to which this rock belongs, and which he represents as quite extensive. The buoy could be seen in clear weather about three miles.

I would respectfully request that a copy of this letter may be sent to the Light-house Board, that their attention may be directed to the placing of a beacon on this ledge.

I enclose herewith a Coast Survey sketch of Cortez Bank, from a reconnaissance by Lieut. Comg. Alden in 1853. In that examination the rock referred to was not found.

A minute survey of this dangerous locality will be directed.

I would respectfully request authority to publish the information contained in this letter.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,

Secretary of the Treasury.

APPENDIX No. 19.

Letter from the Superintendent to the Secretary of the Treasury, communicating extracts from the report of Lieut. Comg. Archibald MacRae, U. S. N., assistant in the Coast Survey, relative to the position of a rock on which the steamer "Uncle Sam" struck, May 7, 1855.

COAST SURVEY STATION, DIXMONT, PENOBSCOT COUNTY, ME.,
July 20, 1855.

SIR: I have the honor to communicate the following extracts from a report made under date June 3d, in conformity with directions given by Lieut. Comg. James Alden, U. S. N., chief of the hydrographic party on the western coast, to Lieut. Comg. Archibald MacRae, U. S. N., assistant, in command of the surveying schooner "Ewing," to search for and mark the position of a rock upon which the steamer "Uncle Sam" struck on the 7th of May of the present year.

"Proceeding to sea yesterday afternoon, and finding it too late to make immediate search between Point San Pedro and Steeple Rock, the schooner was kept off and on until this morning, when we ran in to within half a mile of the shore, about midway between the two points named, and thence, coasting the breakers, proceeded to the vicinity of the 'Steeple,' where we hauled off-shore.

"There was a strong breeze blowing, and so heavy a sea that it was impossible to make any other examination than by watching for breakers. This, however, was entirely satisfactory.

"About two miles north of Steeple Rock, and half a mile off-shore, the sea broke occasionally on a rock between fifty and a hundred yards outside of the point of a reef, which, commencing at the northern end of a small chain of rocks lying close in-shore just above Steeple Rock, sweeps out off-shore at a point intermediate between Point San Pedro and the Steeple, and, judging from the breakers, trends in again to a bay southward of Point San Pedro.

"Whether there is deep water between this rock and the reef we could not decide, but were satisfied that it would not be prudent to attempt a passage.

"By reference to the sketch furnished by Sub-Assistant Johnson, a copy of which is herewith enclosed, it will be observed that the position of the rock is almost identical with that assigned by Captain Baldwin, who probably had a smooth sea at the time his vessel struck, and therefore could not see the line of the reef. On passing the point of the reef we got soundings in nine, eight, twelve, and thirteen fathoms."

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 20.

Letter from the Superintendent to the Secretary of the Treasury, communicating extract from the report of Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey, upon the existence of a deposite of red sand inside of the bar of San Francisco bay, California.

COAST SURVEY STATION, DIXMONT, MAINE,
October 20, 1855.

SIR: I have the honor to communicate, in the following extract from a report made by Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey, the existence of a deposite of red sand inside of the bar at the entrance of San Francisco bay, California.

Lieut. Comg. Alden says, in his letter dated July 20th, "I made a careful examination of that locality just previous to leaving San Francisco, and the result fully sustains our first observations.

"This marked peculiarity (the red sand) exists only inside of the curve or 'horse-shoe' formed by the bar, and as far in as the *Heads*, comprising an area of less than four miles square.

"It is thought that this red sand will serve as a safe and sure guide to vessels entering San Francisco in thick weather, and to steamers it may be regarded as of great importance.

"Passing up the coast to the northward of Point Piedra, keep in ten or twelve fathoms water, gradually shoaling to the bar in from five and a half to six fathoms, and proceeding on, the water will soon deepen inside the bar, where the red sand will verify the position; after which steamers, with proper care, can make good the entrance in the thickest weather."

I would respectfully request authority to publish the foregoing for the benefit of navigation on the western coast.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 21.

Report of Assistant F. H. Gerdes on topography executed by his party on Manhattan island, and on the shores of East and North rivers, including the city of New York.

NEW YORK, *October* 31, 1855.

SIR: I have the honor to report that the following topographical surveys, as directed by you in the early part of July, 1855, have been completed:

1. *East river*, from Hellgate to Gowanus bay, including part of Astoria, Ravenswood, Hunter's Point, Green Point, Williamsburg, and Brooklyn, to the wharf opposite Greenwood cemetery.

2. *North river*, from Jersey City to Gutemberg's wharf, including Jersey City, Pavonia, Hoboken, Washington village, West Hoboken, and parts of Weehawken, and extending westward to the Palisade avenue.

3. *North river*, from Gutemberg's wharf to Normansville, opposite Tubbyhook, embracing shore and characteristic topography.

4. *East river*, both sides from Throg's neck to the city of New York, with characteristic topography, and, in some parts, with considerable interior, embracing also Flushing bay, Riker's and Berrian's islands, the Brothers, and the larger parts of Ward's and Randall's islands, with the improvements thereon since 1850; also the determination of a series of points for the use of the hydrographic party.

5. *Manhattan island*, containing an entire new survey of the shores, also of the opposite shore-lines of Harlem river, with characteristic topography, and a complete topographical survey of the upper part of the island, which had not been included in the map of 1854.

In regard to the survey of Green Point, Williamsburg, Brooklyn, Jersey City, Hoboken, &c., I would remark, that the time allotted for the completion of the harbor map of New York did not admit of a greater extension in the interior. I have included, in the respective sheets generally, from six to eight blocks deep, and in some instances more; and always determined the direction of streets towards the interior. * * * * * * *

In the map of Hell Gate, surveyed in 1850 by Henry L. Whiting, Esq., assistant U. S. Coast Survey, I found it necessary to add many alterations and improvements, particularly in the city and State government possessions on Ward's and Randall's islands. I added all that was necessary, and, furthermore, I determined, over the whole extent of Mr. Whiting's survey, a series of points to be used as sounding points by the hydrographic party. In every other respect the map of Hell Gate was perfectly good, and is one of the finest specimens and handsomest representations of reduction from nature that I have ever compared in the field.

The sheet of East river, from Hell Gate to Throg's neck, I suppose must appear quite different from Mr. Renard's survey of 1837 or 1838. There are now large and flourishing villages and manufacturing places where then only single and scattered farms could be found. Cities, even, are laid out where he must have found marshes and forests. * * * * *

In 1853 I added the improvements and re-surveyed parts included in the topographical Coast Survey maps above Manhattan island on the Hudson river, but I had no points of triangulation and had to trust to chaining. Lieut. Comg. Wainwright was directed by you to re-sound the river from Yonkers downwards, for which purpose Assistant Blunt determined a series of trigonometrical points. Thinking it proper that my survey of 1853, as well as the hydrography of 1855, should have also to be based on this triangulation, I connected the topography up to Yonkers with Mr. Blunt's points, and added, at the same time, all improvements to my sheets, and corrected the slight deviations.

I also furnished, by your direction, to the Commissioners on New York harbor encroachments, a map, running on East river from 10th to 28th streets, and embracing the blocks between the shore and First avenue, made on a scale of $\frac{1}{2500}$ of nature. * * *

Very respectfully, your most obedient servant,

F. H. GERDES,
Assistant U. S. Coast Survey.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey.

APPENDIX No. 22.

Report of Assistant S. A. Gilbert, on the topographical work executed by his party on the western and southern side of Long Island.

FLATLANDS, LONG ISLAND, N. Y., *November* 1, 1855.

SIR: The following is a report of the progress of the topographical work under my charge, in the re-survey of New York harbor and bay:

My party was organized on the 25th of August last, but, owing to circumstances out of my control, did not get into active operations until the 1st September. We then commenced work at Gowanus, near Greenwood cemetery, and run the east side of the harbor and bay to Hog inlet. These limits include the villages Fort Hamilton, Bath, Gravesend, Sheep-head bay, and Rockaway; also localities known as Gravesend bay, Coney island, Pelican island, Barren island, Duck Bar island, Rockaway beach, and the greater part of Jamaica bay, with the numerous creeks and islands in and around it.

The amount of details thus far surveyed is—

Shore-line	178 miles.
Roads	67 "
Area	46 square miles.

* * * * * * * *

I am pleased to be able to report very favorably of my aid, Mr. M. Seaton, he having been of great assistance to me. Whenever it was practicable, we worked with both plane-table and compass at the same time, Mr. Seaton using the compass and chain in the interior, on roads and general details; his work thus done amounts to six square miles in area, in which there are twenty-five miles of roads, and about ten miles of outline of marsh; all of which is included in the previous statement.

Yours, respectfully,

SAMUEL A. GILBERT,
Assistant U. S. Coast Survey.

Professor A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 23.

Report of Assistant A. M. Harrison, on topography executed by his party on the coast of New Jersey, from the head of Raritan bay to Shrewsbury inlet, including Sandy Hook and the highlands of Navesink.

U. S. SCHOONER J. Y. MASON,
Off Perth Amboy, Middlesex Co., N. J., October 31, 1855.

DEAR SIR: I have the honor of sending you my report of the work executed by myself and party during the past season. * * * * * * *

My first work consisted in selecting sites and erecting signals for the triangulation party. Twenty-one signals were erected on the shores of Raritan bay, seven on Staten island, and fourteen on the coast of New Jersey, extending from South Amboy to the highlands of Navesink. Careful topographical sketches, measurements, and written descriptions of these stations, were made and forwarded to Assistant Edmund Blunt, duplicates of which I will send to the office before the close of the season.

This having been completed, I commenced my topographical work at Sandy Hook, on sheet No. 1, that being the only sheet containing any determined points. Previous to commencing plane-table work, however, I searched for six stones erected on Sandy Hook by Sub-Assistant

R. M. Bache, under your directions, in 1851, as fixed points of reference, for the purpose of marking definitely the changes which might occur in that region. I succeeded in finding five of them, and placing signals over them, and subsequently determined their positions carefully on the plane-table sheet. The sixth stone, I am convinced, is not lost, and I will endeavor to find it next season ; it has probably been covered with sand by the wind. The latter appears to me to be one of the causes, if not the chief cause, of the changes which take place annually at the Hook.

My first sheet, No. 1, embraces the survey of Sandy Hook, the adjacent island, and the shoals in the vicinity, which are bare at low water, and a portion of the highlands of Navesink, running from a third to three-quarters of a mile inland. This was inked and forwarded to the office ; and on the 26th of September I commenced sheet No. 2, which includes the shore of New Jersey, from the Highlands to near the village of Union. On the 19th of October a tracing of this sheet was sent to the office.

Since then I have executed the shore-line of sheet No. 3, which extends from Union to about a mile up the Raritan river beyond South Amboy, completing the shore-line of the work originally planned for me by yourself for the season. A tracing of the latter will be immediately forwarded to Washington. I now propose to commence the filling in of the interior topography, and continue eastward until such a time as you may deem it necessary for me to start for the St. John's and St. Mary's rivers.

In regard to the changes which have taken place on the Raritan bay shore of New Jersey since the last survey, the accompanying list of points, where I have made examinations, will give the amount of *washing away* which has come under my observation :

830 yards east of Chesnaquack creek	30 feet.
At Matayan (or Mataven) Point	40 "
At Conaskonk Point	30 "
At Point Comfort	75 "
648 yards west of the wharf at Port Monmouth	30 "

* * * * * * * * *

I have been assisted by the aid of the party, Mr. P. R. Hawley, in the erection of signals, and towards the end of the season in plane-table duties; and I take this opportunity of speaking of his work as having been entirely satisfactory, and executed with a hearty good-will.

* * * * * * * * *

Respectfully submitted by, your obedient servant,

A. M. HARRISON, *Assistant.*

Professor A. D. Bache,
Superintendent U. S. Coast Survey.

APPENDIX No. 24.

Documents relating to resurvey of New York bay and harbor and dependencies, for the Commissioners on Harbor Encroachments.

Harbor Commissioners' Office,
30 *Broadway, New York, June* 23, 1855.

Dear Sir : I am requested by the Commissioners on Harbor Encroachments to transmit you a copy of a preamble and resolution adopted by them, which you will please find enclosed.

Very respectfully, your obedient servant,

G. H. BOUGHTON, *Secretary.*

Professor A. D. Bache,
Superintendent U. S. Coast Survey.

OFFICE OF COMMISSIONERS ON HARBOR ENCROACHMENTS,
30 *Broadway, New York, June* 20, 1855.

Whereas the President of the United States, on the application of this commission, has authorized Professor Bache to grant such assistance in the survey of the harbor of New York as may be consistent with the general progress of the Coast Survey; and

Whereas Professor Bache has expressed his readiness to comply with the desire of the members of this commission, and to furnish a sufficient number of engineers, together with the necessary implements and appliances to make the surveys and examinations contemplated by the law creating this commission, and to superintend and direct the same; therefore,

Resolved, That Professor Bache be, and he is hereby respectfully requested to detail, as soon as may be, such officers and engineers as he may deem necessary to make, under his superintendence, accurate surveys of the shores of the harbor of New York; to take such soundings in the said harbor, and observations of the currents therein, as will enable the commission to present to the legislature an accurate map of the harbor of New York and the adjacent lands, in accordance with the requirements of the act of March 30, 1855, Chapter 121.

I certify the foregoing to be a correct copy of a preamble and resolutions passed by the commission on harbor encroachments.

G. H. BOUGHTON, *Secretary*.

IRVING HOUSE, NEW YORK, *June* 23, 1855.

DEAR SIR: I have to acknowledge the receipt of your note enclosing the preamble and resolution of the Commission on Harbor Encroachments, requesting me to make arrangements for a survey of the harbor of New York and the adjacent lands by parties of the Coast Survey, under authority given by the President of the United States and Secretary of the Treasury.

In compliance with the request of the commissioners, I have already commenced the necessary arrangements by the detail of officers and the assignment of vessels and other appliances for the survey, and will complete all the preliminaries in the course of next week.

I shall endeavor so to arrange the work as to complete at least the shore-line and most essential hydrography by next November, so that it may be accurately mapped in the office; presenting also, if practicable, in time for your report to the legislature next winter, the topography of the immediate shores.

Should the commissioners desire special arrangements in regard to any part of the details of the work, I will be obliged by their communicating their wishes to me, that I may give directions to the several parties.

As soon as the necessary arrangements are completed I will report them to the commissioners.

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

G. H. BOUGHTON, Esq.,
Secretary Commission on Harbor Encroachments, &c.

At a meeting of the Commissioners on Harbor Encroachments, July 9, 1855—

Professor Bache made the following report of his arrangements under the resolutions of the commissioners of June 20, of which he asks the approval of the commissioners.

1. A triangulation party is at work under charge of Edmund Blunt, Esq., assistant U. S. Coast Survey, assisted by C. P. Bolles, Esq., and Lieut. Seward, U. S. A., assistants Coast Survey.

This party has been rendered necessary by the obliteration of many of the points formerly determined by the survey in the progress of improvement, and by other circumstances of a similar kind. The party has been withdrawn from the upper part of the Hudson, and merely the extra expenses will be charged to the commissioners.

2. A plane-table party, under the charge of F. H. Gerdes, Esq., assistant U. S. Coast Survey, will be engaged in New York city, Brooklyn, Jersey City, and in the East river and Long Island sound to Throg's neck.. This party was already provided for, and only its extra expenses will be chargeable to the commissioners.

3. A plane-table party, under the charge of Richard D. Cutts, Esq., assistant U. S. Coast Survey, which will work on Staten island and the adjacent shores.

4. A plane-table party, under the charge of A. M. Harrison, Esq., assistant U. S. Coast Survey, which will work at Sandy Hook and the vicinity, and on the north shore of Raritan bay.

5. A hydrographic party, under the command of Lieut. Comg. T. A. Craven, U. S. N., assistant Coast Survey, having the steamer Corwin and schooner Madison for the use of the party, which will survey the East river, Long Island sound to Throg's neck, the upper and lower bays and approaches.

6. A second hydrographic party, under the command of Lieut. Comg. Richard Wainwright, U. S. N., assistant Coast Survey, having the schooner Nautilus for the use of the party, which will survey the Hudson from Yonkers to the city inclusive and Harlem river. This party has been withdrawn from the upper part of the Hudson, and only the extra expenses are chargeable to the commissioners.

7. Should it prove by the middle of August that the progress is not as rapid as is now expected, other parties may be added if desired.

8. The foregoing parties, officered from the Coast Survey, are all furnished with the vessels needed, instruments, and other appliances; and merely the contingent expenses and such extra expenses as may be incurred by the officers will be charged to the commissioners.

9. To keep the execution of the map as nearly up with the field-work as possible, the hydrographic draughtsman of Lieut. Comg. Craven will work in New York in the office of the commissioners; the plane-table and hydrographic sheets be sent to Washington as early as practicable, and will be compiled there into a map on the scale and with the limits of that presented in project to the commissioners on the 6th of July (marked A, with one to two miles additional on the north side.)

10. To have a copy of the comparative map, with the addition of the survey of 1855, prepared for the commissioners in the office of the Coast Survey.

11. To have a comparative map of the city wharves and exterior line, from surveys at different periods, prepared in the office of the commissioners by the draughtsman of Lieut. Craven's party.

12. The accounts for the expenditures for this work will be rendered monthly. The detailed accounts will go to the office of the disbursing agent of the Coast Survey, who will prepare them for examination of the Superintendent, and an abstract for his signature, approval, and certificate; which abstract, with the signatures of the disbursing agent and Superintendent, will be sent to the commissioners in duplicate.

13. These arrangements are intended to furnish the hydrography, shore-line, and at least the characteristic topography of the adjacent lands of the harbor and bay and the dependencies generally, by the 1st of November to the 1st of December next, and a preliminary map which may be presented to the legislature before the second Tuesday in January; leaving the completion of the topography in the interior, and such parts of the dependencies as cannot be reached, and the complete map to another season.

At a meeting of the Commissioners on Harbor Encroachments, July 9, 1855, the following resolution was adopted:

Resolved, That the report of Prof. Bache this day submitted to the commission on the arrangement and duties of the several parties detailed by him for the survey of the harbor, be and is hereby sanctioned and approved.

G. H. BOUGHTON, *Secretary.*

HARBOR COMMISSION OFFICE, *New York, July* 9, 1855.

At a meeting of the Commissioners on Harbor Encroachments, held at their office on Monday, July 9, 1855—

Prof. Bache having stated to the commissioners that he desired that General Totten, Commander Davis, and Captain Benham might be appointed with him in the consideration of an exterior line for the harbor of New York, and matters relating thereto,

Mr. Bowen offered the following resolution, which was adopted:

Resolved, That this commission, in compliance with the request of Professor Bache, do hereby respectfully request Gen. Joseph G. Totten, Commander C. H. Davis, and Capt. H. W. Benham to meet Professor Bache at such period of time as he may determine, and as will be convenient to themselves, for the purpose of consulting on a proper water-line for the harbor of New York.

Resolved, That a copy of the foregoing resolution be sent to Professor Bache, and that he be requested to communicate the wishes of this commission to the gentlemen therein named.

I certify the foregoing to be a correct extract from the minutes of the proceedings of the commissioners.

G. H. BOUGHTON, *Secretary.*

HARBOR COMMISSIONERS' OFFICE, *New York, July* 9, 1855.

BOSTON, *July* 11, 1855.

DEAR SIR: The project for the Commissioners' map on a scale of $\frac{1}{20000}$ having been communicated to them, has met their approval.

It is desired to have from one to two miles extension on the north side of the map, so as to embrace improvements on the main north of Spuyten Dyvil Creek. With this change the map will be executed.

Please have the projection prepared at once, and arrangements made to put the work in as received. Constant communications should be kept up with the parties and with me in reference to the map, to insure its being kept up with the field-work and work afloat.

One of the best draughtsmen, capable of executing work like that in the Boston harbor, and State and city maps, should be put on this map.

It must be drawn on backed paper, or some arrangements be made for backing.

These details and those of drawing should be carefully matured, and a memorandum be made of them and sent to me. The scale of shades must be studiously followed.

It is expected that the field-work will all be complete, as far as shore-line and characteristic topography of shores are concerned, by November 15, and the *latest day for completing the map is January* 10. Should it turn out that existing plane-table sheets may be used in furnishing topographical details to any extent, topography of as much of the interior as can be prepared will be mapped.

In mapping, care must be taken to work on a uniform system as to the belt of topography to be represented, so that the map may not present a mere fringe at one part and a large space of interior at another, marring its symmetry.

The direction and daily supervision and pushing forward of this work should be assigned to one person, who should be made fully aware of the responsibility in regard to time and execution.

Mr. Balbach is making a small copy of the project, after which he will return the project in the large size to the office. If not soon received, please request that it be forwarded.

Please report half-monthly the progress made.

Yours, respectfully,

A. D. BACHE, *Superintendent.*

Capt. H. W. BENHAM,

Assistant in charge Coast Survey Office.

Description of the manuscript chart of New York harbor, bay, and approaches.

This *chart* is reduced from plane-table and hydrographic surveys made in 1855, "for the Commissioners for the preservation of the harbor from encroachments."

It is projected on a scale of $\frac{1}{20000}$, or 3.168 inches to the mile, with every fifth minute of latitude and longitude marked, (reckoned from Greenwich,) and the whole surface of the sheet is divided by red lines into square miles, for the convenience of estimating areas or distances.

The neat line dimensions are ten feet in length and seven feet ten inches in width, embracing Throg's neck on the east, Hudson river, two miles above Spuyten Duyvil creek, on the north, the mouth of Raritan river on the west, and near old Shrewsbury river on the south, extending over a section of country thirty-eight miles from north to south, and thirty miles from east to west.

The surveys are based upon trigonometrical positions of second and third orders, established principally in 1855.

The topography forms a belt above the high-water line, varying in width from one fourth to one mile, within which the details are minutely preserved, except of such city squares as are fully occupied; these being uniformly shaded, and only the public buildings within them being represented. The hills are developed by blue contour curves, at vertical distances of twenty feet, and the cultivated fields are bounded by broken lines. So far as the surveys and drawing have been carried, the chart is thus complete; but the large body of work to be accomplished within a given time, both in the field and in the office, has rendered several omissions necessary. On this account it is styled a "preliminary chart," until the additions shall have been made, agreeably to the original design.

From the hydrography a chart is produced, showing, by established methods, the form and character of the bottom, the dangers, the courses and ranges for sailing, the buoys, light-houses and beacons, and profiles of sections of the channels and bar. The soundings are reduced to mean low-water, (the plane of reference,) and are selected from numerous soundings, so as to represent the bottom.

The profiles of the channels and bar are constructed upon a horizontal scale of $\frac{1}{20000}$, and a vertical scale of $\frac{1}{336}$, and show the form of bottom *and volume of water* at each cross section.

The sailing directions are prepared from the recent survey, conformable to the ranges and courses of the present establishment.

The current table is made from observations taken at twenty-seven stations, showing the direction and velocity at each station at first quarter, maximum, and third quarter of the tides.

The tide-table exhibits the corrected establishment; the rise of highest and fall of lowest tides; the fall of mean low-water spring-tides; the height of mean low-water neap tides; the mean rise and fall of tides, and spring and neap tides; and the mean duration of rise, fall, and stand.

The magnetic variation, either computed or observed the present year, is given for Sandy Hook light-vessel, Sandy Hook, the Narrows, Governor's island, New York city, and Throg's neck.

The list of light-houses and beacons contains the description and position of each.

Remarks by Mr. Boschke on surveys made at different periods in New York harbor.

NORTH RIVER.

Since 1835 the North river has deepened from about 40th street, southward, on the average nearly one fathom, and the deepest channel-way lies now on the New York side.

On the New Jersey side, opposite Long wharf, the river has also deepened by some two feet, but a considerable deposite has been made south of Cunard dock, and opposite to Canal dock.

EAST RIVER.

Between Newtown creek and the navy-yard the bed of East river has changed slightly in the channel-way, and the flat opposite Rivington street has extended into the river. A tendency to this effect existed in 1835, and is marked by an isolated spot of 16 to 18 feet, projecting out into the river.

From the navy-yard to the Battery the river has deepened somewhat throughout, averaging from three feet to one fathom, without change in the course of the deepest channel-way.

The water front at Brooklyn and Williamsburg has been much changed since the last survey.

The shoal at the head of Buttermilk channel has been diminishing since 1835, *in size*, but the spot of least depth has shoaled from thirteen to twelve feet, and evidently changes in position, and often in size, but has always left to the east and west of it channels of uniform depth and width.

There seems to be at present a tendency to shoaling off the wharves, between South and Atlantic dock ferry, on the Brooklyn side.

The spit from Castle Garden, off the battery, to pier No. 6, is increasing, and there are now two twelve-feet spots extending into the river.

Between 1835 and 1848 Buttermilk channel increased in depth, but diminished in width. The flats at Atlantic dock shoaled in certain spots from twelve to seven feet, and in others from twelve to ten feet.

JERSEY FLATS.

A comparison between the surveys of 1835 and 1853 shows a decrease of water generally over the Jersey flats, with a tendency towards a uniform depth of six feet water, in nearly a straight line from Ellis' island to Robin's reef light-house.

FROM THE NARROWS TO NAVESINK LIGHT. (SHEET NO. 2.)

The *fourteen-feet channel*, and its bar, have undergone scarcely any change in depth, but the channel has been encroached upon in width somewhat. The flat which separates it from East channel has kept its original shape, but is *steadily* shoaling.

East channel may be considered as improving in general depth, although, in the survey of 1848, several small spots of eighteen and sixteen feet occur. The same survey shows that the bar of 1835, carrying nineteen feet, had sanded up to seventeen feet; a small spot of that depth naving so increased as to make the bar of 1848 about half a mile in width. The survey of 1853, however, shows the channel and bar improved, giving the latter eighteen feet water, and a width of about an eighth of a mile.

The main body of the flats, between East channel and Swash channel, seems to have retained its shape, but the general depth is increasing. On this occurs the dry Romer shoal, which follows the same tendency. It is gradually washing away, and at present covers scarcely a fourth of the area shown in 1835.

Swash channel is constantly changing, especially on the southern side, where eighteen-feet lumps are very frequent. The survey of 1855 shows a considerable improvement in this channel, with free access, four fathoms water, and a width of a quarter of a mile; but the survey cannot be regarded as sufficiently detailed to render it certain that no obstructions whatever exist in the channel entrance.

The flat between Swash channel and main ship-channel has changed very little in area; but the shoalest portions, as Flynn's knoll, &c., are diminishing in size, and have improved in depth from one to two feet.

False Hook channel deepened between 1835 and 1848 opposite to Sandy Hook light, and the bulkhead due east of east beacon has been washed away. A fifteen feet spot has formed north of Sandy Hook, projecting into the main ship-channel. The southern part of this channel has in some places shoaled, and the large flat east of the channel, consisting, in 1835, of three distinct eighteen-feet shoals, sanded up previous to 1848, and then constituted a continuous shoal of that depth.

NEW YORK BAR.

Gedney's channel, which in 1835 had a channel-way of $3\frac{3}{4}$ fathoms, sanded up, so as to show in 1848 a very narrow bar, with three and a half fathoms.

North channel had, in 1835, several knolls of three and a half fathoms, but the survey of 1848 shows a bar a mile in width, and, in occasional spots, as little as three and a quarter fathoms water. The survey of 1853 exhibits a considerable improvement in this channel, but its apparent tendency to deepen to four fathoms could be determined only by a minute re-survey. Its direction seems to be due east of a point half a mile north of Sandy Hook east beacon.

South channel, in 1835, carried on its bar three and a half fathoms. The survey of 1848 shows obstructions of eighteen-feet spots; and though that of 1853 represents it as improved, one spot of sixteen feet occurs in the channel-way.

APPENDIX No. 25.

Report to the Commissioner of the General Land Office on the survey of the Florida keys.

COAST SURVEY STATION, DIXMONT, PENOBSCOT CO., ME.
October 13, 1855.

SIR: I have the honor to present herewith, as in direct execution of the work on the Florida keys and main for the General Land Office, or as bearing upon it, the following extracts from reports made to me by the Coast Survey assistants there engaged:

No. 1.—*Extracts from the report of Assistant I. Hull Adams, on the survey of groups and detached keys in the vicinity of Key West, Florida reef.*

QUINCY, MASSACHUSETTS, *August* 9, 1855.

DEAR SIR: Three groups of keys were surveyed and marked during the past season, namely, the *Mud keys*, *Snipe keys*, *Saddle Bunch keys*, (commonly known as Sal Bunce keys,) and several small and detached keys lying about thirteen miles northeast of Key West.

The Mud keys are traversed by three channels running nearly east and west; the portion south of the third channel being broken into small patches of mangrove, growing from deep mud. They comprise an area of about two square miles, and are entirely overflowed at ordinary high tides. On this group nine posts were placed at the intersection of the meridians and parallels with the shore-line or edge of mangrove growth, the meridians being laid off parallel to that passing through Long Point.

The Snipe keys extend in a southeasterly direction, a distance of four and a half miles. The northern group is a mile and a quarter in length, and somewhat less in breadth. It is very much broken up by channels, and overflowed by high tides.

Snipe key No. 1 is a single key, two and a quarter miles in length, and four hundred and fifty yards wide for half a mile from its northern end, narrowing one-half in the next mile, and again widening. Ten posts were placed on this key and numbered, the positions of which are marked upon the map prepared for the Land Office.

Snipe key No. 2, adjacent to the last mentioned, is separated from it by a passage about a hundred and sixty yards wide. It is somewhat over two hundred yards in breadth at the northwestern end, but increases to a breadth of half a mile at the southern extremity. This key was marked by three posts.

The Snipe keys are all covered with mangrove, and parts of them are overflowed at ordinary tides.

The Saddle Bunch keys, divided from the last named by a passage called the Narrows, about two hundred and twenty yards wide, are intersected by three large bays, which nearly separate them into as many distinct groups. The greatest amount of fast-land is at the southern part, included between Sal Bunce harbor and Sugar Loaf creek. This portion embraces an area of nearly ten square miles, most of which is covered with a heavy growth of button-wood, mangrove, and iron-wood. Fifty-nine posts were planted upon these keys, properly marked and numbered, and firmly secured against the effect of the tides.

The meridians and parallels dividing the Snipe keys and Saddle Bunch keys into quarter-sections, were laid off from the middle of the sheet by parallel lines.

The detached keys included in my survey of this season are known as *Marvin key*, about six hundred and fifty yards in circumference, and another of twice its size just south of it, but bearing no name. Both of them are covered with mangrove, and lie about north of Snipe key No. 1, distant two miles.

In a line with these and the southeastern extremity of Snipe key No. 1, is Mallory key, about a quarter of a mile in length, and the same in breadth. One half of it is covered with mangrove, and the other with bushes growing from deep mud. Blake key lies a mile to the southeast of Mallory key. It is a small clump, upon which there is a trigonometrical station.

Whiting key is four hundred and thirty-seven yards in length, and one hundred and ten in breadth. It lies opposite to the Narrows, a passage between Snipe key No. 2 and Saddle Bunch keys, which is the only outlet to the keys lying eastward. Three small keys west of Whiting's key are called the Crane keys.

Wall's key is situated a mile and a quarter from the mouth of Sugar Loaf creek, and nearly north of it. It contains an area of less than a fourth of a mile, and is marked by two posts.

From the outside of Saddle Bunch harbor to the north Saddle Hill station, there is a lagoon of about one mile deep. The distance from Saddle Bunch harbor to the station called "Martha" is seven and a half miles, and the shore is almost straight. In this extent there are some patches of beach and coral bottom; other parts are deep mud, with mangrove; sea-grape and button-wood is the principal growth along this outer shore.

The posts for the division of the land into quarter-sections were all placed, wherever it was possible to get to the positions.

This report is accompanied by three tracings—one of the Mud keys, one of the Snipe keys, and one of the Saddle Bunch keys. The tracings have a sheet of explanatory notes accompanying them.

Very respectfully, your obedient servant,

I. HULL ADAMS.

Professor A. D. BACHE,
Superintendent Coast Survey.

No. 2.—*Extracts from the report of Sub-Assistant S. A. Wainwright, on the determination of shore-line between Point Perry and Excelsior, on the outside of Key Largo, north.*

NEWPORT, RHODE ISLAND, *August* 23, 1855.

SIR: I have the honor to report to you the progress of my work in Section VI, Florida reef, and to send you the accompanying sketch, showing the portion executed by my party during the present season. This comprised the determination of shore-line between Point Perry and Excelsior, on the outside of Key Largo, north. Its aggregate length is about thirty-three miles, including the various indentations of the coast. Three square miles of the interior were surveyed, and the work of the season involved the cutting of somewhat less than two miles, for a line of sight.

Several attempts made to place the section posts for the General Land Office proved ineffectual, and, in accordance with your directions, I have deferred their establishment until the adoption of a method for overcoming the difficulties experienced in the attempts which have been made. Signals were placed in the positions determined for the posts, to serve a convenient purpose in placing them hereafter. The difficulty referred to arises from the nature of the shore, which is entirely of rock, and impenetrable to any of the ordinary means employed for the placing of marks intended to be permanent. Amongst other expedients I tried posts furnished with iron braces, bent at right-angles and placed at opposite sides, but found that the rock crumbled away from the spikes driven in to secure them, and that the posts washed away.

The shore-line has yet to be traced, and the inside of the keys from a point about two miles and a half from Angelfish creek down to the limits of the outside shore-line; and the completion of this will bring the topographical work up to the present limit of triangulation.

The difficulties presented in its execution are almost insuperable. Operations on foot are in many places impossible, and in others the water is so shallow for miles in the coves that boats cannot be got through them. The chief difficulty is in establishing the positions for section posts, a great number of stations being necessary for the purpose. It is often impossible to procure any suitable station, owing to the softness of the bottom, and to the thick growth of bushes on the shores.

My work was very much delayed by the stormy character of the season.

Respectfully,

S. A. WAINWRIGHT,
Sub-Assistant U. S. Coast Survey.

Professor A. D. BACHE, *Superintendent.*

I decided to postpone the definite division into quarter-sections until this key and those adjacent were connected by triangulation with Key West, so as to make the whole system more plain. The marks are secured, however, and afford means of sale, should it be desired to press the sale.

No. 3.—*Extracts from the report of Assistant H. L. Whiting, in regard to cutting of lines and marking quarter-sections.*

COAST SURVEY SCHOONER AGASSIZ, *April* 9, 1855.

DEAR SIR: * * * My operations have been conducted without interruption or delay, and all possible available time has been improved to the utmost. The weather has been generally favorable, and my work itself has been quite satisfactory. I have reviewed three sheets of work in Key Biscayne bay, comprising the work of parts of two seasons; one sheet of work at the north end of Key Largo, executed during the last season and this; two sheets of work northeast from Boca Chica during last season and this; and one sheet of Boca Chica The cruising in execution of this work has been about seven hundred and fifty (750) miles. The time occupied, including all the changes from place to place and from vessel to vessel, has been from the 8th of March to 9th of April.

With regard to the particulars and results of my examination of the topographical work referred to, I can report it as highly satisfactory. I have gone over a large portion of all the work, and where I have examined it I have done so very closely and critically, and I am most glad to say that I have found no important errors whatever.

* * * * * * * * *

With regard to the question of cutting the lines in order to make the corner sections, it can be done, of course; but the *time* and *expense* will be an important consideration. Some of the larger keys are covered with a dense growth of mangrove and other trees, which are the hardest wood to cut. The heat and mosquitoes in the woods, and the work of chopping, make the men of our parties, as now organized, at times absolutely refuse to work. The most practicable and efficient way to accomplish this would be to hire gangs of men expressly for this purpose, or to give out the cutting by contract. If a gang of choppers was engaged equal in force to our parties, I think one topographical party could keep at least *three such gangs* constantly at work. From this comparison (and I am confident I have not overstated it) some idea can be formed of the time and expense which it will take to open all these lines.

There is another point that has suggested itself to me in relation to this question, which may not be admissible in the Land Office survey, however. This is the necessity of cutting these lines or making the interior corner sections. If the object of the Land Office survey is to define and locate the particular sections and quarter-sections sufficiently to enable those who take up the land to identify them, this is accomplished, it appears to me, beyond all question, by the marking as now done. The fact of the section-lines terminating and intersecting with the *shore-line* on all sides of the keys, makes a positive and definite point, and a mathematical determination of the sections.

* * * * * * * * *

Very respectfully, yours,

HENRY L. WHITING.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

No. 4.—*Extract from the report of Sub-Assistant John Rockwell, U. S. Coast Survey.*

ROCKAWAY, *September* 17, 1855.

SIR: * * * The keys extending between the line Rock Point—Eastern Sambo, and eastward as far as the line Loggerhead key—Palmetto (near Newfoundland harbor,) over which the triangulation was carried this season, may safely be characterized as being as valueless as any in Florida. The foundation of Coral Rock is furnished with but a scanty covering of soil. In some places, mangrove and buttonwood trees will grow; in others, nothing more than the bush mangrove; and in most places, nothing at all. The really solid land, moreover, forms but a small proportion of the territory. A large part is covered by an intricate system of shallow creeks and lagoons, which cut up and separate the keys, and another part by swamps, where the mangrove grows to a considerable size and with wonderful density.

Within this region there are two or three settlements of single houses on spots where sufficient soil has been found to cultivate a few vegetables and fruits. The quality of the soil appears to be good enough to produce all that is elsewhere raised in similar climates; and such trees or plants as require no great depth of earth flourish well. But the supply of soil is quite deficient, and the spots where even what I have mentioned can be accomplished are comparatively few. There is still an opportunity, however, to effect a good deal more than has been done in the way of cultivation of the soil. There is available land enough on these keys, within a reasonable distance from Key West, to supply that market with such articles as can be raised; but the town is at present dependent for its supplies upon importation from the main land of Florida and the northern States. Sponges are obtained in the shallow waters amongst the keys in considerable quantity, and though not a very important item, they form one of the articles of export from Key West.

The keys present many obstacles and few facilities for the prosecution of the survey. The shoalness of the water between them prevents access with the vessel oftentimes within five, six, or eight miles from the points where the work may happen to be in progress; and approach even with boats is dependent upon wind and tide, and, in many cases, very difficult. The mangrove swamps which abound on the keys are among the most formidable difficulties. Tall signals become necessary in order to be visible above the trees, and lines have not unfrequently to be opened through the swamps. This is a slow, laborious, and expensive operation. The swamps are overflowed at high tide, and the mud, water, and mosquitoes that abound in them are beyond description, and these, with the intense heat of the climate, render the work of cutting almost impossible. The labor of opening lines and dragging boats over the shoals has proved to be very severe upon the crew of the vessel.

The only locality where provisions and good water can be obtained is at Key West, and no small amount of time is lost in running to that port for supplies.

* * * * * * * * *

Very respectfully, yours,

JOHN ROCKWELL,
Sub-Assistant U. S. Coast Survey.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey.

No. 5.—*Extracts from the report of Lieut. A. H. Seward, U. S. A., assistant in Coast Survey, on the triangulation and reconnaissance of Barnes' sound, Florida.*

Washington, D. C., *May* 20, 1855.

Sir: The triangulation party, under my charge, commenced their field operations on the 7th of January, 1855.

The first two weeks were employed in reconnoitring from Indian key, on the inner side of Key Largo, in a northerly direction, when, finding it impossible to reach my work that way, the vessel proceeded through Angelfish creek to my last anchorage of the preceding year.

Remaining at this point, the triangulation was carried on with small boats until the 20th of February, when it became impossible from the great distance of the work from the schooner.

Proceeding to Key West, the "Bowditch" was turned over to Mr. Whiting, on his arrival, by the steamer.

The statistics of the work are as follows:

Signals erected	4
Stations occupied	6
Number of sets of repetitions of angles measured	133
Number of single observations	800
Longest side	5,158.0 metres.
Shortest side	2,844.7 metres.
Area according to angles measured	7 sq. miles.

Instrument used, 5-inch Coast Survey Gambey, No. 55.
10-inch Coast Survey Gambey, No. 15.

* * * * * *

While employed in carrying on the triangulation, I took advantage of favorable winds to reconnoitre that portion of the sounds between Key Largo and the main shore, and was unable in many places to get more than half way across with the small boat, on account of the bars which connect the different keys having no channels, as heretofore. From this I concluded it was next to impossible to cover this portion of the sounds with triangles coming off my last base; it being some two miles and a half in length, and the sounds fifteen or sixteen in breadth.

I would respectfully suggest coming off the base at Cape Sable, or from one below Indian key, and carrying the triangulation northwardly towards my last points, as more likely to be successful.

Very respectfully,

A. H. SEWARD,
Lieut. U. . A., Assistant Coast Survey.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey.

I would further state that I measured two bases of about four miles in length, one on Key Biscayne and the other on Cape Sable Prairie; which afford means of immediate division of their localities, if it is desired to place them in the market. Cape Sable Prairie is a beautiful piece of ground, though so recently formed that the soil is still highly impregnated with salt. The chief component of the soil is calcareous matter, derived from finely divided corals.

Very respectfully,

A. D. BACHE, *Superintendent.*

Hon. T. H. Hendricks,
Commissioner of the General Land Office, ashington.

APPENDIX No. 26.

Extracts from a descriptive report made to the Superintendent by Assistant George Davidson, upon localities on the western coast of the United States from the north entrance of Rosario strait, W. T., to the southern boundary of California.

Rosario Strait and Canal de Haro.— * * * * A vessel entering Rosario strait with a favorable tide and wind can get through in one tide from either entrance, the other being visible. In coming from the north, if the wind fails, it would be advisable to anchor on the shoal north of the Matia group. Anchorages can be had under Village Point (Lummi island;) in Strawberry bay, (Cypress island;) and in the shoal bight running from James island southward to Kellett's Ledge. No boat can pull against the currents here, and the roar of them is like that of a gale of wind through a forest. A knowledge of their peculiarities is very desirable. There is a long and large, and a short and small tide, the same as on the coast. The greatest height of tide noticed was between twelve and fifteen feet.

Dangers.—Two sunken rocks occur in Rosario strait, visible at very low water, northwest of Lummi island. The Belle Rock, near the Bird Rocks, is likewise visible at extreme low water; as also Kellett's Ledge and Entrance Rock.

These, with Peapods, Black and Bird Rocks, and others not visible, are a drawback to navigation, and occasion much anxiety when the wind fails.

* * * * * *

Canal de Haro is ten miles longer than Rosario strait, and makes a right-angle in its course. The volume of water passing through it is also greater and the currents stronger.

The anchorages are not reliable. It is advisable to keep always in mid-channel, though no unseen dangers now exist within my knowledge except Unit Rock. If the wind is light, vessels bound north should keep quite clear of the inside Nahnymoh channel, so as not to be drifted into it. Good anchorage is found in Cordova bay, with plenty of wood and water; as also on the north side of Sidney island, and under Waldron.

The anchorage at Stuart's I do not consider practicable, especially for sailing-vessels.

Bellevue island (San Juan) is the resort of great numbers of Indians, with an extensive fishery near Henry island, and an old fishing station on the inside of the southeastern extremity.

Canal de Haro is wider than Rosario, and an inside channel leads from it in a northwesterly direction to the Nahnymoh coal mines. It had not been surveyed, so far as I have found, previous to the time of our survey.

The soil of the islands forming the straits is scarce and poor, and very dry during the summer. The islands generally are covered with a thick growth of Oregon pine, other kinds of wood being exceptional. The highest mountains are *Constitution* on Orcas, *Lake* on Cypress, *Erie* on Fidalgo, and *Lummi peak* on Lummi, ranging from 1,200 to 2,500 feet in height. The top of Mount Constitution is destitute of trees. Most of the islands abound in deer, and elk are found in great numbers on Orcas.

All the islands present the same general geological features; sandstone and conglomerate prevail, in some cases to a thickness of several thousand feet, with a very great dip, which in some instances is almost perpendicular.

There are indications of coal on Patos, Lucia, Orcas, and Lopez. On Orcas (N. W. point) there is said to be a seam thirty-two feet thick. At Bellingham bay coal exists in quite numerous and apparently extensive veins, varying from six to sixteen feet, and of several qualities. It ignites readily, burns rapidly, with intense heat, much flame and volumes of smoke, and being lighter requires greater space for stowage than other coals. Some of it produces an almost incredible amount of clinker. Extensive beds no doubt crop out on the borders of the streams, running to the waters west of the main land.

The straits are navigated only by fishing-vessels. Those arriving for Bellingham coal and vessels of the Hudson's Bay Company invariably pass through Rosario strait. All traffic in these waters will eventually be carried on by small steamers or tow-boats. A steamer now runs regularly between Olympia and Victoria, and last year made trips to the Columbia river.

I consider the islands between Canal de Haro and Rosario strait as fitted only for limited settlement, there being little arable land and a great scarcity of fresh water. They can be used as fishing depots, and coal, perhaps, exists on some of them. The Hudson's Bay Company has a settlement on Bellevue island, at the point so designated on my map of last year's work.

Settlers are gradually coming up Admiralty inlet towards the Bellingham bay district, and many have claims on Whidbey island.

Admiralty inlet—Puget's sound.—Of this vast inland arm of the sea I cannot speak as advisedly as of other parts of the coast, though having gone as high up as Olympia, I was able to observe the facilities which it offers for steamboat navigation. These will certainly be called for as population advances. The trade is already very considerable, a number of saw-mills giving freight for a large carrying trade to San Francisco, the Sandwich islands, and Australia.

The soil bordering this sound is not as good, generally, as that of the Wallamut or Columbia river valleys. * * * * The tides at the head of the sound rise and fall about twenty feet at extremes, leaving a muddy flat half a mile in width.

I have been unable thus far to find any site suitable for a base. The country is densely wooded to the water's edge, and the shores and bluffs are high. * * * * * *

Strait of Juan de Fuca.— * * * Commencing at the eastern extremity of the strait, the first object of interest is Smith's island. The sketch of my preliminary survey, furnished to you, will give an idea of its size. (See Appendix No. 76.) * * * *

Vessels coming into the straits from sea should at first hold well to the Vancouver side, and thus avoid Duncan's rock and Tatoosh island if the wind fails, as there is generally a very short, heavy swell coming in, and vessels passing between the two incur much risk. Sub-Assistant Lawson saw from Tatoosh what he supposes to be a rock half way between that island and Duncan's rock. He tried several times to land on Duncan's, but always without success.

A reef occurs between Tatoosh and the main, and the currents in this vicinity are very strong.

After passing Neeáh bay on one side and San Juan on the other, vessels may anchor almost anywhere along the straits close in-shore; but good berth must be given to Race island, the Trial islands, and Discovery islands, as the currents running past them are exceedingly swift.

The southern shore of De Fuca's strait is inhabited by Indians living in stockaded villages. They are tolerably expert in the use of fire-arms, of which they seem to have a good supply. Kind treatment may do much towards conciliating them, but it is well to be prepared to resist any aggression on their part. Polygamy is tolerated among them. They live mostly by fishing, but succeed in cultivating very good potatoes.

Both sides of the Straits of Fuca are covered with an extensive growth of fir, and station points for the survey must necessarily be chosen as near the coast-line as possible, as it will be impracticable to carry the lines inland. Kellett's chart gives a very good idea of the strait, and being on a large scale, it is deservedly prized by navigators.

Settlements are gradually advancing from Puget's sound along the strait towards Cape Flattery, and seem destined to meet those coming up the coast from Gray's harbor and Shoalwater bay. No signs of coal or indications of gold have yet been found along the shores.

New Dungeness is a safe anchorage, where wood and water may be obtained; the last, however, only at particular stages of the tide, as the immense flat at the mouth of the stream will not admit the passage of boats except on full or half tide.

False Dungeness is a better anchorage, but, from my observation made during only one visit, it offers no facilities for watering. Several Indian villages are found on the southern side. Wood and water in abundance will be found at Neeáh bay. * * * *

From Cape Flattery to Gray's harbor (in about 46° 58′ N.) there is nothing special to remark. Vessels bound for that harbor must follow the line of the beach closely till off the entrance.

This stretch of coast has ever been notorious for the hostility and vindictiveness of the Indians inhabiting it—several Spanish and English vessels and crews having been taken and destroyed; and hence the names "*Destruction island,*" "*Isla de Dolores,*" "*Punta de Martyres,*" *&c.*

The number of small streams emptying on this line of coast affords to the Indians a constant source of supply in the salmon, with which they abound. Oil is obtained in considerable quantity from the black-fish and whale, which they fearlessly attack and capture.

Shoalwater bay.—The country in this region is filling up rapidly, and trade is carried on in the shipment of oysters, the bay furnishing nearly all required in the southern markets. *Gray's harbor* is perhaps as productive, but the article is not obtained at any other points north of San Francisco. Shoalwater bay extends nearly to Baker's bay, or the north side of the

Columbia river, and the Indians pass from one to the other over a portage about a mile in width. * * * * * * * * * *

Columbia river.— * * * In summer there is rarely any risk in crossing the bar under the charge of a pilot, but in winter the heavy swell breaking from Cape Disappointment to Point Adams, changing as it does the course of the channel, renders the entrance extremely difficult, and the exit almost impossible. The utmost vigilance of the best pilots is required to keep the run of the gradual but sometimes sudden changes. Vessels are frequently detained for weeks in waiting to get out, and those arriving off the harbor as long to get in. The trade of the river would doubtless warrant the regular employment of a tug, (propeller,) as now in use at Humboldt bay. No loss has occurred there, during three years, to any vessel under charge of the tug and her pilot. The plan seems as well adapted to the Columbia, as the anchorage in Baker's bay, close under the cape, is practicable, and the top of the cape is a good lookout. The north channel would afford a safe and easy exit from the anchorage. (See McArthur's chart.) Judging from the formation of the cape, the passage from the north channel, seaward, is less liable to change than the south, but this can be determined only by a close comparison of all the surveys of the entrance. * * * * * * *

The topography of Columbia river entrance should be executed to include Cathlamet bay, and north along the ocean shore, running thence to Shoalwater bay entrance, as the basaltic formation on this strip is a peculiarity of the approaches of the Columbia. Any navigator noticing the features of the Shoalwater bay entrance will not mistake it for that of the Columbia.

The triangulation should be carried as far as Oregon City, up Wallamut, and to the cascades of the Columbia river. This will be a work of great labor, and must expose the party to sickness, as persons settling rarely escape the fever and ague in the worst form. * *

Though very desirable, it will always be difficult to make the published hydrographic surveys a record of the changes occurring constantly at the entrance of the Columbia. I have designated "*Cape Disappointment*" by that name because it is never known as Cape Hancock on the western coast.

* * * * * * * * * * *

From Columbia river to Cape Blanco.—The name *Blanco* appears to have been applied before "*Orford*," and moreover very well expresses the appearance of the cape. The bluff is about a hundred feet high, and nearly perpendicular, with whitish sides. The top is covered with trees, which give it the appearance of an island in making it from the north or south, the neck and some distance back to the main being destitute of trees.

This line of coast is nearly straight. Tillamuk is a bold, prominent, and readily remembered and recognised headland, at the southern termination of the long sand-beach running from Point Adams. * * * * * * * * *

From Tillamuk the coast presents a country well watered by numerous small streams emptying into the ocean. It is densely covered with timber, and for a few miles back looks favorably from the deck of a vessel. The Tillamuk bay is said to be several miles in length, but the entrance is such that it can be made only under the most favorable circumstances, there being very little water on the bar.

Between Tillamuk and Koos bay the country (excepting the headlands shooting into the ocean) appears low, and well watered for many miles back, but vessels cannot approach from the sea.

North of the Koos is Umpquah river, the largest stream between the Columbia and the Sacramento. The entrance is long and narrow, with about thirteen feet of water on the bar at low tide. This river is said to drain an extremely fertile region, well adapted to agriculture and grazing, and abounding in prairie land. The valley of the Umpquah is filling up with settlers. * * * * * * * * * *

Koos bay has a wide, well-marked entrance, but the bar has but nine or nine and a half feet water on it at low tide. The coal once alleged to exist here is now pronounced a lignite, and cannot be used as fuel. The geology of this section does not give any promise of coal.

I have been informed that vessels anchoring close in with the bluff between Cape Arago and the Koos bar may ride out heavy southeasters; and if so, it is important, no other place between Sir Francis Drake's and Neeáh bay affording that facility.

The Coquille river, entering about fifteen miles south of Cape Arago, has been followed a distance of thirty miles, giving a depth throughout of not less than fifteen feet, and an average width of forty yards. It drains a very fertile region, abounding in many varieties of timber. Numerous Indian encampments are found upon its banks, and quite extensive fish-weirs. When off the entrance last year we saw about a dozen houses which had been built by the miners then engaged in washing the auriferous sand and gravel found on the beach between that point and Rogue's river. A small stream (Six's river) empties into the ocean a mile north of Cape Blanco. A preliminary survey of the reef off Cape Blanco has been made, showing its relative position and the passage through it.

In the country near Port Orford is found the finest white cedar, and, so far as I know, this is the only locality in which it occurs along the coast. *Port Orford* is the best summer anchorage between Drake's bay and the Columbia. It is about seventy miles distant from the mines in the interior, and on the opening of a road would become a large depot of supply.

Rogue's river, so called from the character of the Indians inhabiting its banks, deservedly merits the appellation. One vessel has entered, was attacked, deserted, and was then burnt by the Indians. The water always breaks upon the bar, and the reef off the entrance demands attention.

Illinois river.—The naming of this river is made merely upon the *guess* of some miners and settlers at its mouth, which they had reached by following the coast from Crescent City. * * The river is fifty or sixty yards wide, deep and sluggish, else it would, during summer, force its way through the gravel-beach at its mouth. Indian huts in great number appeared on the banks, but most of the occupants were then engaged higher up the river in taking salmon.

Smith's river.—The entrance of this river I looked for in vain from the deck of the vessel, though scarcely two miles from the shore, and I was able to form a pretty good estimate as to where it should open. The "Smith's river" of the maps is a myth. The reef of the coast hence to Crescent City, like the Rogue's river and Blanco reefs, demands an examination.

Crescent City.—The anchorage is rocky and uncertain. The beach is low and sandy.

Klamath river.—The mouth of this river was closed in 1851. I believe one or two vessels have entered it.

Trinidad bay affords a safe anchorage in summer. * * * The land in the vicinity is very rich and well adapted to agriculture. Red-wood trees grow in this vicinity, and attain an enormous size. The stump of one which we measured was about twenty feet in diameter, and a dozen in its vicinity averaged over ten feet. One is said to be standing on the bank of a small stream on the south side of the bay that will measure thirty-two feet in diameter. The trees are quite straight, branch at fifty to a hundred feet from the ground, and frequently attain a height of two hundred feet. A forest of red-wood presents a magnificent sight.

Mad river empties about a mile above Humboldt bay. Egress is shut out by the breaking on the bar; but the vast amount of lumber in its valley will soon find an exit through a canal to Humboldt bay. A deep slough from the latter approaches quite close to Mad river, near its mouth, thus favoring the execution of such a project. I am informed that the river averages a hundred yards in width.

Humboldt bay.—(See Appendix No. 28, C. S. Report 1854, and Appendix No. 76 of this report.)

The Eel River valley is, perhaps, one of the most fertile on the western coast, and is rapidly filling with settlers. The Indian name of the river or valley is "Weéot," probably signifying *plenty*.

The only vessel taken into this river thumped over the bar in 1850. It is said to have nine feet water on it.

South of Eel river, the first bold headland is False Mendocino, one of the terminations of a ridge from the interior. Bear river empties between that and Cape Mendocino. A minute examination of the coast thereabouts may possibly determine a landing place for boats through the surf during fine weather.

* * * * * * * *

Off Mendocino ("*Cape of Perils*" of Ferrelo) lies Blunt's reef, and I am told that a ridge runs westward from Mendocino, upon which soundings have been obtained at a considerable distance from the coast. The fact would be of great importance to coasters when near the shore in thick weather, as it would give their position and enable them to change their course according to the trend of the shore.

Shelter cove may be regarded as a harbor of refuge, and vessels running for it in great stress of weather will find good anchorage in four fathoms water. In coming from it southward, a good berth must be given to the point, which is rocky. The place affords water and some wood.

Mendocino City is the site of a large lumber establishment, which produces about forty thousand feet per day. The anchorage is small and not available in winter. In entering, the north point should be kept as close aboard as possible, and rounded to the anchorage in four fathoms. There is always an uncomfortable swell here.

The Noyou river cannot be entered, the water constantly breaking on the bar. The same is true of the centre of the bay, about midway between the north and south points.

Albion river is a stream of little importance, and offers no facility whatever as a harbor, at least for sailing-vessels.

Point Arena is comparatively low, partially covered with sand, and bare of trees for some distance from the coast-line. The land is well watered in this region, and suited to agriculture. There is no landing. * * * * * * *

Haven's anchorage would be difficult to recognise, unless the position of a vessel approaching it had been exactly determined. * * * * * *

Bodega bay affords good anchorage under the north side. Vessels coming from the north in thick hazy weather are apt to mistake this locality for Point Reyes, though on making the last mentioned point the same doubt does not arise. The British survey, especially of the northern part of the bay, seems to be accurate.

Tomales bay is entered from the south side of Bodega bay, and forms a sheet of water extending southward and eastward ten or fifteen miles, and terminating in the vicinity of the Lagoon Delimantour, which runs northward from Drake's bay. It is a succession of flats, generally visible at low water, but having a crooked and narrow channel through them.

Point Reyes and Sir Francis Drake's bay.—The Point, as will be seen by the topographical survey of Sub-Assistant Lawson, is a bold and readily distinguishable headland extending about three miles, with a precipitous face to the southward. * * * * The bay affords a good harbor of refuge in heavy weather, from either the north or south, and merits a hydrographic survey, as its facilities are now known only to the coasters. In certain cases it has been resorted to by vessels of the largest class.

Farallones.—On the last map sent to you I have made a note of the alleged existence of a rock about S. S. E. of the north Farallon. * * * * *

The Golden Gate.— * * * It would doubtless be a matter of interest to observe closely the strength of the current making through the Golden Gate, and its general direction across the bar. * * The plan of fog signalling, superior to whistles or bells, and now in practice at Monterey, would doubtless be of service here. A vessel approaching in a fog, or on a thick night, on firing a gun, and being answered from Fort Point, could judge of the proximity by the report.

San Francisco.—A re-survey of the city, a little beyond the limits of the present sheet, would be of much moment, to show the remarkable growth and development of the place, and the changes which have occurred. * * * * * *

From the Golden Gate to *Monterey bay* (the "*Bay of Pines*" of the Spaniards) there is little to attract notice. The mountains rising from the shore are about two thousand feet high, and destitute of trees, but during the rainy season (winter) they present a green and lively appearance. Large herds of cattle roam through the valleys.

Approaching Santa Cruz the country shows the labor of the husbandman, and its productiveness is astonishing. This is one of the garden-spots of California.

Two or three rivers enter into Monterey bay, draining the Salinas. A specimen of silver ore now in my possession was found in the vicinity, and it is affirmed that the ore is found there in abundance. The occurrence of cinnabar is proven by the successful operations of the New Almaden mines. Bitumen is found on the Salinas river.

Monterey presents a beautiful appearance in approaching it from the sea; the surrounding country, by its alternation of hill and valley, attracting the attention of the most casual observer. * * * * * * * *

At *Point Cypress* is found the wood from which it takes its name, and so far as known it is found nowhere else along the coast. From Point Carmel to Piedras Blancas the coast is nearly a straight line, the hills destitute of wood coming down to the line of the coast. The valleys between them are the resort of the grizzly bear. The hills range from fifteen hundred to twenty-five hundred feet in height.

In the vicinity of *San Simeon* the country presents an aspect favorable to agriculture. The soil is light and very productive. On the sketch I have marked the best landing-place for boats.

The hills at *San Luis Obispo* come down to the coast, and the town itself lies about ten miles back, in the middle of a fertile country. On the bay I discovered many fossil remains in a coarse dark-colored sandstone, lying under hills of what appeared to be soft magnesian limestone. The remains are of enormous size, but can be obtained only by great labor.

The landing at San Luis Obispo is at all times bad.

On the coast chart I have directed your attention to a rock, said to exist about S. S. W., eight miles from the first rock north of San Luis Obispo bay.

Point Conception has been already described in my regular reports. The anchorage of the Coxo is a good one in summer. From thence to Santa Barbara the coast is nearly straight, running east and west, the hills for twenty miles coming down to the coast, forcing the traveller to leave the beach for their sea-slope.

The trail passes over hills and down steep slopes, running through valleys in a rich grazing country until within fifteen miles of Santa Barbara, where the hills recede from the shore, leaving a good margin of land for cultivation.

The coast trail from the north comes in through the St. Inez valley to the shore, and from thence turns southward along the coast. A large bitumen pit, about eight miles west of Santa Barbara, empties directly into the ocean, and the bitumen floating on the water works *against* the summer winds, even beyond Point Conception.

Navigators, in making the Santa Barbara channel, readily estimate their approach at night by the peculiar odor of the bitumen. * * * * Santa Barbara is a town of considerable size, and lies in the middle of an agricultural tract running east and west. The mission is one of the best establishments of the kind in California, and in the gardens attached to it the grape and olive are cultivated.

In summer, vessels can easily anchor inside of the kelp, but the winter gales detach and drive the kelp shoreward, in such vast quantity that cables of vessels becoming foul must of necessity be let go.

San Pedro bay.—This anchorage is one of the best on the coast in summer, and I witnessed an instance of a vessel there riding out a gale in winter. The attempt to make an *inner harbor* within the lagoon will never be made by any one who has experienced a southeaster in that vicinity. * * * * * * * *

The town of *Los Angeles* is about twenty-two miles by the road from San Pedro. It is the centre of an extensive grape-growing region, which doubtless will in time furnish the coast with wine.

The quantity of grapes and fruit already shipping to San Francisco is very considerable. The olive grows here.

The country at the foot of the Black hills is as productive as any in California, but its distance from a large market is a great drawback to extensive improvement. The plains are literally covered with herds of cattle, and some of the large proprietors count their yearly increase by thousands. These cattle are driven to the mining districts, and to San Francisco.

The coasting trade of San Pedro is now greater than the aggregate trade of all the other ports southward of San Francisco.

The mission of San Luis Rey is the largest in Alta California. It is the centre of a country unequalled for salubrity and productiveness, and the number of domesticated Indians in its neighborhood give it the appearance of a large and busy town. It is now a military post.

San Diego.— * * This harbor is the second in point of excellence on the coast, and the only drawback is want of wood and water for supplying vessels.

An artesian well was commenced at La Playa, but abandoned after reaching a depth of six hundred and fifty feet, at a cost which would perhaps have sufficed for bringing water from the San Diego river in small pipes. * * It is a curious fact that in summer the current along the coast of the Pacific sets from east to west, while among the islands in Santa Barbara channel it runs southerly. I have no doubt that the "*Winfield Scott*" was set on shore by this current. On *Cortez Bank* it frequently sets against the wind at a rate of nearly two knots per hour. * * * * * *

The kelp of Fuca's straits grows from the bottom, has a very long, very thin, smooth and hollow stem, from an eighth to three sixteenths of an inch in diameter, until it reaches within twenty feet of the surface, when it gradually increases in size to about an inch and a half to two inches, finally expanding to a hollow bulb three or four inches in diameter. This bulb floats upon the surface, sustaining from ten to twenty very long, broad, smooth leaves, the edges of which, being at intervals contracted and expanded in width, present a ruffled appearance. Some of the stems are from twenty to thirty fathoms long. The leaves attain a length of about fifteen feet, and are from eight to ten inches broad.

The kelp of California is different from that just described. Some of the masses in the Santa Barbara channel are arborescent, large stems or trunks coming up from the bottom, which is there generally rocky, and bearing minor stems and leaves.

This kelp does not, like the other, grow from such considerable depths, but, like it, rises to the surface and there floats. The main stems are sometimes a foot in diameter.

The immense fields of kelp on the western coast will in time become a source of profit and revenue to those engaged in obtaining from them their valuable products. At present the want of facilities and scarcity of laborers forbid the attempt.

My experience on the western coast warrants the observation that kelp may be regarded as an indication of a rocky bottom. It is always present where sunken rocks exist, unless torn off by the violence of the weather.

The natural deduction from the fact is, that kelp, growing, should be avoided in general navigation.

In reference to facilities for carrying on the work of the Coast Survey on the western coast I may remark, that the whole of Washington and Oregon Territories may be described in few words as an almost impenetrable forest, the trees acquiring a great size and height, and guarded by a dense undergrowth, barring convenient passage alike to the Indian and the settler.

The rainy season commences in Oregon earlier than at the south, with heavy, soaking rains. At the mouth of the Columbia we had rain in summer, and, what was strange to us, thunder and lightning, which we experienced again only last summer in Rosario strait. The rainy season sets in about the middle of October, and continues until the end of April. The same may be said of Washington Territory, but perhaps the period of wet weather is even longer.

The triangulation of Washington can be carried on from Cape Flattery to the head of Puget's sound and to the 49th parallel, although I have yet found but one base site, and that of very moderate length.

Considering the reliable chart of Kellett, I think it advisable to work from Admiralty inlet up the sound, as this will afford the best means of finding a suitable base, and in another point of view it will commence the work where the population is first settling. The Straits of Fuca may be reconnoitred and signals and stations established, following with the triangulation, as might best answer in conjunction with the work laid out in Puget's sound.

The features of the shores require that the topography should be executed on the scale $\frac{1}{20000}$, working with a double party; a vessel being furnished, so as not to impede the triangulation, as the plane-table work cannot possibly keep pace with it. The chances and facilities for encamping are very few, and the practice would involve vexatious and unprofitable delay.

North from San Francisco, the triangulation can be carried on for a hundred miles without much interference from wooded mountains. North of Bodega the timber commences and increases in density and size as we proceed north, so that at Mendocino none of the hills are left bare. The woods are dense, and progress through them can be effected only by opening roads, or by falling into some Indian trail or deer path.

The woods descending to the ocean, renders it difficult to carry even a small triangulation along the coast. North of Mendocino and the Humboldt region, the country is one sea of timber of immense growth, and the undergrowth and fallen trees would sometimes make it impossible to convey a party beyond a mile in a day. After repeated attempts by a party of government troops with officers, and accompanied by a topographical engineer, the Oregon trail was reached from Port Orford, but not without great privation and hardships. Several contracts taken for the survey of sections near Mendocino have been thrown up, although closed at large prices, and the Surveyor General of Oregon attempted several lines from the Wallamut valley before he could force his way through to the Pacific.

The triangulation can be extended southward from San Francisco to meet that of the Santa Barbara channel. The hills are bare and very high. The elevated ridge back of Santa Barbara channel is sharp and precipitous, with no trails to the summit in the vicinity of Santa Barbara. I found it utterly impossible to gain the top in two trials. The gulches are filled with huge boulders and fragments of rock, and the sides covered with trees and undergrowth. Parties operating here would require camp equipage and full means of transportation by mules. The rainy season commences about the first of November, and ends in the middle of March. In some seasons, November and January are favorable for work, though as a general thing the attempt to work in winter will not warrant the outlay.

The islands in Santa Barbara channel are high and difficult of ascent, and present many obstacles to the triangulation of the channel. On some of the islands it will be necessary to duplicate the stations. Santa Catalina I estimate rises to the height of three thousand feet.

I would recommend the selection of points on the main, near the shore, but sufficiently elevated to admit of lines passing over not only the ordinary exhalations, but the fogs of the channel. In summer the fogs lie between the islands and the main, and coming in from seaward at sunset, frequently envelop the islands themselves. When the islands are not enveloped, their tops can be seen from elevated stations on shore. The rainy season begins between the middle of November and the first of December, and ends about the first of March. Frequent intervals favorable for work occur during the rainy season.

In summer it is impracticable to observe on lines running over plains, such as those near San Pedro, or shallow water.

Water is easily obtained at Prisoner's Harbor and at San Pedro, though it must be carted one or two miles to the landing. Some wood can be procured at Prisoner's Harbor, but it is not so scarce at Santa Barbara.

Water at the Coxo is not good, and wood and water from the St. Inez valley must be taken through the surf in supplying vessels.

Very respectfully,

GEORGE DAVIDSON,
Assistant Coast Survey.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey.

APPENDIX No. 27.

Extracts from letters addressed to the Superintendent by Lieutenant W. P. Trowbridge, U. S. Engineers, assistant in the Coast Survey, stating particulars relative to Bodega bay and its vicinity, and South Farallon island, California.

San Francisco, California, *December* 27, 1854.

Dear Sir: * * * * * * * *

Bodega bay occupies an important position, though it is quite shallow, excepting in the main channel.

Vessels generally lie about half a mile from the entrance, and receive the produce of the country in lighters. These are loaded at what is called the *port*, and from thence floated down to the vessels with the tide. The distance from the *port* to the anchorage is about a mile and a half.

The country in the vicinity of Bodega is very productive, both in the valleys and on the hills which border the bay. A tract of fine agricultural country stretches behind the hill range, extending north towards Russian river and Petaluma.

Riding from the bay towards the State prison, I was surprised at the extent and excellence of the agricultural lands.

Bodega bay must necessarily become an important shipping port for produce, though it is rapidly encroached on, and must ultimately present only a navigable creek, surrounded by marsh.

Large quantities of potatoes are raised in the neighborhood, and hauled to the *port* in wagons drawn by five or six pairs of oxen. This article (cultivated at Bodega) commands a high price in the San Francisco market, being esteemed above all raised elsewhere. Wheat, oats, and barley are also produced in great abundance. * * * * * *

May 28, 1855.

* * * It is difficult to imagine a more desolate and barren place than the South Farallon. It is the out-crop of an immense dyke of granite, which appears to run in the direction of the coast, cropping out again at Point Reyes and at Monterey. The island rises to the height of about three hundred feet, presenting to the eye a mass of broken and jagged rocks, on which no vegetation exists, excepting a few stunted weeds. The rocks present sharp angular

fragments, which, being detached by the operations of natural causes, roll down upon the level parts of the island, covering the ground with irregular boulders. The nature of the rock is such, that the whole could be separated into small fragments by a pick or crowbar.

The length of the island from east to west is nearly a mile, as will be seen by the map. (See Sketch J No. 5.)

The light-house stands on the highest peak near the north end, and the top of the tower is three hundred and thirty feet above high-water level.

* * * * * * * * *

Yours, respectfully,

W. P. TROWBRIDGE,
Lieut. U. S. Engineers, Assistant Coast Survey.

Prof. A. D. BACHE, *Superintendent.*

APPENDIX No. 28.

Extracts from the report of Sub-Assistant W. M. Johnson, relative to the features of Santa Cruz island, the valley of San Buenaventura, and the coast north of Santa Barbara channel.

UNITED STATES COAST SURVEY,
Camp Santa Clara river, California, October 1, 1855.

SIR: * * * * From Año Nuevo to the valley of the Pescador, the general formation of the country is that of a table-land of three terraces, the first or lowest gradually sloping from the foot of the second to the coast, which is exceedingly rocky and inhospitable looking, the underlying strata being sandstone. But a few acres of this part of the country is under cultivation, the remainder being exclusively devoted to the grazing of cattle, to which, from the abundance of water to be had at all seasons of the year, it is admirably suited.

In the valley of the Pescador there are about three square miles of fine arable land, all of which has been taken up by permanent settlers, who are amply rewarded for their labor by abundant harvests.

This valley is well watered by two large streams—the Pescador and Butno. At two miles from the mouth of the valley begins the forest of redwood peculiar to this State; the timber being so near the settlements, and in such abundance, is easily obtained at a small cost. In consequence of the great scarcity of this very necessary article in the larger portion of the State, attention will no doubt be directed to the resources of this valley, as the means of obtaining a supply at a small cost, both from its abundance and the facilities for getting it to market, as it could be transported to, and shipped from, Pigeon Point without difficulty.

The country between the valley of the Pescador and that of the San Gregoria undergoes a striking change, both in the character of its topography and geology; instead of the table-land, we here meet with a spur of the coast range running down to the sea, and no appearance of the sandstone can be found in the bluff, which varies in altitude from two to three hundred feet, and is intersected by a number of small valleys at "gulches" which take their rise in the mountains; all of which are dry during the summer months. These give the country a very broken and rugged appearance. This is also a fine grazing country.

Over this part there is no road except for empty wagons, the beach during the time of low water being made the highway for transporting produce.

From the San Gregoria to the Tunitas the country is of exactly the same character as that between the San Gregoria and Pescador.

The valley of the San Gregoria is small but fertile, and is watered throughout its whole extent by the stream of that name.

At the Tunitas my work on this part of the coast ends, having this creek as the northern boundary. Between the San Gregoria and Tunitas we found and determined one of the trigonometrical points, and also one about a mile north of the Tunitas.

The amount of work between the Tunitas and Point San Pedro yet to be completed is, according to a recent and very good map of San Francisco county, 19 miles of coast-line.

On the 7th of June we began work on the east end of Santa Cruz island, to fulfil your instructions of the 10th and 12th of March, by measuring a base and triangulating each way from it so as to be able, with this triangulation as a base, to determine three or more points on the island of Anacapa, 4½ miles distant.

This was the only way of making the survey with the desired minuteness and accuracy, from the fact that it was impossible to use the chain at all on the western part of the island, which is a solitary peak, 930 feet in altitude, standing on a base of 3,560 by 1,130 metres. On the north side of this peak there are several deep gulches with almost vertical sides, running from its apex to the bluff, which is from 250 to 300 feet above high water; on the south side the inclination is uniform from top to bottom.

The chain might have been used on the other parts of the island, but even there I doubt if we would have been able to make a connected survey. During the survey of Anacapa we were much delayed by fogs, which nearly enveloped the peak, on the top of which was one of my principal signals.

The survey of these islands was attended with no little personal risk. At Santa Cruz, where we were obliged to land on the sand and shingle beaches at the mouth of the "Gulches," the surf was oftentimes so heavy that even with the best management the boat would be swamped. On one of these occasions the cross-hairs in my alhidade were broken by the water getting into the tube before we could get ashore with it, although my men were always ready, instruments in hand, to jump and run as soon as the boat grounded; with this single exception, we escaped without any more serious consequences than a thorough drenching with salt water. At Anacapa our going ashore was attended with less difficulty and danger, as we were fortunate enough to find on the north side of each division of the island places where, by getting on the rocks, we could land with little risk. On the middle and eastern portions these landings are always good at this season, but the one on the west end is oftentimes difficult if not dangerous. This is owing to its being so near the west end of the peak, that it is exposed both to the heavy swell of the ocean and at the same time to the northwest winds. Thus a short chop sea is produced, in which it was oftentimes hard to prevent the boat from being thrown on the rocks.

On the south side of the island there is no place to land except through a very heavy surf.

Anacapa is a place of great resort for the seal, sea-lion, and formerly of the sea otter, but the latter have been all killed off for their fur.

During the time we were surveying at Anacapa there was a small vessel engaged in seal hunting. The party employed consisted of five men; they had erected try-works on the north side of the middle island, at the boat landing, and up to the time of landing had tried out eighty-five barrels of oil. Fish of many varieties abound in such numbers both here and at Santa Cruz, that two or three persons in a short time can load a boat.

The part of Santa Cruz surveyed is extremely ragged, barren, and entirely destitute of water, and the surface of the northeastern portion is thickly strewed with large angular pieces of stone, broken as if by a hammer. Several species of cactus and some of the coarser grasses flourish. The only animal found here is a small gray fox. The species is very numerous.

The foundation of this island, as well as that of Anacapa, is a coarse gray (almost black) sandstone, very rotten, and entirely unsuited for building. This formation is filled with innumerable cavities, which, at a little distance, give it the appearance of an old and blackened honeycomb.

The soil of Anacapa is loose and thin, producing only a stunted species of the cactus, together with a thick-leaved succulent plant common in the vicinity of the sea-coast and in dry, sandy localities. There is not a drop of water on this island. The east end of the island is a place of resort of countless numbers of sea-birds, which deposite their eggs and bring up their young in perfect security from the disturbance of man. I doubt very much whether previous to our arrival that part of the island had ever been visited by a white man. * * * The mission of San Buenaventura was founded in 1782. It is situated at the foot of the dividing ridge between the valleys of Santa Clara and San Buenaventura, about half a mile from the shore, which at this point makes a considerable sweep to the southward, forming a cove that is sufficiently protected from the northwest to make the landing during the summer safe, and I understand that southeast winds have but little effect in comparison with that produced at San Pedro and Santa Barbara.

Fifteen miles west of Buenaventura and immediately on the coast there is quite a rich mine of sulphur. Upon one occasion I visited this locality and found ashes, scoriae, and other indications of recent volcanic action. The ground was so hot as to be painful to the feet, and the gas emitted almost suffocating. Surface specimens which I brought away were found to contain sixty per cent. of pure sulphur. It is but very recently that smoke and flame are said to have been seen issuing from what is called the "*chimney*" in this locality. The mine is known to but few persons, and has not as yet been worked.

The valley of San Buenaventura is thoroughly irrigated by water from the river of the same name, which is carried to every part of it by means of ditches, and to this practice is in a great measure owing its astonishing fertility. Corn, tobacco, and all kinds of grain, fruits, and vegetables, grow to the greatest perfection. The valley of the Santa Clara at its mouth is about twenty miles wide, and through the middle flows the river Santa Clara, at this season of the year an insignificant stream, with but an inch or so of water in its channel; though after the rains of winter begin, it is from a mile to a mile and a quarter in width, and then has water enough to break through the narrow sand-beach at present separating it from the sea.

* * * * * * * * * * *

I have the honor to be, very respectfully, your obedient servant,

W. M. JOHNSON,
U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 29.

Letter of Commander James Alden, U. S. N., assistant in the Coast Survey, communicating information relative to the coast, harbors, and commerce of Washington Territory.

UNITED STATES COAST SURVEY STEAMER "ACTIVE,"
San Francisco, November 3, 1855.

DEAR SIR: Agreeably to your request, I will proceed to give you all the information I possess in regard to the coast, harbors, commerce, &c., of Washington Territory, commencing in the Gulf of Georgia, at Point Roberts, through which the 49th parallel of latitude (the northern boundary of the United States) passes. This point (Point Roberts,) coming down as it does from the north and parallel to the shore, forms a bay some seven or eight miles wide and as many deep. The upper or northern portion of it is dry at low water, but the bay affords good anchorage, except in the winter. The depth of water varies from two to eighteen fathoms. In the eastern extremity of this bay there is another small one, which is quite accessible and entirely land-locked. Just south of the last-named is Birch bay, where a good anchorage in four fathoms is found; but it is open to the westward, and exposed to gales in the winter time from that quarter. Five miles further south, and ten from our boundary, is the shoal discovered by us in 1853. It is in mid-channel, and has on it from five to nine fathoms water, thus affording anchorage to vessels which are often becalmed in that vicinity, and owing to the great depth of water elsewhere, compelled to drift about at the mercy of the tides. Near this point the Gulf of Georgia terminates by a group of islands, which are thickly studded from the main to Vancouver's island, and which also occupy, with their various channels, the space contained between that gulf and the straits of Juan de Fuca—a distance in a southerly direction of about twenty miles. The whole group covers an area of about four hundred (400) square miles.

The Gulf of Georgia and straits of Juan de Fuca are connected by two good ship-channels, called on the charts respectively Haro and Rosario straits; they are of sufficient width, and navigable for vessels of the largest class. The great depth of water presents a difficulty, but anchorages may be had for the most part, as the chart shows, at convenient distances along the shores. To the eastward, between Lummi island and the main, is another channel leading into Bellingham bay. At this point the settlements commence; and here also are found several veins of coal, or what would be more properly called "lignite." The Puget Sound Coal Mining Company have opened one vein, going into the bank, just above the level of the tide, some three hundred feet; but it has not as yet produced an article proper for steam purposes. It burns freely—so much so, that this vessel consumed it in a proportion of nearly three tons to one of good steam coal. The residuum, which is composed of clinker and ashes, amounts to more than one-half of the actual weight of coal put into the furnaces; still it is brought into market and used for domestic purposes at San Francisco, and brings, I am told, a remunerative price.

Bellingham bay opens into Rosario straits to the southward of Lummi island, which communicates with Deception Pass and the channel to the east of Whidbey's island. This pass is at the head of the straits of Juan de Fuca, and on the east side of the entrance to Rosario straits. It is very narrow and difficult for sailing-vessels, owing to the current, which, at certain stages of the tide, runs with great rapidity. Whidbey's island is thirty-five miles long, and averages three miles in width, and, from the number of settlers upon it, I should judge that the land was better for agricultural purposes than any other in that vicinity. It is for the most part prairie, and yields very abundantly.

Port Townshend is at the south entrance of Admiralty inlet, and seems to possess all the requisites of a central point. The present anchorage, under Point Hudson, where the settlement is, is somewhat exposed in the winter, but protection may be had on the opposite side or a little further up the bay.

Fifteen miles up Admiralty inlet, at the entrance of Hood's canal, on the west side, is Port Ludlow. The inner harbor, where there is eight fathoms water, is completely shut in by the land, and forms a perfect basin. The proprietor of the saw-mill which is established there, and his employés, together with a few Indians, are the only inhabitants.

Five or six miles further up the canal, on the opposite side, is Port Gamble, where there is also a fine harbor; but the entrance is more difficult than the last-named on account of the narrowness of the channel. Here, also, is a saw-mill, which is the largest in that section of the country, and here, too, there are no other settlers than those connected with the mill; nor am I aware that there are any whites on Hood's canal, except those employed in getting out logs for the mills.

The statement herewith enclosed (which was furnished me by Captain Pope, one of the proprietors of the mill at Port Gamble) will convey some idea of the amount invested and the immense resources of the country in that particular. Hertofore the lumber business has been very much overdone, and many of the mills are doing but little, while others have stopped. The difficulty of procuring labor during the past season has occasioned much embarrassment among operators. The recent discovery of gold at Fort Colville, near the northern confines of the Territory, has drawn off many of the laboring class, and some of the towns, even, are almost depopulated from the same cause, so that it is quite impossible to get at the number of individuals belonging to a village with any degree of accuracy. The whole number of votes cast at the last election of Delegate, &c., did not exceed fourteen hundred (1,400;) and I am told that, instead of an increase of the population, which should be expected, there is decidedly the reverse.

Passing up the inlet, twenty-five miles from the entrance to Hood's canal, is the village of Seattle. It is situated on the main land, and at the north side of Duwamish bay. Wide mud-flats extend out from the head of the bay nearly to the point on which the town is situated. Coal, similar to that at Bellingham bay, has been discovered some ten miles up the river. The water is too deep in the bay to anchor in, except near the shore. There is also a small settlement at the south part of the entrance, called "Alki."

The next town of any comparative importance is Steilacoom, which is just inside the entrance to Puget's sound, and twenty-seven miles from the last-named place. The fort, where there are stationed at present two companies of infantry, bears the same name, and is situated about one mile back from the landing, which is at the mouth of the river. The anchorage must be more or less exposed in the winter season, owing to the width of the sound at that point. Five miles further up is fort Nisqually, a station still belonging to the Hudson's Bay Company, from whence large quantities of furs are shipped annually. They also possess extensive sheep and cattle farms.

At the head of Budd's inlet, which is the head of navigation, is the flourishing town of Olympia, the seat of government. It is the largest and most important place in the Territory, but at the time when we were there, in July last, many of the inhabitants had gone to the mines, and I should judge that, like the other villages on the sound, its population is, for the most part, of a floating character. The anchorage is good, but owing to a broad flat which extends out from the town, the water does not deepen to three fathoms for nearly a mile and a half.

From Olympia (to retrace my steps) to the entrance of Admiralty inlet, where it opens into the straits of Juan de Fuca, the distance is eighty-five (85) miles. The inlet and the sound, formed by a great arm of the sea, varying from one to three miles in width, added to the straits of Juan de Fuca, which are from ten to twenty miles wide and eighty long, making in the aggregate an inland water communication from Olympia to the Pacific ocean of one hundred and sixty-five miles, with no hidden dangers, bold shores, and water enough for vessels of the largest class, would, I should think, attract the notice of some of our enterprising steamboat companies. One or two comfortable boats running regularly with mails, stopping at different points on the sound between Olympia and Victoria, a settlement of the Hudson's Bay Company on Vancouver's island, would in a short time build up a business that could not but be exceedingly remunerative. At present, the only means of communication to be obtained is through the assistance of Indians in canoes, or small sailing-vessels, which latter is at times the most tedious.

From Admiralty inlet, passing along the south shore of the straits of Juan de Fuca, the first harbors arrived at are Port Discovery and Washington Harbor. The former is perfectly accessible, while the latter has a difficult entrance and has not yet been examined by the Coast Survey; both, it would appear, are safe and commodious. Few or no regular settlers have yet made either of these points a permanent stopping-place. There are a few whites employed there temporarily, I am informed, getting out spars and timber. The anchorages at New and False Dungeness are formed by long, low sand-spits, extending out from the shore and curving gradually to the eastward. The best anchorage in the latter is near the south shore, the water being too deep for that purpose near the spit. There are no settlers found beyond this vicinity, which is about thirty miles from Admiralty inlet, nor are they met with again on the American side of the straits or on the coast, till you arrive at Shoal-water bay.

Near Callam bay, and twenty-five miles inside the straits, several seams of coal have been found, and from the specimens I saw I should think that it is far better than any other yet discovered in this range of country.

Nee-ah bay, which is just inside the straits, forms a tolerable temporary anchorage, but it is, even in summer, very uncomfortable, owing to the roll of the sea, which has a fair sweep into the bay. Much of that can be avoided, however, by anchoring close to the kelp on the west side.

Passing out of the straits, the only danger to be observed is Duncan's rock, which, however, as it is never covered by the tide, can generally be seen in time to be avoided. From Cape Flattery, the south point of the entrance of the straits to Point Grenville, the distance is seventy miles. The shore for the whole distance is for the most part lined with rocks. Flattery rocks are the most important; they are situated about twelve miles south of the cape, and extend out about three miles from the shore. The outer ledge is awash, with a safe passage inside of it. The others are not at any point more than a mile or a mile and a half from the shore. The reef off Destruction island extends out about one mile, and the outer point is three miles from the shore or main land. The anchorage under Point Grenville is only tolerable, even in summer, owing to the shoal water which forces a vessel, except of light draught, to anchor so far out that the point can afford but little protection.

Twenty-three miles from this point is Gray's harbor; it has not yet been examined by us, but I am informed that the entrance is bad, and the anchorage not to be depended upon, owing to the fact, that when the tide is out it is one broad mud-flat, interspersed with narrow channels too intricate for navigable purposes, except by steamers of a small class. The land, too, I am told, is not fit for agricultural purposes; and I should think this true, judging from the fact that there is not a settler in that vicinity.

Shoal-water bay comes next; it is about fifteen miles from the last-named place, and twenty-two to the northward of Cape Disappointment, (Columbia river.) There are two good channels leading into it, but, like Gray's harbor, it is full of channels and mud-flats; still there are many good channels among them, which are easily navigated by vessels of an ordinary size. The bay is from four to eight miles wide, and twenty-three in length. It heads up to the south within five miles of Baker's bay, in the Columbia river; that portion of it being for sixteen miles shut out from the sea by a narrow strip of land about one mile wide, which extends from the entrance to Cape Disappointment.

There are several streams running into the bay, and are of more or less importance. The settlers are for the most part on the Wallahpah river, where, I am informed, the best land is found. Those about the bay are generally employed in collecting oysters for the San Francisco market, where great quantities are being constantly sent. The enclosed statement will give you an idea of the value of that trade, and also the number of inhabitants in that vicinity.

This brings me in my report to the Columbia river, the north or right bank of which is the southern boundary of Washington Territory. I know but little in regard to the number of settlers, or amount of business in that quarter.

With great respect, I am your obedient servant,

JAMES ALDEN,

Lieut. U. S. N., Assistant U. S. Coast Survey.

Professor A. D. BACHE,

Superintendent U. S. Coast Survey, Washington.

Statement of the commerce of Shoalwater bay, Washington Territory, from 1849 *to December* 31, 1854, *communicated by Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey.*

Time.	Months.	Vessels arrived in the bay.					Tonnage.			Shipments.	Valuation.
		Steamers.	Barques.	Brigs.	Schooners.	Total.	Greatest.	Least.	Average.		
1849			*1		*1	2	250	180	215		
1850	12				2	2	100	80	90	2,800 bushels oysters	$16,800
January to April, 1851	4			*1	3	4	130	80	96	3,400 do	20,400
October to December, 1851	3				2	2	130	80	105	1,450 do	8,400
February to September, 1852	8	1		2	18	21	700	80	119	23,225 do 15,000 feet piles	133,530 1,300
November, 1852	1			1		1			200	5,000 do	1,000
January to September, 1853	9		8		10	18	300	70	150	90,000 do 14,900 bushels oysters	46,500 105,000
January to December, 1854	12		2		20	22	350	65	103	29,000 feet piles 28,350 bushels oysters	1,450 170,100
	49	1	11	4	56	72					504,480

* These vessels mistook the entrance of the bay for Columbia river.

Monthly average of valuation of shipments from Shoalwater bay, $10,295 50.

Population in 1855, 190 males and 60 females.

The above information was furnished by Capt. C. W. J. Russell, pioneer in that quarter.

Saw-mills situated on Puget's sound and Hood's canal, Washington Territory.

Where located.	Description.	Number of feet produced per 12 hours.	Remarks.
Three miles below Olympia	Steam-mill	10,000	Not yet completed.
South Bay	Water-mill	4,000	
Scookum	do	4,000	
Nisqually	do	4,000	
Steilacoom	do	4,000	
Do	do	4,000	
Do	do	4,000	
Do	do	4,000	
Seattle	Steam-mill	4,000	
Port Orchard	do	6,000	
Port Madison	do	8,000	
Port Ludlow	do	6,000	2 saws.
Snohomis river	Water-mill	4,000	1 saw.
Bellingham bay	do	4,000	1 saw.
Port Gamble	Steam-mill	25,000	With lath, shingle, and planing mill.
Olympia	3 water-mills	4,000	

In addition to the above list are several large mills in the southern part of Washington Territory. The lumber goes down the Columbia river.

The above information was furnished by W. C. Talbot, Esq.

APPENDIX No. 30.

Catalogue of sailing directions, list of dangers, &c.; prepared under the direction of the Superintendent for publication, as additional to the report of the present year.

The object of this compilation from the published records of the Coast Survey is to give important nautical information in regard to the positions of the coast already surveyed, or examined in the course of the operations of the survey, or for light-house purposes. The facts presented will be added to, from time to time, being made more complete as the work advances.

SECTION I.—COAST OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND.

1. *Noddle's island, Castine.*—Description of locality, dangers, &c.; sailing directions. (See Appendix C. S. report 1854, page 223.)

2. *Buck's harbor, Brookville.*—Description of. (See Appendix C. S. report 1852, page 139, Light-house.)

3. *Eggemoggin reach.*—Description of entrance to; sailing directions; dangers. (See Appendix C. S. report 1854, page 223, and sketch of reconnaissance of the eastern part of Eggemoggin reach, Maine, scale $\frac{1}{20000}$; published in 1854.)

4. *Isle au Haut Thoroughfare.*—Description of; dangers; light-house. (See Appendix C. S. report 1854, pages 223, 224, and sub-sketch of reconnaissance of the eastern part of Eggemoggin reach, Maine, scale $\frac{1}{20000}$; published in 1854.)

5. *Penobscot bay, Muscle Ridge channel.*—Sailing directions; dangers; light-houses. (See Appendix C. S. report 1852, pages 137, 138.)

6. *Tenant's harbor.*—Description of. (See Appendix C. S. report 1854, page 224.)

7. *Cape Small Point harbor.*—Description of. (See Appendix No. 78 C. S. report 1855.)

8. *Portland harbor.*—Description of the locality, the extent, and natural subdivisions of the harbor, &c.; sailing directions; list of dangers; light-houses; latitudes and longitudes of prominent points; magnetic variations; currents; remarks on tides. (See Appendix C. S. report 1855, and preliminary chart of Portland harbor, Maine, scale $\frac{1}{20000}$; published in 1854.)

9. *Alden's rock.*—Description of; bearings and distances; latitudes and longitudes; magnetic variation; description of rocks and dangers in the vicinity of Portland harbor, with the buoys marking them; sketch of Alden's rock, Portland, scale $\frac{1}{1000}$; published in 1853.

10. *Richmond's Island harbor.*—Sailing directions; dangers; description of harbor; latitudes and longitudes; variation of compass; currents; tides. (See chart of Richmond's Island harbor, scale $\frac{1}{20000}$; published in 1851.)

11. *Kennebunk Port.*—Description of dangers. (See Appendix No. 78 C. S. report 1855.)

12. *York River, and Cape Neddick harbors.*—Latitudes and longitudes; magnetic variation; tides. (See chart of York River and Cape Neddick harbors, coast of Maine, scale $\frac{1}{20000}$; published in 1854.)

13. *Portsmouth harbor.*—Sailing directions; dangers; light-house; latitudes and longitudes; magnetic variation; tides. (See preliminary chart of Portsmouth harbor, New Hampshire, scale $\frac{1}{20000}$; published in 1854.)

14. *Newburyport.*—Remarks on harbor; latitudes and longitudes; light-houses; magnetic variation; tides. (See chart of Newburyport harbor, scale $\frac{1}{20000}$; published in 1855.)

15. *Ipswich.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; tides.

16. *Annisquam.*—Sailing directions; light-house; latitudes and longitudes; magnetic variation; tides.

17. *Gloucester harbor.*—Sailing directions; dangers; light-houses; latitudes and longitudes;

magnetic variation; tides. (See preliminary chart of Gloucester harbor, scale $\frac{1}{20000}$; published in 1854.)

18. *Salem harbor.*—Sailing directions; dangers; light-houses; latitudes and longitudes; magnetic variation; currents; tides. (See chart of Salem harbor, Massachusetts, scale $\frac{1}{25000}$; published in 1855.)

19. MASSACHUSETTS BAY. *Stellwagen's bank.*—Description of position and character; buoys marking it; bearings and distances. (See preliminary chart of Stellwagen's bank, Massachusetts bay, discovered in October, 1854, scale $\frac{1}{400000}$; published in 1854, and report of Superintendent of Coast Survey, Appendix No. 9, p. 17.)

20. *Minot's ledge, off Boston harbor.*—Bearings and distances; light-vessel. (See chart of Minot's ledge, scale $\frac{1}{10000}$; published in 1853.)

21. *Boston harbor.*—Sailing directions; dangers; light-houses; latitudes and longitudes; magnetic variation; currents; tides.

22. *Plymouth harbor.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; tides. (See preliminary chart of Plymouth harbor, scale $\frac{1}{20000}$; published in 1854.)

23. *Wellfleet harbor.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; currents; tides. (See chart of Wellfleet harbor, scale $\frac{1}{30000}$; published in 1853.)

24. *Monomoy shoals.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; currents; tides. (See preliminary chart of Monomoy shoals, scale $\frac{1}{40000}$; published in 1854.)

25. *Bass River harbor, Massachusetts.*—Description of anchorage; sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of Bass River harbor, scale $\frac{1}{40000}$; published in 1855.)

26. *Harbor of Hyannis.*—Sailing directions; dangers; light-houses; latitudes and longitudes; magnetic variation; currents; tides. (See chart of harbor of Hyannis, scale $\frac{1}{30000}$; published in 1850.)

27. *Nantucket harbor.*—Sailing directions; light-houses and beacons; latitudes and longitudes; magnetic variation; tides. (See chart of Nantucket harbor, scale $\frac{1}{20000}$; published in 1848.)

28. *Edgartown harbor.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; tides. (See chart of Edgartown harbor, Massachusetts, scale $\frac{1}{20000}$; published in 1848.)

29. *The harbor of Holmes' Hole.*—Sailing directions; light-houses and beacons; latitudes and longitudes; magnetic variation; tides. (See chart of Holmes' Hole harbor, scale $\frac{1}{20000}$; published in 1847.)

30. *Tarpaulin cove.*—Sailing directions; light-house; latitudes and longitudes; magnetic variation; tides. (See chart of Tarpaulin cove, scale $\frac{1}{20000}$; published in 1847.)

31. *Nantucket shoals.*—Bearings and distances; light-houses and light-boat; latitudes and longitudes; discussion of the currents; tides. (See preliminary chart of Nantucket shoals, scale $\frac{1}{200000}$; published in 1854.)

32. *Muskeget channel.*—Sailing directions; light-house; latitudes and longitudes; magnetic variation; remarks on currents; tides. (See preliminary chart of Muskeget channel, scale $\frac{1}{60000}$; published in 1854.)

33. *New Bedford harbor.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; tides. (See preliminary chart of New Bedford harbor, scale $\frac{1}{40000}$; published in 1850.)

SECTION II.—COAST OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE.

34. *Long Island sound.*—Sailing directions; list of dangers; latitudes and longitudes; variation of the magnetic needle at different points; currents; tides; light-houses. (See chart of Long Island sound, 3 sheets, scale $\frac{1}{80000}$; published in 1855.)

35. *Fisher's Island sound.*—Sailing directions; dangers; light-houses; latitudes and longitudes; magnetic variation; currents; tides. (See chart of Fisher's Island sound, scale $\frac{1}{40000}$; re-published in 1847.)

36. *Harbor of New London.*—Sailing directions; dangers; light-houses; latitudes and longitudes; magnetic variation; tides. (See chart of New London harbor, scale $\frac{1}{20000}$; published in 1848.)

37. *New Haven Harbor.*—Sailing directions; light-houses; latitude and longitude; magnetic variation; tides. (See chart of New Haven harbor, scale $\frac{1}{30000}$; published in 1846.)

38. *Mouth of Connecticut river.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of the mouth of Connecticut river, scale $\frac{1}{20000}$; published in 1853.)

39. *Harbors of Black Rock, and Bridgeport.*—Sailing directions; light-houses; latitude and longitude; magnetic variation; tides. (See chart of Black Rock and Bridgeport, scale $\frac{1}{20000}$; published in 1848.)

40. *Huntington bay.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of Huntington bay, scale $\frac{1}{30000}$; published in 1849.)

41. *Harbors of Sheffield island, and Cawkin's island.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; tides. (See chart of Sheffield Island and Cawkin's Island harbors, scale $\frac{1}{20000}$; published in 1848.)

42. *Oyster bay or Syosset harbor.*—Sailing directions; latitudes and longitudes; magnetic variation; tides. (See chart of Oyster or Syosset bay, scale $\frac{1}{30000}$; published in 1847.)

43. *Harbors of Captain's island east, and Captain's island west.*—Sailing directions; dangers; light-house; latitude and longitude; magnetic variation; tides. (See chart of Captain's island east and Captain's island west, scale $\frac{1}{20000}$; published in 1849.)

44. *Sachem's Head harbor.*—Sailing directions; dangers; latitude and longitude; magnetic variation; tides. (See chart of Sachem's Head harbor, scale $\frac{1}{10000}$; published in 1851.)

45. *Hart and City islands.*—Sailing directions; latitude and longitude; magnetic variation; tides. (See chart of Hart and City islands, scale $\frac{1}{20000}$; published in 1851.)

46. *New York bay, harbor, and environs.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; currents; tides. (See chart of New York bay, and harbor, and environs, scale $\frac{1}{80000}$; published in 1845.)

47. *Hell Gate and its approaches.*—Sailing directions; latitude and longitude; magnetic variation; currents; tides. (See chart of Hell Gate and its approaches, scale $\frac{1}{5000}$; published in 1851.)

48. *Buttermilk channel.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of Buttermilk channel, $\frac{1}{5000}$; published in 1849.)

49. *From Gay Head to Cape Henlopen.*—Sailing directions for the approaches to New York and Delaware bay; description of bottom along the coast; dangers; light-houses and light-boats; magnetic variation; tides. (See chart of the coast from Gay Head to Cape Henlopen, scale $\frac{1}{400000}$; published in 1852.)

50. *Little Egg harbor.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of Little Egg harbor, scale $\frac{1}{30000}$; published in 1846.)

51. *Delaware bay and river.*—Sailing directions; dangers, *outside* and *inside* the Capes; light-houses, light-boats, and buoys; latitudes and longitudes; magnetic variations; currents; tides. (See three charts of Delaware bay and river, scale $\frac{1}{80000}$; published in 1848.)

SECTION III.—COAST OF DELAWARE, MARYLAND, AND VIRGINIA.

52. *Seacoast of Delaware, Maryland, and part of Virginia.*—Dangers; light-house; latitude and longitude; magnetic variation; tides. (See chart of seacoast of Delaware, Maryland, and part of Virginia, scale $\frac{1}{200000}$; published in 1852.)

53. *Chincoteague inlet, and shoals in the vicinity.*—Sailing directions; dangers; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of Chincoteague inlet, scale $\frac{1}{40000}$; published in 1852.)

54. *Entrance to Chesapeake bay.*—Sailing directions for approaching and entering; dangers; light-houses; latitudes and longitudes; magnetic variation; tides. (See chart of reconnaissance of the entrance to Chesapeake bay, scale $\frac{1}{100000}$; published in 1851.)

55. *Pungoteague creek.*—Light-house; latitude and longitude; magnetic variation. (See preliminary chart of Pungoteague creek, scale $\frac{1}{40000}$; published in 1853.)

56. *Ship and Sand Shoal inlet.*—Light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of Ship and Sand Shoal inlet, scale $\frac{1}{40000}$; published in 1854.)

57. *Cherrystone inlet.*—Light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of Cherrystone inlet, scale $\frac{1}{40000}$; published in 1853.)

58. *Harbor of Annapolis.*—Sailing directions; light-house; latitude and longitude; magnetic variation; currents; tides. (See chart of Annapolis harbor, scale $\frac{1}{60000}$; published in 1849.)

59. *Patapsco river.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; tides. (See chart of the Patapsco river and the approaches, scale $\frac{1}{60000}$; published in 1849.)

SECTION IV.—FROM CAPE HENRY TO CAPE FEAR, INCLUDING PART OF VIRGINIA AND NORTH CAROLINA.

60. *Albemarle sound.*—Sailing directions; light-house and light-boats; latitudes and longitudes; magnetic variation; tides.

61. *Pasquotank river.*—Sailing directions; light-boat; latitude and longitude; magnetic variation. (See chart of Pasquotank river, North Carolina, scale $\frac{1}{60000}$; published in 1850.)

62. *Hatteras shoals.*—Sailing directions for the channels through the shoals; light-houses; latitude and longitude; magnetic variation; tides. (See preliminary chart of Hatteras shoals, scale $\frac{1}{120000}$; published in 1850.)

63. *Hatteras inlet.*—Sailing directions; light-house; latitude and longitude; magnetic variation; currents; tides. (See reconnaissance chart of Hatteras inlet, scale $\frac{1}{20000}$; published in 1853.)

64. *Ocracoke inlet.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of Ocracoke inlet, North Carolina, scale $\frac{1}{40000}$; published in 1852.)

65. *New river and bar.*—Remarks on the character of the bar; latitude and longitude; remarks on currents and tides. (See chart of reconnaissance of New river and bar, scale $\frac{1}{10000}$; published in 1852.)

66. *Beaufort harbor, North Carolina.*—Sailing directions; light-house and beacons; latitude and longitude; magnetic variation; currents; tides. (See preliminary chart of Beaufort, North Carolina, scale $\frac{1}{20000}$; published in 1854.)

67. *Frying-Pan shoals, and Cape Fear river.*—Sailing directions; light-house and light-vessel; latitude and longitude; magnetic variation; currents; tides. (See chart of Frying-Pan shoals and Cape Fear river, scale $\frac{1}{120000}$; published in 1851.)

68. *Cape Fear river, and New inlet, North Carolina.*—Sailing directions; light-house and light-boat; latitude and longitude; magnetic variation; currents; tides. (See chart of entrance to Cape Fear river and New inlet, North Carolina, scale $\frac{1}{40000}$; published in 1853.)

SECTION V.—FROM CAPE FEAR TO THE ST. MARY'S RIVER, INCLUDING THE COASTS OF SOUTH CAROLINA AND GEORGIA.

69. *Winyah bay, and Cape Roman shoals, South Carolina.*—Sailing directions; remarks on the character of the shoals; light-houses; latitude and longitude; magnetic variation; tides. (See preliminary chart of Winyah bay, and Cape Roman shoals, South Carolina, scale $\frac{1}{100000}$; published in 1854.)

70. *Cape Roman shoals.*—Sailing directions; light-house; latitude and longitude; magnetic

variation; tides. (See preliminary chart of Cape Roman shoals, scale $\frac{1}{100000}$; published in 1853.)

71. *Bull's bay.*—Sailing directions; light-house; latitude and longitude; remarks on currents; tides. (See chart of Bull's bay, South Carolina, scale $\frac{1}{40000}$; published in 1851.)

72. *Charleston harbor, South Carolina.*—Sailing directions; light-houses; beacons and buoys; latitude and longitude; magnetic variation; currents; tides. (See chart of Charleston harbor, South Carolina, scale $\frac{1}{30000}$; published in 1855.)

73. *Maffitt's channel, Charleston harbor.*—Sailing directions; currents. (See comparison chart of Maffitt's channel, scale $\frac{1}{5000}$; published in 1854.)

74. *North Edisto river.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of North Edisto river, scale $\frac{1}{50000}$; published in 1853.)

75. *Port Royal entrance, Beaufort harbor, South Carolina.*—Sailing directions; light-vessel; latitude and longitude; magnetic variation; currents; tides. (See chart of reconnaissance of Port Royal entrance, and Beaufort river, scale $\frac{1}{60000}$; published in 1855.)

76. *Entrance to Savannah river, Georgia.*—Sailing directions; light-houses and beacons; latitude and longitude; magnetic variation; currents; tides. (See chart of entrance to Savannah river, Georgia, scale $\frac{1}{30000}$; published in 1851.)

77. *Savannah river. Reconnaissance of the approaches to the city of Savannah, including Front and Back rivers.*—Sailing directions; light-houses and beacons; latitudes and longitudes; magnetic variation; currents; tides. (See chart of Savannah river. Reconnaissance of the approaches to the city of Savannah, including Front and Back rivers, scale $\frac{1}{20000}$; published in 1851.)

78. *Savannah bar, and entrance to Calibogue sound.*—Sailing directions; light-houses; latitudes and longitudes; magnetic variation; currents; tides. (See chart of Savannah bar, and entrance to Calibogue sound, scale $\frac{1}{20000}$.)

79. *Doboy bar and inlet, Georgia.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of reconnaissance of Doboy bar and inlet, scale $\frac{1}{40000}$; published in 1855.)

80. *St. Andrew's shoals, at the entrance to St. Andrew's sound, Georgia.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of St. Andrew's shoals, at the entrance to St. Andrew's sound, Georgia, scale $\frac{1}{60000}$; published in 1850.)

SECTION VI.—FROM ST. MARY'S RIVER TO ST. JOSEPH'S BAY, COAST OF FLORIDA, INCLUDING THE FLORIDA REEFS AND KEYS.

81. *Entrance to St. John's river, Florida.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of entrance to St. John's river, Florida, scale $\frac{1}{25000}$; published in 1853.)

82. *Mosquito inlet.*—Remarks on bar; latitude and longitude; tides. (See chart of reconnaissance of Mosquito inlet, $\frac{1}{40000}$; published in 1851.)

83. *Cape Canaveral shoals, eastern coast of Florida.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of Cape Canaveral shoals, scale $\frac{1}{60000}$; published in 1850.)

84. *Turtle harbor, Florida reefs.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of Turtle harbor, Florida reefs, scale $\frac{1}{40000}$; published in 1854.)

85. *Key Biscayne and Card's sound.*—Light-house; latitude and longitude; magnetic variation; tides.

86. *Coffin's Patches, Florida reefs.*—Bearings and distances; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of Coffin's Patches, Florida reefs, scale $\frac{1}{20000}$; published in 1854.)

87. *Key West harbor, and its approaches.*—Sailing directions; light-houses and beacons;

latitudes and longitudes; magnetic variation; currents; tides. (See chart of Key West harbor and its approaches, scale $\frac{1}{50000}$; published in 1855.)

88. *Sketch of a general reconnaissance of the coast of Florida.*—Sailing directions for several passes between keys; light-houses; latitudes and longitudes; magnetic variations; tides. (See preliminary chart of a general reconnaissance of the coast of Florida, scale $\frac{1}{1200000}$; published in 1854.)

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

89. *Cedar keys, and approaches.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary charts of Cedar keys and approaches, and of channel No. 4, Cedar keys; scale of Cedar keys chart $\frac{1}{50000}$; published in 1854; scale of chart of Channel No. IV, $\frac{1}{30000}$; published in 1852.)

90. *Ocilla River entrance.*—Description of; latitude and longitude; magnetic variation; tides. (See chart of Ocilla River entrance, scale $\frac{1}{20000}$; published in 1855.)

91. *Bar and channel of St. Mark's.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of reconnaissance of the bar and channel of St. Mark's, Florida, scale $\frac{1}{40000}$; published in 1852.)

92. *Middle or main and west entrance to St. George's sound, Florida.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of middle or main, and west entrance to St. George's sound, scale $\frac{1}{80000}$; published in 1853.)

SECTION VIII.—FROM MOBILE POINT TO VERMILION BAY, INCLUDING THE COAST OF MISSISSIPPI AND PART OF LOUISIANA.

93. *Entrance to Mobile bay.*—Sailing directions; dangers; light-houses and beacons; latitudes and longitudes; magnetic variation; currents; tides; remarks on prevailing winds. (See chart of entrance to Mobile bay, scale $\frac{1}{40000}$; published in 1851.)

94. *Mobile bay.*—Sailing directions; light-houses and beacons; latitudes and longitudes; magnetic variation; remarks on currents and tides. (See preliminary chart of Mobile bay, scale $\frac{1}{2000000}$; published in 1852.)

95. *Entrance to Pascagoula river, Mississippi.*—Light-house; latitude and longitude; magnetic variation; remarks on tides; scale $\frac{1}{20000}$; published in 1853.

96. *Horn Island pass, Mississippi sound.*—Sailing directions; ranges and bearings; dangers; light-house; latitude and longitude; magnetic variation; remarks on tides. (See chart of Horn Island pass, Mississippi sound, scale $\frac{1}{40000}$; published in 1853.)

97. *Cat and Ship Island harbors.*—Sailing directions; dangers; remarks on the localities; ranges; light-houses; latitudes and longitudes; tides; remarks on winds. (See charts of Cat and Ship Island harbors, scale $\frac{1}{40000}$; published in 1850.)

98. *Harbor of Pass Christian, Mississippi sound.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of harbor of Pass Christian, Mississippi sound, scale $\frac{1}{40000}$; published in 1851.)

99. *Delta of the Mississippi, Louisiana.*—Sailing direction for the different passes; remarks; light-houses; latitudes and longitudes; magnetic variation; tides. (See chart of passes, Delta of the Mississippi, Louisiana, scale $\frac{1}{60000}$; published in 1852.)

100. *Entrance to Barataria bay.*—Sailing directions; remarks; latitude and longitude; magnetic variation; tides. (See preliminary chart of the entrance to Barataria bay, Louisiana, scale $\frac{1}{80000}$; published in 1853.)

101. *Pass Fourchon, Louisiana.*—Sailing directions; latitude and longitude; magnetic variation; tides. (See chart of pass Fourchon, Louisiana, scale $\frac{1}{10000}$; published in 1854.)

102. *Entrance to Timballier bay.*—Sailing directions; latitude and longitude; magnetic va-

riation; remarks on tides. (See preliminary chart of entrance to Timballier bay, scale $\frac{1}{200000}$; published in 1853.)

103. *Ship Island shoal.*—Sailing directions; dangers; light-vessel; latitude and longitude; magnetic variation; remarks on currents and tides. (See preliminary chart of Ship Island shoal, scale $\frac{1}{80000}$; published in 1853.)

SECTION IX.—FROM VERMILION BAY TO THE BOUNDARY, INCLUDING PART OF THE COAST OF LOUISIANA AND THAT OF TEXAS.

104. *Sabine pass, Texas.*—Sailing directions; latitude and longitude; magnetic variation; tides. (See chart of Sabine pass, Texas, scale $\frac{1}{400000}$; published in 1853.)

105. *Galveston bay, and entrance, Texas.*—Sailing directions; light-house and light-vessel; dangers; latitude and longitude; magnetic variation; remarks on tides. (See preliminary chart of Galveston entrance, scale $\frac{1}{40000}$; published in 1853.)

106. *San Luis pass, Texas.*—Sailing directions; latitude and longitude; magnetic variation; tides. (See preliminary chart of San Luis pass, Texas, scale $\frac{1}{200000}$; published in 1853.)

107. *Aransas pass, Texas.*—Sailing directions; latitude and longitude; magnetic variation; tides. (See preliminary chart of Aransas pass, Texas, scale $\frac{1}{20000}$; published in 1853.)

108.—*Entrance to the Rio Grande.*—Latitude and longitude; tides; magnetic variation. (See preliminary survey of entrance to the Rio Grande, scale $\frac{1}{20000}$; published in 1854.)

SECTIONS X AND XI.—COAST OF CALIFORNIA; OREGON AND WASHINGTON TERRITORIES.

109. *From San Francisco to Umpquah river.*—Sailing directions; remarks on the harbors; light-houses; latitudes and longitudes; magnetic variation; tides. (See chart of western coast of United States, middle sheet, from San Francisco to Umpquah river, scale $\frac{1}{1200000}$; published in 1854.)

110. *From San Francisco to San Diego.*—Sailing directions and dangers; light-house; latitudes and longitudes; magnetic variation; tides. (See chart of western coast, from San Francisco to San Diego, scale $\frac{1}{1200000}$; published in 1853.)

111. *Western coast of the United States, from Monterey to Columbia river.*—Sailing directions; light-houses; magnetic variation. (See chart of the western coast of the United States, from Monterey to Columbia river, in three sheets; published in 1851.)

112. *San Diego entrance, and approaches, California.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of San Diego entrance, scale $\frac{1}{25000}$; published in 1853.)

113. *Catalina harbor.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See chart of Catalina harbor, and the anchorage on the northeast side of the island, scale $\frac{1}{15000}$; published in 1852.)

114. *San Pedro.*—Sailing directions; latitude and longitude. (See chart of reconnaissance of San Pedro harbor, scale $\frac{1}{30000}$; published in 1852.)

115. *San Clemente, Prisoner's and Cuyler's harbors.*—Sailing directions; latitude and longitude; magnetic variation. (See preliminary chart of San Clemente harbor, Prisoner's harbor, and Cuyler's harbor, island of San Miguel, California, scale $\frac{1}{20000}$; published in 1852.)

116. *Santa Barbara harbor.*—Remarks on the character of the harbor; latitude and longitude; magnetic variation. (See preliminary chart of Santa Barbara, California, scale $\frac{1}{20000}$; published in 1853.)

117. *Santa Cruz, San Simeon, Coxo, and San Luis Obispo harbors.*—Sailing directions; light-house; latitude and longitude; magnetic variation. (See chart of reconnaissance of the harbors of Santa Cruz, San Simeon, Coxo, and San Luis Obispo, California; scale of San Simeon and Santa Cruz, $\frac{1}{20000}$; scale of Coxo and San Luis Obispo, $\frac{1}{40000}$; published in 1852.)

118. *Monterey harbor.*—Sailing directions; light-house; latitude and longitude; magnetic variation. (See chart of Monterey harbor, scale $\frac{1}{40000}$; published in 1852.)

119. *Santa Cruz.*—Latitude and longitude; magnetic variation; tides. (See preliminary survey of Santa Cruz harbor, scale $\frac{1}{40000}$; published in 1854.)

120. *Point Año Nuevo.*—General remarks. (See preliminary survey of Point Año Nuevo anchorage, scale $\frac{1}{40000}$; published in 1854.)

121. *San Francisco and its vicinity.*—Dangers; latitudes and longitudes; magnetic variation; tides. (See chart of city of San Francisco and its vicinity, scale $\frac{1}{10000}$; published in 1852.)

122. *Humboldt bay.*—Sailing directions; light-house and beacon; latitude and longitude; magnetic variation; tides. (See preliminary chart of Humboldt bay, scale $\frac{1}{30000}$; published in 1851.)

123. *Port Orford and Ewing harbor, harbor of Mendocino City, Shelter cove, and Crescent City harbor.*—Sailing directions; latitude and longitude; magnetic variation; tides. (See preliminary chart of harbors on the western coast of the United States, scale $\frac{1}{20000}$; published in 1854.)

124. *Umpquah river, entrance to.*—Sailing directions; latitude and longitude; magnetic variation. (See preliminary chart of Umpquah river, Oregon, scale $\frac{1}{20000}$; published in 1854.)

125. *Columbia river.*—Sailing directions; light-house; latitude and longitude; magnetic variation; tides. (See preliminary chart of entrance to Columbia river, Oregon, scale $\frac{1}{40000}$; published in 1852.)

126. *Smith's or Blunt's island.*—Latitude and longitude; magnetic variation. (See chart of reconnaissance of Smith's or Blunt's island, Washington Territory, scale $\frac{1}{20000}$; published in 1854.)

127. *Grenville harbor.*—Latitude and longitude; magnetic variation. (See chart of reconnaissance of Grenville harbor, Washington Territory, scale $\frac{1}{20000}$; published in 1854.)

128. *Cape Flattery and Nee-ah harbor.*—Sailing directions; latitude and longitude; magnetic variation. (See preliminary chart of Cape Flattery and Nee-ah harbor, scale $\frac{1}{40000}$; published in 1853.)

129. *Shoalwater bay.*—Sailing directions; latitude and longitude; magnetic variation. (See preliminary chart of Shoalwater bay, Washington Territory, scale $\frac{1}{80000}$; published in 1853.)

130. *False Dungeness.*—Sailing directions; latitude and longitude; magnetic variation. (See chart of False Dungeness, scale $\frac{1}{30000}$; published in 1853.)

131. *Port Townsend.*—Latitude and longitude; magnetic variation. (See chart of reconnaissance of Port Townsend harbor, Washington Territory, scale $\frac{1}{40000}$; published in 1854.)

132. *Duwamish bay.*—Latitude and longitude; magnetic variation. (See chart of reconnaissance of Duwamish bay, Washington Territory, scale $\frac{1}{400000}$; published in 1854.)

133. *Canal de Haro and Straits of Rosario.*—Latitude and longitude; magnetic variation. (See chart of Canal de Haro and Straits of Rosario, and approaches, scale $\frac{1}{200000}$; published in 1854.)

APPENDIX No. 31.

Report of Portland Harbor Commission.

The Commission organized by the city of Portland for the purpose of obtaining a plan for regulating, permanently, the line of construction of Portland harbor, and for the general preservation and improvement of the channels and harbor accommodations, met at Portland on Friday evening, October 6, and, after as careful and mature an examination of the subject submitted to it, as the limited time would allow, it is now prepared to report upon one branch of its inquiries.

The information which the Commission has obtained from various sources—as, for example, from the comparison of maps of different dates, from gentlemen who are well acquainted with the former and present conditions of the harbor, and from personal observations; the interrogatories which have been put to the Commission, both by gentlemen actually engaged in the prosecution of great enterprises, and by those who have them in contemplation; the nature itself of the subject, involving as it does the application of some of the most important principles of engineering in tidal harbors;—all combine to render it impossible that the Commission should furnish at present a full and final report of its opinions. Indeed, these opinions must be guided by further observations. The information already acquired has shown the necessity for instituting a systematic investigation into the course and velocity of the tidal currents in the harbor and its approaches.

It is also desirable that the members of the Commission should be able to confer with each other more deliberately than their present occupations will allow. If the knowledge already collected, and that which is yet to be added, be properly arranged and digested, the report of the Commission may be hereafter referred to as a useful compilation of facts and opinions.

The results of the comparisons between the old and new maps of the harbor should be stated in detail. The capacity of the harbor at high and low water, and the condition and area of the reservoirs, should be given. The principle on which the conservation of the inner basin rests, and the circumstances under which this basin may be made most effectually to perform its office of keeping the channel open, ought to be defined, and some analysis should be presented of the mode in which the tidal waters are distributed during the periods of ebb and flood. It will be interesting also to consider the effect of the breakwater upon the bar, the middle ground, and the channel inside of the middle ground; to point out the effect of the extension of several of the wharves, and by this means to arrive at some general conclusions which may at least have the effect of preventing future injury.

In addition to this summation of general principles, and of the results of previous experience, the Commission attaches great importance to a consideration of the future prospects of the city. The opening of new and extensive lines of railroad communication, the direct intercourse with Europe by the use of steam, and the interchanges arising from the ratification of the reciprocity treaty, concur at this moment to create a new era in the commercial history of Portland. It would not be satisfactory, either to the Commission itself or to the authorities by which it has been convened, to limit its views and recommendations to existing necessities. It entertains the hope that, with suitable study and reflection, it may be able to furnish a plan simple in its principles and admitting of a uniform extension, such as will meet the wants of an increasing commerce, and provide a safe and convenient accommodation for a large amount of shipping. This plan has yet to be matured; it has to be drawn out in an intelligible form; and it is to be accompanied by a full explanation of the reasons which govern the Commission in its adoption.

With the foregoing views the Commission has decided to divide its report into two parts, in accordance with the suggestion contained in the instructions of the committee: one part to consist of a recommendation in reference to the line which will form the limit of construction on the north side of the harbor; the second part to consist of a detailed statement of all the information concerning the harbor which has been gained by the study of maps and otherwise, of a comprehensive plan of improvement, and of the views and principles upon which the plan is based.

The Commission will proceed, therefore, at once to the description of what it conceives to be the best limit of construction, and to the recommendation of certain rules of conduct which cannot, as it thinks, be too early adopted or too rigidly enforced.

In this description reference is had to the wharves as now existing, (October, 1854,) and as defined on the Coast Survey topographical sheet executed by Alexander W. Longfellow, Esq.: commencing at the eastern corner of the gas company's wharf, next above the Portland bridge, in a straight line to the southern corner of the end of Robinson's wharf, and along the end of it to the eastern corner; thence, in a straight line, to the southern corner of the end of Central wharf, and along the end of it to the eastern corner; thence, in a straight line, to the southern corner of the end of Custom-house wharf, and along the end of it to the eastern corner; thence, in a straight line, to the southern corner of the end of Railway wharf, and along the end of it to the eastern corner; thence, in a straight line, to the southern corner of the end of St. Lawrence wharf, and along the end of it to the eastern corner; thence, parallel to the straigh portion of the outside railroad track, to the shoals to the southward of Fish Point.

And moreover, the Commission recommends that, if any wharf be constructed to the eastward of St. Lawrence wharf, over the deep water inside of the middle ground, the party constructing it be required to dredge a channel through the middle ground one hundred and fifty feet wide, and to a depth not less than that of the passage leading to the deep water, which depth is now thirteen feet.

The Commission has decided not to draw the line at present, either above the gas company's wharf or below Fish Point.

It will be observed that this harbor line cuts off a portion of Smith's, Brown's, and Union wharves. The Commission has no wish, even if it had the power, to interfere with the established rights of private property. It lays down a line which, in its opinion, is best suited to preserve the channel; but it remains with the city government to determine whether these wharves shall be suffered to remain as they are. There can be no doubt that the extension of those wharves is positively injurious to the harbor, and, conversely, that it would be beneficial to the harbor if the projecting extremities of those wharves were removed. If they are suffered to remain, the owners should be required to maintain, by dredging, the present depth of water as far in as the Commissioners' line. In addition to the above the Commission recommends:

1. That dredging be constantly employed in the slips, and at the extremities of the wharves wherever it is necessary. Although the harbor of Portland is a commodious one, still its capacity is not such as to admit of the neglect of this easy means of preserving its usefulness. Owing to the very soft character of the mud, dredging can be done at a very little expense; and it is to be remembered that the natural advantages of a harbor, like other natural advantages, are only to be preserved and enjoyed through constant care and attention.

2. The Commission recommends that the basin above Portland bridge, known as "Fore river," or "Stroudwater," be jealously kept from encroachment. The existence of Portland harbor is entirely due to this inner basin. If the latter is diminished, the former will suffer in a corresponding degree. This opinion is given without any qualification. Although the Commission is fully aware that improvements might be made in this basin, which, while they served some other valuable purpose, would also increase its scouring power, still, such improvements could only be safely conducted under the superintendence of a competent engineer. If any such alterations are proposed, they ought to be carefully examined and subjected to rigorous conditions. In the present state of things, however, any invasion of the tidal waters above Portland bridge will be attended with danger.

3. The Commission suggests the propriety of obtaining, from the legislature of the State, a law which will vest in the city of Portland authority to remove constructions extending beyond the Commissioners' line, and also exclusive control over all the interior waters which form the natural reservoirs of Portland harbor.

JOS. G. TOTTEN.
A. D. BACHE.
CHARLES HENRY DAVIS.

Second report of the Commissioners on Portland harbor.

In the first report which the Commissioners had the honor to present to the city of Portland, they were compelled, by want of time, to limit themselves to those views and recommendations which, as they were informed, would receive immediate application.

In that report it was stated that materials had been collected, through the kind offices of the mayor and officers of the city government, from intercourse with well-informed citizens, and by a study of the maps of Portland harbor, for a more elaborate and comprehensive communication;

and it was also suggested that the consultation of the Commissioners had led to the conception of a general plan for the preservation and improvement of the harbor. The first report having been designed to meet special exigencies, it does not appear necessary to make any particular references to it in this place. The Commissioners propose to give to the present report a wide scope—to embody in it some of the useful information which they have acquired, and to fortify any opinions they may express by such arguments as have been furnished them either by observation or study.

Previously, however, to entering upon the main subject, they will indulge in some preliminary remarks. And first, they cannot but remark, with great satisfaction, that the case now presented is one of a novel and singularly interesting character. The common occasions for calling together a council of engineers for harbor improvements have been either to remedy natural defects, to repair the consequences of neglect, to restore a regimen which has been disturbed by natural convulsions, or to remove artificial constructions which have proved injurious to the channels.

The Commissioners believe there is not one, in the long list of cases which they have met in the course of their reading, where the engineer has not been required either to undo what has been badly or thoughtlessly done, or else to do something which will supply a positive defect. But the grateful task assigned to this Commission is entirely different. It is not called upon to introduce any change into the natural state of things, or to condemn the errors of the past. Having before it a harbor of excellent capacity, with sufficient natural means of self-preservation, it is only expected to show how that capacity may be safely used, and how those means may be maintained unimpaired. Events of the most recent occurrence have given such extraordinary impulse to the business of Portland, that its shipping may not impossibly be doubled in the next ten years. Under these circumstances, the city government, with great wisdom, as it seems to the Commission, has determined to use its best endeavors to escape, in future, those great evils and expenses which have been so frequently incurred by mismanagement or neglect in other places.

The most frequent examples of this mismanagement are to be found in the harbors of Great Britain and Ireland. Most of them have been brought to light by the rapid expansion of British trade during the long period of peace and prosperity which has just terminated. The study and treatment of these cases has created a special branch of applied science—the branch which treats of engineering in tidal rivers and harbors.

In the circumstances here recited, the Commissioners feel that they are acting under a great responsibility. If the course which they recommend for Portland harbor should be adopted by the present authorities, and pursued hereafter, it will depend upon them whether the expected increase of commerce is attended with a corresponding increase in the facilities for its prosecution. With this charge in view, they have not failed to bestow upon the subject a careful and impartial investigation.

But, secondly, it is very evident, the Commissioners would remark, that, for the adoption and successful prosecution of any plan of improvement, a controlling supervisory power over the harbors of Portland and all its interior basins must be lodged in competent hands. If no such power exists, action will be always desultory, and sometimes mischievous, as it has been in other places. This is a position which need not be maintained by any long argument. It is quite apparent that owners of lands bordering on the tidal waters will, if permitted, follow out their distinct designs without concert of action, with different objects in view, and with a special regard to those objects, irrespective of any general effect that may result from them. It is equally apparent that, in a case of so much general importance as the present, the rights of private property should not be allowed to interfere with public utility. To enforce this consideration, instances may be mentioned where the exercise of private rights has caused great and almost irremediable injury. Chester, Wexford, New Castle, Exeter, Stockton-on-Tees, Whitby, Bridlington, are such instances. Hull, also, furnishes a striking example of the manner in which private and corporate interests have acted mischievously. Others might be adduced from the Parliamentary reports. All of them convey the same lesson, which is, that the want of an intelligent and permanent supervising authority, which will examine and regulate in all respects, however detailed or general, any occupation of the water area, is certain to lead to harm, and to produce effects which must be counteracted at some future period with difficulty, hazard, and expense.

The Commissioners have already said, in their previous report, (and they desire to repeat it here with emphasis,) that the city government of Portland is the proper body to be invested with the controlling supervisory power over the harbor of Portland and all its adjacent waters, unless, indeed, (which is not probable,) the legislature should establish a permanent Commission, with authority to direct constructions in all the tidal harbors of the State.

In order, however, to guard against misapprehension, it may be well to say that there is no desire to encroach upon, much less to defeat, private and corporate rights. It will be readily understood that, in this question, there are two classes of interests somewhat distinct from each other—public and private. There are also two classes of objects—special and general. Neither one of the objects or interests need, necessarily, be sacrificed to the other; but it will often demand a sound discrimination to render them compatible with each other. The exercise of such a discrimination properly belongs to a durable and responsible body. And the Commissioners cannot but express the hope and expectation that they are now addressing a body which either is, or will hereafter be, invested with suitable controlling powers, by means of which it can restrain ignorance, allay contention, reconcile jarring interests, and educe the common (which is the highest) good.

The plan of the present report embraces three general divisions; which are—

1st. A general description of the harbor, comprising its topography, its natural formation, and its past and actual conditions.

2d. The method of increasing its accommodations, and at the same time maintaining its depth and capacity.

3d. Miscellaneous observations.

HARBORS.

Outer Harbor.

Portland, like many harbors of the first rank in this class, is naturally divided into an inner and outer harbor. The natural separation of an enclosed sheet of water into an inner and outer harbor most frequently arises from three leading causes—a better protection due to the conformation of the land in the inner harbor; a nearer approach to the seat of business; and an actual separation, to a certain extent, of the waters of the two parts. The last distinction is an important one to be examined, for where it is marked and definite, the engineer finds his subject of harbor improvement presented to him in two branches, which meet, to be sure, finally, but which are, within certain natural limits, wholly independent of each other, and may be treated in a different manner and at different times. The final place of meeting here spoken of is, of course, the channels conducting to the sea, lying below both the inner and outer harbors. But it is apparent, where these channels are maintained by a flow from two or more interior receptacles, one of which constitutes the harbor proper, or principal seat of business, and has nothing but the lower channels in common with the other receptacles, (except that the waters stand at nearly the same level in all,) that it is not only admissible, but even unavoidable to treat the improvement of each receptacle separately in all respects, except in respect to the effect of the improvement on the passages to the sea. The usual limits of division into upper or lower, or inner and outer harbors, are simply given by the form of the shores. In New York harbor, the Narrows is the point of separation, and Raritan bay and river comprise a grand reservoir, the force of which is expended on the sea channels alone, no portion of it whatever being felt within the Narrows. In Boston harbor, where the inner and outer are equally defined by nature and by man, Dorchester bay and Quincy bay are reservoirs to the Light-house channel, and in this regard are co-operative with, but independent of, the higher receptacle. In Portland harbor, however, the mode of separation is different. The case is one of interest to the student. The position and extent of the *inner* harbor are decided by the better protection and nearer approach to the seat of business, and by an actual separation in part of the waters by the peninsula on which the city of Portland stands. But the northeast boundary of the *outer* harbor is an imaginary line drawn over the summit-level of the waters between Peak's and Great Hog islands, and between Great Hog and Mackey's islands. On one side of this imaginary line, and in its immediate vicinity, the currents of the flood tide *tend* towards the northeast, and on the other side to the southwest. On one side, the currents of the ebb tend towards the southwest, and on the other to the northeast. This is one of the numerous examples of confluence such as take place on coasts having the geographical character of the coast of Maine or the west coast of Ireland. Where these phenomena regularly occur on a grand scale, and are owing to the confluent determination of tide-waves of different periods, as in the Irish channel, they give rise to tides of great height, having little or no apparent motion at the place of meeting, and to tidal nodes, twelve hours apart, at which the currents are very rapid, and run almost unceasingly, while the rise and fall of the water is insignificant.

A mere confluence of currents, like this of Portland, which is on a small scale and quite local, is interesting to the general student only because it exemplifies, by an humble instance, the uniformity of the law of action. But the knowledge of it is indispensable to the engineer, because it defines the limit of the field of his operations.

The outer harbor of Portland, then, must be described as the irregular space comprised between the shores of Cape Elizabeth and the inner harbor on the south and southwest; and Mackey's, Great Hog, and Peak's islands, together with an imaginary line on the water joining these islands, on the north and northeast. There are two reservoirs—the Back cove and the Presumpscot—belonging to this harbor, which have no connection with the receiving basin of the inner, until their waters meet on the ebb in the channels of the outer harbor. The two former, and the latter, are therefore to be considered apart from each other. There will be further occasion to speak of this when the improvement of Back cove comes up in order.

Inner Harbor.

Every harbor possesses some features in form and situation which give it a special character. Portland belongs to that class of harbors which is maintained by the scouring operation of the ebb tide flowing from basins situated within the proper harbor. Its special character is derived from the relative situations of the harbor and interior basins. The harbor itself is contained between the extremity of the peninsula on which the city of Portland stands, and the similar peninsula of Cape Elizabeth on the opposite side.

It is a sheet of water 2,680 yards, or one and thirty-two hundredths (1.32) nautical miles, in length, and at the average high tide, eleven hundred yards in width.* At mean low water the average width is reduced to one hundred and nine yards. It runs in a direction northeast and southwest, the entrance being at the northeast end. The southwest end is terminated by Portland bridge.

Portland harbor may be otherwise described as a figure approaching, in form, to a parallelogram, of which the longest sides are 2,950 yards, and the shortest sides eight hundred and twenty (820) yards, and at low water four hundred and forty (440) yards. The long sides are, both of them, slightly inflected, following the natural sweep, which in this instance is very gradual.

*Measured perpendicularly to an imaginary line representing the axis of the harbor.

Above Portland bridge the channel becomes narrower and shoaler, and less fitted for the purposes of navigation; consequently, Portland bridge appears to be the limit of the harbor. It is true, that if this bridge had been built a little farther up, or a little lower down, the effect would have been the same. There are two circumstances, however, in addition to the position of the bridge itself, and the decrease of the channels above it, which give to the latter the character of a boundary. One of them is, that the best water in depth and extent is below the bridge; the other is, that the city of Portland presents here almost its entire business front. Hereafter, then, that sheet of water which lies below Portland bridge will be spoken of as the harbor of Portland, and the space above as the receiving basin or reservoir. It will be convenient, both in the descriptions and in the plans to be presented, to adhere to these distinctions.

One of the first observations that occur to the engineer, in respect to the territorial position of the harbor of Portland, is, to admire the sagacity, or good fortune, which directed the founders of that city in the choice of its site. Their judgment in the matter may have been controlled by other conditions, and especially by the character of the aborigines. But, whatever it may be owing to, the city of Portland now stands precisely upon that spot which a careful examination would pronounce to be the best. By contrasting its site with Plymouth, Wellfleet, and Sag Harbor, where the harbors are so rapidly deteriorating under the influence of natural causes that the hand of skill would hardly be extended to save them from destruction, one is led to a just estimation of an external position like that of Portland, having an interior basin above it, and being washed by the successive ebbs and flows of the tide.

The area at mean high water of the harbor proper, or of the space between Portland bridge and the breakwater on one side, and Fish Point on the other, is six hundred and seventy-seven (677) acres. The area of the basin above Portland bridge is, at mean high water, about nine hundred and eighty-eight (988) acres, and at mean low water about one hundred and eighty-two (182) acres. The relative proportions of the harbor surface and reservoir are as 2 to 3 at mean high water, and as 3 to 1 at mean low water. The relation of these two spaces to each other will be more exactly conveyed in terms of their capacity. The contents of the harbor at mean low water are about 9,250,000 cubic yards, and at mean high water 18,395,000 cubic yards. The same measures above the bridge are 4,087,000 cubic yards and 12,620,000 cubic yards. The ratios of the capacities of the two parts below and above Portland bridge are as 3 to 2 at high water, and as 9 to 4 at low water; differing somewhat from similar functions of the areas. There will be occasion to make use of these measures hereafter.

The inner basin, called Fore river or Stroudwater, terminates at the tide-mill by a dam or bridge. The distance from this dam to Cape Elizabeth, following the course of the channel, is 4.27 nautical miles, and in this distance the waters make a general circuit of about ninety degrees, the most abrupt bend in the windings of the channel not exceeding eighty degrees, and the other bends being more easy. From this it appears that the windings by which the water enters the receiving basin are not great; and this is one of the best conditions of a reservoir. Again, there is no contraction of any importance in any part of the reservoir; the tide-wave, therefore, if unimpeded by artificial constructions, will ascend freely: this is another one of the good conditions of a reservoir. Where this condition exists, a rate of current is established approaching uniformity; the velocities of the flood and ebb are more nearly equalized throughout the channels. Owing to the first condition, the course of the tidal currents is easy; they are subject to no violent deflections, and have therefore few eddies. This is another of the good conditions of a reservoir, for by this an ebb and flood of tide, regular in period as well as direction, are maintained; confluences and interferences are avoided near the times of change of tide; and the greatest and least levels of high and low water may be attained if, as we said before, not prevented by artificial means. The riparian soil appears not to be liable to easy degradation, either under the action of the tidal current or of the waves of a storm; this is another good condition of the reservoir, and the Commissioners seem to have established this fact by the inspection of water taken from all parts of the harbor and basin during the four quarters of the flood and ebb tides. By this inspection it is satisfactorily ascertained that in a normal state of things the water in this immediate vicinity has no appreciable amount of matter at its disposal. The material of the bottom is generally soft mud; there is no sand deposite even on the bar, and the Commissioners are not aware that such a deposite is to be found in any part of the ground of which they are now speaking.

The maximum velocity of ordinary tides is not sufficient to overcome the adhesiveness and inertia of the surface over which it flows. During the spring-tides, and especially during the equinoctial tides, the maximum of velocity is so much increased in strength and duration that the preceding remark would not probably be applicable; but it is the normal state of things only which is now under consideration. All the conditions of the harbor and reservoir, the enumeration of which has just terminated, imply stability in the waters of Portland.

Portland harbor is in fact a harbor of an original formation, and being well proportioned in its parts (for a harbor of that class,) it would be inferred that it was not liable to any changes except such as are slow and scarcely perceptible. This theoretical view is sustained by an examination of the earlier maps. The Commissioners have been furnished from the office of the Coast Survey of the United States with comparative maps, on which are laid down the shore-line and curves of Major Bache, Colonel Anderson, Moody, Des Barres, and of the Coast Survey of 1854. All these maps are also separately in the hands of the Commissioners.

It results from a very minute and careful comparison of the different periods of time represented by these maps, that the Commissioners cannot discover any conclusive indications of an organic law of change. They have not been able to perceive that any one part of the harbor is especially weak; that there is any dangerous tendency, arising from the operation of the law of deposite or from the action of the tidal currents, to alteration or deterioration. It is to be remembered, in the comparison of maps of an old date, that the rule of reduction of soundings is never satisfactorily given. Unless, therefore, very great changes have taken place, such as transcend the limits of the probable error of reduction, it is not easy always to arrive at any definite conclusions.

In those maps, however, in which the shore is bold and unchangeable, the examiner is furnished with a means of testing the accuracy of the survey by the outline of the shore, and thence he may form a judgment of the reliability of the whole map.

The opinion of the Commissioners, governed by this test, is generally favorable to the maps in their possession, and this has led them to rely, without hesitation, upon the inference that the harbor of Portland is not, as has already been said, subject to organic changes. They are not, therefore, called upon by prospective considerations, to recommend new and important constructions. They will recommend, in its proper place, the extension and completion of the present breakwater.

A few results of the comparisons of the several maps with each other may here be stated. They will exhibit the grounds of the Commissioners' opinion.

The depth on the bar, in Colonel Anderson's map, is the same as at present; he shows eighteen feet on the Cape Elizabeth side, but the erection of the pier has produced changes which deprive Colonel Anderson's map of any value in this place.

The shore-line from Cape Elizabeth or the north shore agrees pretty well with the Coast Survey map, which is the standard. There is greater depth at the bridge, but here another artificial construction interferes with the comparison. The middle ground is reduced in size since Colonel Anderson's time, and the channel between it and Fish Point, though the same as to depth, differs in width and form; here, also, the original state has been artificially disturbed. The depths on the middle ground, notwithstanding its diminution in size, are unaltered.

This is very striking, for if it is assumed (setting aside the ignorance of the datum of reduction) that the apparent changes have actually taken place, still here is an absence of uniformity or harmony of change.

If the Commissioners turn to Major Bache's map of 1820, to which they have given that careful attention demanded by the high reputation of its author, it is found that there was apparently more water on the bar in 1820, by two feet, than at the present time. But if the reduction of the soundings of Major Bache to the zero point of the Coast Survey could be satisfactorily made, this difference would probably be diminished.

On the chart of Major Bache the three-fathom curve is nearer the Cape Elizabeth side, by an average distance of one hundred yards, than now. The change in this respect near Portland bridge is remarkable, and well worth noticing, By showing how much such structures may disturb the existing state of things, it will serve as a warning against multiplying them unnecessarily, and without sufficient precautions as to the mode and conditions of their erection. On the Portland side the same curves are nearly coincident; on the middle ground the eighteen-feet curve nearly coincides with the present. The twelve-feet curve is somewhat less than that which now exists. It is very noticeable, that a portion of the eastern end of the middle ground seems actually to have been removed, whilst, on the other hand, the depth of the water on the middle ground has sensibly diminished.

The most interesting change is the creation of a sort of bar, reaching across from Fish Point to the middle ground, making it shoaler in this spot now than it was in 1820. Further, the channel between the middle ground and the shore is now shorter than it was formerly, which implies an increase of depth in this particular place.

In conclusion, although the Commissioners will not deny that there are indications from Major Bache's map of some slightly unfavorable changes during the last thirty years, yet they are disposed to ascribe the greater part of the apparent variations to those incessant fluctuations in the form of the curves which every student of the subject must have observed, and which, in many cases of projected improvement, are really much more perplexing than alarming.

The actual existence of all these variations, even when admitted without due allowance for the now inappreciable errors of reduction, do not, in the opinion of the Commissioners, tend to establish any constant law under the action of which they can be supposed to take place. The fixed and simple character of the harbor of Portland forbids their entertaining the idea that there can exist, unknown to them, any natural deteriorating agencies, the effects of which are either to be dreaded now or guarded against in time to come.

Those enduring processes of nature which produce secular changes in the earth's surface, are of course left out of consideration; they are beyond the scope of the present inquiry.

PLANS AND RECOMMENDATIONS.

The Commissioners will preface this division of their report with some general views.

When it is proposed to modify the existing state of a tidal harbor of good natural capacity, it is not to be forgotten that the modifications are to be held in strict subordination to certain general natural relations on which the harbor depends. Thus, for example, the area of the natural reservoir should not be diminished without a suitable compensation, unless circumstances require a corresponding diminution in the channel of the harbor; and, in the same manner, the diffusion or divergence of the waters in the reservoir should be carefully avoided.

Again: if the limitation of the natural channels forms a part of the plan, the engineer must be careful that his operations are not carried so far as to produce inconvenience to navigation through an excess of velocity. Again: in modifying the existing state of a channel, attention must be paid to the natural flow of the tidal stream, by which means a uniformity of motion is maintained in the different sections of the channel, and disturbed or violent states of the current are prevented.

Again: the new boundary lines of the channel should be as regular as possible, coinciding with this natural flow; in other words, a broken line of front would be condemned because it would occasion eddies, either by positive obstructions or by unequal expansions and contractions.

Again: the admission of the waters of the reservoir into the channels will be allowed to take place in a manner approaching, as nearly as possible, to that which nature has already prescribed in the case under consideration.

Again: the effect of contemplated alterations on the transmission of the tide-wave will be thoughtfully regarded.

And finally, as all the plans have for their primary object the convenience of commerce, the best and most durable interests of owners and proprietors immediately concerned in their execution will never be lost to sight.

If it were attempted to form an idea of a tidal harbor in every way suited to the purposes of navigation, it would be described as one easy of access in all states of tide and weather; affording, at its first entrance, a partial degree of protection; possessing, in its interior, a common anchorage, both spacious and secure; and having convenient docks into which vessels might haul, and lie with perfect safety while loading and discharging cargoes, or undergoing inspection and refitment. The only quality wanting to the conception of such a harbor is, that it should possess in itself the means of its own preservation. Now, the preceding account of what would constitute a good tidal harbor has approximated very nearly to a description of the harbor of Portland; the only feature which, in the case of the latter, is specially defective, is that of harbor accommodation.

The *plan* of the Commissioners, then, will resolve itself into this: into furnishing the required shipping accommodations, in such a form as will strictly comport with the rules already laid down; and the *recommendations* of the Commissioners will have for their object the preservation of the self-maintaining power in obedience to the same principles.

In the present case, where there is the prospect of a rapid and indefinite enlargement of business, no scheme, on the one hand, would be satisfactory, which was merely designed to meet present necessities; and, on the other hand, any plan involving great expense, and anticipating the growth of the city at some distant future period, would scarcely be less objectionable.

What is wanted is a project simple in its conception, and yet comprehensive, admitting of gradual execution according as parties apply for leave to extend their premises, and also of enlargement just in proportion to the growth of the city; a project which will disturb as little as possible the constructions now in use, and will be unlikely to create conflicting interests, or prevent the co-operative labors of individuals hereafter. Whilst it would be inexpedient, and probably useless, to attempt to sacrifice rights of available property to any of those magnificent designs which an ingenious theorist finds it easy to put upon paper, it is at the same time necessary that the Commissioners, profiting by the frequent examples in the republic, should contemplate a state of things of which the present business and population of Portland are but the healthful and vigorous germs.

Private interests are to be cared for, but they are to be cared for in harmony with, and in subordination to, the general welfare. The present growth of the plant is to be fostered, and space is to be provided for its future expansion.

Having all these principles and considerations before them, the Commissioners have prepared the accompanying plan, which they have now the honor to present to the city government. (Sketch No. 3.) It consists of a series of wharves or piers projecting at right-angles to the line of the shore on both sides of the harbor; between these piers, docks of sufficient width receive the shipping. The requisite depth in these docks will be kept up by the use of a suitable dredging-machine, in skilful hands and well conducted. The entrances to the docks may be closed or not, at the option of the proprietors, by outer gates, and thus the docks may be converted into wet basins. These gates will be constructed at the joint expense of neighboring proprietors, and, wherever closed, they will present a uniform sea-wall, in which there will be no impediments to the easy flow of the tidal waters. To complete the wet basins, the wharves, which are to be enclosed, should be built solid. The walls or ends of piers, on both sides, when finished according to this plan, form the new boundaries of the channel. The channel being thus diminished in breadth, the relative ratios of the reservoir and harbor space, in area and capacity, will be altered. By the time this plan is fully executed, the condition of the reservoir will be unavoidably changed by bridges and other constructions, which will keep pace with the city's progress, and be the necessary concomitants, as well as instruments, of its prosperity and increase. If, however, the recommendations subsequently to be made are followed, the ratios of the reservoir to the harbor will be increased rather than diminished. From this may be expected some increase, not probably important, in the depth of the harbor channel. But, what is more to the present purpose, the tidal stream will acquire greater velocity from this cause. Pains have been taken, therefore, after making the greatest possible estimate of the future capacity of the reservoir, not to narrow the channel so much as to produce a velocity inconvenient to the shipping; the augmentation will not probably exceed one-quarter of the present rate on the flood current, and still less than that on the ebb current. This applies to common neap and spring tides, but not to extraordinary states of the tide. The lines of wharf-front on this plan are drawn to harmonize with the natural flow of the tidal stream, and the form given to the passage from the reservoir to the harbor has been derived from a study of the natural curves of depths.

It further appears, from a discussion of the current observations of the Coast Survey, that the larger body of water passes through the deeper and wider channel between the middle ground and the breakwater, though a considerable portion passes through the channel between the middle ground and the Portland shore. The latter current meets the Back cove and Presumpscot tides off Fish Point. The results, agreeing with the expectations formed from an inspection of the chart, show that, in the lower portion of the harbor and near its mouth, the motion of the waters is controlled by the sub-aqueous deposites. This authorizes the establishment of the new channel limits independently of these currents, the form of the curves near the shore being taken as the safest guide in this part of the harbor.

In general, however, the line from Portland bridge to the middle ground has been regarded as a single "reach," through which the direction of the tide is not essentially changed.

All that the Commissioners contemplate in the fulfilment of this project is such a gradual construction of new wharves or piers, and extension of old ones to the fixed line of front, as private wants may dictate, and the city government approve. However gradual this process may be, the works will form appropriate parts of a whole, and in the mean time no injury will accrue from the slowness of the execution. It does not, in an American at least, demand any great exercise of the imagination to foresee the time when both sides of the harbor of Portland will become the scenes of equally active business, and when the shores of its receiving basins and the islands of Casco bay, in which nature has furnished so many valuable harbors of refuge, will exhibit proofs of the wealth of the city by the increase of their settlement. But the commissioners would not be justified on this account in recommending that any effort should be made to carry out this plan at once, either wholly or even in any great part. On the contrary, it is their advice that its progress should be just in proportion to the progress of the city, and that anything like a spirit of speculation with regard to it should, as far as possible, be avoided.

It is worth while to mention that, when the new water front has been permanently established on both sides, the common anchorage of the inner harbor, between Cape Elizabeth and Portland bridge, will comprise an area of three hundred and fifty-two (352) acres, and the water area of the docks on both sides will altogether amount to about one hundred and fifteen (115) acres, assuming one-half of the enclosed space to be water space. The water area of the London docks is about one hundred and eighty (180) acres; that of the Liverpool docks is less than one hundred (100) acres. Thus, it will be perceived that sufficient accommodations are provided for the greatest probable increase of tonnage.

Finally, the Commissioners have to say that, in the formation of this plan, they have encountered one difficulty, (they have no means of overcoming,) which consists in the distribution of he wharf and dock spaces within the proposed limits of construction. This distribution is somewhat arbitrary; still, a line of wharf drawn at random might abut upon the property of two different proprietors. The Commissioners, therefore, have not filled up the enclosed space with any wharves, except those already built. It is desirable that symmetry should be observed as far as possible, and they will be happy, if the city government wish it, to complete the details, when informed as to the limits of the riparian ownerships.

There is no part of their subject to which the Commissioners have given greater attention, in proportion to its importance, than Back cove and its improvements. It is very certain that no rival scheme of construction ought to be allowed, at the present time, to interrupt the development of the harbor proper—the natural depot of trade. It may be said, without hesitation, that a plan of improvement of the Back cove, projected in the present day, may prove, either because it is on a wrong scale, or because it combines too many objects, or for similar reasons, unsuited to the future wants of the city. And it may also be said, that such a plan might come to be regarded as premature on other accounts; as, for example, on account of the area of the wet basin, the depth and width of the channels, or the action of the scour. A general view of the subject will be properly preceded by a brief description of Back cove, and the channel leading to it. Back cove is a basin of 787 acres in extent. It is irregular in outline, but of nearly equal length and breadth. Its surface is quite level, and is traced by the serpentine drains peculiar to horizontal basins; a long and continuous guzzle stretches from Deering bridge into the channel. It is nearly bare at mean low tide; at mean high tide it is covered to an average depth of seven and a half feet; at this stage of the tide it contains about 10,440,000 cubic yards of water. The basin slopes gradually eastward towards a deep and narrow channel: the depths on the two sides of the draw of Tukey's bridge, at mean low water, are twenty-three and twenty-one and a half feet; at the draw of the Atlantic and St. Lawrence railroad, the depth is seventeen feet at mean low water. This channel is situated at the southeast extremity of the basin, on leaving which it makes a turn of ninety degrees. The scouring force acts unequally, owing to the channels narrowing suddenly; at the inner end it has excavated to the depths of twenty-nine and thirty-one feet, but at the railroad draw the bottom rises to a little more than one half that distance below the level of mean low water. Depths convenient for navigation, however, are carried into the outer harbor. In the description of the outer harbor, Back cove is mentioned as one of its independent reservoirs; it is in fact the principal one. This is to be borne in mind.

Now, if the Commissioners were absolutely required to furnish a plan of improvement of Back cove, such as would render it useful for commerce, they would have to consider, first, the effect of that improvement on all the lower waters; and secondly, the nature and extent of the improvement in itself. But in respect to this last consideration, the Commissioners confess that they would be at a loss to make up their minds. It would be difficult to determine, in the present state of things, whether it would be advisable to convert ninety-six acres (the area of the Liverpool docks) into a wet basin, or more or less. While the harbor proper remains unimproved, no great accommodation of this sort seems to be needed. Still the opportunity is a magnificent one, which should neither be squandered, nor in due season neglected. And the Commissioners, in addressing the public body which has invited their opinions, and between which and themselves there is a common object and a common interest, desire to lay stress upon the words *due season*. To insure the success of a great project like this, it should be seasonable, not lagging behind, nor yet anticipating too much, the times. If boldness, energy, and a speculative spirit, are requisite to the conception and execution of such an undertaking, judgment and prudence are equally wanted to give it a right character and direction. In conclusion, the Commissioners are inclined to think that this is not the occasion to prepare a plan for the improvement of Back cove, and accordingly none is presented.

They are, however, unanimous and clear in one opinion, and that is, that the future occupation of Back cove should be guarded with jealous care, because it is a valuable reservoir, and because it is a means of greater future usefulness. Any plans concerning it should be subjected to a rigorous scrutiny, and any numerical calculations applicable to the plans should be carefully tested and strictly interpreted. This is said in the way of warning. It is not doubted that an opinion so well weighed, and so decided, will receive due consideration. It has been the intention of the Commissioners to make a study of the plan of improvement of the Back cove furnished by Col. Clapp, and to report upon it. They very greatly regret that a want of time has prevented their rendering this service. What has been said is by no means intended to apply to Col. Clapp's project.

After passing Fish Point, in the way to be described, the Commissioners see no objection to the occupation of any reasonable extent of the shoal grounds lying to the northward, and between that point and the Atlantic and St. Lawrence railroad bridge. The front face of works here must follow, in general, the shore-line. The lines on the map of a section of Portland, traced by W. A. P. Marshall, civil engineer, November, 1854, and marked "proposed R. R. or street," are approved. Though there is no objection to pushing out construction on the shoal above mentioned, as far as the railroad bridge, yet there would be great objection at present to carrying it any further out than the proposed lines, in the space between the railroad bridge and Tukey's bridge, on the Portland side. This space and the space opposite, described in the mayor's letter of October 23, 1854, as "on the Westbrook side, between the railroad and Tukey's bridge," bound the channel to the Back cove. Any improvement in these spaces should be made dependent on the plan of improvement of Back cove. It has already been observed, that there is an unequal action of the scouring force in this vicinity; this inequality ought not to be increased. A greater or less water-way will be wanted here according to the general plan. For this reason, it will be most expedient to leave things very much in their present condition. The wharves on the Westbrook side may be allowed to come out to a line marked *a b* on Marshall's tracing, already referred to, which line crosses the extremity of the longest of the present wharves.

This, then, is the wharf-line adopted by the Commissioners, subject to future change when the plan of improvement of Back cove is taken up, of which the whole area contained between Tukey's and the Atlantic and St. Lawrence railroad bridges must necessarily form an integral part.

From the development of their plans, the Commissioners will now proceed to their recommendations.

RECOMMENDATIONS.

The first of their recommendations is, that the sea-wall be continued around Fish Point, in the way most beneficial to the proprietors. The line of this wall should be made to conform to the original shore, and at the extreme limit it should project with an easy turn, such as will conform to the curve produced by the alternate confluence and divergence of the tidal currents. The line upon the accompanying plan shows what is here meant. In all subordinate respects, the greatest benefit will arise from allowing the proprietors to consult their own wants and execute their own measures. The continuation of the line to Tukey's bridge has already been given under the head of plans.

The second recommendation of the Commissioners, and the one to which they attach the highest importance, is directed to the means of maintaining the harbor, and of preserving, in all future time, its present capacity and usefulness. This recommendation is, that the city government should keep a most jealous watch over the waters of the reservoir, or receiving basin, above Portland bridge. Upon the conservation of this reservoir in a state of usefulness, equivalent to that which now exists, depends the usefulness of the harbor. In this field a vigilant supervision and energetic control are absolutely imperative. It is perfectly understood that the harbor of Portland owes its existence to the scouring action of the waters of the reservoir on the returning ebb. The character of the harbor may be regarded as an expression or function of this power. If the power be diminished, the depth and capacity of the harbor will be diminished in the same proportion; if the power be increased, the harbor will be proportionately improved. This statement is simple and accurate. It comprises all that need be said. The harbor now exists;

whether it shall continue to exist in its present state, whether it shall be improved, or whether it shall be suffered to deteriorate, are questions which will be solved hereafter by the action of those to whom this most important trust shall be confided. It is, then, to be duly considered in what manner this trust may be best fulfilled; and the Commissioners will be obliged to conclude that their labor has been vain if they fail to impress on the city government the preservation of the water receptacle to its fullest capacity; but not, however, in any actual or particular form. The question of the conservation of reservoirs demands special treatment. In the first place, in a city situated as Portland is, it is unavoidable that bridges and other means of transit should rise to meet the wants of an increasing population; and further, it is to be observed that instances will frequently occur in which, as the city expands, tidal mud-lands may, and must, be occupied for a variety of purposes with great benefit. But, in all such cases, the rule to be followed is to exact from the parties concerned a full compensation, for any space they may wish to occupy, by means of excavations elsewhere, made generally between high and low water mark. In this way land overflowed at high water may not only be harmlessly, but even beneficially improved; for these excavations should be made in such a manner as to increase the average depth of the reservoir, or of its scouring property. Now, the scouring force has a known ratio to the mass of water and its motion. The velocity is as the square root of the depth, and the mass is proportionate to the depth and velocity; that is, the scouring force depends on the depth of water in the reservoir. These relations are such, that a reservoir of a hundred acres in area, having an average depth of twelve feet, is equal in scouring power to a reservoir of one hundred and eighty-three acres in area, having only an average depth of eight feet. With this statement in view, it will be perceived that the Commissioners are very far from recommending that the growth and business of the city should be retarded or incommoded by the want of proper means of intercommunication between it and the neighboring country, or by the absence of other improvements. They only insist that, in all such cases, the public interests be not sacrificed to private or corporate enterprises. Whenever, accordingly, any party or parties are authorized to raise constructions which will exclude the tidal waters from any portion of the receiving basin, let them be required, as a condition of their grant, to make suitable compensation for the space thus occupied. By this means public and private interests will be harmoniously blended; and while every reasonable latitude will be allowed to speculative energies, the harbor (the common property of all, on the maintenance of which the ultimate success of these energies is dependent) will lose none of its usefulness. But, although no interruption is to be applied to this branch of the city's development, it must always be borne in mind that bridges, weirs, and other similar works, are actual obstructions to the passage of the tidal waters. They, to a certain extent, prevent the waters from obtaining their greatest and least level before the change of tide—or, in other words, the tide-wave may not, in consequence of them, be equally and fully propagated throughout the reservoir; consequently, the reservoir loses some of its characteristic value, and the high-water navigation is neither so advantageous nor of so long duration. A judicious restraint, therefore, is to be exercised upon these constructions. It would be impossible, unless a special case were under advisement, to go beyond this general caution; it may be well, however, to repeat it. Finally, all bridges across Stroudwater should be built on piles.

A third recommendation which the Commissioners will make is, that there be a strict prohibition against throwing ballast or dirt of any kind into the harbor.

A fourth recommendation which the Commissioners will venture to make is, that wherever irreconcilable differences of opinion arise concerning matters of importance to the harbor, advisers be called in who are free from local and personal influences. Rival claims are easily magnified by contending parties, and victory on either side may result injuriously to the general cause. The cases of Norwich and Yarmouth (British harbors) may be appropriately adduced as affording instructive lessons. The calm and enlightened view is, that all parties have a common interest; the aim will be to discover wherein the interest lies.

The fifth suggestion will be, that a method should be devised to prevent the washings by rains into the harbor.

The sixth recommendation of the Commissioners is, that the necessity for using a dredging-machine may be fully and fairly acknowledged. On this subject a word or two may be added. It is worth while to remark, that there are very few good harbors in the commercial world the usefulness of which is not either insured or augmented by some artificial means. Good harbors are, like other natural gifts, to be improved. The very employment of a harbor involves, to some extent, an injury to its resources; and it is particularly true of tidal harbors, that their commercial distinction almost necessarily brings with it the creation of incidental causes of deterioration. It is on this account that the principle of compensation has been so strongly urged. The use of the dredging-machine is the application of this principle in a peculiar way. It is not the intention of the Commissioners to anticipate, by any means, the necessity for their employment; but it should be clearly understood that, sooner or later, recourse must be had to them, and the instruments themselves should be regarded with favor.

Seventhly, it is strongly recommended by the Commissioners that the care of the waters of the harbor and reservoir be immediately assigned to a suitable person. Perhaps, at present, this duty will be apparently insignificant; but if it be established now, and fully recognised, it will be much more easy hereafter to resist encroachments, to arrest the abuse of privileges, to keep the city government advised of the progress of improvements, and of the adherence of projectors to the plans which have received official approval. Let the office be known to exist, and much future trouble will be prevented. It would hardly seem expedient at present to create a new office for this purpose. The city engineer might, if the government think proper, be intrusted with this duty.

In the eighth place, the Commissioners recommend the extension and completion of the breakwater in conformity with the original plan. In their opinion the entrance to the inner harbor would be improved by it, and the harbor itself would be better protected. A small light on the extremity of the breakwater will be very serviceable in turning into the harbor. The work in its present incomplete state does not accomplish all the purposes of its erection. The description of light, and its precise position, would come under the direction of the Light-house Board.

Lastly, the Commissioners beg leave to express their adherence to the views and recommendations contained in their first report.

MISCELLANEOUS.

The Commissioners will close their report with some miscellaneous observations.

The attention of the city government is called to the fact that the draw of the Portland, Saco, and Portsmouth railroad bridge is so built, that vessels in passing through it are obliged to cross the direction of the stream. A similar mistake should on every account be guarded against in future. Wherever it is suffered to happen, alterations will follow, in consequence of it, in the bed of the river and in the course of the stream.

Colonel Anderson's report contains an estimate for a sea-wall or breakwater on the middle ground. The Commissioners are not opposed to this project on any *general* grounds, if properly executed. A solid structure in that part of the harbor would undoubtedly be inconvenient to vessels, and spits would project from it, by natural formation, in the direction of the flood and ebb currents which would sensibly diminish the capacity of the harbor and its freedom of navigation. The middle ground is in itself one of those very common features of tidal harbors and bays, the origin of which is so well undertood that its place might be determined by a knowledge of the currents alone. Upon this base, supplied by nature, a superstructure may be erected if otherwise justified by the wants of the case and by economy. But the Commissioners have no information in their possession which induces them to believe that a work of any kind is really needed here. The problem is an intricate and special one, and is dependent on the extension of the breakwater. It must be treated separately, and the Commissioners will be prepared to investigate it whenever called upon by the city authorities.

It was intended to transmit with this report a plan of a suitable wet basin; but upon reflection it has not been thought necessary. The English engineers, especially Mr. Fairbairn, may be consulted on this subject. The admirable plans and drawings of Mr. Fairbairn and others contain all the information and examples which a constructing engineer could possibly desire, and wherever a wet basin is wanted they will, of course, be studied.

The harbor of Portland is entirely landlocked, but as it lies in a northeast and southwest direction it is swept by northeast winds coming down Casco bay; the distance of the islands in this direction from the mouth of the harbor being one mile. Some inconvenience results from this, especially in violent gales like that of the autumn of 1831. The force of the waves created by the southeast gales of the Atlantic is not wholly spent when they reach the harbor. It appears, also, that this harbor is sometimes incommoded by ice, and occasionally is entirely frozen over, as happened not seldom in the years of the preceding century. But the Commissioners have reason to believe that this last obstruction is now of very rare occurrence. These slight inconveniences are counteracted not only by the security and goodness of the harbor itself, but by the nature of its approaches. A good holding-ground of stiff clay is found in many places in Casco bay inside of the islands; and the islands themselves create, as has been before observed, many natural harbors of refuge. The mud in the harbor affords a safe bed for vessels to lie in when aground.

The rank which Portland holds among the commercial cities of the United States cannot be satisfactorily assigned at this time on account of the rapid extension of its business, arising from the causes referred to in the early part of this report. No persons are better acquainted with the future prospects of the city, or with its statistics of trade and commerce, than those to whom this communication is addressed. The Commissioners allude to them here in order that they may have the pleasure of participating in the present well-founded hopes of prosperity. It sometimes happens that good harbors are wanting where other elements of commercial greatness are found in abundance, and, conversely, that good harbors exist where the materials of trade are absent. In this instance the facilities of nature, territorial position, and the legitimate courses of commerce, all combine to create a large commercial emporium. This promise of future greatness has given great interest to the labors of the Commissioners, who have never suffered themselves to forget that their opinions may, if adopted, exercise a permanent influence in a sphere which is constantly extending in limits and importance.

JOS. G. TOTTEN,
Bvt. Brig. General and Chief Engineer.
A. D. BACHE,
Superintendent U. S. Coast Survey.
CHARLES HENRY DAVIS,
Commander U. S. Navy, Superintendent N. Almanac.

WASHINGTON, *March* 15, 1855.

Extracts from a pamphlet by John A. Poor, Esq., on the commercial importance of Portland.

The harbor of Portland has been known, from the first discovery and settlement of North America by Europeans, as one of the best, if not the most commodious, safe, and accessible of any on the Atlantic coast. It was well described by Christopher Levett, who visited it in 1621; and it was sailed into by the great French navigator, Du Monts, as early as 1603. As the principal seaport of all the region east of Massachusetts, during the period of colonial dependence, and latterly, as the commercial capital of the State of Maine, it has been well known in the commercial history of the country. As a harbor of refuge, in case of storms or severe weather, it is probably more resorted to than any northern seaport of the United States. On the approach of an easterly gale, hundreds of vessels drop into it for shelter, as naturally as ships in the British channel seek the harbor of Portsmouth or Southampton, or those of the North sea make the port of Sunderland.

Portland harbor is so easy of access at all conditions of the tide, and with any direction of wind, and withal is so capacious, deep, and well sheltered, that the largest ships may enter and securely ride at all times and under all conditions of the weather. This will be quite apparent by reference to the charts of the United States Coast Survey.

For reasons which are very readily understood, the city of Portland has not heretofore attained that commercial success to which her position seemed to entitle her. She has, however, grown rapidly into importance within the last few years, and is attracting attention as the terminus of the Grand Trunk railway of Canada, the European packet-station for the valley of the St. Lawrence and the West, and the route for the trade and travel between the Upper and Lower British provinces. Her commercial importance may be considered as first established when measures were entered upon to open a more direct line of communication by railway between the St. Lawrence, at Montreal, and the Atlantic ocean, at Portland, and to extend these lines so as to connect the several British provinces with each other and the United States across the breadth of the State of Maine.

The railway system of Maine, as it may be called, including its provincial connections, embraces an aggregate length of more than two thousand miles, built or in process of construction.

This system of railway has a gauge of five feet and a half, which gives it a character peculiar to itself, and one that makes it independent of the narrow gauge lines of New England and New York.

The first practical effort to carry out this railway system was commenced in 1844. As soon as this movement was understood, and the commercial position of Portland made known through the public journals of the United States and Canada, an immediate enhancement of the value of the real estate of the city took place. This was followed by a corresponding increase of business. The extent of this will be readily perceived by the following table, showing the population and valuation of the city at different periods, as follows:

Period.	Population.	City valuation.
1790	2,240	
1800	3,677	
1810	7,169	
1820	8,581	$2,634,427
1830	12,601	2,757,179
1840	15,218	4,054,095
1850	20,819	13,364,009
1855	27,000	20,502,363

The rapid growth of the city from 1844 to 1854 was mainly attributable to the extension of its railways.

THE RAILWAY SYSTEM OF PORTLAND.

There are four distinct and independent lines extending or radiating from Portland.

I. *The southern line* is the Portland, Saco, and Portsmouth railroad, extending as a trunk line from Portland to South Berwick junction, thirty-eight miles, where it branches into two lines; one extending to Portsmouth, New Hampshire, where it unites with the Eastern railroad, reaching to Salem and Boston, a distance of one hundred and seven miles from Portland; the other extending to Dover, Haverhill, and Boston, a distance of one hundred and eleven miles from Portland to Boston. This line was completed from Boston to Portland, by the way of Portsmouth, November 23, 1842, and the connection between Boston and South Berwick junction, by the way of Dover, New Hampshire, was made July 24, 1843.

II. *The western line* is the York and Cumberland railroad, extending from Portland to Saco river, at Buxton, a distance of eighteen miles, to which place it was opened in February, 1853. It is in contemplation by the friends of this line to extend it westward, so as to connect with the railways of New Hampshire and unite with the Boston and Maine railroad, in the neighborhood of Dover.

III. *The northern line* is the Portland and Montreal railroad, formerly called the Atlantic and St. Lawrence railroad, but now known as the Portland section of the Grand Trunk railway of Canada. This line is completed to Montreal, two hundred and ninety-two miles, with a branch to Quebec of one hundred miles. The plan for building this road was first entered upon in the fall of 1844.

The terminus of the Grand Trunk railway at Portland embraces, probably, the most extensive accommodations for the transaction of business to be found in the United States. The company owns a frontage of nearly two miles upon the deep water of Portland harbor, into which wharves are extended, so as to form a succession of docks of any required number or extent. The passenger station of brick, just completed, four hundred and forty-four feet in length, by ninety-six in width, is arranged with a complete suit of offices, and is fitted up with every convenience and accommodation that could be devised for such a purpose. There is a freight depot, five hundred and fifty feet in length, part of it seventy-five, and the remainder ninety feet in width; another, four hundred and fifty by forty-two, connected with it by covered passage-ways, and several large warehouses upon the wharves, used in connection with lines of steamboats.

IV. *The eastern line* is the Kennebec and Portland railroad. This line is on the narrow gauge, and connects with the Portland, Saco, and Portsmouth, and the York and Cumberland roads, in Portland, all on the same gauge. The line extends to Brunswick, with a branch to Bath, Gardiner, Hallowell, and Augusta, to which place it was opened November 1, 1852, a distance of seventy-two miles, including the Bath branch.

We give below the comparative operations of the railways of Maine, at different periods:

Years.	Length in miles.	Cost.	Number of passengers.	Total receipts.
1850	227	$7,129,692	507,002	$566,511
1854	404	13,809,988	1,066,352	1,280,324

The total receipts upon the entire line of the Atlantic and St. Lawrence railroad to Montreal in 1854, were $833,040. Of this sum $470,647 was on account of business between Island Pond and Portland, and $362,393 for that between Island Pond and Montreal.

The increase of freight receipts between Island Pond and Portland in 1854 over 1853, was equal to seventy-two per cent.

The quantity of lumber brought to Portland in 1854, over the line of the Atlantic and St. Lawrence railroad, was 20,173,803 feet.

The line of this road passes through one of the most valuable lumber districts in New England, and the various streams that it intersects or crosses in its route afford facilities for manufacturing-industry beyond what are found on any line of equal length in the United States. The water power on the route is, for the present, but partially used in the manufacture of lumber. The quantity of sawed lumber brought by this line of the railway in 1855 will undoubtedly exceed 60,000,000 of feet. Various branches of manufacture, especially in wood, are springing up along its route. Large quantities of masts and ship-timber are also brought to tide-water by this railway.

Portland now enjoys a very large trade with different parts of Maine, in supplying materials for building vessels, and in ship-stores. Estimating the cost of our new ships built in 1854 at $60 per ton, it shows a product in that year equal to $15,454,617.

Next to lumber, ships are our greatest export in point of value. The value of ships sold in the year ending June 30, 1854, may be set down at $5,500,000.

The foreign commerce of Portland increased rapidly in 1854 over that of previous years. We give below a table showing the foreign commerce from 1846 to 1854, with the exception of 1852 and 1853, the records of which were lost by the burning of the Portland custom-house last year:

	Exports.	Imports.
1846	$595,925	$454,226
1847	682,592	420,405
1848	623,239	616,045
1849	643,559	498,346
1850	614,306	612,510
1851	716,868	953,347
1854	3,014,340	3,124,676

The increase of the commerce of the city has probably been exceeded by the growth of manufactures in our midst. In addition to the introduction and increase of various branches of home industry, several large manufacturing establishments have grown up within the last few years.

The future prosperity of Portland depends upon its ability to secure the bulk of trade between the United States and the British North American provinces. Its commanding position, aided by the powerful influence of the Grand Trunk railway, will secure this if her own citizens, especially her merchants, are equal to the occasion that is now offered them for the purpose.

Bringing the aggregates into one view, the extent of the trade between the United States and British North America, according to the United States returns of commerce and navigation, is shown to be as follows:

1827	$3,149,014
1849	8,758,986
1852	16,519,305
1853	20,691,246
1854	33,494,320

Lines of steamboats are established, running daily between Portland and Boston, and tri-weekly to the Penobscot river and Bangor, and to Eastport and St. John. A line of screw propellers is also established, running between Portland and New York.

The Canadian Steam Navigation Company makes Portland its winter harbor for five months of the year.

The land on which the city is built was formerly an island, and it is now connected with the main land by a narrow neck, formed entirely of marine deposite, and a few yards only in width, which alone prevents the sweep of the tides entirely around the city. On the margin of tide-water, a broad avenue of nearly two miles in length has been built in front of the town, and the extension of this street around the city on the same level will give an exterior wharf-line exceeding seven miles in length, at which vessels may discharge or receive cargoes. The carrying out of this plan of a commercial street, enclosing the peninsula, will increase, to an extraordinary degree, facilities for the transaction of business, add largely to the area of the city, and enhance the value of all its real estate.

The commercial advantages claimed for Portland, on account of its harbor and its geographical position, may not, in the opinion of some, be justified by its past history. The explanation of this is found in the early history of this portion of the continent.

The English claimed all North America, by right of discovery and prior dominion, from the taking possession of New Foundland, by John and Sebastian Cabot, in 1497, some months before the time when Columbus first came in sight of the main land of the continent of America.

In 1531, Jacques Cartier sailed up the St. Lawrence, as far as Montreal, and received the title of Governor of New France, in 1540, the name by which Canada was first known to Europeans. In 1603, the King of France granted to Du Monts, the great French navigator, all that portion of the continent between the 40th and 46th parallels of north latitude; and from 1603, the whole country east of Sagadahock (the Kennebec) was occupied as French territory, till the peace of Ryswick, in 1697.

King James of England granted all North America, between the 34th and 45th parallels of latitude, to the colonies of north and south Virginia, in 1606, and in the year 1607 the earliest settlement of the English race in the New World was made at the mouth of the Kennebec, prior to the settlement at Jamestown, in Virginia. This settlement was abandoned in 1608, the same year in which Champlain laid the foundation of Quebec.

The settlement of New England by the Pilgrims, in 1620, prevented the French from extending their possessions west of Sagadahock; which became the admitted boundary between Acadia and New England, "not as a line of peace and concord, but the place of future controversies."

The rivalships of French leaders, and the contests of hostile races, in which Indian cruelties bore a conspicuous part, threw a distrust as to their safety, in seeking a home within the territory now held by us, over the minds of European emigrants, who sought the New World; which was increased by those extravagant accounts of the rigor of the climate framed by the early settlers at the mouth of the Kennebec, as an apology for their desertion, giving to all that portion of the continent east of Casco bay a reputation adverse to its growth, from which it slowly recovered.

In 1603, Du Monts entertained, from accounts obtained of the natives, the idea of a shorter route to Canada than through the St. Lawrence, and sailed south from his headquarters at Port Royal, to the Kennebec, for the purpose of finding it; but failing to reach Canada through this route, he explored the coast, and took possession as far west as Cape Porpoise, in the name of the French monarch. Boston was subsequently claimed by French diplomatists, according to Bancroft, as a part of the territory of New France.

While, therefore, the very simple and natural idea of opening a communication between the St. Lawrence and the Atlantic ocean, in the most direct line from Montreal to Europe, was suggested to the philosophical mind of Du Monts, in 1603, the conflict of races, of rival grants and different nationalities, delayed its execution just two centuries and a half. This great idea was first realized by the completion of the Portland and Montreal railway in 1853, two hundred and fifty years from the time of its first suggestion.

The natural advantages which the harbor of Portland was seen to possess for becoming the seaport of Canada, led to the formation of the Grand Turk railway, and to the extensive preparations for business at its terminus. The low charges for pilotage, wharfage, dockage and harbor dues, and the cheapness of insurance from this port, give it advantages for business with which no other Atlantic port can at this time compare.

APPENDIX No. 32.

Report to the Superintendent, by Assistant L. F. Pourtales, of field operations and office-work executed in the Tidal division.

COAST SURVEY OFFICE, *October* 1, 1855.

SIR: I beg to submit the annual report of the work done under your immediate direction by the tidal party under my charge.

It can be naturally divided into the two heads of *field-work* and *office-work*.

FIELD-WORK.

No essential changes have occurred in the general plan of tidal observations.

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, and have generally afforded satisfactory results. The series at Charleston has, however, suffered a rather extensive interruption, caused by the removal of the observer from his station at Castle Pinckney, and the difficulty of obtaining another. A self-registering tide-gauge has been set up, and the supervision of the observations intrusted to Professor Lewis R. Gibbes. It is hoped that the arrangement will prove successful.

On the western coast the observations have continued under the care of Lieutenant W. P. Trowbridge, U. S. Engineers. His well trained and experienced corps of observers have continued to merit the praise which was bestowed upon them in last year's report.

Of temporary stations several have been re-occupied in the southern part of the Atlantic coast, which had failed in last year's scheme. They were intrusted to the experienced care of Mr. Gustavus Würdemann, who has probably done all that could be accomplished under the peculiarly difficult circumstances under which he was placed.

The chain of stations occupied in the Gulf of Mexico has been completed, by the addition of a few stations on the coast of Florida. So far the discussion of the observations would seem to show that they will prove sufficient.

On the western coast several temporary stations have been occupied. The more difficult ones are now in progress under Lieutenant Trowbridge's personal supervision.

Mr. Saxton's self-registering tide-gauges have continued to be used as much as practicable, and when in the hands of careful persons the results have been very satisfactory.

The annexed table shows a list of the tidal observations received at this office during the year ending on this day. I have included in it the observations made in the waters of Nantucket and Martha's Vineyard in 1854, which were received too late to be included in the list for last year.

List of tidal observations received during the year ending October 1, 1855.

Section.	Name of station.	Name of observer.	Kind of gauge.	Station, permanent or temporary.	Time of occupation. From—	Time of occupation. To—	Total days.	Remarks.
I	Boston Dry-Dock	J. Williams	Staff	Perman't	Oct. 1, 1854	Sept. 30, 1855	365	
I	*Monomoy, Mass	G. A. Fairfield	Box.	Tempo'ry	Sept. 7, 1854	Oct. 18, 1854	41	
I	*Great Point, Nantucket	W. S. Allen	do.	do.	July 3, 1854	Sept. 9, 1854	67	
I	*Siasconsett, Mass	H. Mitchell	do.	do.	Sept. 7, 1854	Oct. 23, 1854	46	
I	*Weweeder, Mass	Swain and James	do.	do.	Sept. 15, 1854	Oct. 2, 1854	17	
I	*Smith's Point	G. Würdemann	do.	do.	Aug. 15, 1854	Sept. 26, 1854	42	
I	*Commer'l wh'f, Nantucket	W. Folger	do.	do.	July 17, 1854	Oct. 2, 1854	77	
I	*Brant Point, Nantucket	H. McHenry	do.	do.	July 31, 1854	Sept. 21, 1854	52	
I	*Tuckernuck	C. Fendall	do.	do.	July 29, 1854	Oct. 6, 1854	70	
I	*Nobska	J. Hardy	do.	do.	Aug. 19, 1854	Oct. 21, 1854	63	
I	*West Chop, (inside)	F. W. West	do.	do.	July 17, 1854	Oct. 17, 1854	92	
I	*West Chop, (outside)	W. Clarke	do.	do.	Sept. 23, 1854	Oct. 6, 1854	14	

List of tidal observations—Continued.

Section.	Name of station.	Name of observer.	Kind of gauge.	Station, permanent or temporary.	Time of occupation. From—	Time of occupation. To—	Total days.	Remarks.
I	*Chappaquonsett	A. Smith	Box.	Tempor'y	Sept. 4, 1854	Sept. 10, 1854	6	
I	*Cedar Tree Neck	John Daggett	do.	do.	Aug. 21, 1854	Oct. 7, 1854	48	
I	*Menemsha Bight	E. L. Mayhew	do.	do.	Aug. 20, 1854	Sept. 30, 1854	41	
I	*East side Wood's Hole	Fish and Swift	do.	do.	July 21, 1854	Aug. 19, 1854	29	
I	*Wood's Hole	G. A. Fairfield	S. R.	do.	Aug. 1, 1854	Oct. 31, 1854	92	Partly worthless.
I	*Falmouth, Mass	do.	Box.	do.	Oct. 1, 1854	Oct. 21, 1854	21	
I	*Bowman's Hill	do.	do.	do.	Oct. 12, 1854	Oct. 21, 1854	10	
I	*Davis' Neck	do.	do.	do.	Sept. 18, 1854	Sept. 30, 1854	13	
I	*Point Gammon	do.	do.	do.	Sept. 2, 1854	Oct. 16, 1854	44	
II	Governor's Island	Wm. Head	S. R.	Perman't	Oct. 1, 1854	Sept. 30, 1855	365	Frequent interruptions by freezing in winter.
III	Old Point Comfort	M. C. King	do.	do.	Oct. 1, 1854	Sept. 30, 1855	365	Generally good; some interruptions caused by sand in box, and by injuries from storm; common gauge used during interruptions.
IV	Bald Head, N. C.	W. R. Sellars	do.	Tempo'ry	Oct. 1, 1854	Oct. 22, 1854	22	End of series.
V	Castle Pinckney, S. C	J. Collins	Box.	Perman't	Oct. 1, 1854	April 22, 1855	204	Series interrupted by removal of station.
V	St. Simon's Island, Ga.	G. Wurdemann	S. R.	Tempo'ry	Jan. 17, 1855	Mar. 20, 1855	63	
V	Fort Clinch, Ga.	Lt. Trenchard, U. S. N.	Box.	do.	June 21, 1855	June 29, 1855	9	
VI	St. John's, Hopkins'	do.	do.	do.	May 23, 1855	May 29, 1855	7	
VI	Do.....Dame's Point	do.	do.	do.	do.	do.	7	
VI	Do.....Daniel's Mill	do.	do.	do.	do.	do.	7	
VI	Do.....Taylor's Mill	do.	do.	do.	do.	do.	7	
VI	Do.....Light-house	do.	do.	do.			6	
VI	Do.....Bar	do.	do.	do.			4	
VI	Fort George Inlet	do.	do.	do.			6	
VI	Indian River Inlet, Florida	G. Wurdemann	S. R.	do.	April 29, 1855	June 10, 1855	43	
VI	Indian Key, Florida	L. E. Tansill	do.	do.	Jan. 21, 1855	April 16, 1855	85	
VI	Tortugas, Florida	C. T. Thompson	do.	do.	April 1, 1855	June 22, 1855	83	
VII	St. Mark's, Florida	do.	do.	do.	Nov. 3, 1854	Mar. 2, 1855	122	
X	San Diego, California	A. Cassidy	do.	Perman't	Sept. 1, 1854	July 31, 1855	334	Several stoppages from unsteadiness of building.
X	Fort Point, San Francisco	H. E. Uhrlandt	do.	do.	do.	July 31, 1855	334	Several stoppages from unsteadiness of building.
X	Farallones, California	Lt. W. P. Trowbridge	do.	Tempo'ry	May 18, 1854	July 19, 1855	63	
X	Bodega, California	T. A. Szabo	do.	do.	Dec. 1, 1854	Feb. 28, 1855	90	
X	Humboldt Bay	J. A. Black	Box.	do.	Aug. 21, 1854	Oct. 7, 1854	48	End of series.
X	Port Orford	T. A. Szabo	S. R.	do.	Sept. 22, 1854	Oct. 4, 1854	13	End of series.
XI	Astoria, Oregon	J. Wayne	do.	Perman't	Sept. 1, 1854	July 31, 1855	334	Very good, except in January.

Recapitulation of the stations occupied during the year, exclusive of twenty stations marked with a star in the list, and which properly belong to last year.

Permanent stations	Self-registering	5	7
	Common gauges	2	
Temporary stations	Self-registering	9	18
	Common gauges	9	
Total			25

OFFICE-WORK.

In addition to the ordinary reductions of the observations as they come from the field, the party has been engaged in computations relating to various tidal discussions made under your immediate direction.

Computations and diagrams were also made, to be used by you in the preparation of a paper on the co-tidal lines of the western coast, for the American Association for the Advancement of Science at its late meeting in Providence.

To the series of observations in the Gulf of Mexico, an attempt was made to apply your method for the computation of the co-tidal lines; but considerable difficulties were met with, on account of the anomalous character of those tides, and also for want of observations on the coasts outside of the United States. Diagrams showing the features of the tides at all the stations in the Gulf were prepared, to illustrate a communication made by you at the same meeting of the American Association.

The work mentioned in the last two paragraphs was chiefly executed by Messrs. Heaton and Fendall.

Mr. Kincheloe has continued to group the Boston observations; the groups being found convenient for various purposes.

During my temporary absence last summer Mr. Heaton was in charge of the division.

Respectfully submitted:

L. F. POURTALES,

Assistant U. S. Coast Survey, in charge of Tidal division.

Prof. A. D. BACHE, L. L. D.,

Superintendent U. S. Coast Survey.

APPENDIX No. 33.

Report of Sub-Assistant H. Mitchell, on Tidal observations made in Nantucket sound.

NANTUCKET, MASSACHUSETTS, *October* 6, 1855.

DEAR SIR: The systems of observations on the interference tides of Section I, which have been undertaken by me under your immediate direction, during the past two seasons, commencing at the more general and striking features of this phenomenon, have gradually led us to the careful study of details.

The operations of the former season, as proposed in your instructions, aimed at the determination of the localities in which these interferences take place, the limits of the district of variable tides, the characteristic forms of the interference waves, and of general facts relative to the effect of these interferences upon the larger inequalities, half-monthly and diurnal. By a successful season's work the above results, among others, were obtained.

It now remained to make a more minute survey of the phenomena, to trace not only the *general* history of the two tide-waves as they meet and combine, but to show the nature of this meeting as affecting the elementary *diurnal* and *semi-diurnal* waves.

The observations had shown that the disturbance caused by these interferences in the tide-waves was not confined to the immediate vicinity of what are, strictly speaking, the meeting-points, but that slight distortions in the form of the tide-waves take place at a considerable distance from these points. The precise extent of the region of these disturbances could not be ascertained without additional data.

The interference phenomenon, as observed in the former season, exhibits itself in three localities, viz: at the junction of the Nantucket and Vineyard sounds, in Muskeget channel, and in the open sea southeast of Nantucket island.

During the latter season your instructions directed my operations to the examination of the first of these localities, and of such other points to the eastward and westward as should serve to compare our observations of the interference tides with those of other stations quite beyond the reach of disturbance.

At Falmouth a series of observations, at intervals of fifteen minutes, was taken during a period of sixty days, and in connexion with these the tides of Block island and Menemsha bight to the westward, and Hyannis to the eastward, were simultaneously observed.

The tidal currents have been studied as far as the instructions directed.

The efforts of the sea to maintain its level, among the double disturbances caused by the presence of two tide-waves, which may perhaps be regarded as quite distinct in this relation, give rise to violent currents, by which large bodies of water are *actually transported* from place to place, and enter as an element into the observed rise and fall in certain localities.

The difficulty arising in the discussion of the former observations from such causes, purely local in their character, has led to the attempt to elucidate them by experiments made in bays and small inlets, where, by reason of the small area of operation, the various movements of the water could be subjected to close scrutiny, hoping that the information thus obtained would enable us to recognise the same causes in their more extensive relations and effects.

From these experiments we have obtained curious facts relative to the effect of the peculiar configuration of the coast upon the tide-wave, especially in the case of a wave passing from the sea into a broad basin by a narrow inlet.

The observers at all the tidal stations have been required to record the rise and fall of swells or "wind-waves" each hour of the day, in connection with their meteorological notes.

Having employed skilful and experienced assistants, I am able to present to you a connected series of work without the loss of a single day. I have been greatly indebted to Mr. F. Buxton for his intelligent and steady industry, and I need not call your attention again to the long-tried zeal of Mr. G. Würdemann.

Very respectfully, yours,

HENRY MITCHELL,
Sub-Assistant Coast Survey.

Professor A. D. BACHE,
Superintendent U. S. Coast Survey, Dixmont, Maine.

APPENDIX No. 34.

Report of Lieutenant W. P. Trowbridge, U. S. Engineers, assistant in the Coast Survey, relative to the Tidal and Magnetic operations by the party under his charge on the Western coast.

SAN FRANCISCO, CALIFORNIA, *October* 15, 1855.

SIR: I have the honor to report the progress of the work of the tidal party under my charge, on this coast, since the date of my annual report of September 6, 1854.

At that time there were five stations in operation, viz: San Diego, San Francisco, Humboldt bay, Port Orford, and Astoria.

The observations at Humboldt and Port Orford were completed about the 5th of October, making about two and a half lunations at each place. The observations at Humboldt were conducted by Mr. J. A. Black, and those at Port Orford by Mr. T. A. Szabo. Both of these observers have now left me; Mr. Black having returned to the States, and Mr. Szabo having received the appointment of assistant assayer in the United States branch mint at this place.

The following stations have been added this year: Bodega, Farallon islands, Cape Flattery, Nootka sound, (Vancouver's island,) Port Townshend, Steilacoom, and Shoal-water bay, the base stations having continued in operation till the present time.

The gauges at all of these places have been erected by myself, excepting that at Nootka sound, and the results have been as satisfactory as I could wish. The observations at Bodega were commenced on December 2d, 1854, and completed on February 28th, 1855. These were conducted partly under my own supervision and partly by Mr. Szabo. The observations at the south Farallon were commenced on May 18th, and completed on October 10th, 1855; the curve traced by the register is unbroken for five months. The observations were by Mr. N. N. Wines, now keeper of the light-house at that place.

On the 7th of July I set out on board the Coast Survey steamer "Active" for Cape Flattery, with a party of two or three tidal observers and five or six hands.

We reached the cape on the evening of the 12th, but owing to the darkness and fog were not able to run into Neé-ah bay, and accordingly kept on up the straits. Captain Alden had taken on board a detachment of United States soldiers at Crescent City, whom he found in a destitute and suffering condition, and felt anxious to proceed directly to Steilacoom, and accordingly we anchored for the first time, after leaving Crescent City, in the harbor of Steilacoom on the evening of the 13th. I immediately put up a tide-gauge at the wharf, and left an observer in charge of it, with directions to observe the high and low water for two months. As it was my intention to make observations at Port Townshend and at Cape Flattery, I thought it might be important to observe the progress of the tide up the sound. Observations for a few days were also made at Olympia, by which the difference between the tides at Steilacoom and Olympia can be determined.

Captain Alden having finished surveying the harbors of Steilacoom and Olympia, sailed for Port Townshend, and, with the help of the crew of the "Active," I put up a pier, and set up a self-registering gauge with a detention of only two days. Mr. Bergan, formerly sergeant-major of the 4th regiment of United States infantry, was left in charge of this gauge, which was kept running from August 1st until September 11th. Having completed the erection of the gauge at Port Townshend, I was enabled, through the kindness of Captain Alden, to land my party at Cape Flattery the next day after, (July 28th,) and had erected the gauge and commenced operations on the 4th of August.

I have to acknowledge the kindness of the captain and officers of the United States sloop-of-war "Decatur," for assistance in erecting a structure for the tide-gauge on the beach at Neé-ah bay. Captain Sterrett kindly gave me the assistance of a boat's crew, with boats, anchors, &c.

Magnetic observations were commenced as soon as the tide-gauge was in good running order, and finished within about two weeks with good success. They consist of four sets of observations for absolute declination, with the portable declinator and detached theodolite, in connection with Polaris, five sets of vibration and deflection experiments for intensity, and three sets of observations for dip.

Anxious to carry out your instructions with regard to the tidal observations at Nootka sound, I chartered a small schooner and sent Mr. C. J. W. Russell, who volunteered to do the service, to a point near what is called Nootka sound, with directions to make fourteen days' observations upon the coast tides. Mr. Russell had acted as interpreter for me at the cape, and felt confident that he would be able to get along amicably with the Nootka Indians, notwithstanding the very unfavorable reports which we had received from the Hudson's Bay Company concerning them.

He set sail on the 26th of August, and commenced his observations near an island called Aho-Setle on the 28th. The observations were made outside the general coast line, under the lee of two or three small islands, so that they are strictly coast observations, and are not influenced by any harbor obstructions. The observations were completed on the 11th of September, the party having been daily threatened with destruction by about fifteen hundred savages, who had collected for the purpose of driving them away.

On the 12th of September the "Active" returned to Neé-ah bay on her voyage down the coast, and I broke up my camp, having made six weeks' good observations.

On the 14th of September we entered Shoal-water bay, and, while the officers were engaged in making a chart of the bay, I made two weeks' tidal observations within the bay. It was absolutely impossible to find any point outside at which a staff could be erected, the whole coast in the vicinity being one extended sand-beach of two or three hundred yards in width, upon which the most fearful surf continually breaks. After leaving Shoal-water bay we sailed directly for this place.

I have just despatched Mr. Russell, in whom I have perfect confidence, to Cuyler's harbor, on the island of San Miguel, near Point Conception, with directions to make six weeks' observations upon the tides, according to your wishes.

The observations at the base stations, viz: San Diego, San Francisco, and Astoria, have been kept up with the usual success until the present time. On my return from the north I find, however, that the observer at San Diego had been obliged to renew some parts of his structure which had been destroyed by the worms, and a similar cause has rendered it necessary to put a new float-box in the gauge at Fort Point; the sheet for the last month or two shows the effect of the swells in making a very broad curve. By careful reading, however, the time and height can be obtained with all necessary accuracy, but the defect will soon be remedied.

I transmit herewith a general chart of the coast, showing the stations that have been occupied up to this time, with the dates of the beginning and ending of the observations. The station near Nootka is not marked with certainty, as the latitude and longitude were taken from a chart by the observer, Mr. Russell, and is liable to an error of two or three minutes. A list of the stations which have been occupied during the year is also appended to this report.

It gives me much pleasure to commend again the services of Messrs. T. A. Szabo, James Wayne, Andrew Cassidy, and Sergeant H. E. Uhrlandt. Messrs. Wayne and Cassidy have been honorably discharged from the army during the year; they still retain the places assigned to them two years since in charge of observations at Astoria and San Diego. Mr. Szabo has recently received an appointment in the United States mint, and although I was sorry to lose his services, yet I could not oppose his obtaining so advantageous a position. I would respectfully acknowledge the services of Sergeant Uhrlandt, who, in addition to his duties as tidal and meteorological observer at Fort Point, has tabulated most of the curves of all the stations, and assisted me in my office-work.

The observations have now been extended from San Diego to Nootka sound, Vancouver's island, embracing nearly seventeen degrees of latitude and nine and a half of longitude; all except the two lower stations lying between the longitude 120° 25′ and 126° 37′. Between these limits the geography of the coast presents somewhat remarkable features; and as these must, under any circumstances of the location of the tide-gauges, influence the observations, I have endeavored to gain as much knowledge upon this point as possible, from personal observation, during my voyages along the coast.

The line of coast between San Diego and Point Conception presents the greatest irregularity of the general coast-line, embracing, as it does, about one and three quarter degrees of latitude, and nearly three and a quarter of longitude, while the coast between Point Conception and Nootka sound changes but six degrees in longitude for fifteen of latitude. By a glance at a chart of the coast, this abrupt change in the direction of the coast at Point Conception strikes the attention at once; the chain of islands below Point Conception indicates a less depth of water along this part of the coast, or at least shows the existence of great unevenness in the bottom of the sea at no great depth. The observations at San Diego and San Pedro may be influenced by these causes. Above Point Conception, the only islands are the Farallones, and these are mere rocks. The only obstruction to the motion of a great wave, therefore, between Point Conception and Nootka sound, would be the banks which exist off Cape Orford and the Straits of Fuca, on which forty or fifty fathoms are found twenty or thirty miles from land.

From San Diego to within twenty miles of San Pedro, the coast mountains come down to the sea, and form high cliffs along the whole distance. For twenty or thirty miles in the vicinity of San Pedro, however, the shores are low, the sea entering the land and forming lagoons and salt marshes or low sand beaches.

From a point a few miles above San Pedro to Point Conception, the shores are again high and unbroken by any marked depression. Northward from Point Conception, the mountains slope to the westward very gradually, and finally meet the sea so as to form perpendicular cliffs from one to two hundred feet high. About thirty miles from San Luis Obispo, the shores again become low where the valley of San Luis opens upon the sea. This valley has the shape of a crescent, which embraces the high land called Point San Luis, and opens to the sea above, at the "Estero rock," and below it widens out so as to form a low extent of beach for twenty miles to the south. From the Estero to Monterey, the sea washes the very base range, rendering a passage by land along the coast almost impassable, and indicating a great depth of water close to the shores. The Bay of Monterey presents again a sloping beach for fifteen or twenty miles, when the Salinas and Pajaro valleys debouch upon the sea. Between Santa Cruz and San Francisco again the sea approaches the base of the mountains, leaving, however, generally, a narrow plateau along the coast. In the vicinity of San Francisco, from Point Bonita south ten or fifteen miles, the land is again low; the low beach below Point

Lobos indicating a former delta of the Sacramento river. Low lands occur again near Bodega and Russian river, the coast range being somewhat broken from Point Bonita to the Russian river. Here again the high and impassable mountains commence and slope abruptly to the sea, forming another precipitous wall of rock, which extends above Cape Mendocino. Between this cape and the Columbia river there is an alternation of low and high land, there being no important rivers, and the only irregularities in the coast line being the reefs which generally extend for two or three miles from the main head-lands. The low lands on this portion of the coast are found near Crescent City, Rogues river, Cowes bay, and the Umpquah river. Off Crescent City an important feature is the bank which seems to run out from the main land to a distance of thirty miles, the depth of the water being from forty to seventy fathoms.

The sand-banks of the Columbia river are well known, and this portion of the coast presents some of the most remarkable beaches, I presume, in the world—the Clatsop beach on the south, and the Great Weather beach, as it is called, on the north of the entrance of the river. The Weather beach extends from Mackenzie's head in a direct line northward for nearly fifty miles, the only break in the whole extent being the narrow entrance to Shoalwater bay. This magnificent beach is several hundred yards wide at low water, perfectly even and hard, and the huge waves of the Pacific break in straight lines for many miles, presenting a most sublime appearance. The Che-ha-lis river, or Gray's harbor, is the northern limit. From Gray's harbor to Cape Flattery but little is known of the coast, excepting that no shoal or islands are found extending to any great distance from the land.

The uniformity of the coast line is broken up at Cape Flattery, and beyond the straits of Juan de Fuca a chain of islands and bays extends far to the northward. The tidal stations which would appear to be least influenced by local causes are, I think, the following: San Luis Obispo, Monterey, Farallon islands, Bodega, Port Orford, Cape Flattery, and Nootka. This subject, however, requires more investigation than I have yet been able to bestow upon it.

I would be glad to submit some observations upon the selection of local positions for the gauges, the construction of the gauges, and so forth; but my report is already too long, and these subjects will be reserved for a future time.

I cannot close, however, without expressing to you how much I feel indebted to Captain Alden and the officers of the "Active" for the kindness and courtesy which they have extended to me during my summer's work. Without their assistance, I should have accomplished but little compared with what I was enabled to do. Captain Alden not only transported my party to and from those places which I wished to reach, but gave me every assistance in his power in erecting gauges, moving my baggage, &c.; and I feel greatly indebted, also, to all the officers for many personal favors and attentions.

Very respectfully, your obedient servant,

W. P. TROWBRIDGE,
U. S. E., Assistant United States Coast Survey.

Prof. A. D. BACHE,
Superintendent United States Coast Survey, Washington.

List of tidal stations on the western coast during the year ending October 1, 1855, *under the direction of Lieutenant W. P. Trowbridge, U. S. Engineers, assistant in the Coast Survey.*

No.	Name of station.	Date of occupation.	Latitude.	Longitude. In arc.	Longitude. In time.
			° ′	° ′	h. m.
1	Nootka	From August 28 to September 11, 1855	49 22	126 20	8 23
2	Neé-ah Bay	From August 4 to September 12, 1855	48 21	124 37	8 18
3	Port Townshend	From August 1 to September 10, 1855	48 07	122 45	8 11
4	Shoalwater Bay	From September 19 to October 3, 1855	46 37	124 01	8 16
5	Astoria	Whole year	46 11	123 49	8 15

List of tidal stations—Continued.

No.	Name of station.	Date of occupation.	Latitude.	Longitude.	
				In arc.	In time.
			° ′	° ′	h. m.
6	Port Orford	Finished October 4, 1854	42 44	124 29	8 18
7	Humboldt	Finished October 7, 1854	40 44	124 11	8 17
8	Bodega	From December 2, 1854, to February 28, 1855	38 18	123 02	8 12
9	San Francisco	Whole year	37 47	122 26	8 10
10	Farallon Islands	From May 18 to October 10, 1855	37 42	122 59	8 12
11	San Diego	Whole year	32 42	117 13	7 49

APPENDIX No. 35.

Letter of Lieut. W. P. Trowbridge, U. S. Engineers, assistant in the Coast Survey, stating the incidents attending the observation of tides at Nootka sound.

San Francisco, California, *October* 11, 1855.

Dear Sir: I have the honor to report to you the safe arrival of my party at this place on the 7th instant, after an absence of three months. According to your instructions, I left San Francisco on the 7th of July, in the steamer "Active," for the purpose of extending the tidal observations of the coast above the Columbia river, as far northward as possible. It gives me great pleasure to report that my labors have been attended with quite as good success as I had dared to anticipate.

The very unsatisfactory information that I had been able to gain with regard to the northern coast, and especially concerning the Indian tribes of Cape Flattery and Vancouver's island, had given me some apprehension that my observations might be interrupted, and I found afterwards that my anxiety was not without good cause. The Indians at the cape conceived a foolish notion that I had come to bring back the small-pox, which raged fearfully among them shortly after Mr. Davidson's visit there, and for some time they seemed ready for an open collision. I succeeded, however, in keeping them quiet by explaining to them as well as possible the object of my visit, and showing them my disposition to resist any interference in my operations. The idea of the return of the small-pox, however, had become extensively spread among the northern tribes, and some of them found it a convenient excuse for a hostile feeling, which came near leading to serious results on several occasions.

I informed you in a letter from Cape Flattery, that I had sent Mr. C. J. W. Russell to Nootka sound in a small schooner, with directions to make fourteen days' observations upon the coast tides. Mr. Russell returned to the cape on the 12th of September, after having accomplished, to my perfect satisfaction, the duties intrusted to him; but I regret to say that the observations were made under the most perilous circumstances; nothing, indeed, but the firmness of Mr. Russell, saved the whole party from destruction by the savages. They were obliged to anchor the schooner near the shore, within bow-shot of the beach, and observe the staff from the deck of the vessel by day, and by means of a boat by night. For a few days they were unmolested, but after the news of their arrival had become known, the Indians flocked from all quarters to see them. The idea had been injuriously circulated by some of our enemies near Cape Flattery, that the object of Mr. Russell's visit was to cast some evil spell upon the land and waters, and they demanded that he should leave immediately, telling him plainly that they would attack him if he did not; he told them, however, that he could not leave until he had finished his observations. They then endeavored by all manner of stratagem to get possession of the vessel, and even attempted to sell poisoned provisions.

For several days and nights the crew were unable to take any rest, and Mr. R. was obliged to take the night observations with a lamp in one hand and a pistol in the other. On the 11th of September, having finished the observations, the party set sail for Cape Flattery, leaving the Indians still gathered, with canoes continually bringing reinforcements.

The observations at Nootka were commenced on the 28th of August, and continued uninterrupted until September 11th—fourteen days. I transmit by the mail of the 20th, the curve constructed from the observations, and also a sketch of the locality taken from an English chart.

The observations at Cape Flattery were commenced on the 4th of August, and continued until the 12th of September—six weeks—without interruption; the gauge was placed at Neé-ah bay, under the lee of Waddah island, as it was found impracticable to establish it at the extreme cape.

The observations at Port Townshend were conducted by Mr. Bergan, and were uninterrupted from August 1st until September 11th, excepting during a heavy blow from the southeast, which commenced on the night of 1st September, and continued until the evening of the 4th. The curves traced by the gauges at Cape Flattery and Port Townshend embrace four sheets, all of which are transmitted to the office. I have not yet heard from the observer left at Steilacoom, but presume he will soon reach this place; his instructions were to make observations until the middle of September, and then return by a sailing vessel to San Francisco.

On the 12th of September the "Active" arrived at Neé-ah bay, on her way down the coast, and I struck my camp and left the straits.

In addition to the observations enumerated, I may mention three days' observations at Olympia, two weeks' harbor tides at Shoalwater bay, and one day coast tides at Crescent City.

I also made magnetic observations for declination, intensity and dip, at Neé-ah bay, upon which a separate report will be made; the magnetic observations occupied me two weeks.

In all the tidal observations I have personally superintended the erection of the gauges, whether self-registering or otherwise, excepting at Nootka sound, and the observations at Neé-ah bay were made under my immediate supervision.

It will thus be seen that two new coast stations have been added, extending the observations as far north as Nootka sound, while, simultaneous with these, observations have been made at Port Townshend and Steilacoom. I find also on my return that the observations at the Farallon islands have been uninterrupted to the present time; the last sheet came off yesterday; and from this place three sheets are now ready for transmission.

I propose to send Mr. Russell to the island of San Miguel, near Point Conception, in a few days, as I cannot trust to getting a station at the Point. Mr. R. will leave on Thursday.

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. 36.

Reports of the chiefs of divisions to Captain H. W. Benham, Corps of Engineers, assistant in charge of the office, showing the details of the work executed in each division.

REPORT OF MR. CHARLES A. SCHOTT, IN CHARGE OF THE COMPUTING DIVISION.

COAST SURVEY OFFICE, *October* 1, 1855.

The annual report of the occupation of the computers during the year ending November 1, 1855, and an appendix containing the detailed statements, is herewith respectfully submitted.

The charge of the computing division has been continued with Assistant J. E. Hilgard, and during his absence with myself. I was in charge of the division during ten months, while Mr.

Hilgard was engaged on field or other duty, and was relieved on the 1st of August, when I took the field for six weeks, under special instructions from the Superintendent. After September 24th I resumed the duties of chief of the division.

No change was made in the general organization of the division, which, from the past year and previous experience, has proved efficient in every respect. The distribution of the astronomical, geodetic, and magnetic reductions among the several computers, has remained as stated in last year's report, with such changes as were found expedient under the circumstances. Mr. J. E. Blankenship has been added to the number of computers, Mr. D. A. Burr has resigned, and Mr. McL. Tilton has been transferred to one of the field parties.

The application of the computers to their respective duties has proved as productive as could be desired, and the results have been brought out with a view to approach as near as possible to the form in which they will be needed for publication; in this respect the division and the work of publication will mutually be benefited. The project of work for the last year was adhered to as closely as was found advantageous, and in reference to bringing up reductions of former years a considerable progress has been made, leaving but little of the work of former years to be recomputed.

A statement in detail on the occupation of the several computers during the year ending November 1, 1855, is herewith appended.

Mr. Charles A. Schott was in charge of the computing division for ten months, during which time a number of reports to the Superintendent, or assistant in charge of the office, have been submitted, out of which the following may be specially noticed:

On probable errors derived from observations of horizontal angles at a given station by the method of least squares; on side equations; on the adjustment of horizontal angles of a triangulation, by application of the method of least squares; on the reduction of the Savannah river triangulation; on the chronometric difference of longitude; and on the latitude of stations in Sections VI, VII, and VIII, determined by Assistant F. H. Gerdes; a scheme of reduction of the primary triangulation in Section I; on the latitude of Agamenticus, resulting from three different instruments; on the reduction of the latitude stations, observed with the Military Academy zenith telescope; a discussion on the residual discrepancies in the primary triangulation of Section I, with special reference to lateral refraction; on the Cape Fear river triangulation of Assistant C. P. Bolles; on the resulting longitude by moon culminations of the Rio Grande station; a discussion on the residual discrepancies in the primary triangulation of Section II, with a comparison of the thirty-inch and two-feet theodolites; and on the reduction of the Winyah bay triangulation. During May and June I was principally occupied with the collection and discussion of the results for magnetic declinations on the Atlantic and Gulf coast. In conformity with instructions from the Superintendent I was on field duty during August and part of September, since which time I have been engaged in arranging and discussing my magnetic observations. The magnetic observatory under my charge was in operation from the latter part of November till the latter part of July, when the operations were discontinued, for the purpose of making a new arrangement in the instruments and method. The charge of the division was resumed by me October 1st.

Mr. Eugene Nulty completed the second reduction of the azimuth observed by Assistant Bolles at Wilmington, North Carolina, 1852–'53, and reduced the latitudes of six preliminary stations determined by Assistant Gerdes in Sections VI, VII, and VIII, 1853–'54. He discussed the latitudes of the De Rosset station, Section IV, occupied by Assistant Dean in 1854, of Ragged Mt. station, Section I, occupied by the Superintendent's party in 1854, by G. W. Dean and Mr. Harris. Mr. Nulty reduced the latitude of station Sebattis, Section I, determined by zenith telescopes No. 1 and No. 2 in 1853, and reduced the latitude of east base, Section IX, 1853, and the latitude and azimuth of Jupiter station, in the same section, and by the same observer, G. W. Dean. The reductions of the latitudes of Columbia, South Carolina, occupied by Dr. Gould and Assistant Dean in 1854, and of Macon, Georgia, occupied by Assistant Dean in 1855, were also completed. The reduction of the second computation of the transit and longitude of Sand key will probably be completed.

Assistant Theodore W. Werner has reduced Lieutenant Seward's triangulation in Section VI, near Card's sound, in 1854, and made the second reduction of the Cape Fear river triangulation of Assistant Bolles, of 1852 and '53. He also reduced Lieutenant Totten's triangulation of Winyah bay, South Carolina, in 1853. Mr. Werner computed Assistant Gerdes' triangulation of the Cedar keys, of 1851 and '52; computed rectangular co-ordinates of positions determined by Captain Palmer on the Rappahannock river, in Section III, 1854; reduced Assistant Gilbert's triangulation in Section VIII, of 1853; made a least square abstract of horizontal angles of Ragged Mount, occupied by the Superintendent in 1854; computed Assistant Farley's triangulation, connecting the James and Appomattox rivers, in Section III, and nearly completed the reduction of Assistant Cutts' primary triangulation south of San Francisco, Section X, of 1855. Mr. Werner has besides made, under Assistant Blunt, computations for the New York harbor survey now in progress, and will probably complete Assistant Gilbert's triangulation of 1855, in Section IX.

Mr. James Main reduced the chronometric differences of longitude of ten stations, in Sections VI, VII, and VIII, occupied by Assistant Gerdes' party in 1852, '53, and '54; revised the prime vertical latitude computations of Agamenticus, and the eight latitude stations occupied with the zenith telescope belonging to the Military Academy. He also revised the computations of eight stations occupied with zenith telescope No. 1, and assisted Mr. Hilgard in preparing the form of publication of the zenith sector latitude observations and reductions. The latitudes of east base, Section IX, and of Unkonoonuc, Section I, have also been fully revised. Mr. Main was detached from the division for field duty, assisting Mr. Schott on his magnetic trip, and has reduced the observations for time, azimuth, and declination, for sixteen magnetic stations, since he joined the office on 10th of September. He will probably complete the reduction of the intensities at the same stations.

Mr. G. Rumpf has been in charge of the geographical registers, which includes the revising and correcting of the first and second computations, and prepared the statistics of the astronomical, geodetic, and magnetic records of the survey for the year 1853. Up to the month of July, Mr. Rumpf directed the computations made by Mr. Toomer, and was assisted by him in the revision, second computation, and adjustment of the upper Chesapeake Bay river triangulation in Section III, a revision of great extent. He also computed the positions near the mouth of Cape Fear river, determined by Assistant Bolles in 1851; compared the two reductions of Rappahannock river, Section III; assisted in the reduction of Casco bay triangulation, horizontal and vertical angles observed by Assistant Boutelle in 1854, and will complete the statistics of the survey, relating to this division, for the year 1854. Mr. Rumpf, besides, made some miscellaneous computations.

Mr. J. Wiessner assisted Mr. Schott in making out an abstract of probable errors of observation of horizontal angles of the primary triangulation in Sections II, III, and IV, and performed some miscellaneous calculations. He assisted Messrs. Hilgard and Schott on the computations for the discussion of the magnetic declinations; deduced the length of the San Pedro base, Section X; prepared information for the General Land Office, relative to the Florida keys; reduced the azimuth of Wilmington, Section IV, observed by Assistant Bolles; and deduced the length of the second base on the Rappahannock. Mr. Wiessner made a second computation of the zenith telescope latitude of Marriot, of 1846, and the first reduction of the horizontal angles at Ragged Mount, Section I; and reduced, by the method of least squares, the transits at Humboldt station, Section X, 1854. The laborious reduction of the Casco bay triangulation of Assistant Boutelle, in Section I, was completed; and the reduction of the chronometric difference of longitude between East Pascagoula, Deer island, and Hurricane island, Sections VII and VIII, determined by Assistant Gerdes' party in 1854 and '55, has made considerable progress.

Mr. J. H. Toomer assisted Mr. Rumpf in the revision and second computation of the Chesapeake Bay and river triangulations, made out abstracts of probable errors of horizontal angles, and has performed miscellaneous computations. Mr. Toomer attended daily for more than two months the magnetic observatory, completed the reduction of Assistant Gilbert's triangulation in Section VIII, of 1853, and made progress with the last observations taken in that section, and the computation of the geodetic latitude, longitude, and azimuth of the Rappahannock river, Section III; which work he will probably complete by the first of November. He also assisted on the reduction of the Casco bay triangulation.

Mr. John T. Hoover performed the usual clerical duties of the division, and principally attended to the magnetic observatory, made some computations relative to the zenith sector latitudes, and some triangle and other miscellaneous geodetic computations. Some copying of mathematical papers was done by Mr. Hoover.

Mr. David A. Burr computed right ascensions of stars under Mr. Main's direction, and assisted Mr. Schott on the comparisons of the star places in the Twelve Year and Rumker's Hamburg catalogues. He assisted occasionally as copyist, and also at the magnetic observatory, and resigned about the 1st of April.

Mr. McLane Tilton assisted in copying for the division, and also for field parties, and in February was temporarily transferred to the tidal division, and afterwards detached from this division.

Mr. James E. Blankenship joined the division as a computer on the 22d of June, and assisted Mr. Schott on the discussion of the secular change of the magnetic declinations, and afterwards assisted Mr. Hilgard on the computations relating to the discussion of the magnetic declinations.

Duplicating and miscellaneous copying has been done by R. Freeman; and miscellaneous computations by A. S. Clements, under Assistant Hilgard's immediate direction.

REPORT OF OFFICE OCCUPATION IN THE TIDAL DIVISION, IN CHARGE OF ASSISTANT L. F. POURTALES.

COAST SURVEY OFFICE, *October* 1, 1855.

The observations of tides, and the discussion of their results, being under the immediate direction of the Superintendent, a report on them has been transmitted to him directly.

The general organization of this division has remained the same as heretofore.

In addition to the discussions of tidal observations, &c., made under the Superintendent's immediate direction, the computers of this division have continued to keep up the reduction of the observations as they come from the field, so as to make the results readily available whenever wanted, and, in the case of permanent stations, to enable us to detect more readily inaccuracies and defects, and to remedy them. Numerous tide-tables have been prepared from the results of the reductions, and furnished on demand to the engraving division, to be entered on the maps in the course of publication.

The following is an abstract of the occupation of the different computers during the year:

Mr. H. Heaton has continued the discussion of the tides in the Gulf of Mexico. He has also been engaged in computations preliminary to the determination of the co-tidal lines in that gulf and on the western coast, and in discussing the daily inequality on the latter. This work was done under the immediate direction of the Superintendent.

During my absence, in the months of July, August, and September, Mr. Heaton was in charge of this division.

Mr. R. S. Avery has revised the predictions of tides made by the other computers; has compared them with observation; has prepared tables of corrections to be applied to them. He has also continued the discussion of the Boston observations. Of his abilities and assiduity I have had occasion to speak too often to make a repetition here necessary.

Mr. J. Kincheloe has been engaged in preparing tables of predictions of tides, but has chiefly been occupied with the discussion of the Boston tides. He has continued to show assiduity and ability in the discharge of his duties.

Mr. P. R. Hawley was engaged in reading off and reducing the self-registering tidal observations until January 23, when he was ordered to field duty.

Mr. G. C. Blanchard has been engaged in ordinary tidal reductions, and part of the time in reading off and reducing the self-registering tidal observations. He has also rendered assistance in copying and miscellaneous work. From the 12th to the 30th of April he was employed as clerk in the engraving division.

Mr. C. Fendall was attached to this division until November 7th, when he was ordered to field duty. On his return, on June 7th, he was again attached to it. He has been engaged in preparing tidal diagrams for the Superintendent, and in assisting Mr. Heaton in the working out of the daily inequality in the western coast, besides making miscellaneous reductions. He has shown himself faithful and industrious.

Mr. R. E. Evans reported on the 17th of April, and has been intrusted with the duty of reading off and reducing the self-registering tidal observations.

Mr. H. F. Peters was engaged in working on the tables of predictions of tides and in miscellaneous reductions from December 1st to April 17th, at which time he resigned.

Mr. R. T. Bassett made miscellaneous reductions of tidal and meteorological observations from December 10 until June 23, when he was ordered to the field.

Messrs. Montgomery, Duval, and Baker were also temporarily occupied in this division in the intervals between their coming and going from and to the field.

With very few exceptions, the interest taken in this work by the computers, their punctuality of attendance, and their assiduity during office hours, have continued to be very satisfactory.

REPORT OF LIEUT. J. C. TIDBALL, U. S. A., IN CHARGE OF THE DRAWING DIVISION.

COAST SURVEY OFFICE, *October* 1, 1855.

Herewith I submit a report of the operations of this division of the Coast Survey office for the time included between November 1, 1854, and the present date.

The division was in charge of Capt. A. A. Gibson, U. S. A., up to the 1st of August, since which time it has been under my direction.

The following is a statement of work accomplished in this division during the year 1854–'55, up to this date, in the order of draughtsmen:

Assistant W. M. C. Fairfax has completed the reduction of the topography of Chesapeake bay No. 1, $\frac{1}{80000}$; and has been engaged upon the topography of Chesapeake bay No. 6, $\frac{1}{80000}$; San Francisco entrance, $\frac{1}{50000}$; and upon miscellaneous matters of difficult nature, for which his long experience and general skill eminently qualify him. Assistant Fairfax has been prevented by sickness from attending to his duties since the middle of July last. Assistant M. J. McClery has been employed on the reduction of the topography of Chesapeake bay Nos. 2, 3, and 4, $\frac{1}{80000}$; specimens for general coast chart No. 2, $\frac{1}{400000}$; Biloxi bay, $\frac{1}{40000}$; and miscellaneous work.

Mr. Joseph Welch has been engaged upon the reduction of the topography of Eastern series No. 3, $\frac{1}{80000}$; Congress map, $\frac{1}{1500000}$; Chesapeake bay No. 5, $\frac{1}{80000}$; Mississippi sound Nos. 1 and 2, $\frac{1}{80000}$; Massachusetts bay, $\frac{1}{80000}$; general coast chart No. 2, $\frac{1}{400000}$; and verifications.

Mr. J. J. Ricketts has been engaged upon the reduction of the hydrography of Mississippi sound Nos. 1 and 2, $\frac{1}{80000}$; Long Island sound No. 1, $\frac{1}{80000}$; Columbia river entrance, $\frac{1}{40000}$; Canal de Haro and Strait of Rosario, $\frac{1}{200000}$; Chesapeake bay Nos. 2 and 3, $\frac{1}{80000}$; Nantucket shoals, $\frac{1}{200000}$; San Francisco entrance, $\frac{1}{50000}$; and upon much miscellaneous hydrography.

Mr. A. Boschke rejoined the office on the 3d of January, and has been occupied mainly upon examinations, progress sketches, projections, and miscellaneous work. He has also been engaged upon the comparative maps of New York bay, $\frac{1}{10000}$; and the map of New York harbor, for commissioners, $\frac{1}{20000}$.

Mr. A. Balbach rejoined the office on the 5th of January, and has been engaged upon the maps of Portland harbor, $\frac{1}{10000}$, $\frac{1}{20000}$, and $\frac{1}{80000}$; entrance to Chesapeake bay, $\frac{1}{100000}$; Florida reefs, $\frac{1}{80000}$; and comparative maps, New York bay, $\frac{1}{10000}$. Mr. Balbach was assigned to duty with the hydrographic party, under command of Lieut. Comg. Craven, on the 6th of July.

Mr. L. D. Williams has been engaged on the reduction of topography and hydrography of Plymouth harbor, $\frac{1}{20000}$; Bass river, $\frac{1}{40000}$; Winyah bay and Georgetown harbor, $\frac{1}{100000}$; seacoast of Virginia, $\frac{1}{200000}$; Gulf Stream chart, $\frac{1}{3000000}$; Cape Fear river, $\frac{1}{30000}$; additions to Congress map, $\frac{1}{1500000}$; projections, progress sketches, and verifications.

Mr. A. Lindenkohl has completed the reduction of Alden's reconnaissance western coast No. 3, $\frac{1}{1200000}$; and has been employed on the reduction of Columbia river, $\frac{1}{40000}$; Savannah river, $\frac{1}{40000}$; also, upon projections for field parties, projections on copper, and miscellaneous work.

Mr. J. R. Key has been engaged upon the reduction of the topography of Ipswich and Annisquam harbors, $\frac{1}{20000}$; Albemarle sound, $\frac{1}{200000}$; Port Townshend, $\frac{1}{40000}$; Salem harbor, $\frac{1}{20000}$; Portland harbor, $\frac{1}{80000}$; San Francisco bay, $\frac{1}{50000}$; and miscellaneous matter.

Mr. W. T. Martin has completed the reduction of the topography of Gloucester harbor, $\frac{1}{20000}$; Smith's island, Washington Territory, $\frac{1}{20000}$; San Pedro, $\frac{1}{40000}$; Santa Barbara, $\frac{1}{20000}$; and is now engaged in reducing the topography of St. Andrew's bay, $\frac{1}{40000}$. He has also made several miscellaneous drawings.

Mr. W. P. Schultz has reduced the sketches of Vermilion bay, $\frac{1}{30000}$, and Calcasieu river, $\frac{1}{40000}$; and has been employed mainly upon projects and miscellaneous work, in which his general knowledge of the affairs of the division, his quickness and readiness, are of great service.

Mr. F. Fairfax has been employed on the reductions of Grenville harbor, $\frac{1}{20000}$; York river, $\frac{1}{20000}$; Point Reyes, $\frac{1}{40000}$; Bass river, $\frac{1}{40000}$; Doboy inlet, $\frac{1}{40000}$; and Cape Fear river (upper sheet,) $\frac{1}{30000}$.

Mr. F. Boucher was engaged on the reduction of sketches and on progress sketches until the 23d of April, when he resigned.

Mr. B. Hooe has been continued upon miscellaneous tracings.

Artificer J. A. Campbell has been continued upon tracings and in charge of miscellaneous maps.

Mr. Henry McCormick joined the office on the 18th of May, nce which time he has been employed on tracings.

Mr. James A. Whistler was attached to the division about two months in the early part of the season, and was employed principally upon miscellaneous work.

The clerical duties of the division have been faithfully performed by Mr. G. A. Porterfield.

The following papers were prepared in this division for the Superintendent's report of 1855:

1. List of maps and sketches completed or in progress during the year ending November 1, 1855.

2. List of sketches, diagrams, and drawings for annual report of 1855.

3. List of information furnished by Coast Survey, under authority of the Treasury Department.

4. List of capes, headlands, islands, harbors, and anchorages surveyed on the western coast.

5. Computation of shore-line of plane-table sheets for 1854; the area and shore-line of triangulation for 1854; and area of hydrography surveyed in 1854.

List of maps and sketches completed, or in progress, during the year ending November 1, 1855, 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	1–20,000	Finished chart	In progress.
Do.	1–10,000	Commissioner's chart	Completed.
Do.	1–2,500	do do	Do.
Annisquam and Ipswich harbors, Massachusetts	1–20,000	Finished chart	In progress.
Gloucester harbor, Massachusetts	1–20,000	do	Completed.
Massachusetts bay	1–80,000	do	In progress.
Plymouth harbor, Massachusetts	1–20,000	do	Do.
Eastern series No. 3, Massachusetts	1–80,000	do	Do.
Eastern series No. 2, Massachusetts	1–80,000	do	Do.
Monomoy shoals, Massachusetts	1–40,000	do	Do.
Bass River harbor, Massachusetts	1–40,000	do	Do.
Muskeget channel, Massachusetts	1–60,000	do	Completed.
Nantucket shoals, Massachusetts	1–200,000	Preliminary chart	Do.
General coast-chart from Cape Ann to Point Judith, Massachusetts and Rhode Island	1–400,000	Finished chart	In progress.
SECTION II.—*Coast of Connecticut, New York, New Jersey, Pennsylvania, and Delaware.*			
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.	In progress.
Do do	1–20,000	Finished chart for same	Do.
Manhattan island, south end		Comparative map, showing changes of shore-line.	Do.
SECTION III.—*Coast of Delaware, Maryland, and Virginia.*			
Progress sketch C	1–400,000		Completed.
Patapsco river, Maryland	1–60,000	Finished chart	In progress.
Chesapeake bay, Maryland and Virginia	1–400,000	Preliminary chart	Completed.
Seacoast of Virginia, No. 2	1–200,000	do	Do.
Chesapeake bay, No. 6, Virginia	1–80,000	Finished chart	In progress.
Do No. 5, Virginia	1–80,000	do	Do.
Do No. 4, Virginia and Maryland	1–80,000	do	Do.
Do No. 3, Maryland	1–80,000	do	Do.
Do No. 2, Maryland	1–80,000	do	Do.
Do No. 1, Maryland	1–80,000	do	Do.
SECTION IV.—*Coast of Virginia and North Carolina.*			
Progress sketch D	1–400,000		Completed.
Albemarle sound, North Carolina	1–200,000	Preliminary chart	In progress.
Cape Fear river	1–30,000	Finished chart	Do.
Gulf Stream chart	1–5,000,000	Sketch	Completed.
Diagrams of observations in the Gulf stream			Do.
SECTION V.—*Coast of South Carolina and Georgia.*			
Progress sketch E	1–400,000		Completed.
Winyah bay and Georgetown harbor, South Carolina	1–40,000	Preliminary chart	Do.
Winyah bay and Cape Roman shoals, South Carolina	1–100,000	do	Do.
Charleston harbor, South Carolina	1–30,000	do	Do.
Maffitt's channel, Charleston harbor, South Carolina	1–5,000	Comparative chart, 1852 to 1855	Do.
Savannah river to head of Argyle island, South Carolina and Georgia	1–40,000	Finished chart	In progress.
Doboy bar and inlet, Georgia		Reconnaissance	Completed.
SECTION VI.—*Coast of Florida.*			
Progress sketch F	1–1,200,000		Completed.
Progress sketch F No. 2, (Florida reefs)	1–400,000		Do.
Florida reefs, No. 1	1–80,000	Finished chart	In progress.
Key West, northwest channel	1–10,000	Comparative chart, 1846 to 1851	Completed.
Key Biscayne and Cape Sable bases	1–60,000	Sketches	In progress.
Positions of beacons on Florida reefs	1–400,000	Sketch	Completed.

List of maps and sketches—Continued.

Name.	Scale.	Description.	Remarks.
SECTION VII.—*Coast of Florida.*			
Progress sketch G	1–600, 000		Completed.
Cedar Keys	1–50, 000	Preliminary chart	Do.
Ocilla river	1–20, 000	do	Do.
St. Andrew's bay	1–40, 000	do	Do.
SECTION VIII.—*Coast of Alabama, Mississippi, and Louisiana.*			
Progress sketch H	1–600, 000		Completed.
Mobile bay No. 1, Alabama	1–80, 000	Finished chart	Do.
Mississippi sound No. 2, Alabama	1–80, 000	do	In progress.
Biloxi bay, Mississippi	1–40, 000	do	Do.
Profiles of deep-sea soundings in Gulf of Mexico		Sketch	Completed.
SECTION IX.—*Coast of Louisiana and Texas.*			
Progress sketch I	1–600, 000		Completed.
Entrances to Vermilion bay and Calcasieu river, La.	1–30, 000 1–40, 000	Reconnaissance	Do.
SECTIONS X and XI.—*Coast of California, and of Oregon and Washington Territories.*			
Progress sketches J and K	1–400, 000		Completed.
San Pedro bay ... California	1–40, 000	Light-house sketch	Do.
Santa Barbara ... do	1–40, 000	do	Do.
Anacapa island ... do	1–20, 000	do	Do.
South Farallon island ... do	1–3, 600	do	Do.
Point Reyes and Drake's bay ... do	1–40, 000	do	Do.
Entrance to San Francisco bay ... do	1–50, 000	Preliminary chart	In progress.
Columbia river ... Oregon	1–40, 000	do	Completed.
Port Townshend ... Washington Territory	1–40, 000	Reconnaissance	Do.
Duwamish bay ... do	1–40, 000	do	Do.
Smith's or Blunt's island ... do	1–20, 000	Light-house sketch	Do.
Alden's reconnaissance No. 3, from Umpquah river to the northern boundary line, Oregon and Washington Territories	1–1, 200, 000	Reconnaissance	Do.
Western coast of United States	1–10, 000, 000	Sketch for co-tidal lines	Do.
Diagrams illustrating earthquake waves			Do.
Map of magnetic declinations	1–2, 000, 000		Do.
Lieutenant B. F. Sands' gas-pipe tripod			Do.
Lieutenant B. F. Sands' specimen box		For deep-sea soundings	Do.

REPORT OF LIEUTENANT J. C. CLARK, U. S. A., IN CHARGE OF THE ENGRAVING DIVISION.

COAST SURVEY OFFICE, *November* 1, 1855.

This division has been under my charge since the date of the last annual report—Mr. Edward Wharton assisting in the duties of the division.

Since the date of last report, as was expected, several important finished charts have been completed, viz: Newburyport harbor, Salem harbor, eastern, middle, and western sheets, Long Island sound, Charleston harbor, and Key West harbor and its approaches, $\frac{1}{50000}$.

The middle sheet of Alden's reconnaissance western coast, which partakes of the character of a finished chart, has also been completed. The important first-class charts of Boston harbor and Mobile bay have been well advanced towards completion; and those of Eastern series No. 1, south side of Long Island No. 2, and Albemarle sound No. 2, have made considerable progress.

The northern sheet of Alden's reconnaissance western coast, corresponding in character with the middle sheet, has been nearly completed.

The important charts of Portland harbor; Portsmouth harbor; Gloucester harbor; Plymouth harbor; Monomoy shoals; Bass River harbor; Muskeget channel; Beaufort harbor, North Carolina, on steel; and Cedar keys; have been so far advanced as to admit of being published in a preliminary form, the hydrography being generally complete.

In addition, the following preliminary charts and sketches have been wholly engraved during the year, viz: Eggemoggin reach; York River harbor; Stellwagen's bank; tidal-currents Nantucket shoals; Wimble shoals; comparative chart Maffitt's channel; Doboy bar and inlet; Coffin's Patches; Ocilla river; Pass Fourchon; entrances to Vermilion bay and Calcasieu river; Anacapa and Smith's islands; Point Reyes and Drake's bay; San Pedro anchorage and vicinity of Santa Barbara; entrance to Columbia river; Grenville harbor; Canal de Haro and Strait of Rosario and approaches; Port Townshend; Duwamish bay and Seattle harbor; Craven's current-indicator and specimen box for deep-sea soundings; and Mitchell's seacoast tide-gauge; and the following plates, previously commenced, have been completed during the year, viz: Nantucket shoals, (new edition;) Ship and Sand Shoal inlets; seacoast of Virginia No. 2, (lower part;) Gulf Stream explorations 1854; Winyah bay and Cape Roman shoals; Turtle harbor; entrance to Rio Grande; Santa Cruz and Año Nuevo harbors; Port Orford, Shelter cove, Mendocino City and Crescent City harbors; entrance to Umpquah river; and sketch of the Coast Survey Base apparatus.

The following charts have been commenced during the year, and are in progress, viz: Annisquam and Ipswich harbors; seacoast Virginia and entrance to Chesapeake bay: Chesapeake bay, $\frac{1}{400000}$; Albemar e sound, $\frac{1}{200000}$; Winyah bay and Georgetown harbor; Beacons on Florida reefs; and sketch of South Farallon island.

Additional charts, and additions to those previously published, showing the progress of the survey in the several sections, have been engraved.

Four engravers, Messrs. J. Knight, F. Dankworth, A. Rollé, and J. V. N. Throop, have been employed in the office during the entire year on important topography and hydrography; and six apprentices, J. J. Knight, S. W. Bradley, R. F. Bartle, F. W. Benner, W. A. Thompson, and C. Keller, on preliminary charts and sketches.

Ten engravers, Messrs. G. McCoy, G. B. Metzeroth, A. Maedel, J. L. Hazzard, H. Knight, J. Young, J. C. Kondrup, R. T. Knight, C. A. Knight, and A. Petersen, during part of the year, on views, topography, and hydrography. Mr. G. McCoy has been employed, on contract, during part of the year, on important views and topography, and Messrs. E. Yeager and E. F. Woodward on hydrography and lettering.

I herewith submit a statement of the work executed by the engravers:

Mr. G. McCoy engraved six important views for the chart of Boston harbor; a portion of the topography of Eastern series No. 1, and south side Long Island No. 2; eight important views for Alden's reconnaissance western coast, middle sheet; all of the topography and four views for Alden's reconnaissance western coast, northern sheet.

Mr. John Knight completed the general lettering of Newburyport harbor, eastern, middle, and western sheets Long Island sound; engraved the title and a portion of the general lettering of Portland harbor; the title and part of the sailing directions of Boston harbor; a portion of the lettering of Charleston harbor and Mobile bay; the title, sailing directions, tables, notes, and part of the general lettering of Alden's reconnaissance western coast, middle sheet, and other lettering on important charts.

Mr. Dankworth completed the topography and sanding of Salem harbor and Charleston harbor; engraved the sanding of York River harbor, Bass River harbor, and a portion of Beaufort harbor, North Carolina, on steel; engraved a portion of the topography of Chesapeake bay No. 1; and completed the sanding of Mobile bay.

Mr. A. Rollé engraved important additions to the topography and sanding of Boston harbor; important additions to the topography and completed the sanding of the western sheet Long Island sound; completed the topography of middle sheet Long Island sound; and engraved a portion of that of south side Long Island No. 2; completed the topography and engraved a portion of the sanding of Mobile bay No. 1.

Mr. J. V. N. Throop engraved the sailing directions, notes, tables, soundings, sub-title, and a portion of the general lettering of Portland harbor; the title, sailing directions, notes, tables, and a portion of the general lettering of Monomoy shoals; a portion of the soundings and general lettering of Muskeget channel; all the soundings of Albemarle sound, $\frac{1}{200000}$; the title, sailing directions, notes, tables, and nearly all the soundings and general lettering of Beaufort harbor, North Carolina, on steel; a portion of the lettering of Charleston and Key West harbors; the title and soundings of Alden's reconnaissance western coast, northern sheet; and a large quantity of lettering on other important plates.

Mr. J. L. Hazzard engraved the title, sailing directions, notes, tables, soundings, and general lettering of Gloucester harbor; a portion of the lettering of Portsmouth harbor, Bass River harbor, Nantucket shoals, Gulf Stream explorations 1854, and Key West harbor; the title, sailing directions, notes, tables, soundings, and general lettering of Turtle harbor; the soundings and a portion of the general lettering of Alden's reconnaissance western coast, middle sheet; the title, sailing directions, notes, soundings, and a portion of the lettering of Umpquah river; and lettering upon other plates.

Mr. Metzeroth engraved the outlines and a portion of the sanding of Portland harbor; the outlines, sand dry at low water, and a large portion of the topography of Gloucester harbor; a portion of the shading of Long Island sound, western sheet, and Gulf Stream explorations 1854; nearly all the sand dry at low water of Beaufort harbor, North Carolina, on steel; the topography of entrance to Columbia river; engraved one view and completed three others of Alden's reconnaissance western coast, middle sheet; and executed other miscellaneous engraving.

Mr. Maedel engraved a portion of the topography of York River harbor; most of the outlines of Portsmouth harbor; a portion of the outlines and sand dry at low water of Annisquam and Ipswich harbors; the sand dry at low water and a portion of the topography of Plymouth harbor; a portion of the topography of Albemarle sound No. 2; all the topography and soundings of Point Reyes and Drake's bay; nearly all the topography and a portion of the lettering of Santa Cruz and Año Nuevo harbors; the topography, title, and notes of Port Townshend; and miscellaneous topography and lettering.

Mr. Henry Knight, who has been employed but a short time in the office during the year, engraved a portion of the sanding of Salem harbor and Mobile bay No. 1.

Mr. J. C. Kondrup engraved the sailing directions, tables, notes, and part of the general lettering of Plymouth harbor; part of the lettering of Muskeget channel; all the outlines and part of the topography of Albemarle sound, $\frac{1}{200000}$; and miscellaneous lettering.

Mr. R. T. Knight engraved part of the topography and sanding of Monomoy shoals; a portion of the topography of Bass River harbor; the title of Point Reyes and Drake's bay; the titles, notes, tables, soundings, and general lettering of Canal de Haro and Strait of Rosario.

Mr. J. Young engraved the water-lining of progress section 1, $\frac{1}{600000}$; a portion of the topography of York River harbor and Monomoy shoals; two views of Salem harbor; the sections of Key West harbor; the topography of Anacapa island; Mitchell's sea-coast tide-gauge; and some miscellaneous work.

Mr. C. A. Knight engraved the titles, notes, tables, soundings, and general lettering of York River harbor, Wimble shoals, Coffin's Patches, entrance to Columbia river, Grenville harbor, and Smith's island, Washington Territory; the titles, tables, and notes of Cedar keys and entrance to Rio Grande; titles and notes of Gulf Stream explorations, 1854; comparative map Maffitt's channel and Anacapa island; a portion of the soundings of seacoast Virginia No. 2, (lower part;) the title of Santa Cruz and Año Nuevo harbors; the notes of Port Orford, &c., harbors; the soundings of Port Townshend; and some miscellaneous lettering.

Mr. A. Petersen engraved the title, sailing directions, notes, tables, and soundings of Ocilla river, and some miscellaneous lettering.

Mr. E. Yeager engraved, on contract, the title, sailing directions, tables, and notes of Portsmouth harbor; the title and part of the other lettering of Newburyport harbor; the title and soundings of Plymouth harbor, and Winyah bay and Cape Roman shoals; the title, sailing directions, soundings, and part of the other lettering of Bass River harbor; and the soundings of Albemarle sound No. 2, Winyah bay and Georgetown harbor, and Cedar keys; and part of the sailing directions and notes of Key West harbor.

Mr. E. F. Woodward engraved, on contract, a portion of the soundings of Portsmouth harbor.

Apprentice J. J. Knight engraved part of the topography of Monomoy shoals, Bass River harbor, and Port Orford, &c., harbors; the topography, titles, tables, notes, soundings, and general lettering of San Pedro anchorage and vicinity of Santa Barbara, and Duwamish bay; completed the topography of entrance to Umpquah river; engraved the current-indicator and specimen sounding-box, and a portion of general lettering of progress sections 3, 5, 6, and 9; the title, note, and general lettering of Florida sub-sketches; and miscellaneous work.

Apprentice S. W. Bradley engraved the entire charts of Eggemoggin reach and entrances to Vermilion bay and Calcasieu river; part of the outlines and topography of Bass River harbor; the titles, soundings, and other lettering of Stellwagen's bank and Pass Fourchon; the title and general lettering of tidal currents Nantucket shoals; the topography, title, sailing directions, and other lettering of Doboy bar and inlet; the outlines and part of the general lettering and topography of Cedar keys; the titles and other lettering of progress section 2, and the tide-gauge; part of the general lettering of progress sections 4, 8, 10, and 11, and other miscellaneous work.

Apprentice R. F. Bartle engraved the outlines and triangulation of progress section 1, $\frac{1}{600000}$; the outlines and part of the topography of seacoast of Virginia No. 2; the topography of Pass Fourchon, Grenville harbor, and Smith's island, Washington Territory; additional triangulation of progress sections 1, $\frac{1}{400000}$, 3, 5, 10, and 11; and miscellaneous work, as curves of depth, scales, compasses, &c.

Apprentice F. W. Benner engraved the outlines and curves of comparative maps of Maffitt's channel and South Farallon island; the outlines and topography of Ocilla river; completed the topography of entrance to Rio Grande; engraved the outlines and triangulation of progress section 2, Florida sub-sketches, Strait of Rosario and vicinity, and part of progress section 4, $\frac{1}{400000}$; and miscellaneous work, as outlines, curves of depth, scales, compasses, &c.

Apprentices W. A. Thompson and C. Keller have been employed on miscellaneous work, as diagrams, borders, curves, &c., when not engaged in practising.

I respectfully call your attention to the accompanying lists of maps and charts engraved, preliminary charts and sketches engraved, maps and charts engraving, charts unfinished at the date of last report, charts commenced during the year, and charts finished during the year.

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.	Salem harbor.................do	$\frac{1}{25000}$
4.	Wellfleet harbor.............do	$\frac{1}{50000}$
5.	Nantucket harbor...........do	$\frac{1}{20000}$
6.	Hyannis harbor..............do	$\frac{1}{30000}$
7.	Harbor of Edgartown.......do	$\frac{1}{20000}$
8.	Harbors of Holmes' Hole and Tarpaulin cove, Massachusetts	$\frac{1}{20000}$
9.	Harbor of New Bedford, Massachusetts	$\frac{1}{40000}$
10.	General chart of the coast from Gay Head to Cape Henlopen	$\frac{1}{400000}$
11.	Fisher's Island sound, Connecticut	$\frac{1}{40000}$
12.	Harbor of New London......do	$\frac{1}{20000}$
13.	Mouth of Connecticut river, do	$\frac{1}{20000}$
14.	Harbor of New Haven—new edition, 1852	$\frac{1}{30000}$
15.	Harbors of Black Rock and Bridgeport—new edition, 1852	$\frac{1}{20000}$

No. 16.	Harbors of Sheffield and Cawkin's Island—new edition, 1852	$\frac{1}{20000}$
17.	Huntington bay, New York	$\frac{1}{30000}$
18.	Oyster bay or Syosset harbor, New York	$\frac{1}{30000}$
19.	Harbors of Captain's Islands, East and West, New York	$\frac{1}{20000}$
20.	Hart and City islands, and Sachem's Head harbor, New York	$\frac{1}{20000}$, $\frac{1}{10000}$
21.	Hell Gate, New York	$\frac{1}{5000}$
22.	Long Island sound—east	$\frac{1}{80000}$
23.	Do .... do ..—middle	$\frac{1}{80000}$
24.	Do .... do ..—west	$\frac{1}{80000}$
25.	New York bay and harbor and the environs, New York—sheet No. 1	$\frac{1}{30000}$
26.	Do .... do .... do .... do .... do No. 2	$\frac{1}{30000}$
27.	Do .... do .... do .... do .... do No. 3	$\frac{1}{30000}$
28.	Do .... do .... do .... do .... do No. 4	$\frac{1}{30000}$
29.	Do .... do .... do .... do .... do No. 5	$\frac{1}{30000}$
30.	Do .... do .... do .... do .... do No. 6	$\frac{1}{30000}$
31.	Do .... do .... do .... do	$\frac{1}{80000}$
32.	Western part of south coast of Long Island .... do	$\frac{1}{80000}$
33.	Little Egg harbor, New Jersey	$\frac{1}{30000}$
34.	Delaware bay and river, Delaware—sheet No. 1	$\frac{1}{80000}$
35.	Do .... do ...... New Jersey and Pennsylvania—sheet No. 2	$\frac{1}{80000}$
36.	Do .... do .... do .... do ......—sheet No. 3	$\frac{1}{80000}$
37.	Seacoast of Delaware, Maryland, and part of Virginia	$\frac{1}{200000}$
38.	Harbor of Annapolis and Severn river, Maryland	$\frac{1}{60000}$
39.	Mouth of Chester river, Maryland	$\frac{1}{40000}$
40.	Pasquotank river, North Carolina	$\frac{1}{60000}$
41.	Charleston harbor, South Carolina	$\frac{1}{30000}$
42.	Key West harbor and its approaches, Florida	$\frac{1}{50000}$
43.	Mobile bay entrance, Alabama	$\frac{1}{40000}$
44.	Cat and Ship Islands harbor, Mississippi	$\frac{1}{40000}$
45.	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.	York river harbor, Maine	$\frac{1}{20000}$
5.	Portsmouth harbor, New Hampshire	$\frac{1}{20000}$
6.	Gloucester harbor, Massachusetts	$\frac{1}{20000}$
7.	Stellwagen's bank, Massachusetts	$\frac{1}{400000}$
8.	Current chart Boston harbor, Massachusetts	$\frac{1}{100000}$
9.	Minot's ledge, Massachusetts	$\frac{1}{10000}$
10.	Plymouth harbor, Massachusetts	$\frac{1}{20000}$
11.	Monomoy shoals, Massachusetts	$\frac{1}{40000}$
12.	Bass River harbor, Massachusetts	$\frac{1}{40000}$
13.	Nantucket shoals, Massachusetts—new edition	$\frac{1}{200000}$
14.	Tidal currents Nantucket shoals, Massachusetts	$\frac{1}{300000}$
15.	Muskeget channel, Massachusetts	$\frac{1}{60000}$
16.	Sow and Pigs reef, Massachusetts	$\frac{1}{240}$, $\frac{1}{20000}$
17.	Tidal currents Long Island sound, Massachusetts	$\frac{1}{800000}$
18.	Pot rock and Way's reef, New York	

No. 19.	Buttermilk channel, New York	$\frac{1}{5000}$
20.	Beacon ranges, New York harbor, New York	$\frac{1}{40000}$
21.	Romer shoal and Flynn's knoll, New York	$\frac{1}{40000}$
22.	Changes in Sandy Hook, New Jersey	$\frac{1}{10000}$, $\frac{1}{40000}$
23.	Chincoteague inlet, Virginia	$\frac{1}{40000}$
24.	Seacoast Virginia No. 2, (upper part,) Virginia	$\frac{1}{200000}$
25.	Do.......do....(lower part,)......do	$\frac{1}{200000}$
26.	Wachapreague, Machipongo, and Metomkin inlets, Virginia	$\frac{1}{40000}$
27.	Ship and Sand Shoal inlets.......do	$\frac{1}{40000}$
28.	Entrance to Chesapeake bay.......do	$\frac{1}{100000}$
29.	Cape Charles and vicinity.......do	$\frac{1}{80000}$
30.	Cherrystone inlet.......do	$\frac{1}{40000}$
31.	Pungoteague creek	$\frac{1}{40000}$
32.	Fishing or Donoho's battery, Maryland	$\frac{1}{80000}$
33.	Hatteras shoals, North Carolina	$\frac{1}{20000}$
34.	Cape Hatteras.......do	$\frac{1}{20000}$
35.	Hatteras inlet (4th edition) North Carolina	$\frac{1}{20000}$
36.	Ocracoke inlet.......do	$\frac{1}{40000}$
37.	Wimble shoals.......do	$\frac{1}{80000}$
38.	Beaufort harbor, North Carolina	$\frac{1}{20000}$
39.	Do.......do.......(on steel)	$\frac{1}{20000}$, $\frac{1}{30000}$
40.	New river and bar.....do	$\frac{1}{15000}$
41.	Frying Pan shoals.....do	$\frac{1}{120000}$
42.	Cape Fear river and New Inlet, North Carolina	$\frac{1}{40000}$
43.	Gulf Stream explorations, 1853	$\frac{1}{5000000}$
44.	Diagrams, Gulf Stream explorations, 1853	
45.	Gulf Stream exploration, 1854	$\frac{1}{5000000}$
46.	Diagrams, Gulf Stream explorations, 1854	
47.	Co-tidal lines, Atlantic coast	$\frac{1}{10000000}$, $\frac{1}{1500000}$
48.	Cape Roman shoals, South Carolina	$\frac{1}{100000}$
49.	Winyah bay and Cape Roman shoals, South Carolina	$\frac{1}{100000}$
50.	Bull's bay	$\frac{1}{40000}$
51.	North Edisto river—new edition	$\frac{1}{50000}$
52.	Comparative chart, Maffitt's channel, South Carolina	$\frac{1}{5000}$
53.	Savannah river entrance, Georgia	$\frac{1}{30000}$
54.	Savannah city, Front and Back rivers, Georgia	$\frac{1}{20000}$
55.	Doboy bar and inlet.......do	$\frac{1}{40000}$
56.	St. Andrew's shoals.......do	$\frac{1}{60000}$
57.	St. John's river entrance, Florida	$\frac{1}{25000}$
58.	Mosquito inlet.......do	$\frac{1}{40000}$
59.	Cape Cañaveral.......do	$\frac{1}{50000}$
60.	Turtle harbor, Florida reefs.do	$\frac{1}{40000}$
61.	Coffin's Patches.......do	$\frac{1}{20000}$
62.	Key West harbor (2d edition) Florida	$\frac{1}{100000}$
63–69.	Key West, tidal diagrams.......do	
70.	Rebecca shoals.......do	$\frac{1}{600000}$
71.	Reconnaissance, vicinity of Cedar keys, Florida	$\frac{1}{300000}$
72.	Channel No. 4, Cedar keys.......do	$\frac{1}{30000}$
73.	Cedar keys and approaches.......do	$\frac{1}{50000}$
74.	Ocilla river.......do	$\frac{1}{20000}$
75.	St. Mark's bar and channel.......do	$\frac{1}{40000}$

No. 76. Middle or main and western entrances St. George's sound, Florida......... $\frac{1}{80000}$

77. Entrance to Mobile bay, Alabama......... $\frac{1}{80000}$

78. Mobile bay—2d edition.......do......... $\frac{1}{200000}$

79. Horn Island Pass and Grand bay, Mississippi......... $\frac{1}{300000}$

80. Do......do.—new edition...........do......... $\frac{1}{40000}$

81. Pascagoula river..........do......... $\frac{1}{20000}$

82–91. Cat island—tidal diagrams..........do.........

92. Pass Christian..........do......... $\frac{1}{40000}$

93. Delta of Mississippi, Louisiana......... $\frac{1}{60000}$

94. Barataria bay entrance...do......... $\frac{1}{30000}$

95. Pass Fourchon..........do......... $\frac{1}{10000}$

96. Timballier bay entrance......... $\frac{1}{20000}$

97. Isle Deniere or Ship Island shoals......... $\frac{1}{80000}$

98. Entrance to Vermilion bay and Calcasieu river......... $\frac{1}{300000}$, $\frac{1}{40000}$

99. Sabine Pass, Texas......... $\frac{1}{40000}$

100. Entrance to Galveston bay, Texas......... $\frac{1}{40000}$

101. Galveston bay—2d edition....do......... $\frac{1}{200000}$

102. San Luis Pass..........do......... $\frac{1}{20000}$

103. Aransas Pass—2d edition, (enlarged,) Texas......... $\frac{1}{30000}$

104. Entrance to Rio Grande......... $\frac{1}{20000}$

105. Alden's reconnaissance western coast, lower sheet, San Francisco to San Diego—new edition—California......... $\frac{1}{1200000}$

106. Cortez bank......... $\frac{1}{10000}$, $\frac{1}{1200000}$

107. San Diego entrance, (new edition,) California......... $\frac{1}{15000}$, $\frac{1}{25000}$

108. Catalina harbor......... $\frac{1}{15000}$

109. San Pedro anchorage and vicinity of Santa Barbara, California......... $\frac{1}{200000}$, $\frac{1}{40000}$

110. Anacapa island.........do.........

111. Prisoners' harbor, Cuyler's harbor, and northwest anchorage San Clemente island, California......... $\frac{1}{20000}$

112. Santa Barbara, California......... $\frac{1}{20000}$

113. San Simeon, Santa Cruz, San Luis Obispo, and Coxo harbors......... $\frac{1}{200000}$, $\frac{1}{40000}$

114. Point Conception......... $\frac{1}{40000}$

115. Point Pinos......... $\frac{1}{20000}$

116. Monterey harbor......... $\frac{1}{40000}$

117. Santa Cruz and Año Nuevo harbors......... $\frac{1}{400000}$, $\frac{1}{1200000}$

118. San Pedro harbor, California......... $\frac{1}{20000}$

119. San Francisco bay entrance, California......... $\frac{1}{400000}$

120. San Francisco city, (3d edition,) California......... $\frac{1}{10000}$

121. Tidal diagrams, Rincon Point.........do.........

122. Pulgas base..........do......... $\frac{1}{40000}$, $\frac{1}{400000}$

123. Mare Island straits..........do......... $\frac{1}{30000}$

124. Alden's reconnaissance western coast, middle sheet, San Francisco to Umpquah river, California and Oregon......... $\frac{1}{1200000}$

125. McArthur's reconnaissance western coast, from Monterey to mouth of Columbia river, sheet No. 1—3d edition.........

126. McArthur's reconnaissance western coast, from Monterey to mouth of Columbia river, sheet No. 2—3d edition.........

127. McArthur's reconnaissance western coast, from Monterey to mouth of Columbia river, sheet No. 3—3d edition.........

128. Point Reyes and Drake's bay, California......... $\frac{1}{40000}$

129. Humboldt bay..........do......... $\frac{1}{30000}$

No 130. Trinidad bay, California........ $\frac{1}{20000}$

131. Shelter cove, Mendocino City and Crescent City harbors, and Port Orford or Ewing harbor, California and Oregon........ $\frac{1}{20000}$

132. Umpquah river, Oregon........ $\frac{1}{20000}$

133. Mouth of Columbia river—2d edition—Oregon........ $\frac{1}{40000}$

134. Do........do........do........ $\frac{1}{200000}$

135. Entrance to Columbia river........ $\frac{1}{40000}$

136. Tidal diagrams Rincon Point, San Diego, and Astoria, Cal. and Oregon...

137. Co-tidal lines of the Pacific coast........ $\frac{1}{10000000}$

138. Cape Disappointment, Washington Territory........ $\frac{1}{20000}$

139. Shoalwater bay........do........ $\frac{1}{30000}$

140. Alden's reconnaissance western coast, from Gray's harbor to Admiralty inlet, Washington Territory........ $\frac{1}{600000}$

141. Grenville harbor, Washington Territory........ $\frac{1}{20000}$

142. Cape Flattery and Neé-ah harbor, Washington Territory........ $\frac{1}{40000}$

143. False Dungeness harbor........do........ $\frac{1}{30000}$

144. Canal de Haro and Strait of Rosario and approaches, Wash. Territory.. $\frac{1}{2000000}$, $\frac{1}{600000}$

145. Port Townshend........do........ $\frac{1}{40000}$

146. Duwamish bay and Seattle harbor........do........ $\frac{1}{40000}$

147. Smith's or Blunt's island........do........ $\frac{1}{20000}$

148. Base apparatus........

149. Self-registering tide-gauge........

150. Craven's current-indicator........

151. Craven's specimen box for deep-sea soundings........

152. Mitchell's seacoast tide-gauge........

153. Figures to illustrate Appendix No. 33, 1854........

154. Diagrams of secular variation in magnetic declination........

155. Diagrams illustrating earthquake waves at San Diego and San Francisco...

156-181. Progress sketches........

List of maps, preliminary charts, and sketches, engraved or engraving, during the year ending November 1, 1855—*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.
Reconnaissance of Eggemoggin reach	1–20,000	Light-house sketch	Do.
Portland harbor	1–20,000	Finished chart	Engraving; finished as preliminary.
York River harbor	1–20,000	Light-house sketch	Engraved.
Portsmouth harbor	1–20,000	Preliminary chart	Do.
Newburyport harbor	1–20,000	Finished chart	Do.
Annisquam and Ipswich harbors	1–20,000	Preliminary chart	Engraving.
Gloucester harbor	1–20,000	Finished chart	Engraving; finished as preliminary.
Salem harbor	1–25,000	do	Engraved.
Boston harbor	1–40,000	do	Engraving.
Stellwagen's bank	1–400,000	Preliminary chart	Engraved.
Plymouth harbor	1–20,000	Finished chart	Engraving; finished as preliminary.

List of maps, charts, and sketches—Continued.

Name.	Scale.	Description.	Remarks.
Monomoy shoals	1-40, 000	Finished chart	Engraving; finished as preliminary.
Bass River harbor	1-40, 000	do	Engraving; finished as preliminary.
Nantucket shoals	1-200, 000	Preliminary chart	Engraved.
Tidal currents, Nantucket shoals	1-300, 000	Sketch	Do.
Muskeget channel	1-60, 000	Finished chart	Engraving; finished as preliminary.
Eastern series, No. 1	1-80, 000	do	Engraving.
SECTION II.			
Progress sketch B	1-800, 000		Engraved.
Long Island sound, eastern	1-80, 000	Finished chart	Do.
Do do middle	1-80, 000	do	Do.
Do do western	1-80, 000	do	Do.
South side Long Island, No. 2	1-80, 000	do	Engraving.
Do do No. 3	1-80, 000	do	Do.
SECTION III.			
Progress sketch C	1-400, 000		Engraved.
Seacoast of Virginia, No. 2, (lower part)	1-200, 000	Preliminary chart	Do.
Seacoast of Virginia and entrance to Chesapeake bay	1-100, 000 1-200, 000	do	Engraving.
Chesapeake bay, No. 1	1-80, 000	Finished chart	Do.
Do No. 2	1-80, 000	do	Do.
Chesapeake bay	1-400, 000	Preliminary chart	Do.
Patapsco river	1-60, 000	Finished chart	Do.
SECTION IV.			
Progress sketch D	1-600, 000		Engraved.
Do	1-400, 000		Engraving.
Progress survey, Cape Fear river and vicinity	1-400, 000		Engraved.
Albemarle sound	1-200, 000	Preliminary chart	Engraving.
Do No. 1	1-80, 000	Finished chart	Do.
Do No. 2	1-80, 000	do	Do.
Wimble shoals	1-80, 000	Reconnaissance	Engraved.
Beaufort harbor, North Carolina, on steel	1-20, 000 1-30, 000	Finished chart	Engraving; finished as preliminary.
Gulf Stream explorations, 1854	1-5, 000, 000	Sketch	Engraved.
SECTION V.			
Progress sketch E	1, 400, 000		Engraved.
Do No. 2, (Savannah river)	1-200, 000		Do.
Winyah bay and Cape Roman shoals	1-100, 000	Preliminary chart	Do.
Winyah bay and Georgetown harbor	1-40, 000	do	Engraving.
Charleston harbor	1-30, 000	Finished chart	Engraved.
Maffitt's channel	1-5, 000	Comparative map	Do.
Doboy bar and inlet	1-40, 000	Reconnaissance	Do.
SECTION VI.			
Progress sketch F	1-1, 200, 000		Engraved.
Do No. 2, (Florida reefs)	1-400, 000		Do.
Turtle harbor	1-40, 000	Light-house sketch	Do.
Coffin's Patches	1-20, 000	do	Do.
Beacons on Florida reefs	1-400, 000	Sketch	Engraving.
Key West harbor and its approaches	1-50, 000	Finished chart	Engraved.
SECTION VII.			
Progress sketch G	1-600, 000		Engraved.
Cedar keys and its approaches	1-50, 000	Finished chart	Engraving; finished as preliminary.
Ocilla river	1-20, 000	Reconnaissance	Engraved.

List of maps, charts, and sketches—Continued.

Name.	Scale.	Description.	Remarks.
SECTION VIII.			
Progress sketch H	1-600,000		Engraved.
Mobile bay	1-80,000	Finished chart	Engraving.
Mississippi sound, No. 1	1-80,000	do	Do.
Pass Fourchon	1-10,000	Reconnaissance	Engraved.
Entrances to Vermilion bay and Calcasieu river	1-30,000 1-40,000	do	Do.
SECTION IX.			
Progress sketch I	1-600,000		Engraved.
Entrance to Rio Grande	1-20,000	Preliminary chart	Do.
SECTIONS X and XI.			
Progress sketch J	1-400,000		Engraved.
Do	1-7,000,000		Do.
Progress survey, bay of San Diego	1-200,000	Progress sketch	Do.
San Pedro anchorage, and vicinity of Santa Barbara	1-20,000 1-40,000	Preliminary survey	Do.
Anacapa island		Sketch	Do.
San Pedro and vicinity	1-600,000	Progress sketch	Do.
Santa Cruz and Año Nuevo harbors	1-40,000	Preliminary chart	Do.
Alden's reconnaissance western coast, middle sheet, from San Francisco to Umpquah river	1-1,200,000	Sketch	Do.
Point Reyes and Drake's bay	1-40,000	Preliminary survey	Do.
San Francisco entrance	1-50,000	Finished chart	Engraving.
South Farallon island		Sketch	Do.
Shelter cove, Mendocino City and Crescent City harbors, and Port Orford or Ewing harbor	1-20,000	Preliminary chart	Engraved.
Entrance to Umpquah river	1-20,000	do	Do.
Alden's reconnaissance western coast, northern sheet, from Umpquah river to the boundary	1-1,200,000	Sketch	Engraving.
Entrance to Columbia river	1-40,000	Preliminary chart	Engraved.
Progress survey, Columbia river	1-400,000	Progress sketch	Do.
Grenville harbor	1-20,000	Sketch	Do.
Canal de Haro and Strait of Rosario and approaches	1-200,000 1-600,000	Reconnaissance	Do.
Strait of Rosario and vicinity	1-400,000	Progress sketch	Do.
Port Townshend	1-40,000	Reconnaissance	Do.
Duwamish bay and Seattle harbor	1-40,000	do	Do.
Smith's or Blunt's island	1-20,000	Sketch	Do.
Craven's current-indicator			Do.
Craven's specimen box for deep-sea soundings			Do.
Mitchell's seacoast tide-gauge			Do.
Figures to illustrate Appendix No. 33, 1854			Do.
Diagram to illustrate secular variation in magnetic declination			Do.
Gas-pipe tripod			Engraving.
Co-tidal lines, Pacific coast			Do.
Earthquake waves			Do.

REPORT OF MR. GEORGE MATHIOT, IN CHARGE OF THE ELECTROTYPE DIVISION.

The work of extending and combining the engraved plates has been quite large, and consumed a very considerable amount of time, which I had hoped to devote to experimenting on the actino-engraving process. This has led me to devise a more expeditious method of making these combinations, than the difficult and tedious mechanical process heretofore employed. By the advantages of this new method I hope in future to be able to economise sufficient time for prosecuting my actinic experiments. A detailed description of the new method of combining is presented. (Appendix No. 62.)

Apparatus has been constructed for recovering the mercury from the residual zinc and sweepings of the batteries. This apparatus was finished but quite recently, but near three hundred pounds of quicksilver have been already obtained by it.

Some time has been devoted to the actino-engraving; chiefly in reviewing what was done the previous year. But few experiments have been made; yet I am now satisfied that success will be obtained by a diligent course of study and experiment.

Table of Electrotypes.

Name of the chart.	Number of altos.	Number of bassos.
Harbors of Captain's islands, East and West		1
Wellfleet harbor		1
Galveston entrance	1	1
New York harbor and bay, 1-20,000, sheet No. 1		
Davis' South shoals	1	2
San Luis Pass	1	1
San Francisco bay and vicinity	1	1
Stellwagen's bank	1	
Sketch A No. 7	1	
Sketch F No. 4	1	
Sketch J No. 5	1	
Harbor of Mendocino	1	
Key West harbor	1	1
Umpquah river entrance	1	1
Cape Roman shoals	1	
Winyah bay and Cape Roman shoals		1
West coast reconnaissance No. 2, Alden's	2	2
Santa Cruz	1	
Seacoast of Virginia, sub-sketch No. 1	2	
Seacoast of Virginia, sub-sketch No. 2	2	
Seacoast of Virginia		1
Salem harbor	3	1
Harbor of Monomoy	1	1
Portsmouth harbor	1	
Muskeget channel	1	
Long Island sound, No. 3	1	1
Newburyport harbor	1	
Long Island sound, No. 2	1	1
St. John's river entrance	1	1
Mobile bay, (upper part)	1	
Mississippi sound, No. 1	1	
Mobile bay, (entire)		1
	31	19

In addition to the above, an alto and a basso were also made for another department of the government.

REPORT OF PRINTING BY MR. S. D. O'BRIEN, CHIEF PRINTER.

Since the first of November, 1854, there have been printed from the following plates:

Section I.	Number of impressions.
Sketch A	36
Sketch A *bis*	45
Eggemoggin reach	37
Portland harbor	37
Richmond's island	500
York River harbor	41
Portsmouth harbor	34
Newburyport harbor	300
Gloucester harbor	36
Salem harbor	44

Stellwagen's bank	132
Plymouth harbor	54
Wellfleet harbor	663
Monomoy harbor	47
Bass River harbor	40
Muskeget channel	76
Holmes' Hole and Tarpaulin cove	400
Nantucket shoals	87
Davis' south shoals	100
Sow and Pigs reef	12
Tidal currents, Nantucket shoals	32

SECTION II.

Sketch B	37
Hudson river triangulation	32
General chart of the coast, from Gay Head to Cape Henlopen	385
Tidal currents, Long Island sound	1,686
Long Island sound, East	68
" " " Middle	60
" " " West	23
Fisher's Island sound	800
New London harbor	400
Mouth of Connecticut river	400
Huntington bay	400
Oyster bay or Syosset harbor	400
Captain's islands, east and west	475
New York bay and harbor, $\frac{1}{30000}$	1,160
" " " $\frac{1}{80000}$	540
Romer shoal and Flynn's knoll	30
Delaware bay and river	2,053

SECTION III.

Sketch C	43
Seacoast of Delaware, Maryland, and part of Virginia	400
Seacoast of Virginia No. 2, (lower part)	57
Ship and Sand Shoal inlets	132
Harbor of Annapolis and Severn river	400

SECTION IV.

Sketch D	27
Cape Fear triangulation	32
Pasquotank river	400
Wimble shoals	42
Hatteras inlet	400
Hatteras shoals	100
Ocracoke inlet	500
Beaufort harbor, North Carolina	188
Frying-Pan shoals	400
Co-tidal lines, Atlantic coast	32
Gulf Stream explorations, 1854	129
" " diagrams	1,588

SECTION V.

Sketch E	32
Savannah river triangulation	42
Winyah bay and Georgetown harbor	36
Comparative chart of Maffitt's channel	41
Charleston harbor	12
North Edisto river	845
Savannah city, Front and Back rivers	400

SECTION VI.

Sketch F	32
Florida sub-sketches	32
St. John's river entrance	125
Turtle harbor	77
Coffin's Patches	72
Key West harbor, $\frac{1}{50000}$	563
Key West tidal diagrams	3,000
Reconnaissance, vicinity of Cedar keys	400
Channel No. 4, Cedar keys	100
Cedar keys	37

SECTION VII.

Sketch G	27

SECTION VIII.

Sketch H	29
Entrance to Mobile bay	450
Horn Island pass	100
Delta of the Mississippi	775
Pass Fourchon	67

SECTION IX.

Sketch I	27
Galveston entrance	50
Galveston bay	50
San Luis pass	200
Entrance to the Rio Grande	32

SECTIONS X AND XI.

Sketch J	27
San Francisco triangulation	32
San Diego triangulation	32
Santa Barbara triangulation	32
Straits of Rosario triangulation	32
Alden's reconnaissance of the western coast, No. 1	300
Catalina harbor	500
Anacapa island	57
Monterey harbor	515
Point Pinos	100

San Pedro	109
Alden's reconnaissance of the western coast, No. 2	507
Pulgas base	32
Tidal diagrams—Rincon Point, San Diego, and Astoria	1,531
San Francisco city	550
Port Orford, Mendocino City, &c., harbors	77
Humboldt bay	350
Umpquah river	67
Entrance to Columbia river	300
Grenville harbor	77
Reconnaissance from Gray's harbor to Admiralty inlet	566
Cape Flattery and Neé-ah harbor	400
False Dungeness	400
Prisoner's harbor, &c	100
Canal de Haro and Strait of Rosario	47
Port Townshend	44
Duwamish bay and Seattle harbor	57

MISCELLANEOUS.

Proofs for engraving division	1,556
Circular protractors	230
Scale of shades	50
Topographical signs	20
Tidal diagrams, (blanks)	1,150
Base apparatus	45
Specimen box for deep-sea soundings	32
Current-indicator	32
Diagrams to illustrate Appendix No. 33, 1854	32
Scale of letters	8
Labels for compass	54
Current diagrams, (blanks)	100
Charts and sketches (for binding)	510
Mitchell's seacoast tide-gauge	42
Total	34,927

REPORT OF MR. V. E. KING ON THE DISTRIBUTION AND SALE OF MAPS.

At the date of my last report, (November 6, 1854,) fifty-six sheets of Coast Survey maps had been published. Since then the chart of "Key West harbor and approaches" has been added, which will make the number now published fifty-seven. The following-named charts, although reported as being nearly finished at date of last report, were actually completed during the year, viz: "Newburyport harbor," "Salem harbor," "Long Island sound," (in three sheets,) "Charleston harbor," and Alden's reconnaissance No. 2 of the western coast.

Important additions and corrections having been made to the following preliminary charts, new editions have been published, viz:

Nantucket shoals; Alden's reconnaissance No. 1 of the western coast; entrance to Columbia river.

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	14	5	46	65
Newburyport harbor			12	12
Wellfleet harbor	19	4	233	256
Nantucket harbor	30	3	45	78
Harbor of Edgartown	31	2	43	76
Hyannis harbor	17	4	46	67
Harbors of Holmes' Hole and Tarpaulin cove	27	4	43	74
Harbor of New Bedford	92	3	50	145
General coast chart from Gay Head to Cape Henlopen	158	17	243	418
Fisher's Island sound	35	3	50	88
Harbor of New London	46	2	54	102
Mouth of Connecticut river	24	4	232	260
Harbor of New Haven	31	4	53	88
Harbors of Black Rock and Bridgeport	27	3	40	70
Huntington bay	32	4	52	88
Harbors of Sheffield and Caukin's islands	22	3	42	67
Harbors of Captain's island, East and West	30	3	42	75
Oyster bay or Syosset harbor	113	3	45	161
Hart and City island and Sachem's Head harbor	27	3	43	73
Hell Gate	51	2	57	110
New York bay and harbor, and environs, 1–30,000	66	10	9	85
New York bay, harbor, and environs, 1–8,0000	202	23	64	289
Western part of south coast of Long Island	13	2	39	54
Little Egg harbor	17	1	39	57
Delaware bay and river	337	6	50	393
Seacoast of Delaware, Maryland, and part of Virginia	36	10	42	88
Mouth of Chester river	18	2	40	60
Harbor of Annapolis and Severn river	17	4	43	64
Pasquotank river	12	3	38	53
Cat and Ship Island harbors	12	5	40	57
Mobile Bay entrance	21	5	45	71
Galveston entrance	17	3	38	58
Key West harbor and approaches, 1–50,000			25	25
West coast reconnaissance from Monterey to mouth of Columbia river	32	5	50	87
West coast reconnaissance from San Diego to San Francisco	33	3	245	281
West coast reconnaissance from San Francisco to Umpquah river			12	12
San Diego bay and approaches	23	3	242	268
Trinidad bay	19	6	54	79
Humboldt bay	18	4	53	75
Monterey harbor	17	3	231	251
Mouth of Columbia river			12	12
Nantucket shoals	44	6	40	90
Chincoteague inlet	23	1	37	61
Ocracoke inlet	23	2	38	63
Beaufort harbor, N. C.	30	1	42	73
Frying-pan shoals	23	1	38	62
New river and bar	23	1	38	62
North Edisto	23	1	38	62
Entrance to Savannah river	23	3	38	64
Savannah city, Front and Back rivers	23	2	38	63
Mobile bay	31	1	38	70
Western coast of Florida	13	1	40	54
Key West harbor, 1–100,000	23	1	42	66
St. Mark's bar and channel	29	1	44	74
Entrance to St. John's river		1	5	6
Delta of Mississippi	23	6	36	65
Galveston bay	13	1	38	52
San Luis Pass		1	5	6
Catalina harbor	23	3	52	78
Prisoner's harbor, Cuyler's Northwest anchorage, &c	23	2	52	77
San Pedro harbor	23	5	53	81
San Simeon, Santa Cruz, &c	23	5	53	81
San Francisco city	31	3	57	91
Santa Barbara	19	6	247	272
Shoalwater bay	19	4	242	265
Cape Flattery and Neé-ah harbor	19	3	242	264
Reconnaissance from Gray's harbor to Admiralty inlet	19	5	242	266
False Dungeness	19	3	239	261

List of Coast Survey maps distributed, &c.—Continued.

Names of charts.	Turned over for sale.	For use of office.	Gratuitously distributed.	Total.
Umpquah river	1	2	11	14
Sketches of Current chart, Boston harbor	9	1	5	15
Changes in Sandy Hook	9	2	5	16
Entrance Chesapeake bay	14	2	5	21
Fishing or Donoho's battery	14	1	5	20
Hatteras shoals	26	1	6	33
Hatteras inlet	14	1	6	21
Bull's bay	21	1	5	27
St. Andrew's shoals	21	1	7	29
Mosquito inlet	9	1	7	17
Cape Cañaveral	21	1	7	29
Rebecca shoal	9	1	7	17
Reconnaissance, vicinity Cedar keys	9	1	7	17
Channel No. 4, Cedar keys	9	1	7	17
Horn Island Pass	9	1	10	20
Pass Christian	9	1	4	14
Aransas Pass	9	1	5	15
Mare Island straits	17	1	18	36
Point Conception	17	1	18	36
Point Pinos			6	6
Cape Disappointment	9	1	18	28
	2,577	267	5,125	7,969

APPENDIX No. 37.

Letter of the Superintendent to the Secretary of the Treasury in relation to the necessity for an increased force of topograqhical engravers for the Coast Survey office.

Coast Survey Station, Dixmont, Me., *September* 14, 1855.

Sir: I would respectfully ask permission to advise with the department in regard to the progress of the engraving of the Coast Survey results.

No subject connected with the immediate practical results of the work has employed more of my thought, attention, and observation than this one. The difficulties connected with it have, in most cases, been solved, but there still remain important ones to contend against.

By dividing the maps and charts into two classes—one preliminary, to be published immediately on the execution of the work; another of a finished character, to be engraved in the highest style of the art—a leading and most prominent difficulty is obviated, for it is possible to find numerous persons capable of all but the higher kinds of engraving. The public is satisfied to balance promptness of publication against inferiority of work, provided the highest standard of excellence, such as is consonant with the whole design of the survey and its elaborate methods in the field, is kept up in the finished maps and charts.

The issue of these finished maps and charts must, however, keep pace with the execution of the field work, though at a certain distance behind it.

On taking charge of the Coast Survey in 1844, I found large arrears of unpublished work, and became soon satisfied that the number of engravers in the office must be much increased, and contract work out of the office must be resorted to in order to keep pace with the current work and to bring up the back work. The idea just stated was approved by the department as a cardinal one in the management of the survey.

The engraving establishments in the principal cities were visited by me and by Captain A. A. Humphreys, then assistant in charge of the office, and to whose devotion and knowledge the Coast Survey owes so much, to ascertain what good engravers could be procured to work at the office, and what contracts could be made. At the same time apprentices were introduced, with the design of making engravers in our own establishment.

It would detain you too long to state the degree of success of these experiments, and the causes which rendered all the attempts to increase our corps of engravers, and to have maps engraved out of the office, less successful than could have been desired. It is proper, however, to say that at different times renewed efforts were made, and that I was zealously assisted in this in turn by Major Stevens and Captain Benham, assistants in charge of the office. The plans were modified by close observation of their working. Engravers were invited to work upon our maps at their own homes, and other efforts were made to induce the best artists of the country to work for us.

Meantime the scale of the work of the survey was extended to the whole coast of the United States, and the additional field work demanded new facilities for its publication. The preliminary maps and charts, and sketches, issued at once on the completion of the surveys, were much multiplied in number, and there was danger that the style and finish of the higher grades of maps might actually deteriorate instead of improving.

The application of electrotyping, by which the finest maps could be perpetuated and multiplied at no greater expense than was incident to the copying of the coarser charts, has removed the great objection to this elaborate work on the score of expense.

The fact became, from year to year, more apparent that the talent of the country was so profitably employed in other branches of engraving, that map engraving was comparatively neglected, and that there could not be found in the United States, upon any terms, enough first-class engravers to execute the required number of plates of first-class maps.

The engravers introduced by Mr. Hassler and myself into the office had, during this time, not only acquired the greatest skill of which they were capable in their art, but had in several cases passed the age at which their physical vigor rendered them most capable of work. One of the first-class engravers, brought from abroad by Mr. Hassler, had, with the consent of the office, left the work.

Several attempts were made to obtain the supply of first-class engravers, which was so indispensable to the progress of the engraving, and which could not be had in the United States, from abroad. These were made through our ministers and consular agents, through officers of the survey who were in Europe on private business, and through personal friends of my own, with some of whom I had formed intimate relations while abroad, and some of whom had been officers of the Coast Survey. All these attempts, from various causes easily traced, failed; and the exigency not only still exists, but it increases every month with the progress of the coast survey.

To sum up, we are falling irretrievably behind in our publication of first-class maps and charts, for want of additional first-class engravers, and this demand cannot be supplied in the United States.

The plain duty of seeking it abroad where it is known to exist, has been executed time after time, as far as it can be by correspondence, and that method has failed.

Seeing, then, that we must have more first-class engravers to supply the necessary Coast Survey maps, and that they cannot be had in the United States, nor abroad by correspondence, it is my duty respectfully to propose to the department to try the only resource left, namely, to invest me with authority to send one of the officers of the Coast Survey, and for this I would at present prefer the assistant in charge of the office, Capt. Benham, of the corps of engineers, to such places abroad as, from my knowledge of the condition of engraving there, would seem to promise to afford the indispensable supply of first-class engravers, say four in number, on terms similar to those formerly approved by the department, to be submitted anew to its approval, and under instructions from me, to be also approved by the department.

This is the only mode which remains untried of securing the execution of the maps for which the field work of the Coast Survey has already furnished and annually furnishes materials, in a style creditable to the work and to the country.

Very respectfully, yours, &c.,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 38.

Remarks of Capt. H. W. Benham, U. S. Engineers, assistant in charge of the Coast Survey Office, in his annual report to the Superintendent, showing the necessity for obtaining additional engravers.

COAST SURVEY OFFICE, *October* 15, 1855.

DEAR SIR: * * * * * * * * *

The indispensable necessity there exists for obtaining additional engravers for the execution of our finer charts, which have now been delayed for years in the office, when in all other respects they are fully prepared to lay before the country; and this necessity, I regret to say, no efforts of myself or of my predecessors have been able to meet from any resources that have been open to us, and which, without other efforts or other means available, will leave the most important of the magnificent results of this survey as a mass of inaccessible waste paper in this office, or require that it should be thrown off to the country in a crude, imperfect, and half intelligible manner, corresponding in no degree with the operations of the other part of the work, or with the reasonable expectations of the country, from the liberal appropriations granted in previous years by the confidence of Congress, for the prosecution of this work. These very appropriations, I am compelled to say, while adding most extensively to the progress of the work in all other respects, have but increased in a multiplied degree the difficulties and embarrassments on this subject; the increased sums available enabling you to extend proportionably the field operations, and the office to prepare and reduce, ready for the engraver, the maps of the survey, as skilful surveyors or draughtsmen are obtainable to any extent desired in our country, while the means of throwing the results of these surveys before the country in a form corresponding to their excellence in other respects, in a reasonable time before they shall be out of date, has as yet been unattainable; no other duty or work in this country having heretofore made necessary the artistic skill here required, needing, as it does, an experience of years, with much native taste, to represent with clearness and accuracy the manifold details useful on our maps, on the small scales required for their general utility, and for economy of distribution; and the efforts which have been made in this office, at considerable labor and expense, within the past four or five years, to instruct young men residing in this vicinity in this art, some fourteen of whom have been on trial in the office for the purpose, have not been thus far successful to the extent of our constantly increasing wants, either by the want of native taste needed for the highest skill, or, as in other cases, by the inducements offering for the more stirring and active operations of life, better suited to the genius and temperament of our people, and in other more recent cases where the necessary abilities and industry appear to be combined by the length of time still needed for the attainment of the skill deemed requisite for the execution of our best charts.

In this dilemma, with the urgent necessity, it cannot be gainsaid that the great results of this survey, so important to our commerce and to the world, should be brought forward for publication to the country at the earliest day possible after these results are obtained.

The amount of work now on hand of first-class charts *already reduced and now in the drawing division,* prepared for the engravers, as by a report and estimate which I have had carefully prepared by the chiefs of the drawing and engraving divisions, with the assistance of the chief engraver, amounts to over *thirty years* of labor for one first-class engraver, or at least to the total labor of our whole force suitable for such work, for *four* or *five years*, and necessarily protracting the publication of such work by at least that time beyond the date when it is properly prepared and ready for issue, and of course depriving the commercial and navigating interests of our country of the full benefit of these surveys during such periods; and under such circumstances I feel that I should fail in my duty to yourself, to the survey, and to the country, if I did not recommend, in the strongest terms, that measures should be taken at the earliest day for securing the highest talent in the art of topographical engraving, wherever it shall be found to exist.

* * * * * * * * * * *

Very respectfully, your obedient servant,

H. W. BENHAM,

Capt. U. S. Engineers, Assistant in charge of Coast Survey Office.

Prof. A. D. BACHE,

Superintendent U. S. Coast Survey.

APPENDIX No. 39.

Description of the Congress map, by Lieut. J. C. Tidball, U. S. A., assistant in the Coast Survey.

A proviso in an act passed at the second session of the thirty-second Congress directed that the annual report of the Superintendent of the Coast Survey shall, when presented, "be accompanied by a general chart of the whole coasts of the United States, on as large a scale as convenient and practicable, showing, as near as practicable, the configuration of the coasts, and showing, by lines, the probable limits of the Gulf Stream, and showing, by lines, the probable limits to which the soundings off the coast will extend, and showing, by the use of colors and explanations, the exact portions of our coasts, of which complete charts have been published by the Coast Survey; also, showing such other parts of the coasts of which the triangulation, the topography, and soundings have been completed, but not published; and, also, such parts of the coasts of which the triangulation and topography, or triangulation only, have been completed."

In compliance with this provision, a chart was drawn, in the Coast Survey office, in the winter of 1853, and accompanied the Superintendent's report of that year. It has since, from time to time, received additions as the work of the survey progressed. This chart is known as the *Congress map*, and is made upon a single sheet about nine feet square, which, for preservation and convenience, is backed with linen cloth and attached to a roller.

The scale used is $\frac{1}{1500000}$, or about .04 of an inch to a statute mile, and the meridian lines and parallels of latitude are constructed by this scale for each minute. The projection used is the Polyconic—a method fully explained in Appendix No. 39, report of Superintendent Coast Survey for 1853. The *central meridian* for the eastern coast is 84° W. from Greenwich; the western coast being projected separately, has its *central meridian* 120° W. from Greenwich.

Upon this frame-work of projections is traced, in an unbroken line, the entire coast of the United States from Passamaquoddy bay (the northeastern limit of Maine,) following the indentations of the shore along the Atlantic around the peninsula of Florida to the mouth of the Rio Grande, the coast of the Gulf of Mexico; and from Frazer's river, near the northwesterly limit of Washington Territory, to San Diego, the southern limit of the United States upon the Pacific ocean. The northern shore of Cuba and the coasts of Nova Scotia, island of Cape Breton, and a large part of Newfoundland, are likewise laid down, as also the boundaries of the States and the northern lakes.

The general direction and limits of the Gulf Stream are marked out in their proper positions, and the temperature is indicated by shaded bands, increasing in width to the north and east, which are darker in proportion to its greater warmth at different localities, as determined by a system of explorations extending from Cape Florida to Cape Cod, and by a series of temperature soundings across the axis of the stream from the following points: Cape Cod, Montauk Point, Sandy Hook, Cape Henlopen, Cape Hatteras, Cape Fear, Charleston, St. Simon's, St. Augustine, and Cape Cañaveral.

These lines of soundings are represented upon the map, and show the extent to which the survey has already explored this wonderful and important phenomenon.

Diagrams for each of these lines are shown upon the map, in which the curves of different temperatures at the same depths, and of the same temperature at different depths, are constructed, and also sections representing the form of the bottom of the ocean, which is therein shown to be diversified by mountains and valleys, similar to the earth's surface above water.

Explanations of these diagrams and explorations, and the developments that have been made for the benefit of navigation and science, are given in the several recent annual reports of the Superintendent of the Coast Survey.

Lines of soundings for temperature and deep-sea bottom specimens, made upon different parts of the coasts, are laid down. From observations that have been made, the Isgonic lines, or lines of equal magnetic declination, have been determined, and are given upon the map.

The progress of the various descriptions of work of the survey is shown upon the map by different colors and other conventional signs, which present at a glance the operations in the two grand divisions of the labor—namely, the field and office work; the former of which comprises the topographical and hydrographic reconnaissances, the magnetic and astronomical observations, the primary and secondary triangulations, the topography and hydrography; and the latter, the drawing of topography in progress, drawing of hydrography in progress, engraving of topography in progress, engraving of hydrography in progress, published topography, and published hydrography. The meaning of the colors and signs is explained in the legend upon the map.

The lines and stations where the magnetic telegraph has been used for astronomical observations are marked out, showing the extent to which this great modern invention has been employed for scientific purposes in the ascertaining of longitudes upon the coast survey. The map, therefore, as its title indicates, exhibits at one general view the configuration of the coast of the United States, and the limits of the Gulf Stream, the probable limits of soundings, and, by colors, the charts published or in progress; and the extent to which the reconnaissances, triangulation, topography, and hydrography, respectively, are completed or in progress, to November 1, 1855, as compiled from the archives of the Coast Survey and other authorities; and is susceptible of additions and alterations, to show the advancement of all these different portions of the work in the successive years.

Sub-sketches, upon a scale of $\frac{1}{10000000}$, show the approximate co-tidal lines of the Atlantic and Pacific coasts for each half hour.

A list of base-lines, with their locality and division into primary and local, is given.

A table is laid down upon the map, giving, in a condensed form, the statistics of the Coast Survey at periods from 1844 to 1855, showing the total of the work that has been accomplished during that time.

A list of Coast Survey charts published, giving the locality, class, scale, and date of publication, is also to be found upon the map. The conventional signs for topographical drawings, used, more or less, upon all the Coast Survey charts, are delineated and explained upon the same sheet; as also scales of shade used in topographical drawings, to represent the different declivities of ground, by which accurate graphic representations of portions of the country bordering upon the coast have been obtained in such manner that their respective elevations and declivities may be judged by inspection only. Diagrams of secular variation of magnetic declination, current charts showing the manner of representing by curves the direction and velocity of tidal currents in different harbors and sounds, and tidal diagrams showing the manner of registering the rise and fall of tides by means of curves, are easily understood by inspection.

A tide-table added gives the rise, fall, and mean duration, &c., of tides at the principal harbors upon the coast.

Numerous specimens of the manner of recording hydrographic observations are given upon the map, and also forms of records and computations of the principal astronomical, magnetic, and geodetic determinations in use by the Coast Survey.

APPENDIX No. 40.

Solution of Normal Equations by indirect elimination. By Chas. A. Schott, Computing Division.

The application of the method of least squares in geodetic operations has become so frequent and indispensable, and in consequence of this, the number of linear equations (normal equations) to be solved has so much increased, that any method of solution of more ready application than that ordinarily used must be considered as valuable, both as time-saving and as contributing to a more extensive application of the method of compensating by minimum squares, especially when we consider that frequently the limit of application of the method is prescribed by the practicability or expediency of solving a great number of equations.

It was thought that the method of solution by indirect elimination, not confined to normal equations alone, might prove acceptable to those not having convenient access to the notices on this subject. The method has been tried and successfully used in the computing division.

As stated in my paper on the adjustment of horizontal angles of a triangulation, Superintendent's Annual Report of 1854, Appendix No. 33 S, page *75, the direct method of the solution of normal equations, known as Gauss' process of elimination, has formerly been exclusively made use of, especially in the reduction required for the primary triangulations in Sections I, II, and III, and by it a dozen equations, with as many unknown quantities, may be solved without inconvenience. The ordinary method of elimination requires the formation of $\frac{n\,(n+1)\,(2\,n+4)}{1.2.3}$ numerical co-efficients for n equations by virtue of the symmetrical distribution of the co-efficients. This number is reduced in Gauss' direct process to $\frac{n\,(n+1)\,(n+5)}{1.2.3}$, and shows the diminution of labor, as well as the rapidly-increasing ratio of the number of co-efficients with the number of equations. A full account of this method will be found in Encke's Berlin Astronomische Jahrbuch for 1835, pp. 267, 272; and in the same publication for 1836, p. 265.

In the shorter method of *indirect* elimination communicated by Gauss to Gerling, (see appendix to Gerling's work on the application of the calculus of compensation to practical geometry, 1843, p. 386,) we have been furnished with the means of solving the numerous normal equations which the present state of geodesy demands, and their numbers are frequently counted by the dozen. The method is by no means restricted to normal equations, to which, however, it applies best. However, in an instance where 86 unknown quantities were successfully eliminated, extraordinary means, such as cannot be commanded at all times, have been resorted to. Although the method does not apply with equal facility to all normal equations, yet, in most cases, it will be found time-saving, even for a small number of equations.

The method of indirect elimination premises that the corrections to an assumed value of approximation for the quantities sought are very small, or approximates to zero. By this supposition, the propriety of finding an approximate value for one of the unknown quantities, by putting the sum of the remaining terms equal zero, becomes apparent. Substituting the value so found in the given equations, and thereby changing absolute terms, the liability to error, in our next attempt to find an approximate value for the second unknown quantity, is less. This process will, in turn, furnish approximations for all the unknown quantities, and has to be continued until all absolute terms vanish in the successive substitutions, or until we have carried our approximations to a sufficient degree of accuracy, or to a sufficient number of places of decimals. The closer we follow the rule, to begin always with that quantity which, after consideration, promises the greatest value, the more rapid we will obtain the solution. In normal equations where each unknown quantity necessarily occurs once, with a preponderating co-efficient, there can never arise any doubt as to which equation is to be used for finding the greatest unknown quantity.

The following arrangement will be found convenient. Given the normal equations:

$$\begin{aligned}
o &= +2.8 + 76\,x - 30\,y - 20\,z - 26\,u \\
o &= -4.1 - 30\,x + 83\,y - 25\,z - 28\,u \\
o &= -1.9 - 20\,x - 25\,y + 89\,z - 44\,u \\
o &= +3.2 - 26\,x - 28\,y - 44\,z + 98\,u
\end{aligned}$$

To ascertain which of the unknown quantities will probably be greater, we examine the quotients:

$$\begin{aligned}
x &= -\frac{2.8}{76} = -0.03\,.. \\
y &= +\frac{4.1}{83} = +0.04\,.. \\
z &= +\frac{1.9}{89} = +0.02\,.. \\
u &= -\frac{3.2}{98} = -0.03
\end{aligned}$$

Accordingly, we begin with the substitution of $y = +0.04 + \triangle y$, where $\triangle y$ is a small correction to y, and find:

$$\begin{aligned}
o &= +1.60 + 76\,x - 30\,\triangle y - 20\,z - 26\,u \\
o &= -0.78 - 30\,x + 83\,\triangle y - 25\,z - 28\,u \\
o &= -2.90 - 20\,x - 25\,\triangle y + 89\,z - 44\,u \\
o &= +2.08 - 26\,x - 28\,\triangle y - 44\,z + 98\,u
\end{aligned}$$

In like manner we find:

$$\begin{aligned}
x &= -\frac{1.60}{76} = -0.02 \\
\triangle y &= +\frac{0.78}{83} = +0.01 \\
z &= +\frac{2.90}{89} = +0.03 \\
u &= -\frac{2.08}{98} = -0.02
\end{aligned}$$

We have, therefore, to substitute $z = +0.03 + \triangle z$; and proceeding in this way, the whole solution may be brought in the following form:

$y = +0.04$	$z = +0.03$	$\Delta y = +0.01$	$x = -0.01$	$u = -0.01$	$\Delta x = -0.003$	$\Delta^2 z = -0.002$
$0 = +1.60$	$+1.00$	$+0.70$	-0.06	$+0.20$	-0.028	$+0.012$
-0.78	-1.53	-0.70	-0.40	-0.12	-0.030	$+0.020$
-2.90	-0.23	-0.48	-0.28	$+0.16$	$+0.220$	$+0.042$
$+2.08$	$+0.76$	$+0.48$	$+0.74$	-0.24	-0.162	-0.074

Δu	
$+0.001.$	$\Delta^2 u$ would be -0.0003; but the operation is now completed if we are satisfied with two places of decimals and the first unknown quantity $= x + \Delta x + \Delta^2 x + \ldots\ldots\ldots\ldots$ or $x = -0.013$
	And in like manner .... $y = +0.050$
-0.014	$z = +0.028$
-0.008	$u = -0.009$
-0.002	
$+0.024$	
Sum... 0.000	

The above normal equations have the advantage of a check throughout the operation, on account of the balance of the numercial terms; hence the sum of any of the above vertical columns will be found equal zero. However, only certain normal equations present this advantage, and if we prefer to add a new equation, formed by the sum of the others with the signs changed, the same check may be had for any set of equations.

$$\text{Normal equations}\ldots\ldots \left\{\begin{array}{llll} 0 = +6.167 & +6.000\,K_1 & +\ \ 4.319\,K_2 & -0.763\,K_3 \\ 0 = +4.202 & +4.319\,K_1 & +77.629\,K_2 & +2.663\,K_3 \\ 0 = -7.345 & -0.763\,K_1 & +\ \ 2.663\,K_2 & +3.005\,K_3 \end{array}\right.$$

$$\text{Auxiliary check equation}\ldots\ldots\quad 0 = -3.024 \quad -9.556\,K_1 \quad -84.611\,K_2 \quad -4.905\,K_3$$

Solution.

$K_3 = +2$	$K_1 = -0.6$	$\Delta K_3 = +0.3$	$\Delta K_1 = -0.1$	$K_2 = -0.09$	$\Delta^2 K_3 = +0.04$	Etc., etc.	17th substitution. $\Delta^3 K_2 = -0.0001$
$+4.641$	$+1.041$	$+0.812$	$+0.212$	-0.177	-0.208	11 more substitutions will suffice to make the last place of decimals correct in the constant term.	-0.001
$+9.528$	$+6.937$	$+7.736$	$+7.304$	$+0.317$	$+0.424$		-0.001
-1.335	-0.877	$+0.025$	$+0.101$	-0.139	-0.019		-0.001
-12.834	-7.101	-8.573	-7.617	-0.001	-0.197		$+0.003$
					0.000		0.000

And

$-0.6 \quad +0.03$	-0.09	$+2$
$-0.1 \quad +0.01$	-0.008	$+0.3$
$+0.003$	-0.0007	$+0.04$
$+0.001$	-0.0001	0.01
		0.01
		0.004
		0.001
$K_1 = -0.656$	$K_2 = -0.0988$	$K_3 = +2.365$

A serious difficulty, however, may arise from the circumstance that one of the coefficients of the quantity to be determined is of insufficient magnitude in comparison with the other coefficients in the same normal equation, in consequence of which the convergence of the successive results may become exceedingly small, so that, for instance, the correction applied to the unknown quantity K_p counteracts all corrections previously obtained for other quantities K_q and K_r. The following method was used by Gerling to overcome this difficulty: during the progress of the elimination we soon recognise those K's which thus prevent any closer approximation, and they may be considered as forming a group which must be treated by itself. The respective normal equations forming such a group are separated from the rest and converted into other equations expressing the K's in terms of the absolute terms w, as follows:

Group.

$$0 = w_p + a_1 K_p + a_2 K_q + a_3 K_r$$
$$0 = w_q + a_4 K_p + a_5 K_q + a_6 K_r$$
$$0 = w_r + a_7 K_p + a_8 K_q + a_9 K_r$$

Modified group.

$$K_p = \alpha_1 w_p + \alpha_2 w_q + \alpha_3 w_r$$
$$K_q = \alpha_4 w_p + \alpha_5 w_q + \alpha_6 w_r$$
$$K_r = \alpha_7 w_p + \alpha_8 w_q + \alpha_9 w_r$$

Wherein α represents known quantities depending upon the a's above, the w, however, changing value with the successive approximations, and remaining expressed by letters, until in the progress of elimination it becomes desirable to solve the three equations:—K_p K_q and K_r then become known, and their corresponding w approach to zero. This process may have to be repeated. A different method will be shown in one of the following examples.

In number 523 of the Astronomische Nachrichten, Jacobi has given a method of solution of linear equations very similar to that of Gauss; but in the occurrence of other large coefficients, besides the diagonal coefficient, the process becomes lengthy and is not here inserted. A paper by Argelander in number 491 of the same publication, treats on a particular case of this kind. According to Gerling, Gauss was (in 1843) in possession of other artifices, and the former expresses his desire of seeing them published. The following examples of indirect elimination are given, as solved by Mr. J. Wiessner, of the computing division, principally after methods by Euler and Bezout.

Example of the solution of linear equations with preponderating diagonal coefficients:

Retain from the coefficients of the unknown quantities the highest place, and putting the numerical terms equal to the algebraic quantities $a\ b\ c$ ....., establish simple approximate equations, expressing the unknown quantities $x\ y\ z$ ... in terms as simple as possible. For an application of the method I have selected the same equations as above, viz:

$$0 = +6.167 + 6.000\,x + 4.319\,y - 0.763\,z$$
$$0 = +4.202 + 4.319\,x + 77.629\,y + 2.663\,z$$
$$0 = -7.345 - 0.763\,x + 2.663\,y + 3.005\,z$$

Hence the approximate equations—

$$0 = a + 6\,x + 4\ \ y - \tfrac{3}{4}\,z$$
$$0 = b + 4\,x + 78\ \ y + 2\tfrac{2}{3}\,z$$
$$0 = c - \tfrac{3}{4}\,x + 2\tfrac{2}{3}\,y + 3\ \ z$$

And the rough approximations—

$$x = \frac{-a}{6} = -1\cdot, \quad y = \frac{-b}{78} = -0.05, \quad z = \frac{-c}{3} = +2$$

By means of the above equations these approximations become—

$$x = -0.7$$
$$y = -0.09$$
$$z = +2.$$

The substitution of these values into the original equations changes the absolute terms $a\ b\ c$ into $+0.052$, -0.482, and -1.041, and we obtain for the next approximation the rough values -0.009 for x^1, $+0.006$ for y^1, and $+0.3$ for z^1. These rough values are again corrected as before, and the whole process may be brought into the following form:

	$x = -0.7$ $y = -0.09$ $z = +2.$	$+0.03$ -0.006 $+0.4$	$+0.013$ -0.0024 -0.035	$+0.0008$ -0.0003 $+0.0001$	$= -0.6562$ $= -0.0987$ $= +2.3651$
$a = +6.167$ $b = +4.202$ $c = -7.345$	$+0.052$ -0.482 -1.041	-0.099 $+0.247$ $+0.122$	-0.004 $+0.024$ $+0.001$		

In the above example the process is about the same as in the preceding solutions, though much shortened, and it will be seen that by means of such approximate equations a solution may frequently be obtained with surprising rapidity.

The adjustment of the horizontal angles (directions) at Station Ossipee, in Section I, produced the following six normal equations:

$$\begin{aligned}
0 &= +10.9950 + 53.2143\,A - 7.5523\,B - 7.8024\,C - 10.2190\,D - 8.5190\,E - 9.8357\,F \\
0 &= +12.5032 - 7.5523\,A + 38.9976\,B - 5.6024\,C - 6.7690\,D - 6.3524\,E - 6.8857\,F \\
0 &= -13.6740 - 7.8024\,A - 5.6024\,B + 52.1976\,C - 20.8190\,D - 5.1190\,E - 6.3024\,F \\
0 &= -20.1658 - 10.2190\,A - 6.7690\,B - 20.8190\,C + 64.3310\,D - 8.7190\,E - 9.0524\,F \\
0 &= -36.2916 - 8.5190\,A - 6.3524\,B - 5.1190\,C - 8.7190\,D + 44.7810\,E - 8.4357\,F \\
0 &= +19.5516 - 9.8357\,A - 6.8857\,B - 6.3024\,C - 9.0524\,D - 8.4357\,E + 49.4643\,F
\end{aligned}$$

These and similar equations, originating from the closing of the horizon at any station, can always be brought into the form—

$$\begin{aligned}
0 &= a + n\ x - m\ (x + y + z + \ldots\ldots) \\
0 &= b + n_{,}\ y - m_{,}\ (x + y + z + \ldots\ldots) \\
0 &= c + n_{,,}\ z - m_{,,}\ (x + y + z + \ldots\ldots) \\
&\text{etc.}
\end{aligned}$$

And putting $x + y + z + \ldots = S$, we find—

$$\begin{aligned}
x &= -\frac{a}{n} + \frac{m}{n}S \\
y &= -\frac{b}{n_{,}} + \frac{m_{,}}{n_{,}}S \\
z &= -\frac{c}{n_{,,}} + \frac{m_{,,}}{n_{,,}}S \ \text{ etc.}
\end{aligned}$$

In the first of the above equations we have the mean coefficient, omitting the diagonal coefficient, equal 9; hence by adding $9\,A + 9\,B + 9\,C + 9\,D + 9\,E + 9\,F - 9\,S = 0$, we find approximately—

$$\begin{aligned}
0 &= a + 62\,A - 9\,S & \text{hence } A &= -\frac{a}{63} + \frac{S}{7} \\
0 &= b + 45\,B - 7\,S & B &= -\frac{b}{42} + \frac{S}{6} \\
0 &= c + 58\,C - 6\,S - 15\,D & C &= -\frac{c}{60} + \frac{S}{10} + \frac{D}{5} \\
0 &= d + 73\,D - 9\,S - 12\,C & D &= -\frac{d}{72} + \frac{S}{8} + \frac{C}{8} \\
0 &= e + 53\,E - 8\,S & E &= -\frac{e}{56} + \frac{S}{7} \\
0 &= f + 56\,F - 8\,S & F &= -\frac{f}{56} + \frac{S}{7}
\end{aligned}$$

And approximately, $S = -\dfrac{a+b+c+d+e+f}{60} + \dfrac{6}{8}S$, or $S = -\dfrac{a+b+c+d+e+f}{15}$

$$= \frac{27.2}{15} = +1.9$$

We next find the greatest unknown quantity $E = 0.65 + 0.27 + 0.9$, which we substitute into the original equations, and then proceed as usual. The terms $\frac{D}{5}$ and $\frac{C}{8}$ may be neglected.

E = + 0.9	D = + 0.6	C = + 0.6	A = + 0.2	E = + 0.2	B = + 0.2	D = + 0.2	C + 0.1	F = + 0.1
0 = + 3.3279	— 2.8035	— 7.4849	+ 3.1580	+ 1.4542	— 0.0563	— 2.1001	— [illegible].8803	— 3.8639
+ 6.7860	+ 2.7246	— 0.6368	— 2.1473	— 3.4178	+ 4.3817	+ 3.0279	+ 2.4677	+ 1.7791
— 18.2811	— 30.7725	+ 0.5458	— 1.0147	— 2.0385	— 3.1590	— 7.3228	— 2.1028	— 2.7330
— 28.0129	+ 10.5857	— 1.9057	— 3.9495	— 5.6933	— 7.0471	+ 5.8191	+ 3.7372	+ 2.8320
+ 4.0113	— 1.2201	— 4.2915	— 5.9953	+ 2.9609	+ 1.6904	— 0.0534	— 0.5653	— 1.4089
+ 11.9595	+ 6.5281	+ 2.7467	+ 0.7796	— 0.9075	— 2.2846	— 4.0951	— 4.7253	+ 0.2211
S = + 1.4	+ 1.0	+ 0.7	+ 0.6	+ 0.6	+ 0.4	+ 0.3	+ 0.3	....

By adding up we find the approximate sum of A B C D E F = 3.1 instead of 1.9 ; hence we must use $S = -\frac{a+b+c+d+e+f}{8}$ and continue the reduction as follows, assuming next $s = +0.4$.

A = + 0.1	C = + 0.1	E = + 0.06*	F = + 0.04	D = + 0.03.	E = + 0.02.	A = + 0.02.	B = + 0.02	F = + 0.01
+ 1.4575	+ 0.6773	+ 0.1662	— 0.2272	— 0.5335	— 0.7039	+ 0.3604	+ 0.2094	+ 0.1110
+ 1.0239	+ 0.4637	+ 0.0826	— 0.1928	— 0.3959	— 0.5229	— 0.6739	+ 0.1060	+ 0.0371
— 3.5132	+ 1.7066	+ 1.3995	+ 1.1474	+ 0.5228	+ 0.4204	+ 0.2643	+ 0.1523	+ 0.0893
+ 1.8101	— 0.2718	— 0.7949	— 1.1570	+ 0.7729	+ 0.5985	+ 0.3941	+ 0.2587	+ 0.1682
— 2.2608	— 2.7727	— 0.0858	— 0.4232	— 0.6848	+ 0.2108	+ 0.0404	— 0.0866	— 0.1710
— 0.7625	— 1.3927	— 1.8988	+ 0.0798	— 0.1918	— 0.3605	— 0.5572	— 0.6949	— 0.2003
+ 0.3	+ 0.2	+ 0.1	+ 0.10	+ 0.08	+ 0.04	+ 0.02	+ 0.01	— 0.004

* Having obtained the first place of decimals for all the unknown quantities, the residuals may be checked by substituting into the given equations. The same check may be had after the second place of decimals is found. The check gives the last residuals.

	F = + 0.002	E = + 0.002	D = — 0.003	C = — 0.003	A = — 0.002	B = — 0.001	F = + 0.001	E = + 0.0006
+ 0.1107	+ 0.0910	+ 0.0740	+ 0.1046	+ 0.1280	+ 216	+ 292	+ 194	+ 143
+ 0.0371	+ 0.0233	+ 0.0106	+ 0.0309	+ 0.0477	+ 628	+ 238	+ 169	+ 131
+ 0.0893	+ 0.0767	+ 0.0665	+ 0.1289	— 0.0277	— 121	— 65	— 128	— 159
+ 0.1681	+ 0.1500	+ 0.1326	— 0.0604	+ 0.0020	+ 224	+ 292	+ 202	+ 150
— 0.1709	— 0.1878	— 0.0982	— 0.0721	— 0.0568	— 397	— 334	— 418	— 150
— 0.2005	— 0.1016	— 0.1185	— 0.0913	— 0.0724	— 527	— 458	+ 37	— 14
— 0.005	— 0.007	— 0.009	— 0.005	— 0.004	— 0.0003	+ 0.0005	— 0.0007	....

Which give the quantities correct nearly, to the fourth place in decimals, viz :

$$A = +0.3176$$
$$B = +0.2186$$
$$C = +0.7972$$
$$D = +0.8268$$
$$E = +1.1826$$
$$F = +0.1530$$

In some cases it will be found advantageous to equalize the diagonal coefficients $[a\,a]$ $[b\,b]$ $[c\,c]$ $[d\,d]$ etc. As an example I have selected the normal equations at Station Mt. Pleasant.

$0 = -\ 4.2294 + 36.3655\,A + \text{etc.}$

$0 = -\ 3.6472 -\ 4.8679\,A - 24.7988\,B + \text{etc.}$

$0 = -\ 8.2082 -\ 5.5179\,A -\ 4.8679\,B + 31.9821\,C + \text{etc.}$

$0 = +\ 8.0008 -\ 6.0512\,A -\ 4.8679\,B -\ 5.2679\,C + 50.8655\,D + \text{etc.}$

$0 = +\ 8.3133 -\ 7.9179\,A -\ 2.6012\,B -\ 8.5512\,C -\ 9.4179\,D + 54.6654\,E + \text{etc.}$

$0 = +\ 3.4978 -\ 1.1583\,A -\ 0.6250\,B -\ 0.8250\,C -\ 6.6583\,D -\ 6.6583\,E + 28.0083\,F + \text{etc.}$

$0 = + 30.2151 -\ 3.0012\,A -\ 1.7679\,B -\ 1.8846\,C -\ 8.5012\,D - 11.8012\,E -\ 6.7917\,F + 50.9154\,G.$

And multiplying these equations respectively by

$\frac{10}{4}$, $\frac{10}{3}$, $\frac{10}{4}$, $\frac{10}{6}$, $\frac{10}{6}$, 3 and $\frac{10}{6}$, we get the modified equations.

$0 = - 10.5735 + 90.9137\,A - 12.1697\,B - 13.7947\,C - 15.1280\,D - 19.7947\,E -\ 2.8957\,F -\ 7.5030\,G$

$0 = - 12.1573 - 16.2263\,A + 82.6627\,B - 16.2263\,C - 16.2263\,D -\ 8.6707\,E -\ 2.0833\,F -\ 5.8930\,G$

$0 = - 20.5205 - 13.7947\,A - 12.1697\,B + 79.9552\,C - 13.1697\,D - 21.3780\,E -\ 2.0625\,F -\ 4.7115\,G$

$0 = + 13.3347 - 10.0853\,A -\ 8.1132\,B -\ 8.7798\,C + 84.7758\,D - 15.6965\,E - 11.0972\,F - 14.1687\,G$

$0 = + 13.8555 - 13.1965\,A -\ 4.3353\,B - 14.2520\,C - 15.6965\,D + 91.1090\,E - 11.0972\,F - 19.6687\,G$

$0 = + 10.4934 -\ 3.4749\,A -\ 1.8750\,B -\ 2.4750\,C - 19.9749\,D - 19.9749\,E + 84.0249\,F - 20.3751\,G$

$0 = + 50.3585 -\ 5.0020\,A -\ 2.9465\,B -\ 3.1410\,C - 14.1687\,D - 19.6687\,E - 11.3195\,F + 84.8590\,G$

Putting $A + B + C + D + E + F + G = S$

$a + b + c + d + e + f + g = s$

we get the approximate equations:

$$\left.\begin{aligned} A &= -0.01\,a + 0.11\,S \\ B &= -0.01\,b + 0.12\,S \\ C &= -0.01\,c + 0.12\,S \\ D &= -0.01\,d + 0.12\,S \\ E &= -0.01\,e + 0.13\,S \\ F &= -0.01\,f + 0.12\,S \\ G &= -0.01\,g + 0.10\,S \\ S &= -0.01\,s + 0.12\,S \\ S &= -0.055\,s \end{aligned}\right\}\ \text{hence}\ \begin{aligned} A &= -0.01\,a - 0.005\,s \\ B &= -0.01\,b - 0.005\,s \\ C &= -0.01\,c - 0.005\,s \\ D &= -0.01\,d - 0.005\,s \\ E &= -0.01\,e - 0.005\,s \\ F &= -0.01\,f - 0.005\,s \\ G &= -0.01\,g - 0.005\,s \\ s &= +44.8 \end{aligned}$$

Instead of writing the *a b c d*, etc., in a vertical column, they have been placed in a horizontal line, which has some advantage over the former arrangement.

	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*s.*
	− 10. 5735	− 12. 1573	− 20. 5205	+ 13. 3347	+ 13. 8555	+ 10. 4934	+ 50. 3585	+ 45
G = − 0. 7	+ 5. 2521	+ 4. 1251	+ 3. 2980	+ 9. 9181	+ 13. 7681	+ 14. 2626	− 59. 4013	
	− 5. 3214	− 8. 0322	− 17. 2225	+ 23. 2528	+ 27. 6236	+ 24. 7560	− 9. 0428	+ 35
E = − 0. 5	+ 9. 8974	+ 4. 3354	+ 10. 6890	+ 7. 8483	− 45. 5545	+ 9. 9874	+ 9. 8344	
	+ 4. 5760	− 3. 6968	− 6. 5335	+ 31. 1011	− 17. 9309	+ 34. 7434	+ 0. 7916	+ 42
F = − 0. 6	+ 1. 7374	+ 1. 2500	+ 1. 2375	+ 6. 6583	+ 6. 6583	− 50. 4149	+ 6. 7917	
	+ 6. 3134	− 2. 4468	− 5. 2960	+ 37. 7594	− 11. 2726	− 15. 6715	+ 7. 5833	+ 18
D = − 0. 5	+ 7. 5640	+ 8. 1131	+ 6. 5848	− 42. 3879	+ 7. 8483	+ 9. 9874	+ 7. 0844	
	+ 13. 8774	+ 5. 6663	+ 1. 2888	− 4. 6285	− 3. 4243	− 5. 6841	+ 14. 6677	+ 22
G = − 0. 2	+ 1. 5006	+ 1. 1786	+ 0. 9423	+ 2. 8337	+ 3. 9337	+ 4. 0750	− 16. 9718	
	+ 15. 3780	+ 6. 8449	+ 2. 2311	− 1. 7948	+ 0. 5094	− 1. 6091	− 2. 3041	+ 19
A = − 0. 2	− 18. 1827	+ 3. 2453	+ 2. 7589	+ 2. 0171	+ 2. 6393	+ 0. 6950	+ 1. 0004	
	− 2. 8047	+ 10. 0902	+ 4. 9900	+ 0. 2223	+ 3. 1487	− 0. 9141	− 1. 3037	+ 13
B = − 0. 2	+ 2. 4339	− 16. 5325	+ 2. 4339	+ 1. 6226	+ 0. 8671	+ 0. 3750	+ 0. 5893	
	− 0. 3708	− 6. 4423	+ 7. 4239	+ 1. 8449	+ 4. 0158	− 0. 5391	− 0. 7144	+ 6
C = − 0. 1	+ 1. 3795	+ 1. 6226	− 7. 9955	+ 0. 8780	+ 1. 4252	+ 0. 2475	+ 0. 3141	
	+ 1. 0087	− 4. 8197	− 0. 5716	+ 2. 7229	+ 5. 4410	− 0. 2916	− 0. 4003	+ 4
E = − 0. 1	+ 1. 9795	+ 0. 8671	+ 2. 1378	+ 1. 5697	− 9. 1109	+ 1. 9975	+ 1. 9669	
	+ 2. 9882	− 3. 9526	+ 1. 5662	+ 4. 2926	− 3. 6699	+ 1. 7059	+ 1. 5666	+ 5
Check	+ 2. 9881	− 3. 9527	+ 1. 5663	+ 4. 2925	− 3. 6700	+ 1. 7059	+ 1. 5665	

We find—

$$\begin{aligned} A &= -0.258 & E &= -0.604 \\ B &= -0.193 & F &= -0.654 \\ C &= -0.146 & G &= -0.944 \\ D &= -0.577 \end{aligned}$$

nearly correct in the last place of decimals; the process of elimination may be continued to four places.

The adjustment of a series of triangles, forming a chain and not containing quadrilaterals or other complications, leads to normal equations of the following form, taken from the primary triangulation of the upper part of Chesapeake bay.

	A.	B.	C.	D.	E.	F.	G.	H.	etc.
$0 = +0.789$	$+6$	$+2$							
$0 = +2.059$	$+2$	$+6$	-2						
$0 = -1.422$		-2	$+6$	-2					
$0 = -0.503$			-2	$+6$	-2				
$0 = +0.511$				-2	$+6$	-2			
$0 = +0.895$					-2	$+6$	-2		
etc.									

We put

$$A = -\frac{a}{6} - \frac{B}{3}$$

$$B = -\frac{b}{6} - \frac{A}{3} + \frac{C}{3}$$

$$C = -\frac{c}{6} + \frac{B}{3} + \frac{D}{3}$$

$$D = -\frac{d}{6} + \frac{C}{3} + \frac{E}{3}$$

etc., and the approximate equations become—

$$A = -\frac{a}{6} + \frac{b}{18}$$

$$B = -\frac{b}{6} + \frac{a}{18} - \frac{c}{18}$$

$$C = -\frac{c}{6} - \frac{b}{18} - \frac{d}{18}$$

$$D = -\frac{d}{6} - \frac{c}{18} - \frac{e}{18}$$

etc.; which equations include a sufficient number of terms to secure the first place of decimals in each approximation. We have—

$B = -0.2$	$C = +0.1$	$F = -0.1$	$B = -0.1$	$E = -0.1$	$F = -0.09$	$D = +0.08$	$C = +0.06$	$A = -0.03$	$D = +0.02$
$+0.389$			$+0.189$					$+0.009$	
$+0.859$	$+0.659$		$+0.059$				-0.061	-0.121	
-1.022	-0.422		-0.222			-0.382	-0.022		$+0.018$
	-0.703			-0.503		-0.023	-0.143		-0.023
		$+0.711$		$+0.111$	$+0.291$	$+0.131$			$+0.091$
		$+0.295$		$+0.495$	$+0.045$				
		+ etc.			+ etc.				

$B = +0.02$	$E = -0.01$	$A = -0.01$
$+0.049$		-0.011
-0.001		-0.021
-0.022		
	-0.003	
	$+0.031$	
	-0.025	

Breaking off here, we have—

$A = -0.038$
$B = -0.277$
$C = +0.164$
$D = +0.100$
$E = -0.115$
$F = -0.186$
etc.

Any number of these equations may be solved with facility and without the use of logarithms, but when side equations enter into the normal equations, some of the coefficients may become comparatively large. The solution in this latter case may be effected as follows: The pentagon formed by the primary stations near the Kent island base, on Chesapeake bay, furnishes an example involving two side equations.

	K_1	K_2	K_3	K_4	K_5	K_6	K_7	
$0 = +\ 0.891$	$+ 6$	$- 2$	$+ 2$	$- 2$	0	$- 21.75$	$- 41.97$	
$0 = -\ 0.912$	$- 2$	$+ 6$	$+ 2$	0	0	$+ 15.11$	$+ 79.62$	
$0 = +\ 0.378$	$+ 2$	$+ 2$	$+ 6$	0	$- 2$	$+ 91.12$	$- 17.54$	
$0 = -\ 2.255$	$- 2$	0	0	$+ 6$	$+ 2$	$+ 38.39$	$+ 92.92$	(A.)
$0 = -\ 0.708$	0	0	$- 2$	$+ 2$	$+ 6$	$- 44.07$	$+ 4.84$	
$0 = + 33.417$	$- 21.75$	$+ 15.11$	$+ 91.12$	$+ 38.39$	$- 44.07$	$+ 4015$	$+ 1054$	
$0 = +\ 0.718$	$- 41.97$	$+ 79.62$	$- 17.54$	$+ 92.92$	$+ 4.84$	$+ 1054$	$+ 8909$	

The first step will be to equalize the diagonal coefficients. For this purpose put $\sqrt{\frac{4015}{6}}\,K_6 = K^1_6$ and $\sqrt{\frac{8909}{6}}\,K_7 = K^1_7$ and divide the 6th and 7th equations by the radical quantities respectively. The equations become—

	K_1	K_2	K_3	K_4	K_5	K^1_6	K^1_7	
$0 = + 0.891$	$+ 6$	$- 2$	$+ 2$	$- 2$	0	$- 0.841$	$- 1.089$	
$0 = - 0.912$	$- 2$	$+ 6$	$+ 2$	0	0	$+ 0.584$	$+ 2.066$	
$0 = + 0.378$	$+ 2$	$+ 2$	$+ 6$	0	$- 2$	$+ 3.522$	$- 0.455$	
$0 = - 2.255$	$- 2$	0	0	$+ 6$	$+ 2$	$+ 1.484$	$+ 2.411$	(B.)
$0 = - 0.708$	0	0	$- 2$	$+ 2$	$+ 6$	$- 1.704$	$+ 0.126$	
$0 = + 1.292$	$- 0.841$	$+ 0.584$	$+ 3.522$	$+ 1.484$	$- 1.704$	$+ 6.000$	$+ 1.057$	
$0 = + 0.019$	$- 1.089$	$+ 2.066$	$- 0.455$	$+ 2.411$	$+ 0.126$	$+ 1.057$	$+ 6.000$	

We first exchange $K_1\ K_2\ K_3\ K_4\ K_5$ for $m\ n\ o\ p\ q$, and put in the place of the $a\ b\ c\ d\ e$, the numbers $[af]\ [bf]\ [cf]\ [df]\ [ef]$ respectively, which give the equations—

$$0 = - 0.841 + 6\,m - 2\,n + 2\,o - 2\,p \qquad (1)$$
$$0 = + 0.584 - 2\,m + 6\,n + 2\,o \qquad (2)$$
$$0 = + 3.522 + 2\,m + 2\,n + 6\,o \quad - 2\,q \qquad (3)$$
$$0 = + 1.484 - 2\,m \quad + 6\,p + 2\,q \qquad (4)$$
$$0 = - 1.704 \quad - 2\,o + 2\,p + 6\,q \qquad (5)$$

And in the same way a second set of five equations are derived, when we introduce $[a\,g]\ [b\,g]$ etc.

And find
$$\left.\begin{array}{lr}
0 = + 5.006 \quad + 2\,n + 6\,o + 6\,p & (3) + (4) \\
0 = + 8.862 + 6\,m + 6\,n + 16\,o + 2\,p & 3\,(3) + (5) \\
0 = + 8.021 + 12\,m + 4\,n + 18\,o & 3\,(3) + (5) + (1) \\
0 = + 2.483 + 18\,m - 4\,n + 12\,o & 3\,(1) + (3) + (4) \\
0 = + 2.765 + 30\,m - 50\,n & 3\,(3) + (5) + (1) - 9\,(2) \\
0 = - 1.021 + 30\,m - 40\,n & 1) + (3) + (4) - 6\,(2)
\end{array}\right\} \text{(C)}$$

Hence—

$m = + 0.5389$ and from te 2d set $m^1 = - 0.5051$
$n = + 0.3786$ $\qquad n^1 = - 0.7215$
$o = - 0.8890$ $\qquad o^1 = + 0.6264$
$p = - 0.0715$ $\qquad p^1 = - 0.7119$
$q = + 0.0115$ $\qquad q^1 = + 0.4251$

We next multiply the 1st equation (of set B) by m, the second by n, and so on; and adding up, excluding the last equation, we find an equation of the form—

$0 = \alpha + \beta\ K^1_6 + \gamma\ K^1_7$; and in a similar way,

$0 = \alpha^1 + \beta^1\ K^1_6 + \gamma\ K^1_7$.

The coefficients of $K_1\ K_2\ K_3\ K_4\ K_5$ become necessarily zero. In the above example we find

$$0 = + 1.244 + 2.511\ K^1_6 + 1.486\ K^1_7$$
$$0 = + 1.768 + 1.486\ K^1_6 - 3.112\ K^1_7$$

Whence—

$$\begin{array}{ll} K_6^1 = -0.220 \text{ and } & K_6 = -0.0085 \\ K_7^1 = -0.463 & K_7 = -0.0120 \end{array}$$

If the value for K_6 and K_7 be substituted in the equations (A), we obtain five simple equations, which can be solved readily by means of the algorithm (C.) The solution gives—

$$\begin{array}{llllll} K_1 = +0.341, & K_2 = +0.577, & K_3 = -0.391, & K_4 = +0.846, & K_5 = -0.347 & \text{with the residuals} \\ -0.002 & +0.001 & -0.001 & +0.002 & +0.001 & 0.000 + 0.002 \end{array}$$

The solution of the following linear equations is effected by means of two assumptions of the first unknown quantity leading directly to the value of all the rest. The following equations are derived from observations made at Station Ossipee:

$$\begin{array}{lllllllll} 0 = -0.381 & +4A & -B & -C & -D & & & & (1) \\ 0 = +0.405 & -A & +2B & & & & & & (2) \\ 0 = +0.519 & -A & & +2C & -D & & & & (3) \\ 0 = -0.520 & -A & & -C & +4D & -E & -F & & (4) \\ 0 = -0.356 & & & & -D & +2E & -F & & (5) \\ 0 = +0.379 & & & & -D & -E & +3F & & (6) \end{array}$$

We next assume an approximate value a, for A, by making an estimate for B, C, and D, in equation 1, and find $a = +0.04$; hence

$$\left.\begin{array}{rl} & a = +0.04 \\ (2) & B = -0.1825 \\ (1) + (3) & C = -0.1725 \\ (1) \text{ or } (3) & D = +0.1340 \\ 3\ (5) + (6) & E = +0.2450 \\ (5) \text{ or } (6) & F = 0.0000 \end{array}\right\} \text{From the equation (4), not used in finding any of the unknown quantities, we obtain by substitution, the residual } a = -0.0965.$$

A second assumption $a_1 = +0.1$ leads to

$$\left.\begin{array}{l} B = -0.1525 \\ C = -0.0825 \\ D = +0.2540 \\ E = +0.3410 \\ F = +0.0720 \end{array}\right\} \text{With the residual from equation (4) } a^1 = +0.0655.$$

Let x be the true value of A, then $x - a : a^1 - a = o - a : a^1 - a$, from which x or $A = +0.0758$, and the rest of the unknown quantities will easily result.

APPENDIX No. 41.

Letter to the Superintendent from Assistant C. O. Boutelle, with description of the apparatus devised for the measurement of preliminary bases at Savannah, Georgia, and Georgetown, South Carolina. (*See Sketch No.* 53.)

CAMBRIDGE, MASS., *September* 22, 1855.

DEAR SIR: I forward herewith a tracing of the apparatus contrived by me for supporting the four-metre wooden measuring bars used in measuring the preliminary bases at Savannah and Georgetown.

It appears to me to possess the following advantages for the purpose required, viz:

1. It is cheap—its entire cost being about sixty dollars.

2. It is light, and may be transported by a few men.

3. It may be used upon rough and uneven ground without digging, the measuring bars being at a low and nearly uniform grade. One end of a box may be as low as the knees, while the other end is as high as the top of the head.

4. It is perfectly firm and steady when in position.

5. It is simple in its construction, and may be made from the drawing by any intelligent carpenter and blacksmith, with a little supervision on the part of the person who is to use it.

The apparatus consists of four stands or "boxes," the top of each of which (*d*, figs. 1 and 6—*Sketch No.* 53) is made of white pine twenty-six feet long, six inches wide, and one inch thick, supported and stiffened by two vertical flanches of white pine (*e*, figs. 1 and 6) of the same length and thickness, but tapering from six inches wide in the centre to four inches at each end. Each box is supported by two Gambey stands, as shown in fig. 1, where two boxes are represented in line.

The stands are made like those belonging to Gambey theodolites; (*k*, fig. 2,) is the plan of the top of one of them. In the centre is a hole (*n*) an inch and a half in diameter. The legs (*h*, fig. 3) are of oak or ash, each four feet long, and one and a quarter inches square before splitting through the centre. At the bottom of each leg is an iron ferrule and point. They are secured to the top of the stand by iron bolts, with thumb-screws (fig. 4) passing through the holes (*o*, fig. 2) in the top of the stand.

The boxes are connected with the stands by two pins, (c, figs. 1 and 6,) each moving, in the direction of the box, upon a pin (*b*, fig. 6) held by two gudgeons or journals (*a*, figs. 1, 5, and 6) screwed to the under side of the top of the box (*d*.) The pins (*c*) are each eighteen inches long, and one and a half inches in diameter, fitting into the hole (*n*) in the top of each stand, (*k*.) The wood-screw (*m*) was intended to press against the pin (*c*) in any part of its length, as the box was elevated above the stand in crossing hollows. But it does not work well in practice, as the wood swells and shrinks with the atmospheric changes, and I propose to substitute a metallic clamp like that represented in figure 10.

Figure 6 is a cross-section of one of the boxes, through the centre of the pin (*c*); (*d*) is the top of the box, (*e*) the flanch, (*a*) the gudgeons in which rests the bolt (*b*) upon which the pin (*c*) turns. A front view of one of the gudgeons is shown in figure 5.

The boxes are intended for supporting two wooden bars, each four metres long; each box is 7.93 metres long, or about three inches less than eight metres or two bars. There is thus a space of about six inches between each box, when in position, so that it may be aligned and levelled without disturbing the adjustment of the box behind it.

The wooden bars used by me at Savannah were each four metres long and an inch and a half square, with brass sockets tapering nearly to a point at each end, where are inserted short steel wires of a quarter-inch diameter, one end forming a disk and the other a knife-edge. Figure 8 represents the ends of these bars in contact.

At Georgetown I used two iron wires a quarter-inch in diameter. At each end a flat piece of platinum was inlaid, and a line cut across it. The distance between these lines was nearly four metres at 32° Fahrenheit, and they formed the termini of the measure. To render these wires convenient for use, I enclosed them in grooves cut in inflexible wooden bars made of white pine, each one and a half inches square, and long enough to allow each end of the wire to project about an inch. The wires were held in the grooves by small metallic staples, driven in such a manner as to keep the wire steady, while it allowed free expansion and contraction during changes of temperature. They are shown in position on figure 1, box No. 1, A and B. The ends of the two wires are also shown in figure 9, which is a view of the top surface of the wires, enclosed in the wooden bars, as they appear in use, with the terminal lines in contact at (*p*).

Either kind of measuring bar may be used upon the boxes in the following manner: The boxes are numbered 1, 2, 3, and 4. In commencing the measure they are aligned in that order, the rear end of box No. 1 being placed about six inches ahead of the point selected at the initial point of the base. In aligning the boxes it is best to have two legs of each stand parallel, and the other on a line perpendicular to the line of the base. An approximate alignment only is necessary, care being taken that the true line falls somewhere on the top of the box, which is six inches wide, and also that the ends of two contiguous boxes are in the same plane. Attention is also requisite to the profile of the ground ahead, so as to commence rising to overcome an elevation, sufficiently far back to make the angles of inclination as small as possible.

The four boxes being aligned in the order of their numbers, measuring-bar No. 1 is placed upon box No. 1, the end plumbed over the terminus of the base, and the bar aligned with precision. (The alignment may be carried on by having several signals carefully placed in line along the base by a transit instrument, and these may be kept in one by the eye.) The bar is then clamped firmly to the box by the clamp (*f*, fig. 7) which I have not before described. It is of half-inch square iron, and is four inches on a side. A thumb-screw (*g*) passes through the upper side, and ends in a swivel-plate. The lower side is passed through a hole in the box, made to receive it, (see fig. 1,) and the swivel-plate is pressed firmly down upon the measuring-bar by means of the screw (*g*.) Measuring-bar No. 2 is now placed upon the forward end of box No. 1 aligned, and the ends brought in contact, when this, too, is clamped to the box. The temperature and angle of inclination of the bars to the horizon are now observed and recorded, and these bars are "counted," that is, they are considered as measured and recorded in the note book. I have found the following form of record convenient, viz:

United States Coast Survey, Section V.—Measure of —— base.

Time.	Whole number.	Number of bar.	Number of box.	Temperature.	Angles of inclination.		Corrections.		Remarks.
					+	—	Inclination.	Temp.	
h. m.				°	′	′			
9 21 A. M.	1	1	1	66.0					Commenced measure at north end; weather, &c.
23	2	2		66.1					
26	3	1	2	66.5	10				
28	4	2		66.8	10				
29	5	1	3	67.0					
31	6	2		67.2		5			
35	7	1	4	67.6		5			
38	8	2		68.0		15			To end of descending slope.
9.40	9	1	1	68.1	5	15			

There is here a duplicate check upon errors in counting. The column of whole numbers runs on from one to the end of the measure, but the boxes end with every eight bars measured. The whole number standing opposite box No. 4, bar No. 2, must therefore always be a factor of eight.

The record being complete, bar No. 1 is unclamped, carried forward and placed upon box No. 2, where it is aligned, contact is made, and it is then clamped. As the ends of the bars are now on different boxes, the necessity for having the ends of the boxes in the same plane is evident, since otherwise one end of the bar would be either above or below the other. Bar No. 2 is then unclamped, brought forward, aligned, contact made, and clamped. Temperature and inclination are again observed and recorded, box No. 1 is carried forward and aligned, ready for bar No. 9, and the measure continued in the same manner to the end of the day's work, where stubs are driven and marked with dots upon copper tacks, from which to resume the measure on the next day. I have usually left the boxes in a line at night, taking off and securing the measuring-bars. In plumbing down from the ends of the bars to mark points, I have used a sector, or theodolite, as we do with the large apparatus.

My instrument for measuring the angles of inclination was a cicular finder taken from one of our large astronomical transit instruments. It reads to minutes, and was secured by tacks to a piece of two-inch plank, about two feet long and six inches high, the circle being so adjusted that the lower edge of the plank was parallel to the level, with the verniers at zero. This was placed successively upon each measuring-bar when in position. The angles of inclination were then read off and recorded.

In using this apparatus at Georgetown, I was aided by Major Prince and Mr. Huger, with six men. Major Prince, with all the men, aligned and adjusted the boxes and observed the angles of inclination, while Mr. Huger and myself followed with the measuring-bars. We were sometimes able to measure, over ordinary ground, at the rate of one bar per minute, and frequently made forty-five per hour.

The apparatus might be used to more advantage if the metallic clamp, shown in figure 10, were adapted to it. It would also improve it much if the gudgeons (*a*) and the pin (*b*, figs. 5 and 6) were of metal instead of wood. We have also experienced difficulty in keeping the surface (*d*) of the boxes in a uniform plane, where exposed to the action of the sun and moisture. This may be remedied by inserting pieces of wood about six inches square, and half an inch thick, into the under side of the top of each box, with the grain of the wood running *across* the top of the box. The ends of the box will also be better preserved from sagging by making the vertical flanches six inches deep throughout their length, instead of tapering to four inches at each end, as in the drawing.

Yours, respectfully,

CHAS. O. BOUTELLE.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 42.

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 insure 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 Moon's Parallax constructed from Walker's and Adams' Formulae*" 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.

$\alpha^1 =$ the right ascension of another star or of the moon's centre.

$\beta^1 =$ the declination of the second star or of the moon's centre.

$\Delta\,\alpha = \alpha^1 - \alpha.$

$\Delta\,\beta = \beta^1 - \beta.$

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,

$$\mathrm{A} = 1 - \sin^2 \tfrac{1}{2}\,\Delta\,\beta + \sin^2 \tfrac{1}{2}\,\Delta\,\alpha \cos\beta \cos\beta^1,$$

$$\mathrm{B} \sin 1'' = \sin \Delta\,\alpha \cos \beta^1,$$

$$\mathrm{C} \sin 1'' = \sin \Delta\,\beta + 2 \sin^2 \tfrac{1}{2}\,\Delta\,\alpha \sin\beta \cos\beta^1,$$

$$x = \frac{\mathrm{B}}{\mathrm{A}},$$

$$y = \frac{\mathrm{C}}{\mathrm{A}}.$$

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,

$\Delta_\pi\,\alpha = \alpha^1 - \alpha_0 =$ the parallax in right ascension,

$\Delta_\pi\,\beta = \beta^1 - \beta_0 =$ the parallax in declination.

$$\mathrm{P} \sin 1'' = h \sin \pi \sec \beta_0,$$

$$\tan \Delta_\pi\,\alpha = \frac{\mathrm{P} \sin 1'' \sin (s - \alpha_0)}{1 - \mathrm{P} \sin 1'' \cos (s - \alpha_0)},$$

$$\tan \eta = \frac{K \cos \frac{1}{2} \Delta_\pi \alpha}{h \cos (s - \alpha_0 - \frac{1}{2} \Delta_\pi \alpha)}$$

$$Q \sin 1'' = \frac{K \sin \pi}{\sin \eta}$$

$$\tan \Delta_\pi \beta = \frac{Q \sin 1'' \sin (\beta_0 - \eta)}{1 - Q \sin 1'' \cos (\beta_0 - \eta)}$$

$$\log a = 9.435000.$$

$$\Sigma_1 = a \pi \frac{\sin (\beta^1 - \eta)}{\sin (\beta_0 - \eta)}$$

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^1 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^1_m, y^1_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 right ascension for the instances 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 right ascension for the year 1840,
$\delta \beta_s$ the correction of the star's declination for the year 1840,
δx^1_m the correction of the moon's hourly change of x_m,
$\delta \beta^1_m$ the correction of the moon's hourly motion in declination,
δx^1_s the correction of the star's annual change of x_s,
$\delta \beta^1_s$ 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 in 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^1 are

$$p \cos \theta = x_s - x_m,$$
$$p \sin \theta = y_s - y_m,$$
$$v \cos \theta^1 = x^1_m,$$
$$v \sin \theta^1 = y^1_m,$$

and the equation of condition is

$$\cos \theta \left[\delta x_s - \delta x_m + t_y \, \delta x^1_s - (t - \tau) \, \delta x^1_m \right] + \sin \theta \left[\delta \beta_s - \delta \beta_m + t_y \, \delta \beta^1_s - (t - \tau) \, \delta \beta^1_m \right]$$
$$- \left[\frac{\Delta_\pi \, a \cos \beta_0}{\pi} \cos \theta + \frac{\Delta_\pi \beta}{\pi} \sin \theta + a \right] \delta \pi - \pi \, \delta a - \delta p - v \cos (\theta^1 - \theta) \left[\delta \lambda + \delta t \right] = \Sigma_2 - p.$$

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 the 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 letters marked [1] be relative to the *apparent* position, the unmarked letters relative to the *mean* place of 1840.0, the index s for the star, and we have

$$\begin{cases} x_s = \frac{1}{A}\left\{ \sin(\alpha_s - \alpha)\cos\delta_s \right\} & y_s = \frac{1}{A}\left\{ \sin(\delta_s - \delta) + 2\sin^2\tfrac{1}{2}(\alpha_s - \alpha)\sin\delta\cos\delta_s \right\} \\ x^1_s = \frac{1}{A}\left\{ \sin(\alpha^1_s - \alpha^1)\cos\delta^1_s \right\} & y^1_s = \frac{1}{A}\left\{ \sin(\delta^1_s - \delta^1) + 2\sin^2\tfrac{1}{2}(\alpha^1_s - \alpha^1)\sin\delta^1\cos\delta^1_s \right\} \end{cases}$$

Hence by neglecting the terms of higher order we get the corrections of the co-ordinates x_s and y_s

$$x^1_s - x_s = \left\{ \alpha^1_s - \alpha_s - \alpha^1 + \alpha \right\}\cos\delta - (\alpha^1_s - \alpha^1)(\delta^1 - \delta)\sin\delta\,; \quad y^1_s - y_s = \delta^1_s - \delta_s - \delta^1 + \delta$$

Now we have—

For *Alcyone* $\alpha^1 - \alpha = A\,a + B\,b + C\,c + D\,d$ and $\delta^1 - \delta = A\,a^1 + B\,b^1 + C\,c^1 + D\,d^1$

For the *other star* $\alpha^1_s - \alpha_s = A\,a_s + B\,b_s + C\,c_s + D\,d_s$ and $\delta^1_s - \delta_s = A\,a^1_s + B\,b^1_s + C\,c^1_s + D\,d^1_s$,

which substituted in the preceding equations give

$$\begin{cases} x^1_s - x_s = A\,(a_s - a)\cos\delta + B\,(b_s - b)\cos\delta + C\,(c_s - c)\cos\delta + D\,(d_s - d)\cos\delta \\ \qquad\qquad - (\alpha_s - \alpha)\sin\delta\left\{ A\,a^1 + B\,b^1 + C\,c^1 + D\,d^1 \right\} \\ y^1_s - y_s = A\,(a^1_s - a^1) + B\,(b^1_s - b^1) + C\,(c^1_s - c) + D\,(d^1_s - d^1). \end{cases}$$

But from—

$$\begin{array}{lll} a = m + n\,tg\,\delta\sin\alpha & \text{follows } a_s - a & = n\,tg\,\delta\sin\alpha(\alpha_s - \alpha) + n\sec^2\delta\sin\alpha\,(\delta_s - \delta) \\ b = tg\,\delta\cos\alpha & \quad\text{"}\quad b_s - b & = -tg\,\delta\sin\alpha(\alpha_s - \alpha) + \sec^2\delta\cos\alpha\,(\delta_s - \delta) \\ c = \sec\delta\sin\alpha & \quad\text{"}\quad c_s - c & = -\sec\delta\sin\alpha\,(\alpha_s - \alpha) - \sec^2\delta\sin\alpha\cos\alpha\,(\delta_s - \delta) \\ d = \sec\delta\cos\alpha & \quad\text{"}\quad d_s - d & = \sec\delta\cos\alpha(\alpha_s - \alpha) + \sec^2\delta\sin\alpha\,(\delta_s - \delta) \\ a^1 = n\cos\alpha & \quad\text{"}\quad a_s^1 - a^1 & = -n\sin\alpha\,(\alpha_s - \alpha) \\ b^1 = -\sin\alpha & \quad\text{"}\quad b_s^1 - b^1 & = -\cos\alpha\,(\alpha_s - \alpha) \\ c^1 = tg\,\omega\cos\delta - \sin\delta\sin\alpha & \quad\text{"}\quad c_s^1 - c^1 & = -\sin\delta\cos\alpha(\alpha_s - \alpha) - \left\{ tg\,\omega\sin\delta + \cos\delta\sin\alpha \right\}(\delta^s - \delta) \\ d^1 = \sin\delta\cos\alpha & \quad\text{"}\quad d^1_s - d^1 & = -\sin\delta\sin\delta\,(\alpha_s - \alpha) + \cos\delta\cos\alpha\,(\delta_s - \delta) \end{array}$$

Substituting these values, and putting $\alpha_s - \alpha = x_s\sec\delta$, $\delta_s - \delta = y_s$, we get—

$$\begin{cases} x^1_s - x_s = +\left\{ A n\sec\delta\sin\alpha + B\sec\delta\cos\alpha + C\,tg\,\delta\cos\alpha + D\,tg\,\delta\sin\alpha \right\} y_s + \left\{ C\,tg\,\omega\sin\delta \right. \\ \qquad \left. + C\cos\delta\sin\alpha - D\cos\delta\cos\alpha - 2\,C\sec\delta\sin\alpha + 2\,D\sec\delta\cos\alpha \right\} x_s \\ y^1_s - y_s = -\left\{ A n\sec\delta\sin\alpha + B\sec\delta\cos\alpha + C\,tg\,\delta\cos\alpha + D\,tg\,\delta\sin\alpha \right\} x_s - \left\{ C\,tg\,\omega\sin\delta \right. \\ \qquad \left. + C\cos\delta\sin\alpha - D\cos\delta\cos\alpha \right\} y_s \end{cases}$$

which may also appear under the form (not so convenient for the following development):

$$\begin{cases} x^1_s - x_s = +\left\{ g\sec\delta\sin(G + \alpha) + h\,tg\,\delta\sin(H + \alpha) \right\} y_s + \left\{ C\,tg\,\omega\sin\delta - h\cos\delta\cos \right. \\ \qquad \left. (H + \alpha) - 2\,h\sec\delta\cos(H + \alpha) \right\} x_s \\ y^1_s - y_s = -\left\{ g\sec\delta\sin(G + \alpha) + h\,tg\,\delta\sin(H + \alpha) \right\} x_s + \left\{ C\,tg\,\omega\sin\delta - h\cos\delta\cos \right. \\ \qquad \left. (H + \alpha) \right\} y_s \end{cases}$$

As far as to their principal terms—

$$\begin{cases} A = t_y - 0.34238\sin\Omega & \text{and } \Omega = 339^\circ\ 35'\ 44''.7 - t_y\ 19^\circ\ 20'\ 29''.53 \\ B = -9''.2235\cos\Omega & \qquad = 339^\circ\ 35'\ 44''.7 - (t_y \pm 18^y.61i)\ 19^\circ\ 20'\ 29''.53 \\ C = -20.''4451\cos\omega\cos\odot & \qquad \text{where } i \text{ is any integer number } 0, 1, 2, 3\ldots \\ D = -20.4451\sin\odot & \end{cases}$$

Further we have—

	lg.tg ω	*lg.cos* ω	*lg.n*	*lg.sin* α	*lg.cos* α	*lg.sin* δ	*lg.cos* δ	*lg.tg* δ	
for 1840 ;	9.63747	9.96253	1.30224	9.91246	9.76043	9.60252	9.96205	9.64047,	etc., hence
for 1740 ;	9.63769	9.96250	1.30245	9.90437	9.77587	9.59679	9.96313	9.63367	etc.

	$(x^1 - x)_x$		$(x_1 - x)_y = -(y_1 - y)_x$				$(y_1 - y)_y$	
For year	*lg. coefficient C.*	*lg. coefficient D.*	*lg. coefficient A.*	*lg. coefficient B.*	*lg. coefficient C.*	*lg. coefficient D.*	*lg. coefficient C.*	*lg. coefficient D.*
1840	9.93518 *n*	9.86296	1.25265	9.79838	9.40090	9.55293	9.96512 *n*	9.72248
1740	9.92238 *n*	9.87576	1.24369	9.81274	9.40954	9.53804	9.95840 *n*	9.73900

by which we get (the numerical coefficients being logarithms,)

$$
\begin{array}{l}
(1840) \\ (1740)
\end{array}
\left\{
\begin{aligned}
x_s^1 - x_s = +\Big\{ & \underset{5.9293}{5.9382}\, t_y - \underset{5.2316}{5.2039} \cos \{ (t \pm i\ 18^y.61)\ 10^\circ 20'.5 \} + \underset{5.5730}{5.5758} \sin \{ (t \pm i\ 18^y.61)\ 19^\circ 20'.5 \} \\
& - \underset{5.3662}{5.3596} \cos \odot - \underset{5.5342}{5.5490} \sin \odot \Big\} y_s + \Big\{ \underset{5.8810}{5.8939} \cos \odot - \underset{5.8719}{5.8591} \sin \odot \Big\} x_s \\
y_s^1 - y_s = -\Big\{ & \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \Big\} x_s \\
& + \Big\{ \underset{5.9171}{5.9238} \cos \odot - \underset{5.7352}{5.7186} \sin \odot \Big\} y_s
\end{aligned}
\right.
$$

or by contracting—

$$
\begin{array}{l}
(1840) \\ (1740)
\end{array}
\left\{
\begin{aligned}
x_s^1 - x_s = +\Big\{ & \underset{5.9293}{5.9382}\, t_y - \underset{5.6140}{5.6118} \sin \{ \underset{336^\circ 30'}{336^\circ 59'} + (t \pm i\ 18^y.61)\ 19^\circ 20'.5 \} + \underset{5.6172}{5.6248} \sin \{ \underset{214^\circ 18'}{212^\circ 53'} + \odot \} \Big\} y_s \\
& + \underset{6.0270}{6.0277} \sin \{ \underset{134^\circ 24'}{132^\circ 42'} + \odot \} x_s \\
y_s^1 - y_s = -\Big\{ & \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \Big\} x_s \\
& + \Big\{ + \underset{5.9952}{5.9951} \sin \{ \underset{122^\circ 20'}{121^\circ 56'} + \odot \} \Big\} y_s
\end{aligned}
\right.
$$

As the maximum of the co-ordinates does not reach to 2800″ (log = 3.4471) the following form shows directly the maximum of the different terms:

$$
\left\{
\begin{aligned}
x_s^1 - x_s = + & \underset{5.9293}{(5.9382)}\, t_y\, y_s + \Big\{ \underset{0''.115}{0''.115} \sin \{ \underset{335^\circ 30'}{336^\circ 59'} + (t \pm i\ 18^y.61)\ 19^\circ 20'.5 \} + \underset{0''.116}{0''.118} \sin \{ \underset{214^\circ 18'}{212^\circ 53'} + \odot \} \Big\} \frac{y_s}{2800''} \\
& + \underset{0''.298}{0''.298} \sin \{ \underset{134^\circ 24'}{132^\circ 42'} + \odot \} \frac{x_s}{2800''} \\
y_s^1 - y_s = - & \underset{5.9293}{(5.9382)}\, t_y\, x_s - \Big\{ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \Big\} \frac{x_s}{2800''} \\
& + \underset{0.277}{0''.277} \sin \{ \underset{122^\circ 20'}{121^\circ 56'} + \odot \} \frac{y_s}{2800''}
\end{aligned}
\right.
$$

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 month 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 ± 2 years, consequently the angle under the *sine* between $298^\circ\ 18'$ and $374^\circ\ 40'$; that is to say, the term depending on the ☾'s node cannot exceed $0''.101$, 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 different formula, which I had given him. I have examined and corrected them, and they are contained in the two sheets marked (A^1).*

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* Celaeno	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. 81		
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 01 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 05 15. 46	— 92. 44	1738. 56		
21	8. 9	28 41. 90	09 22. 05	— 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. 47	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 4. 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		

* Omitted.

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 (B^1).* The data for this computation are taken from 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*
Christiana	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	8.8793021	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

* Omitted.

APPENDIX No. 43.

Report of Professor W. C. Bond, on the number of moon culminations observed at Cambridge, Mass., and relative to the Chronometer Expedition for difference of longitude between Cambridge and Liverpool.

CAMBRIDGE, *October* 3, 1855.

DEAR SIR: Since my last report forty-two moon culminations, with the requisite number of star transits, and seven occultations of stars by the moon, and one immersion and emersion of the planet Uranus, have been observed at this station.

To these may be added between one and two hundred single-wire meridian transits of bright spots, or crater-form circular cavities, which were experimentally observed with the moon's limb, for the purpose of ascertaining the relative value of the two methods, when applied to the determination of longitudes.

These observations afford additional evidence that the bisection of the smaller cavities, and the transits of the bright points, may be observed with as great exactness as the transit of a star can be under the most favorable circumstances, and much more accurately than it is possible to observe the moon's limb. No insuperable difficulty is encountered in making a favorable selection from objects of this kind, on the moon's surface. It is necessary, however, that the different observers should be provided with trustworthy charts of the moon; for this purpose large crystalotype copies of the daguerreotype representation of the moon, which was taken by our large equatorial, might be obtained at a small expense and distributed among the observers at the different astronomical stations of the Coast Survey.

The electric method of recording astronomical observations, introduced by the Coast Survey, is perfectly adapted to the rapid succession of time records, which the observed transits of the moon's limb, together with one, two, or three of the better defined points on the lunar surface, at the same culmination, would require.

The Chronometer Expedition for the determination of the difference of longitude between the Cambridge and Greenwich Observatories, has been carried forward this year under very favorable circumstances.

The *temperature trials* of the chronometers to be used on this expedition was commenced early in March, 1855.

On the afternoon of the 5th of June the chronometers were placed on board the steam-packet *America*, under the charge of Messrs. R. F. Bond and P. S. Coolidge; the vessel sailed for Liverpool the next day, and arrived at Liverpool on the 17th of the same month. Every facility was afforded by the Liverpool officials for the immediate landing of the chronometers, and Mr. Hartnup, the director of the Liverpool Observatory, with his wonted kindness, provided a situation for them, as well as for the Coast Survey electric clock and spring governor apparatus, at the observatory.

Messrs. Coolidge and Bond were detained a month in England, under the necessity of waiting for a steamer of larger size than the America, and possessing better accommodations. On the 20th of July the chronometers were placed on board the *Asia*, and sailed the same day, arriving at Boston on the 4th of August. After making the requisite observations and comparisons, the chronometers were replaced on board the *Asia*, in charge of Messrs. P. S. Coolidge and Charles W. Tuttle, on the 14th of August, and landed at the Liverpool Observatory on the 26th. Favorable weather intervening for observation, the instruments were put on board the *Africa* on the 1st of September, and were received at the Cambridge Observatory on the 12th. The condition of the atmosphere having been again propitious for observing, they were again transferred to the *Africa*, on the afternoon of the 25th of September, Messrs. P. S. Coolidge and J. F. Flagg being charged with the duty of making the required observations and comparisons.

It having been ascertained that there was sufficient accommodation in the state-room of the steamer for nine more chronometers, that number was accordingly added to the forty-two embarked in the America, making the whole number fifty-one.

No untoward accident or delay has as yet occurred. The mean temperature of 65° Fahrenheit has been pretty steadily maintained, both at sea and on shore. The thermo-chronometer is very satisfactory in its indications. The weather has been propitious for the determination of local time on both sides of the Atlantic.

I propose to terminate the transportation of the chronometers for the season, on the return voyage, about the 25th of the present month.

I will add, that the report on the computations of the expeditions of 1849, '50, and '51, by Mr. George P. Bond, is ready for the press, and that the reduction of the present expedition was commenced under his charge immediately after the first temperature experiments were made in March last, and is kept in a good state of forwardness.

The present season's work will yield nearly three hundred separate determinations of longitude.

Yours, respectfully,

W. C. BOND.

Prof. A. D. BACHE,
Superintendent Coast Survey, Dixmont, Maine.

APPENDIX No. 44.

Letter to the Superintendent from Assistant George W. Dean, communicating description of the zenith telescope made by Mr. Wm. Würdemann, D. C., 1855, *and used at the astronomical station, Dixmont, Maine.*

COAST SURVEY STATION, DIXMONT, ME., *October*, 1855.

DEAR SIR: I respectfully submit the following report upon the zenith telescope (No. 10) recently completed by Mr. William Würdemann, of Washington, D. C.

This instrument was finished by Mr. Würdemann in June last; and being in Washington at that time, he proposed to me to take charge of it, and to test the accuracy of its mechanical construction by using it at one of the astronomical stations in the Coast Survey. Mr. W rdemann's proposal met with your ready approval, and the instrument, with one of the best of a similar kind, made for the Coast Survey by Troughton & Simms, of London, (C. S. No. 2,) was accordingly taken to this station for trial. This zenith instrument is the largest, and in point of nice mechanical construction and finish far excels all others of a similar kind which have fallen within my notice. The instrument is supported by three levelling screws, which are inserted near the ends of three projecting brass arms, each extending eleven and a half inches from the centre, and equidistant from each other, thus forming an equilateral triangle, the sides of which are eighteen inches in length.

Upon this triangular base is an azimuth circle of fifteen inches in diameter, accurately divided upon silver into equal divisions of fifteen minutes each, which, with the aid of the vernier attached, may be read to thirty seconds. The vertical brass column which covers the vertical steel axis is three inches in diameter at its base, slightly conical in shape, and rises twenty-three and a half inches above the plane of the azimuth circle. To this column is attached a neatly constructed brass frame, which extends across the azimuth circle, and carries at one end the vernier and lens for reading the circle, while at the other is the tangent clamp and screw, by which a delicate motion of the telescope in azimuth may be communicated. Upon this brass frame is fixed, with adjusting-screws, a circular level, which serves for adjusting approximately the vertical axis.

The top of the brass column is furnished with a good bearing-surface, upon which the brass arm which supports the horizontal axis is firmly secured by two capstan-headed steel screws, each one and a half inches in length and one quarter of an inch in diameter. Upon the end of this horizontal bar, and nearest the telescope, is attached by screws a vertical brass plate one-eighth of an inch in thickness, and having a groove one sixteenth of an inch in depth planed across it, flush with the upper surface of the brass bar to which it is secured, thus forming a stiff spring.

This plate supports the end of the steel cylinder nearest the telescope in which the horizontal axis of the telescope turns. The opposite end of this cylinder is supported by two stiff, spiral steel springs, resting upon the horizontal brass bar, and kept in position by a capstan-headed steel screw, which is one quarter of an inch in diameter.

This mode of attaching the horizontal to the vertical axis is both simple and convenient, as it admits of easy and ready adjustment of the axes at right-angles to each other. The horizontal axis of the telescope is kept in position within the steel cylinder by means of a milled-headed nut upon the end of the axis, which presses lightly against a metallic spring washer in contact with the end of the steel cylinder. The construction of the horizontal axis and mode of adjustment are in accordance with the original suggestion of the late R. H. Fauntleroy, assistant United States Coast Survey. He proposed constructing a zenith instrument in which the telescope should move in a vertical plane, eccentric to the vertical axis, and provided with a horizontal axis of sufficient length to make it a reliable transit instrument. The telescope of this instrument is fifty-one inches focal length, with an aperture of three and three-fourths inches.

The diaphragm consists of five vertical threads at convenient equidistant intervals for observing transits, and is provided with an adjusting screw for collimation. The limits of the field are equal to fifty revolutions of the micrometer screw, or a little more than thirty minutes of arc; but in using the instrument I would not advise measuring distances greater than twenty-five minutes on account of the great compression of the spiral spring acting against the screw, and for other reasons which suggest themselves in practice, but which need not here be stated.

The arrangement for illuminating the field is excellent. A small lamp, so constructed that it will give a strong, steady light from seven to eight hours without trimming, is adjusted upon a brass plate connected with the brass bar which supports the remote end of the telescope axis. The light passing through the axis is reflected upon the diaphragm by a mirror one quarter of an inch in diameter, made of silver, and adjusted near the centre of the telescope tube. The eye-piece is provided with a parallactic movement, by which an object passing across any part of the field may be made to pass directly in front of the observer's eye.

The eye-tube, which carries the diaphragm, micrometer, and eye-piece, is provided with a clamp and tangent screws, by which the verticality of the threads is conveniently adjusted and securely kept in position. The pivots, or, perhaps more properly speaking, the bearing-points for the riding level upon the horizontal axis are ten inches apart and made of German silver. For preserving the equality of diameter and their cylindrical form, they appear to have been made with great care and nicety.

Upon the telescope, at right-angles to its axis and twelve inches below it, is attached a neatly made circle or "finder," of six inches in diameter, graduated upon silver into divisions of fifteen minutes each, and with the verniers may be read to thirty seconds. Moving upon an axis in the centre of this circle or "finder" is a brass frame which extends across and beyond it, to which it is attached, by suitable adjusting screws, to the level. Mr. Würdemann's mode of making his levels is original. He grinds the inside of a cylindrical glass tube of suitable size to the required curvature. The ends are then fitted with brass stoppers, which are kept tightly pressed inwards by means of a brass rod which passes lengthwise through the centre of the tube and into the stoppers, both ends of this rod having threads cut upon it, to which the stoppers are screwed. To the rod is given a spiral form, the better to adapt it to changes of temperature. At one end of the level is a vacuum chamber, which admits of making the length of the bubble the same at all temperatures. The levels are filled with rectified ether, heated to its boiling-point (96° Fah.) and then sealed.

The observations at this station show the level upon this instrument to be a very perfect one. The telescope is firmly held at any altitude by means of a simple contrivance. This consists of a friction band with a clamp screw, which moves upon a circular steel plate five inches in diameter attached to the end of the steel cylinder nearest the telescope. To this band is fixed by screws a triangular brass frame eighteen inches in length, to which is secured a steel bar spring which bears against a shoulder upon the telescope tube and presses the brass frame against a tangent screw upon the tube opposite.

The horizontal axis is almost wholly relieved from the weight of the telescope by means of an ingenious contrivance for attaching the counterpoise weight, devised and made by Mr. Würdemann. The telescope tube to which the axis is attached is strengthened by a brass band five and a half inches in width, and one quarter of an inch in thickness. Upon this band, directly opposite the steel axis and coincident with its centre of motion, is a projection of one quarter of an inch and one half inch in diameter, thus forming an outside (if we may so call it) axis of the telescope; upon this outer axis is fitted one end of a steel arm or lever which curves around the tube of the telescope, (but entirely free from it, so as to admit of a movement of more than 360°,) and secured by screws to a strong brass ring which moves upon friction rollers around the steel cylinder before described. This ring is adjusted directly over the centre of the vertical axis and forms the fulcrum for the steel lever which extends to the opposite end of the steel cylinder, and then receives the counterpoise weight which was carefully tested by experiment so as to balance the telescope and its necessary appendages when in adjustment for observing.

All the tangent and adjusting screws upon this instrument are made of German silver, which is a decided improvement over steel for such purposes in field instruments on account of rapid corrosion of the latter.

The design and style of finish of this instrument are highly creditable to the artistic taste and workmanship of Mr. Würdemann.

Very respectfully submitted by

G. W. DEAN.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey, Dixmont, Me.

APPENDIX No. 45.

Report of Mr. Charles A. Schott, Computing Division Coast Survey Office, on a comparison of star-places given in Rümker's and the Twelve-Year Catalogues.

[Communicated to the Astronomical Journal, by authority of the Treasury Department.]

Computing Division, Coast Survey Office,
March 20, 1855.

Dear Sir: The following comparison of the places of stars as given in the Greenwich Twelve-Year Catalogue and Rümker's Hamburg Catalogue, is respectfully submitted.

A notice of this catalogue, "Mean Places of 12,000 Fixed Stars for the Commencement of the Year 1836, from Observations at the Hamburg Observatory, by Charles Rümker," will be found in Nos. 427, 442, and 539 of the *Astronomische Nachrichten*. See, also, No. 38 of the *Astronomical Journal*.

The last division also contains the commencement of a new catalogue for the epoch of January 1, 1850. The constants a, b, c, d, and a', b', c', d', refer to A, B, C, D of the Nautical Almanac, and are consequently Bessel's changed notation. The proper motions are given in a separate table at the end of each hour. The comparison between these two catalogues was made in consequence of the revision of the results for latitudes determined with the zenith telescope, in order to introduce the most reliable places of stars. The comparison extends over each of the twenty-four hours of right ascension, and includes 398 stars. The mean places for 1836 in Rümker's Hamburg Catalogue were reduced to the epoch 1840 of the Twelve-Year Catalogue, and the following table, which is sufficiently explained by the heading of each column, contains the difference:

Hour.	Star's number.		No. of observat'ns for α.		$\Delta\ \alpha$ T. Y. — R.	$\Delta\ \alpha\ \cos\delta$.	No. of observations for N. P. D.		Difference in N. P. D. T. Y. — R.
	Twelve-year.	Rümker.	T. Y.	R.			T. Y.	R.	
					s.	s.			″
0	9	14	100	20	— 0.04	— 0.04	50	20	— 0.22
	10	23	6	2	+ 0.14	+ 0.14	4	2	— 1.61
	15	42	5	2	— 0.07	— 0.07	10	2	+ 1.47
	16	52	7	2	— 0.30	— 0.30	6	2	— 3.57
	21	75	4	3	+ 0.10	+ 0.10	8	3	+ 0.29
	31	122	5	12	+ 0.01	0.00	46	10	1.30
	35	145					4	2	1.97
	36	146	6	5	— 0.10	— 0.10	6	4	+ 1.66
	45	177	5	6	— 0.15	— 0.14	8	5	— 1.21
	50	193	13	6	+ 0.02	+ 0.02	8	6	+ 0.48
	53	196	5	2	0.14	0.11	11	2	2.12
	57	223	3	23	0.18	0.09	18	23	+ 0.86
	58	228	5	4	+ 0.03	+ 0.02	6	4	— 1.26
0	66	246	10	4	— 0.11	— 0.11	14	4	— 0.10
1	106	282	4	4	+ 0.09	+ 0.03	4	4	+ 0.58
	107	285	3	6	+ 0.18	+ 0.09	8	6	+ 2.03
	124	318	6	6	— 0.11	— 0.11	9	6	— 0.12
	137	352	5	5	0.06	0.06	5	3	+ 0.84
	139	373	5	2	0.03	0.03	5	2	0.54
	145	387	2	1	0.24	0.24	3	1	0.27
	147	392	4	3	0.02	0.01	3	3	+ 1.33
	152	412	4	4	— 0.06	— 0.06	4	4	— 1.15
	163	452	6	11	+ 0.06	+ 0.05	30	12	+ 2.38
	170	469	7	9	— 0.23	— 0.22	9	8	— 0.90
	174	486	3	3	— 0.08	— 0.03	2	3	+ 1.63
1	177	491	3	6	+ 0.27	+ 0.08	2	5	0.82
2	206	593	3	3	0.00		2	3	1.31
	223	666	2	2	+ 0.03	+ 0.03	2	2	+ 0.19
	226	677	7	5	— 0.20	— 0.19	10	5	— 1.66
	227	681	3	2	— 0.10	— 0.09	5	2	2.08
	230	688	5	4	+ 0.06	+ 0.06	5	4	0.05
	235	692	56	29	— 0.06	— 0.06	56	28	0.81
	237	696	1	4	0.00		3	3	— 1.06
	247	726	3	5	+ 0.11	+ 0.11	5	5	+ 2.69
	248	727	3	3	0.02	0.01	3	3	0.64
	249	746	3	3	+ 0.24	+ 0.23	5	3	+ 1.34
	254	762	8	4	— 0.21	— 0.20	13	4	— 0.94
	257	769	3	3	0.06	0.04	4	3	0.51
2	265	778	3	3	0.31	0.24	10	3	2.84
3	271	801	11	13	0.07	0.07	21	12	0.27
	275	814	6	8	0.06	0.06	12	7	2.40
	282	843	3	1	0.62	0.58	5	1	— 4.37
	286	851	1	4	— 0.24	— 0.23			
	292	857	8	9	+ 0.01	+ 0.01	2	8	+ 0.47
	293	861	3	3	— 0.04	— 0.04	6	3	— 0.85
	294	863	3	7	+ 0.18	+ 0.12	5	5	1.20
	296	881	7	3	0.00		5	3	0.51
	298	891	3	2	+ 0.02	+ 0.02	4	2	0.21
	299	892	3	14	— 0.20	— 0.13	2	14	0.04
	301	910	6	2	0.00		10	2	1.58
	304	929	3	4	0.07	— 0.06	6	4	— 1.65
	305	930	3	17	— 0.22	— 0.15	34	13	+ 0.45
	322	984	66	54	+ 0.02	+ 0.02	51	45	— 0.76
	334	1016	3	6	+ 0.02	+ 0.02	7	6	— 0.50
	336	1034	6	7	— 0.09	— 0.07	3	6	+ 0.52
	342	1061	9	6	+ 0.05	+ 0.05	7	6	0.48
3	344	1074	15	12	— 0.02	— 0.02	5	13	+ 0.84

TABLE—Continued.

Hour.	Star's number.		No. of observat'ns for *a*.		Δ *a* T. Y. —R.	Δ *a* cos δ.	No. of observations for N. P. D.		Difference in N. P. D. T. Y. —R.
	Twelve-year.	Rümker.	T. Y.	R.			T. Y.	R.	
					s.	s.			″
3	345	1076	1	4	— 0. 28	— 0. 26	4	3	+ 0. 48
3	346	1082	3	5	0. 20	0. 14			
4	355	1107	4	7	— 0. 07	— 0. 05	16	7	— 0. 02
	359	1137	5	3	+ 0. 04	+ 0. 04	7	3	+ 0. 91
	362	1154	3	7	+ 0. 01	+ 0. 01	5	7	— 0. 07
	364	1168	5	9	0. 00		7	10	0. 53
	366	1177	3	3	+ 0. 02	+ 0. 02	5	3	— 0. 23
	369	1183	5	4	— 0. 02	— 0. 02			
	370	1186	12	5	0. 13	0. 12	11	5	— 0. 13
	371	1190	5	2	0. 27	0. 26	6	1	+ 5. 85
	373	1204	1	13	— 0. 19	— 0. 18	6	13	0. 19
	375	1207	2	4	+ 0. 15	+ 0. 14	5	3	1. 93
	378	1209	1	5	0. 08	0. 08	1	3	1. 08
	379	1218	3	4	+ 0. 09	+ 0. 09	10	4	1. 72
	381	1221					6	4	0. 70
	383	1231					7	3	5. 70
	388	1237	3	2	— 0. 05	— 0. 05	4	2	+ 2. 51
	396	1242	1	3	+ 0. 07	+ 0. 07			
	405	1296	1	8	— 0. 02	— 0. 02	2	8	+ 2. 08
	409	1318	5	14	+ 0. 03	+ 0. 03	10	9	0. 85
	410	1325	5	5	0. 03	0. 03	6	6	+ 1. 48
4	411	1328	2	4	+ 0. 10	+ 0. 09	4	5	— 1. 84
5	453	1431	98	104	— 0. 04	— 0. 04	76	105	0. 00
	464	1465	65	47	0. 11	0. 11	34	44	— 0. 28
	474	1489		5	0. 04	0. 04	3	5	+ 0. 93
	473	1491	47	34	— 0. 04	— 0. 04	26	34	0. 23
	475	1492	5	1	+ 0. 11	+ 0. 11	8	1	+ 0. 73
	478	1499	4	2	0. 31	0. 28	7	2	— 0. 05
	481	1524	5	11	+ 0. 01	+ 0. 01	2	10	+ 1. 00
	487	1555	3	2	— 0. 11	— 0. 11	2	2	— 2. 48
	506	1610	6	4	0. 00		4	3	— 0. 47
	508	1614	3	3	— 0. 30	— 0. 18	17	3	+ 2. 32
	516	1636	1	1	+ 0. 01	+ 0. 01	3	1	— 1. 21
	527	1718	7	1	+ 0. 30	+ 0. 29	5	1	+ 0. 48
5	529	1731	2	1	— 0. 21	— 0. 19	3	1	1. 35
6	534	1764	7	9	0. 13	0. 11	10	8	0. 50
	535	1766	5	4	0. 09	0. 08	5	4	+ 0. 16
	538	1796	5	1	0. 15	0. 15	7	1	— 3. 33
	550	1834	62	20	0. 09	0. 08	54	20	0. 30
	560	1874	3	8	0. 04	0. 04	7	7	0. 28
	579	1940	4	10	— 0. 13	— 0. 13	5	10	— 1. 19
	582	1962	6	1	+ 0. 07	+ 0. 05	2	1	+ 1. 24
	587	1979	14	16	0. 01	0. 01	12	13	— 0. 05
	604	2007	3	4	0. 14	0. 12	6	4	+ 0. 43
6	626	2082	5	15	+ 0. 04	+ 0. 04	7	15	— 0. 52
7	638	2122	6	12	— 0. 05	— 0. 04	5	12	+ 1. 50
	640	2125	5	3	+ 0. 07	+ 0. 05	5	3	— 0. 25
	659	2180	6	3	— 0. 02	— 0. 02	6	3	— 0. 12
	661	2184	67	38	+ 0. 01	+ 0. 01	56	37	+ 0. 51
	663	2210	1	1	+ 0. 18	+ 0. 16	4	1	— 1. 44
	664	2215	8	14	0. 00		8	14	— 0. 16
	672	2232	3	1	— 0. 17	— 0. 11	5	1	+ 0. 91
	675	2239	2	2	0. 03	0. 03	5	2	0. 22
	678	2267	110	151	— 0. 05	— 0. 04	90	148	0. 58
	680	2273	5	1	+ 0. 03	+ 0. 03	1	1	+ 2. 52
	692	2280	10	4	0. 11	0. 10	12	4	— 0. 55
	707	2314	6	6	+ 0. 11	+ 0. 10	4	6	+ 1. 58
	709	2335	6	3	— 0. 02	— 0. 02	5	2	0. 91
	712	2366	5	1	— 0. 08	— 0. 08	6	1	+ 0. 25
	716	2377	6	2	+ 0. 07	+ 0. 06	9	2	— 0. 78
	717	2393	5	2	0. 13	0. 13	6	2	+ 0. 82
7	720	2397	5	8	+ 0. 30	+ 0. 11	35	7	+ 3. 73
8	725	2422					4	1	— 1. 83
	732	2443	3	3	— 0. 12	— 0. 06	5	3	+ 0. 74
	740	2457	3	7	— 0. 02	— 0. 01	8	7	+ 1. 86
8	745	2476	12	8	+ 0. 05	+ 0. 05	15	3	— 0. 75

TABLE—Continued.

Hour.	Star's number.		No. of observat'ns for α.		Δ α T. Y. —R.	Δ α cos. δ	No. of observations for N. P. D.		Difference in N. P. D. T. Y. —R.
	Twelve-year.	Rümker.	T. Y.	R.			T. Y.	R.	
					s.	s.			"
8	747	2481	4	4	+ 0.12	+ 0.09	7	4	+ 0.74
	751	2493	10	2	0.25	0.24	5	2	— 3.17
	752	2511	5	2	+ 0.10	+ 0.10	5	2	— 2.71
	753	2513	5	12	— 0.07	— 0.03	25	12	+ 1.57
	758	2547	6	8	— 0.03	— 0.03	7	7	— 0.52
	760	2550					3	1	1.13
	762	2554	11	3	+ 0.04	+ 0.04	13	3	0.84
	768	2596	3	4	— 0.07	— 0.07	4	4	0.75
	770	2609	5	2	— 0.01	— 0.01	5	2	1.43
	775	2624	2	6	+ 0.21	+ 0.20	8	5	0.87
	777	2634	12	16	— 0.08	— 0.08	10	15	— 0.53
	781	2645	54	13	— 0.03	— 0.03	37	13	+ 0.54
	784	2672					6	3	— 1.50
	791	2703	35	44	— 0.11	— 0.07	56	44	+ 0.38
	793	2705	4	1	+ 0.09	+ 0.09	6	1	— 3.03
8	797	2717	2	5	0.01	0.01	9	5	0.12
9	805	2768	4	1	+ 0.21	+ 0.19	1	1	— 0.50
	806	2770	3	5	— 0.17	— 0.08	2	5	+ 4.87
	810	2782	8	4	+ 0.12	+ 0.06	1	4	— 0.51
	812	2786	6	6	— 0.06	— 0.03	21	6	+ 1.50
	823	2864	3	2	— 0.01	0.00	2	1	3.07
	825	2865	5	1	+ 0.27	+ 0.09	2	1	2.57
	829	2868	26	57	0.05	0.03	71	57	+ 0.65
	831	2870	11	4	+ 0.01	+ 0.01	12	3	— 0.54
	832	2871	5	3	— 0.14	— 0.14	2	3	1.84
	833	2872	5	1	+ 0.01	+ 0.01	6	1	1.35
	834	2873	3	1	— 0.09	— 0.05	2	1	4.32
	840	2898	2	1	+ 0.16	+ 0.16	4	1	2.59
	841	2913	8	16	— 0.07	— 0.07	12	14	— 1.22
	843	2923	2	4	0.06	0.06	2	4	+ 1.49
	845	2933	74	38	— 0.05	— 0.05	58	38	— 0.53
	847	2940	5	1	+ 0.27	+ 0.26	5	1	— 0.38
	849	2948	3	2	+ 0.15	+ 0.08	82	2	+ 1.86
	851	2959	2	2	— 0.11	— 0.06	9	2	1.82
	852	2976	5	18	+ 0.03	+ 0.03	6	18	+ 0.30
9	855	3021	6	9	— 0.04	— 0.04	4	7	— 1.29
10	868	3104					3	5	— 0.81
	869	3110	3	13	+ 0.03	+ 0.02	67	12	+ 2.78
	873	3133	2	19	— 0.09	— 0.08	2	19	— 0.16
	880	3150	2	6	— 0.19	— 0.14	5	6	+ 8.30
	885	3178	5	5	+ 0.16	+ 0.16	6	5	— 1.25
	887	3196					8	2	+ 1.26
	888	3197	1	4	+ 0.12	+ 0.09			
	893	3207	3	5	+ 0.37	+ 0.20	12	5	+ 1.54
	896	3233	12	33	— 0.04	— 0.04	17	32	0.67
	897	3235	3	3	+ 0.35	+ 0.19	16	3	+ 5.59
	899	3247	5	3	— 0.12	— 0.12	6	3	— 4.19
	904	3277					4	5	+ 1.85
	908	3299	10	2	— 0.05	— 0.05	4	2	+ 0.12
	914	3324	1	3	+ 0.10	+ 0.10	9	3	— 0.08
	915	3334	5	1	+ 0.11	+ 0.11	5	1	+ 1.25
	916	3348	6	7	— 0.05	— 0.05	11	7	0.08
	917	3352					9	7	2.26
	918	3366	3	3	+ 0.28	+ 0.16	7	3	+ 0.37
	919	3370					2	5	— 0.71
10	925	3424	5	7	— 0.01	— 0.01	4	7	0.00
11	937	3447	3	10	+ 0.04	+ 0.03	59	10	+ 0.68
	938	3481	1	3	+ 0.22	+ 0.22	1	4	— 1.42
	939	3482	96	33	— 0.02	— 0.02	75	33	+ 0.01
	941	3494	2	3	+ 0.17	+ 0.16	3	3	+ 1.11
	942	3500	5	3	— 0.02	— 0.02	6	3	— 0.99
	948	3535	11	31	— 0.02	— 0.02	10	26	+ 1.55
	949	3554	1	13	+ 0.31	+ 0.30	2	14	+ 0.27
	953	3580	1	3	0.01	0.01	5	3	— 0.92
11	955	3587	7	14	+ 0.04	+ 0.04	6	14	+ 0.54
	958	3604	3	12	— 0.14	— 0.05	42	11	+ 1.32

TABLE—Continued.

Hour.	Star's number. Twelve-year.	Star's number. Rümker.	No. of observat'ns for α. T. Y.	No. of observat'ns for α. R.	Δ α T. Y.—R.	Δ α cos. δ	No. of observations for N. P. D. T. Y.	No. of observations for N. P. D. R.	Difference in N. P. D. T. Y.—R.
					s.	s.			″
11	959	3609	5	3	— 0.07	— 0.07	2	3	— 1.02
	964	3659	11	17	0.07	0.07	13	18	0.13
	966	3667	3	1	0.13	0.09	8	1	— 0.76
	969	3733	4	16	0.13	0.09	8	9	+ 0.78
	970	3734	8	6	— 0.02	— 0.02	9	6	0.70
	975	3748	13	8	+ 0.04	+ 0.04	13	8	0.69
	976	3751	13	9	0.07	0.05	16	9	+ 1.52
	983	3767	8	10	0.01	0.01	7	10	— 1.10
	984	3774	1	6	+ 0.18	+ 0.18	9	6	+ 0.30
11	987	3786	6	4	— 0.08	— 0.06	6	1	1.30
12	998	3882	19	50	0.12	0.06	170	44	1.54
	1002	3910	7	29	0.11	0.11	11	29	+ 0.36
	1005	3915	3	2	— 0.11	— 0.11	4	2	— 2.30
	1006	3923	3	5	+ 0.05	+ 0.03	5	5	— 0.85
	1010	3985	4	5	— 0.03	— 0.02	6	5	+ 1.00
	1017	4029	3	7	+ 0.08	+ 0.03	54	7	1.74
	1018	4040	2	8	+ 0.41	+ 0.14	5	9	+ 0.39
	1029	4169	5	1	— 0.07	— 0.07	1	1	— 2.01
	1031	4175	6	10	+ 0.04	+ 0.04	5	10	+ 0.16
	1032	4179	3	13	— 0.12	— 0.06	111	13	— 0.25
	1033	4183	4	2	+ 0.16	+ 0.16	8	2	+ 0.02
	1037	4190	58	12	— 0.13	— 0.10	61	12	+ 0.89
12	1042	4215	3	2	— 0.04	— 0.02	4	1	— 0.19
13	1049	4224	17	6	+ 0.01	+ 0.01	34	5	— 0.81
	1052	4228	5	1	+ 0.18	+ 0.17	3	1	+ 6.71
	1056	4254	5	3	— 0.05	— 0.05	7	3	— 0.86
	1070	4333	2	2	+ 0.08	+ 0.08	1	2	0.75
	1072	4343	4	2	0.21	0.21	5	2	— 1.22
	1075	4356	3	20	0.06	0.06	4	20	+ 1.22
	1077	4369	5	2	0.04	0.03	2	2	1.07
	1080	4410	5	3	0.10	0.09	6	3	+ 1.76
	1082	4413	8	13	+ 0.03	+ 0.03	10	13	— 0.23
	1085	4429	5	6	— 0.04	— 0.04	2	6	+ 0.45
	1091	4449	3	4	0.02	0.02	3	4	+ 1.57
	1095	4460	5	3	— 0.05	— 0.04	5	3	— 1.97
	1097	4463	5	1	+ 0.07	+ 0.07	2	1	+ 0.33
	1102	4470	6	7	0.08	0.08	4	7	— 1.10
	1108	4511	5	2	+ 0.19	+ 0.08	16	2	+ 1.79
	1109	4514	118	57	— 0.09	— 0.08	62	57	— 0.82
13	1125	4605	11	42	+ 0.06	+ 0.02	75	42	+ 1.03
14	1127	4623	5	1	— 0.18	— 0.12	8	1	— 2.31
	1129	4628	3	5	+ 0.11	+ 0.10	2	5	— 0.82
	1131	4634	14	2	— 0.05	— 0.05	16	2	+ 1.87
	1138	4649	202	320	0.09	0.08	236	320	— 0.13
	1144	4652	6	1	0.16	0.11	18	1	+ 1.25
	1151	4671	8	2	0.07	0.07	9	2	2.89
	1157	4707	5	19	0.10	0.06	34	19	1.03
	1161	4736	5	13	0.03	0.03	2	13	+ 1.04
	1163	4738	5	12	— 0.02	— 0.02	12	12	— 0.03
	1168	4753	1	3	+ 0.09	+ 0.08			
	1176	4792	6	5	0.00		3	4	+ 2.79
	1189	4817	4	2	+ 0.28	+ 0.27	2	2	— 0.77
	1201	4864	1	2	+ 0.11	+ 0.11	2	2	+ 1.59
	1204	4874	5	1	— 0.03	— 0.03	5	1	1.84
	1210	4892	10	2	+ 0.11	+ 0.11	7	2	0.18
	1212	4906	10	10	0.08	0.07	24	9	+ 2.13
	1213	4909	5	2	+ 0.05	+ 0.05	5	2	— 0.30
	1214	4917	3	4	— 0.06	— 0.05	10	4	— 0.99
14	1219	4929					4	3	+ 0.43
15	1223	4956	7	3	— 0.02	— 0.02	5	3	— 0.61
	1225	4964	7	6	+ 0.11	+ 0.10	9	6	— 0.61
	1228	4995	5	1	+ 0.04	+ 0.04	6	1	+ 0.46
	1232	5006	73	57	— 0.04	— 0.04	52	57	+ 0.42
	1234	5011	3	2	+ 0.04	+ 0.03	4	2	— 0.30
	1238	5025	5	1	— 0.04	— 0.04	6	1	+ 0.52
15	1253	5092	3	6	— 0.03	— 0.03			

TABLE—Continued.

Hour.	Star's number.		No. of observat'ns for α.		Δ α T. Y. —R.	Δ α cos. δ	No. of observations for N. P. D.		Difference in N. P. D. T. Y. —R.
	Twelve-year.	Rümker.	T. Y.	R.			T. Y.	R.	
					s.	s			″
15	1258	5101	3	6	+ 0.03	+ 0.02	31	6	+ 1.75
	1264	5129	5	3	— 0.10	— 0.10	10	3	1.02
	1273	5136	3	7	+ 0.01	+ 0.01	3	7	+ 0.36
	1276	5143	7	1	— 0.17	— 0.16	16	1	— 0.47
	1277	5148	3	2	0.11	0.08	5	3	— 1.01
	1279	5150	5	2	— 0.01	— 0.01	2	2	+ 0.67
	1296	5199	4	2	+ 0.01	+ 0.01	5	2	— 2.22
	1298	5204	11	2	+ 0.10	+ 0.10	6	2	+ 5.83
	1307	5238	6	2	— 0.14	— 0.14	12	2	3.03
	1309	5245	26	14	+ 0.22	+ 0.05	80	13	1.41
	1312	5248	13	6	0.11	0.10	11	4	+ 0.07
	1311	5249	5	2	+ 0.06	+ 0.05	2	2	— 0.47
15	1318	5280	51	42	— 0.06	— 0.06	37	42	0.23
16	1334	5326	5	2	0.03	0.03	5	2	0.03
	1335	5331	5	3	0.09	0.08	5	3	— 0.06
	1338	5337	74	40	— 0.03	— 0.03	51	40	+ 0.75
	1345	5365	4	21	+ 0.12	+ 0.05	10	18	1.35
	1346	5377	12	6	— 0.05	— 0.05	14	6	+ 3.65
	1349	5400	5	2	+ 0.34	+ 0.32	5	1	— 3.54
	1350	5404	3	1	+ 0.44	+ 0.30	25	1	+ 1.36
	1358	5420	5	1	— 0.07	— 0.06			
	1362	5425	41	61	+ 0.04	+ 0.02	154	61	2.05
	1368	5428	5	3	0.16	0.16	7	3	1.93
	1369	5430	4	1	0.00		1	1	1.58
	1371	5441	8	3	0.08	0.07	11	3	3.41
	1374	5460	4	9	+ 0.10	+ 0.10	3	9	0.48
	1376	5468	5	4	— 0.06	— 0.04	1	4	+ 2.96
	1386	5485	7	1	0.09	0.09	10	1	— 2.64
	1390	5510	4	1	0.23	0.15	5	1	— 1.85
	1392	5516	6	28	— 0.04	— 0.03	8	18	+ 1.08
	1394	5529	5	3	+ 0.05	+ 0.05	3	3	3.65
	1396	5535	6	14	0.00		8	14	+ 1.05
16	1401	5546	5	2	— 0.73	— 0.31			
17	1442	5696	6	12	0.07	0.07	4	12	— 0.56
	1475	5789	5	13	0.13	0.12	6	17	+ 1.71
	1478	5804	1	1	— 0.07	— 0.06	8	1	+ 1.93
	1484	5821	5	5	+ 0.04	+ 0.04	10	5	— 0.39
	1489	5833	3	5	0.10	0.10	5	5	+ 0.94
	1496	5862	5	12	+ 0.05	+ 0.05	2	12	— 0.09
	1500	5885	5	7	— 0.06	— 0.05	6	7	+ 0.87
	1504	5905	40	113	0.05	0.03	102	105	0.44
	1511	5920	3	7	— 0.14	— 0.08	2	5	0.36
	1512	5922	3	6	+ 0.06	+ 0.03	7	2	1.70
	1514	5931	5	11	— 0.26	— 0.24	10	1	2.27
	1519	5942	5	10	+ 0.05	+ 0.05	6	8	3.59
	1518	5946	3	8	— 0.02	— 0.01	4	8	3.88
	1522	5954	5	5	0.05	0.05	5	6	0.52
	1525	5970	3	9	0.09	0.06	45	9	0.75
	1526	5975	6	24	0.08	0.08	8	24	0.05
	1527	6000	8	4	0.01	0.01	7	4	2.31
	1528	6006	3	9	0.04	0.01	4	9	+ 2.97
17	1532	6019	5	19	0.13	0.13	7	16	— 0.17
18	1537	6081	2	1	— 0.05	— 0.03	6	1	+ 0.55
	1577	6251	7	8	+ 0.07	+ 0.06	8	7	+ 0.08
	1578	6284	96	22	— 0.01	— 0.01	59	20	— 0.05
	1583	6307					10	5	— 0.71
	1587	6376	11	10	0.00		6	10	+ 3.28
	1592	6401	5	4	— 0.12	— 0.11	4	3	— 1.67
	1594	6412	1	6	+ 0.03	+ 0.03	5	6	+ 2.57
	1593	6413	3	1	0.38	0.17	35	1	0.74
	1596	6429	5	2	+ 0.10	+ 0.08	6	2	0.70
	1609	6526	3	1	— 0.07	— 0.04	29	1	1.03
	1614	6555	7	1	0.32	0.32	15	1	+ 0.67
	1626	6612	5	1	0.20	0.18	8	1	— 3.49
18	1642	6703	7	6	— 0.14	— 0.11	11	6	+ 0.53
	1643	6704					5	2	— 1.17

TABLE—Continued.

Hour.	Star's number. Twelve-year.	Star's number. Rümker.	No. of observat'ns for α. T. Y.	No. of observat'ns for α. R.	Δ α T. Y. —R.	Δ α cos. δ	No. of observations for N. P. D. T. Y.	No. of observations for N. P. D. R.	Difference in N. P. D. T. Y. —R.
					s.	s.			″
18	1645	6706					5	5	+0.55
	1648	6720	3	4	−0.26	−0.15	8	3	+0.06
	1650	6752	1	1	+0.34	+0.32			
	1655	6793	6	18	−0.02	−0.02	9	18	−0.44
	1656	6797	5	1	−0.25	−0.23	3	1	1.48
	1659	6849					2	2	0.29
	1662	6858	7	2	−0.25	−0.25	6	2	−3.79
18	1666	6867	4	5	0.01	0.01			
19	1690	7159	1	9	0.08	0.08	5	9	−1.37
	1695	7259	3	5	0.04	0.02	18	4	+0.52
	1703	7285	5	4	0.12	0.09	2	4	−2.02
	1704	7290	3	11	−0.02	−0.01	5	12	+1.63
	1708	7316	3	1	+0.04	+0.04	4	1	0.18
	1712	7330	8	9	−0.10	−0.04	62	8	0.96
	1720	7347	3	3	−0.15	−0.09	7	2	2.37
	1728	7390	5	2	+0.14	+0.13	7	2	1.85
	1729	7394	5	5	−0.01	−0.01	6	4	+0.29
	1730	7395	1	2	0.00				
	1733	7403	5	4	+0.01	+0.01	9	4	−0.50
	1734	7408	6	1	+0.14	+0.12	10	1	0.87
	1736	7424	5	1	−0.26	−0.24	5	1	−1.36
	1743	7504	5	5	−0.10	−0.10	6	5	+0.30
	1745	7549	1	15	+0.04	+0.04	2	10	0.22
	1749	7597	3	2	−0.05	−0.05	5	2	0.09
	1756	7716	3	14	0.11	0.11	7	11	0.57
	1761	7738	5	2	−0.01	−0.01	38	2	+0.34
	1762	7757	3	3	+0.03	+0.03	18	3	−1.86
19	1764	7804	3	9	−0.17	−0.17	4	7	+0.94
20	1812	8145	6	2	+0.11	+0.07	5	2	−1.17
	1817	8158	5	3	0.03	0.02	6	3	+0.67
	1829	8261	2	6	+0.25	+0.12	10	6	0.70
	1830	8393					77	7	1.12
	1846	8485	6	2	+0.39	+0.35	8	2	2.01
	1853	8525					8	1	1.62
	1873	8667	3	1	−0.08	−0.06	4	1	+0.59
	1874	8670	4	3	+0.06	+0.05	4	3	−0.71
	1878	8786	10	2	+0.20	+0.03	16	2	+0.36
	1880	8793	2	1	−0.08	−0.05	7	1	−0.40
	1882	8849	5	1	−0.19	−0.18	5	1	−2.26
	1886	8890					57	17	+0.07
20	1887	8890					31	3	−1.77
21	1888	8912	5	10	−0.05	−0.05	3	10	1.19
	1889	8919	2	2	0.08	0.05	7	2	0.11
	1891	9015	106	23	−0.09	−0.08	70	23	0.57
	1892	9033	8	9	+0.02	+0.02	7	9	0.95
	1895	9056	5	1	−0.04	−0.04	12	1	−0.41
	1894	9057	3	1	0.25	0.22	9	1	+4.51
	1902	9164	7	7	0.03	0.03	8	7	+0.10
	1907	9227	89	90	0.07	0.07	58	90	−1.26
	1922	9277	7	7	−0.08	−0.08	5	6	+0.10
	1923	9292	5	2	+0.02	+0.02	4	2	+0.17
	1926	9323	15	30	−0.15	−0.14	9	29	−0.49
	1930	9361	3	6	+0.21	+0.18	5	6	+0.73
	1934	9416	90	35	−0.07	−0.07	65	35	−0.60
	1935	9419	3	1	+0.12	+0.08	7	1	−0.57
	1940	9434	1	2	+0.19	+0.17	4	1	+0.12
	1941	9445	5	4	−0.04	−0.04	6	4	+0.34
	1942	9449	16	46	−0.01	−0.01	12	46	−0.92
	1944	9479	3	2	+0.35	+0.12	5	2	−3.48
	1947	9509	5	3	0.20	0.06	10	3	+1.77
21	1954	9586	5	1	+0.28	+0.25	2	1	−3.78
22	1974	9856	9	2	−0.03	−0.03	10	2	+0.94
	1983	9885	5	2	0.05	0.04	10	2	−0.26
	1989	9943	1	2	−0.29	−0.28	1	2	+0.02
	1990	9953	5	14	+0.14	+0.08	21	14	2.05
22	1993	10018	15	35	−0.14	−0.14	8	35	+0.27

TABLE—Continued.

Hour.	Star's number.		No. of observat'ns for α.		$\Delta\alpha$ T. Y.—R.	$\Delta\alpha\cos\delta$	No. of observations for N. P. D.		Difference in N. P. D. T. Y.—R.
	Twelve-year.	Rümker.	T. Y.	R.			T. Y.	R.	
					s.	s.			″
22	1994	10031	6	3	— 0.07	— 0.04	43	2	+ 0.64
	1999	10119	13	18	0.00		7	18	+ 0.29
	2000	10130	5	5	— 0.11	— 0.10	2	5	— 1.68
	2003	10165	3	1	— 0.13	— 0.13	4	1	1.71
	2004	10194	5	4	+ 0.03	+ 0.03	2	4	— 0.73
	2005	10201	3	2	+ 0.42	+ 0.26	5	2	+ 2.83
	2018	10284	13	18	— 0.14	— 0.14	10	18	+ 0.69
	2025	10343	3	3	0.00		7	3	— 0.75
	2028	10461	2	1	— 0.33	— 0.21	8	1	2.76
	2029	10478	3	1	+ 1.25	+ 0.38	18	1	— 0.03
	2034	10501	3	1	— 0.11	— 0.05	2	1	+ 0.18
	2035	10507	116	50	— 0.12	— 0.12	81	50	+ 0.39
	2038	10525	3	9	+ 0.04	+ 0.04	5	10	— 2 12
	2040	10548	3	9	0.07	0.06	5	8	+ 0.01
22	2046	10651	2	10	+ 0.04	+ 0.04	4	9	+ 0.50
23	2085	10898	5	5	— 0.16	— 0.11	14	5	— 0.16
	2086	10912	7	13	+ 0.01	+ 0.01	6	12	+ 0.80
	2088	10962	14	14	— 0.17	— 0.17	14	15	0.28
	2092	10999	4	2	— 0.22	— 0.22	6	2	3.03
	2098	11147	3	8	+ 0.06	+ 0.06	5	8	0.01
	2103	11199	7	4	0.01	0.01	16	4	0.15
	2115	11418	3	4	+ 0.36	+ 0.25	5	4	2.89
	2116	11429	3	1	— 0.01	— 0.01	5	1	+ 0.21
	2119	11447	78	23	0.16	0.16	58	24	— 0.03
	2121	11461	38	14	0.16	0.04	193	14	+ 1.69
	2122	11480	9	7	0.08	0.08	3	7	0.77
	2126	11569	6	3	— 0.06	— 0.03	11	3	1.00
	2138	11830	17	12	+ 0.01	+ 0.01	11	12	0.61
	2144	11889	7	2	— 0.14	— 0.14	2	2	0.27
	2149	11929	5	3	0.03	0.03	1	3	+ 2.20
23	2153	11953	7	2	— 0.12	— 0.12	2	2	— 0.05

Comparison of Right Ascensions.

The total number of observations in the Greenwich Catalogue for the above 398 stars is 4,113, and in the Hamburg Catalogue 3,852. The average number of observations upon each star is nearly 10 for each Catalogue. The average difference Δ in Right Ascension, irrespective of sign, is $0^s.10$, and when reduced to the equatorial value the average $\Delta\cos\delta$ becomes but $0^s.08$. The greatest difference noticed is $0^s.58$. The number of the positive and negative differences nearly balance.

From an extensive comparison of the Greenwich Twelve-Year Catalogue with the British Association Catalogue, by Prof. LOOMIS, in No. 71 of the *Astronomical Journal,* it appears that 203 stars were found in which the difference amounts to at least $0^s.15$ (in the average $0^s.28$), and there are 23 stars whose equatorial difference amounts to more than a quarter of a second (in maximo $0^s.72$).

Comparison of North Polar Distances.

The number of observations in the Greenwich and Hamburg Catalogues respectively are 5,900 and 3,778; or, for nearly three observations in the Twelve-Year Catalogue, we have two in Rümker's Hamburg Catalogue. The average number of observations in the latter Catalogue is nearly nine. The average difference irrespective of sign is $1''.2$, and the greatest $8''.3$. The north polar distances are in the average $0''.3$ smaller in Rümker's Catalogue; and the proportion of positive and negative differences is as 5 to 3. The comparison in No. 71 contains a table of 218 stars, whose difference in declination in the Twelve-Year and British Association Catalogues amounts to more than 1″.5 (in the average 2″.4), and the greatest 7″.3.

From the above comparison we can infer that Rümker's Catalogue compares more favorably than that of the British Association with the Twelve-Year Catalogue.

Very respectfully, yours,

CHAS. A. SCHOTT.

Capt. H. W. BENHAM,

Corps of Engineers, Assistant in charge of Coast Survey Office.

APPENDIX No. 46.

Report of Dr. B. A. Gould, Jr., assistant, on telegraphic operations for difference of longitude between Columbia, South Carolina, and Macon, Georgia.

CAMBRIDGE, MASS., *September* 21, 1855.

DEAR SIR: The telegraph operations for longitude have been extended during the past year as far as Macon, Georgia, and arrangements have been made for continuing the work to Montgomery and Mobile, and thus reaching New Orleans as speedily as is consistent with due care and precision in the operations.

In December last, in pursuance of your instruction , I reoccupied the observatory erected the preceding season in the grounds of the State House in Columbia, South Carolina, for the purpose of connecting this with Macon, Georgia; Mr. Dean taking charge of the other station, as in former years. The temporary observatory at Macon had been built in the grounds of the academy during the previous winter, although not then occupied; and the building was found in excellent order—thanks to the care of Mr. Miller, the principal of the academy, to whose courtesy Messrs. Dean and Goodfellow express themselves deeply indebted. After a sojourn of a few weeks, I returned to Washington in conformity with your suggestions, leaving the Columbia station in charge of Mr. Edward Goodfellow. The observations were carried out in conformity with the programme, although impeded by serious obstacles; and after successful exchanges of signals on three different nights, Messrs. Dean and Goodfellow interchanged stations, as had been previously arranged, and obtained exchanges on three more nights with satisfactory results. The series of astronomical observations extends from December 30 to March 16; in addition to which a series of observations were undertaken and completed by Mr. Dean at Macon, for the determination of the latitude and magnetic constants. The experience of every year aids in suggesting improvements in methods and implements of observation, and the Columbia-Macon campaign promises to furnish results of great precision.

To Messrs. Dowell and Heiss, superintendents of the line north of Macon, our acknowledgments are due for the facilities which they have uniformly been ready to afford, and their constant, unfailing courtesy.

The stars of the Nautical Almanac follow at such wide intervals as to render it most important that the gaps be filled with a considerable number of equally well determined stars. For the circumpolar list, the catalogue given by Struve in his *Expédition Chronométrique entre Altona et Pulkowa* has been made available, by reduction, to the year 1855, and very accurate positions of zenith and equatorial stars for determination of the adjustments of the instruments have been deduced from the combination of other catalogues. Still further extension is eminently desirable, and I have already taken the preliminary steps for deducing an ample catalogue of great precision, availing myself of the published results of the chief observatories of the world through a long series of years. The materials furnished by the Greenwich, Dorpat, Pulkowa, Bonn, Berlin, and Oxford observations, together with the observations of Groombridge, will, without doubt, prove amply sufficient for the purpose.

The one catalogue should contain the places of stars within 25° of the pole, culminating at intervals not exceeding ten minutes; and the other should consist of a series of stars between the declinations of 10° south and 40° north, and so selected that one, at least, should cross the meridian every five minutes. For the present, so long as the telegraphic field-operations are conducted only between the months of December and May, the latter catalogue need only include the positions of such stars as are easily observable during the winter and early spring months.

It may be well to append the circumpolar and time-star catalogues adopted for the past season.

Mean places of Circumpolar stars, 1855.0.

Star.	Mag.	α.	Ann. prec.	Pr. mot'n.	a.	b.	c.	d.	δ.	Prec.
		h. m. s.	s.	s.					° ′ ″	″
21 Cassiopeiæ . . .	6	0 36 9.11	+ 3.810	− 0.0114	9.3832	8.5826	0.5809	9.3665	74 11 39.0	+ 19.8
α Ursæ Minoris . .	2	1 6 29.54	17.954	....	....	....	....	....	88 32 11 5	19.3
50 Cassiopeiæ . . .	4	1 51 8.58	4.957	0.0132	9.2743	8.9955	0.6951	9.2516	71 42 59 0	17.8
ι Cassiopeiæ . .	4	2 17 10.65	4.824	− 0.0082	9.1448	8.9781	0.6834	9.1079	66 44 49 0	16.6
Cephei, 48 Hev. . .	6	3 2 5.76	7.266	+ 0.0303	9.3239	9.3313	0.8614	9.3115	77 11 42.0	14.2
9 Camelopardis . .	4	4 39 39.79	5.904	− 0.0047	8.7524	9.1888	0.7711	8.7535	66 5 23.0	+ 7.0
Camelop., 22 Hev. .	5.4	6 2 51.86	6.622	+ 0.0130	n 7.3901	9.2768	0.8210	n 7.3613	69 21 48.5	− 0.1
Cephei, 51 Hev. . .	5	6 31 6.87	30.688	....	....	....	....	....	87 15 10.5	2.1
P. VII, 67 . . .	6	7 15 45.22	6.326	+ 0 0150	n 8.7755	9.2407	0.8011	n 8.7449	68 45 17.0	6.4
Ursæ Majoris, 3 Hev.	6	7 58 19.46	6.086	+ 0.0053	n 8.9607	9.2071	0.7844	n 8.9305	68 53 41.5	9.7
σ² Ursæ Majoris . .	5	8 57 34.22	5.412	− 0.0066	n 9.0898	9 0993	0.7328	n 9.0562	67 43 7.5	13.9
Draconis, 1 Hev. .	4.5	9 16 1.39	9.289	0.0450	n 9.5560	9.4957	0.9680	n 9.5518	81 57 39.0	15.0
24d Ursæ Majoris . .	5.4	9 21 35 07	5.476	0.0080	n 9.1863	9.1044	0.7385	n 9.1607	70 27 50.5	15.3
32 Ursæ Majoris . .	6	10 7 26.92	4.478	0.0165	n 9.1571	8.8856	0.6510	n 9.1173	65 49 46.0	17.6
Draconis, 9 Hev. .	5.4	10 22 38.74	5.362	0.0024	n 9.4141	9.0700	0.7294	n 9.4018	76 27 27.0	18.2
λ Draconis	3.4	11 22 44.71	3.672	− 0.0065	n 9.2869	8.5026	0.5647	n 9.2602	70 7 53.5	19.7
Draconis, 4 Hev. .	5.4	12 5 20.99	2.922	+ 0.0057	n 9.5215	n 7.8869	0.4655	n 9.5125	78 25 19.0	20.0
κ Draconis	3.4	12 27 16.08	2.622	− 0.0135	n 9.2994	n 8.3762	0.4186	n 9.2739	70 35 17.5	19.9
Camelopard. 32 Hev.	5.4	12 48 7.32	0.326	0.0167	n 9.8103	n 9.1387	9 5136	n 9.8081	84 12 5.0	19.6
α Draconis	3.4	14 0 27.82	+ 1.629	− 0.0101	n 9.1363	n 8.8995	0.2119	n 9.0938	65 4 11.0	17.4
5 Ursæ Minoris . .	5.4	14 27 53.09	− 0.238	+ 0.0015	n 9.3534	n 9.2160	n 9.3771	n 9.3409	76 20 26.0	16.0
β Ursæ Minoris . .	2	14 51 10.46	0.260	− 0.0078	n 9.2695	n 9.2360	n 9 4155	n 9.2539	74 44 52.5	14.7
γ Ursæ Minoris . .	3	15 20 59.52	0.160	....	n 9.1481	n 9.2281	n 9.2114	n 9.1271	72 21 1.0	12.8
ζ Ursæ Minoris . .	4.5	15 49 20.12	2.319	+ 0.0140	n 9.2468	n 9.4400	n 0.3685	n 9.2376	78 14 18.0	10.8
15 Draconis . . .	5	16 28 17.32	0.150	0.0073	n 8.8619	n 9.2355	n 9.1769	n 8.8322	69 4 55.0	7.8
ε Ursæ Minoris . .	4.5	17 0 59.21	6.454	0 0115	n 9.1003	n 9.6807	n 0.8099	n 9.0964	82 16 7.0	5.0
ω Draconis	5	17 37 48.23	0.364	+ 0.0027	n 8.2513	n 9.2641	n 9.5605	n 8.2208	68 49 23.5	1.9
ψ¹ Draconis pr. . .	4.5	17 44 31.35	1.088	− 0.0032	n 8.1677	n 9.3382	n 0.0366	n 8.1465	72 13 12.5	− 1.3
δ Ursæ Minoris . .	4.5	18 19 6.15	− 19.465	....	....	....	....	....	86 36 0.5	+ 2.1
δ Draconis	3	19 12 30.65	+ 0.019	+ 0.0221	8.7322	n 9.2172	8 2714	8.6976	67 24 22.0	6.2
τ Draconis	5	19 18 18.70	− 1.070	− 0.270	8.8853	n 9.3341	n 0.0293	8.8662	73 5 4.5	6.7
ε Draconis	4	19 48 38.34	0.178	+ 0.0110	8.9472	n 9.2369	n 9.2468	8.9198	69 53 52.5	9.1
κ Cephei	4.5	20 13 41.38	1.867	+ 0.0037	9.2218	n 9.4023	n 0.2712	9.2111	77 16 21 5	11.1
λ Ursæ Minoris . .	5	20 8 34.47	53.887	....	....	....	....	....	88 52 38.0	11.6
Anonyma. (7299*) .	6	20 54 1.23	− 2.428	− 0.0041	9.4236	n 9.4461	n 0 3853	9.4157	80 0 21 0	13.8
β Cephei	3	21 26 46.34	+ 0.804	+ 0 0012	9.1828	n 9.0805	9.9055	9.1557	69 55 27.5	15.7
Cephei, 226 Bode .	5.6	22 29 42 60	1.091	− 0.0070	9.3900	n 9.0087	0.0377	9.3757	75 28 46.5	18.5
ι Cephei	4.3	22 44 31.64	2.126	− 0.0133	9.1810	n 8.7149	0.3275	9.1399	65 26 21.0	19.0
ο Cephei	6.5	23 12 41.57	2.415	+ 0.0195	9.2284	n 8.5506	0.3828	9.1933	67 19 9.0	19.6
γ Cephei	3.4	23 33 25.94	+ 2.411	− 0.0193	9.4630	n 8.5298	0.3821	9.4513	76 49 21.5	+ 19.9

* B. A. C.

1855.0

Time–Star Catalogue for telegraph operations, United States Coast Survey, 1855.0, *for the determination of time and azimuthal deviation.*

Star.	Mag.	α	δ	Star.	Mag.	α	δ
		h. m. s.	° ′			h. m. s.	° ′
ζ Pegasi	3½	22 34 13.80	+ 10 4.5	γ Geminorum	2.3	6 29 20.10	+ 16 31.1
λ Aquarii	4	22 45 2.76	— 8 21.0	Sirius.	1	6 38 45.62	— 16 31.3
α Fomalhaut	1.2	22 49 37.69	— 30 23.4	ε Canis Majoris	2.1	6 52 55.66	28 46.7
α Pegasi.	2	22 57 32.40	+ 14 25.6	δ Canis Majoris	2	7 2 29.81	— 26 10.0
θ Piscium	4.5	23 20 36.83	5 35.0	δ Geminorum.	3.4	7 11 27.61	+ 22 14.7
ι Piscium	4.5	23 32 29.61	4 50.4	α^2 Geminorum.	2.1	7 25 20.51	32 12.1
ω Piscium	4	23 51 52.03	6 3.6	Procyon.	1	7 31 42.51	5 35.6
α Andromedæ	2	0 0 53.97	28 17.4	β Geminorum.	1.2	7 36 26.23	28 22.3
γ Pegasi.	3.2	0 5 46.37	14 22.6	φ Geminorum.	5	7 44 37.05	+ 27 8.2
α Cassiopeiæ	Var.	0 32 18.33	+ 55 44.5	15 Argus.	3	8 1 22.16	— 23 53.3
β Ceti.	2	0 36 18.47	— 18 47.0	ε Hydræ	3.4	8 39 5.67	+ 6 56.9
ε Piscium	4	0 55 25.32	+ 7 6.5	ι Ursæ Majoris	3	8 49 15.48	48 36.4
θ′ Ceti.	3	1 16 46.53	— 8 56.0	κ Cancri	5	8 59 53.46	+ 11 14.9
η Piscium.	3½	1 23 43.80	+ 14 35.8	α Hydræ	2	9 20 27.65	— 8 1.9
ο Piscium.	4	1 37 44.49	5 25.6	θ Ursæ Majoris	3	9 23 7.99	+ 52 20.1
β Arietis.	3.2	1 46 38.17	20 5.8	ε Leonis	3	9 37 36.78	24 26.4
α Arietis.	2	1 59 0.44	22 46.5	μ Leonis	4	9 44 30.55	26 41.3
65 Ceti	4½	2 5 19.08	8 9.9	Regulus	1.2	10 0 38.72	12 40.4
γ Ceti	3.4	2 35 47.41	2 37.3	γ′ Leonis.	2	10 11 58.33	20 34.4
α Ceti	2.3	2 54 42.15	3 31.1	ρ Leonis	4	10 25 10.44	10 3.1
Arietis	4½	3 6 34.36	20 30.2	l Leonis	5	10 41 37.86	11 18.7
Persei.	2	3 13 59.52	49 20.4	α Ursæ Majoris.	2	10 54 44.60	62 32.0
δ Persei.	3	3 32 37.03	47 19.2	δ Leonis	2.3	11 6 23.47	+ 21 19.0
η Tauri	3	3 38 52.29	23 39.2	δ Hydræ	3.4	11 12 5.59	— 13 59.7
ζ Persei.	3	3 45 1.65	+ 31 26.9	τ Leonis	5	11 20 28.76	+ 3 38.9
γ′ Eridani	3	3 51 15.89	— 13 55.4	91 Leonis.	5.4	11 29 31.43	— 0 1.4
γ Tauri	4	4 11 32.76	+ 15 16.4	β Leonis	2	11 41 39.60	+ 15 22.9
ε Tauri	3½	4 20 9.26	18 51.3	γ Ursæ Majoris	2.3	11 46 11.03	54 30.1
Aldebaran.	1	4 27 36.27	16 12.8	ο Virginis	4	11 57 49.36	9 32.3
ι Aurigæ	3	4 47 33.35	32 55.9	η Virginis	3.4	12 12 29.24	+ 0 8.4
11 Orionis	5	4 56 17.20	15 11.9	β Corvi	2.3	12 26 46.56	— 22 35.7
Capella.	1	5 5 59.04	+ 45 50.7	12 Canum Venat.	3	12 49 14.23	+ 39 6.1
Rigel	1	5 7 34.23	— 8 22.4	θ Virginis	4.5	13 2 26.76	— 4 45.8
β Tauri	2	5 17 7.72	+ 28 28.8	Spica	1	13 17 33.50	10 24.2
δ Orionis	2	5 24 36.02	— 0 24.6	ζ Virginis	3.4	13 27 18.52	— 0 8.1
α Leporis.	3	5 26 20.17	17 55.8	η Ursæ Majoris.	2	13 41 49.33	+ 50 2.3
Orionis	2	5 28 51.40	1 17.9	η Bootis	3	13 47 46.80	19 7.6
Columbæ	2	5 34 24.06	— 34 9.2	Arcturus	1	14 9 2.90	19 56.4
Orionis	Var.	5 47 19.35	+ 7 22.5	θ Bootis	3.4	14 20 15.36	52 31.3
Geminorum.	3	6 14 11.27	+ 22 35.0	ε Bootis.	2.3	14 38 39.22	+ 27 41.3

The use of the line, when not required by the telegraph company, has been conceded to the Coast Survey by the Hon. Amos Kendall, president of the Washington and New Orleans Telegraph Company, as had been done by his predecessors in former years. The acknowledgments of the telegraph party are due to him, and to his colleagues in the administration of the company's affairs, Messrs. William M. Swain, of Philadelphia, and Edward J. Hyde, of New York, to whose friendly courtesy we are sincerely indebted.

The general plan of the operations will be gathered from the programme of operations, which was adhered to as rigorously as possible, and which I have the honor to enclose.

Programme of telegraph campaign, Columbia-Macon, 1854–'55.

I. The observers notify one another daily, not later than six p. m., of the state of the weather, "clear" or "cloudy." Should the weather be uncertain, they will send a message to that effect at six o'clock, and a second message of "clear" or "cloudy," not later than half-past eight.

II. Should it be clear at both stations, and the line promise to be available, the observers will prepare for work. This will consist in—

1. Having the main battery filled and set up previous to half-past nine p. m., the zincs having been previously cleaned and amalgamated in the day-time.

2. Observing at least two well-determined circumpolar stars from the MS. catalogue, with reversals of the transit instrument after the middle thread, or between the third and fourth tallies, and with careful readings of the level in each position. Stars within 5° of the pole should always be observed by eye and ear, using, however, the magnet-beats, and not the clock-ticks, to indicate the commencement of the second.

3. Observing a series of zenith or equatorial stars from the Nautical Almanac, or, if this be not possible, from the Greenwich Twelve-Year Catalogue; not less than two such stars being observed in each position of the transit instrument. The level should be read for every star, and, when practicable, without moving the instrument from the corresponding altitude. The clock time of reading the level should always be noted to the nearest minute.

III. After the operators have connected the observations and adjusted their magnets, so that the two stations receive each other's writing well, with the least possible pass, the clock of the most easterly station is put on. The observer at the other station will then strike a dot each alternate second, until the observer at the clock station signifies "aye, aye," by double dots each alternate second. The exchange of signals then begins as follows:

Reading of level.
First star.
Reversal of instrument.
Second star.
Reading of level.
Third star.
Reversal of instrument.
Fourth star.
&c., &c.

In general, it is only desirable to observe on the three middle tallies; when clouds are flying it is best to observe on as many threads as possible, as security against loss. The observer always informs the recorder of the tallies observed, and of any lost or badly-struck threads.

When ten stars have been satisfactorily exchanged, the eastern clock is taken off the circuit and the western clock put on; and the exchange of ten stars more completes the telegraph work for the night. A good determination of the instrumental corrections after the close of telegraph work, is far preferable to any increase of the number of star exchanges above twenty.

IV. The entrance of a star into the field, and the conclusion of an observation, should be intimated by a rattle, *i. e.*, a series of taps in rapid succession. It is often desirable to communicate by means of the break-circuit key without taking off the clock. The following signals will be found convenient for this purpose:

"Star lost;" a series of three or four rattles at intervals of two or three seconds.

"Your signal not received;" a series of breaks, at similar intervals.

"Aye, aye;" double dots every alternate second.

"Do you receive my signals?" double and single dots alternately, like a Morse R.

"Take off clock;" dots until complied with.

The use of these signals will be found important; and in case neither an observation nor an intimation of its loss be received when due from the other station, it will be understood that some change of connection, adjustment, or battery arrangement is requisite.

V. After the exchange of stars for the night is completed, the operators may be dismissed. Two more stars from the circumpolar catalogue are then to be observed with reversals, together with not less than two from the catalogue of time-stars. When daylight or extreme fatigue does not prevent, it is desirable to have two time-stars in each position of the instrument.

VI. When fifty stars have been satisfactorily exchanged, and on not less than three nights, the observers exchange stations, leaving the transit instruments and clocks as before; meeting, however, on one night to observe for personal equation. Fifty stars are then to be exchanged again on not less than three nights in the new position of the observers, and a new series of observations made for personal equation, which completes the series of telegraphic longitude observations. In observing for personal equation, the name of the star and its estimated (not tabular) magnitude should always be recorded.

VII. A series of transits of slow-moving stars should be taken by each observer, at each station, for the determination of the thread-intervals. This series should consist, first—of at least six transits of one of the four polar stars (α, δ and λ Ursæ Minoris and 51 Cephei), half of them observed at the upper, and half at the lower, culmination by eye and ear, with readings of the level before and after each star—the indication of the internal thermometer being also recorded; and, secondly, of an equal number of stars, between 80° and 85° declination, observed, chronographically, with the same precautions. Besides these, it will be well to strike the time, stars on all the threads whenever time and convenience permit.

A series of levellings for determining the inequality of pivots should also be made by each observer at each station as often as once in two weeks. The internal thermometer should be noted at intervals during the continuance of these levellings. The value of the level-divisions should be determined if the station be provided with the zenith telescope.

In adjusting the clock, precision of beat is of the very highest importance. After the best possible adjustment for verticality has been attained by ear, it is important to test it by measurements on the Morse fillet, (which gives the longest second-mark,) and this test should be repeated weekly during the continuance of the campaign, the result being noted in the record-book. The time-book (red) contains an approximate determination of the clock time, azimuth, and collimation, from the whole series of stars observed for instrumental correction on each night. For this purpose, it will be sufficient to estimate the tenths of seconds from the register-sheet by simple inspection, and in most cases the middle tally will be sufficient.

Whenever the error of the clock amounts to twenty seconds, or its daily rate to more than a second, or the azimuth error of the transit instrument to $0^s.3$, or the level error to more than 5″, the adjustment should be corrected.

VIII. Each station will have forty Grove's cups for the main circuit. It is very desirable to experiment during the campaign with heavy and with light batteries at each end; also with batteries of unequal strength at the two stations, if this be found feasible. But it will be found most convenient to retain the same strength of battery during the whole of one night's work, unless external circumstances demand a change.

Main batteries are not to be used on more than one night without being re-amalgamated and supplied with fresh acids. On the morning after a main battery has been used, the cups should be re-amalgamated, the old acids removed, and the cups filled with pure water, until again required for use.

The uniform rule for the direction of the current is for the zincode of the southern and the platinode of the northern station to communicate with the ground.

IX. The OPERATOR will see before telegraph work that the batteries are in proper order, and the connections good; that there is sufficient paper, not before used, on the reel; that the Morse-register is in good recording order; the clocks and signal breaks being as short as possible, consistently with distinctness of marking. The adjustment should never be changed during an observation.

When the astronomer at either station announces the appearance of the star, which he does by a rattle, the operator sets his register in motion, and marks in pencil upon the margin of the fillet the number of the star, and the station at which it is observed, as called out by the recorder. When the second rattle announces the completion of the observation, the register is stopped and wound up, and a pencil-line drawn across the fillet. Due caution will prevent the necessity of ever winding during an observation ; but should this ever happen, the place of winding should be marked by a W. The operator will also keep the fillet wound up, on the reel provided for the purpose, that it may not be soiled by falling on the floor.

At the *beginning* and *end* of each night's work—and of each fillet, should more than one be used on the same night—he will mark the date, place, and the word "Beginning" or "End," as the case may be.

The Morse register ought not to deliver less than one inch per second.

X. The RECORDER will record in ink in the "record-book" (black) all telegraphic messages received and sent ; will note the sidereal time at which the operator arrives and leaves ; and at the beginning and end of observations, as well as once an hour during their continuance, will note the barometer and thermometer readings, and the condition of the line. He will look after the chronographic register, and see that the pen is kept supplied with ink, that fresh sheets are put on when needed, and the weights wound up.

The date, place, and number of the register sheets are to be marked in ink when the sheets are put on the cylinder. The name of the star to be written in the margin opposite the observation the next day. (The chronograph should not be touched during observations.)

When a star is to enter the field at either station, he will warn the operator, and call out the number of the star, and place of observation to be inscribed on the fillet.

He will keep a record of the stars observed and received in their regular order, and of the level readings, and will keep the observers informed of the settings of the instrument, the approach of the star, and the proper times for reversal and levelling.

Telegraphic longitude observations are recorded on the chronograph in dark ink ; observations for instrumental corrections in red.

XI. Meteorological observations (white book) will be kept at all the stations, according to the standard rules prescribed for the purpose.

Accompanying this programme are the following papers :

1. Circumpolar catalogue.
2. Catalogue of time-stars.
3. Method of reduction.
4. Memoranda for care of batteries.
5. Memoranda for putting up Kessel's clock and spring governor.

(3). FOR INSTRUMENTAL CORRECTIONS AND LONGITUDE REDUCTIONS.

M.	Mean of threads.
F.	F is the mean of the thread intervals.
log. F.	
log. ρ.	ρ is the correction for rate, and its log is 0 00000 5 for a gain of 1*s*. daily, and *n* 0.00119 for a clock giving mean time.
log. σ.	σ is the sine-correction, log σ being additive to log. F. For (F sec. δ) $< 2^m$. it may be neglected.
sec. δ.	
log. R.	
R.	R = F sec. δ. σ. ρ, and is the quantity to be added to M for obtaining the time of transit over the mean of all the threads.
T = M + R.	
Levelings.	
b_o.	b_o = level correction in time, corrected for inequality of pivots, &c., (pos. for W. end high.)
a.	
δ.	
φ-δ.	

A. $A = \dfrac{\sin.\ (\varphi - \delta)}{\cos.\ \delta.}$

B. $B = \dfrac{\cos.\ (\varphi - \delta)}{\cos.\ \delta.}$

C. $C = \sec.\ \delta.$

(for A, B, C:) $180^\circ - \delta$ being used instead of δ when the star is below the pole.

$\varkappa$. $\varkappa$ is the diurnal aberration $= 0^s.021.\ \cos.\ \varphi\ \sec.\ \delta$, negative in upper, positive in lower, culmination.

$B\,b_o$.

T.

t. $t = T + B\,b_o + K.$

ω. $\omega = a - t = \triangle\,t + A\,a \pm C\,c.$

C c.

ω_o. $\omega_o = \omega \mp C\,c$ (upper sign for lamp west.)

A a.

The collimation correction c is to be obtained from reversals on circumpolar stars, and is to be obtained from the equation $t_e - t_w = \omega_w - \omega_e = 2\ C.\ c.$

A is positive except for stars between zenith and pole.

B " " " at lower culmination.

C " " " " "

For each longitude station, tables are to be formed for A, B, and K, for arugment δ; or it is better still to compute A and B for the several stars, if these are known; A^1 and B^1, for stars below the pole, are the values of A and B for declination $180^\circ - \delta$.

The local time and azimuth a are to be obtained thus: Assume an approximate value of the clock correction $= \theta$ for an arbitrary time T_o and call $\omega - \theta = \omega'$. If the collimation is known and the corresponding correction applied, we have only to reduce the values of ω_o for the several stars to the time T_o by applying the correction for rate.

$$T\omega_o = t\omega_o + \frac{t - T_o}{24h.} \times \text{daily gain.}$$

and we have, putting $\triangle\,\theta = \triangle\,t - \theta$.

$$\Sigma \triangle\,\theta + \Sigma\,A\,a = \Sigma\,\omega_o'$$
$$\Sigma\,A \triangle\,\theta + \Sigma\,A^2\,a = \Sigma\,A\,\omega_o'$$

whence we determine a, $\triangle\,\theta$, and thence $\triangle\,t$ for the time T_o.

If the collimation is not known from reversals, it will be necessary to determine it approximately from the equations of condition, which then become—

$$\Sigma \triangle\,\theta + \Sigma\,A\,a + \Sigma\,C\,c = \Sigma\,\omega'_o$$
$$\Sigma\,A \triangle\,\theta + \Sigma\,A^2\,a + \Sigma\,A\,C\,c = \Sigma\,A\,\omega'_o$$
$$\Sigma\,C \triangle\,\theta + \Sigma\,A\,C\,a + \Sigma\,C^2\,c = \Sigma\,C\,\omega'_o$$

Before forming these equations the several values must be carefully scrutinized to avoid grouping together observations between which the instrumental adjustments have changed. It is not safe to make use of these equations, unless at least one reversal has take place. The more nearly equal the number of stars observed in each position of the telescope, the more reliable will be the result.

(4.) BATTERY MEMORANDA.

The Grove's cups should be kept filled with pure water when not in use. To set up the battery, pour out the water and fill the cups with a mixture of one part sulphuric acid, and twelve or thirteen parts water. This proportion may be easily recognised by the taste, having about the acidity of sharp vinegar. The porous cups are to be filled with as much nitric acid as can be poured in without endangering the soldering of the platinums, or being liable to run over; but the least mixture of nitric acid in the outer cup will blacken the zinc.

The amalgamation of the zinc should take place on the morning after the battery has been used, the acid having been removed, if possible, immediately upon the close of telegraph operations.

It will be found convenient to use two battery tumblers—one filled with the dilute sulphuric acid of the ordinary battery strength, the other about a quarter full of mercury, and filled up as far as possible with a mixture about twice as strong. Then to amalgamate the zincs well, dip them in the first tumbler until they show an effervescence; next scrub in water with a nail-brush, and then dip them into the mercury tumbler, until the whole surface is brightly coated and all effervescence has ceased. It is desirable to provide a little drain for conducting off waste acid, so that the fumes may do no harm to any of the instruments.

The soldering of all the platinums should be examined daily, as it is so easily corroded by the fumes from the nitric acid. To guard against this corrosion, the soldering should be kept thoroughly coated with the composition provided for the purpose.

Should, by any accident, the zinc become blackened to an extent not easily remediable by this process, they may be brightened by immersion in dilute muriatic acid.

In case the battery should cease to act well during telegraph operations, the nitric acid in the porous cups is to be replenished.

The local or self-sustaining battery (Mathiot) needs only to be kept well supplied with zinc, and the jars filled with a mixture of eight parts water to one sulphuric acid. The mercury in the troughs may need replenishing from time to time. Six cups are sufficient; eight are ample.

The lids of the boxes ought to be kept open while the batteries are in action.

(5.) TO PUT UP KESSEL'S CLOCK.

1. Lift off board with pendulum fast to it, and place it in a safe horizontal position.
2. Lift out clock by straps.
3. Take off outer case of the clock.
4. Take off brass covers to machinery.
5. Unscrew two screws in bottom of clock part, and lift off clock-face and machinery.
6. Hang back of clock to pier, plumbing very carefully in two directions, and fasten by screws at bottom, adjusting by screws near point of suspension.
7. Hang on pendulum with very great care, keeping hands covered, and not permitting any lateral motion to springs near Y's. The suspension pivots of pendulum fasten on to rod by a pin.
8. Put on clock-face and machinery, passing the pin of pendulum-guide into the lower of two holes in pendulum, and unhooking the little hook which confines the counterpoise to pendulum-guide.
9. Adjust pendulum to secure uniformity of beat—first by motion of large bob, and lastly by small screw in right side of guide. Judge by ear when the beats are uniform, then test by chronograph.
10. Hook on weight and set clock in motion.
11. Adjust for rate by turning capstan-head screw in pendulum bob: (turning screw to right, shortens pendulum, and *vice versa.*)

The clocks used were, as in the previous campaign, those by Hardy and Kessel, belonging to the Coast Survey, and both adapted to the chronographic method of observation by Mr. Saxton. The Kessel's clock is an admirable piece of workmanship, and has always performed in a most satisfactory manner. It is worth mentioning that, during a period of three months in the past summer, while this clock was set up at Cloverden, the sum of its daily changes amounted to less than two sidereal seconds. The Hardy clock is a more cumbrous instrument, and its performance has not been so satisfactory. It has been, however, refitted by Mr. Saxton, and much improved since the close of the campaign. The new clock by Krille, the successor of Kessel, which you authorized me to bespeak, is now finished at Altona, and at last accounts was undergoing the tests to which Professor Peters, the director of the observatory, has kindly consented to submit it. The maker has had in its construction especial reference to facility of transportation, and has introduced a number of modifications, all tending to this end.

The spring-governor and Kerrison regulator were used for the chronographic registry of the transit observations, owing to the far greater convenience in managing their records, and in recognising the respective observations. But, during the exchange of telegraphic signals, an ordinary Morse register has also been employed at each station, and gives results well comparable in accuracy with either of the former, owing to the greater length of the seconds as recorded upon the fillet, and to the general uniformity maintained during any change of rate. The spring-governor was not in good order, and gave much trouble to the astronomers at Columbia, but has since been refitted by Messrs. Bond, the makers. It is now mounted at Cloverden, where it is in use for observations upon personal equation, and graduates the sheets with great beauty. Essential modifications have been introduced by the makers; among others, the much-needed improvement of springs for securing the sheets upon the cylinder. The vane fly-wheel has also been removed, and its place supplied by a governor not dissimilar in principle to that which regulates the motion of the Munich equatorials. Many of the disadvantages of the spring-connexion appear thus to be avoided. A careful comparison of the results by different registers, or some thorough test, will, however, be very desirable, and the most searching and trustworthy scrutiny will doubtless be obtained by making use of the suggestion of Professor Peirce, and connecting two circuit-breaking clocks with the instrument—one of these indicating mean, and the other sidereal time. To escape confusion in the record, it would be better if the clock which indicates mean time should give its signals but once in two seconds. Then the several mean-time signals would be successively registered in every part of the sidereal seconds for which the spring-governor is adapted, and any want of uniformity in the movement of the cylinder during the interval between the recorded commencements of two consecutive seconds would thus be made palpable. I hope to find opportunity, during the coming year, to subject the several chronographs to this test.

Both the stations were provided with a self-sustaining battery of six cups of Mr. Mathiot's construction, which have given entire satisfaction, except in the minor details. The variation of the current is but slight; and the battery, if put in proper order, will remain for months ready for immediate use. The material of the cups is not all that could be desired, as they are frequently warped or bent in the making, and liable to leak. But these defects are easily remedied; and I anticipate great advantages from this arrangement of the local batteries. The same main batteries have been used as in former years, though I look forward to the possible future use of magneto-electric machines as a great step in advance. Circumstances prevented the repetition of the experiments for velocity and telegraphic signals during the last winter. Should it be feasible during the ensuing season, I hope to carry out this cherished hope, and to institute experiments with different kinds of batteries, and with the magneto-electric machines.

The station at Cloverden has been continued in use during the past season, and a series of observations for latitude is now making with zenith telescope C. S. No. 5, the previous determination having resulted from measurements with No. 2. The difference of construction and of finish between the two instruments renders a determination with each quite desirable—No. 2 having been furnished by Mr. Simms, in London, while No. 5 is the work of our accomplished mechanic Mr. Würdemann, and finished in every part with much greater precision.

During the present year the reductions have advanced with great rapidity, those of the Raleigh-Columbia and the Columbia-Macon campaign having been carried along with a nearly equal rate. I am not aware that any refinement of reduction has been overlooked; and my chief anxiety is, lest it should be impossible to attain for observations in the field, a delicacy commensurate in degree with these niceties of reduction. But the chronographic method of observation, suggested and developed as it has been from the beginning by and for the Coast Survey, both as regards implements and methods of recording as well as of observing, is entitled to a thorough and unimpeded opportunity of manifesting the amount of its superiority.

I have alluded to the observations for personal equation. These have been made with care, before and after the telegraphic campaign, and at other times. The supply of materials for investigating this most curious problem is augmenting, and the observations are for the most part entirely reduced. For the deduction of inferences, a more extended study is desirable than I have been able to give to the subject during the past year, and I will therefore refrain for the present from adding anything to the conclusions which I presented in behalf of the Coast Survey to the American Association at their meeting in Cleveland.

The telegraphic connection between Columbia and Wilmington is nearly completed, and it is expected that the line will be entirely finished along the Wilmington and Manchester railroad by the first of October next. I would earnestly suggest the importance of availing ourselves of this opportunity to connect the two stations, (De Rosset and Columbia,) each of which has been already connected with Seaton through an intermediate station, and whose telegraphic connexion at present, while attended with the advantage that the line is new and constructed with more than usual care, would furnish an extraneous means not hitherto enjoyed of criticising the precision of a telegraphic connection of distant stations.

In conclusion, I would respectfully submit a few slight modifications to be introduced into the programme for the coming season, and remain, with the sincerest respect,

Most faithfully yours,

B. A. GOULD, Jr.

Prof. A. D. Bache, LL. D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 47.

Table of magnetic declinations, observed in the Coast Survey, with notes by A. D. Bache, Superintendent of the Coast Survey, and J. E. Hilgard, assistant, accompanied by a map. (*Sketch No.* 56.)

The present table of magnetic declinations is enlarged from that published in the annual report for 1854, by the addition of recent observations, and contains all the observations made during the progress of the survey from 1844 to 1855.

The localities are arranged in a natural geographical order, beginning with the northeastern part of the Atlantic coast. The latitudes and longitudes are given to the nearest tenth of a minute. Most of these stations are trigonometrical points, and may be found in the list of geographical positions published in the annual reports for 1851 and 1853.

The magnetic meridian has generally been determined with the portable declinometer of Gauss and Weber; in some instances with a variation transit or a magnetic theodolite. Observations were generally made about the time of the day maxima and minima, the mean of which is the declination given in the table. In some cases, half-hourly observations, from 6*h*. a. m. to 6*h*. p. m., were made; and, in a few instances, the observations were continued for half an hour only. All of these have been reduced to the same mean position by means of the curves of daily variation, derived from observations at the magnetic observatories at the Girard College and Toronto.

The astronomical meridian has generally been obtained from the azimuths of the triangulation, or occasionally by special observations of the Sun or Polaris.

At some of the stations where local attraction was suspected, observations have been made at different times and at different localities not far distant from each other.

Table of Magnetic Declinations.

Sect.	No. of ref.	Name of station.	Latitude.	Longitude.	Declination West.	Date of observation.	Locality, geology, and remarks.
			° ′	° ′	° ′		
I.	1	Mount Harris	44 39.9	69 08.5	14 34.6	1855, Sept. 3-6	Near the geodetic station on the Dixmont hills, Penobscot county, Me. 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	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	1854, October 26, Nov. 1	On Penobscot bay, Waldo county, Me. Gneiss. On ground of Mr. Hugier.
	4	Mount Sebattis	44 09.1	70 04.5	12 53.5	1853, July 25-27	At the foot of Mount Sebattis, town of Wales, Maine, in the meadow of Col. H. Marr. On the top of the hill the declination was found to vary from 9° to 14° in a space of fifty 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	1851, Aug. 21-25	Town of Denmark, Maine. Granite.
	6	Cape Small	43 46.7	69 50.4	12 05.5	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	1849, Oct. 6-9	Town of Falmouth, Maine, in a field of Mr. Josiah Hobbes, close to the old road. Drift, clay and gravel.
	8	Burlington	44 27.5	73 10.0	9 57.1	1855, Aug. 28	At the flag-staff on camp ground, city of Burlington, Vt. Drift, clay and sand, sixty or eighty feet deep, overlying limestone and sandstone.
	9	Bowdoin hill	43 38.8	70 16.2	11 41.1	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	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	1850, Sept. 10-12	Mouth of Saco river, extremity of south point. Metamorphic slate.
	12	Kennebunk Port	43 21.4	70 27.8	11 23.6	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	1847, Sept. 23, Oct. 2	On the summit of Mount Agamenticus, town of York, Maine. Sienite.
	14	Cape Neddock	43 11.6	70 36.1	11 09.0	1851, Aug. 29-31	Town of York, Maine, in the field of Mr. James Wyer, on the north side of Cape Neddock river, to the south of and near the road leading to the sea-shore. Granite underlying the soil.
	15	Patuccawa	43 07.2	71 11.5	10 42.8	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	1850, Aug. 28, Sept. 12	In an enclosure to the east of Mr. R. F. Gerrish's cottages. Argillaceous slate.
	17	Mount Unkonoonuc	42 59.0	71 35.0	9 04.1	1848, Oct. 6-8	The highest and most easterly summit of that name in Goffstown, 10 miles west of Manchester. Mica slate.
	18	Isles of Shoals	42 59.2	70 36.5	10 03.5	1847, Aug. 12-19	On the south side of the harbor of Hog island, 100 yards from the water. Mica slate.
	19	Plum island	42 48.0	70 48.5	10 05.6	1850, Sept. 18-20	Near Thompson's hotel, on Plum island, near Newburyport, Massachusetts. Drift, covered with sea-sand.
	20	Annisquam	42 39.4	70 40.3	11 36.7	1849, Aug. 28	Sienite.†
	21	Beacon hill	42 36.2	70 38.3	11 21.1	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	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	1849, Aug. 20	Salem, Massachusetts. Sienite.†
		" "	" "	" "	10 49.7	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	1849, Aug. 15-17	On the hill. Sienite.†
	26	Dorchester heights	42 20.0	71 02.2	9 31.4	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	1855, Aug. 24	

I.	27	Nantasket	42 18.2	70 54.0	9 37.4	1847, Sept. 1–3	Drift and alluvium, resting on argillaceous slate.
	28	Blue hill	42 12.7	71 06.5	9 13.5	1845, Sept. 28, Oct. 5	Dedham, Massachusetts. Sienite.
	29	Beacon-pole hill	41 59.7	71 26.7	9 27.0	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	1845, Sept. 9–11	Near Plymouth, Massachusetts. Drift.
	31	Copecut hill	41 43.3	71 03.3	9 08.8	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	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	1845, Aug. 15–22	Near Barnstable, Massachusetts. Drift.
		" "	" "	" "	9 40.3	1846, Aug. 28–30.	
	34	Hyannis	41 37.9	70 18.1	9 21.6	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	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	1846, Aug. 7–9	Nashua, Massachusetts; northeast of the light, near the south shore of the cove. Drift.
	37	Indian hill	41 25.7	70 40.3	8 43.9	1845, July 13, Aug. 2	Martha's Vineyard. Tertiary strata.
		" "	" "	" "	8 49.4	1846, Aug. 12–13.	
	38	Sampson's hill	41 22.7	70 28.7	8 48.7	1846, July 22–27	On Chappaquiddick island, opposite Edgartown, Martha's Vineyard. Drift.
	39	Nantucket	41 17.5	70 05.7	9 14.0	1846, July 30–31	On the north beach, near the edge of the town, due north of Mitchell's observatory. Drift.
		"	" "	" "	9 58.6	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	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	1847, Sept. 5–9	100 yards towards Beavertail light.
	42	Providence, Rhode Island	41 50.0	71 23.6	9 31.5	1855, Aug. 20	In the rear of Brown University, 198 feet from the central building. Quartz and gneiss rocks, and mica schist.
II.	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	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	1845, Aug. 20	Connecticut. Granitic gneiss.
	47	Greenport	41 06.0	72 21.0	7 14.4	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	1847, Sept. 25, Oct. 2	Near New Haven, Connecticut. Trap.
		" "	" "	" "	7 25.5	1848, Aug. 21–29.	
	50	Oyster Point	41 17.0	72 55.4	6 31.9	1848, Aug. 30, Sept. 1	Near New Haven, in the meridian of Yale College observatory. Trap.
		" "	41 16.9	72 55.5	7 02.7	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 17.3	1845, Sept. 10	Near Pavilion hotel. Sandstone, underlying drift.
		" "	" "	" "	6 37.9	1848, Aug. 10–14.	
	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	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	1844, Sept. 14	Connecticut, on Judge Isaacs' hill. Granite.
	56	Stamford	41 03.5	73 32.0	6 36.0	1844, Sept. 12	Connecticut, in the rear of the Union hotel. Granite.
	57	Saw-pits	40 59.5	73 39.4	5 58.0	1844, Sept. 11	Steamboat landing at Port Chester, Westchester county, N. York. Gneiss.
II.	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.

* 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.

† The sienite of the coast of Massachusetts is frequently traversed by dykes of trap, porphyritic trap, &c.

MAGNETIC DECLINATIONS—Continued.

Sec.	No. of ref.	Name of station.	Latitude.	Longitude.	Declination West.	Date of observation.	Locality, geology, and remarks.
			° ′	° ′	° ′		
II.	59	Lloyd's harbor	40 55.6	73 24.8	6 11.6	1844, Sept. 15	Huntington, Long island. Drift, with boulders.
	60	Oyster bay	40 52.3	73 31.3	6 50.5	1844, Sept. 16	North shore of Long island. Drift.
	61	New Rochelle	40 52.5	73 47.0	5 29.5	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	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	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	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	1846, April 30	Manhattan island. Gneiss rock, underlying the soil.
	67	Columbia college, N. Y.	40 42.7	74 00.1	6 13.1	1844, Aug. 24	City of New 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	1855, Aug. 7	New York Harbor, between Fort Columbus and Castle William, 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	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	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	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	1846, May 6	Near Brooklyn, Long Island. Drift, with small boulders of granite and trap.
	73	Cole	40 31.9	74 13.8	5 37.4	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	1844, Aug. 20–22	250 yards north of light. Greensand formation; alluvial sand.
		" "	40 27.6	73 59.9	6 11.2	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 to be at least 25 feet deep.
	75	Mount Rose	40 22.2	74 42.9	5 31.8	1852, Aug. 13–15	About five miles west of Princeton, New Jersey, in a field near the house of Mr. Thomas Hunt. Trap rock protruding through secondary red sandstone.
	76	White hill	40 08.3	74 43.6	4 25.9	1846, May 20	Near Bordentown, New Jersey, on the bank of the Delaware river. Cretaceous marl.
	77	Vanuxem	40 06.7	74 52.7	4 27.8	1846, July 10–11	At Professor Vanuxem's, two miles above Bristol, on the Delaware river, 100 yards northwest of the canal. Sand, clay, and gravel, superimposed on metamorphic rock.
	78	Girard college	39 58.4	75 09.9	3 51.1	1846, May 23	In the yard of the magnetical observatory at Girard College, Philadelphia.
		" "	" "	75 09.8	4 31.7	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, &c.
II.	79	Yard	39 58.3	75 22.9	6 42.3	1854, October 25–28	About ten miles west of Philadelphia, and 250 yards E.S.E. of the trigonometrical station.

II	80	Chew	39 48.2	75 09.7	3 45.2	1846, July 15	Near Woodbury, N. J. Marl and green sand of the cretaceous formation.
	81	Tucker's island	39 30.8	74 16.9	4 27.8	1846, November 10	Entrance to Little Egg Harbor, N. J., northwestern point of island. Alluvium and white sand.
	82	Wilmington	39 44.9	75 33.6	2 30.7	1846, May 27	Delaware. A hill 1¼ mile W.N.W. of the town hall. Trap, covered with red clay. Local attraction.
	83	Sawyer	39 42.6	75 33.8	2 48.3	1846, June 3	Three miles south of Wilmington, Delaware. At the edge of the tertiary formation, no rocks or boulders apparent.
	84	Church landing	39 40.6	75 30.4	5 49.1	1846, June 6	New Jersey; on the Delaware river. Drift. Local attraction ascertained to exist, by partial observations at three localities.
	85	Fort Delaware	39 35.3	75 33.8	3 16.8	1846, June 14	Peapatch island, Delaware river. Alluvial mud at least 70 feet deep.
	86	Hawkins	39 25.6	75 17.0	2 55.8	1846, June 20	Near Roadstown, N. J. Cretaceous formation. Some ferruginous sandstone in vicinity.
	87	Pine Mount	39 25.0	75 19.9	3 14.2	1846, June 19	An isolated hill near Greenwich, N. J. Cretaceous; unmagnetic iron ore.
	88	Bombay Hook light	39 21.8	75 30.3	3 18.5	1846, June 17	About 60 yards E.S.E. of the light-house. Alluvial clay and sand.
	89	Port Norris	39 14.6	75 01.0	3 04.4	1846, June 23	New Jersey. Cretaceous marl and sand.
	90	Egg Island light	39 10.5	75 08.0	3 03.0	1846, June 25	Delaware bay; 60 yards south by west of light-house. Cretaceous marl and sand.
	91	Town Bank	38 58.6	74 57.4	2 59.0	1846, June 30	At Price's, near Cape May. Cretaceous marl and sand.
	92	Cape May light (old)	38 55.8	74 57.6	3 05.1	1846, June 28	70 yards southeast of the light-house. Cretaceous marl and sand.
		Cape May light (new)	38 55.8	74 57.4	3 45.4	1855, August 3	About 160 yards to the westward of the light-house, near the sand dunes. Quartz sand and broken shells.
	93	Lewes landing	38 48.8	75 11.5	2 45.0	1846, July 1	Near Cape Henlopen.
	94	Pilot Town	38 47.1	75 09.2	2 42.7	1846, July 2–3	On Cape Henlopen. Clay and sand.
III	95	Osborne's Ruin	39 27.9	76 16.6	2 32.4	1845, June 19 24	Near Abingdon, Md. Talcose slate and hornblende.
	96	Susquehanna light	39 32.4	76 04.8	2 13.7	1847, July 6–7	A short distance to northwest of light-house at the mouth of Susquehanna river. Ferruginous clay and sand.
	97	Finlay	39 24.4	76 31.2	2 14.6	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	1846, April 16	
	98	Pool's island	39 17.1	76 15.5	2 29.3	1847, June 24–27	Chesapeake bay, near the dwelling of P. Wethered, on the upper island. Alluvial clay and sand.
	99	Rosanne	39 17.5	76 42.8	2 10.9	1845, June 10	On Prospect hill, 5 miles from Baltimore, north of the old Frederick road. Alluvial clay and sand.
	100	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.
	101	North Point	39 11.7	76 26.3	1 36.7	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	
	102	Bodkin light	39 08.0	76 25.2	2 01.9	1847, April 25–26	20 yards S.S.E. from light-house. Ferruginous sand and clay.
	103	Kent island (1)	39 01.8	76 18.8	2 30.2	1849, June 27, July 4	North end of Kent island, Chesapeake bay. Ferruginous sand and clay.
	104	South Base, Kent island	38 53.8	76 21.7	2 24.3	1845, June 3–4	On the west shore of Kent island, opposite Thomas' Point, 21 yards north of monument. Ferruginous sand and clay.
	105	Taylor	38 59.8	76 27.6	2 14.4	1845, May 31, June 1	On the north side of Severn river, opposite Annapolis, Maryland. Ferruginous sand and clay.
		"	" "	" "	2 18.0	1847, May 28, June 3	
	106	Marriott	38 52.4	76 36.2	2 09.4	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	1849, June 12–20	
	107	Webb's hill	39 05.3	76 40.2	2 07.9	1850, November 20–23	Anne Arundel county, Md., near the Annapolis railroad, 12 miles from Annapolis. Greensand formation, ferruginous clay and marl.
	108	Soper's hill	39 05.1	76 56.7	2 07.1	1850, July 20–26	Prince George's county, Md., 14 miles from Washington City, on the old Columbia road; property of J. B. Downs. Talcose slate.
	109	Hill's hill	38 53.9	76 52.5	2 18.6	1850, September 19–22	Prince George's county, Md., 6 miles east of Washington City. Ferruginous clay and sand.
III	110	Causten's hill	38 55.5	77 04.1	1 11.3	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.

MAGNETIC DECLINATIONS—Continued.

Sec.	No. of ref.	Name of station.	Latitude.	Longitude.	Declination West.	Date of observation.	Locality, geology, and remarks.
			° ′	° ′	° ′		
III	110	Causten's hill	38 55.5	77 04.1	1 06.2	1855, September 8, Oct. 9	At the geodetic station. 1° 10′.3 in September, and 1° 02′.0 in October, by two different instruments.
		" "	" "	" "	1 06.0	1855, October 9	Same station as in June, 1851.
	111	Washington city, D. C.	38 53.2	77 01.2	5 44.2	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.
	112	Davis	38 20.4	75 06.0	2 33.0	1853, September 25–27	On the west shore of Sinepuxent bay, east of Berlin, Md. Ferruginous clay and sand.
	113	Roslyn	37 14.4	77 23.6	0 26.5	1852, August 9–13	Near Petersburg, Va. Drift, ferruginous clay.
IV	114	Stevenson's Point	36 06.3	76 10.7	1 39.6	1847, Jan. 30, Feb. 15	Western point at the mouth of Little river, Albemarle Sound, N. C. Tertiary clay and sand.
	115	Shellbank	36 03.3	75 43.8	1 44.8	1847, March 27, April 8	On Albemarle Sound, east point of entrance into Currituck Sound. Alluvial mud, sand, and shells.
	116	Bodie's island	35 47.5	75 31.6	1 13.4	1846, December 26–28	North Carolina, near the beach, about 5 miles N.N.W. of the lighthouse. White sand.
					East.		
	117	Raleigh, N. C.	35 46.8	78 37.8	0 44.5	1854, January 7–11	Station 105 feet east and 26 feet north of centre of Capitol dome. Granitic rock underlying the soil.
	118	De Rosset	34 14.0	77 56.5	1 13.5	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.
V	119	Columbia, S. C.	34 00.0	81 02.0	3 01.7	1854, February 19–23	In the Capitol square, near the southwestern corner.
	120	Allston	33 21.7	79 12.3	2 06.5	1853, December 21–27	Near Georgetown, S. C. Alluvium.
	121	Breach inlet	32 46.3	79 48.7	2 16.5	1849, April 1–22	On Sullivan's island, Charleston entrance, S. C. White sand.
	122	East base, Edisto island	32 33.3	80 10.0	2 53.6	1850, April 2–7	Edisto island, S. C. Tertiary formation, alluvial mud, clay, and sand.
	123	Savannah	32 05.0	81 05.2	3 40.3	1852, April 26–28	On Hutchinson's island, in range of Exchange and Presbyterian Church steeples, near the second embankment from the river. Alluvium.
	124	Tybee island	32 01.5	80 50.6	3 32.1	1852, April 30, May 2	Near the mouth of Savannah river, on a sand dune near the boat-house.
VI	125	Cape Florida	25 40.4	80 09.8	4 25.2	1850, February 22–25	On the inside beach of Key Biscayne, the light-house bearing southwest. Black mud and white sand.
	126	Sand key	24 27.2	81 52.7	5 28.8	1849, August 19–21	Near Key West, Florida. A small island on the Florida reef, composed of detritus of marine shells and coral.
VII	127	Depot key	29 07.5	83 02.8	5 20.5	1852, March 14–16	Cedar Keys, Florida, on the highest point of the island. Drifted white sand on alluvial mud.
	128	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.
	129	Dog island	29 47.1	84 36.0	5 51.2	1853, April 1	Apalachicola entrance, (eastern.) White sea-sand.
	130	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, Florida. White sea-sand.
	131	Cape St. Blas	29 39.6	85 23.9	6 06.5	1854, January 31	Florida. White sea-sand.
	132	Hurricane island	30 04.4	85 40.3	6 12.2	1854, February 5	St. Andrew's bay, Florida. White sea-sand.
VIII	133	Fort Morgan	30 13.9	88 00.3	7 04.1	1847, May 21–30	400 yards northeast of the northwest bastion of Fort Morgan, Mobile Point, Alabama. Drifted white sand.

VIII	134	East Pascagoula	30 20. 7	88 31. 8	7 12. 6	1847, January 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.
		" "	" "	" "	7 08. 9	1855, January 23–25	
	135	Fort Livingston	29 16. 7	89 48. 5	7 38. 4	1853, January 9	Barataria bay, Louisiana. Alluvium, covered with drifted white sand.
	136	Atchafalaya					
	137	Isle Dernière	29 02. 0	90 54. 3	8 19. 2	1853, February 20	Caillou bay, Louisiana. Alluvium, covered with drifted white sand.
IX	138	Dollar Point	29 26. 0	94 52. 6	8 57. 4	1848, April 24–28	On Galveston bay, 10 miles northwest of Galveston, Texas. Sandy loam.
	139	East Base	29 12. 9	94 55. 4	9 05. 0	1853, March 16–21	On Galveston island, 10 miles southwest of Galveston, and half a mile from the Gulf shore. Sandy loam.
	140	Jupiter	28 54. 8	95 20. 1	9 08. 7	1853, May 10–15	Four miles southwest of Quintana, Texas, near the beach. Drifted sand.
	141	Rio Grande	25 57. 4	97 07. 6	9 00. 9	1853, November	Near the mouth on the American side. Alluvium.
X	142	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	1853, October 15	At the Plaza, near the Custom-house.
	143	San Pedro	33 46. 0	118 16. 0	13 30. 5	1853, November 24–26	On the open plain, about three miles north of San Pedro. Gravel, resting on beds of recent fossil shells.
	144	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.
	145	San Luis Obispo	35 10. 6	120 43. 5	14 16. 9	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.
	146	Point Pinos	36 38. 0	121 54. 4	14 58. 3	1851, February 6–10	Near Monterey, California. A rich soil, resting on sandstone. Beach formed of large granite boulders.
	147	San Francisco	37 47. 6	122 26. 8	15 26. 9	1852, February 18–28	Near the Presidio. Surrounding hills, limestone.
	148	Bucksport	40 46. 6	124 10. 7	17 06. 5	1853, July 19–20	On the beach; sand and marsh.
	149	Humboldt	40 44. 7	124 11. 0	17 04. 5	1854, April 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*.
XI	150	Ewing harbor	42 44. 4	124 28. 8	18 29. 7	1851, November 19–29	Near Cape Orford, Oregon. Geology very varied. South of Port Orford, coal and plumbago. North, limestone, filled with fossil shells.
	151	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.
		" "	" "	" "	20 45. 3	1851, July 14–19	On the summit of the Cape. Horizontal columnar basalt.
	152	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.
XI	153	Waddah island, Neé-ah bay	48 22. 0	124 36. 6	21 46. 9	1855, August 13–16	Near Cape Flattery, Washington Territory. Sandstone and shales of coal measures.

NOTES.

From the observations in the preceding table, it is proposed to deduce the approximate positions of lines of equal declination, or *isogonic* lines; and, by means of a graphic representation of the same, to furnish the means of obtaining readily the declination at any point near the range of the observed stations.

For this purpose, the observations are divided into three general groups or systems, for separate discussion, viz: those near the Atlantic coast; those on the shore of the Gulf of Mexico; and those on the Pacific coast.

For each of these groups a system of co-ordinates of position is selected, suited to the intended process of interpolation; the stations are then grouped in such a manner, as far as practicable, as to give the best co-ordinates for determining the co-efficients expressing the rate of change of declination.

Each group furnishes a conditional equation, expressing the difference between the mean observed declination of the group and that at the origin of co-ordinates, in terms of the co-ordinates of position, multiplied by unknown co-efficients, which are determined by the combination of a sufficient number of equations, treated by the method of least squares when their number exceeds that of the unknown values.

Previous to forming the equations, the observed declinations are reduced to the common date of January, 1850, the annual change applied being derived from observations made at some of the stations in different years.

After these preliminary statements, we proceed to the discussion of the several systems, beginning with that of the Gulf coast as the most simple.

I. MAGNETIC DECLINATION IN THE NORTHERN PART OF THE GULF OF MEXICO.

For the discussion of the stations along the Gulf coast, from Key West to the Rio Grande, the latitudes and longitudes of the stations are convenient co-ordinates of position, and well adapted to the purpose, as we have considerable changes of either co-ordinate, without much change of the other.

The observed declinations are reduced to the common date of January, 1850, by an assumed annual decrease of easterly declination of $0'.5$, or $0^\circ.008$, derived from observations made at *Pascagoula* in 1847 and 1855, in the absence of any other reliable data. The change is certainly very small, and its influence on the result quite insensible.

Without assuming any general law of distribution of magnetism, it is proposed simply to interpolate between the observations, on the supposition that the declination changes in a definite ratio with the co-ordinates, and that the rate of change is also subject to change, amounting to an interpolation by second differences, and leading to conditional equations of the second degree, which may be written thus:

$$d\,V = v + x\,d\,L + y\,d\,M + z\,d\,L\,d\,M + p\,d\,L^2 + q\,d\,M^2,$$

where $d\,V =$ the difference between the observed declination and the assumed declination V^1 at the origin of co-ordinates.

$v =$ the correction to the assumed V^1.

$d\,L$, $d\,M =$ differences of latitude and longitude from origin.

$x, y, z, p, q, =$ co-efficients to be determined.

This equation containing six unknown quantities, we form of the stations in the Gulf six groups, as shown in the subjoined table, favorably situated for the determination of the co-efficients. The mean of latitudes and longitudes is assumed as origin of co-ordinates, and the mean observed declination as that belonging to that position subject to the correction v. The solution of the conditional equations gives the following expression for the declination V, at any point having the latitude L and longitude M, within the range of observations, viz:

$$d\,L = L - 28^\circ.04\,;\; d\,M = M - 88^\circ.60.$$

$$V = 7^\circ.39 \text{ east} - 0.025\, d\,L + 0.296\, d\,M + 0.0188\, d\,L\, d\,M - 0.0094\, d\,L^2 - 0.0076\, d\,M^2.$$

All the declinations under discussion being *east*, they are treated as essentially positive quantities.

The table also exhibits the computed declinations and residuals for the stations observed, as well as for other stations not used in the discussion.

No. of group.	No. of Reference.	Station.	Latitude.	Longitude.	Declination observed.	Declination computed.	Difference. Obs. — comp.
			°	°	°	°	°
I.	126	Sand Key	24. 45	81. 88	5. 48	5. 48	. 00
II.	127	Depot Key	29. 12	83. 05	5. 36	5. 36	. 00
III.	129	Dog Island	29. 79	84. 60	5. 88	5. 88	. 00
	130	St. George's Island	29. 62	85. 02	6. 06	6. 06	. 00
	131	Cape St. Blas	29. 66	85. 40	6. 14	6. 20	— . 06
	132	Hurricane Island	30. 07	85. 67	6. 23	6. 27	— . 04
		Mean	29. 78	85. 17	6. 10		
IV.	133	Fort Morgan	30. 23	88. 00	7. 05	7. 06	— . 01
	134	East Pascagoula	30. 35	88. 53	7. 19	7. 26	— . 07
	135	Fort Livingston	29. 28	89. 91	7. 66	7. 75	— . 09
	137	Isle Dernière	29. 03	90. 91	8. 34	8. 04	+ . 30
		Mean	29. 72	89. 34	7. 56		
V.	138	Dollar Point	29. 43	94. 88	8. 95	9. 06	— . 11
	139	East Base	29. 22	94. 92	9. 11	9. 06	+ . 05
	140	Jupiter	28. 91	95. 33	9. 17	9. 12	+ . 05
		Mean	29. 19	95. 04	9. 08		
VI.	141	Rio Grande	25. 96	97. 13	9. 04	9. 04	. 00
	125	Cape Florida	25. 67	80. 16	4. 41	4. 74	— . 33
	128	St. Mark's Light	30. 07	84. 18	5. 51	5. 67	— . 16

The average of the residuals is $0^\circ.056$ or $3'.3$.

The *isogonic* lines in the Gulf of Mexico, on the map of the United States, (Sketch No. 56,) represent the result here obtained.

II. MAGNETIC DECLINATION ALONG THE ATLANTIC COAST OF THE UNITED STATES.

The stations extending along the coast in a narrow belt having a southwesterly direction, it was found most advantageous to refer their positions to an axis of abscissae, extending in the same general direction, and balancing nearly the positive and negative ordinates. This axis is a great circle passing through latitude 43° 26′, longitude 70° 24′, and latitude 29° 07′, longitude 83° 03′. The origin of co-ordinates is assumed in the middle between these two positions. The co-ordinates of position are expressed in degrees and decimals of this circle, and were graphically obtained by careful plotting on a large scale.

The observations in the general table have been reduced to January, 1850, by assuming an annual change of 5′ increase of westerly declination for all stations from No. 1 to No. 113, of 4′.5 from No. 114 to No. 117, and of 4′ from No. 118 to No. 124. A reference to the special discussion of this subject, in Appendix No. 48 of this report, will show that these values correspond, as nearly as the value of our data admits of, to the results derived from recent observations. Declination west is considered positive; declination east negative. The form of conditional equations is the same as that in the previous discussion, and may here be written:

$$V = V^1 + v + x\,X + y\,Y + z\,X\,Y + p\,X^2 + q\,Y^2.$$

In order to obtain a better determination of the co-efficients z and q than could be had from the small ordinates of these Coast Survey stations along the Atlantic coast, some of the stations in the Gulf of Mexico were also used in this discussion, and the following data obtained from the sources stated; the annual variation being an estimated approximation, by comparison of the known values at Toronto and on the Atlantic coast, viz:

Station.	Latitude.	Longitude.	Declination.	Date.	Annual change.	Declination, 1850.	Observer.
	° ′	° ′	° ′		′	° ′	
Montreal, C. W.	45 30	73 35	+ 8 58	Aug., 1842	+ 4	+ 9 28	Captain Lefroy, R. A.
Toronto, C. W.	43 39.6	79 21.5	1 36	Jan., 1850	....	1 36	Do.
Detroit, Mich.	42 24	82 58	− 2 00	1840	+ 1	− 1 50	Professor E. Loomis.
Stony Point, Lake Erie.	41 56	83 15	2 07	1848	1	2 05	U. S. topographical engineers.
West Sister Island, Lake Erie.	41 44	83 06	2 20	1847	1	2 17	U. S. topographical engineers.
East Sister Island, Lake Erie.	41 49	82 31	2 18	1847	1	2 15	U. S. topographical engineers.
Kelly's Island, Lake Erie.	41 36	82 43	2 13	1846	1	2 09	U. S. topographical engineers.
Hudson, Ohio	41 15	81 26	− 0 52	1840	3	− 0 22	Professor E. Loomis.
Pittsburg, Penn.	40 26	79 58	+ 0 33	May, 1845	3.5	+ 0 49	Dr. J. Locke.
Carrolton, Ohio.	39 38	84 09	− 4 45.4	Sept., 1845	4	− 4 27	Do.
Richmond, Ind.	39 49	84 47	4 52	Sept., 1845	4	4 34	Do.
Oxford, Ohio	39 30	84 38	4 50	Aug., 1845	4	4 32	Do.
Cincinnati, Ohio	39 06	84 22	− 4 04	April 1845	+ 4	− 3 46	Do.

The stations were arranged in thirty-one groups, as shown in the subjoined table; some stations, where a local error was apparent, being omitted. The conditional equations were satisfied, as nearly as possible, by combining them according to the method of least squares, and the following numerical equation was obtained:

$$V = 0^\circ.44 \text{ west} + 0.945\,X + 0.513\,Y + 0.0211\,X\,Y + 0.0344\,X^2 - 0.0177\,Y^2.$$

On plotting the line of 5° east, according to this expression, it was found that it coincided very nearly in direction with the same line derived from the Gulf of Mexico system, and that it differed only 0°.16, or 10′, in position. An examination of the expression and residuals showed that a change of − 0.0022 in the co-efficient of X^2 would produce an entire agreement of the two systems at this point, while, on the whole, the residuals would be improved, the more reliable observations being benefited by this minute change.

The *isogonic* lines on the map, from 14° west to 5° east, are therefore computed according to the following expression:

$$V = 0^\circ.44 \text{ west} + 0.945\,X + 0.513\,Y + 0.0211\,X\,Y + 0.0322\,X^2 - 0.0177\,Y^2;$$

and the corresponding residuals of the groups are given in the subjoined table.

No. of group.	Designation.	X.	Y.	V observed.	V computed.	Difference, comp. —obs.
		°	°	°	°	°
1	Sebattis	+ 9.36	— 0.02	+ 12.29	+ 12.10	— .19
2	Montreal	8.96	— 3.07	9.45	9.18	— .27
3	Agamenticus	8.38	+ 0.01	10.47	10.63	+ .16
4	Burlington	8.33	— 2.19	9.52	8.96	— .56
5	Boston	7.62	+ 0.37	9.74	9.76	+ .02
6	Vineyard	7.26	1.23	9.56	9.80	+ .24
7	Spencer	6.93	+ 0.55	9.26	8.90	— .36
8	Albany	6.64	— 1.43	7.58	7.16	— .42
9	Connecticut	5.98	+ 0.08	7.18	7.29	+ .11
10	New York	5.09	— 0.38	6.20	5.85	— .35
11	Toronto	5.07	5.38	1.60	2.21	+ .61
12	Philadelphia	3.64	— 0.60	3.85	3.95	.10
13	Cape May	3.17	+ 0.03	3.33	3.78	.45
14	Head of Chesapeake	2.75	— 1.06	+ 2.58	+ 2.65	+ .07
15	Detroit	2.55	6.90	— 1.69	— 1.69	.00
16	Washington	2.34	1.07	+ 2.30	+ 2.14	— .16
17	Hudson	2.20	5.36	— 0.38	— 0.83	.45
18	Pittsburg	2.13	— 3.96	+ 0.82	+ 0.12	.70
19	Albemarle	+ 0.30	+ 1.20	+ 1.76	+ 1.33	— .43
20	Ohio	— 0.53	— 6.43	— 4.33	— 4.01	+ .32
21	Wilmington and Raleigh	1.76	+ 0.27	1.26	1.00	.26
22	Georgetown, S. C.	3.40	+ 0.47	2.36	2.20	.16
23	Columbia	3.74	— 1.18	3.30	3.18	+ .12
24	Charleston	4.35	+ 0.30	2.57	2.94	— .37
25	Savannah	5.32	+ 0.04	3.75	3.66	+ .09
26	Cedar Keys	8.76	0.00	5.36	5.36	.00
27	Apalachicola	9.15	— 1.91	6.08	6.19	— .11
28	Cape Florida	10.31	+ 4.02	4.41	4.96	.55
29	Mobile Point	10.31	— 4.33	7.18	7.48	.30
30	Key West	12.17	+ 3.35	5.48	5.53	.05
31	Isle Dernière	— 12.17	— 5.55	— 7.92	— 8.14	— .22

The mean residual is ± 16′.

III. MAGNETIC DECLINATION ON THE PACIFIC COAST OF THE UNITED STATES.

The stations along this coast are referred to an axis of abscissae graphically assumed on the map, and so situated as to give nearly balanced positive and negative ordinates.

In the absence of any data for obtaining the annual change, the result of the discussion may be assumed to correspond to the mean date of 1852.

Owing to the smallness of the ordinates, we cannot expect to obtain any determination of the rate of change of their co-efficients, and the conditional equation used in the discussion is simply the following:

$$V = 16°.30 \text{ east} + v + x\,X + y\,Y + p\,X^2.$$

Forming eight conditional equations and combining them by the method of least squares, so as to obtain the values of the unknown quantities, we find—

$$V = 16°.88 \text{ east} + 0.534\,Y + 0.104\,X + 0.0022\,X^2;$$

according to which the residuals in the tables and the lines on the map are computed.

No. of group.	Stations.	X.	Y.	V East observed.	V East computed.	Residual, comp. —obs.
		°	°	°	°	°
1	Neé-ah bay	+ 8.31	+ 1.10	21.64	21.58	— .06
2	Cape Disappointment	6.21	+ 0.66	20.54	20.35	.19
3	Ewing harbor	3.00	— 0.84	18.48	18.41	— .07
4	Bucksport and Humboldt	+ 1.10	1.41	17.08	17.32	+ .24
5	San Francisco	— 2.10	1.27	15.45	15.63	.18
6	Point Pinos	3.32	1.26	14.96	15.00	+ .04
7	San Luis Obispo	5.00	0.85	14.29	14.18	— .11
8	Point Conception	5.77	— 0.90	13.82	13.78	.04
9	San Pedro	7.00	+ 0.57	13.55	13.30	— .25
10	San Diego	— 8.31	+ 1.07	12.52	12.70	+ .18

The average residual is ± 8′.

From the chart accompanying this paper the magnetic declination at any point near the range of the observed stations may be found readily by graphic interpolation. As additional material is obtained, it will be from time to time extended and corrected.

APPENDIX No. 48.

Report to the Superintendent of the U. S. Coast Survey of a discussion of the secular variation in the magnetic declination on the Atlantic and part of the Gulf Coast of the United States; by Charles A. Schott, chief of Computing Division U. S. Coast Survey office. (*Sketch No.* 51.)

[Communicated to the American Association for the Advancement of Science, by authority of the Treasury Department.]

DEAR SIR: This investigation was undertaken with a view of deducing the reduction to the same epoch of any of the Coast Survey observations for magnetic declination, and also with a view of predicting or calculating the declination for positions occupied prior to the present time, as well as to restore from present observations the declination at some earlier date.

The extensive use of the compass in the surveys of public lands, renders a knowledge of the law of change in the direction of the needle during this and the latter half of the last century an object of great importance, the aid of which law is not unfrequently called upon in legal proceedings. Though an investigation of the observations taken during the last decennium would have furnished approximate results for the immediate purposes of the survey, yet it is apparent that no general law could be deduced in this way, and it became necessary at once to include all available material from the earliest time to the present. The discussion is based upon one hundred and eighty observations taken at stations distributed over the Atlantic coast and the eastern part of the Gulf coast.

In reference to terrestrial magnetism in general, Prof. Hansteen has lately published his investigations on the secular variation of the magnetic inclination, in the Astronomische Nachrichten, Nos. 947, 948, and 954. (See for a short abstract Comptes Rendus, t. xl, No. 15). The appearance of this paper, and the necessity of the reduction of our observations for declination, published in the Superintendent's annual report of 1854, gave a new impulse to this and similar investigations.

Beyond the fact of the nearly stationary condition of the direction of the needle about the commencement of this century in the northeastern States, and the observed increase of westerly declination in opposition to the former decrease of the same in the New England States, little was known in reference to the law of the secular change, either as to the precise epoch, or as to the geographical relation. It is to Dr. Bowditch and Prof. Loomis that we are mostly indebted on this subject; to the former for having called attention to the phenomenon at the time when the change from the direct to the retrograde motion took place; to the latter for a large collection of valuable observations of magnetic declinations in the United States, and also for two charts of isogonic lines for the years 1838 and 1840. Prof. Loomis states that all the observations indicate a retrograde motion of the needle, which commenced as early as 1819, and in some places, perhaps, as early as 1793. The present (1840) annual change of the variation is about two minutes for the southern States, four for the middle, and six for the New England States. (See Silliman's Journal of Science and Arts, vol. xxxix, 1840).

In the following discussion I have used nearly all the data I was able to collect; yet there can be no doubt that much valuable information might be obtained from the surveyors of public lands, as their results generally are derived from a number of observations at different places, and for this reason are more likely to be free from any local deviation, the effects of which are more to be guarded against than errors of observation. Results obtained by the ordinary surveyor's compass thus show, at the stations Providence, Hatboro', and others, the best agreement. In order to obtain reliable results for the secular change, it is essential that the observations should be made at the same spot; but this is seldom the case, and to this circumstance differences, amounting in some instances to half a degree and more, must be attributed.

The observations at stations mentioned in the following pages have been discussed in three different ways, depending on the dates of their commencement and termination. Those prior to the middle of the eighteenth century require, as will be seen in the discussion, a function involving an additional term in the expression for the declination; to this class belong the stations Providence, R. I., Hatboro', Pa., and Philadelphia. Others reaching as far back as these are too discordant for use. Observations taken on ship-board are unreliable on account of local attraction, and hence have not been employed in the discussion. The second class includes observations made subsequent to the middle of the eighteenth century at the three stations, and at seven others prior to that time, and reaching to the present. The third class includes all stations having two or more observations of comparatively recent date, and these, it may be remarked, are less important for deducing the secular change than for the construction of the isogonic lines.

Throughout the discussion westerly declination has been considered as positive, and easterly as negative. The formulæ used being the same for all stations, require but once to be explained, and are given in full in the discussion of the first station of the first and second class. All observations have been scrutinized, and the references are affixed to the results. The separate heads into which the subject divides itself are as follows:

a. Discussion of the secular change at stations, with reliable observations dating prior to about the year 1740.

b. Discussion of the secular change at stations, with reliable observations dating after that time.

c. Statement of results from comparatively recent observations.

d. Establishment of formulæ expressing the secular variation of the magnetic declination at any place within the limits indicated on the title-page of this paper. Synopsis of results and general remarks.

We commence with the discussion of the observations comprised under the head *a*.

a. Discussion of the secular variation of the magnetic declination from the oldest reliable set of observations, viz: those recorded at Providence, Rhode Island; Hatboro', Pennsylvania; and at Philadelphia. The first-named set includes thirty observations, made between 1717 and 1845; the second, commencing with the year 1680, presents eighteen observations, made at equal intervals, terminating with the year 1850; the third contains ten observations, recorded between the years 1701 and 1847.

I. DISCUSSION OF THE SECULAR CHANGE AT PROVIDENCE, RHODE ISLAND.

This is a very important station, both in regard to the number and to the agreement of the observations. In volume xliv of Silliman's Journal of Science and Arts, 1843, a series of observations have been published under the title, "The variation of the magnetic needle at Providence, Rhode Island, from A. D. 1717 to 1843, by M. B. Lockwood, C. E., from actual observations on record, and recorded bearings of a number of objects."

Providence is in lat. 41° 49′ N., and long. 71° 24′ W.

Declination in 1717, 9° 36′ W.—R. Jackson, on a map of Providence.

1720,	9	28	
1725,	9	14	
1730,	8	54	
1735,	8	39	
1740,	8	15	
1745,	7	59	
1750,	7	40	
1755,	7	21	
1760,	6	57	
1765,	6	43	
1769,	6	30	Dr. West. (See vol. xxxiv, 1838.)
1775,	6	20	
1780,	6	16	
1785,	6	13	
1790,	6	10	
1795,	6	10	
1800,	6	15	
1805,	6	19	
1810,	6	24	
1815,	6	30	By M. Brown, B. Lockwood, and G. Sheldon.
1819,	6	37	
1825,	6	51	
1830,	7	10	
1835,	7	34	Since this time the observations are made with more care.
1840,	8	25	
1841,	8	31	
1842,	8	39	
1843,	8	46	
1844. 8,	9	15	W.—U. S. Coast Survey. This is deduced from observations at three surrounding stations, namely: Beaconpole, Copecut, and Spencer. (See annual report of the Superintendent, for 1854.)

The great number of observations would render the computation unnecessarily laborious; it has therefore been shortened by taking means as indicated, converting, at the same time, the minutes into parts of degrees.

Year.	Declination.		Means.	Mean of column 2 & 4.
		°	°	°
1717		9.60		9.60
1720	9.47			9.47
1725		9.23		
1730	8.90		8.94	8.92
1735		8.65		
1740	8.25		8.31	8.28
1745		7.98		
1750	7.67		7.67	7.67
1755		7.35		
1760	6.95		7.03	6.99
1765		6.72		
1769	6.50 — 0.04		6.52	6.49
1775		6.33		
1780	6.27		6.27	6.27
1785		6.22		
1790	6.17		6.20	6.18
1795		6.17		
1800	6.25		6.24	6.25
1805		6.32		
1810	6.40		6.41	6.40
1815		6.50		
1819	6.62 + 0.03		6.67	6.66
1825		6.85		
1830	7.17		7.21	7.19
1835		7.57		
1840	8.42			8.42
1841		8.52		
1842		8.65	8.65	8.65
1843		8.77		
1844.8	9.25			9.25

We have therefore the following sixteen values:

	°		°
1717	D = + 9.60	1790	D = + 6.18
1720	9.47	1800	6.25
1730	8.92	1810	6.40
1740	8.28	1820	6.66
1750	7.67	1830	7.19
1760	6.99	1840	8.42
1770	6.49	1842	8.65
1780	6.27	1844.8	9.25

The magnetic declination D at the time t may be expressed by the following series:

$$D = d_o + y\,(t - t_o) + z\,(t - t_o)^2 + u\,(t - t_o)^3 + \ldots\ldots$$

where

$y\ z\ u$ .... are unknown co-efficients, and D becomes d_o when t equals t_o. Putting $d_o = d_1 + x$ where x is a small correction to the assumed value d_1, and omitting the fourth and higher powers of the time, the above equation becomes—

$$D = d_1 + x + y\,(t - t_o) + z\,(t - t_o)^2 + u\,(t - t_o)^3$$

If we assume for t_o the commencement of any year, and for d_1 the supposed corresponding declination (expressed in degrees and decimals), then each observed value for D at the time t furnishes an equation of the form—

$$0 = d_1 - D + x + y\,(t - t_o) + z\,(t - t_o)^2 + u\,(t - t_o)^3$$

and known as a conditional equation. By application of the method of least squares, we form the normal equations, and obtain the co-efficients $x\ y\ z\ u$.

The above formula is capable of giving two maxima and two minima, whereas the omission of the third power would give but a minimum; and this, as we know from observation, took place about the commencement of this century. The omission of the term involving the third power constitutes the difference of the classification a and b.

The year 1830 has been assumed throughout the discussions for the arbitrary value t_o for a reason which will appear in the comparison of the results at different stations. Assuming $d_1 = + 7.20$; for $t_o = 1830$, we form the conditional equations—

$$\begin{aligned}
0 &= -2.40 + x - 113\ y + 12769\ z - 1442897\ u \\
0 &= -2.27 + x - 110\ y + 12100\ z - 1331000\ u \\
0 &= -1.72 + x - 100\ y + 10000\ z - 1000000\ u \\
0 &= -1.08 + x - 90\ y + 8100\ z - 729000\ u \\
0 &= -0.47 + x - 80\ y + 6400\ z - 512000\ u \\
0 &= +0.21 + x - 70\ y + 4900\ z - 343000\ u \\
0 &= +0.71 + x - 60\ y + 3600\ z - 216000\ u \\
0 &= +0.93 + x - 50\ y + 2500\ z - 125000\ u \\
0 &= +1.02 + x - 40\ y + 1600\ z - 64000\ u \\
0 &= +0.95 + x - 30\ y + 900\ z - 27000\ u \\
0 &= +0.80 + x - 20\ y + 400\ z - 8000\ u \\
0 &= +0.54 + x - 10\ y + 100\ z - 1000\ u \\
0 &= +0.01 + x \\
0 &= -1.22 + x + 10\ y + 100\ z + 1000\ u \\
0 &= -1.45 + x + 12\ y + 144\ z + 1728\ u \\
0 &= -2.05 + x + 14.8\ y + 219\ z + 3242\ u
\end{aligned}$$

Multiplying each equation by the co-efficient of the first unknown quantity, and adding up, will produce the first of the normal equations, and the same operation performed for each unknown quantity will give the other normal equations—

$$
\begin{aligned}
0 &= -\ 7.49 + 16\,x - 736.2\,y + 63832\,z - 5792927\,u \\
0 &= +\ 573.26 - 736.2\,x + 63832\,y - 5792927\,z + 562891700\,u \\
0 &= -\ 79077 + 63832\,x - 5792927\,y + 562891700\,z - 56610893300\,u \\
0 &= +\ 8782402 - 5792927\,x + 562891700\,y - 56610893300\,z + 5831932000000\,u
\end{aligned}
$$

To facilitate the reduction we can assume

$$
\begin{aligned}
x &= X \\
y &= Y : 10^2 \\
z &= Z : 10^4 \\
u &= U : 10^6
\end{aligned}
$$

and dividing the first equation by 10^0, the second by 10^2, the third by 10^4, and the fourth by 10^6, we get the modified normal equations—

$$
\begin{aligned}
0 &= -\ 7.4900 + 16.0000\,X - 7.3620\,Y + 6.3832\,Z - 5.7929\,U \\
0 &= +\ 5.7326 - 7.3620\,X + 6.3832\,Y - 5.7929\,Z + 5.6289\,U \\
0 &= -\ 7.9077 + 6.3832\,X - 5.7929\,Y + 5.6289\,Z - 5.6611\,U \\
0 &= +\ 8.7824 - 5.7929\,X + 5.6289\,Y - 5.6611\,Z - 5.8319\,U
\end{aligned}
$$

Their solution gives—

$$
\begin{aligned}
X &= +\ 0.239 & \text{hence } x &= +\ 0.239 \\
Y &= +\ 8.543 & y &= +\ 0.08543 \\
Z &= +\ 15.055 & z &= +\ 0.0015055 \\
U &= +\ 5.100 & u &= +\ 0.000005100
\end{aligned}
$$

and the formula for the declination becomes—

$$D = +\ 7^\circ.439 + 0.08543\,(t - 1830) + 0.0015055\,(t - 1830)^2 + 0.000005100\,(t - 1830)^3$$

The observations at this, as well as the other stations, have been represented graphically, the abscissae representing time, and the ordinates the declination. On diagram No. 1 (Plate No. 51) the observations are shown by a heavy curve; the computed declinations by a finer line.

The above formula represents the observations, as follows:

t.	D obs'd.	D comp'd.	Δ	Δ²
	°	°	°	
1717	+ 9.60	+ 9.64	+ 0.04	0.0016
1720	9.47	9.46	— 0.01	0.0001
1720	8.92	8.85	0.07	0.0049
1740	8.28	8.22	— 0.05	0.0025
1750	7.67	7.62	+ 0.05	0.0025
1760	6.99	7.08	0.09	0.0081
1770	6.49	6.63	0.14	0.0196
1780	6.27	6.29	+ 0.02	0.0004
1790	6.18	6.10	— 0.08	0.0064
1800	6.25	6.09	0.16	0.0256
1810	6.40	6.29	— 0.11	0.0121
1820	6.66	6.73	+ 0.07	0.0049
1830	7.19	7.44	0.25	0.0625
1840	8.42	8.45	0.03	0.0009
1842	8.65	8.69	+ 0.04	0.0016
1844.8	+ 9.25	+ 9.05	— 0.20	0.0400

This agreement is as close as can be expected.

Let ε_0 be the probable error of a single observation, n the number of observations, Δ the difference of observed and computed values, then

$$\varepsilon_0 = 0.674\sqrt{\frac{\Sigma\,\Delta^2}{n-4}} = \pm\ 0^\circ.085 = \pm\ 5'.1$$

Differentiating the equation,

$$D = d_o + y\,(t - t_o) + z\,(t - t_o)^2 + u\,(t - t_o)^3 \text{ we obtain}$$

$$\frac{d\,D}{d\,t} = y + 2\,z\,(t - t_o) + 3\,u\,(t - t_o)^2$$

Hence the condition for a maximum and minimum—

$$o = y + 2\,z\,(t - t_o) + 3\,u\,(t - t_o)^2$$

Changing t into T, and T^1 for the time of the minimum and maximum, we find—

$$T = t_o - \frac{z}{3\,u} + \sqrt{\left(\frac{z}{3\,u}\right)^2 - \frac{y}{3\,u}} \text{ and } T^1 = t_o - \frac{z}{3\,u} - \sqrt{\left(\frac{z}{3\,u}\right)^2 - \frac{y}{3\,u}}$$

and substituting the numerical quantities—

$$T = 1795.6 \text{ and } T^1 = 1667.7$$

the point of inflection, or the time of maximum annual variation, will be found by putting the second differential co-efficient zero

$$\frac{d^2\,D}{d\,t^2} = 2\,z + 6\,u\,(t - t_o) = 0$$

Changing t into T'' for the time of maximum annual change, we have—

$$T'' = t_o - \frac{z}{3\,u} = 1731.6$$

The maximum declination δ becomes known by substituting T' for t in the formula for D:

Maximum declination..................	$\delta = +$	$11^\circ.45$
Minimum declination..................	$d = +$	$6\ .07$
Range.....................................		$5\ .38$

The first differential co-efficient gives the formula for the annual variation v:

$$v = y + 2\,z\,(t - t_o) + 3\,u\,(t - t_o)^2$$

$$v = 0^\circ.08543 + 0.003011\,(t - 1830) + 0.00001530\,(t - 1830)^2$$

Substituting T'' for t, we find the maximum annual change $V = 0^\circ.063 = 3'.8$.

We have next to find the probable errors of the quantities $x\ y\ z\ u$ T T' T'', etc.

For the first quantity the weight equations become—

$$0 = -1 + 16\,Q_{\prime} - 736.2\,q_{\prime\prime} + 63832\,q_{\prime\prime\prime} - 5792927\,q_{iv}$$

$$0 = 0 - 736.2\,Q_{\prime} + 63832\,q_{\prime\prime} - 5792927\,q_{\prime\prime\prime} + 562871700\,q_{iv}$$

$$0 = 0 + 63832\,Q_{\prime} - 5792927\,q_{\prime\prime} + 562891700\,q_{\prime\prime\prime} - 56610893300\,q_{iv}$$

$$0 = 0 - 5792927\,Q_{\prime} + 562891700\,q_{\prime\prime} - 56610893300\,q_{\prime\prime\prime} + 5831932000000\,q_{iv}$$

Their solution gives $Q_1 = +\ 0.170$; and similar sets of equations furnish—

$$Q_2 = +\ 0.00055$$

$$Q_3 = +\ 0.00000046$$

$$Q_4 = +\ 0.000000000027$$

These weight-equations may be modified in a similar manner as the normal equations. The quantities $Q_1\ Q_2\ Q_3\ Q_4$ are necessarily positive.

ε expresses generally a probable error, and its index indicates to which quantity this probable error refers. We have—

$$\varepsilon_x = \varepsilon_o\,\sqrt{Q_1} = \pm\ 0.035$$

$$\varepsilon_y = \varepsilon_o\,\sqrt{Q_2} = \pm\ 0.00199$$

$$\varepsilon_z = \varepsilon_o\,\sqrt{Q_3} = \pm\ 0.0000575$$

$$\varepsilon_u = \varepsilon_o\,\sqrt{Q_4} = \pm\ 0.000000441$$

To find the probable error of T T' T'', we differentiate the expression for T T' T'' in regard to the variables $x\ y\ z\ u$.

$$d\,T = -\frac{1}{6\,u\,A}\,d\,y - \left(\frac{1}{3\,u} - \frac{2\,z}{18\,u^2\,A}\right)d\,z + \left(\frac{z}{3\,u^2} + \frac{\frac{2\,z^2}{9\,u^3} - \frac{y}{3\,u^2}}{2\quad A}\right)d\,u$$

$$d\,T' = + \frac{1}{6\,u\,A}\,d\,y - \left(\frac{1}{3\,u} + \frac{2\,z}{18\,u^2\,A}\right) d\,z + \left(\frac{z}{3\,u^2} - \frac{\frac{2\,z^2}{9\,u^3} - \frac{y}{3\,u^2}}{2\,A}\right) d\,u$$

$$d\,T'' = - \frac{1}{3\,u}\,d\,z + \frac{z}{3\,u^2}\,d\,u\text{; in which expressions } A = \sqrt{\left(\frac{z}{3\,u}\right)^2 - \frac{y}{3\,u}}$$

For the above equations we can substitute—

$$d\,T = l_1\ d\,y + l_2\ d\,z + l_3\ d\,u$$
$$d\,T' = l'_1\ d\,y + l'_2\ d\,z + l'_3\ d\,u$$
$$d\,T'' = l''_2\,d\,z + l''_3\,d\,u$$

Hence,

$$\varepsilon\,T = \sqrt{l_1\,l_1\,\varepsilon_y\,\varepsilon_y + l_2\,l_2\,\varepsilon_z\,\varepsilon_z + l_3\,l_3\,\varepsilon_u\,\varepsilon_u} = \pm\ 6.1 \text{ years.}$$
$$\varepsilon\,T' = \sqrt{l'_1\,l'_1\,\varepsilon_y\,\varepsilon_y + l'_2\,l'_2\,\varepsilon_z\,\varepsilon_z + l'_3\,l'_3\,\varepsilon_u\,\varepsilon_u} = \pm\ 9.6 \text{ years.}$$
$$\varepsilon T'' = \sqrt{l''_2\,l''_2\,\varepsilon_z\,\varepsilon_z + l''_3\,l''_3\,\varepsilon_u\,\varepsilon_u} = \pm\ 9.3 \text{ years.}$$

The differential equation,

$$d\,v = d\,y + 2\,(t - t_o)\,d\,z + 3\,(t - t_o)^2\,d\,u,$$

gives the value for

$$\varepsilon_v = \sqrt{\varepsilon_y^2 + 4\,(t - t_o)^2\,\varepsilon_z^2 + 9\,(t - t_o)^4\,\varepsilon_u^2},$$

Substituting $t_o = 1830$ and T″ for t, we find

$$^{\varepsilon}V = \pm\ 0^{\circ}.\ 017 = \pm\ 1'.0$$

Finally, we have,

$$\varepsilon\,D = \sqrt{\varepsilon_x^2 + (t - t_o)^2\,\varepsilon_y^2 + (t - t_o)^4\,\varepsilon_z^2 + (t - t_o)^6\,\varepsilon_u^2}.$$

For the other stations the results merely will be given, the formulæ used being the same.

II. DISCUSSION OF THE SECULAR CHANGE AT HATBORO', PA.

The results for declinations of this excellent set were communicated to Prof. A. D. Bache, Superintendent Coast Survey, by Mr. E. W. Beans, in a letter dated Hatboro', March 1, 1852. This place is about ten miles north of Philadelphia, in latitude 40° 07′ N., longitude 75° 08′ W. Mr. Beans expresses his entire confidence in the accuracy of the data collected, and their agreement sufficiently proves this fact.

The observations are as follows :

Declination in 1680	8°	28′ west.	Declination in 1770	2°	55′ west.
1690	8	15	1780	2	05
1700	7	55	1790	1	50
1710	7	28	1800	1	55
1720	7	00	1810	2	00
1730	6	25	1820	2	27
1740	5	35	1830	3	00
1750	4	55	1840	3	50
1760	4	00	1850	4	25

Assuming $d_1 = 3.00$ for $t_o = 1830$, and proceeding as before, we find—

$$D = + 2^{\circ}.683 + 0.07211\,(t - 1830) + 0.0017489\,(t - 1830)^2 + 0.000006753\,(t - 1830)^3$$

The following table shows the observed and computed declinations and their differences:

t.	D obs'd.	D comp'd.	Δ
	°	°	°
1680	+ 8.47	+ 8.44	− 0.03
1690	8.25	8.35	+ 0.10
1700	7.92	8.04	0.12
1710	7.47	7.57	+ 0.10
1720	7.00	6.97	− 0.03
1730	6.42	6.21	0.21
1740	5.58	5.44	0.14
1750	4.92	4.66	0.26
1760	4.00	3.89	− 0.11
1770	2.92	3.20	+ 0.28
1780	2.08	2.61	0.53
1790	1.83	2.17	+ 0.34
1800	1.92	1.91	− 0.01
1810	2.00	1.89	0.11
1820	2.45	2.12	0.33
1830	3.00	2.68	0.32
1840	3.83	3.58	− 0.25
1850	+ 4.42	+ 4.86	+ 0.24

For the observed and computed values, see diagram No. 2, Plate 51. The results of the other expressions will be found in the synopsis after the discussion of the station Philadelphia.

III. DISCUSSION OF THE SECULAR CHANGE AT PHILADELPHIA, PA.

The latest observations having been made at Girard College, and no particular locality being assigned to the old observations, we may assume for them the position latitude 39° 58′ N., and longitude 75° 10′ W. In volume xxiii of Silliman's Journal, 1833, Mr. Gillet gives the following observations at Philadelphia:

In 1701	the declination was	8°	30′	west by	Mr. Scull.
1793	"	1	30	"	Mr. Brooks.
1802	"	1	30	"	Mr. Howell.
1804	"	2	00	"	several men of science.
1813	"	2	27	"	Mr. Whitney.

In 1770 Cook observed the declination 3° 08′ W. in latitude 40° 10′ N., longitude 75° 16′ W., (see Ency. Metrop.,) but the longitude required a correction of about + 25′ (from comparison of the longitude assigned to Boston and Cambridge.) This observation agrees well with the Hatboro' curve, but being about half a degree to the westward, could not be used in that place. For a similar reason, an observation made by Professor A. D. Bache at Westchester, in 1832, could not be included. In volume xxxiv of Silliman's Journal we find the following additional observations:

In 1710	the declination was	8°	30′	west by	Th. Whitney.
1750	"	5	45	"	Kalm's Travels.
1793	"	1	30	"	Th. Whitney.
1804	"	2	10	"	"
1813	"	2	25	"	Dr. McClure.
1837	"	3	52	"	W. R. Johnson.

On May 23d, 1846, we have a determination by the U. S. Coast Survey, (see report of 1854,) viz: declination 3° 51′ W. This result agrees well with a number of observations made in the vicinity of Philadelphia. The observations made at Girard College (see Pub. Doc. 2d session of the 29th Congress) between June, 1840, and June, 1845, by Prof. A. D. Bache, are differential observations. The observed increase during this time was 25′.5, hence the annual increase = 5′.1. Assuming this same increase during the following year, 1845–6, would give us the declination for May, 1840, + 3°.33. We have, therefore, the following table of declinations for the discussion:

In 1701	D = + 8°.50	
1710	+ 8.50	
1750	+ 5.75	
1793	+ 1.50	mean of two results.
1802	+ 1.50	
1804	+ 2.09	" "
1813	+ 2.43	" "
1837	+ 3.87	
1840.4	+ 3.33	
1846.4	+ 3.85	

Their discussion gives the formula—

$$D = +\,2^{\circ}.573 + 0.06582\,(t - 1830) + 0.0018380\,(t - 1830)^2 + 0.000007420\,(t - 1830)^3$$

For a representation of the observed and computed values, see diagram No. 1, Plate 51, and for the differences the following table:

t.	D observed.	D computed.	Δ.
	°	°	°
1701	+ 8.50	+ 8.77	+ 0.27
1710	8.50	8.38	— 0.12
1750	5.75	5.30	— 0.45
1793	1.50	2.29	+ 0.79
1802	1.50	2.00	+ 0.50
1804	2.09	1.96	— 0.13
1813	2.43	1.93	— 0.50
1837	3.87	3.13	— 0.74
1840.4	3.33	3.46	+ 0.13
1846.4	+ 3.85	+ 4.16	+ 0.31

The greater differences at this station must be attributed to errors of observation alone. The other results are given in the synopsis.

Synopsis of results at the stations Providence, Hatboro' and Philadelphia. (See diagram No. 3, Plate 51.)

Providence....$D = +\,7^{\circ}.439 + 0.08543\,(t - 1830) + 0.001505\,(t - 1830)^2 + 0.00000510\,(t - 1830)^3$.

Hatboro'......$D = +\,2^{\circ}.683 + 0.07211\,(t - 1830) + 0.001749\,(t - 1830)^2 + 0.00000675\,(t - 1830)^3$.

Philadelphia...$D = +\,2^{\circ}.573 + 0.06582\,(t - 1830) + 0.001838\,(t - 1830)^2 + 0.00000742\,(t - 1830)$.

For t any year might be substituted between 1670 or 1680 and the present time. The agreement of the co-efficients is satisfactory, at the same time exhibiting their dependence on the geographical position of the stations.

		V.
Providence....	$v = +\,0^{\circ}.085 + 0.00301\,(t - 1830) + 0.0000153\,(t - 1830)^2$ and	3'.8.
Hatboro'......	$v = +\,0^{\circ}.072 + 0.00350\,(t - 1830) + 0.0000203\,(t - 1830)^2$	4'.8.
Philadelphia,..	$v = +\,0^{\circ}.066 + 0.00368\,(t - 1830) + 0.0000223\,(t - 1830)^2$	5'.2.

	T	T'	T''	δ	d	Range.
Providence	1795.6	1667.7	1731.6	+ 11°.5	+ 6°.1	5°.4
Hatboro'	1806.1	1681.3	1743.7	+ 8 .5	+ 1 .9	6 .6
Philadelphia	1809.5	1688.3	1747.4	+ 9 .0	+ 1 .9	7 .1

	ε_o	ε_x		ε_z	ε_u
Providence	± 5'	± 0.035	± 0.00199	± 0.000057	± 0.00000044
Hatboro'	± 11	± 0.077	± 0.00414	± 0.000040	± 0.00000070
Philadelphia	± 24	± 0.179	± 0.01100	± 0.000250	± 0.00000220

	ε_T	$\varepsilon_{T'}$	$\varepsilon_{T''}$	ε_V
Providence	± 6.1 years.	± 9.6 years.	± 9.3 years.	± 1'.0
Hatboro'	± 19.3 "	± 5.0 "	± 12.9 "	± 1.0
Philadelphia	± 16.7 "	± 26.5 "	± 26.9 "	± 4.0

According to the results deduced from the observations made at these three stations, the minimum declination took place in 1804 ± 9 years. At this time the needle had approached nearest to the true north, the western declination being greater before and after this time. The maximum variation appears to have occurred in 1679 ± ten years. Hence the duration of half an oscillation, if we are allowed to draw the inference, would be one hundred and twenty-five years ± 15; but this must at present be considered as a mere speculation. The uniformity in the epoch of the minimum for a great geographical extent in a north and south direction, as we will see further on, would lead to the inference of a constant duration of half an oscillation in the geographical direction indicated. At Paris and London the maximum of easterly declination (equivalent to a minimum of western) took place about 1680, and the maximum of western declination about 1815, with a range of not less than 34°, while the average range at the above three stations is but 6°. The maximum of westerly declination in the northwestern part of Europe, therefore, took place nearly simultaneously with the minimum westerly declination on the eastern coast of the United States. I shall return to this subject after the discussion of the observations comprised under the head *b*. The maximum annual variation V took place in 1741 ± 10 years; and if, after an equal interval of time T — T'', or sixty-three years, the greater annual change should again take place, we must expect it about the year 1867 ± 15 years. Observations made during the present year yet indicate an increasing change, so far supporting this conjecture. The average value of V for the three stations is — 4'.6 showing, at the same time, an increase with an approach to the line of no variation.

b. Discussion of the secular variation of magnetic declination from reliable observations, dating subsequent to the year 1740, *with notice of others made prior to that time.*

From the preceding discussion it is obvious that all observations after the time T'' can be represented by an equation of the second degree, which will give the epoch of the minimum its corresponding and all other declinations between that time (corresponding to the former point of inflexion of the curve) and the present. This formula will only apply up to the time of a second point of inflexion yet to be observed.

Although this class includes observations reaching considerably beyond the middle of the eighteenth century, yet, for want of general conformity, such have been omitted in the discussion. For the purpose of a ready comparison of the *co-efficients* of the terms involving the interval of time for the several stations, and for the purpose of ascertaining their change with reference to their geographical position, a re-discussion of the preceding three stations becomes necessary, in which the observations after 1740 are alone used.

The stations have been arranged in the order of their geographical position, commencing with the observations in the New England States.

Locality.	Observations included between		No. of observations.
1. Boston, Mass.	1700 and	1847	8
2. Cambridge, Mass.	1708	1855	20
3. Providence, R. I.	1740	1845	25
4. New Haven, Conn.	1761	1849	13
5. New York, N. Y.	1609	1846	12
6. Hatboro', Penn.	1750	1850	11
7. Philadelphia, Penn.	1750	1846	8
8. Charleston, S. C.	1775	1849	5
9. Mobile, Ala.	1809	1850	5
10. Havana, Cuba.	1726	1850	3

I. DISCUSSION OF THE SECULAR CHANGE AT BOSTON, MASS.

In volume xvi of Silliman's Journal a collection of declinations for Boston, Falmouth, and Penobscot has been published under the title "Table exhibiting the variation of the compass in Boston and the parts adjacent from the earliest accounts of it to the eighteenth century, agreeable to *actual* observations, by John Winthrop, Esq." Though the observations were said to be simultaneous, an examination at once shows that the table was formed by interpolation. We are indebted to Professor Loomis for this exposition, who, having obtained a MS. copy, was able to separate the few actual observations from the interpolated results. In distinguishing observations made at or near Boston from others in the vicinity, I was guided by the table given in the Memoirs of the American Academy of Arts and Sciences, volume ii, new series, 1846, and have omitted all Cambridge observations for the declination at Boston, and assumed in Silliman's Journal as Boston observations.

The first observation recorded in the Winthrop table is in 1700, and the declination is put down as 10° W. The next observation is in 1708, (see Ency. Metrop.,) observer Mathews, 9° W. This, however, is not to be confounded with the Cambridge observation of the same year, and recorded result. Brattle observed at Cambridge, while M. observed six miles east of Cambridge. Mathews' observation of 1741 differs half a degree from the Cambridge observation, and was found 7½° W. In Des Barres' *Atlantic Neptune* the magnetic declination for Boston harbor is given 7° 40′ W. for the year 1775; and as this is about 1° too great, it has been omitted in the discussion. Dr. Bowditch, in the first volume of the Mem. of the Academy, gives the declination for 1782, 7° 0′ W.; and in the new series of the Memoirs, volume ii, 1846, we find the mean of 1,644 observations for 1793, 6½° W. Bond, in volume xxxix of Silliman's Journal, 1840, finds the declination at Dorchester in 1839, 9° 6′ W. Dorchester is in latitude 42° 19′ N., longitude 71° 4′ W., and the observation, when reduced to the State-house (Boston) (in latitude 42° 21′ N., longitude 71° 03′.5 W.) becomes 9°.12 W. The nearest Coast Survey station is Dorchester Heights, about a mile and a half to the southward of the State-house. The annual report of the Superintendent for 1854 gives the declination in September, 1846, 9° 31′.4 W. The reduction to the State-house is inconsiderable.

We have, therefore, the following observations for discussion:

		°
In 1741	declination	+ 7.50
1782	"	+ 7.00
1793	"	+ 6.50
1839	"	+ 9.12
1846.7	"	+ 9.52

The formulæ used for the discussion of these observations are as follows:

$$D = d_{,} + x + y\,(t - t_{\circ}) + z\,(t - t_{\circ})^2$$

$$\varepsilon_{\circ} = 0.674\sqrt{\frac{\Sigma \triangle^2}{n-3}}\,;\ \mathrm{T} = t_{\circ} - \frac{y}{2z}\,;\ \ v = y + 2z\,(t - t_{\circ})$$

$$\varepsilon_x = \varepsilon_o \sqrt{Q_1}\,;\ \varepsilon_y = \varepsilon_o \sqrt{Q_2}\,;\ \varepsilon_z = \varepsilon_o \sqrt{Q_3}$$

$$\varepsilon T = \sqrt{\frac{1}{4_z^{\,2}}\,\varepsilon_y^{\,2} + \frac{y^2}{4_z^{\,4}}\,\varepsilon_z^{\,2}} \quad \varepsilon_v = \sqrt{\varepsilon_y^{\,2} + 4\,(t - t_o)^2\,\varepsilon_z^{\,2}}$$

Applying these formulæ, we find for Boston—

$$D = +\,8^\circ.356 + 0.0647\,(t - 1830) + 0.000624\,(t - 1830)^2$$

Which equation represent the observations as follows:

t.	D obs'd.	D comp'd.	Δ.
	°	°	°
1741	+ 7.50	+ 7.54	+ 0.04
1782	7.00	6.69	— 0.31
1793	6.50	6.82	+ 0.32
1839	9.12	8.99	— 0.13
1846.7	+ 9.52	+ 9.61	+ 0.09

The other results will be found in the synopsis at the end of this discussion.

II. DISCUSSION OF THE SECULAR CHANGE AT CAMBRIDGE, MASS.

In the Memoirs of the American Academy of Arts and Sciences, new series, volume ii, Cambridge, 1846, we find an account of magnetic declinations observed at the Harvard University observatory, by Professors J. Lovering and W. C. Bond, and a table of declinations from the period of the earliest observations. To the other observations the authorities are affixed. The position of the observatory is latitude 42° 23′ N.; longitude 71° 07′ W.

In 1708	declination	9°	00′ W.	Mem. A. A., vol. ii, 1846;	also	Ency. Met.: Brattle's observation.
1742	do.	8	00	do.	do.	Professor Winthrop's observation.
1757	do.	7	20	do.	do.	Professor Winthrop's observation.
1761	do.	7	14	do.	do.	Dr. Williams' observation.
1763	do.	7	00	do.	do.	and Ency. Met.: Winthrop's observation.
1780	do.	7	02	do.	do.	and Ency. Met.: Williams' observation.
1782	do.	6	46	do.	do.	Dr. Williams' observation.
1782	do.	6	44	Professor Sewall's observation, (mean of extremes 6° 21′ and 7° 8′.)		
1782	do.	6	45	Ency. Met.: Williams' observation.		
1783	do.	6	52	do.	do.	See also Mem. A. A.
1788	do.	6	38	Mem. A. A., vol. ii, 1846,		Dr. Williams' observation.
1810	do.	7	30	do.	do.	Professor Farrar's observation.
1835	do.	8	51	do.	do.	Professor Farrar's observation.
1837	do.	9	09	do.	do.	
1840	do.	9	18	do.	do.	also Phil. Trans. Roy. Society, 1849.
1842.2	do.	9	34.9	Mem. A. A., vol. iv, P. II, 1850,		from half-hourly observations by Professor J. Lovering, continued during one year.

If we omit the first observation, and take the mean of the three results for 1782, form the conditional equations, etc., etc., we obtain the expression—

$$D = +\,8^\circ.553 + 0.0702\,(t - 1830) + 0.000720\,(t - 1830)^2.$$

The following table contains the observed and computed values:

t	D observed.	D computed.	Δ
	°	°	°
1742	+ 8.00	+ 7.95	− 0.05
1757	+ 7.33	+ 7.27	− 0.06
1761	+ 7.23	+ 7.14	− 0.09
1763	+ 7.00	+ 7.08	+ 0.08
1780	+ 7.03	+ 6.84	− 0.19
1782	+ 6.75	+ 6.84	+ 0.09
1783	+ 6.87	+ 6.84	− 0.03
1788	+ 6.63	+ 6.87	+ 0.24
1810	+ 7.50	+ 7.44	− 0.06
1835	+ 8.85	+ 8.92	+ 0.07
1837	+ 9.15	+ 9.08	− 0.07
1840	+ 9.30	+ 9.33	+ 0.03
1842.2	+ 9.57	+ 9.50	− 0.07

(For the other results see synopsis.)

When this discussion was completed, I received, through the kindness of Professor Lovering, Mr. Bond's latest observations at the observatory; they are as follows:

Declination in 1844.....................	9°	39′	west.
1852.....................	10	08	"
1854.....................	10	39	"
1855.....................	10	54	"

The above formula represents these observations very well, viz:

t	D observed.	D computed.	Δ
	°	°	°
1844	+ 9.65	+ 9.68	+ 0.03
1852	+ 10.13	+ 10.44	+ 0.31
1854	+ 10.65	+ 10.65	0.00
1855	+ 10.90	+ 10.76	− 0.14

This agreement is so close that the introduction of these late observations in the discussion would not alter the formula as deduced above. These observations further indicate that the point of inflexion has probably not been reached; a circumstance of importance for the other stations, which will permit of the extension of the formula deduced at these stations, at least up to the present time. The above Cambridge observation of 1855, and another at East Pascagoula, Mississippi, also of 1855, are the only late ones I could avail myself of for this extension.

III. DISCUSSION OF THE SECULAR CHANGE AT PROVIDENCE, RHODE ISLAND.

Commencing with the observations of 1740, and discussing the observations in the usual way, we find the expression for the declination—

$$D = + 7^\circ.575 + 0.0764\,(t - 1830) + 0.000959\,(t - 1830)^2.$$

The differences of the computed and deduced values are shown in the following table:

t	D observed.	D computed.	Δ
	°	°	°
1740	+ 8.28	+ 8.47	+ 0.19
1750	7.67	7.60	— 0.07
1760	6.99	6.93	0.06
1770	6.49	6.44	0.05
1780	6.27	6.15	0.12
1790	6.18	6.05	0.13
1800	6.25	6.15	— 0.10
1810	6.40	6.43	+ 0.03
1820	6.66	6.91	0.25
1830	7.19	7.57	0.38
1840	8.42	8.43	+ 0.01
1842	8.65	8.63	— 0.02
1844.8	+ 9.25	+ 8.92	— 0.33

(For other results see synopsis.) Discussion No. 1 involving the 1st, 2d, and 3d power of the interval of time, and Discussion No. 2 involving but the 1st and 2d power, compare as follows:

	D for 1830.	ε_o	T	ε T	v in 1850.	d
	°	′			′	°
Discussion No. 1	+ 7.44	± 5	1796	± 6 years	+ 9	+ 6.1
Discussion No. 2	+ 7.57	± 8	1790	± 2 "	+ 7	+ 6.1

The results by Discussion No. 2 are shown in the diagram (No. 1) by a dotted curve.

IV. DISCUSSION OF THE SECULAR CHANGE AT NEW HAVEN, CONNECTICUT.

The position of Yale College spire is latitude 41° 18′ north, longitude 72° 55′ west. In volume xxxiv, of Silliman's Journal, 1838, we find the following observations:

In 1761, declination 5° 47′ west; Pres. Stiles, observer.
1775, " 5 25 " Prof. Strong, observer.
1780, " 5 15 " Pres. Stiles, observer.
1811, " 5 10 " N. Redfield, observer.
1819, " 4 35 " Prof. Fisher, observer.
1828, " 5 17 " N. Goodwin, observer.
1835, " 5 52 " Prof. Loomis, observer.
1836, " 5 55 " E. C. Herrick, observer.

In volume xvi, 1829, of the same Journal, we find an observation by the Hon. De Witt, in August, 1818, viz: 5° 45′ W. This is undoubtedly too large, and will not be used in the discussion. In the same volume Prof. Fisher gives the declination from hourly observations, between May, 1819, and April, 1820, 4° 25′.4 W. In volume xxx, 1836, Prof. Loomis obtained from hourly observations, between November, 1834, and November, 1835, the mean declination 5° 40′ 34″ W. In volume xxxiv, 1838, Mr. Herrick gives the declination 5° 50′ W. for November, 1837. In volume xxxix, 1840, the declination for 1840 is given 6° 10′ W. The following two observations were taken from the list of the United States Coast Survey observations, (Annual Report of Superintendent for 1854,) viz:

Declination at Yale College, September 10, 1845, 6° 17′.3 W., J. Renwick observer.
Declination at Yale College, August 12, 1848, 6° 37′.9 W., J. S. Ruth observer.

The local irregularities near New Haven appear to be very great, as, on a line less than two miles in length, the declination was found to change nearly a whole degree. We have for discussion the following observations:

In 1761, declination		$+ 5°.78$
1775	"	$+ 5.42$
1780	"	$+ 5.25$
1811	"	$+ 5.17$
1819	"	$+ 4.58$
1819.8	"	$+ 4.42$
1828	"	$+ 5.28$
1835.2	"	$+ 5.77$, the mean of 1835 and 1835.4.
1836	"	$+ 5.92$
1837.9	"	$+ 5.83$
1840	"	$+ 6.17$
1845.7	"	$+ 6.29$
1848.6	"	$+ 6.63$

The following formula represents these observations:

$$D = + 5°.395 + 0.05002 (t - 1830) + 0.0008570 (t - 1830.)^2$$

Table of computed and observed results.

t.	D observed.	D computed.	Δ
	°	°	°
1761	+ 5.78	+ 6.02	+ 0.24
1775	5.42	5.24	— 0.18
1780	5.25	5.04	0.21
1811	5.17	4.76	— 0.41
1819	4.58	4.95	+ 0.37
1819.8	4.42	4.97	0.55
1828	5.28	5.30	+ 0.02
1835.2	5.77	5.68	— 0.09
1836	5.92	5.73	— 0.19
1837.9	5.83	5.84	+ 0.01
1840	6.17	5.98	— 0.19
1845.7	6.29	6.39	+ 0.10
1848.6	+ 6.63	+ 6.62	— 0.01

(For other results see synopsis.)

V. DISCUSSION OF THE SECULAR CHANGE AT NEW YORK.

The earliest observations on record are those by Hudson on his third voyage, in 1609. (See volume xxxix of Silliman's Journal, 1840.) In August Hudson observed near the coast, in latitude 39° 11′ N., the declination 11½° W.; in September, a few miles up the Hudson river, 13° W.; in September, near the Jersey shore, a little below the mouth of the Hudson, 8° W. The day before he found not above 2° W. In October, on the coast, in latitude 39° 30′ N., 6° W.

These observations were probably made on ship-board, and for nautical purposes, and have an uncertainty of at least half a point. A mean of all, or 8° W., may be used for a general comparison. In 1686, Mr. Welles observed the declination 8° 45′ W. (See volume xxxiv Silliman's Journal, 1838; also the Encyclopædia Metrop.) In the same place we find G. Burnet's observations in 1723, viz: 7° 20′ W. In Des Barres' *Atlantic Neptune*, published in London, in 1781, the declination near Sandy Hook is given 7° W. for 1775: this determination is about 2° in error, and consequently has not been used. For the discussion we have the following values:

In 1750, Mr. Alexander observed the declination	6° 22′ W.	—Silliman's Jour., vol. xxxiv, 1838.
1755, Mr. Evans	5 00 W.	—Ibid.
1789, No authority given	4 20 W.	—Ency. Met.
1824, Blunt's map	4 40 W.	—Silliman's Journal, 1838.
1834, Captain Owen	4 50 W.	—Ibid.

	° ′
1837, Professor Renwick........................	5 40 W.—Ibid.
1841, Douglass's map of New Jersey.......	6 06 W.—Coast Survey Archives.
1844.7, U. S. Coast Survey observations...	6 13 W.—Report of 1854.
1845.7, U. S. Coast Survey observations...	6 25 W.—Ibid.

The last two observations refer to Columbia College, N. Y., which is in latitude 40° 43′ N., and longitude 74° 00′ W.

The above nine observations are best represented by the formula $D = +5^\circ.071 + 0.0642 (t - 1830) + 0.000944 (t - 1830)^2$.

Differences between the observed and computed values are shown by the table:

t.	D observed.	D computed.	Δ
	°	°	°
1750	+ 6.37	+ 5.98	− 0.39
1755	5.00	5.57	+ 0.57
1789	4.33	4.03	− 0.30
1824	4.67	4.72	+ 0.05
1834	4.83	5.34	+ 0.51
1837	5.67	5.57	− 0.10
1841	6.10	5.89	− 0.21
1844.7	6.22	6.22	0.00
1845.7	+ 6.42	+ 6.31	− 0.11

(For other other results see synopsis.)

VI. DISCUSSION OF THE SECULAR CHANGE AT HATBORO', PENNSYLVANIA.

The observations made subsequent to the beginning of the year 1750, when submitted to discussion, furnish the following equation:

$$D = +2^\circ.861 + 0.0683 (t - 1830) + 0.001169 (t - 1830)^2$$

The table shows the differences between observation and computation:

t.	D observed.	D computed.	Δ
	°	°	°
1750	+ 4.92	+ 4.89	− 0.03
1760	4.00	3.81	− 0.19
1770	2.92	2.97	+ 0.05
1780	2.08	2.37	0.29
1790	1.83	2.00	+ 0.17
1800	1.92	1.87	− 0.05
1810	2.00	1.96	0.04
1820	2.45	2.30	0.15
1830	3.00	2.86	0.14
1840	3.83	3.66	− 0.17
1850	+ 4.42	+ 4.69	+ 0.27

(For other results see synopsis.) On Diagram No. 2, Plate No. 51, the dotted curve shows the above results. Discussions No. 1 and No. 2 compare as follows:

	D for 1830.	ε_o	T.	ε_T	v in 1850.	d.
	°					°
Discussion No. 1......	+ 2.68	± 11′	1806	± 19 years.	+ 9′	+ 1.9
" " 2......	+ 2.86	± 8′	1800	± 1 "	+ 7′	+ 1.9

VII. DISCUSSION OF THE SECULAR CHANGE AT PHILADELPHIA, PA.

The observations made use of commence with 1750, and give the following formula:

$$D = + 2^\circ.599 + 0.0684\ (t - 1830) + 0.001340\ (t - 1830)^2$$

The following table exhibits the observed and computed values:

t.	D. observed.	D computed.	Δ
	°	°	°
1750	+ 5.75	+ 5.70	— 0.05
1793	1.50	1.86	+ 0.36
1802	1.50	1.69	+ 0.19
1804	2.09	1.69	— 0.40
1813	2.43	1.91	0.52
1837	3.87	3.14	— 0.73
1840.4	3.33	3.45	+ 0.12
1846.4	+ 3.85	+ 4.06	+ 0.21

The broken curve (Diagram No. 1) represents these observations. The minimum is now brought over towards the observed minimum, and the observations generally are better represented than by Discussion No. 1.

	D for 1830.	ϵ_o	T	ϵ_T	v in 1850.	d.
	°					°
Discussion No. 1.....	+ 2.57	± 24′	1809	± 17 years.	+ 9′	+ 1.9
" " 2.....	+ 2.60	± 20′	1804	± 3 "	+ 7′	+ 1.7

VIII. DISCUSSION OF THE SECULAR VARIATION AT CHARLESTON, SOUTH CAROLINA.

In Des Barres' *Atlantic Neptune* the declination for 1775 is given 3° 48′ E., which is probably the same observation as given on a map for 1777 in latitude 32° 47′ north, longitude 79° 57′ W. (See Silliman's Journal, vol. xxxiv, 1838.) From Blunt's chart the variation of the compass in 1824 and 1825, by Lieutenant Sherburne, U. S. N., is 3° 45′ E. In 1837, Captain Misroom gives the variation 2° 54′ E. (See Silliman's Journal, vol. xxxiv, 1838.) Barnett observed in May, 1841, the declination 2° 24′ E. in latitude 32° 41′ N., longitude 79° 53′ W. (See Phil. Trans. Roy. Soc., vol. for 1849.) At Breach inlet, near the entrance to Charleston harbor, in latitude 32° 46′.3 N., and longitude 79° 48′.7 W., we have the determination by the United States Coast Survey, (Report for 1854,) viz: 2° 16′.5 E. for April, 1849. This observation, when reduced to Fort Moultrie, in latitude 32° 45′.5 N., longitude 79° 51′.2 W., becomes — 2°.30, and the values for discussion are—

	°
1775 declination	— 3.80
1824.5	— 3.75
1837	— 2.90
1841.4	— 2.40
1849.3	— 2.30

which can be represented by the formula—

$$D = - 3^\circ.330 + 0.04845\ (t - 1830) + 0.0007216\ (t - 1830)^2$$

Table of observed and computed values.

t.	D observed.	D computed.	Δ
	°	°	°
1775	— 3.80	— 3.81	— 0.01
1824.5	3.75	3.57	+ 0.18
1837	2.90	2.96	— 0.06
1841.4	2.40	2.61	— 0.21
1849.3	— 2.30	— 2.13	+ 0.17

(For other results see synopsis.)

IX. DISCUSSION OF THE SECULAR CHANGE AT MOBILE, ALABAMA.

In Silliman's Journal, vol. xxxix, 1840, the declination at Mobile, latitude 30° 40′ N., longitude 88° 11′ W., is given by Mr. J. H. Weakly, 8° 10′ E. for 1809. In vol. xxxiv, 1838, also in the Ency. Brit., 7th edition, the declination in Mobile bay is given 6° 30′ E. for 1814. Taking the mean of these two determinations, we find for the discussion— 7°.33 for 1811.5. In vol. xxxix of Silliman's Journal, Mr. J. H. Weakly gives the declination for 1835, 7° 12′ E. The isogonic lines run nearly parallel with the major axis of Mobile bay, and the observations made at Fort Morgan, at the entrance of the bay, need no reduction for difference of latitude. We have for this the determination by the U. S. Coast Survey in May, 1847, (see Report for 1854,) 7° 04′.1 E., latitude 30° 13′.9 N., longitude 88° 00′.3 W. In a report of Commander Powell, U. S. N., the magnetic declination for Mobile light-house is given 6° 56′ E. for 1843. At East Pascagoula, a re-determination of the declination was made in 1855, after an interval of eight years, which gave for the annual variation a decrease of easterly declination (equal to an increase of westerly) of about 0′.5. Both observations were made by Assistant J. E. Hilgard, of the U. S. Coast Survey. We can now reduce the above observations in 1847.3 to 1850, and find —7°.05.

Table of observed declinations.

1811.5	declination	— 7°.33	
1835		— 7.20	
1843		— 6.93	(This observation being too small, has been omitted.)
1847.3		— 7.07	
1850		— 7.05	

The following formula represents these observations:

$$D = - 7°238 + 0.00723\ (t - 1830) + 0.0001228\ (t - 1830)^2$$

Table of observed and computed declinations.

t.	D observed.	D computed.	Δ.
	°	°	°
1811.5	— 7.33	— 7.33	0.00
1835	7.20	7.20	0.00
(1843)	6.93	(7.12)	(— 0.19)
1847.3	7.07	7.08	— 0.01
1850	— 7.05	— 7.04	+ 0.01

(For other results see synopsis.)

X. DISCUSSION OF THE SECULAR CHANGE AT HAVANA, CUBA.

The oldest observation I was able to reach, is for 1726 by Mathews, who observed near Havana, in latitude 23° 02′ N., longitude 81° 44′ W. The variation is stated at 4° 24′ E., (see Ency. Met. 1848.) J. Harris observed off Havana, in latitude 23° 08′ N., longitude 82° 32′ W., in April, 1732, the variation $4\frac{1}{2}°$ E., (see Ency. Met. 1848, and Phil. Trans. Roy. Soc., vol. vii *(abridged)* 1724—1734.) The Moro Castle is in latitude 23° 09′ N., and longitude 82° 22′ W. These observations agree, and were therefore used in the discussion; and although the date is somewhat early, the general flatness of the corresponding curve shows their admissibility for the discussion. In the Ency. Brit., 7th edition, we find the declination in 1815, 7° 00′ E., and in August, 1816, 5° 30′ E. The mean of these two, or —6°.25, has been used. The above data, however, would not suffice to deduce the law of change; I have therefore made use of the modern observations on the Gulf of Mexico, which have been represented within a few minutes by the following formula:

$$d\,V = -\,0.0250\,d\,L + 0.2963\,d\,M + 0.0188\,d\,L\,d\,M - 0.0094\,d\,L^2 - 0.0076\,d\,M^2;$$

where

$d\,L = L' - 28°.04$, or the difference in latitude.
$d\,M = M' - 88\,.60$ " " " " longitude.
$d\,V = V' - 7\,.39$ E.; the differences in the magnetic declination for 1850.

This formula exactly represents the observation at Sand key, opposite Havana, and gives for this latter place the declination in 1850, 5°.72 E., which can only differ from the true declination by the effect of local deviation.

For the discussion, we have 1726.0 observed declination.................................. —4°.40
1732.3 .... —4 .50
1815.8 .... —6 .25
1850.0 .... —5 .72

Which observations are represented by the formula—

$$D = -\,6°.076 + 0.00981\,(t - 1830) + 0.000255\,(t - 1830)^2$$

Table of observed and computed values.

t	D observed.	D computed.	Δ.
	°	°	°
1726. 0	4. 40	4. 33	+ 0. 07
1732. 3	4. 50	4. 59	— 0. 09
1815. 8	6. 25	6. 16	+ 0. 09
1850. 0	— 5. 72	— 5. 78	— 0. 06

(For other results see synopsis.)

Synopsis of results of the discussion for secular variation at the ten preceding stations.—(See *Diagram No.* 4.)

No.	Station.	Lat. N.	Long. W.	Declination.
		° ′	° ′	
1	Boston	42 20	71 02	$D = +\,8°.356 + 0.0647\,(t - 1830) + 0.000624\,(t - 1830)^2$
2	Cambridge	42 23	71 07	$D = +\,8°.553 + 0.0702\,(t - 1830) + 0.000720\,(t - 1830)^2$
3	Providence	41 49	71 24	$D = +\,7°.575 + 0.0764\,(t - 1830) + 0.000959\,(t - 1830)^2$
4	New Haven	41 18	72 55	$D = +\,5°.395 + 0.0500\,(t - 1830) + 0.000857\,(t - 1830)^2$
5	New York	40 43	74 00	$D = +\,5°.071 + 0.0642\,(t - 1830) + 0.000944\,(t - 1830)^2$
6	Hatboro'	40 07	75 08	$D = +\,2°.861 + 0.0683\,(t - 1830) + 0.001169\,(t - 1830)^2$
7	Philadelphia	39 58	75 10	$D = +\,2°.599 + 0.0684\,(t - 1830) + 0.001340\,(t - 1830)^2$
8	Charleston	32 45	79 51	$D = -\,3°.330 + 0.0485\,(t - 1830) + 0.000722\,(t - 1830)^2$
9	Mobile	30 14	88 00	$D = -\,7°.238 + 0.0072\,(t - 1830) + 0.000123\,(t - 1830)^2$
10	Havana	23 09	82 22	$D = -\,6°.076 + 0.0098\,(t - 1830) + 0.000255\,(t - 1830)^2$

No.	Station.	ε_0	T	ε_T	$d.$	Annual variation.
		′			′	
1	Boston	± 13	1778.2	± 11.3 yrs.	+ 6.68	$v = +0'.065 + 0.00125\,(t - 1830)$
2	Cambridge	5	1781.2	1.8	6.83	$v = +0'.070 + 0.00144\,(t - 1830)$
3	Providence	8	1790.1	2.2	6.05	$v = +0'.076 + 0.00192\,(t - 1830)$
4	New Haven	12	1800.8	4.1	4.67	$v = +0'.050 + 0.00171\,(t - 1830)$
5	New York	16	1796.0	6.1	3.98	$v = +0'.064 + 0.00189\,(t - 1830)$
6	Hatboro'	8	1799.5	1.2	1.87	$v = +0'.068 + 0.00224\,(t - 1830)$
7	Philadelphia	20	1804.5	± 3.1	+ 1.69	$v = +0'.068 + 0.00268\,(t - 1830)$
8	Charleston	10	1796.4	----------	− 4.16	$v = +0'.048 + 0.00144\,(t - 1830)$
9	Mobile	(6)	1800.6	----------	7.35	$v = +0'.007 + 0.00024\,(t - 1830)$
10	Havana	(± 5)	1810.8	----------	− 6.17	$v = +0'.010 + 0.00051\,(t - 1830)$

No.	Station.	v in 1850.	ε_v	x	ε_y	ε_z
		′	′	′		
1	Boston	+ 5.4	± 0.5	± 8	± 0.0061	± 0.00016
2	Cambridge	5.9	0.1	2	0.0017	0.00002
3	Providence	6.9	0.2	3	0.0028	0.00004
4	New Haven	5.0	0.4	4	0.0047	0.00009
5	New York	6.2	0.6	7	0.0080	0.00012
6	Hatboro'	6.8	0.1	3	0.0008	0.00005
7	Philadelphia	6.8	± 0.5	± 8	± 0.0082	± 0.00011
8	Charleston	4.6	----------	----------	----------	----------
9	Mobile	0.7	----------	----------	----------	----------
10	Havana	+ 1.2	----------	----------	----------	----------

The order in which the stations have been arranged serves to show the dependence of the co-efficients x, y, z, upon the geographical position of the stations; but it is the last two co-efficients which will be investigated further on, as on these alone depend the secular change and the time of the minimum.

The epoch of the minimum (T) appears to be subject to local irregularities, as disclosed by the probable errors (ε_T), and a general law or dependence on the same cause is strongly marked as affecting every station on the Atlantic seaboard, and even traceable from the southern shore of Hudson's bay to Jamaica. The mean T, without regard to the probable error, is 1796, and when we form the differences, T — mean, the figures at once show that in the eastern States the minimum of magnetic declination took place about a decennium earlier, and about the same number of years later in the eastern gulf States than in the middle States. In the last chapter this geographical relation of the co-efficients y and z, and of the epoch T, will be more fully investigated. It is no more surprising to find local deviations in the epoch of the minimum than in the declination itself.

The general flatness of the curves as we approach the Gulf of Mexico is remarkable, and induced me to collect a few observations for declination at Jamaica, W. I., latitude 17° 58′ N., longitude 76° 46′ W. Permanent declination at Kingston, Jamaica, from 1660 to 1800, 6° 30′ E., (J. Robertson, Phil. Trans. Royal Society, 1806.) Declination from a plan of Kingston, by J. Leard, in 1791 and 1792, 6° 45′ E., and by the same authority in 1789 and 1793, 6° 50′ E. On Minories' map, published in London, 1854, the declination is given 4° 40′ E., which is probably for 1833. Col. Sabine, in the Phil. Trans. Royal Society, P. II, 1849, Cont'n IX, gives the declination —3°.8 and — 4°.2, the mean of which is 4° E. for 1840 (?). The latter two determinations show that there is an end to the permanency in the direction of the needle since the commencement of this century. Sir John Herschel says: "The "whole mass of West Indian property has been saved from the bottomless pit of endless litigation by the invariability of the magnetic declination in Jamaica and the surrounding archipelago during the whole of the last century, all surveys of property there having been conducted solely by the compass." Examining, on the other hand, the declinations at Fort Albany, at the southern extremity of Hudson's bay, latitude 52° 22′ N., longitude 82° 38′ W., we find the declination in 1668, according to Halley, 19° 15′ W. (See Hansteen's Erdmagnetismus, vol. I). Declination in August, 1730, according to Capt. Middleton, 23° 00′ W.; and by the same authority, declination in September, 1774, 17° 00′ W. Hansteen's map for 1787 gives 14° W., and Barlow's map for 1833, (Phil. Trans.) 3° W. We may here particularly notice the maximum which must have taken place between 1668 and 1730. Hence we see that the curves for these extreme stations agree well in their general character with the previous investigation, which is thereby considerably expanded in the direction of the meridian, and it becomes of interest to examine the same in the direction of the parallel, which, however, does does not come within the compass of this paper.

c. Statement of results from comparatively recent observations and discussion of some anomalous stations.

I. SECULAR CHANGE AT BURLINGTON, VERMONT—LATITUDE 44° 28′ N., LONGITUDE 73° 14′ W.

At this place the curvature appears to be greater than at other stations; the station, however, is 2° higher north than Boston. The minimum is displaced to 1808 ± 4 years; yet this anomaly may be due in great measure to the observation of 1793, upon which the curvature principally depends. We have the following observations for discussion. (See Silliman's Journal, vol. xxxiv, 1838.)

t.	D observed.	
1793	7° 38′ west,	by Dr. Williams.
1818	7 30	by J. Johnson.
1822	7 42	" "
1830	8 10	" "
1831	8 15	" "
1832	8 25	" "
1834	8 50	" "
1837	9 45	by Prof. Benedict.

The observations at Keesville, New York, cannot be used here, the distance between the two places being too great. From the above data we find $D = +8°.363 + 0.1207 (t - 1830) + 0.002755 (t - 1830)^2$ $\varepsilon_o = \pm 10'.7$; $T = 1808.1$; $v = + 0°.121 + 0.0055 (t - 1830)$ $d = \pm 7.01$; $\varepsilon_T = \pm 3.8$; v for $1850 = + 13'.9$; $\varepsilon_v = \pm 1'.2$. (See Diagram No. 5 for this and the following stations.)

II. SECULAR CHANGE AT CHESTERFIELD, N. HAMPSHIRE—LATITUDE 42° 53′ N., LONGITUDE 72° 20′ W.

The observations commence in 1812 and terminate in 1837; after the year 1826 they show a regular increase, but prior to this year the errors greatly affect the epoch of the minimum. Proceeding in the same way as at Providence, the twenty-six observations reduce themselves to the following fourteen:

t	D observed.	*t*	D observed.
	°		°
1812	+ 6.43	1825	+ 6.60
1813	6.39	1827	6.73
1815	6.14	1829	6.99
1817	6.03	1831	7.17
1819	6.02	1833	7.46
1821	6.11	1835	7.66
1823	+ 6.46	1837	+ 8.08

From these observations we obtain—

$$D = +\,7^\circ.040 + 0.1053\,(t - 1830) + 0.003289\,(t - 1830)^2$$

$$\varepsilon_0 = \pm\,6'.6 \qquad T = 1814.1 \qquad v = +\,0.105 + 0.00658\,(t - 1830).$$

$$d = +\,6^\circ.20 \qquad v = +\,14'.2 \text{ for } 1850.$$

The above observations will be found in Silliman's Journal, vol xxxiv, 1838.

III. SECULAR CHANGE AT SALEM, MASSACHUSETTS.

Salem is in lat. 42° 31′ N., long. 70° 54′ W. The first observation recorded is by President Willard, in August, 1781, at Beverly, (lat. 42° 33′ N., long. 70° 52′ W.,) viz: 7° 2′ W., the mean of seven observations. (See Silliman's Journal, vol. xvi, 1829.) (The Ency. Brit., 7th edition, gives 7° 4′ W.) The next observation is by Dr. Bowditch, 5° 57′ W., in 1805.8, the mean of one hundred and fifteen observations. (See Mems. Am. Ac., new series, vol. ii, Cambridge, 1846; also Silliman's Journal, vol. xvi, 1829.) By the same observer in 1808.4, declination from one hundred and twelve observations 5° 20′ W., and the mean of results by two theodolites in 1810.3, and from two hundred observations, + 5°.51. In 1810.8 he found with another needle from 5,125 observations 6° 22′ 35″ W. The three combined give + 5°.80 for 1810.5. The United States Coast Survey has the following determinations in the vicinity of Salem:

Little Nahant, lat...............	42° 26′.2 long.	70° 55′.5 decl'n	9° 40′.9
Fort Lee...........................	42 31′.9	70 52′.1	10 14′.5
Baker's Island....................	42 32′.2	70 46′.8	11 21′.1
Coddon Hill.......................	42 30′.9	70 50′.9	11 49′.8
			for 1849.

The disturbed region around Cape Ann extends, as seen by the above results, as far as Salem, and I have therefore selected that station, which agrees best with the previous results.

At Fort Lee we have for 1849.6 the declination + 10°.24.

Discussing these results, we find—

$D = +\,7^\circ.420 + 0.1235\,(t - 1830) + 0.002137\,(t - 1830)^2$ and $T = 1801.1$; $d = +\,5^\circ.63$, $v = +\,0^\circ.123 + 0.0043\,(t - 1830)$; v for $1850 = +\,12'.5$, which is nearly as great an annual change as at Burlington and Chesterfield.

IV. SECULAR CHANGE AT NANTUCKET, MASSACHUSETTS—LATITUDE 41° 17′ N., LONGITUDE 70° 06′ W.

In Des Barres' *Atlantic Neptune* the magnetic declination for 1775 is given 6° 30′ W. This is probably the same as the variation of 1776 in Silliman's Journal, vol. xxxiv, 1838, viz: 6° 30′ W.

In vol. xlvi of the same Journal, Mr. Mitchell, of Nantucket, gives the following observations:

In 1834	declination	8° 27′ W.
1838.9	do.	9° 02′ 19″ W.
1842	do.	9° 09′ 00″ W. in August and September.
1843	do.	9° 09′ 59″ W. in September.

The United States Coast Survey determination in July, 1846, makes the declination 9° 14′ W. Before the observations can be worked up, it is necessary to interpolate an observation about the year 1810, in order to force the curve, to show the minimum after 1775, which otherwise would not be the case. The omission of the first observation would give an equally bad result. By means of the formulæ deduced in the last chapter, we find $y = +\,0.0613$ and $z = +\,0.000613$; and from the first and second observations, $D = +\,8^\circ.12 + y\,(t - 1830) + z\,(t - 1830)^2$; hence d for 1810, $+\,7^\circ.13$.

From these seven values we find—

$$D = + 8^\circ.232 + 0.0612\,(t - 1830) + 0.000534\,(t - 1830)^2$$
$$\varepsilon_0 \pm + 6'.8 \qquad T = 1772.8\,;\; v = + 0.061 + 0.0011\,(t - 1830)$$
$$d = + 6^\circ.48 \qquad v \text{ for } 1850 = + 5'.0$$

V. SECULAR CHANGE AT ALBANY, NEW YORK—LATITUDE 42° 39′, LONGITUDE 73° 44′.

We have the following observations:

October,	1817,	declination	50° 44′ W.,	Mr. DeWitt, in Silliman's Journal, vol. xvi, 1829.
August,	1818,	"	5 45 W.,	" " " " " "
April,	1825,	"	6 00 W.,	" " " " " "
	1828,	"	6 14 W.,	Silliman's Journal, vol. xxxix, 1840.
	1830,	"	6 18 W.,	Silliman's Journal, " "
	1831,	"	6 32 W.,	Silliman's Journal, " "
	1834,	"	6 40 W.,	Regent's report in Silliman's Jour., vol. xxxiv, 1838.
	1836,	"	6 47 W.,	Regent's report in Silliman's Journal, vol. xliii, 1842.

From the above we deduce—

$$D = + 6^\circ.356 + 0.0682\,(t - 1830) + 0.00128\,(t - 1830)^2$$
$$\varepsilon_0 = \pm 5'.9 \qquad T = 1803.4\,;\; v = + 0^\circ.068 + 0.0026\,(t - 1830)$$
$$d = + 5^\circ.43 \qquad v \text{ for } 1850 = + 7'.2$$

VI. SECULAR CHANGE AT WASHINGTON, D. C., AND PENSACOLA, FLORIDA.

At these two stations the observations are as yet too few in number to be submitted to a discussion, but this may be done as soon as a new determination can be had. The same may be said of Baltimore, Md., Milledgeville, Ga., Savannah, Ga., and New Orleans.

New observations at the stations Burlington, Nantucket, Albany, and probably Chesterfield, will render them available for the general discussion. The early minimum at Nantucket is probably as anomalous as the late minimum at Chesterfield. The preceding discussion, with the exception of the result at Nantucket, tends again to a later minimum for stations to the northward of New York and Boston. The best value at present deducible for the epoch of the minimum, including the whole geographical extent, may be assumed to be the general mean of the T's, which is 1797.2 ± 8.0 years.

d. Establishment of formulæ expressing the secular variation in the magnetic declination at any place within the geographical limits of stations named in the discussion.

We have seen that the co-efficients in the formula for the magnetic declination depend upon the geographical position of the station, and it now remains to express this dependence analytically.

The declination has been expressed by the formula $D = C + C'\,(t - 1830) + C''\,(t - 1830)^2$, where C is a constant (the former x) and C' and C'' stand for the former co-efficients y and z.

Now, C' may be expressed by a formula involving a constant term and terms of differences of latitude and longitude, viz:

$$C' = c' + x + y\,(l - L) + z\,(m - M)\cos l + u\,(l - L)^2 + v\,(m - M)^2 \cos^2 l,$$

where c' is an average value of all the C'.

L the mean latitude, M the mean longitude, and $x\ y\ z\ u\ v$, are unknown co-efficients to be determined.

The following table has been formed from the preceding discussion:

Station.	l.	m.	10000 C′	1000000 C″
	°	°		
Boston	42.3	71.0	647	624
Cambridge	42.4	71.1	702	720
Providence	41.8	71.4	764	959
New Haven	41.3	72.9	500	857
New York	40.7	74.0	642	944
Hatboro'	40.1	75.1	683	1169
Philadelphia	40.0	75.2	684	1340
Charleston	32.8	79.8	485	722
Mobile	30.2	88.0	72	123
Havana	23.1	82.4	98	255
Mean	L = 37.5	M = 76.1	c' = 528	c'' = 771

Putting $l - \mathrm{L} = \lambda$

$(m - \mathrm{M}) \cos l = \mu$ and $c' - \mathrm{C}' = \Delta'$, we obtain the conditional equation—

$$0 = \Delta' + x + y\,\lambda + z\,\mu + u\,\lambda^2 + v\,\mu^2$$

Substituting the above values and forming the conditional and normal equations, we find the values for $x\ y\ z\ u$ and v as follows:

$$x = +\ 79\ ;\ y = +\ 24\ ;\ z = +\ 2.5$$
$$u = -\ 0.28 \text{ and } v = -\ 3.42$$

Hence the expression for C′ becomes—

$$\mathrm{C}' = +\ 0.0607 + 0.00240\,\lambda + 0.00025\,\mu - 0.000028\,\lambda^2 - 0.000342\,\mu^2$$

The original equations are represented as follows:

Station.	C′	C′ comp'd.	Δ
Boston	0.0647	0.0658	+ 0.0011
Cambridge	0.0702	0.0663	— 0.0039
Providence	0.0764	0.0655	— 0.0109
New Haven	0.0500	0.0668	+ 0.0168
New York	0.0642	0.0669	+ 0.0027
Hatboro'	0.0683	0.0665	— 0.0018
Philadelphia	0.0684	0.0668	— 0.0016
Charleston	0.0485	0.0463	— 0.0022
Mobile	0.0072	0.0080	+ 0.0008
Havana	0.0098	0.0114	+ 0.0016

This is a satisfactory agreement, as appears from a comparison of the average probable error ε_y (of a former table) and the probable error of C′ as deduced from the above Δ.

$$\text{We have } \varepsilon_y = \pm\ 0.0046 \text{ and } \varepsilon_{\mathrm{C}'} = 0.674\sqrt{\frac{\Delta^2}{n-5}}\ ;\ \varepsilon_{\mathrm{C}'} = \pm\ 0.0063.$$

Hence the above formula represents the co-efficient C′ nearly as close as it was itself deduced at the separate stations.

Similarly, the second co-efficient C″ may be expressed by—

$$\mathrm{C}'' = c'' + x + y\,(l - \mathrm{L}) + z\,(m - \mathrm{M}) \cos l + u\,(l - \mathrm{L})^2 + v\,(m - \mathrm{M})^2 \cos^2 l$$

$$\text{and } 0 = \Delta'' + x + y\,\lambda + z\,\mu + u\,\lambda^2 + v\,\mu^2$$

We find

$$\mathrm{C}'' = +\ 0.000850 + 0.000196\,\lambda + 0.000251\,\mu + 0.000008\,\lambda^2 - 0.000023\,\mu^2$$

This formula does not represent the values of C″ as closely as we might have expected, yet differences of 0.00200 might have been anticipated from an inspection of C″ for Hatboro' and Philadelphia. The greatest difference is for Providence, viz: — 0.000274. When the station for which C″ is to be found is situated within the range of the position of the above places, the formula may be applied, yet it will be found preferable to make use of a more simple relation of the co-efficients C' and C''. Referring to the table showing C' and C'', their increasing ratio is apparent, and putting $C'' = n\,C'$ we have for

Boston	$n = 0.010$
Cambridge	0.010
Providence	0.013
New Haven	0.017
New York	0.015
Hatboro'	0.017
Philadelphia	0.018
Charleston	0.015
Mobile	0.017
Havana	0.026

which relation is sufficiently regular to allow the interpolation of any value desired within its range.

C' and C'' being thus known, an observed value of the declination at a given place will determine the constant C, and will enable us to deduce the declination for any time t. For this place the epoch of the minimum becomes known by the expression $1830 - \frac{C'}{2C''}$ andthe annual variation by $v = C' + 2C''\,(t - 1830.)$

Before concluding this paper it was thought proper to refer to a few circumstances closely related to the preceding discussion, and tending to modify conclusions arrived at by others.

1. In the Phil. Trans. Royal Society, vol. xi (abrid.) from 1755 to 1763, we find the paper on the variations which Prof. Hansteen has made use of in the construction of some his charts of isogonic lines in his "Erdmagnetismus." The following is an abstract of a small part of this paper: "On the variation of the magnetic needle, with a set of tables exhibiting the results of upwards of 50,000 observations in six periodic reviews from the year 1700 to the year 1756, and adapted to every fifth degree of latitude and longitude, by W. Mountaine and J. Dodson, F. F. R. S."

Latitude.	Longitude.	Declinations in			
		1700.	1730.	1744.	1756.
25	80	$4\frac{3}{4}$ E.	------------	$3\frac{1}{2}$ E.	3 E.
30	80	$2\frac{1}{2}$ E.	------------	$\frac{3}{4}$ E.	0
35	75	$2\frac{1}{4}$ W.	------------	$6\frac{1}{2}$ W.	7 W.
40	70	7 W.	9 W.	$11\frac{1}{2}$ W.	$12\frac{3}{4}$ W.

Now we know, from the preceding discussion, that the western declination had been *decreasing* since 1700, reached a maximum annual decrease in 1744, and continued decreasing down to about 1797, while the above table (see the last two lines in the above table) gives an *increase* during that interval of time, and is therefore entirely at variance with the observations taken on land. From this cause some of the geographical representations in the "Erdmagnetismus," based thereon, require considerable correction.

2. The rate of secular change used for the construction of the lines of equal magnetic declination on the Atlantic ocean, by Col. Sabine, (Phil. Trans. Royal Society, 1849,) was derived from comparison with the map of declination for 1787, in Prof. Hansteen's work referred to above. This assumes a uniform progressive rate of the secular change, and though applicable for other places, St. Helena for instance, (see Col. Sabine's paper, read May 18th, 1854,) is, as we have seen, entirely inadmissible on our Atlantic coast, and may even give no rate at all for the time of the maximum rate. In consequence of this, the rates deduced in Table No. X,

Trans. of 1849, are much in error, and affect more or less the resulting isogonic lines depending on it. For latitude 40° N., longitude 75° W., the table gives an annual variation for 1840 = 0'.0, when it should be + 5'.7.

3. In Professor Hansteen's paper on the changes in the magnetic inclination in the north temperate zone, (Astronomische Nachricten, Nos. 947, 948, and 954,) the declination is stated to have a retrograde motion, as inferred from Professor Loomis' table in Silliman's Journal, volume xxxix, and in consequence of which an easterly motion is assigned to the pole B, (pages 187 and 192, No. 948.) Again, on page 282, No. 954, it is said that in North America the *western* declination *decreases* and the easterly increases; which, however, is not the case, as has been seen, for, since the minimum about the beginning of the present century, the reverse has taken place, the westerly declination having ever since *increased*, (or the easterly diminished.) Professor H.'s pole B, therefore, appears to have reached its most easterly position about 1797, and has ever since been moving to the *westward*.

After the above paper had been submitted to you, under date of July 6, 1855, *I received your instructions to proceed to the eastern States and determine the three magnetic elements at a number of stations. The results of this trip, made in August and September*, 1855, *are herewith appended, (as far as referring to this investigation,) together with the corrected numerical co-efficients in the formula of the preceding discussion, resulting from the addition of the newly observed declinations.*

Confining this appendix to the discussion headed *b* and *d*, the following improvements may be inserted in their respective place:

To *b*.—Commencing with the northernmost station, Burlington Vt., we have the additional observation 9° 57'.1 west in August, 1855. This observation proves that of 1837 to have been considerably in error; and as it was principally upon the testimony of this determination that the result for secular change was not in conformity with other stations, its omission and the substitution of my new observation will at once produce the normal shape in the curve expressing the secular variation. The discussion gives:

$$D = +\ 8^{\circ}.22 + 0.0494\ (t - 1830) + 0.000831\ (t - 1830)^2$$

The observations are satisfied as follows:

t.	D observed.	D computed.	C — O.
	°	°	°
1793	+ 7.63	+ 7.53	— 0.10
1818	7.50	7.74	+ 0.24
1822	7.70	7.87	0.17
1830	8.17	8.22	+ 0.05
1831	8.25	8.27	— 0.02
1832	8.42	8.32	0.10
1834	8.83	8.43	— 0.40
1855.6	+ 9.95	+ 10.02	+ 0.07

The second station presenting itself is Boston, where the declination was observed 10° 13'.7 W. in August, 1855; the introduction of this observation produces the expression—

$$D = +\ 8^{\circ}.33 + 0.0622\ (t - 1830) + 0.000596\ (t - 1830)^2.$$

which leaves a difference of + 0°.07 in the computed and observed declination of 1855; ε_0 becomes ± 12'.

The next station is Providence, at which place the interpolated declination for 1844.8 will be omitted and the new one introduced, viz: 9° 31'.5 W. for August, 1855; we then have

$$D = +\ 7^{\circ}.43 + 0.0664\ (t - 1830) + 0.000852\ (t - 1830)^2.$$

For 1855.6 this formula gives D = + 9°.52 and C — O = + 0°.16; ε_0 becomes ± 7'.

Next in order is Nantucket, where, as it was to be expected, the introduction of the observation of August, 1855, viz: 9° 58'.6 W., would not suffice to give the proper curvature to the secular line; it became, therefore, necessary to assume $C'' = 0.01\ C'$. The conditional equations then take the shape—

$$o = d_1 - \mathrm{D} + x + y\left((t - 1830) + 0.01\ (t - 1830)^2\right)$$

The former interpolated value for 1810 is of course omitted, and we find—

$$\mathrm{D} = +\ 8^{\circ}.16 + 0.0619\ (t - 1830) + 0.\ 000619\ (t - 1830)^2$$

The observations are represented as follows:

t.	D observed.	D computed.	C — O.
	°	°	
1775	+ 6.50	+ 6.64	+ 0.14
1834	8.45	8.42	— 0.03
1838.9	9.04	8.76	0.28
1842.7	9.15	9.05	0.10
1843.7	9.17	9.13	— 0.04
1846.6	9.23	9.36	+ 0.13
1855.6	+ 9.98	+ 10.15	+ 0.17

and $\varepsilon_0 = \pm\ 8'$.

The next station, Albany, New York, presents a peculiarity in its discussion, arising from the want of observations prior to 1817, of which the new observation in August, 1855, viz: 7° 54′.7 W., could not free it. This observation was taken at Greenbush, latitude 42° 37′.5 N., and longitude 73° 44′.0 W., and opposite Albany. In order to distribute the observations, as near as may be, over the time elapsed between 1817 and 1855, the means of the first two observations, of the four following, and of the two preceding the last, have severally been taken. Their discussion furnishes the equation:

$$\mathrm{D} = +\ 6^{\circ}.40 + 0.0581\ (t - 1830) + 0.000040\ (t - 1830)^2;$$

which, like the preceding at Nantucket, can only be used for local interpolation.

The observations are represented as follows:

(Mean t.)	D observed.	D computed.	C — O.
	°	°	°
1818.2	+ 5.74	+ 5.73	— 0.01
1828.6	6.27	6.32	+ 0.05
1835.0	6.72	6.69	— 0.03
1855.7	+ 7.91	+ 7.92	+ 0.01

The curve is nearly straight, and no minimum can be obtained.

At Salem we have the following observation:

Declination in August, 1855, 10° 49′.7 W. at Fort Lee. Introducing this, we obtain the formula:

$$\mathrm{D} = +\ 6^{\circ}.96 + 0.1060\ (t - 1830) + 0.002222\ (t - 1830)^2$$

confirming the abnormal character of the station.

The observations are represented as follows:

t.	D observed.	D computed.	C — O.
	°	°	°
1781.6	+ 7.05	+ 7.04	— 0.01
1805.8	5.95	5.70	— 0.25
1808.4	5.33	5.70	+ 0.37
1810.5	5.80	5.75	— 0.05
1849.6	10.24	9.89	— 0.35
1855.6	+ 10.83	+ 11.12	+ 0.29

The ε_0 becomes ± 15′.

The next regular station reoccupied is New Haven, Ct. The declination observed in August, 1855, was 7° 02′.7 W. at Oyster Point, and its introduction changes the formula to

$$D = + 5^{\circ}.40 + 0.0475\,(t - 1830) + 0.000814\,(t - 1830)^2;$$

the last observation is represented within + 0°.11, and ε_0 becomes ± 11′.

We have next, at New York, the following observations, in August, 1855:

	° ′
At Governor's island	6 39.6
Bedloe's island	6 62.1
Receiving reservoir	6 28.0

The mean + 6°.72 is here introduced, together with the declination observed at Mount Prospect, near New York, latitude 40° 40′.3 N., and longitude 73° 57′.7 W., viz: 5° 54′.7 W. in April, 1846; U. S. Coast Survey, Dr. J. Locke, observer. The discussion gives the following expression:

$$D = 5^{\circ}.07 + 0.0536\,(t - 1830) + 0.000800\,(t - 1830)^2$$

The observations are represented as follows:

t.	D obs'd.	D comp'd.	C. — O.
	°	°	°
1750	+ 6.37	+ 5.90	— 0.47
1755	5.00	5.55	+ 0.55
1789	4.33	4.22	— 0.11
1824	4.67	4.78	+ 0.11
1834	4.83	5.29	+ 0.46
1837	5.67	5.48	— 0.19
1841	6.10	5.76	0.34
1844.7	6.22	6.03	0.19
1845.7	6.42	6.11	— 0.31
1846.3	5.91	6.16	+ 0.25
1855.6	+ 6.72	+ 6.97	+ 0.25

ε_0 becomes ± 15′.

The declination at Sandy Hook may be made to depend on that of New York. Sandy Hook light is in latitude 40° 27′.6 N., longitude 73° 59′.9 W. The observation of 1775 has already been noticed and found unreliable. We have the following determination of the U. S. Coast Survey. In August, 1844, declination 5° 54′.0 W., by J. Renwick; in August, 1855, declination 6° 11′.2 W., by myself. The difference between the observed declinations at New York and Sandy Hook, of the same date, makes in the mean, the latter smaller by 0°.43.

At Philadelphia, the Girard College station was re-occupied in September, 1855, and the declination found 4° 31′. 7 W.; the substitution of this observation in the former discussion gives

$$D = + 2^{\circ}.52 + 0.0595\,(t - 1830) + 0.001232\,(t - 1830)^2$$

The last observation is represented with a difference of C. — O. = + 0°.32, mostly due to the errors of former observations. ε_0 becomes ± 21′.

For Cape May and vicinity the observations are numerous, but many of them very erroneous, as seen in the following collection.

In Des Barres' *Atlantic Neptune* we find the declination 6° W. for 1775; this is quite unreliable. In the same place the declination between Cape May and Cape Henlopen for 1775 is given 6° 45′ W. In Silliman's Journal, vol. xxxiv, 1838, we find the declination at Lewistown, latitude 38° 44′ N., longitude 75° 00′ W., 0° 55′ W. for the year 1795. The Phil. Trans. Royal Society, 1849, give the declination for Cape Henlopen 4° 42′ W. for May, 1841, as determined by Barnett. The following declinations have been determined by the U. S. Coast Survey: At Cape May light-house (old) in June, 1846, 3° 05′.1 W., latitude 38° 55′.8 N., longitude 74° 57′.6 W.; Dr. J. Locke, observer. (See annual Report of 1854.) The declination at Pilot Town, Cape Henlopen, in latitude 38° 47′.1 N., longitude 75° 09′.2 W., in July, 1846, 2° 42′.7 W., by the same observer; the declination at Lewis' landing, latitude 38° 48′.8 N., longitude 75° 11′.5 W., in July, 1846, 2° 47′.7 W.; and the declination at Townbank, latitude 38° 58′.6 N., longitude 74° 57′.4 W., in June, 1846, 2° 59′ W.; all by the same observer. The last determination is by myself, in latitude 38° 55′.8 N., and longitude 74° 57′.4 W.; near the light-house, in August, 1855, 3° 45′.4 W.

We have, therefore, for discussion—

Year.	Station.	Declination.	Reduced to Cape May.	Remarks.
		°	°	
1775.0	Cape Henlopen	+ 6.00	+ 6.12	Rejected; 4¾° in error.
1775.0	Between Cape Henlopen and Cape May	6.75	6.80	Rejected; 5¼° in error.
1795.0	Lewistown	0.92	1.00	
1841.4	Cape Henlopen	4.70	4.82	Rejected; 2° in error.
1846.5	Cape May Light	3.09	3.09	Mean + 2°.96.
"	Pilot Town	2.71	2.86	
"	Lewis' Landing	2.78	2.93	
"	Townbank	2.98	2.98	
1855.6	Cape May Light	+ 3.76	+ 3.76	

From the remaining three values we deduce the formula—

$$D = + 0°.88 + 0.0532\,(t - 1830) + 0.000809\,(t - 1830)^2$$

The minimum occurs in 1797.1 with the corresponding $d = 1°.00$

At Washington, D. C., the results for declination are greatly affected by local attraction, as seen from the following observations.

In Silliman's Journal, vol. xxxiv, 1838, we find King's observation of 1809, when the declination was 52′ W. In the Senate Documents, 2d Session 28th Congress, 1844–45, we find the record of the observations made on Capitol Hill, in latitude 38° 53′ N., longitude 77° 00′ W., by Lieut. J. M. Gilliss, in 1840–41–42, when the declination was 1° 20′ 12″.7 W. for 1840–41, and 1° 23′ 56″.9 W. for 1841–42. The following observations are by the U. S. Coast Survey: Causten, occupied by Assistant G. W. Dean, in June, 1851, gave as result 1° 11′.3 W. In September, 1855, I found 1° 10′.3; in October, 1855, 1° 02′.0, and at the old magnetic station, a short distance off, 1° 06′.0. At the Smithsonian Institution grounds, a few feet to the eastward of the Magnetic Observatory, I found in July, 1855, the declination 5° 44′.2 W., and greatly varying on the ground, and a back sight from near Gilliss' station on Capitol Hill gave for this latter locality 2° 24′ (within 10′, the limit of reading off). We have, therefore, for discussion, the observations of 1809, of 1841.5, and of 1855.5, from which

$$D = + 0°.88 + 0.0412\,(t - 1830) + 0.001080\,(t - 1830)^2$$

and the following differences:

t	D observed.	D computed.	C. — O.
	°	°	°
1809	+ 0.87	+ 0.49	— 0.38
1840.5	1.37	1.43	+ 0.06
1841.5	1.40	1.49	0.09
1855.5	+ 2.40	+ 2.63	+ 0.23

T = 1810.9, and the corresponding $d = + 0°.49$.

Combining the above new results with those before reduced, we can now substitute the following table for the corresponding preceding one:

Synopsis of results for the secular variation in the magnetic declination. (See dotted curves, Diagrams Nos. 4 and 5.)

No.	Name of station.	Latitude.	Longitude.	$D = x + y(t-1830) + z(t-1830)^2$		
				x.	y.	z.
		° ′	° ′	°		
1	Burlington, Vt.	44 28	73 10	+ 8.22	0.0494	+ 0.000831
2	Boston	42 20	71 02	8.33	0.0622	0.000596
3	Cambridge	42 23	71 07	8.55	0.0702	0.000720
4	Providence	41 50	71 24	7.51	0.0664	0.000852
5	New Haven	41 17	72 55	5.40	0.0475	0.000814
6	New York	40 43	74 00	5.07	0.0536	0.000800
7	Hatboro'	40 07	75 08	2.86	0.0683	0.001'69
8	Philadelphia	39 58	75 10	2.52	0.0595	0.00.232
9	Cape May	38 56	74 57	0.88	0.0532	0.000809
10	Washington	38 53	77 01	+ 0.88	0.0412	0.001080
11	Charleston	32 45	79 51	− 3.33	0.0485	0.000722
12	Mobile	30 14	88 00	7.24	0.0072	0.000123
13	Havana, Cuba	23 09	82 22	− 6.08	+ 0.0098	+ 0.000255

Second table of results.

No.	Name of station.	ε	T		$v = y + 2z(t-1830.)$		v
					y	$2z$	1850.
		′		°	°		′
1	Burlington, Vt.	± 10	1800.3	+ 7.49	+ 0.049	+ 0.00166	+ 4.9
2	Boston	12	1777.8	6.72	0.062	0.00119	5.2
3	Cambridge	5	1781.2	6.83	0.070	0.00144	5.9
4	Providence	7	1791.0	6.14	0.070	0.00178	6.0
5	New Haven	11	1800.8	4.71	0.047	0.00163	4.8
6	New York	15	1796.5	4.15	0.054	0.00160	5.2
7	Hatboro'	8	1799.5	1.87	0.068	0.00224	6.8
8	Philadelphia	± 21	1805.9	1.80	0.060	0.00246	6.5
9	Cape May	....	1797.1	1.00	0.053	0.00162	5.1
10	Washington	....	1810.9	+ 0.49	0.041	0.00216	5.0
11	Charleston	± 10	1796.4	− 4.16	0.048	0.00144	4.6
12	Mobile	....	1800.6	7.35	0.007	0.00024	0.7
13	Havana, Cuba	....	1810.8	− 6.17	+ 0.010	+ 0.00051	+ 1.2

ε_x ε_y and ε_z remain the same, the change in ε_0 being too inconsiderable.

The average T from the first seven stations is 1792.4, and from the last six 1803.6, and the mean T = 1797.6 ± 1.8 years.

To the northward and eastward of Philadelphia, within the limits of the discussion, we may therefore assume the minimum to have taken place about five years earlier, and to the southward of that place about the same number of years later than the mean epoch.

To *d*.—The re-discussion of the co-efficient C^1 in regard to the geographical position of the stations furnished the following numerical result for the co-efficients x, y, z, u, and v:

$$10000\, C^1 = +556 - 10.4\,(l - 37^\circ.5) - 44.4\,(m - 76^\circ.1) \cos l - 1.65\,(l - 37^\circ.5)^2 - 0.08\,(m - 76^\circ.1)^2 \cos^2 l\,;$$

or,

$$C^1 = +0.0556 - 0.00104\,\lambda - 0.00444\,\mu - 0.000165\,\lambda^2 - 0.000008\,\mu^2$$

which equation satisfies the co-efficients C^1 (or the former y) as follows:

No.	Name of station.	C′	C′ computed.	Δ
1	Burlington, Vt.	0.0494	0.0496	+ 0.0002
2	Boston	0.0622	0.0636	+ 0.0014
3	Cambridge	0.0702	0.0629	— 0.0073
4	Providence	0.0664	0.0634	— 0.0030
5	New Haven	0.0475	0.0600	+ 0.0125
6	New York	0.0536	0.0577	+ 0.0041
7	Hatboro'	0.0683	0.0533	— 0.0130
8	Philadelphia	0.0595	0.0551	— 0.0044
9	Cape May	0.0532	0.0534	+ 0.0002
10	Washington, D. C.	0.0412	0.0507	+ 0.0095
11	Charleston	0.0485	0.0431	— 0.0054
12	Mobile	0.0072	0.0129	+ 0.0057
13	Havana, Cuba	0.0098	0.0105	+ 0.0007

The last column gives $\varepsilon_{C''} = \pm 0.0057$, which approaches still closer to $\varepsilon_y = \pm 0.0046$, as deduced from the differences at each station.

The second co-efficient C″ has been deduced from the mean of the values for C′, and C′ computed, and was found as follows:

From Burlington	$n =$ 0.016	
Boston	0.010	
Cambridge	0.012	
Providence	0.013	
New Haven	0.015	
New York	0.016	
Hatboro'	0.019	
Philadelphia	0.021	
Cape May	0.015	
Washington	0.023	
Charleston	0.016	
Mobile	0.014	
Havana	0.025 ;	where $C'' = n\,C'$

The values just deduced should be used in connection with the formulæ—

$$D = C + C'\,(t - 1830) + C''\,(t - 1830)^2 \text{ and}$$
$$v = C' + 2\,C''\,(t - 1830)$$

Before closing this appendix it will be seen that a lookout for the time of inflexion, to be expected about 1867 ± 15 years, was not premature; and, indeed, we find from the following comparison of the computed and my last observed declinations that the latter always falls short of the former—a plain indication that the curve commenced turning its concave side towards the axis of abscissæ; or, in other words, that in 1855.5 the maximum annual increase had already been passed.

Station.	D computed for 1855.5.	D observed in 1855.5.	C. — O.
	°	°	°
Burlington, Vt.	+ 10.02	+ 9.95	+ 0.07
Albany	8.45	7.91	0.54
Salem	11.12	10.83	0.29
Boston	10.30	10.23	+ 0.07
Cambridge	10.76	10.90	— 0.14
Providence	9.68	9.52	+ 0.16
Nantucket	10.15	9.98	0.17
New Haven	7.16	7.05	0.11
New York	6.97	6.72	0.25
Philadelphia	4.85	4.53	0.32
Washington	+ 2.63	+ 2.40	+ 0.23

The average difference is $+ 0°.19 = 11'$. The precise date of the maximum annual change cannot now be ascertained, and must be left to a future series of observations; but it is recommended, in the application of the formulæ, for the present time to use the annual variation of 1850 as a constant for some years, at least till a new series clears up the point in question. Thus, for example, the declination at Boston in 1870 will be found by computing the increase for 20 years (the difference of 1870 and 1850) prior to 1850 and adding the same to the declination for 1850; the declination at Boston for 1870 becomes $+ 9°.81 + 1°.48 = 11° 18'$ W.

Without stepping off the positive ground heretofore occupied, I may be allowed to direct your attention to the following epochs:

		Differences.
Deduced maximum declination in	1679 ± 10 years.	
		62 years.
Known first point of inflexion	1741 ± 10 years.	
		57 years.
Known minimum declination	1798 ± 2 years.	
		52 years.
Supposed second point of inflexion,	1850.	

From which it appears that the periods are diminishing, or the velocity of the secular variation is increasing, which latter remark is sustained by the comparison of $V_{1741} = - 4'.6$ with $V_{1850} = + 6'.8$ or $+ 5'.9$, as deduced from all the northern stations. Finally, I consider the prediction of the next maximum too hazardous to deserve our attention at present.

I remain, sir, very respectfully yours,

CHAS. A. SCHOTT.

Prof. A. D. BACHE,
Superintendent Coast Survey.

APPENDIX No. 49.

Results of observations made by Chas. A. Schott, Esq., computing division Coast Survey Office, for magnetic declination, dip, and horizontal intensity.

No. of stat'n.	Name of station.	Date.	Latitude.	Longitude.	Declination W.	Dip.	Horizontal force.	Intensity.
		1855.	° ′	° ′	° ′	° ′		
1°	Washington, Smithsonian grounds	July 20, 31	38 53.2	77 01.2	5 44.2	71 27.0	4.338	13.64
2	Cape May, light-house	August 3	38 55.8	74 57.4	3 45.4	71 34.4	4.182	13.23
3	New York, Governor's island	August 7	40 41.5	74 00.8	6 39.6	72 46.3	3.926	13.25
4	New York, Bedloe's island	August 8	40 41.4	74 02.3	7 02.1	72 59.3	3.920	13.40
5	New York, receiving reservoir	August 10, 11	40 46.7	73 57.8	6 28.0	72 44.4	3.938	13.27
6	Sandy Hook, light-house	August 14	40 27.6	73 59.9	6 11.2	72 52.0	3.917	13.30
7	New Haven, Oyster Point	August 17	41 16.9	72 55.5	7 02.7	73 44.4	3.690	13.18
8	Providence, Brown University	August 20	41 50.0	71 23.6	9 31.5	74 15.9	3.590	13.24
9	Nantucket, harbor-light	August 22	41 17.5	70 05.7	9 58.6	74 00.6	3.626	13.16
10	South Boston, heights	August 24	42 20.0	71 02.2	10 13.7	74 29.5	3.545	13.25
11	Salem, Fort Lee	August 25	42 31.9	70 52.1	10 49.7	75 36.9	3.489	14.03
12	Burlington, Vt., encampment	August 28	44 27.5	73 10.0	9 57.1	75 56.8	3.425	14.19
13	Greenbush, opposite Albany	August 31	42 37.5	73 44.0	7 54.7	75 11.1	3.587	14.03
14	Cold spring, on the Hudson	September 1	41 25.0	73 57.3	5 34.0	73 54.8	3.790	13.68
15	Philadelphia, Girard College	September 5	39 58.4	75 09.8	4 31.7	72 17.7	4.226	13.89
16	Georgetown, Causten	Sept. 8, Oct. 9	38 55.5	77 04.1	1 06.1†	71 29.5	4.250	13.40

° Reoccupied September 7 and 13; also October 6.

† Declination, September 8, 1° 10.′3, and October 9, 1° 02′; and at Assistant Dean's station, 1° 06′ W.

APPENDIX No. 50.

Approximate cotidal lines of the Pacific coast of the United States, from observations in the United States Coast Survey, by A. D. Bache, Superintendent.

[Communicated to the American Association for the Advancement of Science, under authority of the Treasury Department.]

The western coast of the United States, between San Diego, California, and Columbia river, extending through 13° 35′ of latitude and 6° 43′ of longitude, is divided into three reaches, (Plate No. 49,) the first from San Diego to Point Conception, the second from this point to Cape Mendocino, and the third from that cape to Cape Disappointment at the mouth of the Columbia. The first reach, about 220 miles in extent, is curved, the general trend being about N. 56° W. The second, about 430 miles in extent, is, in general, straight, with moderate indentations only, and its trend is about N. 27° W. The third, 370 miles in extent, is also nearly straight, trending nearly N. 5° E.

The soundings on the coast generally, except in the harbors, have been for the purpose of general reconnaisance, and are not detailed enough to show the configuration of the bottom.

TIDAL OBSERVATIONS.

Tidal stations for long series of observations have been established at San Diego, San Francisco, and Astoria, (Columbia river,) and between these, temporary stations at the points and for the periods stated in the annexed general table. Saxton's self-registering gauge has been employed at the permanent stations generally, and at some of the temporary stations also.

The observations are under the direction of Lieutenant W. P. Trowbridge, U. S. corps of Engineers and assistant in the Coast Survey. They were commenced in 1853, and are still in progress. The very intelligent and careful supervision of this officer is a guaranty for the character of the observations. The observers, too, were especially selected by him for their faithfulness and intelligence.

The number of results collected is such as to warrant an approximate determination of the cotidal lines of this coast, to be checked when further results are obtained. This attempt has the advantage of pointing out deficiencies in the series which otherwise would not so clearly appear. The following table shows the localities of observation and the duration of each series embraced in this discussion, the name of the observer, and the kind of gauge employed.

TABLE I.

Tide stations on the western coast of the United States, the results of which are discussed in this paper.

	Stations.	Time.	Gauges.	Observers.
1	San Diego	9 months, (1853–'54)	Self-registering	A. Cassidy.
2	San Pedro	4 months, (1853–'54)	do	T. A. Szabo.
3	San Luis Obispo	2 months, (1854)	Box	G. Sherman.
4	Monterey	2 months, (1854)	Self-registering	J. Ord.
5	Santa Cruz	1 month, (1853)	Staff	
6	San Francisco	12 months, (1853–'54)	Self-registering	G. Sherman, H. E. Uhrlandt.
7	Bodega	3 months, (1854)	do	T. A. Szabo.
8	Humboldt bay	2½ months, (1854)	Box	J. A. Black.
9	Port Orford	2½ months, (1854)	Self-registering	T. A. Szabo.
10	Cape Disappointment	2 months, (1854)	Staff	J. A. Black.
11	Astoria	9 months, (1853–'54)	Self-registering	J. Wayne.

These results were in part tabulated by Lieutenant Trowbridge and in part in the tidal division of the Coast Survey office, under the immediate direction of Assistant L. F. Pourtales. The discussions were made in general by Messrs. Heaton and Hawley of the same division.

The times of high water are referred to the next preceding transit of the moon, transit F of Mr. Lubbock's nomenclature, the epoch having been found to correspond to that transit. The mean interval between the time of the moon's transit and the time of high water, or the establishment corrected for half-monthly inequality for each station, is given in the following table. A correction to carry the results to deep water is applied in the way described in my paper on the cotidal lines of the Atlantic coast of the United States,* giving the establishment used in obtaining the cotidal hour.

The latitude and longitude from Greenwich of each tidal station is given in the table to the nearest minute. The cotidal hour, found from the establishment corrected for depth and the longitude from Greenwich, is in the last column of the table. It is not necessary to apply a correction for the different transits, as the difference between the greatest and least corrections amounts to but five minutes.

TABLE II.

Data for the cotidal lines of the Pacific coast of the United States.

No.	Stations.	Corrected Establ.		Correction for depth.	Final corr. Establ.		Latitude north.		Longitude west.		Cotidal hour.	
		h.	*m.*	*m.*	*h.*	*m.*	°	′	°	′	*h.*	*m.*
1	San Diego	9	42	10	9	32	32	42	117	13	17	21
2	San Pedro	9	37	10	9	27	33	43	118	16	17	20
3	San Luis Obispo	10	4	3	10	1	35	11	120	43	18	04
4	Monterey	10	20	0	10	20	36	36	121	54	18	28
5	Santa Cruz	10	16	3	10	13	36	57	122	00	18	21
6	San Francisco, north beach	11	56	9	11	47	37	48	122	26	19	57
7	Bodega	11	19	9	11	10	38	18	123	03	19	22
8	Humboldt bay	12	2	9	11	53	40	45	124	10	20	10
9	Port Orford	11	26	0	11	26	42	44	124	29	19	44
10	Columbia river, Cape Disappointment	12	0	16	11	44	46	17	123	56	20	00

COTIDAL HOURS.

The cotidal hours thus far obtained between San Diego and Cape Disappointment, Columbia river, are contained between 17*h.* 20*m.* and 20*h.* 10*m.*, increasing as a general rule, but with striking exceptional cases, and not regularly in passing northward. The cotidal hour of 17*h.* 20*m.* characterizes the two stations in the southern reach, referred to in the description of the coast; 18*h.*, 19*h.*, 20*h.*, are found on the middle reach, and 20*h.* characterizes the northern.

COTIDAL GROUPS.

In discussing these results I have followed the same course as in the paper on the cotidal lines of the Atlantic, dividing the stations into natural groups and applying Lloyd's mode of discussion of magnetic lines to them.

The *northern group* of stations, between Cape Disappointment and Cape Mendocino, (Plate No. 49,) is composed of Cape Disappointment, Port Orford, and Humboldt. The mean cotidal hour is 19*h.* 58*m.* The mean of the longitudes of the stations is 124° 12′, the mean of latitudes 42° 15′. Calling the differences between the mean longitude and the longitude of each station when reduced to nautical miles x, the differences between the latitude of each station and the mean y, the difference between the cotidal hour at each station and the mean codital hour z, and assuming Σ as the sign of the algebraic sum of the numerical quantities obtained for the co-efficients of the equations furnished by each station, we form and solve the equations—

* Proceedings of the American Association for the Advancement of Science, Washington meeting, 1854.

$$\mathrm{M}\ \Sigma\, x^2 + \mathrm{N}\ \Sigma\, x\, y = \Sigma\, x\, z$$
$$\mathrm{M}\ \Sigma\, x\, y + \mathrm{N}\ \Sigma\, y^2 = \Sigma\, y\, z$$

In the case before us, M gives for the co-efficient of the longitude 1.2, and N for that of latitude $=0.006$. The tangent of the angle which the cotidal line makes with the meridian $-\frac{\mathrm{N}}{\mathrm{M}}=$ 0.05, and the angle is 2° 52′. The distance in nautical miles perpendicular to the cotidal line corresponding to one minute of establishment, or $\sqrt{\mathrm{M}^2+\mathrm{N}^2}$, is 1.2 miles, and therefore the progress of the tide-wave in one hour, 50 miles.

This is a velocity less than the depth would indicate to be correct, and from the small differences in the establishment of the stations, this must be an uncertain datum. We shall see, however, that in the next group, where the establishment varies more considerably, this datum is still less probable than the one here obtained.

The direction of the line is nearly coincident with that of the trend of the coast, the cotidal angle being 2° 52′, and the general trend of the coast differing but two degrees from it.

The cotidal hours calculated from the separate equations are, for Cape Disappointment 20*h.* 00*m.*, Port Orford 19*h.* 44*m.*, agreeing precisely with the observed; and for Humboldt 20*h.* 09*m.*, differing but one minute from the observed.

The observations bearing upon this group are extending northward; but the difficulties in the way of maintaining the stations are such on a coast inhabited by aborigines, that I do not venture to count upon speedy results. Lieut. Trowbridge is using his best efforts to establish the necessary stations.

I precede the discussion of the *middle group* of stations by a table giving the results corresponding to several different hypotheses, which will in turn be examined.

TABLE III.

Discussion of the middle group of tidal stations between Cape Mendocino and Point Conception.

Stations.	Mean longitude.	Mean latitude.	*Mean cotidal hour.*	M. Difference of cotidal hour for one geographical mile of— Longitude.	N. Latitude.	Angle. $\left\{\tan = -\frac{\mathrm{N}}{\mathrm{M}}\right\}$ Cotidal angle.	$\sqrt{\mathrm{M}^2+\mathrm{N}^2}$. Difference of cotidal hour corresponding to one geographical mile perpendicular to cotidal line.	*Miles per hour tidal wave.*	Observed — computed cotidal hour for— San Luis Obispo.	Monterey.	Santa Cruz.	San Francisco.	Bodega.
	° ′	° ′	*h. m.*			° ′	*m.*		*m.*	*m.*	*m.*	*m.*	*m.*
1. San Luis Obispo, Monterey, Santa Cruz, San Francisco, Bodega	122 01	36 58	18 50	3.83	2.73	35 30	4.7	13	7	12	30	12	4
2. San Luis Obispo, Monterey, San Francisco, Bodega...............	122 02	36 58	18 58	3.11	2.32	36 43	3.9	15	1	1	......	2	8
3. San Luis Obispo, Monterey, San Francisco	121 41	36 32	18 50	3.07	2 35	37 26	3.9	15	......	......	......	......	....
4. San Luis Obispo, Monterey, Santa Cruz..........................	121 32	36 15	18 18	4.10	2.70	33 06	4.9	13	......	.....	......	......	....
5. Monterey, Santa Cruz, San Francisco, Bodega	122 21	37 25	18 47	3.50	2.60	36 30	4.4	14	......	......	......	......	...
6. Monterey, San Francisco, Bodega	122 28	37 34	19 16	3.35	2.60	37 37	4.2	14	......	0	......	—1	—2

Taking the five stations between Cape Mendocino and Point Conception as one group, we find from the table the angle of the cotidal line with the meridian N. 35° 30′ W., and the mean cotidal hour 18*h.* 50*m.*, the difference of establishment for one geographical mile perpendicular to the cotidal line 4.7 minutes. As the observations at Santa Cruz were comparatively few in number, it may be more proper to leave out that station, which will give for the corresponding results to those just stated, N. 36° 43′ W. for the angle of the cotidal line, 18*h.* 58*m.* for the mean cotidal hour, and 3.9 minutes for the cotidal difference in one geographical mile.

Omitting Bodega from this group, we obtain for the cotidal angle N. 37° 26′ W., for the mean cotidal hour 18*h* 50*m.*, and for the change of hour in one mile 3.9 minutes.

Omitting Bodega and San Francisco from the first group, the three southern stations, San Luis Obispo, Monterey, and Santa Cruz, give for the same values N. 33° 06′ W., 18*h*. 18*m*., and 4.9 minutes. The direction of the cotidal line being nearly the same, its denomination only is changed.

The $18\frac{1}{4}$ hours would give nearly $18\frac{3}{4}$ if carried to the cotidal line of the first hypothesis 18*h*. 50*m*., which is a good agreement.

Omissions at the other end of the group produce the same result. Leaving out San Luis Obispo from 1, we obtain for the cotidal angle N. 36° 30′ W.; cotidal hour 18*h*. 47*m*.; change per mile 4.4 minutes. The same result is obtained by other omissions in the series.

The introduction of Humboldt into a group with Bodega and San Francisco, gives results materially different from those obtained, reducing the cotidal angle to 18° 05′, and increasing the velocity to 40 miles per hour.

The combination of San Pedro with southern stations also changes the results so rapidly as to prove that the group is limited to the south of Point Conception.

The proof seems complete that these five stations form a single group. Using the determination in which Santa Cruz is omitted, for reasons already stated, we have for the cotidal angle N. 36° 43′ W., which gives an inclination to the general line of the coast of about ten degrees. The line of nineteen hours meets the coast north of Point Año Nuevo, and between it and Point San Pedro.

The comparison of the observed and computed establishments from either of these hypotheses is very satisfactory; from that of the five stations, Santa Cruz alone stands out with a difference greater than fifteen minutes. For the second list of four stations the greatest difference is twelve minutes, and the mean without regard to signs is but six minutes.

The velocity of the tide-wave is less satisfactory from the other data, rising to but fifteen miles per hour. The depth should give a greater velocity, and the comparison with the northern group would indicate a much greater.

In drawing the chart of cotidal lines, I have not followed the velocities strictly. This group, however, lies favorably for the determination of the rate of motion of the tide-wave, and the results of the various hypotheses in the table are quite consistent with each other in giving a low velocity.

The *southern group* is imperfect, as having but two stations in it. Further observations are required here, and on the islands which separate Santa Barbara sound from the great ocean.

Combining San Luis Obispo with San Diego and San Pedro, would require a retrograde wave, showing that they do not belong to the same group. The computations required in these discussions were generally made by Mr. Heaton, of the tidal division, under my immediate direction, or that of Assistant Pourtales.

CHART OF CO-TIDAL LINES.

From this discussion I have drawn a chart of approximate cotidal lines for the coast of Oregon and California (Plate No. 49.) The chart, on a scale of $\frac{1}{10000000}$, the same which was used in presenting the cotidal lines of the Atlantic coast of the United States, shows the general configuration of the coast.

The cotidal hours are marked near the several tidal stations. The straight lines resulting from the discussion of the northern and middle groups are delineated, for the northern group the cotidal lines of XIX and XX hours, and for the middle group of XVII, XVIII, XIX and XX hours.

The curves representing the approximate cotidal lines of 17, 18, 19 and 20 hours, are drawn in dotted lines, the character of the dots differing for the several lines.

The line of $17\frac{1}{2}$ hours would follow the coast nearly from San Diego to Point Conception, then the line of 18 hours nearly to Point Pinos; north of this point the lines of 18 and 19 hours meet the coast obliquely at an angle of about ten degrees, the line of 20 hours appearing near Point Arena, and following the coast generally to Cape Disappointment, the receding parts having a little later and the projecting parts a little earlier hour.

Throughout the extent of coast examined, the cotidal lines are either sensibly parallel to, or make a small angle with, the general directions of the coast. The angle made with the coast between Point Conception and Cape Mendocino is greater than is general on the long reaches of Atlantic coast.

The successive charts of cotidal lines of the Pacific have been tending towards the representation now given, as more reliable observations have been collected.

The last chart, in 1848, of the Master of Trinity, (Rev. W. Whewell*) to whom this subject owes so much of its progress, in comparison with that of Rear Admiral Lutke,† or with his own earlier map,‡ shows this tendency, the inclinations of the lines to the coast being lessened at each step.

APPENDIX No. 51.

Notice of Earthquake waves on the western coast of the United States, on the 23d and 25th December, 1854.

[Communicated to the American Association for the Advancement of Science, by A. D. Bache, Superintendent, under authority of the Treasury Department.]

In February, 1855, I received from Lieut. W. P. Trowbridge, of the Corps of Engineers, assistant in the Coast Survey, in charge of the tidal observation on the Pacific coast, a letter calling my attention to the singular curves traced by the self-registering tide-gauge at San Diego, on the 23d and 25th of December, and remarking that the irregularities of the curve could not be produced by disturbances from storms, as the meteorological records for the whole coast showed a continuance at that time of an ordinary state of weather, and the length of the wave was too great to be explained by such action. "There is every reason to presume (he continues) that the effect was caused by a sub-marine earthquake." No shock, however, has been felt at San Francisco.

When the record sheet of the self-registering gauge at San Francisco was received, similar irregularities in the curves for the same days were found upon it. The sheet for Astoria presented little or no special irregularity. These were the only self-registering gauges actually in operation at this time.

Waves of short period would, of course, escape detection by the ordinary hourly or half-hourly observations.

About the 20th of June, we received accounts from Japan of a violent earthquake on the 23d of December, the notice of which was more circumstantial than usual, from the damage to the Russian frigate *Diana*, in the port of Simoda, on the island of Niphon, from the excessive and rapid rise and fall of the water.

A detailed account of the phenomena of this earthquake, and of the rise and fall of the sea produced by it in different places on the coasts of the Pacific, is much to be desired, and I have thought that by the publication of the results obtained by the Coast Survey, the publication of official reports of the phenomena might be induced. Perhaps even similar observations may have been made, and these registers of the self-acting tide-gauge will show what observations it is desirable to have for comparison.

* Royal Society's Transactions, Vol. 66, 1848.

† Bulletin de la classe Physico-Mathematique de l'Acad. Imp. des Sciences de Petersburg, Tome II, No. 1.

‡ Royal Society's Transactions, Vol. 51, 1833.

Thus far we are left to the public prints for the information obtained,* and the different accounts are quite discrepant where they give details, and are usually, as intended merely for general information, too vague in the statements to give satisfactory means of comparison.

A correspondent of the New York Herald, writing from Shanghae, gives the following notes, stated to be derived from an officer of the frigate *Diana:*

"At 9 a. m., on the 23d of December, weather clear, thermometer 72°, barometer 30°, a severe shock of an earthquake was felt on board the frigate, shaking the ship most severely. This shock lasted full five minutes, and was followed at quick intervals by rapid and severe shocks for thirty minutes."

"At 9.30 a. m. the sea was observed washing into the bay in one immense wave, thirty feet high, with awful velocity; in an instant the town of Simoda was overwhelmed, and swept from its foundations" * * * * "This advance and recession of the water occurred five times * * * By 2*h.* 30*m.* p. m. all was quiet."

A communication in the same paper, purporting to give an extract from the log-book of the *Diana*, states that—

"At a quarter past nine, without any previous indication, the shock of an earthquake, which lasted two or three minutes, causing the vessel to shake very much, was felt both on deck and in the cabin; at ten o'clock a large wave was observed entering the bay. * * * * The rising and falling of the water were very great, the depth varying from less than eight to more than forty feet; and these changes, at intervals of about five minutes, continued until noon. * * * * * Scarcely had half an hour elapsed when the rising and falling of the water became more violent than before. Between this time and a quarter past two (when the agitation again became much less) the frigate was left four times on her side, and once while thus, laid in only four feet of water."

"Continuing to decrease in violence and frequency by three p. m., the agitation of the water, and the motion of the vessel consequent thereon, were very slow. * * * * At this time a fresh west wind was blowing, the barometer stood at 29.87, and the thermometer was 10.50 degrees R. (about 55.63 degrees F.)"

The official report of the disaster to the frigate will probably contain further and more precise particulars of the phenomena.

Mr. P. W. Graves gives, in the *Polynesian*, a notice, for which I am indebted to Mr. Meriam, of an extraordinary rise and fall of the waters at Peel's island, one of the Bonin islands, on the 23d of December. The first rise noticed was fifteen feet above high water, followed by a fall which left the reefs entirely bare. The hour when this occurred is not stated. "The tide continued to rise and fall during the day at intervals of fifteen minutes, gradually lessening until the evening."

At Peel's island, the waters rose, on the evening of the 25th of December, to the height of twelve feet; I have not, however, seen any notice of an earthquake on that day.

I present to the Association a copy of the curves traced by the self-registering gauges at the Coast Survey tidal stations at San Diego, San Francisco, and Astoria, on the 23d and 25th of December, 1854, (Plate No. 50.)

The curves, representing tides of short period, being traced upon the falling or rising curve

*Since reading this paper I have received, through the kindness of Commodore M. C. Perry, a copy of a letter from Captain H. A. Adams, U. S. N., who visited Japan in the steamer Powhatan, to exchange ratifications of the treaty between Japan and the United States. Captain Adams says: "Simoda has suffered dreadfully since your visit there. On the 23d of December there were several shocks of earthquake. The sea rose in a wave five fathoms above its usual height, overflowing the town and carrying houses and temples before it in its retreat. When it fell, it left but four feet of water in the harbor. It rose and sunk this way five or six times, covering the shores of the bay with the wrecks of boats, junks and buildings. Only sixteen houses were left standing in the whole place. The entire coast of Japan seems to have suffered by this calamity. Yedo itself was injured, and the fine city of Osaka entirely destroyed." Captain Adams then gives an account of the disaster to the Russian frigate Diana, Admiral Pontiatine commanding, which was so injured in the harbor of Simoda as to lead finally to her entire loss.

of the regular tide, their peculiarities are not so readily seen as when shown in the second diagram, (Plate No. 50) where the regular tidal curve is represented as a horizontal line. The times of the San Diego curve are reduced to San Francisco time. The curve at San Diego presents many minor irregularities, from the motion of the float not having been sufficiently checked to prevent the recording of the waves caused by the wind.

Upon a falling tide the crests of these waves will be met earlier, and the hollows later, than upon a horizontal surface, and the intervals from crest to crest, or from hollow to hollow, will be affected by the change of rate of fall. Upon a rising tide the reverse will occur.

There can be no doubt that these extraordinary rises and falls of the water at short intervals were produced by the same cause which determined the extraordinary rise and fall in the harbor of Simoda, in Japan, and at Peel's island.

The San Francisco curve presents three sets of waves of short interval.

The first begins at about *4h. 12m.* and ends at *8h. 52m.*, the interval being *4h. 40m.* The second begins at about *9h 35m.* and ends at *13h. 45.*, the interval being *4h. 10m.* The beginning of the third is about $13\frac{3}{4}h.$, and its end is not distinctly traceable.

The crest of the first large wave of the three sets occurred at the respective times of *4h. 42m.*, *9h. 54m.*, and *14h. 17m.*, giving intervals of *5h. 12m.* and *4h. 23m.*

The average time of oscillation of one of the first set of waves was *35m.*, one of the second *31m.*, and of one of the third about the same. The average height of the first set of waves was .45 of a foot on a tide which fell two feet, of the second .19 of a foot on a tide which rose three feet, of the third somewhat less than .10 of a foot on a tide which fell some seven feet. The phenomena occurred on a day when the diurnal inequality of the tide was very considerable. The greatest fall of the tide during the occurrence of the first set of waves was .70 of a foot, and the corresponding rise .60 of a foot. In the second the corresponding quantities were .30 of a foot, and in the third .20 of a foot. These waves would not have attracted general attention.

There is a general analogy in the sequence of the waves of the three sets which seems to mark them as belonging to a recurrence of the same series of phenomena. In the Diagram No. 3 A, (Plate No. 50,) the heights of the successive waves of the first set at San Francisco are shown by the dots joined by full lines, and of the second by those joined by the fine dotted line. The full faint lines show the heights of the first series at San Diego, and the broken faint lines the heights of the second.

The heights in hundredths of a foot are marked at the side of the diagram, and those of the successive waves are placed at regular intervals, the waves being numbered from 0 to 7 at the top of the diagram. The height is the mean of the fall from a crest to a hollow, and of the succeeding rise from the same hollow to the next crest. The times of oscillation from one crest to the next succeeding are placed on the same diagram, the times being written at the right hand, and the wave being designated at the lower part of the Diagram No. 3 B, Plate No. 50. The full line represents the times of the first series at San Francisco, and the broken line the times of the second. The full and broken faint lines represent the times of the first and second series at San Diego. The intervals between the times of occurrence of the crests of the successive waves in the first and second series diminish from *5h. 10m.* to *4h. 48m.* by irregular differences.

The effect of the rising or falling tide, upon which these waves occur, is of course greater in disturbing the heights than the times.

The series itself looks like the result of several impulses, not of a single one, the heights rapidly increasing to the third wave, then diminishing as if the impulse had ceased; then renewed, then ceasing, leaving the oscillation to extinguish itself.

If we had a good scientific report of the facts as they occurred at Simoda, the subject would lose the conjectural character which must otherwise belong to it. Although we have no account of the place where the earthquake had its origin, the violence of its effects in Japan, and the diminished effects at Peel's island, show that Japan was certainly not far from the seat of action.

Five successive waves of considerable height are spoken of as having occurred at Simoda, while by the gauge we trace eight, of which seven are of considerable height. The highest wave at Simoda was estimated at thirty feet, at Peel's island at fifteen feet. At San Francisco it was .65 foot, and at San Diego in the first series .50 foot.

At *San Diego*, the same three series of waves are distinctly shown. The first begins 1*h.* 22*m.* later than at San Francisco, correction having been made for the difference of longitude, and ends 0*h.* 52*m.* later. The interval is 30*m.* less than at San Francisco, the oscillations being rather shorter than at the last named point. The second begins 0*h.* 54*m.* later than at San Francisco, and ends 34*m.* later. The third begins about 54*m.* later than at San Francisco. The average time of oscillation of the first set of waves is 31*m.*, and of the second 29*m.*, being respectively 4*m.* and 2*m.* less than of the corresponding series at San Francisco.

The average height of the first set of waves was .17 foot lower than at San Francisco, and the second as much higher. This fact, taken with the difference in the times of oscillation, leads me to suppose the difference in the two series due to interference, which is also suggested by the position of San Diego, in reference to the islands separating the Santa Barbara sound from the ocean.

The general analogy in the succession of heights of the mean of the two series, as shown in Diagram No. 3 C, and in the times as shown in D, of the same diagram, is very satisfactory.

The difference in the periods of the tide at which the waves occurred would tend to cause discrepancies.

The first series occurred on a rising tide of four feet, while at San Francisco it was upon a falling tide of two feet. The second began near high water, and was chiefly upon a falling tide of seven feet, while at San Francisco it was upon a rising tide of four feet.

The forms of some of the individual waves in the second series at San Francisco and San Diego accord remarkably, as those marked 1, 3, 4, 5, and 6, when reduced to the horizontal line. The comparison on the curve where the distortion remains, is also very instructive. The waves marked 1, 4, 6, and 7, are not unlike in the first and second sets at San Diego.

The observations at San Diego confirm, then, in general, the inferences derived from those at San Francisco. The register at Astoria throws no new light upon the subject. The bar at the entrance of the Columbia river would explain why the oscillations were lost or greatly reduced at Astoria, even if they arrived off the entrance of the river. The disturbance is marked on the register, but in an irregular and confused manner.

It was also, apparently, preceded by unusual oscillations of the water.

After allowing for the very free action of the float of the San Diego gauge, there appear to have been indications of disturbance previous to the great earthquake shocks, and following them, occurring at intervals for several days after the 23d of December. The San Francisco gauge presents similar indications.

No special effect appears to have been produced upon the time or height of high or low water by the earthquake, which merely caused series of oscillations upon the great tidal wave.

I now proceed to draw from these results some conclusions as to the progress of the ocean wave accompanying the earthquake.

The latitudes and longitudes of the places referred to are as follows:

	Latitude N.		Longitude W.			
	°	′	°	′	*h.*	*m.*
San Diego	32	42	117	13	9	42
San Francisco	37	48	122	26	8	10
Simoda	34	40	221	02	14	44

The distance from San Diego to Simoda, from these data, is 4,917 nautical miles, and from San Francisco to Simoda 4,527 nautical miles.

According to one account, the disturbance began at Simoda at 9 a. m., or 22d. 23*h.* 44*m.* Greenwich mean time, and the first great wave half an hour after. The first disturbance at San Francisco was at 23d. 12*h.* 22*m.*, or 12*h.* 38*m.* after that at Simoda, and the first great wave at 23d. 4*h.* 42*m.*, giving the same interval. The distance and time from this account give for the rate of motion of the wave 358 miles per hour, or 6.0 miles per minute.

The second account would give for the time of transmission 12*h.* 13*m.*, and for the rate of motion 370 miles per hour, or 6.2 miles per minute.

The San Diego observations give for the time of transmission of the wave from Simoda to San Diego 13*h.* 50*m.* by the first account, which, combined with the distance, gives 355 miles per hour, or, sensibly, the same result as derived from the beginning at San Francisco. The first great wave would give identically the same result.

From the results obtained, we may determine the mean depth of the Pacific ocean in the path of the earthquake waves. We have found for the rate of motion from 6.0 to 6.2 miles per minute, and for the duration of an oscillation 35 minutes at San Francisco, and 31 at San Diego. This would give for the length of the wave on the San Francisco path 210 miles to 217 miles; and on the San Diego path, 186 to 192 miles.

A wave of 210 miles in length would move with a velocity of 6.0 miles per minute in a depth of 2,230 fathoms, (Airy, *Tides and Waves*, Encyc. Metrop., p. 291, Table II;) one of 217 miles, with a velocity of 6.2 miles per minute in a depth of 2,500 fathoms. The corresponding depth on the San Diego path is 2,100 fathoms.

The disturbance of the 25th of December presents at San Francisco three sets of waves of seven each, and at San Diego one set of seven, agreeing in their general features with those at San Francisco; and then a set of seventeen, in which, at first, intermediate waves seem to be wanting at San Francisco, or which have no analogous oscillations there. The crests of the first set occurred at a mean about 17 minutes earlier at San Diego than at San Francisco; the heights on the average were nearly the same, being .39 foot at San Diego, and .44 foot at San Francisco, and the time of oscillation at the two places the same, namely, 41*m.* The origin of the disturbance was probably nearer to San Diego than to San Francisco.

APPENDIX No. 52.

Notice of the tidal observations made on the coast of the United States on the Gulf of Mexico, and type curves at the several stations, showing their decomposition into the curves of diurnal and semi-diurnal tides; by A. D. Bache, Superintendent.

[Communicated to the American Association for the Advancement of Science, under authority of the Treasury Department.]

ABSTRACT.

The stations are eighteen in number. At four, hourly observations were made for one year or more, and at the remainder for not less than two lunations, and generally for more. The stations at Cape Florida, Indian key, Key West, and Tortugas, were intended to trace the tide-wave through the Florida channel; those at Egmont key, Tampa, Cedar keys, and St. Mark's, to trace it along the western coast of Florida; at St. George's, Pensacola, Fort Morgan, Cat island, and East Bayou, (entrance to the Mississippi,) to trace it along the south coast of Florida, Alabama, Mississippi, and part of Louisiana; at East Bayou, Dernière Isle, Calcasieu, Bolivar Point, and Galveston, Aransas, and Brazos Santiago, for the coast of Louisiana and Texas.

The observations were chiefly made by Mr. Gustavus Würdemann, with different assistants. At a few stations they were made by Corporal Thompson, of the engineers, Mr. Basset, Mr. Tansill, and Mr. Muhr. The reductions were made in the tidal division of the Coast Survey by

Assistant Pourtales, Mr. Gordon, Mr. Mitchell, Mr. Heaton, and others. The methods used were those pointed out in my previous papers to the Association; the decomposition being in some cases made graphically, and at a part of the stations, where the semi-diurnal wave is considerable, the ordinary method of working being used, as well as those considered peculiarly applicable to these tides.

As it would be tedious to present the results of these elaborate discussions in detail, when the cotidal lines are introduced, I have thought it best briefly to refer now to the types of different tides, and to present to the Association the diagrams for the several stations, showing, upon a uniform scale, the normal curves and their decompositions into the diurnal and semi-diurnal waves.

APPENDIX No. 53.

Tide tables, for the use of navigators; prepared from the Coast Survey observations by A. D. Bache, Superintendent.

[Prepared by authority of the Treasury Department, for E. and G. W. Blunt, New York.]

The following tables will enable navigators to ascertain the time and height of high and low water in 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 on the next succeeding low water. The intervals, too, between successive high and 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 shortness' sake, 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 tide, 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."*

*This term was introduced by the Rev. Mr. Whewell, who has done so much for the investigation of the laws of the tides.

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 the 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 and referred to in a note,) as of no particular interest in this connexion.

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 Pinkney, 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	Maine	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 07	21
Newburyport	Mass	11 22	50	7.8	9.1	6.6	5 16	7 09	24
Salem	Mass	11 13	50	9.2	10.6	7.6	6 19	6 06	06
Boston light	Mass	11 12	35	9.3	10.9	8.1	6 20	6 06	15
Boston*	Mass	11 27	44	10.0	11.3	8.5	6 13	6 13	09

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.)
		h. m.	h. m.	feet.	feet.	feet.	h. m.	h. m.	h. m.
Nantucket	Mass	12 25	0 37	3 1	3.6	2.6	6 23	5 44	0 09
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 04	49	2 4	2.6	2.0	6 09	6 17	34
Wood's Hole, N. side	Mass	8 06	....	3.9	....	....	6 31	5 51	....
Wood's Hole, S. side	Mass	8 56	....	1.5	....	....	6 03	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 03	23
Point Judith	R. I.	7 32	46	3.1	3.7	2.6	6 12	6 10	1 00
Montauk Point, L. I	N. Y	8 10	1 42	2 0	2.5	1 4	6 13	6 11	....
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 0	6 25	28
Long Island sound.									
Watch Hill	R. I.	9 00	23	2.7	3.1	2.4	6 35	5 56	14
Stonington	Conn	9 07	30	2.3	3 4	2.1	6 15	6 10	25
Little Gull island	N. Y	9 38	1 07	2.5	2.9	2.3	6 01	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 08	5.8	6.6	5.1	6 24	6 05	....
Bridgeport	Conn	11 11	1 03	6.5	8.0	4.7	6 01	6 07	....
Oyster bay, L. I	N. Y	11 07	51	7.3	9.2	5.4	6 08	6 24	....
Sands' 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 08	6 10	....
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 06	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 04	51	6.0	7.0	5.1	5 52	6 27	....
Mahon's 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 06	6 43	47
Philadelphia	Penn	13 18	48	6.0	6.8	5.1	4 52	7 06	....
Chesapeake bay and river.									
Old Point Comfort‡	Va	8 17	50	2.5	3.0	2.0	6 01	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 08	....
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 04	57	2.0	2 2	1.8	6 07	6 07	50
Beaufort	N. C.	7 26	50	2.8	3.3	2.2	6 11	6 10	42
Smithville, (Cape Fear)	N. C.	7 19	47	4.5	5.5	3.8	6 01	6 26	26
Charleston,§ (Castle Pinckney.)	S. C.	7 13	36	5.3	6.3	4.6	6 36	6 09	33
Fort Pulaski, (Savannah 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 04	7 22	14
St. Augustine	Fla	8 32	43	4.2	4.7	3.5	6 07	6 19	35
Cape Florida	Fla	8 16	51	1.5	1.7	1.2	6 00	6 25	25
Sand Key	Fla	8 40	....	1.9	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
Tampa Bay, (Egmont Key	Fla	11 21	1 39	1.4	1.7	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	....
Western coast.									
San Diego	Cal	9 50	1 45	3.7	5 0	2.3	6 22	6 0	30
San Pedro	Cal	9 45	1 48	3.9	4.7	2.2	6 18	6 5	30
San Luis Obispo	*Cal*	*10 14*	1 52	3.6	4.8	2.4	6 37	5 50	....
Monterey	Cal	10 28	0 49	3.4	4.3	2.5	6 31	6 02	35
San Francisco, (N. beach)	Cal	12 12	1 04	3.6	4.3	2.8	6 39	5 51	34
Astoria	Or. Ter.	12 48	1 13	6.1	7.3	4.5	6 03	6 28	33

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 mouth. 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 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, *5h. 18m.* a. m., and from Table I the mean interval at Boston dry dock is *11h. 27m.*

We have then *5h. 18m.* time of transit; to which add

11	27	mean interval from Table I.
16	45	time of high water, or *4h. 45m.* p. m.

If the Greenwich Nautical Almanac is used, add *2m.* 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 *4h. 44m.* W. of Greenwich. The correction to be applied to the time of transit of the moon at Greenwich is, for the four hours, eight minutes, and for *44m.* one minute. The time of transit on the date assumed in the preceding example is *5h. 09m.*; to which add nine minutes, the correction just found gives *5h. 18m.*, 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 *4h. 45m.* 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, *10h. 32m.* a. m., recollecting that *4h. 45m.* p. m. is the same as *16h. 45m.* reckoned from midnight.

The height of this tide corresponding to the transit of *5h.* 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: *10h. 58m.* p. m., time of low water 23d of January.

	6	13	duration of flood from Table I.
Sum	17	11	or *5h. 11m.* a. m. on the 24th of January.

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:

6h.	*13m.*,	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 *5h. 11m.* 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:

4h. 45*m.* p. m., or 16*h.* 45*m.* from midnight, is the time of high water.

12 26 the duration of flood and ebb.

4 19 a. m. of the 23d for the preceding high water. The duration of the flood and ebb being 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 transit, and for several different ports.

Time of moon's transit.	Boston, Mass.	New York, N. Y.	Philadelphia, Penn.	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 11
0 30	11 33	8 18	1 28	8 27	6 42	7 21	7 34	7 25	9 19	12 5
1 0	11 28	8 15	1 25	8 21	6 37	7 16	7 28	7 19	9 12	11 59
1 30	11 24	8 10	1 21	8 15	6 31	7 13	7 22	7 15	9 6	11 53
2 0	11 20	8 6	1 18	8 9	6 26	7 9	7 16	7 11	9 0	11 47
2 30	11 16	8 0	1 14	8 4	6 21	7 6	7 11	7 8	8 55	11 42
3 0	11 13	7 55	1 11	8 0	6 17	7 4	7 7	7 6	8 51	11 39
3 30	11 10	7 52	1 8	7 56	6 13	7 3	7 3	7 5	8 50	11 39
4 0	11 7	7 52	1 6	7 52	6 11	7 2	7 0	7 4	8 49	11 44
4 30	11 6	7 52	1 3	7 49	6 10	7 3	6 58	7 3	8 53	11 52
5 0	11 6	7 53	1 0	7 48	6 10	7 4	6 58	7 4	8 57	12 1
5 30	11 9	7 56	0 59	7 50	6 13	7 6	6 59	7 6	9 7	12 9
6 0	11 13	7 59	0 59	7 53	6 19	7 9	7 1	7 8	9 17	12 17
6 30	11 19	8 5	1 1	8 0	6 25	7 13	7 4	7 12	9 28	12 22
7 0	11 25	8 11	1 7	8 7	6 32	7 17	7 10	7 16	9 39	12 29
7 30	11 32	8 17	1 15	8 15	6 39	7 23	7 19	7 22	9 45	12 35
8 0	11 38	8 23	1 23	8 24	6 44	7 28	7 28	7 28	9 52	12 40
8 30	11 43	8 27	1 29	8 33	6 49	7 33	7 36	7 34	9 54	12 43
9 0	11 47	8 32	1 34	8 40	6 52	7 37	7 42	7 39	9 56	12 42
9 30	11 48	8 34	1 39	8 45	6 54	7 39	7 45	7 42	9 53	12 40
10 0	11 49	8 35	1 42	8 48	6 53	7 40	7 48	7 43	9 51	12 36
10 30	11 48	8 34	1 43	8 48	6 52	7 40	7 48	7 41	9 45	12 30
11 0	11 47	8 31	1 41	8 46	6 50	7 36	7 46	7 37	9 39	12 23
11 30	11 43	8 25	1 37	8 40	6 48	7 30	7 42	7 34	9 32	12 15

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, Mass.			New York, N. Y.			Philadelphia, Penn.			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	10.0	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 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.

1st. By united duration of flood and ebb.

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.

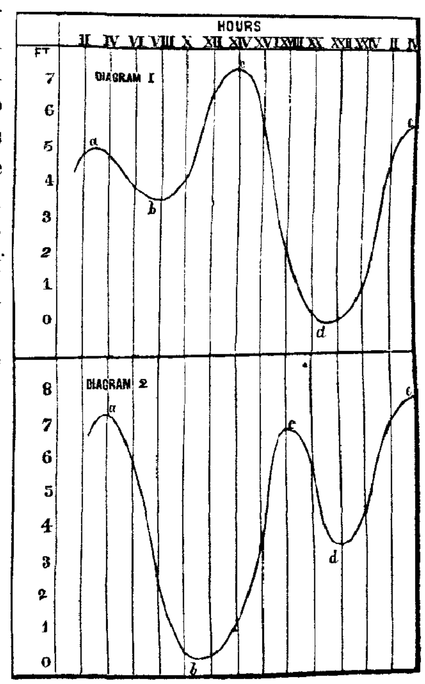
Sum, 21 49, or 9*h.* 59*m.* a. m. of October 2, the time of the next high water.

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 about this 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.

Time of moon's transit.	TABLE IV.								TABLE V.								Time of moon's transit.
	South declination.—Days from greatest declination.								North declination.—Days from greatest 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 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	0 0
0 30	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 30
1 0	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	1 0
1 30	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 30
2 0	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	2 0
2 30	12 42	12 39	12 34	12 27	12 19	12 9	11 56	11 42	10 42	10 45	10 50	10 57	11 5	11 15	11 28	11 42	2 30
3 0	12 39	12 36	12 31	12 24	12 16	12 6	11 53	11 39	10 39	10 42	10 47	10 54	11 2	11 12	11 25	11 39	3 0
3 30	12 39	12 36	12 31	12 24	12 16	12 6	11 53	11 39	10 39	10 42	10 47	10 54	11 2	11 12	11 25	11 39	3 30
4 0	12 44	12 41	12 36	12 29	12 21	12 11	11 58	11 44	10 44	10 47	10 52	10 59	11 7	11 17	11 30	11 44	4 0
4 30	12 52	12 49	12 44	12 37	12 29	12 19	12 6	11 52	10 52	10 55	11 0	11 7	11 15	11 25	11 38	11 52	4 30
5 0	13 1	12 58	12 53	12 46	12 38	12 28	12 15	12 1	11 1	11 4	11 9	11 16	11 24	11 34	11 47	12 1	5 0
5 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	5 30
6 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	6 0
6 30	13 22	13 19	13 14	13 7	12 59	12 49	12 36	12 22	11 22	11 25	11 30	11 37	11 45	11 55	12 8	12 22	6 30
7 0	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 0
7 30	13 35	13 32	13 27	13 20	13 12	13 2	12 49	12 35	11 35	11 38	11 43	11 50	11 58	12 8	12 21	12 35	7 30
8 0	13 40	13 37	13 32	13 25	13 17	13 7	12 54	12 40	11 40	11 43	11 48	11 55	12 3	12 13	12 26	12 40	8 0
8 30	13 43	13 40	13 35	13 28	13 20	13 10	12 57	12 43	11 43	11 46	11 51	11 58	12 6	12 16	12 29	12 43	8 30
9 0	13 42	13 39	13 34	13 27	13 19	13 9	12 56	12 42	11 42	11 45	11 50	11 57	12 5	12 15	12 28	12 42	9 0
9 30	13 40	13 37	13 32	13 25	13 17	13 7	12 54	12 40	11 40	11 43	11 48	11 55	12 3	12 13	12 26	12 40	9 30
10 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	10 0
10 30	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 30
11 0	13 23	13 20	13 15	13 8	13 0	12 50	12 37	12 23	11 23	11 25	11 31	11 38	11 46	11 56	12 9	12 23	11 0
11 30	13 15	13 12	13 7	13 0	12 52	12 42	12 29	12 15	11 15	11 18	11 23	11 30	11 38	11 48	12 1	12 15	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 Rincon Point, San Francisco, California, on the 7th of February, 1853.

1st. The time of the 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. 350) 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 13*h.* 3*m.*

To 11*h.* 57*m.* time of transit of moon, February 7, San Francisco,
Add 13 3 from column 0*h.* transit, and two days from greatest declination.
The sum is 25 0 or 1*h.* 0*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 20 number for 11*h.* transit, and one day from greatest declination.
Sum 24 21 time of high water 0*h.* 21*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.

Tables showing the numbers 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.

Time of moon's transit.	SOUTH DECLINATION. 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.

Time of moon's transit.	NORTH DECLINATION. 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	4.8	4.5	4.3
7	5.4	5.3	5.3	5.2	5.1	4.9	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 waters 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 declinat'n.	SOUTH DECLINATION. Low water. (Small.)	SOUTH DECLINATION. High water. (Large.)	SOUTH DECLINATION. Low water (Large.)	NORTH DECLINATION. Low water. (Large.)	NORTH DECLINATION. High water. (Small.)	NORTH DECLINATION. Low water. (Small.)	Days from greatest declinat'n.
	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 09	18 32	2
3	4 33	10 55	18 02	7 07	13 55	18 28	3
4	4 45	11 11	18 06	6 55	13 39	18 24	4
5	5 03	11 31	18 08	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 those 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
H.	*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	2.3	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	2.8	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 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
H.	*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 7th 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 feet, 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 to St. George's island, near Cape San Blas, the tides are of the ordinary kind, but with a large daily inequality, and the data are inserted in the general Tables I and II. From St. George's island, Apalachicola entrance, to Dernière Isle, the tides are usually of the single-day class, ebbing and flowing but once in twenty-four (lunar) hours. At Calcasieu entrance the double tides re-appear, and, except for some days about the period of the moon's greatest declination, the tides are double at Galveston, Texas. At Aransas and Brazos Santiago the single-day tides are as perfectly well marked as at St. George's, Pensacola, Fort Morgan, Cat island, and the mouths of the Mississippi. The observations on the Gulf coast are nearly completed, but the discussions have not been carried to the point necessary to present the results in a simple form. For the present, therefore, I merely give a table, (Table X,) showing the mean rise and fall at the several ports between St. George's island and the Brazos Santiago; the greatest rise and fall which occur when the moon's declination is greatest, and the least, when the moon's declination is very small or nothing. For some three to five days, about the time when the moon's declination is nothing, there are generally two tides at all these places in the twenty-four hours, the rise and fall being quite small.

The highest high, and lowest low waters, occur when the greatest declination of the moon happens at full or change; the least tides 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	1.1	1.5	0.6
* 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

* More properly belonging to Table I.

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. 54.

Copy of card contained in a current-bottle thrown over near Sandy Hook, from the U. S. Coast Survey steamer Gallatin, Lieut. Comg. M. Woodhull, and picked up on the bar at Santa Cruz, one of the Western Islands.

UNITED STATES COAST SURVEY,
October 30, 1854, 3*h.* 25*m.* p. 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 Prof. A. D. Bache, Superintendent of 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: U. S. Schooner Gallatin.

Latitude, 40° 26′ 30″
Longitude, 73° 50′

Where picked up: *Island of Graciosa, Azores.*
Local name of beach: *Bar (while floating.)*
Near what place: *Santa Cruz.*
In what month: *June.*
On what day: *Wednesday, about six o'clock, p. m.*
Date and year: 13, 1855.

In advance receive the thanks of the U. S. Coast Survey, for your obliging attention to the above request.

Respectfully,

MAXWELL WOODHULL,
Lieut. Comg. U. S. Navy.

Endorsed:
CHARLES BOWEN JONES,
H. B. Majesty's Vice Consulate, Santa Cruz, Graciosa, Azores, June 14, 1855.

APPENDIX No. 55.

Letter from Professor J. W. Bailey, U. S. Military Academy, at West Point, relative to the characteristics deducible from specimens of bottom, brought up in sounding the Florida section of the Gulf Stream.

West Point, N. Y., *October* 16, 1855.

Dear Sir: As it will still require a long time to complete the microscopic examination of the soundings sent to me from the Coast Survey Office, I can at present only make a brief statement of some of the most striking and important facts afforded by the study of the Gulf Stream soundings, near Key Biscayne, Florida.

The soundings, which vary in depth from 147 fathoms to 205 fathoms, agree in their general characters, as well as in their organic contents; they are light greenish grey mud, composed chiefly of Foraminifera, Diatoms, Polycistins, and Geolites, in a profusion hitherto unrivalled in any known deposite of the present oceans, and only surpassed in the fossil state by the polycistinous strata of the island of Barbadoes.

The *Foraminifera* compose the largest parts of these muds, and among them I found considerable numbers of the Textilaria Americana, Marginulina Bachei, and other forms previously noticed in the soundings off Cape Henlopen.*

Mingled with these were many forms not yet noticed in the northern soundings, and particularly a considerable number of species of the group Agathistegues, (Plicatilia of Ehrenberg). These are believed to live only in very moderate depths near shore, but in these soundings they are as abundant at 205 fathoms as in the shallower soundings, rendering it probable that they have been transported from their natural haunts.

The silicious shells of *Diatoms* are found in large numbers in the residue left after the calcareous Foraminifera have been dissolved by means of acids. The number of known species which are thus found is very great, and there is also present a considerable number of entirely new and very interesting genera, as well as species of this group. The presence of numerous Diatoms, whose well known habitat is upon Algae, &c., in quite shallow water, proves that a transporting action has taken place, either by currents or by means of animals, which have swallowed these shells with their food. It is probable that both these modes of transportation have been employed in forming the deposite at the bottom of the Gulf Stream.

The *Polycistinea,* with their beautiful silicious frame-works, are remarkably abundant in these soundings. Besides the species which have been noticed by Ehrenberg and myself, in the deep soundings of the Atlantic, the deposites off Key Biscayne contain a great number of quite novel and beautiful forms. Many of these resemble the fossil species occurring so abundantly at Barbadoes; but few of them, however, if any, are identical. The fact that immense deposites, abounding in polycistinous forms, are now forming near the coast of Florida, and at quite moderate depths, shows that Ehrenberg's supposition that Barbadoes was raised from a very deep sea, is not necessarily correct.

The *Geolitharia,* including sponge spicules, gemmules, and various organic silicious bodies of unknown nature, also occur abundantly in these soundings.

The *inorganic* portion of the soundings is chiefly quartz sand, in fine grains, and its proportion is quite small.

I am now engaged in describing and figuring the new forms above alluded to, and I hope soon to have a considerable number of the most interesting Polycistinea and Diatomaceæ ready for publication. I hope, also, to be able to complete, at the same time, a general comparison of the soundings of the Gulf Stream and Atlantic ocean, at different localities.

Yours, very respectfully,

J. W. BAILEY.

Prof. A. D. Bache,

Superintendent of the Coast Survey.

* See Smithsonian Contributions, vol. 2, art. 3.

APPENDIX No. 56.

Letter from Lieutenant Commanding B. F. Sands, U. S. N., assistant in the Coast Survey, transmitting drawings of an instrument for procuring specimens of bottom in sounding. (Sketch No. 55.)

U. S. Coast Survey Steamer Walker,
Mississippi Sound, May 20, 1855.

Sir: Frequent failures to procure specimens of the bottom of the sea in our sounding operations with the ordinary means, particularly when the bottom is sand or broken shells, without mud, and liable to be washed out of the cup in the jerking motion of hauling in the line, (even from the depth of ten or twelve fathoms,) while going at our usual rate of five or six knots the hour, induced me to attempt a remedy; and I submit to you an instrument, which the accompanying drawing and reference will explain, and which I think will obviate that difficulty. (Sketch No. 55.)

The instrument has never failed to bring up an ample specimen at every depth at which I have sounded, even without slackening the steamer's "way" to haul in the line. That which I have had in use is made of composition metal, in preference to iron, which corrodes too easily.

Respectfully, &c., your obedient servant,

B. F. SANDS,
Lieutenant Commanding, and Assistant U. S. Coast Survey.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey, Washington.

APPENDIX No. 57.

Description of tripod and scaffold constructed and used by Assistant C. O. Boutelle, at the stations of the primary triangulation in Section V. (Sketch No. 52.)

Coast Survey Office, *December* 5, 1855.

Dear Sir: Accompanying this report are drawings of the tripod and scaffold used by me at the primary stations in Section V.

The country over which the primary triangulation in Section V extends is flat. The primary sides average about ten miles in length. They pass over water, marsh, and cultivated land, and through forest-trees. Avenues through woods, varying in length from narrow belts of fifty or sixty feet in width to four or five miles in unbroken extent of forest growth, occur on some of them.

The stratum of air lying near the surface of the ground is so disturbed by exhalations and by inequalities of temperature and density, as to render accurate or frequent observations through it impossible. It has been found necessary to elevate the theodolite about forty-five feet at each primary station to overcome this radical difficulty. Since I have been in charge of the primary triangulation in Section V, I have tried various forms of observing tripods, and have found that shown in figure 1, Sketch No. 52, to possess advantages over all others which I have used.

The form of the tripod is an equilateral triangular pyramid, having a height of forty-three feet, the base of which is a triangle inscribed in the periphery of a circle of eight feet radius from the station point. It is surrounded, but not touched, by a scaffold eighteen feet square at the base, and nine feet square at the floor, forty feet from the ground.

Each face of the tripod is trussed with five tiers of horizontal and diagonal braces. The height of each tier is equal to the length of the lower horizontal brace of the tier. The diagonal braces of the lower tier are of 3×2 inch scantling; the rest of the braces being of 3×1 inch scantling. Three interior braces, each 3×4 inches and twenty feet long, are bolted to each upright and come to the ground midway between the opposite legs of the tripod. The dimensions of the three legs of the tripod are of 6×6 inch yellow-pine joists. They meet at the top at a point in the vertical of the station point beneath. Here they are surmounted by a cap-block, fourteen inches square, and not less than six inches thick, secured to each upright by tree-nails.

In the centre of the cap-block and top of the tripod is mortised a hole four inches square, in which is placed a signal-pole from sixteen to twenty feet long, painted in black and white bands and surmounted by a small tin signal. The pole where it enters the mortise in the cap-block is three inches square, to allow for accurate adjustment over the station point by means of the "*Temple*" sectors, or portable transit instruments, which, from first to last during the erection of the tripod, and in the use of it afterwards, are constantly used to watch and detect any error in adjustment of tripod, signal or theodolite.

The uprights of the surrounding scaffold are 5×5 inch yellow-pine joists, and are as high above the ground as the top of the cap-block. Each face has two sets of horizontal braces at the heights of twenty and forty feet respectively. These braces and the sleepers of the floor are of 3×4 inch scantling, and are "halved in." Four diagonal braces of 2×2 inch scantling are bolted on each face. A railing is also bolted to the top of the uprights. Access is had to the top by two permanent ladders, each having a vertical height of twenty feet.

When a heliotroper is stationed at one of these tripods, a board nailed across the railing of the scaffold furnishes a stand, and the signal-pole is undisturbed. When the station is occupied for observing, the pole is lifted out and the top of a Gambey stand is screwed to the cap-block, its centre being brought carefully over the station point below. The instrument, resting in the Y's of the stand, is in the axis of the station.

In erecting one of these tripods, I first set up a single stick, about thirty feet long, secured by four rope guys, with a double-fall tackle as a derrick. Three holes are then dug two and a half feet deep, at equal distances from each other and from the station point. Plank are laid in the bottom of each hole for a bearing, and care is taken to have them in the same horizontal plane. The three legs of the tripod are each cut to the length of 46.3 feet, which gives them a vertical height of forty-three feet when in position. The tops of them are also cut, as shown in figures 3 and 4, Sketch No. 52, to allow them to meet when set up. The bottoms are also sawed to the same level as the top (1.06 inch in 6 inches) to allow them to rest firmly upon the level bearings in the bottoms of the holes. A double rope guy is secured to each upright, about ten feet below the top, and they are hoisted singly to their positions and secured from falling by the guys. A nail is driven in the top of each upright before raising at the angle of 120°, where all three should meet when in position. The portable transits are then set up and levelled at some two hundred feet distance from the station point and nearly at right-angles with each other, and the cross-hairs brought upon the station point. The telescopes, moving in a vertical plane, are then raised until the top of the tripod is seen, and each nail is successively brought to the intersection of the cross-hairs of each instrument, by working the guys which secure the uprights. When the three nails meet in the intersection of two vertical planes passing through the station point and at right-angles to each other, the holes at the base are filled up, and the lower tier of braces bolted on. The trussing of each face of the tripod to the top next proceeds until completed, when the guys and derrick are taken down and the tackle is secured to the top of the tripod, which serves as a derrick for raising the scaffold.

The holes for the uprights of the scaffold are then dug, forming a square eighteen feet upon a side, and each 12.72 feet from the station point. The relation of the feet of the scaffold and tripod to each other and to the station point is shown in figure 2, Sketch No. 52. Two sides of the scaffold are framed and bolted together upon the ground, the upper end being nearest the tripod, and are hoisted to their positions, resting upon the tripod as they go up, until they are raised sufficiently high to bring the feet into the holes dug to receive them. Temporary diagonal pieces are nailed to each upright, and the top is pressed outward from the tripod until each upright is 6.36 feet from the centre of the top of the tripod, to which it is temporarily secured until the other two sides of the scaffold are framed in their proper places and the ladders and floor laid. No part of the scaffold is allowed to touch the tripod when it is completed. The cap-block is then fitted to its place, signal erected, and the whole structure whitewashed. The time necessary for completing the whole work varies from three to five days, according to the convenience of access to the position chosen.

The dimensions given are for the height found most convenient in my own work. Of course they may be increased or diminished for larger or smaller tripods, merely preserving the proportions.

This kind of tripod is very firm. It does not vibrate, and has less jar than any other I have tried. It can be used on windy days, which is a great point gained, since our best seeing often occurs when the wind is high. Its great stiffness is due to its form and the small surface exposed to the action of the wind. The superficial area of each face is about 315 square feet, while the solid surface exposed to the action of the wind is but twenty-five square feet.

A model of this scaffold and tripod, on a scale of two feet to an inch, was deposited in the office in November, 1853. From it Lieutenant J. C. Tidball, U. S. Army, in charge of the drawing division, has reduced the very accurate and elegant sketch of the tripod, No. 52. I hope that it may be of service in helping us to overcome the difficulties encountered in the southern sections of our work.

Yours respectfully,

CHAS. O. BOUTELLE,
Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 58.

Letter of Assistant John Farley, communicating description and drawing of a convenient signal for observing on secondary stations. (*Sketch No.* 52.)

NEWPORT, RHODE ISLAND, *July* 24, 1855.

DEAR SIR: The following is a brief description of a signal which I have been compelled to adopt in lieu of the old method of elevating the pole upon a tripod for secondary stations; and the main recommendation I shall give is in the simple fact, that every signal established upon this plan remains now as firm and exact as when first planted, while the others are constantly being affected by storms or other causes.

The plan is very simple and economical, consisting of four stanchions of 3×4 inch white pine scantling, and about seven feet long, sawed at the upper end at an angle of nearly twenty degrees, so that the bevelled side may rest against and support the pole; the whole being confined within about six inches of the top of the stanchions by a strong iron hoop from eight to ten inches diameter.

In order to give additional strength and permanency, four cross-ties are so nailed across from opposite stanchions as to form a box four inches square, which serves the double purpose of protecting the stone and affording a secure footing for the signal-pole. It is believed that the severest storm could thus obtain no hold upon it, and nothing short of force could uproot it, when well wedged and hooped. The pole should be so made as to fit evenly and well in the aperture between the stanchions, and gradually be rounded off from thence towards the top. The cross-ties should be well secured by nails to the stanchions.

Great care is necessary in setting this signal; but when once established, and the ground well settled and rammed, the combination possesses great strength and immobility as an observing stand for the theodolite. On approaching a station the wedges and hoop are loosened, the pole drawn out, and a cap fitting well to the aperture is inserted in its place; any slight motion is easily corrected by wedging.

The cross-ties are sawed half and half, so as to let into each other, as shown by the diagram, (Sketch No. 52.)

A side and perspective view is also there given, together with the necessary dimensions. The iron hoops are required to be strong and substantial, and, although fitting on a rectangular shape, the round hoop is found to be the best. The depth for sinking the stanchions depends upon the height of the observer, and in order to insure greater permanency it would be advisable to char the foot of the stanchion, or immerse it in asphaltum or tar to prevent rotting below the surface. Still greater strength may be insured by burying horizontal pieces, and spiking them to the lower part of the stanchions.

J. FARLEY,
Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 59.

Extract of a letter from Commander B. F. Sands, U. S. Navy, assistant in the Coast Survey, communicating a description of the revolving heliotrope devised by him for geodetic purposes.

WASHINGTON, *November* 27, 1855.

SIR: * * * * Four pieces of tin, narrow at the upper part, to serve as reflectors, and cut with a swell at the lower portion, (see Sketch No. 55,) are arranged so as to serve as wings for giving a rotary motion. These are bent nearly in the form of the letter S, the upper or reflecting part being less curved than the lower, and connected at the top and bottom by two square pieces of tin with holes in the centre to receive the iron spindle or axis, the wings being so placed vertically and at right-angles to each other that the concave surface of the narrow or reflector portion may be outward to reflect the sun's rays, and the concave surface of the lower part be inward, to catch the wind, which causes it to revolve, keeping up a succession of flashes of reflected rays of the sun towards the observer.

Separate reflectors may be attached, made of plated metal, and curved accurately for reflecting the rays, to be renewed at pleasure; and the axis may be made with a cup in the upper end for oil, and to receive the point of a short inverted spindle attached to the upper square piece of tin, which would, by lessening the friction, allow it to revolve more freely, and render it less liable to rust from exposure to the weather.

I have the honor to be, very respectfully, yours,

B. F. SANDS,
Commander U. S. Navy, and Assistant U. S. Coast Survey.

A. D. BACHE, LL. D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 60.

Extracts of a letter from Lieut. Comg. B. F. Sands, U. S. Navy, assistant in the Coast Survey, communicating description and drawing of a signal recently devised and placed by him in the breakers on Dog Island bar, Mississippi sound. (*See Sketch No.* 54.)

U. S. Coast Survey Steamer Walker,
Mississippi Sound, off Montgomery Station, April 30, 1855.

Dear Sir: * * * In order to test the strength and stability of iron gas-pipe for tripods, in positions exposed to the sea, I placed one, in May, 1853, on a shoal off the west end of Horn island, in the entrance between Horn and Ship islands; a situation exposed to heavy seas from the Gulf of Mexico. Upon resuming my work here this season I found it unmoved, more firmly fixed even than when first placed, after a lapse of two years, during which it had withstood the heavy gales that often visit this coast, winter and summer.

The success of the experiment induced me to place it in the midst of the breakers on Dog Island bar in the same inlet, as a signal to be used in my hydrographic work; and I leave it there to serve as a beacon for vessels navigating Mississippi sound, as the bar is close upon the southern side of the deep channel running along to the northward of Ship and Horn islands.

Its simplicity of construction, economy, and facility of transportation and erection, make it worthy of a description, which I herewith submit to you, accompanied by a drawing, supposing that it will be as useful to others as it has been to me; and I recommend its use as a beacon for navigation, or form of signal for the Coast Survey in such exposed places. The one represented was made by the armorer and firemen of the steamer, of some old pieces of gas-pipe which had been used for a tide-gauge.

DESCRIPTION OF TRIPOD.

The legs are each made of two lengths of wrought-iron gas-pipe, ten feet long—the lower piece of two inches and a half diameter, the upper a size smaller—coupled together by the screw coupling used in gas fitting, making them as strong as if one piece; an iron ring one inch in diameter, through three eye-bolts of four or five inches in length, which are inserted into the upper end of the leg, and wedged in or confined by a "set screw," keeps them together at the head. They are spread, and kept in that position by an open triangle of four-inch scantling, with scores at the outside of the angles which receive the legs, and these are secured to it by straps of hoop-iron. The triangle is also a "step" for the signal-staff, which is inserted through the ring connecting the heads of the tripod legs. The pole bears a revolving ball of three feet diameter, made of five hogshead-hoops, with white and black cotton cloth or canvass stretched over the alternate vertical halves of the hoops, so as to keep the ball revolving horizontally, and not presenting too much resistance to the wind. Four of the hoops are placed transversely to each other in pairs, kept in position by a single hoop surrounding them horizontally, and in the upper and lower square places made by their intersection are placed two square pieces of board or sheet iron, with holes large enough to receive the staff upon which it is to revolve. A cap or "truck" is nailed or bolted on the staff over all, to prevent the ball being blown off. The black and white canvass is stretched over the alternate vertical halves of the hoops, reaching nearly to the axis of the ball, to serve as wings to revolve it and to flash black and white. These wings may be made of tin, and contrived to work on pivots like wings of a horizontal windmill, being becalmed or "in the wind" on one side of the ball, while "filled" on the opposite side, thereby offering less resistance to strong winds.

To make it more conspicuous while observing angles upon it, the tripod was wrapped with strips of cheap white cotton, spirally from the top down to within a third of its height, leaving a space of one foot between the turns. The cotton was preferred, as it would give way to the force of the sea without injury to the tripod, and could readily be replaced when wanted to observe upon.

The tripod may be taken, in pieces, to the place where it is to be erected, and put together in the boat with the aid of a pair of gas-pipe tongs, or a seaman's "Spanish windlass," to screw the couplings. My boat's crew of five men took the one in use down and erected it in a new position in the breakers with ease.

Respectfully, &c., your obedient servant,

B. F. SANDS,
Lieutenant Commanding, and Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 61.

On a new voltaic experiment made with reference to the time required to produce the maximum intensity of a voltaic current; communicated to the Superintendent, by Assistant George Mathiot, electrotypist.

WASHINGTON, *January* 11, 1855.

DEAR SIR: The enclosed paper was prepared several years ago, for publication in Silliman's Journal; but, from motives which you will readily appreciate, its communication has been deferred since my connection with the Coast Survey, until the present time. The peculiarity of certain views of *wave time* recently put forth by an eminent English experimentalist, and my own later deductions in regard to the nature of electricity, based upon the experiment described in the paper, have determined me to present it in its original form.

It stands precisely as it was written in 1850, with the addition of the paragraph relating to the constancy of the tensions, and, under a sense of duty and respect, it is now submitted to you as the scientific head of the organization to which I am attached.

The result of my experiment points to an important modification of the theories of electricity, and furnishes a clue to account for the different velocities observed in transmitting signals through telegraph wires.

Much reflection on the subject has led me to the formation of a theory respecting the distribution of electricity, which seems to include all the cases heretofore regarded as anomalous. The requisite mathematical demonstrations will be prepared in due time; and I trust that the theory thus completed will not only bear an important part in settling the question of "*contact*" or "*chemical action*," but also furnish a conclusive test applicable to the celebrated demonstration by Prof. Ohm.

It has not been deemed necessary to append to the paper any special statement in regard to the *date* of the experiment, as a drawing illustrative of it, with descriptions, &c., was exhibited in the spring of 1849 to Professor Joseph Henry, who entirely coincided with me in the explanation of the phenomenon.

Very respectfully, your obedient servant,

GEORGE MATHIOT.

Prof. A. D. BACHE.
Superintendent U. S. Coast Survey.

ON A NEW VOLTAIC EXPERIMENT, AND THE TIME REQUIRED TO PRODUCE THE MAXIMUM INTENSITY OF A VOLTAIC CURRENT.

The experiment to be described, proves that a sensible interval of time is employed in raising a galvanic current to its maximum under certain circumstances; or, in other words, that before a battery can affect *any* conductor, time is required to generate the quantity of electricity which will give the tension requisite to produce the maximum intensity of current due to the battery with that conductor.

In my daily employment with the voltaic battery, I was led to observe, that at certain times, its force was other than that due to the specific voltaic arrangement employed. Occasionally the force of the battery on the first moments of completing the circuit through the electrolyte, would be so great as to deposite metal in the amorphous state, while at other times the same battery with the same electrolyte, and under precisely similar conditions, even to that of temperature, would be so feeble, that before sufficient metal could be deposited to cover the electrode, its face would be corroded by chemical action.

The consequences of these variations of the electrical force involved losses of time and of means employed in the operations. In the process of electro plating, if the *decrease* of power took place, the adhesion of the deposited film was entirely hindered; while in the electrotype operation, if the *increase* took place, the fine lines of the engraved plate to be copied were liable to be choked by a deposite of the powdery metal. In one case the damage thus resulting amounted to over five hundred dollars. This circumstance, and an urgent desire to find some infallible method for producing perfect adhesion in the process of plating and gilding, induced me to experiment, and to watch closely for the conditions which attended these variations of the battery power.

The great force which the galvanometer exhibits as generally prevailing for the first moments after completing the battery circuit, I at that time attributed to the *prime* condition of the plates—the zinc being then unaffected by sulphate, and the conducting plate free from adhering hydrogen. As such a condition of the plates would be equivalent to an increase of the *average* conducting section, or, what amounts to the same, a diminution of conduction resistance; this would clearly account for an *increase* of force above that due to the uniform or general flow of the current. Yet, while it was not clear that an increase of conduction resistance ever took place, I felt satisfied, from observation, that there were moments when the power was greatly reduced.

In the theory of the distribution of electricity proposed by Dr. G. S. Ohm, and now very generally received, the tension on the generating surfaces is supposed to be constant, however the conductor may be varied; and consequently, the tension at any part of the conductor will be inversely proportional to the resistance up to that part. From these premises it may be inferred, that when any part of a conductor conveying a current is made to change place with reference to the whole conducting line, such variations of quantity as I have noted above may take place. It may also be inferred, that *time* is required to change the tension in the altered parts. But the great velocity of electrical distribution being well known, it would seem improbable that this interval of time should be appreciable, or that the changes of tension thus occurring could be so great as to affect important electro-metallurgical conditions.

These changes of tension, and the time involved in their production, I have made sensible by the simple apparatus which is represented in the accompanying sketch, (No. 52, Diagram A.)

A B C are three Smee's batteries, with their generating and conducting plates Z S, Z S, Z S, joined in consecutive order by the conductors *r*, *r*, and connected with a voltameter V, by the conductors R, R. The conductors R, R have each a branch *b*, *b*, which are to be so arranged that contact may be made at K by a tap of the finger, in order to complete the circuit through the branches. The electrodes P, N, of the voltameter may be two inches long, by half an inch wide, and should be well platinized, (covered with amorphous platinum); but other sized electrodes may be used, provided the battery plates are not more than five times as large as the electrode plates. The batteries and voltameter are to be charged with a mixture of ten parts of water to one of sulphuric acid. No other acid than sulphuric should be used, as the least quantity of any acid capable of combining with hydrogen, in the batteries or voltameter, will defeat the experiment.

The arrangement being complete, gas will rise freely from the electrodes of the voltameter. Now while the decomposition of the acidulated water in the voltameter is going on, let the contact be suddenly made at K, and the evolution of gas will instantly cease. If, however, the current be suddenly broken at K, the gas will not immediately rise from the electrodes, but nearly one second may elapse before the electrolysis appears.

The gas ceases to be evolved from the electrodes when the contact is made at K, because the electricity passes almost entirely by the metallic branch, *though the circuit through the electrolyte is still complete;* for, the respective quantities of electricity passing through the branches of a divided circuit will not in such case be inversely as the conduction resistances of these branches; the electrolyte requiring for its decomposition a specific tension, which is greater than the tension prevailing at the point of the conductor where the bifurcation takes place. The same would be the case if the bifurcations could be made to arise from the generating surfaces; the tension of the conducting plate would certainly be lessened, but without affecting the relation of the two circuits, unless indeed the metallic branches should be made so long as to counterbalance by their conduction resistance, the tension required for the decomposition of the electrolyte. *But here it may be observed, that if the bifurcations could take place directly from both the generating surfaces, the current ought to pass by both branches, if Ohm's position respecting the constancy of tension at these surfaces be correct.*

The fact that gas does not immediately arise from the electrodes, on breaking the contact at K, might at first appear referable to conditions requiring an accumulated product of the decomposing agency. But, that no immediate decomposition of the electrolyte takes place may easily be shown, by observing the time required to evolve the gas, after diverting the current from the metallic branch, and then alternately breaking and restoring the contact at K, at intervals somewhat less than this observed time. If now the electrodes of the voltameter be covered in the usual manner, and the current be made to traverse the electrolyte during as many of the observed intervals as would amount to hours, no gas will be found under the inverted cups. Let, however, the contact at K remain broken, and then alternately *break* and restore the current at very small intervals through the voltameter, instead of merely deflecting it through the branch; and it will be found impossible to prevent the decomposition. If a sufficient number of contacts of the least possible duration be made, the gas cups will at length be filled.

I regard the result of this experiment conclusive of the fact, that a specific interval of time does elapse before a current in a conductor attains its maximum.

It may be said that the current does not pass *at all* before the tension required for decomposition is reached; but as water conducts the electricity from a single voltaic pair without suffering decomposition, the current most probably passes from the first moment the circuit is completed, precisely as by a metallic conductor. But, the time for attaining the maximum intensity being proportional to the resistance, it does not appear in the metal, though in the electrolyte the small quantity of electricity which passes at the tension too low for decomposition, and the great increase in the quantity which suddenly takes place on the attainment of a certain tension, serve to mark the phenomenon very strongly.

The experiment I have described above is perhaps not new, but I know of nothing precisely similar. In a philosophical view it is analogous to the charging of a Leyden jar by the galvanic trough, in the respect that some time must elapse before a second charge can be given. It suggests also a recurrence to the well known fact, that if, when the tension of a De Luc's column is sufficient to diverge the leaves of a gold-leaf electroscope, the poles should be but momentarily connected by a metallic conductor, the leaves instantly collapse, and a considerable time must pass before the tension is sufficient to make them diverge again.

APPENDIX No. 62.

Letter of George Mathiot, Esq., Electrotypist Coast Survey Office, communicating an improved method for taking entire casts from detached plates by the electrotype process.

ELECTROTYPE LABORATORY, COAST SURVEY OFFICE,
July 16, 1855.

DEAR SIR: I have recently devised a very simple and easy method for joining plates to be combined for taking entire casts by the electrotype process; and as it seems to increase the utility and application of the electrotype art in reproducing the charts of the Coast Survey, some account of the advantages which it presents in practice may not be uninteresting.

The idea of taking a single cast from several detached pieces (combined for the purpose) was one of the first suggestions of electro-metallurgy, yet the means hitherto employed have involved much expense and loss of time, as well in the operation of filing the edges of thick plates for nice adjustment, as in guarding against injury to their engraved surfaces while in the hands of the mechanic. Hence, though the ordinary mode has been in several instances used with advantage, economy has forbidden its general application, except in cases wherein even a tedious process offered manifest facilities in respect to the time required to reproduce an engraved plate.

The plan which I have devised supersedes the mechanical method formerly used, by taking from the plates to be joined electrotype casts weighing not more than three or four ounces to the square foot. These being cut in any required form with a pair of scissors, require merely to be cemented, each in its proper place, on a blank plate coated thinly with shoemaker's wax. Any superfluous wax may be readily removed by a cloth saturated with oil of turpentine, after which the plate is ready for the electrotypist.

The adjustment of the parts of a map plate can thus be made or supervised by the engineer, or by the engraver or draughtsman, and entirely without the aid of the mechanic.

I have used this method with complete success in remodelling the plate of *Salem harbor*, decidedly the most complicated operation in joining of all I have yet taken in hand, and the time actually spent on it was less than a day. By the former process it could not have been remodelled in less than a month, if at all.

The combination, a few years since, of four plates to form the lower sheet of *Delaware bay*, required about four weeks of mechanical work, and the operation, tedious as it was, gave satisfaction: the saving of time in restoring the lost sheet being highly important. If it were now necessary to combine these plates, the operation could be performed in a few hours.

In cases where parts of a plate require to be changed in position the mode here described is peculiarly applicable, whereas the old process, by removing a portion of each by the saw and file, renders the transfer of parts extremely difficult, if not wholly impracticable.

Large maps may now be put in detached parts into the hands of any number of engravers for more speedy completion, the thin electrotypes taken from the several pieces serving for the production of entire casts in all respects as well as the thick plates, even when joined by the most elaborate mechanical means.

Electrotypes to be used in the method of joining now communicated, if begun in the morning, will by the next day be thick enough for the purpose required. The saving in time, and in the material hitherto used for thick plates, becomes, on a comparison of the results of the two methods, very important.

Very respectfully,

GEORGE MATHIOT.

Captain H. W. BENHAM,
U. S. Engineers, Assistant in charge of Coast Survey Office.

APPENDIX No. 63.

On a method of measuring electrical currents of great quantity; by George Mathiot, Esq., chief of the electrotype division of the Coast Survey Office.

THE BRANCH CIRCUIT GALVANOMETER.

In the application of electrical currents it is indispensable to have some idea of what is called the *quantity* of the current, for the application of a greater or less quantity affects not only the *amount* of the product of the current, but also its nature. This dependence of the quality or nature of the product on the strength of the current will hold good in every known effect produced by the current. Thus, a current of a certain quantity flowing through a wire will develop magnetism in the wire, but an increased quantity produces heat sufficient to melt or even deflagrate the metal. Again, a solution of metallic salt will yield metal and acid to a certain strength of current, but the product of a greater quantity may be hydrogen and oxygen; and, indeed, a solution of various metallic salts may be all successively decomposed by varying the force of the current. And not only is the specific substance produced dependent on the quantity of the current, but in all the derived solids, the state of molecular aggregation is affected by the quantity of the current. The aggregation of gaseous products is perhaps modified in the same way, for it is now well ascertained that, in the electrical resolution of water into hydrogen and oxygen, more or less of oxygen is rendered as ozone, according to the intensity of the electrolytic action. This is plainly exhibited in thunder showers, the enormous electrical currents even by their inductive action on the drops of falling water, generating sufficient ozone to scent a considerable district.

In the electro-metallurgic processes, the knowledge of the quantity of the current is of the very first importance, for reductions formed by various quantities of electricity may exhibit opposite qualities. In the reduction of copper the amateur electrotypist finds that, though he may sometimes obtain a casting which will compare favorably with the best specimens of rolled and hammered copper, in hardness, elasticity, and every other desirable property, it often happens that some one of the metallic properties is but imperfectly developed, or perhaps greatly in excess, causing the copper to be hard and brittle like cast iron, or soft and flexible like lead, or even as an incoherent mass of small crystals or a layer of mud; and what is here stated in regard to copper, is even more applicable to the electro formation of the other metals; the influence on the state of aggregation is often such as to modify not only the *mechanical* properties, but also the chemical constitution of the metals. I have deposited thin plates of iron, which seemed to have the same qualities as the purest forms of cast-iron, (unwrought cast steel,) and which had no more tendency to oxidation than ordinary iron; yet iron can readily be precipitated of such quality that, shortly after being taken from the decomposing cell and dried, it spontaneously heats, takes fire, and undergoes vivid combustion. The precious metals are not exceptions to this liability to an apparent transformation of their chemical properties. Filings of silver, or even the minute crystals precipitated by copper from the nitrate, will not dissolve to any considerable extent in a solution of cyanide of potassium; yet I have seen a solid plate of electro-reduced silver dissolved entirely away in a few hours in the same solution. Even gold is seen apparently to acquire the strong affinity of a baser metal. And yet in contrast to increased tendency to chemical combination, pieces of well formed copper lie about the laboratory, or in the damp cellar beneath, for long periods, without becoming tarnished—the oxidable copper having apparently taken a quality in this respect analogous to that of the precious metals.

From what has been stated concerning the results produced by different forces of current, it will at once appear that successful operations in electro-metallurgy require even an accurate knowledge of every change that takes place in the strength of the current. The want of this knowledge has much retarded the progress of the art of electro-gilding and silvering, and, though perhaps to a less extent, the process of electrotyping.

None of the electrometers hitherto proposed supply the desideratum of the electro-metallurgist for measuring the large quantity currents employed in precipitating the metals, for these instruments, as constructed, require to be interposed in the circuit and travered by the whole current; and as the circuit is necessarily short, in order that the quantity may be large, the additional resistance produced by the increased length of the circuit, due to the instrument, causes a very great reduction in the quantity of electricity. The amount of resistance which the measuring instrument will oppose to the current is found to be quite considerable, if the necessities of the arrangement are considered. Putting the voltameter aside for the present, on account of the low tension of the current to be measured, we will consider the suitableness of the galvanometer and electro-magnet, (magnetometer.) Of the galvanometer it must be observed that it cannot be used in the vicinity of the batteries or decomposition cells, for the current in these parts of the apparatus will affect the magnetic needle; and as the currents are constantly changing in magnitude and in location by the necessary changes of the plate in the cell, the galvanometer must be placed at some distance from the apparatus. With respect to the magnet, it will appear that it is not very easy to form a short helix for conducting large currents around the iron core; for the current being great in quantity, necessarily requires a heavy conductor. In the batteries of the Coast Survey laboratory the wire which conveys the current from the batteries to the decomposition cell is one inch in diameter, and a rod of this size, or its equivalent in smaller wire, could not very readily be worked into a helix without employing considerable length.

But though the electro-metallurgist might have been aware of the consequences of using too great or too small a current for his work, and however desirable might be a knowledge of its force at any given moment, it is certain that none of the electrometers heretofore offered have served the purposes required.

After much investigation, with a view to overcome the difficulties hitherto experienced, I have now the good fortune to present a description of a form of measuring apparatus which seems to be free from all objections. The galvanometer which I have devised adds nothing to the length or resistance of the circuit, and may be employed at any desirable distance from the batteries and decomposition cells. It is compact in form, costs but little, and may be made of extreme sensibility.

The principle of this galvanometer rests on that well-known property of the electrical current, that when several circuits are offered it divides between them, in quantities proportional to the relative conduction resistances of the various branches. On this property it is evident a portion of a current may be led off to any desired distance from the main conductor, and then subjected to the nicest measurement without the least liability of disturbance from the parts of the current in the main conductor, or in the plates of the batteries and decomposition cells.

It would be superfluous to discuss the principle on which I have based the new galvanometer, as Professor Ohm, in his celebrated mathematical investigation of the galvanic current, deduced it from the phenomena attending conduction through a single circuit. It was afterwards verified by experiment by M. Lenz upon currents generated by the magneto-electric machine, and more recently it has been experimentally verified by Mr. J. Lane for the currents generated by the voltaic battery. That the current in the branch circuit is always the same proportional, in respect to the whole amount flowing, is not to be doubted, and nothing more is here required in relation to the *principle* of the branch circuit galvanometer, for the name is suggestive to every electrician both of the principle and construction.

The construction of the branch circuit galvanometer employed in the laboratory of this office is extremely simple, yet its performance has been highly satisfactory; and, indeed, I could not imagine anything more desirable for the purpose required. A description of this crude apparatus will include sufficient directions for constructing and using it.

In the Coast Survey laboratory the batteries and decomposition cells are in separate rooms, but are ranged against the partition wall, in order that they may still be as near together as practicable. Two bars of copper, each one inch in diameter and about four feet long, pass through the wall, and make the electrical connexion between the batteries and decomposition troughs. On the ends of the copper rods, in the battery room, are iron cups containing mercury; these cups receive the currents from the several parts of the battery, and combine them into one in the main conductor. A copper wire a fifth of an inch in diameter is attached to one of the copper bars near the cup, and from thence the wire is let down through and under the floor of the laboratory, to a point above which it is convenient to have the galvanometer. The wire is then brought through the floor to a table, and, forming a multiplier of six rectangular coils over a magnetic needle five inches long, again descends and passes under the floor to the main conductor, where it is brought through and attached to the other end of the copper bar. When a current comes on the bar a portion of it is led off into the branch and deflects the magnetic needle in the coils of the multiplier, but the deflection cannot be noted by observing the ends of the needle—these being hid by the multiplier. To make the deflection visible, the needle has a slender brass wire six inches long, soldered across it near the centre and at right-angles to the axis. The end of the wire moves before a graduated arc which serves for measuring the deflection. It only remains now to note the deflections produced by currents dissolving various weights of copper, and we have a scale of working which points out how many pounds or ounces of copper the batteries are making per hour or day. The scale is soon established, by weighing the electrotype supply plates from day to day, and noting the deflections. A scale may be established in a few days, by a set of experiments made for this purpose. It will be most convenient to commence with a large pair of electrodes and strong battery, weighing the electrodes every three or four hours and lessening the number of the battery plates each time, till the needle recedes one or two degrees. In this way a full scale may be had in a few days.

It might be thought that the quantity of electricity deflected from the main conductor in some cases may not be enough to affect the needle, but it must be borne in mind that the indications of the galvanometer are relatively the same in a branch as they would be in the main circuit. The quantity which can be led off will generally be found sufficient to work the ordinary galvanometers, as will appear evident by considering the particular arrangement described above, as employed in the Coast Survey laboratory. Here the arrangement is purposely such, that only a small relative quantity is led off; the main conductor is one inch thick, which is uncommonly heavy, and though the branch wire is one-fifth of an inch in diameter, its section, compared with that of the inch-bar, is only as one to twenty-five. The branch wire is eighty feet long and the bar four feet; then we have the branch resisting twenty-five times more than the bar by its lesser section; and this is repeated twenty times in its greater length, making the whole resistance of the wires five hundred times greater than the bar. Here, then, for every five hundred and one parts of electricity flowing through the whole circuit, one part will pass through the branch. Now, as the solution of one grain of zinc per twenty-four hours generates enough electricity to affect the ordinary galvanometers, if the electrotype apparatus is making but once ounce of metal per day, the branch circuit galvanometer may be used for measuring the current. But it is not necessary that the proportion in the branch should be so very small; it may conveniently be a twentieth or more, or it may even be the greater proportion; for when the main conductor is but small, which is generally the case where but small currents are employed, then the branch wire may greatly exceed the main in thickness.

The branch circuit galvanometer may be made portable, and is thus well adapted for general purposes. I have had one of them for some time in use for measuring the smaller currents employed for miscellaneous purposes, such as making electrotypes of single views in a plate, making the silver plates employed for the negative plates of the batteries, platinising, gold-plating thermometers, experimenting on electro etching, &c., &c., and always with the same degree of satisfaction. The peculiarity in this instrument is the use of a metallic bar which is made part of the circuit; the branch being taken from it, and the same bar being always used, the proportional conductivity of the branch and bar is always the same, and consequently the same scale of deflection referred to weights always serves, thus giving the apparatus a universality in application.

The portable instrument in use is constucted with the usual magnetic needle, graduated circle, and multiplying coil; but in addition to these there are the bar and two flexible wire cords for conveying the electricity to the compass placed beyond the disturbing influence of the current in the other parts of the circuit. The magnetic needle is five inches long, suspended on an agate centre, and provided with a "lifter." The circle is divided to half degrees, and numbered at every tenth degree east and west from the zero points or magnetic meridian. The needle and ring are placed, as usual, in a brass box provided with a glass cover. The multiplying coil is composed of copper ribbon twelve feet long, one inch wide, and one-thirtieth of an inch thick. This is wound into a circle seven inches in diameter. The multiplying coil is placed vertically around the compass-box, and in the magnetic meridian on zero lines. The ends of the coil are brought through the centre of the stand which supports the compass-box to two clamps. So far the construction is similar to the generality of galvanometers, excepting in the multiplier being formed of so heavy a conductor. Two wire cords, each six feet long, and supposed to have the same section as the conductor in the coil, are attached to the clamps at one extremity, and the other near the ends of a copper bar one foot long and one-fourth of an inch square. At the extremities of the bar are clamps for making connection with the conductors of currents to be measured. When a measurement is made with this instrument, the bar is put in the circuit by means of the clamps, and the deflection noted and referred to the corresponding weight, previously ascertained by experiment. The supposition here is that the addition of the bar to the circuit does not affect the quantity of the current; but this is not strictly true. The amount is unimportant, and may be avoided by having a similar bar always in the circuit when the galvanometer bar is out.

In constructing the branch circuit galvanometer it should be borne in mind that the needle cannot be indefinitely affected, as in other galvanometers, by making many turns to the multiplier. The first point to be determined is the distance at which the instrument must be placed from the disturbing influence of the various parts of the circuit; then having determined the length of the wire to convey the electricity from the circuit to the instrument and back, we have the precise length for the conductor in the coil; if the length of the multiplier is either greater or less than this, the deflection will be less. With any given length of connecting cord between the instrument and main circuit, the deflection can be a maximum only when there is the same length in the coil as in the connecting cords.

By the use of this instrument in the electrotype work of the Coast Survey, the very great advantage has been obtained of being able to ascertain by a mere glance, at what rate the batteries are working and the quality of the reduced metal. The desideratum thus acquired in the apparatus has surpassed even the most ardent wishes entertained within my knowledge in reference to the object which it accomplishes.

APPENDIX No. 64.

Abstract of a complete historical acccount of the progress of discovery on the western coast of the United States from the earliest period; compiled, under direction of the Superintendent, by J. G. Kohl.

WASHINGTON, *March* 1, 1855.

DEAR SIR: I am gratified in being able to announce the completion of the work undertaken by your direction. The following short account of it is intended only as preliminary to your critical examination of the work itself, and as such, it is hoped that it may be found acceptable.

Your communication mentioned as desirable—

1. A complete historical account of the progress of discovery, as connected with the hydrography of the western coast, from Coronados island to Cape Scott, the northern point of Vancouver's island.

2. A map to illustrate the historical account, showing in colors the range and limits appertaining to each discoverer and explorer.

3. A collection of maps, reduced copies of originals or duplicates of ancient and modern maps, in further illustration of the history.

4. A list of names of bays, capes, harbors, &c., on the western coast, with critical and historical remarks, settling the orthography of the names.

5. A catalogue of books, maps, manuscripts, etc., relative to discoveries on the western coast.

As intimated in a former letter, the last two particulars seemed to present insuperable difficulties; but in the progress of the others, certain advantages arising therefrom have enabled me to include them also, in accordance with your expressed desire.

The historical account is divided into the following periods: 1. From Columbus to Cortez; 2. From Cortez to Drake; 3. From Drake to the Jesuits; 4. From the Jesuits to the Franciscan missionaries and their expeditions; 5. From the Franciscans to Vancouver; 6. From Vancouver to Wilkes. The seventh period, which is excluded from the narrative by an explicit understanding, would embrace a notice of the crowning work now in progress under your direction for the development of the hydrography of the coast of California and Oregon and Washington Territories.

Some things relating to early Spanish expeditions of great importance, hitherto overlooked by historians, will be found in this memoir. I may mention as examples the first explorations of Fuca strait, by the three Spanish navigators De Haro, Quimper, and Eliza, prior to Gray and Vancouver.

In appendices I have comprised information which may be found both interesting and useful. One of these contains a list of the Spanish governors of Vancouver's island, who, as famous explorers, have their titles and dates of government associated with the geography of the western coast. A list, similar in character, is given of the viceroys of Mexico.

The short introduction and index attached to the historical account exhibit its plan of arrangement and the particulars of its contents.

The map illustrative of the memoir just noticed, exhibits in colors the extent of coast included in the discoveries of each navigator and traveller, with names, dates, etc. A brief description which accompanies the map explains the plan adopted in its construction.

The collection of historical maps shows the condition of discovery and the limit of geographical knowledge in regard to the western coast at various periods between 1492 and 1841. It includes, as far as possible, copies from original maps, on which had been marked by successive explorers the tracks and routes pursued, and which thus serve to show the opinions entertained of the discovered countries by them and their contemporaries. Others in the collection were copied from manuscripts or from rare prints. The copies taken from more modern and better known maps are not without interest as links in the chain of historical connection.

An explanatory note accompanies each map and sets forth its relative value in the series.

The list of geographical names includes the history of nearly three hundred objects, as capes, inlets, harbors, etc., on the western coast. To each name have assigned a separate sheet, at the top of which is written the orthography used in the Coast Survey maps, and for Vancouver's island that found in the charts of the English admiralty.

Brief mention is made of the first application, and by whom, of each name to the corresponding object. Changes in the terms employed are accounted for by reasons which would seem to have recurred naturally in the course of progressive explorations, as affording from time to time more definite information. The treatise on each name is concluded with an attempt to settle, as far as possible, its orthography. Between thirty and forty names yet remain to be discussed in order to form a complete list.

The catalogue of printed and manuscript books and maps relating to the western coast contains two hundred and thirty titles, exclusive of those of the maps comprised in the *collection* before mentioned, (which is accompanied by a list separately,) and I have no knowledge of a more complete catalogue of works on this interesting subject. Maps contained in books are referred to specially.

To most of the titles short critical notes are added, indicating the value of each book as connected with historical research, or noting parts of it for reference. The arrangement is made in chronological order, and the titles of the most indispensable works are distinguished by the letters N. B.

It would seem desirable to append to the foregoing, which includes all that I have now compiled by your direction, *a geographical description of the whole coast*, its configuration, with details respecting the size, figure, and nature of its various capes, straits, harbors, inlets, bays, river entrances, rocks, banks, shoals, and currents, prevalent winds, and other phenomena of general interest to navigation. This could readily be made up from the records of the Coast Survey, and it would add much to the relative value of early accounts of the western coast.

In many cases, while engaged on the work just completed, I was enabled to decide in regard to certain historical doubts only by following your reports, in connection with letters and views and the descriptions given by officers engaged in the work under your superintendence. To give but one instance from many which occurred, I could make out that the old "*Cabo Galera*" of the Spaniards was our *Point Conception* only by comparing the old descriptions of it with the Coast Survey views and delineations of that cape. The expediency of preparing at this time such a compilation as that suggested, is submitted for your consideration.

In the execution of the work, the nature of which is set forth in the short abstract here given, every attainable facility has been afforded in the libraries of the Department of State, the War Department, Navy Department, Topographical Bureau, and National Observatory. In these, and in the valuable collection of Colonel Peter Force, my applications were met by the most prompt and liberal assistance.

I have the honor to be, your most obedient servant,

J. G. KOHL.

A. D. Bache, LL.D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 65.

Observations on the Physical Geography and Geology of the coast of California, from Bodega bay to San Diego.

[Prepared for Prof. A. D. Bache, Superintendent of the United States Coast Survey, by William P. Blake.]

WASHINGTON, D. C., *November* 15, 1855.

DEAR SIR : I have the honor to present herewith a brief memoir on the physical geography and geology of portions of the coast of California, from Point Reyes to the southern boundary; prepared in conformity with your request of March last.

Very respectfully, yours,

W. P. BLAKE.

Prof. A. D. BACHE,
Superintendent United States Coast Survey.

CONTENTS.

ILLUSTRATIONS.

I.

PHYSICAL GEOGRAPHY OF THE MOUNTAIN RANGES OF CALIFORNIA, ADJOINING THE COAST.

1. COAST MOUNTAINS.

The mariner or traveller who has only frequented the Atlantic coast of the United States, has but a slight conception of the great contrast that is presented between it and that of the Pacific. The eastern coast is characterized by numerous and deeply indented bays, stretching far inland, and receiving the waters of numerous navigable streams, producing a broken and serrated coast line. The western is characterized by its remarkably regular and unbroken line of coast, affording but two secure harbors in a distance of 600 miles, and receiving but at one or two points the waters of any large streams. This great difference is due to the geological structure of the regions. Mountain ranges extend parallel with the coast on both sides of the continent; but on the Atlantic side, the mountains are separated from the shore by a broad slope of sedimentary strata, in which the long and deep bays have been excavated; while on the Pacific side, the mountains rise directly from the ocean like a great wall, and are rarely flanked by a broad and low slope. These mountains, by their hardness and continuity, prevent the formation of inlets and the outlet of interior rivers. The importance of a knowledge of the configuration and general topography of these mountains to the student of the coast and its hydrography, will be fully recognised when the fact that the mountain ranges, by their composition and position, have determined the present direction and form of the California coast, is duly appreciated, and it is seen that they furnish the true key to a knowledge of its hydrography.

The ranges near the coast, in the latitude of San Francisco, were formerly called the "Coast Range;" but this name has been gradually giving place to the more general term, *Coast Mountains.*

In California this term is generally understood to refer to the several ranges of mountains lying west of the Sierra Nevada, and forming the barrier between the long interior valleys of the Sacramento and San Joaquin, and the Pacific ocean. By some, the same term has been applied to the great ranges south of the junction of the Sierra with the Coast mountains at the head of the Tulare valley, near the parallel of 35°. It will, however, be seen that these southern mountain ranges, although not separated from the coast by continuous and subordinate ridges, are yet more properly the continuation of the great chain of the Sierra Nevada, and that to apply the name *Coast mountains* to them would lead to misapprehension and be productive of confusion.

The term Coast mountains, therefore, in this article will be understood to refer to the mountain ranges which separate the valleys of the Sacramento and the Joaquin, from the Pacific, or to those which extend along, or near, the coast line from Oregon to Point Conception. South of this point the mountains are different in character and direction, and will be described under other names.

The Coast mountains consist of a series of parallel ranges separated by long longitudinal valleys. In the latitude of San Francisco, there are three prominent ranges: the first, or most western, is called the San Francisco and San Bruno range, and forms the peninsula, which bounds the bay on the west; the second is called Contra Costa; and the third, Diablo range. The last borders the valley of the San Joaquin, and consists chiefly of the peak of Monte Diablo, nearly 4,000 feet high. This peak is visible from the bay, and in clear weather from a long distance seaward. It has been reported to be volcanic, but there is no good reason for the opinion.

The Golden Gate, and the channel of the bays and rivers connecting the Pacific with the interior, have the general character of a great fissure through these three ranges, for the adjoining lines of elevation are apparently continuous with the same trend on both sides of the channel, and exhibit the same parallelisms and general elevation.

In the latitude of Monterey, we find the same conditions of long parallel ranges. Point Pinos, which extends out into the sea and forms the bulwark of the bay of Monterey, is the end of a long and elevated range, formerly called the *Sierra de Santa Lucia*, which extends southward and forms the coast line nearly to San Luis Obispo. This range is probably composed almost wholly of granite, and it forms a bold rocky shore for nearly its entire length.

Beyond this range, towards the interior, we find the long and extensive low valley of the Salinas or San Buenaventura river, which is bounded on its eastern side by another high range, also composed, in part, of hard granitic rocks, with uplifted sandstone strata. This range appears to be the southern prolongation of the mountains forming the northeastern shore of the bay of Monterey, extending to Santa Cruz and Point Año Nuevo, where they are known as the Santa Cruz range. The road from Monterey to San Francisco crosses this range near the mission of San Juan, and at that point it has received the name of San Juan range; further south it is sometimes called the Gavilan or the Salinas range. The third range forms the eastern side of the Benito valley, and divides it from the San Joaquin. The valley of the Salinas is about sixty miles in length, and near its northern extremity about twelve wide. The bay of Monterey may be considered as formed by the junction of this valley with the sea.

In the latitude of San Luis Obispo, the same characteristic parallelism of ranges prevails. At that point they are bold and elevated, and the topography of the interior is as yet but little known. We have thus seen that the Coast mountains do not form one single continuous ridge bordering the sea, but that they consist of a series of parallel ranges enclosing long and extensive valleys. The general direction of the ranges between Sir Francis Drake's bay and Point Conception, is N. W. and S. E.; to which the coast conforms, except where one range ceases and passes beneath the waters, as at Point Pinos, Monterey, forming in this manner a sudden bend in the coast line, constituting a bay.

The general form of the bay of Monterey, occupying as it does the space between the end of one long ridge and the side of another, shows an overlapping character in the ranges in a most distinct manner. This is a characteristic of the California mountain ranges; they appear to be distributed *en echelon*, and to overlap towards the northwest in an ascending order from south to north. This character is visible on a good topographical map of the country, and may be seen on a small scale, on the charts of the bay of San Francisco and San Pablo, where the inner ranges pass beyond and terminate north of the outer.

With regard to the general or average elevation of the Coast mountains, we are without sufficient data to form an accurate conclusion. Several determinations of altitude have been made in the vicinity of San Francisco, but the observations along the ranges south of that point are very few. Table Hill, north of the entrance to San Francisco bay, is 2,569 feet high, and there are many higher summits beyond. South of the entrance, the San Francisco range commences in hills of moderate elevation, increasing in altitude towards the south until, opposite the valley of Jan José, the average elevation of the range is not less than 2,000 feet, and there are many lofty ridges between that point and Santa Cruz. "Blue Mountain," a few miles southwest of the city, is 1,097 feet high, and another point a little further south is 1,263. The second, or Contra Costa range, opposite San Francisco, probably has the average elevation of 1,800 or 2,000 feet. One of the summits nearly opposite the entrance to the bay is reputed to be 1,952 feet high.

The Diablo range chiefly consists of that mountain, with a long spur of low hills connecting it with the second, or Contra Costa range, nearly opposite the mission of San José. The mountain, according to the measurement of Lieut. R. S. Williamson, is 3,960 feet high; while the pass through the range, a few miles south of the peak, is only 686 feet in elevation, and the adjoining hills are not over 300 feet higher.

The range extending along the coast southwardly from Point Pinos has not been instrumentally explored, but is a continuous lofty chain, its average elevation probably being not less than 3,000 feet.

At the southern end of the Coast mountains, where they unite with the great range of the Sierra Nevada, at the pass called the *Cañada de las Uvas*, the ridges near the junction are over 6,000 feet in height. This is about that of the ranges which at that place constitute the termination of the Sierra Nevada. The summit level of the Cañada de las Uvas is 4,256 feet above tide, and the Tejon, a pass about twenty-five miles north, is 5,285; the adjoining ridges rising from 6,500 to 7,000 feet. Between these points and the coast at Santa Barbara there are many lofty and rugged mountains, the topography of which is not yet known, but which compare in altitude with the terminal ridges of the Sierra Nevada.

2. POINT CONCEPTION AND BERNARDINO SIERRA.

Point Conception is the most prominent feature in the outline of the California coast between San Francisco and the peninsula of California. It has been termed the "Hatteras of the Pacific;" and the appellation is not inappropriate, as mariners experience a great change of climate and meteorological conditions on passing it, and though the air to the southward may be warm and soft, fierce and chilling winds may be met on rounding it towards the north. A climatic change is remarkably sudden and well defined at this place, and a great difference in the temperature of the ocean north and south of the cape is believed to exist. This would naturally be expected from the sudden change in the direction of the mountains and the coast-line, which commence at this point. The coast, instead of holding the N. W. and S. E. direction, as along the base of the Coast mountains between the cape and San Francisco, deflects suddenly to the eastward and becomes nearly east and west in its direction. This change of direction has been determined by the trend of the great mountain range which stretches from Point Conception and its vicinity eastward to the peak of San Benardino in longitude 116° 45′, a distance of over 200 miles. Geologically this chain is composed chiefly of granite, gneiss, mica slate, and talcose or nacreous slates in various forms and modifications; erupted porphyries and dikes of igneous rocks are not unfrequent, but there is no evidence of the existence of volcanoes.

The rocks and the topography of the chain, and the fact that it joins the Sierra Nevada at the Cañada de las Uvas, show that in a geographical point of view it must be regarded as the southern prolongation of that chain, and not of the Coast mountains. It forms the southern boundary of the Great Basin, and indeed is the only wall of separation between it and the Pacific. Prior to the recent explorations by the railroad surveying expedition under the command of Lieutenant R. S. Williamson, the topography of the chain was but little known to geographers, and it has been without an appropriate and distinctive appellation. Its peculiar direction being nearly transverse not only to the Sierra Nevada, but to the several ranges of the Coast mountains just described, and the definite geographical limits which are presented by its termination in the bold capes of Conception and Arguila at one end, and the intersection with a north and south chain at the other, in the high peak of San Bernardino, suggests the necessity and propriety of a new name by which it may be known and distinguished from the adjoining chains. In the absence of any other term the name Coast Range has been used by Lieutenant Williamson and others, but in the most general way, without assigning limits or boundaries. I have proposed the appellation *Conception and Bernardino Sierra*, or *Bernardino Sierra** for the chain within the boundaries named, in order to facilitate description and avoid the confusion and misconception incident to the use of the general term *Coast Range* or *Coast Mountains.*

From Point Conception eastwardly to Santa Barbara one of the ranges of this chain rises boldly up from the Pacific, and the beach or shore-line trends exactly with the range in a nearly east and west line. East of Santa Barbara, however, the shore-line deflects towards the south, and beyond San Buenaventura does not follow the base of the mountains but is separated from it by a broad slope with a gentle descent from the foot of the mountains to the beach. This broad slope is most developed to the north and east of San Pedro. The mountain chain rising from the upper portion of this slope, and thus separated from the sea, preserves very nearly the direction of the portion between Santa Barbara and Point Conception; it, however, bends slightly to the south until it unites with the peak of Bernardino. This part of the chain is crossed by several passes, which are generally in valleys, oblique to the trend of the chain, and not at right-angles with it.

The principal passes, known as the San Francisquito, Williamson's, and the Cajon, lead to the surface of the Great Basin, and their summit levels are respectively 3,437, 3,164, and 4,676 feet in altitude. The average elevation of the chain may be regarded as about 6,000 feet. When viewed from the slope or from the sea, the outline of this chain appears rugged and broken, and would by some be called volcanic, though the examination of the rocks does not warrant this conclusion. The peak of San Bernardino is the most lofty and prominent. It is a well known land-mark, and has been used as one of the initial points in the United States land surveys. It has a bald, rounded summit, which is covered with snow during the greater part of the year. Its altitude has not, to my knowledge, been instrumentally ascertained. It is variously estimated at from 7,000 to 9,000 feet, but is probably not over 8,500. Granite appears to be the principal rock of which it is composed, and there is no indication of its being volcanic, other than several thermal springs which gush out from its flanks near the Mormon settlement of San Bernardino. The broad slope which separates the eastern part of the chain from the ocean appears to be composed of tertiary strata and more recent alluvial deposits, forming by their admixture a rich and fertile soil, which, with the advantage of a most genial climate, has encouraged numerous settlements.

It is on this slope, between the mountain and the sea, that we find the city of Los Angeles, San Bernardino, and several thriving villages. The same slope flanking the mountains is

* See the writer's preliminary Geological Report accompanying the Report of Lieutenant R. S. Williamson, H. Doc. 129: Washington, 1854.

continued southward to San Diego, the shore-line curving gradually round and conforming with the change in the direction of the mountains, which commences at the peak of San Bernardino.

It is worthy of remark that this slope, or plain and valleys, lying between the mountains and the beach, is a remarkable exception to the general configuration of the Pacific coast, which, as before remarked, is characterized by its bold and precipitous shores. If, however, the region could be depressed for a thousand feet, or as low as it has been within recent geological periods, we should find that the greater part of all these plains and the slope would be submerged, and that the shore-line would be nearly at the base of the mountains, and become coincident with their trend, as is now the case near Santa Barbara.

Under these supposed conditions of depression, the topography, or the shore-line of the coast, would exhibit in a very distinct and striking manner the east and west trend of the Bernardino Sierra, and a remarkably sudden and angular bend of the mountains at the peak of San Bernardino would become evident.

3. PENINSULA SIERRA.

At the eastern end of the Bernardino Sierra, just south of the mountain of San Bernardino, there is a remarkable pass in the mountains leading from the coast slope to the interior plain of the Colorado Desert. This is called the Pass of San Gorgonio, or San Bernardino, and is bounded on its southern side by the sharp and rugged peak of San Gorgonio. This peak, like San Bernardino opposite it, is formed of granitic rocks; they are, however, more slaty, being chiefly gniessose, and they wear away with sharp angular outlines. From this mountain the chain of heights continues southward, forming the great dividing crest between the Colorado desert and the slope to the Pacific on the western side, upon which San Diego is situated. Further south it separates between the waters of the Pacific and those of the gulf, being continuous in a high rugged chain to Cape St. Lucas, at the end of the peninsula. For this great chain I have proposed the name of *Peninsula Sierra*.

The predominant or general trend of this chain, in its northern portions, is south a few degrees east, or nearly southeast, forming an abrupt angle with the Bernardino Sierra. In elevation, its northern portion, or that part north of the present head of the gulf, will probably average from 5,000 to 6,000 feet; the peak of Gorgonio is probably 7,000, and the ridges south of it are much elevated.

The summit level of the San Bernardino pass is 2,808 feet above the sea; but the next well known pass south of it ("Warner's") is much more elevated, the summit being 3,780 feet above tide. A third pass, still further south, and leading from San Diego over towards the Gila, near or below the boundary line, has about the same elevation. From there to the end of the peninsula the chain appears lofty, rugged, and unbroken by any favorable passes.

The aspect of this mountain chain from the sea is peculiar; it has a singularly rugged and rocky aspect, and many high peaks rise above the general mass of mountains with a conical outline, suggestive of volcanoes. The portion over which my observations have extended, from San Bernardino to the boundary, did not, however, give good evidence of the presence of volcanoes.

Many of the peculiarly conical and sharp peaks were found, on examination, to consist wholly of gneiss or mica slate, much upheaved and worn into the sharp points and peaks by long weathering. A peculiar blackness and lustre which characterizes these rocks on the desert side of the range, leads many persons to consider the rocks volcanic, when they, in reality, are ordinary granite or the allied rocks.

The chain from its northern end at the pass of San Bernardino, southward to the boundary line and beyond it, is flanked on the Pacific side by a continuation of the slope bordering the Bernardino Sierra. It is, however, more narrow, and the sloping character is more distinctly shown. The streams which descend the mountains traverse this slope and cut canal-like channels, with steep banks on each side, so that they are nearly invisible to the traveller on the general surface when a short distance from their margin.

On the eastern side of the chain we find the remarkable desert-region bordering the Colorado. The surface of the country on that side is *lower* than on the west, affording a striking contrast with the conditions presented on both sides of the Benardino Sierra, but a few miles further north, where the interior base of the mountains has an elevation of over 3,000 feet, or, nearly 2,000 feet higher than the seaward base. There is also good reason to believe that the interior surface of the desert is lower than the surface of the gulf, and that it was formerly submerged by its waters, the upper end of the gulf having been shut off by the accumulation of silt at the delta of the Colorado. This singular valley is now dry; but its surface of fine clay, highly charged with shells of fresh-water species, shows that it was for a long time in the condition of a great lake of fresh or brackish water.

The eastern side of the chain is singularly devoid of trees and vegetation, but the high valleys of the western side are wooded with pines and many varieties of the oak, and the foot-hills at the base of the granitic ridges are covered in the winter and spring with a thick growth of the wild oat, so characteristic of the California hills.

4. SUB-MARINE MOUNTAIN RANGES BORDERING THE COAST.

Those who are familiar with the charts of the California coast, or with the map published by the Coast Survey in 1853, will not fail to observe groups of islands rising above the waters in lines nearly parallel with the adjoining shore of the main land. These islands are most numerous, and attain their greatest size between Point Conception and San Diego, but the prolongation of the group is found to extend far to the southward of San Diego; and we find islands skirting the shore of the peninsula, and even further south off the coast of Mexico. We also find a small group of islands, called the *Farallones de los Frayles*, northward of Point Conception, and nearly opposite the entrance to the bay of San Francisco.

All these islands have, as will presently be shown at length, a linear arrangement, extending in long lines parallel with the adjoining coast; and they may be regarded as the crests or culminating points of extended but submerged mountain chains, nearly co-incident in their direction with those that have been drained by the uprising of the continent.

If, however, these *Oceanic ranges* were not sufficiently lofty to raise their crests above the waves, we should still be able to declare their existence and general trend from a knowledge of the configuration of the ranges of the adjoining coasts. Their presence, however, is of great importance to the geographer and hydrographer, indicating, as they do, the exact position and direction of the ranges, and enabling him to point out the probable position of shoals and rocks, and of great longitudinal valleys beneath the sea. It is, therefore, important to the interests of navigation that these submerged mountain ranges, indicated by the islands, should receive careful consideration. South of Point Conception we find six large islands, between the parallels of 32° and 34°, at different distances from the coast. There are also several small islands, and numerous rocks and reefs. Santa Rosa, the largest of these islands, is about fifteen miles in length and nine in breadth.

Santa Cruz is about twenty-one miles long and from four to five broad. Santa Catalina is about eight miles long and three broad. They are all elongated, and the direction of greatest length is parallel with the coast off which they rise. They all have bold precipitous shores, and rise into high peaks and ridges, that have during the summer season a peculiarly barren and forbidding aspect to the traveller who views them from the decks of the steamers as they pass back and forth from San Francisco to Panama.

The three large islands of San Miguel, Santa Cruz, and Santa Rosa, together with the smaller one called Anacapa, form one prominent group. They are distributed in one continuous line, their ends being opposed and separated by comparatively narrow channels. The line thus formed is sixty-five miles in length; its direction is nearly east and west; in fact the parallel of 34° intersects each island parallel with its axis of greatest length.

The east and west trend of these islands is exactly that of the opposite coast of the main land, between Point Conception and San Buenaventura, and it has already been noticed as characterizing the mountain ranges of the interior in that latitude. The relative positions of these three islands and the coast will be seen on the charts of the survey representing the coast from San Francisco to San Diego. The distance of this line of islands from the adjoining coast is about thirty miles, forming a broad valley or channel known as the Santa Barbara channel. The peculiar hydrographical conditions indicated by this group will be subsequently considered.

South of the group just described we find three more islands of nearly the same size; they also present the elongated character, but they are not disposed in one straight line; their direction of greatest length is, however, the same, being parallel with themselves and with the adjoining coast. This direction differs from that of the group just described, being very nearly northwest and southeast; and this is likewise the trend of the coast.

A beautiful exhibition of parallelism between the islands, the coast, and the interior mountain ranges, is presented here; for, as we have already seen, the mountains south of San Bernardino become nearly northwest and southeast in their direction.

Santa Catalina is the nearest of these three islands to the main land, and is twenty-five miles distant from the shores of the bay of San Pedro. It is about seventeen miles in length, and about five in breadth. San Clemente is about the same length, and lies at nearly double the distance from the coast, and a little further south. The island of San Nicolas lies still further seaward, and is about sixty-five miles from the coast, measured in a direction transverse to the trend. We thus find the distances of these islands from the coast to be twenty-five, fifty, and sixty-five miles; and they indicate the existence of three parallel ranges skirting the coast at these distances.

The island of Santa Catalina, although very much elongated in a northwest and southeast direction, and thus having a well marked trend, appears to be nearly isolated, and is without any apparent connexion with the other islands. The line of trend, however, if prolonged far to the southeast, intersects the group of islands called Los Coronados, off San Diego. The island of San Clemente has also a very distinctly marked trend northwest and southeast; and about forty miles distant from its northern extremity we find the island of Santa Barbara lying directly in the prolongation of the line of trend, thus indicating the submarine continuation of the range between them. A similar submarine prolongation is shown at the island of San Nicolas, where Begg's rock rises above the water seven miles distant from its northwest end. This rock is directly in the line of trend of the island, and is a good index of the direction of the submerged range. This direction is nearly northwest and southeast, and a line of soundings to the southeast of the main island would probably detect the prolongation of the range in that direction.

I have thus considered these three principal islands as culminating points of as many distinct but parallel partly submerged mountain ranges skirting the coast, and I propose to give them provisionally the names of the principal islands which indicate them. In considering the direction of these oceanic ranges, we should bear in mind the peculiar westward deflection of the ranges of the main land, which commences at the peak of San Bernardino, nearly abreast of the northern extremities of the islands. We should expect to find a similar and corresponding deflection impressed upon the marine ranges under consideration; and this is rendered more probable by the existence of the east and west marine range indicated by the islands of San Miguel, Santa Rosa, and Santa Cruz. It is therefore possible that the islands of Santa Barbara do not belong to the San Clemente range, but that they are on the prolongation of Santa Catalina; and possibly also the island of San Nicolas is on the continuation of the San Clemente range. If this be found to be so, the number of ranges would be reduced from three to two, and their direction would be curvilinear, or deflected more towards the west as they approach the San Miguel and Anacapa range. Indeed, I consider these conditions as extremely probable, and partly indicated by the soundings between the north end of Santa Catalina and Santa Barbara; but further soundings in a direct northwest line from Catalina, and from the other islands also, and in a line a few degrees north of west from the Santa Barbara islands, are required to throw further light upon this point. Such soundings would probably result in the discovery of extensive reefs and shoals, separated by longitudinal valleys.

Still another marine range is indicated by the bank known as the Cortez shoal, about forty-five miles beyond San Clemente, and probably twenty-five miles beyond the San Nicolas range, if this be found to extend in the direction of the trend of the island. This shoal is of peculiar interest, from its supposed volcanic origin. It was found by Captain Cropper, of the steamer Cortez, in March, 1853, who says the water around it was in violent commotion, and thrown up suddenly into columns, at regular intervals of four or five minutes. He at first thought he saw breakers, and, at times, the water broke as if on a reef.* The recent observations of Lieutenant McRea have shown that there is a ledge of rocks at this place. They will probably be found to be a part of an extended reef, trending in a northwest and southeast direction, or parallel with the neighboring islands. A line of soundings, northwesterly and southeasterly from the shoal, is very desirable.

5. HYDROGRAPHICAL INDICATIONS, PRESENTED BY THE TOPOGRAPHY OF THE COAST AND THE MARINE RANGES.

In deducing the hydrography of the coast, from a consideration of the physical and geological features of the land, we are guided principally by the direction and character of the consolidated and rocky frame-work upon which the looser and more modern sedimentary deposits have accumulated. We, however, find that the topography of all the principal valleys of the Coast mountains is considerably modified by sedimentary deposits, formed when they were submerged, and which have since been much changed and modified by degradation and the currents of rivers. The extent and character of these deposits cannot be well determined from a consideration of the topography of the bordering rocky elevations. The marine ranges, which have been described, doubtless modify, and in some cases determine, the direction of the oceanic currents in their vicinity. Where these currents are strong, we must expect great changes to be produced among the loose sedimentary materials of the bottom, which would be shifted about and deposited in banks and shoals, and in valleys among the rocks, where, from a consideration of the topography alone, we are led to expect to find deep water. This cause of the modification of the ocean bottom should not be lost sight of in the discussion of the hydrography indicated by the marine ranges.

Of the several marine ranges which have been indicated, that of San Miguel and Anacapa, along the parallel of 34°, is the most distinctly defined, and clearly marked in its direction, and is sufficient proof of the continuance of the main physical features of the adjoining land under the waters of the ocean. The broad valley between this range and the main land probably corresponds, in general form, with those of the Salinas and the bay of San Francisco. It is merely a trough or depression between two ranges of mountains, and though now covered by the waters, the elevation of that region several hundred feet would effect its drainage, and we would find it to correspond in configuration with the valleys mentioned.

In searching for the submerged portions of the bordering range of this broad valley, we should look in the lines of prolongation of the island group. This, on the eastern end, would intersect the coast near Point Duma, and it is possible, and in accordance with the diverging character of the ranges of the interior in that latitude, that this marine range unites with the coast near that point. In this case, a line of elevation of submerged hills and rocks will be found by sounding between Anacapa island and the shore. The western prolongation of the range will

* Verbal communication to the writer.

probably be found by sounding in a line a few degrees north of west of the island of San Miguel. It is probable that the range is not prolonged to a great distance in that direction, and that it either sinks down to low hills, or unites with ranges having the direction of the coast, north of Point Conception and Arguila. The fact that the western end of the high chain of the Bernardino Sierra does not project into the sea, in a bold promontory of great elevation, but rather breaks down into low hills and diverges in a series of ridges towards the north, indicates similar conditions in the marine ranges, and it is not, therefore, improbable that the marine range of San Miguel and Anacapa breaks down into subordinate ridges, and soon becomes lost under the waves. For the same reason, it is possible that a westerly submarine prolongation of the Bernardino Sierra will not be found to extend far, or with any considerable altitude, off Point Conception. We may, however, conclude that the hydrography off Point Conception and Arguila is exceedingly complicated, simulating the confusion and complexity of the topography at the junction of the Coast mountains with the Bernardino Sierra between the south end of the Tulare valley and the coast at Santa Barbara and Point Conception.

Shallow places, or submerged rocks and reefs, may be expected northwest and southeast of Santa Catalina, San Clemente and San Nicolas, or along the prolongation of the line of trend of these islands. It is desirable to have a line of soundings from both ends of these islands, in the direction of their trend, and especially between San Clemente and the Santa Barbara islands. The probable direction of the ranges indicated by these islands has already been considered, and will serve as a guide to the selection of lines for sounding.

The soundings already made and recorded by the Survey, indicate that the prolongation of San Clemente is not in the direction of San Nicolas, rendering it more probable that the range extends to Santa Barbara island. Soundings northwest and southeast of the Cortez shoal are also desirable.

From topographical indications alone, we are led to expect deep water, and an absence of rocks near the surface in the spaces between the lines of trend of the marine ranges; in other words, in the submerged valleys. The soundings already made, however, show in some instances a very uniform but not great depth; as, for example, between Santa Barbara island and Santa Catalina, where the depth does not exceed 90 fathoms. Between San Clemente and San Nicolas the depth exceeds 120 fathoms near each island, and about midway is 115. Deposits of sedimentary materials among these islands are indicated by these results.

North of Point Conception and Arguila, the coast topography leads us to suspect the existence of submarine ranges parallel with the coast, the first of which is probably within a distance of twenty or twenty-five miles of the shore. It probably conforms in trend with the Santa Lucia range of the Coast mountains, which is remarkably uniform in elevation and direction, and terminates at Point Pinos. A series of soundings on lines transverse to the trend of the coast in this latitude, between Point Pinos and San Luis Obispo, would probably detect these supposed submerged ranges, and show that the bottom is undulated in a series of parallel ridges and valleys, corresponding with the valleys of the Coast mountains; as, for example, the Salinas valley and its bordering ranges. The probability of such results, indicated as they are by the topography of the coast and by the marine ranges just indicated, is rendered still more certain by the beautiful discovery, under the direction of Professor Bache, of submerged mountain ranges and valleys off the Atlantic coast, conforming in their direction with the shore-line and with the current of the Gulf Stream. The section off Charleston, by Lieutenant J. N. Maffitt, has shown the presence of two ranges—the first 96 miles, and the second 136 miles from the coast.*

The distinct and well-defined range of Santa Lucia passes under the waves at Point Pinos; but there is every reason to believe that it is continued in a range of submerged rocky points across the outer portion of the wide bay of Monterey, as far north as the Farallones islands, off

* See Report of Professor A. D. Bache, Superintendent of the U. S. Coast Survey, 1853, p. 47.

the entrance to San Francisco bay. These seven small islands are of great hydrographical interest, being disposed in one continuous line exactly parallel with the coast, and about twenty miles distant from it.

The probability of their being portions of the prolonged range of Santa Lucia, (Point Pinos,) is not only shown by their being nearly on the line of trend, but by their similar geological character. I have long been inclined to consider them as formed of the same kind of granite which is found at Point Pinos, and this has been recently proved by the examination of the islands by Lieutenant Trowbridge. The line of trend of these islands is northwest and southeast, and the exact prolongation southeasterly of this line would intersect the coast line near Point Miramontes, where the central range of the mountains, or main axis of the ranges, is of granite rock. It is, therefore, possible that the submerged range upon which these islands rise are branches from the main land, near or at that point, and that the prolongation of the Santa Lucia range from Point Pinos must be sought for further seaward ; and this is likewise indicated by the fact that the exact prolongation of the trend of that range would pass to the westward of the Farallones.

II.

GEOLOGY OF THE PRINCIPAL BAYS AND PORTS FROM POINT REYES TO SAN DIEGO.

GEOLOGY OF PUNTA DE LOS REYES.

The bold projecting promontory of Point Reyes extends into the sea like an arm, nearly at right angles to the coast. It is a natural breakwater, which forms on its inner side the bay discovered by, and named from, Sir Francis Drake. The promontory may be regarded as a rocky island, connected with the main coast by a low neck of soft strata of sand and clay, which would become submerged and washed away by the sea if the country were but slightly depressed. The extreme point or head of the promontory is formed of hard sienitic granite, and this is the firm bulwark that preserves the soft and yielding sedimentary strata that connect it with the main land from rapid denudation and destruction by the surges of the Pacific. The resistance of this sienite to degradation, as compared with that of the soft strata, is strikingly shown by the form of the head of the promontory, which, as will be seen by inspecting the geological map of the point accompanying the memoir, (Sketch No. 59,) is broadest along the granitic portion, and extends outwards beyond the sedimentary rocks on each side, and on the inner side, far enough into the bay to form a sheltered cove, secure from heavy waves. The granite, in fact, is a narrow strip at the end of the promontory, about three and a quarter miles in length, and one third of a mile broad ; while the width of the adjoining exposure of sedimentary rock, measured parallel with the length of the granite, is only one and a half mile.

This granitic strip rises to the height of 597 feet, and its southern side presents a bold bluff to the Pacific. Its base is fringed with hundreds of rocky islets, thickly clustered together, and rising in dark pinnacles among the angry waves which bathe their summits and the foot of the bluff in dense masses of white foam. The general form of this bluff, and the relative positions of the granite and the sedimentary strata, are shown on the geological section which accompanies the map. It is constructed from the measurements of the survey ; the contour lines of the plane-table sheet serving to give the elevations of the points cut by the line of section. The direction of this line is north, 33° east, and it is drawn on the map.

The sedimentary strata are unconsolidated, and consist chiefly of yellowish clay and sand having a regular stratification, and resting horizontally upon the rugged surface of the granite. The wearing action of the surf along the shore of the bay has formed a continuous vertical bluff of these strata, varying from fifty to eighty feet in height, in which their edges are well exposed to view, and are distinctly seen when entering the bay from the south. The bay appears as if surrounded by a white wall, and its resemblance to portions of the coast of England is said to have induced Sir Francis Drake to give the land the name of New Albion. The stratification is not perfectly horizontal; there are slight dips of from two to fifteen degrees, producing a gentle wave-like flexure in the lines of stratification.

I searched carefully for fossils along the base of the cliff, and among the masses of earth that had fallen from above, but did not succeed in finding any. The formation is, however, without doubt, Tertiary, and probably belongs to the miocene division. Several very interesting faults of the strata, from six to fifteen feet in extent, were observed on the face of the bluff as shown in the section, some being in long vertical lines, and others oblique. The beautifully accurate and minute measurements and topography of the survey, as exhibited on the plane-table sheet, show that these faults are the result of local land-slips of small extent; but when viewed from the beach at the base of the bluff, they appeared to traverse the strata for great distances.

Several isolated patches of sandstone and conglomerate of pebbles were found on the granite near the top of the bluff. They were harder than the materials composing the strata just described, but they are probably upper portions of the same series of deposites.

Mineralogical character of the Granite forming the Point.—The granite of the point is practically interesting, it being the nearest locality of the material to the city of San Francisco. A quarry has already been opened near the shore, and a considerable quantity of stone has been removed. Some difficulty was experienced in procuring large dimension-stone near the surface, as there are many cracks and seams resulting from decomposition. There are also "dry seams," which traverse the undecomposed portions and give smooth curved surfaces to the blocks. It is, however, possible to procure good building-stone from the locality by judicious working, and the selection of favorable points. In quality, the stone may be considered excellent; it has a fine grey color, like the Massachusetts sienite, and is free from pyrites or other objectionable minerals. Both hornblende and mica are found in it—the former being dark green, and not very hard; the latter is in small and brilliant black scales. The feldspathic base appears to consist of two varieties: one is of a light yellow color, and is possibly albite; the other is hard and glassy, and is disseminated in distinct crystals, varying in size from a fraction of an inch to two inches or more in length, and giving a porphyritic character to the mass. These large crystals resist decomposition exceedingly well, and stand out in relief upon the weathered surfaces of the rock. The yellowish spar is not so durable, and in decomposing assumes a rusty brown color; it forms, however, but an inconsiderable part of the rock in the best locality for quarrying. A distinct lamination or structural arrangement of the minerals is visible in this granite. It is not very distinct on the weathered surfaces, but shows plainly in blocks that have been cut out and "dressed." The direction of these planes of structure, as exhibited in the quarry, is about north 20° east—a direction almost transverse to the trend of the bluff. It is possible that this direction is local and confined to a portion of the granite, which seems to form a distinct outcrop, like a dyke in the surrounding mass.

The trend of the bluff of this point is nearly east and west. This is peculiar, and would not be expected from a consideration of the trend of the ranges of the coast and of the Farallones, which are northwest and southeast. It is worthy of remark, that the granite of this point bears a general resemblance to that of Point Pinos, at Monterey, differing chiefly in the presence of the dark green hornblende, and the greater ratio in quantity of the hard feldspar to the other minerals.

The bold, rocky character of this point, and its prominence beyond the general line of the coast, render the erection of a light-house upon it very desirable and important. It is fortunate that such excellent material for its construction is found upon the spot. Granite is also found east of the low neck of Tertiary strata, and forms the main ridge which bounds Tomales bay, on the west. The laminated or gneissose rocks are also found, and with them, thick beds of good white limestone, which is quarried and calcined for the San Francisco market.

GEOLOGY OF THE ENTRANCE TO THE BAY OF SAN FRANCISCO.

The peculiar break or cleft in the outer range of the Coast mountains, called the Golden Gate, and connecting the bay of San Francisco with the Pacific, is not only an interesting physical feature, but presents a variety of rock formations and a complex geological structure. Both shores of the entrance are bold and rocky; that on the south is broken into a series of projecting points, between which there are sand-beaches; the northern is more bold, and rises in some places almost vertically from the water, reaching a height of 1,000 feet only a short distance back from the shore. The principal points of the southern side, in their order of succession from the Pacific eastward, are Point Lobos, Fort Point, San Josef, Tonquin, and North Point. The two latter are within the limits of the city of San Francisco, and are already covered with buildings.

The rocks of North Point, Tonquin Point, and San Josef are continuous southwardly, and form Russian and Telegraph hills. They consist of a fine-grained and very compact sandstone of a dark bluish-green color. It is regularly stratified in beds of varying thickness, ranging from a few inches to many feet, and often separated by thin layers of argillaceous shale. Thick beds of these shales are also found to alternate with the masses of sandstone strata. Wherever this sandstone and the shales are quarried into, the dark color is invariably found in portions below the reach of the atmosphere; but the outer and exposed portions are very much decomposed, and their color is a rusty brown or drab. The rock appears to contain a large amount of protoxide of iron, which changes to the hydrous sesquioxide on exposure. All these strata are upheaved and thrown into flexures. This may be seen along the shores and in the street cuttings of the city around the base of Telegraph hill. The dips are variable, and range from 15° to 60°, and in many places there is much contortion and folding of the strata. The extent and localities of this sandstone will be seen on the small geological map of the headlands which accompanies this article, (Sketch No. 58.) It is found to constitute the principal islands of the bay and the projecting points of land around Sancelito, and the outer point or headland on the south side of the Golden Gate, (Point Lobos.)

It has been quarried for building-stone at several places, the principal openings being at Yerba Buena, State's Prison, Angel island, and Marin island. The stone has a pleasing color, and in dry places is firm and durable, but will probably become rusty and decomposed where exposed to moist air.

The geological age of this sandstone formation is not yet determined. It appears to be remarkably free from fossil remains, and, hitherto, with the exception of the fragments of plants in the form of lignite, the only fossil found in it near San Francisco is a species of spatangus of the genus *Scutella*, which was cast up on the beach from a submarine outcrop, and indicates a Tertiary age for the formation. This fossil occurs in a rock of similar mineral character to that of Point Lobos; and although the spatangi have not been found *in situ*, there is every reason to consider them as broken from the strata. A group of softer strata are found at Benicia, which are probably of the same series. They are much uplifted, and contain sharks' teeth and casts of shells of undoubted Tertiary age.

Metamorphosed rocks.—At several places on the peninsula of San Francisco, a peculiar, hard, and flinty rock appears at the surface, and exhibits distinct stratification. It has a variety of colors, but a dark reddish brown is most common. It is much traversed by irregular veins or seams of quartz, and has a banded or belted structure, so that it resembles varieties of jasper. It is found near the Presidio, (about half way between the ocean and the bay,) near the Mission, and on the northern shore of the entrance, where it forms the principal bluff, and exhibits its stratified character most distinctly. It is also found at the cinnabar mine of New Almaden, near San José.

All the characters of this rock, and its positions, indicate that it is an altered portion of the San Francisco sandstone formation. The stratification of this rock on the north side of the Golden Gate is best seen from the deck of a vessel or boat when passing in or out of the channel, the shores being so precipitous that it is impossible to land except at one or two points in little valleys or coves. The direction of the channel is directly transverse to the trend of the rocks; the edges of the strata are therefore exposed, and their dip and flexures are brought to view. This dip appears to be westerly, at an angle of forty degrees; several thick and hard beds form the crest of the highest hills, and outcrop there in long lines. At Lime Point the stratification is beautifully distinct and very uniform; the dip is nearly vertical, and in some places the most intricate plications of the strata are visible within the space of a few feet. Several high needle-shaped pinnacles of this rock rise from the waves at a short distance from the main bluff.

Erupted rocks and serpentine.—At the base of the bluff of Lime Point, and on the eastern side along the shore of a little cove, a dark line may be observed near the tide-level, caused by the junction of the metamorphosed strata, with a black and hard intrusive rock of the trappean class. This line of junction appears to conform very nearly to the water-level, and indicates that the overlying rocks have been removed by the undermining action of the surf, until the more unyielding formation of crystalline rock was reached. The position of this erupted rock is shown on the map.

Fort Point, which projects so boldly into the channel, is formed of a hard serpentinoid rock, containing distinct crystals of augite, and is evidently eruptive. The outcrops of this rock are composed of loose rounded masses of a dark color, and often traversed with seams of amianthus; a globular structure of the rock is thus indicated, and is found to exist where deep excavations into the body of the rock are made. This was well shown in cutting away the bluff at the end of the point preparatory to the erection of fortifications. The whole rock consisted of a mass of spherical or spheroidal masses, incrusted with thin layers of green talcose rock, in a state of partial decomposition, resembling the lamellar portions of the serpentine of Hoboken, N. J., where it has been exposed to the weather. Outcrops of this serpentine are found at the Orphan Asylum and near the Mission. It is also abundant in the mountains between San José and the ocean, (the San Francisco range.) This serpentine ridge is flanked on both sides by the sandstone strata, and appears to have been intruded among them. A portion of the sandstone formation, consisting of beds of sandstone and shale, about 300 feet thick, are found included or imbedded in the serpentine ridge, and crop out in the bluff along the beach just east of the fort. They do not exhibit any indications of having been heated, as their color is only a little darker than the portions outside of the serpentine; they, however, are a little more hard and compact.

Alluvial deposites and sand-dunes.—It is a curious and interesting fact, that the sand-beach between Fort Point and San Josef has been thrown up by the surf upon an extensive alluvial deposite, which has the character of a peat-bog or swamp. When the tide is very low, the edge of this peat formation may be seen. Large masses of the peat are also broken out during storms, and thrown up on the sand of the beach. This sand, and all the loose round boulders, from three to eight inches, or more, in diameter, rest upon a foundation of the peat, and the continuation of the peat is found in the swamp or flat meadow-land which lies inside of this belt of sand, and between it and the base of the sandstone hills. It is very difficult to account for the formation of this swamp under conditions like those at present existing.

A strong current is constantly setting back and forth through the channel, and the action of the surf constantly undermines and encroaches upon the beach, so that the present action is destructive, and the swamp could not possibly have been formed while the Golden Gate was open, as we now find it.

A similar peat-swamp is found bordering Mission bay, between Rincon Point and Point San

Quentin, and is believed to underlie a part of Happy valley. Artesian borings in Happy valley have shown that the sand-dunes, which cover the surface there, rest upon a substratum of fine blue clay, which has been pierced to a depth of seventy-five feet, without showing any great variation in its composition. An equal thickness of soft strata of fine clays and sand, with some pebbles, all evidently derived from the surrounding rocks, has been perforated in the borings, to ascertain the nature of the foundations for the new custom-house, outside of the old shore-line of the city, in the cove between Clark's Point and Rincon Point. On the Contra Costa shores of the bay there is a border of low flat land of alluvial or recent origin, which appears to have been derived in great part from the wash of the adjoining hills. It forms an almost continuous margin, or shore, to the bay southwards as far as the mouth of the little creek that drains the valley of San José, and empties into the bay at its southern extremity. At this point there is a wide extent of land of alluvial origin, and the shores are very muddy and shelving, so that large areas are left bare at low tide. Higher up the streams the low lands become meadows, covered with grass, and resemble the broad salt meadows at the mouth of the Hackensack and Passaic rivers, in New Jersey, and West and Quinnippiac rivers, in Connecticut.

Sand-dunes.—The sand-dunes of the San Francisco peninsula are an important feature in its geology. They cover a large space in Happy valley, and, indeed, are found in every sheltered nook in the depressions between the hills. The persistent winds that pour in from the ocean raise the sands of the long beach south of Point Lobos, and carry them inland up the hill-sides over bushes and dwarf oaks, so that hundreds of acres are covered and rendered desert-like.

In Happy valley the dunes appear to be protected from the winds by the mountains, and here have probably attained their greatest elevation, which is believed not to exceed fifty feet. The hills are now covered with dwarf oaks and shrubbery; but, where they are cut through to form streets, the lines of stratification produced by the winds are visible. The broad sand-beach, and the desert-like region lying directly east of it, form a conspicuous feature of the coast. The quantity of sand which has been driven inland from this beach is enormous, and its accumulation has greatly modified the topography of the peninsula. Another, but much more limited accumulation of blown sand, is found east of Point San Josef, and extends across to the eastern slope of Tonquin Point, over which it pours when the wind is high. This sand appears to be derived from the beach extending eastward from Fort Point.

The limits of the principal formations along the entrance are shown on the small geological map. The sandstone strata are believed to extend from the serpentine ridge in a series of wave-like flexures under the bay to Yerba Buena; and beyond it, to the flanks of the Contra Costa range opposite the city.

GEOLOGY OF POINT PINOS AND THE BAY OF MONTEREY.

Point Pinos is the first prominent headland of the coast south of Punta de los Reyes, and, like this, consists of granite rock, which, by the resistance it offers to the surges of the Pacific, forms the outer wall or protecting barrier of the bay. It has already been stated that this point is the northern termination of a long and high mountain range—the Santa Lucia range—the central axis of which is probably formed of granite rock similar to that of the point. Point Pinos has well-marked physical features, and is readily recognised on approaching the coast by the peculiar outline of its surface and the grey rocks and islets along its shores, differing from the rounded outlines and soft banks of sedimentary clays and sand which border the greater part of the coast further south. It it also characterized by a thick growth of pine trees covering its surface, and constituting a remarkable and peculiar feature on that almost treeless coast. It is from this peculiarity that the point has received its name. These trees abound to the exclusion of others, except on that portion of the promontory near the bay of San Carlos, where cypress trees are found. The limits within which these evergreens extend, appear to coincide with the boundaries of the granite formation. The rock formations adjoining the granite of the point, and underlying the city of Monterey, and forming the hills on the eastern side of the bay, are composed of Tertiary strata of clay and sand. This formation supports a growth of oaks, which contrast finely with the more pointed outlines of the pines.

Granite.—This rock is well exposed along the beach, between the landing at the custom-house and the outside of the point. It extends out into the water in long lines of rock, producing numerous islets and a rocky uneven bottom. Further inland it rises into low bluffs and isolated knobs, consisting chiefly of large weather-worn masses.

The extent of this granite, and the dividing line between it and the Tertiary formation, is shown upon the map accompanying this memoir.

Quarries have been opened at one or two points along the beach; the most extensive excavation being at Point Almeja, or Muscle Point. The rock has a light grey color, and a fine and even grain, the grey color being given by small crystals of black mica. It is, however, porphyritic, containing numerous large crystals of glassy feldspar. Feldspathic veins are also very common, traversing the rock in straight lines in different directions, some of them being nearly horizontal, and others highly inclined. They vary in width from one to six inches or more, and are very coarse grained. These veins do not appear to affect the strength of the rock sensibly. Wherever decomposition has taken place, the rock assumes a brown iron-rust color. Along the beach, where all the decayed parts are removed by the surf, the surface is white and crumbling. After penetrating below the decomposed portions, fine solid blocks can be obtained for building purposes. Stone is readily shipped from this point to San Francisco, where it is used in the construction of the fort at Fort Point, and for paving the streets of the city. This granite has also been used for the Point Pinos light-house, and appears remarkably well.

Tertiary strata.—The stratified rocks which adjoin the granite of Point Pinos are of Tertiary age, and present many interesting peculiarities. The line of junction of the two formations is shown on the map, and coincides very nearly with the curve of a small creek which winds along the base of the hill on which the fort is built. The Tertiary strata are of different colors, but are generally composed of fine materials, such as clay and minute grains of sand closely impacted together, so that a rock resembling half-burned crockery-ware is formed. This rock is sufficiently tough and firm to be wrought into square blocks for building purposes. The Mission church is constructed of it, and it appears to resist decomposition very well. The predominant color is a light yellow or drab, but some of the rocks are an olive-green. The strata do not rest horizontally, but have been disturbed, so that they present various degrees of inclination at different points. The angles of dip, however, are not large; and in the city, where several quarries are open, the inclination is less than 10°. This formation is remarkable at this point for the number of fossils it contains. The casts of a small Tellina are found covering square yards of the argillaceous layers as they are broken out from the quarry, and the same rock is frequently found charged with minute calcareous shells of polythalamia or foraminifera. They may be seen by the naked eye, but the microscope is required to trace out their form and structure. Higher up in the series of beds, and at a point about two miles southeast of the fort, thick white beds resembling chalk are found cropping out on the side of a hill. This outcrop forms a conspicuous object in the scenery of the shore-line of the bay; appearing as a white spot in the midst of a dense growth of green chamisal or dwarf oaks and *larrea*. It is readily seen from the town and the anchorage in the bay.

These beds are chiefly composed of fine white clay and silex, with innumerable silicious skeletons of marine infusoria.

Among these microscopic skeletons the genus Coscinodiscus is well represented, and beautiful objects for the microscope can be readily obtained. According to Professor Bailey, this deposite contains numerous species only recently found to be living in the Pacific, and some which could only have grown in shallow water.

The following is the order in which the strata occur from above downwards:

	Ft.	In.
1. White silicious earth, light, and charged with infusoria	50	0
2. Compact and silicious, probably bituminous	0	3
3. White and earthy, resembling No. 1	1	0
4. Compact, silicious, dark colored, and bituminous	0	6
5. White and earthy, like No. 1	12	0
6. Compact, silicious, dark colored, and bituminous	0	6
7. White and earthy, like No. 1	2	0
8. Compact, flint-like, very hard, and nearly white; in thin layers	2	0
9. Thin layers of white earthy material, similar to No. 1; intercalated with thin sheets of compact and semi-opaline silica	10	0
10. Compact and silicious; hard and drab-colored	3	0
11. White and earthy, similar to No. 1. (The thickness of this stratum was not estimated; it extends downwards, under the chamisal, for a long distance.)		

The total or combined thickness of the white infusorial beds is seventy-five feet, and there are probably many more beds below, which were not measured. This estimate is exclusive of the compact silicious beds, which are also fossiliferous and very curious, several being as compact as semi-opal, and breaking with a conchoidal fracture like glass.

On the top of this deposite there is a well-defined accumulation of beach pebbles, and worn fragments of the infusorial beds are found among them. This beach and the fossils are now over 300 feet above the bay, and they show conclusively that great changes in the form of the highlands or mountain ranges of the California coast have taken place since the Tertiary epoch. The comparatively recent action of the sea is also shown on the surfaces of the strata about Monterey; they are much worn and smoothed, and the round perforations of the boring shells may be found under the beach-shingle and soil.

CYPRESS POINT AND BAY OF SAN CARLOS.

Cypress Point is about five miles south of Point Pinos, and is formed of a similar granite rock. The shore-line between the two points is also of granite, forming a bold rocky shore, with an occasional small cove, and a beach of white sand derived from the abrasion of the granite. This point forms the northern boundary of the small bay of San Carlos, which appears to be merely a re-entering angle in a depression of the granite, this rock being also found on the southern side of the bay. It there rises in bluffs, and is much fissured and broken, so that several small coves are formed. The position of these outcrops of granite, and the general trend of the range, indicate that the bottom of this bay, or its entrance, is rocky and very uneven. It is probable that, in many places, pinnacles of granite rise near to the surface. On the northern side of this bay, east of Cypress Point, strata of a coarse conglomerate are exposed, and rest upon the granite. The inclination of these strata is very slight, and at that place they do not appear to have been uplifted by the granite. On the southern side of the bay, however, a similar conglomerate and sandy strata are exposed, and are much hardened and consolidated as if by heat and pressure. The conglomerate at this place forms the outermost point of the coast, and is known as Point Lobos. It consists entirely of a very thick mass of water-worn boulders, and pebbles from one inch to eight inches in diameter, and remarkably free from finer materials. These boulders are, however, firmly cemented together—so firmly, that it is almost impossible to detach one from the mass. The strata are very thick, and dip eastwardly. No granite or erupted rock is visible in the immediate vicinity. This conglomerate is so hard that it resists the action of the most violent waves of the Pacific, and it is constantly bathed in a heavy surf. Several small islets of this rock rise from the water a short distance from the point, and are frequented by vast numbers of sea-lions, whose roar may be heard above the noise of the breaking surf. The continued action of the water has gradually worn caverns in the softer parts of the strata, and the firmer layers project over the waves. Some of these caverns extend into the strata for long distances, and the tumultuous rushing of the waters may be witnessed through openings from above.

The granite rocks do not appear in connection with the conglomerate: they are further inland. There is, however, reason to believe that the conglomerate of the northern side of the bay is of the same age, and that this granite is newer. No fossils were seen in or near the conglomerate, but I was inclined to consider it of tertiary age. Near one of the quarries on the south side of the bay, the line of contact between a sandstone and the granite is visible, and, although there is no great alteration or baking of the strata due to heat, the relative position of the two formations indicates that the granite is the most recent and intrusive. I was not, however, able to extend my observations so as to determine this interesting question to my satisfaction. The pebbles and rocks of the conglomerate are chiefly of the erupted class, being trap and porphyries of various textures and colors.

At the upper end of the bay the shores are low and formed of alluvial deposits. These border a small stream called the *Carmello*, for two or three miles, and afford broad and very fertile fields for cultivation. The mission of San Carlos is situated on the bank of this small river.

SAN LUIS OBISPO AND SANTA BARBARA.

These ports are merely open bays or slight curvatures of the coast line at the base or side of high and rugged ranges of mountains.

The shore line at both places is formed by the edges of nearly horizontal strata of tertiary or post tertiary age. The erosion of the sea has worn these deposits away by gradually undermining them, so that at some places bluff banks from twenty to fifty feet, or more, in height are produced. These are generally of a light color, and the strata are not firmly consolidated. Layers of fossil shells are found about twenty feet above the tide-level. They have a littoral aspect, and indicate a comparatively recent elevation of the coast. They are, in all respects, similar to the fossils obtained at San Pedro, and presently to be described. The slope which flanks the mountains at Santa Barbara, and extends to the beach, is probably composed of tertiary strata, covered, especially at the upper portion, by the loose drift or wash from the adjoining mountains. The town is built on this slope, and the observatory of the survey is also upon it; it terminates in front of the town in a broad sandy beach, and its lowest portions are partly occupied by an irregularly shaped pond or *laguna*, called El Estero, which is bordered by alluvial deposits.

The mountains rise abruptly in the rear of the town, and present a rugged, desolate appearance. They are, probably, composed of uplifted strata of sandstone, like that of San Francisco, and are probably of tertiary age. The peculiarly rugged and sharp outlines of these mountains cause them to resemble volcanic rocks when viewed from a distance, but there is no reason to believe that volcanoes exist there; on the contrary, there is good reason to consider the rocks as sandstone. The mountains, however, bear a great resemblance to those further south, which are found to be entirely of granite and the allied rocks. In that climate the gneiss and laminated rocks of the granitic class become weathered into singularly rugged and sharp outlines, and often form conical peaks, which, seen from a distance, are readily imagined to be volcanic.

GEOLOGY OF SAN PEDRO AND ITS VICINITY.

The bay of San Pedro is the most important between Monterey and San Diego. Unlike the other bays or coves between these two places, it is formed by a curve in the margin of an extended low plain, or gentle slope of the land, and is not rock-bound or protected by the projecting rocks of mountain ranges. The only high ground in the vicinity is a rounded swell of the surface north of the landing. This hill stands isolated from any range, and its base on the west is washed by the Pacific, and on the east is bordered by the low and nearly level plain.

It thus stands like an island, and a depression of the coast for about fifty feet would cause it to be surrounded by water.

The shore of the bay consists of bluff, precipitous banks from forty to sixty feet high, which are constantly being undermined by the action of the waves. They are formed of sedimentary strata, lying in nearly horizontal planes, and greatly differing in their mineral characters; some of them are almost wholly formed of clay, others of soft sandstone, and others of a more compact fine rock, formed by the mingling of the two materials. With the exception of some beds at the base of the series they are all light colored, and have a modern appearance. The lower and dark colored beds are bituminous, and emit a strong odor of the substance when struck by the hammer. This bituminous mass is thinly stratified, and is, in fact, a mass of clay-shales, which are soft and plastic where washed by the tide. They are exposed along the shore, the base of the series being below the surface of the water, but the upper limit rising at places to a height five feet or more above it. The best exposure is found on the projecting point nearly opposite the small island near the shore, called "Dead Man's island."

Above these bituminous shales the argillaceous beds are charged in many places with nodular masses, or concretions of oxide of iron; they are seen to protrude from the face of the bank in long lines. The clay is also much stained by the infiltration of ferruginous waters. Between the point spoken of and the landing, the upper part of the beach under the cliff, is strewn with large tabular blocks of sandstone, of a brown color, and evidently derived from the wear of the bank. They lie piled together in considerable quantities, and resist the continued action of the surf very well. These blocks present on their surfaces peculiar markings or reticulations, which are readily recognised as sun-cracks, and are precisely similar in appearance to those often found on the slabs of red sandstone in the quarries of New Jersey and Connecticut. They also resemble the deep cracks produced in the clay soils of California by the sun and air, after the wet season. It would thus appear, that at the time of the deposition of this stratum of sandstone it was alternately above and below the surface of the water, and it may have been the surface layer of a broad shelving beach. The edges of all these strata, as exposed in the bank, are slightly bent, and form curved lines with a large radius; at one place, however, near the point between the landing and the mouth of the Los Angeles river, more abrupt and sharp flexures were seen, and indicated considerable disturbance or lateral pressure of the beds. There is also evidence of an anti-clinal axis of the strata, the series having a general dip each way from the point. The direction of the axis of the dip or of the flexure is nearly N. 50° W., and thus conforms with the general direction of the coast and the longer axis of the hill. No igneous or erupted rocks were seen, but their presence in the vicinity, or not far below the surface, was suspected. Dead Man's island, which is a mass of rocks a short distance off the shore, rises nearly in the line of trend of this point, and may prove to be of igneous origin, but I was not able to visit it. It is interesting to note the fact of the presence of these rocks in a line with the axis of disturbance of the sedimentary beds.

It becomes an interesting point to determine the character of the rocks forming the summit of the hills; from external appearance alone, they would be considered as sedimentary, and not very hard.

The geology and the topography unite here in indicating the existence of a line of elevation in the ocean-bed, in the direction of the main axis of the hill forming Point Fermin. It is probable that this will be detected by soundings, if the currents have not so far filled up the bay with sand and sediment that the ridge-like character of the elevation is obliterated.

Near the mouth of the Los Angeles river, and just beyond the tide-register, the banks of the coast are lower, and consist chiefly of a coarse sea or river sand in regular layers; near the surface, coarser materials are found in layers from four to six feet thick, consisting of pebbles and fossil-shells mingled together and mixed with sand; above these, we find about three feet of soil, also charged with shells. A great variety of beautiful fossils were obtained here; most of them being new species, but all of them indicating a comparatively modern age for the deposit, which is, without doubt, Post Tertiary, or Quarternary. Its littoral character is evident from the fossils, many of them being much worn, and imbedded in a mass of comminuted fragments resulting from the action of the surf of former ages. These fossils were referred to Mr. T. A. Conrad, of Philadelphia, and his description of them, with the figures, will be found in the writer's report of a geological reconnaissance in California.*

The following are the names of several species obtained at this locality: *Tellina pedroana, Venerupis cycladiformis, Saxicava abrupta, Petricola pedroana, Schizothœrus Nutalli, Mytilus pedroanus, Penitella spelœum, Fissurella crenulata, Crepidula princeps, Nassa interstriata, N. pedroana, Strephona pedroana, Littorina pedroana.*

In addition to these shells the tooth of a mammoth was taken from this bank. It was procured by a brother of Capt. Ord, of the Coast Survey, who kindly placed it in my hands for examination. It is a lower molar of an extinct elephant, (*Elephas primogenius?*) and weighs eight pounds.

I regard this deposit of sand and shells as more recent than the sandstone and bituminous strata of the bluffs, but these last are doubtless Tertiary. No fossils were found in them; but in the interior, beyond Los Angeles, similar strata are upheaved and traversed by erupted trappean rocks, and fossils of the tertiary period were found there.

The same beds probably underlie the whole broad slope extending from the Bernardino Sierra to the sea, and are the repositories of great quantities of bitumen which exudes from the surface in many places, and forms springs or lakes. These deposits are known as *tar springs*, and the residents of Los Angeles use large quantities of the material for making roofs and pavements.

Large masses of bitumen in great black sheets are frequently met with by navigators off San Pedro or its vicinity, and northward in Santa Barbara channel. This may be derived from submarine springs, or it may float down some of the streams from the interior. I am also informed by Lieut. W. P. Trowbridge, U. S. Engineers, and connected with the survey, that the channel of Santa Barbara is sometimes covered with a film of mineral oil, giving to the surface of the water the beautiful prismatic hues seen when oil is poured on water.

The odor of bitumen, or petroleum, is often perceptible to the mariner along the coast when in the vicinity of the springs, and in places it is so distinct, that if the positions of all the springs were known, it would serve as an excellent land-mark or guide during fogs. The floating masses of bitumen may serve a similar end, but they are liable to be carried to great distances from their source by the currents, and thus their value as an index of any precise locality is lost. The odor of bitumen, however, is only perceptible near the springs, but the distance at which it is distinct will, of course, be determined by the direction and force of the wind.

REMARKS ON THE GEOLOGY OF THE BAY OF SAN DIEGO AND ITS VICINITY.

The shores of the bay of San Diego offer little of marked interest to the geologist. The only formations present to view are loose and unconsolidated strata of clays and sand, forming on the left of the entrance a series of rounded hills, rising to the elevation of from 200 to 400 feet. Like the hill at San Pedro, they stand alone or isolated at the lower edge, or sea-margin, of a broad and remarkably regular slope, which flanks the inland range of mountains, and extends from them to the sea. In addition to these stratified hills, we find, nearer the town, the alluvial deposits of the river, and extensive beaches and bars of fine, river and sea sand.

The strata of the hill which forms Punta Loma are much cut away and undermined by the action of the surf, so that their edges are brought to view, and a slight inclination or dip is seen. The materials composing these strata are chiefly sand and pebbles, and they are not firmly united, but crumble and wear away with rapidity. In passing inland from the beach to

*Report upon the geology of that part of California traversed by the expedition under the command of Lieut. R. S. Williamson, U. S. Topographical Engineers, to ascertain a practical railroad route from the Mississippi river to the Pacific ocean.

the old town and Mission of San Diego, horizontal strata of tertiary age are seen outcropping along the bank of the stream. These strata are nearly horizontal, or exhibit but slight flexures. Numerous fossil shells were obtained near the Mission, sufficient to characterize the deposits as tertiary; among them are the following species: *Cardium modestum, Nucula decisa, Corbula Diegoana, Tellina congesta, Mactra Diegoana, Natica Diegoana,* and *Trochita Diegoana.*

Further inland, east and northeast of the mission, outbursts of trappean rocks are found, and beyond them the granite formations which compose the mass of mountains between San Diego and the head of the California gulf. The upper layer or surface of the slope from the mountain is composed in most places of beach-shingle, the pebbles being well rolled and water-worn. The streams which course over the slope, or rather which run in the numerous ravines worn below its general level, bring down large quantities of sand, and deposit it in the harbor, thus gradually filling it up. The attempt has been made to turn this river into a channel which it formerly occupied, and which opened into the sea north of the present harbor and Point Loma.

The broad flats on the right or east side of the entrance to the bay, are formed wholly of sea or beach sand thrown up by the waves. This deposit is very deep, and there is no indication of former formations.

The little map or general sketch of San Diego bay published by the Survey, exhibits, in a most beautiful manner, the topography and character of the surface, and from it the outlines of the different geological formations can be readily traced; indeed, by using the topographical signs employed there to represent the geological formations, and providing an index to them, it would become a beautiful geological map, and at the same time retain its topographical value.

The geological map (Sketch No. 60) which accompanies this memoir, represents not only the geology around San Diego, but of a wide area west of it, as far as the Colorado river. This region will be fully described in the author's report on the geology of California.

GEOLOGY OF THE ISLANDS NEAR THE COAST.

Very little is yet known respecting the nature of the rocks forming the islands lying off the coast from Los Coronados, at San Diego, to the Farallones, at San Francisco. Not having visited either of them, it is not possible to speak definitely or positively of their geological character, but their appearance leads to the belief that they are composed of metamorphosed sandstones and shales, and of trappean rocks. They all have a most barren, forbidding appearance to the mariner; they are nearly treeless, and in the dry season look like masses of mere rocks. The rocks of the groups south of Point Conception have a dark drab or brownish-yellow color, and show traces of stratification which has been much disturbed. The sketch of the harbor of Santa Catalina by Mr. McMurtrie, and published by the Survey, presents some remarkable appearances, indicating to the geologist the presence of stratified rocks in a highly disturbed state. Indeed, the presence of a great thickness of strata dipping northwest at a high angle is distinctly shown. A difference in the hardness of the strata is also exhibited by the peculiar notched and irregular sky-outline of the hill on the left of the entrance, the elevated points corresponding with the rib-like prominence on the side of the hill. The sketch also shows a distinct and regular dip of the strata, especially at the left or northerly side of the entrance, while on the right or south side, the hill rises much higher, and the outcrops of the rock are not so distinct; the same general dip or inclination of the strata is, however, observable. The island is remarkable for a great transverse break or channel running partly through it, forming an anchorage. It is probable that this cleft or depression is along the crest of a great fold of the strata, the folding having been carried to such an extent as to bring the beds on both sides of the axis of flexure into parallelism, while they are all turned or pressed over towards the southeast or south. A lateral pressure or force acting from the north is thus indicated, a plication having been produced exactly similar to that characterizing the ranges of the Apalachians, and so distinctly revealed to geologists by the joint labors of the Messrs. Rogers.

The great value of accurate sketches of coast scenery, when the topography is given in detail, could scarcely be more clearly shown than in this instance. Aside from the importance of such sketches in enabling the navigator, who may have never visited the coast, to recognise his position at once, the sketch under consideration not only authorizes valuable deductions respecting the rocks, their sedimentary character, and geological age, but we are enabled to recognise a grand dynamical result, hitherto unobserved west of the Rocky mountains.

Cortez shoal.—The probable volcanic character of the Cortez shoal has been adverted to, but there is little reason to regard it as a single peak or cone of igneous rocks. It is possible that the phenomena witnessed by Captain Cropper were not volcanic, and that the apparent spouting of the water at intervals was merely the breaking of the waves on a reef. He, however, was confident that the commotion was of a different kind, and that the depth of water was reduced from forty-two to nine fathoms. It is, however, not improbable that the phenomena were volcanic, for the adjoining coast is subject to frequent earthquake shocks, and two or more salses or mud volcanoes have burst out at different times in the valley of the Colorado desert, in about the same latitude. Whatever the nature of the materials producing the disturbance and elevation, (which possibly was only apparent,) whether igneous or due to the decomposition of substances contained in the rocks, producing steam and a consequent explosion, it is doubtless the fact, that the outburst was at the summit of a ridge-like elevation, conforming in general direction with the adjoining islands and coast, and composed of similar rocks. This view is strengthened by the recent discovery of a ledge of rocks near the shoal by Lieutenant MacRae.

The phenomena attending the discovery of this shoal were not unlike those presented by the eruption of Graham island in the Mediterranean. The captain of a Sicilian vessel reported that, as he passed near the place in July, 1831, where the island afterwards appeared, he saw a column of water like a water-spout, 60 feet high and 800 yards in circumference, rising from the sea, and soon afterwards a dense steam in its place. On his return a week after, he found a small island twelve feet high, with a crater in its centre. This island afterwards reached the height of 200 feet, with a circumference of three miles, but then began to diminish in size by the action of the waves, until, in the latter part of October, no vestige of the crater remained, and the island was nearly levelled with the surface of the ocean. It was reported that, at the commencement of the following year, (1832,) there was a depth of 150 feet where the island had been; but this account was quite erroneous, for in the early part of that year Captain Swinburne found a shoal and discolored water there, and towards the end of 1833 a dangerous reef existed of an oval figure, about three-fifths of a mile in extent.*

The peculiar spouting up of the water in columns observed by Captain Cropper, together with his observation of the change in the form of the bottom, are the only evidences of the volcanic character of the disturbance. It is, however, possible that the depth has always been slight over the Cortez shoal, and that it remained unnoticed up to the time of the eruption, or the breaking of the waves. If an eruption did take place, the depth was very probably lessened, but the subsequent action of the sea may have removed all the accumulation, and even produced a greater depth than before.

FARALLONES ISLANDS.

The Farallones are separated from those just under consideration by more than three and a half degrees of latitude, and they border a portion of the coast with a very different trend. We have already seen that they are nearly in the line of prolongation of Point Pinos, and this fact leads to the belief that they are likewise of granite. Point Reyes, nearly abreast of them, being of granite, lends support to this conclusion. These suppositions are verified by the observations of Lieutenant Trowbridge, who visited the islands last May, by direction of the Survey. In his letter to the Superintendent, he describes the South Farallon as an "immense dyke of

* See Lyell's Principles of Geology, pages 433, 434.

granite, running in the direction of the coast." It rises to the height of three hundred and thirty feet, and presents a mass of broken and jagged rocks, so much shattered and softened that "the whole could be separated into small fragments with a pick and crow-bar." (See Sketch No. 46.) These small rocky islands, rising above the waste of waters so far from the main land, are certainly a remarkable physical feature. It is probable that the granite was originally flanked by stratified rocks, much softer and more yielding to the powerful action of the sea, and which are now washed away.

GENERAL REMARKS ON THE ISLANDS SOUTH OF POINT CONCEPTION.

Most of the islands bordering and south of, the Santa Barbara channel present interesting examples of the wearing action of the sea upon the rocks which compose them. Great caves are hollowed out in the soft layers of rock, while the harder beds form arched roofs, and reverberate the thunder-like sounds of the beating surges. Circular openings are frequently forced through their walls of rock, and huge arched gateways are formed for the rush of the waters. The small island of Anacapa has a fine arch of rock at its eastern extremity, a beautiful and accurate drawing of which has been made by the Survey.* Alcatraz island, on the bay of San Francisco, has a cavern of considerable size in its northern end, just at the water-line, and there are many other examples on the coast.

In the absence of positive knowledge of the geology of these islands, we may consider that the rocks bear a general resemblance in their mineral characters to those of the ranges, or heights, of the adjoining parallel coasts. Thus, from north of Los Angeles and San Fernando, southward to San Diego, we find ridges of trappean rocks in contact with upraised stratified sandstone, flanking the higher and more extended sierras of granite. Between San Pedro and Point Conception, this border, or belt, of upheaved stratified rocks is not found; the granite ranges come down to the very beach, but it is most in accordance with the phenomena to regard the outlying submerged range as corresponding in general character with those which flank the granite further south.

The peculiar rusty-drab color presented by the sandstone of San Francisco, wherever exposed to the action of salt water, is seen on the shores of nearly all the islands of the Santa Barbara channel and its vicinity; and this identity of color in the weathered rocks, together with the evidences of stratification and upheaval, leads me to consider their synchronous origin extremely probable.

APPENDIX No. 66.

Letters of Lieut. Comg. J. J. Almy, U. S. N., and Captain A. A. Gibson, U. S. A., assistants in the Coast Survey, communicating particulars of fatal disaster by the explosion of a boiler of the surveying steamer Hetzel, off Sand Shoal inlet, coast of Virginia.

U. S. Coast Survey Steamer Hetzel,
Sand Shoal Inlet, Sea-coast of Virginia,
Friday Afternoon, August 24, 1855.

Dear Sir: Captain Gibson, U. S. A., has already, at my request, communicated to you hastily an account of the sad accident which happened to the Hetzel at 8 o'clock this morning, by the bursting of the port boiler. At that time we were a little outside of Sand Shoal inlet, standing out. Anxiety at the moment, and pressure of duties, prevented my writing to you before the mail started, as the steamer was not only on fire, but also in danger of sinking. These additional catastrophes, I am happy to say, were prevented by prompt effort.

* Sketch No. 43, C. S. Report, 1854.

There were but twenty-two pounds of steam on when the boiler exploded, although the usual quantity used, when running, was twenty-eight pounds, and it was thought that thirty pounds could have been carried.

By this disaster, I regret to say that three persons were scalded to death, viz: Mr. Samuel C. Latimer, third assistant engineer U. S. N., Wm. Bulger, first-class fireman, and Bernard Moran, seaman. Six others are seriously injured—some, I fear, fatally—whose names are as follows: William Gardner, first-class fireman, Benjamin Van Horn, second-class fireman, John T. Knight, second-class fireman, David E. Marshall, quartermaster, Coleman Welsh, ordinary seaman, Michael Scanlan, ordinary seaman. I was slightly scalded by the explosion.

Third Assistant Engineer Samuel C. Latimer, whose sudden and unfortunate death I have mentioned above, was a young man of great promise, far above mediocrity, gentlemanly, and intelligent, possessing an exalted sense of honor, and the highest sense of duty. His removal from among us on board the Hetzel is sadly and deeply deplored by his messmates and shipmates.

The hurricane-deck, wheel-house, and bulk-heads around the boiler are a perfect wreck, as also the smoke-stack, steam-pipe, and some other parts.

I immediately despatched an officer (Passed Midshipman McGary) to the main land, distant seven miles, with orders to proceed to Cherrystone inlet, and from thence to Norfolk, to make known the condition of the Hetzel to Commodore McKeever, requesting him to send the steamer *Engineer* to our relief, so that the vessel might be towed to Old Point Comfort, where I will await your communications.

This afternoon, a fair wind setting in, with the aid of the tide, and boats towing, we were enabled to reach a safe anchorage inside of Sand shoal. The scalded have been removed to houses on shore, where they are receiving every attention from Passed Assistant Surgeon Williamson, of this vessel, and from a medical gentleman on shore, who happened to be here on a visit. Coffins are being made, and other preparations for burying the dead.

I presume that you will address a communication to the Treasury Department, which will be transmitted to the Navy Department, in regard to the persons killed and wounded.

In my next communication, I will state what, in my opinion, can and ought to be done with the Hetzel, and venture some suggestions in regard to the manner of prosecuting the work assigned me for this season.

SATURDAY, *August* 25, 1855.

DEAR SIR: Since writing the preceding yesterday afternoon, it becomes my sad duty to report two more deaths from their injuries, viz: William Gardner, first-class fireman, and John T. Knight, second-class fireman. These make *five* deaths in all, thus far, and the surgeon fears that Michael Scanlan, ordinary seaman, cannot survive.

The men, who have thus met an untimely fate, were all excellent in character, behaved well, performed their duty faithfully, and were good citizens of Norfolk and Portsmouth, where their families reside.

Yesterday afternoon, towards sunset, I read the burial service over two of them, and this morning I shall read it over three others. They will be buried upon Sand Shoal island, which is inhabited and cultivated, and head-boards, with their names, will be placed to mark their graves. Mr. Cobb, the owner and occupant of the island, is doing all in his power to assist me in every way.

I am, sir, very respectfully, your obedient servant,

JOHN J. ALMY,

Lieut. Commanding, U. S. N., Assistant Coast Survey.

Prof. A. D. BACHE,

Superintendent U. S. Coast Survey.

U. S. COAST SURVEY STEAMER HETZEL,
Sand Shoal, Va., August 27, 1855.

DEAR SIR: I regret to have to inform you that Michael Scanlan, ordinary seaman, died to-day, from injuries received by the bursting of the boiler of the Hetzel. This will probably be the last death caused by the sad catastrophe, as the injuries of the other men are comparatively slight, and they are doing very well.

Will you please communicate this, in addition to the others, to be reported to the Navy Department.

Very respectfully, your obedient servant,

JOHN J. ALMY,
Lieut. Commanding, U. S. N., Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

U. S. STEAMER HETZEL,
Sand Shoal Inlet, Friday, August 24, 1855.

DEAR SIR: At the request of Lieut. Comg. Almy, it becomes my melancholy duty to announce to you that this steamer burst one of her boilers at eight o'clock this morning, killing one man instantly, fatally injuring Mr. Latimer, third assistant engineer, and scalding six others, but to what extent it is not yet known.

The Hetzel, after a detention of five days, put out yesterday for Hog island, for the purpose of taking views; but was driven into this port about three o'clock in the afternoon, by an easterly wind, which subsided towards morning. She was just under way, and about a thousand yards from the head of the island, in eight and a half feet of water, when the occurrence took place. There were about twenty-two and a half pounds of steam on.

Further particulars will be reported when opportunity permits. The wrecked material is being removed by the boats, in which Mr. Cobb, and other citizens of the place, are rendering efficient aid.

* * * * * * * * *

Very respectfully, your obedient servant,

A. A. GIBSON,
Captain Second Artillery, U. S. A.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 67.

Extract from the report of Lieut. Comg. E. J. De Haven, U. S. Navy, assistant in the Coast Survey, relative to the stranding of the U. S. surveying schooner Arago, under his command, on the coast of Texas.

PHILADELPHIA, *September* 25, 1855.

SIR: * * * * On the 15th of May the *Arago* was anchored about half a mile from the shore, abreast of "St. Bernard" station, in seventeen feet water, and we had commenced landing lumber and materials for the purpose of establishing an observer at that point.

At dark the boats had returned, but a few articles remaining still to be landed, and there being no appearance of bad weather, I deemed it advisable to remain at anchor during the night, so as to finish our operations in the morning.

The wind and sea were both setting, as usual on the coast, square on to the shore, but not unusually strong. At 8.10 p. m. the vessel was reported as dragging, when the other anchor was immediately let go and additional chain veered out, but before bringing up, the vessel was in the breakers, with her keel striking heavily; and in this manner she rode until 1.30 a. m., when the starboard chain parted, and the vessel commenced setting in towards the beach. We discharged the water, and threw overboard a quantity of sand ballast, to lighten and enable her to beat through the heavy outer breakers. This she did effectually, for by daylight we were high and dry on the beach, about a hundred yards to the east of San Bernard river.

Our port anchor—the one first let go—came home, and on heaving it up the stock was found broken. Thus we were left without an anchor to haul off by. As no assistance whatever could be had from San Bernard, an officer was despatched forthwith on foot to Velasco to procure ground tackle, and on the following day a small schooner with two kedges and hawsers came to our relief. These were led out and a strain brought upon them, but the vessel remained immovable. The anchors being too light, came home, and no others could be procured at Velasco. Mr. Walker was now despatched by land to Galveston, where he fortunately found the schooner *Belle*, and, a couple of good anchors having been shipped, she proceeded at once to our relief, and reached us on the morning of the 22d. With much difficulty, owing to the heavy swell, we got the anchors planted, and the end of a strong hawser attached to them on board the *Arago*, and by keeping a constant and heavy strain upon it the vessel gradually worked her way through the sand, which had by that time formed outside of her.

At high water on the 25th I was relieved by finding the *Arago* once more afloat outside of the breakers, and apparently not injured to any extent. There was still, however, much hard work required to render her efficient. All our material from truck to keelson was on shore, and was yet to be boated off through a dangerous surf. The boats were capsized occasionally, but the alacrity and perseverance of officers and men overcame all difficulties, and the vessel was equipped and under way by the 27th. We anchored at Galveston the same night.

* * * * * * * * *

Very respectfully, &c.,

EDWIN J. DE HAVEN,
Lieutenant U. S. N., and Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent Coast Survey.

APPENDIX No. 68.

Letter to the Secretary of the Treasury, transmitting a copy of a letter addressed to Brevet Major H. Prince, U. S. Army, on his detachment from Coast Survey service.

COAST SURVEY OFFICE, *March* 3, 1855.

SIR: I have the honor to communicate to the Treasury Department, for its files, a copy of a letter addressed to Brevet Major Henry Prince, U. S. Army, recently relieved from Coast Survey duty, and would respectfully request that a copy may be transmitted to the honorable Secretary of War, for the files of the War Department.

The services of Major Prince call, in my judgment, for this expression of high appreciation.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

COAST SURVEY OFFICE, *February* 28, 1855.

SIR: In communicating to you the order of the Hon. Secretary of the Treasury, relieving you from duty on the Coast Survey by request of the War Department, I feel it to be my duty to express to you the high sense which I entertain of the efficient, zealous, and thorough services which you have rendered to the Coast Survey.

The adaptation to this branch of service, which was shown in your former connection with the survey, has again been strongly marked, with the advantage of increased experience in its operations. The character of service which you have rendered is that which military habits and experience, and strong military bias, would naturally render most acceptable to an officer, and I have not seen among the accomplished officers of the Coast Survey one who could surpass you, and but two who could rival you, in reconnaissance. It is a source of congratulation to me, that while you have shrunk from no exposure on this service, your health has steadily improved, and that the disastrous consequences of your wound at the battle of Molino were averted, as I believe, by the character of the duty in which you have been engaged. To your hard-earned reputation as a soldier you have added whatever reputation is to be acquired by the most successful discharge of Coast Survey duty. This expression of opinion I propose to place on file in the Treasury Department, under which you have served, and to request the Secretary to communicate it to the Hon. Secretary of War, as a testimonial from the Department which you have so faithfully, and efficiently, and disinterestedly served.

Yours, respectfully,

A. D. BACHE, *Superintendent.*

Brevet Major HENRY PRINCE,
U. S. Army, Assistant Coast Survey.

APPENDIX No. 69.

Extract from a letter of Lieut. Comg. James Alden, U. S. Navy, assistant in the Coast Survey, relative to transportation, in the steamer Active, of a detachment of recruits under command of Major Prince, U. S. Army, from Crescent City to Fort Steilacoom, and General Order issued thereon.

UNITED STATES COAST SURVEY STEAMER ACTIVE,
Olympia, W. T., July 20, 1855.

DEAR SIR: My last was dated at Crescent City, wherein I informed you why the programme of my season's work had been changed; and fearing lest those letters should miscarry, I will here state, that I found a detachment of recruits under the command of Major Prince, U. S. Army, at Crescent City, cast on shore by the burning of their transport, and in such a condition that their immediate removal appeared absolutely necessary. Trusting that the action would meet your approval, I therefore without hesitancy received them on board, and transported them to Fort Steilacoom, where we arrived in a little more than three days, without trouble or accident.

I enclose a copy of the general order issued by Major Prince on our arrival at the post, which shows his appreciation of the service.

* * * * * * *

With great respect, I am your obedient servant,

JAMES ALDEN,
Lieut. Comg. U. S. N., Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

[ORDER No. 20.]

HEADQUARTERS, FORT STEILACOOM,
July 14, 1855.

The undersigned deems it incumbent on him to acknowledge formally, and in behalf of the arm of service to which he belongs, the obligation it is under to Lieut. Comg. James Alden, of the Navy, who, being in command of the Coast Survey steamer *Active*, and arriving opportunely at Crescent City, received on board a detachment of army recruits, cast ashore there by the burning of their transport, and conveyed them to their destination here. From its disagreeable, if not ruinous circumstances, Lieutenant Alden felt the importance of succoring the detachment, and, while executing his purpose, he set aside his immediate occupation. Instances of like conduct renew the assurance, from time to time, that the chivalrous fame of the Navy cannot be clouded, and show that the incalculable usefulness and renown of the United States Coast Survey can extend with occasion, while its officers have the capacity to take the highest view of their duty.

To the surgeon of the *Active*, for attention to the sick, and to the other officers for their interest in rendering the detachment comfortable on board a ship not at all intended for a transport, the undersigned presents his unfeigned acknowledgments.

HENRY PRINCE,
Major Brevet U. S. Army, Commanding Post.

APPENDIX No. 70.

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.
II.	Buoy to mark "*Craven's knoll*," in the main ship-channel, entrance to New York harbor.	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, November 21, 1855. (Appendix No. 12.)
III.	Light-house or day-beacon on York spit, Chesapeake bay, Virginia.	Lieut. Comg. J. J. Almy, U. S. N.	Referred to the Light-House Board, June 25, 1855. (Appendix No. 71.)
VI.	Beacon midway between St. Augustine and Cape Cañaveral, Florida.	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, May 19, 1855. (Appendix No. 72.)
"	Beacon-light at Mosquito inlet, Florida	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, May 19, 1855.
"	Beacon-light at Indian River inlet, Florida.	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, May 19, 1855.
"	Beacon at Hillsboro', Florida	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, May 19, 1855.
"	Buoy on Margot Fish shoals, off Elliott's key, Florida reef.	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, May 19, 1855.
"	Buoy on "Hen and Chickens," S. W. of Key Tavernier, Florida reef.	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, May 19, 1855.
"	Buoy on Seven-feet shoal, N. E. entrance of channel abreast of Key Vacas, Florida reef.	Lieut. Comg. T. A. Craven, U. S. N.	Referred to the Light-House Board, May 19, 1855.
IX.	Light-house on Half Moon reef, Matagorda bay, Texas.	Lieut. Comg. E. J. De Haven, U. S. N.	Referred to the Light-House Board, May 23, 1855. (Appendix No. 73.)
"	Light-house or light-boat on Alligator Head, Matagorda bay, Texas.	Lieut. Comg. E. J. De Haven, U. S. N.	Referred to the Light-House Board, May 23, 1855.
"	Light on Sand Point, entrance to Lavacca bay, Texas.	Lieut. Comg. E. J. De Haven, U. S. N.	Referred to the Light-House Board, May 23, 1855.
X. XI.	Light on San Miguel, Santa Barbara channel, California.	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855. (Appendix No. 76.)
"	Light house on Pigeon Point, California, in lieu of one on Point Año Nuevo.	W. M. Johnson, sub-assistant	Referred to the Light-House Board, June 9, 1855. (Appendix No. 74.)
"	Buoys outside of bar at the Golden Gate, entrance to San Francisco bay, California.	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855. (Appendix No. 76.)

AIDS TO NAVIGATION—Continued.

Section.	Object.	By whom recommended.	Date of report, &c.
X. XI.	Light-house on Point Arena, California.	George Davidson, assistant	Referred to the Light-House Board, Mar. 26, 1855. (Appendix No. 76.)
"	Light-house on Red bluff, and discontinuance of that now in use at Humboldt bay, California.	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855.
"	Light-house on Point Adams, Oregon Territory	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855.
"	Light-house on Tatoosh island, entrance of straits of Juan de Fuca, Washington Territory.	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855.
"	Buoys on New Dungeness spit, Washington Territory.	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855.
"	Buoys on Ediz Point, Washington Territory.	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855.
"	Light-house on Smith's island, entrance of the straits of Rosario, Washington Territory.	George Davidson, assistant	Referred to the Light-House Board, March 26, 1855.
"	Light-house on Point Wilson, Washington Territory.	Lieut. Comg. James Alden, U. S. N.	Referred to the Light-House Board, Feb. 28, 1855. (Appendix No. 75.)
		George Davidson, assistant.	Referred to the Light-House Board, March 26, 1855. (Appendix No. 76.)

APPENDIX No. 71.

Extracts from a letter of Lieut. Comg. J. J. Almy, U. S. Navy, assistant in the Coast Survey, recommending the establishment of a light or day-beacon on York Spit, Chesapeake bay.

U. S. Coast Survey Steamer Hetzel,
Old Point Comfort, Va., June 18, 1855.

Sir: I have received yours of the 14th instant, enclosing a copy of a letter from the Secretary of the Light-house Board, requesting a tracing of York Spit and vicinity, showing the position of the *nine-foot* spot, and soliciting such other information as I may be able to give upon the practicability of placing a light-house instead of a light-boat at that point.

Herewith I transmit the tracing, as requested, upon which the *nine-foot* spot (at low tide) will be plainly seen. The average rise and fall of tide here is two and a half feet, which will give eleven and a half feet at high water. The character of the bottom is *fine light-gray sand, fine white gravel*, and *black specks*, in which sand greatly predominates.

It strikes me as being a feasible matter to erect a screw-pile light-house here. I deem it very important that a light of some kind be placed here as soon as practicable; or even a day-beacon or a large buoy to guide vessels in and out of York river. At present there is no guide of any kind except the compass and the lead, with a rough estimate of distances. There is a great sameness in the appearance of the woods and trees at the mouth of York river, so as to make it extremely difficult to obtain land-marks; and if they are found and used the present year, they may be gone the next year, as there is so much cutting down and clearing of woods in that vicinity. There is an extensive wood trade from York river. * * * *

I am, sir, very respectfully, your obedient servant,

JOHN J. ALMY,
Lieutenant U. S. Navy, Assistant in Coast Survey.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey.

APPENDIX No. 72.

Letter from the Superintendent to the Secretary of the Treasury, transmitting a report made by Lieut. Comg. T. A. Craven, U. S. Navy, assistant in the Coast Survey, upon aids to navigation for the eastern coast and reefs of Florida.

COAST SURVEY STEAMER CORWIN,
Florida Reef, May 19, 1855.

SIR: I have the honor to transmit for the information of the Light-house Board a report of Lieut. Comg. Craven, in reference to facilities for navigation on the coast and reefs of Florida. Concurring fully in the recommendations contained in the report, I would respectfully request that it may be forwarded with a copy of this letter to the Light-house Board.

Very respectfully yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

U. S. STEAMER CORWIN,
Florida Reef, April 24, 1855.

SIR: There are several points on the coast of East Florida which require lights, land-marks, and buoys, as aids to navigation.

1. Beacon about midway between St. Augustine and Cape Cañaveral.
2. Beacon-light at Mosquito inlet.
3. Beacon-light at Indian River inlet.
4. Beacon at Hillsboro'.

Buoys are required in the channel way between Florida reef and the keys.

1. Buoy on Margot Fish shoals, off Elliott's key.
2. Buoy on "Hen and Chickens," about three miles and a half southwest of Tavernier key.
3. Buoy on seven-foot shoal at the northeast entrance of the channel abreast of Key Vacas.

When this channel, from Cape Florida through to the Tortugas, becomes well marked and known, it must in future years be the great thoroughfare of coasting steamers.

In connection with the subject I will call attention to the light on Cape Cañaveral, which is decidedly one of the worst on our coast. The light is hardly visible at six miles, and then only to the careful observer, as the duration of its flash is only about seven seconds, and the periods of eclipse very long. It should be a first-class light, and there is no reason why it should be revolving.

Very respectfully, your obedient servant,

T. A. CRAVEN,
Lieutenant U. S. Navy, Assistant in Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 73.

Letter from the Superintendent to the Secretary of the Treasury, transmitting extracts from a report by Lieut. Comg E. J. De Haven, U. S. N., assistant in the Coast Survey, on the necessity for aids to navigation in Matagorda bay, Texas.

CHARLESTON, S. C., *May* 23, 1855.

SIR: I would respectfully request that the enclosed extracts from a report recently made by Lieut. Comg. E. J. De Haven, U. S. N., assistant in the Coast Survey, containing recommendations in regard to aids for the navigation of Matagorda bay, and for entering Lavacca bay, Texas, may be transmitted to the Light-house Board.

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

U. S. SURVEYING SCHOONER ARAGO,
Galveston, Texas, April 20, 1855.

SIR: * * * * * * * * * * * * * * * *

"A light-house or light-boat is much needed on or near *Alligator Head,* (Matagorda bay,) to enable vessels, after having crossed the bar, to pass the shoals lying off that point. Thence to Sand Point, on the north side of the entrance to Lavacca bay, the course is free of danger. Several experienced and intelligent resident pilots concur with me in regard to the necessity for this aid to navigation, and they have suggested, also, that the general navigation of Matagorda bay would be greatly facilitated by a light placed on Half-Moon reef.

"A more minute examination of these localities should be made before deciding upon the character of the lights to be adopted.

"A small light on *Sand Point* would materially aid vessels in reaching, by night, the anchorage near the entrance to Lavacca bay."

Very respectfully, yours &c.,

EDWIN J. DE HAVEN,
Lieut. Comg. and Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent Coast Survey.

APPENDIX No. 74.

Letter from the Superintendent to the Secretary of the Treasury, communicating extracts from the report of Sub-Assistant W. M. Johnson, relative to the facilities and advantages of Pigeon Point, California, as a light-house site.

COAST SURVEY OFFICE, *June* 9, 1855.

SIR: I have the honor to transmit, for the information of the Light-house Board, the following extract from a report of Sub-Assistant W. M. Johnson, and a tracing of the topography recently executed by him between Point Año Nuevo and Pigeon Point, California:

"Pigeon Point possesses many advantages over Point Año Nuevo as a location for a light-house. It is four miles westward, and about six miles distant from Point Año Nuevo, and has a sector of visibility about ten degrees greater.

"All the mail-steamers, and coasters trading to the southward, pass very near Pigeon Point. In favorable weather, steamers usually pass within one mile of it.

"From Pigeon Point, in clear weather, the Golden Gate, or entrance to San Francisco bay, Point Pinos, and a point far to the southward of it, are distinctly visible, and the course to the Golden Gate is direct.

"Pigeon Point is composed of conglomerated sandstone, rising about forty feet above high water. Eastward of the point there is a good boat-landing, well protected and accessible at almost any time during eight or nine months of the year, except in gales from the southwest, south, or southeast."

The information now communicated, though desirable in connection with the examination for a light-house site at Point Año Nuevo, reported upon from this office under dates January 17 and February 16, 1854, had not been reached at that time in the regular progress of the topographical survey of the Pacific coast, between the points named.

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 75.

Letter of the Superintendent to the Secretary of the Treasury, transmitting a communication from Lieut. Comg. James Alden, U. S. N., assistant Coast Survey, with letters of Governor Stevens and Capt. James M. Hunt, relative to the necessity for a light on Point Wilson, Admiralty inlet.

COAST SURVEY OFFICE, *February* 28, 1855.

SIR: I have the honor to forward herewith a copy of a communication from Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey, enclosing copies of letters from Gov. I. I. Stevens, of Washington Territory, and Capt. Hunt, of the steamer "*Major Tomkpins*," in relation to the necessity for a light on Point Wilson, at the entrance to Admiralty inlet.

Fully concurring as I do in the strong recommendations made in favor of this proposed aid to navigation on the coast of Washington Territory, I would respectfully request that the correspondence in regard to it, together with the enclosed tracing of Point Wilson, may be transmitted to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

UNITED STATES COAST SURVEY STEAMER ACTIVE,
San Francisco Bay, January 31, 1855.

DEAR SIR: I send herewith a copy of a letter from Gov. Stevens, Washington Territory, also of one enclosed by him to me from Capt. Hunt, of the steamer "*Major Tompkins*," relative to the importance of a light on Point Wilson, the south point of the entrance to Admiralty inlet.

I fully concur with them as to the necessity for a light at the point named, and would recommend that one should be placed there, of the third or fourth order, on one of the sand-hills at the extreme end of the point, as shown on our survey of last year.

With great respect, I am your obedient servant,

JAMES ALDEN,
Lieut. Comg. U. S. Navy, Assistant Coast Survey.

Prof. A. D. BACHE, *Superintendent.*

OLYMPIA, W. T., *December* 21, 1854.

DEAR SIR: I will respectfully call your attention to a letter from Capt. Hunt, of the steamer "*Major Tompkins,*" a copy of which is herewith enclosed, setting forth the importance of a light on Point Wilson, at the entrance to the water of the sound, and I will request that should you concur with Capt. Hunt as to the necessity of the light proposed, you will, as early as practicable, report for the information of the secretary of the Light-house Board, so that action in Congress may be had at its present session.

Very truly, yours,

ISAAC I. STEVENS,
Governor of Washington Territory.

Lieut. Comg. JAMES ALDEN, U. S. N.,
Coast Survey Steamer Active.

OLYMPIA, *December* 14, 1854.

SIR: Having been engaged for some time past in the navigation of Puget's sound as commander of the steamer "*Major Tompkins,*" my attention has been directed to the want of a light-house, in addition to the two already ordered by government, which would, I think, secure vessels bound into the sound from all the dangers not provided against by the light on Dungeness spit, and that proposed for Smith's island.

The two sites just named are most judiciously chosen, as the localities are dangerous at night to vessels bound either into Puget's sound, or through Rosario staits to Bellingham bay, and, at present, ship-masters sailing either way make a wide detour, or heave to until day-light. The most experienced can make no certain calculations as to their position where the tides are so strong and irregular.

The usual course for vessels bound into the sound, from the entrance to the Straits of Fuca, is *east half south* (magnetic,) which would bring them along (with a leading breeze) on the southern shore as far as Dungeness spit, and with a strong ebb-tide probably inside of it. This the establishment of the light at that point will enable them to avoid. From the spit to the shore is entirely clear, and the course is plain to Point Wilson, at the entrance of the sound, and distant from Dungeness spit sixteen miles. This point is exceeedingly foul, without any holding-ground that can be relied on, and in bad weather it is extremely dangerous. It is here I would respectfully suggest the placing of a light, for the benefit of those trading upon the sound proper. A light of the third magnitude would be sufficient, as the channel is comparatively narrow. It would greatly benefit all interested in shipping on these waters, as, after passing Point Wilson safely, harbors frequently occur in which the ground is good, and where, with the wind from any quarter, vessels may ride in security in a moderate depth of water.

The opinion I have taken the liberty to give is in consonance with that of all nautical men with whom I have conversed on the subject, and I trust it may appear to your Excellency of sufficient importance to make it a matter of correspondence with the authority at Washington that may have power in the premises.

With great respect, I remain, sir, your obedient servant,

JAMES M. HUNT,
Commanding Steamer "Major Tompkins."

ISAAC I. STEVENS, Esq.,
Governor of Washington Territory.

APPENDIX No. 76.

Letter from the Superintendent to the Secretary of the Treasury, transmitting extracts from a report of Assistant George Davidson, relative to the establishment of light-houses and other aids to navigation on the Western Coast.

SAVANNAH, GEO., *March* 26, 1855.

SIR: I have the honor to enclose, herewith, extracts from a general report recently made by Assistant George Davidson, containing suggestions relative to the establishment of light-houses and other aids to navigation on the Western Coast.

As the conclusions presented are, in each case, the result of personal observation and inquiry made by Assistant Davidson, while engaged in the regular work of triangulation on that coast, I would respectfully request that the extracts, as bearing upon the important subject of a general system of lights for the coast of California, and Oregon and Washington Territories, may be transmitted to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

Extracts from a general report made to the Superintendent of the Coast Survey, by Assistant George Davidson.

Point Wilson.—"A light-house is necessary at Point Wilson,* north of Point Hudson. The first named is the northwest point at the entrance of the bay called 'Port Townsend,' Admiralty inlet."

Smith's island, Washington Territory.—"There is urgent need for a light-house on this island. [See Appendix No. 83.] It lies south of the entrance to Rosario strait, is quite small, and rises gradually from the eastern side to the western, where it attains a height of about fifty feet, with almost perpendicular bluffs of clay and gravel. The surface is covered with a growth of bushes ten or twelve feet high, but these could easily be burnt off. The soil sustains a few trees, but none of great thickness or height. Digging to the depth of a very few feet will bring the builder to a good foundation. There is no water on the island. Good anchorage is found at the north side, between Smith's and Minor islands, which, at one point, become connected at very low water."

Ediz Point and New Dungeness.—"There should be large and easily recognisable beacons on Ediz Point and New Dungeness, as the spits are long, low, and narrow, and vessels may be almost upon them before they can be aware."

Tatoosh island.—"A light-house of the first class should be placed on Tatoosh, which lies a short distance seaward of Cape Flattery, at the southern part of the outer entrance to the straits of Juan de Fuca. The highest part of the island rises about a hundred feet above low water. A light eighty-five feet high would show on the horizon at a distance of eighteen miles, so that vessels before reaching Flattery rocks would be able to see it from a height of thirty feet above the water. The angle of visibility, from the land south, around to the extreme visible western point of Vancouver's island, is 131 degrees, and from the same starting point, around and up the Straits of Fuca, 263 degrees.

"The island is a conglomerate, rising perpendicularly; but one reef is basalt. It is destitute of wood; affords but little water, and that found is not good; yet the soil is cultivated by the Indians, who resort to the island in summer, about a hundred and fifty strong. The only landing place is small, lies on the inside, and is practicable only in good weather."

*See Appendix No. 75.

Point Adams, mouth of Columbia river.—"It is my decided opinion that a light on Point Adams would be an important aid to navigation, as it is around this point that all vessels pass on entering or leaving, and the point whence they derive their first ranges.

"After a clear night, the fog sweeping down the river in dense masses leaves the top of the cape clear, longer than any other point in the vicinity. At evening the fog comes in as densely from the north, having formed on the shoal water of Gray's and Shoalwater bays, and shuts in Cape Disappointment, long before it crosses the entrance to the river."

"*The light-house at Humboldt bay* might be discontinued, as, owing to its location and want of elevation, (twenty-five feet above the water,) it is of no use to vessels entering the harbor."

"*A light on Red Bluff*, in lieu of that last named, would always serve as a leading range in and out, as the flag-staff and ensign placed there are now thus used by pilots. A light on the bluff, which is about a hundred feet high, would be distinguished readily at sea, while the present one is frequently obscured by the mist that hangs over the surf on the beach."

"The view now expressed has been repeatedly and earnestly urged upon my attention by the captains, pilots, and merchants of Humboldt bay."

Point Arena.—"A light-house is needed at Point Arena, California.

The Golden Gate.—"Numbered buoys, just outside the bar, at the entrance to San Francisco bay, would enable steamers, upon making them in thick weather, to steer into the harbor."

"The fog sometimes stands like a wall outside of a line from Fort Point, across the entrance, while the bay inside is clear. As a rule, the fog never reaches the city of San Francisco, from seaward, until the greatest heat of the day is past.

"A light should be placed on *San Miguel*, (one of the Santa Barbara islands.) This, with the light on Point Conception, would guide to the western entrance of Santa Barbara channel. A light on *Anacapa* would give a good departure at night to vessels bound south through the islands, though, as the practice of steamers in passing through them either north or south, is *to keep between Santa Rosa and Santa Cruz, and close in with Point Conception*, a light would seem to be requisite on *Santa Barbara*, or the southwest point of *Clemente*, and another on the western end of *Santa Cruz*, or the eastern end of *Santa Rosa*.

"For coast lights on the main, (Santa Barbara channel,) *Point Vincent* and *San Fermin* are entitled to some consideration."

FEBRUARY 3, 1855.

APPENDIX No. 77.

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.

Sect.	Locality.	Object.	By whom examined.	Report of Superintendent.
I	Wood island, entrance to Small Point harbor, Maine.	Examination for light-house site.	Lieut. Comg. T. A. Craven	Reported February 22, 1855. (Appendix No. 78.)
"	Pier-head at Kennebunk harbor, Maine.	Examination for light-house site.	Lieut. Comg. T. A. Craven	Site recommended February 22, 1855. (Appendix No. 78.)
II	Absecom bar, coast of New Jersey.	Examination for position of bell-buoy.	Lieut. Comg. M. Woodhull	Site recommended February 12, 1855. (Appendix No. 79.)
VIII	Entrance to Vermilion bay, Louisiana. (Sketch No. 40.)	Examination to discontinue light.	Lieut. Comg. B. F. Sands..	Recommended January 31, 1855. (Appendix No. 80.)
IX	Mouth of Calcasieu river, Louisiana. (Sketch No. 40.)	Examination for light-house site.	Lieut. Comg. B. F. Sands..	Reported February 2, 1855. (Appendix No. 81.)
"	Gallinipper Point, Lavacca bay, Texas.	Examination for light-house site.	Lieut. Comg. E. J. De Haven.	Reported May 23, 1855. (Appendix No. 82.)

RESULTS OF EXAMINATIONS—Continued.

Sect.	Locality.	Object.	By whom examined.	Report of Superintendent.
X & XI	Santa Cruz island, channel of Santa Barbara, California.	Examination for light-house site.	Lieut. Comg. T. H. Stevens	Reported February 5, 1855. (Appendix No. 83.)
"	Coast of California, from Buenaventura to Point Duma and Anacapa and Santa Cruz islands.	Re-examinat'n for light-house site.	Lieut. Comg. Archibald McRae.	Progress reported October 11, 1855. (Appendix No. 84.) Site recommended December 22, 1855.
"	Harbor of San Pedro, California. (Sketch No. 45.)	Examination for site of harbor light.	Lieut. Comg. T. H. Stevens	Site recommended February 5, 1855. (Appendix No. 83.)
"	Harbor of Santa Barbara, California. (Sketch No. 45.)	Examination for site of harbor light.	Lieut. Comg. T. H. Stevens	Site recommended February 5, 1855. (Appendix No. 83.)
"	Harbor of Santa Cruz, bay of Monterey, California.	Examination for light-house site.	Lieut. Comg. T. H. Stevens	Site recommended February 5, 1855. (Appendix No. 83.)
"	Point Lobos, California	Examination for light-house site.	Lieut. Comg. James Alden	Reported June 11, 1855. (Appendix No. 86.)
"	Point Reyes, California. (Sketch No. 47.)	Examination for light-house site.	Lieut. Comg. James Alden	Site recommended February 5, 1855. (Appendix No. 83.)
"	Trinidad bay, California	Examination for light-house site.	Lieut. Comg. James Alden	Reported November 20, 1855. (Appendix No. 85.)
"	Crescent City harbor, California	Examination for light-house site.	Lieut. Comg. James Alden	Site recommended November 20, 1855. (Appendix No. 85.)
"	Umpqua, Oregon Territory	Examination for light-house site.	Lieut. Comg. James Alden	Reported June 11, 1855. (Appendix No. 86.)
"	Cape Shoalwater, Washington Territory.	Examination for light-house site.	Lieut. Comg. James Alden	Reported June 11, 1855. (Appendix No. 86.)
"	New Dungeness, Washington Territory.	Examination for light-house site.	Lieut. Comg. James Alden	Site recommended June 11, 1855. (Appendix No. 86.)
"	Smith's or Blunt's island, entrance to straits of Rosario, Washington Territory.	Examination for light-house site.	Lieut. Comg. James Alden	Site recommended February 5, 1855. (Appendix No. 83.)

APPENDIX No. 78.

Letter from the Superintendent to the Secretary of the Treasury, communicating the result of examinations made by Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, at Wood island (Small Point harbor) and Kennebunk, Maine, for light-house sites.

COAST SURVEY OFFICE, *February* 22, 1855.

SIR: I have the honor to forward extracts from the reports of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, showing the results of examinations made for the selection of sites for light-houses at Wood island (Small Point harbor) and Kennebunk, Maine, with a tracing of a topographical survey made in the vicinity of the first named point.

1. *Wood island.*—"I am of opinion that no light is requisite at Small Point bay. The harbor is small, open to the westward, and has a dangerous ledge in its entrance, which leaves a narrow channel on each side. I did not consider a hydrographic reconnaissance necessary, as the situation, want of capacity, and insecurity, made it apparent to me that no light is needed there, particularly as it is a place of no resort. It may be an occasional place of refuge, but with winds from N. E. to S. E. vessels cannot enter it, and with bad weather from any other quarter can seek better shelter elsewhere."

2. *Kennebunk.*—"A small light is very necessary on the pier-head of this port. The entrance is very narrow and the approach is made hazardous by the Fisherman's ledge, nearly S. S. W., distant half a mile from the pier-head.

"Many fine vessels belong to this port, and to those approaching at night it may be of vital importance to save the tide, as the loss of it would involve a serious loss of time, which in bad weather might be disastrous. At present it is not safe to enter at night, but with a light it would be a good harbor of refuge, and there is good anchorage outside of the pier, sheltered from N. E. winds. There is a dangerous rock lying S. E. about half a mile from Fisherman's ledge, with seven feet on it at low water. A buoy is needed on it." (Appendix No. 63, C. S. Report, 1854.)

I concur with Lieut. Comg. Craven upon the results of the examinations herein reported, and in regard to the recommendation for a buoy to mark the rock near Fisherman's ledge.

Very respectfully yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 79.

Extracts from a report made to the Superintendent by Lieut. Comg. M. Woodhull, U. S. Navy, assistant in the Coast Survey, upon the examination of Absecom inlet, coast of New Jersey, for the location of a bell-buoy.

UNITED STATES SCHOONER GALLATIN,
New York, November 15, 1854.

DEAR SIR: * * * * * *

"Absecom inlet is situated about thirty miles to the north of Cape May, and about eight or nine miles to the south of Little Egg harbor. As regards ease of entrance and egress, general good depth of water on the bar, and safe anchorage, it is sufficient at all times for the classes of vessels (coasters and colliers) which make use of it as a harbor of refuge. On either side of the main channel are extensive shoals, which have been the cause of much disaster. Between the north shoal and the beach there is a good channel, much used by the coasters at certain seasons, and when the winds are from the eastward, but dangerous with the winds from the southward or westward."

"The channel between the beach and the south shoal is in some respects similar, but at the best has not more than four feet water, while the *north* and *main channels* have ordinarily not less than seven and a half feet water on the bars. This south shoal, judging from the number of wrecks which I was able to count within its limits, (some twenty-five or thirty,) is the most dangerous and least guarded of any portion of the coast between Cape May and Sandy Hook. To give a correct understanding of the subject, I deem it proper to mention that the fleets of colliers and coasters trading between the waters of the Delaware and the New England States, via New York and Long Island sound, rarely, either in going or returning, make an offing, or even, excepting under stress of weather, lose sight of the land. This is done to insure a quick and certain passage, by taking advantage of the land and sea breezes which, as a general thing, prevail close in with the coast, while at the distance of a few miles calms might be encountered. The *south shoal* becomes in consequence, in the darkness of night and in thick weather, a danger of no inconsiderable importance and a cause of much anxiety, requiring the exercise of the best judgment in order to avoid it."

"The advantages of the proposed aid to navigation are: The timely notice it will give the navigator of his proximity to the shoals, the good service it will render to the general coastwise trade, and the local purpose it will serve in showing the entrance of the inlet. These are all-sufficient to demonstrate the necessity for it. I would, therefore, earnestly recommend that a bell-buoy be placed on the site marked on the accompanying sketch of reconnaissance of Absecom inlet, at the earliest time practicable."

* * * * * * *

Respectfully submitted:

M. WOODHULL,
Lieut. Comg., and Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 80.

Letter from the Superintendent to the Secretary of the Treasury, transmitting the report of Lieut. Comg. B. F. Sands, U. S. Navy, assistant in the Coast Survey, upon the expediency of discontinuing the light at the entrance of Vermilion bay, Louisiana.

COAST SURVEY OFFICE, *January* 31, 1855.

SIR: I have the honor to transmit a copy of the report made by Lieut. Comg. B. F. Sands, U. S. Navy, assistant in the Coast Survey, upon his reconnaissance of the entrance and approaches of Vermilion bay, Louisiana, with reference to the propriety of discontinuing the light now at the entrance, and forward herewith a tracing showing the hydrography of that vicinity.

I concur in the conclusion which Lieut. Comg. Sands has drawn from a comparison of the soundings and other concurrent information, and would respectfully recommend that the light at the entrance of Vermilion bay be discontinued.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

U. S. COAST SURVEY STEAMER WALKER,
Off Vermilion bay, January 15, 1855.

SIR: Agreeably to your instructions of 15th September last, I have to report that I have made a careful reconnaissance of the entrance and approaches to Vermilion bay, a sketch of which on a scale of $\frac{1}{20000}$ is herewith enclosed.

You will perceive that none but very light-draught vessels can get over the bar, and I learn from the light-house keeper, who has been long a resident here, that about three vessels only a year enter the bay, generally during the winter season, for the sugar made at two plantations in the vicinity.

The produce of nearly all the neighboring plantations goes to Atchafalaya bay, which has more water and is easier of access.

From this information in regard to the commerce of Vermilion bay, I consider that the amount of trade does not warrant the expense of a light-house, and the result of the survey shows that none but the lightest-draught vessels would attempt its entrance for a harbor, and even such would seek in preference that of Atchafalaya or under Point au Fer. I, therefore, deem the maintenance of the light at the entrance of Vermilion bay of very doubtful utility, and respectfully recommend that it be discontinued.

Respectfully, &c., your most obedient servant,

B. F. SANDS,
Lieut. Comg., and Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 81.

Letter from the Superintendent to the Secretary of the Treasury, transmitting the report of Lieut. Comg. B. F. Sands, U. S. N., assistant in the Coast Survey, upon an examination made in reference to the necessity for a light at the entrance of Calcasieu river, Louisiana.

COAST SURVEY OFFICE, *February* 2, 1855.

SIR: I have the honor to transmit herewith a report and tracing showing the result of a hydrographic reconnaissance made by Lieut. Comg. B. F. Sands, U. S. N., assistant in the

Coast Survey, with reference to the necessity for a light at the entrance of Calcasieu river, Louisiana.

The reasons urged in the report against the expediency of erecting a light at that point have met my concurrence.

Very respectfully yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

UNITED STATES COAST SURVEY STEAMER WALKER,
Off Calcasieu river, Louisiana, January 20, 1855.

SIR: In pursuance of your instructions of the 10th of October last, I have made an examination of the mouth of Calcasieu river, and enclose herewith a tracing of the reconnaissance on the scale $\frac{1}{200000}$.

The bar has five and a half feet at low water, shoaling gradually to that depth from three fathoms, and deepening on the inside to twelve and fourteen feet in the river. There is no other danger near for which a light-house would be required.

The houses mark the entrance sufficiently well for the small craft that can cross the bar, and in a commercial point of view it is of but little importance; I therefore cannot see any necessity for erecting a light-house here.

Respectfully, &c., your most obedient servant,

B. F. SANDS,
Lieut. Comg. and Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent Coast Survey.

APPENDIX No. 82.

Letter from the Superintendent to the Secretary of the Treasury, transmitting a report made by Lieut. Comg. E. J. De Haven, U. S. N., assistant in the Coast Survey, upon examination with reference to the expediency of establishing a light at Gallinipper Point, Lavacca bay, Texas.

CHARLESTON, SOUTH CAROLINA,
May 23, 1855.

SIR: I have the honor to report the result of an examination made by Lieut. Comg. E. J. De Haven, U. S. N., assistant in the Coast Survey, in reference to the expediency of establishing a light-house at or near Gallinipper Point, Lavacca bay, Texas.

The views expressed by that officer, as contained in the enclosed copy of his communication on the subject, seem conclusive against the necessity for a light at Gallinipper Point to serve as a guide to vessels entering the channel of Lavacca bay.

I concur with Lieut. Comg. De Haven in regard to the result of the examination, and approve his recommendation relative to the erection of a small light on Sand Point, which is also submitted for the consideration of the Light-house Board.

Very respectfully yours,

A. D. BACHE,
Superintendent United States Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

UNITED STATES SURVEYING SCHOONER ARAGO,
Galveston, Texas, April 20, 1855.

SIR: In accordance with your instructions of October 10, 1854, I have visited Lavacca bay, with the view of determining as to the utility of placing a light-house on or near *Gallinipper Point,* as authorized in the light-house bill of 1853–'54.

A light-house on or near Gallinipper Point would be useless for purposes of navigation. It is not probable that any system of lights would enable a vessel to run up to the town of Lavacca by night. The channel, which is both narrow and intricate, is marked by stakes, but vessels of near six feet draught require day-light to enable them to get through, and even then must resort to warping.

Vessels bound to Lavacca should attain the safe and convenient anchorage at the entrance of Lavacca bay, between *Sand Point* and *Indian Point,* and there await a favorable opportunity for going up the bay. A small light on *Sand Point* would materially aid them in reaching this anchorage by night.

Very respectfully yours, &c.,

EDWIN J. DE HAVEN,
Lieut. Comg., and Assistant Coast Survey.

Prof. A. D. BACHE, *Superintendent.*

APPENDIX No. 83.

Letter from the Superintendent to the Secretary of the Treasury, reporting the results of examinations for the selection of sites for light-houses on the coast of California, and in Washington Territory.

COAST SURVEY OFFICE, *February* 5, 1855.

SIR: I have the honor to report that examinations for the selection of sites for light-houses on the Western Coast, directed from the Department at the request of the Light-house Board, under date August 21st and December 9th, 1854, and in accordance with the letter of the Secretary of the Light-house Board, of August 26th, 1854, have been made by Lieuts. Comg. James Alden and T. H. Stevens, U. S. N., assistants in the Coast Survey.

The report of Lieut. Stevens upon the island of Anacapa, made under my previous instructions, was communicated to the Department under date November 1, 1854; anticipating the directions from the Department of August 21st, in regard to the examination of that island. I now transmit extracts from the reports of Lieut. Comg. Stevens upon the sites at *Santa Cruz island; harbor of Santa Barbara; harbor of San Pedro;* and *Santa Cruz harbor, California*; and from the report of Lieut. Comg. Alden, upon the sites at *Point Reyes, California;* and *Smith's* or *Blunt's island, Washington Territory.* The sketches necessary to illustrate the results of examinations of the points marked 2, 3, and 5, have been forwarded to the Light-house Board.

1. *Santa Cruz island.*—"From the various inquiries which I have made in relation to the necessity for a light upon the island of Santa Cruz, and from my own knowledge of its broken character, I am induced to report against the establishment of a light upon it. If the light is designed as a guide to vessels passing through the Santa Barbara channel, I would suggest, as a much more important and accessible point, the sand-beach to the southward of San Buenaventura, which is low and dangerous, and lies a considerable distance seaward of the high land. A light erected upon this sand-beach would be seen clear of the land by vessels passing either way, and would serve the double purpose of marking the entrance to the channel, and of designating an exceedingly dangerous point.

"If, however, the light is intended to benefit the commerce passing between Santa Rosa and Santa Cruz, I would recommend it to be placed upon the east side of the first named island, where good anchorage is to be found during nine months of the year. The means of communication with it are quite easy as compared with Santa Cruz. In my opinion, it would be found almost impossible to land building materials for light-house purposes upon any part of the island of Santa Cruz, on account of its exposure to prevailing winds, and the heavy surf which constantly prevails upon the weather side."

2. *Harbor of Santa Barbara.*—"The site selected as the most suitable for the erection of a light-house at Santa Barbara, (marked on the sketch already in the possession of the Light-house Board,) is elevated one hundred and forty-six feet above the level of the sea, and has a firm and solid foundation of mixed clay and sand. A light fifty feet high, erected upon this site, would have an angle of visibility of 198 degrees, and could be seen at a distance of eighteen statute miles by vessels coming down the coast after doubling Point Conception, and by those bound up after rounding Point Moga. Wood, water, and building material are convenient to the locality. The land on which the site was selected belongs to the town of Santa Barbara, and, I am informed, could be bought at a fair valuation."

3. *Harbor of San Pedro.*—"The foundation of the site selected, and marked on the sketch (which has been sent to the Light-house Board,) is a conglomerate of clay and sand, and the elevation such, that a light sixty feet high may be seen over the adjoining land on the bays of San Pedro and San Vincent. The sector of visibility of a light at that elevation is 243 degrees, and it would meet the horizon at a distance of twenty-one statute miles.

"In making these examinations and selections (2, 3) I have endeavored, while keeping within the requirements of the law, to designate as suitable localities, such sites as would combine the purposes of a harbor light in each case with adaptation to the general wants of commerce. To carry out this purpose, considerable additional hydrography was required, which will be found laid down on the sketches. The site at San Pedro is upon land claimed under a Spanish grant by the SEPULVIDA family."

4. *Santa Cruz harbor.*—"The establishment of a light is desirable, not only as a harbor light, but as a guide to vessels bound further up the bay to the numerous small settlements which are springing up upon its borders, and, as auxiliary to the light at Point Pinos, to the coasting trade generally. I still entertain the opinion expressed in my former report, that if but one light is to be established, it should be placed at Point Año Nuevo instead of Santa Cruz.*

"The site selected at Santa Cruz (bay of Monterey) is marked on the accompanying tracing (No. 4). A light, fifty feet high, erected on it, could be seen twelve statute miles, and over the low lands to the westward; and the angle of visibility measured from the bluff, outside of which the light can be seen, to the point in the harbor marked A, is 246 degrees.

"The tract which includes the site is owned by Mr. Alexander McLean, under an Alcalde's grant.

"Wood and water are convenient to the site, and bricks of good quality are made in the neighborhood."

5. *Point Reyes.*—"The purposes to be answered by this light, which should be of the first class, are, that lying somewhat in the track of coasters, nearly all sailing-vessels arriving from seaward in the summer-time endeavor to make the land thereabouts; and besides, as it is the nearest and most important cape or headland to the northward of San Francisco, it has been not unfrequently, in the night or in thick weather, taken for the entrance to that bay. Occurrences of this kind could be avoided by the erection of the proposed light." The site selected is marked on the chart of Point Reyes which has been sent to the Light-house Board. "Its height is about four hundred and eighty-five feet, and the elevation of the light above this need not be over twenty feet to illuminate a sector of 255 degrees. The light would be visible from the long beach to the northward, around to the south face of the point, where the view is obstructed by the cliffs, which are much higher in that direction. It will be seen also in the northern part of Sir Francis Drake's bay, over the low land. I have drawn lines on the chart, in the direction of all the principal objects that can be seen from Point Reyes."

6. *Blunt's or Smith's island.*—"It will be seen by the chart accompanying (No. 6), that

*Appendix No. 67, C. S. Report, 1854.

this island is quite small, only about five hundred metres across, and very regular in its shape. It is about sixty feet high at its western face, with a gradual slope to the eastward, and, excepting on that side, its shore is nearly perpendicular.

"A light of the second class will, I think, answer all the requirements, as there is but one direction looking towards the entrance of the straits of Juan de Fuca, where it is necessary that it should be seen more than ten or twelve miles. The tower for the light should be placed so that it can be seen in all directions, and need not be more than twenty or twenty-five feet in height.

"Wood is plenty on the island, but there is no water.

"The large bed of kelp extending out from the west side of the island is a good guide to vessels approaching it from the westward in thick weather."

The position of Smith's island is shown on the general sketch marked 6 *bis*.

I concur in the recommendations of the hydrographic officers by whom these examinations were made.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 84.

Letter from the Superintendent to the Secretary of the Treasury, reporting progress upon the re-examination of Santa Cruz island, California, made by Lieut. Comg. Archibald MacRae, U. S. N., assistant in the Coast Survey.

COAST SURVEY STATION, DIXMONT, ME.,
October 11, 1855.

SIR: I have the honor to state, with reference to the letter from the Treasury Department, dated December 9, 1854, directing further examination to be made of *Santa Cruz island*, California, for light-house purposes, that Lieut. Comg. Archibald MacRae, U. S. N., assistant in the Coast Survey, has reported progress in the execution of my instructions to that effect. These include the examination of the adjacent islands in Santa Barbara channel, and of the main between Buenaventura and Point Duma, in which duty Lieut. Comg. MacRae is now engaged. He reports the completion of the examination in conjunction with the topographical survey, of the western end of Santa Cruz island, and thinks the establishment of a light on that island would be unadvisable, but is of opinion that a point on the portion of the main coast now under examination may offer the desired facilities for a light-house site.

I would respectfully request that a copy of this letter, for information, may be forwarded to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 85.

Letter from the Superintendent to the Secretary of the Treasury, reporting the results of examinations for light-house sites at Crescent City harbor and at Trinidad bay, California, made under directions from the Treasury Department.

COAST SURVEY OFFICE, *November* 20, 1855.

SIR: I have the honor to report that, in accordance with directions from the Department, examinations for light-house sites have been made at *Crescent City harbor* and at *Trinidad* *bay*, California, by the hydrographic party on duty on the western coast, under Commander James Alden, U. S. N., assistant in the Coast Survey.

I append extracts from the report of Commander Alden, and enclose, for the information of the Light-house Board, a tracing from a corrected chart of *Crescent City harbor*, furnished by that officer, with the site for a light-house marked thereon.

"The site is on an elevated point, and the tower need not be over twenty-five feet high. As the object of the light is for local purposes, it need not be above the fourth or lowest order. Material, either brick or stone, for building the tower, can be obtained on the spot."

"As the commerce at *Trinidad bay* is so trifling, I can see no necessity for a light at that point at present."

I concur with Commander Alden in regard to the results of his examinations of the two points herewith reported upon.

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 86.

Letter of the Superintendent to the Secretary of the Treasury, transmitting the results of examinations made by Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey, in reference to sites for light-houses on the western coast of the United States.

COAST SURVEY OFFICE, *June* 11, 1855.

SIR: I have the honor to forward the following extracts from a report by Lieut. Comg. James Alden, U. S. N., assistant in the Coast Survey, made in accordance with directions from the Department, for examinations with reference to the expediency of establishing lights at the several points named:

"The harbor of San Francisco will very soon have two lights in operation at the entrance—one on Point Bonita, and the other at Fort Point; and these, in addition to the light on Alcatraz, it seems to me, will obviate the necessity for a light on *Point Lobos*. An eligible site on the last-named point, now occupied by a light which for a long time has been kept up by private enterprise, is marked on the enclosed tracing."

"There is no immediate necessity for lights at *Umpquah river* and *Shoalwater bay*, as not more than one vessel in a month visits either place. They are entirely inaccessible at night, and lights could afford no facilities for entering. The points marked on the sketches may be considered as good as any, for lights. The only purpose, however, which the lights could serve, would be to enable vessels to hold a position during the night.

"A light is necessary on *New Dungeness*, W. T., and it should be placed on the extreme outer end of the sand-spit. The scale of the enclosed tracing does not admit of marking an exact position for a site, but the proper location on the spit cannot be mistaken."

I concur with Lieut. Comg. Alden in regard to the results of his examination of these localities on the Western Coast, and enclose herewith, for the information of the Light-house Board, the several tracings and sketches referred to in the extracts from his report.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

INDEX OF SKETCHES AND DIAGRAMS.

No. 41. I No. 3, Galveston bay, (preliminary chart.)
42. J, Progress sketch, Western Coast, $\frac{1}{7000000}$.
43. J No. 2, Progress sketch, Sections X. and XI.
44. J No. 3, Progress sketch, Washington sound and vicinity, Washington Territory.
45. J No. 4, San Pedro anchorage and vicinity of Santa Barbara.
46. J No. 5, South Farallon island.
47. J No. 6, Point Reyes and Drake's bay.
48. J No. 7, Alden's reconnaissance of Western Coast, from Umpquah river to northern boundary.
49. J No. 8, Co-tidal lines, Pacific coast.
50. J No. 9, Earthquake waves.—Pacific coast.
51. Diagrams to illustrate secular variation in Magnetic Declination.
52. Boutelle's scaffold for stations, and Farley's signal.
53. Boutelle's apparatus for measuring preliminary bases.
54. Sands' gas-pipe Tripod.
55. Sands' specimen Sounding Box and Revolving Heliotrope.
56. Lines of equal Magnetic Declination on the coast of the United States.
57. Geological map, Point Reyes and vicinity.
58. Geological map, vicinity of the Golden Gate.
59. Geological map, vicinity of Monterey bay.
60. Geological map of the country between San Diego and the Colorado river.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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