38TH CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 11.

REPORT

OF

THE SUPERINTENDENT

OF THE

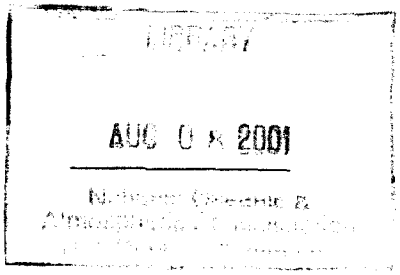
COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1863.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1864.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

ERRATA NOTICE

One or more conditions of the original document may affect the quality of the image, such as:

Discolored pages
Faded or light ink
Binding intrudes into the text

This has been a co-operative project between the NOAA Central Library, the Office of Coast Survey and the National Geodetic Survey. To view the original document, please contact the NOAA Central Library in Silver Spring, MD at (301) 713-2607 x124 or www.reference@nodc.noaa.gov.

Please Note:
This project currently includes the imaging of the full text of each volume up to the "List of Sketches" (maps) at the end. Future online links, by the National Ocean Service, located on the Historical Map and Chart Project webpage (http://historicals.ncd.noaa.gov/historicals/histmap.asp) will includes these images.

LASON
Imaging Contractor
12200 Kiln Court
Beltsville, MD 20704-1387
January 10, 2003

IN THE HOUSE OF REPRESENTATIVES, *January* 22, 1864.

Resolved, That there be printed three thousand copies (extra) of the Report of the Superintendent of the Coast Survey for the year 1863 ; two thousand for the use of the Superintendent of the Coast Survey, and one thousand for the use of the members of this house.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

THE REPORT OF THE SUPERINTENDENT OF THE UNITED STATES COAST SURVEY.

TREASURY DEPARTMENT, *December* 15, 1863.

SIR : I have the honor to transmit to the House of Representatives a report made to this department by Professor A. D. Bache, Superintendent of the United States Coast Survey, showing the progress in that work during the year ending November 1, 1863, accompanied by an engraved sketch illustrating the general progress which has been made in the survey of the coast; also, the large manuscript map of progress, brought up to the same date; in conformity with the act of Congress approved March 3, 1853.

I have the honor to be, very respectfully,

S. P. CHASE,
Secretary of the Treasury.

Hon. SCHUYLER COLFAX,
Speaker of the House of Representatives.

Blank page retained for pagination

ABSTRACT OF CONTENTS OF REPORT.

Blank page retained for pagination

CONTENTS OF APPENDIX.

I.—FIELD, HYDROGRAPHIC, AND OFFICE DETAILS.

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

B.—NAVIGATION.

C.—TIDAL.

D.—OFFICE-WORK.

II.—SPECIAL OPERATIONS AND SCIENTIFIC DISCUSSIONS.

A.—ASTRONOMICAL.

B.—MAGNETISM.

ALPHABETICAL INDEX.

REPORT.

COAST SURVEY OFFICE,
Washington, D. C., December 15, 1863.

SIR: I have the honor to submit, in accordance with the law and regulations of the Treasury Department, my report for the surveying year ending November 1, 1863, and with it an engraved map showing the general progress of the work, and a manuscript map prepared at the office, in accordance with the act of Congress of March 3, 1853.

The survey has been in progress, in its field or office work, in all the States of the Atlantic and Pacific coast, upon the diminished scale of the previous year. The officers have been, as heretofore, detailed where they could render important service in the armies and fleets of the Union, and in reply to applications from the officers commanding, and of the departments. A condensed statement of the whole of the operations of the survey and its officers will be given in the prefatory chapter of the report, part I, and a more detailed statement in part II of the report.

The estimates for the next fiscal year are made to conform to those of the past, as having received the approval of the Treasury Department, of Congress, and of the Executive.

The policy of the department to press forward the survey on the more exposed portions of the coast, and in the rivers connected with the blockades, has been carefully followed up, and aid has been rendered by reconnaissance and other operations whenever the War Department or the Navy Department indicated that it was desirable. These subjects will be treated in detail, and some of the acknowledgments received will be produced as showing the incidental advantages of the survey, (Appendix No. 26.)

In the plan for conducting the survey, furnished by the act of Congress of March 3, 1843, the surveys of the rivers were required to extend as far as needed by commerce or defence. The importance of the military and naval operations upon the rivers has been fully developed by the war, and I have called the attention of the honorable Secretary of the Treasury to the matter. The letter of the Navy Department, with the applications of the distinguished admirals who serve in North Carolina, and on the Mississippi and its tributaries, has been an additional stimulus to this undertaking. The usefulness of the river maps of the survey, though their extent towards the sources was in many cases quite inadequate, has been acknowledged in the strongest terms by distinguished authorities and officers both of the military and naval service.

I should not omit to state that the officers of the survey have rendered other incidental services in regard to lights, beacons, and buoys on the coast, and to certain of the tax commissioners of the Treasury Department.

The regular operations have, meanwhile, been assiduously carried on, making the estimated progress in the Eastern and Middle States, and also at the South, wherever adequate protection could be had from our military or naval forces, or such protection was not needed.

The Superintendent of the Coast Survey has continued to serve on the Light-house Board, in the permanent commission of the Navy Department, to whom inventions submitted to the department are referred; and has served also upon several committees of the National Academy of Sciences, whose services have been asked by the departments of the government, as upon the Committee on Weights and Measures, and on correcting compasses of iron or iron-clad vessels-of-war. Other officers of the survey have in this connexion rendered similar services.

The maps compiled at the Coast Survey Office for illustrating the movements of the war have been kept up to date, and their sale has reimbursed us for the gratuitous supply to officers of the army and navy, and of the government generally.

I must earnestly commend the officers of the Coast Survey who have thrown themselves into dangerous service at the call of their country, and have yielded effective service in surveys and reconnaissances, and in cases of exigency in engineering. They have already received the commendation of those in whose regular duties and services they have assisted as volunteers. The city of Philadelphia, in the time of supposed danger, was indebted to several of the officers for ready, zealous, and disinterested service, the value of which, had not the gallantry of our army relieved the city by distant operations, would have been inestimable, and which, in fact, was so termed at the time by the general in immediate command.

DIVISION OF THE REPORT.

Of the report, the first part or introduction contains a general summary of the progress of the year, the estimates for the next fiscal year, and generally remarks on portions of the field and office work of particular interest.

The second division of the report describes, under the heads of sections, the work done in each, its character, the persons and vessels employed, and the particulars of each survey. This part is closed by a chapter stating in a general way the character of work done in the office.

The Appendix contains generalized lists of the surveys of the year, of the developments in hydrography, and special lists showing the details of work in the office. Besides these, are included in it articles of scientific import. The items are classed under different heads, and the title of each given under its proper heading in a separate index.

An abstract of the contents of the report and an alphabetical index are given as usual.

GENERAL STATEMENT OF PROGRESS.

The general progress made in the survey is shown by the sketch, No. 29, which accompanies this report. The progress of the present year in field and office work will be here presented in a condensed form, the statements in detail being given in the second part of the report as heretofore.

In the northern sections of the Atlantic coast the regular work of triangulation has been carried on, reaching from Machias into Passamaquoddy bay, on the coast of Maine, under Sub-Assistant Webber; from Blue Hill bay towards Mt. Desert, by Assistant Fairfield; and above the mouth of Penobscot river, by Assistant McCorkle. For the connexion of primary bases, it has been continued by my own party on the coast of Connecticut; additional work to connect with it has been done by Assistant Blunt, east of the Hudson; and the verification work, on the coast of New Jersey, has been extended to the vicinity of Manasquam inlet, by Assistant Farley.

The detailed topography of Eastport harbor has been prosecuted by Sub-Assistant Dennis; that of the coast of Maine, from Winter harbor eastward, by Sub-Assistant Rockwell, but discontinued to meet the call for service near Chattanooga, Tennessee. The topography of the western side of the entrance, and that of the western shore of Penobscot bay, near Camden, by Sub-Assistants Ferguson and Dorr; that of the passages between the Sheepscot and Kennebec rivers has been nearly completed by Sub-Assistant Iardella, and the detailed survey of the vicinity of Harpswell Neck, Maine, continued by Assistant Longfellow.

Assistant Harrison has extended the triangulation required, and continued the plane-table survey of Narragansct bay. The shore-line survey of the Hudson river has been completed by work between Coxsackie and New Baltimore, by the party of Messrs. Harding and Strausz, and repeated examinations have been made of Sandy Hook and its vicinity for physical changes, by Assistants Whiting and Mitchell.

The hydrography of the year in the northern sections has embraced additional lines of deep-sea soundings, and the development of rocks and ledges near Portland entrance, and off the coast of Maine, by Lieut. Commander Phelps, with the steamer Corwin; that of Rockland harbor, by Assistant Edwards, (now in similar service at Charleston bar, S. C.;) the in-shore hydrography, which includes the approaches to Muscongus bay and Penobscot bay, (western approach,) by Acting Assistant Cordell, with the steamer Vixen; that of the northern part of Casco bay, by Assistant Gerdes; that of the Hudson river, completed by the party of Messrs. Harding and Strausz; a development of ledges off the eastern end of Long island, and re-examination of part of New York harbor for the pilot commissioners, by Lieut. Commander Phelps; one near the Delaware breakwater, for the engineer department, by Capt. Patterson, hydrographic inspector

of the Coast Survey; and soundings off the coast of Maryland, and completion of the hydrography of the Potomac river, by Lieut. Commander Phelps.

Under directions of the Boston harbor commissioners, Assistant Mitchell has continued the observations of tides and currents in South bay and Fort Point channel, and in the outlets of the Charles and Mystic rivers.

As during the year previous more than the customary number of parties has worked this season on the coast of New England and that of the Middle States, all of them having been on duty in the earlier part of the year, with but two exceptions, either in the sections of the coast now under blockade, or in surveys for the use of the armies of the Union. One of the parties not so engaged was employed in the survey of Sandy Hook. The other had assisted in the survey of the Potomac, within the present fiscal year, for the Navy Department.

The several examinations made during the year at Sandy Hook are to keep in view the important changes going on there, and which may develop into dangerous circumstances. These surveys have been furnished to the engineer department, the operations of which keep steadily in contact with the changes from time to time going on. Services having a bearing on defensive purposes, rendered to that department by three of the assistants of the Coast Survey while working this season on the coast of Maine, have been acknowledged in communications addressed to me by the chief engineer.

The regular work has gone forward on the Pacific coast of the United States, though on a scale somewhat reduced by the peculiar circumstances of the currency there.

On the Atlantic and Gulf coasts, of nineteen assistants, fourteen sub-assistants, and twenty-two aids engaged in field-work or in hydrography, twelve assistants, seven sub-assistants, and ten aids have rendered service in connexion with military and naval operations, and most of those who have so co-operated have also been employed in duty on parts of the coast where the regular operations of the survey have been advanced during the latter part of the season.

The work done in the vicinity of the capital, and along the southern coast, having been performed under the immediate orders of military or naval authorities, will be briefly reviewed under a separate head.

SERVICE WITH THE ARMY AND NAVY.

Of the surveys which were steadily carried on in the vicinity of Washington city until the end of June, that of the banks of the Potomac near Alexandria, though specially ordered for purposes of defence, and executed by Assistant Harrison, combines with the regular work of the survey, as does also the triangulation of the river between Alexandria and Georgetown by Sub-Assistant Boyd. The topography of the eastern approaches to the District of Columbia has been extended by Assistant Adams, Sub-Assistant Ferguson, and Mr. Donn, and the survey near Fort Lyon by Assistant C. M. Bache. Sub-Assistant Boyd made a triangulation, and Mr. Donn took up the topography of the approaches to Baltimore, in the latter part of June, at the special call of the authorities charged with the defences of that city. This work has been suspended within a few days by the emergency which requires topographical service near Chattanooga, but will be completed as soon as practicable, as will also the plane-table surveys in the neighborhood of Washington. The heights of all the field-works near the capital have been determined and furnished to the chief engineer of defences.

The services at Port Royal and at the mouths of the Mississippi, referred to in my last report, have been followed up this year in the military department of North Carolina; on the coast of South Carolina and Georgia, particularly near Charleston, and at Tybee and Wassaw; in Louisiana, west of the Mississippi; and in the Mississippi and Yazoo rivers, during the sieges of Vicksburg and Port Hudson. In the first-named department, besides the triangulation of part of Neuse river by Assistant Fairfield, reconnaissance maps were made by Assistant West and Sub-Assistant Rockwell, while the enemy threatened Newbern and Little Washington. Charleston bar was surveyed by night, and lighted and buoyed by Assistant Boutelle with the steamer Bibb, just previous to the naval attack of April last. Port Royal bar was resurveyed by his party, and the buoys needed there and at the other entrances on the coast of South Carolina and Georgia were set, and have been properly marked on the charts which are supplied from the office for the blockading squadron. A hydrographic reconnaissance was made by the Bibb, in December, of the channel into Winyah bay, under the orders of Admiral DuPont. In returning from duty at the same station, in February, the Bibb took in tow one of the steam transports of General Foster, which had burst her boilers within twenty miles of the hostile shore, and delivered the vessel at Hilton Head. Mr. Boutelle also accompanied the

engineer of the Light-house Board for determining the aids to navigation needed for the naval service between Port Royal and St. John's river, Florida.

Assistant Edwards, in this section, sounded out two important branches of the inland passage between St. Helena and Port Royal sounds; examined the channels into Tybee roads; and pushed the hydrography of Wassaw sound, for which shore-line was furnished by a party under Sub-Assistant Dennis. Mr. Talcott, of the topographical party, narrowly escaped capture while working on Little Tybee island.

Six parties were actively and constantly engaged during an average period of about six months of the present surveying year on the coast of North Carolina, South Carolina, and Georgia, and their labors are warmly commended in communications to me from Major General Foster and Admiral DuPont.

At the request of the tax commissioners of Florida, one of the most active of the Coast Survey topographers was assigned to serve under their orders at Fernandina and St. Augustine. His services during the ensuing winter were prospectively called for by the commissioners, but, under a pressing call received from Chattanooga, within a few days, he has been assigned to topographical duty for the army of Major General Rosecrans. Three others, Assistant West, Sub-Assistant Rockwell, and Mr. Donn, are under orders for duty there, in compliance with the application.

Sub-Assistant Dorr, while in service with the tax commissioners, supervised the erection of additional earthworks at Jacksonville, Florida, when that place was reoccupied by the government forces in March last.

Under the protection afforded in the vicinity of Admiral Bailey's blockading vessels, the hydrography outside of the Florida keys has been completed within the year by a party under Acting Assistant Cordell, with the steamer Vixen. The same party sounded the main entrance and approach of Charlotte harbor. Both these surveys are in continuation of previous work, and fall into place with the regular progress of the Coast Survey.

In connexion with the military and naval operations on the Mississippi river and in Louisiana, three topographers have served with the army of Major General Banks, (Assistant Oltmanns, Sub-Assistant Hosmer, and Mr. Lyman,) and two, Sub-Assistant Fendall and Mr. Strausz, under the direction of Assistant Gerdes, with the fleet of Admiral Porter, and subsequently with the army of Major General Grant. A minute topographical survey of the west bank of the Mississippi opposite to New Orleans for defensive purposes; reconnaissance maps of the middle districts of Louisiana and of the Red river as far up as Alexandria; the topography of the approaches to Vicksburg while the siege was in progress, and the survey of those of Port Hudson after the surrender of that post, are part of the results of their labors.

The high terms of approval used by Admiral Porter in reviewing the arduous duties and progress of the parties assigned to service with his fleet have induced me to renew the surveying force on the Mississippi during the coming season. Both of the topographers before assigned kept the field until entirely disabled by sickness in the latter part of July, after the surrender of Vicksburg. Their work had been repeatedly pushed forward in the presence of the enemy, as was also that of the parties with the army of General Banks. Assistant Oltmanns, on reconnaissance duty before Port Hudson, had his horse killed by a rebel shot, and previously, himself and Mr. Lyman being on board of the gunboat Kinsman, were in imminent peril when that vessel snagged and went down in the Atchafalaya with a number of the soldiers on board. Mr. Oltmanns has continued in service in the military department of the Gulf during the entire year. Mr. Hosmer, having closed surveying duty assigned at the north, has been reassigned to service with the army of General Banks. These and similar arrangements are detailed in my report, together with the changes in disposition in the transfer of officers of the survey from the east and north to the south. The transfers are also shown by lists in the Appendix, Nos. 27 and 28. The minute survey of the approaches to the defensive works near St. Louis, and of the ground which they occupy, has been completed, and the sheet turned in, by Assistant R. M. Bache.

During the invasion of the State of Pennsylvania last summer, and in view of the possible danger of the city of Philadelphia, I volunteered my services, under your authority, to the governor of Pennsylvania, and, by his request, was associated with the military and civil authorities in charge of the defences, as chief engineer. The exigency was pressing, as was proved by the efforts to procure regular engineers for this work, and by the failure even to obtain officers for consultation. The character of my association, first with Major General Dana, and, since August, with Major General Cadwalader, in command of the post of Philadelphia, was such as to add a relish to the labor. The circumstances of alarm, too, occasioned by the progress of the enemy, though soon passed, were attested most substantially by the number of volunteers for active service from the citizens, even the reverend clergy taking part, enthusiastically, for their home defence;

retired officers of the regular army and of the volunteers came forward with officers of the Coast Survey, those of the railroads centring at Philadelphia, officers and members of the municipal bodies of the city, and graduates of the institutions of learning.

The surveys made under my immediate direction for the defences of Philadelphia have occupied Assistants H. L. Whiting, George Davidson, R. M. Bache, and C. M. Bache, and at the outset of the work, Assistants C. O. Boutelle and P. C. F. West, the last-named having been just previously in military service with the division of General W. F. Smith, at Carlisle, Pennsylvania; Sub-Assistants R. E. Halter, Cleveland Rockwell, and J. S. Bradford, also assisted in the work.

Having occasion to discuss the river maps extending to tide-water with one of the generals-in-chief of our armies, I received the gratifying assurance that he could not have arranged the plans for the operations of the army without the use of those maps. This strong expression was coincided in by an admiral of high distinction then engaged in the interior of several adjacent States. I would propose to make this network of the rivers more complete by passing above tide-water, and by the help of observations of latitude and of telegraphic longitudes, effected partly in past years, to lay the basis for a connected map.

During the progress of the year new and highly gratifying testimonials have been spontaneously rendered by officers in the military and naval service to the value of the maps, charts, and memoirs prepared by the Coast Survey, in facilitating the important operations with which they have been charged. Naval commanders have pronounced these aids to be invaluable in promoting the efficiency of the blockade and in securing the safety of the blockading vessels; and the commanders of military departments and generals in the field have, directly and through their engineer officers, repeatedly expressed to the Superintendent their high sense of the usefulness to their commands of the maps of their several fields of operations, which have been prepared at the office of the survey. Besides the regular publications of the survey, maps of the localities of the different expeditions, sieges, &c., have been prepared for popular use.

The operations just mentioned have been executed by the civilians of the Coast Survey; all of the naval officers but one, and all the army officers, having been detached from service with us.

As during last year the means of usefulness, and not the opportunities, have limited the range of our parties.

No losses of vessels or other property, excepting by ordinary wear, have been encountered during the year. The two vessels seized at Charleston in the winter of 1860–'61 have, however, been destroyed; the schooner Petrel by a broadside from the United States frigate St. Lawrence, and the tender Fire Fly by fire at Savannah.

OFFICE-WORK.

The details of the work of the year in the computing, drawing, engraving, photographing, lithographing, and electrotyping divisions of the office are given in Appendix No. 14. I append here merely the titles of the maps, charts, and sketches that have been completed, or were in progress during the year.

SECTION I. The engraving of Portland harbor, as a finished chart, has been completed; the drawing and engraving of preliminary charts of Dutch Island harbor, Bristol harbor, and Coaster's harbor, (Narragansett bay,) have been completed. Progress has been made in the drawing and engraving of the chart of Kennebec and Sheepscot rivers, Maine, and of coast charts No. 7, Muscongus bay to Portland, Maine; No. 8, Seguin island to Kennebunkport, Maine; No. 10, Cape Ann to Plymouth, Massachusetts; and No. 11, Plymouth to Hyannis, Massachusetts. The engraving of coast chart No. 9, Cape Neddick to Cape Ann, Massachusetts, and of Barnstable harbor, as a finished map, has been continued; the drawing of Rockland harbor, Maine, has been commenced; additions have been made to preliminary coast chart No. 3, Cape Small Point to Cape Cod, and to the progress sketches of the section; and a new progress sketch, showing the primary triangulation and the connexion of the base lines in Sections I and II, has been drawn and engraved.

SECTION II. Sheet No. II, of a general chart of the Atlantic coast of the United States, scale 1:1,200,000, Nantucket to Cape Hatteras, has been drawn and engraved; the engraving of the outlines and hydrography of coast chart No. 21, New York bay and harbor, (resurvey,) has been completed, and that of the topography of the same has been commenced; the drawing and engraving of the chart of Hudson river, sheet No. 2, Haverstraw to Poughkeepsie, and No. 3, Poughkeepsie to Glasco, in a preliminary form, have been completed; that of Hudson river, No. 1, New York to Haverstraw, as a finished map, has been continued; a hydrographic sketch of Phelps's ledge and Great Eastern rock, off Montauk Point, has been engraved, and additions have been made to the progress sketches of the section.

SECTION III. The engraving of general coast chart No. IV, Cape May to Cape Henry, as a preliminary chart; of coast chart No. 36, Chesapeake entrance, as a finished chart, and of Rappahannock river, (sheet No. 5,) from Occupacia creek to Punch Bowl, has been completed. The drawing and engraving of preliminary charts of Metomkin inlet, Virginia, and of Potomac river, sheet No. 1, from the entrance upward to Piney Point; No. 2, Piney Point to Lower Cedar Point; No. 3, Lower Cedar Point to Indian Head, have been completed. Progress has been made in the drawing and engraving of Potomac river, No. 4, Indian Head to Chain Bridge. The engraving of coast chart No. 29, sea-coast of Maryland and Virginia, and of Hampton Roads and Elizabeth river, Virginia, has been commenced. Additions have been made to the progress sketch of the section. A preliminary edition of the chart of Potomac river, sheet No. 4, Indian Head to Chain Bridge, and a military map of southeastern Virginia, have been engraved on stone, and considerable additions have been made to the general map of Virginia in colors.

SECTION IV. The drawing and engraving of preliminary charts of Hatteras inlet and Oregon inlet, North Carolina, have been completed. Progress has been made in the engraving of coast chart No. 37, Cape Henry to Currituck sound. The drawing of coast chart No. 47, Bogue inlet to Barren inlet, North Carolina, has been continued, and the engraving of the same and that of coast chart No. 48, Barren inlet to Lockwood's Folly inlet, embracing Cape Fear and approaches, has been commenced. A lithographic edition of the latter, in a preliminary form, and also of general coast chart No. V, Chesapeake entrance to Ocracoke inlet, have been produced for the use of the North Atlantic blockading squadron, Admiral S. P. Lee; and a map of the mountain region of North Carolina and Tennessee, including also parts of the States of Virginia, Kentucky, Alabama, Georgia, and South Carolina, has been drawn and engraved on stone for the use of the armies in the field.

SECTION V. The drawing and engraving of sheet No. III, of a general chart of the Atlantic coast, Cape Hatteras to Mosquito inlet, and of Calibogue sound and Skull creek, forming the inland passage between Tybee roads and Port Royal sound, as a preliminary chart, have been completed. The drawing of coast chart No. 53, Rattlesnake shoals to St. Helena sound, has been continued, and the engraving of the same commenced. Progress has been made in the drawing and engraving of the chart of Port Royal sound, with Beaufort, Broad and Chechessee rivers, and of Wassaw sound. A map of the coast region of South Carolina and Georgia, from Bull's bay to Ossabaw sound, and a map of James's island and Stono river, have been engraved on stone, and a map and chart of Charleston harbor has been lithographed on the scale of the original surveys for use in the siege operations.

SECTION VI. The drawing and engraving of general coast chart No. X, Straits of Florida, and of coast chart No. 71, Newfound Harbor key to Boca Grande key, have been completed. The drawing, sheet No. IV, of a general chart of the Atlantic coast, Mosquito inlet to Key West, including Bahama banks and Straits of Florida, has been completed, and the engraving of the same commenced. A new edition of the chart of Key West harbor, with improved sailing directions, has been lithographed, and the preliminary chart of the northeastern part of the Gulf of Mexico, in two sheets, (scale $\frac{1}{600000}$,) has been engraved on stone.

SECTIONS VII, VIII, IX. The engraving of a preliminary chart of the Southwest Pass of the Mississippi river has been completed, and that of coast chart No. 93, Lakes Borgne and Pontchartrain, has been executed as far as the field-work is completed. The drawing of Gulf coast chart, from Key West to the Rio Grande, has been completed, and the engraving of the same has been commenced. Progress has been made in the drawing of general coast chart No. XIV, Choctawhatchee bay to the Mississippi delta, and in the engraving of coast chart No. 100, Atchafalaya bay, and Côte Blanche bay. The preliminary chart of the northwestern part of the Gulf of Mexico in two sheets, (scale $\frac{1}{6000000}$,) has been engraved on stone. A map of the vicinity of St. Louis and its military defences, on a large scale, has been drawn, and maps of parts of Louisiana and Mississippi, showing the fields of military operations in those States, have been lithographed.

SECTION X. The drawing and engraving of charts of the upper part of San Francisco bay; of the Pacific coast from Point Pinos to Bodega Head; and of Bodega bay, as preliminary charts, have been completed. The engraving of San Pablo bay, as a finished chart, has been completed. Progress has been made in the drawing and engraving of charts of Tomales bay and Drake's bay, as finished charts. Additions have been made to plates of charts previously engraved, and to the progress sketches of the section, and a hydrographic sketch of the Fanny shoal has been published.

SECTION XI. The drawing and engraving of a chart of the entrance to Koos bay, Oregon, have been completed, and the entrance to Gray's harbor, Washington Territory, has been drawn and engraved as a preliminary chart.

MAPS AND CHARTS.

The maps and charts published by the Coast Survey Office, as has been explained in several of my previous reports, are of two general descriptions, which may be distinguished as *preliminary* and *finished*. The preliminary charts are those which are issued as soon after the several surveys as is consistent with accuracy of general delineation, and are designed to supply the immediate and pressing demands of navigation. The finished charts embody *all* the information furnished by the survey, including the minutest details, and embrace not only the hydrography, but the topography likewise. The two classes of charts differ in regard to the amount of the information which they furnish, but not in regard to the correctness of that which is given.

The charts are various in character, according to the objects which they are designed to serve. The most important distinctions are the following:

1. *General charts of the coast*, on a scale of $\frac{1}{400000}$, for off-shore navigation. These represent the shore-line, and in its characteristic features, so as to be readily recognized by the navigator approaching it. The entire Atlantic and Gulf coasts will be comprehended in sixteen charts of this class.

2. *Preliminary sea-coast charts*, on a scale of $\frac{1}{200000}$, for in-shore navigation. These will all be ultimately superseded by the more complete charts next to be named.

3. *Coast charts* for in shore navigation, on a scale of $\frac{1}{80000}$, exhibiting with minute accuracy every natural and every permanent artificial feature, above or below the water, which can be introduced without occasioning confusion. They exhibit, also, the topography for some distance from the shore.

4. *Charts of harbors, bays, anchorages, &c.*, on various scales adapted to the subject; also, sketches of local dangers, &c.

To the above there has been added, during the present year, upon the request of the Superintendent of the Naval Observatory, a series of *sailing charts*, upon a scale of $\frac{1}{1200000}$, embracing the largest area of any, and designed to enable the navigator to protract his course. Four of these embrace the entire Atlantic coast of the United States, with the adjacent British possessions, for the delineation of which the British admiralty charts have been made use of. The Gulf coast is contained on two similar sheets. The surveys being still incomplete in some localities, the present edition of these charts, all of which are appended to this report, is necessarily a preliminary one. (Sketches Nos. 18—23.)

A like series for the Pacific coast, on the same scale, in three sheets, has been published since 1855, under the title of "Reconnaissance of the Western Coast."

The whole number of charts which have been engraved upon copper for publication, and which are now in use, is three hundred and twenty-six. This is exclusive of twenty-four copper plates containing the progress sketches, and thirty-five plates of diagrams.

Seventy-five sheets have been worked upon in the drawing division during the year ending October 31, 1863. Of this number five are the sailing charts above spoken of; three are general, or off-shore charts; two, preliminary sea-coast charts; eight, finished coast maps and charts; twenty-six, harbor charts; twenty, sketches; two, sheets of diagrams; nine, maps and sketches for engraving on stone, or for lithographic transfer. Fifty-four sheets have been completed, and twenty-one are in progress. Of those completed, six are finished harbor charts, and the others preliminary charts and sketches.

In the engraving division six first class maps and charts have been completed within the year, and nine plates of second class charts and sketches, exclusive of three diagrams. Preliminary editions of eleven, in outline and hydrography, preparatory to their final completion, have also been engraved. Thirty-three plates are now in progress, of which twelve were commenced within the present year.

This gives a total of eighteen plates completed, and thirty-three in progress, or of fifty-one plates worked upon during the year. There are, besides, in the division, seven plates in various stages of forwardness that have received no additions during the year, having already received all the material which the field-work has yet furnished.

In the lithographic division twenty-four maps or charts have been engraved or drawn upon stone; considerable additions have been made to others previously lithographed, and fifty-nine transfers for lithographic printing have been made from engravings or lithograph drawings.

All the details in regard to the production and distribution of maps and charts will be found in the report of the assistant in charge of the office. (Appendix No. 14.)

The following list contains the titles of the maps, charts, and sketches, the material for which is in the office, and which are intended to accompany this report, with the exception of such of their number as the

public interest may still require to be withheld from general issue at the time of its publication. They are arranged in geographical order, as usual, and marked with numbers corresponding to the numbers in the margin of the list.

1.—A. Progress sketch, Section I, primary triangulation.
2.—A bis. Progress sketch, Section I, upper sheet, coast of Maine.
3.— Rockland harbor, Maine.
4.— Casco bay, Maine.
5.— Boston harbor, resurvey of 1862.
6.— Nantucket shoals, new edition.
7.— Phelps's ledge and Great Eastern rock, off Montauk Point.
8.— Hudson river, from New York to Haverstraw.
9.— Hudson river, from Poughkeepsie to Troy.
10.—C. Progress sketch, Section III, Chesapeake bay and estuaries.
11.— Beaufort harbor, North Carolina, resurvey.
12.— Port Royal entrance, South Carolina, resurvey of 1863.
13.—F. Progress sketch, Section VI, Florida keys.
14.— Straits of Florida, general coast chart No. X.
15.— Florida keys, from the Elbow to Lower Matecumbe key, coast chart No. 69.
16.— Florida reefs, from Long key to Newfound Harbor key, coast chart No. 70.
17.— Western end of Florida reefs, including Tortugas keys.
18.— Atlantic coast, No. I, Cape Sable to Sandy Hook.
19.— Atlantic coast, No. II, Nantucket to Cape Hatteras.
20.— Atlantic coast, No. III, Cape Hatteras to Mosquito inlet.
21.— Atlantic coast, No. IV, Mosquito inlet to Key West.
22.— Gulf coast, eastern part, Key West to Mississippi river.
23.— Gulf coast, western part, Mississippi river to Rio Grande.
24.—J. Progress sketch, Section X, coast of California.
25.— Halfmoon bay, California.
26.— San Pablo bay, California.
27.— Tomales bay, California.
28.— Washington sound, Washington Territory, (new edition.)
29.— General progress sketch for 1863.
30.— Diagrams illustrating discussion of magnetic observations at Girard College.

DISTRIBUTION OF MAPS AND ANNUAL REPORTS.

During the year there has been a total distribution of volumes of the reports on the Coast Survey, amounting to 6,124 copies. This embraces reports of all years from 1851 to 1861, inclusive. A limited foreign distribution has been made of the volumes for 1859 and 1860, through the Smithsonian Institution. The total number thus sent abroad amounts to 333 for each year. It is proper to remark, in making this statement, that the maps and sketches originally designed to be appended to the volumes mentioned, in so far as they relate to portions of the coast under blockade, have been withheld from the copies distributed.

There remain on hand at present, of the report for 1861, only 137 copies; of that for 1855, 344 copies; and of that for 1857, 252 copies. Of the reports for other years the numbers exceed five hundred each, and for the last three years are upwards of two thousand.

During the year there have been distributed to libraries and other permanent institutions in different parts of the United States more than fifty copies of the volumes, of which the impressions are now most nearly exhausted, in order to complete sets which may be accessible to the public, at as many convenient points of the country as possible.

Of maps, charts, and sketches, about forty-six thousand have been distributed within the year. In this aggregate are embraced not only the publications strictly nautical, but also those maps and sketches of portions of the coast, and occasionally of the interior, as were likely to promote the successful prosecution of the important operations in which the navy and armies of the country have been engaged.

The details in regard to the distribution of reports, maps, charts, etc., will be found in the report from the miscellaneous division of the office. (Appendix No. 14.)

ESTIMATES FOR THE FISCAL YEAR 1864–'65.

The estimates for the present fiscal year, to which the appropriations corresponded, were much diminished from those of 1860–'61 and 1861–'62, being $306,000 for all the branches of service on the Atlantic, Gulf, and Pacific coasts. The estimates now submitted agree with the sums appropriated last year, and will enable us to continue the field and office work on the same reduced scale; to keep up the organization of our trained officers in field and office operations; to put into practical form, for the use of the departments and officers of the government, the information already collected; to continue the office compilations for use by the fleets, armies, and expeditions, and the publication of such maps as general public interests may render desirable or expedient, and to provide for the assignment of special parties, as heretofore, with your concurrence, when such parties can be useful, as the experience of the past two years shows they have been, in service with the fleets and armies.

The estimates for progress on the Atlantic, Gulf coast, Florida reefs, and western coast of the United States, are given as usual, in separate items, and are exclusive of the aid formerly, but not now, extended for the work, by the detail of officers of the army and navy.

Estimates in detail.

For general expenses of all the sections, namely, rent, fuel, materials for drawing, engraving, and printing, and for ruling forms, binding, transportation of instruments, maps, and charts; for miscellaneous office expenses, and for 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 triangulation of *Passamaquoddy bay*, and extend it so as to include the north-eastern boundary along the *St. Croix river;* to complete the secondary triangulation of the coast of Maine in the vicinity of *Mount Desert island;* to continue that of the *Penobscot river;* to continue the topography of *Passamaquoddy* bay and its dependencies; to complete that of *Prospect harbor*, and commence that of *Goldsborough bay*, (coast of Maine;) to continue that of the islands at the entrance of *Penobscot bay*, and the western shore of the bay above *Camden;* that of *St. George's river* and the adjacent shores of *Muscongus sound;* to complete the topography of the eastern shore of the *Sheepscot river*, and continue the survey of the eastern shores of *Casco bay;* to continue the detailed survey of the shores and islands of *Narragansett bay;* to continue off-shore soundings along the coast of Maine, and the hydrography of *Passamaquoddy bay, Frenchman's bay*, the approaches of *Penobscot bay*, and *Goldsborough* and *Prospect harbors;* to continue tidal and magnetic observations at Eastport, and tidal observations in the progress of the hydrography. OFFICE-WORK.—To make the computations required for, and reductions from the field observations; to commence the drawing of coast chart No. 1, *Passamaquoddy bay;* to continue the drawing and commence the engraving of coast chart No. 6, *approaches of Penobscot bay;* to continue the drawing and engraving of coast chart No. 7, *approaches to Muscongus bay* and *Kennebec river*, and coast chart No. 8, *approaches to Casco bay;* to continue the drawing of No. 9, coast of Maine, New Hampshire, and Massachusetts, from *Kennebunkport* to *Cape Ann*, and the drawing and engraving of No. 10, coast of Massachusetts, from *Cape Ann to Plymouth*, and of No. 14, *Narragansett bay, R. I., and approaches;* to continue the drawing and commence the engraving of general coast chart No. I, *Quoddy Head, Me.*, to *Cape Cod., Mass.*, and complete the drawing and engraving of No. II, *Cape Ann to Gay Head;* to complete the drawing and commence the engraving of charts of *Eastport harbor*, Me., and *Rockland harbor;* to continue the drawing and commence the engraving of a chart of the *Damariscotta river;* to commence the drawing and engraving of charts of *Winter harbor, Rockport harbor*, and *Tennant's harbor;* and to complete the drawing and engraving of charts of the *Kennebec* and *Sheepscot rivers*, Me.; of *Newport harbor*, and of *Bristol harbor, R. I.*, will require 61,000

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.* FIELD-WORK.—To complete the observations required for connecting the *Epping base*, in section I, with the *Fire Island base*, in section II; to continue the triangulation of *Connecticut river*, between Higganam and Hartford, and that of the *Thames river*, above *New London;* to continue verification work on the *coast of New Jersey*, south of Manasquam inlet; to continue the

topography of the shores of the *Connecticut* and *Thames rivers*, and the detailed survey of the shores of the *Hudson*, above the mouth of Croton river; to make a resurvey of *Absecom inlet*, and execute such supplementary hydrography as may be required in *New York bay* and *Delaware bay;* to continue the tidal observations. OFFICE-WORK—To make the computations and reductions; to continue the engraving of coast chart No. 21, *New York harbor*, and its approaches, (new edition;) to continue the drawing and engraving of *sheets Nos. 2 and* 3, of the chart of *Hudson river*, (from Haverstraw to Glasco;) continue the drawing and commence the engraving of *sheet No.* 4, (Glasco to Coxsackie;) and commence the drawing and engraving of *sheet No.* 5, (Coxsackie northward to Troy, N. Y.;) to commence the drawing and engraving of a chart of the *Connecticut river*, and one of the resurvey of *Absecom inlet*, N. J.; and to complete the engraving of *coast chart* No. 28, from Cape May, N. J., to Isle of Wight, Del., will require..... $17,500

SECTION III. *Coast of part of Delaware and that of Maryland, and part of Virginia.* FIELD-WORK.—To continue astronomical and magnetic observations in the section, and secure the stations of the triangulation; to make extensions of the triangulation for including the detached plane-table surveys in the vicinity of *Washington city;* to complete the topography near *Baltimore* and *Washington*, required for defensive purposes, and continue that of the eastern shore of Virginia; to make such detailed surveys as may be necessary at points on the *Potomac and Rappahannock rivers;* and to continue the off-shore hydrography and tidal observations in the section. OFFICE-WORK.—To make the computations from field-work; to continue the engraving of *coast chart No.* 29, (from Isle of Wight, Del., to Chincoteague, Va.,) and the drawing of *No.* 30, (from Chincoteague to Great Machipongo inlet, Va.;) to commence the engraving of that chart; and to continue the drawing and engraving of coast chart *No.* 30, bis.; (Chesapeake entrance,) and *general coast chart* No. IV (approaches to Delaware and Chesapeake bays) will require..... 13,500

SECTION IV. *Coast of part of Virginia and part of North Carolina.* FIELD-WORK.—To complete, if practicable, the primary triangulation of *Pamplico sound*, and make the requisite magnetic observations; to complete the triangulation of *Neuse river*, and take up that of *Pamplico river;* to continue the topography about *Newbern*, and the survey of the shores of *Neuse river;* to complete the topography of the outer *coast* of *North Carolina*, between Hatteras inlet and Core sound; to continue the in-shore and off-shore hydrography in the vicinity of *Cape Lookout;* and to execute that of Neuse river, and such other soundings as may be required in the waters of *Pamplico* or *Albemarle sounds;* to make observations of the tides and currents, and in the Gulf *stream.* OFFICE-WORK.—To make the computations and reductions; to continue the engraving of *coast chart No.* 38, (from Currituck, Va., to New inlet, N. C.,) and of No. 48, (from Barren inlet to Lockwood's Folly inlet, N. C.;) to commence the engraving of charts Nos. 46 and 47, (from Cape Lookout to Barren inlet,) and the drawing and engraving of a chart of the *Neuse river*, will require..... 15,000

SECTION V. *Coast of part of North Carolina and that of South Carolina and Georgia.* FIELD-WORK.—To execute such triangulation and topography as may be practicable in places not yet embraced in the survey; to execute the hydrography that may be required, and additional soundings in the shifting bars in this section, with tidal observations. OFFICE-WORK.—To complete the drawing and continue the engraving of coast chart No. 53, (from Rattlesnake shoal to St. Helena sound, S. C.;) to continue the drawing and engraving of No. 54, (from Fripp's inlet, S. C., to Ossabaw sound, Ga.;) to continue the drawing of No. 57, (from Sapelo sound to St. Andrew's sound, Ga.;) and that of *general coast chart* No. VII, (from Winyah bay, S. C., to St. John's river, Fla.,) and commence the engraving of the last-named chart; to complete the drawing and engraving for a chart of the resurvey of *Charleston bar*, and the drawing of that of *Wassaw sound, Ga.*, will require..... 16,000

SECTION VI. *Coast, keys, and reefs of Florida.*—(See estimates of appropriation for those special objects.)

SECTIONS VII, VIII, AND IX. *Part of the western and northern coast of Florida, and the coasts of Alabama, Mississippi, Louisiana, and Texas.* FIELD-WORK.—To execute such triangulation, topography, and hydrography, in continuation of the surveys in these sections, as may

be practicable, and such special surveys as may be required for public service. OFFICE-WORK.—To continue the computations and reductions of previous field-work; to continue the engraving of *coast charts* Nos. 84 and 85, (western coast of Florida, from Ocilla river to Cape St. Blas;) the drawing of No. 96 (delta of the Mississippi) and that of *general coast chart* No. XIV, (northeastern coast of the Gulf of Mexico;) to commence the engraving of the last-named chart, and to continue the drawing of *general coast chart No. XVI*, (western coast of the Gulf of Mexico,) will require..... $36,000

Total for the Atlantic coast and Gulf of Mexico..... 178,000

The estimates for the Florida coast, keys, and reefs, and for the western coast of the United States, (California, Oregon, and Washington Territory,) are intended to provide for the following purposes:

SECTION VI. *Coast, keys, and reefs of Florida.* FIELD-WORK.—To continue, if practicable, the survey of the eastern coast of the peninsula south of the present limit at *Matanzas inlet*, or north of *Indian river;* to complete the triangulation of keys inside of the *Florida reefs*, and between *Chatham bay* and *Cape Sable;* to continue the topography of those in *Chatham bay*, and the topography of *Charlotte harbor;* to complete the hydrography of the approaches to that harbor, and run off-shore lines of soundings from the reef and from the coast of this section; to continue magnetic observations at *Key West*, and such tidal observations as may be requisite. OFFICE-WORK.—To compute the results of field-work; to continue the drawing and engraving of *coast charts Nos. 69 and 70*, (Florida reefs, from Garden key to Big Pine key,) and *general coast chart* No. X, (Florida reefs, from Key Biscayne to the Marquesas;) and to continue the drawing and engraving of a chart of the approaches to Charlotte harbor, will require..... $11,000

SECTION X. *Coast of California.* FIELD-WORK.—To continue the coast triangulation southward to the *San Pedro* base, or northward of *Santa Barbara*, and the work for connecting the *Santa Barbara* islands by triangulation with the coast of California; to continue the triangulation northward from *Bodega;* to continue the topography of the islands in *Santa Barbara channel*, and that of the shore of *Bahia Ona;* to complete that of *Half-moon bay;* to complete the in-shore hydrography in the vicinity of *Half-moon bay*, below San Francisco entrance; to run off-shore lines of soundings from the principal headlands of the section; to extend the in-shore hydrography northward of *Bodega*, and re-examine bars subject to change in *San Pablo bay;* to continue tidal observations at *San Diego* and *San Francisco*. OFFICE-WORK.—To make the computations from field-work; to complete the drawing and engraving of a chart of *Bodega* bay; the engraving of that of *Tomales* bay, and of the upper sheet of *San Francisco bay;* to continue the drawing of *general coast chart* of the *Pacific*, (from San Diego to Point Conception,) and commence the engraving of the same; to continue the drawing and engraving of a chart of *San Francisco bay*, to be issued in one sheet.

Also, for the operations in—

SECTION XI. *Coast of Oregon and that of Washington Territory.* FIELD-WORK.—To make the astronomical and magnetic observations required in this section, or in Section X; to continue the triangulation of *Washington sound* in connexion with former work, and to make such plane-table surveys in continuation of previous work as may be practicable; to continue the hydrography in *Admiralty inlet*, or execute soundings in special localities of Oregon or Washington Territories, as may be called for by public interests; to continue tidal observations at *Astoria*, and make such as may be required by the hydrography. OFFICE-WORK.—To continue the computations of field-work; to continue the drawing and engraving of a chart of *Washington sound*, W. T.; to continue the drawing and engraving of surveys, as far as now made, for a chart of *Admiralty inlet* and *Puget's sound*, and for the chart of *Gray's harbor;* and to add to the general chart of the Pacific coast the soundings made off *Port Orford* and *Cape Blanco*, will require..... 100,000

The three small items following are in terms and amount the same as were asked for last year:

For publishing the observations made in the progress of the survey of the coast of the United States, per act of March 3, 1843..... $4,000

For repairs of steamers and sailing schooners used in the survey, per act of March 2, 1853..... 4,000

For pay and rations of engineers for four steamers to be used in the hydrography of the Coast Survey, and no longer supplied by the Navy Department..... 9,000

The amounts thus estimated for the fiscal year 1864–'65, and the appropriations for the present year, are here given in parallel columns.

Object.	Estimates for fiscal year 1864–'65.	Appropriated for fiscal year 1863–'64.
For survey of the Atlantic and Gulf coasts of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	$178,000	$178,000
For continuing the survey of the western coast of the United States, including compensation of civilians engaged in the work, per act of September 30, 1850	100,000	100,000
For continuing the survey of the Florida reefs and keys, including compensation of civilians engaged in the work, per act of March 3, 1849	11,000	11,000
For publishing the observations made in the progress of the survey of the coast of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	4,000	4,000
For repairs of steamers and sailing schooners used in the survey, per act of March 2, 1853	4,000	4,000
For pay and rations of engineers for four steamers used in the hydrography of the Coast Survey, no longer supplied by the Navy Department	*9,000	*9,000
Total	306,000	306,000

*Formerly included in estimates of Navy Department.

DEVELOPMENTS AND DISCOVERIES.

Closer research than would be probably required for the in-shore hydrography of any part of the Atlantic coast south of New England, has developed the positions of a number of rocks near the approaches to Portland harbor. These, with other determinations of the same kind, are referred to below in geographical order. The general list of developments and discoveries, made in the progress of the hydrography in previous years, is given in Appendix No. 4. Those for the present year are as follows:

1. The examination of the channels leading into Carver's harbor, (Penobscot bay,) with reference to the positions of rocks and shoals dangerous to navigation.

2. A dangerous ledge, determined in position, with only eleven feet at mean low water, two miles west of the north end of Metinic island, mouth of Penobscot bay.

3. Determination in position and depth of ten rocks near the approaches of Portland harbor, and of a spot with only fourteen feet water on Bulwark shoal; on Witch rock, twenty-four; on Corwin rock, twenty-four and a half; on Mitchel rock, thirty-one; on Willard rock, thirty-one and a half; on Bache rock, thirty-two feet; on Round rock, thirty feet; on Old Anthony, or Vapor rock, twenty feet; on the Western Hue-and-Cry, twenty-seven and a half feet; on West Cod ledge, thirty-four feet; and on East Cod ledge, forty-nine feet.

4. Several dangerous rocks and ledges developed in the approaches of Sippican harbor, (Buzzard's bay,) and others inside of the harbor.

5. Development of a ledge, (Great Eastern ledge,) off Montauk Point, having at one point only twenty-four feet at mean low water, and at another twenty-seven feet.

6. Development of shore-line and hydrographic changes at Sandy Hook, with reference to the effect of the great storm of January, 1863.

7. The alteration of shore-line and sea encroachment near Absecom light-house, coast of New Jersey.

8. Development of hydrographic changes at the Delaware breakwater.

9. Special survey of part of League island, Delaware river, and comparison of changes with previous surveys.

10. Examination of soundings eastward of Winter Quarter shoal, to determine the alleged existence of a second shoal.

11. A shoal found with only fourteen feet of water, S. by E. ½ E., and distant ten and a half miles from Cape Lookout light-house.

12. Development in position of the point, with only twenty-one feet at mean low water, of Noonday

rock, (called also Fanny shoal,) in the track of vessels passing the North Farrallon, approaching San Francisco bay.

13. Determination of the position of the wreck of the ship Flying Dragon, in the track of vessels navigating San Francisco bay.

SPECIAL SURVEYS.

1. The surveys of Boston harbor, under the United States commissioners, and at the expense of the city, have made good progress, the resurvey of the outer harbor having been completed by Mr. Boschke and his assistants, and the survey of the South bay being now in hand. The subject of drainage of the city and districts adjacent has been investigated, with results which will lay the foundation of an excellent system. The maps are now drawing by Mr. Boschke.

Assistant Henry Mitchell has completed his useful series of experiments on tides and currents in the upper harbor of Boston, and has continued his investigations in Fort Point channel and South bay.

2. Assistant Henry L. Whiting made special examinations, for the United States engineer department, of several islands and sites along the coast, from Rhode Island to Maryland, and a report, all of which was acceptable to the chief engineer.

3. Resurveys, including the shore-line and hydrography of the vicinity of Sandy Hook, were made; the former, by Assistant H. L. Whiting, in November and December, 1862, and the latter by Assistant Henry Mitchell, in June and July of the present year, the great storm of January last having inundated a considerable part of the surface of the hook. The hydrographic resurvey embraced the False Hook channel north of the Oil spot, and about a mile and a half of the main ship channel abreast of the hook, including also Flynn's knoll and soundings along the western side of the hook.

4. An examination was made by Lieutenant Commander Phelps, United States navy, commanding the steamer Corwin, at the request of the pilot commissioners, to ascertain whether the material from the dredging of the slips at New York had caused any changes in the main ship channel.

5. A special survey of Absecom inlet, on the shore of New Jersey, has been commenced at the request of the president of the Atlantic Railroad Company, and in reference also to the safety of the light-house at Absecom inlet, which the changes of the entrance were supposed to have, perhaps, endangered.

6. By request of the United States chief engineer a resurvey of the Delaware Breakwater harbor has been made, and the chart has been furnished to the engineer department. A few changes in the depth of water were found. These, though not sufficient to alter the character of the harbor, may be of great importance in regard to the permanent condition of the breakwater itself.

7. The upper part of League island, in the Delaware, was surveyed for purposes of comparison last winter, and the channel which passes behind it sounded at the request of the Navy Department.

8. A special reconnaissance of the approaches to the city of Philadelphia has been made, with the approval of the Secretary of the Treasury, on the north side of the city, from the Delaware to the Schuylkill, by Assistant George Davidson, of the Coast Survey, and on the west side, from the Schuylkill, near Conshohocken, to the mouth of the river, by Assistant H. L. Whiting. A portion of the latter district, from the Falls of Schuylkill to Fort Mifflin, near the river bank, was examined by Assistant R. M. Bache, who also planned and erected several small redoubts and batteries, aided by Mr. R. E. McMath. Assistant C. O. Boutelle also planned an earthwork near Hestonville. Mr. Whiting was assisted by Mr. E. Hergesheimer and Mr. W. B. McMurtrie, of the Coast Survey, and by Strickland Kneass, esquire, city engineer, W. C. Gatzmer and Mr. Emerson, civil volunteers; Assistant Davidson, by Messrs. S. C. Ford, Jesse Lightfoot, J. B. Tyson, James Rowland, J. F. Wolf, D. H. Shedaker, James Reilly, J. P. Davis, Andrew French, Joseph Mercer, J. M. Seads, Alfred Young, C. McDonald, R. McCaffrey, Henry Stout, W. C. Cleveland, T. Guilford Smith, Chauncey Ives, Edward Sloan, T. R. Stocket, J. B. Atkinson, W. G. Neilson, E. D. Hallowell, Captain J. B. Williams, Charles Perkins, James Steele, Wm. T. Gummey, W. E. Weber, B. H. Smith, Edward T. Hyatt, L. R. Walton, Professor George Franck, of the Polytechnic College, J. F. Clarke, A. L. Kern, H. McIntyre, G. S. Bethel, S. Brandies, W. H. Bennett, W. C. Gatzmer, L. H. Steele, and W. H. Clarke. Mr. A. R. Fauntleroy, of the Coast Survey, assisted Mr. Davidson throughout the working season. Assistants C. M. Bache and P. C. F. West, and Sub-Assistants J. S. Bradford and Cleveland Rockwell, were here engaged during part of the season. Assistant Boutelle was aided by James F. McCabe, and Assistant R. M. Bache, by R. E. McMath, of the Coast Survey, and by Captain C. H. Gibson, second cavalry, Captain H. C. Ulman, Mr. J. W. Walker, Captain B. H. Smith, Mr. Charles Perkins, and Mr. H.

McIntyre. Sub-Assistant R. E. Halter made a survey along the Schuylkill, near Fairmount, connecting with another made by Mr. Edwin Hergesheimer, of the drawing division of the Coast Survey Office. Mr. Hergesheimer was aided by Mr. W. E. Weber. I was in charge of the surveys and works under the general direction of the mayor and Committee of Defence of the councils of Philadelphia; first under General N. J. T. Dana, major general commanding the post under Major General Couch, commanding the military department, and next under Major General George Cadwalader. To both of these officers I feel much indebted for their interest in the matter, and for their courtesy to me personally, and to my assistants, and their kind aid rendered on every occasion.

TIDE TABLES FOR MARINERS.—TIDES AND CURRENTS.

The tide tables for the use of mariners are contained in Appendix No. 12. Eastport, Maine, has been added to the list of stations given in Table I.

Tidal observations have been continued at four regular stations on the Atlantic coast, but have not been resumed at either of the stations of the coast now under blockade. From the officer who is now provost marshal at Brashear City, Louisiana, it has been ascertained that the tide-gauge which was delivered to his predecessor, and who had advised us of the delivery, cannot now be found. The probable conclusion is, that the instrument was destroyed or carried off in the summer, when that post was temporarily in possession of the enemy, whose advance was made soon after the provost marshal had been requested to forward the instrument to Washington.

Some special remarks on the character of the currents of New York harbor will be found in the second part of the report, under the head of Section II.

INFORMATION FURNISHED.

The information furnished from the office in reply to special calls, and generally in the form of tracings from the original sheets of the survey, is stated in the form of a list in Appendix No. 2.

Since the commencement of the rebellion, much the larger part of the matter so furnished has been for the use of the army and navy. The applications from civil life are complied with under the sanction of the Treasury Department, and on the condition that due credit is given to the government in any publication of the material obtained from the office.

STATISTICS.

The table of statistics has been added to so as to bring it up to the present surveying year, and is given in Appendix No. 3.

Up to 1862, inclusive, the triangulation has covered an area of about sixty-two thousand six hundred square miles, extending along a general coast-line of nearly forty-seven hundred miles, and developing a shore-line, reckoning the river indentations, of twenty-four thousand miles, by the determination of nine thousand nine hundred geographical positions.

For latitude observations one hundred and twenty-nine stations have been occupied, for longitude eighty-five, and for azimuth eighty-six stations.

The topography had extended over an area of seventeen thousand three hundred square miles, having a general coast-line of forty-two hundred miles, and a shore-line of over forty-three thousand three hundred.

The hydrography extended over an area estimated at forty-six thousand five hundred square miles, in which nearly two hundred and five thousand miles were run in sounding, six million seven hundred and eighty-four thousand casts of the lead were taken, and over eighty-four hundred specimens of bottom collected.

The number of manuscript maps and charts was twenty-two hundred and seventy-four, and of engraved maps, charts, and sketches, five hundred and seven. The combination of several for publication in one sheet, and transfer of material for new editions, have considerably lessened this aggregate of the engraved plates.

TOPOGRAPHICAL AND HYDROGRAPHIC SHEETS.

The titles of the topographical and hydrographic sheets registered at the office since 1861 are given in Appendix Nos. 15 and 16. Of the entire number seventy-one are plane-table sheets, and sixty-one are original hydrographic charts. The list containing the titles is in continuation of previous ones which have been published with my report biennially since 1857. The scale of each survey is stated in the lists.

PLEIADES COMPUTATIONS.

During the past year the ephemerides of the moon for all the occultations of the Pleiades, from 1838 to 1842, have been completed by Professor Benjamin Peirce, and verified by a duplicate computation by Mr. C. S. Peirce.

The remainder of the work has also been completed for three occultations, those of April 13, 1842, of January 21, 1842, and of September 6, 1841.

All the other occultations will be finished in the course of the coming year, at the rate of about one in a month.

The report of Professor Peirce, on the occultations of 1841–'42, is given in the Appendix, (No. 17.)

A part of the computations connected with the method of determining longitude by occultations of the Pleiades has been made in the office, under the charge of Assistant Schott, two computers being so engaged since the 1st of November. The series undertaken comprise the observations made between the beginning of the year 1856 and the end of 1861, and are to be reduced according to the plan laid out by Professor Peirce, and under his supervision. The necessary revisions are made by the chief of the computing division.

COMPUTATIONS OF LONGITUDES.

The computation of the longitudes obtained by telegraph observations has been continued by Dr. Gould through the last year. The longitudes of seven places have been deduced from observations made at stations on the line Wilmington—New Orleans. The details of results are given in Appendix No. 18.

A curious series of facts in regard to a diurnal movement in azimuth, of the transit instrument, was noticed in Dr. Gould's last report, and is discussed in his report for this year. The labor expended on the determinations of right ascensions appears fully justified by the observations of the past year, in which these results were used. The preparation of a list of declinations for the time stars has made considerable progress.

MAGNETISM.

The series of papers on the results of the discussion of magnetic observations made at Girard College, Philadelphia, from 1840 to 1845, and now being published by the Smithsonian Institution, is continued this year by the insertion of Parts VII, VIII, and IX, which contain the investigation of the vertical component of the magnetic force. As these discussions are very similar to those of the horizontal component given last year in Parts IV and V, but little additional explanation is needed in regard to their method.

Part VII commences with the discussion of the effect of temperature upon the readings of the magnetometer, and the reduction of the observations to a uniform temperature, (66° Fahrenheit,) and then the progressive and apparently irregular changes in the readings of the instrument are inquired into. Peirce's criterion was applied, as in the former papers, for the recognition and separation of the disturbances. The limit found was thirty scale divisions. The existence of the eleven-year period, in the amplitude of the diurnal variation of the vertical force, is proved, and the force found greatest between 1 p. m and 2 p. m., and least between $8\frac{1}{2}$ p. m. and $10\frac{1}{2}$ p. m. The investigation proceeds with a general analysis of the disturbances, showing their dependence in number and amount on the eleven-year period. Their annual and diurnal inequality are also shown. The months of greatest disturbance are March and September, the least disturbance being in June. The greatest number of disturbances occurs about 1 a. m., and the least number at 10 a. m. There is, however, a secondary period in each case. In these inquiries, the disturbances which increase the force, and those which diminish it, are separately examined. The paper concludes with a classification of the disturbances according to their magnitude.

To this paper is added a discussion of the effect of the brighter auroras upon the magnetic declination, and upon the horizontal and vertical forces. Each account of an aurora is specially collated with the corresponding observations of the magnetic elements. The apparent effect of the aurora upon each of the magnetic elements is stated in tabular form.

Part VIII treats of the solar diurnal variation, and of the annual inequality of the vertical force: also, of the semi-annual inequality of the diurnal variation, and of the diurnal range of the same. The greatest diurnal variation occurs about $1\frac{1}{2}$ p. m., and the least about 10 p. m. with indications of a secondary maximum and minimum. At $5\frac{1}{2}$ a. m. and 7 p. m. there is no change in the diurnal variation throughout the year. The force also appears to be greatest in May, June, July, and August. The results are expressed in part analytically, and in part graphically.

The full papers will be found in the Appendix Nos. 19, 20, and 21, and the illustrative diagrams in Sketch No. 30.

Part IX contains the investigation of the lunar influence upon the vertical force, and on the inclination and total force. The method of investigation being precisely the same as that pursued in the investigation for the horizontal force, no further explanation is here required. In tracing out the lunar effect upon the vertical force, we have to contend with greater irregularities than were experienced in the preceding case of the other component, a large share of which is probably due to the great temperature reductions required for the magnet. In all, 19,513 observations have been discussed and arranged for inquiry, 9,719 belonging to western, and 9,794 to eastern hour angles of the moon. A separation of the results for winter and summer season was found impracticable owing to the shortness of the whole series. The lunar diurnal variation, presented analytically and graphically, shows a double crested curve, with a principal maximum a little before the upper culmination, and a principal minimum, about $3\frac{1}{2}$ hours after the lower culmination of the moon; the average epoch of the vertical force tide is, therefore, about $1\frac{1}{2}$ hour apparently in advance of the culminations. The secondary wave is very feeble, its greatest value happens about nine hours, western hour angle, and its least value about three hours before, giving a range of nearly a tenth part of the principal range, which is 0.000027 parts of the force. The subject of the epochs of the lunar diurnal variation is yet very imperfectly brought out, and more observations are desirable. The Toronto and Philadelphia curves are also examined and their accordances or differences stated.

The lunar effect upon the inclination and total force is obtained by a proper combination of the horizontal and vertical components of the force. For the inclination we have maxima at $8h.$ and $20h.$ (principal;) minima at $3h.$ (principal) and $13\frac{1}{2}h.$; total range, 3."6. The Philadelphia and Toronto curves are remarkably accordant. For the total force we have maxima at $\frac{1}{2}h.$ (principal) and $11h.$, minima at $7\frac{1}{4}h.$ and $17h.$ (principal;) total range, 0.000026 parts of the force.

The ordinary observations for the determination of the magnetic elements along our eastern Atlantic coast have been prosecuted by Assistant Charles A. Schott, who occupied nine stations in July last. Assistant G. W. Dean also observed at two of the primary stations. The results found are presented in Appendix No. 22.

Observations have been continued at Eastport, Maine, and at Key West, Florida. As heretofore the observations are made near the middle of each month of the year for the magnetic declination, dip, and intensity. At Key West, in addition to these, a continuous record of the three magnetic elements is kept up by photographic self-registering instruments.

At the request of the Navy Department observations were instituted last spring, by a committee of the National Academy of Science, on the deviation of compasses on iron and iron-clad vessels in the government service.

The following is a brief account of work done under my immediate direction for the compass committee since June last. Four magnetic surveys were made of two vessels, viz: of the United States steamer *Roanoke*, (iron plated and turretted,) and of the Ericsson battery *Passaic*, (iron vessel with turret.) Another vessel, the *Monadnock*, was also visited, but was only partially examined, as only part of the armor was in place. Four reports have been submitted by Assistant Charles A. Schott, to whom this work was intrusted. The special points embraced in the reports are the following: First, the local deflections of the needle on board of the Roanoke (at the Brooklyn navy yard) were ascertained at nine stations of equal elevation above deck, and a curve of no deviation was located. Some experiments were made as to the height above deck and above turret, at which the local deflection would disappear. At the same deck stations the horizontal magnetic force was measured, also the total force, both in connexion with the same elements at a shore station. The distribution of magnetic polarity on the outer and inner surface of the turrets (gun and steering turrets) was traced out graphically.

The second paper reports on the compasses of the Roanoke compared in two opposite headings of the vessel, additional observations having been made as to the extent in altitude of the local deviations. The heading of the vessel being opposite, a new set of observations of deflections at the deck stations was made, also a re-examination of the polarity of the turrets. The experiments for relative horizontal and total intensity were extended to the ship's cabin, and to the interior of the turrets. The magnetism of armor plates, some in situ, and others in the yard of Mr. Webb, intended for the "Dunderberg," was examined.

The third report treats of experiments and investigations which were made on the "Passaic," similar to those above stated. These include the polarity of the turrets, and of side armor, the horizontal, and total force below and above deck, and within the turret; also the local deflection of the compass together with

notes on the polarity of the plating of the "Monadnock," at the Charlestown navy yard. Some experiments on the polarity of iron were included.

In the fourth report the results are stated of experiments for the local deflection of the compass at various headings of the "Roanoke," when lying in James river, Virginia, in November. By means of a standard azimuth compass mounted on deck, the deviation of which had been determined, simultaneous readings were taken on four other compasses. The deviations of the latter being thus determined were tabulated, and steering tables were made out. These results were also shown graphically. A design for mounting and using compasses on board of turreted iron-clads was also submitted.

EXPERIMENTAL INQUIRIES.

Careful experiments were made in the early part of the present year by Assistant George W. Dean, at the office of the Coast Survey, on two forms of the relay magnets used in long telegraph lines to repeat the signals, which led him to the conclusion that the scientific principles involved in the construction of the instrument had not been sufficiently considered. In one set of instruments the time lost by breaking the circuit ("induction time") varied from 0.02 of a second to 0.06 of a second, while in another the time lost varied from 0.06 to 0.016 of a second. These variations would be encountered in using relay magnets in determinations of differences of longitude. The subject is still under discussion experimentally, by Mr. Dean, who has the kind advice of Professor Henry in the improvement of the construction of the instruments, and the assistance of the best mechanicians who are occupied in such work. Mr. Dean's report on the experiments is given in Appendix No. 23.

The globe lens of Messrs. Harrison and Schnitzer has been found, by trial at the office, well adapted to photographic purposes. A report by the assistant in charge of the office, J. E. Hilgard, esq., on the tests to which it was subjected before its adoption for our use, will be found in the Appendix, No. 24.

SAXTON'S HYDROMETER.

This instrument, intended to replace the ordinary hydrometer in the test of the strength of alcoholic liquids, the importance of which has been very much increased by the new tariff and revenue laws, has been invented by Joseph Saxton, esq., of the Office of Weights and Measures. It is thus described by Professor J. F. Frazer, the chairman of the committee of the National Academy of Sciences, to whom it was referred by the Office of Weights and Measures for examination: "The instrument consists of a glass bulb of a spheroidal form, to which is attached a chain of one hundred links, which are smaller in proportion as they are nearer to the lower end of the chain. For the sake of convenience in reading, each tenth link is of a different form from the others. The instrument is so graduated that, in pure water, at the normal temperature of 60° Fahrenheit, it floats entirely immersed, and carrying suspended its whole chain; whilst in absolute alcohol, at the same temperature, the bulb alone floats, the whole chain lying on the bottom of the vessel. Each link of the chain is made of such weight that the number lying on the bottom in any given mixture of alcohol and water, at the normal temperature, represents the percentage of alcohol in that mixture. Should the liquor be at any other temperature, the ordinary tables will suffice for the reduction of the apparent to the true strength."

The committee, consisting of Professor Frazer, General Totten, Dr. Barnard, and Chancellor Chauvenet, after a close and critical examination of the instrument, recommended its use by the government in place of the alcoholometer now used.

AIDS TO NAVIGATION.

The recommendations of assistants working on various parts of the coast, in regard to buoys, deemed desirable as aids to navigation, will be found in Appendix No. 29. The list contains, in particular, the recommendations of Assistant Edwards for buoys to mark the channels into Carver's harbor, (Penobscot bay,) and those of Lieutenant Commander Phelps for the rock on which the steamer Great Eastern struck in 1862. The recommendations of that officer in regard to the buoys of the Potomac are also given, and those of other assistants in different sections of the coast.

In continuation of the work of last year, the party of Assistant Boutelle set the buoys needed at the entrance of Ossabaw sound, having rendered similar duty at all the principal entrances used by the South Atlantic blockading squadron.

OBITUARY.

Major E. B. Hunt, of the United States engineers, though relieved before the commencement of the

war from service on the Coast Survey, maintained a most active interest in its welfare and progress, and in the subjects embraced by or contributing to its operations. His sudden death was appalling to us, occurring as it did at the very time we were about to call upon him for services which were so much in his line that there was no doubt he would cheerfully have rendered them, had his professional duties permitted. He was occupied, indeed, to the full extent of the capabilities and physical power of an ordinary man, but his great mental activity and bodily strength made it appear as though there was no limit to his power of undertaking congenial work. As an officer of engineers, he had occupations connected with the defence of New Haven, of New London, of the western entrance into Narragansett bay, and of the city of Providence, R. I. As an experimentalist, he was engaged, under the auspices of the Navy Department, in perfecting his sea-miner or submarine projectile, for operations offensive and defensive against vessels in harbor defence.

Major E. B. Hunt was born in Allegany county, New York, in 1822, and entered the Military Academy at West Point in 1841. He graduated first in his class, and was commissioned in the corps of engineers, in which he rose to the rank of major.

The habits of study which belonged to his youth adhered to him in manhood, and the powers of his mind were always kept alive by close reading, and by original researches in mechanical and physical philosophy. General speculations were more congenial to his mind than detailed investigations, and while occupied with manifold professional duties, he was especially at home on the meetings of the American Association for the Advancement of Science, to which he contributed numerous papers. He found a congenial field of operations in the office of the Coast Survey, where he served during three years, (1851—1853,) always eager for improvement, and contributing liberally his ideas towards progress in its various departments. His love of system induced him early to propose an index of the scientific papers published throughout the world, and he had made, when the absorbing duties of the war took him to other fields of labor, considerable progress in a special index for the subjects embraced in this work. The extensive plan matured by the Royal Society at the suggestion of the Smithsonian Institution of the United States, and of the British Association for the Promotion of Science, had rendered this work comparatively of little moment, and I suppose Major Hunt had yielded, though with reluctance, to this necessity of the case. Classification was such a favorite mental occupation with him that he was tolerant of labor which is generally found to be disgusting to men of his mental calibre and success in original investigation. It may truly be said of Major Hunt that he never changed his place or opportunity of observation without producing something on the facts, relations, and causes of things observed. This general habit of investigation won for him the acquaintance of a large circle of scientific men who have shown their appreciation of his mental culture and original thought by the expressions of their profound regret at his decease. The melancholy termination of a distinguished career is thus stated on the authority of Colonel Richard Delafield, of the corps of engineers, by Professor Alexander C. Twining, who attended, as a delegate from the Connecticut Academy of Sciences, the funeral of Major Hunt, at West Point, on the 5th of October, 1863, a few days after he had breathed his last at the New York navy yard.

"Major Hunt was practicing, at a place about five miles below the navy yard at Brooklyn, in experiments upon his new invention for breaking through the armor of iron-plated ships. His gun had just been fired from the upper deck—being itself on the deck beneath. Perceiving an effect that was wrong, Major Hunt passed part way down a ladder into the apartment below, but soon made his way back and lifted his hand for help. The fact appears to have been that the missile had been thrown backward, instead of forward, out of the gun, and the gun-room, from which the experimenter was escaping, had become full of an irrespirable gas from the burning composition. The lifted hand was caught by one of the laborers on deck, but could not be held, and Major Hunt fell into the hold with his face down and immersed in water. He was followed by the laborer, who turned his face upward, but could do no more. Afterwards a fresh hand went down and fastened a rope around the body, but not securely, for in the after lifting, when partly accomplished, Major Hunt slipped through with a second fall. He was not brought up until the gas was dispersed or absorbed by water thrown down. Then he was taken to the navy yard, but in an insensible condition, and surgical aid was obtained not till then, and then in vain."

In Appendix No. 25 will be found a list of the scientific papers published by Major Hunt. A monument of his labor is in the ten-years index of the annual reports of the Coast Survey, published in the volume for 1854. It has not been reserved for him to repeat this onerous task a second time, a task for which he was probably better qualified than any other man living, and which we were about to ask him to undertake when the shock of his death came suddenly upon us.

PART II.

Under the head of Sections, beginning at the northeastern boundary of the United States, and passing from north to south along the Atlantic coast, and in a reverse order on the Pacific, will now be given statements of the work done by each party during the surveying year. The triangulation will generally be noticed first, and in proper order the topography and hydrogaphy, each being, as far as practicable, arranged in the geographical order in which the sections follow each other.

SECTION I.

FROM PASSAMAQUODDY BAY TO POINT JUDITH, INCLUDING THE COASTS OF THE STATES OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND.—(SKETCHES NOS. 1 AND 2.)

The field-work done in this section has occupied sixteen parties during the working season of summer and autumn, viz: three parties in triangulation, six in topographical surveys, and four in hydrography. Two others were employed in determining the magnetic elements, and one in observations on tides and currents. Nearly all of the assistants thus engaged had been in service in the early part of the year in various sections of the Atlantic coast now under blockade. Their transfer from the southern sections will be referred to generally in the separate notices, which follow, of work done in each of the sections of the Atlantic and Gulf coast. The progress made in the survey of the coast of New England will be described in the following order:

1. Triangulation of Letite Passage, completing the preliminary work required in Passamaquoddy bay. The triangulation is now connected from Mount Desert eastward through the bay and into the mouth of the St. Croix river.

2. The triangulation of the coast of Maine, in the vicinity of Blue Hill bay, for connecting with the work noticed above, at Mount Desert.

3. Triangulation of the Penobscot river in connexion with the last, and extending from Castine to stations above Bucksport.

4. Detailed topography of Moose island, (Passamaquoddy bay,) including the vicinity of Eastport, Maine.

5. Plane-table survey of the coast of Maine, east of Frenchman's bay, comprising Winter harbor and Prospect harbor.

6. Topography of the western shore of Penobscot bay above Clam cove, including the harbors of Rockport and Camden.

7. A detailed plane-table survey of the shores of St. George's river from the narrows up to Thomaston. Supplementary triangulation was made for this work, and for extending it southward.

8. The topography of Middle bay and Maquoit bay, west of Harpswell. This work connects with, and essentially completes, the detailed survey of the shores of Casco bay.

9. Shore-line survey of Providence river, Greenwich bay, and Wickford bay, connecting with previous work, and completing the preliminary survey of Narragansett bay, Rhode Island.

10. Off-shore soundings across Jeffrey's ledge, off the coast of New England, and the development of position and depth of numerous detached rocks in the approaches to Portland harbor.

11. Hydrography of the western approach to Penobscot bay, joining with in-shore soundings at Manhegan island, and extending northward and eastward to White Head. Bulwark shoal and the vicinity of Vapor rock, off Portland entrance, were also sounded by this party.

12. Rockland harbor, thoroughly sounded, including its approaches on the western side of Penobscot bay. The same party determined the position for buoys to mark the channels which lead into Carver's harbor, at the entrance of Penobscot bay.

13. The sounding of Maquoit bay and Middle bay, westward of Harpswell, Maine. This work completes the hydrography of the upper part of Casco bay.

14. Determination of the magnetic declination, dip, and intensity at Portland and Bangor, Maine, at five intermediate stations, and at Ivy Hill and Tashua, Connecticut. Magnetic observations have also been made at the station in Eastport, Maine.

15. Observations were made for a special study of the tides and currents of Boston harbor, particularly of the Fort Point channel and South bay. The currents in Martha's Vineyard sound were observed by the same party, and hydrographic developments made in Wareham and Sippican harbors.

16. Tidal observations at Eastport, Maine, and at the Charlestown navy yard, Mass.

Office-work.—The engraving of Portland harbor as a finished chart has been completed; the drawing and engraving of preliminary charts of Dutch Island harbor, Bristol harbor and Coaster's harbor, Narragansett bay, have been completed. Progress has been made in the drawing and engraving of the chart of Kennebec and Sheepscot rivers, Maine; and of coast charts No. 7, Muscongus bay to Portland, Maine; No. 8, Seguin island to Kennebunkport, Maine; No. 10, Cape Ann to Plymouth, Massachusetts, and No. 11, Plymouth to Hyannis, Massachusetts. The engraving of coast chart No. 9, Cape Neddick to Cape Ann, Massachusetts, and of Barnstable harbor, as a finished map, has been continued; the drawing of a chart of Rockland harbor, Maine, has been commenced; additions have been made to preliminary coast chart No. 3, Cape Small Point to Cape Cod, and to the progress sketches of the section; and a new progress sketch, showing the primary triangulation and the connexion of the base lines in Sections I and II, has been drawn and engraved.

Triangulation of Passamaquoddy bay and adjacent coast of Maine.—The secondary triangulation executed this year by the party of Sub-Assistant F. P. Webber, has embraced the Letite Passage and Deer island, and completes that required for the survey of Passamaquoddy bay. On the British side of the northeastern boundary points were determined sufficient to show in connexion the shore and islands of the bay and the adjacent shore of the province of New Brunswick, as far from the coast as St. Andrews.

From the Passamaquoddy entrance Mr. Webber has also completed the secondary triangulation of the coast going southward and westward to Machias, as shown on sketch No. 2, which accompanies this report. The secondary work was kept in connexion with the primary triangulation by taking in the first order stations Howard, Trescott Rock, and Chamcook, and observing on their signals from the stations occupied this season.

The party of Sub-Assistant Webber took up this duty in the middle of June, having the schooner Hassler for transportation. At station Bell, marked on the sketch, a tripod and scaffold signal forty-five feet high was required to connect the points on Machias bay with stations intended to be observed on in Passamaquoddy bay, the country in the intervening region being made up of heavily wooded hills. In passing along the coast, between Trescott Rock and Machias, a tertiary triangulation was made, and points determined for the survey of Little Kennebec river.

At six of the stations occupied by Mr. Webber vertical angles were measured on twelve others, and recorded, with descriptions of the stations observed on. The records in duplicate of the horizontal angles, descriptions of the signals used, notes for identifying the stations, and the computation of results by Sub-Assistant Webber, have been received at the office. The field-work he reports as having been much hindered by the prevalence of fogs.

Beginning at the northeastern boundary of the United States, the secondary triangulation of the coast of Maine is continuous, and complete to the vicinity of Mount Desert island, as may be seen by reference to the progress sketch. The part eastward of Machias, taken up at midsummer, was completed by the 12th of October, when Mr. Webber had carried the work to the mouth of the St. Croix.

The following synopsis comprises the statistics of his work preceding that date.

Signals erected	44
Stations occupied	23
Angles measured	495
Number of observations	2,940

The instruments used were the ten-inch Gambey theodolite, No. 63, and the six-inch Brunner, No. 61. Fifty-four points were determined in position by horizontal angles.

Sub-Assistant Webber in his field report expresses his obligations for the intelligent services of Mr. John Odell, of Eastport, who volunteered as aid for the work in Passamaquoddy bay, and, by his knowledge of the signals used by Assistant Boutelle in laying out the secondary triangulation, rendered effective assistance.

On the 15th of October the schooner Hassler was taken to Portland and laid up.

Triangulation of Blue Hill bay, Maine.—This work was continued by the party of Assistant G. A. Fairfield, after the completion of measurements at the end of July, at station Patterson, (sketch No. 2,) on the west side of the Penobscot, which is in connexion with the triangles carried last season over Isle au Haut bay, and also in connexion with the work laid out for the present season. The party used the schooner James Hall for transportation. Nine signals were erected, ten stations occupied, and one hundred and sixteen angles measured by seventeen hundred and forty-nine observations with the ten-inch theodolite, No. 91.

It will be seen by the progress sketch that the triangulation already done, requisite to define this part of the coast of Maine in outline, and the islands lying off the coast in position, is in full connexion with the primary work.

Assistant Fairfield continued the triangulation in the vicinity of Blue Hill bay until the 10th of October, and then returned the vessel to New York. He had employed the first part of the surveying year in Section IV, in which duty, as also in that on the coast of Maine, he was aided by Mr. Horace Anderson.

This party rendered effective assistance to Captain Casey, of the Engineer department, as did several others in the section. Their services in furnishing information connected with the question of defences at Belfast and Eastport have been highly commended by the chief engineer.

Triangulation of Penobscot river, Maine.—Assistant S. C. McCorkle took up this work on the 23d of July, with a party in the schooner Torrey, starting at the line "Patterson—Castine," shown on the progress sketch No. 2. He had previously erected some of the signals necessary, and in the course of the season, which terminated on the 12th of October, set up fourteen in all, of which nine were tripod signals. These, as will be seen by the sketch, extend the triangulation of the Penobscot river as far up as North Bucksport. The stations have been selected for continuing the preliminary work to Bangor. Of the work of the present season the following are statistics:

Signals erected	14
Stations occupied	13
Angles measured	289
Number of observations	3,968

The horizontal angles were measured with the Gambey theodolites, ten-inch, No. 74, and six-inch, No. 29.

The present working season, as reported by Assistant McCorkle and others engaged on the coast of Maine, was more than usually unfavorable. After discharging his party, Mr. McCorkle laid up his vessel at Portland.

In referring to the aid given by this party and others, in detailed information respecting sites at Belfast and Eastport, for works of defence, Captain Casey remarks: "Their instrumental observations, and the maps furnished me by them, were of great value in furthering the wishes of the government, for the establishment of field works at these places." This acknowledgment was transmitted to me through the office of the chief engineer.

Topography of Passamaquoddy bay, Me.—The progress made in the plane-table survey of Passamaquoddy bay, up to the present time, is shown on sketch No. 2. Most of the outline work was done in the two previous seasons. In the field-work of this year, Sub-Assistant W. H. Dennis commenced on the 1st of July, and ran the low-water line of the vicinity of Eastport harbor. He then filled in the details of topography on Moose island, and completed the plane-table survey of the town of Eastport. The town of Lubec was also surveyed, and is shown on the sheet which contains the topography of Moose island. The detailed work was continued until the 15th of October. Mr. R. H. Talcott was attached to this party, and aided in the plane-table survey. The statistics are as follows:

Shore-line traced	13 miles.
Roads	33 "
Area of topography, (square miles)	7½

In the course of the season Mr. Dennis rendered service to the Engineer department by information which was found useful by Captain T. L. Casey, in locating defensive works. He also assisted in laying the works out after the sites were selected. This and similar service rendered by other assistants in this section has been acknowledged in communications addressed to me from the office of the chief engineer.

The occupation of the party of Sub-Assistant Dennis, during the first half of the surveying year, will be stated under the head of Section V.

Topography of Winter harbor and adjacent coast of Me.—The plane-table survey east of Frenchman's bay, Maine, was resumed by Sub-Assistant Cleveland Rockwell on the 9th of September. His party had

been organized for this work early in the summer, but was soon after disbanded in consequence of the emergency for the services of Mr. Rockwell near Philadelphia, where he was engaged until the 18th of August. The schooner Caswell was then without delay fitted and sent to Winter harbor, (sketch No. 2,) to complete the plane-table survey, and extend the coast topography eastward. Mr. Rockwell completed the survey of the harbor and that of Schoodic Point, and the islands in its vicinity, by the 8th of October, running ten miles of shore-line, and filling in with details an aggregate of four square miles of area. He was then reassigned to duty in the military department of Virginia and North Carolina, where he had been in service during the early part of the year. At the request of Major General Foster he is now engaged in topographical duty with the army corps in Tennessee. The previous service of Sub-Assistant Rockwell will be stated under the head of Section IV.

Topography of Camden harbor and Rockport harbor, Me.—The plane-table survey of the western side of Penobscot bay was resumed by Sub-Assistant F. W. Dorr, on the 1st of July, at Clam cove, to which point the detailed topography of that side of the bay had been carried in previous seasons by Sub-Assistant Ferguson. The following is an extract from the report of Mr. Dorr, who continued the survey until the 1st of October:

"From Clam cove the topography was extended northward to a point about two miles north of Camden harbor, and was carried back from the shore of Penobscot bay, an average distance of a mile and a half. Many of the prominent elevations, as Beach Hill, Mount Beattie, and Mount Megunticook were thus included, ranging in height from five hundred to fourteen hundred feet; also, the villages of Rockport and Camden, with their approaches.

"The shore-line, which includes the small harbors of Rockport and Camden, is much broken, and mostly rocky and bold. There are many ledges lying off the shore at distances varying from a few hundred yards to as much as a mile. Most of these are visible only at low water. They have been carefully determined in position and marked on the topographical sheet."

Sub-Assistant Dorr was aided in field duty by Mr. J. F. McCabe. A summary of the plane-table statistics is here given:

Shore-line traced	16½ miles.
Roads surveyed	48 "
Area of topography, (square miles)	13½

The locality of the work is shown on sketch No. 2.

Under another head in this report reference will be made to the previous duty of Sub-Assistant Dorr. He is now at Chattanooga, Tennessee, engaged in topographical service for the use of the army under Major General Grant. The sheet of work done in this section is now at the office.

Triangulation and topography of St. George's river, Me.—For the plane-table survey of this river, which is in continuation of his work of last year, Sub-Assistant Charles Ferguson determined additional points by a triangulation from the entrance as far up as Thomaston. Field operations were commenced on the 12th of June with a party in the schooner Bowditch, and on the basis of the triangulation the topography was taken up on the 24th, in the vicinity of Thomaston. From thence down the river the shore-lines were traced to the Narrows, (see sketch No. 2,) and a detailed survey was made, extending about a mile back from either bank of the river. The contour of hills within that limit are embraced amongst other natural features on the sheet, as are also the several indentations or coves between the Narrows and Thomaston, the river being at some points a mile and a half wide, and at others quite narrow. The two main roads which pass, one on the east, and the other on the west side of the St. George's below the town, were each traced about eight miles, and are included on the plane-table sheet. It has marked on it also the positions of the buoys which define the channel above the Narrows. Mr. Ferguson continued the topographical survey until the 25th of September. He then occupied additional stations below the Narrows for the survey of the entrance of the St. George's, and was so employed until the 12th of October, when he discharged his party for the season. The statistics of the field-work are as follows:

Shore-line surveyed	37 miles.
Roads	34 "
Area of topography, (square miles)	12¾

The village of Thomaston was surveyed, and is represented on the topographical sheet which has been inked by Sub-Assistant Ferguson and turned in at the office.

Mr. Ferguson had been previously employed in plane-table duty in Section III.

Topography of Maquoit bay and Middle bay, near Harpswell, Me.—In continuation of the plane-table survey of the upper shores of Casco bay, Assistant A. W. Longfellow took up the work on the 15th of July with a party in the schooner Meredith, at Little Flying Point. Thence on towards the northward and eastward, he extended the detailed survey until the middle of October, when he had included the shores of Maquoit and Middle bays, (sketch No. 2,) the small peninsula between them, the islands in Middle bay, the principal of which are White's and Birch island, and a part of Harpswell Neck. The roads communicating with the interior, immediately adjacent to the shores, are also included on the plane-table sheet. Tracings of shore-line and points were furnished from this work to the hydrographic party of Assistant Gerdes, and the shore-line was run in advance to facilitate progress in the soundings. The statistics of the topography are as follows:

Shore-line surveyed	42 miles.
Roads	22 "
Area of detailed topography, (square miles)	8

At the close of the working season of last year Assistant Longfellow took charge of the vessels used by parties in this section, and had them properly laid up for the winter at Portland. Before taking the field in July he attended to their repairs, and as called for, turned them over to the parties to which they were assigned for the field-work of the present season. The schooner Meredith, used by his party, is now laid up at Portland.

During March, April, May, and June, of the present year, Mr. Longfellow kept records of the temperature of the air, and also of the water of Portland harbor, at depths of three, six, nine, and twelve feet, recording mostly at high water. Three observations were made daily, including readings for the specific gravity of the water.

Plane-table survey of Narragansett bay, R. I.—The preliminary survey of Narragansett bay has been completed by the party of Assistant A. M. Harrison. The work done this season comprises Providence river up to the city of Providence, and the shores of Greenwich and Wickford bays. For the shore-line survey, Mr. Harrison laid out and measured a triangulation taking in the greater part of the ground which was to be passed over by the plane-table party. Sketch No. 1 shows the limits of the work done in the present year. The party began their work on the 29th of June with the schooner M. L. Stevens, and closed on the 15th of October.

Sub-Assistant Charles Hosmer and Mr. H. W. Bache were attached to the plane-table party. Mr. Hosmer, who had been previously employed in Sections VIII and IX, was reassigned in the latter part of September to duty for the army of Major General Banks.

Assistant Harrison had in the early part of the season made detailed surveys for engineering purposes on the Potomac. He is now employed in inking the sheets of his survey of Narragansett bay. Mr. Bache has been assigned to field service in Section II. On closing the work in Narragansett bay, the vessel used by this party was laid up at New York.

In his triangulation, Mr. Harrison occupied nineteen stations, and determined eighteen points by the measurement of eight hundred and thirty-two angles. The topographical statistics are as follows:

Shore-line surveyed	81
Creeks and ponds	7
Roads	13
Area of topography, (square miles)	5

The shore-line from Narragansett ferry to Wickford bay was furnished for the use of the Engineer department at the request of the late Major E. B. Hunt.

Hydrography of Jeffrey's ledge.—The more than usually unfavorable weather in this section prevented the completion of work on the various ledges off the coast of New England by the party of Lieutenant Commander T. S. Phelps, U. S. N., Assistant Coast Survey, in the steamer Corwin. He was able, however, during a few days of August and September, to make soundings at the north and south ends of Jeffrey's ledge, and to run a line with soundings between the two localities. The depth found on the ledge, which seems to be a prolongation of Cape Ann, varied between twenty-two and thirty-three fathoms. Lieutenant Commander Phelps reports that the tide sets strong over it both at flood and ebb, the former to the northward and eastward, and the latter to the southward and westward, though varied somewhat in direction by the wind.

The following are the statistics of this work:

Miles run in sounding	276
Number of soundings	408

Hydrography of the approaches to Penobscot bay, Maine.—The in-shore soundings along the coast of this section have been extended from Manhegan island northward and eastward, so as to include the western approach of Penobscot bay, as far in as White Head light. Acting-Assistant Edward Cordell resumed work on the 16th of June, joining near Manhegan island with the hydrography of the approaches to Muscongus bay, which had been executed in a former season by Lieutenant Commander Phelps. The space included in this season's work stretches about fifteen miles along shore, with an average breadth of nearly nine miles. The deepest water sounded (58 fathoms) was found in the vicinity of Manhegan island. Sketch No. 2 shows the progress made by the party of Mr. Cordell with the steamer Vixen. Two miles west of the north end of Metinic island the soundings developed a ledge having only eleven feet on it at mean low water. This ledge is reported by Mr. Cordell as being very little known, though several vessels have struck on it in beating in and out of Penobscot bay. Other ledges outside and to the southward of the channel were developed in the course of the working season, and are shown on the hydrographic sheet. In connexion with the soundings, tides were observed in Herring Gut harbor day and night for a period of seven weeks, the work of the party being closed on the 5th of August. The statistics are as follows:

Miles run in sounding	853
Angles measured	3,787
Number of soundings	5,974
Area of hydrography, (square miles)	134

The steamer Vixen having been on duty previously in Section VI, and much in need of repairs, returned to New York and was there refitted.

The chart of work done at the entrance of Penobscot bay has been plotted, and is now in the office, with the records of soundings, angles, and tidal observations.

Messrs. L. A. Sengteller, H. M. DeWees, and Gershom Bradford served as aids in the hydrographic party. The first-named aid is now in service at Charleston bar, South Carolina, with the party of Assistant Edwards, and the second with Sub-Assistant Bradford in Section IV.

Hydrography of Rockland harbor, Me.—This work was taken up on the 3d of July, and was completed at the end of August by Assistant W. S. Edwards, with a party in the schooner Arago. The topography of the shores of the harbor having been executed previously, the engraved chart of the vicinity, in preliminary form, is given with this report, (sketch No. 3.) Its position with reference to the waters of Penobscot bay is shown on sketch No. 2. Mr. Edwards was aided in this duty by Mr. F. H. Dietz, and was joined before its close by Messrs. Persifer Frazer, jr., and H. G. Ogden.

The following is a summary of the statistics of work:

Miles run in sounding	199
Angles measured	2,266
Number of soundings	9,188

The party erected and observed on fifteen signals in prosecuting the hydrography, and kept a record of the rise and fall of the tide as usual.

On the night of the 24th of August Assistant Edwards was applied to by the authorities of the town of Rockport to assist in preventing a popular outbreak, which was apprehended by them as imminent. He moved up immediately with the Arago, and placed himself and party at the disposal of the mayor, but fortunately no occasion arose for further proceedings.

The original hydrographic sheet, containing the soundings made in the vicinity of Rockland, has been filed in the office, with the records pertaining to the work.

The aids of the party and the schooner Arago were transferred to Section II in September. Assistant Edwards completed arrangements before the close of that month and returned to Section V, where he had been engaged during the first half of the surveying year. His services in furthering the interests of the Engineer department by furnishing information to Captain Casey respecting the sites for defensive works near Rockland, have been officially acknowledged.

Hydrographic examination of the approaches to Carver's harbor, (Penobscot bay,) Me.—The party of Assistant Edwards being at Rockland in the middle of July, attention was called by the Hon. Samuel C. Fessenden to the large general interest that would be served if positions were indicated suitable for buoys to mark

the approaches to Carver's harbor. Of the very large number of vessels that pass through the channels, three hundred are employed in carrying granite under government contracts. I at once issued instructions to Mr. Edwards, and the needful examination was made without delay. Twelve positions were selected by him, and the particulars concerning them communicated in his report, a copy of which was transmitted to the chairman of the Light-house Board in September, together with recommendation that buoys be placed in the several positions assigned. A list of the aids to navigation thus recommended is comprised in Appendix No. 29.

Assistant Edwards was accompanied in this service by Captain J. K. Thomas, of Rockland, Maine, by whose intimate knowledge of the locality and effective co-operation the work was greatly furthered. The position of the harbor, being an indentation of one of the islands which lie between Isle au Haut and Owl's Head, at the entrance of Penobscot bay, is shown on Sketch No. 2.

Hydrographic developments in the approaches to Portland harbor.—Special examinations made this season by Lieutenant Commander Phelps, with a party in the steamer Corwin, and by Acting-Assistant Cordell, have developed a number of rocks and ledges, the existence of which has been generally but little known, though most of them lie near the direct approaches to Portland harbor. Of these, the first one examined was "Old Anthony," near which a second rock was supposed to exist called "Vapor Rock." Separate searches made by the two parties show that the two names in use should properly apply to the same rock. It has, therefore, been marked on the engraved chart of the entrance to Portland harbor "*Old Anthony or Vapor Rock*," being locally well known by the name now appended. The least depth on it is twenty feet at mean low water.

About a mile to the southward and eastward of Vapor Rock, Lieutenant Commander Phelps developed the *Western Hue-and-Cry*, finding on it twenty-seven feet at mean low water.

To the northward and eastward, and about two miles from the last mentioned, *Corwin Rock* was developed in position and depth, (twenty-four and a half feet at mean low water,) and named after the steamer which carried the hydrographic party. About a mile further in the same direction Lieutenant Commander Phelps sounded across *West Cod Ledge*, finding in one place thirty-three feet of water. In a subsequent examination as little as twenty-six feet was found. *Bulwark Shoal*, lying further out, but in the same course, was thoroughly sounded by Mr. Cordell, who reports fourteen feet at mean low water as the least depth. This return is confirmed by the lines incidentally run by Lieutenant Commander Phelps while verifying former soundings in that vicinity.

Nearer to Portland entrance, and not more than a mile and a half eastward from Portland light, Lieutenant Commander Phelps determined in position *Witch Rock*, with only twenty-four feet, and to the southward and westward of it *Pine Tree Ledge*, with as little as twenty-one feet, and *Willard's Rock*, with thirty-one and a half feet at mean low water. These recent developments have all been included on the engraved chart. The particulars concerning them, as to bearing and distance from points well known, were published collectively in a Notice to Mariners in September. Pine Tree Ledge, having been sounded subsequently, was named in a separate notice. The bearings from the other are given in Appendix No. 5. In making these several developments eight hundred and twenty-nine angles were measured, and two thousand three hundred and twenty casts made with the lead.

In subsequent examinations made in the middle of October, *Mitchel's Rock* was developed off Cape Elizabeth, and a depth found of thirty-one feet; also *East Cod Ledge*, with a depth of forty-five feet at mean low tide. The sea breaks on this ledge during heavy gales. In running in the vicinity of *Corwin Rock*, at the same time, Lieutenant Commander Phelps found and reported in reference to a sharp point on which there was as little as twenty-one feet. *Round Rock*, a little to the eastward of Bulwark Shoal, was found to have twenty-nine feet of water, and a rock midway between that shoal and West Cod Ledge as little as twenty-five feet.

Hydrography of Casco bay, Me.—The soundings made this year by the party of Assistant F. H Gerdes in Maquoit bay and Middle bay, (see Sketch No. 2,) complete the hydrography required for the finished chart of Casco bay. As already mentioned, under the head of topography, the necessary shore-line was run and furnished by Assistant Longfellow.

Assistant Gerdes resumed duty afloat on the 1st of July with the schooner G. M. Bache, and returned to New York in the latter part of September. Sub-Assistant C. T. Iardella was attached to his party. Sub-Assistant Fendall, who had been on field duty, which will be stated under the head of Section VIII, joined the party in August, and assisted during the remainder of the season. Mr. T. C. Bowie served as aid, having been previously employed in Section III. The soundings made this year, as will be seen by the

sketch, complete the hydrography which was outstanding on the western side of Harpswell Neck. The statistics are as follows:

Miles run in sounding	175
Angles measured	1,576
Number of casts of the lead	11,653

During August the tides were observed daily at two temporary stations. At another station consecutive observations were made for seven days to determine the plane of reference for the soundings. Bad weather and prevailing fogs hindered the work of this as of other parties on the coast of Maine.

The sheet containing the results of soundings in Middle bay and Maquoit bay has been inked, and is now at the office with the records which pertain to it, of angles and soundings.

Assistant Gerdes and Sub-Assistant Fendall are preparing to resume duty on the Mississippi, in continuation of the service which was done last year in Section VIII. The last named passed the greater part of the month of October in surveying duty for the army near Chattanooga, but early in November again rejoined Admiral Porter.

Magnetic observations.—In continuation of the series of determinations commenced several years ago, Assistant C. A. Schott was temporarily detached from the charge of the computing division of the office, and occupied several stations on the coast of Maine in the month of July. At Portland two stations were occupied, one near the observatory, and the other on Bramhall's Hill, the declination, dip, and magnetic intensity being determined at both. Proceeding eastward, the three elements were in like manner ascertained at Harpswell and Freeport, on Casco bay, at Bath, on the Kennebec, and at Rockland and Belfast, on the Penobscot. The magnetic dip and intensity were determined also on Thomas's Hill, at Bangor, which had been occupied by my party in the course of the primary triangulation in 1857.

For his observations Mr. Schott used the magnetometer No. 3 and the Barrow dip circle No. 8. Time was recorded on the Hutton chronometer No. 211. The astronomical azimuth was determined by observations upon the sun.

Mr. E. H. Courtenay accompanied Assistant Schott as aid, and recorded the observations. The results are given in tabular form in Appendix No. 22.

At Eastport, Maine, the series has been kept up regularly of observations during four days about the middle of each month of the year. As during the three years preceding, the observations have been recorded half-hourly for the three magnetic elements. The station at Eastport has been in charge of Assistant Edward Goodfellow during the entire surveying year. Similar observations are made at Key West, Florida.

Physical survey of Boston harbor.—In August and September Assistant Henry Mitchell carried forward the physical examination of Boston harbor, under the direction of the United States commissioners, but at the expense of the city government of Boston. He also made similar examinations in South bay and its approaches, the expenses of which were met by the commissioners on harbors of the State of Massachusetts. The results of these investigations will appear in the reports of the United States commissioners.

Assistant Mitchell was aided in the work at Boston by Messrs. C. P. Dillaway, A. M. Wetherill, and J. W. Brown. Mr. H. W. Longfellow, who had formerly aided in this party, resigned on the 5th of June.

Currents of Vineyard sound, Mass.—The hydrographic party of Assistant Mitchell, after the completion of duty in Section II, made some special current observations in Martha's Vineyard sound for the purpose of ascertaining the curve of velocities for tidal currents at different depths. This locality was chosen on account of its strong tidal drifts and absence of river outflows.

Mr. Mitchell reports that he found a uniform motion at all depths to ten fathoms, a result quite in contrast with those obtained in harbors and rivers. The value of such experiments is great, for it enables us more easily to distinguish among the complications in New York harbor and elsewhere the comparative parts taken by the river and the tidal currents in bringing about the observed hydrographic changes.

Hydrography of Sippican harbor, (Buzzard's bay, Mass.)—The harbor of Sippican and its approaches were sounded in the latter part of October by the party in the schooner Dana. In the approaches from Buzzard's bay several dangerous rocks and ledges were carefully developed, and some of more or less importance in Sippican harbor. The statistics of the hydrography are as follows:

Miles run	146½
Angles measured	2,177
Casts of the lead	10,356

Messrs. Dillaway, Wetherill and Brown aided Mr. Mitchell in duty afloat.

Tidal observations.—The series of tidal and magnetic observations at Eastport, Maine, was kept up by Mr. R. H. Talcott until November, 1862, when he was assigned to field duty with a surveying party on the coast of Georgia. Assistant Edward Goodfellow has had charge of the station during the year just past.

At the Charlestown navy yard, Massachusetts, Mr. T. E. Ready has continued an unbroken series of observations on the tides with an ordinary box-gauge.

Meteorological observations have been recorded regularly at both of the permanent stations in New England.

SECTION II.

FROM POINT JUDITH TO CAPE HENLOPEN, INCLUDING THE COAST OF THE STATES OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND PART OF DELAWARE.

The following work has been executed in this section:

1. The primary triangulation has been extended from the Epping base, in Section I, to Long Island sound, by observations at Ivy Hill and Tashua, in Connecticut, for connecting that base with the one on Fire island.

2. Triangulation has been made in extension of that on the eastern side of the Hudson river, and a connexion across to the primary work has been effected.

3. Verification work has been done at stations on the coast of New Jersey in the vicinity of Shark river and Manasquam inlet. The same party has also commenced a triangulation of Absecum inlet for the plane-table resurvey.

4. Examination of the shore-lines of New Haven harbor, Connecticut, for comparison with the engraved chart of 1846. The comparison shows that no material changes have taken place in the natural features of the harbor shores.

5. Plane-table resurvey of Sandy Hook, for comparison, and to determine the progress and cause of the alterations there going on.

6. Surveys of sites, contour of ground, and general reconnaissance under the direction of the superintendent, as chief engineer, have been made for the military defences of Philadelphia.

7. The position and general dimensions of the ledge upon which the steamer Great Eastern struck in 1862, and the depth of water upon it, have been determined.

The same hydrographic party resurveyed part of the main channel of New York harbor to determine a question which had been referred by the pilot commissioners.

8. Completion of the hydrography of Hudson river by soundings between Coxsackie and New Baltimore and between Albany and Troy. The shore-line of the river was traced within the same limits. This work suffices for the issue of a chart of the entire river from New York to Troy, in preliminary form. The detailed topography of the shores of the Hudson from below was advanced last year as far up as Croton river, on the eastern side, and to a point nearly opposite to Tarrytown, on the western side.

9. Examination of tides and currents at the entrance of New York bay, with reference to their effect in changing the shore-line and hydrography of the vicinity of Sandy Hook.

10. Plane-table survey of part of League island, (Delaware river,) and soundings in its vicinity, for the Navy Department.

11. Hydrographic examination of the vicinity of the Delaware breakwater. This work was for the Engineer department, and to determine the extent and nature of the changes which have taken place in that locality.

12. Tidal observations continued in New York harbor.

OFFICE-WORK.—Sheet No. II, of a general chart of the Atlantic coast of the United States, scale 1: 1,200,000, from Nantucket to Cape Hatteras, has been drawn and engraved; the engraving of outlines and hydrography of coast chart No. 21, New York bay and harbor, (resurvey,) has been completed, and that of the topography of the same has been commenced; the drawing and engraving of Hudson river, sheet No. 2, Haverstraw to Poughkeepsie, and No. 3, Poughkeepsie to Glasco, in a preliminary form, have been completed; that of Hudson river, No. 1, New York to Haverstraw, as a finished map, has been continued; a hydrographic sketch of Phelps's ledge and Great Eastern Rock, off Montauk Point, has been engraved, and additions have been made to the progress sketches of the section.

Geodetic observations at Ivy Hill and Tashua Hill, Conn.—The party under my immediate direction for the work of this year was organized early in June. In extending the primary triangulations southward towards Fire island, for connecting the primary base line there with the one measured on Epping Plains, in Section I, Ivy Hill, in Litchfield county, Connecticut, was occupied. The preliminary arrangements, such as the erection of signals to be observed on from that station, and posting the heliotropers, were executed by Assistant G. W. Dean and Sub-Assistant R. E. Halter. Mr. Thomas McDonnell, as heretofore, attended to the transportation of the instruments and to the preparation required for the use of the geodetic party.

Assistant Dean, on the 19th of June, adjusted the thirty-inch theodolite in position on Ivy Hill, and commenced measuring the horizontal angles to join that station with those which had been previously occupied.

A few days after personally joining my party, I was summoned by telegraph to Philadelphia to assist in the defence of that city against the apprehended approach of an invading rebel army, which was then crossing the southern border of the State of Pennsylvania. Having previously tendered my services to the authorities of the State, their call was at once responded to, after obtaining the authority of the department. Sub-Assistant Halter was recalled from the station to join me for service at Philadelphia on the 28th, and remained on duty there until the 7th of August, when he reported to Assistant Dean, at Ivy Hill. The measurement of horizontal angles at Ivy station was completed on the 14th of August. Four primary and five secondary signals were observed on, and eight hundred and twenty-five observations were recorded. The vertical angles requisite for determining the heights of six of the outlying stations were measured and recorded by Sub-Assistant Halter and Mr. S. H. Lyman. Three hundred and seventy-five measurements were made with the eight-inch Gambey vertical circle No. 57.

While my party was on duty at this station arrangements were made for observing and recording the phenomena of meteors in the early part of August, and more especially on the evenings of the 8th, 9th, and 10th of that month. This was designed to be in co-operation with a series of observations suggested by Professor H. A. Newton, of Yale College, himself and other observers intending to record the same phenomena at New Haven and Hartford, Connecticut. A few meteors were seen between passing clouds from Ivy station, and recorded on the night of the 10th, but not satisfactorily. Clouds with rain prevented observations on the previous evenings.

On the 15th of August the instruments and equipments of the geodoetic party were transferred to Tashua Hill, in Fairfield county, and after the needful preparation and adjustment, Assistant Dean commenced observing there on the 1st of September, at which date I rejoined the party. The observations were made, as heretofore, with the thirty-inch theodolite. By the 1st of October seven hundred and fifty observations of horizontal angles were made, four primary and two secondary signals being observed on. For ascertaining the heights of stations connected in this work with Tashua, three hundred and fifty measurements of vertical angles were made by Mr. Halter.

In this season's work the most distant signal observed upon was fifty-three miles from the theodolite station. Five of the lines of the triangulation were between thirty and forty miles in length.

The position of the trigonometrical station on Tashua Hill, being favorable for determining its height above the sea with the levelling instrument and target, a line was run by Sub-Assistant J. A. Sullivan, starting at the station and terminating at bench-marks at Bridgeport, and on the light-house at Black Rock. He repeated the observations in returning to Tashua, and recorded one thousand and seventy-six measurements with the instrument, the two lines making an aggregate of about twenty-five miles. At Bridgeport a tide staff was set up by Mr. McDonnell, and arrangements made for the requisite number of tidal observations. The zero of the staff graduation was referred to the bench-mark established by Mr. Sullivan, and the mean level of the sea was ascertained from one hundred and fifty readings of the tide staff, near the times of high and low water during seven days. A preliminary reduction of the tidal and level observations gives for the height of Tashua Hill geodetic station six hundred and eight feet above the mean level of Long Island sound.

The geodetic records were kept in duplicate as the field-work advanced, and the volumes containing them are now in the office.

Sketch No. 1, accompanying this report, shows the scheme of primary triangulation for connecting the Epping base with the base on Fire island, in Section II.

Magnetic observations at Ivy Hill and Tashua, Conn.—While the geodetic work was in progress at Ivy Hill, Assistant Dean made experimental observations with the dip-circle, and finding no unusual local attraction, selected a station near the summit for the customary series, to determine the magnetic declination, dip, and intensity. The first-named element was ascertained from one hundred and forty-six readings of the

magnet scale on three days, with the declinometer No. 1. The horizontal intensity of the bar, and moment of inertia, were determined from three sets of vibration and deflection. For the dip, four complete series were observed with dip-circle No. 4, three days being given to the determination of each of the elements.

At Tashua, the foot of the western slope of the hill appearing most favorable, the observations were made at a spot about one hundred and twenty-five feet below the summit, and about a quarter of a mile from the geodetic station. Mr. Dean determined the declination by one hundred and ninety-six readings on four days, and the dip and horizontal intensity in the usual way, employing two days in the series. The results deduced from the observations made at Ivy Hill and Tashua are stated in Appendix No. 22.

Mr. Lyman aided in the magnetic observations, and made the computation of results.

As before intimated, pressing official duties separated me from my party during part of the present season. Its operations, however, were efficiently conducted in my absence, by Assistant Dean, and were closed at Tashua on the 26th of October.

Meteorological observations.—The meteorological journals were kept at Ivy Hill and Tashua by Mr. F. W. Perkins, who also served as geodetic recorder. The aggregate of entries for readings of the barometer, and for temperature by the wet and dry bulb thermometers, was six hundred and thirty. The direction and force of the wind were recorded as usual.

Triangulation eastward of Hudson river.—The triangulation laid out by Assistant Edmund Blunt, to extend along the east side of the Hudson, has been continued to the southwestern corner of the boundaries of Massachusetts, and kept in connexion with the preliminary work done in passing up the Hudson. In the latter part of the season, Mr. Blunt joined his work with stations which had been occupied by my own party in this section, for which the observations necessary at Tashua station were made by Assistant Dean. This triangulation joins with the primary work on the line Tashua—Wooster, (see Sketch No. 1,) the connexion being at Good Hill.

Assistant Blunt took up field-work on the 6th of June, and will probably continue the triangulation until the end of November.

Sub-Assistant A. T. Mosman has been attached to his party throughout, and Sub-Assistant J. A. Sullivan since the 5th of October.

The following are statistics of the triangulation:

Stations occupied	12
Stations observed on (with signals)	23
Angles measured	127
Number of observations	8,158

The area comprised in this triangulation is about five hundred and eighty-one square miles.

Triangulation of the coast of New Jersey.—In his reconnaissance of September, 1862, Assistant John Farley reached the vicinity of Squam village, having revised the triangulation of the coast southwards from Sandy Hook in the previous season, and brought his measurements to stations in the neighborhood of Shark river. The work was resumed early in July, and that and the following month passed in efforts to connect the stations near Shark river with others at the head of Barnegat sound. This has proved to be a matter of much difficulty, the direction of the lines being shut in by forests or other obstacles to sight. In extending the triangulation about Shark river, southward to Squam village, Mr. Farley occupied nine stations, and recorded about thirteen hundred observations with the theodolite. In the vicinity of Squam Mr. Farley found two of the stations which had been used in 1839, and made some observations in September for connecting them with the stations which he had occupied in the earlier part of the season. These it is expected will materially facilitate the revision work in passing through Barnegat bay.

Examination of shore-line in New Haven harbor, Conn.—A few days before his death, the late and much lamented Major E. B. Hunt, of the corps of engineers, who had just fixed his residence at New Haven, and whose interest in the progress of the coast survey had been unremitting, notwithstanding his detachment from the work, suggested the expediency of comparing the present shore-line of that harbor with the outline shown by the engraved chart of 1846. I at once detailed Sub-Assistant Halter, who was then on duty in my party, to make the examination. He visited the harbor on the 1st of October, and reported very few other than artificial changes as being noticeable on the western shore. Near the mouth of West river, where the ground is of alluvial character, the alterations were more preceptible, but were thought to be due in part to the effect of the causeway built there since the survey was made. Slight changes were noticed also at Sandy Point.

The eastern shore of the harbor was found unchanged, except by the addition of wharves, houses, and other adjuncts of the increase of population since the year 1837.

Having completed this duty Mr. Halter rejoined my party, and remained with it until the close of the season. He is now preparing for active service in the waters of North Carolina.

Resurvey of Sandy Hook.—During the past three years the point of Sandy Hook has been rapidly extending, and the east and west shores suffering encroachments from the ocean. In order to ascertain the character of these changes, Assistant Henry Mitchell was instructed in November, 1862, to make a preliminary examination. This was done promptly, and the account furnished convinced me that resurveys were necessary to ascertain the extent of the alterations.

Assistant H. L. Whiting made a new topographical survey of the Hook in November and December, and promptly forwarded the sheet to the office. He was assisted in the field by Sub-Assistant F. P. Webber and Mr. J. W. Donn. The scale of the survey was such as to admit of ready comparison with sheets of the former surveys.

Assistant Mitchell, with a party in the schooner Dana, executed the hydrographic resurvey in June and July, and at once plotted and sent the new chart to the office. The following are statistics of this work:

Miles run in sounding	89
Angles measured	1,447
Number of soundings	6,263

Messrs. C. P. Dillaway, A. M. Wetherill, and J. W. Brown served as aids in the hydrographic party.

Currents of New York harbor.—I have referred in former reports to a northwardly sub-current underrunning the tidal drifts at and above the Narrows, discovered while the survey of the harbor was in progress for the Commissioners on Harbor Encroachments, and allude to the subject now to mention a further development of the causes of this singular phenomenon. In a letter received from Assistant Mitchell, he states that the occasion of his passage to and from Peekskill for arrangements connected with his vessel and party was improved to make some experiments on the specific gravity of different strata of water, in the hope of finding a clue for explaining the observed fact. The aids of the party made trials of the water from point to point in the Hudson, both in the spring and in the autumn of the present year.

In the spring the water was found to be fresh at the surface, even as low down as the Battery; but, near the mouth of the river, the lower water stratum was found to be salt. In the autumn, the river at all depths was found to be somewhat salt as high up as Yonkers, and to increase in density with the depth. From inquiries, it was ascertained that in the fall of the year salt water had been known to extend as high up as Poughkeepsie.

The probable inference from these facts is that during the wet season the fresh-water rise causes the expulsion of sea-water from the river, but that during the summer, the *head* of the river becoming much reduced, the denser sea-water flows up along the bed of the stream, displacing the fresh water. The levelling by Assistant Mitchell from the city of New York to Albany, in 1857, shows that the bed of the river lies below the level of the sea, and that the half tidal surface of the stream had but about three feet fall between the two cities. It may be seen, then, that the contrast of densities, taken in connexion with the variable fresh-water head, renders the theory plausible that the lower part of the Hudson may be alternately a river and an arm of the sea. That the sea-water may underrun the fresh water when the vertical column of the former is equal to or greater than the latter, is not only admissible in theory, but is confirmed by observations made in several localities where movements of this kind actually go on. Mr. Mitchell attributes the northwardly subcurrent which he has observed during the *dry season* of the year, to the advance of the sea in order to occupy the bed of the river.

As our experience gains, the causes of physical change in New York harbor are gradually revealed; but I deem it prudent to await the development of investigations in other harbors now under inspection, before attempting to make any final deductions.

An inquiry growing out of a trial for murder committed at Brooklyn, Long Island, in October, 1861, and which involved the question of set of current and the state of the tide at a certain hour of the night on which the crime was perpetrated, was referred to me in March last by S. D. Morris, esq., district attorney for Kings county, New York, while the trial was pending. The conviction which followed was strengthened in the mind of the prosecuting attorney by the facts furnished from the office record, and his acknowledgment states explicitly that they materially aided in the course of justice.

Defensive works and surveys near Philadelphia.—In anticipation of the movement of the rebel forces into Pennsylvania in June last, I offered my services on the 16th of that month to the governor of the State and to the mayor of Philadelphia, through Benjamin Gerhard, esq., with the consent of the Secretary of the Treasury. After the receipt of a telegram from Major General N. J. T. Dana, in the following terms: "I am advised by some of your friends here of your offer to make a reconnaissance for the construction of defensive works at this place. We have no engineer, and your aid would be invaluable if you are still able to renew your kind offer and could come at once, with such of your corps as you can bring," I proceeded to Philadelphia without delay, reaching that city on the 27th of June.

Assistant George Davidson, who had volunteered for the service, was directed to make a reconnaissance of the environs for military purposes, to embrace the northern approaches of the city.

The site of Fort Dana having been approved, its construction was begun on the 2d of July by a party of sixty men, detailed by J. C. Cresson, esq., from the city gas-works. The work was completed as soon as possible, under the direction of Mr. Davidson. Several gentlemen not connected with the survey had volunteered with alacrity for the occasion, and were assigned to his aid, and he was thus enabled to carry forward the reconnaissance, in some detail, of the ground deemed most important.

Feasible lines of defence having been developed and examined, I then minutely inspected them, and also the proposed sites for field-works, being accompanied in this duty by Assistant Davidson. A map of the reconnaissance, upon a scale of eight hundred feet to the inch, has been furnished. It includes an area of eighty square miles, of which rather more than half was minutely examined for defensive purposes. The map gives the general features of the country with as much fidelity as the means and time afforded. Mr. Davidson's report points out the necessity of a close and detailed survey for the proper study of a complete system of defences.

In his report full credit is given to all who volunteered and were assigned to him for field duty. He makes acknowledgment also for valuable data received from the North Pennsylvania Railroad Company, for plans and profiles of part of their road. Similar information was furnished by the connecting railroad company and by Messrs. S. C. Ford, Jesse Lightfoot and Jacob P. Tyson. The assistance of James Rowland, esq., who was familiar with the localities, and who kindly accompanied the party and furnished his own horses for the service, was very acceptable.

Of the members of the Coast Survey, Assistant C. M. Bache made a plane-table survey near the city, and was then transferred to a point on the outer line of approach for similar duty. His work embraced an area of about two and a half square miles, and included thirteen miles of roads and eight miles of watercourses. These and other surveys were reduced to the proper scale as they came in for the general map. Assistant Bache, after turning in the two plane-table sheets, returned to the work in Section III which he had left for the duty near Philadelphia.

Assistant P. C. F. West reported in July and made a plane-table survey of part of the northwestern approach. During the military operations near Harrisburg, Pennsylvania, he had been attached to the staff of Brigadier General W. F. Smith.

Mr. Robert E. McMath commenced work with Assistant R. M. Bache, but in the latter part of the season aided Mr. Davidson and made a reconnaissance of one of the ridges near the city. His aptness and capacity for field-work are warmly commended.

Sub-Assistants J. S. Bradford and Cleveland Rockwell reported, the first on the 29th of June, and the latter on the 1st of July. Mr. Bradford was employed a short time in contour work, and was then assigned to duty with Assistant Boutelle. Mr. Rockwell when called was about to take up plane-table duty in Section I. He commenced work near Philadelphia, but was taken ill. After recovering he reported to Assistant Whiting, and made topographical reconnaissance of several localities west of the Schuylkill.

Mr. A. R. Fauntleroy joined Mr. Davidson as aid on the 26th of June, and has been steadily and actively engaged, either in the field or in reducing and plotting work for the large map. He surveyed about sixty miles of roads, ran a number of lines of level, and contoured part of the ground occupied by the inner line of defence, and is commended in the field report for the prompt and intelligent discharge of all the duties assigned to him.

The department of surveys of the city of Philadelphia having volunteered their services, several of the surveyors and regulators of the different districts were referred to Assistant Davidson and took up duty in the field. The early part of July was rainy and unfavorable for progress, but all worked with commendable zeal and without charge for their party expenses. A preliminary survey around the site of Fort Dana was made

by Messrs. Jesse Lightfoot and J. F. Wolf, and they subsequently assisted with their party in the general survey. Mr. Lightfoot was for some time in charge of the map, and directed the proper arrangement of the materials furnished by the other parties. He generously placed at my disposal a large office, in which the field-work was reduced and plotted.

Messrs. D. H. Shedaker and James Keily assisted with a transit and levelling party until the 20th of July. Mr. Keily also furnished data for the map in plans and profiles.

Messrs. J. P. Davis, Andrew French, Joseph Mercer and Jacob M. Seads, with a similar party, traced part of the ground of approach and the roads intersecting it. This party was from Kensington, and worked assiduously under many disadvantages during the first week of July. Another, with transit and level, under Mr. Alfred Young, was engaged about a week in the same neighborhood.

Several of the railroad companies promptly sent their engineers to the assistance of the city. The Reading Railroad Company placed at my disposal the services of Messrs. Charles McDonald, Richard McCaffrey, Henry Stout and William C. Cleveland, who were during the month of July steadily engaged in extending the survey outward from the city.

The Broad Mountain Railroad Company at the same time sent Messrs. T. Guilford Smith and Chauncey Ives, who continued in field duty until the 20th of August. They made levellings of a large extent of ground. Mr. Edward Sloan, of the Polytechnic Institute at Philadelphia, was assigned to this party, and after they were relieved continued levelling for the contour work until the 10th of October.

The Mine Hill Railroad Company sent Mr. T. R. Stocket, who contoured portions of the ground from data furnished by the surveyors and engineers. He also plotted details for the map after the departure of Mr. Lightfoot.

One of the first volunteers for surveying duty was Joseph Lesley, esq., of the Pennsylvania Central Railroad Company, who remained two weeks with Assistant Davidson, and furthered the work by his knowledge of the environs of Philadelphia. Mr. J. B. Atkinson offered on the 2d of July, and assisted until the 21st of October, showing great aptness in contouring. Mr. W. G. Neilson came at the same time, and continued until the latter part of August, part of the time aiding in the party of Assistant C. M. Bache. Mr. E. D. Hallowell reported among the first, and remained with Assistant Davidson until the close of field-work, giving very important aid. Captain J. B. Williams was among the first volunteers. After assisting in reconnaissance, he was placed in charge of one of the forts. Mr. Charles Perkins was on duty a short time with this party, but will be mentioned again as connected with another. Mr. James Steele volunteered and assisted in the field until prostrated by sickness. Mr. W. T. Gummey aided for a short time in compiling for the map. Mr. W. E. Weber volunteered on the 2d of July, and worked efficiently at several periods throughout the season. E. T. Hyatt, esq., offered his services on the 1st of July, and took charge of the men detailed from the gas-works for the erection of defences. He remained with failing health until the completion of Fort Dana, but, to our deep regret, his energy and usefulness were cut short by his death in October.

Mr. L. R. Walton took service on the 2d of July, remained for nearly a month, and performed some good service after his return in October.

Professor George Franck, of the Polytechnic Institute of Philadelphia, reported early in July, and assisted until the middle of September in reconnaissance. Messrs. J. F. Clark, Albert L. Kern, H. McIntyre, George S. Bethel, S. Brandeis, L. H. Steele, A. L. Massey, Benjamin Allen, and W. H. Clarke, joined about the same time, and were efficient and useful during the time which they were able to devote to the public service. Mr. W. H. Bennett assisted in reconnaissance until the 3d of October, and Mr. W. C. Gatzmer until the middle of September.

Many of the gentlemen whose names have been mentioned in connexion with the work of this party were recent graduates of the Polytechnic Institute.

During the time referred to in the previous notice, a general reconnaissance of the south, the southwest, and the northwest approaches to Philadelphia was made by Assistant W. L. Whiting. His map and report presented in August was accompanied by local sketches of the most important sites for works of defence, and by remarks on the advantages of each of the positions. This reconnaissance took in all the approaches by southerly ranges from Fort Mifflin westward, and at the northwest approach joined with the surveys made by Mr. Davidson. As in the first instance, Mr. Whiting specified in his report the field-works and redoubts deemed requisite within the area of the reconnaissance.

In summing up his report, Assistant Whiting says: "The country was examined with as much care, and the positions, distances, bearings, and connexions of the different works were studied with as much discrimination, as the time allotted, and the nature of a preliminary reconnaissance would allow. An elaborate and accurate survey of the country embraced within the natural limits of defence for so large a city would be most desirable. Such a survey would settle all questions of position, distance, bearing, elevation, intercepted or open fire, and the nature of the intervening ground, and would probably lead to the modification of the present project for defence." It is indispensable for a complete study of the question in regard to suitable defences.

Mr. W. B. McMurtrie, of the Coast Survey office, was on duty with Assistant Whiting as draughtsman.

Assistant R. M. Bache, who had been steadily employed in Section VIII, reached Philadelphia on the 27th of June, from St. Louis. On the 29th he volunteered for the surveys needed near Philadelphia, and made topographical sketches of the points deemed most suitable for immediate occupation. His aid, Mr. Robert E. McMath, mapped in a preliminary way the grounds adjacent to those points. This service being completed, the duties of Mr. Bache were changed to reconnaissance and construction, field-works being commenced at suitable positions for guarding the western approaches of the city. Besides these, he had selected and staked out several other sites for defensive purposes, and, with the aid of gentlemen who volunteered for the service, quickly gave shape to the works which were first put under construction.

Captain Charles H. Gibson, second cavalry, joined himself to the party of Assistant Bache for the surveys, and in selecting the site for one of the earthworks, and also assisted in its construction. He was aiding in the work when a call was made for his services elsewhere.

Captain H. C. Ulman, formerly of the volunteer service, also joined the party early, and aided in the service.

Mr. J. W. Walker, a graduate of the Polytechnic Institute, volunteered and acted as engineer of site at one of the field-works. He was very assiduous in the performance of that duty.

Captain Benjamin H. Smith, formerly of the volunteer service, was engineer of site at one of the works, and aided materially by his practical knowledge. After its completion he took charge of the works at another fort which was then in progress.

Mr. Charles Perkins, a graduate of the University of Pennsylvania, was making favorable progress on the work last referred to, as engineer of site, when he was obliged to relinquish the charge and resume his regular duties connected with one of the State railroads.

Mr. H. McIntyre, of the water department of Philadelphia, acted as engineer of site, and rendered very effective service in that capacity.

Of his aid, Mr. McMath, Assistant Bache makes special reference in his report, both in regard to the good judgment shown in projecting the defensive works that lay within the scope of the reconnaissance, and as to his care and industry in prosecuting the details.

The report of Assistant Bache, made at the end of August, specified the details of size and position of each of the works projected and constructed by his party under my direction, and furnished also careful notes of the military advantages of each of them for defending the western approach to the city of Philadelphia.

One of the forts was planned and constructed by Assistant C. O. Boutelle, who had volunteered for the work of defences of the city. Sub-Assistant J. S. Bradford assisted in this duty.

Sub-Assistant R. E. Halter, who had been in service in my own party on the coast of Connecticut, was recalled, having volunteered for duty at Philadelphia, and reported to me there on the 30th of June. He was first detailed to throw up an earthwork for defending one of the western lines of approach. After its completion, he started with a party of five men and made a plane-table survey, including both banks of the Schuylkill in the neighborhood of the city. On the west side of the river, his map was extended as far as the junction of Belmont avenue. This work was completed by the 5th of August, after which Mr. Halter returned to the party in Connecticut.

From the drawing division of the Coast Survey office Mr. Edwin Hergesheimer reported at Philadelphia, under my instructions on the 29th of June. He at once made reconnaissance maps of parts of the northwestern approaches to the city, and during July and part of August, a map of the most important ground in the same vicinity. This survey included a district of about eight square miles. Mr. W. E. Weber, of the Polytechnic College of Philadelphia, volunteered and gave cheerful and valuable aid in the field-work.

The details of Mr. Hergesheimer's maps show decided aptitude and facility in reconnaissance.

Hydrographic development off Montauk Point, N. Y.—In the latter part of June, before proceeding to

Section I with the steamer Corwin, Lieutenant Commander Phelps examined the eastern approach to Montauk, in the immediate vicinity of which the steamer Great Eastern had struck in 1862. Several days were passed in establishing positions, and in running lines of soundings, the result of which was that the Corwin was finally anchored on the rock by which the great steamer was damaged. Lieutenant Commander Phelps reports as follows respecting it: "This rock has twenty-four feet water on it at low tide, and is a mile and a half (nautical) from Montauk Point light-house, and bears from it east 14° 45′ north (true.) It is apparently the southern point of a ledge extending to the northward about a mile and a quarter. This, on being developed, gave from four to six and three-quarter fathoms on a general course N. by W. ½ W. and S. by E. ½ E. (true.)"

"About half a nautical mile, and N. 35° 30′ W. from the Great Eastern rock, is another, (or a projecting point of the ledge,) on which there is twenty-eight feet water at low tide. This rock bears from Montauk light-house E. 34° 41′ N. (true,) and is about a mile and three-eighths from it. Two points of the rock give only twenty-eight feet, with deeper water between."

The party of Lieutenant Commander Phelps determined positions by one hundred and thirty-two angles, and recorded thirteen hundred soundings in making the examination. A copy of the report, accompanied by a sketch showing the soundings, was forwarded to the Light-house Board in September, with recommendation that a buoy should be placed on the southern end of the ledge on which the Great Eastern had struck.

Hydrographic examination in New York harbor.—In a communication addressed to me at the end of April, by Russell Sturgis, esq., president of the Board of Pilot Commissioners of New York, it was stated that, by order of the board, all matter excavated or dredged from the slips along the city front since 1859 had been deposited on Oyster island, or in the channel near it. Request was made at the same time for such an examination as might determine whether or not the deposits had affected the capacity of the channel.

The examination desired was made in June, by the party of Lieutenant Commander Phelps, with the steamer Corwin. Soundings were made between Governor's island and Robbin's reef, and additional boat lines were run on the Jersey Flats.

The results of this survey were obtained under such adverse circumstances as strong currents, high winds, and smoky weather; but, as reported, a comparison with the soundings made in the same vicinity in 1855 shows no material change. The probable effect of the deposits with reference to the action of the tides and currents will be made the subject of further study.

The statistics of the work done in New York harbor by the party in the Corwin are as follows:

Miles run in sounding	61
Angles measured	327
Casts of the lead	2,382

The chart of this resurvey has been inked, and a copy of it furnished to the Pilot Commissioners.

Hydrography of Hudson river, N. Y.—This work has been completed by soundings made this year above Hudson city, and extended to New Baltimore, where the work of recent seasons joins a survey which was made in 1855, and by soundings between Albany and Troy.

The work of this season in the Hudson was taken up by Mr. W. W. Harding, on the 1st of July, with a party in the schooner Caswell. As last year, and previously, arrangements were made for keeping the shore-line survey even with the hydrography. Mr. Harding revised some of the soundings made last year in the neighborhood of Malden, and then continued the regular hydrography up the river, to a point above Coxsackie.

Mr. Alexander Strausz, who had served with Lieutenant Commanding Wainwright in the survey of the Hudson above New Baltimore, where the soundings of this year were to join with the work done in 1855, took charge of the hydrographic party in the middle of September. He was aided by Messrs. C. S. Hein and H. G. Ogden, who had served in the work of this season near Coxsackie, and by Mr. P. Frazer, jr., the last two transferred from the party of Assistant Edwards, as was also the schooner Arago, which had been used by him in Section I.

By the 1st of October Mr. Strausz had defined the channel between Coxsackie and Stuyvesant, which is made intricate by the Kinderhook Flats, and by the middle of that month joined soundings above Stuyvesant with the previous work at New Baltimore.

He then proceeded to Albany, and sounded the river between that city and Troy, closing the hydrography early in November.

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

Miles run in sounding	165
Angles measured	1,827
Casts of the lead	16,670

In addition to the hydrography, thirty-eight miles of shore-line were traced for the sheets containing the soundings. Fifty-nine signals were set up and determined in position in the course of the season.

Sketch No. 9 shows, in preliminary form, the chart of one part of the Hudson which was sounded this year. The original chart of the work is now in the office, with the journals of soundings and angles. Mr. Strausz had passed the former part of the surveying year in active duty, which will be stated under the head of Section VIII. Mr. Harding was employed during the same period in Section V, and is now preparing to resume duty there. Mr. Strausz will be engaged in hydrographic service in Section IV.

Survey of League island, Delaware river.—In the latter part of January, at the request of the Navy Department, Assistant Davidson was directed to make a plane-table survey of the north end of League island, and to sound out the narrow channel which passed behind the island. He reported the results early in February, and with his topographical sheet turned in a comparative map, on which the changes which have taken place since the first survey are clearly shown. The topography was based on twenty-two points, determined for the purpose by triangulation. For reducing his soundings to mean low water, Mr. Davidson transferred the bench-mark at Red Bank ferry. His full and explicit report demonstrates the causes that are concerned in the change of the hydrography.

Hydrography around Delaware Breakwater.—The vicinity of the harbor at the Delaware breakwater was sounded during the first two weeks in August by Captain C. P. Patterson, hydrographic inspector of the Coast Survey. Since the completion of this hydrography a comparative chart has been made at the office for the Chief Engineer of the army, at whose request the survey was made. Captain Patterson reports that the point of Cape Henlopen has extended two hundred and fifty yards to the northward since 1842. A few changes in the depth of water were noticed, which, although not such as to affect navigation or to make the harbor less available, are of much importance in regard to the permanency of the breakwater. The statistics of the hydrography are as follow:

Miles run in sounding	70
Angles measured	265
Number of soundings	3,417

The expense incurred in this survey was defrayed by the Engineer department.

Tidal observations.—The self-registering tide-gauge at Governor's island (New York harbor) has been very successfully kept in operation during the year by Mr. R. T. Bassett, there having been fewer interruptions, probably, than in any other year. For comparison with the record at Governor's island, the observations with a box-gauge at Brooklyn have been regularly continued in the day-time. Meteorological observations have been steadily recorded at the permanent tidal station.

SECTION III.

FROM CAPE HENLOPEN TO CAPE HENRY, INCLUDING THE COAST OF PART OF DELAWARE, THE COAST OF MARYLAND, AND PART OF THE COAST OF VIRGINIA.—(Sketch No. 10)

The work of all the parties assigned to field duty in this section has been done in connexion with the army, except that of the hydrographic party which completed the chart of the Potomac for the Navy Department. The surveys made have been almost entirely for defensive purposes and chiefly for the Engineer department. They are as follow:

1. Triangulation to determine points in the environs west and north of Baltimore, Maryland.
2. Determination of the heights of points now fortified in the vicinity of Washington, D. C.
3. Plane-table survey of part of the environs of Baltimore.
4. Topography above and below Bladensburg, Maryland, extending the survey of the District of Columbia beyond the northeastern boundary into the State of Maryland.
5. Plane-table survey to connect with that last mentioned, and running beyond the southeastern boundary of the District, north of the Potomac. Part of this work at the eastern corner of the District is yet to be completed. The party here engaged also added details to the topography about Chain bridge, above Georgetown, D. C.

6. Minute topography of Rosier's Bluff. The surface of the ground was very carefully contoured between Oxen Hill and Broad creek, Maryland. A plane-table survey was made, by the same party, of Jones's Point, near Alexandria, Virginia.

7. Triangulation and shore-line survey of the Potomac river, between Alexandria and Georgetown, and of the Eastern Branch to Anacostia bridge. This party also furnished points for extending the survey about Fort Lyon.

8. Topography of the vicinity of Fort Lyon, and connexion with surveys near Alexandria. Survey of roads meeting at King George Court House, and reconnaissance duty for the army of the Potomac.

9. Special examination of the roads and country north and west of Stafford Court House, connected with army movements.

10. Hydrographic examination to the eastward of Winter Quarter shoal, off the coast of Maryland, and completion of the hydrography of the Potomac river by soundings between Indian Head and Alexandria.

11. Magnetic declination, dip, and intensity, observed at the station in Washington city.

12. Tidal observation continued at the permanent station at Old Point Comfort, Virginia.

Office-work.—The engraving of general coast chart No. 1V, Cape May to Cape Henry, as a preliminary chart; of coast chart No. 36, Chesapeake entrance, as a finished chart, and of Rappahanock river, sheet No. 5, from Occupacia creek to Punch Bowl, has been completed. The drawing and engraving of preliminary charts of Metomkin inlet, Virginia, and of Potomac river, sheet No. 1, from the entrance upward to Piney Point; No. 2, from Piney Point to Lower Cedar Point; No. 3, from Lower Cedar Point to Indian Head, have been completed. Progress has been made in the drawing and engraving of Potomac river, sheet No. 4, from Indian Head to the Chain bridge. The engraving of coast chart No. 29, seacoast of Maryland and Virginia, and of Hampton Roads, Elizabeth river, Virginia, has been commenced. Additions have been made to the progress sketch of the Section. A preliminary edition of Potomac river, sheet No. 4, from Indian Head to the Chain bridge, and a military map of southeastern Virginia, have been engraved on stone, and considerable additions have been made to the general map of Virginia in colors.

Triangulation of the environs of Baltimore, Md.—This work was taken up by Sub-Assistant C. H. Boyd, on the 1st of August, and was done under the direction of Colonel Raynolds, chief engineer 8th army corps, in order to furnish the basis for the plane-table survey of ground that would be commanded by the military defences of the city of Baltimore. The triangulation, as far as desired for that purpose, was concluded on the 28th of the month. Mr. Boyd was aided by a working party of soldiers which he had employed in similar duty in the vicinity of Washington, and which were transferred for the service at Baltimore by an order from the commander-in-chief. At one of the stations near that city a tripod was required, with a scaffold thirty feet high, for observing with the theodolite. The statistics of the work are as follows:

Stations occupied	8
Angles measured	16
Number of observations	902

Sixteen points were determined for the use of the topographical party. The record of angles and other field-notes was made in the usual form and sent to the office.

Triangulation of the military defences of Washington city, D. C.—At the request of Major General Barnard, in charge of the fortifications, who desired to have notes of the elevation of each fort above the tide-level of the Potomac, Assistant C. A. Schott was directed in January to make such horizontal and vertical measurements as would furnish the required data. This was done at intervals in the course of the spring, when the range of duties in the computing division of the office concurred with favorable weather for the use of the theodolite in the field. The operations concluded at the end of May were carried on under the general direction of Lieutenant Colonel J. N. Macomb, United States engineers. Some of the positions and heights were furnished immediately to the plane-table parties then engaged in completing the survey of the environs of the District of Columbia. No signals were erected by the party of Mr. Schott, but as the flagstaffs were in all cases observed on as signals, each station was of necessity occupied eccentrically. The labor of computation was thereby increased, but outlay for materials and fixtures was avoided. Each of the stations was visited but once, the measurements of horizontal angles being repeated three times, and the vertical measurements four times, and in some cases more. The statistics of the horizontal or triangular measures are as follows:

Stations occupied	59
Positions determined	54
Horizontal angles measured	440
Number of observations	1,016
Area of triangulation, (square miles)	86

The heights depend upon a series of tidal observations continued for rather more than a year at the navy yard, and completed at the end of the year 1860, the records of which are on file in the tidal division.

The half-tide level of the Potomac was adopted as the plane of reference, and the elevations were corrected in the computations so as to conform to it. The statistics of the vertical angles are as follows:

Heights determined	68
Stations occupied	59
Zenith distances measured	216
Number of observations	674

Mr. E. H. Courtenay aided Mr. Schott in the field-work and prepared the duplicate records. The originals, amongst which are descriptions of seventy stations in the vicinity of the District boundary, are now at the office.

Assistant Schott used the Gambey theodolite No. 57 and the Würdemann No. 88 for determining horizontal angles. The first only was used in the vertical measurements.

In the latter part of June Mr. Schott was assigned to special duty in Section I, which has been already noticed under the head of magnetic observations in that chapter. I have referred elsewhere to his co-operation in the experiments designed to settle the question as to the proper treatment of magnetic needles on iron vessels.

Notes giving the geographical positions, the heights, and the distances intervening between the fortifications, were furnished to General Barnard in March, and further information of the same kind as the results were reached.

Topography of the suburbs of Baltimore city, Md.—The advance of the rebel army in the latter part of June seeming to threaten the city of Baltimore, application was made to me for the services of topographers to map the ground which it was intended by the military authorities to occupy with defensive works. The call of Colonel J. H. Alexander, acting chief engineer of defences, was immediately met by the assignment of Mr. A. Lindenkohl from the Coast Survey office. For the rapid reconnaissance then needed, Sub-Assistant J. W. Donn was also detailed.

On the return of the chief engineer of the middle department, Colonel W. F. Raynolds, who at the juncture was at Harper's Ferry, it was deemed advisable that a full topographical survey should be made of the ground extending three miles beyond the city limits of Baltimore on that part of the northern and western sides of the city which were to be defended. This survey was taken up by Mr. Donn, and was prosecuted during the month of July as far as the triangulation points allowed. As already stated, additional points were furnished by Sub-Assistant Boyd in August; after which time the topography was steadily continued. Sub-Assistant Donn was withdrawn early in October to meet a call for topographical service near Chattanooga, Tennessee, and was relieved by Sub-Assistant Iardella, who is still at work in the environs of Baltimore. Messrs. F. A. Lueber and C. S. Klein served as aids in the plane-table party, the former until the 10th of November, when he resigned.

Topography between Bladensburg and Leesboro', Md.—The plane-table survey which was in progress at the date of my last annual report, under the direction of Colonel Macomb, was continued during the winter along the northeastern boundary-line of the District of Columbia. Sub-Assistant Charles Ferguson relieved Assistant C. M. Bache on the 8th of December, and extended the topography northward and westward to Leesboro', joining there with work done in the preceding season by Sub-Assistants Dorr and Rockwell. The lower limit of Mr. Ferguson's sheet is the Washington branch of the Baltimore and Ohio railroad in the vicinity of Bladensburg. Below Bladensburg or southeast of that village, the Maryland approaches of the District were surveyed by Assistant I. Hull Adams, who relieved Mr. Ferguson on the 18th of March. The belt of topography so added to the survey of the District of Columbia is about three miles wide. Mr. Adams extended the work towards the eastern corner, intending to join there with a survey by Sub-Assistant Donn. The statistics of the topography above and below Bladensburg are as follows:

Roads surveyed	42
Creeks	22
Area, (square miles)	12

On being detached from service in this section, Sub-Assistant Ferguson took up and continued a survey on which he had been previously employed in Section I. The party of Mr. Adams continued the work in Maryland until the end of June.

Plane-table survey adjoining the southeastern boundary of the District of Columbia.—A plane-table survey for the extension of the map of the District of Columbia on its southeastern side was begun in the middle of January by Sub-Assistant J. W. Donn. Like the additional work mentioned in the last notice, a breadth of three miles was given to the supplementary topography along the entire southeastern boundary. Sub-Assistant Donn was aided in the field by Mr F. A. Lueber and Mr. C. S. Hein. The work was continued until the end of June, when Mr. Donn was called to Baltimore for the emergency which seemed to threaten by the approach of rebel forces towards that city. His survey supplementary to that of the District of Columbia shows the contour of ground, and all the surface details within an area of twenty-five square miles. The sheet containing them is now in the office.

Part of the ground outside of and adjacent to the eastern corner of the District where the two additional surveys were intended to meet, yet remains to be surveyed. The statistics of the work done are as follows:

Roads and streams traced	173 miles.
Area of topography, (square miles)	25

Plane-table survey near Chain bridge, above Georgetown, D. C.—The topography of Fairfax county, in the vicinity of Fort Marcy, and between it and Langley, Virginia, was continued for a short period after the end of the last surveying year by the party of Sub-Assistant John Mechan. The surface details then traced in have been added to the plane-table sheet of the survey which was made by Mr. Robbins before the close of that season. Mr. Mechan resigned on the 3d of January, since which time the work of the party has been conducted by Mr. Donn. For joining the contour lines which had been run by the topographers before engaged, Mr. Donn determined the position and height of several points under the direction of Colonel Macomb, and then took up plane-table work in the vicinity of Fort Meigs, for extending the District survey, as already stated.

Topography of Rosier's Bluff, Md.—At the request of the Engineer department, a minute survey has been made of the Maryland bank of the Potomac from Oxen Hill to Broad creek, and from the shore two miles back, or to the bounds of the valley of St. Philip. The ground surveyed includes Rosier's Bluff and its vicinity, or about four miles of the eastern bank of the river opposite to Alexandria. This work was commenced early in December, 1862, by Assistant A. M. Harrison. In contouring the topography of the bluff, the horizontal curves were carefully levelled and drawn in to represent successive elevations of ten feet. Those of other parts of the ground show heights of twenty feet. All the surface details are comprised on the sheet that could be called for in military purposes. The survey was made on a large scale, and when complete, a tracing of it was furnished to General Barnard, chief engineer of the defences of Washington.

Mr. Harrison, being in charge of the drawing division of the office when called on for this survey, occupied at intervals, parts of the first three months of the year in its execution, his aid, Mr. H. W. Bache, continuing the field-work when Assistant Harrison was necessarily absent.

The closing of this survey was followed by a further request from the chief engineer for a special topographical map of the ground around Fort Lyon, on the south side of Hunting creek, below Alexandria. It was also thought advisable that a closer delineation should be made of the shore-line of the Potomac between Alexandria and the "Chain bridge." Mr. Harrison, with these objects in view, organized a second party, to be in charge of Sub-Assistant C. H. Boyd, as already stated, intending, in person, to make the survey around Fort Lyon. The work was begun, but was deferred by a request from General Barnard for a plane-table survey of Jones's Point, which juts out into the Potomac below Alexandria. This duty was immediately taken up, and was completed on the 27th of April. A map of the point, showing the character of all the objects then on it, and the surface contour for elevations of two feet, was furnished to the chief engineer.

Assistant Harrison then took up the levelling required for the topography about Fort Lyon, and continued that service until the 11th of May, when his party was transferred to Assistant C. M. Bache. All the requisite points of triangulation and level marks covering the area to be mapped, as also a carefully prepared projection, had been provided by Mr. Harrison, who was soon after assigned to plane-table duty in Section I.

Mr. A. Lindenkohl assisted Mr. Harrison in the survey of Rosier's Bluff in December. The following are general statistics of the work done by his party in Section III:

Shore-line surveyed	11	miles.
Creeks and ponds	24	"
Marsh-line traced	$9\frac{3}{4}$	"
Roads	$27\frac{3}{4}$	"
Area, (square miles)	7	

In levelling, the total number of pegs set was four hundred and ninety-five, and an aggregate of forty-one miles and a half was run in tracing the lines of contour.

Topography of the vicinity of Fort Lyon, Va.—This work was continued in May and June by Assistant C. M. Bache, but suspended during the next three months, the services of Mr. Bache being then required near Philadelphia. He resumed the plane-table survey about Fort Lyon in October, and completed it at the end of the surveying year. A tracing from the topographical sheet has been furnished to the chief engineer of defences.

Triangulation between Alexandria, Va., and Georgetown, D. C.—Points being desired for extending the plane-table survey of the vicinity of Alexandria beyond Fort Lyon, in accordance with the wishes of the chief engineer of defences for the city of Washington, the angular measurements necessary were taken up on the 1st and completed by the 28th of April. Assistant A. M. Harrison had the general direction of the work, the plane-table surveys being also in his charge. Major General Barnard furnished details of men, and the Quartermaster's department the requisite means for moving from station to station. Sub-Assistant Boyd conducted the field-work, and after completing the determinations near Alexandria, extended the triangulation up the Potomac to Georgetown. In doing so, the positions of the hydrographic signals used by the party of Captain Patterson in sounding that part of the river, were determined, and also points for a resurvey of the shore-line. Thirteen stations were occupied, and twenty-seven points determined by eleven hundred and four measurements with the theodolite.

Shore-line survey of the Potomac, between Alexandria and Georgetown, D. C.—Following the triangulation referred to above, Mr. Boyd commenced work with the plane-table on the 1st of May, and traced both shores of the Potomac from Little Falls bridge to Alexandria, including the wharves there and similar details along the Washington side of the river, and of the eastern branch of the Potomac to Anacostia bridge. This duty occupied his party until the 26th of July. Thirty miles of shore-line were traced. An aggregate of five miles of wharf-line is shown on the plane-table sheet, and ten miles of road and canal. The resulting map has been inked and is now at the office, with the records of angular determinations on which it depends.

Topographical service near Fredericksburg, Va.—Assistant C. M. Bache, who had continued the topographical work near Bladensburg, under the orders of Colonel Macomb, after the close of the previous surveying year, was assigned to duty with the left grand division of the army of the Potomac, and reported to Major General Franklin on the 9th of December, 1862. He crossed the Rappahannock with the army on the 12th, and after its return to the north bank was employed in making surveys, with the compass and chain, of the road to King George Court House, and of the lateral roads between that and the Potomac on one side and the Rappahannock on the other. General service was also rendered by reconnoitering and reporting the condition of other roads in the vicinity of Fredericksburg, with reference to their fitness for the passage of artillery and infantry. The road surveys were plotted in January and made over to the military authorities for the use of the army. In the previous season Assistant Bache had executed the topography of the north bank of the Rappahannock opposite to Fredericksburg, and had then extended his examination of roads in two directions as far as the Potomac. He was employed during the summer in the surveys for defensive works near Philadelphia, in Section II.

Sub-Assistant Charles Hosmer, when my last annual report closed, was on duty with the division of Major General Franklin, having joined it in Maryland, and proceeded with it to Virginia, after aiding in the survey of the vicinity of Williamsport. Assistant P. C. F. West was also attached to the left grand division, and himself and Mr. Hosmer rendered service along the route to Stafford Court House in the advance, by the examination of roads for the movement of troops.

Application having been made previously by Major General Banks for the services of a topographer acquainted with the coast of Louisiana and Texas, Mr. Hosmer was detached from duty in this section and reported for service on the Gulf coast on the 28th of November, to which further allusion will be made under

the head of Section VIII. He was employed in Section I during the summer, but in September proceeded again under orders to join the army of the Gulf.

The subsequent occupation of Assistant West will be referred to in the notices of work in Section IV. He was also engaged in Section II.

Examination near Winter Quarter shoal.—It having been brought to my notice that the steamer Baltic had struck, or was supposed to have struck, on a shoal off the boundary-line between Maryland and Virginia, in the autumn of 1862, Lieutenant Commander T. S. Phelps, United States navy, was directed to make a thorough examination of the locality with the surveying steamer Corwin. No such feature to the eastward and near to Winter Quarter shoal existed when the chart of that part of the coast was published.

The examination by the party in the Corwin was made in April last, and the result is stated in the Appendix (No. 6.) It will be seen by reference to it that careful soundings, made under favorable circumstances, gave no indication of the existence of a shoal outside of the Winter Quarter shoal. The conclusion of Lieutenant Commander Phelps relative to the non-existence of the supposed danger was published in May.

Hydrography of the Potomac river.—The steady labors of Lieutenant Commander Phelps, with his party in the steamer Corwin, as stated in my report of last year, had far advanced the survey of the Potomac towards completion when my report was handed in. The soundings were continued above Indian Head during the winter of 1862–'63, and joined at Alexandria with the hydrography of the party of Captain C. P. Patterson, who had closed work in the stretch between Alexandria and Georgetown in the previous autumn.

Lieutenant Commander Phelps, before taking up the plotting of his chart, made additional soundings in the "Kettle Bottoms," and thus remarks on the character of that part of the work: "The soundings on the "Kettle Bottoms" were made very close, six hundred and fifty-two miles being run in developing the shoals, or between Lower Cedar Point and the neighborhood of Cob Point. I believe that we succeeded in finding most of the lumps, but they are abrupt, and apparently cone-shaped, and some are so very small that it is possible others may have escaped between casts of the lead. They seem to be composed principally of oysters and sand. Ten feet was the least water found on them."

Of the Nanjemoy Reach of the Potomac, Lieutenant Commander Phelps states that the shoals appear to be formed of sand, gravel, rocks, and oyster shells. Further up the river they are of sand and pebbles.

The southern bank of the Potomac was traversed by bands of rebel soldiers while the party in the Corwin was prosecuting the hydrography; but, though often within gunshot, the boat parties were in no instance molested. These bands were supposed to be concerned in receiving and aiding the contraband traffic across the river. In his progress up the Potomac the place chiefly used for crossing with contraband articles became known to Lieutenant Commander Phelps, and was promptly reported to the naval authorities.

Between Blakistone island and Indian Head eight tidal stations were occupied. The mean rise and fall of the tide was found to be about one foot and five-tenths.

The aggregate statistics of the hydrographic work below Alexandria show the thoroughness of the survey. They include those given in my last annual report, which was turned in while the party was still on duty afloat:

Miles run in sounding	2,447
Angles observed	10,551
Casts of the lead	165,048
Length of river course sounded, (miles)	77

The chart of the Potomac, in four sheets, was speedily issued, and has been largely distributed for the use of the naval and transport service. In the middle of February Lieutenant Commander Phelps, on learning that Major General Hooker, then in command of the army of the Potomac, needed information as to the soundings and landings on the Virginia shore to the southward and eastward of Aquia creek, supplied what was desired.

In April the steamer Corwin proceeded to New York, and was there employed in duty which has been mentioned under the head of hydrography in Section II. Later in the season the party was employed in Section I.

The recommendations sent in by Lieutenant Commander Phelps for additional buoys in the lower part of the Potomac, and in regard to changes desirable in the position of some already placed, are contained in the Appendix (No. 29.)

Magnetic observations.—After his return from Section I, in which he had occupied a number of stations,

Assistant C. A. Schott determined anew the magnetic declination, dip, and intensity at Washington. The site selected, and in which the observations have been repeated several times, is near the Coast Survey office. The determinations were made with the instruments used in Section I. The results last found are given in Appendix No. 22.

Tidal observations.—The series of records at the permanent tidal station at Old Point Comfort, Virginia, has been continued during the present year with a self-registering tide-gauge. Mr. M. C. King, as heretofore, has charge of the station.

SECTION IV.

FROM CAPE HENRY, VIRGINIA, TO CAPE FEAR, NORTH CAROLINA, INCLUDING PART OF THE COAST OF VIRGINIA AND NORTH CAROLINA.

The three parties sent to this section worked under the orders of Major General J. G. Foster. In the triangulation of the Neuse river, which was executed by one of the parties, the regular progress of the survey in Section IV has been advanced. The two topographical parties moved and acted at special call for military purposes. Their work between the Neuse and Tar rivers, and in the vicinity of Washington, North Carolina, as well as that of the triangulation party, is referred to in a communication from General Foster, which I have placed in the Appendix, (No. 26.)

OFFICE-WORK.—The drawing and engraving of preliminary charts of Hatteras inlet and of Oregon inlet, North Carolina, have been completed. Progress has been made in the engraving of coast chart No. 37, Cape Henry to Currituck sound. The drawing of coast chart No. 47, Bogue inlet to Barren inlet, North Carolina, has been continued, and the engraving of the same, and that of coast chart No. 48, Barren inlet to Lockwood's Folly inlet, embracing Cape Fear and approaches, has been commenced. A lithographic edition of the latter, in a preliminary form, and also of general coast chart No. V, Chesapeake entrance to Ocracoke inlet, have been produced for the use of the North Atlantic blockading squadron, Admiral S. P. Lee; and a map of the mountain region of North Carolina and Tennessee, including also parts of the States of Virginia, Kentucky, Alabama, Georgia and South Carolina, has been drawn and engraved on stone for the use of the armies in the field.

Triangulation of Neuse river, N. C.—For this work a party was assigned to the charge of Assistant G. A. Fairfield, and the use of the schooner James Hall for transportation. The vessel left New York on the 2d, and reached Newbern on the 12th of February. In the course of a few days Mr. Fairfield reported to Major General Foster, who had just returned to the department, and tendered the services of himself and his party for special duty. No occasion immediately arising for their employment in military surveys, the triangulation of the Neuse river was commenced, and in the course of the season completed from Newbern downward as far as Goose creek. The site of the preliminary base which was measured by Mr. Fairfield in March is at the forks of the Neuse and Trent rivers. The measured line was found to be 1,592.09 metres in length. Every facility requisite for this work, and for that dependent upon it, not afforded by the outfit of the party, was supplied by General Foster. Brigadier General Prince also made kind offers of assistance to further the survey.

Sub-Assistants P. C. F. West and Cleveland Rockwell, who were to be employed directly in connexion with the army of General Foster, aided Mr. Fairfield, the last named in the base line, and the former in erecting signals for the triangulation. The series of triangles follow the course of the Neuse river to a point about twelve miles below Newbern. All the stations had been occupied by the 16th of May, when the work was closed. The statistics are as follows:

Signals erected	19
Stations occupied	18
Angles measured	117
Number of observations	2,600

Mr. Fairfield's measurements with the theodolite determined the positions of twenty-two points. On completing the field-work and computations, a sketch showing the triangles and the contiguous shore-lines of the river, with a list giving the exact lengths of the triangle sides, was furnished to General Foster.

The existing maps of the Neuse river being very imperfect, the triangulation which was executed by Mr. Fairfield had been much needed. The demands on the survey in other sections did not admit of the assignment of a party to sound out the river at this time.

Mr. Horace Anderson aided in the triangulation, and accompanied Assistant Fairfield in duty which has been noticed under Section I in this report.

Service in the military department of North Carolina—Besides the regular work of the survey accomplished this season in the section, and noticed under the preceding head, the circumstances of the military service in North Carolina at the opening of the present year led to a very effective co-operation by Assistant P. C. F. West and Sub-Assistant Cleveland Rockwell with the forces under command of Major General Foster. Mr. Rockwell reached Newbern on the 2d of February, just after the departure of the general. On being advised by Brigadier General Prince of the need of a topographical survey of the approaches to the city, that work was immediately commenced, and was for a short time steadily prosecuted. Frequent calls, however, were made in the following two months for Mr. Rockwell's services in reconnaissance, and for the compilation of such maps as rapid tours would afford. On the 16th of March he was ordered to make a thorough reconnaissance of the roads and of the country generally on the northern side of the Neuse. For this purpose the 85th regiment New York volunteers, Colonel Belknap, was assigned as escort. Mr. Rockwell was engaged in this service until the 1st of April, and brought back with him material for a reliable map of the district within a circuit of ten to twelve miles. Some time after, when General Foster was still at Washington, on the Tar river, and during the siege of that place, Mr. Rockwell accompanied General Prince to the Tar river at his request, to reconnoitre the battery of the enemy at Hill's Point. The garrison of Washington was relieved soon after by a force led by General Foster in person. Under his direction Mr. Rockwell accompanied the detachment and completed the map of the road between the besieged town and Newbern. At Washington he sketched the ground held by the enemy, their batteries and field-works, and also the lines of defence erected to repel the attack, and the country adjoining, and furnished copies of the map to General Foster and General Prince.

Early in May Sub-Assistant Rockwell was sent on a reconnaissance with four companies of cavalry, with direction to pass through Pollockville, Young's Cross-roads, Pelatier's Mills, and by White Oak river, to return by way of Newport barracks. Lieutenant Colonel Lewis, of the 3d regiment New York cavalry, was in command of the escort. One of the enemy's mounted videttes was captured at Young's Cross-roads. On learning soon after that a company of rebel cavalry had passed down the same road, the purpose of the expedition was changed to a pursuit. The enemy was taken by surprise at Pelatier's Mills. Sub-Assistant Rockwell rode in the cavalry charge, the result of which was the capture of thirteen prisoners with their arms, and thirty-five horses with their accoutrements. Though the rapidity of the march on the enemy's camp did not admit of gathering local information, Mr. Rockwell noted that the command had passed over the more elevated part of a great swampy track between the Trent and White Oak rivers, and that the railroad to Beaufort could be approached from the southward for a stretch of about twenty-seven miles, only by a few swampy roads branching from the main road which runs along White Oak river. Mr. Rockwell had previously added to his map of the upper side of the Neuse by attending the command of General Spinola in a movement towards Washington before it was relieved. In June he was relieved from duty in this section and assigned to service in Section I. The sense of Major General Foster of the aid afforded in his department by the parties sent there is given in a communication which he addressed to me on the 1st of June, a copy of which will be found in the Appendix, (No. 26.)

Sub-Assistant Rockwell took up work in Section I at the opening of the summer season, and after an interval in July employed in surveys for defences at Philadelphia, returned to the coast of Maine, and was there engaged until the close of the surveying year. He is now on duty in the military department of Virginia and North Carolina.

Sub-Assistant P. C. F. West reported to Major General Foster on the 18th of March, but a movement being then on foot in the military department, there was no immediate occasion for his assignment to duty in reconnaissance outside of the ground held by the United States forces. He therefore joined the party of Assistant Fairfield, and assisted in the triangulation of the Neuse river, as already stated. While this work was advancing, Mr. West was called on for a reconnaissance of Wilkinson's Point, near the mouth of the Neuse, and for an examination of the northeast bank of the river up to Fort Anderson, opposite to Newbern. This was done before the garrison at Washington, North Carolina, was relieved from the siege of that post by the rebel forces in April. Soon after the return of General Foster to Newbern, Sub-Assistant West was directed to map the country along the railroad above Morehead City, and, if practicable, a stretch of four miles on each side of it, but other calls from the military authorities intervening, but little progress was made in this special survey. He continued in general reconnaissance duty until relieved by General Foster.

At the end of June, and beginning of July, Mr. West was in active military duty on the staff of General

W. F. Smith, in the vicinity of Carlisle, Pennsylvania. He was, later in the season, engaged in topography near Philadelphia, but the application of General Smith for his services being renewed in September, he reported to that commander for duty at Chattanooga, Tennessee.

At the request of Admiral Lee, a party has been assigned to work under his orders in Albemarle sound.

SECTION V.

FROM CAPE FEAR, N. C., TO ST. MARY'S RIVER, GEORGIA, INCLUDING THE COAST OF PART OF NORTH CAROLINA, AND THE COAST OF SOUTH CAROLINA AND GEORGIA.

In three localities of this section the regular work of the survey has been advanced by the assignment of three parties. One has made a complete hydrographic resurvey of the channels into Port Royal sound, and a special survey inside for the use of the blockading squadron. The northern part of Hilton Head island, with the defences and structures put up in 1862, has been surveyed and mapped. The same party mapped the part of Beaufort island now occupied by field works, and on the coast of Georgia made a topographical survey of the shores of Wassaw sound. This work was extended to the limits usual on the coast of Georgia, though the presence of the insurgents in some places rendered its prosecution somewhat dangerous. A considerable part of the hydrography of the sound was executed by a third party.

In addition to the regular work just alluded to, the party acting more immediately under the orders of Admiral DuPont, made special reconnaissances which will be described in this chapter, and performed also essential duties connected with the light-house service between Winyah bay and the mouth of St. John's river. Amongst these was the sounding of Charleston bar in advance of the attack made upon the rebel defences in April. General despatch service was rendered by this party in addition to the regular work to be mentioned in the body of this chapter. The testimony of Flag-Officer DuPont has been explicit in regard to the assistance offered in the operations of the blockading squadron, by the assignment of the party to its usual site of work. Appendix No. 26 contains also a testimonial from Major General Foster for incidental service rendered, in bringing into port one of his transports which had been disabled and was in danger of falling into the hands of the enemy in the vicinity of Winyah bay.

The arrangements for work in the section were substantially the same as were made last year, the larger party of the former season being divided into three, all working as before, with three vessels. The parties returned north in June. One of them was reassigned for the survey of Charleston bar in the beginning of October, and the others are now about to follow.

Office-work.—The drawing and engraving of sheet No. III, of a general chart of the Atlantic coast, Cape Hatteras to Mosquito inlet, and of Calibogue sound and Skull creek, forming the inland passage between Tybee roads and Port Royal sound, as a preliminary chart have been completed. The drawing of coast chart No. 53, Rattlesnake shoals to St. Helena sound, has been continued, and the engraving of the same commenced. Progress has been made in the drawing and engraving of a chart of Port Royal sound, with Beaufort, Broad, and Chechessee rivers, and of Wassaw sound. A map of the coast region of South Carolina and Georgia, from Bull's bay to Ossabaw sound, and a map of James island and Stono river, have been engraved on stone, and a map and chart of Charleston harbor has been lithographed on the scale of the original surveys for use in the siege operations.

Hydrographic reconnaissance in Winyah bay, S. C.—This was the first service called for by Admiral DuPont after the arrival of the party of Assistant Boutelle at Port Royal, on the 27th of November. The steamer Bibb sailed for Winyah bay on the 1st of December. Mr. Boutelle examined the Bottle channel, and reported it as being then the best entrance to that harbor, but the stormy east wind that prevailed during the limited time given to the work allowed only a partial reconnaissance. The party returned to Port Royal on the 6th. An additional buoy was set for leading through the Bottle channel into Winyah bay, and a tracing showing the soundings was forwarded to the office. Sailing directions for the entrance of Georgetown harbor were at once furnished to the admiral.

On the 12th of January, and under the order of the admiral, Assistant Boutelle, with his party, in the steamer Bibb, accompanied the engineer who had been detailed by the Light-house Board to examine and report in reference to the aids for navigation between Port Royal and the St. John's river, Florida. The party had previously delivered important despatches to Captain Godon, the senior naval officer off Charleston, and on the return had, by order of the admiral, called at Stono entrance and at North Edisto.

On the 1st of February the Bibb delivered despatches and ordnance stores at Georgetown entrance, South Carolina. Learning there that the army steamer Pilot Boy, of General Foster's command, had burst her boilers, and was at anchor near the hostile shore, about twenty miles northeast of the mouth of Winyah bay, Mr. Boutelle proceeded at once to her anchorage, took the vessel in tow, and delivered her at Hilton Head. This service was formally acknowledged in a letter addressed to him by order of General Foster, a copy of which will be found in the Appendix, (No. 26.)

Reconnaissance of Charleston harbor, S. C.—On the 30th of January, under special orders from Admiral DuPont, the steamer Bibb was anchored inside of the stations occupied by the blockading vessels, near the bar of the old ship channel of Charleston harbor. Assistant Boutelle then proceeded in with his party in boats, and returned on two nights without discovery, after accomplishing the service required. The results were at once made known to the flag-officer, and were adopted in passing in the iron-clads for the attack which was made early in April upon Fort Sumter. This examination, though it was made at night, satisfied Mr. Boutelle that the "Pumpkin Hill" channel was the best, and that view was confirmed by the soundings made on the bar on the 5th of April. Mr. Platt and Sub-Assistant Bradford, in the steamer Keokuk, assisted in placing the buoys just previous to the attack, and the party in the Bibb kept the bar lighted at night to facilitate the movements of the gunboats. The sailing lines then chosen differ very little from those drawn by Mr. Boutelle as the result of the night reconnaissance at the end of January.

His special knowledge in regard to the harbor of South Carolina, and his fitness for the service being unquestionable, he had been much employed in piloting. In that line of duty he had taken the frigate Wabash, and all the heavy vessels of the South Atlantic blockading squadron into Port Royal in the autumn of 1861, and detachments from that squadron over the bars of all the Atlantic harbors between Charleston and St. Augustine.

Mr. Boutelle's offer to pilot in the flagship for the attack on Fort Sumter, was declined by the admiral, on the ground that it might be attended with greater hazard than had usually attached to similar service performed for the squadron.

Mr. Robert Platt, the executive officer of the Bibb, was permitted to pilot the Weehawken, (monitor,) Captain John Rodgers, to the position selected for trying the effect of her guns on Fort Sumter. Mr. Platt had been long attached to the Coast Survey, and was known as an excellent pilot. After the attack at Charleston entrance he was retained by Admiral DuPont for further service in the squadron.

On the 13th of April the Bibb returned to Port Royal, taking with her in tow from Charleston bar the monitor Montauk. It was then found that the state of the Bibb's engine would not permit the use of the vessel in active co-operation with the naval squadron. With the consent of the admiral, therefore, the party resumed the ordinary duties of the survey.

From copies of several communications of similar tenor from Admiral DuPont, which were sent to me with the report of Assistant Boutelle, I have placed in the Appendix (No. 26) the one which refers to the sounding of the channels of Charleston harbor.

During the action at Fort Sumter Mr. Platt was knocked down in the turret of the Weehawken, and was temporarily disabled by the breaking of a bolt under the concussion of a heavy shot from one of the rebel batteries. He was again at his post before the withdrawal of the vessel. The mention made of his conduct by Captain Rodgers, of the Weehawken, in his report to the admiral, led to his appointment as acting master in the navy.

It was clearly ascertained by Mr. Boutelle, while working, in December, 1862, on the coast of South Carolina, that the rebel privateer which was sunk by a broadside from the United States frigate St. Lawrence, early in the course of the war, was the schooner Petrel, belonging to the Coast Survey. The particulars of her seizure by the State authorities of South Carolina, in December, 1860, were given in my annual report for 1861.

The small steam tender Fire Fly, also belonging to the Survey, and seized at Charleston in December, 1860, was used for some time by the insurgents on the Savannah river. In October, 1862, she accidentally took fire at her wharf in Savannah and was consumed. This fact was communicated to Mr. Boutelle by one of the Savannah pilots, who came within the federal lines in the following month.

Hydrography of Port Royal sound, S. C.—Assistant Boutelle, with a party in the steamer Bibb, sailed from New York on the 23d of November, 1862, and arrived at Port Royal on the 27th, where he reported to Admiral DuPont for duty similar to that which had employed the Coast Survey parties in the preceding year.

After a short visit, under orders, to Winyah bay, from which the Bibb returned on the 6th of December,

a survey was made of a site at Bay Point, suitable for a coaling station for the navy. This work included the determination of the depth to which piles must be driven to give stability to the wharf. A comprehensive report was made to the flag-officer on the 12th on the topographical and hydrographic facilities of the site, accompanied by a plan for the structures and full details respecting the current at Bay Point, the rise and fall of tide, the location of timber, saw-mills, and the like. The topography was executed by Mr. W. W. Harding. Soundings in the vicinity of the proposed wharf were carried out to a depth of five fathoms.

Mr. Boutelle at the same time presented a plan for lighting and marking the southeast channel into Port Royal, suggested by the use of elevated platforms which he had found necessary in the primary triangulation of the coast of South Carolina.

Before completing the survey of the coaling station, it was found that the southeast channel had shifted somewhat to the southward in the course of the year. This change, though nowhere considerable, required a transfer of the buoys, and that duty was at once taken up. As a preliminary, soundings were commenced on Martin's Industry shoal on the 12th of December. The pressure tide-gauge, invented by Captain (now Major) E. B. Hunt, United States engineers, was at the same time put in use at the light-ship. Mr. Boutelle observed that the depth of the south channel into Port Royal had somewhat increased during the year. The examination included part of the Gaskin Bank, and, generally, the approaches to Port Royal entrance. Bad weather hindered progress somewhat, but the work was pushed by the use of the steamer and two boats, and was rapidly advanced in January. While thus engaged, assistance was also rendered in forwarding to her destination, for duty on the Florida reef, the steamer Vixen, which needed coal.

The elastic bag of the pressure tide-gauge at Martin's Industry light-ship was sunk in nine fathoms water, with about one hundred and fifty feet of flexible tube attached. On the 23d of December the registering dial of the instrument indicated a tidal rise of nine feet and a half.

Frequent calls for the services of the Bibb in delivering despatches, and in other duties incident to the naval service, protracted the completion of the hydrography at the approaches to Port Royal entrance. It was at the same time known that important changes had taken place in the depth at some places, and that a revision of the chart was very desirable for the use of the deep draught-vessels of the squadron. At the end of January, and in the beginning of April, the party was again recalled to Charleston entrance, as has been already mentioned. Returning to Port Royal after the attack of the 7th of April, Mr. Boutelle surveyed and buoyed the northeast channel and reported sailing directions. The concluding work off Port Royal was the sounding and setting buoys in the channel west of Fishing Rip, and the marking by buoys of the middle ground of the harbor and of other dangerous spots in the approaches. The statistics of the hydrography are here appended:

Miles run in sounding	1,409
Casts of the lead	57,000

Besides the tide-gauge at the light-ship, Assistant Boutelle had constant observations made at Station creek. In reference to results, as bearing on the reduction of the daily soundings to "mean low water," he remarks: "The difference of time and of rise and fall of the tide at these two stations (about twelve miles apart) are frequently very great, and apparently depend much upon the state of the wind and sea. The mean difference in time is about one hour."

The duties in connexion with the light-houses of this district which were performed by Mr. Boutelle occupied much of his time in the latter part of the season.

Sub-Assistant J. S. Bradford, Mr. W. W. Harding, and Mr. P. F. Frazer, jr., were attached to the party in the steamer Bibb. Assistant Boutelle returned to New York with the vessel on the 17th of June. He afterwards volunteered, under my immediate direction, at Philadelphia, at the end of that month, to meet the emergency which seemed to be threatened by the invasion of the State of Pennsylvania.

Topography of parts of Hilton Head and Beaufort island, S. C.—On his return from the lower part of this section in April, Sub-Assistant W. H. Dennis stopped at Port Royal with his plane-table party in the schooner Caswell. The time of his stay was occupied in making a resurvey of the northern end of Hilton Head island, to show the forts, batteries, and government buildings which have been erected since the regular plane-table survey of Port Royal entrance. The batteries on Beaufort island were also determined in position, and marked on a traced copy of the plane-table sheet. The Caswell left Port Royal on the 25th of May, and was subsequently employed in service which has been mentioned under the head of Section I.

Topography of Wassaw sound, Ga.—For this work, which would have been completed in 1861 but for the breaking out of the rebellion, arrangements were made in December, 1862. Sub-Assistant Dennis, with his

party in the schooner Caswell, reached Port Royal on the 3d of January, and after reporting to Admiral DuPont, proceeded to Wassaw and took up the plane-table survey. A party was at the same time assigned to make soundings while the shore-line was being traced. Sub-Assistant Dennis was aided by Mr. R. H. Talcott. The topographical survey was continued until the increased activity on the side of the insurgents made it necessary to desist. The rebel steamer *Nashville*, destroyed by the fire of the United States gunboat Montauk, in the lower part of the Ogeechee river, and the *Fingal*, (or *Atlanta*,) since captured by the Weehawken, (monitor,) were then preparing to run out, either for the destruction of government transports or for adventures at sea. Both of the surveying parties at work in Wassaw sound closed only when notified to do so by Admiral DuPont, in consequence of the state of affairs to which I have alluded.

The sheet executed by Mr. Dennis comprises the coast of Georgia from Savannah river southward and westward to Odingsell's river. It includes the whole of Wassaw sound, and the mouths of the rivers which fall into it; the greater part of Wassaw island; Great and Little Tybee islands; part of Cabbage island, and Cockspur and Long island, in the Savannah river. From the coast line the plane-table survey was carried towards the interior at an average of from four to five miles.

Besides the discovery of a schooner which had grounded in attempting to run the blockade of Savannah river, and of which the party in the Caswell took possession and turned over to the naval authorities, the only special incident attending the work was a demonstration made by the enemy towards the capture of Mr. Talcott. In the latter part of March he camped out a few days to complete the topographical survey of Little Tybee island, having an escort of seven pickets detailed by Colonel Barton, commandant at Fort Pulaski. On the night of the 26th the pickets observed a rebel boat reconnoitring the position used by Mr. Talcott, but without discovering themselves. On the following night the surveying party was driven in by the approach of three hostile boats towards the dyke behind which they were concealed. Mr. Talcott kept his boat in Little Tybee creek, and on receiving the alarm his papers and instruments were at once moved to a place of safety. He camped for the night on the sand-hills, and in the morning returned to the Caswell, having accomplished the object sought in the separation of a few days from the party on board of the vessel.

The following are statistics of the work done this year in Wassaw sound and its dependencies:

Main shore-line traced	42	miles.
Shore-line of creeks	247	"
Outline of marsh	96	"
Roads surveyed	6	"
Area in square miles	33	

The plane-table sheet containing this work was inked and turned in at the office early in April. The party then returned to Port Royal, and there made a supplementary survey, which has been already alluded to.

Sub-Assistant Dennis and Mr. Talcott passed the working season at the north in duty in Section I. Special mention is made in the field report from Section V of the obliging kindness shown towards the party in the Caswell by Captain C. R. P. Rodgers, U. S. N., and by Colonel W. S. Barton, 48th New York volunteers, while the party was on the coast of Georgia.

Hydrography of Story's river and Station creek, S. C.—The hydrography of these and of other passages which connect the waters of St. Helena with those of Port Royal sound was taken up on the 1st of May by a party in charge of Sub-Assistant W. S. Edwards, with the schooner Arago. The result will afford very desirable facilities for the transport service in a thorough knowledge of that part of the Inland Passage of which the link between Savannah river and Port Royal sound was developed by the same party last year. Mr. Edwards was aided in this service by Mr. A. R. Fauntleroy and Mr. F. H. Dietz. The statistics of the work are as follow:

Miles run in sounding	206
Angles measured	1,084
Number of soundings	13,370

Twenty-five signals were erected and determined in position as points of reference for the soundings. The hydrography occupied the party until the 25th of May. The tides of fourteen successive days were observed and recorded for the reduction of the soundings.

After closing this work the party proceeded to New York in the Arago, and was employed during the summer in hydrographic duty in Section I. Its occupation in the early part of the season will be referred to presently in this chapter.

Assistant Edwards is now preparing to return to the blockading squadron, in order to resurvey the bar of Charleston harbor.

Hydrography of Tybee entrance, Ga.—It was incidentally noticed in the middle of December, 1862, shortly after the return to this section of the party of Assistant Boutelle, that the depth along the sailing lines at the entrance of Savannah river had decreased about two feet within the year, giving only eighteen instead of twenty feet in the channel. This was, at the time, referred to a probable movement of the channel to the southward, as had been remarked at Port Royal.

On the 2d of March Sub-Assistant Edwards, who had previously been at work in Wassaw sound, commenced an examination of Tybee roads and of the channel of the Savannah river, including the bulkhead which stretches from it across to Calibogue sound. The main channel of the river above the "wrecks" was also sounded at the request of Colonel Barton, then in command of the United States forces at Savannah entrance. This work was completed before the close of April. The statistics are as follows:

Miles run in sounding	114
Angles measured	1,172
Number of soundings	8,974

Sub-Assistant Edwards was aided in this service by Messrs. Fauntleroy and Dietz.

Forty-seven day tides were recorded by the party in the schooner Arago, for the adjustment of soundings for the manuscript chart of Savannah river entrance.

Hydrography of Wassaw sound, Ga.—With a favorable prospect that opportunity might hold for the completion of the hydrography inside of Wassaw sound, the party of Sub-Assistant Edwards was despatched with the Arago, and commenced work on the 17th of January. The hydrography was prosecuted until the 1st of March without interruption, though it was generally known that the enemy was preparing for offensive operations afloat. In consequence of this, the soundings were discontinued at the last-named date by advice of Admiral DuPont. The following statistics show the progress which had been made:

Miles run in sounding	92
Angles measured	396
Number of soundings	7,275

In the preparation for his work Mr. Edwards had set up and determined the positions of ten signals. The tides of the sound were observed during eighteen days. The shore-line for the intended chart was taken from the plane-table sheet of Sub-Assistant Dennis.

Messrs. Fauntleroy and Dietz assisted Mr. Edwards in the hydrography.

The incident already mentioned, concerning the capture of the schooner Pembroke, occurring near where the Arago was at work, a boat with the party of Mr. Edwards reached the prize a few moments after the one sent from the Caswell. After assisting to get the prize afloat, the Pembroke was delivered to Captain Scott, of the United States gunboat Marblehead.

In the latter part of the working season Sub-Assistant Edwards was engaged with his party in sounding the passages between St. Helena sound and Port Royal bay.

Hydrography of Ossabaw sound, Ga.—To render of effective use the chart of this sound, derived from the hydrography completed just previous to the breaking out of the rebellion, and the engraving of which has since been completed, Assistant Boutelle went there in April last and placed the buoys necessary to enable the naval and transport vessels to cross the bar.

SECTION VI.

FROM ST. MARY'S RIVER, GA., TO ST. JOSEPH'S BAR, FLA., INCLUDING THE EASTERN AND PART OF THE WESTERN COAST OF FLORIDA, PENINSULA, AND THE FLORIDA REEFS AND KEYS.—(SKETCH No. 13.)

The circumstances of the war have not interfered with the completion of a work of much importance in this section, the hydrography of the Florida reefs. Some additional work yet remains to be done between Key West and the Tortugas, but the soundings are now continuous from Cape Florida, along the outer sides of the keys southward and westward, to the Marquesas. The regular work has been added to, also, by the hydrography of the north entrance bar, and approaches of Charlotte harbor, the execution of which was intended by my instructions of 1860–'61. The hydrographic party was subject to the orders of Admiral

Bailey. At his request the position of the buoys of Key West harbor were examined, and sailing directions made out to suit the changes

At the request of the tax commissioners of Florida, one of the topographers, who had in previous years worked in several parts of the section, was assigned for their service. By force of circumstances only partial opportunity offered for the intended co-operation. Ample testimony as to his qualification for duty has been given in a communication from the chairman of the commission. An extract from the same letter, relative to engineer duty performed at Fernandina, will be found in the notice of field-work in this chapter.

OFFICE-WORK.—The drawing and engraving of general coast chart No. X, Straits of Florida, and of coast chart No. 71, Newfound Harbor key to Boca Grande key, have been completed. The drawing of sheet No. IV, of a general chart of the Atlantic coast from Mosquito inlet to Key West, including the Bahama Banks and Straits of Florida, has been completed, and the engraving of the same commenced. A new edition of the chart of Key West harbor, with improved sailing directions, has been lithographed, and the preliminary chart of the northeastern part of the Gulf of Mexico in two sheets (scale $\frac{1}{600000}$) has been engraved on stone.

Service with tax commissioners in Florida.—The assignment of Sub-Assistant F. W. Dorr to duty in connexion with the Florida tax commission was alluded to in my report of last year. He left New York with the commissioners on the 21st of December, and after staying a few days at Port Royal, arrived with them at Fernandina on the 4th of January. Here it was expected that his services as topographer might be called for in aiding the labors of the commission, but an accurate plan of the city being found, it was necessary only to make transfers, and compile a map for the use of the members. Later in January, Mr. Dorr made a reconnaissance of the middle and lower part of Amelia island, at the request of the commander of the post, Colonel Hawley, of the seventh Connecticut volunteers.

Early in February Sub-Assistant Dorr accompanied one of the commissioners to St. Augustine, in the hope of finding official maps and records of the Florida land office that might further the object of the commission, but on ascertaining that all such material had been sent to Tallahassee before the occupation of St. Augustine by the forces of the government, the search was discontinued. With the same object Mr. Dorr went to Key West in one of the public vessels, and was on the return passage landed at Hilton Head, from whence he rejoined the commissioners on the 7th of March, at Fernandina. Jacksonville being reoccupied a few days after, Mr. Dorr, by request, accompanied the sixth regiment of Connecticut volunteers to superintend the construction of some earthworks for the defence of the place, additional to those constructed by the troops under the command of Colonel Higginson. The intended fortification was nearly completed when an emergency arose which called for the services of all the forces then in the vicinity, and Jacksonville was in consequence evacuated. Mr. Dorr again reached Fernandina at the end of March. In the following month he was assigned to duty at St. Augustine, and was several weeks occupied in compiling a map of that city for the use of the commissioners. He reported to them at Fernandina on the 7th of May, and, as they had previously resolved to defer further operations until autumn, was then relieved from duty.

During the summer Mr. Dorr was actively engaged in plane-table duty in Section I, and was in readiness to rejoin the commissioners according to the understanding expressed by them in the order which relieved him from duty in Section VI. In October, however, a pressing call for such duty as he had been accustomed to render, in connexion with military operations, led to his assignment to service with the army of General Grant, near Chattanooga.

The chairman of the tax commission for Florida thus concludes a letter which he addressed to me in May last, after Mr. Dorr had been relieved for the season: "Mr. Dorr unhesitatingly volunteered to encounter the hazard of arms, without rank or emolument, to plan and superintend the construction of the defences of Jacksonville, prompted solely by a desire to serve his government. I deem it fortunate for the safety of the post that an officer of the Coast Survey was at hand, willing to undertake a difficult and dangerous trust, and so competent to its execution as Mr. Dorr proved himself to be."

Hydrography of the Florida reefs.—For the completion of the hydrography outside of the line of the Florida reefs, a party was assigned to the charge of Acting Assistant Edward Cordell, and reached Key West on the 4th of January, in the steamer Vixen. Of the two gaps that remained to be sounded, that below Key Rodriguez (see Sketch No. 13) extended about fifteen miles to the southward and westward; the other embraced only about ten square miles off the south shore of Boca Chica island, near Key West. The steamer started in a few days after her arrival, to commence work in the larger interval, but was met by a southeast gale, which somewhat strained the vessel before the anchorage was reached, off Indian key. This and the

boisterous weather of the following week caused an accident to the machinery, making it impracticable to begin the soundings until the 21st. Sub-Assistant C. T. Iardella was attached to the party, and acted as pilot of the Vixen. The hydrography of this part of the reef was completed by the 1st of April. A full development was made of the outer reef between the previous work of Captain T. A. Craven and that of last year by Assistant Davidson, including also the shoals, and the channels inside of them. Lines of soundings were carried out two miles to seaward from the outer reef, and to a depth of forty fathoms, and the approaches from the gulf stream were carefully examined.

With reference to the method pursued in closing the hydrography of this part of the section, Mr. Cordell remarks: "In prosecuting the work I endeavored to adhere as much as practicable to the admirable system adopted by Captain Craven in the survey of other parts of the reef. The soundings were extended out rather more than six nautical miles from the outer shore of the keys, and the sheets containing them embrace the SW. end of French reef, Pickle reef, Conch and Little Conch, Davis's reef, Crocus reef, and the bank north of Alligator reef." Along this line, the sheet now in the office exhibits a stretch of about fifteen miles, of which the main peculiarities are described in the Appendix No. 8, in extracts from the report of Mr. Cordell.

In the early part of May, the party in the Vixen sounded out the unfinished space at the south end of Boca Chica, and connected the work of Captain John Rodgers with that of Captain Craven. This sheet with the one already mentioned furnishes material for completing the chart of the Florida reef, the engraving of which has been waiting the execution of the final hydrography. The soundings added by Mr. Cordell extend from Boca Chica channel, along the south side of the island, to Geiger's signal. A number of coral heads running in a line nearly parallel with the shore, and about half a mile from it, was closely examined, and their positions established.

The effectiveness of the party in the steamer Vixen was secured by the assignment of five aids, several of whom had previous experience in hydrographic work. These were Messrs. T. C. Bowie, L. L. Nicholson, L. A. Sengteller, H. M. DeWees, and A. M. Wetherill. Besides being engaged in the work which will be next noticed, all of them have been since employed in duty on other parts of the Atlantic coast.

The following statistics are derived from the reports of Mr. Cordell on closing the reef hydrography:

Miles run in sounding	1,067
Angles taken	4,263
Number of soundings	30,339
Area sounded out, (square miles)	114

The charts of the two localities are now on file, with records in duplicate of the angles taken, and registers of tidal observations.

In February Rear-Admiral Bailey, to whom Mr. Cordell had reported, directed that the position of the buoys for entering the harbor of Key West should be examined, it having been suggested by the pilots that one or more of them might be more advantageously placed. This duty was discharged at once, and the results of the examination communicated to the flag-officer, with sailing directions. Only one buoy, that on the "west triangle," was moved, and was set about thirty yards from its former position in twenty feet water. The "Western Head," to which attention had been called in the instructions to Mr. Cordell, was examined, and is thus mentioned in his report to Admiral Bailey: "About one-third of a mile S.SW. of Mississippi buoy is the 'Western Head,' with eighteeen feet of water upon it; and three hundred yards to the northward and westward of it there is another head of rock, with only sixteen feet. These heads being dangerous to vessels of heavy draught beating through the channel, a third-class can-buoy, painted black, was placed on the one first named. Black buoy No. 3 was placed on the middle ground, in sixteen feet water."

The report of Mr. Cordell was accompanied by a map showing the position of the buoys as now established, and notes giving the bearings from each of them.

"Mr. Whalton, the light-house inspector of the district, placed the schooner Florida at our disposal for carrying out Admiral Bailey's instructions, the steamer Vixen being at the time disabled. He also furnished the buoys, and assisted in placing them."

In the course of the winter, Assistant George Davidson, who had prosecuted the reef hydrography last year, completed and turned in his chart, with duplicate records of the soundings, angles, and tidal observations. He has also forwarded a view of Indian key, drawn under his direction by Mr. W. B. McMurtrie, which will be engraved for the chart of that part of the reef.

Hydrography of Charlotte harbor.—The circumstances which have delayed the completion of the survey, and the issue of a chart of this harbor, were explained in my report for 1861, timely provision having been made in all the necessary preliminaries for the work.

In April last the approaches and bar, the entrance and the anchorage inside of Charlotte harbor, were sounded by Mr. Cordell with the working party of the steamer Vixen. The following is an extract from his report: "The outer bar, and channel leading into the bay, were thoroughly sounded out, and a full development made of the banks on either side. Soundings were carried out six miles from shore into seven fathoms water, and extended over a space of about nine miles in length abreast of the entrance, including rather more than four miles of the shore of La Costa island to the southward, and as much of Gasparilla island to the northward of the entrance. The hydrography was extended into the Gulf of Mexico nearly three miles outside of the bar."

Mr. Cordell found that the bar gave seventeen feet of water at low tide. The capacity of the channel, and directions for entering the harbor, are stated in further extracts from his report which will be found in Appendix No. 9.

Day and night observations of the tides were made for the last twenty days of April, at the inside of the point of Boca Grande. The currents were observed at four stations in and outside of the harbor, one of them being beyond the bar, and another about midway between it and the entrance.

The statistics of the hydrographic work at Charlotte harbor are as follows:

Signals erected and determined	8
Sextant angles observed	2,102
Miles run in sounding	574
Number of soundings	11,744
Area, in square miles	66

The manuscript chart is now at the office, with duplicate records of the work in the usual form.

Soon after the return of the Vixen to New York, the party was assigned to hydrographic duty in charge of Mr. Cordell in Section I, the details of which have been stated in a previous chapter of this report. Sub-Assistant Iardella, at the close of the working season at the south, was transferred to the party of Assistant F. H. Gerdes for service which has been referred to under the head of Section I.

Tidal Observations.—The series of observations intended to be secured at Fernandina was interrupted by the breaking out of the war, as explained in my annual report for 1861. It was at first thought that the tide gauge (self-registering,) which was left there, had been destroyed, but there is now reason for believing that it was sent to Tallahassee, Florida, when the forces of the government took possession of Fernandina, in March, 1862.

SECTIONS VII, VIII, IX.

FROM ST. JOSEPH'S BAY, FLA., WESTWARD TO THE RIO GRANDE, INCLUDING PART OF THE WESTERN COAST OF FLORIDA, AND THE COAST OF ALABAMA, MISSISSIPPI, LOUISIANA, AND TEXAS.

Of the six parties sent for duty in the Gulf of Mexico, and on the Mississippi river, three were attached to the army of Major General Banks, two served with the squadron of Admiral Porter, and one was engaged near St. Louis, Missouri, in completing the survey for the defences of that city. By their labors a large addition has been made in topographical information respecting the ground passed over or occupied by the armies of the Union during the present year. Special surveys have been made of all the posts gained from the enemy, among which are included Vicksburg, Port Hudson, Arkansas Post, the vicinity of Fort Butte à la Rose, on the Atchafalaya, extended reconnaissances through the middle districts of Louisiana, reconnaissance of the Red river from the Mississippi up to Alexandria, and a special topographical survey of the western approaches to New Orleans. One of the parties has remained during the entire year, and is now engaged in service with the army division which is operating against the rebel forces in the upper part of Louisiana. The work of all of them will be referred to in more detail in subsequent parts of this chapter.

OFFICE-WORK.—The engraving of a preliminary chart of the Southwest Pass of Mississippi river has been completed, and that of coast chart No. 93, Lakes Borgne and Pontchartrain, has been executed as far as the field-work is completed. The drawing of the gulf coast chart from Key West to the Rio Grande has

been completed, and the engraving of the same has been commenced. Progress has been made in the drawing of general coast chart No. XIV, Choctawhatchee bay to the Mississippi delta, and on the engraving of coast chart No. 100, Atchafalaya bay and Cote Blanche. The preliminary chart of northwestern part of the Gulf of Mexico, in two sheets, (scale $\frac{1}{600000}$,) has been engraved on stone. A map of the vicinity of St. Louis, Missouri, and its military defences, on a large scale, has been drawn, and maps of parts of Louisiana and Mississippi, showing the fields of military operations in those States, have been lithographed.

Topographical service in Louisiana.—No question being left as to the effectiveness of co-operation by the party assigned to this military department last year, I made arrangements in December for the detail of a party of three to accompany the expedition of Major General Banks. Sub-Assistant J. G. Oltmanns with that view had preceded the expedition, and after examining the astronomical station of the Coast Survey at New Orleans, he reported by letter to Lieutenant Colonel R. B. Irwin, of the staff, directing to Ship island. These details were made in compliance with the special request of the major general commanding the department, whose requisition also for maps and charts, and for unpublished local information, was met at the same time.

Mr. Charles Hosmer and Mr. S. N. Lyman were directed to aid in topographical or general field duty, and arrived in December and passed on to Baton Rouge, the former to remain for any service that might be needed in connexion with the operations of General Grover. Mr. Lyman returned to New Orleans in January, and joined the party of Sub-Assistant Oltmanns, who had taken up duty under the orders of Captain H. L. Abbott, chief topographical engineer. This first service comprised the survey of the right bank of the Mississippi abreast of New Orleans, beginning at Labrance's canal and extending to McGee's plantation, below the breastworks on the west side of the river. The map turned in to Captain Abbott, accompanied by a detailed report of the measurements and character of the various features of surface, embraces fifteen and a half square miles. It shows within that area every road, footpath, canal, bayou, etc., leading either from the levee or from the railroad to the Cypress swamps, or in other directions. Mr. Lyman aided in this survey. Several reconnaissances were made in February, and among others an examination in conjunction with Lieutenant Loring, of the staff of Brigadier General Emory, of the water-courses which connect the Atchafalaya, the Red river, and the Mississippi. This was accomplished by means of the United States gunboat Kinsman. Maps and tracings had fortunately been made, as well as a preliminary survey of the Atchafalaya river, before the 25th, in the night of which the Kinsman snagged and sunk in deep water. By this accident Sub-Assistant Oltmanns and Mr. Lyman lost all that they had taken with them when they set out for duty in the section.

In March Mr. Lyman reported to Major D. C. Houston at Baton Rouge, and, under his direction and that of Lieutenant Harwood, made a survey for the defences along the southern boundary of the city, and rendered assistance in constructing the fortifications. While these were in progress, Sub-Assistant Oltmanns engaged in such local surveys and reconnaissances in the neighborhood of Baton Rouge as were called for by the direct orders of General Banks, and in conjunction with Lieutenant Harwood, of the topographical engineers, assisted in all the reconnaissances between that post and Port Hudson. At the close of March he was reassigned to duty in the fleet, and in connexion with General Weitzel's command at Berwyck bay, and served as engineer and topographer. Mr. Lyman meanwhile had completed the service assigned by Major Houston at Baton Rouge, and in the latter part of April returned to New Orleans to await further orders. On being relieved by Major Houston he returned north, and was employed during the summer in my own party in Section I.

Mr. Oltmanns joined the staff of Brigadier General Weitzel at Bayou Bœuff, made several reconnaissances in advance, and built some of the bridges necessary for the march of the division on the road to Brashear city. When the greater part of the army had passed Berwyck bay, he went in company with Lieutenant Harwood, on the gunboat Clifton, to attend the division under command of General Grover, by whom Mr. Oltmanns' personal knowledge of the country back of Bayou Teche was thought to be of special value. He was present during the short but severe engagement at Irish Bend, and thence proceeded in advance of the army beyond New Iberia, making such sketches and reconnaissances as were desired. A naval expedition was here determined upon to assault Fort Butte à la Rose, and to open the Atchafalaya river throughout its course. Being well acquainted with the locality of the fort and vicinity, Mr. Oltmanns was attached to the expedition. The Clifton being disabled in the successful attack which followed, he went on board of the Estrella at the request of Commander A. P. Cooke, of that vessel. A few days after, the Estrella pushed through the Atchafalaya to Red river, and then communicated with Admiral Farragut. The

Arizona accompanied, and was followed on the 4th of May by the Albatross. The three vessels passed on up the Red river without opposition as far as Fort DeRussy, at Gordon's Landing. Two of the gunboats of the enemy were engaged here, the result of which was the evacuation of the rebel forts; but a strong raft across the river resisted the passage of the small vessels that had gone in the advance. The arrival of Admiral D. D. Porter with several iron-clads and rams at once opened the river as far as Alexandria, Louisiana. Mr. Oltmanns employed the time on board of the Estrella in making a reconnaissance map of Red river from its mouth, for the use of the fleet. A copy of this map, and of that which he had made of the vicinity of Fort Butte à la Rose, were sent to the office, and, with other material of special value for the purpose, were used in the compilation of lithographed sketches of this military department. Mr. Oltmanns also furnished a reconnaissance map with soundings through Grand lake and the waters connecting with it on the north, and plans of the forts which were taken from the enemy.

After the surrender of Port Hudson to the forces of Major General Banks, Mr. Oltmanns, who had given his services in the approaches to that city, returned to New Orleans and endeavored to arrange for the triangulation of the Mississippi river between New Orleans and Fort Jackson. This being found impracticable at the time, he returned and made a complete topographical survey of the vicinity of Port Hudson, showing as well the defensive works as the approaches to them. The original sheet of this work was delivered to the military authorities at Port Hudson. Returning to New Orleans on the 4th of September, Mr. Oltmanns was at once assigned to duty with the army division intended to operate above Sabine Pass, and at that place he witnessed the destruction of the small steamer Sachem, which had been formerly in Coast Survey service, and during part of the previous season under his charge in the reconnaissance of Pearl river. Ten days after the return from Sabine Pass he reported to Major General Franklin, and started with the land forces for the western part of Louisiana.

Sub-Assistant Charles Hosmer was detached from duty with the left grand division of the army of the Potomac on the 27th of November, 1862, and proceeding under orders, reported to the chief of General Banks's staff, in New York, on the 1st of December, for duty in the department of the gulf. He was intimately acquainted with a large part of the coast of Texas, and his assignment was made with reference to the possibility of its reoccupation by the government forces. Mr. Hosmer reached New Orleans on the 14th, and a few days after reported to General Grover at Baton Rouge. There a plane-table survey was made of the ground inside of the picket lines, including the town and the defensive earthworks. Mr. Lyman aided in this duty, and after its completion was transferred to the party of Sub-Assistant Oltmanns, as already stated.

In the latter part of January Mr. Hosmer reported to Captain Abbott at New Orleans, and assisted in making reconnaissance maps of the vicinity of that city in the direction towards Lake Pontchartrain. Under the orders of Major Houston he also determined points with the plane-table around Fort Jackson and Fort St. Philip, in February, for the range in artillery practice. The following month was passed at Pensacola, in the expectation that arrangements there set on foot would have issued in the sending of a force to the coast of Texas, which Mr. Hosmer had made preparations to accompany. The design not being carried out, he returned to New Orleans on the 25th of March, and early in April again reported to General Grover at Bayou Bœuff, and accompanied his staff through the Teche campaign. On the route, there being no occasion for the use of the plane-table, Mr. Hosmer assisted in directing the building of bridges, and in such other service as would facilitate the advance of the army. During the movement up the Teche, and at the battle of Irish Bend, he aided in delivering the orders of the general. From thence on he continued with the division of General Grover to Thompson's plantation, seventeen miles below Alexandria, and with the staff visited that town on the 9th of May. No call arising in this part of the campaign for special surveys, he returned with the forces to Semmesport, and on the following day proceeded to New Orleans. A few days after he took passage for New York, and arrived there on the 2d of June. Mr. Hosmer has since been employed in Section I, but is now on his way to rejoin the army of General Banks.

Services connected with the naval and military operations against Vicksburg, Miss.—The field which opened last winter for the employ of topographers specially qualified by practice in army and navy movements, induced me to place at the disposal of Rear-Admiral David D. Porter the services of a party under the direction of Assistant F. H. Gerdes, who had acted under the orders of the admiral in similar duty in the reduction of Forts Jackson and St. Philip in the spring of 1862.

Sub-Assistant Clarence Fendall and Mr. Alexander Strausz reported for duty at Cairo, Illinois, on the 27th of November. Sub-Assistant R. E. Halter arrived on the 5th of December, but being taken seriously ill before the close of that month, was detached from the party in Yazoo river. Mr. Fendall had been

assigned to quarters on the flag-ship (Black Hawk,) and was fully employed in compiling maps of the Yazoo region, and in supplying duplicates so as to meet the needs of both the land and naval forces.

On the 9th of December Mr. Strausz was sent from Cairo, with the gunboat Tyler, to sketch as much as possible of the topography of the banks of the Yazoo. The gunboat went up that river on the 23d. Five miles from the mouth she encountered a heavy fire of musketry from both shores, but kept on up during the day, and anchored for the night. Next day the survey of the banks was resumed and completed for the purpose then held in view by General Sherman and Admiral Porter, though the enemy, as before, continued to annoy the vessel. On Christmas day, while Mr. Strausz was sketching from the cabin on deck, a bullet from the enemy on shore struck the timber but a few inches from his head. The map which he brought back to the admiral, and which was immediately duplicated for use, proved to be a preliminary means for the attack made by the land forces on the defences northeast of Vicksburg in the latter part of December. In a communication addressed to me early in January Admiral Porter thus alludes to the nature of the service in the Yazoo: "During the ascent of the Yazoo river, and while engaged in taking up torpedoes, our passage was contested at every step by two or three thousand riflemen in pits, and behind levees, so protected that our guns could not hurt them. The vessels were much cut up, the rifle-balls going through and through the light upper works. Mr. Strausz accompanied the expedition, and while under the enemy's fire produced a good chart of the river and back country, with which we have made our advances." The following extract shows not less clearly the estimation of that energetic and practical commander as to the bearing of special practice in topography in the attack of places very difficult of approach: "Mr. Strausz and Mr. Fendall have rendered themselves extremely useful to me in compiling maps for the use of the army and navy and making surveys of the field of operations before Vicksburg. I sent Mr. Strausz down in a vessel near the front of the city to make plans and take sketches of the batteries, which he did to my satisfaction, giving us information that we have not possessed before, and showing the impracticability of attacking Vicksburg by water alone.

"Both of them are very assiduous in making maps for future use. They are now engaged on one of the Arkansas, where we intend striking a blow before returning to Vicksburg, the water being still too low to operate there with any hope of success." The important capture of Fort Hindman and Arkansas Post, here foreshadowed, took place a few days after the date of the letter from which these extracts have been taken. Just previous to the attack Mr. Strausz, by order of the admiral, accompanied a file of marines to ascertain the precise location of the rifle-pits in front of the rebel works, and, in conjunction with Mr. Fendall, surveyed and furnished a map of the vicinity of the post after its capture. Of the sketches which up to this time had been traced to show the approaches of Vicksburg, calls for more than thirty copies made on Mr. Fendall alone had been promptly met. Others were supplied by Mr. Strausz. The topography of the approaches to that stronghold was pushed steadily after the 20th of January, and at one point to within six hundred yards of the batteries, or about three miles beyond the pickets of our own forces. A guard accompanied the topographers, and on one occasion made prisoner of a rebel officer who had taken means to capture Mr. Fendall and his plane-table. The work done by him in February comprised the survey of the peninsula opposite to Vicksburg, and the town front of the Mississippi, with the positions of the several defensive works. From tracings sent to the office a lithographic sketch of the vicinity was issued soon after. The use of a boat not being always allowed by the exigencies of the naval service, the survey of the western approaches of the city was conducted under many difficulties and privations. The tug sent down near the middle of February, and which Mr. Fendall accompanied to establish the ranges, if places were selected for the use of mortars, narrowly escaped the heavy shot. It was found that mortars could not be brought within four thousand yards of the enemy's works without more than ordinary exposure to damage from the hostile fire.

At this period of the naval and military operations in the vicinity of Vicksburg Admiral Porter judged it expedient to have the services of a photographer for taking views of places that might be reached, but that could not be permanently held in the further reconnaissances that might be necessary. Acting Volunteer Lieutenant Julius Kroehl was sent to him by the Navy Department after taking practice in the photograph division of the Coast Survey office. Mr. Kroehl had been on duty in the South Atlantic blockading squadron, and by steadiness in service was well fitted for usefulness in the fleet near Vicksburg. He reported early in March, and, until opportunity offered for special duty, assisted Messrs. Strausz and Fendall. He, in conjunction with Mr. Strausz, accompanied the expedition through Steel's bayou and Deer creek, the object of which was to pass the gunboats, if practicable, into the Yazoo at a point some miles above the rebel works on Haines's Bluff. Mr. Strausz returned with a map of the entire route followed by the expedition. It is well known that the expedition was stopped within a few miles of the water-course which leads into the main river, only by insuperable natural difficulties. Immediately after its return the attention of the military and

naval authorities was given to the approach of Vicksburg from the southward, the preliminary to which was the passing of the Vicksburg batteries by the fleet of Admiral Porter on the night of the 16th of April. A movement nearly simultaneous was made with the land forces under command of Major General Grant. It is not here in place to trace the series of actions which marked the summer campaign in the western circuit of the State of Mississippi, and which terminated in the surrender of Vicksburg on the 4th of July. Messrs. Fendall and Strausz continued work until the latter part of the month, when both were unfitted for duty by illness, and were relieved by Admiral Porter from present service, with letters commendatory of their constant and effective labors. In the vicinity of Vicksburg alone the details were surveyed and mapped to cover an area of twenty square miles. Amongst these are shown in position an aggregate of eighteen miles of rifle-pits and ordinary breastworks and twenty-five miles of road. Twenty-eight miles of river shore-line are shown on the same sheet. The aggregate statistics of surveys made by the party at Arkansas Post, Walnut bayou, and along the Yazoo river, including the district about Haines's Bluff, embrace an area of six and a quarter square miles, within which were traced and mapped nearly eight miles of rifle-pits and batteries, about eighteen miles of road, and twenty-six and a half miles of river shore-line.

The report of Sub-Assistant Fendall closes with the following remarks: "The country surveyed is principally alluvial bottom land of about the average height of the Mississippi at its full stage. The part under cultivation is kept from the river by dikes or levees, the rest covered by a thick growth of willows or cotton wood. The irregular hills about Vicksburg and Haines's Bluff are, generally, barren of trees, and are not cultivated. They comprise the only high land to be met with below Helena. The country was favorable for plane-table surveying, the only obstacles being the current, which it was sometimes impossible to breast with a row-boat, and the pickets and scouts of the enemy, who fired on the party at every opportunity."

Topography of the military defences of St. Louis, Mo.—The survey of the environs of the city of St. Louis has been completed by the addition of the topography of Carondelet. This work was steadily prosecuted by Assistant R. M. Bache, and was closed in June. For the supplementary plane-table survey he measured a suitable base, which passes through the town, and connected with it a triangulation which determined all the points to be included in the new sheet. In conjunction with the surveys of last year the sheet turned in completes the topography of all the approaches to the city of St. Louis, the defences, roads, creeks, contour of ground, etc., and furnishes all the data that could be called for in engineering purposes. The details of the additional work comprise the following:

Shore-line of river and creeks	15¼ miles.
Roads, etc.	23½ "
Area of details, (square miles)	2½

The plane-table sheet shows the environs of Carondelet eastward to the bank of the Mississippi and westward to include the river Des Peres, in the vicinity of the town.

Assistant Bache was aided in this duty by Mr. Robert E. McMath. The subsequent labors of both have been mentioned under the head of Section II.

Tidal observations.—It was stated in my annual report for 1861 that the series of observations with a self-registering tide-gauge at Last island, (coast of Louisiana,) had been continued until the month of April of that year by Mr. H. P. Wilson, and that he had been instructed to discontinue the record and box up the instruments, there being no mail communication certain between his station and the office after that time. His compliance with the directions, and success in securing the instruments, were made known in March last in a communication addressed to me by Captain E. H. McLaflin, 21st Indiana volunteers, then acting as provost marshal of Brashear city, to whom Mr. Wilson had turned over the articles in good order. In the same letter assurance was given that the property would be safely kept until orders were received from the office. Request was promptly made that the instruments should be forwarded to Washington, if practicable; but as they have not yet arrived at the north, it is presumed that the commendable intention of the provost marshal is for the time being suspended by the exigencies of the transport service in the department of Major General Banks; or else that the instrument has been destroyed, with other property of the government, during the recent occupancy of the post by rebel forces.

SECTION X.

FROM SAN DIEGO, ON THE PACIFIC, NORTHWARD TO THE FORTY-SECOND PARALLEL, INCLUDING THE COAST OF CALIFORNIA.—(SKETCH No. 24.)

The peculiar circumstances of the currency threatened in the early part of the year to interfere with the progress of the work in this section, but fortunately the difficulties in regard to it have been in part averted. Taking into account with them the lessened appropriation for the work of the survey on the western coast, its continuance during the surveying year, and the progress made, have been subjects of gratification. The following is a summary of the operations which will be referred to further on under their respective heads:

1. Triangulation of the coast of California, east and west of Santa Barbara, and its connexion with stations on Santa Cruz and Anacapa islands, across the Santa Barbara channel.

2. The topography and hydrography of Half Moon bay, nearly completing the previously unsurveyed interval of the coast between Monterey bay and San Francisco entrance.

3. Hydrographic resurveys of Karquines strait, and of the bar in San Pablo bay, for determining questions in regard to the permanence of the channels. The party engaged in this duty also performed service for the light-house inspector, by determining the position of the buoys of San Francisco bay.

4. A thorough hydrographic development in regard to position, depth, and approaches of the Fanny Rock, near the Farallones.

5. Tidal observations continued at the permanent stations San Diego, and near San Francisco.

OFFICE-WORK.—The drawing and engraving of charts of the upper part of San Francisco bay; of the Pacific coast from Point Pinos to Bodega head; and of Bodega bay, in preliminary form, have been completed. The engraving of San Pablo bay as a finished chart has been completed. Progress has been made in drawing and engraving the charts of Tomales bay and Drake's bay. Additions have been made to plates of charts previously engraved, and to the progress sketches of the section, and a hydrographic sketch of the Fanny shoal has been published.

Triangulation.—East and west of Santa Barbara the coast triangulation of California has been extended about twenty-two miles during the past season by the party of Assistant W. E. Greenwell. Santa Cruz island, lying on the outer side of the Santa Barbara channel, as will be seen by reference to the progress sketch, (No. 24,) has been connected with the main triangulation of the coast, and with the chain of triangles going westward from Santa Barbara. The party resumed work on this part of the coast with the schooner Humboldt on the 18th of November, 1862, and at the date last received, August 27, was still in the field. The following is a summary of the statistics of work up to that date:

Signals erected	22
Stations occupied	19
Signals observed on	36
Number of observations	5,620

During part of the winter, when Assistant Greenwell was absent, Sub-Assistant Julius Kincheloe, of his party, continued its operations. The eight-inch Gambey theodolite, No. 44, was used in measuring the angles.

Topography and hydrography of Half Moon bay, Cal.—The plane-table survey of the gap in the topography of the coast below San Francisco entrance will probably be completed before the close of the present surveying year, Assistant Rodgers having transferred his party in the schooner Marcy to that locality. During July and August his party co-operated with the party of Sub-Assistant W. M. Johnson in the plane-table survey, so as to provide shore-line for the hydrographic sheet. Assistant Rodgers gave attention also to the determination of triangulation points for connecting the three plane-table sheets projected for the survey with the triangulation which passes from San Francisco bay to Monterey bay.

Hydrography.—The charge of the hydrographic work of this section devolved, by my instructions, on Assistant A. F. Rodgers on the 10th of October, 1862. Commander B. F. Sands, U. S. N., who had previously conducted the hydrographic operations, had been relieved at his own request, and was then about returning to the Atlantic coast to resume naval duties.

Mr. Rodgers as soon as possible completed the outstanding office-work of his topographical party, and forwarded to the office the plane-table sheets of Tomales bay, Point Reyes, and Bodega bay. He then

selected points in San Francisco bay and made observations on the currents, employing in that service the schooner Marcy and the hydrographic party.

The light-house inspector of the twelfth district, Commander Watson, not having at immediate command the means of making an inspection of the buoys of San Francisco bay in November last, requested that this service might be done by the party in the cutter Marcy. Assistant Rodgers, having himself previously furnished the bearings by which the buoys were placed, examined those set upon Rincon Rock, Blossom Rock, and Anita Rock, and those upon Southampton shoal, and Whiting and Invincible rocks, and found them as near the dangers intended to be marked as the nature of the ground upon which they were anchored would admit. He examined also the buoy on the shoal at the entrance of Mare Island strait, the growth of which was developed by Commander Sands in the last season of his service on the Coast Survey. This was found in the proper position.

For the spar buoy on Commission Rock, in Mare Island strait, Mr. Rodgers recommends the substitution of a spindle, the rock being bare at extreme low water, and lying directly in the channel-way to the navy yard.

For the rock known as "Little Alcatraz," off the northwest end of Alcatraz island, and awash at low tide, it was recommended that a buoy should be provided, or a spindle set to mark it permanently. This is believed to be the only rock in San Francisco bay not distinguished by a mark.

The position of the wreck of the ship "Flying Dragon," which sunk early in the year 1862 in the track of vessels passing between Shag Rock and Bird Rock, was determined by Mr. Rodgers in February, and published as a notice to mariners. The bearings for the position of the wreck are given in a copy of the notice contained in the Appendix, (No. 11.) This wreck has been lying in the channel-way for nearly a year, and, its true position being unknown, has been a cause of apprehension to pilots and others in navigating the bay.

During March and April the party in the Marcy was occupied in running test-lines of the soundings previously found in Karquines strait, and on the "bar" off Point Wilson, in San Pablo bay. It was a gratifying result that the examination of the bar this year by Assistant Rodgers, though made at an interval of six years subsequent to the survey of Commander Alden, (in 1857,) developed no change in depth, there being still twenty-two and a half feet at mean low water. The mean rise of the tide is six feet. Only a small increase in the length of the bar was found in comparing the two surveys. These results are fully confirmed by the intermediate survey of Commander Sands, in 1862, made soon after the occurrence of the heaviest floods ever known in California. The conclusion drawn from comparison of the several sheets of soundings in this locality was communicated to the honorable Secretary of the Navy in June, as favoring confidence in the stability of the channel through San Pablo bay to the navy yard at Mare island.

The survey of Karquines strait by Mr. Rodgers, compared with that of 1857, shows that quite material changes have occurred, none, however, affecting navigation, as reported on by the hydrographic inspector of the office, excepting the change in position of the middle ground. In reference to this, Captain Patterson says: "The eighteen feet, (seventeen in 1857,) middle ground was S.SE. from the steamboat wharf in 1857, but in 1863 is due south from the same wharf. It has separated into three lumps, and moved during the interval between the surveys two hundred and eighty metres to the southward and westward."

The engraved chart of Karquines strait will be revised in accordance with the results given by the survey of this year. While Assistant Rodgers was engaged in the vicinity, some additional soundings, requested by Commandant Selfridge, were made on the San Pablo side of Mare island, and furnished for use in the projected defences of the navy yard, which were deemed to be necessary at the opening of the present summer. Mr. Rodgers held his vessel and party at the disposal of the naval authorities for any emergency, and reported changes of position as the work went on, so as to be at command, if occasion should arise for his co-operation.

Fanny Rock, near the North Farallon.—To the short list of dangers to be guarded against in approaching San Francisco entrance, is now to be added the *Fanny Rock*, reported by the pilot-boat of that name. It lies outside of the limit required by the regular coast hydrography, and several miles to the northward and westward of the North Farallon. Being, as shown by Assistant Rodgers, after full examination within the present season, very small in extent, not more than ten feet long, and a foot wide across the top, and having on the ridge about twenty-two feet of water at low tide, with steep, smooth sides, it might readily be missed by the lead in the closest system of examination that could have been undertaken without some knowledge of its approximate place. The reputed position, moreover, has been found to be several miles wide of the true, the determination with only ordinary means by any single vessel not being at all practicable. From these circumstances, or from the fact that it could be dangerous only to vessels of deep draught, the

report in regard to its existence had been for several years discredited by many at San Francisco whose interests would otherwise have prompted a call for its precise determination and development. The immediate occasion was an unfortunate event that occurred on the 2d of January. The ship Noonday, drawing at least twenty-one feet, struck at 1 o'clock p. m. of that day, and within two hours sunk in forty fathoms. Her position at the time of the disaster was thought to be eight miles from the North Farallon.

Assistant Rodgers, having taken immediate steps for enabling him to fix the position of the rock or ledge, spent two days in the middle of January in running ranges, but without finding the object of search, his party being driven in by thick and stormy weather. He had, in addition to his own vessel, (the cutter Marcy,) chartered the schooner Naiad, of San Francisco, and towards the end of the month resumed the examination with more success. The result was the development of a rock of the dimensions already given, in a direction northwest, and rather more than three miles from the North Farollon. Respecting it he says: "The rock, in apparent size and shape, may be described by comparing it to a small boat bottom up. Its sides seem to be very smooth, and the lead could only be kept on it by holding the line taut, for if allowed to run, it would slip off into deep water of twenty fathoms or more in a boat's length." These particulars, and others giving the bearings of the rock from known points, (Appendix No. 10,) were fully verified by Mr. Rodgers in an examination of the locality in June. In his report acknowledgment is made of the earnest co-operation of Mr. W. G. Bloomfield, of the schooner Naiad, and of the efficient service rendered by Acting Master A. S. Hussey and Acting Masters Mates J. T. Pitman and A. F. Askin, of the cutter Marcy. Though the rock found differs in the distance assigned from the Farallones, the correspondence of the bearings, and the general search made of the locality by Assistant Rodgers, thus far satisfy the shipping interest at San Francisco that it occasioned the loss of the Noonday, and that no other danger of like character exists in its immediate vicinity. It is, however, but common prudence to admit the possibility that this present conclusion may hereafter be set aside, the sharpness of the point found, and the deep water around it not being peculiar even to this part of the coast of California.

Mr. Alexander Chase, the aid in the hydrographic party, while engaged about the Fanny Rock, made sketches of the appearance of Point Reyes and Mount St. Helens, and also of the grouping of the North and South Farallones. These have been approved by Assistant Rodgers as true and characteristic, and will be engraved for the entrance chart of San Francisco harbor.

The existence of red coral within six miles of the Farallones was discovered by one of the San Francisco pilots in January. Assistant J. S. Lawson was then in port, and having his attention drawn to the fact, took to Professor Whitney a specimen which had been brought up from a depth of twenty-eight fathoms. Similar coral is said to have been found at the bottom of Monterey bay. Further examination will be incidentally made with reference to the nautical interest attaching to this discovery. The report of Assistant Rodgers relative to his examination of the Fanny Rock, and given in the Appendix, (No. 10,) bears upon the question.

On the 8th of April Assistant George Davidson made a full and detailed report of the prospects of telegraph work across the continent for the determination of longitude between the Atlantic and Pacific stations of the Coast Survey. Full details were furnished of the route and distance traversed, the supporting poles, methods of crossing streams, forests passed through, size and kind of wire, different kind of pole insulators used, insulation, batteries, repeaters, supply of materials, and repairs. The present condition for transmitting through messages is stated, with the best time and season for longitude operations, and the prospect of connecting the different portions of the Pacific coast.

From Mr. Davidson's acquaintance with the shores and waters of the strait of Juan de Fuca, Admiralty inlet, Puget's sound, &c., he has been able to furnish, with the consent of the Treasury Department, much valuable information in relation to projected telegraph routes in that region.

Tidal observations.—Under the supervision of Captain G. H. Elliot, of the corps of engineers, U. S. A., the tidal stations at San Diego and San Francisco have been kept up with success during the present year, and no delay has occurred in the receipt of the records at the office in Washington. The self-registering gauge at the first-named station has been, as heretofore, in charge of Mr. A. Cassidy, and that at San Francisco in charge of Mr. H. E. Uhrlandt. The usual meteorological observations were also recorded by these observers, and have been regularly forwarded with the tidal records.

The third permanent tidal station of the western coast will be referred to under the head of Section XI.

SECTION XI.

FROM THE FORTY-SECOND PARALLEL, ON THE PACIFIC, TO THE NORTHWESTERN BOUNDARY OF THE UNITED STATES, INCLUDING THE COAST OF OREGON AND THAT OF WASHINGTON TERRITORY.—(SKETCH NO. 24.)

The field-work in this section, by the only party working there, has been confined to the extension of the survey of Koos bay, Oregon.

OFFICE-WORK.—The drawing and engraving of a preliminary chart of the bar of Koos bay has been completed and published, as also a preliminary chart of the entrance to Gray's harbor, Washington Territory.

Supplementary triangulation of Koos bay, Oregon.—The survey of Koos bay was resumed on the 25th of June, by the party of Assistant J. S. Lawson, with the brig Fauntleroy. The material procured in addition to that of last year, which was presented in the form of a preliminary chart of the entrance, will probably suffice for the completion of the plane-table survey and the hydrography.

Mr. C. B. Boutelle joined the party of Assistant Lawson as aid in April. The vessel returned to San Francisco on the 28th of October. Entering Koos bay in June, Mr. Lawson found at the first quarter of flood tide 16 feet of water. He reports that during the preceding winter "the channel had undergone one of its deepening changes. It still remains so that at high water twenty-two feet can be found. The ranges for entering remain very nearly the same."

In extending the triangulation, thirty-two of the signals previously used were examined and adjusted, and ten additional signals were erected. Over twenty points were determined in position, and marked for hydrographic purposes. Seventeen stations were occupied at which was used the 10-inch Gambey theodolite No. 20. Mr. Lawson reports the statistics as follows:

Objects observed on	122
Angles measured	157
Number of observations	6,970

The triangulation made this year is shown on Sketch No. 24.

Tidal observations.—The tidal station at Astoria has been, as heretofore, in the charge of Mr. L. Wilson, under the general direction of Captain G. H. Elliot, United States engineers. The meteorological observations at the station have also been recorded by Mr. Wilson with the usual care and completeness.

Besides the station in Oregon, Captain Elliot has directed the observers employed at the two stations in California, already mentioned under the head of Section X.

COAST SURVEY OFFICE.

The office in Washington has remained under the charge of Assistant J. E. Hilgard. Professor F. A. P. Barnard has discharged the duties of general assistant since June. The report of the assistant in charge (Appendix No. 14) contains the names of the persons employed, and, in summary form, the work done in each division. Referring for the particulars to that appendix, I will here briefly review the report of Assistant Hilgard, to show the organization of the office. The several divisions remain as in previous years. The lithographing division was added two years ago, to meet the increased demand for charts.

Hydrographic division.—The duties in this division, which has remained in charge of ***Captain C. P. Patterson***, include the verification of original charts, and the preparation of notes, sailing directions, &c., for the engraved charts. Under his direction, also, the vessels used in the survey have been refitted, and turned over to the parties to which they were assigned for the work of the season. Of the two draughtsmen attached to the division, ***Mr. Arthur Balbach*** has been employed in verifying original sheets, and the reductions from them previous to engraving, and in examining engraved proofs before publication, in preparing comparative maps and miscellaneous work. ***Mr. L. Karcher*** made the projections used by the hydrographic parties this year; plotted hydrographic sheets from the original notes, and made some reductions and hydrographic sketches. He also assisted in verifying the original and engraved work.

Tidal division.—The number of persons attached to the tidal division of the office has gradually diminished as the work on hand has been disposed of, leaving the force sufficient to attend to the current work as it comes in from the stations yet in operation. Under the direction, as heretofore, of ***Assistant L. F. Pourtales*** the force now in the division has been thus employed: ***Mr. R. S. Avery*** has discussed the

diurnal tides of the western coast, and has completed various series of reductions; *Mr. J. Downes* reduced the observations from self-registering gauges until the 1st of June, when he was placed in charge of the archives of the survey. Since that date the self-registering observations have been reduced by *Mr. P. H. Donegan*, who has also made other tidal reductions. *M. Thomas* and *S. D. Pendleton* have made ordinary reductions and transcripts—the latter until the 1st of August, and *F. R. Pendleton* since the 15th of September.

Computing division.—This division has remained under the effecient direction of *Assistant C. A. Schott.* During winter and spring, at the opening of the present year, Mr. Schott was engaged in field-work in the vicinity of Washington, and later in the season in Section I, mention of which has been made in the corresponding chapters of this report. He also made observations out of the office, connected with the study of the distribution of magnetism in iron vessels. A statement of the current work of the computers is given in the report of the assistant in charge, Appendix No. 14.

Assistant T. W. Werner has computed triangulations; *Mr. E. Nulty*, the observations of time, azimuth, latitude and longitude. *Mr. J. Main* revised astronomical observations, and made geodetic and astronomical computations, and others from records of magnetic observations. *Mr. G. Rumpf* has attended to the insertion of geodetic results in the register of geographical positions; revised geodetic calculations, and has also computed triangulations. *Mr. E. H. Courtenay* has performed the clerical duties of the division, and aided Mr. Schott in field service. The transcripts of the records have been made, as usual, by *R. Freeman.*

Drawing division.—At the date of my last annual report *Assistant A. M. Harrison* was temporarily in charge of the drawing division, and so remained until May, when he took field service again in Section I, as stated in a previous chapter of my report. Since that time the work of this branch of the office has been directed by *Assistant Hilgard*, in addition to the general oversight of the other office divisions. In this supervision of details he was aided by *Mr. W. T. Bright.* The distribution of work amongst the draughtsmen has been as follows: *Assistant M. J. McClery* has added details from plane-table sheets to the photographs intended for the engraver, and has drawn the hill topography for the first class maps. *Mr. E. Hergesheimer* has generalized the sheets intended to be photographed, and lettered the maps and charts that have been engraved during the year. In the summer he engaged in field-work in the survey for defences near Philadelphia. *Mr. A. Lindenkohl* has made topographical and hydrographic reductions; projections on copper; maps for military purposes, and also made additions to the sketches of progress. He was employed in field-work during part of last winter, and is now engaged in similar duty. *Mr. L. D. Williams* was employed on reductions of various kinds, in verification work, and in making projections for plane-table sheets until October, when he left the office. *Mr. H. Lindenkohl* has made reductions for engraved charts and sketches, and has engraved some of them on stone. *Mr. F. Fairfax* has been employed on reductions generally; *Mr. F. Engel* upon copper-plate projections, others for field parties, and in drawing diagrams. *Mr. W. B. McMurtrie* and *Mr. E. Willenbucher*, during part of the season, were employed in making tracings. The first has been on service since June, at Philadelphia, in connexion with the surveys for defences. Both have been also engaged in plotting hydrographic work.

Messrs. T. Petingale, T. R. Smith, B. Hooe, W. Fairfax and *J. H. Logan* have been employed on tracings, in compiling statistics, and in other miscellaneous duties. *Mr. J. W. Maedel* has made tracings from the original sheets for use in the photograph division. Mr. Petingale resigned on the 9th of March, and Mr. Smith on the 22d of May.

Engraving division.—The details of work done in this division have been continued in charge of *Mr. Edward Wharton*, who has been assisted in the clerical duties by *Mr. G. J. Pinckard.*

The system of engraving figures by means of punches, in place of cutting them with the graver, has been further perfected during the year, and has been fully adopted for second class charts, with a great reduction of expense of the maps accompanying this report. The series of "sailing charts," (Nos. 18 to 23,) and others, have had the soundings engraved in this way. Another advance in lessening the expense of engraving, by the application of mechanical means, has been made in the use of a pantograph of superior construction, adapted to engraving outlines upon copper, on a reduced scale, by direct copying from the drawing. A reduction in the number of engravers was made at the end of the last surveying year. Of the number retained, *Mr. G. McCoy* until June, and *Messrs. A. Rollé*, and *J. Enthoffer* during the year, have been engaged in engraving topography from photographic reductions; *Messrs. John Knight* and *E. A. Maedel* in lettering and engraving figures on first class charts; *Messrs. A. Sengteller, W. Phillips, G. B. Metzeroth*, and *H. C. Evans* in engraving topography and sanding; *Mr. A. Maedel* in topography; *Mr. H. S. Barnard* in sanding; *Mr. J. C. Kondrup* in engraving outlines; *Mr. A. Petersen* in lettering and engraving figures; *Messrs. R.*

F. Bartle, W. A. Thompson, and F. W. Benner in topography, sanding, and miscellaneous engraving; *Messrs. E. H. Sipe* and *W. H. Davis* in engraving outlines and letters; *J. G. Thompson* on letters and topography; and *Mr. A. Buckle* in punching figures to represent soundings on engraved plates.

Photograph and electrotyping division.—The details of the work done in this and the other divisions of the office are stated in Appendix No 14. The division has remained in charge of *Mr. George Mathiot*. *Mr. David Hinkle* was attached to the division until April 1, when he resigned and was replaced by *Mr. A. Zumbrock*.

The photographic process is now the principal means used in the office in preparing reductions for the engraver. The facility it affords, too, in duplicating has made it an important auxiliary in cases wherein the press of time for sketches, military maps, &c., would not admit of making even the lithographic transfer. The use of Harrison & Schnitzers "globe lens," of the performance of which an account is given in Appendix No. 24, has materially aided the success of the photographic operations.

Lithographing division.—This division, which was organized two years ago as a measure of necessity to meet the largely increased demands for charts, was, during the first part of the year, under the charge of *Mr. W. L. Nicholson*. Since his resignation (May 1) the details have been directed by *Professor F. A. P. Barnard*.

The number of hydrographic charts printed from stone during the year has been nearly twelve thousand. Of maps and sketches, exhibiting the fields of operation of the national forces, or illustrating particular localities connected with the progress of the war, there have been printed an aggregate number of about eighteen thousand. Many of these have been found very serviceable by our military commanders in the field. Some of the sketches have been improved by data contributed to us by the commanders through their engineer officers.

The distribution of the memoirs of the coast now under blockade has been continued to military and naval commanders.

Miscellaneous division.—This division was also in charge of *Mr. Nicholson* until May, when he was succeeded by *Professor Barnard*.

The distribution of maps and charts of all descriptions during the year has been nearly forty-seven thousand, of which about thirty thousand copies were nautical charts. The map-room has been under the charge of *Mr. M. T. Johnstone*.

Of the annual report of the Superintendent for 1861, thirty-six hundred copies have been distributed, and of the reports of previous years, at home and abroad, since the date of my last annual report, more than six thousand copies. *Mr. J. J. Hendricks* until his resignation (July 26,) *Mr. L. A. Sengteller* until September, and *Mr. H. C. Saxton* since that period, have served as clerks in the division.

Mr. John Rutherdale, aided by *Mr. I. Fries*, has carried on the copper-plate printing. *Mr. W. Mertz*, until October, and subsequently *Mr. G. W. Francis*, have prepared the paper used for topographical and hydrographic sheets, and attended to the other duties of the folding-room.

Mr. T. J. Hunt, principal instrument maker, and *Mr. A. Yeatman*, master carpenter, have discharged their various duties satisfactorily and promptly.

I have, as heretofore, to acknowledge the useful and acceptable services of *Captain C. P. Patterson*, hydrographic inspector, whose zeal continues without abatement.

The discharge of the duties of general disbursing agent of the survey by *Samuel Hein, esq.*, has, as heretofore, given great satisfaction.

The clerks in my office, *W. W. Cooper, esq.*, and *J. T. Hoover, esq.*, have continued to discharge their duties most acceptably. Upon Mr. Hoover devolved important and difficult duties connected with my work at Philadelphia, which he has discharged with zeal and fidelity.

Respectfully submitted by

A. D. BACHE,
Superintendent United States Coast Survey.

Hon S. P. CHASE,
Secretary of the Treasury.

APPENDIX.

APPENDIX No. 1.

Distribution of the parties of the Coast Survey upon the coasts of the United States during the surveying season of 1862–'63.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I.				
From Passamaquoddy bay to Point Judith, including the coast of Maine, New Hampshire, Massachusetts, and Rhode Island.	No. 1	Triangulation	F. P. Webber, sub-assistant	Triangulation of Passamaquoddy bay completed by extending work through Letite passage; secondary triangulation of the coast of Maine extended north and east from Machias, and connected with the former at Quoddy Head.
	2	Triangulation	G. A. Fairfield, assistant; H. Anderson, aid.	Triangulation continued in the vicinity of Great Blue Hill bay, Me., and connected with that of Penobscot bay.—(See also Section IV.)
	3	Triangulation	S. C. McCorkle, assistant	Triangulation extended up Penobscot river from Castine to Cobb's Hill, above Bucksport, Me.
	4	Topography	W. H. Dennis, sub-assistant	Detailed topography of Moose island, in Passamaquoddy bay, Me., including the survey of Eastport, the low-water line of the island, and the survey of the town of Lubec. (See also Section V.)
	5	Topography	C. Rockwell, sub assistant	Plane-table survey of Winter harbor, Me., completed, and topography extended eastward to Schoodic Point. (See also Section IV.)
	6	Topography	F. W. Dorr, sub-assistant	Plane-table survey of the western shore of Penobscot bay extended from Clam cove northward, and including Rockport and Camden harbors. (See also section VI.)
	7	Topography	C. Ferguson, sub-assistant	Determination of additional points by triangulation, and topographical survey of St. George's river, Me, from the Narrows up to Thomaston. (See also Section III.)
	8	Topography	A. W. Longfellow, assistant	Topography completed from Little Flying Point eastward to Harpswell, including the shores of Maquoit bay and Middle bay, Me.
	9	Topography	A M. Harrison, assistant; C. Hosmer, sub-assistant; H. W. Bache, aid.	Shore-line survey of Providence river, Greenwich bay, and Wickford bay, completing the preliminary plane-table work of Narragansett bay. (See also Sections III and VIII.)
	10	Hydrography	Lieut Comdr. T. S. Phelps, U. S. N., assistant.	Soundings on Jeffrey's ledge, and development of numerous rocks and ledges near the approaches to Portland harbor. (See also Sections II and III.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I—(Continued)	No. 11	Hydrography	Edward Cordell, acting assistant; L. A. Sengteller, H. M. Dewees, Gershom Bradford, aids.	Inshore hydrography extended in the western approach to Penobscot bay from Manhegan island to White Head light. Bulwark shoal sounded, and the vicinity of Vapor Rock, off the entrance to Portland harbor. (See also Section VI.)
	12	Hydrography	W. S. Edwards, assistant; F. H Dietz, aid; Persifer Frazer, jr., and H. G. Ogden, aids, (part of season.)	Rockland harbor, Me., sounded, including its approaches, on the western side of Penobscot bay. Rocks and ledges examined on the eastern side of the bay, and positions selected for buoys to mark the channels leading into Carver's harbor. (See also Section V.)
	13	Hydrography	F. H Gerdes, assistant; C. T. Iardella, sub-assistant; Clarence Fendall, sub-assistant, (part of season;) T. C. Bowie, aid.	Maquoit bay and Middle bay sounded out, completing the hydrography of Casco bay, Maine. (See also Section VIII.)
	14	Magnetic observations.	C. A. Schott, assistant; E. H. Courtenay, aid.	Determination of the magnetic elements at Bangor, Freeport, Belfast, Rockland, Bath, Harpswell, and Portland, on the coast of Maine. (See also Section III.)
	15	Physical survey and hydrography.	H. Mitchell, assistant; C. P Dillaway, A. M Wetherill, J. W. Brown, aids.	Physical survey continued in Boston harbor for the United States commissioners. Observations on the currents of Martha's Vineyard sound, and hydrographic examination of Sippican harbor, Mass. (See also section II.)
	16	Tidal and magnetic observations.	Edward Goodfellow, assistant; T. E. Ready.	Tidal and magnetic observations continued at Eastport, Me. Tidal observations continued at Charlestown navy yard, Mass.
SECTION II.				
From Point Judith to Cape Henlopen, including the coast of the States of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.	1	Geodetic and magnetic observations.	A. D. Bache, superintendent; G. W. Dean, assistant; R E. Halter, sub assistant; J. A. Sullivan, sub-assistant, (part of season;) S H. Lyman, F. W. Perkins, aids.	Primary triangulation continued southward of Epping base towards Fire island base, by observations at Ivy hill and Tashua hill, Conn. Magnetic declination, dip, and intensity determined at both stations, and line of levels run from Tashua station to determine its height above the sea level at Black Rock, on Long Island sound.
	2	Triangulation	Edmund Blunt, assistant; A. T. Mosman, sub-assistant; J. A Sullivan, sub-assistant, (part of season.)	Triangulation to connect the primary work in this section at stations Tashua and Wooster with the triangulation of the Hudson river.
	3	Triangulation	John Farley, assistant.	Verification work continued on the coast of New Jersey, by occupying stations in the vicinity of Shark river for extending triangulation to Manasquam inlet Triangulation made for determining the extent of changes at Absecom inlet.
	4	Reconnaissance	R. E. Halter, sub-assistant.	Examination of the shore lines of New Haven harbor, and comparison made with the previous survey.
	5	Topography	H. L. Whiting, assistant; F. P. Webber. sub-assistant; J. W. Donn, aid.	Resurvey of Sandy Hook for comparison with former surveys. (See also Sections I and III.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION II—(Continued.)	No. 6	Military defences and special surveys.	A. D. Bache, superintendent, chief engineer; H. L. Whiting, Geo. Davidson, R. M. Bache, C. M. Bache, C. O. Boutelle, P. C. F. West, assistants; R. E. Halter, Cleveland Rockwell, J. S. Bradford, sub-assistants; A. R. Fauntleroy, aid; E. Hergesheimer and W. B. McMurtrie, draughtsmen.	Reconnaissance, plane-table surveys, plans, and the erection of numerous field-works for defending the south-western, the western, and the north-western approaches to the city of Philadelphia during the invasion of Pennsylvania in June and July.
	7	Hydrography.....	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Development of a ledge of rock near Montauk Point, and determination of the position of Great Eastern Rock. Resurvey of the main channel of New York harbor between Governor's island and Robbins's reef, and of part of the adjacent Jersey flats. (See also sections I and III.)
	8	Hydrography and shore-line surveys.	W. W. Harding, (part of season,) Alexr. Strausz, (part of season,) C. S. Hein, Persifer Frazer, jr., H. G. Ogden, aids.	Hydrography of the Hudson river completed by soundings between Hudson city and New Baltimore and between Albany and Troy, with shore-line survey above Coxsackie. (See also Sections V and VIII.)
	9	Physical survey....	H. Mitchell, assistant.....	Hydrography at Sandy Hook examined with reference to the effect of tides and currents in causing the alterations. (See also Section I.)
	10	Special survey.....	George Davidson, assistant ..	Plane-table survey of part of League island, (Delaware river,) and soundings in its vicinity, for the Navy Department.
	11	Hydrography.....	Capt. C. P. Patterson.....	Soundings to determine the extent and character of changes in the vicinity of the breakwater in Delaware bay, for the Engineer Department.
		Tidal observations.	R. T. Bassett	Tidal observations continued at the permanent station on the shore of Governor's island, New York harbor.
SECTION III.				
From Cape Henlopen to Cape Henry, including the coast of part of Delaware, the coast of Maryland, and part of the coast of Virginia.	1	Triangulation and topography.	C. H. Boyd, sub-assistant....	Triangulation made for military survey of the western and northern approaches to the city of Baltimore, Md Triangulation of the vicinity of Fort Lyon, near Alexandria, Va., and of the Potomac river from thence up to Georgetown, with shore-line survey of the river within the same limits.
	2	Triangulation and vertical measurements.	C. A. Schott, assistant; E H Courtenay, aid.	Triangulation made and heights of field-works in the vicinity of Washington city determined and referred to the level of the Potomac, for the chief engineer of defences. (See also Section I.)
	3	Topography	J. W. Donn, F. A. Lueber; C. T. Iardella, sub assistant, (part of season.)	Plane-table survey of the western and northern approaches to the city of Baltimore, Md., for the engineer of defences.
	4	Topography.....	Charles Ferguson, sub assistant; I. Hull Adams, assistant, (part of season.)	Topography joining that of the District of Columbia, extended from the vicinity of Bladensburg north, and west to Leesboro', Md., and continued south and east of Bladensburg towards the District line.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION III—(Continued)	No. 5	Topography.....	J. W. Donn, in charge; F. A. Lueber, C. S. Hein, aids.	Plane-table survey from the Potomac river northward, outside of but adjoining the southeastern boundary of the District of Columbia, and extending nearly to its eastern corner. Supplementary topography in the vicinity of Chain bridge, above Georgetown, D.C.
	6	Topography.....	A. M. Harrison, assistant; H. W. Bache, aid; A. Lindenkohl, aid, (part of season)	Minute plane-table survey of Rosier's bluff and adjacent bank of the Potomac river, from Oxon hill to Broad creek, Md, for the chief engineer of military defences of Washington city. Topography of Jones's Point, near Alexandria, Va. (See also Section I.)
	7	Topography.....	C. M. Bache, assistant.....	Plane-table survey made of the approaches to Fort Lyon, and joined with former surveys of the vicinity of Alexandria, Va. Surveys with compass and chain of roads leading from the Rappahannock river to King George Court-house, Va., near the end of December, 1862, for the army of the Potomac. (See also Section II.)
	8	Reconnaissance....	P. C. F. West, assistant; Chas. Hosmer, sub-assistant.	Special examination and tracing of roads approaching Stafford Court-house, Va., for the use of the army of the Potomac. See also Sections I, II, and VIII.)
	9	Hydrography.....	Lieut. Comdr. T. S. Phelps, U. S. N, assistant.	Hydrographic examination to determine depth on the site of a shoal supposed to exist eastward of the Winter Quarter shoal, off the boundary line of Maryland and Virginia. Extension of the hydrography of Potomac river from Indian Head to Alexandria, Va., and completion of that work by joining with previous soundings above Alexandria. (See also Sections I and II.)
	10	Magnetic observations.	C. A. Schott, assistant; E. H. Courtenay, aid.	Magnetic declination, dip, and intensity observed at the station near the Coast Survey office, in Washington. (See also section I.)
	11	Tidal observations.	M. C. King.....	Observations continued at the permanent station at Old Point Comfort, Va., with self-registering tide-gauge.
SECTION IV.				
From Cape Henry, Va., to Cape Fear, N. C., including part of the coast of Virginia and North Carolina.	1	Triangulation.....	G. A. Fairfield, assistant; H. Anderson, aid.	Triangulation of the Neuse river, N. C., from New Berne downward towards Pamplico sound. (See also Section I.)
	2	Topography and reconnaissance.	P. C. F. West, assistant; Cleveland Rockwell, sub-assistant.	Topography of the environs of New Berne, N. C., for military purposes, and reconnaissance maps of the country north of the Neuse river, and between it and Washington, N. C. Reconnaissance of Wilkinson's Point, and survey of the lines of defence at the mouth of Tar river. (See also Sections I and II.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties	Operations.	Persons conducting operations.	Localities of operations.
SECTION V.				
From Cape Fear, N. C., to St. Mary's river, Ga., including the coast of part of North Carolina, and the coast of South Carolina and Georgia.	No. 1	Topography and hydrography.	C. O. Boutelle, assistant; J. S. Bradford, sub-assistant; W. W. Harding and Persifer Frazer, jr., aids.	Hydrographic reconnaissance of the entrance of Winyah bay, S. C. Survey of Charleston bar by night, in January. Special topography and soundings for a coaling station at Bay Point. Hydrographic resurvey of the approaches and bars of Port Royal sound. Examination of the channels at Tybee entrance and of Ossabaw sound, Ga. General service in light house duty between Charleston bar and St. John's river, Fla., and despatch service for the flag-officer of the South Atlantic blockading squadron. (See also Section II.)
	2	Topography.....	W. H. Dennis, sub-assistant; B. H. Talcott, aid.	Plane-table resurvey of the north end of Hilton Head island, and part of Beaufort island, S. C., with the defensive works and structures erected since the former survey. Topography of the shores of Wassaw sound, Ga., including the mouths of the streams that fall into it; also Great and Little Tybee islands, and Cockspur and Long island, in Savannah river. (See also Section I.)
	3	Hydrography.....	W. S. Edwards, assistant; A. R. Fauntleroy and F. H. Dietz, aids.	Hydrography of the inland passage between St. Helena and Port Royal sounds, S. C., including Story's river and Station creek. Hydrography of the entrance to Savannah river, Ga., and examination of the bulkhead between the Tybee channel and Calibogue sound. Hydrographic survey of the bar and entrance, and of part of the inside of Wassaw sound, Ga. (See also Section I.)
SECTION VI.				
From St. Mary's river, Ga., to St. Joseph's bay, Fla., including the eastern and part of the western coast of Florida peninsula, and the Florida reefs and keys.	1	Topography.....	F. W. Dorr, sub-assistant....	Topographical service for the tax commission of Florida at Fernandina, St. Augustine, and Key West, and plans for defensive works at Fernandina. (See also Section I.)
	2	Hydrography.....	Edward Cordell, acting assistant; C. T. Iardella, sub-assistant; T. C. Bowie, L. L. Nicholson, L. A. Sengteller, H. M. DeWees, and A. M. Wetherill, aids.	Hydrography of the Florida reef completed by soundings from Rodriguez key southward to join with former work near Tavernier creek and Conch reef; also abreast of Boca Chica from Boca Chica channel to Geiger's signal. Examination of the position of buoys in Key West harbor. Hydrography of the approaches, bar, and northern entrance of Charlotte harbor, Fla., with tidal observations. (See also Section I.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTIONS VII, VIII, AND IX.				
From St. Joseph's bay, Fla., westward to the Rio Grande, including part of the western coast of Florida, and the coast of Alabama, Mississippi, Louisiana, and Texas.	No. 1	Topography and reconnaissance.	J. G. Oltmanns, assistant; Chas. Hosmer, sub-assistant; S. H. Lyman, aid.	Topography of the right bank of the Mississippi river, opposite to New Orleans, from Labrance's canal to McGee's plantation. Reconnaissance of water-courses which connect the Atchafalaya with Red river. Survey of the defences of Baton Rouge. Reconnaissance and maps of Bayou Teche and of Red river from its mouth up to Alexandria; also of captured field-works. Topography of Port Hudson, including the defensive lines and their approaches; and general reconnaissance duty in Louisiana with the army of Major General Banks.
	2	Topography.....	F. H. Gerdes, assistant; Clarence Fendall, sub-assistant; Alex'r Strausz.	Surveys for the flag-officer of the Mississippi fleet during the siege of Vicksburg, including the banks of the river and northern and western approaches to the city, and the banks of Yazoo river below Haines's bluff, the topography of the eastern approaches to Vicksburg, for the use of the army of Major General Grant; the survey of Arkansas Post, and special reconnaissance maps of the Sunflower and other bayous of the Mississippi. (See also Sections I and II.)
	3	Topography.....	R. M. Bache, assistant; R. E. McMath, aid.	Plane-table survey of Carondelet, completing the topography of the approaches and ground occupied by the defensive works at St. Louis, Mo. (See also Section II.)
SECTION X.				
From San Diego, or the southern boundary of the United States on the Pacific, to the forty-second parallel, including the coast of California.	1	Triangulation.....	W. E. Greenwell, assistant; Julius Kinchelce, sub-assistant.	Coast triangulation of California extended east and west of Santa Barbara, and connected with Santa Cruz island.
	2	Topography and hydrography	A. F. Rodgers, assistant; W. M. Johnson, sub-assistant; Alex'r Chase, aid.	Plane-table survey of the shores of Half Moon bay, Cal., completed, and connected with former work going northward towards San Francisco entrance and southward towards Monterey bay. Hydrography of the coast in the vicinity of Half Moon bay nearly completed.
	3	Hydrography	A. F. Rodgers, assistant; Alexander Chase, aid; T. M. Ver Mehr, aid, (part of season.)	Hydrographic resurveys of Karquines strait and of the bar in San Pablo bay, Cal., to determine changes. Observations on the currents of San Francisco bay. Determination of the positions of buoys. Development, by soundings, of the depth on Noonday or Fanny rock, off the Farallones, and determination of its position.
		Tidal observations..	Capt. G. H. Elliot, U. S. engineers, in charge; A. Cassidy and H. E. Uhrlandt.	Series of observations continued with the self-registering tide-gauges at San Diego and near San Francisco.

APPENDIX No. 1—Continued.

Limits of sections	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION XI.				
From the 42d parallel of latitude to the northwestern boundary of the United States, including the coast of the State of Oregon and the coast of Washington Territory.	.....	Topography and hydrography.	Jas S. Lawson, assistant; C. B. Boutelle, aid.	Supplementary triangulation for extending the plane-table survey and hydrography of Koos bay, Oregon.
		Tidal observations..	Louis Wilson.	Series continued with the self-registering gauge at Astoria, Oregon.

APPENDIX No. 2.

Information furnished from the Coast Survey office, by authority of the Treasury Department, in reply to special calls during the year 1862–'63.

Date.	Names.	Data furnished.
1862.		
Nov. 19	Major Gen. W. B. Franklin, U. S. A.....	Tracing of the hydrographic and topographic sheets of Fredericksburg and vicinity, Va.
25	.....do.....	Tracings from topographic sheets of the Rappahannock river from Urbana to Fredericksburg, Va.
25	Major Gen. N. P. Banks, U. S. A.....	Tracings of the hydrographic sheets of Matagorda entrance and part of Matagorda bay, Texas.
25	Major Gen. W. B. Franklin, U. S. A.....	Data and description of trigonometrical points in the vicinity of Fredericksburg, Va.
26	Col. J. N. Macomb, A. D. C.....	Four photographic copies of the topographical survey near Fredericksburg, Va.
26	.....do.....	Three colored photographic copies of the topographical survey near Fredericksburg, Va.
Dec. 4	Commander George F. Emmons, U. S. N.....	Tracing showing the positions of Forts Sumter and Moultrie, S. C.
8	Major Gen. W. B. Franklin, U. S. A.....	Tracing from military survey near Williamsport, Md.
10	Lt. Col. B. S. Alexander, A. D. C.....	Tracing of topographical survey of Rosier's bluff and vicinity, Maryland.
17	Engineer Department.....	Tracing of topography of Cape Disappointment, Oregon.
17	.....do.....	Tracing of topography of Point Adams, Oregon.
17	.....do.....	Tracing of topographical reconnaissance of Columbia river, Oregon.
19	Hon. F. A. Conkling, New York.....	Tracing of profile of St. Lawrence canal from Montreal to Lake Ontario.
20	Navy Department.....	Tracing of hydrographic reconnaissance of Bottle channel, Georgetown harbor, S. C.
20	Engineer department.....	Tracing of hydrographic reconnaissance of Bottle channel, Georgetown harbor, S. C.
20	Light-house Board.....	Tracing of hydrographic reconnaissance of Bottle channel, Georgetown harbor, S. C.
23	Major Gen. W. B. Franklin, U. S. A.....	Tracing of topography of Potomac river from Potomac creek to Persimmon Point.

APPENDIX No. 2—Continued.

Date.		Names.	Data furnished.
1863.			
Jan.	3	Rear-Admiral S. P. Lee, U. S. N	Reduced drawing of resurvey of New inlet, Cape Fear river, North Carolina.
	3	do	Reduced drawing of resurvey of Western Bar channel, Cape Fear river, N. C.
	3	do	Tracings of the topography of New Topsail inlet, including the intermediate sea-coast and inlets between it and Cape Fear river, N. C.
	9	do	Tracings of topography of the coast of North Carolina, from Cape Fear entrance to Bacon's inlet.
	10	Major Gen. J. G. Foster, U. S. A	Tracing of the topography of Georgetown harbor, S. C.
	10	do	Tracing of the topography above Sullivan's island, S. C.
	16	Brig. Gen. J. G. Totten, U. S. A	Tracing of comparative map of Sandy Hook from 1855 to 1862.
	17	Major Gen. W. B. Franklin, U. S. A	Tracing of shore-line of parts of Potomac and Rappahannock rivers, (on one sheet.)
	26	Major Gen. J. G. Foster, U. S. A	Tracing of sketch of North Carolina west of Cape Fear river.
	29	Hon. W. H. Wallace, House of Representatives	Tracing of the hydrography of Gray's harbor, W. T.
Feb.	23	Capt. C. B. Comstock, corps of engineers	Tracings of the topography of the Rappahannock river from Port Royal to Fredericksburg, Va.
	23	Hon. James R. Doolittle, United States Senate	Map with the boundary lines of new Territories, for the use of the United States Senate.
March	9	Lt. Col. R Delafield, corps of engineers	Projection of Sandy Hook with shore-line of 1862.
	9	do	Data of trigonometrical points at Sandy Hook, N. J.
	24	Lt. Col. B. S. Alexander, A. D. C	Tracing of the topography of Rosier's bluff, Oxon hill, and vicinity, Md.
	24	Col. W. F. Raynolds, A. D. C	Tracings of the topography of Baltimore city, Patapsco river, eastern shore of Maryland, and Kent island.
	24	U. S. tax commission, State of South Carolina	Tracings of the topography of Port Royal sound, North Edisto river, South Edisto river, including all the surveyed topography from Savannah river to Charleston light.
April	1	Engineer department	Tracing, on large scale, of the topography of Portland and environs, Maine.
	7	War Department	Tracings of the topography of the coast of North Carolina from Masonboro' inlet to Federal Point, Cape Fear river.
	11	E. & G. W. Blunt, New York	Table of geographical positions.
	13	Lt. Col. B. S. Alexander, A. D. C	Tracing of the topographical survey of entrance to Salem harbor, Mass.
	13	do	Tracing of the topographical survey of Merrimack river entrance, Mass.
	13	do	Tracing of the topographical survey of the mouth of the Connecticut river.
	13	do	Tracing of the topography of Gloucester harbor, Mass.
	13	do	Tracing of the topography of Plymouth harbor, Mass.
	20	A. G. Richardson, esq., New York	Tracing of hydrography west of Horton's Point, north shore of Long Island sound.
	28	Col. J. N. Macomb, A. D. C	One copy of photograph of topographical survey of northeast side of District of Columbia.
	29	do	One copy of photograph of topographical survey of northeast side of District of Columbia, (colored.)
May	4	Engineer department	Tracing of special topographical survey of Jones's Point, near Alexandria, Va.
	18	Major Charles E. Blunt, corps of engineers	Tracing of topographical survey of Governor's and Castle island, Boston harbor, Mass.
	23	Hon. J. F Haughton, surveyor general of California.	Length and bearing of the east boundary of California.
	26	Brig. Gen. J. G. Barnard, U. S. A	Tracing of topographical survey of north side of Hunting creek, Va.

APPENDIX No. 2—Continued.

Date.		Names.	Data furnished.
1863.			
May	27	James Gamble, esq., superintendent California State Telegraph Company.	Tracing of the hydrography of the Golden Gate and of Karquines straits.
	27	James Gamble, esq., superintendent California State Telegraph Company.	Maps of Washington sound and Admiralty inlet.
	28	Major Gen. J. G. Foster, U. S. A	Traced copy of map of Cape Fear river, N. C.
June	3	Brig. Gen. J. G. Barnard, U. S. A	Tracing of the topographical survey of the Maryland side of Potomac river from Broad creek to Giesboro' Point.
June	4	Col. J. N. Macomb, A. D. C	Four copies of photograph of topographical survey of N. W. approaches to Washington.
	6	do	One copy of photograph of topographical survey of N. W. approaches to Washington.
	6	do	Five copies of photograph (colored) of topographical survey of N. W. approaches to Washington.
	11	Lt. Col. Geo. D. Ramsay, comd'g Washington Arsenal.	Tracing of the topographical survey of the Arsenal grounds and vicinity, with the determination of the buoys in the river off the Arsenal.
	11	Wm. Keeler, civil engineer Washington navy yard.	Tracing of the hydrographic survey of the Eastern branch of the Potomac river from Giesboro' Point to Anacostia bridge.
	13	Ariel Patterson, esq., New York	Tracing of part of the hydrographic survey of the East river, N. Y.
July	14	Major E. B. Hunt, corps of engineers	Tracing of the topographical and hydrographic survey of Dutch island and vicinity, R. I.
	29	Howland & Aspinwall, New York	Tracing showing position of Great Eastern rock, off Montauk Point, L. I.
	30	W. H. Gardner, assistant surgeon, U. S. A	Tracing of the topographical survey of Point Lookout, Md.
Aug.	10	Brig. Gen. G. Marston, U. S. A	Tracing of the topographical survey of Point Lookout, Md.
	16	Capt. T. B. Brooks, A. D. C	Tracing of the topographical survey of Morris island, S. C.
	16	do	Tracing of the topographical survey of Folly island, S. C.
	16	do	Tracing of the topographical survey of Charleston city and vicinity, S. C.
	17	Lieut. J. R. Meigs, corps of engineers	Tracing of the military survey of Williamsport, Md.
Sept.	5	Rear Admiral S. P. Lee, U. S. N	Tracing of the topographical survey of Myrtle sound, N. C.
	10	Capt. T. Lincoln Casey, corps of engineers	Tracing of the topographical survey of the environs of Portland, Me.
	14	John Maginn, pilot, New York	Tracing of the hydrographic survey of the East river, N. Y., from Governor's island to 23d street.
	14	Rear Admiral S. P. Lee, U. S. N	Tracing of the topographical survey of Cape Fear river and adjoining coast of North Carolina.
	23	Navy Department	Tracing of the topographical survey of Cape Fear river and adjoining coast of North Carolina.
	23	Capt. T. Lincoln Casey, corps of engineers	Tracing of the topographical survey of Cape Elizabeth and vicinity, Me.
	30	Lt. N. M. Edwards, N. Y. vol. engineers	Tracings of part of Morris and James islands, S. C.
Oct.	1	Navy Department	Tracing of the topographical and hydrographic survey of the Delaware river from Tonkin's island to Old Man's Point.
	5	Major Gen. H. W. Halleck, commander-in-chief.	Tracing of the topographical survey of the environs of St. Louis, Mo.
	6	Prof. A. G. Pendleton, U. S. N	Geodetic and magnetic information, District of Columbia.
	20	Major Gen. Geo. Stoneman, U. S. N	Tracing of the hydrographic survey of the Potomac river off Giesboro' Point.
	20	do	Tracing of the shore-line of the Potomac river from Alexandria to the Long bridge, including the Eastern branch.
	30	Fleet Capt. Daniel Ammen, U. S. N	Tracing of part of Charleston district, S. C.

APPENDIX No. 3.

Statistics of field and office work of the United States Coast Survey during the years—

	Previous to 1844.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	Total.
Reconnaissance—																					
Area, in square miles	9,642	1,140	3,739	1,830	2,950	3,940	10,159	3,280	3,510	1,706	1,708	795	1,487	4,072	2,855	709	1,782	6,050	585	716	62,655
Parties, number of, each year	4	2	4	5	5	7	6	4	6	6	5	13	7	5	8	4	3	1	1	4	.....
Base lines—																					
Primary, number of	1	2	.....	.....	1	1	.....	1	.....	.....	1	.....	2	.....	1	.....	.....	.....	.....	.....	10
Secondary, number of	2	.....	.....	.....	2	1	4	3	3	4	5	2	8	8	1	4	5	2	1	2	57
Length of, in miles	19⅛	16	.....	.....	9½	13	6½	17⅛	2	4½	18½	3½	24½	9⅛	9	3⅛	6½	1⅛	⅛	1¼	166
Triangulation—																					
Area, in square miles	9,076	795	2,166	1,185	1,903	2,592	4,091	2,097	2,465	1,703	3,089	2,701	2,729	2,793	1,640	3,033	3,724	4,773	1,632	1,514	55,701
Extent of general coast, in miles	570	179	162	123	159	115	285	216	243	220	94	216	188	320	357	278	358	232	173	152	4,670
Extent of shore-line, in miles, including bays, sounds, islands, and rivers	1,588	589	554	1,018	541	796	1,328	730	1,097	1,104	884	1,269	1,401	1,895	1,481	1,715	2,092	1,617	1,200	1,061	23,960
Horizontal angle stations occupied	750	120	80	197	120	98	204	157	184	223	224	204	410	544	385	384	344	322	159	168	5,277
Geographical positions determined	1,183	147	148	372	194	227	319	294	397	446	346	388	584	1,210	777	603	794	681	402	452	9,904
Vertical angle stations occupied	15	2	5	7	3	1	18	13	22	14	7	89	6	1	4	11	17	17	10	18	280
Elevations determined, number of	44	12	7	46	44	1	59	22	53	66	9	127	6	12	15	14	31	44	11	26	649
Parties, number of, in each year	4	5	8	7	8	10	13	14	14	13	18	17	17	20	20	19	21	21	14	12	.....
Astronomical operations—																					
Stations occupied for azimuth	9	8	2	2	3	3	4	4	6	6	9	5	4	2	1	2	7	5	2	2	86
Stations occupied for latitude	9	8	5	3	8	2	4	6	8	17	20	6	4	6	3	5	5	6	2	2	129
Stations occupied for longitude	1	1	.....	2	3	3	7	3	7	18	21	4	1	1	2	2	.....	7	2	.....	85
Permanent longitude stations	.....	1	1	2	1	1	2	3	5	5	5	4	3	1	1	1	1	1	1	1	.....
Special longitude stations for occultations, &c	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23	30	24	24	.....	.....	.....
Parties, number of, in each year	1	3	2	2	3	3	5	5	6	4	7	7	6	4	3	4	5	6	2	2	.....
Magnetic stations occupied temporarily	8	14	21	28	19	4	11	9	10	8	13	9	8	23	4	5	18	17	4	4	237
Permanent magnetic stations	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	2	.....
Parties, number of, each year	1	2	3	3	3	3	5	4	3	2	3	6	3	4	3	3	4	7	4	2	.....
Topography—																					
Area surveyed, square miles	6,131	195	503	750	595	471	532	652	681	653	554	513	656	536	1,003	798	657	592	478	365	17,315

APPENDIX No. 3—Continued.

	Previous to 1844.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	Total.
Topography—																					
Length of general coast, in miles	414	110	168	119	117	185	95	133	260	236	251	174	176	165	309	292	224	320	190	259	4,197
Length of shore-line, in miles, including rivers, creeks, and ponds	7,667	424	879	1,120	1,460	1,703	1,709	1,557	1,780	1,737	2,100	1,796	2,138	2,398	3,913	3,563	2,669	2,052	1,595	1,114	43,374
Length of road, in miles	11,734	395	997	1,402	1,354	640	504	511	500	732	502	618	733	750	1,404	885	482	260	669	903	25,975
Parties, number of, each year	6	5	6	8	9	9	11	11	13	13	17	12	17	17	23	23	22	23	17	20	.....
Hydrography—																					
Parties, number of, each year	2	5	5	6	6	8	11	11	12	9	9	10	11	12	12	10	9	9	9	13	.....
Number of miles run while sounding	29,214	1,857	3,493	3,559	3,138	8,047	4,299	5,995	10,590	9,534	9,050	9,141	13,115	15,305	12,377	8,884	9,426	9,438	2,434	5,916	174,812
Area sounded out, square miles	9,601	663	677	574	979	2,185	1,335	2,012	3,200	2,823	2,061	1,937	3,433	3,743	2,705	1,799	4,310	1,651	225	611	46,524
Miles run additional of outside or deep-sea soundings	1,800	1,020	.....	.....	210	2,240	.....	1,198	2,037	360	1,902	2,793	5,219	1,202	3,218	2,092	2,353	2,375	.....	.....	30,019
Soundings, number of	808,147	120,827	125,173	220,402	228,402	255,003	265,824	264,718	371,660	288,375	305,377	163,454	526,875	439,614	506,034	513,607	398,053	373,251	224,978	385,405	6,784,179
Soundings in Gulf Stream for temperature	.....	.....	118	581	207	425	.....	.....	.....	.....	1,053	257	310	.....	478	172	235	236	.....	.....	4,072
Tidal stations, permanent	.....	2	2	2	3	3	3	3	4	4	7	7	7	8	8	10	10	11	7	7	.....
Tidal stations occupied temporarily	127	14	33	39	33	29	35	41	51	76	78	89	80	77	74	53	32	50	26	32	1,069
Tidal parties, number of, in each year	2	5	5	5	5	8	11	11	12	9	11	12	13	14	14	13	10	12	7	9	.....
Current stations occupied	.....	27	42	41	59	54	28	44	41	24	89	10	84	84	156	47	38	84	44	7	1,003
Current parties, number of, in each year	.....	3	5	3	3	4	6	4	7	7	5	3	5	6	6	2	2	1	2	1	....
Specimens of bottom, number of	1,029	2,776	89	129	371	769	287	381	278	215	141	135	255	146	422	668	154	188	11	.....	8,454
Records—																					
Triangulation, originals, number of volumes	97	12	17	23	17	32	38	40	33	33	64	46	79	98	76	96	94	120	82	57	1,152
Astronomical observations, originals, number of volumes	17	10	11	10	16	22	72	30	41	48	29	88	35	12	35	63	27	35	13	17	631
Magnetical observations, originals, number of volumes	4	2	1	6	7	4	3	5	5	7	6	4	33	13	4	10	9	13	17	6	159
Duplicates of the above, number of volumes	27	26	32	32	44	49	19	23	45	73	76	84	139	101	140	168	77	111	103	53	1,422
Computations, number of volumes	78	25	17	21	26	23	57	24	40	72	101	91	109	99	83	101	88	115	66	24	1,260

APPENDIX No. 3—Continued.

	Previous to 1844.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	Total.
Records—																					
Hydrographic soundings and angles, originals, volumes.	188	22	26	152	54	154	134	170	213	206	183	66	332	197	319	322	306	194	129	86	3,451
Hydrographic soundings and angles, duplicates, volumes	28	2	5	4	11	11	12	12	16	27	15	7	26	27	21	20	19	10	4	2	279
Tidal and current observations, originals, volumes	127	23	47	51	44	40	67	88	114	139	123	70	196	110	213	104	75	64	39	27	1,761
Tidal and current observations, duplicates, volumes.	.....	23	47	51	44	41	63	79	385	132	114	79	87	100	67	74	57	53	14	12	1,532
Sheets from self-registering tide-gauges, number of	.....	.....	.....	.....	.....	.....	.....	.....	.....	26	72	106	80	103	119	141	149	180	118	75	1,169
Tidal reductions, number of volumes	.....	46	94	102	88	80	16	58	22	26	17	99	79	73	63	64	52	60	46	28	1,113
Total number of volumes of records	566	191	297	452	351	456	481	529	914	763	728	634	1,115	828	1,021	1,022	804	775	511	312	12,750
Maps and charts—																					
Topographical maps, originals	168	14	16	25	29	20	22	30	41	47	54	45	55	51	76	46	45	47	33	44	908
Hydrographic charts, originals	142	9	8	18	18	21	16	20	47	56	56	52	65	62	51	33	41	37	10	32	600
Reductions from original sheets, number of	15	9	15	16	17	13	18	22	26	48	35	27	36	39	40	35	92	23	21	19	566
Total number of manuscript maps and charts	325	32	39	59	64	54	56	72	114	151	145	124	156	152	167	114	178	107	70	95	2,274
Number of sketches made in field and office	311	24	33	32	29	48	82	85	126	137	103	101	132	125	132	127	353	108	62	65	2,215
Engraving and printing—																					
Engraved plates of finished charts, number of	5	2	3	5	3	6	3	5	6	5	4	2	7	3	7	6	8	8	9	6	103
Engraved plates of preliminary charts, sketches, and diagrams for the Coast Survey reports, number of.	.....	.....	.....	4	5	7	6	10	38	20	39	42	46	51	51	25	21	17	14	8	404
Electrotype plates made in each year	.....	.....	.....	.....	1	7	6	25	16	23	47	77	50	69	79	95	97	58	43	43	726
Finished charts published in each year	.....	4	3	4	3	10	3	4	6	6	3	2	8	3	5	6	6	7	7	6	96
Preliminary charts and hydrographic sketches published.	.....	.....	.....	2	4	2	4	10	36	19	34	34	34	38	41	22	15	15	31	34	375
Printed sheets of maps and charts distributed	.....	169	416	1,708	1,104	2,923	1,848	326	5,649	5,799	8,042	5,195	5,392	6,858	19,147	4,209	10,466	4,092	13,094	36,273	134,730
Printed sheets of ditto deposited with sale agents	.....	.....	880	1,686	4,981	5,018	1,506	3,115	5,168	6,866	4,375	3,232	2,577	2,898	648	1,717	3,564	2,145	733	4,448	55,575

APPENDIX No. 3—Continued.

	Previous to 1844.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	Total.
Library—																					
Number of volumes						655	95	590	333	171	273	155	250	389	106	116	174	159	163	91	3,720
Instruments—																					
Cost of							$8,326	$4,652	$4,603	$3,835	$5,296	$5,402	$3,958	$5,369	$3,185	$1,224	$1,852	$1,729	$2,522	$894 93	

GENERAL NOTE.

Parties.—An average number is given for the years previous to 1844. A party operating in more than one section during the year is counted but once.

Triangulation.—The extent of general coast is measured in general outline, including Delaware and Chesapeake, as well as all open bays, but omitting the minor indentations of the sea-coast. The extent of shore-line is also measured in general outline, and includes such rivers only as have been triangulated.

Topography.—The length of general coast is measured similarly to that under triangulation; but shore-line under topography represents the whole water-line surveyed, including all the minor indentations, as represented on the plane-table sheets.

Records.—The total number of volumes of records given in the table is greater than the number now on hand, owing to the binding up of separate volumes.

Engraved plates.—Progress sketches (averaging fourteen yearly) are not counted.

Preliminary charts and sketches published.—Including a large number of maps of the scene of operation of the war.

Library.—The number of volumes purchased and donated up to 1849 was 655.

It is to be remarked that the numbers appearing in the column of this table for the year immediately preceding that of its compilation are, in some cases, subject to be changed, more or less, in the succeeding report, owing to data not being, at the time of compilation, fully turned into the office from the distant parties in the field.

APPENDIX No. 4.

GENERAL LIST OF COAST SURVEY DISCOVERIES AND DEVELOPMENTS TO 1862, INCLUSIVE.

1. A ledge with four fathoms of water on it, discovered S.SW. $\frac{1}{4}$ W., (true,) and a mile and a quarter from Pemaquid light-house, coast of Maine, 1860.

2. Numerous dangerous reefs and ledges developed at the entrance and in the approaches of Damariscotta river, Maine, 1860.

3. Two rocks, one with three and a quarter fathoms, the other with only ten feet of water, and a ledge with three and a half fathoms, found in the channel of Booth bay, Maine, 1860.

4. Jeffrey's bank and Jeffrey's ledge, off the coast of Maine, thoroughly sounded out, 1860.

5. Only eighteen feet at mean low water found on the rock one mile to the southward of Seguin island, coast of Maine, 1859.

6. Temple's ledge, near Cape Small Point, Maine, 1857.

7. True position of the Hussey Rock, in Casco bay, determined, correcting the erroneous one assigned on previous charts, 1859.

8. Determination of the position of a sunken rock on which the steamer Daniel Webster struck, in Casco bay, on the evening of the 13th of October, 1856.

9. Determination of the dimensions of Alden's Rock, near Cape Elizabeth, Maine, 1854.

10. Determination of the position of the "Hue and Cry," the "Old Proprietor," and other dangers off Cape Elizabeth, Maine, 1859.

11. Huzzy's Rock, south of Fletcher's Neck, Maine, determined in position, 1859.

12. Development of a four-fathom bank off Cape Porpoise, Maine, 1859.

13. Fishing ledge, off Kennebunk, Maine, thoroughly sounded, 1859.

14. A rock one mile to the southward and westward of Boon island, with seventeen feet water. The sea breaks on it in heavy weather, 1858.

15. Development of a rock off Ogunquit, bare at low tides, and very little known, 1859.

16. Development of Boon Island ledge, coast of Maine, 1858.

17. A rock off Cape Neddick, Maine, determined in position, 1858.

18. A detached rock, two-thirds of a mile northward and eastward of York ledge, Maine, 1858.

19. Determination of the position of a rock more than a mile off the mouth of York river, Maine, bare at low tides and dangerous to coasters, 1858.

20. Development of Duck Island ledge, 1858.

21. A fishing bank sounded out off Wood island, coast of Maine, 1859.

22. A very dangerous rock, with only six and a half feet water, off the entrance to Portsmouth harbor, New Hampshire, about four nautical miles eastward from the Whale's Back light, 1858.

23. A rock with twelve feet at mean low water, about four miles and a third eastward of the Whale's Back, 1858.

24. Determination of the positions of four points of rock in Sandy bay, (Cape Ann,) Massachusetts, 1861.

25. A rock (not on any chart) in the inner harbor of Gloucester, Massachusetts, discovered in 1853.

26. Determination of rocks off Marblehead and Nahant, 1855.

27. Determination of the position of White Rock ledge, at the entrance of Saugus river, Massachusetts, 1860.

28. 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.

29. Boston harbor; Broad Sound channel thoroughly surveyed and marks recommended, 1848.

30. Several rocks in the fair channel-way in Boston harbor entrance, 1854.

31. An extension of the sand-pit to the southward of Sunken ledge, Boston harbor, since the survey of 1847, 1858.

32. Discovery of a rock with only seventeen feet of water at mean low tide in the Narrows of Boston harbor, 1860.

33. Special investigation of the currents of Boston harbor, 1860 and 1861.

34. 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.

35. Extension of Stellwagen's bank to the southward and eastward some sixteen or seventeen square miles, enclosed by the twenty-fathom curve, 1855.

36. Changes in the vicinity of East harbor, (Cape Cod,) 1857.

37. Special tidal and current observations at the mouth of Scusset river, (Cape Cod bay,) 1860.

38. A dangerous sunken ledge (Davis's ledge) to the eastward and in the neighborhood of Minot's ledge, 1854.

39. Development of a reef extending between Minot's and Scituate light, 1856.

40. A sunken rock, with only six feet on it at low water, off Webster's Flag-staff, Massachusetts bay, 1856.

41. A dangerous rock near Saquish Head, entrance to Plymouth harbor, 1856.

42. Three rocks determined in position, partly bare at low water, off Manomet Point, Massachusetts bay, 1856.

43. Determination of a very dangerous rock off Indian Hill, and four miles southward of Manomet Point, Massachusetts bay, with as little as six feet water on it, 1856.

44. The currents of Cape Cod bay observed with reference to their physical effects on the shores, 1861.

45. Determination of the position of a small rock with less than four feet at mean low water, near the channel and in the vicinity of Great Rock, Hyannis harbor, Massachusetts, 1859.

46. Probable connexion of George's bank and the deep sea banks north and east of Nantucket, 1855.

47. The decrease of depth, with general permanence of form of George's bank, off the coast of Massachusetts, 1857.

48. A shoal spot near Little George's bank, 1857.

49. Non-existence determined of "Clark's bank" and "Crab ledge," laid down on certain charts as distinct from an immense shoal ground off Cape Cod peninsula, 1856.

50. Nantucket shoals; Davis's New South shoals, six miles south of the old Nantucket south shoals in the track of all vessels going between New York and Europe, or running along the coast from the eastern to the southern States, or to South America; discovered in 1846.

51. Two new shoals north and east of Nantucket; discovered in 1847.

52. Six new shoals near Nantucket, the outermost fourteen and a half miles from land, and with only ten feet water; discovered in 1848.

53. McBlair's shoals off Nantucket; discovered in 1849.

54. The tidal currents of Nantucket shoals and the approaches, 1854.

55. Davis's bank, Nantucket shoals; discovered in 1848, and survey finished in 1851.

56. Fishing Rip, a large shoal extending north and south, about ten miles to the eastward of Davis's bank, and thirty miles from Nantucket, with four and a half fathoms; surveyed in 1852.

57. A ridge connecting Davis's New South shoal and Davis's bank; found in 1853.

58. 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's bank and Fishing Rip, the water gradually deepening outside of it to the northward and eastward beyond the limits of the series of shoals, 1853.

59. Discovery of a shoal lying N.NE., over six miles long, and twenty-four miles southeast of Davis's south shoal, with ten to ten and a half fathoms of water, 1860.

60. Discovery of three small banks off the Nantucket shoals in the vicinity of Phelps's bank, and further development of the extent of that shoal ground, 1861.

61. Discovery of Edward's shoal, one mile and seven-eighths southward of Nantucket light-boat, 1855.

62. Examination of the interference tides of Nantucket and Martha's Vineyard sounds, 1855.

63. The study of the tidal currents of the Vineyard and Nantucket sounds, 1857.

64. Contraction of the inlet at the north end of Monomoy island, and opening of a new entrance to Chatham harbor, 1853.

65. Muskeget channel, surveyed by Lieutenant C. H. Davis, in 1848, and Lieutenant C. H. McBlair, in 1850.

66. Discovery of two shoal spots, with twelve and thirteen feet water, eastward from Great and Little Round shoals, Nantucket sound, 1856.

67. Determination of two shoal spots near the northern extremity of Davis's bank, with fourteen and eighteen feet water, 1856.

68. Further development of Edward's shoal, three-fourths of a mile from the southern Cross Rip, Nantucket sound, 1856.

69. Shoal sand ridges discovered northward of Great Point light, Nantucket sound, 1856.

70. Important changes in geographical feature at the southeastern end of Martha's Vineyard, Muskeget channel, 1856.

71. Numerous rocks in Martha's Vineyard sound, Long Island sound, and the various bays and harbors connected with them.

72. Two rocks discovered in the approaches to Newport harbor, R. I. One of these has fourteen and a quarter feet of water on it at mean low tide; the other has seventeen feet at low water. Ten other rocks, before known, were determined in position, 1862.

73. Luddington rocks determined in position, about ten yards apart, a mile and a half (nautical) southwest by compass from New Haven light, 1858.

74. The tidal currents of Long Island sound, 1854.

75. The tidal currents of Hell Gate, 1857.

76. Least water on the Hell Gate rocks determined by dragging, 1857.

77. Tidal currents in East river, New York, and surface and sub-currents investigated in New York harbor, the lower bay, and on the bar, 1858.

78. The currents of the great bay between Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, 1855.

79. Gedney's channel in New York bay, having two feet more water than the old channels. Had the true depth of this channel been known in 1778, (then probably existing, as seen by comparing old and new charts,) the French fleet under Count D'Estaing would have passed into the bay and taken the assembled British vessels, 1845.

80. The changes in New York harbor, near New York city, between 1845 and 1858.

81. Increase of depth in Buttermilk channel, ascertained and made known in 1848 by survey of Lieutenant D. D. Porter, United States navy.

82. The existence of a seventeen-foot spot on the shoal off the battery, New York harbor, the extension of the shoal towards the channel, and the shoaling of the water generally between the shoal and shore, 1859.

83. Shoal in the main ship channel of New York harbor, 1855.

84. The existence and character of sub-currents ascertained as bearing on the physical conditions of New York harbor, 1859.

85. The tides of Hudson river, 1856.

86. Sandy Hook; its remarkable increase traced from the surveys of the topographical engineers and others, and by several successive special surveys made between 1844 and 1857.

87. Development, by soundings, of a ridge lying sixteen miles off Barnegat, N. J., with eleven to thirteen fathoms of water, and sixteen fathoms between it and the coast, 1861.

88. Special examination made and changes noted in the vicinity of the Five-fathom bank, off Cape May, 1861.

89. Delaware bay; Blake's channel at the entrance, discovered in 1844; open when the eastern channel is closed by ice. This discovery has served to develop strikingly the resources of that portion of Delaware.

90. Blunt's channel in Delaware bay.

91. Changes in the Delaware, near the Pea Patch, 1847.

92. Hydrographic changes developed in the Delaware river, at the Bulk Head shoal, near Fort Delaware, at the bar off Fort Mifflin, and opposite to Philadelphia, 1861.

93. The true extent and position of the dangerous shoals near Chincoteague inlet, Virginia, 1852.

94. Metomkin inlet, Virginia, shoaling from eleven to eight feet in the channel during 1852.

95. The shifting of the bar of Metomkin inlet, Va., and changes of shore-line, but without alteration of depth on the bar, 1862.

96. 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.

97. A shoal half a mile in extent, not put down on any chart, five and a half miles east from the north end of Paramore's island, Virginia. It has but four fathoms water on it, and nine fathoms around it, 1852.

98. Great Machipongo inlet, Virginia. Found to have a fine wide channel, with eleven feet water on the bar at low ebb and fourteen at high tide. Good anchorage inside, from two to eight fathoms. The best harbor between the Chesapeake and Delaware entrances, 1852.

99. Two shoals near the entrance to the Chesapeake—one four and three-quarters nautical miles SE. by E. from Smith's Island light-house, with seventeen feet water upon it; the other, E. by S., nearly seven and three-quarters miles from the same light, with nineteen and a half feet upon it, 1853.

100. 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.

101. A twenty-five fathom hole two and a half miles W.SW. from Tazewell triangulation point, eastern shore of the Chesapeake. All other charts give not more than sixteen fathoms in this vicinity.

102. A shoal at the mouth of the Great and Little Choptank, in Chesapeake bay, 1848.

103. The sounding and measurement of the bars in Rappahannock river, 1855.

104. The general permanence of the Bodkin channel and shoals in its vicinity, at the entrance of the Patapsco river, between 1844 and 1854.

105. Changes developed in the shore-lines at the entrance of Little Annemessex river, Chesapeake bay, 1859.

106. 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.

107. Re-examination of York spit, Chesapeake bay, and least water determined, (nine feet,) 1855.

108. York river, Va., as a harbor, 1857.

109. Development of the best line of water for crossing the Kettlebottom shoals, Potomac river, there being no well defined channel, 1862.

110. Changes in depth and outline at Oregon inlet, N. C., 1862.

111. A reconnaissance of the Wimble shoals, near Nag's Head, coast of North Carolina, 1854.

112. Submarine range of hills beyond the Gulf Stream tracked from Cape Florida to Cape Lookout, 1855.

113. Deep water found on Diamond shoal, and a dangerous nine-feet shoal off Cape Hatteras, 1850.

114. A new channel, with fourteen feet water, into Hatteras inlet, formed during the year 1852, which is better and straighter than the old channel.

115. Changes at Hatteras and Ocracoke inlets, 1857.

116. Extent of the sea encroachment at Cape Hatteras, and changes found near Hatteras inlet, N. C., 1860 and 1861.

117. Special examination of the tides and currents, with reference to the hydrographic and shore-line changes at Hatteras inlet, N. C., 1862.

118. The general permanence in depth on the bar of Beaufort, N. C., with the changes of position of the channel, 1854.

119. Changes on the bar of Beaufort, N. C., 1857.

120. Development of the alteration in outline and depth at the entrance of Beaufort harbor, N. C., 1862.

121. 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 that harbor, 1853.

122. Changes in the main Western and New Inlet channels in Cape Fear, 1855.

123. Frying Pan shoals, off Cape Fear, N. C.; a channel of two and a half fathoms upwards of a mile wide, distant eleven nautical miles from Bald Head light-house across the Frying Pan shoals. A channel extending from three to four miles from the point of Cape Fear to eight or eight and a half miles from it, with sufficient water at low tide to allow vessels drawing from nine to ten feet to cross safely. A channel at the distance of fourteen nautical miles from Bald Head light-house, one mile wide, with three and a half to seven fathoms water on it. The Frying Pan shoals extend twenty nautical miles from Bald Head light-house, and sixteen, seventeen, and eighteen feet water is found seventeen and eighteen nautical miles out from the light, 1851.

124. Shoaling of Cape Fear River bar thoroughly examined for purposes of improvement, 1852.

125. Changes of shore-line and hydrography determined at the Cape Fear entrances, N. C., 1858.

126. Changes of the Cape Fear bars and channels, 1857.

127. Changes at the entrance of Winyah bay and Georgetown harbor, and the washing away of Light-house Point at the same entrance, 1853.

128. Less water found off Cape Romain, by preliminary examination, than has been heretofore assigned, 1859.

129. Re-examination, by soundings, of the Rattlesnake shoal, S. C., 1862.

130. Maffitt's new channel, Charleston harbor, with the same depth of water as the ship channel, 1850.

131. The changes in Maffitt's channel, Charleston harbor, S. C., from 1852 to 1857.

132. Increase of depth developed in Maffitt's channel, Charleston harbor, S. C., 1858.

133. Changes in the main ship channel, Charleston harbor, 1851.

134. Changes in the channels at the entrance of Charleston harbor, 1852.

135. 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.

136. Stono entrance, S. C., sounded, and channel found half a mile to westward of its former position, with slight increase of depth, 1862.

137. Development of the changes affecting the entrance to North Edisto river, S. C., 1856.

138. The shoaling of North Edisto entrance from its former depth, to nine feet of water.

139. St. Helena entrance, S. C., examined, and a new channel from the eastward found, giving sixteen feet at mean low water, 1862.

140. Greater depth found through the channel of Coosaw river, S. C., (inland passage,) than has been hitherto supposed to exist, 1860.

141. Discovery of a new channel between Martin's Industry (shoal) and the southeast breakers, Port Royal entrance, S. C., 1856.

142. The south channel of Port Royal sound developed, and nineteen and a half feet found to be the least depth of water, 1862.

143. The channel of the inland passage thoroughly sounded, leading from Port Royal sound to Tybee roads, through Skull creek and Calibogue sound, 1862.

144. Discovery of cold water at the bottom of the ocean below the Gulf Stream, along the coast of North and South Carolina, Georgia and Florida, 1853.

145. The discovery of the cold wall, alternate warm and cold bands, and various other features of the Gulf Stream, especially such as concern its surface and deep-sea temperatures, and its distribution relative to the shore and bottom of the ocean.

146. Various facts relative to the distribution of minute shells on the ocean bottom, of probable use to navigators for recognizing their positions.

147. Changes in shore-line and in depth observed in Ossabaw sound, Ga., 1860.

148. A new channel developed leading into Sapelo sound, Ga., three-quarters of a mile southward, and better than the one in use, 1860.

149. Examination of Doboy, St. Simon's, and Cumberland entrances, 1855.

150. The bar and entrance of St. Simon's sound, Ga., examined, showing no material change of depth within the past two years, 1862.

151. The shifting to southward and shoaling by several feet of the channel into Fernandina harbor, Fla., having now only eleven feet at mean low water, 1862.

152. A shoal inside of the entrance to Amelia river, Fla., 1857.

153. Hetzel Shoal, off Cape Cañaveral, Fla., 1850.

154. A shoal spot found off the coast of Florida, ten miles from land and fifteen miles NE. of Indian River inlet, 1860.

155. Temperature of 34° beneath the Gulf Stream, thirty-five miles east of Cape Florida, at a depth of three hundred and seventy fathoms, 1855.

156. Further explorations and investigations in developing the character of the Gulf Stream in the Florida channel, 1859 and 1860.

157. 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.

158. A new passage, with three fathoms water, across the Florida reef, to Legaré harbor, under Triumph reef, (latitude 25° 30′ N., longitude 80° 03′ W.,) which, if properly buoyed, will be valuable as a harbor of refuge, 1852.

159. A safe rule for crossing the Florida reef near Indian key, 1854.

160. Tennessee shoal, Florida reef, developed, giving only twelve feet of water on its outer patch, 1860.

161. The position of a sunken wreck determined and marked, lying off Grassy key, Florida reef, and near the track of vessels, 1860.

162. A new channel into Key West harbor, 1850.

163. Co-tidal lines for the Atlantic coast of the United States, 1854.

164. Rules for navigators in regard to the tidal currents of the coast, 1857.

165. Isaac shoal, near Rebecca shoal, Florida reef; not laid down on any chart; 1852.

166. Channel No. 4, a northeast entrance into Cedar Keys bay, 1852.

167. Directions for entering the harbor from Crystal River offing, west coast of Florida peninsula, 1856.

168. A new channel discovered, leading into St. George's sound, (Apalachicola, Fla.,) at the east end of Dog island, and anchorage connected with it, 1858.

169. Shoals near the east and west passes of St. George's sound, (Apalachicola, Fla.,) and a new channel found between St. George's and St. Vincent's islands, 1858.

170. Indications noticed of a deeper and better channel forming to lead to the East Pass anchorage, St. George's sound, Fla., 1860.

171. Changes in the depth of water observed by comparison of soundings at Perdido entrance, 1860.

172. Mobile Bay Entrance bar; in 1832 only seventeen feet at low water could be carried over it; in 1841 it had nineteen, and in 1847 it had twenty feet and three quarters, as shown by successive surveys; 1847.

173. The diminution, almost closing, of the passage between Dauphine and Pelican islands, at the entrance of Mobile bay, 1853.

174. The currents of Mobile bay specially investigated, 1860.

175. Horn Island channel, Mississippi sound, 1852.

176. 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.

177. The accurate determination of Ship shoal, off the coast of Louisiana, in connexion with the site for a light-house, 1853.

178. An increase of depth of water on the bar of Pass Fourchon, La., 1854.

179. Deep-sea soundings in the Gulf of Mexico, 1855–'56.

180. Tidal phenomena of the Gulf, 1855.

181. The changes at Aransas Pass, Texas, as bearing on the question of a light-house site, 1853.

182. Co-tidal lines of the Gulf of Mexico, 1856.

183. On the effect of wind in disturbing the tides of the Gulf of Mexico, 1856.

184. Development of a bar at the entrance of San Diego bay, Cal., 1856.

185. A shoal inside of Ballast Point, San Diego bay, with only twelve and a half feet of water, not laid down on any chart, 1852.

186. The determination of the position and soundings on Cortez bank, off the coast of California, 1853.

187. Complete hydrographic survey and determination of a point of rock on Cortez shoal, 1856.

188. Tides of San Diego, San Francisco, and Astoria, 1854.

189. The non-existence of San Juan island, usually laid among the Santa Barbara group, 1852.

190. Co-tidal lines of the Pacific coast, 1855.

191. Determination of Uncle Sam Rock, 1855.

192. Investigation of the currents of Santa Barbara channel, 1856.

193. Red sand marking the entrance to the Golden Gate, 1855.

194. Channel sounded out between Yerba Buena and the Contra Costa, San Francisco bay, 1855.

195. A reef developed off the Contra Costa flats, San Francisco bay, Cal., 1858.

196. Whiting's Rock determined in position, near the "Brothers," at the entrance of San Pablo bay, Cal., 1858.

197. The further encroachment of the sand spit at the confluence of Karquines and Mare Island straits upon the channels which lead to the navy yard and to Benicia, 1862.

198. Further development of the extent of Commission Rock, San Pablo bay, 1856.

199. Changes in the channel entrance of Humboldt bay or harbor, Cal., 1852 and 1853.

200. 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.

201. The depth of water on the bars at the entrance of Rogue river and Umpquah river, Oregon, 1853.

202. A shoal at the northern entrance to the strait of Rosario, W. T., giving good holding ground in thirty-three feet, 1854.

203. Boulder reef, northwest of Sinclair island, Rosario strait, partly bare at unusually low tides, and surrounded by kelp, 1854.

204. A bank of three and a half fathoms, about a mile off the southwest point of Sucia island, at the northern entrance of Washington sound, W. T., 1858.

205. Belle rock, in the middle of Rosario strait, visible only at extreme low tides, 1854.

206. Entrance rock, at the entrance of Rosario strait, 1854.

207. Unit rock, in the Canal de Haro, W. T., visible only at extreme low tides, 1854.

208. A three-fathom shoal in the strait of Juan de Fuca, off the southeast part of Bellevue or San Juan island, 1854.

209. Allen's bank, Admiralty inlet, W. T., 1857.

210. A five-fathom shoal in the strait of Juan de Fuca, between Canal de Haro and Rosario strait, 1854.

211. A bank in eleven fathoms off the southern entrance to Canal de Haro, 1854.

212. The non-existence of two islands at the northern entrance of Canal de Haro, laid down on charts, 1853.

213. Various surveys and charts of small harbors on the Pacific coast of the United States, and a continuous reconnaissance of the entire Western Coast and islands adjacent, a great part of which was imperfectly known.

214. Winds of the Western Coast of the United States, 1857.

ADDITIONAL LIST FOR 1863.

1. Examination of the channels leading into Carver's harbor, (Penobscot bay,) with reference to the positions of rocks and shoals dangerous to navigation.

2. A dangerous ledge determined in position, with only eleven feet at mean low water, two miles west of the north end of Metinic island, mouth of Penobscot bay.

3. Determination in position and depth of ten rocks near the approaches of Portland harbor, and of a spot with only fourteen feet water on Bulwark shoal; on Vapor Rock, twenty feet; on Witch Rock, twenty-four; on Corwin Rock, twenty-four and a half; on Mitchel Rock, thirty-one; on Willard Rock, thirty-one and a half; on Bache Rock, thirty-two feet; on Round Rock, thirty feet; on Old Anthony or Vapor Rock, twenty feet; on the Western Hue-and-Cry, twenty-seven and a half feet; on West Cod Ledge, thirty-four feet, and on East Cod ledge, forty-nine feet.

4. Several dangerous rocks and ledges developed in the approaches of Sippican harbor, (Buzzard's bay,) and others inside of the harbor.

5. Development of a ledge, (Great Eastern ledge,) off Montauk Point, having at one point only twenty-four feet at mean low water, and at another twenty-seven feet.

6. Development of shore-line and hydrographic changes at Sandy Hook, with reference to the effect of the great storm of January, 1863.

7. The alteration of shore-line and sea encroachment near Absecom light-house, coast of New Jersey.

8. Development of hydrographic changes at the Delaware breakwater.

9. Special survey of part of League island, Delaware river, and comparison of changes with previous surveys.

10. Examination of soundings eastward of Winter Quarter shoal to determine the alleged existence of a second shoal.

11. A shoal found with only fourteen feet of water S. by E. $\frac{1}{2}$ E. and distant ten and a half miles from Cape Lookout light-house.

12. Development in position of the point with only twenty-one feet at mean low water, of Noonday Rock, (called also Fanny shoal,) in the track of vessels passing the North Farallon, approaching San Francisco bay.

13. Determination of the position of the wreck of the ship Flying Dragon, in the track of vessels navigating San Francisco bay.

APPENDIX No. 5.

BEARINGS AND DISTANCES FROM ROCKS AND LEDGES DEVELOPED BY LIEUTENANT COMMANDER T. S. PHELPS, U. S. N., ASSISTANT COAST SURVEY, AND BY ACTING ASSISTANT EDWARD CORDELL, IN THE APPROACHES TO PORTLAND HARBOR, ME.

1. *Witch Rock*, 24 feet water.
   Portland Light-house, W. by N. nearly, distant $1\frac{3}{8}$ miles.
   Middle of Ram Island, N.NW., distant $\frac{7}{8}$ mile.
2. *Willard's Rock*, $31\frac{1}{2}$ feet water.
   Portland Light-house, NW. by N. $\frac{1}{2}$ N. nearly, distant $1\frac{3}{4}$ miles.
   Cape Elizabeth East Light-house, SW. by S. $\frac{1}{4}$ S., distant $2\frac{1}{4}$ miles.
   Trundy's Reef Buoy, SW. $\frac{1}{2}$ W., distant $\frac{3}{8}$ mile.
3. *West Cod Ledge*, 33* feet water.
   Portland Light-house, NW. $\frac{3}{4}$ N., distant $4\frac{5}{8}$ miles.
   Cape Elizabeth East Light-house, W. $\frac{1}{2}$ N., distant $3\frac{1}{8}$ miles.
   Alden's Rock Buoy, SW. by W., distant $1\frac{5}{8}$ miles.
4. *Corwin Rock*, $24\frac{1}{2}$† feet water.
   Portland Light-house, N.NW. nearly, distant $4\frac{3}{4}$ miles.
   Cape Elizabeth East Light-house, NW. by W. $\frac{3}{4}$ W., distant $2\frac{3}{8}$ miles.
   Alden's Rock Buoy, SW. by W., distant $\frac{1}{2}$ mile.
5. *West Hue-and-Cry Rocks*, 27 feet water.
   Cape Elizabeth East Light-house, N.NW., distant $2\frac{3}{4}$ miles.
   Barn on Richmond Island, NW. by W. $\frac{1}{2}$ W., distant $3\frac{1}{4}$ miles.
   Alden's Rock Buoy, NE. by N. $\frac{3}{4}$ N., distant $1\frac{1}{2}$ miles.
6. *Bulwark Shoal*, surveyed by E. Cordell, Acting Assistant, has *fourteen* feet water on it. The depth of six feet heretofore given on the Chart is an error.

The bearings are magnetic.
The distances are in nautical miles.
The depths are at Mean Low Water.

The above notes were published in September in the form of a Notice to Mariners.

APPENDIX No. 6.

NON-EXISTENCE OF A SUPPOSED SHOAL EASTWARD OF WINTER QUARTER SHOAL, COAST OF VIRGINIA.

COAST SURVEY OFFICE, *May* 4, 1863.

SIR: I have the honor to report that the locality to the eastward and near to Winter Quarter Shoal, off the boundary between Maryland and Virginia, where the steamer Baltic was supposed to have struck in the autumn of 1862, has been thoroughly examined by Lieutenant Commander T. S. Phelps, U. S. N., assistant in the Coast Survey. The following extract from his report I would respectfully request permission to publish in the usual form:

"I carefully and thoroughly sounded out the locality east of Winter Quarter Shoal, where the steamer Baltic was supposed to have 'run aground in 18 feet water' last autumn, and no indication whatever could be found of the existence of such a shoal. Our soundings throughout proved the correctness of the Coast Survey charts. The sea at the time was sufficiently heavy to indicate the outlines of Winter Quarter Shoal, even where there were four fathoms water, and if the alleged shoal existed, the heavy and confused swell over it would alone have been sufficient to determine its position."

Very respectfully, yours,

A. D. BACHE,
Superintendent United States Coast Survey.

Hon. S. P. CHASE, *Secretary of the Treasury.*

---

* One point with only 26 feet water was found later in the season.
† A point with only 21 feet has been since found.

APPENDIX No. 7.

LETTER TO THE SECRETARY OF THE TREASURY COMMUNICATING THE DISCOVERY OF A SHOAL OFF CAPE LOOKOUT, N. C.

COAST SURVEY OFFICE, *January* 2, 1863.

SIR: I have the honor to report that on the passage southward of the Coast Survey steamer Bibb with the party of Assistant C. O. Boutelle, a shoal was found on the 25th of November, 1862, with only fourteen feet of water, bearing S. by E. ½ E. from Cape Lookout Light-house, and distant from it ten and a half miles.

I would respectfully request authority to publish this information in the form of a notice to mariners.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. S. P. CHASE, *Secretary of the Treasury.*

APPENDIX No. 8.

EXTRACTS FROM THE REPORT OF ACTING ASSISTANT EDWARD CORDELL UPON THE DEVELOPMENT BY HYDROGRAPHIC SURVEY OF THE PART OF FLORIDA REEF INCLUDED BETWEEN RODRIGUEZ KEY AND ALLIGATOR REEF.

COAST SURVEY STEAMER VIXEN,
Key West, Florida, April 3, 1863.

DEAR SIR: * * * * * * *

The principal reefs coming within the limits of my work of this season are as follows:

French Reef.—The southwestern extremity of this reef, situated about half way between French Reef Beacon and the beacon on Pickle's Reef, is one of the most dangerous points on the Florida range for vessels intending to follow the line of the Beacons. It projects half a mile to the eastward of a straight line between the two Beacons referred to, and has as little as one foot of water upon it.

Pickle Reef is marked at its middle by beacon F. In a NE. and SW. direction its extent is about a mile and a quarter, with a foot of water at its shoalest part. Between the north end of it and French Reef is an opening three-quarters of a mile wide, through which sixteen feet can be carried. The southern portion of the Reef deepens gradually to twelve feet, that depth being a mile and a quarter from the Beacon, but there is a narrow cut of deeper water at less distance in the same direction. Thence on, and to within three-quarters of a mile from Beacon E, on Conch Reef, there is an opening of a mile and a half which has three and four fathoms of water.

Conch Reef has as little as eighteen inches of water on it. It is a mile and a quarter long, lying NE. and SW., and separated from Little Conch Reef by a narrow cut of four and five fathoms. The shoalest water on Little Conch is six feet, and breaks in moderate breezes.

Davis Reef is about half way between Little Conch and Crocus Reef, with four feet of water, which breaks generally at low tide. This is a small reef running NW. and SE. There are openings of a mile and a half on either side of it which give three and four fathoms of water.

Crocus Reef extends about three hundred yards NW. and SE., and can be approached within one hundred and fifty yards. On its shoalest part the water is two feet deep. Beacon D, which marked this reef, and Beacon C, set up on Alligator Reef, were both destroyed in the gale of August, 1861. It is very important that these marks should be replaced at the earliest moment practicable.

Between the Florida Reefs and the line of Keys there are two channels; one, known as the Hawk Channel, extends all the way from Cape Florida to Key West. Two of the buoys which mark it come within the limits of this season's work, the sheet embracing a stretch of about fifteen miles. These are Triangle Shoal buoy, and the buoy on Hen and Chicken. The other channel is not buoyed out, and is very seldom used except by wreckers familiar with its bends and intricacies. It runs inside of the outer reef from Cape Florida to Alligator Bank. Vessels that drift on the reef, and succeed in getting over into deeper water inside, may avail themselves of this channel to make their way to the nearest opening between the reefs, and through it into the Gulf, by means of the chart, and by using the lead and observing the shaded color of the water. * *

Very respectfully,

EDW. CORDELL, *in charge of Hydrographic Party.*

Prof. A. D. BACHE,
Superintendent United States Coast Survey.

APPENDIX No. 9.

EXTRACTS FROM THE REPORT OF ACTING ASSISTANT EDWARD CORDELL ON THE APPROACHES AND ENTRANCE OF CHARLOTTE HARBOR, FLA.

UNITED STATES COAST SURVEY STEAMER VIXEN,
Key West, Florida, May 2, 1863.

DEAR SIR: * * * * * * *

The outer bar and the channel leading into the bay were thoroughly sounded out, and a full development was made of the banks on either side. Soundings were carried out six miles from shore into seven fathoms of water, and extended over a space of about nine miles in length abreast of the entrance, including more than four miles of the shore of La Costa island to the southward, and as many of Gasparilla island to the northward.

Seventeen feet at low water can be carried over the Bar of Charlotte Harbor. Inside of the bar the channel widens to three-quarters of a mile, with a depth of three and a half and four fathoms, the best water being on its northern edge.

Vessels in approaching should not go into less than five fathoms, if from the south; and in not less than six fathoms, if coming from the northward. When off the entrance, with Boca Grande bearing NE. $\frac{1}{2}$ E., and the north point of La Costa island E.NE., vessels can steer in NE. by E. $\frac{1}{4}$ E. for the entrance, and choose an anchorage in four or five fathoms inside.

A Black and White Buoy placed in eighteen feet water, marks at present the mid-channel. I would recommend that it be moved a third of a mile further out and placed in three and a half fathoms on the edge of the bar.

Very respectfully,

EDWARD CORDELL,
In charge of Hydrographic Party.

Prof. A. D. BACHE,
Superintendent United States Coast Survey.

APPENDIX No. 10.

DETERMINATION OF POSITION, AND SAILING DIRECTIONS FOR CLEARING THE FANNY ROCK, NEAR THE NORTH FARALLONES, OFF SAN FRANCISCO ENTRANCE, CAL.

NOTICE TO MARINERS.

The following position of the Fanny, or Noonday Rock, near the North Farallones, (off San Francisco entrance,) has been received by telegraph from Assistant A. F. Rodgers, United States Coast Survey, as determined by him on the 29th of January, 1863:

Bearings at Noonday Rock.

Point Reyes (west end)	N. 13° 25′ E. (mag.)	N. 29° 03′ E. (true)	$13\frac{7}{8}$ naut. miles.
North Farallon,	S. 79° 30′ E. (mag.)	S. 63° 52′ E. (true)	$3\frac{1}{8}$ " "
S. Farallon Light-house	S. 69° 45′ E. (mag.)	S. 54° 07′ E. (true)	$9\frac{3}{4}$ " "

Variation of the compass in 1863, 15° 38′ east.

The ship Noonday, drawing twenty-one feet, struck on this rock on the 2d of January, and was totally lost.

SAILING DIRECTIONS.

To clear Noonday Rock.—Do not go to eastward of Point Reyes, bearing N.NE. until the North and South Farallones are in range. Vessels can then bear away safely for San Francisco bar.

A. D. BACHE,
Superintendent United States Coast Survey.

COAST SURVEY OFFICE, *February* 3, 1863.

SAN FRANCISCO, CALIFORNIA, *June* 15, 1863.

DEAR SIR: I returned on the 12th from an examination of *Noonday* or *Fanny Rock*, having spent nearly a week in that service.

We sounded in $3\frac{3}{4}$ fathoms at 11*h*. 52*m*., June 11. This will, at extreme low water, reduce to less than $3\frac{1}{2}$ fathoms, and sets at rest the question of a ship striking it without regard to weather or sea. The battered end of the lead used gave good evidence of the hard character of the bottom in the vicinity of the Rock, which is either itself of coral, or encrusted with some coralline formation, as detached particles were driven into the lead so as to inlay it thoroughly and change its color. With our means no pieces large enough for specimens could be procured.

There are no indications of the vicinity of the rock to be relied upon. Any vessel near enough to be warned by her lead would be too close to it for safety. The length of the ledge seems to be in the direction of a line to the North or South Farallones, and not more than twenty yards in extent, within twenty fathoms of the surface of the water. The top of the rock is an edge in three and a half fathoms, just large enough to hold a lead, and no more.

I believe that the determination in position of the Noonday or Fanny Rock need no longer be considered approximate. The hydrographic draughtsman, Mr. Farquhar, was stationed at Point Reyes and observed upon the vessel while she was at the rock; and although the weather was not so clear as I wished, the limit of errors shown by a series of angles from the vessel and Point Reyes is so small as to satisfy me that the first determination was correct. I have now ranges by which, in clear weather, the rock can be found without difficulty. Mt. St. Helena, Coast Survey station, is conspicuously prominent, open about two ship-lengths to the westward of Point Reyes head, while a peak of the high land to the southward of Pt. San Pedro affords an excellent cross bearing. This last could not be seen sufficiently long to identify it by name while we were at the rock.

Very respectfully, yours,

AUG. F. RODGERS, *Assistant Coast Survey.*

Prof. A. D. BACHE,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX No. 11.

POSITION OF THE WRECK OF THE SHIP FLYING DRAGON, IN SAN FRANCISCO BAY, CAL.

COAST SURVEY OFFICE, *February* 11, 1863.

SIR: I have the honor to state that, in a telegram dated this morning at San Francisco, and just received, Assistant A. F. Rodgers reports having swept for and found the wreck of the ship "Flying Dragon," which was sunk a year ago inside of San Francisco entrance, and in the track of vessels passing between Shag Rock and Bird Rock. The bearings of the wreck from both rocks are here given, from the report of Assistant Rodgers:

At Bird Rock, the wreck bears N. 88° W. (magnetic,) N. 72° 22′ W. (true.) Dist. 330 yards.
At Shag Rock, the wreck bears S. 14° W. (magnetic,) S. 29° 38′ W. (true.) Dist. 670 yards.

I would respectfully request authority to publish this information in the form of a notice to mariners.

Very respectfully, yours,

A. D. BACHE, *Superintendent United States Coast Survey.*

Hon. S. P. CHASE, *Secretary of the Treasury.*

APPENDIX No. 12.

TIDE TABLES FOR THE USE OF NAVIGATORS, PREPARED FROM THE COAST SURVEY OBSERVATIONS, BY A. D. BACHE, SUPERINTENDENT.

[Furnished by authority of the Treasury Department to E. and G. W. Blunt, New York, and revised—1863.]

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, and the time during which many of them have been made are steadily on the increase as the coast survey advances.

The tides on 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, 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 interval during a month's tides, it is a less convenient and less accurate quantity for the use of the navigation than the average interval which is used on the Coast Survey charts, and is sometimes called the "mean" or "corrected establishment."* The following table gives the principal tidal quantities for the different ports named in the first column, where they are arranged under specific heads. The third column of the table gives the mean interval, in hours and minutes, between the moon's transit and the time of high water next after the transit; the fourth, the difference between the greatest and the 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 from 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 the 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 the 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 the following localities,) as of no particular interest in this connexion.

BENCH MARKS.

Boston.—The top of the wall or quay at the entrance of the dry dock in the Charlestown navy yard is fourteen feet $\frac{69}{100}$ (or 14.69 feet) above mean low water.†

New York.—The lower edge of a straight line cut in a stone wall, at the head of a wooden wharf on Governor's island, is thirteen feet $\frac{97}{100}$ (or 13.97 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 southwest side, is eleven feet (11 feet) above mean low water.

Charleston, S. C.—The outer and lower edge of embrasure of gun No. 3, at Castle Pinckney, is ten feet $\frac{13}{100}$ (10.13 feet) above mean low water.

---

* This term was introduced by the Rev. Dr. Whewell, who has done so much for the investigation of the laws of the tides.

† In consequence of alterations made to the wall during the year 1860 the coping is seven-hundredths of a foot lower than formerly.

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 OF—		
		Mean interval	Diff. between greatest and least int'val	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.
Eastport	Maine	11 8	0 51	18.1	20.6	15.4	6 3	6 23	.....
Hanniwell's Point, Kennebec river	....do	11 15	1 14	8.1	9.3	7.0	6 16	6 11	0 22
Portland	....do	11 25	0 44	8.9	9.9	7.6	6 14	6 12	20
Portsmouth	New Hampshire	11 23	53	8.6	9.9	7.2	6 22	6 7	21
Newburyport	Massachusetts	11 22	50	7.8	9.1	6.6	5 16	7 9	24
Rockport	....do	10 57	42	8.6	10.2	7.1	6 17	6 9	30
Salem	....do	11 13	50	9.2	10.6	7.6	6 19	6 6	6
Boston light	....do	11 12	35	9.3	10.9	8.1	6 20	6 6	15
Boston	....do	11 27	43	10.0	11.3	8.5	6 13	6 13	9
Plymouth	....do	11 19	51	10.2	11.4	9.0	6 13	6 17	29
Wellfleet	....do	11 5	1 13	11.2	13.2	9.2	6 6	6 17	15
Provincetown*	....do	11 22	40	9.2	10.8	7.7	6 16	6 10	21
Monomoy	....do	11 58	37	3.8	5.3	2.6	6 25	5 59	36
Nantucket	....do	12 24	37	3.1	3.6	2.6	6 23	5 44	9
Hyannis	....do	12 22	30	3.2	3.9	1.8	6 44	5 41	9
Edgartown	... do	12 16	34	2.0	2.5	1.6	6 51	5 29	24
Holmes's Hole	....do	11 43	31	1.7	1.8	1.3	6 41	5 21	12
Tarpaulin Cove	....do	8 4	49	2.3	2.8	1.8	6 9	6 17	34
Wood's Hole, north side	....do	7 59	53	4.0	4.7	3.1	6 51	5 31	38
Wood's Hole, south side	....do	8 34	45	1.6	2.0	1.2	5 17	7 10	59
Menemsha Bight	....do	7 45	1 0	2.7	3.9	1.8	6 14	6 14	4
Quick's Hole, north side	....do	7 31	1 15	3.7	4.3	2.9	6 31	5 54	39
Quick's Hole, south side	....do	7 36	1 10	3.1	3.8	2.3	6 29	5 55	40
Cuttyhunk	....do	7 40	49	3.5	4.2	2.9	6 31	5 54	39
Kettle Cove	....do	7 48	1 0	4.3	5.0	3.7	6 17	6 4	29
Bird Island light	....do	7 59	45	4.4	5.3	3.5	6 51	5 58	.....
New Bedford entrance, (Dumpling Rock)	....do	7 57	41	3.8	4.6	2.8	6 50	5 33	42
Newport	Rhode Island	7 45	24	3.9	4.6	3.1	6 21	6 3	23
Point Judith	....do	7 32	46	3.1	3.7	2.6	6 12	6 10	1 0
Block island	....do	7 36	41	2.8	3 5	2.0	6 23	6 2	5
Montauk Point, L. I	New York	8 20	1 11	1.9	2.4	1.8	6 17	6 7	31
Sandy Hook	....do	7 29	47	4.8	5.6	4.0	6 10	6 15	21
New York	....do	8 13	43	4.3	5.4	3.4	6 0	6 25	28
HUDSON RIVER.									
Dobb's Ferry	New York	9 19	44	3.6	4.4	2.7	6 5	6 18	17
Tarrytown	....do	9 57	58	3.5	4.0	2.7	6 6	6 20	43
Verplanck's Point	....do	10 8	34	3.1	3.8	2.5	5 25	7 12	16
West Point	....do	11 2	37	2.7	3.2	2.0	5 28	7 10	20
Poughkeepsie	....do	12 34	54	3.2	3.9	2.4	5 41	6 44	22
Tivoli	....do	1 24	51	4.0	4.6	3.2	5 40	6 54	25
Stuyvesant	....do	3 23	48	3.8	4.4	3.0	5 18	7 2	31
Castleton	....do	4 29	55	2.7	3.0	2.3	5 1	7 23	20
Greenbush	....do	5 22	40	2.3	2.5	1.9	4 26	7 59	.....
LONG ISLAND SOUND.									
Watch Hill	Rhode Island	9 0	23	2.7	3.1	2.4	6 35	5 56	14
Stonington	Connecticut	9 7	30	2.7	3.2	2.2	6 15	6 10	25
Little Gull island	New York	9 38	1 7	2.5	2.9	2.3	6 1	6 21	37
New London	Connecticut	9 28	52	2.6	3.1	2.1	5 56	6 26	22
New Haven	....do	11 16	1 8	5.9	6.2	5.2	6 24	6 5	33
Bridgeport	....do	11 11	1 3	6.5	8.0	4.7	6 1	6 7	30

*From Major J. D. Graham's observations.

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Diff. between greatest and least int'val.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
LONG ISLAND SOUND—Continued.		h. m.	h. m.	Feet.	Feet.	Feet.	h. m.	h. m.	h. m.
Oyster Bay, L. I.	New York	11 7	0 51	7.3	9.2	5.4	6 8	6 24	0 25
Sand's Point, L. I.	do	11 13	31	7.7	8.9	6.4	5 55	6 30	14
New Rochelle	do	11 22	32	7.6	8.6	6.6	5 51	6 35	12
Throg's Neck	do	11 20	39	7.3	9.2	6.1	5 50	6 33	42
COAST OF NEW JERSEY.									
Cold Spring inlet	New Jersey	7 32	51	4.4	5.4	3 6	6 8	6 18	19
Cape May landing	do	8 19	47	4.8	6.0	4.3	6 11	6 15	20
DELAWARE BAY AND RIVER.									
Delaware breakwater	Delaware	8 0	50	3.5	4.5	3.0	6 15	6 6	25
Higbee's, Cape May	New Jersey	8 33	43	4.9	6.2	3.9	6 26	6 0	19
Egg Island light	do	9 4	51	6.0	7.0	5.1	5 52	5 27	36
Mahon's river	Delaware	9 52	48	5.9	6.9	5.0	6 11	6 11	26
Newcastle	do	11 53	24	6.5	6.9	6.0	5 6	5 43	47
Philadelphia	Pennsylvania	13 44	44	6.0	6.8	5.1	4 52	7 6	15
CHESAPEAKE BAY AND RIVERS.									
Old Point Comfort	Virginia	8 17	60	2.5	3.0	2 0	6 1	6 25	14
Point Lookout	Maryland	12 58	45	1.4	1.9	0.7	5 59	6 19	35
Annapolis	do	17 4	40	0.9	1.0	0.8	6 11	6 15	32
Bodkin light	do	18 8	48	1.0	1.3	0.8	5 23	7 8	15
Baltimore	do	18 59	44	1.3	1.5	0.9	5 54	6 33	44
Washington	Dist. of Columbia	20 10	52	3.0	3.4	2.6	5 37	6 49	.....
James river, (City Point)	Virginia	14 37	1 0	2.8	3.0	2.5	5 14	6 58	32
Richmond	do	16 54	1 6	2.9	3.4	2.3	4 53	7 31	35
Tappahannock	do	13 8	46	1.6	1.9	1.3	5 21	7 6	.....
COAST OF NORTH AND SOUTH CAROLINA, GEORGIA, AND FLORIDA.									
Hatteras inlet	North Carolina	7 4	57	2.0	2.2	1.8	6 7	6 7	50
Beaufort	do	7 26	50	2.8	3.3	2.2	6 11	6 10	42
Bald Head	do	7 26	34	4.3	5.0	3.4	6 18	6 17	31
Smithville	do	7 19	38	4.5	5.5	3.8	6 1	6 26	26
Wilmington	do	9 6	1 0	2.7	3.1	2.2	4 45	7 40	30
Georgetown entrance	South Carolina	7 56	42	3.8	4.7	2.7	6 4	6 19	35
Bull's Island bay	do	7 16	57	4.8	5.7	3.7	6 20	6 6	30
Charleston, (custom-house wharf)	do	7 26	48	5.1	6.0	4.1	6 19	6 7	33
St. Helena sound	do	7 8	1 0	5.9	7.4	4.4	6 13	6 12	23
Fort Pulaski, (Savannah entrance)	Georgia	7 20	40	7.0	8.0	5.9	5 49	6 35	26
Savannah, (dry dock wharf)	do	8 13	51	6.5	7.6	5.5	5 4	7 22	14
Doboy Light-house	do	7 33	55	6.6	7.8	5.4	6 2	6 20	.....
St. Simon's	do	7 43	46	6.8	8.2	5.4	6 10	6 16	20
Fort Clinch	Florida	7 53	1 6	5.9	6.7	5.3	6 9	6 17	.....
St. John's river	do	7 28	48	4.5	5.5	3.7	5 58	6 28	16
St. Augustine	do	8 21	43	4.2	4.9	3.6	6 5	6 11	32
Cape Florida	do	8 34	51	1.5	1.8	1.2	6 0	6 26	45
Indian key	do	8 23	49	1.8	2.2	1.3	6 25	5 59	19
Sand key	do	8 40	....	1.2	2.0	0.6	6 31	5 55	13
Key West	do	9 30	1 15	1.3	1.5	0.9	6 55	5 29	12
Tortugas	do	9 56	1 32	1.2	1.5	0.6	6 43	5 40	.....
Charlotte harbor	do	13 9	1 38	1.1	1.3	0.8	6 51	5 35	.....
Tampa Bay, (Egmont key)	do	11 21	1 33	1.4	1.8	1.0	6 36	6 11	43
Cedar Keys, (Depot key)	do	13 15	1 55	2.6	3.2	1.6	6 12	6 13	.....
St. Mark's	do	13 38	2 0	2.2	2.9	1.4	6 12	6 11	.....

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Diff. between greatest and least int'val.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
WESTERN COAST.		*h.* *m.*	*h.* *m.*	*Feet.*	*Feet.*	*Feet.*	*h.* *m.*	*h.* *m.*	*h.* *m.*
San Diego	California	9 38	1 35	3.7	5.0	2.3	6 22	6 0	0 30
San Pedro	....do	9 39	1 48	3.7	4.7	2.2	6 18	6 5	30
Cuyler's harbor	....do	9 25	1 2	3.7	5.1	2.8	6 13	6 5	.....
San Luis Obispo	....do	10 8	1 52	3.6	4.8	2.4	6 25	5 58	.....
Monterey	....do	10 22	49	3.4	4.3	2.5	6 31	6 2	35
South Farallon	....do	10 37	1 16	3.6	4.4	2.8	6 18	6 9	.....
San Francisco, (north beach)	....do	12 6	1 4	3.6	4.3	2.8	6 39	5 51	34
Mare island, (San Francisco bay)	....do	13 40	1 15	4.8	5.2	4.1	6 13	6 7	.....
Benicia ....do	....do	14 10	1 0	4.5	5.1	3.7	6 26	5 59	.....
Ravenswood ....do	....do	12 36	57	6.3	7.3	4.9	6 15	6 11	.....
Bodega	....do	11 17	1 54	3.6	4.7	2.7	6 19	5 59	.....
Humboldt bay	....do	12 2	1 11	4.4	5.5	3.5	6 19	6 0	.....
Port Orford	Oregon Territory	11 26	1 6	5.1	6.8	3.7	6 19	6 7	39
Astoria	....do	12 42	1 13	6.1	7.4	4.6	6 3	6 28	33
Nee ah harbor	Washington Ter'y	12 33	1 28	5.6	7.4	4.8	6 20	6 6	.....
Port Townshend*	....do	3 49	1 3	4.6	5.5	4.0	6 34	5 52	.....
Steilacoom*	....do	4 46	1 6	9.2	11.1	7.2	6 3	6 25	28
Semi-ah-moo bay*	....do	4 50	1 2	5.7	6.6	4.8	6 11	6 19	26

* See remarks on page 92, and following.

Note.—The mean interval in column 3 has been increased by 12*h.* 26*m.*, (half a mean lunar day,) for some of the ports in Delaware river and Chesapeake bay, so as to show the succession of times from the mouth. Therefore 12*h.* 26*m.* ought to be subtracted from the establishments which are greater than that quantity 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 November 5, 1854. The American Almanac gives 0*h.* 0*m.* as the time of transit of the moon on that day. The mean interval for New York, from Table I, column 3, is 8*h.* 13*m.*, which, as the transit was at 0*h.*, is, roughly, the time of high water. The moon being full, the height is that of spring tides of column 6, viz., 5.4 feet. If the soundings on the chart are reduced to low water spring tides, 5.4 feet are 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 of 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 four feet ten inches.

Example II.—Required, the time of high water at Boston on January 23, 1851. From the American Almanac we find the time of the moon's southing or transit on that day 5*h.* 18*m.* a. m., and from Table I the mean interval at Boston dry dock is 11*h.* 27*m.*

We have then 5*h.* 18*m.*, time of transit.

To which add 11 27 mean interval from Table I.

16 45 time of high water, or 4*h.* 45*m.* p. m.

If the Greenwich Nautical Almanac is used, add 2*m.* to the time of transit of Greenwich for every hour of west longitude, and its proportional part for less than an hour. It will suffice to take the half hour which may be over any number of hours, as the correction for less than this would be less than one minute, and

need not be taken into account. Thus, Boston is $4h.$ $44m.$ west of Greenwich. The correction to be applied to the time of transit of the moon is, for the four hours, eight minutes, and for the forty-four minutes, one minute. The time of transit on the date assumed in the preceding example is $17h.$ $9m.$ of the 22d, or $5h.$ $9m.$ a. m. of the 23d, 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 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 January 23.
6 13 duration of flood from Table I.

Sum 17 11 or $5h.$ $11m.$ on January 24.

Or, having found the time of high water, the time of the next following high water may be found by adding the duration of flood and 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.

Sum 12 26 duration of whole tide.
4 45 p. m., January 23, time of high water.

Sum 17 11 or $5h.$ $11m.$ a. m., January 24, time of the next succeeding high water.

Subtracting the same quantity will give the time of the preceding high water, thus:

$4h.$ $45m.$ p. m., or $16h.$ $45m.$ from midnight, is the time of high water.
12 26 duration of flood and ebb tide.

4 19 a. m. of the 23d for the preceding high water.

The duration of the flood and the 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 the 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 Pt. Comfort, Va.	Baltimore, Md.	Smithville, N. C.	Charleston, S. C.	Ft. Pulaski, Savannah, 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 33	12 5
0 30	11 33	8 18	1 28	8 27	6 42	7 21	7 33	7 25	9 26	11 59
1 0	11 28	8 15	1 25	8 21	6 37	7 16	7 27	7 19	9 19	11 53
1 30	11 24	8 10	1 21	8 15	6 31	7 13	7 21	7 15	9 13	11 47
2 0	11 20	8 6	1 18	8 9	6 26	7 9	7 16	7 11	9 6	11 41
2 30	11 16	8 0	1 14	8 4	6 21	7 6	7 12	7 8	9 1	11 36
3 0	11 13	7 55	1 11	8 0	6 17	7 4	7 8	7 6	8 57	11 33
3 30	11 10	7 52	1 8	7 56	6 13	7 3	7 5	7 5	8 53	11 33
4 0	11 7	7 52	1 6	7 52	6 11	7 2	7 2	7 4	8 53	11 38
4 30	11 6	7 52	1 3	7 49	6 10	7 3	7 2	7 3	8 56	11 46
5 0	11 6	7 53	1 0	7 48	6 10	7 4	7 3	7 4	9 2	11 55
5 30	11 9	7 56	0 59	7 50	6 13	7 6	7 7	7 6	9 10	12 3
6 0	11 13	7 59	0 59	7 53	6 19	7 9	7 12	7 8	9 22	12 11
6 30	11 19	8 5	1 1	8 0	6 25	7 13	7 19	7 12	9 33	12 16
7 0	11 25	8 11	1 7	8 7	6 32	7 17	7 24	7 16	9 49	12 23
7 30	11 32	8 17	1 15	8 15	6 39	7 23	7 32	7 22	10 0	12 29
8 0	11 38	8 23	1 23	8 24	6 44	7 28	7 38	7 28	10 6	12 34
8 30	11 43	8 27	1 29	8 33	6 49	7 33	7 45	7 34	10 7	12 37
9 0	11 47	8 32	1 34	8 40	6 52	7 37	7 48	7 39	10 6	12 36
9 30	11 48	8 34	1 39	8 45	6 54	7 39	7 50	7 42	10 3	12 34
10 0	11 49	8 35	1 42	8 48	6 53	7 40	7 50	7 43	9 59	12 30
10 30	11 48	8 34	1 43	8 48	6 52	7 40	7 47	7 41	9 56	12 24
11 0	11 47	8 31	1 41	8 46	6 50	7 36	7 44	7 37	9 48	12 17
11 30	11 43	8 25	1 37	8 40	6 48	7 30	7 41	7 34	9 40	12 9

TABLE III,

Showing the rise and fall of tides, and corrections to be applied to determine the depth at high water of soundings on charts referred to mean low water, and to low water spring tides.

Time of moon's transit.	Boston, Mass.			New York, N. Y.			Philadelphia, Pa.			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	2.5	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.			Fort Pulaski, Savannah entrance.			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	6.0	5.5	6.0	7.8	7.4	7.8	1.5	1.4	1.5	4.5	4.0	4.4	0
1	5.1	4.8	5.1	5.9	5.5	5.9	7.9	7.4	7.9	1.5	1.4	1.5	3.9	3.7	4.1	1
2	5.0	4.7	5.0	5.7	5.4	5.8	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	5.3	5.2	5.6	7.1	7.0	7.5	1.4	1.3	1.4	3.5	3.5	4.0	3
4	4.3	4.4	4.7	4.7	4.9	5.4	6.5	6.7	7.2	1.2	1.2	1.3	3.1	3.3	3.8	4
5	4.0	4.3	4.6	4.4	4.8	5.2	6.1	6.5	7.0	1.0	1.1	1.2	2.8	3.1	3.6	5
6	3.8	4.2	4.5	4.2	4.6	5.1	5.8	6.4	6.8	0.9	1.0	1.1	2.7	3.1	3.6	6
7	3.8	4.1	4.4	4.3	4.7	5.1	6.0	6.5	6.9	0.9	1.1	1.2	3.0	3.3	3.7	7
8	4.0	4.2	4.5	4.5	4.8	5.3	6.4	6.7	7.1	1.0	1.2	1.3	3.4	3.5	3.9	8
9	4.3	4.3	4.6	5.0	5.0	5.5	6.9	6.9	7.4	1.2	1.3	1.4	3.8	3.6	4.1	9
10	4.7	4.6	4.9	5.5	5.3	5.8	7.4	7.0	7.6	1.4	1.4	1.5	4.0	3.8	4.2	10
11	5.0	4.7	5.0	5.9	5.5	5.9	7.8	7.2	7.8	1.5	1.4	1.5	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 intervals 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 the $0h.$ 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 of $0h.$, and for 13 hours (or $1h.$ 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 column.

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 quarters. 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 the 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 the 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 in Table III.

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 2, and we must have gone back to the transit of the day before and computed with it to obtain the tide of October 1.

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 tides on the 1st of October, 1856, between 4.9 and 4.7; the number to be added to soundings given for mean low water 4.5 feet, (column B,) and for low water spring tides (column C) 4.9 feet.

Having found the time of high water, that of low water may be obtained, nearly, by adding the duration of ebb from column 9, Table I. The time of the next preceding low water may be found by subtracting the duration of flood from column 8, Table I. The time of the next following high water may be found by adding the duration of both flood and ebb; and of the next preceding high water by subtracting the same duration of the whole tide.

Example IV.—To find the next high water following that of Example III.

The duration of flood, column 8, Table I, for New York, is 6*h.* 0*m.*, and of ebb, from column 9, is 6*h.* 25*m.*; the sum is 12*h.* 25*m.*

To 9*h.* 34*m.* p. m., October 1, time of high water found,
Add 12 25 duration of flood and ebb.

Sum 21 59 or 9*h.* 59*m.* a. m of October 2, the time of the next high water.

TIDES OF THE PACIFIC COAST AND OF PART OF THE COAST OF FLORIDA.

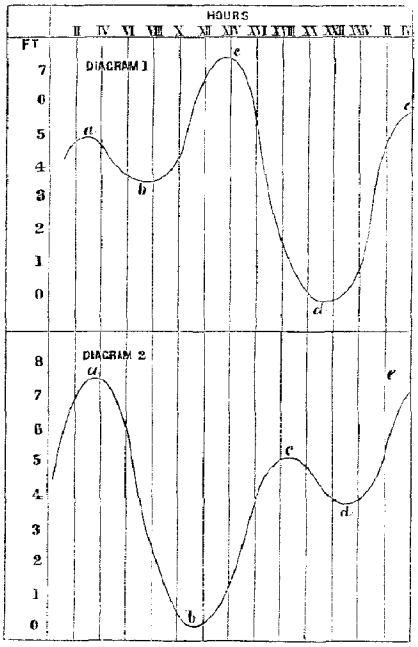
On the Pacific coast there are, as a general rule, one large and one small tide during the day, the height of the two successive high waters occurring one a. m. the other p. m. of the same twenty-four hours, and the intervals from the next preceding transit of the moon are very different. The inequalities depend upon the moon's declination; they disappear near the time of the moon's declination being nothing, and are greatest about the time of its being 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. The tides of the southern part of Florida and of the western coast of that peninsula, as far as St. Mark's, are of the same character.

In Puget's sound the inequalities for the interval of high water and for the height of low water follow this rule; but those for the interval of low water and height of high water disappear about one day before the moon's declination is greatest, and are greatest about four or five days before the greatest declination.

When the moon's declination is north, the highest of the two 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 that interval.

The lowest of the two low waters of the day is the one which follows next the highest high water. The nature of these tides will probably appear more plainly from the annexed diagrams. In them the height of the tide is set off at the side on a scale of feet, and the hours of the day are at the top. At 12 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*, 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. At Key West the contrary obtains, diagram 1 applying when the moon's declination is north, and diagram 2 when south. 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. They are 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 had the greatest declination is arranged at the top of the table. Entering the first column with the time of transit, and following the line horizontally until we come under the column containing the days from the greatest declination, we find the number to be added to the time of the 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.



Tables IV to IX, inclusive, have been recomputed, using more complete data for the inequalities above referred to, and to those for San Francisco similar tables have been added for San Diego, Astoria, Port Townshend, and Key West, Fla. For the other places on the Western Coast given in Table I the following rules will give sufficiently close approximations.

To obtain the times of high or low water for San Pedro, Cuyler's harbor, and San Luis Obispo, compute first the time for San Diego by Tables IV, V, or VIII; then add to the time thus obtained 30 minutes to obtain the time for San Luis Obispo, and subtract 13 minutes for Cuyler's harbor. At San Pedro the time of high or low water is sensibly the same as at San Diego.

For Monterey, South Farallon, Mare Island, Benicia, Ravenswood, and Bodega, compute first the time for San Francisco, then subtract from the time thus obtained 1*h*. 44*m*. for Monterey, 1*h*. 29*m*. for the South Farallon, and 49*m*. for Bodega; and add 34*m*. for Mare Island, 1*h*. 4*m*. for Benicia, and 30*m*. for Ravenswood. For Humboldt bay, Port Orford, and Neeah harbor, compute first the time for Astoria, then subtract from it 40*m*. for Humboldt bay, 1*h*. 16*m*. for Port Orford, and 9*m*. for Neeah harbor.

For Steilacoom and Semiahmoo bay, compute first the time for Port Townshend, and add to it 57*m*. for Steilacoom and 1*h*. for Semiahmoo. The approximation will be only a rough one for Steilacoom.

For the heights, Tables VI, VII, and IX for San Diego can be used without change for San Pedro, Cuyler's harbor, and San Luis Obispo. These tables for San Francisco are also applicable to Monterey, South Farallon, and Bodega. For Mare Island add 1.2 foot, for Benicia, 0.9 foot, and for Ravenswood, 2.7 feet to the quantities for San Francisco.

For Humboldt bay, Port Orford, and Neeah harbor, the tables for Astoria may be used, subtracting 1.7 foot for Humboldt bay, and 1.0 foot for Port Orford. For Neeah harbor the tables will give approximate results without change.

For Semiahmoo bay, add one foot to the quantities in the tables for Port Townshend. For Steilacoom, a rough approximation may be obtained by adding 4.6 feet to them.

For the coast of Florida, compute the times of high or low water for Key West, and subtract 1*h*. 7*m*. for Indian key, and add 26*m*. for Tortugas, 3*h*. 39*m*. for Charlotte harbor, 1*h*. 51*m*. for Egmont key, 3*h*. 45*m*. for Cedar keys, and 4*h*. 8*m*. for St. Mark's. For the heights, add half a foot for Indian key, and use the tables without change for Tortugas and Egmont key. For Cedar keys and St. Mark's the results could not be obtained with much accuracy in this way; special tables will be prepared for those places.

TABLE IV.—KEY WEST.

Time of moon's transit	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.*
0 0	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
0 30	9 33	9 23	9 11	9 00	8 54	8 42	8 37	8 33	8 33	8 39	8 47	8 59	9 09	9 20	9 30
1 0	9 26	9 16	9 04	8 53	8 47	8 35	8 30	8 26	8 26	8 32	8 40	8 52	9 02	8 13	9 23
1 30	9 20	9 10	8 58	8 47	8 41	8 29	8 24	8 20	8 20	8 26	8 34	8 46	8 56	9 07	9 17
2 0	9 13	9 03	8 51	8 40	8 34	8 22	8 17	8 13	8 13	8 19	8 27	8 39	8 49	9 00	9 10
2 30	9 08	8 58	8 46	8 35	8 29	8 17	8 12	8 08	8 08	8 14	8 22	8 34	8 44	8 55	9 05
3 0	9 04	8 54	8 42	8 31	8 25	8 13	8 08	8 04	8 04	8 10	8 18	8 30	8 40	8 51	9 01
3 30	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 0	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 30	9 03	8 53	8 41	8 30	8 24	8 12	8 07	8 03	8 03	8 09	8 17	8 29	8 39	8 50	9 00
5 0	9 09	8 59	8 47	8 36	8 30	8 18	8 13	8 09	8 09	9 15	8 23	8 35	8 45	8 56	9 06
5 30	9 17	9 07	8 55	8 44	8 38	8 26	8 21	8 17	8 17	8 23	8 31	8 43	8 53	9 04	9 14
6 0	9 29	9 19	9 07	8 56	8 50	8 38	8 33	8 29	8 29	8 35	8 43	8 55	9 05	9 16	9 26
6 30	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
7 0	9 56	9 46	9 34	9 23	9 17	9 05	9 00	8 56	8 56	9 02	9 10	9 22	9 32	9 43	9 53
7 30	10 07	9 57	9 45	9 34	9 28	9 16	9 11	9 07	9 07	9 13	9 21	9 33	9 43	9 54	10 04
8 0	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 00
8 30	10 14	10 04	9 52	9 41	9 35	9 23	9 18	9 14	9 14	9 20	9 28	9 40	9 50	10 01	10 11
9 0	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 10
9 30	10 10	10 00	9 48	9 37	9 31	9 19	9 14	9 10	9 10	9 16	9 24	9 36	9 46	9 57	10 07
10 0	10 06	9 56	9 44	9 33	9 27	9 15	9 10	9 06	9 06	9 12	9 20	9 32	9 42	9 53	10 03
10 30	10 03	9 53	9 41	9 30	9 24	9 12	9 07	9 03	9 03	9 09	9 17	9 29	9 39	9 50	10 00
11 0	9 55	9 45	9 33	9 22	9 16	9 04	8 59	8 55	8 55	9 01	9 09	9 21	9 31	9 42	9 52
11 30	9 47	9 37	9 25	9 14	9 08	8 56	8 51	8 47	8 47	8 53	9 01	9 13	9 23	9 34	9 44

TABLE V.—KEY WEST.

Time of moon's transit	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.*
0 0	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
0 30	9 22	9 29	9 36	9 46	9 59	10 09	10 15	10 15	10 15	10 11	9 59	9 49	9 36	9 27	9 20
1 0	9 15	9 22	9 29	9 39	9 52	10 02	10 08	10 08	10 08	10 04	9 52	9 42	9 29	9 20	9 13
1 30	9 09	9 16	9 23	9 33	9 46	9 56	10 02	10 02	10 02	9 58	9 46	9 36	9 23	9 14	9 07
2 0	9 02	9 09	9 16	9 26	9 39	9 49	9 55	9 55	9 55	9 51	9 39	9 29	9 16	9 07	9 00
2 30	8 57	9 04	9 11	9 21	9 34	9 44	9 50	9 50	9 50	9 46	9 34	9 24	9 11	9 02	8 55
3 0	8 53	9 00	9 07	9 17	9 30	9 40	9 46	9 46	9 46	9 42	9 30	9 20	9 07	8 58	8 51
3 30	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 0	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 30	8 52	8 59	9 06	9 16	9 29	9 39	9 45	9 45	9 45	9 41	9 39	9 29	9 06	8 57	8 50
5 0	8 58	9 05	9 12	9 22	9 35	9 45	9 51	9 51	9 51	9 47	9 35	9 25	9 12	9 03	8 56
5 30	9 06	9 13	9 20	9 30	9 43	9 53	9 59	9 59	9 59	9 55	9 43	9 33	9 20	9 11	9 04
6 0	9 18	9 25	9 32	9 42	9 55	10 05	10 11	10 11	10 11	10 07	9 55	9 45	9 32	9 23	9 16
6 30	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
7 0	9 45	9 52	9 59	10 09	10 22	10 32	10 38	10 38	10 38	10 34	10 22	10 12	9 59	9 50	9 43
7 30	9 56	10 03	10 10	10 20	10 33	10 43	10 49	10 49	10 49	10 45	10 33	10 23	10 10	10 01	9 54
8 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
8 30	10 03	10 10	10 17	10 27	10 40	10 50	10 56	10 56	10 56	10 52	10 40	10 30	10 17	10 08	10 01
9 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
9 30	9 59	10 06	10 13	10 23	10 36	10 46	10 52	10 52	10 52	10 48	10 36	10 26	10 13	10 04	9 57
10 0	9 55	10 02	10 09	10 19	10 32	10 42	10 48	10 48	10 48	10 44	10 32	10 22	10 09	10 00	9 53
10 30	9 52	9 59	10 06	10 16	10 29	10 39	10 45	10 45	10 45	10 41	10 29	10 19	10 06	9 57	9 50
11 0	9 44	9 51	9 58	10 08	10 21	10 31	10 37	10 37	10 37	10 33	10 21	10 11	9 58	9 49	9 42
11 30	9 36	9 43	9 50	10 00	10 13	10 23	10 29	10 29	10 29	10 25	10 13	10 03	9 50	9 41	9 34

TABLE IV.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.*
0 0	9 25	9 40	9 52	10 3	10 12	10 20	10 25	10 29	10 29	10 25	10 19	10 10	10 0	9 47	9 30
0 30	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 27	9 20
1 0	9 8	9 23	9 35	9 46	9 55	10 3	10 8	10 12	10 12	10 8	10 2	9 53	9 43	9 30	9 13
1 30	9 1	9 16	9 28	9 39	9 48	9 56	10 1	10 5	10 5	10 1	9 55	9 46	9 36	9 23	9 6
2 0	8 54	9 9	9 21	9 32	9 41	9 49	9 54	9 58	9 58	9 54	9 48	9 39	9 29	9 16	8 59
2 30	8 49	9 4	9 16	9 27	9 36	9 44	9 49	9 53	9 53	9 49	9 43	9 34	9 24	9 11	8 54
3 0	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
3 30	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
4 0	8 52	9 7	9 19	9 30	9 39	9 47	9 52	9 56	9 56	9 52	9 46	9 37	9 27	9 14	8 57
4 30	8 56	9 11	9 23	9 34	9 43	9 51	9 56	10 0	10 0	9 56	9 50	9 41	9 31	9 18	9 1
5 0	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 37	9 20
5 30	9 37	9 52	10 4	10 15	10 24	10 32	10 37	10 41	10 41	10 37	10 31	10 22	10 12	9 59	9 42
6 0	9 55	10 10	10 22	10 33	10 42	10 50	10 55	10 59	10 59	10 55	10 49	10 40	10 30	10 17	10 0
6 30	10 12	10 27	10 39	10 50	10 59	11 7	11 12	10 16	10 16	11 12	11 6	10 57	10 47	10 34	10 17
7 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
7 30	10 20	10 35	10 47	10 58	11 7	11 15	11 20	11 24	11 24	11 20	11 14	11 5	10 55	10 42	10 25
8 0	10 22	10 37	10 49	11 0	11 9	11 17	11 22	11 26	11 26	11 22	11 16	11 7	10 57	10 44	10 27
8 30	10 24	10 39	10 51	11 2	11 11	11 19	11 24	11 28	11 28	11 24	11 18	11 9	10 59	10 46	10 29
9 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
9 30	10 10	10 25	10 37	10 48	10 57	11 5	11 10	11 14	11 14	11 10	11 4	10 55	10 45	10 32	10 15
10 0	10 0	10 15	10 27	10 38	10 47	10 55	11 0	11 4	11 4	11 0	10 54	10 45	10 35	10 22	10 5
10 30	9 53	10 8	10 20	10 31	10 40	10 48	10 53	10 57	10 57	10 53	10 47	10 38	10 28	10 15	9 58
11 0	9 45	10 0	10 12	10 23	10 32	10 40	10 45	10 49	10 49	10 45	10 39	10 30	10 20	10 7	9 50
11 30	9 36	9 51	10 3	10 14	10 23	10 31	10 36	10 40	10 40	10 36	10 30	10 21	10 11	9 58	9 41

TABLE V.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.*
0 0	9 30	9 16	9 4	8 53	8 44	8 36	8 31	8 27	8 27	8 31	8 37	8 46	8 56	9 9	9 26
0 30	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
1 0	9 14	8 59	8 47	8 36	8 27	8 19	8 14	8 10	8 10	8 14	8 20	8 29	8 39	8 52	9 9
1 30	9 7	8 52	8 40	8 29	8 20	8 12	8 7	8 3	8 3	8 7	8 13	8 22	8 32	8 45	9 2
2 0	9 0	8 45	8 33	8 22	8 13	8 5	8 0	7 56	7 56	8 0	8 6	8 15	8 25	8 38	8 55
2 30	8 55	8 40	8 28	8 17	8 8	8 0	7 55	7 51	7 51	7 55	8 1	8 10	8 20	8 33	8 50
3 0	8 54	8 39	8 27	8 1	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
3 30	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
4 0	8 58	8 43	8 31	8 20	8 11	8 3	7 58	7 54	7 54	7 58	8 4	8 13	8 23	8 36	8 53
4 30	9 2	8 47	8 35	8 24	8 15	8 7	8 2	7 58	7 58	8 2	8 8	8 17	8 27	8 40	8 57
5 0	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
5 30	9 43	9 28	9 16	9 5	8 56	8 48	8 43	8 39	8 39	8 43	8 49	8 58	9 8	9 21	9 38
6 0	10 1	9 46	9 34	9 23	9 14	9 6	9 1	8 57	8 57	9 1	9 7	9 16	9 26	9 39	9 56
6 30	10 18	10 3	9 51	9 40	9 31	9 23	9 18	9 14	9 14	9 18	9 24	9 33	9 43	9 56	10 13
7 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
7 30	10 26	10 11	9 59	9 48	9 39	9 31	9 26	9 22	9 22	9 26	9 32	9 41	9 51	10 4	10 21
8 0	10 28	10 13	10 1	9 50	9 41	9 33	9 28	9 24	9 24	9 28	9 34	9 43	9 53	10 6	10 23
8 30	10 30	10 15	10 3	9 52	9 43	9 35	9 30	9 26	9 26	9 30	9 36	9 45	9 55	10 8	10 25
9 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
9 30	10 16	10 1	9 49	9 38	9 29	9 21	9 16	9 12	9 12	9 16	9 22	9 31	9 41	9 54	10 11
10 0	10 6	9 51	9 39	9 28	9 19	9 11	9 6	9 2	9 2	9 6	9 12	9 21	9 31	9 44	10 1
10 30	9 59	9 44	9 32	9 21	9 12	9 4	8 59	8 55	8 55	8 59	9 5	9 14	9 24	9 37	9 54
11 0	9 51	9 36	9 24	9 13	9 4	8 56	8 51	8 47	8 47	8 51	8 57	9 6	9 16	9 29	9 46
11 30	9 42	9 27	9 15	9 4	8 55	8 47	8 42	8 38	8 38	8 42	8 48	8 57	9 7	9 20	9 37

TABLE IV.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.
0 0	11 43	11 59	12 15	12 33	12 50	13 03	13 17	13 20	13 19	13 14	13 07	12 57	12 45	12 32	12 18
0 30	11 37	11 53	12 09	12 27	12 44	12 57	13 11	13 14	13 13	13 08	13 01	12 51	12 39	12 26	12 12
1 0	11 31	11 47	12 03	12 21	12 38	12 51	13 05	13 08	13 07	13 02	12 55	12 45	12 33	12 20	12 06
1 30	11 25	11 41	11 57	12 15	12 32	12 45	12 59	13 02	13 01	12 56	12 49	12 39	12 27	12 14	12 00
2 0	11 19	11 35	11 51	12 09	12 26	12 39	12 53	12 56	12 55	12 50	12 43	12 33	12 21	12 08	11 54
2 30	11 14	11 30	11 46	12 04	12 21	12 34	12 48	12 51	12 50	12 45	12 38	12 28	12 16	12 03	11 49
3 0	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
3 30	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 36	12 25	12 13	12 00	11 46
4 0	11 16	11 32	11 48	12 06	12 23	12 36	12 50	12 53	12 52	12 47	12 40	12 30	12 18	12 05	11 51
4 30	11 24	11 40	11 56	12 14	12 31	12 44	12 58	13 01	13 00	12 55	12 48	12 38	12 26	12 13	11 59
5 0	11 33	11 49	12 05	12 23	12 40	12 53	13 07	13 10	13 09	13 04	12 57	12 47	12 35	12 22	12 08
5 30	11 41	11 57	12 13	12 31	12 48	13 01	13 15	13 18	13 17	13 12	13 05	12 55	12 43	12 30	12 16
6 0	11 49	12 05	12 21	12 39	12 56	13 09	13 23	13 26	13 25	13 20	13 13	13 03	12 51	12 38	12 24
6 30	11 54	12 10	12 26	12 44	13 01	13 14	13 28	13 31	13 30	13 25	13 18	13 08	12 56	12 43	12 29
7 0	12 01	12 17	12 33	12 51	13 08	13 21	13 35	13 38	13 37	13 32	13 25	13 15	13 03	12 50	12 36
7 30	12 07	12 23	12 39	12 57	13 14	13 27	13 41	13 44	13 43	13 38	13 31	13 21	13 09	12 56	12 42
8 0	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
8 30	12 15	12 31	12 47	13 05	13 22	13 35	13 49	13 52	13 51	13 46	13 39	13 29	13 17	13 04	12 50
9 0	12 14	12 30	12 46	13 04	13 21	13 34	13 48	13 57	13 50	13 45	13 36	13 26	13 16	13 03	12 49
9 30	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
10 0	12 08	12 24	12 40	12 58	13 15	13 28	13 42	13 45	13 44	13 39	13 32	13 22	13 10	12 57	12 43
10 30	12 02	12 18	12 34	12 52	13 09	13 22	13 36	13 39	13 38	13 33	13 26	13 16	13 04	12 51	12 37
11 0	11 55	12 11	12 27	12 45	13 02	13 15	13 29	13 32	13 31	13 26	13 19	13 09	12 57	12 44	12 30
11 30	11 47	12 03	12 19	12 37	12 54	13 07	13 21	13 24	13 23	13 18	13	13 01	12 49	12 36	12 22

TABLE V.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.
0 0	12 27	12 11	11 55	11 37	11 20	11 07	10 53	10 50	10 51	10 56	11 03	11 13	11 25	11 38	11 52
0 30	12 21	12 05	11 49	11 31	11 14	11 01	10 47	10 44	10 45	10 50	10 57	11 07	11 19	11 32	11 46
1 0	12 15	11 59	11 43	11 25	11 08	10 55	10 41	10 38	10 39	10 44	10 51	11 01	11 13	11 26	11 40
1 30	12 09	11 53	11 37	11 19	11 02	10 49	10 35	10 32	10 33	10 38	10 45	10 55	11 07	11 20	11 34
2 0	12 03	11 47	11 31	11 13	10 56	10 43	10 29	10 26	10 27	10 32	10 39	10 49	11 01	11 14	11 28
2 30	11 58	11 42	11 26	11 08	10 51	10 38	10 24	10 21	10 22	10 27	10 34	10 44	10 56	11 09	11 23
3 0	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
3 30	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
4 0	12 00	11 44	11 28	11 10	10 53	10 40	10 26	10 23	10 24	10 29	10 36	10 46	10 58	11 11	11 25
4 30	12 08	11 52	11 36	11 18	11 01	10 48	10 34	10 31	10 32	10 37	10 44	10 54	11 06	11 19	11 33
5 0	12 17	12 01	11 45	11 27	11 10	10 57	10 43	10 40	10 41	10 46	10 53	11 03	11 15	11 28	11 42
5 30	12 25	12 09	11 53	11 35	11 18	11 05	10 51	10 48	10 49	10 54	11 01	11 11	11 23	11 36	11 50
6 0	12 33	12 17	12 01	11 43	11 26	11 13	10 59	10 56	10 57	11 02	11 09	11 19	11 31	11 44	11 58
6 30	12 38	12 22	12 06	11 48	11 31	11 18	11 04	11 01	11 02	11 07	11 14	11 24	11 36	11 49	12 03
7 0	12 45	12 29	12 13	11 55	11 38	11 25	11 11	11 08	11 09	11 14	11 21	11 31	11 43	11 56	12 10
7 30	12 51	12 35	12 19	12 01	11 44	11 31	11 17	11 14	11 15	11 20	11 27	11 37	11 49	12 02	12 16
8 0	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
8 30	12 59	12 43	12 27	12 09	11 52	11 39	11 25	11 22	11 23	11 28	11 35	11 45	11 57	12 10	12 24
9 0	12 58	12 42	12 26	12 08	11 51	11 38	11 24	11 21	11 22	11 27	11 34	11 44	11 56	12 09	12 23
9 30	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
10 0	12 52	12 36	12 20	12 02	11 45	11 32	11 18	11 15	11 16	11 21	11 28	11 38	11 50	12 03	12 17
10 30	12 46	12 30	12 14	11 56	11 39	11 26	11 12	11 09	11 10	11 15	11 22	11 32	11 44	11 57	12 11
11 0	12 39	12 23	12 07	11 49	11 32	11 19	11 05	11 02	11 03	11 08	11 15	11 25	11 37	11 50	12 04
11 30	12 31	12 15	11 59	11 41	11 24	11 11	10 57	10 54	10 55	11 00	11 07	11 17	11 29	11 42	11 56

TABLE IV.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.*
0 0	12 42	12 55	13 5	13 18	13 28	13 38	13 41	13 45	13 46	13 44	13 40	13 34	13 24	13 14	13 2
0 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
1 0	12 29	12 42	12 52	13 5	13 15	13 25	13 28	13 32	13 33	13 31	13 27	13 21	13 11	13 1	12 49
1 30	12 23	12 36	12 46	12 59	13 9	13 19	13 22	13 26	13 27	13 25	13 21	13 15	13 5	12 55	12 43
2 0	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
2 30	12 9	12 22	12 32	12 45	12 55	13 5	13 8	13 12	13 13	13 11	13 7	13 1	12 51	12 41	12 29
3 0	12 3	12 16	12 26	12 39	12 49	12 59	13 2	13 6	13 7	13 5	13 1	12 55	12 45	12 35	12 23
3 30	11 58	12 11	12 21	12 34	12 44	12 54	12 57	13 1	13 2	13 0	12 56	12 50	12 40	12 30	12 18
4 0	11 57	12 10	12 20	12 33	12 43	12 53	12 56	13 0	13 1	12 59	12 55	12 49	12 39	12 29	12 17
4 30	12 0	12 13	12 23	12 36	12 46	12 56	12 59	13 3	13 4	13 2	12 58	12 52	12 42	12 32	12 20
5 0	12 8	12 21	12 31	12 44	12 54	13 4	13 7	13 11	13 12	13 10	13 6	13 0	12 50	12 40	12 28
5 30	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
6 0	12 25	12 38	12 48	13 1	13 11	13 21	13 24	13 28	13 29	13 27	13 23	13 17	13 7	12 57	12 45
6 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
7 0	12 45	12 58	13 8	13 21	13 31	13 41	13 44	13 48	13 49	13 47	13 43	13 37	13 27	13 17	13 5
7 30	12 55	13 8	13 18	13 31	13 41	13 51	13 54	13 58	13 59	13 57	13 53	13 47	13 37	13 27	13 15
8 0	13 3	13 16	13 26	13 39	13 49	13 59	14 2	14 6	14 7	14 5	14 1	13 55	13 45	13 35	13 23
8 30	13 8	13 21	13 31	13 44	13 54	14 4	14 7	14 11	14 12	14 10	14 6	14 0	13 50	13 40	13 28
9 0	13 10	13 23	13 33	13 46	13 56	14 6	14 9	14 13	14 14	14 12	14 8	14 2	13 52	13 42	13 30
9 30	13 9	13 22	13 32	13 45	13 55	14 5	14 8	14 12	14 13	14 11	14 7	14 1	13 51	13 41	13 29
10 0	13 5	13 18	13 28	13 41	13 51	14 1	14 4	14 8	14 9	14 7	14 3	13 57	13 47	13 37	13 25
10 30	12 59	13 12	13 22	13 35	13 45	13 55	13 58	14 2	14 3	14 1	13 57	13 51	13 41	13 31	13 19
11 0	12 53	13 6	13 16	13 29	13 39	13 49	13 52	13 56	13 57	13 55	13 51	13 45	13 35	13 25	13 13
11 30	12 46	12 59	13 9	13 22	13 32	13 42	13 45	13 49	13 50	13 48	13 44	13 38	13 28	13 18	13 6

TABLE V.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.*
0 0	13 10	12 57	12 47	12 34	12 24	12 14	12 11	12 7	12 6	12 8	12 12	12 18	12 28	12 38	12 50
0 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
1 0	12 57	12 44	12 34	12 21	12 11	12 1	11 58	11 54	11 53	11 55	11 59	12 5	12 15	12 25	12 37
1 30	12 51	12 38	12 28	12 15	12 5	11 55	11 52	11 48	11 47	11 49	11 53	11 59	12 9	12 19	12 31
2 0	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
2 30	12 37	12 24	12 14	12 1	11 51	11 41	11 38	11 34	11 33	11 35	11 39	11 45	11 55	12 5	12 17
3 0	12 31	12 18	12 8	11 55	11 45	11 35	11 32	11 28	11 27	11 29	11 33	11 39	11 49	11 59	12 11
3 30	12 26	12 13	12 3	11 50	11 40	11 30	11 27	11 23	11 22	11 24	11 28	11 34	11 44	11 54	12 6
4 0	12 25	12 12	12 2	11 49	11 39	11 29	11 26	11 22	11 21	11 23	11 27	11 33	11 43	11 53	12 5
4 30	12 28	12 15	12 5	11 52	11 42	11 32	11 29	11 25	11 24	11 26	11 30	11 36	11 46	11 56	12 8
5 0	12 36	12 23	12 13	12 0	11 50	11 40	11 37	11 33	11 32	11 34	11 38	11 44	11 54	12 4	12 16
5 30	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
6 0	12 53	12 40	12 30	12 17	12 7	11 57	11 54	11 50	11 49	11 51	11 55	12 1	12 11	12 21	12 33
6 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
7 0	13 13	13 0	12 50	12 37	12 27	12 17	12 14	12 10	12 9	12 11	12 15	12 21	12 31	12 41	12 53
7 30	13 23	13 10	13 0	12 47	12 37	12 27	12 24	12 20	12 19	12 21	12 25	12 31	12 41	12 51	13 3
8 0	13 31	13 18	13 8	12 55	12 45	12 35	12 32	12 28	12 27	12 29	12 33	12 39	12 49	12 59	13 11
8 30	13 36	13 23	13 13	13 0	12 50	12 40	12 37	12 33	12 32	12 34	12 38	12 44	12 54	13 4	13 16
9 0	13 38	13 25	13 15	13 2	12 52	12 42	12 39	12 35	12 34	12 36	12 40	12 46	12 56	13 6	13 18
9 30	13 37	13 24	13 14	13 1	12 51	12 41	12 38	12 34	12 33	12 35	12 39	12 45	12 55	13 5	13 17
10 0	13 33	13 20	13 10	12 57	12 47	12 37	12 34	12 30	12 29	12 31	12 35	12 41	12 51	13 1	13 13
10 30	13 27	13 14	13 4	12 51	12 41	12 31	12 28	12 24	12 23	12 25	12 29	12 35	12 45	12 55	13 7
11 0	13 21	13 8	12 58	12 45	12 35	12 25	12 22	12 18	12 17	12 19	12 23	12 29	12 39	12 49	13 1
11 30	13 14	13 1	12 51	12 38	12 28	12 18	12 15	12 11	12 10	12 12	12 16	12 22	12 32	12 42	12 54

TABLE IV.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.
0 0	3 45	3 21	2 51	2 2	1 32	1 13	1 26	1 44	2 2	2 21	2 42	2 57	3 15	3 33	3 45
0 30	3 38	3 14	2 44	1 55	1 25	1 6	1 19	1 37	1 55	2 14	2 35	2 50	3 8	3 26	3 38
1 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
1 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
2 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
2 30	3 18	2 54	2 24	1 35	1 5	0 46	0 59	1 17	1 35	1 54	2 15	2 30	2 48	3 6	3 18
3 0	3 16	2 52	2 22	1 33	1 3	0 44	0 57	1 15	1 33	1 52	2 13	2 28	2 46	3 4	3 16
3 30	3 17	2 53	2 23	1 34	1 4	0 45	0 58	1 16	1 34	1 53	2 14	2 29	2 47	3 5	3 17
4 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
4 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
5 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
5 30	3 41	3 17	2 47	1 58	1 28	1 9	1 22	1 40	1 58	2 17	2 38	2 53	3 11	3 29	3 41
6 0	3 52	3 28	2 58	2 9	1 39	1 20	1 33	1 51	2 9	2 28	2 49	3 4	3 22	3 40	3 52
6 30	4 1	3 37	3 7	2 18	1 48	1 29	1 42	2 0	2 18	2 37	2 58	3 13	3 31	3 49	4 1
7 0	4 8	3 44	3 14	2 25	1 55	1 36	1 49	2 7	2 25	2 44	3 5	3 20	3 38	3 56	4 8
7 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
8 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
8 30	4 19	3 55	3 25	2 36	2 6	1 47	2 0	2 18	2 36	2 55	3 16	3 31	3 49	4 7	4 19
9 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
9 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
10 0	4 10	3 46	3 16	2 27	1 57	1 38	1 51	2 9	2 27	2 46	3 7	3 22	3 40	3 58	4 10
10 30	4 6	3 42	3 12	2 23	1 53	1 34	1 47	2 5	2 23	2 42	3 3	3 18	3 36	3 54	4 6
11 0	4 0	3 36	3 6	2 17	1 47	1 28	1 41	1 59	2 17	2 36	2 57	3 12	3 30	3 48	4 0
11 30	3 54	3 30	3 0	2 11	1 41	1 22	1 35	1 53	2 11	2 30	2 51	3 6	3 24	3 42	3 54

TABLE V.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	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.
0 0	3 45	4 9	4 39	5 22	5 58	6 17	6 4	5 46	5 28	5 9	4 48	4 33	4 15	3 57	3 45
0 30	3 38	4 2	4 32	5 21	5 51	6 10	5 57	5 39	5 21	5 2	4 41	4 26	4 8	3 50	3 38
1 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
1 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
2 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
2 30	3 18	3 42	4 12	5 1	5 31	5 50	5 37	5 19	5 1	4 42	4 21	4 6	3 48	3 30	3 18
3 0	3 16	3 40	4 10	4 59	5 29	5 48	5 35	5 17	4 59	4 40	4 19	4 4	3 46	3 28	3 16
3 30	3 17	3 41	4 11	5 0	5 30	5 49	5 36	5 18	5 0	4 41	4 20	4 5	3 47	3 29	3 17
4 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
4 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
5 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
5 30	3 41	4 5	4 35	5 24	5 54	6 13	6 0	5 42	5 24	5 5	4 44	4 29	4 11	3 53	3 41
6 0	3 52	4 16	4 46	5 35	6 5	6 24	6 11	5 53	5 35	5 16	4 55	4 40	4 22	4 4	3 52
6 30	4 1	4 25	4 55	5 44	6 14	6 33	6 20	6 2	5 44	5 25	5 4	4 49	4 31	4 13	4 1
7 0	4 8	4 32	5 2	5 51	6 21	6 40	6 27	6 9	5 51	5 32	5 11	4 56	4 38	4 20	4 8
7 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
8 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
8 30	4 19	4 43	5 13	6 2	6 32	6 51	6 38	6 20	6 2	5 43	5 22	5 7	4 49	4 31	4 19
9 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
9 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
10 0	4 10	4 34	5 4	5 53	6 23	6 42	6 29	6 11	5 53	5 34	5 13	4 58	4 40	4 22	4 10
10 30	4 6	4 30	5 0	5 49	6 19	6 38	6 25	6 7	5 49	5 30	5 9	4 54	4 36	4 18	4 6
11 0	4 0	4 24	4 54	5 43	6 13	6 32	6 19	6 1	5 43	5 24	5 3	4 48	4 30	4 12	4 0
11 30	3 54	4 18	4 48	5 37	6 7	6 26	6 13	5 55	5 37	5 18	4 57	4 42	4 24	4 6	3 54

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.

Example V.—Required, the time of high water at North Beach, San Francisco, Cal., on the 7th of February, 1853.

1st. The time of the moon's transit at Greenwich, from the Nautical Almanac, is $11h.\ 41m.$; the longitude of San Francisco $8h.\ 10m.$, requiring a correction of $16m.$ to the time of transit for San Francisco, which is thus found to be $11h.\ 57m.$

2d. The moon's declination is south, and at the time of transit about two days after the greatest. Entering Table IV we find $12h.$ (or $0h.$) of transit, the nearest number to $11h.\ 57m.$ which the table gives; and following the line horizontally until we come to two days after the greatest declination, we find $13h.\ 14m.$

To $11h.\ 57m.$, time of transit of the moon February 7, San Francisco, add $13h.\ 14m.$, from column $0h.$, transit, and two days after greatest declination; the sum, $25h.\ 11m.$, or $1h.\ 11m.$, 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.

$11h.$	$01m.$	time of transit February 6, 1853.
13	31	number for $11h.$ transit, and one day from greatest declination.
Sum 24	32	time of high water $0h.\ 32m.$ a. m., February 7.

The height of high water.—The height of high water is obtained in a similar manner by the use of Table VI and Table VII, entering these in the same way with the time of transit and days from the greatest declination. Table VI is for south declination, and Table VII for north.

TABLE VI.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
1	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
2	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
3	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
4	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
5	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
6	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
7	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
8	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
9	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
10	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
11	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5

TABLE VII.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
1	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
2	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
3	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
4	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
5	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
6	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
7	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
8	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
9	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
10	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
11	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8

TABLE VI.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
1	4.6	4.4	4.2	4.1	4.0	4.0	4.0	4.0	4.1	4.2	4.4	4.7	5.0	5.4	5.7
2	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
3	4.1	3.9	3.7	3.6	3.5	3.5	3.5	3.5	3.6	3.7	3.9	4.2	4.5	4.9	5.2
4	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
5	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
6	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
7	3.7	3.5	3.3	3.2	3.1	3.1	3.1	3.1	3.2	3.3	3.5	3.8	4.1	4.5	4.8
8	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
9	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
10	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
11	4.8	4.6	4.4	4.3	4.2	4.2	4.2	4.2	4.3	4.4	4.6	4.9	5.2	5.6	5.9

TABLE VII.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
1	5.6	5.8	6.0	6.1	6.2	6.2	6.2	6.2	6.1	6.0	5.8	5.5	5.2	4.8	4.5
2	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
3	5.1	5.3	5.5	5.6	5.7	5.7	5.7	5.7	5.6	5.5	5.3	5.0	4.7	4.3	4.0
4	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
5	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
6	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
7	4.7	4.9	5.1	5.2	5.3	5.3	5.3	5.3	5.2	5.1	4.9	4.6	4.3	3.9	3.6
8	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
9	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
10	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
11	5.8	6.0	6.2	6.3	6.4	6.4	6.4	6.4	6.3	6.2	6.0	5.7	5.4	5.0	4.7

TABLE VI.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5
1	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
2	4.6	4.5	4.3	4.1	4.1	4.0	4.1	4.1	4.2	4.3	4.5	4.6	4.8	5.1	5.3
3	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
4	4.3	4.2	4.0	3.8	3.8	3.7	3.8	3.8	3.9	4.0	4.2	4.3	4.5	4.8	5.0
5	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
6	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
7	4.2	4.1	3.9	3.7	3.7	3.6	3.7	3.7	3.8	3.9	4.1	4.2	4.4	4.7	4.9
8	4.4	4.3	4.1	3.9	3.9	3.8	3.9	3.9	4.0	4.1	4.3	4.4	4.6	4.9	5.1
9	4.5	4.4	4.2	4.0	4 0	3 9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
10	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
11	4 8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5

TABLE VII.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	5.4	5.5	5.7	5.9	5.9	6 0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7
1	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
2	5.2	5.3	5.5	5.7	5.7	5.8	5.7	5.7	5.6	5.5	5.3	5.2	5.0	4.7	4.5
3	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
4	4.9	5.0	5 2	5.4	5.4	5.5	5.4	5.4	5.3	5.2	5.0	4.9	4 7	4.4	4.2
5	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
6	4.7	4.8	5.0	5.2	5.2	5 3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
7	4.8	4.9	5.1	5.3	5.3	5.4	5.3	5.3	5.2	5.1	4 9	4.8	4.6	4.3	4.1
8	5.0	5.1	5.3	5.5	5.5	5.6	5.5	5.5	5.4	5 3	5.1	5.0	4.8	4.5	4.3
9	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
10	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5 4	5 3	5.1	4.8	4.6
11	5.4	5 5	5.7	5.9	5.9	6 0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7

TABLE VI.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM M N'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	8.0	8.3	8 4	8 5	8.6	8.6	8.6	8.6	8.5	8.4	8.3	8.1	7.7	7.4	7.0
1	8.0	8.2	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.2	8.1	7.7	7.4	7.0
2	7.8	8.1	8.2	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8.1	7.9	7.5	7.2	6 8
3	7.5	7.8	7.9	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7 8	7.6	7.2	6.9	6.5
4	7.1	7.4	7.5	7.7	7.7	7.7	7.7	7.7	7.6	7.5	7.4	7.2	6.8	6.5	6.1
5	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.5	6.1	5.7
6	6.5	6.8	7.0	7.1	7.1	7.1	7.1	7.1	7.0	6.9	6.8	6 6	6.3	5.9	5.5
7	6.7	7.0	7.1	7.2	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.4	6.1	5.7
8	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.6	7.5	7.4	7.3	7.1	6.8	6.4	6.0
9	7.5	7.8	8.0	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.3	6.9	6.5
10	7.9	8.2	8.4	8.5	8.5	8.5	8 5	8.5	8.4	8.3	8.2	8.0	7 7	7.3	6.9
11	8.1	8.4	8 6	8.7	8.7	8.7	8.7	8.7	8.6	8.5	8.4	8.2	7.9	7.5	7.1

TABLE VII.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
1	7.4	7 1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
2	7.2	6.9	6.8	6.6	6.6	6.6	6.6	6.6	6.7	6.8	6.9	7.1	7.5	7.8	8.2
3	6.9	6.6	6.5	6.3	6.3	6.3	6.3	6.3	6.4	6.5	6.6	6.8	7.2	7.5	7.9
4	6.5	6.2	6.1	5.9	5.9	5.9	5.9	5.9	6.0	6.1	6.2	6 4	6.7	7.1	7.5
5	6.1	5.9	5.7	5.6	5.5	5.5	5.6	5.6	5.7	5.7	5.9	6.0	6.4	6.7	7.1
6	5.9	5.7	5.5	5.4	5 3	5.3	5.3	5.4	5.5	5.5	5.7	5 9	6.2	6.5	6.9
7	6.1	5.8	5.6	5 5	5.5	5.5	5.5	5.5	5.6	5.7	5.8	6.0	6.3	6.7	7.1
8	6.4	6.2	6.0	5.9	5.8	5.8	5.8	5.8	5.9	6.0	6.2	6.3	6.7	7.0	7 4
9	6.9	6.7	6.5	6.4	6.3	6.3	6.3	6.4	6.4	6.5	6.7	6.8	7.2	7 5	7.9
10	7.3	7.1	6.9	6 8	6.7	6.7	6.7	6.8	6.9	6.9	7.0	7.2	7.6	7 9	8.3
11	7.5	7 2	7.1	7.0	6.9	6.9	6.9	6.9	7.0	7.1	7.2	7.4	7.8	8.1	8.5

TABLE VI.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*
0	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
1	6.7	6.4	6.0	6.2	6.5	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.7	7.8	8.0
2	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7 5	7.6	7.7	7.9
3	6.3	6.0	5.6	5.8	6.1	6.6	6.9	7.1	7.2	7.2	7.2	7.2	7.3	7.4	7.6
4	6.0	5.7	5.3	5.5	5 8	6.3	6.6	6.8	6.9	6.9	6.9	6.9	7.0	7.1	7.3
5	5.9	5.6	5.2	5.4	5.7	6.2	6.5	6.7	6.8	6.8	6.8	6.8	6.9	7.0	7.2
6	6.1	5.8	5.4	5.6	5.9	6.4	6.7	6.9	7.0	7.0	7.0	7.0	7.1	7.2	7.4
7	6.4	6.1	5.7	5.9	6 2	6.7	7.0	7.2	7.3	7 3	7.3	7.3	7.4	7.5	7.7
8	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7 3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
9	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7 4	7.5	7.6	7.8
10	6.6	6.3	5.9	6.1	6 4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7 6	7.7	7 9
11	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9

TABLE VII.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
1	7.7	8.0	8.4	8.2	7.9	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.7	6.6	6.4
2	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
3	7.3	7.6	8.0	7 8	7.5	7.0	6.7	6.5	6.4	6.4	6.4	6.4	6.3	6 2	6.0
4	7.0	7.3	7.7	7.5	7.2	6.7	6.4	6.2	6.1	6.1	6.1	6.1	6.0	5.9	5.7
5	6.9	7.2	7.6	7.4	7.1	6.6	6.3	6.1	6.0	6.0	6.0	6.0	5.9	5.8	5.6
6	7.1	7.4	7.8	7.6	7.3	6.8	6.5	6.3	6.2	6.2	6.2	6.2	6.1	6.0	5.8
7	7.4	7.7	8.1	7.9	7.6	7.1	6.8	6.6	6.5	6.5	6.5	6.5	6.4	6.3	6.1
8	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6 6	6.6	6.6	6.5	6.4	6.2
9	7 5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
10	7.6	7 9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
11	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract 1.2 foot from the numbers in the tables from San Diego to Astoria, 1.7 foot for Nee-ah harbor, 2.3 for Port Townshend, and 2.7 for Semiahmoo and Steilacoom.

Example VI.—In Example V, to obtain the height of tide on February 7, the declination being south, we enter Table VI for San Francisco, with 0*h.* of transit, and two days after greatest declination, and find that the tide will be 4.5 feet above the mean of the lowest low water, or that 4.5 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 are given for mean low water, then 1.2 feet ought to be subtracted from the Table VI and VII; thus, in this example, it would be 3.3 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.

Tables containing numbers to be added to the time of high water found from Tables IV and V, to obtain the successive high and low waters.

TABLE VIII.—KEY WEST.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Large.)	High water. (Small.)	Low water. (Small.)	Low water. (Small.)	High water. (Large.)	Low water. (Large.)		
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 22	12 10	17 38	5 36	12 33	17 46	7	Before.
	6	5 42	12 31	17 40	5 18	12 18	17 50	6	
	5	6 05	12 55	17 41	4 58	12 03	17 56	5	
	4	6 24	13 17	17 44	4 35	11 44	17 59	4	
	3	6 39	13 28	17 39	4 11	11 18	17 58	3	
	2	7 02	13 52	17 40	3 50	10 58	17 58	2	
	1	7 13	14 01	17 39	3 39	10 46	17 56	1	
	0	7 18	14 10	17 42	3 37	10 46	17 59	0	
After.	1	7 12	14 10	17 48	3 44	10 46	17 52	1	After.
	2	6 57	13 58	17 51	3 57	10 51	17 47	2	
	3	6 39	13 41	17 53	4 21	11 19	17 48	3	
	4	6 15	13 18	17 53	4 43	11 38	17 45	4	
	5	5 57	12 59	17 53	5 09	12 03	17 44	5	
	6	5 32	12 36	17 54	5 25	12 22	17 46	6	
	7	5 13	12 16	17 53	5 40	12 36	17 46	7	

TABLE VIII.—SAN DIEGO.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 44	12 28	18 44	6 16	12 16	18 00	7	Before.
	6	5 18	11 58	18 40	6 42	12 46	18 04	6	
	5	5 00	11 34	18 34	7 00	13 10	18 10	5	
	4	4 47	11 12	18 25	7 13	13 32	18 19	4	
	3	4 34	10 54	18 20	7 26	13 50	18 24	3	
	2	4 24	10 38	18 14	7 36	14 06	18 30	2	
	1	4 17	10 28	18 11	7 43	14 16	18 33	1	
	0	4 12	10 20	18 08	7 48	14 24	18 36	0	
After.	1	4 14	10 20	18 06	7 46	14 24	18 38	1	After.
	2	4 24	10 28	18 04	7 36	14 16	18 40	2	
	3	4 38	10 40	18 02	7 22	14 04	18 42	3	
	4	5 01	10 58	17 57	6 59	13 46	18 47	4	
	5	5 25	11 18	17 53	6 35	13 26	18 51	5	
	6	5 49	11 44	17 55	6 11	13 00	18 49	6	
	7	6 18	12 18	18 00	5 42	12 26	18 44	7	

TABLE VIII.—SAN FRANCISCO.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. *m.*	*h.* *m.*	*h.* *m.*	*h.* *m.*	*h.* *m.*	*h.* *m.*		
Before.	7	5 58	13 14	18 58	5 44	11 46	17 44	7	Before.
	6	5 36	12 42	18 48	6 06	12 18	17 54	6	
	5	5 14	12 10	18 38	6 28	12 50	18 04	5	
	4	4 55	11 34	18 21	6 47	13 26	18 21	4	
	3	4 37	11 00	18 05	7 05	14 00	18 37	3	
	2	4 24	10 34	17 52	7 18	14 26	18 50	2	
	1	4 12	10 06	17 36	7 30	14 54	19 06	1	
	0	4 12	10 00	17 30	7 30	15 00	19 12	0	
After.	1	4 17	10 02	17 27	7 25	14 58	19 15	1	After.
	2	4 27	10 12	17 27	7 15	14 48	19 15	2	
	3	4 41	10 26	17 27	7 01	14 34	19 15	3	
	4	4 56	10 46	17 32	6 46	14 14	19 10	4	
	5	5 14	11 10	17 38	6 28	13 50	19 04	5	
	6	5 36	11 36	17 42	6 06	13 24	19 00	6	
	7	5 57	12 04	17 49	5 45	12 56	18 53	7	

TABLE VIII.—ASTORIA.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. *m.*	*h.* *m.*	*h.* *m.*	*h.* *m.*	*h.* *m.*	*h.* *m.*		
Before.	7	6 38	12 59	19 17	6 18	12 03	18 41	7	Before.
	6	6 14	12 33	19 15	6 42	12 29	18 43	6	
	5	5 55	12 13	19 14	7 01	12 49	18 44	5	
	4	5 34	11 47	19 09	7 22	13 15	18 49	4	
	3	5 20	11 27	19 03	7 36	13 35	18 55	3	
	2	5 09	11 07	18 54	7 47	13 55	19 04	2	
	1	5 05	11 01	18 52	7 51	14 01	19 06	1	
	0	5 03	10 53	18 46	7 53	14 09	19 12	0	
After.	1	5 05	10 51	18 42	7 51	14 11	19 16	1	After.
	2	5 11	10 55	18 40	7 45	14 07	19 18	2	
	3	5 18	11 03	18 41	7 38	13 59	19 17	3	
	4	5 32	11 15	18 39	7 24	13 47	19 19	4	
	5	5 50	11 35	18 41	7 06	13 27	19 17	5	
	6	6 11	11 55	18 40	6 45	13 07	19 18	6	
	7	6 35	12 19	18 40	6 21	12 43	19 18	7	

TABLE VIII.—PORT TOWNSHEND

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water.	High water.	Low water.	Low water.	High water.	Low water.		
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 05	12 26	18 05	5 39	12 26	18 31	7	Before.
	6	6 38	13 14	18 20	5 06	11 38	18 16	6	
	5	7 18	14 14	18 40	4 26	10 38	17 56	5	
	4	8 13	15 52	19 23	3 31	9 00	17 13	4	
	3	8 36	16 52	20 00	3 08	8 00	16 36	3	
	2	8 43	17 30	20 31	3 01	7 22	16 05	2	
	1	8 12	17 04	20 36	3 32	7 48	16 00	1	
	0	7 40	16 28	20 32	4 04	8 24	16 04	0	
After.	1	7 18	15 52	20 18	4 26	9 00	16 18	1	After.
	2	6 59	15 14	19 59	4 45	9 38	16 37	2	
	3	6 38	14 32	19 38	5 06	10 20	16 58	3	
	4	6 24	14 02	19 22	5 20	10 50	17 14	4	
	5	6 10	13 26	19 00	5 34	11 26	17 36	5	
	6	5 59	12 50	18 35	5 45	12 02	18 01	6	
	7	5 42	12 26	18 28	6 02	12 26	18 08	7	

The days from the greatest declination are written in the first and last columns of the table. The second, third, and fourth columns refer to south declination, and fifth, sixth, and seventh to north, and the reverse for Key West. 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 declination 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 waters, *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.—KEY WEST.

Time of moon's transit.	SMALL EBB TIDE. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	SMALL LOW TO LARGE HIGH WATER. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	Time of moon's transit.
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	0
1	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	1
2	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	2
3	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	3
4	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	4
5	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	5
6	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	6
7	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	7
8	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	8
9	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	9
10	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	10
11	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	11

TABLE IX.—KEY WEST—Continued.

Time of moon's transit.	LARGE EBB TIDE. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	LARGE LOW TO SMALL HIGH WATER. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	Time of moon's transit.
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	0
1	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	1
2	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	2
3	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	3
4	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	4
5	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	5
6	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	6
7	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	7
8	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	8
9	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	9
10	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	10
11	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	11

TABLE IX.—SAN DIEGO.

SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.

Days from moon's greatest declination.

Time of moon's transit.	Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft*	*Ft.*	*H.*
0	4.0	3.4	3.0	2 6	2.3	2.1	2.0	2.0	2 1	2.3	2.7	3.2	3.8	4 6	5.2	0
1	3.8	3.2	2.8	2 4	2.1	1.9	1 8	1.8	1.9	2.1	2.5	3 0	3.6	4.4	5.0	1
2	3 5	2.9	2.5	2.1	1.8	1 6	1.5	1.5	1.6	1.8	2.2	2 7	3 3	4 1	4 7	2
3	3.0	2.4	2.0	1.6	1.3	1.1	1.0	1 0	1.1	1.3	1.7	2.2	2.8	3.6	4.2	3
4	2.2	1.6	1.2	0.8	0.5	0.3	0.2	0.2	0.3	0.5	0.9	1.4	2.0	2 8	3 4	4
5	1.7	1.1	0.7	0.3	0.0	-.2	-.3	-.3	-.2	0 0	0.4	0.9	1.5	2.3	2 9	5
6	1.8	1.2	0.8	0.4	0.1	-.1	-.2	-.2	-.1	0.1	0.5	1.0	1.6	2.4	3.0	6
7	2.3	1 7	1.3	0.9	0.6	0.4	0.3	0.3	0.4	0.6	1.0	1 5	2.1	2.9	3.5	7
8	2.9	2.3	1.9	1.5	1.2	1.0	0.9	0.9	1.0	1.2	1.6	2.1	2.7	3.5	4.1	8
9	3 7	3.1	2.7	2.3	2.0	1.8	1.7	1.7	1.8	2.0	2 4	2.9	3.5	4.3	4 9	9
10	4.2	3.6	3.2	2.8	2.5	2.3	2.2	2.2	2.3	2.5	2.9	3.4	4.0	4.8	5.4	10
11	4.3	3.7	3.3	2.9	2.6	2.4	2.3	2.3	2 4	2.6	3.0	3.5	4.1	4.9	5.5	11

From *a* to *b* ..... Diagram I

From *c* to *d* ..... Diagram II

FROM SMALL LOW WATER TO LARGE HIGH WATER.

Days from moon's greatest declination.

Time of moon's transit.	Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft*	*Ft.*	*H.*
0	5.1	4.9	4.7	4.5	4.4	4.3	4.2	4.2	4.1	4 1	4.0	4.0	3 9	3.9	4.0	0
1	4.6	4.4	4.2	4.0	3 9	3 8	3.7	3.7	3.6	3.6	3.5	3.5	3 4	3.4	3.5	1
2	4.1	3.9	3.7	3.5	3.4	3.3	3.2	3.2	3.1	3.1	3.0	3.0	2.9	2.9	3.0	2
3	3.6	3.4	3.2	3.0	2.8	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.3	3
4	3.1	2.9	2.7	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.8	4
5	2.6	2.4	2.2	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.2	1.3	5
6	2.2	2.0	1.8	1.6	1.5	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.9	0.8	0.9	6
7	2.7	2.5	2.3	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.5	1.4	1.4	1.3	1.4	7
8	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.3	2.2	2.1	2.1	2.0	2.0	1.9	2.0	8
9	4.0	3.8	3.6	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.7	2.6	2.7	9
10	4.8	4.6	4.4	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.6	3.5	3.5	3.4	3.5	10
11	5.4	5.2	5.0	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.2	4.1	4.1	4.0	4.1	11

From *b* to *c* ..... Diagram I

From *d* to *e* ..... Diagram II

TABLE IX.—SAN DIEGO—Continued.

LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.

Days from moon's greatest declination

Time of moon's transit.	Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	5.2	5.8	6.2	6 6	6.9	7.1	7.2	7.2	7.1	6.9	6.5	6.0	5.4	4.6	4.0	0
1	5.0	5.6	6.0	6.4	6.7	6.9	7.0	7.0	6.9	6.7	6.3	5 8	5.2	4.4	3.8	1
2	4.7	5 3	5.7	6.1	6.4	6 6	6 7	6.7	6.6	6.4	6.0	5.5	4.9	4.1	3.5	2
3	4 2	4.8	5.2	5.6	5.9	6.1	6.2	6.2	6.1	5.9	5.5	5.0	4.4	3.6	3.0	3
4	3.4	4.0	4.4	4.8	5.1	5.3	5.4	5.4	5.3	5.1	4.7	4.2	3.6	2 8	2.2	4
5	2.9	3.5	3.9	4.3	4 6	4.8	4.9	4.9	4.8	4.6	4.2	3 7	3.1	2.3	1.7	5
6	3.0	3.6	4 0	4.4	4.7	4.9	5.0	5.0	4.9	4.7	4.3	3.8	3.2	2.4	1.8	6
7	3.5	4.1	4.5	4 9	5.2	5.4	5.5	5.5	5.4	5.2	4.8	4.3	3.7	2.9	2.3	7
8	4.1	4.7	5.1	5.5	5.8	6.0	6 1	6.1	6 0	5.8	5.4	4.9	4.3	3.5	2.9	8
9	4.9	5.5	5.9	6.3	6.6	6.8	6.9	6.9	6.8	6.6	6.2	5.7	5.1	4 3	3.7	9
10	5.4	6.0	6.4	6.8	7.1	7.3	7.4	7.4	7.3	7.1	6.7	6.2	5.6	4.8	4.2	10
11	5.5	6.1	6.5	6.9	7.2	7.4	7.5	7.5	7.4	7.2	6.8	6.3	5.7	4.9	4.3	11

From *c* to *d* ..... Diagram I

From *a* to *b* ..... Diagram II

FROM LARGE LOW WATER TO SMALL HIGH WATER.

Days from moon's greatest declination.

Time of moon's transit.	Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	4.1	4.3	4 5	4.7	4.8	4.9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.2	0
1	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.2	5.1	5.0	4.9	4.8	4.6	4.3	3.8	1
2	4.7	4.9	5.1	5.3	5.4	5.5	5.5	5.4	5.3	5.2	5.0	4.8	4.5	4.1	3.5	2
3	5.0	5.2	5.4	5.6	5.7	5.8	5.8	5.7	5.6	5.4	5.2	4.9	4.6	4.1	3.5	3
4	5.3	5.5	5.7	5.9	6.0	6.1	6.1	6.0	5.9	5.7	5.5	5.2	4.8	4.3	3.7	4
5	5.6	5.8	6.0	6.2	6.3	6.4	6.4	6.3	6.2	6.0	5.8	5.5	5.1	4.6	4.0	5
6	5.9	6.1	6.3	6.5	6.6	6.7	6.7	6.6	6.5	6.3	6.1	5.8	5.4	4.9	4.3	6
7	6.2	6.4	6.6	6.8	6.9	7.0	7.0	6.9	6.8	6.6	6.4	6.1	5.7	5.2	4.6	7
8	6.5	6.7	6.9	7.1	7.2	7.3	7.3	7.2	7.1	6.9	6.7	6.4	6.0	5.5	4.9	8
9	6.8	7.0	7.2	7.4	7.5	7.6	7.6	7.5	7.4	7.2	7.0	6.7	6.3	5.8	5.2	9
10	7.1	7.3	7.5	7.7	7.8	7.9	7.9	7.8	7.7	7.5	7.3	7.0	6.6	6.1	5.5	10
11	7.4	7.6	7.8	8.0	8.1	8.2	8.2	8.1	8.0	7.8	7.6	7.3	6.9	6.4	5.8	11

From *d* to *e* ..... Diagram I

From *b* to *c* ..... Diagram II

TABLE IX.—SAN FRANCISCO.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	Hours of moon's transit.
H.	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	0
1	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	1
2	4.3	3.6	3.0	2.5	2.0	1.6	1.4	1.3	1.3	1.5	1.8	2.2	2.7	3.3	4.0	4.8	4.5	4.2	4.1	3.6	3.3	3.0	2.8	2.7	2.6	2.7	2.7	2.9	3.0	3.1	2
3	4.0	3.3	2.7	2.2	1.7	1.3	1.1	1.0	1.0	1.2	1.5	1.9	2.4	3.0	3.7	4.5	4.2	3.9	3.8	3.3	3.0	2.7	2.5	2.4	2.3	2.4	2.4	2.6	2.7	2.8	3
4	3.6	2.9	2.3	1.8	1.3	0.9	0.7	0.6	0.6	0.8	1.1	1.5	2.0	2.6	3.3	4.1	3.8	3.5	3.4	2.9	2.6	2.3	2.1	2.0	1.9	2.0	2.0	2.2	2.3	2.4	4
5	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	5
6	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	6
7	3.4	2.7	2.1	1.6	1.1	0.7	0.5	0.4	0.4	0.6	0.9	1.3	1.8	2.4	3.1	3.9	3.6	3.3	3.2	2.7	2.4	2.1	1.9	1.8	1.7	1.8	1.8	2.0	2.1	2.2	7
8	3.8	3.1	2.5	2.0	1.5	1.1	0.9	0.8	0.8	1.0	1.3	1.7	2.2	2.8	3.5	4.3	4.0	3.7	3.6	3.1	2.8	2.5	2.3	2.2	2.1	2.2	2.2	2.4	2.5	2.6	8
9	4.1	3.4	2.8	2.3	1.8	1.4	1.2	1.1	1.1	1.3	1.6	2.0	2.5	3.1	3.8	4.6	4.3	4.0	3.9	3.4	3.1	2.8	2.6	2.5	2.4	2.5	2.5	2.7	2.8	2.9	9
10	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	10
11	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	11

From *a* to *b* ..... Diagram I
From *c* to *d* ..... Diagram II

From *b* to *c* ..... Diagram I
From *d* to *e* ..... Diagram II

TABLE IX.—SAN FRANCISCO—Continued.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	FROM LARGE LOW WATER TO SMALL HIGH WATER. Days from moon's greatest declination. Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7	Time of moon's transit.
H.	*Ft*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft*	*Ft.*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.6	5.5	5.3	5.2	5.2	0
1	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.5	5.3	5.1	5.0	5.0	1
2	3.5	4.2	4.8	5.3	5.8	6.2	6.4	6.5	6.5	6.3	6.0	5.6	5.1	4.5	3.8	3.0	3.3	3.6	3.7	4.2	4.5	4.8	5.0	5.1	5.2	5.1	5.1	4.9	4.8	4.8	2
3	3.2	3.9	4.5	5.0	5.5	5.9	6.1	6.2	6.2	6.0	5.7	5.3	4.8	4.2	3.5	2.7	3.0	3.3	3.4	3.9	4.2	4.5	4.7	4.8	4.9	4.8	4.8	4.6	4.5	4.5	3
4	2.8	3.5	4.1	4.6	5.1	5.5	5.7	5.8	5.8	5.6	5.3	4.9	4.4	3.8	3.1	2.3	2.6	2.9	3.0	3.5	3.8	4.1	4.3	4.4	4.5	4.4	4.4	4.2	4.1	4.1	4
5	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	5
6	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	6
7	2.6	3.3	3.9	4.4	4.9	5.3	5.5	5.6	5.6	5.4	5.1	4.7	4.2	3.6	2.9	2.1	2.4	2.7	2.8	3.3	3.6	3.9	4.1	4.2	4.3	4.2	4.2	4.0	3.9	3.9	7
8	3.0	3.7	4.3	4.8	5.3	5.7	5.9	6.0	6.0	5.8	5.5	5.1	4.6	4.0	3.3	2.5	2.8	3.1	3.2	3.7	4.0	4.3	4.5	4.6	4.7	4.6	4.6	4.4	4.3	4.3	8
9	3.3	4.0	4.6	5.1	5.6	6.0	6.2	6.3	6.3	6.1	5.8	5.4	4.9	4.3	3.6	2.8	3.1	3.4	3.5	4.0	4.3	4.6	4.8	4.9	5.0	4.9	4.9	4.7	4.6	4.6	9
10	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.3	5.3	5.1	5.0	5.0	10
11	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.5	5.5	5.3	5.2	5.2	11

From *c* to *d* ..... Diagram I
From *a* to *c* ..... Diagram II

From *d* to *e* ..... Diagram I
From *b* to *c* ..... Diagram II

TABLE IX.—ASTORIA.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination.															FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination.														Hours of moon's transit.
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H	*Ft*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft.*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft*	*Ft*	*H.*
0	7.4	6.7	6.0	5.4	5.0	4.6	4.5	4.5	4.6	4.7	5.1	5.5	6.2	6.9	7.8	8.0	7.8	7.5	7.2	6.8	6.4	6.3	6.2	6.1	6.2	6.3	6.3	6.3	6.4	6.4	0
1	7.5	6.8	6.1	5.5	5.1	4.7	4.6	4.6	4.7	4.8	5.2	5.6	6.5	7.0	7.9	8.1	7.9	7.6	7.3	6.9	6.5	6.4	6.3	6.2	6.5	6.3	6.4	6.4	6.4	6.5	1
2	7.2	6.5	5.8	5.2	4.8	4.4	4.3	4.3	4.4	4.5	4.9	5.3	6.0	6.7	7.6	7.8	7.6	7.3	7.0	6.6	6.2	6.1	6.0	5.9	6.0	6.0	6.1	6.1	6.1	6.2	2
3	6.6	5.9	5.2	4.6	4.2	3.8	3.7	3.7	3.8	3.9	4.3	4.7	5.4	6.1	7.0	7.2	7.0	6.7	6.4	6.0	5.6	5.5	5.4	5.3	5.4	5.4	5.5	5.5	5.5	5.6	3
4	5.9	5.2	4.5	3.9	3.5	3.1	3.0	3.0	3.1	3.2	3.6	4.0	4.7	5.4	6.3	6.5	6.3	6.0	5.7	5.3	4.9	4.8	4.7	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4
5	5.2	4.5	3.8	3.2	2.8	2.4	2.3	2.3	2.4	2.5	2.9	3.3	4.0	4.7	5.6	5.8	5.6	5.3	5.0	4.6	4.2	4.1	4.0	3.9	4.0	4.0	4.1	4.1	4.1	4.2	5
6	4.8	4.1	3.4	2.8	2.4	2.0	1.9	1.9	2.0	2.1	2.5	2.9	3.6	4.3	5.2	5.4	5.2	4.9	4.6	4.2	3.8	3.7	3.6	3.5	3.6	3.6	3.7	3.7	3.7	3.8	6
7	5.0	4.3	3.6	3.0	2.6	2.2	2.1	2.1	2.2	2.3	2.7	2.1	3.8	4.5	5.4	5.6	5.4	5.1	4.8	4.4	4.0	3.9	3.8	3.7	3.8	3.8	3.9	3.9	3.9	4.0	7
8	5.5	4.8	4.1	3.5	3.1	2.7	2.6	2.6	2.7	2.8	3.2	3.6	4.3	5.0	5.9	6.1	5.9	5.6	5.3	4.9	4.5	4.4	4.3	4.2	4.3	4.3	4.4	4.4	4.4	4.5	8
9	6.3	5.6	4.9	4.3	3.9	3.5	3.4	3.4	3.5	3.6	4.0	4.4	5.1	5.8	6.7	6.9	6.7	6.4	6.1	5.7	5.3	5.2	5.1	5.0	5.1	5.1	5.2	5.2	5.2	5.3	9
10	7.0	6.3	5.6	5.0	4.6	4.2	4.1	4.1	4.2	4.3	4.7	5.1	5.8	6.5	7.4	7.6	7.4	7.1	6.8	6.4	6.0	5.9	5.8	5.7	5.8	5.8	5.9	5.9	5.9	6.0	10
11	7.3	6.6	6.9	5.3	4.9	4.5	4.4	4.4	4.5	4.6	5.0	5.4	6.1	6.8	7.7	7.9	7.5	7.4	7.1	6.7	6.3	6.2	6.1	6.0	6.1	6.1	6.2	6.2	6.2	6.3	11

From *a* to *b*..... Diagram I
From *b* to *c*..... Diagram I
From *c* to *d*..... Diagram II
From *d* to *e*..... Diagram II

TABLE IX.—ASTORIA—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination.															FROM LARGE LOW WATER TO SMALL HIGH WATER. Days from moon's greatest declination														Hours of moon's transit.
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	7.0	7.7	8.4	9.0	9.4	9.8	9.9	9.9	9.8	9.7	9.3	8.9	8.2	7.5	6.6	6.4	6.6	6.9	7.2	7.6	8.0	8.1	8.2	8.3	8.2	8.2	8.1	8.1	8.1	8.0	0
1	7.1	7.8	8.5	9.1	9.5	9.9	10.0	10.0	9.9	9.8	9.4	9.0	8.3	7.6	6.7	6.5	6.7	7.0	7.3	7.7	8.1	8.2	8.3	8.4	8.3	8.2	8.2	8.2	8.2	8.1	1
2	6.8	7.5	8.2	8.8	9.2	9.6	9.7	9.7	9.6	9.5	9.1	8.7	8.0	7.3	6.4	6.2	6.4	6.7	7.0	7.4	7.8	7.9	8.0	8.1	8.0	8.0	7.9	7.9	7.9	7.8	2
3	6.2	6.9	7.6	8.2	8.6	9.0	9.1	9.1	9.0	8.9	8.5	8.1	7.4	6.7	5.8	5.6	5.8	6.1	6.4	6.8	7.2	7.3	7.4	7.5	7.4	7.4	7.3	7.3	7.3	7.2	3
4	5.5	6.2	6.9	7.5	7.9	8.3	8.4	8.4	8.3	8.2	7.8	7.4	6.7	6.0	5.1	4.9	5.1	5.4	5.7	6.1	6.5	6.6	6.7	6.8	6.7	6.7	6.6	6.6	6.6	6.5	4
5	4.8	5.5	6.2	6.8	7.2	7.6	7.7	7.7	7.6	7.5	7.1	6.7	6.0	5.3	4.4	4.2	4.4	4.7	5.0	5.4	5.8	5.9	6.0	6.1	6.0	6.0	5.9	5.9	5.9	5.8	5
6	4.4	5.1	5.8	6.4	6.8	7.2	7.3	7.3	7.2	7.1	6.7	6.3	5.6	4.9	4.0	3.8	4.0	4.3	4.6	5.0	5.4	5.5	5.6	5.7	5.6	5.6	5.5	5.5	5.5	5.4	6
7	4.6	5.3	6.0	6.6	7.0	7.4	7.5	7.5	7.4	7.3	6.9	6.5	5.8	5.1	4.2	4.0	4.2	4.5	4.8	5.2	5.6	5.7	5.8	5.9	5.8	5.8	5.7	5.7	5.7	5.6	7
8	5.1	5.8	6.5	7.1	7.5	7.9	8.0	8.0	7.9	7.8	7.4	7.0	6.3	5.6	4.7	4.5	4.7	5.0	5.3	5.7	6.1	6.2	6.3	6.4	6.3	6.3	6.2	6.2	6.2	6.1	8
9	5.9	6.6	7.3	7.9	8.3	8.7	8.8	8.8	8.7	8.6	8.2	7.8	7.1	6.4	5.5	5.3	5.5	5.8	6.1	6.5	6.9	7.0	7.1	7.2	7.1	7.1	7.0	7.0	7.0	6.9	9
10	6.6	7.3	8.0	8.6	9.0	9.4	9.5	9.5	9.4	9.3	8.9	8.5	7.8	7.1	6.2	6.0	6.2	6.5	6.8	7.2	7.6	7.7	7.8	7.9	7.8	7.8	7.7	7.7	7.7	7.6	10
11	6.9	7.6	8.3	8.9	9.3	9.7	9.8	9.8	9.7	9.6	9.2	8.8	8.1	7.4	7.5	6.3	6.5	6.8	7.1	7.5	7.9	8.0	8.1	8.2	8.1	8.1	8.0	8.0	8.0	7.9	11

From *c* to *d*..... Diagram I
From *d* to *e*..... Diagram I
From *a* to *b*..... Diagram II
From *b* to *c*..... Diagram II

TABLE IX.—PORT TOWNSHEND.

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.														Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.														
	Before—								After—							Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	0
1	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	1
2	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	2
3	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	3
4	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	4
5	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	5
6	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	6
7	3.3	4.4	5.7	6.8	7.4	7.7	7.6	7.6	7.5	7.5	7.3	6.8	6.1	5.4	4.3	2.3	2.7	3.4	4.8	6.0	7.2	7.8	8.3	8.4	8.2	8.0	7.5	7.0	6.7	5.9	7
8	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	8
9	3.7	4.8	6.1	7.2	7.8	8.1	8.0	8.0	7.9	7.9	7.7	7.2	6.5	5.8	4.7	2.7	3.1	3.8	5.2	6.4	7.6	8.2	8.7	8.8	8.6	8.4	7.9	7.4	7.1	6.3	9
10	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	10
11	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.7	5.9	7.1	8.2	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	11

TABLE IX.—PORT TOWNSHEND—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.														Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.														
	Before—								After—							Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	0
1	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	1
2	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	2
3	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	3
4	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	4
5	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	5
6	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	6
7	5.3	4.2	2.9	1.8	1.2	0.9	1.0	1.0	1.1	1.1	1.3	1.8	2.5	3.3	4.3	6.3	5.9	5.2	3.8	2.6	1.4	0.8	0.3	0.2	0.4	0.6	1.1	1.6	1.9	2.7	7
8	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	8
9	5.7	4.6	3.3	2.2	1.6	1.3	1.4	1.4	1.5	1.5	1.7	2.2	2.9	3.6	4.7	6.7	6.3	5.6	4.2	3.0	1.8	1.2	0.7	0.6	0.8	1.0	1.5	2.0	2.3	3.1	9
10	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	10
11	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	11

Example VII.—Thus, in Example VI, the high water of February 7 was found to be 3.3 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, for San Francisco, with 0*h.* of moon's transit, and two days after the greatest declination in the first part of the table, and find 1.9 foot, which will be the difference in the height of this high and low water. Entering with the same transit and day in the second part, we find 3.0 feet, which is the rise of the large high above the small low water; the difference between 1.9 and 3.0, or 1.1 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.

TIDES OF THE GULF OF MEXICO.

On the coast of Florida, from Cape Florida around the peninsula to St. Mark's, the tides are of the ordinary kind, but with a daily inequality which, small at Cape Florida, goes on increasing as we proceed westward to Tortugas. From the Tortugas to St. Mark's the daily inequality is large and sensibly the same

giving the tides a great resemblance to those of the Pacific coast, though the rise and fall is much smaller. Between St. Mark's and St. George's island, Apalachicola entrance, the tides change to the single-day class, ebbing and flowing but once in the twenty-four (lunar) hours.

At St. George's island there are two tides a day, for three or four days, about the time of the moon's declination being zero. At other times there is but one tide a day, with a long stand at high water of from six to nine hours. From Cape St. Blas to and including the mouth of the Mississippi, the single-day tides are very regular, and the small and irregular double tides appear only for two or three days, (and frequently even not at all,) about the time of zero declination of the moon. The stand at high and low water is comparatively short, seldom exceeding an hour.

To the west of the mouth of the Mississippi the double tides reappear. At Isle Dernière they are distinct, though a little irregular for three or four days near the time of the moon's zero declination. At all other times the single-day type prevails, the double tides modifying it, however, in the shape of a long stand of from six to ten hours at high water. This stand is shortest at the time of the moon's greatest declination, sometimes being reduced to but one hour. At Calcasieu the tides are distinctly double, but with a large daily inequality. The rise and fall being small, they would often present to the ordinary observer the same appearance as at Isle Dernière. At Galveston the double tides are plainly perceptible, though small, for five or six days at the time of the moon's zero declination. At other times they present the single-day type, with the peculiarity that, after standing at high water for a short time, the water falls a small distance, and stands again at that height for several hours, then continues to fall to low water. Sometimes it falls very slowly for nine or ten hours following high water, and then acquires a more rapid rate to low water. At Aransas Pass and Brazos Santiago the single-day tides prevail. Small, irregular, double tides are only perceived for two or three days at the moon's zero declination. At all other times there is but one high water in the day, with a long stand of from six to nine hours, during which there are often small, irregular fluctuations or a very slow fall. In the following table the mean rise and fall of tides at the above stations are given.

The highest high and the lowest low water occur when the greatest declination of the moon happens at full or change; the least tide when the moon's declination is nothing at the first or last quarter. The rise and fall being so small, the times and heights are both much influenced by the winds, and are thus rendered quite irregular.

TABLE X.

Rise and fall at several stations on the Gulf of Mexico.

Stations.	Mean rise and fall of tides.		
	Mean.	At moon's greatest declination.	At moon's least declination.
	Feet.	*Feet.*	*Feet.*
St. George's island, Florida	1.1	1.8	0.6
Pensacola, Florida	1.0	1.5	0.4
Fort Morgan, Mobile bay, Alabama	1.0	1.5	0.4
Cat island, Mississippi	1.3	1.9	0.6
Southwest Pass, Louisiana	1.1	1.4	0.5
Isle Dernière, Louisiana	1.4	2.2	0.7
Entrance to Lake Calcasieu, Louisiana	1.9	2.4	1.7
Galveston, Texas	1.1	1.6	0.8
Aransas Pass, Texas	1.1	1.8	0.6
Brazos Santiago, Texas	0.9	1.2	0.5

TO DETERMINE THE RISE AND FALL OF THE TIDES 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 and 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 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

TIDES IN COASTING.

By observing the time of high water and low water along the coast we find the places at which they are the same. The map of co-tidal lines (Sketch No. 65, C. S. Rep., 1857) shows that it is high water nearly at the same hour all along the coast from Sandy Hook to Cape Cañaveral; of course not in bays and harbors and up the rivers, but on the outer coast.

It is high water exactly at the same hour all along the line marked XII, seen on the chart, near Sandy Hook, and north and south of Hatteras, and, with small interruptions at Cape Lookout and Cape Fear, all the way to near Cape Cañaveral. The same line extends eastward to near Block island, and south of Nantucket, and then passes away from our coast. At full and change of the moon, along this line, (approximately,) it is

high water at twelve o'clock, Greenwich time, the local time of high water depending upon the longitude of the place; or, to speak more correctly, in the average of a lunar month it is high water so many hours after the time of the moon's passing the meridian of Greenwich. By these lines, called co-tidal lines, we can determine what tidal currents the navigators must expect to meet in coasting; and for this purpose we divide the ports of the coast into two sets, those south and those north of New York.

The sailing lines of coasters, bound to southern ports this side of the straits of Florida, are marked upon the map, and also those bound through the sounds to eastern ports, and outside to Halifax and European ports.

VESSELS TO AND FROM PORTS SOUTH OF NEW YORK.

South of Sandy Hook, New Jersey, the line of XII hours is nowhere more than 18 miles from the coast; that of XI$\frac{3}{4}$ nowhere more than 35 miles; that of XI$\frac{1}{2}$ nowhere more than 48; and XI nowhere more than 110. The distance of these lines of XII to XI hours (corresponding within four minutes to VII and VI of New York time,) for different parts of the coast, is shown from Table A, where the first column gives the name of the place, and the second, third, fourth, fifth, respectively, the distances of the co-tidal lines of XII, XI$\frac{3}{4}$, XI$\frac{1}{2}$, and XI hours. The distances are measured from the ports on perpendiculars to the co-tidal lines. They may be taken as if measured on the parallel of latitude at all the points for the line of XII hours, and at all between Sandy Hook and Cape Hatteras for the lines of XI$\frac{3}{4}$ and XI$\frac{1}{2}$ hours.

A.

Names of locations.	Distance from coast, measured on perpendicular to co-tidal lines.			
	At XII hours.	At XI$\frac{3}{4}$ hours.	At XI$\frac{1}{2}$ hours.	At XI hours.
	Nautical miles.	*Nautical miles.*	*Nautical miles.*	*Nautical miles.*
Sandy Hook	12	32	53	100
Barnegat	2	29	39	78
Cape May	15	30	46	92
Cape Henlopen	18	33	47	92
Assateague	7	22	36	82
Cape Henry	12	28	43	100
Cape Hatteras	----------	8	20	63
Ocracoke inlet	----------	11	26	71
Cape Lookout	----------	7	18	56
Beaufort entrance, North Carolina	6	15	24	63
Cape Fear	----------	6	16	55
Cape Roman	----------	10	21	67
Charleston light	3	15	27	70
Port Royal entrance	5	17	29	78
Tybee entrance	6	17	31	82
St. Mary's entrance	12	25	40	110
St. John's entrance	17	35	48	----------
Cape Cañaveral	16	----------	----------	----------
Cape Florida	----------	----------	----------	----------

The co-tidal lines are in such directions that at 10, 20, and 30 miles from the coast, between Sandy Hook and the St. John's, there is but a variation of seven minutes, and even to Cape Cañaveral only of eight minutes.

Keeping ten miles from the shore the coaster would pass from 12 hours at Sandy Hook to 11 hours 45 minutes at Hatteras, and increase again irregularly to 12 hours 7 minutes at the St. John's, as shown more explicitly in Table B. These three tracks of 10, 20, and 30 miles are inside of the cold wall of the Gulf Stream, and generally in the cold current, except at Cape Cañaveral.

B.

Names of stations.	Co-tidal hour at 10, 20, and 30 nautical miles from the coast, perpendicular to the coast.		
	Ten miles off.	Twenty miles off.	Thirty miles off.
	h. m.	*h. m.*	*h. m.*
Sandy Hook	12 0	11 52	11 45
Barnegat	11 52	11 44	11 35
Cape May	12 5	11 53	11 45
Cape Henlopen	12 7	11 57	11 48
Assateague	12 0	11 48	11 37
Cape Henry	12 5	11 48	11 42
Cape Hatteras	11 45	11 30	11 22
Ocracoke inlet	11 47	11 36	11 25
Cape Lookout	11 45	11 30	11 20
Beaufort entrance, North Carolina	11 55	11 38	11 25
Cape Fear	11 38	11 25	11 18
Cape Roman	11 45	11 33	11 24
Charleston light	11 52	11 38	11 25
Port Royal entrance	11 57	11 45	11 32
Tybee entrance	11 55	11 43	11 30
St. Mary's entrance	12 8	11 57	11 47
St. John's entrance	12 7	11 57	11 50
Cape Cañaveral	12 8	----------	----------
Cape Florida	13 10	----------	----------

It follows, then, as a general thing, from these two tables, that the coaster, in passing from Sandy Hook to the St. John's, would have the tides the same, within some fifteen minutes, as if he remained at Sandy Hook; so that leaving, for example, at high water, he would, according to the elapsed time, have the ebb and flood alternating every six hours and a quarter, nearly, as if he had remained near Sandy Hook. As the flood tide sets in generally to the northward and on shore, and the ebb to the southward and off shore, he would know by the time that elapsed from his departure and the period of the tide at which he started, what tidal currents he might expect to meet as he passed along the coast. This, of course, is not peculiar to Sandy Hook as a point of departure, but would be true for any of the entrances given in the table, taking care not to mistake the time of tides within for that at the entrance.

By referring to George W. Blunt, esq., I have obtained the tracks of sailing and steam vessels passing from New York to ports to the south of it, as shown by the lines on the chart accompanying this paper. (See Sketch No. 65, C. S. Rep., 1857.) Tracing these on the map of co-tidal lines, I have determined how the navigator would find the tides as he passes from port to port. The results are shown in the annexed table, (C,) in which the port between which and Sandy Hook the mariner passes is at the head of the table, and, at the side, the place off which the co-tidal hours will be found, as stated in the table.

C.

Off—	Co-tidal hours on sailing lines measured on parallels of latitude of places named in the first column, between New York and—							
	Delaware bay.	Chesapeake bay.	Ocracoke inlet.	Cape Fear.	Charleston.	Savannah.	St. John's.	Cape Florida.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Sandy Hook	12 5	12 5	12 5	12 5	12 5	12 5	12 5	12 5
Barnegat	11 57	11 57	11 57	11 57	11 57	11 57	11 57	11 57
Cape May	12 10	11 52	11 45	11 45	11 45	11 45	11 45	11 45
Cape Henlopen	.....	11 51	11 43	11 43	11 43	11 43	11 43	11 43
Assateague	.....	11 55	11 33	11 33	11 33	11 33	11 33	11 33
Cape Henry	.....	12 13	11 24	11 24	11 24	11 24	11 24	11 24
Cape Hatteras	.....	.....	11 48	11 48	11 48	11 48	11 48	11 48
Ocracoke inlet	.....	.....	.....	11 42	11 42	11 42	11 42	11 42
Cape Lookout	.....	.....	.....	11 39	11 39	11 39	11 32	11 24
Beaufort entrance	.....	.....	.....	11 39	11 39	11 39	11 32	11 24
Cape Fear	.....	.....	.....	....	11 36	11 36	11 24	11 0
Cape Roman	.....	.....	....	.....	11 46	11 46	11 19	.....
Charleston light	.....	.....	.....	.....	.....	11 52	11 18	.....
Port Royal entrance	.....	.....	.....	.....	.....	12 3	11 18	.....
Tybee entrance	.....	.....	.....	.....	.....	.....	11 16	.....
St. Mary's entrance	.....	.....	.....	.....	.....	.....	11 55	.....
St. John's entrance	.....	.....	.....	.....	.....	.....	12 10	.....
Cape Cañaveral	.....	.....	.....	.....	.....	.....	.....	.....
Cape Florida	.....	.....	.....	.....	.....	.....	.....	.....

Thus from Sandy Hook to Delaware bay, starting with 12 hours 5 minutes, off Barnegat there would be, at the same instant, 11 hours 57 minutes, and off Cape May 12 hours 10 minutes, so that the navigator would have the same succession of tides whether he remained at Sandy Hook or passed onward to Delaware bay, or whether he came from Delaware bay to Sandy Hook. So from Sandy Hook to Charleston he will find, at the same instant, 12 hours 5 minutes at Sandy Hook, 11 hours 57 minutes off Barnegat, 11 hours 45 minutes off Cape May, and so onward upon the parallels of latitude for the several points. *For all practical purposes, then, of coasting, the succession of the tides, and, of course, of the tidal currents of flow and ebb, will be the same as if the navigator remained stationary.* Leaving at low water he will meet the flood for 6 hours 15 minutes, and then the ebb for another 6 hours 15 minutes, and so on. It is the simplest of all rules that has thus come out of this investigation. That remarkable change of the temperature between the waters of the in-shore cold current and the warm waters of the Gulf Stream, occurring in so short a distance that Lieutenant Bache called it the "cold wall," takes place at distances off the coast of from 170 to 29 miles, (see Table D,) between Sandy Hook and Cape Cañaveral, measured, from the several points named in the table, at right angles to the direction of the course, or measured along the parallels of latitude of the points, at distances from 195 to 28 miles, between Assateague and Cape Cañaveral, (Table D.) The points where the parallels north of Assateague meet this division line have not been accurately determined.

The annexed table shows these distances measured at right angles and on the parallels.

D.

Distance from coast to "cold wall" of Gulf Stream, off—	Measured at right angles to coast.	Measured on parallel of latitude.
	Nautical miles.	*Nautical miles.*
Sandy Hook	170	----------
Barnegat	135	----------
Cape May	137	----------
Cape Henlopen	137	----------
Assateague	95	195
Cape Henry	92	107
Cape Hatteras	30	31
Ocracoke inlet	53	52
Cape Lookout	53	65
Beaufort entrance	62	----------
Cape Fear	54	97
Cape Roman	57	103
Charleston light	61	95
Port Royal entrance	79	97
Tybee entrance	79	95
St. Mary's	90	87
St. John's	85	82
Cape Cañaveral	29	28
Cape Florida	----------	----------

The coasting line of thirty miles keeps inside of the cold wall all the way to Cañaveral, and all the routes traced on the chart from Sandy Hook to southern ports are on the inside of it. The Gulf Stream lines, as drawn on the chart, show how the route to Bermuda and to the Bahamas cuts the alternate bands of warm and cold water of the Gulf Stream.

Vessels to and from ports east of New York.

The plate shows the sailing lines of vessels bound from New York to eastern ports and to Halifax, outside. The annexed table (E) gives the Greenwich time of high water off the several points named in the first column on the routes to and from the places named in the heading of the table. The distances are measured at right angles to the co-tidal curves.

E.

Off—	Co-tidal hours on sailing lines between New York and—						
	Newport.	New Bedford.	Nantucket.	Boston.	Portsmouth.	Portland.	Halifax.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Sandy Hook	----------	----------	----------	----------	----------	----------	12 5
Throg's Point	16 16	16 16	16 16	16 16	16 16	16 16	----------
Fisher's island	13 48	13 48	13 48	13 48	13 48	13 48	----------
Block island	12 16	12 16	12 16	12 16	12 16	12 16	11 30
Monomoy	----------	----------	----------	16 10	16 10	16 10	----------
Cape Cod	----------	----------	----------	14 35	14 35	14 35	12 15
Cape Ann	----------	----------	----------	----------	15 00	14 40	----------
Portland	----------	----------	----------	----------	----------	15 30	----------

In passing from New York to an eastern port the first great change in the tides and tidal currents is between the East river and Long Island sound; the difference between Governor's island and Negro Point, on Ward's island, at the eastern entrance to Hell Gate, is two hours and forty-five minutes. Between this point and Throg's Point the change is small. The mariner is now in the full tide of the sound, and between Throg's Point and Fisher's island there is a difference of time of but two hours and twenty minutes, the greatest part of which is at the head of the sound and at its entrance—that is, near Throg's Point and Fisher's island. From off New London to off Sand's Point the difference is but one hour and forty minutes; so that if the mariner, instead of remaining at Throg's Point, passes onward to Fisher's island, he would lose but half a tide in the whole passage. In other words, he would have the same succession of rise and fall, according to the time elapsed, whether stationary or passing onward, within two hours and a half, or less than half a tide.

The tidal current lines show that even a less allowance is to be made for the change of current than for the change of tide; the difference in the change of current between Throg's Point and Fisher's island, along the middle of the sound, being of no practical importance. Passing out of Long Island sound the tidal hours grow earlier, until off Block island that of Sandy Hook is again reached. The co-tidal line of Sandy Hook and Block island being the same, it is the struggle of the same tide through New York bay and the narrow East river, and obstructed Hell Gate, and through Fisher's island and Long Island sound, and to Throg's Point. The tidal currents meet near Throg's Point.

The lower part of Narragansett bay has the co-tidal hour twelve hours, nearly. Buzzard's bay has nearly the same co-tidal hour, the tide wave reaching the shore at nearly the same time all around the bay.

It would be impossible to give in a small compass a minute account of the tides of Martha's Vineyard and Nantucket sound. In general it may be said that as far as Holmes's Hole and Wood's Hole they resemble those of Block Island sound, and afterwards those of Monomoy, at the eastern entrance; but this generalization is unsatisfactory without more details than there is space here to give. In these sounds takes place the remarkable change of between three and four hours, the greatest change of our coast, dislocating, as it were, the times of high water at places south and west and east and north of Nantucket. The whole of this change takes place between the eastern entrance of Nantucket sound and the western of Martha's Vineyard, giving rise to quite a complex condition of both tides and currents, which it has occupied much time to unravel. The dominant co-tidal line of our coast, from Block island to Cape Cañaveral, is that of 12 hours of Greenwich time; that of our eastern coast, from Nantucket to Passamaquoddy, is, in general, 15 hours. Passing out of Nantucket sound, coasters carry nearly the same co-tidal hour to Cape Cod, and thence vary their time about half an hour in passing to Boston, to Portsmouth, to Portland, or to Passamaquoddy. It has long been known that the tidal almanac for Boston might practically be used for eastern ports. Vessels from New York to Halifax, and New York to Europe, which keep outside, and should keep well off the Nantucket shoals, and off George's, as shown by the track on the chart, vary their co-tidal hour but little, keeping between the lines of 12 and 11½ until quite well on their course, and beyond Cape Sable. The same rule will apply to their case as has been given for vessels between New York and a southern port.

APPENDIX No. 13.

REPORT TO THE SUPERINTENDENT BY ASSISTANT L. F. POURTALES, IN CHARGE OF THE FIELD AND OFFICE WORK, RELATING TO TIDAL OBSERVATIONS.

COAST SURVEY OFFICE, *October* 1, 1863.

SIR: I have the honor to submit the following report on the field and office work performed by the tidal party under my charge during the past year.

Field-work.—The tidal stations occupied during the past year have been the same as stated in my last report, viz: Eastport, Me., Boston, Mass., New York, Old Point Comfort, Va., San Diego and San Francisco, Cal., and Astoria, Oregon. All of these stations are permanent ones. No temporary stations were established or occupied, with the exception of those connected with the hydrographic parties, but which do not come under the charge of this division.

The station at Eastport remained in charge of Mr. R. H. Talcott until November 1, 1862, when he was ordered to the field. His place was supplied by Assistant E. Goodfellow, who is still in charge of the station. He continues also the magnetic observations at that station. During some severe weather in the past winter,

the protection afforded by kerosene oil in the float-box of the tide-gauge proved insufficient; the oil by becoming thick impeded the motion of the float. The experience of former winters proves, however, that this will occur only in exceptional cases.

The observations in Boston have, as usual, been carried on with the greatest regularity, and have offered no incident worthy of notice. The same may be said of the stations at Governor's island and Old Point Comfort, though in a less degree, as the self-registering gauges in those places are now liable to be interfered with by the numerous vessels landing at the wharves.

The observations on the western coast have been very satisfactory. They are still in charge of the same observers, under the supervision of Captain G. H. Elliot, of the corps of engineers, U. S. A.

Information was received last spring from the provost marshal of Brashear city, Louisiana, that the self-registering tide-gauge formerly in use at Last island, and supposed to have been seized by the rebels, had been turned over to him by the former observer, H. P. Wilson. A reply was sent requesting the provost marshal to forward the tide-gauge to this office, and to inquire into the loyalty of Wilson, so that a balance due to him since the beginning of the rebellion might be paid. No answer was received, probably on account of the military movements in that neighborhood. Further steps have, however, been taken in the matter.

The following table gives a recapitulation of the observations received at the office during the years exclusive of those taken by the hydrographic parties:

Section.	Name of station.	Name of observer.	Kind of gauge.	Station permanent or temporary.	Time of occupation.		Total days.
					From—	To—	
					1862.	1863.	
I	Eastport, Maine	R. H. Talcott, E. Goodfellow	S. R.	Perm.	Oct. 1	Sept. 30	365
	Boston dry dock	T. E Ready	Box.	do	do	do	365
II	Governor's island, N. Y.	R. T. Bassett	S. R.	do	do	do	365
	Brooklyn, N. Y.*	R. T. Bassett	Box.	do	do	do	365
III	Old Point Comfort, Va	M. C. King	S. R.	do	do	do	365
X	San Diego, Cal	A. Cassidy	S. R.	do	do	do	365
	San Francisco, Cal	H. E Uhrlandt	S. R.	do	do	do	365
XI	Astoria, Oregon	L. Wilson	S. R.	do.	do	do	365

* Day tides for comparison with Governor's island.

Office-work.—The persons employed in this division during the year were R. S. Avery, J. Downes, P. H. Donegan, M. Thomas, S. D. Pendleton, and F. R. Pendleton.

Mr. R. S. Avery continued the work on a discussion of the diurnal tides of the western coast. He was afterwards engaged in finishing the reductions of some of the stations which had been interrupted on the southern coast, so as to deduce the final results, and in revising the work of others, and bringing it up to date for other stations still occupied.

Mr. J. Downes was engaged in reading off the sheets from the self-registering tide-gauges, and reducing the results. He was detached from this division on the first of June, and put in charge of the archives.

Mr. P. H. Donegan made ordinary reductions of tides, and did miscellaneous work until the first of June, when he took up the reading from self-registering tide-sheets, which up to that time had been done by Mr. Downes.

M. Thomas was chiefly engaged in copying the readings of the self-registering tide-gauges according to a uniform system for preservation in the archives, and has also done other copying of a miscellaneous character.

S. D. Pendleton continued to make the reductions of the tides of the western coast until August 1. Having then resigned, the continuation of that work was put in the hands of F. R. Pendleton on the 15th of September.

Very respectfully, your obedient servant,

L. F. POURTALES,

Assistant United States Coast Survey, in charge of tidal division.

Prof. A. D. BACHE, LL.D., *Superintendent United States Coast Survey.*

APPENDIX No. 14.

REPORT OF ASSISTANT J. E. HILGARD, IN CHARGE OF THE OFFICE, AND SUB-REPORTS OF THE CHIEFS OF OFFICE DIVISIONS.

COAST SURVEY OFFICE, *Washington, November* 1, 1863.

DEAR SIR: I have the honor to submit herewith the annual report of the operations of the Coast Survey office, which has remained under my charge during the past year.

From the detailed statements of the work done in its several branches, it will appear that while no effort has been spared to meet the extraordinary demands for information and special maps and charts arising from the military and naval operations of the national forces, the regular progress of the office-work has been kept steadily in view, although prosecuted with a reduced force, and a correspondingly lessened expenditure.

In the general direction of the office, I have been ably assisted since June by Prof. F. A. P. Barnard, general assistant, who has besides had the immediate charge of the lithographing and miscellaneous divisions, upon which branches the burden of the calls arising from the present war mainly falls.

I have received acceptable aid from Assistant A. M. Harrison, who during the intervals of field-work relieved me in the immediate direction of the drawing division, and from Sub-Assistants P. C. F. West, J. S. Bradford, and C. H. Boyd, who at different times during the year have been temporarily attached to the office, and have aided in preparing information for the use of other departments of the public service.

The clerical duties of the office have been efficiently performed by Mr. V. E. King, assisted at different times by Messrs. J. A. Sample, H. Ogden, and Wm. Gadsby, jr.

My acknowledgments are due to Samuel Hein, esq., the disbursing officer of the Coast Survey, and to Joseph Saxton, esq., the assistant in charge of the office of weights and measures, whose experience and advice has at all times been freely available; and to the chiefs of divisions for their prompt co-operation in the direction of the work under their charge, a detailed account of which is now presented.

Yours, respectfully,

J. E. HILGARD,
Assistant Coast Survey, in charge of office.

HYDROGRAPHIC DIVISION.—The operations of this division, which embrace the planning and preparation of sheets for hydrographic surveys, their verification when the work has been plotted, the verification of the reduced hydrography for engraving, the preparation of sailing directions, and all hydrographic notes for charts, and all other matters pertaining specially to hydrography, have continued to be under the efficient direction of the hydrographic inspector, Captain *C. P. Patterson*. Two draughtsmen have been employed under his immediate direction, whose occupation during the past year may be thus stated:

Mr. Arthur Balbach has made verifications of original hydrographic sheets, examined and corrected proofs of maps and charts to be published, brought up to date charts published showing additional surveys, and has examined original hydrographic records with reference to discrepancies on original and published charts. He has selected soundings for reduction of original sheets to represent the character of the bottom; verified and corrected reduced hydrographic drawings; has laid down sailing lines and current stations on the various charts preparing for publication. He has, besides, compiled comparative maps and sketches, and prepared tables showing the depth at certain inlets, bars, etc., of the coast of the United States.

Mr. Louis Karcher has been engaged in making projections for hydrographic parties in the field; has plotted original hydrographic work; made reductions of that of the Potomac river for engraving; assisted in the verification of original charts and reduced drawings; made tracings of parts of the coast for the use of the navy, and is at present engaged upon the reduction of the hydrography of a part of the Florida reefs.

TIDAL DIVISION.—This division has been, as heretofore, under the charge of Assistant L. F. Pourtales; its operations, relating to general discussions of tides, are carried on under the immediate direction of the superintendent, while the office derives from it the data required for surveys and charts. The following is a report of occupations of persons employed:

Mr. R. S. Avery was engaged in the discussion of the diurnal tides of the western coast. He afterwards took up the reduction of the permanent stations to deduce the final results of those of which the series has been interrupted on the southern coast, and to revise and bring up to date those made by different computers.

Mr. John Downes was engaged in reading off the sheets from the self-registering tide-gauges and reducing the results until the 1st of June, when he was put in charge of the archives.

Mr. P. H. Donegan made ordinary reductions of tides and miscellaneous work until the 1st of June, when he took up the reading off of the self-registering tide-sheets made up to that time by Mr. Downes.

M. Thomas was chiefly engaged in copying the readings of the self-registering tide-gauges, according to a uniform system, for preservation in the archives, and has also done miscellaneous copying.

S. D. Pendleton continued to make the reductions of the tides of the western coast until August 1. The continuation of that work was put in the hands of *F. R. Pendleton* on the 15th of September.

COMPUTING DIVISION.—Under the continued direction of Assistant *Charles A. Schott* this division has kept up its usual efficiency. The force has been diminished by the discontinuance of the services of Mr. J. Wiessner. The computations of current work have nevertheless been kept up, and while some of the more refined adjustments of geodetic work have been postponed, the astronomical work has been kept up to date.

The perfect organization and system of work in this division has allowed Mr. Schott time to render valuable services in other branches of the survey. Under instructions from the Superintendent, dated January 21, he commenced a trigonometrical survey of the fortifications of the District of Columbia, both for heights and positions, in the last week of January, and completed the work before the close of May. Early in June, and again during the last week of that month, he was engaged on magnetic surveys of certain iron vessels, and afterwards made magnetic observations in the State of Maine, under instructions from the Superintendent, dated June 20. The statistics of his field-work are given elsewhere in this report.

In the office he has computed and discussed the results of the experiments for length and expansion of the standard bar; submitted three reports on the magnetic survey of iron-clad vessels, and one on local deflections of the plumb line at astronomical stations in Sections I, II, III. All calls by observers for office information connected with this division have been attended to. The duplicates of records of the astronomical, geodetic and magnetic work of the survey are under his immediate care, and number 1,485 volumes, kept in 49 cases.

A detailed statement of the work done by each computer is herewith presented.

Assistant Theodore W. Werner completed the computation of the new triangulation up the Connecticut river; supplied L. M. Z. computations to Mr. Ferguson's triangulation, near Washington, 1862; and made progress with the new triangulation on the sea-coast of New Jersey of 1861. He also prepared an abstract of the primary angles at stations Sandford and Mount Tom, 1862; completed the reduction of the triangulation east of Mount Desert, 1860–'61–'62, by Mr. Webber, and calculated the heights as far as data permitted; computed the triangulation of Assistant Boutelle, in the vicinity of Eastport, 1861, and that of Assistant Greenwell, of the island of San Clemente, 1860–'62.

Mr. Eugene Nulty reduced the transit observations at stations Mount Tom and Sandford, and brought out the azimuth and latitude for those places; deduced the longitudes for some stations on the western coast from the observations of the solar eclipse of May, 1854; and made progress with the computation of the triangulation of Penobscot bay by Assistant McCorkle, in 1862.

Mr. James Main revised the time and azimuth computations at stations Azimuth Point, on Monterey bay, Point Hudson, Mount Tom, Sandford and Lummi island, and the latitude computations of stations Wachusett, Humboldt, Point Hudson, Lummi island, Mount Tom and Sandford; introduced improved star-places into the latitudes of Cape Florida and Sand key; made a preliminary reduction of longitudes of Coast Survey stations from observations of the solar eclipse of July, 1860; made a second computation of the magnetic observations at Apalachicola, Eufaula, and Barkley No. 2; attended to some miscellaneous magnetic and geodetic computations; and completed the reduction of the magnetic observations for horizontal force at Key West, from February, 1860, to date. He was on leave of absence during July.

Dr. Gottlieb Rumpf attended to the preparation of the annual statistics of the geodetic work, to the insertion of the new geographical positions in the registers, and to miscellaneous geodetic information required for the field parties; made an adjustment of the primary triangulation from Kent island to the mouth of the Potomac, and of the triangulation of that river as far as Blakistone light; adjusted the geographical positions of Sections V and VI to a continuous series; computed Mr. Schott's observations for heights and position of the fortifications of the District of Columbia of 1863, and computed a new series of L. M. Z. for points of the primary triangulation for a special investigation between Sections I and II.

Mr. John Wiessner made progress with the least square adjustment of the primary triangulation, near the Epping base, and assisted on the adjustment of the Potomac triangulation, (upper part.) His services were discontinued on the 19th of November last. He had been connected with the computing division since January, 1853, and especially commended himself to this division by his mathematical acquirements, uniform industry, and close attention to business.

Mr. E. H. Courtenay attended to the clerical duty of the division, and supplied duplicates of original records, principally of work prior to 1843. He accompanied Mr. Schott as recorder on his triangulation of the fortifications of the District, and on his magnetic survey in June and July in Section I.

R. Freeman attended to the copying of the records of the geodetic survey.

DRAWING DIVISION.—This branch of the office has been under the immediate direction of the assistant in charge, relieved at times by Assistant A. M. Harrison, when not engaged in field-work. Much credit is due to the intelligent zeal of Mr. W. T. Bright, clerk of the division, in arranging the details of the work.

The occupation of the several draughtsmen, whose number has remained the same as last year, is given below, followed by a synopsis of the several maps, charts, and sketches that have been worked upon during the year. Seventy-five sheets have been in hand, of which forty-four are maps and charts of the regular series of publication, twenty sketches or diagrams, and nine maps for lithographing.

Assistant M. J. McClery has drawn the hill topography on photographed outlines of coast maps No. 7, Muscongus bay to Portland, Me., and No. 11, Plymouth to Hyannis, Mass., on a scale of $\frac{1}{40000}$, to be reduced by photography to that of $\frac{1}{80000}$. He has also drawn the hill-work for the finished map of Barnstable harbor, Mass., scale $\frac{1}{20000}$, and is now engaged in filling in the details upon a photographed outline of coast map No. 53, Rattlesnake shoals to St. Helena sound, S. C., scale $\frac{1}{80000}$.

Mr. E. Hergesheimer, as heretofore, has had charge of the preparation of tracings from plane-table sheets for the photographic reduction with generalized details adapted to the reduced scale, and in that department of the work has been engaged upon the following coast maps and charts of the regular $\frac{1}{80000}$ series, viz: No. 7, Muscongus bay to Portland, Me.; No. 8, Seguin island to Kennebunk Port, Me.; No. 10, Cape Ann to Plymouth harbor, Mass.; No. 21, New York bay and harbor; No. 47, Bogue inlet to Barren inlet, N. C.; No. 53, Rattlesnake shoals to St. Helena sound, S. C.; also upon the map of Hudson river, from New York to Haverstraw, scale $\frac{1}{60000}$, and Kennebec and Sheepscot rivers, Me., scale $\frac{1}{40000}$. He hachured the finished map of Dutch Island harbor, Narraganset bay, R. I., scale $\frac{1}{10000}$, and has drawn a sketch of photographical signs for the use of plane-table parties. He has generally verified the engraved topography, arranged the general lettering for all the maps in process of engraving, and has been engaged upon diagrams, projections for field parties and projections on copper, and superintended the drawing of a map, on a scale of $\frac{1}{10000}$, of the environs of St. Louis, Mo., for the military authorities. From June to August Mr. Hergesheimer was in the field, engaged upon the special survey for defences at Philadelphia.

Mr. A. Lindenkohl has drawn the preliminary chart of part of the western coast of the United States, from Point Pinos to Bodega Head, including the Bay of San Francisco, scale $\frac{1}{200000}$; continued the hydrography upon general coast chart No. X, Straits of Florida, scale $\frac{1}{400000}$, and that of the topography of No. XIV Pensacola bay, to the Mississippi Delta, La. He has drawn four of a series of five sailing charts of the Atlantic and Gulf coasts, scale $\frac{1}{1200000}$, and reduced additional hydrography for coast chart No. 8, Seguin island, to Kennebunk Port, Me., as well as to preliminary sea-coast chart No. 3, Cape Small Point to Cape Cod, Mass., scale $\frac{1}{200000}$. He has also drawn, for engraving on stone, a map of the mountain region of Tennessee and North Carolina, a military map of Southeastern Virginia, a sketch of the approaches to Fort Wagner, Morris island, S. C.; has made additions to the preliminary charts of the Gulf of Mexico, in four sheets, scale $\frac{1}{600000}$, and to the progress sketches of the several sections, and has been engaged upon projections for field parties, projections on copper, verifications, and projects. In addition to Mr. Lindenkohl's regular office-work, he was assigned to special field duty on several occasions, and was engaged upon the survey of Rosier's Bluff and vicinity, Potomac river, for the engineer department, on the defences of Baltimore city, Md., and since the 3d of October has been on duty with Lieutenant J. R. Meigs, corps of engineers, in West Virginia.

Mr. L. D. Williams has completed the drawing of preliminary chart of San Francisco bay, (upper post,) scale $\frac{1}{50000}$, and continued the topography of Hudson river, sheet No. 1, from New York to Haverstraw, scale $\frac{1}{60000}$; selected and traced, for reduction by photography, the hydrography of Hudson river, sheet No. 3, from Poughkeepsie to Glasco, scale $\frac{1}{40000}$, and made the annual additions to the Congress map. He has also been engaged upon projects, projections for field parties, projections on copper, and verifications.

Mr. H. Lindenkohl, who has alternately been employed in this and the lithographic division, has reduced the shore line of the preliminary chart of Gray's harbor, W. T., scale $\frac{1}{40000}$; the hydrography of Port Royal sound, including Beaufort, Broad, and Chechessee rivers, S. C., scale $\frac{1}{60000}$, (additions,) and selected and traced for reduction by photography the hydrography of part of Kennebec and Sheepscot rivers, Me., scale $\frac{1}{40000}$. He engraved on stone the military map of South Eastern Virginia, and the military map of

the mountain region of Tennessee and North Carolina. He traced for lithographic transfer Charleston harbor, S. C., scale $\frac{1}{10000}$, and added additional work to numerous lithographic drawings on stone. He has also been engaged upon tracings and statistics, and made additions to the chart of Hampton Roads, embracing the mouth of James river, Va., scale $\frac{1}{40000}$.

Mr. F. Fairfax has completed the preliminary charts of Bristol harbor, scale $\frac{1}{20000}$, and Coasters' Harbor island, Narraganset bay, R. I., scale $\frac{1}{20000}$, and drawn in outline the map of Dutch Island harbor, (Narraganset bay,) scale $\frac{1}{10000}$. He has also completed the finished map of Calibogue sound and Skull creek, S. C., scale $\frac{1}{20000}$ and $\frac{1}{40000}$, and traced for photographing the topography of Rockland harbor, Me., scale $\frac{1}{20000}$. He has also been engaged upon tracings, projections for field parties, and miscellaneous work, and has now in hand a tracing of sheet of Bodega bay, Cal., scale $\frac{1}{30000}$.

Mr. F. Engel, while temporarily attached to this division, has made the progress sketch showing the primary triangulation of Sections I and II, and prepared projections for field parties, projections on copper, and diagrams.

Mr. W. B. McMurtrie was engaged in plotting hydrographic work, on tracings, and on miscellaneous lithographic transfers, and has finished the preliminary chart of Bodega bay, Cal., scale $\frac{1}{30000}$. Since June 29 has been on duty at Philadelphia, compiling the surveys for defences of that city.

Mr. E. Willenbucher was assigned to duty in the office in June, since which time he has been engaged in plotting hydrographic sheets, from the original notes, of Hudson river, N. Y., and Rockland harbor, Me., and in tracing and coloring maps required for the military or naval services.

Mr. J. W. Maedel has been principally engaged in making tracings, under Mr. Hergesheimer's direction, of original sheets for photographic reduction, and in other miscellaneous work.

Mr. T. R. Smith was engaged, under Mr. Hergesheimer's direction, in making tracings, and in drawing a map of St. Louis and approaches, Mo., on the scale of the original surveys, until June, when he resigned, and was replaced by Mr. J. H. Logan.

Messrs. F. Petingale, B. Hooe, and *W. Fairfax* have been engaged upon tracings, lettering plane-table sheets, statistics, and other miscellaneous work.

Mr. Petingale resigned on the 9th of March.

List of maps and sketches completed or in progress in the Drawing Division during the year ending November 1, 1863, arranged in geographical order.

Name.	Scale.	Description.	Remarks.
SECTION I.—*Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.*			
Progress sketch A, (primary triangulation)	1–1,000,000		
Progress sketch A *bis*, northern part } secondary triangulation, topog-			
Progress sketch A *bis*, southern part } raphy, and hydrography	1–400,000		
Sheepscot and Kennebec rivers, Me	1–40,000	Finished map	In progress; outline by photography.
Rockland harbor, Me	1–20,000	do	Do.
Barnstable harbor, Mass. (hill topography)	1–20,000	do	Completed; outline by photography.
Coast map and chart, No. 7, Muscongus bay to Portland harbor, Me	1–80,000	Finished map and chart.	In progress; outline by photography.
Coast map and chart, No. 8, Seguin island to Kennebunk Port, Me	1–80,000	do	Do.
Coast map and chart, No. 10, Cape Ann to Plymouth harbor, Mass	1–80,000	do	Do.
Coast map and chart, No. 11, Plymouth harbor to Hyannis harbor, Mass	1–80,000	do	Do.
Preliminary sea-coast chart, No. 3, Cape Small Point, Me., to Cape Cod, Mass	1–200,000	Preliminary chart	Additions.
Dutch Island harbor, Narraganset bay, R. I	1–10,000	Finished map	Completed.
Bristol harbor, Narraganset bay, R. I	1–20,000	Preliminary chart	Do.
Coaster's harbor, Narraganset bay, R. I	1–20,000	do	Do.
SECTION II.—*Coast of Connecticut, New York, New Jersey, and Delaware, north of Cape Henlopen.*			
Progress sketch, Connecticut river	1–200,000		
Progress sketch, Hudson river, (in two parts)	1–100,000		
	1–200,000		
Progress sketch, coast of N. J	1–400,000		

List of maps and sketches completed or in progress in the Drawing Division during the year ending November 1, 1863, &c.—Continued.

Name.	Scale.	Description.	Remarks.
SECTION II—Continued.			
Coast map and chart, No. 21, New York bay and harbor	1–80,000	Finished map and chart.	In progress; outline by photography.
Hudson river, No. 1, New York to Haverstraw	1–60,000	Finished map	In progress.
Hudson river, No. 2, Haverstraw to Poughkeepsie	1–60,000	Preliminary chart	Completed.
Hudson river, No. 3, Poughkeepsie to Glasco	1–40,000	do	Do.
Atlantic coast, sheet No. II, Nantucket to Cape Hatteras	1–1,200,000	do	Do.
Phelps's ledge and Great Eastern Rock, off Montauk Point, L. I.	1–40,000	Sketch	Do.
SECTION III.—*Coast of Delaware south of Cape Henlopen, Maryland and Virginia north of Cape Henry.*			
Progress sketch C	1–400,000		
General coast chart, No. IV, Cape May, N J., to Currituck sound, North Carolina	1–400,000	Finished chart	In progress.
Potomac river, sheet No. 2, Piney Point to Lower Cedar Point	1–60,000	Preliminary chart	Completed.
Potomac river, sheet No. 3, Lower Cedar Point to Indian Head	1–60,000	do	Do.
Potomac river, sheet No. 4, Indian Head to Chain Bridge	1–40,000	Finishe d map	In progress.
Hampton Roads and James river entrance	1–40,000	Preliminary chart	Completed.
Metomkin inlet, Va.	1–20,000	Finished map	Do.
Military map, southeastern Va.		For engraving on stone.	Do.
SECTION IV.—*Coast of Virginia south of Cape Henry, and North Carolina north of Cape Fear.*			
Progress sketch D	1–400,000		
Coast map and chart, No. 47, Bogue inlet to Barren inlet, N. C.	1–80,000	Finished map	Photographic reduction of topography completed.
Coast map and chart, No. 48, Barren inlet to Lockwood's Folly inlet, N. C.	1–80,000	do	Lithographic outlines and hydrography completed.
Oregon inlet, N. C.	1–20,000	Preliminary chart	Completed.
Mountain region of North Carolina and Tennessee		For engraving on stone.	Do.
SECTION V.—*Coast of North Carolina south of Cape Fear, South Carolina and Georgia.*			
Progress sketch E	1–600,000		
Coast map and chart, No. 53, Rattlesnake shoals to St. Helena sound, S. C.	1–80,000	Finished map	In progress; outline by photography.
Coast map and chart, No. 54, St. Helena sound, S. C., to Ossabaw sound, Ga.	1–80,000	do	Do.
Port Royal sound, including Beaufort, Broad, and Chechessee rivers, S. C., (additions)	1–60,000	Preliminary chart	Completed.
Calibogue sound and Skull creek, S. C., (on one sheet)	1–20,000		
	1–40,000	Finished maps	Do.
Wassaw sound, S. C	1–40,000	Finished map	In progress; outline by photography.
Charleston harbor, (lithographic edition)	1–10,000	Special map for siege operations.	Completed.
Atlantic coast, sheet No. III, Hatteras to Mosquito inlet, Fla.	1–1,200,000	Preliminary chart	Do.
St. Helena sound, S. C	1–40,000	do	In progress.
SECTION VI.—*Coast of Florida, from St. Mary's river to St. Joseph's bay.*			
Progress sketch F, (reefs and keys)	1–400,000		
General coast chart, No. X, Cape Florida to Cape Sable, Fla.	1–400,000	Finished map and chart.	In progress.
Atlantic coast, sheet No. IV, Mosquito inlet to Key West, Fla.	1–1,200,000	Preliminary chart	Completed.
Southeastern part of the Gulf of Mexico, including the Straits of Florida, (additions)	1–600,000	do	Lithographic edition completed.
SECTION VII.—*Coast of Florida west of St. Joseph's bay, and Alabama east of Mobile bay.*			
Progress sketch G	1–600,000		
General coast chart, No. XIV, Choctawhatchee bay, Fla., to the Mississippi delta, La.	1–400,000	Finished chart	In progress.

List of maps and sketches completed or in progress in the Drawing Division during the year ending November 1, 1863, *&c.*—Continued.

Name.	Scale.	Description.	Remarks.
SECTION VII—Continued.			
Northeastern part of the Gulf of Mexico, (additions)	1-600,000	Preliminary chart	Lithographic edition completed.
SECTION VIII.—*Coast of Alabama west of Mobile bay, and Mississippi and Louisiana east of Vermilion bay.*			
Progress sketch H	1-600,000		
Gulf coast of the United States, eastern sheets	1-1,200,000	Preliminary chart	Completed.
Northern part of the Gulf of Mexico, (additions)	1-600,000	do	Lithographic edition completed.
Military map of the Gulf Department		For engraving on stone.	Do.
Map of St. Louis and approaches, Mo	1-10,000	Military map for General-in-chief.	Completed.
SECTION IX.—*Coast of Louisiana west of Vermilion bay, and Texas.*			
Progress sketch I	1-600,000		
Gulf coast of the United States, Western sheet	1-1,200,000	Preliminary chart	Completed.
Northwestern part of the Gulf of Mexico, (additions)	1-600,000	do	Lithographic edition completed.
SECTION X.—*Coast of California.*			
Progress sketch J, (from San Diego to Point Sal)	1-600,000		
Progress sketch J, (from Point Sal to Tomales)	1-600,000		
Pacific coast, from Bodega Head to Point Piños, including the bay of San Francisco and its approaches	1-200,000	Preliminary chart	Completed.
San Francisco bay, Cal., (upper part)	1-50,000	do	Do.
Bodega bay, Cal.	1-30,000	do	Do.
Tomales bay, Cal.	1-30,000	do	Do.
SECTION XI.—*Coast of Oregon and Washington Territory.*			
Progress sketch K	1-600,000		
Progress sketch K *bis*	1-600,000		
Koos bay, Oregon	1-20,000	Finished map	Completed.
Gray's harbor, W. T.	1-40,000	Preliminary chart	In progress.
Miscellaneous.			
Diagram illustrating the results of experiments on the expansion and contraction of drawing paper		Diagram	Completed.
Topographical signs for the use of topographers		Specimen drawing	Do.
Gulf stream	1-5,000,000	Diagram	In progress.
Congress map, (additions up to date)	1-1,500,000		Completed.

ENGRAVING DIVISION.—This division has remained under the charge of Mr. Edward Wharton, assisted in clerical duties by Mr. G. J. Pinckard. The engraving of the regular series of maps and charts has made steady progress during the year, although prosecuted with a diminished force. The number of engravers, which was twenty-three during the preceding year, has been reduced to nineteen. A detailed statement of the occupation of each will be found below.

The practice of engraving from photographic reductions of large scale drawings has been continued with increased satisfaction and success. The greater portion of the charts, and particularly those of the series of finished coast charts on $\frac{1}{80000}$ scale, are now engraved in that way.

The system of engraving figures by means of punches, in place of cutting them with the graver, has been further perfected during the year, and has been fully adopted for second-class charts, with a great reduction of expense. Of the maps accompanying this report, the series of "sailing charts" No. 18 to 23, and others, have had the soundings engraved in this way. Another advance in lessening the expense of engraving, by the application of mechanical means, has been made in the use of a pantograph of superior construction, adapted to engraving outlines upon copper on a reduced scale by direct copying from the drawing.

During the year ending October, 1863, the engraving of the following finished maps and charts has been completed, viz: Portland harbor, Me., $\frac{1}{20000}$; Dutch Island harbor, Narraganset bay, R. I., $\frac{1}{10000}$; coast chart No. 36, Chesapeake bay, No. 6, from the bay entrance up to York river, $\frac{1}{80000}$; coast chart No. 71, Florida reefs, from New-found Harbor key to Boca Grande key, $\frac{1}{80000}$; San Pablo bay, Cal., $\frac{1}{80000}$; and Koos bay, Oregon, $\frac{1}{20000}$.

In addition to these, two charts of the Atlantic coast, on a scale of $\frac{1}{1200000}$, extending from Nantucket to Mosquito inlet, have been engraved.

The following maps and charts have been prepared for preliminary editions: Bristol harbor, R. I., $\frac{1}{20000}$; Potomac river, sheet No. 1, from the river entrance up to Piney Point, $\frac{1}{60000}$; Potomac river, sheet No. 2, from Piney Point to Lower Cedar Point, $\frac{1}{60000}$; Potomac river, sheet No. 3, from Lower Cedar Point to Indian Head, $\frac{1}{60000}$; Rappahannock river, sheet No. 5, from Occupacia creek to Deep creek, $\frac{1}{60000}$; general coast chart No. IV, from Cape May to Cape Henry, $\frac{1}{400000}$; Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$; Port Royal entrance, Beaufort, Broad, and Chechessee rivers, S. C., $\frac{1}{60000}$; Pacific coast, from Point Pinos to Bodega Head, $\frac{1}{200000}$; upper part of San Francisco bay, $\frac{1}{50000}$; Drake's bay, Cal., $\frac{1}{40000}$; Bodega bay, Cal., $\frac{1}{30000}$; and Gray's harbor, W. T., $\frac{1}{40000}$. And the following sketches have been also engraved, viz: Phelps's Ledge and Great Eastern Rock, off Montauk Point, $\frac{1}{40000}$; Metomkin inlet, Va., $\frac{1}{20000}$; Oregon inlet, N. C., $\frac{1}{20000}$; Southwest Pass, Mississippi river, $\frac{1}{20000}$.

Considerable progress has been made upon the following important charts, viz: Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$; coast charts Nos. 7, 8, 9, 10, and 11, scale $\frac{1}{80000}$, extending from Muscongus bay, Me., to the southern extremity of Cape Cod, Mass.; Barnstable harbor, Mass., $\frac{1}{20000}$; coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$, as a finished chart; Hudson river, sheet No. 1, from New York to Haverstraw, $\frac{1}{60000}$; coast chart No. 37, from Cape Henry to Currituck, $\frac{1}{80000}$; general coast chart No. X, Florida reefs, from Key Biscayne to Marquesas Keys, $\frac{1}{400000}$; coast chart No. 93, Lakes Borgne and Pontchartrain, La., $\frac{1}{80000}$, and Tomales bay, Cal., $\frac{1}{30000}$.

The engraving of the following charts has been commenced, viz: Newport harbor, R. I., $\frac{1}{20000}$; Hudson river, sheet No. 3, from Poughkeepsie to Glasco, $\frac{1}{40000}$; coast chart No. 29, from Green Run inlet to Little Machipongo inlet, Md., $\frac{1}{80000}$; Hampton Roads and Elizabeth river, Va., $\frac{1}{40000}$; Potomac river, sheet No. 4, from Indian Head to Little Falls, $\frac{1}{40000}$; coast charts No. 47 and 48, embracing a portion of the coast of North Carolina, from Bogue inlet to Lockwood's Folly inlet, $\frac{1}{80000}$; coast chart No. 53, from Rattlesnake shoals to St. Helena sound, S. C., $\frac{1}{80000}$; chart of the Atlantic coast, No. 4, from Mosquito inlet to Key West, $\frac{1}{1200000}$, and chart No. 5, embracing the Gulf of Mexico entire in two plates, $\frac{1}{1200000}$, and coast chart No. 100, Point au Fer to Marsh island, La., $\frac{1}{80000}$.

The engraving force has been principally employed as follows:

Mr. McCoy, topographical engraver, completed the topography upon the eastern half of coast chart No. 11, $\frac{1}{80000}$, from photographic reductions, embracing Cape Cod, Mass. Mr. McCoy has since returned to Europe.

Mr. Rollé, topographical engraver, has been principally employed upon the continuation of the topography upon coast chart No. 9, from Cape Neddick to Cape Ann, Mass., $\frac{1}{80000}$, and coast chart No. 11, from Plymouth to Hyannis, Mass., $\frac{1}{80000}$, and has commenced the outlines of coast chart No. 29, from Green Run inlet to Little Machipongo inlet, Md., $\frac{1}{80000}$.

Mr. Knight, letter engraver, has engraved additional soundings upon coast chart No. 8, from Seguin island to Kennebunk Port, Maine, $\frac{1}{80000}$; completed the notes and general lettering upon coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$; additional soundings upon coast chart No. 71, from Newfound Harbor Key to Boca Grande Key, $\frac{1}{80000}$; a portion of the lettering upon coast chart No. 100, Point au Fer to Marsh island, La., $\frac{1}{80000}$; the soundings, title, and general lettering upon upper part of San Francisco bay, Cal., $\frac{1}{50000}$; the soundings, title, notes, and general lettering upon a chart of the Pacific coast, from Point Piños to Bodega Head, Cal., $\frac{1}{200000}$, and miscellaneous corrections and additions to other plates.

Mr. Enthoffer, topographical engraver, has continued the topography upon coast charts Nos. 7 and 8, from Muscongus bay to Kennebunk Port, Maine, $\frac{1}{80000}$; has engraved additions and corrections upon coast charts Nos. 32 and 33, embracing portions of Chesapeake bay, $\frac{1}{80000}$, and is at present employed on contract upon topography of coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$.

Mr. Sengteller, topographical engraver, has completed the topography upon coast chart No. 37, Cape Henry to Currituck, $\frac{1}{80000}$; miscellaneous corrections upon other plates, and is at present engaged upon the outlines of coast chart No. 53, Rattlesnake shoals to St. Helena sound, S. C., $\frac{1}{80000}$, entirely from photographic reductions.

Mr. Phillips, topographical engraver, has completed the topography upon coast chart No. 93, Lakes Borgne and Pontchartrain, La., $\frac{1}{80000}$; and also that of coast chart No. 100, Point au Fer to Marsh island, La., $\frac{1}{80000}$.

Mr. Metzeroth, topographical engraver, completed the views upon San Pablo bay, Cal., $\frac{1}{30000}$; and

completed also the sand upon Portland harbor, Maine, $\frac{1}{20000}$; upon coast chart No. 2, New York bay and harbor, $\frac{1}{80000}$; and upon general coast chart No. IV, from Cape May to Cape Henry, $\frac{1}{400000}$, besides miscellaneous corrections in topography and sand. During a portion of the year Mr. Metzeroth has been absent from the office on account of ill health.

Mr. Evans, topographical engraver, engraved the topography upon Koos bay, Oregon, $\frac{1}{20000}$, and has continued the topography upon Hudson river, sheet No. 1, from New York to Haverstraw, $\frac{1}{60000}$, upon which he is at present engaged.

Mr. Barnard, topographical engraver, completed the sand upon coast chart No. 36, Chesapeake bay, No. 6, from entrance to York river, $\frac{1}{80000}$; a portion of the sand upon coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$; all the sand upon Potomac river, No. 1, from entrance to Piney Point, $\frac{1}{60000}$; a portion of that upon Potomac river, sheets Nos. 2 and 3, from Piney Point to Indian Head, $\frac{1}{60000}$, and additions and corrections in sanding upon various plates.

Mr. A. Maedel, topaphical engraver, has engraved the topography upon Potomac river, sheets Nos. 2 and 3, from Piney Point to Indian Head, $\frac{1}{60000}$; a portion of that upon sheet No. 4, from Indian Head to Little Falls, $\frac{1}{40000}$; all the topography upon Dutch Island harbor, R. I., $\frac{1}{10000}$; and the outlines upon coast chart No. 47, and coast chart No. 48, extending from Bogue inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$, and some miscellaneous work.

Mr. Kondrup, miscellaneous engraver, has engraved the outlines upon general coast chart No. IV, Cape May to Cape Henry, $\frac{1}{400000}$; the outlines upon upper part of San Francisco bay, Cal., $\frac{1}{50000}$; has engraved with the pantograph the shore-line upon chart of the Atlantic coast, sheet No. 2, from Nantucket to Cape Hatteras, $\frac{1}{1200000}$, and is continuing the outlines upon coast chart No. 10, Cape Ann to Plymouth, Mass., $\frac{1}{80000}$.

Mr. E. A. Maedel, letter engraver, has completed the soundings and general lettering upon general coast chart No. IV, from Cape May to Cape Henry, $\frac{1}{400000}$; the notes upon upper part of San Francisco bay, Cal., $\frac{1}{50000}$; corrections and additions in hydrography, and lettering upon Portland harbor, Me., $\frac{1}{20000}$, and a large amount of miscellaneous work; figures upon steel plates for dies, from which punches are struck, and is now engaged upon the soundings of Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$.

Mr. Petersen, miscellaneous engraver, has engraved additions to the soundings of Portland harbor, Me., $\frac{1}{120000}$; the soundings, titles, general lettering, and notes of Potomac river, sheets Nos. 1, 2, and 3, from entrance to Indian Head, $\frac{1}{60000}$; the titles, notes, &c., upon Dutch Island harbor, R. I., $\frac{1}{10000}$, and upon Gray's harbor, W. T, $\frac{1}{40000}$, and some miscellaneous work, and is now engaged upon the title, general lettering, and notes of Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$.

Mr. Bartle, topographical engraver, completed the sand upon Barnstable harbor, Mass, $\frac{1}{20000}$; Petaluma and Napa creeks, Cal., $\frac{1}{30000}$, and upon Bodega bay, Cal., $\frac{1}{30000}$; all the outlines of chart of Pacific coast, from Point Piños to Bodega Head, Cal., $\frac{1}{200000}$; a portion of the outlines of upper part San Francisco bay, Cal., $\frac{1}{50000}$, and of chart of Atlantic coast, No. 4, from Mosquito inlet to Key West, $\frac{1}{1200000}$; the shore-line of Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$, and of Gray's harbor, W. T., $\frac{1}{40000}$; and is now employed upon the topography of Barnstable harbor, Mass., $\frac{1}{20000}$.

Mr. Benner, miscellaneous engraver, has engraved the shore-line and sand of Hudson river, No. 3, from Poughkeepsie to Glasco, $\frac{1}{40000}$; the sand of Tomales bay, Cal., $\frac{1}{30000}$; of Dutch Island harbor, R. I., $\frac{1}{10000}$; and of Rappahannock river, sheet No. 5, from Occupacia creek to Deep creek, $\frac{1}{60000}$; besides progress sketches and miscellaneous work.

Mr. W. A. Thompson, topographical engraver, has completed the hill curves, woods, &c., upon Drake's bay, Cal., $\frac{1}{40000}$; the outlines of Newport harbor, R. I., $\frac{1}{20000}$; and of Potomac river, sheet No. 1, from entrance to Piney Point, $\frac{1}{60000}$; the topography of Metomkin inlet, Va., $\frac{1}{20000}$; of Oregon inlet, N. C., $\frac{1}{20000}$; and of Southwest Pass, Mississippi river, $\frac{1}{20000}$; and engraved with the pantograph the shore-line of the charts of the Atlantic coast, Nos. 3 and 4, from Cape Hatteras to Key West, $\frac{1}{1200000}$; and of the Gulf coast in two parts; and has also engraved the sand upon two of these charts, Nos. 2 and 3, besides progress sketches and miscellaneous work.

Mr. Sipe, miscellaneous engraver, has completed the notes, &c., of Mount Hope bay, R. I., $\frac{1}{40000}$; the outlines, titles, general lettering, and notes of Bristol harbor, R. I., $\frac{1}{20000}$, and of Hatteras inlet, N. C., $\frac{1}{20000}$; the lettering of Dutch Island harbor, R. I., $\frac{1}{10000}$; the notes of Bodega bay, Cal., $\frac{1}{30000}$, and the title, notes, and lettering of Southwest Pass, Mississippi river, $\frac{1}{20000}$, and miscellaneous work and progress sketches. A portion of the year Mr. Sipe was employed in the printing division of the office.

Mr. J. G. Thompson, miscellaneous engraver, has engraved the outlines of Dutch Island harbor, R. I.,

$\frac{1}{10000}$; of Bodega bay, Cal., $\frac{1}{30000}$; of Gray's harbor, W. T., $\frac{1}{40000}$; the shore-line and all the lettering of approximate co-tidal lines Atlantic coast; the lettering and sand of Metomkin inlet, Va., $\frac{1}{20000}$; the notes of Oregon inlet, N. C., $\frac{1}{20000}$, besides progress sketches and miscellaneous work, and is now engaged upon the shore-line and lettering of Port Royal entrance, &c., S. C., $\frac{1}{60000}$.

Mr. Buckle has punched the figures of soundings upon the following plates, viz: Newport harbor, R. I., $\frac{1}{20000}$; Dutch Island harbor, R. I., $\frac{1}{10000}$; Bristol harbor, R. I., $\frac{1}{20000}$; Great Eastern Rock, off Montauk Point, $\frac{1}{40000}$; Hudson river, No. 3, from Poughkeepsie to Glasco, $\frac{1}{40000}$; Hampton Roads and Elizabeth river, Va., $\frac{1}{40000}$; Oregon inlet, N. C., $\frac{1}{20000}$; Hatteras inlet, N. C., $\frac{1}{20000}$; Port Royal entrance, &c., S. C., $\frac{1}{60000}$; Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$; Southwest Pass, Mississippi river, $\frac{1}{20000}$; Bodega bay, Cal., $\frac{1}{30000}$; Gray's harbor, W. T., $\frac{1}{40000}$; and upon the charts of the Atlantic coast, Nos. 2, 3, and 4, and of the Gulf coast in two parts, besides some miscellaneous work and practice.

Mr. Davis, apprentice, has engraved the plate of approximate co-tidal lines, Gulf of Mexico; the lettering of Great Eastern Rock, off Montauk Point, $\frac{1}{40000}$, besides work upon progress sketches, and miscellaneous work and practice.

List of maps, preliminary charts, and sketches engraved or engraving during the year ending October 31, 1863, *arranged in order of sections.*

Name.	Scale.	Description.	Remarks.
SECTION I.			
Progress sketch A, (primary triangulation)	1-1,000,000	Sketch	Engraved.
Progress sketch A *bis*, (upper) (additions)	1-400,000	do	Do.
Progress sketch A *bis*, (lower) (additions)	1-400,000	do	Do.
Kennebec and Sheepscot rivers, Maine	1-40,000	Finished chart	Engraving.
Portland harbor, Maine	1-20,000	Finished harbor chart	Engraved.
Coast chart, No. 7, Muscongus bay to Portland, Maine	1-80,000	Finished chart	Engraving.
Coast chart, No. 8, Seguin island to Kennebunk Port	1-80,000	do	Do.
Coast chart, No. 9, Cape Neddick to Cape Ann	1-80,000	do	Do.
Coast chart, No. 10, Cape Ann to Plymouth harbor	1-80,000	do	Do.
Coast chart, No. 11, Plymouth harbor to Hyannis harbor	1-80,000	do	Do.
Barnstable harbor, Mass	1-20,000	Finished harbor chart	Do.
Dutch Island harbor, Narraganset bay, R. I	1-10,000	do	Engraved.
Bristol harbor, Narraganset bay, R. I	1-20,000	Preliminary chart	Do.
Newport and Coaster's harbor, Narragansct bay, R. I	1-20,000	do	Engraving.
SECTION II.			
Progress sketch, New York bay and Hudson river, (additions)	1-100,000 1-200,000	Sketch	Engraved.
Atlantic coast of the United States, (in four sheets,) sheet No. 2, Nantucket to Cape Hatteras	1-1,200,000	Preliminary chart	Do.
Hudson river, No. 1, New York to Haverstraw	1-60,000	Finished chart	Engraving.
Hudson river, No. 3, Poughkeepsie to Glasco	1-40,000	Preliminary chart	Do.
New York bay and harbor, coast chart No. 21	1-80,000	Finished chart	Do.
Phelps's ledge and Great Eastern Rock	1-40,000	Sketch	Engraved.
SECTION III.			
Progress sketch C, (additions)	1-400,000	Sketch	Engraved.
General chart of the coast, No. IV, Cape May to Cape Henry	1-400,000	General coast chart, (preliminary)	Do.
Potomac river, (in four sheets,) sheet No. 1, entrance to Piney Point	1-60,000	Preliminary chart	Do.
Potomac river, (in four sheets,) sheet No. 2, Piney Point to Lower Cedar Point	1-60,000	do	Do.
Potomac river, (in four sheets,) sheet No. 3, Lower Cedar Point to Indian Head	1-60,000	do	Do.
Potomac river, (in four sheets,) sheet No. 4, Indian Head to Little Falls	1-40,000	do	Engraving.
Rappahannock river, sheet No. 5, Occupacia creek to Deep creek	1-60,000	do	Engraved.
Coast chart, No. 29, Green Run inlet to Little Machipongo inlet	1-80,000	Finished chart	Engraving.
Coast chart, No. 36, Chesapeake bay, No. 6, entrance to York river	1-80,000	do	Engraved.
Coast chart, No. 37, Cape Henry to Currituck, N. C	1-80,000	do	Engraving.
Hampton Roads and Elizabeth rivers, Va	1-40,000	Preliminary chart	Do.
Metomkin inlet, Va	1-20,000	Sketch	Engraved.
SECTION IV.			
Progress sketch D, (additions)	1-400,000	Sketch	Engraved.
Hatteras inlet	1-20,000	do	Do.
Oregon inlet	1-20,000	do	Do.
Coast chart, No. 47, Bogue inlet to Barren inlet, N. C	1-80,000	Finished chart	Engraving.
Coast chart, No. 48, Barren inlet to Lockwood's Folly inlet, N. C	1-80,000	do	Do.

List of maps, charts, and preliminary sketches engraved or engraving, &c.—Continued.

Name.	Scale.	Description.	Remarks.
SECTION V.			
Progress sketch E, (additions)	1-600,000	Sketch	Engraved.
Atlantic coast of the United States, sheet No. 3, Cape Hatteras to Mosquito inlet	1-1,200,000	Preliminary chart	Do.
Port Royal entrance, &c., (additions and corrections)	1-60,000	do	Do.
Calibogue sound and Skull creek, S. C	1-40,000 1-20,000	do	Do.
Coast chart, No. 53, Rattlesnake shoals to St. Helena sound, S. C	1-80,000	Finished chart	Engraving.
SECTION VI.			
Progress sketch F, Florida Keys, (additions)	1-400,000	Sketch	Engraved.
Atlantic coast of the United States, sheet No. 4, Mosquito inlet to Key West	1-1,200,000	Preliminary chart	Engraving.
General chart of the coast, No. X, Key Biscayne to Marquesas Keys	1-400,000	General coast chart	Do.
Coast chart, No. 71, Newfound Harbor Key to Boca Grande Key	1-80,000	Finished chart	Engraved.
SECTIONS VII, VIII, IX.			
Progress sketch H, (additions)	1-600,000	Sketch	Engraved.
Gulf coast of the United States, eastern part	1-1,200,000	Preliminary chart	Engraving.
Southwest Pass of the Mississippi river	1-20,000	Sketch	Engraved.
Coast chart, No. 93, Lakes Borgne and Pontchartrain, La	1-80,000	Finished chart	Engraving.
Coast chart, No. 100, Atchafalaya bay and Côte Blanche bay La	1 80,000	do	Do.
SECTION X.			
Progress sketch J, (lower sheet) (additions)	1-600,000	Sketch	Engraved.
Progress sketch J, (middle sheet) (additions)	1-600,000	do	Do.
Pacific coast, from Point Piños to Bodega Head, Cal	1-200,000	Preliminary chart	Do.
Upper part of San Francisco bay, Cal	1-50,000	do	Do.
San Pablo bay, Cal	1-50,000	Finished chart	Do.
Drake's bay, Cal	1-40,000	Preliminary chart	Do.
Tomale's bay, Cal	1-30,000	Finished chart	Engraving.
Bodega bay, Cal	1-30,000	Preliminary chart	Engraved.
SECTION XI.			
Progress sketch K, (upper sheet) (additions)	1-600,000	Sketch	Engraved.
Koos bay, Oregon	1-20,000	Finished chart	Do.
Gray's harbor, W. T	1-40,000	Preliminary chart	Do.
MISCELLANEOUS.			
Sketch showing progress of coast survey	1-5,000,000	Sketch	Engraved.
Approximate co-tidal lines, sailing lines, &c., Atlantic coast	1-10,000,000	do	Do.
Co-tidal lines, semi-diurnal tides, Gulf of Mexico	1-6,000,000	do	Do.

LIST OF COAST SURVEY MAPS, PRELIMINARY CHARTS, AND SKETCHES, ENGRAVED, GEOGRAPHICALLY ARRANGED.

1. *List of maps and charts engraved.*

No. 1.	Portland harbor, Me	1-20,000
2.	Richmond's island, Me	1-20,000
3.	Newburyport harbor, Mass	1-20,000
4.	Ipswich and Annisquam harbors, Mass	1-20,000
5.	Rockport harbor do	1-20,000
6.	Gloucester harbor do	1-20,000
7.	Salem harbor do	1-25,000
8.	Lynn harbor do	1-20,000
9.	Boston harbor, (new edition,) 1859 do	1-40,000
10.	Plymouth harbor do	1-20,000
11.	Wellfleet harbor do	1-50,000
12.	Provincetown harbor do	1-50,000

No. 13.	Bass River harbor.....Mass.....	1–40, 000
14.	Nantucket harbor.....do.....	1–20, 000
15.	Muskeget channel, (new edition,).....do.....	1–60, 000
16.	Hyannis harbor.....do.....	1–30, 000
17.	Harbor of Edgartown.....do.....	1–20, 000
18.	Harbor of Wood's Hole.....do.....	1–20, 000
19.	Harbor of Holmes's Hole and Tarpaulin Cove, Mass.....	1–20, 000
20.	Harbor of New Bedford, Mass.....	1–40, 000
21.	Dutch Island harbor, R. I.....	1–10, 000
22.	General chart of the coast from Gay Head to Cape Henlopen.....	1–400, 000
23.	Fisher's Island sound.....Conn.....	1–40, 000
24.	Harbor of New London....do.....	1–20, 000
25.	Mouth of Connecticut river, do.....	1–20, 000
26.	Harbor of New Haven, Conn., (new edition,) 1852.....	1–30, 000
27.	Harbors of Black Rock and Bridgeport, Conn., (new edition,) 1852.....	1–20, 000
28.	Harbors of Sheffield and Cawkin's islands, (new edition,) 1852.....	1–20, 000
29.	Huntington bay, N. Y.....	1–30, 000
30.	Oyster bay or Syosset harbor, N. Y.....	1–30, 000
31.	Harbors of Captain's island, East and West, Conn.....	1–20, 000
32.	Hempstead harbor, Long Island, N. Y.....	1–20, 000
33.	Hart and City island, and Sachem's Head harbor, N. Y.....1–20, 000 &	1–10, 000
34.	Hell Gate, N. Y.....	1–5, 000
35.	Coast chart, No. 15, Long Island sound—east.....	1–80, 000
36.	Coast chart, No. 16, Long Island sound—middle.....	1–80, 000
37.	Coast chart, No. 17, Long Island sound—west.....	1–80, 000
38.	Coast chart, No. 18, Long Island, south coast—west.....	1–80, 000
39.	Coast chart, No. 19, Long Island—middle.....	1–80, 000
40.	Coast chart, No. 20, Long Island—east.....	1–80, 000
41.	New York bay and harbor, and the environs, N. Y., No. 1.....	1–30, 000
42.	Do.....do.....do.....do.....do..No. 2.....	1–30, 000
43.	Do.....do.....do.....do.....do..No. 3.....	1–30, 000
44.	Do.....do.....do.....do.....do..No. 4.....	1–30, 000
45.	Do.....do.....do.....do.....do..No. 5.....	1–30, 000
46.	Do.....do.....do.....do.....do..No. 6.....	1–30, 000
47.	Do.....do.....do.....do.....do.....	1–80, 000
48.	Little Egg harbor, N. J.....	1–30, 000
49.	Coast chart, No. 25, Delaware bay and river—sheet No. 1, Del.....	1–80, 000
50.	Coast chart, No. 26, Delaware bay and river—sheet No. 2, Del., N. J., and Penn'a..	1–80, 000
51.	Coast chart, No. 57, Delaware bay and river—sheet No. 3.....	1–80, 000
52.	Do....No. 31, Chesapeake bay, No. 1, (upper series,).....	1–80, 000
53.	Do....No. 32.....do....No. 2.....do.....	1–80, 000
54.	Do....No. 33.....do....No. 3.....do.....	1–80, 000
55.	Do....No. 35.....do....No. 5, (lower series,).....	1–80, 000
56.	Do....No. 36.....do....No. 6.....	1–80, 000
57.	Patapsco river, Md.....	1–60, 000
58.	Harbor of Annapolis and Severn river, Md.....	1–60, 000
59.	Mouth of Chester river, Md.....	1–40, 000
60.	St. Mary's river, Cornfield harbor, and Point Lookout, Md.....	1–60, 000
61.	Rappahannock river—sheet No. 1, from Fredericksburg to Moss Neck, Va.....	1–60, 000
62.	Do.....do....sheet No. 2, from Moss Neck to Port Royal, Va.....	1–60, 000
63.	Do.....do....sheet No. 6, from entrance to Deep creek, Va.....	1–60, 000
64.	York river, from entrance to King's creek, Va.....	1–60, 000
65.	York river, from King's creek to West Point, Va.....	1–60, 000
66.	Pasquotank river, N. C.....	1–60, 000

No. 67.	Coast chart, No. 40, Albemarle sound, N. C.—west	1–80, 000
68.	Coast chart, No. 41, Albemarle sound, N. C.—east	1–80, 000
69.	Beaufort harbor, N. C	1–20, 000
70.	Cape Fear river, from entrance to Federal Point, N. C	1–30, 000
71.	Cape Fear river, from Federal Point to Wilmington, N. C	1–30, 000
72.	Charleston harbor, S. C., (new edition,) 1858	1–30, 000
73.	North Edisto river, S. C., (new edition,)	1–50, 000
74.	Ossabaw sound, Ga	1–30, 000
75.	Sapelo sound, Ga	1–30, 000
76.	St. Simon's sound, Brunswick harbor, and Turtle river, Ga	1–40, 000
77.	St. Mary's river, and Fernandina harbor, Fla	1–20, 000
78.	St. John's river, from entrance to Brown's creek, Fla	1–25, 000
79.	St. Augustine harbor....do	1–30, 000
80.	Key West harbor and approaches....do	1–50, 000
81.	Coast chart, No. 68, Florida reefs, Key Biscayne to Carysfort reef	1–80, 000
82.	Coast chart, No. 71, Florida reefs, Newfound Harbor key to Boca Grande key	1–80, 000
83.	Entrance to Pensacola bay, Fla	1–30, 000
84.	Entrance to Mobile bay, Ala	1–40, 000
85.	Coast chart, No. 90, Mobile bay, Ala	1–80, 000
86.	Coast chart, No. 91, eastern part of Mississippi sound, Bonsecour's bay to Round island,	1–80, 000
87.	Coast chart, No. 92, western part of Mississippi sound, Round island to Grand island	1–80, 000
88.	Cat and Ship Island harbors, Miss	1–40, 000
89.	Entrance to Galveston bay, Texas, (new edition,) 1856	1–40, 000
90.	San Diego bay, California	1–40, 000
91.	Entrance to San Francisco bay, Cal	1–50, 000
92.	San Pablo bay....do	1–50, 000
93.	Mare Island straits....do	1–30, 000
94.	Koos bay, Oregon	1–40, 000

2. List of preliminary charts and sketches engraved.

No. 1.	Alden's Rock, Me	1–1, 000
2.	Eggemoggin reach, Me	1–20, 000
3.	Kennebec river....do	1–30, 000
4.	Portland harbor....do	1–20, 000
5.	Portland harbor, (commissioners' line,) Me	1–10, 000
6.	York River harbor, Me	1–20, 000
7.	Portsmouth harbor, N. H	1–20, 000
8.	Stellwagen's bank, (2d edition,) Mass	1–400, 000
9.	Boston bay....do	1–175, 000
10.	Current chart, Boston bay....do	1–100, 000
11.	Minot's ledge....do	1–10, 000
12.	Sea-coast United States, No. 4—south part of Massachusetts	1–200, 000
13.	Barnstable harbor, Mass	1–20, 000
14.	Nantucket shoals, Mass., (new edition,)	1–200, 000
15.	Tidal currents, Nantucket shoals, Mass	1–300, 000
16.	Sow and Pig's reef	1–240 & 1–20, 000
17.	Mount Hope bay, R. I	1–40, 000
18.	Bristol harbor....do	1–20, 000
19.	Phelps's ledge and Great Eastern Rock off Montauk Point	1–40, 000
20.	Tidal currents Long Island, N. Y	1–800, 000
21.	Coast chart, No. 21, New York bay and harbor, N. Y	1–80, 000
22.	Pot rock and Way's reef....do	
23.	Hudson river, No. 1, from New York to Haverstraw, do	1–60, 000

No. 24.	Hudson river, No. 2, from Haverstraw to Poughkeepsie, N. Y	1–60, 000
25.	Buttermilk channel do	1–5, 000
26.	Beacon ranges do	1–40, 000
27.	Romer shoals and Flynn's knoll do	1–40, 000
28.	Changes in Sandy Hook, New Jersey	1–10, 000 & 1–40, 000
29.	Sea-coast Delaware, Maryland, and part of Virginia	1–200, 000
30.	Delaware and Chesapeake bays	1–400, 000
31.	Patuxent river, Md., (upper sheet.)	1–30, 00 0
32.	Patuxent river, M., (lower sheet,)	1–60, 000
33.	Chincoteague inlet, Va	1–40, 000
34.	Sea-coast of Virginia and entrance to Chesapeake bay	1–200, 000
35.	James river, (upper sheet,) Va	1–40, 000
36.	Rappahannock river, No. 3....Va	1–20, 000
37.	Do.....do..No. 4....do	1–20, 000
38.	Do.....do..No. 5....do	1–60, 000
39.	Potomac river—sheet No. 1, entrance to Piney Point	1–60, 000
40.	Do....do....do..No. 2, Piney Point to Lower Cedar Point	1–60, 000
41.	Do....do....do..No. 3, Lower Cedar Point to Indian Head	1–60, 000
42.	Wachapreague, Machipongo, and Metomkin inlets, Va	1–40, 000
43.	Metomkin inlet do	1–20, 000
44.	Ship and Sand Shoal inlets do	1–40, 000
45.	Entrance to Chesapeake bay do	1–100, 000
46.	Cape Charles and vicinity do	1–80, 000
47.	Cherrystone inlet do	1–40, 000
48.	Pungoteague inlet do	1–40, 000
49.	Fishing or Donoho's battery, Md	1–80, 000
50.	General chart of the coast, No. 4, Cape May to Cape Henry	1–400, 000
51.	Albemarle sound, N. C	1–200, 000
52.	North Landing river, Virginia and North Carolina	1–40, 000
53.	Diagrams, showing the effect of the wind in elevating and depressing the water in Albemarle sound	
54.	Oregon inlet, N. C., 1862	1–20, 000
55.	Hatteras shoals, N. C	1–120, 000
56.	Cape Hatteras, N. C	1–20, 000
57.	Hatteras inlet, N. C., (4th edition,)	1–20, 000
58.	Hatteras inlet, N. C.—survey of 1861	1–20, 000
59.	Atlantic coast of United States—sheet No. 2, Nantucket to Hatteras	1–1, 200, 000
60.	Atlantic coast of United States—sheet No. 3, Hatteras to Mosquito inlet	1–1, 200, 000
61.	Ocracoke inlet, N. C	1–40, 000
62.	Sea-coast of North Carolina from Cape Hatteras to Ocracoke	1–200, 000
63.	Thimble shoals, N. C	1–80, 000
64.	Beaufort harbor.....N. C	1–20, 000
65.	New river and bar....do	1–15, 000
66.	Frying Pan shoals....do	1–120, 000
67.	Cape Fear river and New inlet, N. C	1–40, 000
68.	Gulf Steam explorations, 1853	1–5, 000, 000
69.	Diagrams Gulf Stream explorations, 1853	
70.	Gulf Stream explorations, 1854	1–5, 000, 000
71.	Diagrams Gulf Stream explorations, 1854	
72.	Gulf Stream explorations, 1855	1–5, 000, 000
73.	Diagrams Gulf Stream explorations, 1859	
74.	Do.....do.....do....1860	
75.	Gulf Stream chart from 1845 to 1860	
76.	Cape Roman shoals, S. C	1–100, 000

No. 77.	Sea-coast of the United States, No. 14, S. C	1–200, 000
78.	Winyah bay and Cape Roman shoals . do	1–100, 000
79.	Winyah bay and Georgetown harbor....do	1–40, 000
80.	Bull's bay.....do	1–40, 000
81.	Comparative chart, Maffitt's channel, S. C., (new edition,)	1–5, 000
82.	Maffitt's channel, sections, S. C	
83.	Romerly marshes, S. C	1–10, 000
84.	Port Royal entrance, Beaufort, Broad, and Chechessee rivers, S. C	1–60, 000
85.	Calibogue sound and Skull creek.....do	1–20, 000 & 1–40,000
86.	Savannah river entrance, Ga	1–30, 000
87.	Savannah city, Front and Back rivers, Ga	1–20, 000
88.	Savannah river .....do	1–40, 000
89.	Doboy bar and inlet.....do	1–40, 000
90.	St. Simon's sound and Brunswick harbor, Ga	1–40, 000
91.	St. Andrew's shoal, Ga	1–60, 000
92.	St. Mary's bar and Fernandina harbor, Fla., comparative chart	1–20, 000
93.	Mosquito inlet, Fla	1–40, 000
94.	Cape Canaveral do	1–60, 000
95.	Florida reefs....do	1–200, 000
96.	Turtle harbor...do	1–40, 000
97.	Beacons on Florida reefs, Fla	
98.	Coffin's Patches, Fla	1–20, 000
99.	Key Biscayne, Cape Sable and bases, Fla	1–60, 000 & 1–400, 000
100.	Legaré anchorage.....do	1–20, 000
101.	Key West harbor, (2d edition).....do	1–100, 000
102–07.	Key West tidal diagrams.....do	
108.	Rebecca shoals.....do	1–600, 000
109.	Reconnaissance of vicinity of Cedar Keys, Fla	1–300, 000
110.	Channel No. 4, Cedar Keys.....do	1–30, 000
111.	Cedar Keys, and approaches, (new edition,)..do	1–50, 000
112.	Ocilla river.....do	1–20, 000
113.	St. Mark's bar and channel.....do	1–40, 000
114.	Middle or main and western entrances St. George's sound, Fla	1–80, 000
115.	Eastern part of St. George's sound.....do	1–40, 000
116.	Western part of St. George's sound.....do	1–40, 000
117.	St. Andrew's bay.....do	1–40, 000
118.	Escambia and Santa Maria de Galvaez bays.....do	1–30, 000
119.	Sea-coast of part of Alabama and Miss	1–200, 000
120.	Mobile bay, (2d edition,) Ala	1–200, 000
121.	Horn Island Pass, and Grand bay, Miss	1–300, 000
122.	Horn Island Pass, and Grand bay, Miss., (new edition,)	1–40, 000
124.	Biloxi bay.....do	1–40, 000
123.	Pascagoula river.....do	1–20, 000
125–34.	Cat island tidal diagrams.....do	
135.	Pass Christian.....do	1–40, 000
136.	Delta of the Mississippi, La	1–60, 000
137.	Passe à Loutre, La	1–20, 000
138.	Reconnaissance of Southwest Pass, Mississippi river, 1862	1–20, 000
139.	Gulf of Mexico, with profiles of deep-sea soundings, (new edition)	1–2, 400, 000
140.	Barataria bay entrance, La	1–30, 000
141.	Pass Fourchon.....do	1–10, 000
142.	Timbalier bay entrance.do	1–20, 000
143.	Isle Dernière, or Ship Island shoals, La	1–80, 000
144.	**Atchafalaya bay.....do**	**1–50, 000**

No. 145.	Entrance to Vermillion bay and Calcasieu river, La	1–30, 000 & 1–40, 000
146.	Sabine Pass, Texas	1–40, 000
147.	Sea-coast of Texas, from Galveston south	1–200, 000
148.	Sea-coast of United States, No. 31, part of Texas	1–200, 000
149.	San Louis Pass, Texas	1–20, 000
150.	Aransas Pass, (2d edition,) Texas	1–30, 000
151.	Entrance to Brazos river.....do	1–10, 000
152.	Entrance to Rio Grande river.do	1–20, 000
153.	Diagrams of heights and lunitidal intervals of diurnal and semi-diurnal tides in the Gulf of Mexico	
154–55.	Co-tidal lines, Gulf of Mexico, (2 plates)	
156.	Type curves...do.....do	
157.	Wind curves, Cat island	
158.	Alden's reconnaissance, western coast—lower sheet, San Francisco to San Diego, (new edition,) Cal	1–1, 200, 000
159.	Cortez bank...do	1–100, 000 & 1–1, 200, 000
160.	San Diego entrance, (new edition,) Cal	1–150, 000 & 1–25, 000
161	Geological map of San Diego.....do	1–1, 608, 000
162.	Catalina harbor.....do	1–15, 000
163.	San Pedro anchorage, and vicinity of Santa Barbara, Cal	1–20, 000 & 1–40, 000
164.	Anacapa island, (sketch).....do	
165.	Anacapa island, and east end of Santa Cruz island....do	1–30, 000
166.	Prisoner's harbor, Cuyler's harbor, and north anchorage San Clemente island, Cal	1–20, 000
167.	Santa Barbara, Cal	1–20, 000
168.	Eastern entrance to Santa Barbara channel, Cal	1–80, 000
169	San Simeon, Santa Cruz, San Luis Obispo, and Coxo harbors, Cal	1–0, 000 & 1–40, 000
170.	Point Conception.....do	1–40, 000
171.	Point Piños.....do	1–20, 000
172.	Monterey harbor.....do	1–40 000
173.	Monterey bay.....do	1–60, 000
174.	Geological map of Monterey.....do	1–150, 000
175.	Santa Cruz and Año Nuevo harbors.....do...1–1, 200, 000	& 1–40, 000
176.	San Pedro harbor.....do	1–20, 000
177.	Entrance to San Francisco bay.....do	1–400, 000
178.	San Francisco city, (new edition).....do	1–10, 000
179.	Upper part San Francisco bay.....do	1–50, 000
180.	Preliminary chart of Pacific coast from Point Piños to Bodega Head, Cal	1–200, 000
181.	Geological map of San Francisco.....do	1–150, 000
182.	South Farallon island.....do	
183.	Tidal diagrams, Rincon Point.....do	
184.	Pulgas base.....do	1–400, 000
185.	San Antonio creek.....do	1–20, 000
186.	Petaluma and Napa creeks.....do	1–30, 000
187.	Alden's reconnaissance, western coast—middle sheet, San Francisco to Umpqua river, California and Oregon	1–1, 200, 000
188.	McArthur's reconnaissance, western coast, from Monterey to mouth of Columbia river, sheet No. 1, (3d edition)	
189.	McArthur's reconnaissance, western coast, from Monterey to mouth of Columbia river, sheet No. 2, (3d edition)	
190.	McArthur's reconnaissance, western coast, from Monterey to mouth of Columbia river, sheet No. 3, (3d edition)	
191.	Alden's reconnaissance, western coast, northern sheet	1–1, 200, 000
192.	Point Reyes and Drake's bay, Cal	1–40, 000
193.	Drake's bay.....do	1–40, 000

No. 194.	Geological map of Point Reyes, Cal.	
195.	Tomales bay.....do.....	1–30, 000
196.	Bodega bay.....do.....	1–30, 000
197.	Humboldt bay, (new edition).....do.....	1–30, 000
198.	Trinidad bay.....do.....	1–20, 000
199.	Shelter cove, Mendocino city, Crescent City harbors, and Port Orford or Ewing harbor, California and Oregon.....	1–20, 000
200.	Crescent City harbor, Cal.....	1–20, 000
201.	Coquille river, Oregon.....	1–10, 000
202.	Umpqua river, Oregon.....	1–20, 000
203.	Mouth of Columbia river, Oregon, (2d edition).....	1–40, 000
204.	Do.....do.....do.....	1–200, 000
205.	Entrance to Columbia river, Oregon.....	1–40, 000
206.	Tidal diagrams, Rincon Point, San Diego, and Astoria, California and Oregon.....	
207.	Cape Disappointment, W. T.....	1–20, 000
208.	Shoalwater bay.....do.....	1–80, 000
209.	Gray's harbor.....do.....	1–40, 000
210.	Alden's reconnaissance, western coast, from Gray's harbor to Admiralty inlet, W. T.	1–600, 000
211.	Grenville harbor, W. T.....	1–20, 000
212.	Cape Flattery and Nee-ah harbor, W. T.....	1–40, 000
213.	False Dungeness.....do.....	1–30, 000
214.	New Dungeness.....do.....	1–40, 000
215.	Washington sound, (new edition).....do.....1–200, 000 &	1–600, 000
216.	Port Townshend.....do.....	1–40, 000
217.	Duwamish bay, Seattle harbor.....do.....	1–40, 000
218.	Smith's or Blunt's island.....do.....	1–20, 000
219.	Port Ludlow.....do.....	1–20, 000
220.	Port Gamble.....do.....	1–20, 000
221.	Olympia harbor.....do.....	1–20, 000
222.	Steilacoom harbor.....do.....	1–30, 000
223.	Bellingham bay.....do.....	1–40, 000
224.	Blakeley harbor.....do.....	1–10, 000
225.	Semi-ah-moo bay.....do.....	1–30, 000
226.	Base apparatus.....	
227.	Co-tidal lines Atlantic coast.....	1–10, 000, 000
228.	Co-tidal lines Pacific coast.....	1–10, 000, 000
229.	Self-registering tide-gauge.....	
230.	Craven's current indicator.....	
231.	Craven's specimen box for deep-sea soundings.....	
232.	Mitchell's sea-coast tide-gauge.....	
233.	Figures to illustrate Appendix No. 33, 1854.....	
234.	Diagrams of secular variation of magnetic dip, Atlantic coast.....	
235.	Diagrams of secular variation in magnetic declination, 1855.....	
236.	Lines of equal magnetic declination.....	1–1, 500, 000
237.	Boutelle's scaffold for stations, and Farley's signal.....	
238.	Boutelle's apparatus for measuring preliminary bases.....	
239.	Diagrams to illustrate earthquake waves at San Diego and San Francisco.....	
240.	Diagram of secular variation in magnetic declination, 1856.....	
241.	Sands's gas-pipe tripod.....	
242.	Sands's specimen-box for deep-sea soundings and revolving heliotropes.....	
243.	Map of magnetic declination.....	
244.	Map of magnetic dip and intensity.....	
245.	Apparatus for measuring minor bases.....	

No. 246. Polyconic development of sphere
247. Diagrams illustrating telegraphic methods for difference of longitude
248. Diagrams showing injury to boiler of steamer Hetzel
249. Project limits for charts $\frac{1}{200000}$ and $\frac{1}{400000}$
250. Diagrams of winds of the western coast
251. Diagrams illustrating loss of magnetism
252. Apparatus for measuring preliminary base lines
253. Trenchard's tide-gauge
254. Mitchell's tide-gauge
255. Diagrams illustrating the descent of sounding-weight and line in deep-sea soundings.
256. Project limits for finished maps, $\frac{1}{80000}$, on the Atlantic and Gulf coasts
257. Three sketches illustrating the Superintendent's paper on currents near Sandy Hook.
258. Diagrams of magnetic and metereological observations at Girard College, Philadelphia, in 1840–'41–'42–'43–'44 and –'45
259. Diagrams of observations for temperature, wind, and atmospheric pressure, made by Dr. E. K. Kane, U. S. N., at Van Rensselaer harbor, in 1853 and 1855
260. Lines of equal magnetic variation for 1858
261. Trowbridge's improved deep-sea sounding apparatus
262. Mitchell's sub-current apparatus and form of pile for sea structures
263. Sketch showing the progress of the Coast Survey to 1862
264. Plan of magnetic observations at Key West
265. Diagrams showing the results of magnetic observations at Key West
266. Mitchell's specimen cup and Gilliss's dividers
267. Diagram illustrating phenomena of the solar eclipse of July, 1860
268. Diagram illustrating the results of experiments on the expansion of drawing paper
269. Diagram of magnetic and meteorological observations at Girard College, Philadelphia, 1862
270. Approximate co-tidal lines, sailing lines, &c., Atlantic coast 1–10, 000, 000
271. Co-tidal lines, semi-diurnal tides, Gulf of Mexico 1–6, 000, 000
272–94. Progress sketches

ELECTROTYPE AND PHOTOGRAPH DIVISION.—This branch of the work has been, as heretofore, conducted by *Mr. George Mathiot*, ably assisted by *Mr. D. Hinkle* until April, and since then by *Mr. A. Zumbrock.*

The application of the electrotype process to the duplication of the engraved plates, and to the formation of large-sized plates by joining the separately engraved parts, has been continued with the usual success. Thirty-two plates, of which twenty were "*bassos*" and twelve "*altos*," have been produced during the year.

The use of photography for the reduction of the original surveys to the scales of publication has become a settled practice, and has been successfully employed throughout the past year. The acquisition of a new "globe" lens, of Harrison & Schnitzer's construction, affording a great amount of light, with sharp definition and geometrical correctness of image, has materially aided the success of our photographic operations. A report of the tests to which it was subjected is given in Appendix No. 11.

Besides the reduction of maps and charts for engraving in the office, the copying of maps for other branches of the public service has been part of the work in the photographic room in cases when the press of time or the limited number of copies required would not admit of the employment of the lithographic process. During the year forty-seven glass positives, one hundred and sixty-eight glass negatives, and nine hundred and eleven paper prints, many of them of very large size, have been made from one hundred and thirty-eight different maps, drawings, &c. Of this number of subjects photographed, seventy-nine have belonged to the regular work of the office, and fifty-nine had reference to the military and naval operations of the government.

The appended tables state in detail the work performed in this division.

Table of electrotype plates made during the year ending October 1, 1863.

ALTOS.

Lake Huron, (for Engineer Bureau.)
Barnstable harbor.
New York bay and harbor.
Kennebec and Sheepscot rivers.
Tomales bay.
Sapelo sound.
Ossabaw sound.
Lynn harbor.
Portland harbor.
Coast chart No. 71, Newfound Harbor Key to Boca Grande Key.
Coast chart No. 13, Muskeget channel to Buzzard's bay.
Rappahannock river, sheet No. 1.

BASSOS.

San Diego bay.
Chesapeake bay, (sheet No. 2.)
Barnstable harbor.
Lake Huron, (for Engineer bureau.)
Tomales bay.
New York bay and harbor.
Western coast reconnaissance, sheet No. 3.
Delaware bay and river, sheet No. 3.
Sapelo sound.
Ossabaw sound.
Delaware bay and river, sheet No. 2.
Annapolis harbor.
Lynn harbor.
East part of the south coast of Long Island.
Kennebec and Sheepscot rivers.
Monterey harbor.
Coast chart No. 14, Buzzard's bay to Block island.
Nantucket harbor.
Portland harbor.

Names of originals photographed.	Positives.	Negatives.	Prints.	Scales of positives.	Scales of prints.
Map of Rockland harbor, Me., 1 tracing		2	2	1/20000	1/20000
Map of Kennebec and Sheepscot rivers, 1 tracing	1	2	4	1/40000	1/40000
Coast map, No. 7, 2 tracings	2	2	4	1/80000	2, 1/40000 2, 1/80000
Coast map, No. 8, 1 tracing	1	1	1	1/80000	1/80000
Coast map, No. 10, 13 tracings and 21 original maps	11	42	85	1/80000	21, 1/10000 32, 1/80000 32, 1/40000
Coast map, No. 11, 3 originals	1	4	9	1/80000	5, 1/80000 4, 1/40000
Coast map, No. 21, 4 originals	4	1	2	1/80000	1/80000
Hudson river map, 1/10000, 11 tracings	11	2	2	1/60000	1/60000
Coast map, No. 48, 4 tracings	4	4	8	1/80000	4, 1/80000 4, 1/40000
Coast map, No. 53, 9 tracings	9	18	36	1/80000	18, 1/80000 18, 1/40000
Map of Wassaw sound, Ga , 1 tracing	1	2	1	1/40000	1/40000
Map of San Francisco bay, Cal., 1 original		1	2		1/60000
Map of rebel defences, Boston harbor, 1776		2	10		
General coast chart, No. 4, Gay Head to Cape Henlopen, reduced from sailing chart, No. 2	1	1	2	1/200000	1/200000
Surveys in vicinity of Washington city, 2 tracings		2	4		1/30000
Surveys of Rosier's Bluff and Jones's Point, Potomac river, 2 originals		2	4		1/20000
4 campaign maps of Peninsula, from Fortress Monroe to Richmond, for War Department		19	477		
Map of Fredericksburg and vicinity		2	8		
Potomac river, 2 tracings		2	4		1/5000
Rebel fortifications in vicinity of Norfolk, 16 drawings		16	32		
Virginia county maps, (11 tracings,) for War Department		11	17		1 inch to 1 mile.
Drawings of rebel rams, 2 originals		6	60		
Map of mountain region of North Carolina and Tennessee		2	14		
Map of St. Louis approaches		2	1		1/10000
View of Hilton Head, S. C.		1	10		
Military map of Alabama and Mississippi		1	1		
Map of Mobile river	1			1/20000	
Drawing of curve of increased velocity of projectiles		1	3		
Sample of topography for field sheets		1	15		
Naval and military operations in the Mississippi valley, 11 originals		14	30		
Maps of northwest boundary, 2 originals		2	3		1/8 of originals.
	47	168	911		

LITHOGRAPHING DIVISION.—The operations of this division have been conducted under the supervision of *Prof. F. A. P. Barnard* since June, having been previously in charge of *Mr. W. L Nicholson*, who withdrew upon being appointed topographer in the General Post Office. Besides directing the details of this and the miscellaneous division, Mr. Nicholson rendered valuable service by collecting and supervising the compilation of materials for a map of the mountain region of North Carolina and Tennessee, which has proved to be very useful to the armies in the field. Prof. Barnard gives the following summary of the operations for the year.

Two lithographic presses have been kept in constant operation throughout the year, and such has occasionally been the pressure on the division that it has been found necessary to employ other lithographic establishments in the execution of special jobs.

During the first part of the year, the printing was executed by *Mr. D. B. Morgan* and *Mr. Walter Benner*. *Mr. A. Brown* subsequently took *Mr. Morgan's* place, and upon *Mr. Benner's* withdrawal in June, his place was supplied by *Mr. James Ruhl.*

Mr. C. G. Krebs has been employed throughout the year, as during a considerable portion of the preceding, in engraving on stone. He has been assisted by *Mr. H. Lindenkohl*, detached from the drawing division from time to time for the purpose, both in engraving and drawing; and occasional assistance has been rendered in preparing autograph transfers by *Mr. W. B. McMurtrie* and *Mr. J. W. Maedel*, of the drawing division, and by *Mr. E. Molitor* and *Mr. A. Hausman*, temporarily employed for the purpose.

It appears from the records that there have been printed on the lithographic presses belonging to this division twenty-eight thousand two hundred and twenty-nine sheets during the year. There have been also printed during the same time for the office ten thousand three hundred and fifty-two sheets by other lithographers, making the total production for the year thirty-eight thousand five hundred and eighty-one sheets. In this total are included some maps for military purposes prepared or printed for the Engineer bureau, a sketch of Gettysburg and the hospitals in the vicinity, engraved and printed for the Sanitary Commission, a map showing the isogonic magnetic lines in the State of Pennsylvania, a circular for the Secretary of the Treasury, and several circulars and other forms for the office of the survey.

The number of different hydrographic charts printed on stone during the year has been fifty-nine; the aggregate number of impressions taken of these amounts to eleven thousand nine hundred and sixty-seven. The number of different maps and sketches which have been prepared to illustrate the operations of the war is twenty-four. Several of these maps have been issued in successive editions, with such additions, improvements and corrections as have been suggested by engineer officers serving with the armies in the field, who have kindly and very freely communicated to the office of the survey such valuable information as their personal observations had enabled them to gather. The total number of impressions taken of all these maps and sketches amounts to seventeen thousand nine hundred and sixteen.

In the case of nine or ten of the maps above mentioned, color printing has been employed for the purpose of making the indications more distinct. This, while it has much improved the usefulness of the maps, has rendered their production more laborious and less rapid than it would otherwise have been.

Very many copies have been supplied to officers of the army, who have found them very serviceable in the field. Large numbers have also been called for by booksellers, and have met with ready sale in our principal cities. The returns from this source have defrayed for the most part the expense of production.

The hydrographic notes or memoirs of the coast have been kept up. Copies have been distributed among naval officers as required, and others held in readiness to meet any new demand.

In the summary appended will be found a statement of the principal drawings, transfers and engravings on stone which have been executed during the year.

Drawings, transfers and engravings on stone made in the Lithographing Division during the year ending October 31, 1863.

SECTION	II.	Hart and City islands, and Sachem's Head harbor, (transfer.)
		Black Rock and Bridgeport harbors, (transfer.)
		Sheffield island and Cawkin's island harbors, (transfer.)
		New York bay and harbor, (twice transferred.)
SECTION	III.	Potomac, No. 4, transferred, (twice.)
		Map of West Virginia, transferred.
		Chart of Annapolis harbor, transferred.

Chart of Rappahannock river entrance, transferred.
Military map of part of Virginia for Engineer department, transferred.
Potomac, No. 3, transferred.
Potomac, No. 2, transferred.
Potomac, No. 1, transferred.
Lower half S. E. Virginia, engraved.
Military map S. E. Virginia, transferred.
Hampton Roads and entrance to James river.

SECTION IV. North Carolina and Virginia coast, retransfer of part.
Additions to Hatteras inlet, drawing.
Coast from Chesapeake entrance to Ocracoke inlet, engraving.

SECTION V. Charleston harbor, transfer and drawing of James island.
N. Edisto river, transfer and additions.
Calibogue sound and Scull creek, drawing and transfer.
St. Helena sound, (second transfer.)
St. Simon's sound, transfer.
Sapelo sound, transfer.
Ossabaw sound, drawing and transfer.
Coast of South Carolina and Georgia, drawing, also engraving.
Map of Charleston harbor, with batteries, (repeatedly transferred.)
Charleston harbor, with James island and Stono, transferred and engraved.
Charleston harbor, scale $\frac{1}{10000}$, drawing, transfer, and engraved.
Port Royal entrance, transferred.
James island, new engraving.
Fort McAllister and approaches, drawing.

SECTION VI. St. Augustine harbor, transfer.
St. Mary's and Fernandina harbors, transfer.

SECTION VIII. Chart of Mobile bay, transfer.
Coast of Alabama and Mississippi, transfer.
Map of Alabama and Mississippi, showing approaches to Mobile, drawing and engraving.

SECTION IX. Aransas Pass, transfer.
Sabine Pass, transfer.
Galveston bay, transfer.
Coast of Texas, (coast chart 106,) transfer.
Coast of Texas, (coast chart 107,) transfer.
Yazoo river expedition, drawing and transfer.
Sketches (4) in the vicinity of Vicksburg, drawing and transfer.
Map of operations against Vicksburg, two drawings and transfers.
Fort Butte La Rose, drawing and transfer.
Map of Louisiana and Mississippi, two drawings.

SECTION X. Fanny shoal and Noonday Rock, drawing and transfer.

Miscellaneous. Fort Hindman, drawing and transfer.
Map of mountain region of North Carolina and Tennessee, engraving and four transfers.
Map of Pennsylvania, for magnetic curves, engraving.
Historical sketch of the rebellion, new transfer.
Map of Gettysburg hospitals, for Sanitary Commission, engraving.
Map of Montgomery county, Maryland, for Engineer bureau, transfer.
Circular for Secretary Chase, transfer.
Circulars, labels, letter-heads, forms of contract, sailing directions, titles, &c., &c., engraved, transferred, and printed in great numbers.

Miscellaneous division.—This division, comprising the copper-plate printing, the issuing of maps and reports, and the bookbinders' work incidental to the operations of the office, was under the charge of *Mr. W. L. Nicholson* until May, when he retired, and was subsequently under the immediate direction of the general assistant, *Prof. F. A. P. Barnard*, who gives the following summary for the year ending November 1, 1863.

The charge of the map-room has continued through the year in the hands of *Mr. M. T. Johnstone*, who has shown great efficiency in the management of the business.

The copper-plate printing has been executed principally by *Mr. John Rutherdale*, who for several years has had charge of this branch of industry, with the occasional assistance of *Mr. E. H. Sipe*. The exigencies of the office have rendered it necessary, however, during a considerable portion of the time, to employ outside assistance. This has been furnished by *Mr. Henry Benner*, of Washington.

Mr. W. Mertz continued to be employed in the preparation of backed chart paper for plane-table work and for hydrographic parties; and also in joining charts, in repairing sheets in use, and other analogous occupations until September 1, when he withdrew, and was succeeded by *Mr. G. W. Francis*.

The total number of sheets printed by the copper-plate presses during the year has been sixteen thousand eight hundred and nineteen, (16,819.) If to this number we add the total production by the lithographic presses, (viz: 38,581 sheets,) we shall have an aggregate of 55,400 sheets. Of this number, forty-five thousand seven hundred and fifty-seven, (45,757) have been issued from the office, of which 29,274 have been hydrographic charts, distributed as follows:

To the navy	13,818
To sea captains and pilots employed in government service	2,929
To military officers	1,638
By sale	3,615
Miscellaneous	7,274
Total	29,274

Of the charts distributed to the navy, 10,894 have been distributed through the Naval Observatory.

Under the general head "miscellaneous" are included all those which have been sent to light-house engineers, inspectors, and superintendents, on the requisition of the Light-house Board; all those required by Coast Survey assistants in the office or at their stations, or when accompanying naval or military expeditions; all those furnished to public libraries, Union leagues, and other useful or patriotic associations, and also the very considerable number called for by members of Congress.

The remaining sheets distributed, sixteen thousand four hundred and eighty-three (16,483) in number, have been maps of the coast prepared for the immediate use of the blockading squadrons, or of commanders conducting military operations on the coast; maps of the most important fields of operation of the armies in the interior, and sketches of more limited extent illustrating the operations of attack and defence of important points. In this number are not included the maps printed for the Engineer department, the Sanitary Commission, or any other branch of service not connected with the Coast Survey.

The total distribution falls about two thousand sheets short of that of the preceding year, for which the report covered the period of thirteen months, and which was stated in the annual report for that year to have been double that of the year ending November 1, 1861, and more than five times the average of former years. In the report for that year the distinction between hydrographic charts and other maps and sketches is not observed, and hence the number of these several classes distributed in each cannot be directly compared.

It appears, however, that the demand for hydrographic charts during the year which has just closed has not been so great as in the year preceding, a circumstance arising from the fact that the number of additional vessels brought into the public service during the year has not been so great as in the former year, while those which have been already supplied have for the most part continued to operate in the waters to which they were first assigned. Every new movement of the navy is, however, attended with demands for charts of particular portions of the coast to be supplied promptly and abundantly, and care is constantly taken to keep such a stock on hand of every important point on the coast of the Atlantic or of the Gulf as to meet any sudden requisition.

The report of the superintendent of the Coast Survey for the year 1861 has been distributed to individuals and institutions in the loyal States only to the extent of 4,551 copies. In the month of May a foreign distribution of the report for 1859 and 1860 was made through the Smithsonian Institution, amount-

ing to three hundred and thirty-three (333) copies of each. The countries embraced in this distribution and the numbers sent to each will be found in the following statement:

To Russia	14	To Chili	2
" Norway	4	" Vancouver's island	2
" Sweden	5	" Iceland	1
" Denmark	2	" Turkey	1
" Switzerland	9	" Greece	1
" Germany	44	" Asia	6
" Belgium	2	" Cuba	1
" Austria	9	" Mexico	4
" Prussia	17	" Brazil	3
" Holland	14	" Australia	1
" France	25	" Africa	3
" Italy	18	" Agents in foreign countries	25
" Spain	4		
" Portugal	2	Total	333
" Great Britain	114		

In the month of September there were also presented to the Imperial Royal Institute for Military Geography, at Vienna, through the Engineer Bureau of the United States, copies of all the reports of the Coast Survey from 1851 to 1861, inclusive.

There remain on hand an aggregate number of 13,716 copies of the reports of all years. The numbers are quite unequal for different years, and of some of the early reports the stock is very nearly exhausted.

At the close of his last annual report, the chief of this division states that a circular had been issued to the principal public libraries in the United States, and to those of universities, colleges, &c., inquiring into their deficiencies in regard to these reports, with a view of supplying them while it remained possible, in order that complete sets of these important records might be within reach in every part of the country. The responses to this circular have led to a considerable distribution of the earlier reports, so that, in respect at least to the loyal States, it is believed that the object aimed at has been secured.

It gives me pleasure, in conclusion, to bear witness to the assiduity and attention to duty of the various employés in this branch of the service since it came under my supervision.

Distribution made during the year of reports of the United States Coast Survey for the years 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, *and* 1861.

Names of States, &c.	Report of 1851.		Report of 1852.		Report of 1853.		Report of 1854.		Report of 1855.		Report of 1856.		Report of 1857.		Report of 1858.		Report of 1859.		Report of 1860.		Report of 1861.		Total number distributed.
	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	
Maine	....	5	...	4	....	4	...	3	...	4	...	2	...	3	...	7	3	6	48	14	107	8	218
New Hampshire	....	...	..	1	...	....	....	..	...	...	....	...	....	..	....	1	...	...	1	...	75	15	93
Vermont	....	2	..	2	....	...	....	1	...	...	...	1	...	....	....	2	...	..	1	5	37	15	66
Massachusetts	1	12	1	8	1	8	1	9	1	5	2	5	1	5	4	16	9	10	31	15	287	49	481
Rhode Island	....	5	1	2	....	3	....	3	....	2	...	2	...	2	1	3	1	2	7	2	60	20	116
Connecticut	1	...	...	..	2	...	....	....	...	...	1	....	....	....	5	1	6	..	19	2	161	13	211
New York	3	15	3	11	8	13	4	11	4	12	6	14	7	10	15	17	33	15	144	25	561	74	995
New Jersey	....	...	....	..	1	....	....	....	....	...	1	1	1	1	2	3	4	3	26	3	124	14	183
Pennsylvania	1	6	1	5	1	7	1	3	1	4	3	6	2	3	8	8	7	8	103	57	318	120	676
Delaware	....	....	...	2	....	....	....	....	....	...	....	2	...	2	...	2	...	2	1	2	18	6	37
Maryland	....	3	1	3	1	3	1	3	1	3	1	2	1	2	1	3	2	3	11	2	93	19	159
District of Columbia	2	...	4	....	3	....	2	....	3	....	3	....	2	....	6	....	10	....	34	....	39	3	111
Louisiana	....	...	...	..	....	....	....	....	..	...	....	....	...	....	....	....	..	..	.....	....	1	...	1
Ohio	1	8	1	9	3	8	3	7	2	6	3	8	2	7	5	9	6	7	85	30	220	73	503
Kentucky	....	...	....	....	....	....	1	....	1	...	1	....	1	....	1	...	4	..	13	....	.....	...	22
Indiana	....	....	...	...	....	...	....	....	..	...	....	.....	....	....	.....	....	..	..	30	13	120	29	192
Illinois	....	...	...	..	..	....	1	...	1	...	1	....	1	...	1	....	1	....	32	2	101	25	166
Missouri	....	....	1	..	1	....	1	...	1	...	1	....	1	....	1	....	1	..	1	...	1	...	10
Kansas	..	1	...	1	...	1	....	1	....	1	...	1	....	1	....	1	....	1	.....	1	1	..	11
Michigan	....	1	...	1	....	2	....	1	....	4	...	4	...	4	....	4	....	4	29	16	65	26	163
Iowa	...	2	..	2	...	3	..	2	...	2	...	2	...	1	....	3	...	3	.....	3	43	16	82
Wisconsin	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2	44	10	77
California	....	1	..	....	...	...	....	1	....	1	....	1	....	1	1	1	...	1	1	1	11	5	26
Minnesota	....	....	....	..	2	...	...	....	...	..	2	....	....	....	....	....	..	....	10	6	17	13	50
Oregon	....	...	...	..	...	...	1	...	1	....	1	....	1	...	1	....	1	..	1	..	2	....	9
Nebraska Territory	....	1	..	1	....	1	....	1	..	1	...	1	....	1	....	1	....	1	...	..	1	..	11
Washington Territory	....	...	...	...	....	...	....	....	....	...	...	....	....	....	....	....	..	..	1	...	2	...	3
Dakota Territory	....	....	...	....	....	....	....	...	....	...	1	....	....	...	....	....	1	..	.....	....	.....	..	2
Arizona Territory	....	1	....	1	..	1	....	1	....	1	....	1	...	1	....	1	...	1	.....	1	.....	....	10
Members of Congress	4	....	4	....	4	....	4	....	4	....	5	....	5	....	4	....	5	....	12	...	.....	....	51
Officers of the navy	...	....	....	....	....	....	....	...	....	....	....	...	....	....	....	....	4	....	4	....	1	....	9
Officers of the army	....	....	....	....	....	....	...	...	....	....	2	....	....	....	....	....	2	....	9	..	.....	....	13
Executive departments	4	....	4	....	5	....	5	....	4	....	4	.. .	3	....	5	....	5	....	5	...	108	....	152
Revenue bureau	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	....	30	....	30
Naval observatory	....	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	..	56	...	50
Light-house Board	....	....	....	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	...	20	....	20
Coast Survey Office and assistants	....	....	....	....	1	....	....	....	....	....	....	....	2	....	....	....	4	....	8	...	84	...	99
Newspapers	....	....	..	....	....	....	....	...	....	....	....	....	....	....	...	....	....	....	.....	...	294	....	294
Foreign	....	2	2	2	2	2	2	2	3	2	4	2	3	2	4	2	338	....	342	2	2	....	722
	18	66	24	56	36	57	28	50	28	49	45	56	34	47	67	67	449	71	1,020	205	3,098	553	6,124

Archives and library.—The archives and library continued in charge of *Mr. Eugene Fitzgerald* until May, when he resigned, and was succeeded by *Mr. John Downes.* Three hundred and twenty-nine volumes of original and duplicate records, thirty-eight volumes and copies of computations and reductions, and seventy-nine original topographical and hydrographical sheets, have been added to the archives of the survey during the past year. Eighty-four volumes have been purchased for the library, and thirty-eight added by presentation during the same period.

Instrument shop.—The charge of this shop remained with *Mr. J. Vierbuchen* until the date of his death, April 1, 1863, when he was succeeded by *Mr. T. J. Hunt*, who is assisted by two workmen and two apprentices, which is only half of the force of the preceding year. With this diminished force the shop has been able to accomplish but little more than the necessary repairs to the instruments. During the year two sectors, four compasses for plane-tables, one standard metre scale, thirteen small metre scales, four prismatic compasses, one frame for figure punching, four sets of figure punches, two andrometors, two facial angle sectors, one contact piece for astronomical clock, two sectors for base rods, two metre chains, and seven stands for theodolites, have been made; and all the repairs of instruments used during the year have been made, consisting in part of two self-registering tide-gauges, twenty-five sextants, thirty-seven theodolites, forty-eight plane-tables, fourteen reconnoitering telescopes, ten heliotropes, three prismatic compasses, eight surveyors' compasses, six marine spy-glasses, nine three-arm protractors, twenty-five metre chains, five beam compasses, four sectors, eight levelling instruments, seven sounding apparatus, three aneroid barometers, three telegraph instruments, two ship's liquid compasses, one dip-circle, one declinometer, one zenith telescope, and two base rods, in addition to a variety of miscellaneous work for the use of the office and parties in the field.

Carpenter shop.—*Mr. A. Yeatman* still remains in charge of the shop, assisted by one workman and an apprentice. The work executed during the year consists of seventy-four rough packing-boxes for the transportation of instruments and records, thirty-eight fine cases and thirteen new stands for instruments, four new boards for plane-tables, one vat, fourteen frames, and twelve clamp clocks for the electrotype division, three large water-troughs, six printing frames and one large sash for photographic purposes, four paper-wetting boards for copper-plate printer, cornice and rollers for thirty-two maps, eight book and map cases, six frames for charts, four map stands, one large derrick for hoisting lithographic stones from the basement to the printing rooms above, one andrometer, and two dynamometers, and one hundred and twenty-five tin cases for holding original sheets of the survey have been painted and numbered. A large amount of miscellaneous work has been done, and the wood-work of instruments returned from the field have been carefully repaired. The office buildings have also received all necessary repairs.

APPENDIX No. 15.

List of registered topographical sheets received subsequent to No. 844.

Localities.	State.	Scale.	Date.	Topographers.	Register number.
Frenchman's bay, east side, from Waukeag Neck to Winter harbor	Maine	1-10,000	1862	C. Rockwell	891
Muscle Ridge islands, Penobscot bay	do	1-10,000	1862	C. Ferguson	877
Seal, Tennant's, and Mosquito harbors, Penobscot bay	do	1-10,000	1862	do	904
St. George's river	do	1-10,000	1863	do	915
Georgetown island and vicinity	do	1-10,000	1862	C. T. Iardella	889
Part of Sheepscot river and vicinity	do	1-10,000	1859	W. H. Dennis	845
Part of Harpswell Neck, with the adjacent islands in Casco bay	do	1-10,000	1860-'61	A. W. Longfellow	847
Portland, reconnaissance of the environs of and approaches to	do	1-20,000	1862	F. W. Dorr	878
Cape Cod, part of, from Sandy Neck, near Barnstable, to West Sandwich	Massachusetts	1-10,000	1860-'61	A. M. Harrison	901
Fall river, part of	do	1-10,000	1861	do	885
Mount Hope bay, including parts of Taunton, Lee, and Cole's rivers	Massachusetts and Rhode Island	1-10,000	1861	A. M. Harrison and P. C. F. West	886
Mount Hope bay, part of	Rhode Island	1-10,000	1861	A. M. Harrison	884
Mount Hope and Bristol bays, part of	do	1-10,000	1862	do	888
Prudence island, Narraganset bay	do	1-10,000	1862	do	887
Part of the west shore of the island of Rhode Island, from Coddington cove northward	do	1-10,000	1862	do	896
Part of the west shore of Rhode Island, from Bristol bay southward	do	1-10,000	1861	do	897
Canonicut island, part of Narraganset bay	do	1-10,000	1861	do	898
Narraganset bay, including Coaster's Island harbor and adjacent shores	do	1-5,000	1862	H. L. Whiting	869
Shore-line of the western side of the western passage of Narraganset bay	do	1-10,000	1863	A. M. Harrison	911
Part of the western shore of Narraganset bay, including Greenwich bay and Hope island	do	1-10,000	1863	do	912
Part of shore-line of Narraganset bay and Providence river	do	1-10,000	1863	do	913
Shore-line of part of Providence river	do	1-10,000	1863	do	914
Sandy Hook, resurvey of	New Jersey	1-5,000	1862	H. L. Whiting	894
Williamsport and vicinity	Maryland	1-20,000	1862	J. Mechan and C. Hosmer	879
Accomack county, part of	Virginia	1-20,000	1862	C. Hosmer	868
Line across the peninsula of Eastern Virginia, Accomack county	do		1862	A. M. Harrison	890
Potomac river, from Cobb Point to Swan Point	Maryland	1-20,000	1862	C. Hosmer	858
Potomac river, from Swan Point to the Trunk	do	1-20,000	1862	J. Mechan	859
Potomac river, from Lone Point to Persimmon Point	Virginia	1-20,000	1862	do	860
Potomac river, from Metomkin to Persimmon Point	Maryland and Virginia	1-20,000	1862	H. L. Whiting	861
Potomac river, Cedar Point to Nanjemoy Store	Maryland	1-20,000	1862	J. Mechan	862
Potomac river, from Smith's Point to Nanjemoy Store	do	1-20,000	1862	A. W. Longfellow	863
Potomac river, Metomkin Point to Aquia creek	Virginia	1-20,000	1862	J. Mechan	864
Potomac river, from Smith's Point to Fair Oak	Maryland and Virginia	1-20,000	1862	C. Hosmer	865
Potomac river, from Fair Oaks to Indian Head	Maryland	1-20,000	1862	A. W. Longfellow	866
Potomac river, from Shipping Point to High Point	Virginia	1-20,000	1862	J. Mechan	867
Potomac river, from Indian Head to Fox Ferry	Maryland and Virginia	1-20,000	1862	C. Hosmer	875
Potomac river, Broad creek to Oxen Hill	Maryland	1-10,000	1863	A. M. Harrison	902

List of topographical sheets, &c.—Continued.

Localities.	State.	Scale.	Date.	Topographers.	Register number.
Vicinity of Rosier's Bluff	Maryland	1-5,000	1862	A. M. Harrison	895
From Bladensburg to Leesboro', adjacent to District of Columbia	do	1-15,000	1863	C. Ferguson	903
Jones's Point, Potomac river	Virginia	1-10,000	1863	A. M. Harrison	905
Jones's Point, near Alexandria; continuation of special survey	do	1-1,000	1863	C. M. Bache	909
Potomac river, from Jones's Point to Little Falls Bridge	do	1-15,000	1863	C. H. Boyd	910
Manassas, rebel defences	do	1-10,000	1862	H. L. Whiting and C. M. Bache	848
Fredericksburg, vicinity of	do	1-10,000	1862	C. M. Bache	871
Rappahannock river, part of the left bank in the vicinity of Fredericksburg	do	1-10,000	1862	T. W. Robbins	872
Rappahannock river, reconnaissance of roads, part of left bank	do	1-10,000	1862	do	873
United States Navy Yard, Gosport, and rebel battery at St. Helena, opposite the navy yard	do	1-2,500	1862	A. M. Harrison	850
Plans of confederate fortifications, Elizabeth river	do	1-2,500	1862	do	851
Beaufort harbor, resurvey	North Carolina	1-10,000	1862	A. Bosche	874
Stono river, mouth of, and rebel earthworks of Cole's island	South Carolina	1-20,000	1862	C. Rockwell	899
Rebel earthworks on Cole's island, and fort at Old Battery, Stono river	do	1-10,000 1-2,500	1862	do	900
Wassaw sound and vicinity	Georgia	1-20,000	1863	W. H. Dennis	906
Barnes's sound, part of	Florida	1-20,000	1860	C. T. Iardella	857
Charlotte harbor, from Boca Grande entrance to north of Boca Nueva Pass	do	1-20,000	1860	do	853
Charlotte harbor, part of	do	1-20,000	1860	do	854
Charlotte harbor, from El Gabo to Peas creek	do	1-20,000	1863	do	855
Peas Creek, head of Charlotte harbor	do	1-20,000	1860	do	856
Fort Jackson, plan of, showing the effect of the bombardment of	Louisiana	1-600	1862	F. H. Gerdes and J. S. Harris	870
St. Louis, military defences of	Missouri	1-10,000	1862	J. Mechan	852
Vicinity and fortifications of St. Louis	do	1-10,000	1862	R. M. Bache	908
Carondelet	do	1-10,000	1863	do	907
Part of the island of Santa Cruz, Santa Barbara Channel	California	1-10,000	1859	W. M. Johnson	876
Coast from Point Fermin eastward to San Gabriel river	do	1-10,000	1859	do	892
Coast from Hueneme eastward to Point Mugu	do	1-10,000	1857	do	893
Punta de los Reyes, part of	do	1-10,000	1862	A. F. Rodgers and D. Kerr	881
Coast north of Punta de los Reyes, part of	do	1-10,000	1862	do	882
Tomales bay, part of	do	1-10,000	1862	A. F. Rodgers	849
Tomales bay, part of	do	1-10,000	1862	do	880
Coast from Tomales bay to Salmon creek	do	1-10,000	1862	A. F. Rodgers and D. Kerr	883
Entrance to Koos bay	Oregon	1-10,000	1861	J. S. Lawson	846

APPENDIX No. 16.

List of registered hydrographic sheets received subsequent to No. 738.

Localities.	State.	Scale.	Date.	Hydrographers.	Register number.
Damariscotta river and approaches	Maine	1-10,000	1860	Lieut. Comg. J. B. Bankhead	791
Coast from Manhegan island to Damiscove Point	do	1-20,000	1860	Lieut. T. S. Phelps	746
Mouth of Sheepscott river and Booth bay	do	1-20,000	1860	do	771
Wiscasset bay, Back river, and Montseag bay to Westport Bridge	do	1-10,000	1862	F. H. Gerdes	775
Hockomock bay, including the river emptying into the Kennebec and Sheepscott rivers	do	1-10,000	1862	do	776
Merrymeeting bay and Kennebec river	do	1-10,000	1861	do	790
Casco bay, lower part of	do	1-20,000	1861	C. A. Schott	754
Portland harbor, additional soundings	do	1-20,000	1862	Ed. Cordell	788
Rocks off Portland harbor	do	1-20,000	1863	Lieut. Comg. T. S. Phelps and Ed. Cordell	796
Wood Island harbor, reconnaissance of	do	1-10,000	1859	Lieut. A. Murray	739
Stage Island and Cape Porpoise harbors, reconnaissance of	do	1-10,000	1859	do	740
Isles of Shoals	New Hampshire	1-10,000	1859	do	741
Barnstable harbor	Massachusetts	1-10,000	1861	H. Mitchell	752
Part of Barnstable bay	do	1-10,000	1860	Lieut. J. Wilkinson	772
Phelps's Bank and Asia Rip, Nantucket shoals, reconnaissance of	do	1-100,000	1860-'61	Lieut. T. S. Phelps	745
Narraganset bay	Rhode Island	1-20,000	1861	W. P. Trowbridge	792
Narraganset bay	do	1-20,000	1862	H. Mitchell	787
Dutch Island harbor	do	1-10,000	1862	do	786
Coasters' harbor	do	1-10,000	1863	do	785
Additional soundings off Montauk Point; Great Eastern Rock		1-20,000	1863	Lieut. Comg. T. S. Phelps	780
Baltic Rock, New York harbor	New York	1-2,500	1861	do	748
Hudson river, from Rhine Cliff to Glasco	do	1-10,000	1861	J. Mechan	752
Hudson river, from Glasco to Tivoli	do	1-10,000	1861	do	753
Hudson river, from Esopus creek to Puddecart Point	do	1-10,000	1862	do	798
Hudson river, from Puddecart Point to Brandon Point	do	1-10,000	1862	do	799
Hudson river, from Brandon Point to Coxackie	do	1-10,000	1862	do	800
Sandy Point, (resurvey)	New Jersey	1-5,000	1863	H. Mitchell	784
Additional soundings in New York bay	New York	1-10,000	1863	Lieut. Comg. T. S. Phelps	783
Additional soundings off the coast of New Jersey	New Jersey	1-200,000	1861	do	749
Examination of False Hook	do	1-20,000	1860	Lieut. A. Murray	769
Winter-Quarter Shoal	Maryland	1-40,000	1863	Lieut. Comg. T. S. Phelps	761
Metomkin inlet, sea-coast of Virginia	Virginia	1-20,000	1862	A. M. Harrison	795
Potomac river, from Hunter's Point to Long bridge, and Eastern Branch to Anacostia Bridge	District of Columbia	1-5,000	1862	Capt. C. P. Patterson, U. S. N.	764
Potomac river, from Long Bridge to the Aqueduct	do	1-5,000	1862	do	765
Potomac river, from Alexandria to Hunter's Point	do	1-10,000	1862	do	766
Potomac river, from Cob Point to Mathias Point	Virginia	1-20,000	1862	Lieut. T. S. Phelps	778
Potomac river, from Piney Point to Blackstone island	do	1-20,000	1860	Comdr. W. T. Muse	793
Yeocomico and Cone rivers	Virginia and Maryland	1-20,000	1860	do	794
Soundings off False Cape	Virginia	1-40,000	1861	Lieut. T. S. Phelps	750
Oregon inlet	North Carolina	1-10,000	1862	H. Mitchell	762
Hatteras inlet		1-10,000	1861	Lieut. T. S. Phelps	763
Beaufort harbor, (resurvey)	North Carolina	1-10,000	1862	A. Boschke	789
Deep-sea Soundings from Cape Henry to Cape Lookout		1-500,000	1860	Lieut. A. Murray	768
Deep-sea Soundings from Cape Lookout to St. Augustine		1-500,000	1860	do	768
Coosaw river, from Combahee river to Brickyard Creek	South Carolina	1-10,000	1860	Lieut. J. P. Bankhead	742
Brickyard Creek, from Coosaw river to Beaufort	do	1-10,000	1860	do	743

List of registered hydrographic sheets, &c.—Continued.

Localities.	State.	Scale.	Date.	Hydrographers.	Register number.
Parrott Creek, from Coosaw to Morgan river, and part of Morgan river	South Carolina	1–10,000	1860	Lieut. J. P. Bankhead	744
Off-shore soundings from Fernandina to Cape Florida		1–400,000	1860	Lieut. A. Murray	770
Florida Reefs, from Coffin's Patches to Tennessee Reef	Florida	1–20,000	1860	Lieut. J. Wilkinson	773
Florida Reefs, abreast of upper and lower Matacumbe Keys	do	1–20,000	1862	G. Davidson	774
Florida Reefs, between Alligator and French Reef	do	1–40,000	1863	E. Cordell	777
Additional soundings off Boca Chica	do	1–20,000	1863	do	779
Charlotte harbor, main entrance	do	1–40,000	1863	do	797
Apalachicola bay	do	1–20,000	1860	Lieut. T. S. Phelps	747
Channel off Point Wilson, San Pablo bay	California	1–20,000	1863	A. F. Rodgers	781
Part of Carquines Straits	do	1–20,000	1863	do	----
Resurvey of channel off Point Wilson, San Pablo bay	do	1–20,000	1862	Comdr. B. F. Sands	758
Resurvey of approaches to Mare Island Navy Yard	do	1–10,000	1862	do	759
Resurvey of part of Carquines straits	do	1–10,000	1862	do	760
Tomales bay, entrance and port of	do	1–10,000	1861	do	756
Tomales bay, from Tom's Point to head of navigation	do	1–10,000	1861	do	757
Koos bay, entrance and port of	Oregon	1–10,000	1861	J. S. Lawson	755

APPENDIX No. 17.

REPORTS OF PROFESSOR BENJAMIN PEIRCE, OF HARVARD, UPON THE OCCULTATIONS OF THE PLEIADES, IN 1841 AND 1842.

No. I.

CAMBRIDGE, *November* 7, 1863.

DEAR SIR: I have the honor to communicate the following report upon the observations of the occultations of the Pleiades of April 13, 1842, which I designate as No. I, because it is the last of the group of the Pleiades occultations, (1838–'42.)

The immersions were on the moon's dark limb, and were observed at Edinburgh by Professor Henderson.

RECORD OF OBSERVATIONS.

The observations were made by Professor Henderson with the Sheepshanks Equatorial, and are published on page 273 of the Edinburgh Observations.

No. of star.	Edinburgh sid. time.
22	9*h*. 50*m*. 29.0*s*.
35	9 56 00.8
40	10 39 16.0

The latitude and longitude of Edinburgh Observatory were taken from the collection prepared by Dr. Gould for the Nautical Almanac.

EPHEMERIS.

The places of the moon were computed from Hansen's tables for 9*h*. 50*m*., 10*h*. 15*m*., and 10*h*. 40*m*. of Edinburgh sidereal time, and are as follows:

Edinb. sid. time.	☽'s longitude by B. P.	☽'s longitude. C. S. P.—B. P.	☽'s latitude by B. P.	☽'s latitude C. S. P.—B.P.	☽'s Hor. Par. by B. P.	Hor. Par. C. S. P.—B.P.
h. *m*	° ′ ″	″	° ′ ″	″	′ ″	″
9 50	58 05 30.73	—0.01	4 12 41.94	0.00	56 49.04	0.00
10 15	58 19 08.02	—0.07	4 13 03.13	0.00	56 49.55	0.00
10 40	58 32 45.31	0.02	4 13 24.08	0.00	56 50.08	0.00

The obliquity of the ecliptic = 23° 27′ 39″.47.
Hence the moon's right ascension and declination were computed.

Edinb. sid. time.	☽'s R. A. by B. P.	☽'s R. A. C. S. P.—B. P.	☽'s declension by B. P.	☽'s declension C. S. P.—B. P.
h. *m.*	° ′ ″	″	° ′ ″	″
9 50	54 48 15.82	—0.03	23 51 17.98	0.00
10 15	55 02 53.16	—0.11	23 53 47.15	—0.03
10 40	55 17 31.08	0.03	23 56 15.05	—0.03

The constants of Alcyone were found to be—

	By B. P.	C. S. P.—B. P.
	° ′ ″	″
R. A. of Alcyone	54 31 41.71	—0.09
Decl. of Alcyone	23 36 47.89	0.08
Log. F	—0.000026	—2
Log. E	—4.2392	—.0006

STEREOGRAPHIC CO-ORDINATES OF THE MOON REFERRED TO ALCYONE.

The parallax of the moon in right ascension and declination and the moon's augmented semidiameter were computed for Edinburgh for each ten minutes from 9*h*. 50*m*. to 10*h* 40*m*. The following are the values:

Edinb. sid. time.	$-\Delta_\pi \alpha$ by B. P.	$-\Delta_\pi \alpha$ C. S. P. —B. P.	$-\Delta_\pi \beta$ by B. P.	$-\Delta_\pi \beta$ C. S. P. —B. P.	Σ_1 by B. P.	Σ_1 C. S. P. —B. P.
h. *m.*	′ ″	″	′ ″	″	″	″
9 50	34 48.04	0.00	43 45.47	—0.01	936.02	—0.01
10 00	34 41.59	0.00	44 16.92	—0.02	935.74	—0.01
10 10	34 31.49	0.00	44 48.25	—0.03	935.47	—0.02
10 20	34 17.77	0.00	45 19.42	—0.03	935.20	0.01
10 30	34 00.44	0.00	45 50.37	—0.03	934.93	—0.02
10 40	33 39.54	0.00	46 21.05	—0.02	934.67	—0.02

The co-ordinates of the moon for the stereographic projection of the Pleiades referred to Alcyone as the pole, and to the chart of the Pleiades for 1840, were next computed.

Edinb. sid. time.	$+x_m$ by B. P.	x_m C. S. P. —B. P.	$-y_m$ by B. P.	y_m C. S. P. —B. P.	Σ_2 by B. P.	Σ_2 C. S. P. —B. P.
h. *m.*	″	″	″	″	″	″
9 50	—1005.67	0.02	1754.39	—0.08	935.98	—0.01
10 00	—677.05	0.01	1726.55	—0.08	935.71	0.01
10 10	—345.03	—0.04	1698.56	—0.07	935.43	—0.02
10 20	—9.62	—0.02	1670.38	—0.10	935.16	0.01
10 30	329.15	0.02	1641.96	—0.09	934.89	—0.02
10 40	671.26	0.09	1613.22	—0.09	934.63	—0.02

EQUATIONS FOR THE CORRECTION OF THE MOON'S PLACE, AND OF THE LONGITUDE.

The following are the coefficients of the equations for the correction of the moon's place, and of the longitude:

No. of star.	$D_l p$		$D_b p$		$D_\pi p$		$D_\lambda p$		δp	
	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.
									"	
22	—.9815	0	—.1908	—3	.5544	0	—.5348	0	—0.94	0
35	—.9616	0	.2748	0	.2507	—11	—.5240	0	—1.14	.04
40	—.7712	0	—.6365	0	.7031	0	—.4203	0	—0.47	—.03

SOLUTION OF THE EQUATIONS.

The solution of these equations by the method of least squares, gives the following values of the coefficients of the final equations:

	By B. P.	C. S. P.—B. P.		By B. P.	C. S. P.—B. P.
$[a^2]$ =	2.4830	—.0001	$[bn]$	.165	.030
$[ab]$ =	.4139	—.0003	$[c^2]$	.8648	.0002
$[ac]$ =	—1.3276	.0004	$[cd]$	—.7234	.0003
$[ad]$ =	1.3529	—.0002	$[cm]$	—1.138	—.010
$[an]$ =	2.381	—.022	$[d^2]$	.7371	.0
$[b^2]$ =	.5170	.0002	$[dm]$	1.298	—.009
$[bc]$ =	—.4844	—.0008	$[m^2]$	2.404	—.061
$[bd]$ =	.2255	—.0002			

And their solution gives—

By B. P., $\delta l = 0.''959 - 0.167\ \delta b_m + 0.535\ \delta \pi - 0.545\ \delta \lambda$, Edinburgh, with corrected $[m^2] = 0.121$.

By C. S. P., $\delta l = 0.\ 950 - 0.167\ \delta b_m + 0.534\ \delta \pi - 0.545\ \delta \lambda$, Edinburgh, with corrected $[m^2] = 0.102$.

The coefficients of the residual equations are—

Stars.	$D_l p$.	$D\pi p$.	$D\lambda p$.	δp by B. P.	δp by C. S. P.
22	—.027	.029	0	0	0
35	.400	—.263	0	—0.22	—0.18
40	—.509	.291	0	0.12	0.09

No. II.

DEAR SIR: I have the honor to communicate the following report upon the observations of the Pleiades of January 21, 1842, which I designate as No. II, because it is the second from the last of the group of Pleiades occultations, (1838–'42.)

The immersions were on the moon's dark limb, and were observed in the United States, at Washington by Mr. Gilliss, and at Cambridge by Mr. Bond.

RECORD OF OBSERVATIONS.

Washington.—The observations made at Washington are printed in Gilliss's astronomical observations, page 581, and all marked as "good."

No of star.	Mean Washington time of immersion.			Sidereal time.		
1	5*h.*	40*m.*	06.9*s.*	1*h.*	43*m.*	38.68*s.*
4	6	02	24.0	2	05	59.44
8	6	09	26.7	2	13	03.29
11	6	16	44.2	2	20	21.99
13	6	31	07.4	2	34	47.55
14	6	32	25.9	2	36	06.27
20	7	01	45.1	3	05	30.28

Cambridge.—The observations are printed in the Memoirs of the American Academy, new series, vol. III, p. 67.

No. of star.	Mean Cambridge time of immersion.
4	6*h*. 41*m*. 04.6*s*.
11	6 55 26.0

The latitudes and longitudes of the places are taken from a manuscript table which will be sent to the office at another time. It is sufficient, for the present, to state that the assumed longitude of the observatory of Washington is 5*h*. 08*m*. 12*s*. W. of Greenwich, to which all American positions are referred.

The computations are contained in the accompanying sheets marked B. P. 1—7, and C. S. P. 1—14, and they are partly in duplicate and partly in quadruplicate.

EPHEMERIS.

The places of the moon were computed from Hansen's tables for 1*h*. 40*m*., 2*h*. 10*m*., 2*h*. 40*m*., and 3*h*. 10*m*. of Washington sidereal time, and were as follows:

Wash. sid. time.	☽'s longitude by B. P.	C. S. P. —B. P.	☽'s latitude by B. P.	C. S. P. —B. P.	☽'s Hor. Par. by B. P.	C. S. P. —B. P.
h. *m*.	° ′ ″	″	° ′ ″	″	′ ″	″
1 40	56 39 46.19	—.01	4 44 08.27	.04	57 57.77	.02
2 10	56 56 41.25	—.01	4 43 25.94	—.02	57 58.99	.01
2 40	57 13 37.09	.03	4 42 43.15	—.04	58 00.21	.00
3 10	57 30 33.70	—.04	4 41 59.95	.01	58 01.44	.00

The obliquity of the ecliptic = 23° 27′ 39″.52.

Hence were computed the moon's right ascension and declination.

Wash. sid. time.	☽'s R. A. by B. P.	C. S. P. —B. P.	☽'s decl. by B. P.	C. S. P. —B. P.
h. *m*.	° ′ ″	″	° ′ ″	″
1 40	53 09 16.27	0.04	24 01 47.17	0.00
2 10	53 27 23.18	—0.01	24 05 07.58	—.07
2 40	53 45 31.88	0.05	24 08 25.97	—.08
3 10	54 03 42.37	—0.09	24 11 42.34	—.04

The constants of Alcyone were found to be as follows:

	By B. P.	C. S. P.—B. P.
R. A. of Alcyone	54° 31′ 52″.15	—0.12
Decl. of Alcyone	23 36 52 .08	0.00
Log. F	—0.000038	—0.000000
Log. E	4.3214	—0.0005

STEREOGRAPHIC COORDINATES OF THE MOON REFERRED TO ALCYONE.

The parallax of the moon in right ascension and declination, and its augmented semidiameter were then computed for the Wilkes Observatory at Washington, and for the temporary Observatory at Cambridge. The computations for Washington were made for each ten minutes from 1*h*. 40*m*. to 3*h*. 10*m*. of Washington sidereal time, and for Cambridge, from 2*h*. 10*m*. to 2*h*. 40*m*. The following are the values:

1. *For Washington.*

Wash. sid. time.	$\Delta_\pi \alpha$ by B. P.	C. S. P. —B. P.	$-\Delta_\pi \beta$ by B. P.	C. S. P. —B. P.	Semidiameter by B. P.	C. S. P. —B. P.
h. *m.*	′ ″	″	′ ″	″	″	″
1 40	23 36.19	0.01	17 07.10	0.00	964.44	—0.03
1 50	21 44.68	0.02	16 44.91	0.01	964.79	—0.03
2 00	19 50.73	0.00	16 24.47	0.00	965.10	0.00
2 10	17 54.55	0.02	16 05.80	—0.01	965.41	0.02
2 20	15 56.35	—0.01	15 48.93	—0.01	965.69	—0.02
2 30	13 56.33	—0.01	15 33.90	0.00	965.96	0.00
2 40	11 54.72	0.01	15 20.76	0.00	966.20	0.03
2 50	9 51.75	0.00	15 09.53	—0.02	966.43	0.04
3 00	7 47.64	—0.01	15 00.23	0.13	966.63	0.02
3 10	5 42.61	0.00	14 52.88	—0.01	966.82	0.01

2. *For Cambridge.*

2 10	12 20.47	0.05	18 52.93	0.06	965.52	0.10
2 20	10 24.55	0.05	18 41.32	0.08	965.75	0.11
2 30	8 27.43	0.05	18 31.51	0.11	965.96	0.13
2 40	6 29.32	0.03	18 23.55	0.12	966.15	0.14

The coordinates of the moon for the stereographic projection of the Pleiades referred to Alcyone as the pole are then computed:

1. *For Washington.*

Wash. sid. time.	$-x_m$ by B. P.	x_m by C. S. P. $-x_m$ by B. P.	y_m by B. P.	y_m by C. S. P. $-y_m$ by B. P.	Σ_2 by B. P.	Σ_2 by C. S. P. $-\Sigma_2$ by B. P.
h. *m.*	″	″	″	″		
1 40	3246.33	+0.01	478.47	—0.02	964.42	—0.01
1 50	3016.39	—0.03	566.21	—0.05	964.76	—0.01
2 00	2788.63	—0.03	652.09	—0.06	965.07	—0.01
2 10	2562.82	—0.02	736.09	—0.07	965.36	0.00
2 20	2338.75	—0.03	818.19	—0.08	965.64	0.00
2 30	2116.25	—0.03	898.34	—0.09	965.91	—0.01
2 40	1895.12	—0.03	976.49	—0.09	966.15	—0.01
2 50	1675.13	—0.05	1052.60	—0.07	966.37	0.00
3 00	1456.07	—0.09	1126.66	—0.04	966.57	0.00
3 10	1237.76	—0.09	1198.67	—0.03	966.75	0.00

2. *For Cambridge.*

2 10	2869.41	—0.01	570.67	—0.05	965.48	0.00
2 20	2643.15	—0.05	647.36	—0.06	965.71	—0.01
2 30	2417.90	—0.05	722.13	—0.08	965.91	0.00
2 40	2193.45	—0.03	794.94	—0.17	966.10	0.00

EQUATIONS FOR CORRECTION OF MOON'S PLACE AND LONGITUDE.

The following are the coefficients of the equations for the correction of the moon's place, and of the longitude:

	Star.	$-D_i p$		$D_b p$		$-D_\pi p$		$-D_\lambda p$		δp	
		By B. P.	C. S. P. —B. P.	By B. P.	C. S. P. —B. P.	By B. P.	C. S. P. —B. P.	By B. P.	C. S. P. —B. P.	By B. P.	C. S. P. —B. P.
			.00		.00		.00		.00	"	"
1. Wash.	1	.9940	02	.1080	00	.5927	00	.5604	00	—2.07	.09
	4	.9202	—02	—.3915	—03	.3413	19	.5191	—01	—2.07	.09
	8	.9824	02	.1863	—07	.5286	27	.5544	00	—2.57	.09
	11	.9920	00	.1271	—02	.4917	04	.5599	07	—2.68	.11
	13	.8670	00	—.4983	—01	.2388	—11	.4896	00	—1.39	.05
	14	.9298	—04	—.3713	—04	.2824	—04	.5245	—04	—1.52	—.05
	20	.9943	00	—.1021	—01	.2864	02	.5624	—07	—2.91	.14
2.	4	.8944	—02	—.4473	—03	.1871	04	.5048	—01	—2.78	.09
	11	.9984	00	.0570	—02	.3363	02	.5643	—08	+2.26	.13

SOLUTION OF THE EQUATIONS.

The solution of these equations by the method of least squares gives for the final coefficients:

	B. P.	C. S. P.—B. P.		B. P.	C. S. P.—B. P.
$[a^2]$	= .71872	.0002	$[bm]$	= 2.5652	—.0512
$[ab]$	= 1.2224	.0006	$[c^2]$	= 1.2429	.0005
$[ac]$	= 2.8313	.0003	$[cd]$	= 1.5984	—.0003
$[ad]$	= 4.0572	—.0008	$[cm]$	= 6.724	—.239
$[am]$	= 17.143	—.587	$[d^2]$	= 2.2901	—.0001
$[b^2]$	= .8126	.0003	$[dn]$	= 9.676	—.339
$[bc]$	= .2455	—.0011	$[m^2]$	= 42.794	—3.023
$[bd]$	= .6903	.0004			

The solution of these equations gives:

By B. P. $\delta b = .3903\ \delta\pi - 0.''58.$

By C. S. P. $\delta b = .3926\ \delta\pi - 0.''501.$

By B. P. $\delta l = -.4603\ \delta\pi - 0.5644\ \delta\lambda + 2.''484.$

By C. S. P. $\delta l = -.4607\ \delta\pi - 0.5643\ \delta\lambda + 2.''389.$

The substitution of these values in the given equations for each observation leaves for the residual coefficients the following values:

By B. P. and C. S. P.

Place.	Star.	$D_\pi p$	$D_\lambda p$	δp B. P.	δp C. S. P.
1	1	—.093	0	.46	.45
1	4	—.070	0	—.01	.02
1	8	—.005	0	—.02	—.04
1	11	.016	0	—.14	—.14
1	13	—.034	0	.47	.48
1	14	.00	0	.57	.46
1	20	.132	0	—.50	—.44
2	4	.050	0	—.82	—.78
2	11	.146	0	4.77	

The observation of place 2, star 11, was omitted in the computations, from its evident error. The computations are contained in the accompanying 21 sheets, marked B. P. $_{1—7}$, and C. S. P. $_{1—14}$.

Very respectfully,

BENJAMIN PEIRCE.

A. D. BACHE, LL.D.,
Superintendent United States Coast Survey.

DEAR SIR: I have the honor to communicate the following report upon the occultations of the Pleiades of September 6, 1841, which I designate as No. V.

The immersions were on the moon's dark limb, and were observed at Washington, by Mr. Gilliss.

RECORD OF OBSERVATIONS.

Washington.—The observations are printed in Gilliss's astronomical observations, page 480, and all are marked as "good."

No. of star.	Mean Washington time of immersion.	Sidereal time.
2	11*h*. 54*m*. 53.2*s*.	22*h*. 58*m*. 18.35*s*.
1	12 04 13.9	23 08 40.59
4	12 14 55.2	23 19 23.64
11	12 33 53.5	23 38 35.06
13	12 34 34.6	23 39 06.27
14	12 40 33.0	23 45 05.65

EPHEMERIS.

The places of the moon were computed from Hansen's tables for 23*h*. 50*m*., 23*h*. 20*m*., 23*h*. 50*m*., sidereal time of Wilkes's Observatory at Washington, and were as follows:

Wash. sid. time.	☽'s longitude by B. P.	C. S. P. —B. P.	☽'s latitude by B. P.	C. S. P. —B. P.	☽'s Hor. Par. B. P.	C. S. P. —B. P.
h. *m.*	° ′ ″	″	° ′ ″	″	′ ″	″
22 50	56 44 56.72	0.00	4 54 56.96	—0.04	57 41.88	0.02
23 20	57 01 44.22	0.12	4 55 28.17	—0.03	57 42.65	0.01
23 50	57 18 32.18	0.13	4 55 58.97	—0.03	57 43.42	0.01

The obliquity of the ecliptic = 23° 27′ 41.″41.

Hence the moon's right ascension and declination were computed.

Wash. sid time.	☽'s R. A. by B. P.	C. S. P. —B. P.	☽'s declination B. P.	C. S. P. —B. P.
h. *m.*	° ′ ″	″	° ′ ″	″
22 50	53 11 39.01	0.03	24 14 30.85	—0.04
23 20	53 29 35.86	0.15	24 18 02.40	—0.04
23 50	53 47 34.21	0.16	24 21 31.89	0.00

The following were the constants of Alcyone:

	B. P.	C. S. P.—B. P.
R. A. of Alcyone	54° 31′ 33.″32	—0.″09
Decl. of Alcyone	23 36 45.34	0.01
Log. F	0.000040	0
Log. E	6.2118	0

STEREOGRAPHIC CO-ORDINATES OF THE MOON REFERRED TO ALCYONE.

The parallax of the moon in right ascension and declination, and its augmented semidiameter, were computed for the place of observation for every ten minutes from $22h.\ 50m.$ to $23h.\ 50m.$ sidereal time.

The following are the values:

Wash. sid. time.	$\Delta_\pi \alpha$		$-\Delta_\pi \beta$		Σ_1	
	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.
h. m.	′ ″	″	′ ″	″	″	
22 50	46 45.57	0.01	27 05.35	—0.05	953.55	0
23 00	46 04.15	0.00	26 21.55	—.01	954.08	0
23 10	45 17.77	0.01	25 38.35	—.01	954.60	0
23 20	44 26.52	0.02	24 55.81	—.01	955.11	0
23 30	43 30.49	0.02	24 14.01	.00	955.61	0
23 40	42 29.76	0.02	23 33.03	.01	956.10	0
23 50	41 24.42	0.03	22 52.95	.01	956.59	0

The following are the coordinates of the moon for the stereographic projection of the Pleiades referred to Alcyone as the pole:

Wash. sid. time.	$-x_m$		y_m		Σ_2	
	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.
h. m.	″	″	″	″	″	
22 50	1820.03	—0.09	643.30	0.17	953.66	0.01
23 00	1529.25	—.13	757.00	—.01	954.18	.00
23 10	1243.00	—.17	869.95	—.05	954.70	.00
23 20	961.19	—.20	982.17	—.04	955.21	.00
23 30	683.74	—.22	1093.60	—.02	955.71	.00
23 40	410.56	—.22	1204.14	.00	956.20	.00
23 50	141.58	—.23	1313.73	—.01	956.69	—.01

EQUATIONS FOR CORRECTION OF THE MOON'S PLACE AND OF THE LONGITUDE.

The following are the coefficients for the correction of the moon's place and of the longitude; the star 13 is omitted because there seems to be an error in the record:

Place	Star.	$D_l p$		$D_b p$		$D_\pi p$		$D_\lambda p$		δp	
		B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.	B. P.	C. S. P. —B. P.
			.00		.00		.00		.00	″	″
1	2	.7922	02	.6103	—02	—.1767	0	.4435	30	1.30	—0.08
1	1	1.	0	—.0106	—02	.3233	01	.5599	37	1.95	—.08
1	4	.8442	0	—.5361	—01	.5326	—14	.4726	31	.32	—.20
1	11	.9992	02	.0347	—05	.2608	33	.5595	40	1.88	—.23
1	14	.8826	—02	—.4699	—07	.4673	—08	.4942	34	2.75	—.36

SOLUTION OF THE EQUATIONS.

The solution of these equations by the method of least squares gives the following values of the coefficients of the final equations:

By B. P.	C. S. P.—B. P.	By B. P.	C. S. P.—B. P.
$[a^2] = 4.1177$	.0003	$[bc] = -.6027$	−.0035
$[ab] = -.3598$	−.0003	$[bm] = -.7815$	.3427
$[ac] = 1.3060$	.0013	$[c^2] = .7058$	−.0004
$[am] = 7.506$	− .863	$[cm] = 2.3335$	−.3433
$[b^2] = .8826$	−.0002	$[m^2] = 16.507$	−3.236

The solution of these equations gives:

By B. P., $\delta b = .5741\ \delta\pi + 0''.12.$
By C. S. P., $\delta b = .5781\ \delta\pi + 0''.20.$
By B. P., $\delta l = -.2670\ \delta\pi - .5600\ \delta\lambda + 1''.833.$
By C. S. P., $\delta l = -.2669\ \delta\pi - .5600\ \delta\lambda + 1''.631.$

The substitution of these values in the individual equations leaves for the residual coefficients the following values:

Star.	B. P. and C. S. P.		δp	δp
	$D_{\pi} p$	$D_{\pi} \lambda$	B. P.	C. S. P.
			"	"
2	—.036	0	—0.22	—0.19
1	.050	0	.12	.24
4	.0	0	—1.14	—1.15
11	.016	0	—.01	—.02
14	—.040	0	1.19	1.04

The computations are contained in the accompanying sheets, marked B. P. $_{1—4}$, C. S. P. $_{1—7}$.

Very respectfully,

BENJAMIN PEIRCE.

A. D. BACHE, LL.D.,
Superintendent United States Coast Survey.

APPENDIX No. 18.

REPORT OF DR. B. A. GOULD, ON THE COMPUTATIONS CONNECTED WITH OBSERVATIONS BY THE TELEGRAPHIC METHOD FOR DIFFERENCE OF LONGITUDE.

CAMBRIDGE, *November*, 1863.

DEAR SIR: The work under my direction during the past year has been of the same character as during the year preceding, consisting in great measure of computations and reductions of the field-work of former years. The determinations of six differences of longitude have been completed, and the former reductions repeated, wherever the new and more accurate data now at our disposal promised any appreciable improvement in the accuracy of the main result, or of any important collateral ones.

The subsidiary results continue to offer new inducements to further research, and but for the smallness of the force at my disposal many of the yet unexplained indications would have been further investigated. But my primary duty was manifestly to complete the definite determinations of longitude, and the greater part of our labor has been directed exclusively to this end.

The campaigns upon which the longitude work has been completed since my last report, or so thoroughly revised as to lead to the adoption of a new value for the results, are: Wilmington—Columbia; Columbia—Macon; Macon—Montgomery; Montgomery—Peach Tree; Peach Tree—Mobile; Mobile—New Orleans; so that only five campaigns now remain for discussion; from all of which provisional results were long since attained.

The reductions now in hand will be chiefly of a mechanical character, and but for the difficulties arising from our national troubles would have been long since completed. As the further prosecution of the field-work seems not yet near at hand, I have felt justified in directing some portion of our time and effort to the preparation of a catalogue of standard declinations for the time star list, to accompany the investigation of Right Ascensions, of which the final values were printed in 1862.

It may perhaps be well to enumerate in this place those determinations of differences of longitude made by my party which may fairly be regarded as final. They are as follows, the positions referred to being in all cases the astronomical stations of the Coast Survey:

	m.	*s.*
Calais—Bangor	6	0.31
Albany—New York	0	57.45
Wilmington—Columbia	12	21.72
Columbia—Macon	10	22.18
Macon—Eufaula	6	3.02
Apalachicola—Eufaula	0	36.66
Macon—Montgomery	10	41.58
Montgomery—Peach Tree	4	58.77
Peach Tree—Mobile	1	59.75
Mobile—New Orleans	8	7.16
Pensacola—Mobile	3	20.28

During the Calais—Bangor campaign one night was devoted to an exchange of star-signals with the observatory of the college at Fredericton. Only three stars were satisfactorily exchanged, but the observations for determining the instrumental corrections at Calais were so full, and the positions of the instruments at both places have been so carefully investigated, that I think the resultant longitude cannot be in error by so much as two-tenths of a second, and that we may adopt the value:

	m.	*s.*
Fredericton—Calais	2	32.8

The preceding determinations give for the longitudes west from Wilmington the following values:

	m.	*s.*
Columbia	12	21.72
Macon	22	43.90
Apalachicola	28	10.26
Eufaula	25	46.92
Montgomery	33	25.48
Peach Tree	38	24 25
Pensacola	37	3.72
Mobile	40	24.00
New Orleans	48	31.16

And the longitudes west from the Seaton station in Washington, the zero of all our telegraphic longitude measurements, may be deduced with sufficient precision for ordinary purposes by using the provisional value.

	m.	*s.*
Seaton—Wilmington	3	47.17

No special discussions of signal-time or of personal equation have been made during the year, further than has been required for the particular work in hand, nor has time been available for continuing on any extended scale the investigation of the curious phenomena of the diurnal motion in azimuth, the main facts of which were contained in my last report. I ought, however, to mention that a few cases have presented themselves in apparent opposition to the law which seems almost universal, that this motion during the

night carries the western end of the axis southward. The exceptional cases are, however, so inconsiderable as but little to modify my conviction of the generality of the law, and this inference has received an interesting and important corroboration from the observations at the United States Naval Observatory. The Superintendent informs me that this motion, in the same direction, has been found very manifest in the large meridian instruments. And the reduction of the observations in former years, which has been made under my supervision, exhibits the same motion, both in the Transit instrument and in the mural circle, to a marked degree. A careful scrutiny, moreover, of the published observations of the late Professor Henderson, at Edinburgh, has led me to the conviction that irregularities, to which he frequently refers, were attributable to the same phenomenon. There is room for much further inquiry in the same direction, and I look forward with great interest to the opportunity of prosecuting the research.

Those recent observations of stars in our standard Right Ascensions which have reached me during the year seem to warrant great confidence in the results, and to show that the labor expended on their preparation was not lost. The cases are very few where the discordance during the last year seems to have amounted to the tenth of a second; and for the principal stars of the Time-Star List, the agreement of observations with the computed place has been very much closer. For some years to come it will probably be difficult to improve the great majority of these Right Ascensions.

The preparation of a list of declinations for the time-stars on the principles previously adopted in determining the Right Ascensions has been nearly completed since my last report. The determination and discussion of the systematic corrections due to the several catalogues has been essentially completed, and the observations have been collected, scrutinized and tabulated. Nothing remains but to solve the equations of condition, the mechanical labor of which can be performed from time to time, as a relaxation from the monotony of other routine work. In case of need, the results could be furnished at short notice, but the final solutions have been of late postponed for more pressing duties.

Soon after the date of my last report I had the misfortune to lose the valuable aid of Professor Searle who was transferred to a wider field of usefulness at the United States Naval Academy. The loss of so excellent an assistant was no small drawback to the work in hand, and only the conviction that science might ultimately be the gainer reconciled me to parting with this gifted astronomer, whose whole scientific life had been passed in my immediate party. I have, however, to thank Mr. Cleveland Abbe for assiduous, conscientious, and most serviceable aid, and during the last two months have been assisted also by Mr. W. H. Palmer, a recent graduate of Harvard College, and whose ability and zeal promise much usefulness.

I am, dear sir, very respectfully and truly yours,

B. A. GOULD.

Professor A. D. BACHE,
Superintendent United States Coast Survey.

APPENDIX No. 19.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART VII. INVESTIGATION OF THE ELEVEN-YEAR PERIOD, AND OF THE DISTURBANCES OF THE VERTICAL COMPONENT OF THE MAGNETIC FORCE, WITH A SUPPLEMENT ON THE EFFECT OF AURORAL LIGHTS, BY A. D. BACHE, LL.D.

[From the Smithsonian Contributions to Knowledge.]

The observations of the vertical component of the magnetic force were commenced in June, 1840, and continued, with an exception in January, 1841, without interruption to the last of June, 1845. To keep up the continuity of the series a daily reading was taken at $2h.\ 17m.$ p. m. during the months of January, February, and March, 1843. Up to October, 1843, the observations were bi-hourly, afterwards hourly.

Instruments.—From June, 1840, to the end of the year, the observations were made with a balance vertical force magnetometer of Lloyd's pattern. It was at first mounted in the eastern building of the college, but was removed to the observatory in the latter part of July. While in the college an increase of the readings corresponds to a decrease of vertical force; at the observatory increasing readings denote increasing force. The instrument was made by Robinson, of London; the magnet, the axis of which was mounted as nearly as possible transversely to the magnetic meridian, was 12 inches in length, having at its ends cross

wires set in copper rings. For a full description, see Dr. Lloyd's account of the Magnetical Observatory of Dublin, and the preface in volume I of the record of the Philadelphia observations. In January, 1841, the Lloyd instrument was replaced by a reflecting vertical force magnetometer, made at my suggestion by Mr. J. Saxton. The bar of this instrument was two feet and one inch in length, two inches wide in the middle, one and a half near the ends, tapering to nothing at the ends, and a quarter of an inch thick. The magnet was of steel, and hardened as perfectly as the maker could effect. By means of a ball moving on a fine screw, its equilibrium could be changed. The mirror projected outside the box, and the motion of the bar was observed by means of a telescope. At the top of the box was a piece of plate glass, through which a thermometer (of Francis's make) could be read. For further particulars see p. VII of the preface to volume I of the record. For some time (between three and four months) after being put up, the bar lost considerably of its magnetic force, and after being in use for four months, a movement of the adjusting ball upon the screw was required for placing the readings again near the middle of the scale. By this adjustment the sensibility of the apparatus was not interfered with. The value of a scale division of the Lloyd instrument, expressed in parts of the vertical force, was carefully determined and found to be $=0.0000165$, both in the college building and at the observatory. This value being known, I consider that the value of the scale of the new reflecting magnetometer could best be ascertained by comparison with the former. The result of this, continued at intervals, was that two divisions of the new scale were equivalent to one of the old, or that a change of one division of the reflecting instrument corresponded to a change of vertical force of 0.000033 parts. This was after the instrument had been finally adjusted.

The only disadvantage in the new instrument was the large effect of changes of temperature upon it; by direct observations it was found that a change of 1° (F.) of temperature produced a corresponding change of 13.5 ± 0.25 scale readings, whereas in the Lloyd instrument the corresponding change was but 3.12 scale divisions. We have accordingly for the Lloyd instrument $q=0.0000515$, and for the reflecting instrument $q=0.000446$. The values actually used in the reduction of the observed reading to a standard temperature will be seen further on.

The importance of ascertaining the most correct and suitable coefficients of temperature for the two series of observations, demands a more detailed statement and elaborate discussion of the observations themselves, independently of the special trials. Experience has shown that the value for q deduced from the differential intensity observations themselves, with the magnet subject generally to gradual and small changes of temperature, is smaller by a considerable fraction than the value found by direct and special observation, during which the temperature changes are necessarily more violent. There is no doubt that in the reduction to a standard temperature, that value of q should be used which was obtained while the magnet was under its ordinary influences and condition. The same view is taken by General Sabine, and was also carried out in the discussion of the horizontal component of the magnetic force; for which see the preceding paper (Part IV.)

Determination of the effect of a change of temperature on the readings of the vertical force.

(A.) Results of special observations made for determining the temperature coefficient. The correction for temperature of the Lloyd vertical force magnetometer was ascertained by the usual method of vibrating the bar when suspended horizontally, and when alternately heated and cooled artificially. The thermometer was placed with its ball near the axis of the magnet. The changes of the horizontal force magnetometer, while these experiments were going on, were noted and allowed for.

Date, Feb'y, 1841	Time of 10 oscillations.	Temp. (F.)	Readings of Horz'l force.	Temp. (F.)
9th	87s 950	37°.2	1128 8	25° 6
"	87.900	41.0	1079.3	36.5
"	88.117	94.6	1139.5	36.1
Result	87.990	39.1	hence $q=\frac{2}{t'-t}\cdot\frac{\tau^2-\tau^2}{\tau^2+\tau^2}=0.0000520$	
"	88 117	94.6		

which is equivalent to 3.15 scale divisions; in the first reduction of the record 3.12 was used.

Before putting the reflecting vertical force magnetometer in its place in January, 1841, observations were made for its correction for temperature by means of deflections; the result, however, was not satisfactory, owing to the small difference in the deflections at high and low temperatures, and the necessity of keeping the bar at a proper distance from the declinometer to prevent the possibility of a permanent change of magnetism. The weight of the mirror and other fixtures of the bar rendered the method of horizontal oscillations impracticable without their removal, and it was finally decided to determine the value of q by means of a subsidiary instrument kept at a uniform temperature in a separate building, while the vertical force instrument at the observatory was subject to considerable fluctuations of temperature. The subsidiary instrument consisted of a small dipping needle mounted on a knife-edge, and rendered horizontal by weighting it. The indications, however, did not prove very satisfactory; 14 scale divisions were indicated as the correction for 1° change in temperature. Subsequently an inclinometer, according to Prof. Lloyd's plan, was mounted as a subsidiary instrument, and observed twice a day with the vertical force instrument at the observatory. The mean values, expressed in scale divisions, thus found between February, 1843, and January, 1844, are as follows:

13.3 14.3 14.4 12.3 12.2 13.1 and 15.4.

Average value 13.56±0.25. In the first reduction the value 13.5 was used.

(B.) Investigation of the temperature coefficient from the regular series of observations. We will first examine the principal series observed between 1841 (February) and 1845 (June,) with the reflecting magnetometer. In February, March, April, and May, 1841, the readings gradually increased and approached the end of the scale, requiring a readjustment of the instrument after May 22. It was supposed that —529 scale divisions would be an approximate correction for referring the observations to the indications of the scale subsequent to May 22, the uninterrupted series of observations commencing with June 1, 1841. The following table contains the *uncorrected* monthly means of the vertical force magnetometer, together with the observed mean monthly temperature, taken directly from the record. The tabular means for January, February, and March, 1843, when the instrument was read only once a day (at $2h.\ 17m.$ p. m.,) were obtained as follows: The difference between the daily mean and the mean at $2h.\ 17m.$ p. m. was ascertained for each month, from the records of the preceding year (1842) and the following year (1844.) The mean correction to the average reading at $2h.\ 17m.$ p. m., to refer the same to the mean of the day and month, is +18.6, +14.4, and +11.2 scale divisions for the months of January, February, and March, respectively. These corrections have been applied.

TABLE I.

Uncorrected monthly means of vertical force magnetometer and corresponding mean monthly temperatures.

1841.						1844.		
February	1059d.0	35°.58	July	792d.9	77°,5	January	636d.1	57° 0
March	1236. 2	43. 96	August	775. 9	75. 4	February	657. 4	59. 2
April	1357. 4	50. 8	September	775. 0	74. 3	March	769. 5	67. 2
May	1445. 6	56. 2	October	763. 8	71. 4	April	750. 1	65. 4
June	722. 6	74. 5	November	725. 0	66. 8	May	798. 4	69. 9
July	810. 3	77. 6	December	672. 8	62. 5	June	845. 1	73. 6
August	776. 1	75. 85	1843.			July	913. 2	77. 2
September	702. 5	71. 1				August	877. 2	75. 4
October	448. 7	54. 5	January	681. 9	64. 0	September	860. 7	71. 7
November	339. 8	47. 8	February	615. 8	57. 6	October	834. 7	71. 2
December	534. 1	59. 6	March	555. 5	53. 8	November	748. 2	63. 9
1842.			April	762. 4	71. 3	December	695. 6	60. 8
			May	734. 1	70. 4	1845.		
January	679. 4	67. 7	June	784 6	75. 9			
February	695. 5	65. 0	July	800. 5	77. 4	January	712. 6	62. 2
March	668. 9	66. 8	August	817. 1	77. 8	February	650. 1	56. 3
April	671. 2	67. 4	September	797. 9	74. 3	March	775. 7	60. 2
May	693. 9	69. 7	October	749. 0	69. 6	April	721. 1	65. 7
June	718. 0	71. 9	November	728. 0	64. 7	May	688. 8	64. 1
			December	705. 9	62. 5	June	811. 1	74. 2

Combining the preceding values by months, we obtain a complete series extending over four years. The first five months are necessarily omitted; the break in the series occurred between the 4th and 5th months.

Uncorrected readings of the vertical force magnetometer. One division of scale =0.000033 parts of the vertical force:

Month.	1841–'42.	1842–'43.	1843–'44	1844–'45.	1841–'45.
July	810.3	792.9	800.5	913.2	829.2
August	776.1	775.9	817.1	877.2	811.6
September	702.5	775.0	797.9	860.7	784.0
October	448.7	763.8	749.0	834.7	699.1
November	339.8	725.0	728.0	748.2	635.2
December	534.1	672.8	705.9	695.6	652.1
January	679.4	681.9	636.1	712.6	677.5
February	695.5	615.8	657.4	650.1	654.7
March	668.9	555.5	769.5	675.7	667.4
April	671.2	762.4	750.1	721.1	726.2
May	693.9	734.1	798.4	688.8	728.8
June	718.0	784.6	845.1	811.1	789.6
			Mean		721.3

Corresponding readings of the thermometer (F.)

Month.	1841–'42.	1842–'43.	1843–'44.	1844–'45.	1841–'45.
July	° 77.6	° 77.5	° 77.4	° 77.2	° 77.42
August	75.85	75.4	77.8	75.4	76.11
September	71.1	74.3	74.3	71.7	72.85
October	54.5	71.4	69.6	71.2	66.68
November	47.8	66.8	64.7	63.9	60.80
December	59.6	62.5	62.5	60.8	61.35
January	67.7	64.0	57.0	62.2	62.72
February	65.0	57.6	59.2	56.3	59.53
March	66.8	53.8	67.2	60.2	62.00
April	67.4	71.3	65.4	65.7	67.45
May	69.7	70.4	69.9	64.1	68.52
June	71.9	75.9	73.6	74.2	73.90
			Mean		67.45

The last column contains the mean readings. They may be represented by the equation—

$$V = V_m + \triangle e\, x + \triangle t\, y$$

where x = monthly amount of loss of magnetism and effect of secular change.

y = change in magnetometer reading for a change of temperature 1° F.

$\triangle e$ = epoch—middle epoch. The middle epoch is January 1st.

$\triangle t$ = temperature—mean temperature.

V_m = mean reading of the vertical force magnetometer.

V = any of the monthly means to be represented.

From the 12 conditional equations, we form the normal equations—

$$-\ 828.90 = +\ 143.000\ x -\ 85.335\ y$$
$$+\ 4685.73 = -\ 85.335\ x +\ 443.120\ y$$

whence $x = +\ 0.577$, the monthly change, equal to nearly 7 scale divisions for each year.

And $y = +\ 10.68$ scale divisions, the correction for temperature for 1° F. This is not quite three-fourths of the value found by direct measure.

Second determination of the temperature coefficient by means of alternate combinations by seasons.

The mean values for each season have been directly formed from table No. 1.

The value in June, 1845, is necessarily omitted.

				Alternate means.		erences.		Temp. coefficient.
			°		°		°	
1841	June to November	633d. 3	66. 89					
1841–2	December to May	657. 2	66. 03	605d. 8	69. 88	+38d. 6	+3. 85	10d. 0
1842	June to November	758. 4	72. 88	663. 8	64. 65	—94. 6	—8. 23	11. 5
1842–3	December to May	670. 4	63. 27	769. 0	73. 08	+98. 6	+9. 81	10. 1
1843	June to November	779. 5	73. 28	695. 0	63. 40	—84. 5	—9. 88	8. 6
1843–4	December to May	719. 6	63. 53	813. 0	72. 72	+93. 4	+9. 19	10. 2
1844	June to November	846. 5	72. 17	705. 1	65. 54	—141. 4	—9. 63	14. 7
1844–5	December to May	690. 6	61. 55					
					Mean			10. 85
					By preceding method			10. 68
					Mean, adopted			10. 77

We have for the reflecting magnetometer $k = 0.000033\ \frac{q}{k} = 10.77$, hence $q = 0.000355$. For comparison we have the corresponding values at Toronto $\frac{q}{k} = 1.80$ and $q = 0.000113$.

The scale value k at Toronto is 0.0000628, nearly twice as large as at Philadelphia. The comparatively large value for q at Philadelphia is most probably due to the large size of the bar, which prevents a thorough hardening—a circumstance which undoubtedly also contributes to the difference exhibited by the resulting value of q as found by the direct and indirect methods.

The magnitude of the temperature coefficient requires that the standard temperature should be the mean temperature at all the readings. The average temperature between February, 1841, and June, 1845, is 66°.0, which has been adopted as the standard temperature to which all the vertical force readings, taken with the reflecting magnetometer, have been referred.

A close examination of the record of the Lloyd balance magnetometer, which was used in June and July, 1840, in the College, and afterwards at the Observatory during five months, proved that in point of accuracy it would not compete with the reflecting magnetometer mounted in January, 1841, and continued in use for four years and a half. Owing to some imperfection in the first-named instrument, its indications were very unsteady, and at times fitfully changeable; thus in September, October, and December, there are differences in the daily means (deduced from twelve readings and referred to 32° Fahrenheit) of adjacent days of more than 200 scale divisions, and in one instance, (October 19–20,) amounting even to 256 divisions. In August there is a change of 389 scale divisions in three consecutive days, and in October, (17th to the 20th,) one of 477 divisions in the means during the same interval. There is, besides, a large progressive change, showing that the instrument was in a very unstable equilibrium; this change amounted in the first month to over 300 scale divisions. An attempt was also made to deduce a temperature coefficient by comparing mean daily readings of short and specially selected periods of a few days each, with average high and low temperatures, but it failed for want of sufficient uniformity in the indications of the instrument. In such a series the disturbed indications could not be recognized and separated from the regular readings. It was finally concluded to make no use of the observations prior to January, 1841.

Reduction of the observations, between February, 1841, and June, 1845, to a uniform temperature.—A table has been constructed, with the observed temperature as the argument, giving the reduction for difference of temperature from the normal temperature (66° Fahr.); by means of this table each observation has been referred to its corresponding value as the standard temperature. Table No. 2 contains the monthly mean readings for each observing hour; the time is local time, and reckoned from midnight to midnight to 24 hours. The tenths in the record have been omitted, as of no special value, since an error in the recorded temperature of only 0°.1 affects the magnetometer reading by more than a scale division. An increase of scale readings corresponds to a decrease of vertical force, and one division equals 0.000033 parts of the force. Accidental irregularities in the record are specially referred to in foot-notes.

The tabular values are directly taken from the manuscript tables containing the single reduced readings, and their monthly means.

In the present state of our knowledge regarding the occurrence of the disturbances, it is not safe to make any interpolations in the magnetometer record in case of an accidental omission; a rule which has been strictly adhered to.

TABLE II.

Record of the monthly means of the vertical force magnetometer readings for each observing hour, and reduced to uniform temperature of 66° Fah.

1841.	0*h.*	2	4	6	8	10	Noon.	14	16	18	20	22*h.*	+17*m.*
February	861	861	860	857	851	846	845	849	847	878	872	867	
March	956	954	949	943	936	933	931	928	941	953	957	957	
April	1004	997	994	988	982	982	981	982	989	997	1006	1009	
May	1033	1031	1030	1021	1012	1009	1008	1008	1012	1022	1037	1043	
June	641	634	631	621	618	618	616	620	627	641	652	653	
July	704	698	686	675	669	666	667	700	684	695	708	707	
August	684	680	673	665	664	655	653	659	663	672	686	690	
September	665	660	657	651	642	633	632	632	637	646	656	662	
October	583	582	578	572	562	559	561	561	569	577	581	582	
November	540	543	540	544	531	528	526	527	532	535	538	540	
December	602	595	595	599	593	598	605	600	606	613	613	613	

Notes to the above table.—February 25th, 6*h.* 17*m.*, temperature interpolated, 28°. March 2d, 0*h.* 17*m.*, reading 32 minutes late, t=46°.8. March 11th, 22*h.* 17*m.*, reading 49*m.* late, t=41°.7. March 27th, 20*h.* 17*m.*, reading 40*m.* late, t=64°.8. March 29th, 22*h.* 17*m.*, reading 43*m.* late, t=50°.5. April 9th, 16*h.* 17*m.*, reading 25*m.* late, r=920, t=57°.6. April 30th, 0*h.* 17*m.*, reading 59*m.* late, r=805, t=49°.3. May 22d, 14*h.* 17*m.*, observations discontinued. Between this date and June 1st the instrument was readjusted, the corrections required to make the readings of the first four months comparable with the continuous series following will be investigated further on. June 29th, 22*h.* 17*m.*, reading 38*m.* late, temperature 81°.8 interpolated. July 22d, 16*h.* 17*m.*, temperature 84°.5 interpolated. August 23d, 24th, seven observations were omitted between 20*h.* 17*m.* and 8*h.* 17*m.* on account of the magnet being fixed by a spider's line which was found attached to the mirror. August 24th, 14*h.* 17*m.*, observation rejected, the sun shining on the box. October 4th, 16*h.* 17*m.*, sun shining on the needle; October 13th, 22*h.* 17*m.*, observation 7*m.* late; October 28th, 22*h.* 17*m.*, observation 67*m.* late. In December the variations of temperature are unusually large; they seem to demand a greater value of the temperature coefficient. December 8th, 16*h.* 17*m.*, observation 8*m.* late; December 20th, 4*h.* 17*m*, observation 9*m.* late; December 30th, 18*h.* 17*m.*, temperature 69°.0, interpolated.

TABLE II—Continued.

Vertical force readings at 66° Fah.

1842.	0h.	2	4	6	8	10	Noon.	14	16	18	20	22h.	+17½m.
January	651	651	663	659	657	651	661	648	660	679	674	674	
February	705	704	714	714	707	698	704	696	699	714	707	701	
March	661	656	662	664	663	662	655	649	655	667	673	666	
April	666	655	659	655	653	654	649	643	645	655	667	670	
May	662	665	657	649	646	647	652	644	647	654	664	665	
June	674	669	663	658	648	643	639	640	636	652	665	663	
July	690	685	675	667	663	656	652	651	656	669	681	684	
August	689	687	685	682	675	668	655	655	665	677	684	686	
September	698	692	696	689	686	677	671	671	673	679	690	698	
October	707	699	703	712	696	709	708	707	707	709	711	706	
November	718	710	723	725	713	715	713	713	716	711	718	718	
December	708	708	714	709	716	711	709	707	705	710	713	713	

Notes to the above table.—February 3d, 14h. 17½m., the temperature 73°.5 is interpolated. May 9th, 10h. 17½m., the temperature 59°.6 is interpolated. June 6th, 0h. 17½m., 2h. 17½m., and 18h. 17½m., the temperatures 70°.4, 71°.0, and 74°.4, respectively, were interpolated. August 3d, 12h. 17½m.; 5th, 22h. 17½m.; 6th, 10h. 17½m, and 31st, 14h. 17½m., the temperatures 69°.0, 73°.7, 76°.0, and 67°.6, respectively, were interpolated. September 1st, 22h. 17½m., the temperature 77°.0 is interpolated. October 8th, 2h. 17½m.; 21st, 10h. 17½m., and 28th, 6h. 17½m., the temperatures 66°.1, 68°.1, and 70°.8, respectively, were interpolated. November 3d, 14h. 17½m., and 16th, 6h. 17½m., the observations are 6m. and 7m. late.

TABLE II—Continued.

Vertical force readings at 66° Fah.

1843.	0h.	2	4	6	8	10	Noon.	14 +17m.	16	18	20	22h.	+23½m.
January	------	------	------	------	------	------	------	685	------	------	------	------	
February	------	------	------	------	------	------	------	692	------	------	------	------	
March	------	------	------	------	------	------	------	676	------	------	------	------	
April	715	713	713	712	708	702	705	687	697	696	706	709	
May	698	697	695	690	683	680	677	666	678	679	697	690	
June	696	691	693	690	677	669	664	660	659	671	681	690	
July	692	693	693	689	681	673	664	660	660	667	678	686	
August	702	703	707	705	695	682	670	672	672	682	694	698	
September	722	720	721	716	707	705	694	693	694	701	710	708	
October	714	708	714	717	704	703	702	703	704	714	719	714	
November	740	737	744	744	743	740	734	735	746	750	748	745	
December	749	737	740	740	739	728	724	738	755	759	762	754	

Additional odd hours observed.

1843.	1h.	3	5	7	9	11	13	15	17	19	21	23h.	+23½m.
October	710	709	718	712	704	700	701	702	709	717	715	717	
November	737	740	745	747	742	735	731	741	750	751	746	747	
December	744	738	742	743	738	720	726	747	755	763	756	757	

Notes to the above table.—January 4th, February 1st, and March 24th, observations 7m., 7½m., and 20m late, respectively. In April seven readings were supplied by the observers, also one in May and one in June. July 14th, 0h. 23½m., observation 6m. late. August 10th, 16h. 23½m., observation supplied by observer. August 29th, 0h. 23½m., observation 12m. late. September 20th, 0h. 23½m., temperature supplied by observer. November, six readings supplied by observers. December 1st, 4h. 23½m.; December 9th, 1h. 23½m.; December 12th, 21h. 23½m., and December 22d, 5h. 23½m., observations 5m., 6m., 15m., and 8m. late, respectively. December 19th, 2h. 23½m., a printing error of 200 scale divisions was corrected. December 30th, 9h. 23½m., reading supplied by observer.

TABLE II—Continued.

Vertical force readings at 66° *Fah.*

1844.	0h.	1	2	3	4	5	6	7	8	9	10	11h.	+23½m.
January	735	733	731	731	733	736	733	733	731	730	726	717	
February	736	731	729	730	733	732	733	734	727	725	727	720	
March	763	758	758	759	760	762	763	760	755	759	761	762	
April	766	765	763	765	766	765	763	759	752	751	746	740	
May	772	769	766	768	767	764	760	754	749	747	747	744	
June	778	776	772	772	771	768	765	760	752	750	749	747	
July	809	807	803	802	801	798	794	789	780	779	778	777	
August	794	792	788	787	785	783	780	774	768	765	761	759	
September	815	813	811	808	809	807	805	802	796	793	788	783	
October	779	776	773	776	778	780	781	782	775	774	775	771	
November	775	771	768	769	772	772	771	773	768	772	772	767	
December	756	752	753	754	756	757	756	760	752	752	754	749	

1844.	Noon.	13	14	15	16	17	18	19	20	21	22	23h.	+23½m.
January	717	713	717	724	732	740	743	745	747	746	744	745	
February	716	719	720	723	731	735	742	743	743	739	738	737	
March	758	751	752	755	752	751	751	749	750	751	759	762	
April	739	735	738	744	750	754	758	764	764	762	765	766	
May	744	740	740	744	746	748	753	762	765	766	768	772	
June	746	745	748	752	754	757	765	772	775	774	775	778	
July	776	775	772	778	780	787	795	801	804	804	806	809	
August	756	756	752	765	767	769	777	787	788	788	790	793	
September	779	777	766	791	790	793	804	810	809	810	812	815	
October	769	767	771	778	787	789	792	790	786	786	782	782	
November	766	763	761	758	774	779	777	778	774	770	769	772	
December	745	739	740	735	750	756	754	753	753	750	751	754	

Notes to the preceding table.—January 2d, 10h. 23½m., temperature observation 30m. late. January 8th, 10h. 23½m., instrument disturbed. January 15th, 3h. 23½m., temperature 56°.3 interpolated. February 6th, 4h. 23½m., and 13th, 9h. 23½m., temperature observation 15m. and 20m. late, respectively. April 11th, 0h. 23½m, and 1h. 23½m., readings supplied by observer. July 13th, 12h. 23½m., observation 36m. late. August 26th and 27th, thirteen readings supplied by observers. October 1st, 22h. 23½m., observation 8m. late.

TABLE II—Continued.

Vertical force readings at 66° *Fah.*

1845.	0h.	1	2	3	4	5	6	7	8	9	10	11h.	+23½m.
January	754	748	749	751	752	756	762	767	760	758	753	751	
February	761	756	753	757	759	760	763	764	756	756	752	749	
March	749	743	739	742	745	744	745	743	735	733	732	729	
April	732	727	726	728	729	727	725	724	719	718	718	717	
May	722	720	718	721	718	717	715	711	707	704	702	701	
June	733	731	729	729	729	727	726	722	717	715	715	711	

TABLE II—Continued.

1845.	Noon.	13	14	15	16	17	18	19	20	21	22	23*h.*	+23½*m.*
January	752	748	749	739	754	759	756	753	748	746	746	753	
February	747	741	740	739	753	759	761	761	758	753	752	756	
March	730	729	713	731	737	741	745	746	740	740	739	742	
April	716	713	715	724	726	723	732	737	735	729	726	728	
May	699	698	680	700	704	704	712	719	719	717	719	720	
June	711	711	711	714	713	715	722	730	733	731	731	732	

Notes to above table.—April 27th, 4*h.* 23½*m.*, reading supplied by observer. April 14th, 2*h.* 23½*m.*, observation 12*m.* late. April 22d, 23d, and 28th, 14*h.* 23½*m.*, also April 22d, 15*h.* 23½*m.*, readings supplied by observer. April 22d, 16*h.* 23½*m.*, temperature supplied by observer. May 2d, 14*h.* 23½*m.*, reading supplied by observer. May 12th, 4*h.* 23½*m.*, 9*m.* late. June 6th, 5*h.* 23½*m.*, and 28th, 1*h.* 23½*m.*, observations 13*m.* and 9*m.* late, respectively. June 12th, 0*h.* 23½*m.* and 1*h.* 23½*m.*, readings supplied by observer.

TABLE III.

Mean monthly readings of the vertical force reduced to the temperature of 66° *Fah.*

	1841.	1842.	1843.	1844.	1845.
January	------	661	699	733	752
February	858	705	702	731	754
March	945	661	684	757	738
April	993	656	705	756	725
May	1022	654	686	756	710
June	631	654	678	762	722
July	688	669	678	792	------
August	670	676	690	776	------
September	648	685	708	799	------
October	572	706	710	779	------
November	535	716	742	770	------
December	603	710	744	751	------
Mean	------	679	702	763	------

The monthly mean for January, February, and March, 1843, was obtained by adding 14, 10, and 8 divisions to the readings at 14*h.* 7*m.*, respectively. These corrections were found by comparisons in 1842 and 1844.

Corrections for progressive and irregular changes.—The difficulty of fully eliminating all effects of changes of temperature and adjustment, particularly during the first year, (1841), demanded the application of a secondary process analogous to that used in the reduction of the horizontal force for progressive change. The progressive change in the readings of the vertical force is less decided and more fluctuating than in the horizontal force. Half-monthly means, and in special cases, means of even less periods of time, have been taken and were compared with the monthly mean; the differences were applied either progressively (increasing or diminishing) or as constants, as the case seemed to demand.

Seventeen months required no such correction, and in many months it was applied very sparingly.

The process leaves the diurnal variation, relatively, undisturbed, and prepares the series for the application of Peirce's Criterion for the recognition of the disturbances. The individual figures thus corrected were inserted in blue ink in the manuscript tables.

Recognition and separation of the larger disturbances.—Peirce's Criterion for the recognition of the disturbances was applied to the observations extending over four years, and commencing with July, 1841, in

the following order: July 0*h*., August 2*h*., September 4*h*., October 6*h*., November 8*h*., December 10*h*., January, (1842,) 12*h*., etc. The odd hours were selected from July, 1844, to the close of the series, thus: July 1*h*., August 3*h*., September 5*h*., etc. The following limits of separation, in scale divisions, have been found for each year:

July,	1841—	June,	1842,	limit,	52
"	1842—	"	1843,	"	46
"	1843—	"	1844,	"	40
"	1844—	"	1845,	"	33
			Average limit,		43

As this limit would only separate one in every 34 observations, and would not furnish a sufficient number of disturbances to investigate their laws to advantage, it was necessary to contract the above limit, and 30 scale divisions were finally selected. There can be no doubt that the limiting number as found by the use of the criterion is too high, owing to the unavoidable presence of irregularities ascribable to imperfection in the corrections for temperature in some cases, and in others due to apparently fitful changes in the instrument. 30 scale division =0.00099 parts of the vertical force =0.0127[1] in absolute measure, adopted as limit of deviation of any observation from its corresponding mean monthly value for the same hour, will furnish an average value for the ratio of the number of disturbances to the whole number of observations. The ratio of a disturbance to the whole force is also nearly the same for the horizontal and vertical component.

All deviations over 30 divisions from the mean were marked, and a new mean was taken; the hourly observations were again compared with this new mean, and the process was repeated, if necessary, until all deviations above 30 had been separated; the final hourly means for each month, thus found and known as the "normals," are given in the following tables:

TABLE IV.

Bi-hourly normals of the vertical component of the magnetic force in 1841.

One division of the scale =0.000033 parts of the vertical force. Increasing numbers denote decrease of force. The observations are made 17*m*. after the full hours.

1841.	0*h*.	2	4	6	8	10	Noon.	14	16	18	20	22*h*.
February	664	664	662	656	654	650	644	648	647	673	668	665
March	670	661	661	655	651	645	643	646	656	665	666	673
April	671	662	658	653	645	646	646	649	656	666	670	676
May	669	665	660	654	647	649	644	646	650	660	674	679
June	646	631	622	617	624	616	603	624	635	650	653	657
July	703	697	687	671	667	664	665	676	680	698	708	706
August	686	680	676	664	662	652	653	662	666	676	689	691
September	663	655	646	647	637	631	627	628	634	645	653	660
October	579	578	573	568	558	556	561	562	571	577	581	583
November	532	537	538	533	526	523	520	521	526	529	531	538
December	597	591	590	606	592	598	605	597	607	610	605	604

The normals for February, March, April, and May, have been diminished by 198, 278, 333, and 361 scale divisions respectively; the uncorrected monthly means are 856, 936, 991, and 1019, which can be exactly represented by the expression $r = 966 + 54.4\ \Delta t - 12.8\ \Delta t^2$, where r = monthly reading, and t, expressed in units of a month, counts from April 1 as the epoch. It shows that the monthly increase is uniformly retarded. The mean reading from the four succeeding months is 658; the corrections to February, March, April, and May, as applied, will produce the same mean.

The rapid change in the monthly means for some adjacent months makes a small correction necessary to the monthly means, viz: of plus one scale division to the February, March, and December means of the

[1] The vertical force, in absolute measure, is, on the average, between 1841 and 1845, equal to 12.84 (English units,) as stated in a subsequent number of this discussion.

hours 0, 2, and 4, and to the September and October means at the hours 18, 20, and 22; of minus one scale division to the February, March, and December means at the hours 18, 20, and 22, and to the September and October means at the hours 0, 2, and 4. This small correction is included in the above normals.

TABLE IV—Continued.

Bi-hourly normals of the vertical component in 1842.

The observations are made $17\frac{1}{2}m$ after the full hours.

1842.	0h.	2	4	6	8	10	Noon.	14	16	18	20	22h.
January	(658)	642	656	649	656	653	664	650	663	675	670	663
February	706	701	713	721	699	698	709	692	698	712	723	710
March	655	643	654	663	657	661	651	650	657	668	673	665
April	668	658	655	655	656	654	657	651	650	660	672	672
May	673	670	661	644	646	647	651	644	645	656	668	670
June	674	669	664	658	647	642	635	639	635	653	671	668
July	683	672	664	659	657	650	643	643	647	663	677	682
August	689	689	683	682	679	672	652	659	669	679	688	688
September	692	686	689	690	681	671	671	673	672	679	687	693
October	706	698	702	714	695	708	707	706	706	708	710	709
November	717	713	723	725	712	715	711	713	716	712	718	718
December	713	707	709	706	715	711	709	707	706	711	713	713

In January at 0h. the final mean is 637, which differs so much from the standard value at this hour that it was preferred to substitute the mean of the month (658), as a close approximation.

TABLE IV—Continued.

Bi-hourly normals of the vertical component in 1843.

The observations are made $23\frac{1}{2}m$. after the full hours.

1843.	0h.	2	4	6	8	10	Noon.	14	16	18	20	22h.
January	------	------	------	------	------	------	------	690	------	------	------	------
February	------	------	------	------	------	------	------	697	------	------	------	------
March	------	------	------	------	------	------	------	686	------	------	------	------
April	715	712	717	716	708	702	709	700	696	696	710	709
May	698	699	695	690	682	680	677	668	677	685	691	695
June	698	691	693	687	677	668	663	658	659	669	681	689
July	691	692	692	686	679	672	662	658	659	666	677	685
August	703	703	708	706	698	683	669	671	672	682	695	699
September	721	719	721	716	707	706	693	692	692	703	714	710
October	714	707	712	717	706	703	702	703	704	714	719	714
November	742	745	745	744	742	737	735	731	746	749	749	746
December	752	733	740	740	740	729	727	743	758	767	764	754

Normals at additional odd hours.

1843.	1h.	3	5	7	9	11	13	15	17	19	21	23h.
October	710	713	714	714	704	701	700	701	709	717	715	717
November	740	743	744	748	739	729	731	738	749	751	747	748
December	744	742	742	743	740	720	729	749	760	763	757	757

TABLE IV—Continued.

Hourly normals of the vertical component in 1844.

The observations were made $23\frac{1}{2}m$ after the full hours.

1844.	0h.	1	2	3	4	5	6	7	8	9	10	11h.
January	733	739	730	728	732	733	732	732	730	725	720	713
February	734	729	725	726	729	728	729	730	723	724	722	717
March	768	761	763	760	764	762	765	762	758	761	762	764
April	776	773	771	765	766	765	759	755	749	749	744	740
May	772	769	766	768	767	764	760	754	749	747	747	744
June	776	772	767	768	767	764	760	755	747	745	744	744
July	816	811	804	806	805	802	798	793	784	783	782	780
August	794	790	786	781	783	777	776	769	763	760	756	754
September	816	815	813	812	811	810	809	805	798	795	790	785
October	775	771	769	773	776	779	780	780	774	773	773	770
November	775	772	768	769	772	771	770	773	768	772	772	767
December	754	753	754	755	757	756	755	758	749	751	750	746

1844.	Noon.	13	14	15	16	17	18	19	20	21	22	23h.
January	715	708	715	724	737	740	741	743	744	745	744	744
February	718	716	716	720	727	731	738	739	740	737	735	733
March	662	753	758	760	754	757	753	754	752	753	763	764
April	737	733	737	741	745	744	756	767	768	765	767	775
May	744	740	747	744	746	748	754	763	766	766	768	772
June	742	739	744	747	749	754	760	769	771	770	771	775
July	780	776	773	781	783	791	799	805	808	809	811	816
August	750	750	746	759	764	771	778	789	790	789	792	794
September	780	779	772	794	793	795	806	813	812	812	814	817
October	769	766	773	777	786	788	791	789	785	785	781	781
November	766	763	762	765	774	779	777	778	774	770	769	772
December	743	733	736	724	748	757	755	751	751	748	750	750

TABLE IV—Continued.

Hourly normals of the vertical component in 1845.

The observations are made $23\frac{1}{2}m$. after the full hours.

1845.	0h	1	2	3	4	5	6	7	8	9	10	11h.
January	754	747	747	752	752	757	763	767	760	758	753	752
February	760	756	752	757	759	760	763	764	756	756	752	749
March	749	741	736	742	746	748	749	746	736	733	732	729
April	732	727	728	729	728	727	725	721	718	715	717	717
May	720	718	717	719	716	715	713	709	705	702	701	699
June	733	731	729	730	729	728	726	722	717	715	715	711

TABLE IV—Continued.

1845.	Noon.	13	14	15	16	17	18	19	20	21	22	23h.
January	751	748	749	742	753	760	756	753	749	746	747	754
February	747	741	740	744	753	759	761	761	758	753	752	756
March	729	729	713	734	740	747	751	746	741	740	739	743
April	716	713	717	720	724	724	732	737	736	729	726	727
May	697	696	701	698	702	705	710	720	718	717	718	719
June	711	711	713	714	713	714	722	730	735	731	731	733

TABLE V.

Number of observations and larger disturbances in each month.

	1841.		1842.		1843.		1844.		1845.	
	Obs.	Dis.	Obs.	Dis.	Obs.	Dis.	Obs.	Dis.	Obs.	Dis.
January	.....	.....	300	76	26	5	646	81	648	17
February	288	49	284	86	24	3	600	33	576	5
March	321	64	322	36	27	12	624	106	624	68
April	304	46	306	51	300	50	624	83	624	24
May	223	16	293	47	324	36	648	8	648	28
June	310	91	310	37	312	16	600	52	600	9
July	323	64	305	24	312	4	648	45	.....	.....
August	304	21	318	34	324	10	648	94	.....	.....
September	307	40	303	57	312	20	600	14	.....	.....
October	308	28	310	12	624	25	648	20	.....	.....
November	312	37	312	13	624	79	624	10	.....	.....
December	323	84	319	15	624	65	624	47	.....	.....
Sum	3323	540	3682	488	3833	325	7534	593	3720	151
Ratio	1 dis. in 6.2 obs.		1 dis. in 7.5 obs.		1 dis. in 11.8 obs.		1 dis. in 12.7 obs.		1 dis. in 24.6 obs.	

Total number of observations used, 22092; total number of larger disturbances, 2097; ratio of disturbances to observations, 1 to 10.5.

Investigation of the eleven-year (also called ten-year) period in the inequality of the amplitude of the diurnal variation of the vertical force.—The preceding monthly means of the bi-hourly and hourly normals were rearranged in four groups of one year each, necessarily omitting the first five months; the annual means have for their mean epoch, January, as the monthly means were arranged from July to July.

The means for the year 1842–'43 depend on nine months only. To refer them to the mean of twelve months, the differences for every observing hour between the same nine months and twelve months for the preceding and following year were made out, and the mean correction, giving the weight two to the following year, as indicated by the readings taken at the hour 14, was applied to the values of 1842–'43.

	From 9 months.	Correction.	Annual means.		From 9 months.	Correction.	Annual means.
0h	701	+3	704	Noon.	682	+8	690
2	696	+3	699	14	681	+6	687
4	697	+5	702	16	683	+7	690
6	697	+6	703	18	689	+7	696
8	690	+6	696	20	697	+5	702
10	686	+7	693	22	700	+5	705

The normals for 1843–'44 at the even hours are complete; at the odd hours they extend only over nine months. To refer the latter to twelve months, the difference between the means of the same nine months and the annual mean at the even hours was made out and applied as a correction to the means of the odd hours; the correction thus applied is the mean difference as deduced from the preceding and following even hour.

	Means of 9 months.	Correction.	Annual means.		Means of 9 months.	Correction.	Annual means.
1h	749	—11	738	13h	728	—14	714
3	746	—10	736	15	726	—16	720
5	746	—11	735	17	744	—16	728
7	744	—11	733	19	752	—15	737
9	737	—12	725	21	751	—14	737
11	730	—13	717	23	754	—13	741

TABLE VI.

Annual means of the bi-hourly and hourly normal values of the regular solar-diurnal variation of the vertical force.

The numbers are expressed in scale divisions; increasing values indicate decrease of force. The minutes at the head of each column are to be added to the hour given in the first column. Each year commences with the month of July. The time is local Philadelphia time counted from midnight to midnight.

Hour.	1841–'42. $+17\frac{1}{4}^m$	1842–'43. $+20\frac{1}{2}^m$	1843–'44. $+23\frac{1}{2}^m$	1844–'45. $+23\frac{1}{2}^m$
0 A. M.	650	704	740	765
1 "			738	761
2 "	643	699	735	759
3 "			736	760
4 "	643	702	737	761
5 "			735	761
6 "	640	703	734	761
7 "			733	759
8 "	634	696	727	752
9 "			725	751
10 "	632	693	722	749
11 "			717	747
12 "	633	690	717	745
13 P. M.			714	742
14 "	631	687	718	741
15 "			720	746
16 "	636	690	724	753
17 "			728	758
18 "	647	696	732	762
19 "			737	764
20 "	654	702	738	763
21 "			737	761
22 "	652	705	738	761
23 "			741	764
Means	641	697	730	756

The following formulæ of the mean diurnal variation of the vertical force were deduced from the above tabular values. The angle θ counts from midnight at the rate of 15° an hour.

1841–'42 $V = 641^d + 10^d.4 \sin(\theta + 106° 40') + 3^d.1 \sin(2\theta + 198° 25') + 1^d.7 \sin(3\theta + 250°)$
1842–'43 $V = 697 + 7.6 \sin(\theta + 69\ 17) + 2.9 \sin(2\theta + 196\ 48) + 1.3 \sin(3\theta + 195)$
1843–'44 $V = 730 + 11.0 \sin(\theta + 79\ 54) + 3.4 \sin(2\theta + 226\ 29) + 0.6 \sin(3\theta + 45)$
1844–'45 $V = 756 + 9.2 \sin(\theta + 83\ 40) + 4.3 \sin(2\theta + 233\ 41) + 1.1 \sin(3\theta + 1)$

In the construction of the equation for 1843–'44 weighted normals were used; those of the even hours have the weight 4, of the odd hours the weight 3.

To show the degree of accordance in the expressions when deduced from the even and odd hours separately, the resulting equations for the last year are added:—

Even hours: $V = 756 + 9.32 \sin(\theta + 84°45') + 4.07 \sin(2\theta + 235°17') + 1.2 \sin(3\theta + 353°)$
Odd " $V = 756 + 8.99 \sin(\theta + 82\ 36) + 4.52 \sin(2\theta + 232\ 05) + 1.0 \sin(3\theta + 10)$

The observed and computed values compare as follows. The differences, observed less computed, are expressed in scale divisions:

Hour.	1841–'42.	1842–'43.	1843–'44.	1844–'45.	
0	+2	+2	+1	+3	
2	−1	−1	−2	−2	
4	0	+1	+1	0	
6	+1	+1	+1	+2	17¼, 20½, 23¼, and 23½ minutes are to be added to the full hours for the four years respectively.
8	0	−1	−2	−3	
10	0	+1	+1	0	
Noon.	+1	+1	+1	+2	
14	−1	−1	+1	−2	
16	0	+1	0	+1	
18	+1	+1	0	+1	
20	0	0	+1	−1	
22	−1	0	−1	−1	

The graphical representation of the observed and computed values (Sketch No. 30) exhibits a maximum of the vertical force between 1 and 2 p. m., and a minimum of force between 8½ and 10½ a. m.; the diagrams also show a tendency to a secondary maximum about two hours after midnight, followed by a secondary minimum about two hours later, with a range probably less than two scale divisions (0.000066 parts of the force, or 0.00085 in absolute measure.) This small nocturnal inequality is only exhibited by one of the formulæ, in 1842–'43, when it has its greatest value; in the preceding year there is but a faint trace of it; in the two succeeding years it is indicated in the diagram by dashes. The average diurnal range is nearly 22 scale divisions (0.00073 parts of the vertical force, or 0.00932 in absolute measure.)

Epoch and amount of the principal maximum and minimum and amplitude of the diurnal inequality.

Year.	Maximum.		Minimum.		Amplitude.		
	Reading.	Epoch.	Reading.	Epoch.	Scale div.	In parts of v. f.	In absol. meas.
	d	*h. m.*	*d.*	*h. m.*	*d.*		
1841–'42	630.9	13 15	654.5	20 50	23.6	0.00078	0.01000
1842–'43	687.8	14 25	705.1	22 10	17.3	0.00057	0.00733
1843–'44	715.1	13 00	739.3	23 00	24.2	0.00080	0.01025
1844–'45	741.8	13 10	763.8	20 30	22.0	0.00073	0.00932
Mean		13½		21½	21.8		

The epochs are given to the nearest quarter of an hour.

If we compare the Philadelphia and Toronto curves, we find a general correspondence in their form, the early morning secondary inflection being well exhibited at Toronto; the epochs of the two curves, however, are shifted by nearly three hours, thus: at Toronto, principal maximum at 5 p. m., at Philadelphia 1½ p. m.; principal minimum at Toronto 10 a. m., at Philadelphia 9½ a. m.; the epochs of the early morning inflection are also about 3½ hours later at Toronto. The curves exhibit also a difference in the amplitude; at Toronto, Vol. III, the diurnal range is 0.00019 parts, whereas at Philadelphia we found it much larger.

The special study of the solar-diurnal variation of the vertical force is reserved for Part VIII.

The minimum diurnal range occurred in 1842–'43; on the average, therefore, we may assume May, 1843. as the epoch of the minimum range in the eleven (or ten) year period, resulting from the discussion of the declination, horizontal, and vertical force observations.

To facilitate the comparison with similar expressions at other stations, the preceding equations of the diurnal variation are also presented, expressed in parts of the vertical force. The angles have been changed 180° to reverse the order of progression of the scale numbers.

$$1841\text{–}'42\ V = +0.00034\ \sin(\theta + 286^\circ\ 40') + 0.00010\ \sin(2\theta + 18^\circ\ 25') + 0.00006\ \sin(3\theta + 70^\circ)$$
$$1842\text{–}'43\ V = +0.00025\ \sin(\theta + 249\ \ 17) + 0.00010\ \sin(2\theta + 16\ \ 48) + 0.00004\ \sin(3\theta + 15\ \ )$$
$$1843\text{–}'44\ V = +0.00036\ \sin(\theta + 259\ \ 54) + 0.00011\ \sin(2\theta + 46\ \ 29) + 0.00002\ \sin(3\theta + 255)$$
$$1844\text{–}'45\ V = +0.00030\ \sin(\theta + 263\ \ 40) + 0.00014\ \sin(2\theta + 53\ \ 41) + 0.00004\ \sin(3\theta + 181)$$

The constant terms and numerical coefficients, when expressed in absolute measure (English units), are as follows:

	Y	Term involving—		
		θ	2θ	3θ
1841–'42	12.85	0.00441	0.00131	0.00072
1842–'43	12.84	0.00322	0.00123	0.00055
1843–'44	12.83	0.00468	0.00144	0.00025
1844–'45	12.83	0.00388	0.00172	0.00047

The angle θ counts from midnight.

Investigation of the eleven (or ten) year inequality in the disturbances, and general analysis of the disturbances of the vertical force.—By means of Table V a new table was formed of the number of disturbances in each month for the years 1841–'42, 1842–'43, 1843–'44, 1844–'45, commencing with July, and all referred to a uniform series of bi-hourly observations; the numbers for and after October, 1843, were halved. The number of disturbances for January, February, and March, 1843, are the means between the same months in the preceding and following year. The annual means of this Table (VII) are as follows:

	Mean number of disturbances.
In 1841–'42	51
" 1842–'43	34
" 1843–'44	25
" 1844–'45	16

This seems to indicate the end of the year 1844 as the epoch of the minimum number of disturbances in the eleven year period, taking the numbers collectively for declination, horizontal and vertical force; the minimum probably took place in the spring of 1844.

If we take the monthly aggregate amount of the disturbances, all referred to a uniform series of bi-hourly observations, and form a table of these values for each year (Table VIII,) the mean aggregate amount for each year is as follows:

	Mean amount of disturbances.
In 1841–'42	2306 div.
" 1842–'43	1521
" 1843–'44	959
" 1844–'45	636

This again points to the end of the year 1844 for the epoch of the minimum amount of disturbances; and considering the three elements, declination, horizontal, and vertical force, the spring of 1844 might be assumed as the time of the minimum magnitude of the magnetic disturbances.

Altogether, the inequalities in the diurnal amplitude and in the number and magnitude of the disturbances of the magnetic elements, as observed at Philadelphia, fix the end of the year 1843, or the beginning of 1844, as the epoch of the minimum of the eleven (or ten) year inequality.

We now proceed with the analysis of the disturbances, their diurnal and annual inequality in number and amount, and for increasing and decreasing values.

Annual inequality in the number of disturbances.—The numbers for each month have been referred to a uniform series of bi-hourly observations as explained above. The ratios of the monthly means to the annual means are given, and also, for comparison, similar ratios found for the horizontal force and declination.

TABLE VII.

Annual inequality in the number of disturbances.

	1841-42	1842-43	1843-44	1844-45	Means from four years.	Vert. force ratio.	Hor. force. ratio.	Declination ratio.	Mean ratio of Vert. force, Hor. force, & declination.	Mean ratio of Hor. force and declination.
July	64	24	4	22	28	0.9	1.1	0.9	1.0	0.9
August	21	34	10	47	28	0.9	0.9	1.6	1.3	1.1
September	40	57	20	7	31	1.0	1.4	1.4	1.4	1.2
October	28	12	12	10	15	0.5	1.4	2.1	1.7	1.3
November	37	13	40	5	24	0.8	1.0	1.1	1.1	1.0
December	84	15	33	23	39	1.3	1.0	1.0	1.0	1.1
January	76	58	40	9	46	1.5	0.6	0.8	0.7	0.9
February	86	51	16	3	39	1.3	1.0	0.5	0.7	0.9
March	36	44	53	34	42	1.4	1.1	0.7	0.9	1.1
April	51	50	42	12	39	1.3	1.1	0.9	1.0	1.1
May	47	36	4	14	25	0.8	1.0	0.6	0.8	0.8
June	37	16	26	4	21	0.7	0.6	0.5	0.6	0.6
Mean	51	34	25	16	31					

The months of maximum disturbance are March and September, (the high value in January and the low one in October appear anomalous, and would no doubt disappear in a longer series of observations.) The minimum occurs in June; there is no well-expressed second minimum, (Sketch No. 30.) The horizontal force and declination ratios, as well as the ratios of the three elements at Toronto, give the maximum number of disturbances at the equinoxes and the minimum number at the solstices; and as the winter solstice minimum only is wanting in the Philadelphia vertical force ratios, it is probably due to the small number of observations, and the difficulty in keeping the instrument in adjustment and allowing for its irregularities. I have, therefore, given the mean ratio of the Philadelphia disturbances in the last column of Table VII, and compared the result, graphically, with those deduced by General Sabine for Toronto.*

If we separate the disturbances into two parts, those increasing and those decreasing the force, we obtain the numbers of Table VIII. A positive sign indicates disturbances increasing, a negative sign those decreasing the vertical force. The law of the annual variation seems to be the same as shown by the ratios in the last two columns; this accords with the result at Toronto.

* Page lxx., Vol. III.

TABLE VIII.

Annual inequality of disturbances increasing and decreasing the force.

	1841–'42.		1842–'43.		1843–'44.		1844–'45.		Ratios.	
	+	−	+	−	+	−	+	−	+	−
July	31	33	8	16	0	4	12	10	0.7	1.1
August	14	7	9	25	8	2	36	11	1.0	0.8
September	22	18	16	41	9	11	5	2	0.7	1.2
October	22	6	8	4	6	6	3	7	0.6	0.4
November	17	20	5	8	14	26	4	1	0.6	1.0
December	51	33	8	7	23	10	13	10	1.4	1.1
January	38	38	32	26	26	14	6	3	1.5	1.5
February	53	33	32	19	11	5	2	1	1.4	1.0
March	16	20	23	21	30	23	23	11	1.3	1.3
April	32	19	30	20	23	19	5	7	1.3	1.1
May	28	19	18	18	3	1	11	3	0.9	0.7
June	23	14	5	11	7	19	3	1	0.6	0.8

TABLE IX.

Aggregate and mean amount of disturbances in each month of the year.

The numbers are expressed in scale divisions and referred to a uniform series of bi-hourly observations. The mean amount or average magnitude is found by dividing the number in the preceding column by 4 and by the number of disturbances found in Table VII.

	Aggregate amount.				Sum of 4 years.	Mean amount.
	1841–'42.	1842–'43.	1843–'44.	1844–'45.		
July	2593	1255	149	784	4781	42
August	791	1323	622	2017	4753	43
September	1612	2798	770	301	5481	44
October	1216	432	488	438	2574	42
November	1564	503	1504	206	3777	40
December	4187	560	831	872	6450	42
January	3899	2745	1592	314	8550	47
February	3900	2279	659	109	6947	45
March	1672	1898	2125	1245	6940	42
April	2324	2111	1642	468	6545	42
May	2445	1625	186	704	4960	49
June	1472	723	934	168	3297	40

The last column shows that the magnitude of the disturbances is rather irregularly distributed over the several months wi hout following any apparent law.

TABLE X.

Aggregate and Mean Amount of Disturbances in each Month of the Year, separated into Two Groups of Increasing(+) and Decreasing Force (—).

The mean amount is obtained by means of the numbers of Table VIII.

	1841–'42.		1842–'43.		1843–'44.		1844–'45.		Sum of 4 years.		Mean amount.	
	+	—	+	—	+	—	+	—	+	—	+	—
July	1130	1463	340	915	0	149	402	382	1872	2909	37	46
August	555	236	359	964	279	343	1568	449	2761	1992	41	45
September	835	777	775	2023	397	373	251	50	2258	3223	43	45
October	999	217	300	132	250	238	128	310	1677	897	43	39
November	653	911	223	280	504	1000	154	52	1534	2243	38	41
December	2745	1442	276	284	508	323	489	383	4018	2432	42	41
January	2128	1771	1589	1156	1050	542	208	106	4975	3575	48	44
February	2615	1285	1533	741	462	197	76	33	4691	2256	48	39
March	671	1001	910	988	1149	976	875	370	3605	3335	39	44
April	1471	853	1361	750	853	790	172	296	3856	2689	43	41
May	1535	910	928	697	170	16	598	106	3231	1729	54	42
June	999	473	246	477	246	688	133	35	1624	1673	43	37
Sums	16336	11339	8845	9407	5867	5635	5054	2572	36102	28953		
Mean											43	42

The magnitudes of the disturbances, as before, do not appear to follow any law.

The disturbances which increase the force preponderate over those which decrease it; the ratio of the annual means is 1.3 to 1.0. At Toronto the reverse was found; the disturbances which decrease the force preponderate over those which increase it, in the ratio of 1.4 to 1.0.

Diurnal inequality of the disturbances.—In the bi-hourly combination of the disturbances we make use of the series of observations extending from February, 1841, to June, 1845, omitting only the single daily observation in January, February, and March, 1843. Strictly speaking, the time is 21 minutes later than indicated in the table.

TABLE XI.

Diurnal inequality in the number of disturbances.

The ratios of the three elements have been collected to facilitate comparison.

	Number vertical force.	Ratios.		
		Vertical force.	Horizontal force.	Declination.
0h.	168	1.3	1.1	1.0
2	159	1.2	0.9	1.2
4	156	1.2	0.7	1.0
6	133	1.0	0.7	1.1
8	117	0.9	0.8	1.0
10	115	0.8	1.1	1.1
Noon	131	1.0	1.3	0.9
14	163	1.2	1.0	0.8
16	127	0.9	1.1	0.9
18	116	0.8	1.1	0.9
20	110	0.8	1.1	1.0
22	123	0.9	1.1	1.1
Mean.	135			

The greatest number of disturbances occur about 0*h*. a. m., (at Toronto at 3 a. m.,) with the least number at 10 a. m., (at Toronto at 11 a. m.;) the secondary maximum and minimum occur about 2 p. m. and 7 p. m., (at Toronto the hours are 5 p. m. and 9 p. m.) On the average, therefore, the maxima and minima occur 1*h*. 40*m*. earlier at Philadelphia than at Toronto. At neither station do the three elements show the same law; they agree only in so far as to exhibit a systematic increase and decrease with the solar hours, and in having two maxima and two minima.

The diagram (Sketch No. 30) shows the law of the disturbances of the vertical force for Philadelphia and Toronto.

TABLE XII,

Contains the number of disturbances distributed over the hours of the day, separated into those which increase (+) and those which decrease (—) the vertical force.

	Number of disturbances.		Ratios.	
	+	—	+	—
0*h*.	93	75	1.3	1.2
2	73	86	1.0	1.3
4	69	87	1.0	1 4
6	62	71	0.9	1.1
8	59	58	0 8	0.9
10	53	62	0.8	1.0
Noon	61	70	0.9	1.1
14	96	67	1.3	1.0
16	69	58	1.0	0.9
18	72	44	1.0	0.7
20	67	43	0.9	0.7
22	76	47	1.1	0.7
Mean	71	64		

The laws which regulate the diurnal occurrence of the number of disturbances, increasing and decreasing the vertical force, are evidently not the same, yet they are by no means the converse of one another, as has been found to be the case in the disturbances of the declination and the horizontal force. At Toronto, also, where the horizontal force and declination curves were exactly opposed, that of the vertical force is not so, and at Philadelphia rather favors an agreement between the increasing and decreasing disturbances than an opposition.

Principal maximum of increasing disturbances 2 p. m., principal minimum 9 a. m., (at Toronto 5 p. m. and 5 a. m., respectively.) Secondary maximum at midnight; this may possibly be the principal maximum; secondary minimum at 8 p. m.

Principal maximum of decreasing disturbances 4 a. m., principal minimum 8 p. m., (at Toronto 3. a. m. and 6 p. m., respectively.) The secondary maximum at noon is less distinctly marked; secondary minimum at 8 a. m.

Thus the epochs of the curves for increasing and decreasing force seem to be 12 hours apart.

DIURNAL INEQUALITY IN THE MAGNITUDE OF THE DISTURBANCES.

TABLE XIII,

Contains the aggregate amount of disturbances and their average magnitude, the latter found by means of Table XI. All expressed in scale divisions.

	Aggregate amount.	n	Mean amount.
0*h*.	7049	168	42
2	6876	159	43
4	6480	156	42
6	5418	133	41
8	5022	117	43
10	5096	115	44
Noon	5526	131	42
14	7101	163	44
16	5591	127	44
18	5571	116	48
20	4773	110	43
22	5246	123	43

Average magnitude 43 scale divisions. The disturbances appear to be nearly of the same size at all hours; there is a slight preponderance in magnitude between 10 a. m. and 10 p. m. over the other half of the day.

TABLE XIV.

Aggregate amount and mean amount of disturbances, separated into those which increase and those which decrease the vertical force.

	Aggregate amount.		Mean amount.		Difference of aggregate amount.
	+	−	+	−	
0*h*.	3737	3312	40	44	+ 425
2	3221	3655	44	43	− 434
4	2866	3614	42	42	− 748
6	2577	2841	42	40	− 264
8	2524	2498	43	43	+ 26
10	2507	2589	47	42	− 82
Noon	2731	2795	45	40	− 64
14	4456	2645	46	40	+ 1811
16	2969	2622	43	45	+ 347
18	3456	2115	48	48	+ 1341
20	3003	1170	45	41	+ 1233
22	3258	1988	43	42	+ 1270
Mean	----------	----------	44.0	42.5	+ 4861

The magnitude of the disturbances, either increasing or decreasing the force, apparently does not vary with the hours of the day. The disturbances which increase the force preponderate between the hours 2 p. m. and 2 a. m.; those which decrease the same occur in the other half of the day. The average ratio of the preponderance of increase over decrease is as 4 to 1.

Dividing the numbers in the last column of the preceding table, or the excess of the sum of disturbances increasing the force over the sum of those decreasing the same, by the total number of days (1297) of observation, we find the diurnal disturbance variation as follows:

	Scale divisions.	In parts of vertical force.	In absolute measure.
0h.	+0.3	+0.00001	+0.00013
2	—0.3	—0.00001	—0.00013
4	—0.6	—0.00002	—0.00025
6	—0.2	—0 00001	—0.00008
8	0.0	0.00000	0.00000
10	—0.1	0.00000	—0.00004
Noon	0.0	0.00000	0 00000
14	+1.4	+0.00004	+0.00059
16	+0.3	+0.00001	+0.00013
18	+1.0	+0.00003	+0.00042
20	+1.0	+0.00003	+0.00042
22	+1.0	+0.00003	+0.00042
Mean	+0 3	+0.00001	+0 00013

The value for the hour 14 is evidently anomalous; the mean of the hours 12 and 16, or $+0^{d}.2$ (0.00001 in parts of force, 0.00008 in absolute measure,) should be substituted. The average daily effect of the larger disturbances is therefore to increase the vertical force between 1 p. m. and midnight, and to decrease it between 1 a. m. and noon, with an amplitude of about 1.6 scale division, (0.00005 parts of the force, 0.00067 in absolute measure.) The maximum value takes place at 8 p. m., the same hour at which the horizontal force disturbance is greatest (decreasing that force.)

The disturbance law at Toronto is nearly the same as at Philadelphia; the disturbances increase the force between noon and 9 p. m., and decrease it in the remaining hours of the day; the range at Toronto appears to be larger.

If we classify the disturbances, according to their magnitude, in eight groups, each differing 25 scale divisions from the preceding, we find the following scale numbers:

Disturbances, in scale divisions.	Between limits in parts of the force.	Number.
30 and 55	0 00099 and 0.00181	1840
55 and 80	0.00181 and 0.00263	211
80 and 105	0.00263 and 0.00346	28
105 and 130	0.00346 and 0.00428	15
130 and 155	0.00428 and 0.00511	0
155 and 180	0.00511 and 0.00593	2
180 and 205	0.00593 and 0.00676	0
205 and 230	0.00676 and 0.00759	1
Beyond		None.

SUPPLEMENT TO PART VII.

EFFECT OF THE AURORA BOREALIS ON THE MAGNETIC DECLINATION, AND THE HORIZONTAL AND VERTICAL FORCE, AS OBSERVED AT THE GIRARD COLLEGE OBSERVATORY.

There were in all 22 auroras recorded; these, however, comprise only the brighter displays. Of those observed, 7 occurred between May 30, 1840, and July 1, 1841; 1 occurred between July, 1841, and July, 1842; 6 occurred between July, 1842, and July, 1843; and 7 between July, 1843, and July, 1844. One is recorded in the last year, ending June 30, 1845. They are distributed over the several months as follows:

January	2	July	6
February	0	August	3
March	1	September	2
April	2	October	0
May	3	November	1
June	2	December	0

In the summer months there were 18, in the winter months 4. In reference to the hours of the night, the phenomenon was visible, on the average, between 9½ p. m. and 11¼ p. m.

Individual examination of the magnetic record during auroral displays. The time is local time, counted, for convenience sake, from midnight to midnight to 24 hours.

I. 1840, May 29th—30th. As the twilight faded an aurora became visible. In the course of the display there were moving pillars, flashes from a low segment of light in the north, and a beautiful arch nearly or quite at right angles to the magnetic meridian. Pillars of aurora from 21*h*. 18*m*. to 22*h*. 2*m*., varying in brightness and position; low segment of light to the north, continued throughout the appearances; at 22*h*. 5*m*. an arch forms from east to west; streams of light, varying in brightness, fading and reappearing from 22*h*. 20*m*. to about 23*h*. 10*m*.; the brightest flash at 23*h*. 6*m*. From 18*h*. 54*m*. the declination magnet commenced to move eastward (declination decreasing,) reaching an extreme position at 20*h*. 34*m*., difference from average position about 56 divisions, or 19′; the movement then became westerly with smaller fluctuations till 22*h*. 39*m*., when it reached its westerly extreme of about 71 divisions, or 24′ from the normal place; the magnet reached a second easterly extreme at 23*h*. 44*m*. of about 48 divisions, or 17′, at 1*h*. 24*m*. (30th) again a westerly extreme of about 7′, and at 2*h*. 49*m*. an easterly deflection of about 14′; after this the needle returned gradually to its ordinary position. About the time of the brightest flash the change (easterly motion) was very rapid; no extreme value, however, was reached. When the arch formed, the position was nearly normal. The horizontal force decreased steadily until 22*h*. 42*m*., when the readings fell beyond the scale; a minimum was reached between that time and 22*h*. 52*m*. of at least 0.016 (parts of the force) below the normal force. At the time of the brightest flash the retrograde movement was in progress. The disturbance of the vertical force commenced before 17*h*. 52*m*., at which time the force was a maximum; it then decreased very rapidly, and finally moved off the scale after 22*h*. 2*m*. (The value of a division of the scale was not ascertained.)

II. 1840, July 4th. At 20*h*. auroral light in the N. NW. about 10° above the horizon; at 22*h*. very faint aurora still visible in NW. The declination was not at all affected. The horizontal force at these hours was 85 divisions (0.003 parts of the force) less than the normal amount. The vertical force is apparently undisturbed; it is slightly above the normal value.

III. 1840, July 6th. An aurora was noticed at 0*h*. 25*m*. and 2*h*. 25*m*. The declination was disturbed at 0*h*. 19½*m*. and 2*h*. 19½*m*.; it indicated 50 divisions and 34 divisions, or 17′ and 12′ of easterly deflection. It is likely that there were disturbances two hours preceding and two hours following the above times, as the scale could not be read. The horizontal force was disturbed from midnight till 2 p. m.; the force was less during this time, and reached its minimum value at 2*h*. 22*m*. of 130 divisions, or 0.005 parts of the force; between 2 and 8 a. m., the diminution was about 0.004 parts. The vertical force was also less from midnight till after 2*h*. 17*m*.; the greatest diminution probably took place later, as the observations failed at 4*h*. 17*m*. Minimum value at 2*h*. 17*m*., 0.004 parts of the force.

IV. 1840, July 29th. At 22*h*. 25*m*. a faint aurora. The declination was not disturbed. The horizontal force was very slightly affected. At 2*h*. 22*m*. it was 0.001 parts less than the normal, at 22*h*. 22*m*. it was nearly normal, and at 0*h*. 22*m*. (30th) it was greater by 0.002. There may have been ordinary disturbances not immediately connected with the aurora. At 22*h*. 17*m*. the vertical force was slightly affected; the force decreased 0.002 parts below the normal.

V. 1840, August 19th. At 20*h*. 25*m*. auroral light in N.; 22*h*. 25*m*. aurora continues in N. and NW. The declination disturbance commenced at 22*h*. 20*m*. and continued to 2*h*. 20*m*. (20th,) west deflection 48 divisions (22′,) 10 divisions, and 10 divisions. The horizontal force was disturbed from 16*h*. 22*m*. to 22*h*. 22*m*., force less 43 divisions, 49, 102, and 85 divisions (in minimo 0.004 parts of the force.) The vertical force seems lower than usual, but hardly reached the limit of a recognized disturbance.

VI. 1840, August 28th and 29th. An aurora appeared at 20*h*. 39½*m*. in N.NE., disappeared at 21*h*. 19½*m*., reviving at 21*h*. 59½*m*.; at 22*h*. 9½*m*. streamers moving from E. to W.; light continued in N.; streamers again in NE. at 22*h*. 59½*m*. and 1*h*. 14½*m*., after which time the aurora was not observed. An easterly movement of the needle commenced about 20*h*. 19*m*. with a maximum eastern deflection of 125 divisions (or 57′) at 21*h*. 0*m*.; the westerly motion continued till 21*h*. 55*m*. when the needle was yet 5′ east of its normal position; smaller fluctuations were observed till midnight; the deflection was then 19′ east; half an hour later it was 20′ east; the morning extreme was reached at 1*h*. 35*m*., when the deflection was 25′ east; after this the disturbance gradually subsided. There was a disturbance of the horizontal force about 18*h*. 20*m*.; from about 21*h*. 52*m*. till 10 the next morning the horizontal force remained below its normal value. At 23*h*. 32*m*. it was 0.009 (parts) below, at 0*h*. 22*m*. it was 0.007, and at 1*h*. 22*m*. its minimum value of 0.010 (parts of the force) was reached. The disturbance in the vertical force appears to have commenced about 21*h*. 7*m*., when the force gradually decreased till 21*h*. 57*m*., when it reached a minimum of about 0.003 (parts); after this it gradually increased.

VII. 1840, September 21st. At 20*h*. 25*m*. faint aurora; 22*h*. 25*m*. aurora disappeared. Disturbance of the declination commenced at 20*h*. 20*m*., and continued to 4*h*. 20*m*. (22d;) deflections 40 divisions (18′) W., 10 divisions E., 14 divisions W., and 23 divisions E. The horizontal force disturbance commenced at 16*h*. 22*m*., and ceased at 4*h*. 22*m*. next day; force less 69 divisions, 47 divisions, 71 divisions, 42 divisions, 94 divisions, 124 divisions (0.005 parts of the force), and 93 divisions. The vertical force between 16*h*. and 22*h*. was slightly above the average, but suddenly became much smaller than the normal between midnight and 3 a. m. Minimum about 0.002 parts of the force.

VIII. 1842, April 14th. At 22*h*. 40*m*. appearance of aurora, a bright light in the N.; at 0*h*. 20*m*. (15th) an arc of light was visible extending to about 15° above the north horizon. Declination disturbed from 22*h*. 20*m*. to 8*h*. 20*m*. (15th); deflections at the regular observing hours 23 divisions W., 39 E., 11, 37, 10, and 14 divisions W. Maximum west deflection at 22*h*. 56*m*., 58 divisions (26′,) maximum east deflection 39 divisions (18′), derived from the series of extra observations. The horizontal force disturbances commenced at 22*h*. 22*m*., and ceased at 4*h*. 22*m*; force less 39 divisions, 149 divisions, 37 divisions, and 50 divisions; minimum 279 divisions (0.010 parts of the force,) at 1*h*. 16*m*. (15th.) But one of the 69 extra readings during this aurora shows an increase of force. The vertical force disturbances commenced at 0*h*. 17½*m*. (15th,) and continued to 6*h*. 17½*m*.; force less 68 divisions, 69 divisions, 59 divisions, and 38 divisions. Minimum value 111 divisions, or 0.0037 parts of the force, at 1*h*. 24*m*. (15th.)

IX. 1842, September 2d. At 2*h*. 22m. a bright light extending on each side of N. point about 15°, and to about 6° above the horizon; at 2*h*. 49*m*. light spreading and becoming more faint; at 3*h*. 12*m*. light faint and gradually subsiding. The declination was very slightly affected; maximum west deflection at 3*h*. 26*m*., 19 divisions (9′.) The horizontal force was not disturbed. The vertical force was likewise undisturbed.

X. 1842, November 21st, and 22d. A well developed aurora, and the best observed of the series. At 22*h*. 23*m*. a very luminous arc extending to about 15° above the horizon, and about 90° along it in the north; 22*h*. 38*m*. light slightly increasing; 22*h*. 53*m*. a slight decrease of light; 23*h*. 18*m*. light alternately appearing and disappearing; 23*h*. 33*m*. four streamers of unusual brightness, reaching 30° above horizon; 23*h*. 36*m*. light particularly bright in NW., whence a large streamer of 20° is shooting, also one due north of 15°; 23*h*. 40*m*. light subsided, no streamers; 23*h*. 43*m*. small streamers appearing; 23*h*. 46*m*. large streamers attended with great light in NW.; 23*h*. 48*m*. the arc still remains about 15° above horizon, but has shortened its chord to 30°, no streamers; 23*h*. 51*m*. arc scarcely visible; 0*h*. 23*m*. (22d) two arcs visible; 0*h*. 28*m*. a large streamer of 20° in length; 0*h*. 36*m*. considerable light without the arc; 1*h*. 08*m*. light very faint; 1*h*. 23*m*. slight appearances of arc; 1*h*. 33*m*. faint streamer of 10°; 1*h*. 58*m*. faint streamer of 20°; 2*h*. 48*m*. a large

but faint streamer due N. about 20° in length; light has nearly disappeared; 3*h*. 3*m*. light scarcely visible; 3*h*. 33*m*. no light visible, and readings of instrument ordinary. The declination disturbances commenced at 22*h*. 20*m*., and ceased at 10*h*. 20*m*. (22d); deflections 49 divisions W., 20 divisions W., 25, 20, 8, 25, and 16 divisions E. The maximum W. deflection (22′) occurred at the commencement, with the appearance of the luminous arc; the needle remained deflected to the westward until towards the end, when there was a smaller easterly deflection. No special effect of the streamers is noticed. The horizontal force disturbances commenced at 16*h*. 22*m*., and continued to 2*h*. 22*m*. (22d); horizontal force less 33 divisions, 68, 82, 183 divisions (0.007 parts of the force); this diminution was about the time of the appearance of the arc, 125 divisions and 73 divisions at the last two regular observing times. The streamers did not appear to have any special effect. The horizontal force always remained smaller than the normal value at the respective hours. The vertical component was not affected.

XI. 1843, May 6 and 7. At 19*h*. 48*m*. a bright light; at 2*h*. 18*m*. (7th) light to N. about 23° high, but faint. The declination disturbances commenced at 16*h*. 20*m*., and continued to about 3*h*. (7th). The deflections at the regular hours were 28, 30, 16 divisions E., 15 divisions W. (20*m*. after midnight), maximum east deflection 18′, succeeding maximum west deflection 9′, next following maximum east deflection 33′, following maximum west deflection 15′. The horizontal force disturbances commenced at the same hour with the declination disturbances, and continued to the end of the series of observations. The change commenced with a violent increase of 113 divisions above the normal value, and increased to 330 divisions (0.012 parts of the force) at 18*h*. 04*m*., corresponding in time to the first maximum east deflection. The force then decreased, reaching 132 divisions below the normal value, and attaining shortly (16*m*.) after midnight the extraordinary low value 348 divisions (0.013 parts of the force); up to the end of the disturbance the force remained below the standard amount. The vertical force was suddenly disturbed; at 18*h*. 23½*m*. it was 161 divisions greater than the mean, and at 22*h*. 23½*m*. but 41 divisions above the normal. Maximum value 164 divisions (equal to 0.0054 parts of the force) at 18*h*. 12*m*.

XII. 1843, May 8. At 0*h*. an aurora visible to north. The declination was but slightly affected; at 19*h*. 32*m*. there was an easterly deflection of 15 divisions, or 7′; at 20*h*. 26*m*. it was west 4′; after this there was an easterly motion, changing again to west, which reached an extreme value at 23*h*. 44*m*. of 17 divisions, or 8′ W. From the commencement of the horizontal force observations (17*h*. 38*m*.) the force was less than the normal; at 20*h*. 4*m*. the greatest depression was 0.003 (parts of the force). The disturbance continued till 6 a. m., the force being less than the standard value. From 17*h*. 38*m*., when the vertical force was observed, it was found less than the normal; at 20*h*. 36*m*. depression 20 divisions, at 0*h*. 23*m*. it was 31 divisions, or 0.001 parts of the force below the standard value.

XIII. 1843, June 27. At 22*h*. a bright diffused light to north, particularly bright to NW., whence streamers are shooting up; general light weakens as it rises at 20*h*. 45*m*.; at 21*h*. 15*m*. a brilliant light, dark cumulus spots in the bright light, and long streaks of dark clouds to N. Fades at 22*h*. 13*m*., light to N. faint; dark, fuzzy, low cumuli form and disappear to N. Neither the declination nor the horizontal force was disturbed by this aurora. The vertical force was slightly affected; force less 38 divisions, or 0.0012 parts of the force.

XIV. 1843, June 30. At 23*h*. aurora visible to the N.NE., flaming to about 10°. The declination disturbances commenced at 22*h*. 20*m*., (9 divisions W.,) they reach a maximum at 0*h*. 02*m*. (July 1) of 20 divisions (9′,) and gradually disappear, the deflections having been west throughout. The horizontal force is smaller than the normal value; a first minimum is reached about 20*h*. 44*m*., (about 45 divisions,) and the principal minimum about 0*h*. 10*m*. (July 1) of nearly 50 divisions, (0.0018 parts of the force.) The vertical force remained undisturbed.

XV. 1843, July 7. At 20*h*. 52*m*. very light in the N.NE. and NW. The declination at 18*h*. 20*m*. is deflected 15 divisions E.; the motion then became westerly and reached 29 divisions (13′) W. at 23*h*. 33*m*.; at 2*h*. 20*m*. (8th) the deflection is again 16 divisions W. The horizontal force is less than usual, with a minimum value about 20*h*. 52*m*. of 55 divisions, (0.002 parts). The force then increases, and about midnight reaches slightly above the normal. The vertical force was not disturbed.

XVI. 1843, July 24 and 25. According to a letter (dated July 25) from one of the observers, auroral disturbances commenced about 16*h*. (July 24) and quieted down about 21*h*. At 16*h*. 20*m*. the declinometer was deflected 15 divisions E.; about 4*h*. (25th) the disturbances reappeared, deflecting 10 divisions W., and changed to east deflection at 6*h*. 20*m*., reaching a maximum east of 34 divisions (15′) at 13*h*. 20*m*. At 16*h*.

22*m*. the horizontal force was about 46 divisions less, with disturbances reappearing about 8*h*. 22*m*., reaching at 8*h*. 46*m*. 96 divisions (0.0015 parts of the force) below the normal, and quieting down about one hour after noon. The vertical force was not sensibly disturbed.

XVII. 1843, July 25. At 21*h*. 30*m*. (25th) streamers to N., flaming to about 30°; at 22*h*. streamers very bright, reaching about 40°; at 22*h*. 15*m*. light very faint and gradually disappearing. The declination was disturbed (deflections west) between 20*h*. 20*m*. and 22*h*. 20*m*., reaching a maximum at 21*h*. 58*m*. of 36 divisions (16′). The horizontal force decreased between 18*h*. 22*m*. and 22*h*. 22*m*., reaching at 21*h*. 34*m*. 91 divisions (0.0033 parts) below the normal value. The vertical force apparently undisturbed.

XVIII. 1843, August 22. At 20*h*. 22*m*. there were streamers of 35° in length, bright light in N. Between 14*h*. 20*m*. and 18*h*. 20*m*. there was a small east deflection of the magnet, reaching 28 divisions at the latter hour; at 19*h*. 56*m*. it changed to a west deflection of the same amount (13.′) At the time of the appearance of the streamers the declination was normal. During the aurora the horizontal force diminished, reaching at 20*h*. 28*m*. 91 divisions (0.0033 parts) below the normal. The low value continued for about two hours after this time. The vertical force was not sensibly affected.

XIX. 1844, January 24 and 25. Aurora visible to N. and N.NE. at 0*h*. 22*m*. (25th,) streamers running up 30°; 0*h*. 33*m*. streamers running up 15° and 20°. During this aurora the horizontal needle was deflected to the westward about 10 divisions, reaching a maximum at 6*h*. 58*m*. of 15 divisions (7′); at the time of the appearance of the shorter streamers the deflection was near 7′, the horizontal force was below the normal value, viz: decrease 36 divisions, 41 and 35 divisions at 22*h*. 22*m*., 23*h*. 22*m*., and 0*h*. 22*m*. (25th,) minimum 47 divisions, (0.0017 parts). At the time of the longer streamers there was an average decrease, and during the continuance of the shorter streamers the horizontal force was normal. At 0*h*. 23½*m*. and 2*h*. 23½*m*. the vertical force was 36 and 32 divisions smaller than the normal. Difference, 0.0011 parts of the force.

XX. 1844, March 29. At 16*h*. 51*m*. cloudy, aurora visible. The declination magnet is deflected to the east and west several times in succession; between 16*h*. 20*m*. and 18*h*. 20*m*., about 14 divisions E., and 16 divisions E.; the following greatest west deflection of 61 divisions (27′) occurred at 20*h*. 10*m*.; the next east deflection reached a maximum at 0*h*. 22*m*. (30th) of 41 divisions; a maximum west deflection was again reached at 1*h*. 14*m*. of 50 divisions (23′). The horizontal force is throughout smaller than the normal value, with differences varying on the average from 50 to 70 divisions. The greatest difference was reached at 20*h*. 2*m*. of nearly 100 divisions, (0.0036 parts of the force;) at 23*h*. 47*m*. another small value of 90 divisions was observed. The vertical force was disturbed from 21*h*. 23½*m*. to 4*h*. 23½*m*. (30th.) Force less 49 divisions, 55, 44, 73, 49, 52, 55, and 31 divisions. Minimum value, 0.0024 parts of the force.

XXI. 1844, April 17. At 2*h* 20*m*., although cloudy, it was very bright at the north; same remark at 22*h*. 20*m*. The declination disturbances extend nearly over the whole day. The deflection was at first west, (between 0*h*. 20*m*. and 4*h*. 20*m*.,) with a maximum value of 48 divisions (22′) at 3*h*. 10*m*.; it then changed to the east, at 6*h*. 04*m*. it reached 52 divisions (23′;) up to 20*h*. 20*m*. the deflection was slightly to the east. The horizontal force was diminished early in the morning, attaining a first minimum at 2*h*. 40*m*. of 47 divisions; it increased for a short time, reaching at 4*h*. 14*m*. 52 divisions above the normal; the force again decreased and reached at 5*h*. 47*m*. the lowest value of 151 divisions (0.0055 parts;) it remained below the normal value for several hours. At 19*h*. 53*m*. the diminution was 41 divisions. Vertical force disturbed from 3*h*. to 8*h*. (+23½*m*.), force less 52 divisions, 58, 61, 66, 53, and 35 divisions. Minimum value, 0.0022 parts of the force.

XXII. 1845, January 9. At 17*h*. 20*m*. an aurora visible. The declination magnet is deflected east and west alternately; first maximum east deflection at 16*h*. 32*m*. of 20 divisions; following maximum west at 17*h*. 02*m*. of 11 divisions; following east deflection about 20 divisions 12*m*. later; next west deflection at 17*h*. 2*m*. 21 divisions; at 19*h*. 56*m*. the deflection again east 32 divisions; at 21*h*. 38*m*. it is west 40 divisions (18′); at 22*h*. 20*m*. it is east 33 divisions. The horizontal force between 15*h*. 52*m*. and midnight is considerably smaller than the normal value; a minimum is reached at 17*h*. 16*m*. of 155 divisions, (0.0056 parts of the force). The disturbances ceased between 2*h*. and 3*h*. on the morning of the 10th. The vertical force was disturbed at 17*h*. 20, 22, and 23*h*. (+23½*m*.,) force greater 44 divisions, 31, 35, and 33 divisions. Average increase, 0.0012 parts of the force.

From the preceding detailed account of the condition of the declination, and of the horizontal and vertical components of the magnetic force during auroral displays, we obtain the following general results: Each of the 22 auroras recorded was accompanied by a corresponding disturbance of the earth's magnetism, at least in one of the three elements; in one case the declination alone was affected, in another case only the horizontal force, and in a third only the vertical force. The latter force was less subject to disturbances than the other two elements.

In the following table, showing the condition of the magnetic components during auroras, the first column contains the number of the aurora; the second the amount of declination deflection; the third its direction or the successive large excursions of the north end eastward or westward; the fourth the amount of the horizontal force disturbance expressed in parts of that force, (a minus sign indicates less force than the normal belonging to that time, a plus sign indicates the reverse); the last column contains the amount of disturbance in the vertical force expressed in parts of that force; the signs have the same signification as for the horizontal force.

Number.	Amount of deflection.	Direction of deflection and excursions.	Excess (+) or defect (—) of horizontal force.	Excess (+) or defect (—) of vertical force.
1	24′	E. W. E. W. E.	—0.016	— (?)
2	----------	----------	—0.003	----------
3	17	E.	—0.005	—0.004
4	----------	----------	∓0.002	—0.002
5	22	W.	—0.004	----------
6	57	E.	—0.010	—0.003
7	18	W. E. W. E.	—0.005	—0.002
8	26	W. E. W.	—0.010	—0.004
9	9	W.	----------	----------
10	22	W. E.	—0 007	----------
11	33	E. W. E. W.	±0.013	+0.005
12	8	E. W. E. W.	—0.003	—0.001
13	----------	----------	----------	—0.001
14	9	W.	—0.002	----------
15	13	E. W.	—0.002	----------
16	15	E. W. E.	—0.002	----------
17	16	W.	—0.003	----------
18	13	E. W.	—0.003	----------
19	7	W.	—0.002	—0.001
20	27	E. W. E. W.	—0.004	—0.002
21	23	W. E.	+0.006	—0.002
22	18	E. W. E. W. E. W. E.	—0.006	+0.001

The action on the declination magnet appears to be that of alternate deflections either way from the normal position; in five cases the deflection was west; in two cases east; more frequently there were one or two successions of west and east deflections (or the reverse); in one instance even three; these alternate excursions appear to be a characteristic sign. In five cases the tendency of the deflection was easterly, in six cases westerly, and in the remaining eight cases in both directions. The average amount of deflection is 17′. With but one exception the uniform effect upon the horizontal force was to decrease it. In the exceptional case a decrease followed the increase; in another case the reverse took place; during one aurora there was at first a fall in the force, then a rise, and again a fall. The average depression of the horizontal force below the normal value was 0.005 parts of the force, (0.021 in absolute measure). The effect upon the vertical force is small; in nine cases no disturbance occurred; in general the force is less than the normal; there are two exceptions to this in the 13 cases. The average depression of the vertical force below its normal was 0.0007 parts of the force (0.009 in absolute measure). or, irrespective of sign, 0.0013 parts of the force. If we wish to compare the tabular differences in declination and horizontal and vertical force with the magnitude of the recognized disturbances, the latter are 4′ and 0.001 (parts of the force) for either the horizontal or vertical component.

Of the auroras noted that of May 29, 1840, was in many respects the most remarkable, and the best observed both as to its appearance and as to its magnetic effect; its study can be recommended to those who have occasion to test their theoretical views in reference to this phenomenon, and to terrestrial magnetism. Its appearance at New Haven, Conn., has been described by E. C. Herrick, (Sill. Jour., 1840, Vol. XXXIX, p. 194). It was seen over a great portion of the United States, in Canada, and England. See, also, description in the volume of the Toronto observations; also an extract from the proceedings of the British Association, (Sill. Jour., Vol. XL, p. 337); also (p. 338, ibid.) note on the same by the astronomer royal.

The total number of auroras which occurred at Philadelphia was much greater than the number given above, as has already been stated. At Toronto the annual distribution of the phenomenon over the same period of time, and for three years beyond the close of the record at Philadelphia, is as follows:

In 1840, (from March)	on 23	nights.
" 1841	36	"
" 1842	14	"
" 1843	16	"
" 1844	20	"
" 1845	19	"
" 1846	27	"
" 1847	29	"
" 1848	66	"

These figures seem to indicate the existence of a period of frequency, probably of eleven years, as conjectured by Prof. Wolf; the least number probably occurred in 1843, if we make an allowance for invisibility of the phenomenon either by daylight or by cloudy weather.

Between June, 1840, and July, 1845, (inclusive,) there were seen, according to the Toronto record, 109 auroras. The disturbances at Philadelphia on the dates of their appearance have been classified as follows: The numbers give the relative proportion to the total number, which latter is expressed by 100; the average numbers are given resulting from the examination of the disturbances of the declination, the horizontal and the vertical force.

	Number of cases.
No record at Philadelphia	19
None of the elements disturbed	30
But very few disturbances	20
An ordinary number of disturbances	14
An unusual number of disturbances	17

The number of unusual disturbances is, therefore, less than one-fifth of the total amount and in fully one-half of the cases the magnetic elements were either not at all or but very slightly affected.

APPENDIX No. 20.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844 AND 1845.—PART VIII. INVESTIGATION OF THE SOLAR-DIURNAL VARIATION AND OF THE ANNUAL IRREGULARITY OF THE VERTICAL COMPONENT OF THE MAGNETIC FORCE.—BY A. D. BACHE, LL.D.

(From the Smithsonian Contributions to Knowledge.)

THE necessary data for this investigation are given in the preceding part (VII), which contains the normals resulting from the reduction of the observations to the same temperature (66° Fah.), from the allowance for irregularity in the progressive change, and the exclusion of all recognized disturbances.

Owing to the greater irregularity in the indications of the vertical force instrument, and the comparatively small number of observations at odd hours, the normals are given for the even hours only; the observations at odd hours, however, are used to improve those taken at the intermediate even hours by means of a suitable process of interpolation.

The tabular numbers are expressed in scale divisions—one division being equal to 0 000033 parts of the vertical force, or equal to 0.000423 in absolute measure. Increasing numbers denote decrease of force. The hours count from midnight to midnight to 24 hours; the number of minutes the observations are made later than the full hour are given in the last column for each month.

Normals of the vertical force for July.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	703	.....	697	.....		.....	671	.....	667	.....	664	.....
1842	683	.....	672	.....	687	.....	659	.....	657	.....	650	.....
1843	691	.....	692	.....	664	.....	686	.....	679	.....	672	.....
1844	816	811	804	806	692	802	798	793	784	783	782	780
					805							
Means[1]	722	.....	717	.....	712	.....	703	.....	698	.....	692	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	665	.....	676	.....	680	.....	698	.....	708	.....	706	.....	+17
1842	643	.....	643	.....	647	.....	663	.....	677	.....	682	.....	+17½
1843	662	.....	658	.....	659	.....	666	.....	677	.....	685	.....	+23½
1844	780	776	773	781	783	791	799	805	808	809	811	816	+23½
Means[1]	687	.....	688	.....	693	.....	706	.....	717	.....	721	.....	+20.4

[1] Let reading for any even hour $= n$ for the year 1844, for the odd hours preceding and following $n\,p$ & $n\,f$, mean $\frac{n\,p+n\,f}{2}$; hence mean for the even hour $\frac{1}{2}\left(n+\frac{n\,p+n\,f}{2}\right)$ which was substituted before the general mean for the four years was taken.

Normals of the vertical force for August.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	686	.....	680	.....	676	.....	664	.....	662	.....	652	.....
1842	689	.....	689	.....	683	.....	682	.....	679	.....	672	.....
1843	703	.....	703	.....	708	.....	706	.....	698	.....	683	.....
1844	794	790	786	781	783	777	776	769	763	760	756	754
Means	718	.....	715	.....	712	.....	706	.....	700	.....	691	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	653	.....	662	.....	666	.....	676	.....	689	.....	691	.....	+17
1842	652	.....	659	.....	669	.....	679	.....	688	.....	688	.....	+17½
1843	669	.....	671	.....	672	.....	682	.....	695	.....	699	.....	+23½
1844	750	750	746	759	764	771	778	789	790	789	792	794	+23½
Means	681	.....	686	.....	693	.....	704	.....	715	.....	718	.....	+20.4

Normals of the vertical force for September.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	663	.....	655	.....	646	.....	647	.....	637	.....	631	.....
1842	692	.....	686	.....	689	.....	690	.....	681	.....	671	.....
1843	721	.....	719	.....	721	.....	716	.....	707	.....	706	.....
1844	816	815	813	812	811	810	809	805	798	795	790	785
Means	723	.....	718	.....	717	.....	715	.....	706	.....	699	.....

Normals of the vertical force for September—Continued.

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	627	.....	628	.....	634	.....	645	.....	653	.....	660	.....	+17
1842	671	.....	673	.....	672	.....	679	.....	687	.....	693	.....	+17½
1843	693	.....	692	.....	692	.....	703	.....	714	.....	710	.....	+23½
1844	780	779	772	794	793	795	806	813	812	812	814	817	+23½
Means	693	.....	693	.....	698	.....	708	.....	717	.....	719	.....	+20.4

Normals of the vertical force for October.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	579	.....	578	.....	573	.....	568	.....	558	.....	556	.....
1842	706	.....	698	.....	702	.....	714	.....	695	.....	708	.....
1843	714	710	707	713	712	714	717	714	706	704	703	701
1844	775	771	769	773	776	779	780	780	774	773	773	770
Means*	694	.....	689	.....	691	.....	694	.....	684	.....	685	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	561	.....	562	.....	571	.....	577	.....	581	.....	583	.....	+17
1842	707	.....	706	.....	706	.....	708	.....	710	.....	709	.....	+17½
1843	702	700	703	701	704	709	714	717	719	715	714	717	+23½
1844	769	766	773	777	786	788	791	789	785	785	781	781	+23½
Means	685	.....	685	.....	692	.....	697	.....	699	.....	697	.....	+20.4

Normals of the vertical force for November.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	532	.....	537	.....	538	.....	533	.....	526	.....	523	.....
1842	717	.....	713	.....	723	.....	725	.....	712	.....	715	.....
1843	742	740	745	743	745	744	744	748	742	739	737	729
1844	775	772	768	769	772	771	770	773	768	772	772	767
Means	691	.....	691	.....	694	.....	693	.....	688	.....	686	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	520	.....	521	.....	526	.....	529	.....	531	.....	538	.....	+17
1842	711	.....	713	.....	716	.....	712	.....	718	.....	718	.....	+17½
1843	735	731	731	738	746	749	749	751	749	747	746	748	+23½
1844	766	763	762	765	774	779	777	778	774	770	769	772	+23½
Means	682	.....	683	.....	690	.....	692	.....	693	.....	693	.....	+20.4

* Let m equal any reading at an even hour in 1843 or 1844, $m\,p$ and $m\,f$ the same for the odd hours preceding and following, then mean for the even hour $\frac{1}{4}\left(m+\frac{mp+mf}{2}\right)$ which was substituted for the above value at the even hour in 1843 and 1844 before the general mean of the four years was taken.

Normals of the vertical force for December.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	597	.....	591	.....	590	.....	606	.....	592	.....	598	.....
1842	713	.....	707	.....	709	.....	706	.....	715	.....	711	.....
1843	752	744	733	742	740	742	740	743	740	740	729	720
1844	754	753	754	755	757	756	755	758	749	751	750	746
Means	703	.....	697	.....	699	.....	703	.....	700	.....	697	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	605	.....	597	.....	607	.....	610	.....	605	.....	604	.....	+17
1842	709	.....	707	.....	706	.....	711	.....	713	.....	713	.....	+17½
1843	727	729	743	749	758	760	767	763	764	757	754	757	+23½
1844	743	733	736	724	748	757	755	751	751	748	750	750	+23½
Means	695	.....	695	.....	704	.....	710	.....	707	.....	705	.....	+20.4

Normals of the vertical force for January.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1842	658	.....	642	.....	656	.....	649	.....	656	.....	653	.....
1843	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1844	733	739	730	728	732	733	732	732	730	725	720	713
1845	754	747	747	752	752	757	763	767	760	758	753	752
Means	716	.....	707	.....	713	.....	715	.....	715	.....	709	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1842	664	.....	650	.....	663	.....	675	.....	670	.....	663	.....	+17½
1843	.....	.....	*690	.....	.....	.....	.....	.....	.....	.....	.....	.....	+17
1844	715	708	715	724	737	740	741	743	744	745	744	744	+23½
1845	751	748	749	742	753	760	756	753	749	746	747	754	+23½
Means	709	.....	705	.....	717	.....	724	.....	721	.....	719	.....	+21.5

Normals of the vertical force for February.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	664	.....	664	.....	662	.....	656	.....	654	.....	650	.....
1842	706	.....	701	.....	713	.....	721	.....	699	.....	698	.....
1843	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1844	734	729	725	726	729	728	729	730	723	724	722	717
1845	760	756	752	757	759	760	763	764	756	756	752	749
Means	718	.....	711	.....	716	.....	717	.....	709	.....	705	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	644	.....	648	.....	647	.....	673	.....	668	.....	665	.....	+17
1842	709	.....	692	.....	698	.....	712	.....	723	.....	710	.....	+17½
1843	.....	.....	(697)	.....	.....	.....	.....	.....	.....	.....	.....	.....	+17
1844	718	716	716	720	727	731	738	739	740	737	735	733	+23½
1845	747	741	740	744	753	759	761	761	758	753	752	756	+23½
Means	704	.....	700	.....	706	.....	720	.....	722	.....	716	.....	+20.4

* No use is made of this reading, nor of the analogous readings in the following two months.

Normals of the vertical force for March.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	670	.....	661	.....	661	.....	655	.....	651	.....	645	.....
1842	655	.....	643	.....	654	.....	663	.....	657	.....	661	.....
1843	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1844	768	761	763	760	764	762	765	762	758	761	762	764
1845	749	741	736	742	746	748	749	746	736	733	732	729
Means	709	.....	701	.....	705	.....	707	.....	701	.....	700	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	643	.....	646	.....	656	.....	665	.....	666	.....	673	.....	+17
1842	651	.....	650	.....	657	.....	668	.....	673	.....	665	.....	+17½
1843	.....	.....	(686)	.....	.....	.....	.....	.....	.....	.....	.....	.....	+17
1844	762	753	758	760	754	757	753	754	752	753	763	764	+23½
1845	729	729	713	734	740	747	751	746	741	740	739	743	+23½
Means	696	.....	694	.....	703	.....	709	.....	708	.....	710	.....	+20.4

Normals of the vertical force for April.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	671	.....	662	.....	658	.....	653	.....	645	.....	646	.....
1842	668	.....	658	.....	655	.....	655	.....	656	.....	654	.....
1843	715	.....	712	.....	717	.....	716	.....	708	.....	702	.....
1844	776	773	771	765	766	765	759	755	749	749	744	740
1845	732	727	728	729	728	727	725	721	718	715	717	717
Means	712	.....	706	.....	705	.....	702	.....	696	.....	693	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	646	.....	649	.....	656	.....	666	.....	670	.....	676	.....	+17
1842	657	.....	651	.....	650	.....	660	.....	672	.....	672	.....	+17½
1843	709	.....	700	.....	696	.....	696	.....	710	.....	709	.....	+23½
1844	737	733	737	741	745	744	756	767	768	765	767	775	+23½
1845	716	713	717	720	724	724	732	737	736	729	726	727	+23½
Means	693	.....	691	.....	694	.....	702	.....	711	.....	711	.....	+21.0

Normals of the vertical force for May.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	669	.....	665	.....	660	.....	654	.....	647	.....	649	.....
1842	673	.....	670	.....	661	.....	644	.....	646	.....	647	.....
1843	698	.....	699	.....	695	.....	690	.....	682	.....	680	.....
1844	772	769	766	768	767	764	760	754	749	747	747	744
1845	720	718	717	719	716	715	713	709	705	702	701	699
Means	706	.....	704	.....	700	.....	692	.....	686	.....	685	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	644	.....	646	.....	650	.....	660	.....	674	.....	679	.....	+17
1842	651	.....	644	.....	645	.....	656	.....	668	.....	670	.....	+17½
1843	677	.....	668	.....	677	.....	685	.....	691	.....	695	.....	+23½
1844	744	740	747	744	746	748	754	763	766	766	768	772	+23½
1845	697	696	701	698	702	705	710	720	718	717	718	719	+23½
Means	683	.....	680	.....	684	.....	693	.....	703	.....	706	.....	+21.0

Normals of the vertical force for June.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1841	646	.....	631	.....	622	.....	617	.....	624	.....	616	.....
1842	674	.....	669	.....	664	.....	658	.....	647	.....	642	.....
1843	698	.....	691	.....	693	.....	687	.....	677	.....	668	.....
1844	776	772	767	768	767	764	760	755	747	745	744	744
1845	733	731	729	730	729	728	726	722	717	715	715	711
Means	705	.....	698	.....	695	.....	690	.....	683	.....	677	.....

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Min.
1841	603	.....	624	.....	635	.....	650	.....	653	.....	657	.....	+17
1842	635	.....	639	.....	635	.....	653	.....	671	.....	668	.....	+17½
1843	663	.....	658	.....	659	.....	669	.....	681	.....	689	.....	+23½
1844	742	739	744	747	749	754	760	769	771	770	771	775	+23½
1845	711	711	713	714	713	714	722	730	735	731	731	733	+23½
Means	671	.....	675	.....	678	.....	691	.....	702	.....	703	.....	+21.0

TABLE I.—*Recapitulation of the bi-hourly normals of the vertical force (expressed in scale divisions) for each month of the year.*

(Increase of scale readings denotes decrease of force.)

1841–'45.	0h.	2h.	4h.	6h.	8h.	10h.	Noon.	14h.	16h.	18h.	20h.	22h.	(+20m.6)
January	716	707	713	715	715	709	709	705	717	724	721	719	.....
February	718	711	716	717	709	705	704	700	706	720	722	716	.....
March	709	701	705	707	701	700	696	694	703	709	708	710	.....
April	712	706	705	702	696	693	693	691	694	702	711	711	.....
May	706	704	700	692	686	685	683	680	684	693	703	706	.....
June	705	698	695	690	683	677	671	675	678	691	702	703	.....
July	722	717	712	703	698	692	687	688	693	706	717	721	.....
August	718	715	712	706	700	691	681	686	693	704	715	718	.....
September	723	718	717	715	706	699	693	693	698	708	717	719	.....
October	694	689	691	694	684	685	685	685	692	697	699	697	.....
November	691	691	694	693	688	686	682	683	690	692	693	693	.....
December	703	697	699	703	700	697	695	695	704	710	707	705	.....
Year	709.7	704.5	704.9	703.1	697.2	693.2	689.9	689.6	696.0	704.7	709.6	709.8	.....
Summer	714.3	709.7	706.8	701.3	694.8	689.5	684.7	685.5	690.0	700.7	710.8	713.0	.....
Winter	705.2	699.3	703.0	704.8	699.5	697.0	695.2	693.7	702.0	708.7	708.3	706.7	.....

The months from April to September, inclusive, comprise the summer half year; those from October to March, inclusive, the winter half year.

TABLE II.—*Mean values of the normals for each month and season.*

1841–'45.		1841–'44.		1841–'45.	
January	714.2	July	704.7		
February	712.0	August	703.3	Year	701.0
March	703.6	September	708.8	Summer	700.0
April	701.3	October	691.0	Winter	702.0
May	693.5	November	689.7		
June	689.0	December	701.2		

Subtracting each value of Table I from its respective monthly mean as given in Table II, and converting the remainder into parts of the force, we find the regular solar-diurnal variation presented in the following table:

TABLE III.—*Regular solar-diurnal variation of the vertical force expressed in parts of the force.*

(A plus sign indicates a greater, a minus sign a less, value than the mean. The first three places of decimals 0.000 have been placed on the side.)

0.000	1841–'45.	0h.	2h.	4h.	6h.	8h.	10h.	Noon.	14h.	16h.	18h.	20h.	22h.	+20m.6
	January	—059	+238	+040	—026	—026	+172	+172	+304	—092	—323	—224	—158	
	February	—198	+033	—132	—165	+099	+231	+264	+396	+198	—264	—330	—132	
	March	—178	+086	—046	—112	+086	+119	+251	+317	+020	—178	—145	—211	
	April	—353	—155	—122	—023	+175	+274	+274	+340	+241	—023	—329	—320	
	May	—412	—346	—214	+049	+247	+280	+346	+445	+313	+016	—315	—412	
	June	—528	—297	—198	—033	+198	+396	+594	+462	+363	—066	—429	—462	
	July	—571	—406	—241	+056	+221	+419	+584	+551	+386	—043	—406	—538	
	August	—485	—386	—287	—089	+109	+406	+736	+571	+340	—023	—386	—485	
	September	—469	—304	—271	—205	+092	+323	+521	+521	+356	+026	—271	—337	
	October	—099	+066	—000	—099	+231	+198	+198	+198	—033	—198	—264	—198	
	November	—043	—043	—142	—109	+086	+122	+254	+221	—010	—076	—109	—109	
	December	—059	+139	+040	—059	+040	+139	+205	+205	—092	—290	—191	—125	
	Year	—287	—115	—131	—068	+129	+257	+366	+377	+165	—121	—282	—290	
	Summer	—469	—317	—221	—040	+175	+350	+508	+482	+333	—020	—353	—426	
	Winter	—106	+086	—040	—096	+082	+162	+224	+274	—000	—221	—211	—155	

Multiplying the above numbers by Y=12.83, we obtain the solar-diurnal variation in absolute value.

TABLE IV.—*Regular solar-diurnal variation of the vertical force in absolute measure.*

(A greater force than the mean is indicated by a plus sign, a less force by a minus sign. The first two places of decimals 0.00 are placed on the side.)

0.00	1841–'45.	0h.	2h.	4h.	6h.	8h.	10h.	Noon.	14h.	16h.	18h.	20h.	22h.	+20m.6
	January	—076	+305	+051	—034	—034	+220	+220	+389	—118	—415	—289	—203	
	February	—254	+042	—170	—212	+127	+296	+338	+508	+254	—338	—423	—169	
	March	—229	+110	—059	—144	+110	+152	+321	+406	+025	—228	—186	—271	
	April	—452	—198	—157	—030	+224	+351	+351	+436	+309	—030	—410	—410	
	May	—529	—444	—275	+064	+317	+360	+444	+571	+402	+021	—402	—529	
	June	—677	—380	—254	—042	+254	+508	+761	+592	+465	—085	—550	—592	
	July	—732	—520	—308	+072	+283	+537	+749	+706	+495	—055	—520	—690	
	August	—622	—495	—368	—114	+140	+520	+943	+732	+436	—030	—495	—622	
	September	—601	—389	—346	—263	+118	+415	+668	+668	+457	+034	—347	—431	
	October	—127	+085	—000	—127	+296	+254	+254	+254	—042	—254	—338	—254	
	November	—055	—055	—182	—140	+072	+157	+326	+283	—013	—098	—140	—140	
	December	—076	+178	+051	—076	+051	+178	+263	+263	—118	—372	—245	—161	
	Year	—368	—148	—168	—087	+165	+329	+470	+483	+212	—156	—364	—372	
	Summer	—601	—406	—284	—051	+224	+448	+651	+618	+426	—025	—453	—546	
	Winter	—136	+110	—051	—123	+106	+207	+288	+351	—000	—283	—271	—199	

Annual inequality in the diurnal variation of the vertical force.—If we examine the average curve of the diurnal variation as observed throughout the year, and shown on diagram A, (sketch No. 30,) by a full black line, we find the principal maximum value about 1 p. m., and the principal minimum value about 9½ p. m.; besides these characteristic values there is an indication of a secondary maximum about 2 a. m., and of a secondary minimum about 4 a. m. Dividing the year into a summer and winter season, the diagram exhibits the diurnal variation in summer to be a curve of but one maximum and one minimum, occurring about noon and midnight, respectively; whereas in winter the double feature of the curve becomes very conspicuous, the secondary maximum and minimum occurring about 2 and 6 a. m., respectively. The phenomenon, in the two seasons, changes, therefore, from a single to a double crested curve.

The semi-annual change of the diurnal variation is better shown in diagram B, (sketch No. 30,) which contains the difference from the annual curve in summer and winter, viz :

	0h.	2h.	4h.	6h.	8h.	10h.	Noon.	14h.	16h.	18h.	20h.	22h.	(+20m. 6)
Summer.....	—182	—201	—90	+28	+46	+93	+142	+105	+168	+101	—71	—136	
Winter.....	+181	+202	+91	—28	—47	—95	—142	—103	—165	—100	+71	+135	

At $5\frac{1}{2}$ a. m. and 7 p. m. there is no change in the diurnal variation throughout the year; at the hours 2 a. m. and 4 p. m. the change is a maximum, viz: range equal 0.000403 parts and 0.000333 parts of the force, or equal 0.00517 and 0.00427 when expressed in absolute measure.

The turning epochs of the annual inequality as found from the hours 2 a. m. and 4 p. m., are derived from the following table, in which the numbers are expressed in parts of the force; the numbers in the last column were obtained by changing the sign of the afternoon difference before taking the mean.

	2 a. m. 0.000.	Differences. 0.000.	4 p. m. 0.000.	Differences. 0.000.	Mean difference. 0.000.
January.....	+238	+353	—092	—257	+305
February.....	+033	+148	+198	+033	+058
March.....	+086	+201	+020	—145	+173
April.....	—155	—040	+241	+076	—058
May.....	—346	—231	+313	+148	—190
June.....	—297	—182	+363	+198	—190
July.....	—406	—291	+386	+221	—256
August.....	—386	—271	+340	+175	—223
September.....	—304	—189	+356	+191	—190
October.....	+066	+181	—033	—198	+190
November.....	—043	+072	—010	—177	+125
December.....	+139	+254	—092	—257	+256
Mean.....	—115	.....	+165	.....	.....

The figures in the last column are represented by the equation

$$\Delta_a = +\ 0.000260\ \sin\ (\theta + 86^\circ) + 0.000031\ \sin\ (2\theta + 180^\circ)$$

the angle θ counting from January 1 at the rate of 30° a month. According to this expression the transition of the inequality from a positive to a negative value, and vice versa, takes place in the first quarter of April and October, or about 17 days after the equinoxes. The retardation of the phenomenon in the declination, horizontal and vertical force, is, therefore, 10, 22, and 17 days, respectively, or 16 days on the average.

Analysis of the solar-diurnal variation of the vertical force.—For greater facility of the investigation, and for purposes of comparison, the numbers of Table I have been expressed analytically. The angle θ counts from midnight at the rate of 15° an hour.

For January, $\Delta_v = 714^d.2 + 4.8\ \sin\ (\theta + 134^\circ\ 09') + 5.5\ \sin\ (2\theta + 224^\circ\ 22') + 0.8\ \sin\ (3\theta + 61^\circ)$

For February, $\Delta_v = 712^d.0 + 7.5\ \sin\ (\theta + 91^\circ\ 47') + 5.1\ \sin\ (2\theta + 226^\circ\ 22') + 1.6\ \sin\ (3\theta + 273^\circ)$

For March, $\Delta_v = 703^d.6 + 5.5\ \sin\ (\theta + 98^\circ\ 24') + 3.6\ \sin\ (2\theta + 220^\circ\ 22') + 0.7\ \sin\ (3\theta + 95^\circ)$

For April, $\Delta_v = 701^d.3 + 10.5\ \sin\ (\theta + 89^\circ\ 12') + 2.2\ \sin\ (2\theta + 175^\circ\ 59') + 1.3\ \sin\ (3\theta + 232^\circ)$

For May, $\Delta_v = 693^d.5 + 13.1\ \sin\ (\theta + 85^\circ\ 17') + 1.9\ \sin\ (2\theta + 144^\circ\ 31') + 1.8\ \sin\ (3\theta + 278^\circ)$

For June, $\Delta_v = 689^d.0 + 15.8\ \sin\ (\theta + 87^\circ\ 22') + 3.1\ \sin\ (2\theta + 193^\circ\ 56') + 0.4\ \sin\ (3\theta + 210^\circ)$

For July, $\Delta_v = 704^d.7 + 17.4\ \sin\ (\theta + 86^\circ\ 30') + 2.6\ \sin\ (2\theta + 174^\circ\ 16') + 0.7\ \sin\ (3\theta + 300^\circ)$

For August, $\Delta_v = 703^d.3 + 17.1\ \sin\ (\theta + 81^\circ\ 10') + 3.7\ \sin\ (2\theta + 215^\circ\ 50') + 0.5\ \sin\ (3\theta + 75^\circ)$

For September, $\Delta_v = 708^d.8 + 14.3\ \sin\ (\theta + 73^\circ\ 57') + 2.9\ \sin\ (2\theta + 210^\circ\ 24') + 0\ 3\ \sin\ (3\theta + 165^\circ)$

For October, $\Delta_v = 691^d.0 + 6.1\ \sin\ (\theta + 119^\circ\ 48') + 3.1\ \sin\ (2\theta + 236^\circ\ 28') + 1.1\ \sin\ (3\theta + 210^\circ)$

$$\text{For November, } \triangle_v = 689^d.7 + 4.4 \sin(\theta + 83^\circ 33') + 3.0 \sin(2\theta + 254^\circ 00') + 0.0$$

$$\text{For December, } \triangle_v = 701^d.2 + 4.5 \sin(\theta + 133^\circ 49') + 4.3 \sin(2\theta + 231^\circ 57') + 1.0 \sin(3\theta + 63^\circ)$$

We have also for summer half year (April to September inclusive), for winter half year (October to March inclusive), and for the whole year, the following expressions for the diurnal variation:

$$\text{For summer, } \triangle_v = 700^d.1 + 14.6 \sin(\theta + 83^\circ 40') + 2.5 \sin(2\theta + 191^\circ 01') + 0.5 \sin(3\theta + 255^\circ)$$

$$\text{For winter, } \triangle_v = 702^d.0 + 5.1 \sin(\theta + 108^\circ 54') + 4.0 \sin(2\theta + 229^\circ 58') + 0.0$$

$$\text{For year, } \triangle_v = 701^d.0 + 9.7 \sin(\theta + 90^\circ 17') + 3.0 \sin(2\theta + 216^\circ 22') + 0.2 \sin(3\theta + 255^\circ)$$

The following comparison may serve to show the general representation of the observations by the analytical expressions:

Comparison for August.

	Observed.	Computed.	Difference.
h. *m.*			
0. 20.6	718	718.2	0
2...do	715	715.1	0
4...do	712	711.3	+1
6...do	706	707.0	−1
8...do	700	699.9	0
10...do	691	690.6	+1
12...do	681	683.0	−2
14...do	686	684.3	+2
16...do	693	693.5	0
18...do	704	705.0	−1
20...do	715	713.9	+1
22...do	718	718.4	0

The summer months are better represented than the winter months; in May the difference is below half a scale division; in the winter season in several instances it rises to 3, and in one case to 4 scale divisions.

Diagram C (Sketch No. 30) exhibits the diurnal variation, observed and computed, for the six summer months. Diagram D the same for the six winter months.

The numerical values of the coefficients B_1 B_2 B_3 in the general equation

$$\triangle_v = A + B_1 \sin(\theta + C_1) + B_2 \sin(2\theta + C_2) + B_3 \sin(3\theta + C_3)$$

expressed in parts of the horizontal force, are given in Table V. The first three decimals (0.000) have been placed in front of the table.

TABLE V.

Month.		B_1	B_2	B_3
January	0.000	158	181	026
February		247	168	053
March		181	119	023
April		346	073	043
May		432	063	059
June		521	102	013
July		574	086	023
August		564	122	016
September		472	096	010
October		201	102	036
November		145	099	000
December		148	142	033
Summer		482	082	016
Winter		170	132	001
Year		320	099	007

The next table contains the numerical values of B_1 B_2 B_3 expressed in absolute measure, and the angles C_1 C_2 C_3 obtained by the addition of 180° to their preceding values, so as to make increasing values correspond to increasing force. The first two decimals for B are placed at the head of the columns.

TABE VI.

Mouth.	B_1 0. 00.	C_1	B_2 0. 00.	C_2	B_3 0. 00.	C_3
		° ′		° ′		°
January	203	314 09	233	44 22	034	241
February	317	271 47	216	46 22	068	93
March	233	278 24	152	40 22	030	275
April	444	269 12	093	355 59	055	52
May	554	265 17	080	324 31	076	98
June	668	267 22	131	13 56	017	30
July	736	266 30	110	354 16	030	120
August	723	261 10	157	35 50	021	255
September	606	253 57	123	30 24	013	345
October	258	299 48	131	56 28	047	30
November	186	263 33	127	74 00	000	----------
December	190	313 49	182	51 57	042	243
Summer	618	263 40	106	11 01	021	75
Winter	218	288 54	169	49 58	002	----------
Year	410	270 17	127	36 22	008	75

The next diagram E (Sketch No. 30) exhibits the general feature of the diurnal inequality for the year and its summer and winter season, as computed by means of the preceding formulæ. The greatest difference between the observed and computed values at any one hour is but $2\frac{1}{3}$ scale divisions at 2 a. m. in the winter season, and $1\frac{1}{2}$ divisions at the same hour in the annual curve. The absence of the secondary wave in the early morning hours during summer is as conspicuous as its presence in the winter season; in the annual curve there is barely a trace of it left. We also recognize again the earlier occurrence of the maximum and minimum values in winter and their later appearance in summer. If we examine the resulting curves at Toronto* we find there the secondary morning fluctuation equally well marked in summer and winter; and if we inquire into this feature for each year separately, we find great irregularities between the hours 14 (Toronto astronomical time) and 22; in 1843 the secondary maximum and minimum is plainly developed; in 1844, and especially in 1845, it cannot be traced. Diagram F (Sketch No. 30) exhibits the curves for Philadelphia for each year. In 1841 and 1842 the curves are smooth, in 1843 the wave appears well marked, in 1844 it is just perceptible. These apparent irregularities are probably due to imperfections in our instruments; on the other hand, if we take the Philadelphia series, there may be a cyclic appearance and disappearance of this wave.

Table VII exhibits the computed times of the principal maximum and minimum of the vertical force, together with the amount of difference from its average daily value at these epochs, expressed in scale divisions; also the time and amount of the early morning secondary fluctuation traceable only in the winter months; for these last values the diagrams have been made use of.

* Vol. III of the Toronto Observations, Table LXVIII.

TABLE VII.

	Maximum at	Amount in scale divisions.	Minimum at	Amount in scale divisions.	Time elapsed between max. & min.	Secondary maximum at	Amount.	Secondary minimum at	Amount.	Secondary range.
	h. m.	*d.*	*h. m.*	*d.*	*h. m.*	*h.*		*h.*		
January	13 7	— 8.5	19 27	+ 9.4	6 20	$2\frac{1}{2}$	—4	7	+2	6
February	13 41	—11.5	20 21	+10.6	6 40	$1\frac{1}{2}$	+1	$4\frac{1}{2}$	+4	3
March	12 46	— 8.9	21 4	+ 6.7	8 18	3	—1	$6\frac{1}{2}$	+2	3
April	13 52	—10.2	22 4	+11.8	8 12	----------	------	----------	------	----------
May	14 34	—13.1	22 58	+12.6	8 24	----------	------	----------	------	----------
June	13 9	—17.2	22 35	+16.2	8 26	----------	------	----------	------	----------
July	13 33	—18.2	23 10	+17.3	9 37	----------	------	----------	------	----------
August	13 2	—20.8	23 6	+15.5	10 04	----------	------	----------	------	----------
September	13 23	—16.8	23 20	+12.6	9 57	----------	------	----------	------	----------
October	11 16	— 7.6	20 34	+ 8.7	9 18	2	—1	5	+1	2
November	12 35	— 7.4	19 59	+ 3.9	7 24	1	+1	$4\frac{1}{2}$	+3	2
December	12 31	— 7.8	19 9	+ 7.8	6 38	3	—3	7	+1	4
Summer	13 29	—15.8	22 55	+14.1	9 26	----------	------	----------	------	----------
Winter	12 43	— 8.2	20 8	+ 7.6	7 25	2	—1	6	+2	3
Year	13 2	—11.9	21 25	+ 9.7	8 23	----------	------	----------	------	----------

The extreme variation in the time of the maximum in the course of a year is $3^h\ 18^m$, and of the minimum $4^h\ 11^m$.

At Toronto the occurrence of the maxima and minima is later than at Philadelphia; from Table LXVIII, Vol. III of the Toronto Observations, we find the maximum at 5^h, a secondary minimum at 14^h, a secondary maximum at 18^h, and the minimum at 22^h; the maximum is therefore apparently delayed at Toronto 4^h, the minimum $4\frac{3}{4}^h$, the secondary wave is likewise retarded by about 4 hours. This epochal difference I take, most likely, to be a distinctive feature due to the localities; there is also a remarkable difference in the amount of the diurnal range, as will presently appear. The degree of sensibility in the adjustment of the centre of gravity of the instrument affects most the latter difference, whereas the epochal difference may be supposed to depend, in a measure, upon the sensibility of the magnet in regard to changes of temperature and consequent changes of magnetism.

The change in the adopted value of the correction for 1° of change in the temperature (expressed in scale divisions) as used in present reduction (10.8), and as used in four volumes of record and reduction (13.5) gives us the means of a partial test of the effect on the epochs: we find from the plates in Vol. IV the time of the maximum $1\frac{1}{2}$ p. m. and of the minimum $11\frac{1}{2}$ p. m., which, though somewhat nearer to the Toronto epochs, still leave a large discrepancy.

TABLE VIII.

Amplitude of the diurnal variation of the vertical force.

	Maximum 0.00	Minimum 0.00	Range 0.00	Maximum 0.00	Minimum 0.00	Range 0.0
January	028	031	059	359	398	0757
February	038	035	073	484	447	0931
March	029	022	051	377	283	0660
April	034	039	073	431	500	0931
May	043	042	085	555	535	1090
June	057	054	110	725	686	1411
July	060	057	117	769	733	1502
August	068	051	119	878	654	1532
September	055	041	097	712	532	1244
October	025	029	054	323	369	0692
November	024	013	037	313	166	0479
December	026	026	052	330	332	0662
Summer	052	046	098	667	597	1264
Winter	027	025	052	349	322	0671
Year	039	032	071	503	410	0913
	In parts of the force.			In absolute measure.		

The diurnal range at Toronto is very much less than at Philadelphia; in 1841–'42 the range was but one-half of that observed at Philadelphia, and for later years (see Table LXVIII of Vol. III of the Toronto Observations) the ranges compare as follows: Toronto 0.00019, Philadelphia 0.00071.

In diagram G (Sketch No. 30) the diurnal range for each month is exhibited (expressed in parts of the force.)

Table IX contains the times when the mean value of the vertical force is reached each day, arranged for monthly averages. In some months the average daily value is attained four times, but generally only twice. The table contains the two principal epochs (one a. m. the other p. m.;) those produced by the secondary wave can easily be made out by means of the diagrams.

TABLE IX.

Principal epochs of mean vertical force.

	A. M.	P. M.
	h. m.	*h. m.*
January	8 58	3 47
February	7 42	5 16
March	8 27	4 53
April	6 15	6 13
May	5 55	6 21
June	6 36	6 4
July	6 8	6 10
August	7 30	6 4
September	7 51	6 28
October	6 34	4 19
November	8 11	4 49
December	8 27	3 39
Summer	6 43	6 13
Winter	7 52	4 29
Year	7 6	5 33

The next table contains the computed diurnal variation of the vertical force, expressed in absolute measure; compared with Table IV, it shows the differences between the observed and computed values.

TABLE X.

Computed solar-diurnal variation of the vertical force, expressed in absolute measure.

The first two places of decimals 0.00 are placed on the side; + indicates more, — less than the monthly average.

0.00	1841–45.	0h.	2	4	6	8	10	Noon.	14	16	18	20	22h.	+20m.6
	January	+025	+165	+123	—030	—046	+161	+355	+258	—080	—351	—376	—203	
	February	—072	—085	—178	—123	+063	+258	+436	+465	+203	—241	—444	—283	
	March	—135	—017	—008	—072	—013	+207	+372	+304	+059	—165	—275	—258	
	April	—385	—266	—165	+008	+216	+338	+402	+436	+317	—025	—385	—491	
	May	—516	—461	—262	+068	+309	+372	+448	+554	+423	—000	—402	—533	
	June	—601	—419	—245	—042	+241	+533	+711	+681	+398	—068	—503	—685	
	July	—706	—550	—279	+034	+305	+537	+723	+744	+457	—051	—499	—714	
	August	—630	—499	—338	—157	+144	+563	+859	+804	+414	—072	—448	—639	
	September	—512	—431	—351	—207	+076	+431	+673	+677	+436	+047	—321	—516	
	October	—055	+030	—030	—008	+165	+309	+300	+182	—004	—237	—377	—275	
	November	—059	—089	—148	—131	+017	+207	+313	+233	+046	—123	—161	—106	
	December	—008	+110	+097	—008	—008	+182	+330	+203	—114	—313	—304	—165	
	Year	—309	—211	—152	—055	+123	+343	+495	+457	+211	—131	—368	—402	
	Summer	—558	—440	—275	—050	+212	+465	+634	+651	+410	—025	—423	—600	
	Winter	—046	+017	—021	—051	+034	+216	+338	+271	+021	—228	—321	—216	

A graphical representation of the above tabular numbers is given in diagram H, (Sketch No. 30,) based upon the three variables: the hour of the day, the month, and the difference of vertical force from the normal monthly value. The contour lines of the magnetic surface differ 0.001 of vertical force (in absolute measure.) Full lines indicate greater value, lines of dashes less value than the normal, dotted lines represent the normal value.

Annual inequality of the vertical force.—The minor and irregular disturbances in the adjustment of the magnetometer, as well as the effect of the progressive and secular changes, tend to make the determination of the annual inequality in the vertical force a task of some delicacy, and the results deduced from our series of observations should be considered as approximate.

Taking the monthly normals of the years 1842, 1843, and 1844, the only years which could be made complete, and correcting the monthly means for 42 scale divisions of annual increase, the following table was formed:

Monthly normals.

Year.	January.	Feb'u'ry	March.	April.	May.	June.	July.	August.	Sept'ber.	October.	Nov'ber.	Dec'ber.
1842	658	707	658	659	656	655	662	677	682	706	716	710
1843	702	710	691	707	686	678	677	691	708	710	742	746
1844	731	728	760	756	756	758	796	773	801	778	770	749
Mean	697	715	703	707	699	697	712	714	730	731	743	735
Corr'n	+19	+16	+12	+ 9	+ 5	+ 2	— 2	— 5	— 9	—12	—16	—19
Corr'd m.	716	731	715	716	704	699	710	709	721	719	727	716
Mean monthly val.	— 1	—16	0	— 1	+11	+16	+ 5	+ 6	— 6	— 4	—12	— 1

The vertical force appears, therefore, to be greater in May, June, July, and August, and less in the remaining months; the range is about 32 scale divisions =0.00105 parts of the force, or 0.0135 in absolute measure.

APPENDIX No. 21.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART IX, INVESTIGATION OF THE INFLUENCE OF THE MOON ON THE MAGNETIC VERTICAL FORCE. BY A. D. BACHE, L.L. D., SUPERINTENDENT UNITED STATES COAST SURVEY.

The method of discussion of the lunar effect on the vertical component of the magnetic force in no way differs from that employed for the horizontal component, which latter has been explained in Part VI.

The series of observations available for the lunar discussion extends from February, 1841, to June, 1845, inclusive. From February, 1841, to October, 1843, the observations are bi-hourly; from October, 1843, to the end of the series they are hourly. The record of May, 1841, is not quite complete, and in January, February, and March, 1843, but one observation a day is recorded. As increasing numbers denote a decrease of force, a positive sign of the tabulated differences between monthly normals and each individual undisturbed reading (at the normal temperature) indicates a greater force than the normal value, a negative sign indicates the reverse. 30 scale divisions being the limit beyond which difference an observation has been considered as belonging to the class of disturbances, all differences here recorded are below this limit. One scale division is 0.000033 parts of the force. The tabular numbers are expressed in scale divisions.

In tracing out the lunar effect upon the vertical force, we have to contend with greater irregularities than was experienced in the case of the horizontal force. The vertical force magnetometer is more subject to changes, and the correction for temperature far exceeds that of the horizontal force.

The total number of observations and differences formed in the inquiry of the dependence of the force upon the moon's hour angle is 19513, which distribute themselves over the months and years as follows:

TABLE I.

Number of observations for lunar discussion.

Month.	1841.	1842.	1843.	1844.	1845.	Sum.
January	----------	207	----------	544	611	1362
February	239	198	----------	549	554	1540
March	257	286	----------	502	539	1584
April	256	255	250	512	581	1854
May	207	246	288	617	602	1960
June	219	275	296	529	571	1890
July	258	281	308	581	----------	1428
August	283	284	314	535	----------	1416
September	267	246	292	568	----------	1373
October	280	298	580	607	----------	1765
November	275	299	528	596	----------	1698
December	239	304	541	559	----------	1643
Year	2780	3179	3397	6699	3458	19513

TABLE II.

Distribution of numbers according to western and eastern hour angles of the moon.

Year.	Western hour angles.	Eastern hour angles.
1841	1388	1392
1842	1588	1591
1843	1694	1703
1844	3321	3378
1845	1728	1730
Sum	9719	9794

TABLE III.

Differences from the monthly normals, 1841.

Western hour angles of the moon.

1841.	U. cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January												
February	+3	+1	+3	−2	+8	−5	0	+1	−1	+4	−2	−3
March	−6	+5	−3	+6	+1	+9	−6	+2	−7	−1	−3	0
April	−1	+1	0	+2	−1	+3	−1	0	−1	+7	−7	+2
May	+5	−1	+2	+1	+4	+7	+3	+4	+4	+1	+5	−5
June	0	−6	−5	+2	−8	−2	+5	−3	−4	+8	+7	0
July	−4	+8	−6	+2	−7	+5	−3	+1	−1	−7	+5	−4
August	−1	−5	+1	−6	−5	−6	0	−1	0	+1	−3	−1
September	+3	+3	+1	+1	−6	+5	−2	+2	0	−4	−3	−3
October	−8	−1	−2	0	−2	−1	−4	0	+1	0	+6	+4
November	−3	+3	−1	+3	−3	−3	−6	−5	+1	−3	+4	−1
December	−5	−4	0	−1	−2	−5	−3	−3	+5	+2	−3	−2
Year	−1.5	+0.4	−0.9	+0.7	−2.0	+0.6	−1.5	−0.2	−0.3	+0.7	+0.5	−1.2

Eastern hour angles.

1841.	L. cul 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January												
February	−3	−2	+1	−3	+3	−2	+4	−3	+3	+2	+2	−1
March	0	+2	+3	+7	−1	+8	−7	+1	−8	0	−6	+1
April	0	−4	0	−1	0	−2	−1	−3	−1	−1	−1	+1
May	−2	−2	+1	−6	+1	−5	+1	−8	+3	−10	+3	−4
June	+1	+5	−2	+1	+5	−7	+5	+3	−1	−6	−2	−8
July	+1	−4	+6	0	−2	+5	−2	+5	−2	+2	−2	+7
August	+1	−1	+2	0	0	+1	+4	+5	+2	+4	+1	+3
September	−3	+2	−4	0	−1	+2	−1	−2	+1	0	+2	+8
October	+3	+4	+4	−1	+1	+1	+4	−1	+2	−2	−4	−4
November	+2	−3	+1	0	−1	+5	−3	+5	0	+8	−2	+2
December	+6	+6	+1	+6	+3	+2	+3	−10	0	−10	0	−7
Year	+0.5	+0.3	+1.2	+0.3	+0.7	+0.7	+0.6	−0.7	−0.1	−1.2	−0.8	−0.2

TABLE IV.

Differences from the monthly normals, 1842.

Western hour angles of the moon.

1842.	U. cul. 0*h.*	1	2	3	4	5	6	7	8	9	10	11*h.*
January	−6	0	−1	−7	−6	−5	+4	+8	−3	+9	+4	+7
February	−3	0	+5	−6	+4	−3	−9	−11	+6	+3	+7	+6
March	+5	+2	+3	0	+2	−4	−6	−6	+4	−1	−5	+5
April	+2	+2	0	0	−11	−2	−5	−3	−7	−1	+1	−5
May	−5	+3	−3	+2	−3	+4	0	0	+5	−2	+3	−7
June	+3	+5	+3	+2	−2	+1	+3	−3	+8	−7	+6	−7
July	−2	−4	−3	+2	−6	−2	0	+2	+4	+3	+7	+1
August	+2	−2	+1	−4	0	+1	−3	−2	+1	−1	+8	−3
September	+3	−5	−2	−7	−5	−3	+3	−1	−3	+6	−4	+5
October	0	0	−3	+4	+1	−5	+4	−1	+1	+4	−3	0
November	−3	+1	+1	−3	+2	+2	+3	0	+1	−4	+2	0
December	−1	−3	+1	+4	−4	+4	−1	+1	+4	−1	−3	+3
Year	−0.4	−0.1	+0.2	−1.1	−2.3	−1.0	−0.6	−1.3	+1.8	+0.7	+2.0	+0.4

Eastern hour angles.

1842.	L. cul. 0*h.*	1	2	3	4	5	6	7	8	9	10	11*h.*
January	+5	+4	−3	−1	−5	−3	−2	+3	−4	+4	0	−4
February	+6	+1	−2	+4	−3	+3	−1	−7	−1	+9	−5	+3
March	−4	+3	−4	−3	−4	−6	+2	−4	+2	+2	0	+4
April	−3	+4	−1	+6	+3	+10	+1	+4	+1	0	+6	+2
May	+5	+2	+6	−4	0	−2	−2	−1	−12	+8	−8	+3
June	0	−6	0	−8	+3	−5	−3	−9	+3	−5	+3	−5
July	+2	+1	+2	+1	−3	−1	+1	−2	−1	0	−3	−1
August	+5	−3	−1	0	+1	0	+2	0	+2	0	+7	−3
September	−6	−2	−1	+2	−1	−1	+2	+9	+2	+12	+4	−3
October	−9	+1	−4	−3	0	−3	+2	+2	+2	+2	0	+2
November	+3	−1	−6	−2	−2	0	+2	+2	+1	+3	−1	0
December	+5	−1	−2	−1	−1	0	0	0	−5	+1	−3	−3
Year	+0.8	+0.2	−1.3	−0.8	−1.0	−0.7	+0.3	−0.3	−0.8	+3.0	0.0	−0.4

TABLE V.

Differences from the monthly normals, 1843.

Western hour angles of the moon.

1843.	U. cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January												
February												
March												
April	+10	−3	+14	−5	+8	+1	0	+1	−5	+3	−2	−3
May	+6	−3	+4	+3	3	−3	−3	−5	−1	−4	+1	−5
June	+1	−1	−4	+2	+2	+2	+1	+2	+1	+3	+4	+4
July	+7	+5	+4	+5	+4	+8	+3	+3	+3	+1	−1	−1
August	0	−2	+2	−1	+4	0	+5	−3	+3	−4	+2	−2
September	−3	+8	0	+5	−3	+4	+4	−7	+3	−3	+1	−3
October	+2	+2	+3	+3	+2	+2	−1	−4	−2	−3	−2	+3
November	+1	2	+2	−3	+1	−2	−1	+1	0	+1	+4	0
December	+1	+2	+3	−2	0	+2	+2	+1	−1	0	+1	−2
Year	+2.4	+1.3	+3.0	+0.4	+2.0	+1.3	+0.8	−1.1	−0.2	−0.6	+0.9	−1.7

Eastern hour angles.

1843.	L. cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January												
February												
March												
April	−2	0	−1	−6	−5	−6	+5	+1	+4	0	−2	+1
May	−2	−6	−3	0	+2	−1	+1	+2	+4	+2	+6	+2
June	+2	0	+1	+2	−1	+2	−2	+1	−1	0	+2	−2
July	−5	−4	−5	−5	−3	−5	−6	−3	+2	+1	+3	+4
August	+2	−2	0	−1	−1	−1	+5	−2	+2	−4	+4	+2
September	−2	0	−3	−1	−6	−3	−2	+4	+3	+1	−2	+4
October	−5	−1	+1	+1	0	0	0	0	0	+2	+3	0
November	−1	0	−3	+1	+3	−1	−1	−3	−1	+2	−2	+1
December	−2	0	−2	−1	−3	−2	−3	−3	−3	−2	−3	0
Year	−1.9	−1.2	−1.6	−0.9	−1.2	−1.7	−0.6	−0.8	+0.5	0.0	+0.6	+1.1

In making up the annual means, the October, November, and December values have received double weight. They are derived from double the number of observations.

TABLE VI.

Differences from the monthly normals, 1844.

Western hour angles of the moon.

1844.	U.cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January	+1	+5	0	0	−2	−1	−2	−1	−1	−1	−1	0
February	−1	−1	+1	+1	0	−1	+3	+3	0	+1	−1	−3
March	+4	−5	+2	−1	+3	−1	+1	−2	+1	−1	0	−3
April	+1	−1	+5	+2	0	+1	−4	+3	+3	0	−2	−3
May	0	+1	+1	+1	+1	+2	+3	+2	+2	+1	+2	0
June	+1	−2	−2	−2	−2	−1	−2	0	0	+3	0	+3
July	+2	+2	+2	+1	+1	+3	0	0	−2	0	0	0
August	+1	−2	−2	−2	−1	−2	−2	−6	−2	−4	−1	0
September	+1	+1	+1	−1	−1	−1	−2	0	−2	−2	−3	0
October	0	0	0	−2	−1	−3	−2	−3	−3	−2	0	+3
November	+2	+5	+5	+3	+2	0	+1	+3	+1	0	−2	−3
December	−1	0	+1	+3	0	−1	−1	−1	+2	+1	0	0
Year	+0.3	+0.3	+1.2	+0.3	0.0	−0.4	−0.6	−0.2	−0.1	−0.3	−0.7	−0.5

Eastern hour angles.

1844.	L.cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January	−1	−4	−2	−3	−2	−2	−3	0	+1	−2	−1	+3
February	−3	−1	+2	+1	0	−3	−4	−2	+1	−1	−1	0
March	−6	+1	−4	−2	−1	+4	+2	+5	+2	−4	−4	−1
April	−1	+1	+1	0	−1	−1	−3	−1	0	−1	−1	+2
May	−1	−2	0	−2	−2	−1	−3	−2	−2	−1	0	0
June	+1	0	+1	+1	0	+1	+2	−2	−1	+2	0	−1
July	+1	0	0	+1	0	−1	+1	+2	+1	0	+1	+1
August	−2	−1	−1	0	+2	+6	+4	+4	+3	+2	+1	−1
September	−1	−2	−1	−1	0	0	+2	+3	+2	+1	+4	+4
October	+4	+1	+1	+1	0	+2	+1	+1	0	+3	+1	+3
November	−4	−4	−1	+1	+1	+1	+2	+1	0	+1	+3	+2
December	+2	+2	+1	+2	0	+1	−3	−3	−1	−1	+2	−1
Year	−1.0	−0.8	−0.2	−0.1	−0.3	+0.6	−0.2	+0.5	+0.5	−0.1	+0.4	+1.0

TABLE VII.

Differences from the monthly normals, 1845.

Western hour angles of the moon.

1845.	U.cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January	+1	+2	+2	+2	+2	+4	+1	+1	−2	0	+3	+2
February	−2	0	−3	−2	−2	−2	0	0	+1	0	−1	+1
March	0	−1	−2	+1	+1	0	+2	+1	−2	0	+4	−1
April	−2	−4	−2	0	−1	−1	0	+2	+5	+4	+4	+2
May	−1	+1	+2	+1	+2	+3	−2	−1	0	+1	−1	0
June	+1	+1	+2	0	−2	0	−1	−1	−3	−4	−3	−2
Mean	−0.5	−0.2	−0.2	+0.3	0.0	+0.7	0.0	+0.3	−0.2	+0.2	+1.0	+0.3

Eastern hour angles.

1845.	L.cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
January	0	−1	−5	−3	0	−1	0	−2	−2	−4	−3	0
February	+2	+3	+3	+3	+2	0	0	−1	0	−1	−2	0
March	+4	+2	−1	+2	−2	+1	−1	+1	−2	−2	−3	−3
April	−1	+1	−1	−1	−2	−2	−1	−1	0	+1	+1	+1
May	−1	−1	−2	−3	−2	−1	−1	0	+1	+1	0	−1
June	−1	+1	0	+1	+2	+1	+2	+2	+1	+3	+2	+3
Mean	+0.5	+0.9	−1.0	−0.2	−0.3	−0.3	−0.2	−0.2	−0.3	−0.3	−0.9	0.0

Before we combine the above results of years and parts of years, it is desirable to inquire into the variability of the lunar effect in summer and winter. Considering the months from April to September (inclusive) as summer months, and those from October to March (inclusive) as winter months, and combining the differences from the monthly normals in each year according to the number of observations, we obtain the following results:—

TABLE VIII.

Lunar-diurnal variation in summer and winter, 1841 *to* 1845, *(expressed in scale divisions.)*

Western hour angles.

	U.cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
Summer	+1.0	−0.1	+0.6	+0.2	−1.0	+0.8	−0.4	−0.4	+0.1	−0.1	+0.6	−1.0
Winter	−0.8	+0.8	+0.9	+0.1	+0.4	−0.6	−0.5	−0.5	0.0	+0.1	+0.4	0.0

Eastern hour angles.

	L.cul. 0h.	1	2	3	4	5	6	7	8	9	10	11h.
Summer	−0.5	−0.8	−0.3	−0.9	−0.4	−0.4	+0.4	+0.4	+0.6	+0.6	+1.1	+0.8
Winter	−0.2	+0.3	−0.9	+0.3	+0.4	+0.2	−0.5	−0.7	−0.5	0.0	−1.1	0.0

These numbers are sufficiently irregular to indicate that we cannot hope to deduce any separate results for the seasons, the number of observations (about 9800) being altogether insufficient. We can, therefore, in our general combination of the annual means, give equal weight to the results from the six months of hourly observations in 1845, and to the results from the twelve months of bi-hourly observations in 1842; compared with these results, those of 1844 have the weight two.

TABLE IX.

Recapitulation of the annual means exhibiting the lunar-diurnal variation from over 19500 *observations between February,* 1841, *and June,* 1845, *inclusive.*

Western hour angles.

Weight.	Year.	U. cul. 0*h*.	1	2	3	4	5	6	7	8	9	10	11*h*.
1	1841	−1.5	+0.4	−0.9	+0.7	−2.0	+0.6	−1.5	−0.2	−0.3	+0.7	+0.5	−1.2
1	1842	−0.4	−0.1	+0.2	−1.1	−2.3	−1.0	−0.6	−1.3	+1.8	+0.7	+2.0	+0.4
1	1843	+2.4	+1.3	+3.0	+0.4	+2.0	+1.3	+0.8	−1.1	−0.2	−0.6	+0.9	−1.7
2	1844	+0.3	+0.3	+1.2	+0.3	0.0	−0.4	−0.6	−0.2	−0.1	−0.3	−0.7	−0.5
1	1845	−0.5	−0.2	−0.2	+0.3	0.0	+0.7	0.0	+0.3	−0.2	+0.2	+1.0	+0.3
	Mean	+0.10	+0.33	+0.75	+0.15	−0.38	+0.20	−0.42	−0.45	+0.15	+0.07	+0.50	−0.53

Eastern hour angles.

Weight.	Year.	L cul. 0*h*.	1	2	3	4	5	6	7	8	9	10	11*h*.
1	1841	+0.5	+0.3	+1.2	+0.3	+0.7	+0.7	+0.6	−0.7	−0.1	−1.2	−0.8	−0.2
1	1842	+0.8	+0.2	−1.3	−0.8	−1.0	−0.7	+0.3	−0.3	−0.8	+3.0	0.0	−0.4
1	1843	−1.9	−1.2	−1.6	−0.9	−1.2	−1.7	−0.6	−0.8	+0.5	0.0	+0.6	+1.1
2	1844	−1.0	−0.8	−0.2	−0.1	−0.3	+0.6	−0.2	+0.5	+0.5	+0.1	+0.4	+1.0
1	1845	+0.5	+0.9	−1.0	−0.2	−0.3	−0.3	−0.2	−0.2	−0.3	−0.3	−0.9	0.0
	Mean	−0.35	−0.23	−0.52	−0.30	−0.40	−0.13	−0.05	−0.17	+0.05	+0.22	−0.05	+0.42

If we represent these values graphically, we find the general shape of the curve to be similar to that of the horizontal component; it is double crested, with a principal maximum a little before the upper culmination, and a principal minimum about 3½ hours after the lower culmination of the moon; the average epoch of the vertical force tide is, therefore, about one and a half hour apparently in advance of the culminations. The secondary wave is very feeble, its greatest value happens about 9*h*., western hour angle, and its least value about three hours before, giving a range of nearly one-tenth part of the principal range. The observed values for the hours 8, 9, 10 (west), however, seem to indicate that the secondary wave is really larger, but in the present case apparently reduced by the accidentally low values at the hours 11 and 12.

The following expression has been deduced to express the lunar-diurnal variation of the vertical force:—

$$V_{\mathbb{Q}} = -0.04 + 0.27 \sin(\theta + 72^\circ) + 0.20 \sin(2\theta + 134^\circ)$$

θ counts from the upper culmination, westward; $V_{\mathbb{Q}}$ is expressed in scale divisions. The smooth, full curve in diagram A (Sketch No. 30) is computed by the formula; the differences between the observed and computed values are sufficiently well exhibited in the diagram. The probable error of any single hourly value is ±0.20 scale divisions.

In the following expression, m signifies millionth parts of the force:—

$$V_{\mathbb{Q}} = -1.3^{m} + 8.9^{m} \sin(\theta + 72^\circ) + 6.6^{m} \sin(2\theta + 134^\circ)$$

Maximum value of V ☾, 28*m*. before the upper culmination, $=+.38$ scale divisions; minimum value at 15*h*. 30*m*., —0.43 scale divisions, hence lunar-diurnal range 0.81 scale divisions $=0.000027$ parts of the force $=0.00034$ in absolute measure. This range is so small that the correction for temperature due to a change of but 0°.08 would surpass it.

We have already seen that we cannot bring a sufficient number of observations to bear upon any *part* of the entire series, and are therefore not in a condition to pursue this subject of the lunar effect to any greater length.

At Toronto the curve is also double-crested with maxima three and a half hours after the moon's transits, but compared with Philadelphia the principal and secondary waves appear exchanged. The range at Toronto is 0.000012 parts of the force, nearly one half of the Philadelphia range; we have already noticed a similar difference of range in the solar-diurnal variation, the Toronto range of which was also about one-half of that at Philadelphia. In connexion with this it may be well to state that the dip at Toronto is 75° 15′, and at Philadelphia 71° 59′.

Lunar Effect upon Inclination and *Total Force.*—The combination of the horizontal and vertical components to inclination and total force, is effected by the formulæ:

$$\Delta\theta = \sin\theta\cos\theta\left(\frac{\Delta Y}{Y}-\frac{\Delta X}{X}\right)$$

$$\frac{\Delta\varphi}{\varphi} = \cos^2\theta\frac{\Delta X}{X}+\sin^2\theta\frac{\Delta Y}{Y}$$

in which expressions $X=$ horizontal force, $Y=$ vertical force, $\varphi=$ total force, and $\theta=$ inclination. The discussion of the observations for dip, in Part XII, gives the value $\theta = 71°\ 59'$, answering to the year 1843. Column 2 of the following table is derived from the preceding Table IX, after changing the scale divisions into their equivalent parts of the force, one division being equal to 0.000033; column 3 is formed similarly from Table VIII, of Part VI, one division being equal to 0.0000365. Columns 4 and 5 contain the corresponding values of the lunar diurnal variation of the inclination and total force, the former expressed in seconds, the latter in parts of the total force. The letter M. heading columns 2, 3, and 5 signifies units of the sixth place of decimals or millionth parts of the force.

TABLE X.

Lunar-diurnal variation of the inclination and total force.

☾'s hour angle.	$\frac{\Delta Y}{Y}$	$\frac{\Delta X}{X}$	$\Delta\theta$	$\frac{\Delta\phi}{\phi}$
	m.	m.	″	m.
U. C.	+ 3.3	+11.0	—0.5	+ 4.0
1	+10.9	+18.2	—0.4	+11.6
2	+24.7	+32.8	—0.5	+25.4
3	+ 5.0	+40.1	—2.1	+ 8.3
4	—12.5	+ 7.3	—1.2	—10.6
5	+ 6.6	+25.5	—1.1	+ 8.4
	—13.9	0.0	—0.9	—12.6
7	—14.8	+ 3.6	—1.1	—13.0
8	+ 5.0	—21.9	+1.6	+ 2.4
9	+ 2.3	—14.6	+1.0	+ 0.7
10	+16.5	— 7.3	+1.4	+14.2
11	—17.5	+ 3.6	—1.3	—15.4
L. C.	—11.6	+25.5	—2.2	— 8.1
1	— 7.6	+ 7.3	—0.9	— 6.2
2	—17.2	+14.6	—1.9	—14.1
3	— 9.9	—11.0	+0.1	— 9.9
4	—13.2	+ 3.6	—1.0	—11.5
5	— 4.3	— 25.5	+1.3	— 6.3
6	— 1.7	—17.1	+2.8	— 6.1
7	— 5.6	—21 9	+1.0	— 7.2
8	+ 1.6	—18.2	+1.2	— 0.3
9	+ 7.3	—36.5	+2.7	+ 3.1
10	— 1.7	— 3.6	+0.2	— 1.9
11	+13.9	+ 7.3	+0.4	+ 3.3

The numbers in column 2 are deduced from observations between 1841 and 1845, those in column 3 from observations between 1840 and 1845; the difference, however, is immaterial as far as it refers to the dip and total force, the lunar variations being the same for a few adjacent years. The total number of observations employed in the combination is 41558.

The lunar-diurnal variation in the dip is well represented by the formula,

$$\theta_{\mathbb{C}} = -0''.06 + 0''.86 \sin(\theta + 156^\circ) + 1''.30 \sin(2\theta + 206^\circ);$$

the corresponding curve, as well as the observed values, are exhibited in diagram B (Sketch No. 30.) The heavy smooth curve is the Philadelphia computed variation, the dotted curve the Toronto variation, inserted here for comparison. The correspondence between these curves is certainly remarkably close considering the minuteness of the lunar effect and the somewhat long process of deducing it.

Maxima at 8^h and 20^h (principal), minima at 3^h (principal) and $13\frac{1}{2}^h$.

Total range 3''.6. Probable error of any single hourly representation $\pm$ 0''.7.

The lunar diurnal variation in the total force is represented by the equation:—

$$\varphi_{\mathbb{C}} = -\overset{m}{1.3} + \overset{m}{8.9} \sin(\theta + 63^\circ) + \overset{m}{6.3} \sin(2\theta + 84^\circ)$$

an expression not differing much from $V_{\mathbb{C}}$ owing to the large dip. The observed and computed values of $\frac{\Delta\varphi}{\varphi}$ are shown in diagram C (Sketch No. 30) which nearly resembles that of the vertical force.

Maxima at $\frac{1}{2}^h$ (principal) and 11^h; minima at $7\frac{1}{2}^h$ and 17^h (principal).

Total range 0.000026 parts of the force. Probable error of any single hourly representation 0.000006.

APPENDIX No. 22.

Results reported from the observations made by Assistants Charles A. Schott and G. W. Dean for magnetic declination, dip, and horizontal intensity, in Maine and Connecticut, including also a station in the District of Columbia.

Instruments used by Mr. Schott: Magnetometer No. 3 and dip circle (Barrow) No. 8, with two new position needles by Würdemann; on the coast of Connecticut, declinometer No. 2 and dip circle No. 4.

No.	Locality.	Date.	Latitude.	Longitude.	Declination west.	Dip.	Horizontal intensity.	Total intensity.
		1863.	° ′	° ′	° ′	° ′		
1	Bangor, Thomas hill	July 10	44 48.2	68 46.7	----------	76 5.3	3.174	13.20
2	Belfast, Penobscot	July 8	44 26.0	69 0.5	15 30.3	75 38.1	3.295	13.28
3	Rockland, Penobscot	July 7	44 6.3	69 5.9	15 2.1	75 30.9	3.283	13.13
4	Bath, Kennebec	July 11	43 54.9	69 48.7	12 51.8	75 25.5	3.320	13.19
[a]5	Harpswell, Casco bay	July 22	43 44.5	70 0.5	14 25.5	75 52.4	3.151	12.91
6	Freeport, Casco bay	July 13	43 51.1	70 5.6	14 11.7	75 20.3	3.359	13.27
7	Portland, observatory	July 6	43 39.9	70 14.6	12 18.1	75 4.6	3.389	13.16
8	Portland, Bramhall hill	July 15	43 38.8	70 16.3	12 28.2	75 5.9	3.403	13.24
9	Ivy Hill, Litchfield county, Conn	July 1	41 52.3	73 13.1	8 25.7	73 32	3.800	13.41
10	Tashua, Fairfield county, Conn	Sept. 9	41 15.6	73 14.7	8 2.5	73 0.7	3.875	13.26
11	Washington, D. C. Coast Survey office	J'e 18, 19 / July 28	38 53.1	77 0.2	2 41.8	71 14.3	4.249	13.21

[a] This station is affected with local attraction; also Freeport, though to a less extent.

NOTE.—The above values for horizontal intensity, excepting Nos. 9 and 10, require a correction of about + 0.033. A corresponding change of the total intensity is also to be made. The constants of magnetometer No. 3 will be redetermined. The same corrections should be applied to the results for intensity in 1862 of Appendix No. 18 and No. 19 of last year's report.—DECEMBER, 1864.

APPENDIX No. 23

REPORT ON PRELIMINARY EXPERIMENTS MADE BY ASSISTANT GEORGE W. DEAN TO DETERMINE THE VARIATIONS OF "INDUCTION TIME" IN RELAY MAGNETS NOW IN USE.

FALL RIVER, MASS., *April* 29, 1863.

DEAR SIR: The results of the experiments which I have recently made at the Coast Survey Office with several relay magnets, indicate that the telegraphic instruments now in general use are not constructed in accordance with any definite rules.

Two of the relay magnets were each $2\frac{1}{10}$ inches in length, and $1\frac{1}{4}$ inch in diameter, with 2,200 feet, or 0.4 of a mile of No. 30 copper wire, 0.015 inches in diameter.

The results obtained for "induction time" in the first-named magnets varied from 0.^{s}02 to 0.^{s}06, while the "induction time" in the latter varied from 0.^{s}06 to 0.^{s}16, the size of the battery being the same in both cases.

These results appear to indicate that the relay magnets would be improved by constructing them of minimum length and diameter, and further experiments will enable us to judge within what limits we may expect to obtain the most satisfactory results.

As you are also informed, Prof. Henry has suggested that, perhaps, the "induction time" might be diminished by making the cores of the helices of the best iron wire of small size, each wire being insulated by a coating of varnish or silk covering.

My plans having met your approval, I have arranged with Mr. Hicks, the inventor of the "Hicks Repeater," for the construction of one of these instruments, with modifications which have been suggested by the experiments thus far made.

I propose to have one relay constructed, with two small helices, each about $1\frac{3}{4}$ inch in length and $1\frac{1}{4}$ inch in diameter. One of these helices to be adjusted *above* the armature axis, the other to be at an equal distance *below* the axis, and upon the opposite side of the armature from the first-named helix. It seems to me that, by this arrangement, we shall obtain a maximum tension upon the armature, with a minimum intensity and resistance in the coils; but further experiments must show how far this opinion is well founded.

I have also authorized Mr. Hicks to have two extra helices constructed for further experiments. One to be $2\frac{1}{2}$ inches in length, $1\frac{3}{4}$ inch in diameter, and the copper wire, No. 30, (0.015 inches in diameter.) The other coil to be similar, except that the wire is to be a little larger, (0.020 inches in diameter.)

The wire upon each coil is to be accurately measured and arranged in sections of six layers each, the ends of the several section wires to project at one end of the helix for the purpose of determining the relative force of the magnet by increasing or diminishing the size of the coils. Several helix cores are to be made of small annealed iron wire, in accordance with the plan suggested by Prof. Henry.

At the earliest opportunity, after these instruments shall have been constructed, I propose to proceed to the Coast Survey Office and test the several helices in the following manner:

1st. To ascertain the intensity of the current through each coil with a galvanometer.

2d. To determine the *force* (magnetic) by adjusting each helix in a vertical position, and from the armature below suspend a small vessel, into which water may be poured until its weight shall be just sufficient to break the armature contact. The exact weight of the vessel and water to be ascertained upon a delicate balance, which I hope to obtain for this purpose from the office of weights and measures.

3d. The "induction time" of each helix to be determined with the Kessel clock, and the apparatus which has already been constructed and successfully used for this purpose.

Very respectfully submitted,

GEO. W. DEAN,
Assistant Coast Survey.

Prof. A. D. BACHE,
Sup't U. S. Coast Survey, Washington, D. C.

APPENDIX No. 24.

REPORT BY ASSISTANT J. E. HILGARD, ON THE TRIAL OF HARRISON'S GLOBE LENS AT THE UNITED STATES COAST SURVEY OFFICE, PREVIOUS TO ITS USE IN THE PHOTOGRAPH DIVISION.

WASHINGTON, D. C., *March* 15, 1863.

SIR: I have the honor to submit the following report of the examination made of Harrison's and Schnitzer's "Globe Lens," previous to its purchase by this office. The want of a lens which would in dull weather produce good negatives of a size approaching twenty-four inches square, without sensible distortion, had been seriously felt during the past year. It was claimed that a globe lens of the largest class—four inches diameter and sixteen inches solar focus—would in a great degree satisfy those requirements; and the Harrison Lens Company agreed to furnish one for trial. In view of the high price of two hundred dollars demanded, it was deemed proper to have the most stringest tests of its performance before making the purchase.

The lens received is formed of two achromactic meniscuses, each a little over four inches in diameter-their convex sides turned from each other, and measuring six inches from front to back; the surfaces apparently forming the segments of a globe of that diameter. The solar focus of the combination measures sixteen inches from the back lens. Between the two lenses is a revolving diaphragm, containing five openings, the smallest opening being three-eighths of an inch in diameter, and the largest seven-eighths.

The advantage of this lens in light was immediately made manifest by its producing very dense negatives in copying line drawings within doors in very dull and hazy weather. Under such circumstances a map nearly a century old, the paper of which had turned quite yellow, produced a perfectly satisfactory negative, which printed a full black line on a white ground, presenting a surprising renovation of the work.

In order to test the lens for extent of field, defining power and correctness of figures, a system of squares and circles was constructed with geometrical exactness on a drawing-board; the outside figure was thirty-two inches square, divided by fine lines into square inches, and from the centre six circles were described at distances from ten to sixteen inches.

The drawing was placed before the camera, and the distance adjusted to make a reduced copy of near twenty-two inches square. Wet collodion was used. The aperture was the smallest. The weather fair. The focus was adjusted on the very centre, in order that the full aberration might be exhibited at the edges of the copy. The time of exposure was three minutes, (in doors.) The result was a plate of such density as would be satisfactory for printing after it had been intensified.

The plate after being dried and varnished was submitted to very colse measurement of the four extremes, and two middle lines, with the following result in metres.

Perpendicular Lines.	Metres.
Right hand	0.5524
Middle	0.5517
Left hand	0.5522
Horizontal Lines.	**Metres.**
Upper	0.5520
Middle	0.5515
Lower	0.5520

From the above measurements it is seen that the glass was not precisely parallel with the plane of the drawing. It is also seen that the lines are slightly curved outwards, or the figure is "pin cusioned shaped." Comparing the mean of the extremes with the middle line, the difference is seen to be six deci-millimetres in one direction, and five in the other, or an average five and a half deci-millimetres; one half of this, only, or rather less than one hundredth of an inch, is the measure of the curvature of the outside lines.

In definition, this plate is clear and bright without variation from the centre out to the first circle, or through a disc of about fourteen inches diameter. In looking from line to line of the circles not much variation is discernible; but in comparing the outermost circle with the inner one, the inevitable widening of the line is seen with its attendant mistiness. From this to the corner, the widening and mistiness increases, but the lines are good for printing out to the very corners.

A second test of the lens was made by copying, in its own size, of so much of the drawing as would go on a 24 × 24 inch plate. This time the weather was dull, and the middle opening (nearly five eighths of an inch) was used. The time of exposure was three minutes, (in doors,) and the result satisfactory as to density. This plate gave the following measurements:

Perpendicular Lines.	Metres.
Right hand	0.5667
Middle	0.5655
Left hand	0.5648
Horizontal Lines.	**Metres.**
Upper	0.5652
Middle	0.5651
Lower	0.5656

In this plate the effect of prolonging the focus, is immediately seen in its flattening the field, for the difference between the mean of the outside and the middle lines is only 3 deci-millimetres in the horizontal lines, and 2.5 in the perpendicular lines, in the mean 2.75 deci-millimetres, giving only about $\frac{1}{200}$th of an inch as the measure of greatest curvature in the outside lines—an inappreciable quantity in operations of this sort. The lens may therefore be said to copy free from distortion.

The latter plate, like the former, was focussed accurately for the centre. Yet only the very corners exhibited a sensible widening of the line and the consequent mistiness. It may be remarked, however, that by focusing for a good general definition of the whole field instead of its central portion a better definition of the lines near the edges would have been obtained.

The performance of the globe lens having thus not only been proved very satisfactory, but giving results far superior to those we had been able to obtain with our orthoscopic lens of twenty-two inches solar focus, it was with your consent purchased for the government. Since then it has been in constant use during three months of unusually dark and misty weather, and the results have abundantly shown its great advantage in the quantity of light, enabling the photographer to work at times when with our former apparatus the attempt would have seemed hopeless.

J. E. HILGARD,
Assistant in charge of office.

A. D. BACHE, LL.D.,
Superintendent United States Coast Survey.

APPENDIX No. 25.

TITLES OF SCIENTIFIC PAPERS COMMUNICATED BY THE LATE MAJOR E. B. HUNT, UNITED STATES ENGINEERS, AND PUBLISHED EITHER IN THE COAST SURVEY REPORTS OR WITH THE PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

1. Remarks on terrestrial thermotics. Read at the Cambridge meeting of the association in 1849.
2. Detailed report on the progress of engraving in the Coast Survey office, 1853.
3. On cohesion of fluids, evaporation, and steam-boiler explosions. Read at the Cleveland meeting of the Association in 1853.
4. Project of a geographical department of the library of Congress. Read at the same meeting.
5. Remarks on lithography and lithographic transfers. Published in the Coast Survey report for 1853.
6. Tables for projecting maps, with notes on map projections. Coast Survey report for 1853.
7. Description of Saxton's self-registering tide-gauge. Coast Survey report for 1853.
8. General list of developments and discoveries made in the progress of the Coast Survey hydrography. Compiled for the Coast Survey report of 1854.
9. Description of the United States Coast Survey apparatus for measuring base lines. Coast Survey report for 1854.
10. Report on engraving, in relation to the Coast Survey. Coast Survey report for 1854.
11. Consolidated alphabetical index of the Coast Survey reports for 1844–1853. Published in the volume for 1854.

12. On our sense of the vertical and horizontal, and on our perception of distance. Read at the Providence meeting of the Association in 1855.

13. On an index of papers on subjects of mathematical and physical science. Read at the same meeting.

14. On the use of salt marsh sods in fortifications for facing the steep slopes of parapets, terraces, etc. Read at the same meeting.

15. On an index of reference to memoirs and papers on subjects related to the Coast Survey operations. Coast Survey reports for 1856, 1857.

16. On systematizing the abbreviations of titles of periodicals, transactions, etc. Coast Survey reports for 1856, 1857.

17. Notes on a new form of sounding apparatus, proposed for Coast Survey use. Coast Survey report for 1857.

18. On the idea of physical and metaphysical infinity. Read at the Montreal meeting of the Association in 1857.

19. Views and suggestions on the practice and theory of scientific publication. Read at the same meeting.

20. On some anomalies in the Florida Gulf Stream, and on their further investigation. Coast Survey report for 1858.

21. On the origin, growth, substructure, and chronology of the Florida reef. Coast Survey report for 1862.

APPENDIX No. 26.

LETTERS FROM GOVERNMENT OFFICERS, INCLUDING COMMANDERS IN THE ARMY AND NAVY, RELATIVE TO THE FIELD AND OFFICE WORK OF THE COAST SURVEY.

UNITED STATES MISSISSIPPI SQUADRON, *January* 5, 1863.

SIR:

* * * * * * * * * * * *

Mr. Strausz and Mr. Fendall [of the Coast Survey] have rendered themselves extremely useful to me in compiling maps for the use of the army and navy, and making surveys of the field of operations before Vicksburg. I sent Mr. Strausz down in a vessel near the front of the city to make plans and take sketches of the batteries, which he did to my satisfaction, giving us information that we have not possessed before, and showing the impracticability of attacking Vicksburg by water alone. We might otherwise have run our heads against a stone wall. During the ascent of the Yazoo river, and while engaged in taking up torpedoes, our passage was contested at every step by two or three thousand riflemen in pits and behind levees, so protected that our guns could not hurt them. The vessels were much cut up, the rifle-balls going through and through the light upper works. Mr. Strausz accompanied the expedition, and while under fire produced a good chart of the river and back country, with which we have made our advances. I could not have got along very well without these maps. Both Strausz and Fendall are very assiduous in making maps for future use. They are now making one of the State of Arkansas, where we intend striking a blow before returning to Vicksburg, the water being still too low to operate there with any hope of success. It is all swamp now, except in front. When the water rises our vessels can get near to dry land, where they can cover the troops.

I am, very respectfully, your most obedient servant,

(Signed,) DAVID D. PORTER.

A. D. BACHE, *Superintendent Coast Survey.*

HEADQUARTERS EIGHTEENTH ARMY CORPS, STEAMER JOHN FARON,
Hilton Head Bay, February 9, 1863.

SIR: I am desired by General Foster to tender you his thanks for your prompt action in rescuing the steamer Pilot Boy, which was obliged to be left anchored at sea, owing to a defect in her boilers that entirely disabled her.

Your thoughtfulness in towing the steamer into this port undoubtedly saved to the government one of our most valuable light-draught transports.

I am, sir, your obedient servant,

JOHN F. ANDERSON,
Major and A. A. General.

CHARLES O. BOUTELLE, Esq.,
Assistant United States Coast Survey.

FLAGSHIP WABASH, PORT ROYAL HARBOR, S. C., *February* 10, 1863.

SIR: I have to acknowledge the receipt of your communication of the 31st ult., reporting your operations in pursuance of my orders of the 24th ult.

Your examination of the channels and water on the Charleston bar seems to have been conducted with great skill and boldness, and I beg you to receive my thanks and commendation for the same, and for the important information obtained.

Respectfully your obedient servant,

S. F. DUPONT,
Rear-Admiral, Commanding South Atlantic Blockading Squadron.

C. O. BOUTELLE, Esq.,
Assistant U. S. Coast Survey,
Commanding United States Steamer Bibb, Port Royal.

NAVY DEPARTMENT, BUREAU OF NAVIGATION, *February* 21, 1863.

SIR: In compliance with the request of the Secretary of the Treasury, under date of the 29th ultimo, that he might be furnished with an account of the number of charts from the Coast Survey office, which have been distributed since the war began, from the Bureau of Navigation, or from the Observatory, and also with the judgment of the department as to the value of such charts, and of the personal services rendered by the Coast Survey officers in the blockades and naval expeditions of the war, I have the honor to report:

That the whole number of Coast Survey charts distributed by the Bureau of Navigation to vessels of the navy between April 20, 1861, and February 10, 1863, is 38, 595, besides 105 memoirs on the coast of the United States, containing 909 charts; 50 reports containing 1, 500 charts, sketches, etc.; 180 tide tables and 12 Notices to Mariners. See statement,* and letter of the superintendent of the Naval Observatory accompanying this report.

And in reference to the second part of this inquiry, I am gratified to have it in my power to express, as the result of personal observation and experience, my profound conviction of the great value of the Coast Survey charts to the operations of the navy during the present war, as also my high estimate of the personal services of the officers of the Coast Survey who have been detailed for duty in the blockades and naval expeditions of the war.

I am, very respectfully, your obedient servant,

CHARLES H. DAVIS,
Chief of the Bureau.

Hon. GIDEON WELLES,
Secretary of the Navy.

UNITED STATES NAVAL OBSERVATORY, WASHINGTON, D. C., *February* 10, 1863.

SIR: In compliance with the instructions from the bureau, dated the 2d instant, I have the honor to transmit a statement, showing, opposite to its name, the numbers of each United States Coast Survey chart, and the aggregate numbers of said charts received from the Superintendent of the Coast Survey for distri-

* Omitted, the titles of the charts supplied being printed elsewhere in this report.

bution to vessels of the navy since the 20th of April, 1861; and beg to be permitted to express the great obligation of this office to Professor A. D. Bache for the promptness and cordiality with which he has met all the extraordinary demands for information absolutely indispensable to the blockading squadrons.

Very respectfully, your obedient servant,

J. M. GILLISS,
Captain U. S. N., Superintendent.

Commodore CHARLES H. DAVIS,
Chief of Bureau of Navigation, Navy Department.

NEWBERN, NORTH CAROLINA, *June* 1, 1863.

MY DEAR SIR: Mr. Fairfield has just given me a copy of his triangulation work on the Neuse river, which puts me in mind to thank you for the assistance which you have rendered me in sending him, Mr. West, and Mr. Rockwell here. Their labors have aided very much in obtaining a correct knowledge of the country for military purposes.

Mr. West's work, from Newport barracks to Morehead City, has been especially valuable. Hardly less so is the mapped reconnaissance of Mr. Rockwell on the north side of the Neuse. Mr. Rockwell's work about Little Washington, and on the route from Newbern to that place, was excellent, and of great military value.

Thanking you again for the military aid that you have been able to give this department, I remain, with respect and kindest regards, ever truly yours,

J. G. FOSTER,
Major General, Commanding.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

ENGINEER DEPARTMENT,
Washington, D. C., July 24, 1863.

SIR: I have the honor to enclose herewith a copy of a letter just received from Captain T. L. Casey, corps of engineers, expressing his indebtedness to Assistant W. S. Edwards, of the Coast Survey, for valuable assistance rendered him in making an examination of Rockland harbor, Maine, with a view to its defence, and I desire to add my thanks to this acknowledgment of Captain Casey's for the aid to our operations thus received.

Very respectfully, your obedient servant,

JOS. G. TOTTEN,
Brigadier General, Chief Engineer.

Prof. A. D. BACHE, *Superintendent United States Coast Survey.*

UNITED STATES ENGINEER OFFICE,
Rockland, Maine, July 18, 1863.

GENERAL: I feel it incumbent on me to report that my reconnaissance of the shores of this harbor on the 15th instant, for the purpose of selecting sites for batteries, was very much expedited and assisted through the courtesy of Mr. W. S. Edwards, of the United States Coast Survey schooner Arago, who kindly accompanied me and furnished me with a manuscript map.

There can be no doubt that such co-operation between different branches of the government service tends to the best interests of the country at large.

I am, general, very respectfully, your obedient servant,

THOS. LINCOLN CASEY, *Corps Engineers.*

Brigadier General JOSEPH G. TOTTEN,
Chief Engineer U. S. A., Washington, D. C.

HEADQUARTERS DEPARTMENT OF THE SOUTH,
In the Field, Engineer's Office, Morris Island, S. C., August 5, 1863.

SIR: The maps of Charleston harbor came duly, and have been of the greatest service to us.

Your charts of this coast are invaluable to us. Their great amount of detail and extreme accuracy leave nothing to be desired in a military map. * * * Little high-tide marsh-streams and hummocks no larger than a tent-floor, which apparently could never possess the least interest or value on a map, have proven to be important landmarks and lines of communication for scouts and pickets. * * *

Very respectfully, your obedient servant,

T. B. BROOKS,
Captain Volunteer Engineers, A. D. C. and Assistant Engineer.

To the assistant in charge United States Coast Survey office, Washington, D. C.

U. S. MISSISSIPPI SQUADRON, FLAGSHIP BLACK HAWK,
Off New Orleans, August 5, 1863.

DEAR SIR: * * * * I cannot speak too highly of the interest shown by the gentlemen of the Coast Survey, Messrs. Fendall and Strausz, in the difficult works in which they were engaged, and I feel much indebted to them for the willingness and ability manifested in any service required of them.

I regret exceedingly that Mr. Fendall was disabled by sickness while employed on the survey of Vicksburg and its vicinity. He succeeded, however, in finishing all except the approaches dug by our army, which, as remarkable specimens of energy, bravery, skill, and endurance, should accompany the map. * * * With many thanks to yourself for allowing me the use of your assistants, and hoping that you will always permit me to call on you for hydrographic assistants, I remain, very truly and respectfully, yours, &c.,

DAVID D. PORTER, *Rear-Admiral.*

A. D. BACHE, Esq., *Superintendent Coast Survey, Washington, D. C.*

DEPARTMENT OF STATE,
Washington, D. C., August 18, 1863.

SIR: In the early part of the rebellion, the department found it convenient and useful to transmit to the diplomatic and consular officers of the United States at the principal places in foreign countries a map showing the progress of the Union armies in crushing the rebellion. During the present month a review of the operations of the war on sea and land has been prepared and sent to many of our agents abroad. A few only of the maps prepared, as it is believed, at your office, which were intended to accompany it, were received in time to be transmitted with this review.

The public interest would be promoted if the department could receive from your office three hundred additional copies of the map above mentioned.

I am, sir, your obedient servant,

F. W. SEWARD, *Acting Secretary.*

Prof. A. D. BACHE, *Superintendent United States Coast Survey.*

ENGINEER DEPARTMENT,
Washington, D. C., September 4, 1863.

SIR: I take pleasure in sending you the copy of a letter from Captain T. L. Casey, corps of engineers, in which he returns his thanks for the valuable services rendered by certain officers of the Coast Survey in aiding him in the prosecution of his labor, in erecting temporary batteries for the defences of Belfast and Eastport, Me.

The department takes leave on this occasion to renew the sentiments recently expressed to you by the chief engineer, in acknowledgment of similar important aid to engineering operations derived from the resources of the Coast Survey.

Very respectfully, your obedient servant,

J. C. WOODRUFF, *Major Engineers in charge.*

Prof. A. D. BACHE, *Superintendent United States Coast Survey.*

UNITED STATES ENGINEER'S OFFICE,
Portland, Maine, September 1, 1863.

GENERAL: I have the honor at this time, and through the department, to return my thanks to the United States Coast Survey for the assistance and kindly co-operation given me by Assistants S. C. McCorkle and G. A. Fairfield, and by Sub-Assistant W. H. Dennis, and their efficient aids, during the past two months, in the establishment of temporary batteries for the defence of Belfast and Eastport, Me. Their instrumental observations, and the maps furnished by them, were of great value in furthering the wishes of the government for the establishment of field-works at these places.

I am, general, very respectfully, your obedient servant,
THOS. LINCOLN CASEY, *Captain of Engineers.*

Brigadier General JOS. G. TOTTEN,
Chief Engineer U. S. A., Washington, D. C.

FORTRESS MONROE, VA., *November* 6, 1863.

DEAR SIR: In leaving this department, I beg leave to express to you my warm thanks for your kindness in detailing officers of the Coast Survey at various times to act as topographical officers on my staff. Their services in making military surveys have been very valuable, and fully show the advantages to the government of having this trained corps of scientific gentlemen in time of peace to be used in the survey of the coast, and in time of war in military surveys and reconnaissances.

Again, be pleased to accept my thanks, and believe me, yours most truly,
J. G. FOSTER, *Major General.*

Prof. A. D. BACHE, *Superintendent United States Coast Survey, Washington, D. C.*

HEADQUARTERS DEPARTMENT OF THE CUMBERLAND,
Chattanooga, November 22, 1863.

DEAR SIR: Permit me to thank you most cordially for your kindness in placing under the direction of Brigadier General W. F. Smith, chief engineer department of the Cumberland, Messrs. P. C. F. West, Clarence Fendall, F. W. Dorr, and J. W. Donn, officers of the Coast Survey service. In the short time they have been on duty at these headquarters, they have rendered most valuable service in reconnoitring, surveying, and mapping the country.

Would it not be a legitimate branch of the duties of the Coast Survey to have the important rivers running through the country occupied by our armies accurately surveyed? As lines of communication and supply, it would be very important to possess information concerning their adaptability to navigation at all reasons of the year.

I shall desire to retain these officers with General Smith as long as you can spare their services.

Very respectfully, your obedient servant,
GEO. H. THOMAS,
Major General U. S. A., Commanding.

Prof. A. D. BACHE, *Superintendent United States Coast Survey, Washington, D. C.*

FLAG-STEAMER PHILADELPHIA,
Off Morris Island, November 26, 1863.

DEAR SIR: I have received the copies of Charleston harbor, with positions of batteries, vessels, &c., and to-day the colored charts of the harbor.

For these, as well as for previous plans, &c., please accept my thanks.

And be so good as to assure Professor Bache of my earnest appreciation of the value of the noble work over which he presides, and which he has rendered an honor to the country.

Very respectfully, your obedient servant,

J. A. DAHLGREN,
Rear-Admiral, Commanding South Atlantic Blockading Squadron.

Mr. J. E. HILGARD, *Assistant in charge of United States Coast Survey Office, &c.*

HEADQUARTERS ARMY AND DISTRICT OF NORTH CAROLINA,
Newbern, N. C., November 30, 1863.

DEAR SIR: I have the honor to acknowledge the receipt of several valuable maps and a memoir relating to the coast of North Carolina. In the valuable memoir I found reliable information touching the character of the sounds between New Inlet and New River inlet, not to be had elsewhere. For these and former contributions from your ably administered department, please accept my thanks.

Very respectfully, your obedient servant,

JOHN PECK, *Major General.*

A. D. BACHE, LL. D., *Superintendent United States Coast Survey, Washington, D. C.*

APPENDIX No. 27.

Coast Survey parties engaged in military departments or on duty with blockading squadrons during the working season ending with June, 1863.

Section.	Locality.	Under the immediate command of—	Names of assistants and aids.	Service.
II	Sandy Hook	For use of Engineer department.	H. L. Whiting, assistant	Topography.
			F. P. Webber, sub-assistant	Topography.
			J. W. Donn, aid	Topography.
			H. Mitchell, assistant	Hydrography.
			C. P. Dillaway, aid	Hydrography.
			A. M. Wetherill, aid	Hydrography.
			J. W. Brown, aid	Hydrography.
	League island, Pa	For Navy Department.	Geo. Davidson, assistant	Topography and hydrography.
III	Montgomery and Prince George's counties, Md.	Col. J. N. Macomb, U. S. E.	C. M. Bache, sub-assistant	Topography.
			C. Ferguson, sub-assistant	Topography.
			I. Hull Adams, assistant	Topography.
	Prince George's county, Md.	Col. J. N. Macomb, U. S. E.	J. W. Donn, aid	Topography.
			F. A. Lueber, aid	Topography.
			C. S. Hein, aid	Topography.
	Fortifications of Washington, D. C.	Gen. J. G. Barnard	C. A. Schott, assistant	Triangulation.
			E. H. Courtenay, aid	Triangulation.
	Rosier's bluff, Md	Gen. J. G. Barnard	A. M. Harrison, assistant	Topography.
			H. W. Bache, aid	Topography.
			A. Lindenkohl	Topography.
	Fairfax county, Va	Gen. J. G. Barnard	C. H. Boyd, sub-assistant	Triangulation and topography.
	Near Fort Lyon, Va	Gen. J. G. Barnard	C. M. Bache, sub-assistant	Topography.
			T. C. Bowie, aid	Topography.
	Stafford county, Va., and Fredericksburg.	Gen. W. B. Franklin	C. M. Bache, sub-assistant	Reconnaissance surveys.
			P. C. F. West, sub-assistant	Reconnaissance surveys.
			Charles Hosmer, aid	Reconnaissance surveys.
	Sea-coast of Maryland and [c] Potomac river. (Steamer Corwin.)	[c] By request of Navy Department.	Lt. Comdr. T. S. Phelps, U. S. N.	Hydrography.
			C. Junken	Draughtsman.
IV	Neuse river, N. C. (Schr. James Hall.)	Gen. J. G. Foster	G. A. Fairfield, assistant	Triangulation.
			H. Anderson, aid	Triangulation.
	Craven and Beaufort counties, N. C.	Gen. J. G. Foster	P. C. F. West, sub-assistant	Reconnaissance surveys.
			C. Rockwell, aid	Reconnaissance surveys.
V	Winyah bay, Charleston bar, Port Royal, S. C.; Savannah entrance, and Ossabaw, Georgia. (Steamer Bibb.)	Admiral S. F. DuPont.	C. O. Boutelle, assistant	Hydrography.
			J. S. Bradford, aid	Hydrography.
			W. W. Harding, aid	Hydrography.
			P. Frazer, jr., aid	Hydrography.
			Robert Platt	Hydrography.
			C. Willenbucher	Draughtsman.
	Wassaw sound, Georgia. (Schooner Arago.)	Admiral S. F. DuPont.	W. S. Edwards, sub-assistant	Hydrography.
			A. R. Fauntleroy, aid	Hydrography.
			F. H. Dietz, aid	Hydrography.
	Wassaw sound, Georgia. (Schooner Caswell.)	Admiral S. F. DuPont.	W. H. Dennis, sub-assistant	Topography.
			R. H. Talcott, aid	Topography.

APPENDIX No. 27—Continued.

Section	Locality.	Under the immediate command of—	Names of assistants and aids.	Service.
VI	Fernandina and St. Augustine, Fla.	Direct tax commissioners.	F. W. Dorr	General service as topographer.
	Florida reef and Charlotte harbor. (Steamer Vixen.)	Admiral Theodorus Badley.	Edward Cordell, acting assistant. C. T. Iardella, sub-assistant T. C. Bowie, aid, L. L. Nicholson, aid H. M. De Wees, aid L. A. Sengteller, aid A. M. Wetherill, aid	Hydrography. Hydrography. Hydrography. Hydrography. Hydrography. Hydrography. Hydrography.
VIII	Louisiana	Gen. N. P. Banks	J. G. Oltmanns, sub-assistant; Charles Hosmer, aid; S. H. Lyman, aid.	Topography and reconnaissance surveys.
	Mississippi and Arkansas rivers.	Admiral D. D Porter.	F. H. Gerdes, assistant; C. Fendall, sub-assistant; Alexander Strausz.	Topography and reconnaissance surveys.
	St. Louis	Col. R. D. Cutts	R. M. Bache, assistant; R. E. McMath, aid.	Topography.

APPENDIX No. 28.

Occupation of parties on the Atlantic coast and in military departments between June and November, 1863.

Section.	Locality.	Under the immediate command of—	Names of assistants and aids.	Service.
I	Passamaquoddy bay, Me.		W. H. Dennis, sub-assistant R. H. Talcott, aid	Topography. Topography.
	Coast of Maine		F. P. Webber, sub-assistant	Triangulation.
	Winter harbor, Me.		C. Rockwell, sub-assistant	Topography.
	Blue Hill bay, Me.		G. A. Fairfield, assistant H. Anderson, aid	Triangulation. Triangulation.
	Penobscot river, Me.		S. C. McCorkle, assistant	Triangulation.
	Rockland harbor, Me.		W. S. Edwards, sub-assistant F. H. Dietz, aid	Hydrography. Hydrography.
	Camden harbor, Me.		F. W. Dorr, sub assistant J. F. McCabe, aid	Topography. Topography.
	St. George's river, Me., entrance of Penobscot bay.		C. Ferguson, sub-assistant Edw'd Cordell, acting assistant H. M. DeWees, aid L. A. Sengteller, aid G. Bradford, aid	Triangulation and topography. Hydrography. Hydrography. Hydrography. Hydrography.
	Casco bay, Me.		F. H. Gerdes, assistant C. T. Iardella, sub-assistant C. Fendall, sub-assistant T. C. Bowie, aid	Hydrography. Hydrography. Hydrography. Hydrography.
	Maquoit and Middle bays, Me.		A. W. Longfellow, assistant	Topography.
	Approaches to Portland harbor.		Lt. Comdr. T. S. Phelps, U. S. N. C. Junken	Hydrography. Draughtsman.

APPENDIX No. 28—Continued.

Section.	Locality.	Under the immediate command of—	Names of assistants and aids.	Service.
I	Boston harbor		H. Mitchell, assistant C. P. Dillaway, aid	Hydrography. Hydrography.
	Narragansett bay, R. I.		A. M. Harrison, assistant; C. Hosmer, sub-assistant; H. W. Bache, aid.	Triangulation and topography.
II	Coast of Connecticut		A. D. Bache, superintendent; G. W. Dean, assistant; R. E. Halter, sub-assistant; S. H. Lyman, aid; F. W. Perkins, aid.	Primary triangulation and magnetic observations.
	New Haven harbor		R. E. Halter, sub-assistant	Reconnaissance.
	Hudson river, N. Y.		Edmund Blunt, assistant A. T. Mosman, sub-assistant J. A. Sullivan, sub-assistant	Triangulation. Triangulation. Triangulation.
	New York harbor and Montauk point.		Lt. Comdr. T. S. Phelps, U. S. N. C. Junken	Hydrography. Draughtsman.
	Hudson river		W. W. Harding, aid; Alex'r Strausz, acting assistant; C. S. Hein, aid; P. Frazer, jr., aid; H. G. Ogden, aid.	Shore-line survey and hydrography.
	Coast of New Jersey		John Farley, assistant	Triangulation.
	Philadelphia and environs.	Gen. N. J. T. Dana, Gen. Geo. Cadwalader.	A. D. Bache, superintendent; George Davidson, assistant; H. L. Whiting, assistant; C. O. Boutelle, assistant; C. M. Bache, assistant; R. M. Bache, assistant; C. Rockwell, sub-assistant; J. S. Bradford, sub-assistant; A. R. Fauntleroy, aid; R. E. McMath, aid; E. Hergesheimer, W. B. McMurtrie.	Military reconnaissance, surveys for sites, and erection of field-works for defensive purposes.
	Delaware breakwater	For Engineer department.	Capt. C. P. Patterson, hydrographic inspector.	Hydrography.
III	Baltimore, Md.	Col. W. F. Raynolds	J. W. Donn, aid A. Lindenkohl C. H. Boyd, sub-assistant	Topography. Topography. Triangulation.
IV	Near Fort Lyon, Va.	Gen. J. G. Barnard	C. M. Bache, assistant T. C. Bowie, aid	Topography. Topography.
V	Charleston bar. (Schr. Bailey.)	Admiral J. A. Dahlgren.	W. S. Edwards, assistant F. H. Dietz, aid L. A. Sengteller, aid	Hydrography. Hydrography. Hydrography.
VIII	Chattanooga, Tenn.	Gen. U. S. Grant, (Gen. W. F. Smith.)	P. C. F. West, assistant; C. Fendall, sub-assistant; F. W. Dorr, sub-assistant; J. W. Donn, aid.	Under orders for topographical surveys and reconnaissance.
	Louisiana	General N. P. Banks, (Gen. W. B. Franklin.)	J. G. Oltmanns, assistant; Chas. Hosmer, sub-assistant.	Topographical reconnaissance.

APPENDIX No. 29.

Aids to navigation placed or recommended by Coast Survey assistants, and referred for the information of the Light-house Board.

Section.	Object.	By whom recommended.	Date of report, etc.
I	Second-class can buoy to mark the outer bay ledges on the edge of the main channel of Penobscot bay.	Assistant W. S. Edwards	Recommended to the Light house Board September 21, 1863.
	Spar buoy on the north end of the inner bay ledges off Leadbetter's narrows, Penobscot bay.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Small spar buoy on a rock in Leadbetter's narrows.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Spar buoy on a ledge at the southeast side of Leadbetter s island, Penobscot bay.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Spar buoy to mark a dangerous ledge in the passage between Lairey's island and Leadbetter's island.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Spar buoy to mark a dangerous ledge in the channel between Hurricane island and the White islands, entrance of Penobscot bay.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Spar buoy in the reach off Dog Point, and between it and Green island, to mark the channel towards Carver's harbor.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Buoy to mark a rock in the reach, having only six feet at low water, opposite to Creed's Point.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Spar buoy on the ledge at Pearce's narrows, on the north side of the entrance to Carver's harbor.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	In the main channel to Carver's harbor, a spar buoy off the western point of sunken ledges projecting from Airey's ledge.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Spar buoy in the main channel of Carver's harbor, to mark the eastern end of sunken ledges, and, with the former, to show the breadth of the channel.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Iron spindle on Norton's Point ledge, in the entrance to Carver's harbor.	Assistant W. S. Edwards	Recommended to the Light-house Board September 21, 1863.
	Buoy on a dangerous ledge with eleven feet water, on the south side of the channel into Penobscot bay, and about two miles west of the north end of Metinic island.	Acting Assistant Edward Cordell	Reported August 7, 1863.
II	Buoy to mark the rock in twenty-four feet water one mile and a half from Montauk Point light-house.	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Recommended to the Light-house Board September 21, 1863.
III	A black spar buoy to be placed about three-quarters of a mile S.SE. $\frac{3}{4}$ E. from Maryland Point, north of and close to a ten-feet lump. Position marked on the chart of the Potomac.	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Recommended to the Light-house Board September 21, 1863.
	A red spar buoy to mark the position for turning at Maryland Point.	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Recommended to the Light-house Board September 21, 1863.

APPENDIX No. 29—Continued.

Section.	Object.	By whom recommended.	Date of report, etc.
III	To move the black buoy off Lower Thom's Point and set it near the eighteen-feet lump indicated by the chart of the Potomac.	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Recommended to the Light-house Board September 21, 1863.
	To set the Smith Point red buoy so as to mark a seventeen-feet lump near the point.	Lieut. Comdr. T. S. Phelps, U. S N., assistant.	Recommended to the Light-house Board September 21, 1863.
X	To move the Persimmon Point black buoy (Potomac river) and set it east of a seventeen-feet lump as marked on the chart.	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	December 31, 1862.
	That a black spar buoy be placed near the three and a half feet lump shown by the chart to be a mile and three-quarters SW. ½ S. (magnetic) from Upper Cedar Point, Potomac river.	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	December 31, 1862.
	For a red spar buoy in eighteen feet water off Speak's house, to enable vessels to turn through Nanjemoy reach, Potomac river.	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	December 31, 1862.
	Spindle in lieu of the spar buoy on Commission Rock, Mare Island strait, Cal.	Assistant A. F. Rodgers	December —, 1862.
	Buoy or spindle to mark Little Alcatraz, a rock off the northwest end of Alcatraz island, San Francisco bay.	Assistant A. F. Rodgers	December —, 1862.

LIST OF SKETCHES.

1.—A. Progress sketch, Section I, primary triangulation.
2.—A. bis. Progress sketch, Section I, upper sheet, coast of Maine.
3.— Rockland harbor, Maine.
4.— Casco bay, Maine.
5.— Boston harbor, resurvey of 1862.
6.— Nantucket shoals, new edition.
7.— Phelps's ledge and Great Eastern rock, off Montauk Point.
8.— Hudson river, from New York to Haverstraw.
9.— Hudson river, from Poughkeepsie to Troy.
10.—C. Progress sketch, Section III, Chesapeake bay and estuaries.
11.— Beaufort harbor, North Carolina, resurvey.
12.— Port Royal entrance, South Carolina, resurvey of 1863.
13.—F. Progress sketch, Section VI, Florida keys.
14.— Straits of Florida, general coast chart No. X.
15.— Florida keys, from the Elbow to Lower Matecumbe key, coast chart No. 69.
16.— Florida reefs, from Long key to Newfound Harbor key, coast chart No. 70.
17.— Western end of Florida reefs, including Tortugas keys.
18.— Atlantic coast, No. I, Cape Sable to Sandy Hook.
19.— Atlantic coast, No. II, Nantucket to Cape Hatteras.
20.— Atlantic coast, No. III, Cape Hatteras to Mosquito inlet.
21.— Atlantic coast, No. IV, Mosquito inlet to Key West.
22.— Gulf coast, eastern part, Key West to Mississippi river.
23.— Gulf coast, western part, Mississippi river to Rio Grande.
24.—J. Progress sketch, Section X, coast of California.
25.— Halfmoon bay, California.
26.— San Pablo bay, California.
27.— Tomales bay, California.
28.— Washington sound, Washington Territory, (new edition.)
29.— General progress sketch for 1863.
30.— Diagrams illustrating discussion of magnetic observations at Girard College.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

Please Note:

This project currently includes the imaging of the full text of each volume up to the "List of Sketches" (maps) at the end. Future online links, by the National Ocean Service, located on the Historical Map and Chart Project webpage (http://historicals.ncd.noaa.gov/historicals/histmap.asp) will includes these images.

NOAA Central Library
1315 East-West Highway
Silver Spring, Maryland 20910