

For general expenses of all the work, rent, fuel; for transportation of instruments, maps, and charts; miscellaneous office-expenses, and for the purchase of new instruments, books, maps, and charts, will require \$40,000.

PENDULUM-OBSERVATIONS.

By the measurements of arcs of the meridian, the approximate figure and magnitude of the earth was ascertained at an early period in the history of geodetic surveys. This was matter of necessity, as any extended survey, in respect of final precision, would depend on knowledge of the terrestrial outlines. In confirmation of the result from ordinary geodetic processes, the average figure of the earth, though not its magnitude, has been inferred also from observations of gravity in various latitudes by means of the pendulum. This was the first method employed, and the one preferred by Newton. The several results so derived have been long on record, and although imperfect, as were the instruments and methods used in a former day, the results are in such general accord as to warrant the application of refinements in apparatus and improvement in the methods of observation that had not been reached in the time of Borda and Biot. Natural difficulties that beset the early observers of course yet interfere.

In the measurement of arc local deflections of the plumb-line affect the astronomical amplitudes, and the pendulum reveals deviations in the force of gravity due to inequality of density in the earth's strata. Hence it is, notwithstanding the great precision with which latitudes and longitudes are determined, and the force of gravity ascertained at any one point, that very sensible residuals or apparent errors are found when we attempt to refer these results to any geometrical form. The cause of these discrepancies or "station errors" being beyond reach we can only endeavor to infer from all attainable sources what, under the denomination of figure of the earth, will best reconcile determinations of geographical position. The measure of the force of gravity, commonly denoted by the letter g , independently of what application is to be made of it, is universally recognized as one of the results due in a geodetic survey.

Within the last sixty years the solution of the problem respecting the measure of the force of gravity and figure of the earth as deduced from such measures has been aided by the experimental researches of Kater, Sabine, Plantamour, and others. Fresh stimulus in the inquiry was manifest in 1862, when the Geodetic Association of Europe, after due examination, recognized the pendulum as an instrument of great precision, and approved of its use in geodetic surveys. Since that year it has been employed in the great trigonometrical survey of India, and in 1865 and 1873 the pendulums used in India and in the Russian survey were swung at Kew Observatory, England, so that the results obtained at widely-separated positions on the surface of the earth are now comparable. They are also to be swung in Berlin.

With a view of providing for a comparison of the pendulum-observations of the Coast Survey with European and Asiatic systems which have been further advanced practically, Assistant Chas. S. Peirce was directed early in the spring of 1875 to procure apparatus of the invariable and reversible pendulum, and to observe with them at Paris, Geneva, Berlin, and Kew. His inquiries on the subject in Europe include also the details of the most approved forms of apparatus and the best methods in use for the improvement of the pendulum as an instrument for geodetic purposes. Theoretically and practically the study is such as to require extreme care and special attention in regard to the efficiency of the vacuum-chamber, the elasticity of the support, the loss of energy by propagated vibrations in the stand, the real temperature of the pendulum-bar, and many other conditions. There are several important forms, including that proposed by Bessel, but the two forms of apparatus specially referred to in this notice may be defined as follows: The invariable pendulum is a plain bar having near one of its ends a knife-edge by which it is suspended. This form is usually employed as a differential instrument, and for general use it therefore requires to be swung at a station where the force of gravity has been ascertained. But the reversible pendulum carries a knife-edge near each of its ends, and it may be swung from either. By means of movable weights (the use of which has been generally abandoned) the reversible pendulum can be so adjusted that when swung by either knife-edge the center of oscillation will coincide with the opposite knife-edge. The distance between

the knife-edges is then precisely equal to the length of the mathematical or simple pendulum oscillating in the same time. A chief advantage of the reversible pendulum is that it eliminates the effect of buoyancy and resistance of the air. The axes of suspension being interchangeable, this instrument is known also as the convertible pendulum. If it oscillates in a second of mean time it is known as the seconds pendulum, and the force of gravity at the place may be deduced from accurate measurements of its length. If, as usual, its oscillations do not exactly coincide with mean time, a small correction is applied to its measured length to give the true length answering to coincidence, and for that purpose a measure of the position of its center of gravity is requisite. The length of the reversible pendulum is one meter.

In the Appendix (No. 15), a paper by Assistant Peirce is given descriptive of his pendulum-observations at European stations, and also a scheme for a history and discussion of the pendulum and its relations to gravitation.

Assistant Peirce sailed from New York on the 3d of April, 1875. He proceeded at once to England, where he ascertained that the Kew Observatory is regarded as the initial point for British pendulum-work. This observatory, which is situated in the old deer-park at Richmond, is the property of the Crown, but the operations conducted there, which are chiefly of a magnetical and meteorological description, have been kept up by the Royal Society, through a special committee, and also by the Royal Meteorological Office. R. H. Scott, esq., who directs the Meteorological Bureau, is also chairman of the Kew committee. The pendulums of the Great Survey of India were swung at this observatory, both before and after the operations in India, the observatory being occupied at first by Captain Basseri during a year for this purpose, and afterward by Captain Heavyside during a year and a half. It is believed that the pendulums of Major-General Sir Edward Sabine were also oscillated here; in any case, all the historical English pendulums are here collected, and can be swung at any time if necessary. By the action of the American minister, General Schenck, an application was made, through the British Foreign Office, for permission to experiment with the American apparatus at the Kew Observatory, and to this request a favorable response was eventually received. Late in May, 1875, Assistant Peirce proceeded to Germany, where a Bessel's convertible pendulum, having the length of one meter between the knife-edges and being a copy of the instrument used in the Prussian survey, had already been ordered of the Messrs. Repsold. It may be mentioned that the convertible pendulum, which was invented by Bohnenberger, had been first seriously employed by Kater. Bessel, however, described such an improvement as to effect the complete elimination of all effect of atmospheric resistance and friction. Long after Bessel's death this improved instrument was constructed by Repsold, and was adopted by the Swiss survey and first used by Professor Plantamour, who developed the method of employing it. It is now exclusively used on the continent of Europe, and has received the unanimous sanction of the International Geodetical Association. An instrument of this sort had been ordered by the Coast Survey at the commencement of the pendulum-operations in 1872, but owing to the Messrs. Repsold being then occupied with preparations for the transit of Venus, the apparatus was not completed until the spring of 1875. This is not the place for any description of this instrument, which was executed with the consummate art and precision for which this celebrated firm of mechanics is distinguished. This instrument having been procured, Assistant Peirce readily obtained from Professor Förster, the eminent director of the Berlin Observatory and president of the Imperial German Commission of Weights and Measures, the permission to make all necessary experiments in the building of the Office of Weights and Measures in Berlin, upon the very spot where the determination of Bessel had been made. This building has been erected expressly for the purpose of making accurate comparisons of standards of length. It is built with very thick walls of hollow brick, and the comparison chambers are lined with systems of flues, through which, by means of an engine in an adjoining building, hot air can be conveyed from a furnace or cold air from an ice-house. This building, which will serve as a model for similar buildings in other countries (as it already has in France), is the most suitable possible place for pendulum-experiments. The building, however, was not sufficiently completed in the summer of 1875 to allow of pendulum-experiments being made there to the greatest advantage. It was thought desirable to make a careful comparison of the

American reversible pendulum with that of Prussia. The celebrated geodesist, Lieutenant-General Dr. Baeyer, the director of the Royal Prussian Survey, who furthered Assistant Peirce's operations in the most gratifying manner throughout his stay upon the continent, at once placed the Prussian instrument at his disposal, and the meter-scale of this apparatus, which had already been carefully compared with the Prussian normal meter at different temperatures by Professor Förster, was submitted to fifty independent series of comparisons with the similar scale of the American standard by Assistant Peirce. These operations, which yielded a very satisfactory result, lasted until July 7. Assistant Peirce afterward proceeded to Geneva, where, upon the return of Professor Plantamour (who was at first absent), arrangements were readily made for oscillating the reversible pendulum at the observatory of this city. Assistant Peirce had thus, at the outset of his operations with Bessel's pendulum, the signal advantage of receiving the counsels of the distinguished *savant* who first introduced the use of it, and who has studied so carefully the methods of its manipulation. Actual experiments were made upon seventeen days, between August 26 and September 17. The method of making the experiments, adopted by Assistant Peirce, may here be described. It has been slightly modified from time to time, but its latest form is as follows: On the first day, the rigidity of the stand and the position of the center of gravity of the pendulum are measured. The next day is devoted to comparisons of the pendulum and standard. The oscillations are then commenced; and no measures of the pendulum are made upon days devoted to these experiments. During the swingings of the pendulum the Repsolds "firma" is always forward. Each day the pendulum is first swung with the heavy end up, then with the heavy end down, and then with the heavy end up again. Two such sets of experiments are sometimes made in one day, but this is considered rather objectionable. After four such sets, the pendulum is remeasured the next day. A day is then devoted to remeasuring the frame of the stand, to interchanging the knife-edges, and to determining the center of gravity before and after this change. In interchanging the knife-edges, they are never reversed end for end. A day is then given to measuring the pendulum. Four more sets of swingings are then made. The pendulum is then again measured as before, and then the determinations of center of gravity and flexure are repeated. Fifteen days might be occupied by such a determination, but in practice it is necessary to vary the proceeding more or less. The times of oscillation are determined by observing transits of the pendulum across the web of a telescope and registering the time upon a chronograph. One hundred transits are observed each time, and in one of the following orders:

- A. 25 transits from right to left, then 50 from left to right, then 25 from right to left.
- B. 50 transits from left to right, then 50 from right to left.
- C. 50 transits from right to left, then 50 from left to right.
- D. 25 transits from left to right, then 50 from right to left, then 25 from left to right.

Choice is made between these methods, so that the signals will not interfere with the two-second breaks of the chronometer, which affect the same pen. Four sets of transits are so taken that at their mean times respectively the oscillations of the pendulum have the half-amplitudes 2° , $1\frac{1}{2}^\circ$, 1° , and $\frac{1}{2}^\circ$. Different eye-pieces are used with magnifying powers nearly inversely proportional to the amplitudes, so that the apparent velocity shall remain constant.

The observatory of Geneva is a small building with one main room, opening by large glass doors to the north and south. The floor is of asphalt, and the instrument rested upon the floor. There was necessarily more or less walking about, and several visitors each day entered at the glass doors just mentioned. Assistant Peirce received every possible assistance and attention from Professor Plantamour and his assistants, but it is necessary to note the fact that the place was hardly suitable for such operations. Observations of time were made by the assistants of the observatory.

At Geneva, Assistant Peirce set up a micrometer in front of the pendulum-stand, and by means of a weight passing over a pulley, whose friction was determined, he measured the flexure of the support of the pendulum, and determined the important correction, amounting to over $0^{\text{mm}}.2$, to be applied to the length of the seconds pendulum on account of the swinging of the stand from side to side as the pendulum swings.

Proceeding to Paris, Assistant Peirce had the honor and advantage of attending the sittings of

the International Geodetical Association and of its standing committee, which met in September, 1875, in the palace of the Ministry of Foreign Affairs. The whole subject of the pendulum received a thorough discussion, and a resolution was unanimously passed expressing the sympathy and interest of the association in the expedition of Assistant Peirce. The reversible pendulum had unfortunately sustained grievous damage in transportation from Paris to Geneva. Thus one of the great advantages of this instrument received illustration; for if it had been an invariable pendulum, the connection between previous and subsequent operations would have been entirely destroyed; whereas, with the existing construction, the pendulum had only to be put again in condition in order to give results perfectly comparable with those which had gone before. During the interval created by this accident the Geneva observations were completely reduced.

Permission was granted by his excellency M. Wallon, Minister of Public Instruction, Worship, and the Fine Arts, for oscillating the American pendulum at the observatory at Paris. M. Leverrier afforded every assistance; and the operations were conducted in the great Salle du Meridien, where the pendulums of Borda, of Sabine, and others had previously been swung. The experiments were conducted in the recess at the northern end of this hall, and were made upon eighteen days, between January 18 and February 29, 1876. The standard clock of the observatory was made use of, and its corrections were furnished by the observatory. M. Wolf, the well-known astronomer attached to the observatory, to whom the arrangements for the experiments were intrusted by the illustrious director, rendered Assistant Peirce in the most gracious manner all the aid that this magnificent institution could furnish.

On the conclusion of the experiments in Paris, Assistant Peirce again repaired to Berlin, and as soon as the great comparing chamber of the Bureau of Weights and Measures was ready, experiments were commenced there upon a pier at the northern end. As before, every possible assistance was received from Professor Förster and Lieutenant-General Baeyer. The experiments were made upon twenty-four days, from April 19 to June 6, 1876. A clock was furnished by the observatory, which was compared with the normal clock whose corrections were furnished by the observatory.

A standard meter with lines and also cylinders for comparison with an end measure was, at a subsequent visit, furnished to Assistant Peirce by the Imperial Commission of Weights and Measures.

After the experiments in Berlin, a favorable response having been received to the application of Assistant Peirce for permission to make his experiments at the Kew Observatory, he went to England and commenced experiments without delay. The observations commenced in June, and were finished in July. The time was observed by Mr. Henry Farquhar, with the transit of the observatory, and four chronometers were kept running at once.

Mr. Peirce arrived at Boston August 26, 1876. He is at present occupied in completing the connection of the determinations of gravity in Europe and America.

MAGNETISM.

In the operations of the survey from year to year, determinations have been made of the variation of the compass or magnetic declination, and also of the dip of the needle and the magnetic intensity. Part of these observations were merely incidental to the prosecution of other branches of the work, but in that way much information has been gathered, and this from time to time has been combined with data from other sources for the means of marking our coast charts with the variation of the compass. To this prime necessity in the interest of navigation have been added in later years increasing inquiries in regard to the bearing of lines in land-surveys of old date. Numerous inquiries of this kind have been answered at the office, but thus far the means for precision have been limited by the scarcity of observations in the interior. In the course of the coming year it is proposed to select and occupy such points as will most effectually combine with those at which the variation of the compass has been already determined and thus to gain, as early as possible, the means of tracing lines for equal magnetic declination from the interior across the coast and with assured accuracy to continue them out to sea. On sketch No. 2 all the magnetic stations occupied by Coast Survey observers between 1833 and 1877 are marked. At all of these the declination, and at most of them the magnetic dip and intensity have been determined. Several of the stations have

been reoccupied for the study of the secular change, and these are indicated in the sketch by a larger dot. In my next annual report such stations as it may be practicable to occupy in the interior during the fiscal year '77-'78 will be indicated in a similar sketch.

LONGITUDE.

The first notice published by the Coast Survey in regard to the use of the electric telegraph for geodetic purposes appears in the Coast Survey Report for 1846, in which the method devised by officers of the Coast Survey for determining differences of longitude is fully described and where the first results are given.

These gave difference in time to the tenth of a second between the Naval Observatory at Washington and the High School Observatory at Philadelphia. In the course of a few years all the details requisite for the utmost precision were completed in this office, and all was in readiness when the opportunity was afforded for determining by that method the difference in longitude between points in America and Europe.

At this day this method enjoys extreme favor on account of its simplicity in theory and the great accuracy in its results, in Europe as well as in America, as shown by its wide-spread application.

On sketch No. 3 all stations of which the longitudes have been determined by the survey through the means of the electric telegraph between the year 1846 and the end of the present year are marked. The connection by telegraph between the stations is indicated by broken lines.

PART II.

The abstracts which follow under separate heads are arranged in geographical order, beginning with mention of work done on the coast of Maine, and closing with notices of work on the coast of Texas. For the Pacific coast, the abstracts will mention first the operations near San Diego, and proceeding northward, will close with a description of the operations in Washington Territory. Appendix No. 1 shows, in tabular form, the distribution of surveying parties in the course of the fiscal year ending June 30, 1876, and sketch No. 1 exhibits in a general way the progress so far made in the main branches of the survey. In the concluding chapter of the report will be found a brief statement of the work of the year in the office, of which the details have been conducted as heretofore by Assistant J. E. Hilgard.

The hydrographic inspector of the Coast Survey, Commander Edward P. Lull, U. S. N., has earnestly co-operated in the arrangements needful for such of the parties as require vessels. Within the year three steamers, three schooners, a small steam-cutter, and two steam-launches have been completed and equipped in accordance with plans devised to insure their efficiency in the service for which each of the vessels was designed. Of the old vessels entirely worn out in the service, seven have been sold within the year.

Lieut. H. E. Nichols, U. S. N., remained on duty until the 17th of December. After performing the special service for which he was then detached, Lieutenant Nichols was reassigned to the Hydrographic Division on the 16th of June. All the original hydrographic sheets are carefully examined in this Division in advance of being registered and deposited in the archives.

SECTION I.

ATLANTIC COAST OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND, INCLUDING SEAPORTS, BAYS, AND RIVERS.—(SKETCHES NOS. 4 AND 5.)

Hydrography, Gulf of Maine.—The party in charge of Lieut. Commander C. D. Sigsbee, U. S. N., assistant in the Coast Survey, with the steamer Blake, was in effective condition on the coast of Maine in July, 1875, and resumed hydrographic work late in that month on Cashe's Ledge. Special attention was first given to the development of the vicinity of Ammen's Rock on this ledge, determined by Lieut. C. H. Davis, U. S. N., assistant in the Coast Survey in 1848, and having as little as twenty-six feet of water. Another rock was found by Lieutenant-Commander Sigsbee, and its carefully determined position proved to be about four miles southwest of the place assigned to Ammen's Rock. The depth at mean low water on the rock last found is five fathoms. Current-observations were recorded while the party was engaged in this work, which was prosecuted with frequent interruptions, the weather being generally either foggy or stormy. Early in September, and after riding out a severe gale of several days, the steamer returned to Portland, sounding at intervals on the line between that port and Cashe's Ledge. Later in the month Lieutenant-Commander Sigsbee repeated soundings on the same line, passed around the ledge, and continued soundings toward Matinicus Rock. From thence it was intended to extend the deep-sea work by a line across George's Bank, but the weather proved too stormy for continuing below Jeffrey's Bank. Soundings were repeated on this line on the return to Matinicus. During a severe gale which followed, the steamer remained in Rockland Harbor, but operations were resumed near Matinicus on the 20th of September. A line of soundings was extended southward and westward, and then southward and eastward to a position on the line which had been previously carried south of Matinicus, and thence onward soundings were recorded to the southward of George's Bank, a depth of 1,171 fathoms being found where the work was discontinued. There a line was commenced and continued to Head Harbor light-house, and from the end of this latter line soundings were carried to Cape Cod.

Lieutenant-Commander Sigsbee reports that in crossing George's Bank, some of the soundings gave as little as 10 fathoms of water.

Intending to complete the hydrographic survey of the vicinity of Cashe's Ledge, the steamer was employed early in October in sounding on a course between the ledge and Provincetown, to

which harbor the vessel had been forced for shelter from a heavy gale. But on the night of the 3d the wind and sea having increased so as to make further soundings impracticable near the ledge, the course was changed and a deep-sea line was extended toward Cape Porpoise. The heavy weather which had prevailed almost continuously having constrained the postponement of further operations in hydrography, Lieutenant-Commander Sigsbee proceeded with the steamer to Portland and made arrangements for completing the office-work resulting from the service performed afloat. Surface currents were observed generally at all the positions at which depths were determined. The devices perfected by Lieutenant-Commander Sigsbee for sounding at sea with wire have been applied with uniform success both in this section and in the Gulf of Mexico. His operations in the last mentioned quarter will be described under Section VIII in this report.

The statistics of work done by the party in the steamer *Blake* on the coast of Maine, include records of temperature at the sea bottom, at the surface of the water, and at intermediate depths, and records of the density corresponding to each of the temperatures thus ascertained. Specimens of the water and of the bottom were sealed for future reference or investigation.

The general hydrographic statistics are:

Miles run in sounding	2, 065
Number of soundings	664
Currents observed (stations)	65

Lieutenant-Commander Sigsbee was assisted in the hydrographic operations here noticed by Lieut. J. E. Pillsbury and W. O. Sharrer, by Masters R. G. Peck and M. F. Wright, and by Ensign W. E. Sewell, U. S. N.

Triangulation and topography of Placentia Bay, Me.—In continuation of the plane-table survey of the coast of Maine, in the vicinity of Mount Desert Island, Assistant J. W. Donn proceeded to this section in July with his party in the schooner *Scoresby*. In order to provide points for topographical work, several stations were first occupied with the theodolite on Swan Island, and horizontal angles were measured to determine by triangulation the relative positions of Pond Island, Black Island, Long Island, and others in that immediate neighborhood. These were all surveyed carefully with the plane-table in August and September, and that work completes the detailed topography of the islands of Maine as far eastward as Mount Desert. Fogs prevailed early in August, but the latter part of the season was more than usually favorable for progress. The statistics of the work are:

Stations occupied ..	8
Angles measured	135
Shore-line surveyed, miles	109
Roads, miles	13
Streams, miles	21
Area of topography, square miles	23

Sixty-eight islands, large and small, are represented on the plane-table sheet and the outlines of thirteen ponds. Earlier in the season the party of Assistant Donn was employed in Section II and subsequently in Section III. Messrs. F. C. Donn and F. H. Parsons served as aids in the plane-table party.

Topography of Blue Hill Bay, Me.—In previous seasons the plane-table survey had been advanced eastward by Assistant W. H. Dennis to the vicinity of Blue Hill Bay. Field-work was resumed by a party under his charge in the middle of July, 1875, and was continued until the 20th of October. The ground mapped by the party includes a breadth of about two miles along the western shore of Blue Hill Bay, and extending northward nearly ten miles or beyond the village known as Blue Hill.

An extensive salt-pond and several post-towns are among the details represented on the topographical sheet. The roads following the course of the shore-line were traced as in all like cases, as were also the outlines of such rocks and ledges as were found bare at low water. Mr. Dennis was aided in this section by Subassistant H. W. Bache and Mr. S. N. Ogden. Reference

will be made under Section V to the subsequent operations of the party. The statistics of work done on the shore of Blue Hill Bay are:

Shore-line surveyed, miles.....	42
Roads, miles.....	43
Area of details, square miles.....	20

Assistant Dennis found the weather more than commonly favorable in this section.

Hydrography of Isle au Haut Bay, Me.—Lieut. J. M. Hawley, U. S. N., assistant in the Coast Survey, sailed from Boston on the 12th of July, 1875, with his party, in the schooner G. M. Bache. On reaching Portland the steam-launch Sagadahoc was repaired for service in the hydrography, and the two vessels arrived at their site of work in the eastern part of Isle au Haut Bay before the close of the month. Stations of the triangulation were soon identified, and signals for the work were set up without delay. Frequent fogs and gales interrupted the progress of the party, but soundings were recorded at all favorable intervals until the 20th of October. The hydrographic sheet resulting from the work represents the water space and depths to the westward of Deer Isle and between it and the western ends of Bradbury and Pickering Island, and as far to southward as Mark Island. As usual, the rocks and ledges within working limits were carefully developed. Tidal observations were recorded at two stations for an entire lunation, and at several temporary stations as the work advanced. In reference to the currents near Northwest Harbor and Green's Landing, Lieutenant Hawley remarks: "Although the rise and fall of the tide at these places was considerable there seemed to be but little tidal current, vessels invariably swinging to the wind. In sounding, the currents experienced were few, and those very slight."

The bottom as developed by the soundings is very irregular, and where rocky is covered with kelp. In the harbor of Deer Isle the bottom is soft mud, and affords excellent anchorage. After closing work for the season the steam-launch was laid up at Burnt Cove. The schooner was taken to Baltimore and refitted for service on the southern coast. A synopsis of the statistics of hydrographic work is thus given in the report of Lieutenant Hawley:

Miles run in soundings.....	270
Angles measured.....	1,824
Number of soundings.....	19,771

During the winter and spring of the present fiscal year this party was employed on the Gulf coast, as will be mentioned under the head of Section VI. On the coast of Maine, Lieutenant Hawley was assisted by Master G. L. Hanus and Ensign J. M. Wight, U. S. N.

Topography of Bagaduce River.—For the completion of this work Assistant Hull Adams resumed operations early in July, 1875, at the limit of his survey of the preceding season. After mapping the surface details in the vicinity of Northern Bay and the reefs and islands adjacent, a second plane-table sheet was completed, showing the head of Bagaduce River, Walker's Pond, Herrick's Bay-South Bay, the contour of intervening ground, and the roads that traverse that quarter. Among the features represented are the villages of Brooksville and West Brooksville and granite quarries in the neighborhood. The detailed survey was completed on the 15th of October. Mr. W. E. McClintock served as aid in the field. In statistics the results are:

Shore-line traced, miles.....	32
Roads, miles.....	50
Streams, miles.....	51
Area of topography, square miles.....	28

The plane-table sheet last referred to essentially completes the topography of the coast between the Penobscot and Blue Hill Bay.

Topography of Penobscot River, Me.—The survey of the shores of the Penobscot was resumed in the middle of July, 1875, by Assistant A. W. Longfellow at limits near Bucksport and Winterport, which had been reached in the work of previous seasons. On the west bank the detailed topographical survey was extended upwards to Crosby's Narrows, above the Sowndabscook Branch, which enters the river about a mile above Hampden Upper Corner. The work on the east bank was carried to a corresponding limit in the town of Orrington. On both sides of the Penobscot, a mar-

gin averaging rather more than a mile was mapped in detail, giving a considerable aggregate of contour at the towns of Winterport and Hampden, and also along the east side of the river. The character of the topography is diversified; but the prominent features on the plane-table sheet show arable and wood land along the valley of the Penobscot and the roads, farms, and surface characteristics generally. The survey was continued until the 4th of November, but with many interruptions of bad weather during the latter part of the season. Assistant Longfellow was aided by Mr. W. C. Hodgkins. The statistics of work are:

Shore-line surveyed, miles	25
Streams, miles	56
Roads, miles	43
Area of topography, square miles.....	18

Tidal observations.—At North Haven, on one of the Fox Islands in Penobscot Bay, an excellent series of tidal and meteorological observations begun in 1870 has been continued through the fiscal year by Mr. J. G. Spaulding. The self-regulating gauge there in use is one of the best, and being provided with means for circulating hot water through the float-box, the register has never been stopped by freezing. When stopped at short intervals occasionally for repairs, the series of observations have been continued by means of a staff-gauge. Every high water and low water from the beginning appears on the record of this station.

Coast Pilot.—The work of compiling and verifying sailing-directions has been continued by Assistant J. S. Bradford with a party in the schooner *Palinurus*. That vessel sailed from Norfolk on the 13th of July, 1875, and continued work in the vicinity of New York until the 4th of September, when the party was transferred to the coast of Maine, the season being then favorable for taking the views needed for charts. All points of interest about Passamaquoddy Bay were sketched by the draughtsman, Mr. John R. Barker, previous to the middle of September. At Eastport, where the strength of the tide was such as to make it doubtful whether the *Palinurus* would be of service, Capt. David Evans cordially tendered the use of the revenue marine steamer *Levi Woodbury*, and with that vessel the work in the vicinity was well and quickly done.

Between September 24 and the 20th of October the party was fully occupied in revising the first edition of the *Coast Pilot* and making views of the coast between Passamaquoddy and Penobscot Bays. Thirty-seven views of intervening parts of the coast were completed satisfactorily.

Broad Cove Rock in Portland entrance was examined on the way southward, its crest having been reported as bare at extreme low water. Careful soundings by the party in the *Palinurus* developed nothing less than seven feet at low water. Proceeding direct to Boston Harbor close inspection was made by Assistant Bradford of the harbor improvements and alterations, and corresponding changes were made in the manuscript of the *Coast Pilot*. At the end of October the vessel left Boston and returned to New York. Work done in the vicinity of the last-named port will be stated under the head of Section II.

On the coast of Maine two views were taken of approaches to Eastport; one showing the Wolves (in the waters of the British provinces); two of Little River, Me.; two of Machias Bay; one of the entrance to Little Kennebec River; one of Englishman's Bay; two of Moose-a-bec Reach; one of the approaches to Head Harbor; two of Narraguagus Bay; two of Petit Manan Island; two of approaches to Frenchman's Bay; one of Mount Desert Eastern Pass; two of approaches to Southwest Harbor; one of Bass Harbor; one of Blue Hill Bay; one of the entrance to Burnt Coat Harbor; two of Isle au Haut; two of Eggemoggin Reach; two of Deer Island Thoroughfare; two showing outlying islands of Penobscot Bay; two of Penobscot entrance; two of Fox Island Thoroughfare; one of Belfast Bay; and one of the Penobscot River entrance.

Lieut. C. A. Bradbury, U. S. N., was attached to the party in the *Palinurus*, and succeeded to the charge of the vessel in December, as will be referred to under the head of Section II.

Coefficient of refraction.—Valuable series of observations were recorded in July, August, and September, 1874, at Ragged Mountain, near Camden, Me., and of these mention was made in my last annual report. Assistant F. W. Perkins then determined the elevation of six points by running lines

with the spirit-level from tidal bench-marks in the vicinity of Penobscot Bay. Two of these heights were proved by the use of the barometer and by measurements with the vertical circle.

In October, 1875, Assistant Perkins returned to the primary-station point on the summit of Ragged Mountain, and repeated his measurement for height with the spirit-level, extending the line to the tidal bench-mark at Camden. The records of work done by Mr. Perkins at that point of the primary triangulation show the hourly observation of zenith distances as measured upon outlying signals, the heights of which above sea had been previously determined. These measurements were originally made between 5 a. m. and 7 p. m., and another series on only one object during the intervening hours of the night, to give means for investigating the law of variation in atmospheric refraction throughout the twenty-four hours. Series of hourly barometric observations were recorded between 6 a. m. and 6 p. m. at Ragged Mountain, at Mount Desert, and also at White Head light-house. These and the data afforded by the other observations have been subjected to discussion by Assistant C. A. Schott. The results found are given in the Appendix No. 17.

Triangulation in New Hampshire.—On the 1st of June, 1875, Prof. E. T. Quimby, of Dartmouth College, took the field for continuing this work, and devoted some days to reconnaissance, in which signals were set up at new secondary points, and such as had been more or less disturbed by the storms of the preceding winter were adjusted. Stations were added to the scheme at Stowell Hill in Rockingham, Vt.; Hawk's Mountain, in Baltimore, Vt.; Mount Washington, and the mountain named Starr King, in New Hampshire. The attention and labor requisite for clearing the lines of sight were given at the outset of the season in advance of resuming angular measurements at either of the stations. These were commenced at Croydon Mountain early in July, and the horizontal angles centering at that station were completed by the 2d of August. The following extracts from the report of Professor Quimby contain a clear statement of the progress made, and a gratifying reference to the incidental co-operation of Prof. C. A. Young, the able astronomer, also of Dartmouth College:

"Besides the usual observations of direction with the 24-inch theodolite, and measurement of vertical angles with the vertical circle, several evenings were employed in recording astronomical azimuths for which the station on Croydon Mountain afforded some peculiar facilities. By the courtesy and kindness of Professor Young we were enabled to make our station near the observatory in Hanover, an elongation mark, thus gaining advantage in distance, and saving the time of observing an extra point in our day work. On each evening on which azimuth was observed Professor Young sent the true time for determining the error of our chronometer, thus saving us the trouble of observations for that purpose. The professor, moreover, favored us by a personal visit one evening, and by valuable assistance in the series of observations then recorded.

"After the completion of work on Croydon, the camp and instruments were immediately moved and were reset on Bald Ledge, in Monroe, N. H. On account of the long lines to be observed from that station, and the very unfavorable weather, the observations were not completed till September 22, when the instruments were transferred to Observatory Hill for supplementary measurements needful at that station."

A synopsis appended to the field-report gives as statistics of the work:

Signals, &c., observed on.....	101
Number of observations.....	2, 220
Observations with vertical circle	1, 524

Twenty points were determined in geographical position in the course of the season. Professor Quimby took the field again in June of the present year and will prosecute triangulation work during the summer.

Hydrography of the approaches to Saco River, Me.—The supplementary soundings needed for completing a chart of the vicinity above and below Fletcher's Neck were begun on the 12th of October by Assistant F. F. Nes, who had previously in the season worked at two other localities between New York and Boston. Off Old Orchard Beach some of the requisite lines were run, and at intervals previous to the end of the month, the hydrography was filled in near Fletcher's Neck and Whale's

Rock Ledge. Additional work intended was laid aside in consequence of the severe illness which compelled the return of Mr. Nes. The statistics of the work done are as follows:

Miles run in sounding.....	50
Angles measured	347
Number of soundings	4,328

Tidal observations.—Within the year ending June 30, 1876, some interruptions and several short stoppages occurred in the series of tidal observations at Boston navy-yard, under the charge of Mr. H. Howland. The gauge is one of the old form, and was furnished with heating apparatus, but though not long used at the location, mud had accumulated around the float-box, rendering the action of the float uncertain. In November, the instrument was moved to the wharf on which it had been used formerly. The change proved advantageous, and further means will be taken to preserve the continuity of the series. Meteorological observations have been recorded at that station as heretofore.

Life-saving stations.—The expediency of marking the original topographical sheets of the Coast Survey with the positions of all the life-saving stations having been decided upon in conference with the inspector, Capt. J. H. Merryman, of the United States Revenue Marine, direction was given to that effect. The details of the service were intrusted to Assistant F. H. Gerdes, who proceeded in the middle of July, 1875, to Rockland, Me., accompanied by Mr. C. H. Sinclair, who aided in the observations requisite. The determination in position of each of the 94 stations between Quoddy Head and Cape May was made by various methods. "As soon as the general locality was identified on the maps, angular measurements were taken on permanent objects, such as light-houses, old buildings, sharp points of topography, and particularly on stations that had been occupied for triangulation in the Coast Survey. Linear measurements were in all cases to objects that were not too remote from the life-saving station, and the general topography was referred to when that on the plane-table sheet showed that no change had occurred in natural features." For the present, stations were passed by at which no reference-points have been as yet determined; but these will in time be included, when the positions can be ascertained incidentally and without incurring any considerable outlay.

The report of Assistant Gerdes at the end of the season was accompanied by two quarto notebooks containing his field-records and sketches, and the angular and linear measurements made in the progress of the work. At the office, the notes were carefully examined with respect to the latitude and longitude assigned for each of the stations, and the result, when accepted as complete, was applied in each case with a note of the date on which the determination was made.

Hydrography near Plymouth, Mass.—In the vicinity of Plymouth, Mass., supplementary soundings were made by Assistant F. F. Nes, in September, 1875. Across the entrance to Plymouth Harbor the hydrography was revised, and also along the eastern side of the spit, between Pier Head Station and Clifford House. Further eastward, soundings were made along the shore from Rocky Point southward to Manomet Point, including the vicinity of White Horse Rock. Five shore-signals were erected for this work, and angles were observed on thirty-nine stations. The ordinary hydrographic statistics are:

Miles run in sounding.....	109
Angles with sextant	367
Number of soundings.....	4,413

While prosecuting the supplementary soundings, observations were recorded for determining the level of mean high water, and also that of mean low water.

Assistant Nes was subsequently engaged in similar work on the coast of Maine, as already mentioned, and previously on the coast of Long Island, as will be noticed under the head of Section II.

Plymouth Harbor, Mass.—Assistant Henry Mitchell has pointed out, after comparing old and new maps of the vicinity of Plymouth, that a very large deposit has taken place in the outer roadstead, south of Brown's Island, since the visit of De Mons and Champlain in 1605, and an equally remarkable deposit in the main ship-channel since the survey of Charles Blaskowitz in 1774.

In Appendix No. 9 is given for purposes of reference hereafter the condition of this port for the two early dates, compared with the condition found by the Coast Survey, allowing only the limited credit due to old maps in respect of accuracy. The fact that these deposits have been made in the deepest places without much alteration of shore-line (judging from the old maps) has led Professor Mitchell to conclude, as may be seen by his paper in the appendix, that part of the material has been brought into this vicinity by the Barnstable Bay current, which he discovered and reported on when assisting the United States commissioners in 1860-'61 on the proposed route for a ship-canal across Cape Cod. This current sweeps around the bay, pressing upon the western shore, and from its low temperature is believed by Mr. Mitchell to be an outcrop of a stream *following the bottom* on its way from the ocean. Such a stream, it is evident, might move material along the bottom and cause a deposit in any pocket, or re-entrant angle met in its course. The localities most subject to change in the section here under notice were surveyed last in 1853. A resurvey not being needed now for practical purposes, the general circumstances affecting the vicinity are put on record for action when the matter brought to notice by Assistant Mitchell can be tested incidentally.

Hydrography near Monomoy Point, Mass.—With the steamer *Bache*, a party in charge of Lieut. Commander J. C. Kennett, U. S. N., assistant in the Coast Survey, commenced soundings at the eastern approach to Nantucket Sound on the 29th of July, 1875. The hydrography was extended north and south from the Pollock Rip light-vessel about twelve miles and twenty miles to seaward. Inshore soundings were also made along the eastern side of Monomoy Point, the work extending about five miles along the beach, above and below the light-house. Acting Ensign George Glass was attached to the party in the steamer *Bache*. Hydrographic operations were closed on the 24th of September. The following synopsis appears as statistics on the working-sheet:

Miles run in sounding.....	224
Angles measured.....	915
Number of soundings.....	5,385

After closing this service the steamer was refitted for the performance of duty, which will be referred to in this report under the head of Section VI.

Hydrography of the Handkerchief Shoal (Vineyard Sound).—This work was begun by Lieut. R. D. Hitchcock, U. S. N., assistant in the Coast Survey, on the 28th of August, 1875, with his party in the steamer *Gedney*, and was closed on the 9th of October, after which date the vessel was refitted for duty, which will be mentioned under the head of Section VII.

While sounding on the Handkerchief the tides were observed at Powder Hole, on the west side of Monomoy Point. The space sounded includes about four miles of the south part of the shoal adjacent to the light-vessel. East and west the lines run in soundings averaged nearly three miles. The general statistics of the work are:

Miles run in soundings.....	74
Angles measured.....	270
Number of soundings.....	4,890

Lieut. James Franklin, U. S. N., assisted in this service, and also in Section VII. Masters John Hubbard, H. C. T. Nye, and J. L. Hunsicker, U. S. N., were attached to the party in the steamer *Gedney*.

On the 1st of September Lieutenant Franklin was rescued from imminent peril by Masters Nye and Hunsicker at the risk of their own lives. Becoming suddenly exhausted while swimming, the lieutenant was swept astern by the tide. The young officers plunged overboard instantly, and though much exhausted in the effort, sustained Mr. Franklin, who was then insensible, until all were taken from the water by a boat from the *Gedney*.

In recognition of the prompt gallantry by which the life of their messmate was saved, the Humane Society of Massachusetts issued silver medals, properly inscribed, to Masters Nye and Hunsicker.

While sounding on the Handkerchief Lieutenant Hitchcock was informed that a wreck had sunk on Pollock Rip in the track of vessels. Proceeding to the place the wreck was found in seven fathoms, but dangerous while the spars held. A mark was placed to warn vessels from the wreck, and notice was sent to the Light-House Board with recommendation for the placing of a buoy.

Topography of Taunton River, Mass.—In continuation of this survey Assistant A. M. Harrison resumed field-work on the 13th of July, 1875, below Fall River, and prosecuted the topography of the banks of Taunton River steadily until the close of November. Including the ground mapped last year in the vicinity of Somerset, when the triangulation of the river was advanced from Prudence Island to points within three miles of the city of Taunton, the plane-table work has produced seven sheets of which the details are full, and the scale ample for any purpose of future local improvement. In its progress up the river the survey included Assonet Bay and River, a tributary of the Taunton, the wharf outlines at Fall River, and the villages of Somerset, Dighton, Berkley, and Weir. The immediate vicinity of Dighton Rock was also mapped separately on a large scale, and such particulars of interest concerning it as Mr. Harrison was able to gather by incidental research were embodied in a separate paper and filed in the office.

The ground surveyed along the banks of the Taunton presents the usual topographical characteristics peculiar to a long-settled river-district. Contour-lines on the plane-table sheets show successive elevations of ten feet along the banks as far up as Broad Cove. Between Broad Cove and Weir Village the lines were traced to show each rise of five feet in ground above the water-line.

Assistant Harrison was aided in the field by Messrs. Bion Bradbury and W. B. French. The following are statistics of the field-work:

Shore-line surveyed, miles	56
Marsh, creeks, and ponds, miles	54
Roads, miles	31
Area of topography, square miles	12½

Mr. Harrison is now engaged in prosecuting the detailed survey in the vicinity of Taunton.

Tidal observations.—From the self-registering tide-gauge lent to the city of Providence, records of four consecutive years, ending with the year 1875, have been received from J. H. Shedd, esq., civil engineer. These were accompanied with registers showing the tabulated high waters and low waters and the hourly ordinates. The series is marked by frequent interruptions which occurred especially in winter, but will ultimately be useful for discussing the tides of Narragansett Bay. The instrument is yet in use at Providence for surveys relative to a system of sewerage and other local improvements, and the expense attending the management of the gauge is consequently borne by the city authorities.

Light-house positions.—In continuation of similar work prosecuted in the preceding fiscal year, Assistant J. A. Sullivan took the field at Greenport (Long Island, N. Y.) on the 1st of July, 1875. In the course of the season, which was closed November 8, following, the positions of twenty lights were determined between Wood's Hole, Mass., and Greenport, N. Y. The determinations include the lights at Cedar Island, Long Beach, Block Island, Faulkner's Island, Manhasset, Bass River, Hyannis, Nantucket, Brant Point, South Bay and North Bay, Edgartown, Cape Poge, West Chop and East Chop, Gay Head, Nobska, Palmer's Island, Wing's Neck, and the light on "Bishop and Clerks," a shoal off Hyannis. These are distributed at intervals in a stretch of about a hundred and forty miles along the south coast of New England. Exclusive of the permanent lights the positions of four light-ships and of sixteen fixed objects on land were ascertained by observations with the theodolite. The general statistics of the work are:

Signals erected	18
Stations occupied	23
Angular measurements with theodolite	2, 850

SECTION II.

ATLANTIC COAST AND SEAPORTS OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING BAYS AND RIVERS.—(SKETCHES NOS. 6 AND 7.)

Triangulation of Connecticut River.—In a previous year stations had been determined along the lower part of Connecticut River. For extending the work upward Assistant R. E. Halter took the field at the opening of the present fiscal year. He readily identified the stations at which the oper-

ations had been discontinued, and selected others as high up as Hartford. These in succession were occupied with the theodolite, and from them subsidiary points were determined for use in the topographical survey. The triangulation of the river was connected with the primary work by occupying Box Hill, a point well determined in the general triangulation of the coast of New England. Field-work was continued until the middle of October. Mr. Hugh Caperton served as aid in the triangulation-party. The statistics of work are:

Signals erected	16
Stations occupied	14
Sets of observations (six repetitions each)	525
Number of observations recorded	6, 698

After completing the records and computations of his work, Assistant Halter made arrangements for field-service on the coast of Texas, as will be mentioned under the head of Section IX.

Topographical survey north of New Haven, Conn.—This work has been prosecuted by Assistant R. M. Bache, with the aid of graduates from the Sheffield Scientific School. In order to connect the plane-table survey with the detailed topography of the harbor-shores, a tertiary triangulation was made to include the district between Woodbridge and North Haven, and extending northward to Mount Carmel. Within that region lines were carefully run with the spirit-level to an aggregate of twenty-two miles to establish bench-marks for contouring. The topography is in close detail, and special care has been manifested in the delineation of surface-features. Assistant Bache took the field in July, 1875, and prosecuted the survey until the following January. The party was then disbanded, and the maps resulting from the field-work were inked and completed by the middle of April. In May last Mr. Bache resumed the topographical survey. Mr. Horace Andrews, as heretofore, served as principal aid, with other members of the Sheffield school, selected for their steady interest in the work. The details mapped in the course of the year make the following aggregate in statistics:

Shore-line of river, creeks, &c., miles	110
Roads, miles	138
Area of topography, square miles	29

Hydrography of Cumberland Shoal.—Between September 11 and 25, 1875, the passage between Plum Island and Gull Island, and to the northward and eastward of it the rocky bed known as Cumberland Shoal, were sounded by Lieut. C. T. Hutchins, U. S. N., with a party in the steamer Endeavor. Middle Rock was plotted in position from angles taken with theodolites on Little Gull light-house and Gardiner's Point light-house, and for verification the rock was occupied with a sextant for measuring the angle made there by lines leading to the light-houses.

"Between Middle Rock and the eastern end of Plum Island lies between two rocks an old boiler, part of the wreck of one of the revenue-cutters. The boiler readily offering for the purpose, its position was accurately determined, and the rocks were located accordingly on the chart. In range with them, and about three hundred and fifty yards from the beach of Plum Island, a rock was found with only six feet of water on it at low tide. The channel between the island and Middle Rock is rocky and dangerous."

On Cumberland Shoal the least depth found was $3\frac{1}{2}$ fathoms, in a position corresponding to that assigned by Captain Breese, U. S. N., when the United States ship Constellation, under his command, struck a rock off the east end of Long Island in the preceding year. Because of the limit in time available for the work near Plum Island, the state of the tides was not recorded while the soundings were in progress; hence the depth here mentioned is to be understood as corresponding to the reduction called for by applying a prediction for the state of the tide when that particular sounding was recorded.

The statistics of the work are:

Miles run in sounding	51
Angles measured	1, 574
Number of soundings	3, 260

Lieutenant Hutchins was assisted in this section by Master S. H. May and W. M. Wood, and

by Ensign H. McCrea, U. S. N. The party was subsequently in hydrographic service, as will be seen under the head of Section V.

Triangulation.—In continuation of the field-work in this section, Assistant Richard D. Cutts, after needful preparation, occupied Mount Rafinesque, near the eastern border of the State of New York, early in July. The aid in the party, Mr. J. F. Pratt, as soon as practicable, cleared the lines of sight on the summits of Mounts Equinox and Greylock, and brought the respective signals into view from the theodolite-station.

The measurement of horizontal and vertical angles was begun at Rafinesque on the 1st of August. When the records were complete for that station, the party was transferred to Greenwich Hill, a station about twenty-five miles to the northward, where similar series of measurements were recorded by the 7th of October. A few days after the instruments were moved to South Adams, in expectation that the weather might admit of occupying the primary station Greylock before closing field-work for the season. The summit of Greylock, however, was covered by snow on the 13th of October, and no ready means were at hand for the transfer of instruments to the station. A suggestion made by Mr. Cutts to leading residents in South Adams, in regard to the advisability of having a road by which tourists might reach the top of the highest mountain in the State, was favorably received. That station being next in order in the primary series, the field-work was closed, and the party disbanded at South Adams, to resume in the summer of 1876. On returning to the station with his party in June of the present year, Assistant Cutts was gratified to find that the promise of the inhabitants had been fulfilled. By a practicable road, constructed during his absence, the party and instruments were moved to the summit of Greylock, which is about 3,500 feet above tide-water. When this report closes, Mr. Cutts had all preliminaries arranged for the measurement of horizontal and vertical angles. The statistics of work at the stations Mount Rafinesque and Greenwich Hill, which were occupied in the summer and autumn of 1875, are:

Horizontal angles measured	17
Number of measurements	1, 008
Vertical angles	14
Number of measurements	180

While personally engaged in the field-work of his own party, Assistant Cutts was in correspondence with several observers who were at the same time prosecuting work for the determination of points to aid in the geological surveys of several of the seaboard and interior States. The work here referred to will be mentioned under separate heads in this report, and in accordance with the geographical positions of the several localities.

Coast Pilot.—As already stated under the head of Section I, the party of Assistant J. S. Bradford, in the schooner *Palinurus*, arrived at New York soon after the middle of July, 1875. The weather was exceptionally rainy during that month and the following, but advantage was taken of every opportunity for examinations in New York Bay and its tributaries, with reference to notes and revisions for the Coast Pilot. The last three weeks in August were spent in similar service on the Hudson River. Mr. Bradford then transferred his party to the coast of Maine, but returned to this section early in November. In passing Block Island Sound, views were taken by Mr. J. R. Barker, the draughtsman attached to the party, and thence on westward to Sandy Hook all points of interest were sketched as features for completing the local or general charts within the same limits. The artistic skill and faithful accuracy evidenced by the views are subjects of special remark in the final report of Assistant Bradford. Lient. C. A. Bradbury, at the outset of the season, was attached to the party in the *Palinurus*, and acted as executive officer and sailing-master while the vessel was in service on the coast of Maine, and also in this section. He had in the course of the season observed the methods for procuring and arranging the data intended for the Coast Pilot, and with a view to continuing that work he assisted in the details of the service in New York Harbor until the 1st of December, when the vessel sailed for Norfolk. A few days after, the *Palinurus* was transferred to the charge of Lieutenant Bradbury, and was employed subsequently in duty on the southern coast, as will be mentioned further on in this report.

During the winter, Assistant Bradford prepared for publication the manuscript of a second vol-

ume of the Coast Pilot, to include ports and harbors between Boston and New York. The series of views needful for this volume was completed in June of the present year, by the co-operation of Capt. A. C. Rhind, U. S. N., light-house inspector of the third district. The steamer Putnam, courteously tendered by Captain Rhind, was at the service of Assistant Bradford during four days, and in that interval eleven views were drawn by Mr. Barker of points of interest along the Hudson. These, with previous sketches, make an aggregate of fifty-nine views of the Atlantic coast between the northeastern boundary and New York. Most of them have been etched on copper, and the plates are ready for printing. Those taken in this section comprise two views of Montauk Point, two of Fire Island Inlet, one of the Highlands of Navesink, and sixteen views of points on the Hudson River.

When the failing health of Mr. Edwin Hergesheimer, in March last, rendered him unable to conduct the details of work in the Engraving Division of the office, Assistant Bradford was assigned to that charge, keeping meanwhile in hand the adjustment of materials for the Coast Pilot, in which he has been aided by Mr. J. W. Parsons.

Shore-lines of New York Harbor.—With five sheets projected for the purpose, Assistant H. L. Whiting took the field early in July, 1875, and by the end of October traced and mapped the shore-line as it then existed for the greater part of New York Bay. One sheet represents in outline the Narrows as high up as Bay Ridge and Saug Harbor Landing; another contains the shore-line and wharf-details from Owl's Head below Gowanus Bay and the water-front of Brooklyn; the navy-yard; the vicinity of Newtown Creek, and features above it as far as Astoria. On a third sheet, containing the wharf-outlines of Jersey City, the detailed work was extended above Castle Point to Guttenberg, and was continued on a fourth sheet as far as Bull's Ferry. The fifth sheet shows in position the quarantine piers in New York Bay. Assistant Whiting was aided in this work by Mr. R. B. Palfrey.

Physical survey of New York Harbor.—The study of the tides, currents, and character of the deposits in New York Harbor has been continued by Prof. Henry Mitchell, and the advance made justifies the publication of some of the resulting tables, which will be found in the appendix (No. 10), with explanatory remarks by Mr. Mitchell, who directed the observations.

The practical uses to which such tables may be applied for locating harbor-lines, adjusting riparian interests, and accommodating private to public purposes in the extension of water-frontage for commerce, will be obvious on examination. The completion of physical research will reveal also the mutual relations of different parts of the harbor and its numerous channels, and thus the injury, even distant and indirect, that will be likely to result from irregular or excessive encroachment may be predicted with confidence.

This survey has, of necessity, been prosecuted at intervals, and differing considerably in date the observations could be reconciled only by a large amount of office-work. Points that have relatively the least force in the compiled data are indicated in the report, so that reliance may not be misplaced.

The tables show the *transverse sections*, the *curve of velocity* from shore to shore, the points about which the areas and volumes balance each other (mid-area and mid-volume), &c. From these data the relations of the channels to the streams which traverse them may be known in a general way, though the diversity of material of beds and banks in partly alluvial, partly rocky neighborhoods somewhat complicates the phenomena.

The plan for observations in each season, after being arranged by Mr. Mitchell, is intrusted for the prosecution of details to Assistant H. L. Marindin with a party in the schooner Research. Mr. J. B. Weir served as aid in this section and also in Section VIII, under which head notice will be made of the subsequent work of the same party.

The statistics of the work done in New York Harbor during August, September, and October, 1875, are:

Stations occupied	8
Signals erected.....	10
Current-observations	4, 783

Tidal observations were recorded at five stations. Seventeen transverse sections were determined by observations at ninety-six positions in the sections. Assistant Mitchell reports that the space from the Narrows up to Seventy-ninth street, on the Hudson, and to Hell Gate on the East River, may now be regarded as gauged in accordance with the plan marked out in the beginning of the physical survey.

After the completion of a local survey, which will be mentioned under the next head, Lieut. H. O. Handy, U. S. N., assistant in the Coast Survey, with his party, in the steamer *Arago*, co-operated with Assistant Mitchell in regard to details in the physical survey of New York Harbor. During September and October, 1875, the *Arago* worked in conjunction with the schooner *Research* in determining currents in Hudson River, in New York Upper Bay, and in the east channel of East River. Twenty-three stations were occupied along ten lines. The positions were ascertained by the measurement of eight hundred and fifteen angles, and the velocity of the current by fourteen hundred and thirty-two observations. While the *Arago* was employed on the sections for recording currents, tidal observations were simultaneously recorded at Governor's Island, and at two stations in East River.

Lieutenant Handy was assisted in this service by Master W. P. Ray and Ensign F. H. Lefavor, U. S. N. Closing work on the 2d of November, Lieutenant Handy, a few days after, passed the steamer through the Delaware and Raritan Canal, and laid up the vessel at Baltimore.

Shrewsbury Rocks.—For developing by soundings the vicinity of the rocks off Shrewsbury Inlet, south of Sandy Hook, Lieutenant Handy, with a party in the steamer *Arago*, made preparation late in July, 1875. As the best available point on shore, the position of the telegraph-station was determined for reference in sounding. While the work was in progress the tides were observed at the government wharf at Sandy Hook during each five minutes of the day. The hydrography was prosecuted at all intervals admitting of work between the 9th and 30th of August, but the weather was generally unfavorable. The statistics of the work are:

Miles run in sounding.....	55
Angles measured.....	578
Number of soundings.....	1,524

The subsequent work of the party in the *Arago* was mentioned under a preceding head, in its proper geographical order.

Tidal observations.—The series of tidal observations at Governor's Island, in New York Harbor, has been continued through the year very successfully by the observer, Mr. R. T. Bassett. Though of the old form, the apparatus, by the experience and care of Mr. Bassett, was made to work well throughout the winter, with the free application of hot water when ice was likely to impede action in the float of the gauge. The same observer recorded day-observations with a box-gauge at Ham-ilton Avenue Ferry, in Brooklyn, for comparison with the series at Governor's Island.

In my annual report for the year 1875, a paper was given showing the results of discussion by Prof. William Ferrel, based on the continuous series of tidal observations which have been maintained at the permanent station in New York Harbor.

Triangulation near New York City.—As incidental to the determination of latitude and azimuth at Beacon Hill, N. J., one of the primary stations occupied at an early period in the survey of the coast, Assistant G. W. Dean, in the course of the summer of 1875, connected that station by angular measurements with the principal points used in the survey of New York Harbor. Careful reconnaissance resulted in the selection of eleven stations, at seven of which signals were set up. The daily smoke near the city, as was expected, much delayed the measurement of horizontal angles at Beacon Hill, where, however, other work was in progress during the season, as will be stated under the next head. The statistics of the triangulation are:

Signals erected.....	7
Angles measured.....	11
Number of observations.....	1,246

The angles at Beacon Hill were measured with a 12-inch repeating theodolite. Assistant Dean was aided in this service, and also in astronomical observations, by Messrs. J. B. Baylor and Charles Tappan.

Latitude and azimuth at Beacon Hill, N. J.—The station-marks placed at Beacon Hill in 1839 having been identified, as mentioned in my last annual report, and provision made for mounting the requisite astronomical instruments, Assistant Dean was there in readiness at the close of July, 1875, for determining azimuth with the 46-inch transit, No. 5. The instrument was adjusted on a brick pier, directly over the geodetic station. Measurements made with the micrometer upon the star δ Ursæ Minoris near upper, and on 51 Cephei near its lower culmination, were referred to a meridian-mark about eight miles north of Beacon Hill. One hundred and seventy-nine observations were recorded on six nights. The angle between the meridian-mark and the primary station on Weasel Mountain, in the northern part of the State of New Jersey, was carefully measured with a 12-inch theodolite.

At Beacon Hill, Mr. Baylor, in observing for the latitude with zenith-telescope No. 4, recorded one hundred and eighty-one measurements upon thirty-two sets of stars. For ascertaining the arc-value of the micrometer, one hundred and sixty-four observations were made upon Polaris near eastern elongation. The level-scale was determined in value in the usual manner from sixty-four measurements with the micrometer. Local time was obtained from five hundred and thirty-four observations upon thirty-one zenith and circumpolar stars with the transit-instrument No. 5.

The field-operations here noticed were closed in November, 1875. In the course of the winter and spring the resulting computations were made and sent to the office with the originals and duplicates of the record of observations.

Hydrography of Fire Island Inlet, N. Y.—In August, 1875, this inlet was examined by Assistant F. F. Nes. Considerable changes in shore-line were observed as having taken place in the course of two years on the eastern side of the entrance. The soundings showed, however, no material change in the general course of the channel. Mr. Nes erected five signals for this survey, and under his direction the tides were recorded during nineteen days. The general statistics of the work are:

Miles run in sounding.....	254
Angles measured.....	199
Number of soundings.....	1, 673

Work done subsequently by Assistant Nes has been mentioned under Section I.

Triangulation west of Fire Island Inlet, N. Y.—In order to provide for the detailed survey of the south coast of Long Island, Subassistant B. A. Colonna was assigned to field-duty early in July, 1875, to determine stations in position between Fire Island Inlet and Rockaway. Two points previously occupied with the theodolite in the vicinity of Babylon having been identified, stations visible from them and from each other were selected and connected by angular measurement. The scheme, as far as completed, extends westward to Far Rockaway. To connect his series of triangles with the primary work, Mr. Colonna occupied West Hills station and completed observations there on the 28th of October. Fifty points were determined in position in the course of the season. The general statistics of the triangulation are:

Signals erected.....	21
Stations occupied.....	15
Angles measured.....	248
Number of observations.....	6, 950

This work was pushed under natural disadvantages in passing from station to station in summer through shallow waters in an open boat, and in which the party sometimes remained all night because of the distance from more acceptable sleeping-quarters. All positions occupied with the theodolite were well secured by surface and underground marks before the party left this section. During the winter, Subassistant Colonna was on field-duty in Section VIII.

Survey of Great South Bay, N. Y.—This survey was resumed on the 14th of July, 1875, by a party in charge of Assistant C. T. Iardella. Beginning with the plane-table near Patchogue, the details of topography between the shore-line and the road running parallel with it were mapped as far as Carman's River. Farther eastward the work done includes several miles of the course of that river, the head of Great South Bay as far as Roberts' Dock, and about five miles of the barrier

which separates the bay from the ocean. Among the details represented are the several small islands in the bay opposite to Howell's Point.

Within the shore-line limits of the plane-table sheet here noticed, Assistant Iardella completed soundings in Great South Bay, and then transferred his party to the vicinity of Babylon, for continuing the detailed survey westward. In that quarter the railroad was taken as the limit of work. East and west, the shore-line and surface-features were mapped between Conklin's Point and Negun-tatogue Creek.

Assistant Iardella was aided in this work by Mr. W. Fraser. The party was disbanded at the end of October. A synopsis in the field-report gives as statistics:

Shore-line surveyed, miles.....	48
Streams and ponds, miles.....	18
Roads, miles.....	61
Area of topography, square miles.....	10
Miles run in sounding.....	139
Angles measured.....	688
Casts of the lead.....	9,670

Tidal observations.—As intimated in my previous report in regard to the erection of a tide-gauge at Sandy Hook, when the arrangements needful were complete, Mr. R. S. Avery, of the Tidal Division of the Coast Survey Office, proceeded to the vicinity early in October, 1875. Under his supervision a structure five feet by eight, for covering the tide-gauge and high enough to stand in, had been made in sections and was forwarded to the place. The self-registering gauge designated for use at Sandy Hook is of the best construction and is furnished with a balance-clock, reading-box, and all accessories requisite for preserving continuity in the series of observations. With the sanction of W. S. Sneden, esq., general manager of the Southern New Jersey Railroad Company, the tidal apparatus was fastened securely to the middle of a wharf about 60 feet wide, and far enough from the outer end of the wharf to be free from the jarring action of the ice of Raritan Bay when it is driven by strong wind from the westward. The float-box of the gauge was let down through a square opening in the deck of the wharf, and is protected on all sides by a great number of piles that stand upright to bear up the wharf and its burdens of freight. At maximum tides the water under the tide-gauge is about 20 feet deep. After bracing the float-box firmly in its proper place the tide-house was set up and fastened to the wharf by screws passed through the sills of the house and into the wharf-planks. Part of the roof is put on with screws to admit of taking up, if needful, either the inner float-tube, or both. The piling that sustains the wharf will not allow the passage of cakes of ice greater than four feet in width, but to guard against possible injury to the float-box a crib was made around it by spiking 2-inch Virginia pine plank firmly to three of the piles nearest to the box, which is nearly 17 feet long and 6½ inches square. It was constructed at the office, and inside as well as outside is covered with sheet-copper, slips of which were continued over the ends. When corroded at the lower end the box can be reversed and continued in use. Inside of the float-box was placed a round tube of five inches and eight-tenths aperture supported by a flange at top and terminating at the lower end with a funnel of which the aperture is only three-quarters of an inch to admit the water. The float is a hollow water-tight copper cylinder 5 inches in diameter and 4½ inches high, and was adjusted so as to float erect with the rise and fall of water in the cylindrical tube. A plan devised by Mr. Avery and applied in the tide-gauge set up on Sandy Hook will be understood by the following extract from his report:

“Two lines run up from the copper float, one, a round, well-varnished fish-line, to connect with the large wheel of the gauge as usual, but the other is part of a surveyor's tape-line, the chain of it being brass or copper wire, and the filling of linen thread. The tape is painted and marked in feet. This goes over a pulley of 6 inches, having on its axis another pulley of 2 inches diameter for a counterweight, which is just sufficient to keep the tape-line straight. These pulleys run in a frame attached to the roof of the tide-house, and are so placed that the line can run down in the middle of the float-box, and in so doing pass along the side of a staff, one foot of which, at the height of the eye, is graduated in tenths and hundredths, to serve as a vernier. While the water was oscillating as much as 2 feet up and down at the plain tide-staff (spiked up for the purpose), the height

of tide was read to the nearest hundredth on the tape-line, before the work about the tide-house was completed."

For bench-marks, Mr. Avery sunk two cedar posts at the edge of a grove of red cedars, which border the marsh at a point nearest to the tide-gauge. Each of the posts was marked with copper nails, and was set in ground a few feet higher than the marsh, where natural changes will be very slow and artificial works not likely to be called for. By estimation, the bench-marks are about one hundred rods northeasterly from the tide-house.

The gauge at the neck of Sandy Hook was placed in charge of Mr. J. W. Banford, a very intelligent employé of the railroad company. Since October, 1875, when the apparatus was put in running order, a very good set of observations had been made, though the water is often agitated more than is usual at tidal stations. Nearer to the point of Sandy Hook, where the violent action of ice, driven by storms in winter, had crushed the outer piling of the government wharf, it was deemed inexpedient to establish the tide-gauge, which, for that reason alone, was put in operation at a position more distant from the point of the Hook, where it would be less exposed to the violence of the sea.

Topography, coast of New Jersey.—For completing the plane-table survey at the north end of Barnegat Bay, Assistant C. M. Bache took the field in the latter part of July, 1875. Joining with the limits of his previous work below Tom's River, that stream was included in the survey as far up as the town so named. The coast-line and shores of the bay were then traced, including on the western side Mosquito Cove and Kettle Creek. A short distance above the latter, the work was joined with the general topographical survey of the coast, which is now continuous from Sandy Hook to a point several miles below Atlantic City. The nearest road following the western shore of the bay was taken as the limit of the survey inland. Mr. A. G. Pendleton joined this party as aid early in August, and remained in service till the close of work on the 8th of November. The statistics are:

Shore-line surveyed, miles	109
Roads, miles	117
Area, square miles	43

After laying up the barge which had been used by his party in the survey of the coast of New Jersey, Mr. Bache returned to Philadelphia and there completed and inked the sheet containing the season's work.

Triangulation in New Jersey.—The requirements of the geological survey, which has been some time in full activity under the direction of Prof. G. H. Cook, the State geologist, have been met by Prof. E. A. Bowser, who took the field late in June, 1875, and passed several months in selecting points suitably related to stations of the Coast Survey. His reconnaissance included about seven hundred square miles, within which nineteen stations were selected and marked. These will be hereafter occupied with the theodolite for the measurement of horizontal angles. In general, the triangle sides will range from six to nineteen miles in length, over a region varying from four hundred to twelve hundred feet above tide. As far as now advanced, the reconnaissance includes the northern part of New Jersey, and extends southward from the boundary between that State and New York to Newtown and Mount Rose, where the scheme joins with the Coast Survey primary triangulation. Similar work being now in progress westward from the Delaware, the reconnaissance on both sides, to be effective for all future purposes, must keep in view the selection of two or more points at which both schemes of triangulation will join. The labor and hardship involved in the selection of intervisible points over a wooded country are commonly very considerable where the region offers no well-defined elevations. To the sameness of the hills in contour, and the consequent difficulty of identification, the observer finds added the dense undergrowth through which lines of sight must be cut, and which, notwithstanding the labor, do not in all cases avail in perfecting the desired scheme of triangulation.

Closing for the season at the end of September, 1875, Professor Bowser again took the field early in March of the present year, and has improved the scheme as first marked out, by slightly altering the position of some of the stations. He reports the necessity of high scaffolds for the

theodolite at some of the points which, although favorably situated, cannot be seen from the stations adjacent without laborious and expensive cutting through the intervening timber.

At the end of June, when this report was closed, the reconnaissance for station-points was still in progress, under the general direction of Professor Cook.

While conducting work with his own party in the field, as mentioned under a preceding head of this section, Assistant Richard D. Cutts advised by correspondence in regard to the reconnaissance in New Jersey, and also for the examination then in progress in Eastern Pennsylvania, which will be the next subject of notice.

Triangulation in Eastern Pennsylvania.—As stated in my report of last year, arrangements had been made for determining points in the vicinity of the Lehigh Valley by Prof. L. M. Haupt, in accordance with the wishes of Prof. J. P. Lesley, State geologist of Pennsylvania.

Professor Haupt took the field on the 1st of July, 1875, and, giving attention to the means for joining with known points of the primary triangulation which passed some years ago along the Delaware River through the State of New Jersey, stations were selected at *Smith's Gap* and *Bake-Oven Knob*, the latter being a conspicuous elevation of the Blue Ridge. From that station reconnaissance was extended northward to Broad Mountain, and in other directions, but under some disadvantage, as most of the summits deemed available, when visited were found to be cumbered with underbrush and trees that hindered the view. Ultimately, a point was selected on Broad Mountain, and to the southward another near Topton. Other stations to the westward were chosen in succession, and by the 11th of September an acceptable scheme of triangulation had been laid out reaching to points westward of Reading. A few preliminary measurements were made, but the purpose is to complete the scheme previous to the final measurement of horizontal angles.

Professor Haupt left Philadelphia on the 19th of June of the present year, and resumed reconnaissance for perfecting the connection between his own and some geodetic stations which had been selected by another observer on the east side of Delaware River in New Jersey. Until the close of the month the region south and west of the Delaware Water Gap was carefully examined. The work is in progress when this report closes, and the prospect is good for developing before the close of the season a satisfactory scheme of points to include the ground between the Delaware and the Susquehanna Rivers.

For the immediate purposes of the geological survey, Professor Haupt measured a short baseline, and recorded the approximate readings of angles at several of the stations. These operations will be repeated systematically when the positions are hereafter occupied with the theodolite. The six stations now marked will form two well-shaped quadrilaterals from which the scheme of triangulation can be readily extended westward or eastward. The triangle sides vary from sixteen to thirty miles in length. On the east and south this triangulation will be properly connected with the chain of great triangles that defines the outline of the coast along the Middle States.

To further the means for determining points in Eastern Pennsylvania, Assistant G. A. Fairfield was directed, in the autumn of 1875, to seek for the ground-marks which had been set at the primary stations Principio and Osborne's Ruin when the triangulation of Chesapeake Bay was in progress. One of these stations is on the east side of the Susquehanna and the other on the western side. Principio had been identified in 1866, and Mr. Fairfield readily found the station-mark. The ground at Osborne's had not been disturbed since the station was first occupied. Within the limits indicated by the reference-marks the cone was found where it had been first buried. On looking to the northward from these two stations no points were in view favorable for extending the triangulation in that direction. Proceeding to the northward and eastward, Mr. Fairfield visited the station at Meeting House Hill, and there found, without difficulty, the station-mark in the position in which it was placed thirty-five years ago. The base being sufficient for the addition of subsidiary points if the ground in Southeastern Pennsylvania proved favorable for triangulation, Assistant Fairfield made a reconnaissance through Chester County and noted such points as might be available for extending the triangulation northward. On the approach of severe weather the reconnaissance was discontinued, but will be resumed hereafter.

Hydrography of Delaware River.—With a party organized for service on board the steamer *Fathomer*, Lieut. J. M. Grimes, U. S. N., assistant in the Coast Survey, took charge of that vessel at New

York in July, and, after needful repairs, passed through the Raritan Canal and reached Delaware City on the 20th of August, 1875. The work assigned in that vicinity was the extension of soundings along both sides of the main channel between Delaware City and Ship John Shoal Light. Eleven signals were erected by the party in the Fathomer, and their positions were determined by occupying thirty stations. While soundings were in progress, the tides were observed and recorded at a wharf in Delaware City and also at Reedy Island. Considerable changes were noticed as having occurred in the shore-lines, the river-bank receding in some places and advancing in others.

In midchannel and S. 25° 35' E. (true), distant 2,503 meters from Reedy Island light-house, Lieutenant Grimes developed a shoal on which the depth is 19½ feet at mean low water. Having filled with soundings the projection sent for this part of the river, the Fathomer was moved up to a position between Marcus Hook and Chester, in which vicinity a ledge was developed by careful soundings in October. This impediment in navigation seems to have been caused by a sunken schooner or sloop which became imbedded in the sandy bottom between some rocks. Hence in the notice to mariners, which issued from the Coast Survey Office early in November, the danger is named Schooner Ledge. As far as practicable with the means at hand, all the rocks in the vicinity of the place were developed and marked on the chart. The statistics of hydrographic work in the Delaware are:

Miles run in sounding.....	315
Angles measured.....	3,602
Number of soundings.....	25,101

Lieutenant Grimes was aided in this work by Mr. C. A. Ives. The steamer Fathomer was subsequently employed in service which will be noticed under the head of Section IV in this report.

Liston's Tree range-lights.—The expediency of a range on the New Jersey side of the Delaware, in lieu of one of the two ranges marked last year on the west bank of that river, having been decided in the Light-House Board in February, the service was committed to Mr. Charles Junken. After consultation with General W. F. Reynolds, engineer of the fourth district, who had arranged for the purchase of sites, the requisite observations were made by Mr. Junken. The positions of the range-points were marked on the ground and on the original chart of that part of the river, as also on a copy of the original which had been made for the uses of the Light-House Board.

Sites for range-beacons, Delaware River.—Request having been made by General Reynolds, engineer of the fourth light-house district, for topographical surveys of the two sites selected on the west bank of the Delaware, near Liston's Tree, the work was committed early in July, 1875, to Messrs. F. C. Donn and F. H. Parsons, aids in the party of Assistant J. W. Donn, who was then completing arrangements for work which has been mentioned under the head of Section I. The mapping requisite for the ranges was completed in the field on the 17th of July. Soon after, the sheets were forwarded to the Light-House Board, and the two aids joined the party to which they had been previously assigned.

Shoal near Delaware Breakwater.—In June of the present year my attention was drawn to the existence of a shoal, reported by one of the bay pilots, near the Delaware Breakwater. Neither of the vessels of the survey being immediately available, the needful examination could not be made before the close of the fiscal year, at which time this report was closed. Arrangements were, however, promptly made for sounding the locality. The results will be stated in my next annual report, in which notice will be taken of all work prosecuted in the survey after the end of June, 1876.

SECTION III.

ATLANTIC COAST AND BAYS OF MARYLAND AND VIRGINIA, INCLUDING SEAPORTS AND RIVERS.
(SKETCH NO. 8.)

Harbor of Baltimore, Md.—Local interest as manifested by the city authorities of Baltimore in regard to the preservation and improvement of the harbor, took definite form in May last, when the President of the United States authorized a board to confer with the governor of the State of Maryland, the legislature of the State having previously appropriated means for a special survey of the harbor. With the concurrence of the board, the members of which are General A. A. Humphreys, Chief of Engineers, C. P. Patterson, Superintendent United States Coast Survey, and Maj. William P. Craighill, of the Corps of Engineers, Assistant J. W. Donn was detailed in June, 1876, to make the survey which will be needful in the deliberations of the board for the establishment of bulk-head lines. Three sheets have been projected to contain the outline and hydrographic details of the inner harbor above its entrance at Fort McHenry. With an effective party, Assistant Donn is now prosecuting the desired survey.

Norfolk Harbor, Va.—As a preliminary to action by the harbor commissioners of Norfolk for the establishment of port-warden lines to restrict encroachments on the harbor, application was made in the usual way for an advisory board. At the first meeting of the members of the board it was deemed advisable to procure data of the kind which is very generally in requisition when measures are pending for the preservation of harbor channels. Fortunately, a very careful hydrographic survey had been made in 1873. It was needful only for the purposes of the board to determine, in addition, the dynamic axis in each channel, the curve of velocities from shore to shore, and the volume of discharge, as with such elements the problems involved in defining between artificial and natural limits are much simplified.

The requisite physical survey in the channels at Norfolk and Portsmouth was prosecuted under the direction of Assistant Henry Mitchell by Messrs. John B. Weir and E. H. Wyvill in May, 1876. Messrs. T. A. Harrison and C. A. Ives were attached to the party as aids, and the schooner *Caswell* was assigned for use in the work. The expenses incident to the special survey were met by the harbor commissioners of Norfolk.

Observations of the character shown in the appended statistics were recorded at numerous stations from the second bridge of Eastern Branch and the upper end of the navy-yard in the Southern Branch downward and beyond the bar to Lambert's Point light-house. The statistics are:

Angles measured	6, 331
Number of soundings	3, 016
Observations for velocity recorded	4, 506

The tides were observed at four stations within the working-limits, and twenty-seven transverse sections were traced by an aggregate of two hundred and forty-six points.

Under Section VIII, notice will be taken of work previously done by Mr. Weir.

Tidal observations.—During the year, a self-registering tide-gauge, furnished with large interchangeable cylinders, reading-box, and a balance-wheel clock, has been kept in operation by Mr W. J. Bodell at the station on Old Point Comfort, Va. Interruptions in the series of observations at this station have ceased since the pendulum-clock was replaced by the one now in use. The wharf which supports the apparatus will soon be removed, but arrangements will be made to occupy the position on the engineer's wharf, at which the series was commenced some years ago.

Boundary between Maryland and Virginia.—Previous to the meeting of the boundary commissioners of the two States in June last at Crisfield, Md., request had been made by them for the services of a topographer of the Coast Survey to work under their immediate direction in mapping such ground as might be indicated in the course of their deliberations. Mr. Charles Junken, having been assigned for the special duty, reported in person to the commissioners at Crisfield, and commenced work on the 16th of June on Smith's Island. He was there engaged until the end of the

month. As the fiscal year then closed, the summary of his work will properly appear in my next annual report.

Triangulation.—Among the conditions requisite for final accuracy in triangulation is that the height of each of the primary stations above the sea-level should be known. Hence vertical angles are measured at the primary stations, and it remains only to refer the heights of a few stations near the coast to the level of the sea by running lines for that purpose with the spirit-level. For the chain of main triangles which passes near Washington City and follows the Blue Ridge in its course along the Atlantic seaboard, the plane of reference was ascertained in November, 1875. Assistant F. W. Perkins started from a well-determined bench-mark at the Washington navy-yard with a leveling-instrument, followed the line of the Baltimore and Potomac Railroad to its junction with the Annapolis Railroad, and thence passed down the last-mentioned road to Annapolis, where he established a mark at the level of mean tide. An offset was made from Wilson's Station on the railroad to the primary triangulation-point named Hills; and another offset was run across the Severn River at Annapolis to the primary station Taylor.

The main line of levels was begun at Washington on the 9th of November, and six hundred and thirty-four stations were made between the navy-yard and the level of Chesapeake Bay at Annapolis. By several well-marked objects the station there at which tides were recorded for one month was connected with the line of levels. All the lines were run twice, making in the aggregate eighty-six miles. Including the two lines of offsets, seven hundred and sixty-two stations were made. The two measurements for level show a close agreement. Mr. J. De Wolf joined the party on the 29th of November. Assistant Perkins was aided throughout by Mr. R. E. Duval. Operations were closed on the 24th of December. The work subsequently prosecuted by Mr. Perkins will be noticed under the head of Section VII.

Magnetic observations.—The usual annual determinations of the magnetic declination, dip, and intensity at the station on Capitol Hill in Washington City were made by Assistant C. A. Schott in April last, and by some weeks earlier than the period at which the observations have been annually made during the last ten years. The ground occupied being required for building purposes, a new station will be established in the vicinity.

As the instruments used in the observations here noticed are good specimens of their class, they were early in the summer sent to Philadelphia to form part of the Coast Survey exhibit in the Centennial Exposition.

Triangulation of James River, Va.—The schooner Scoresby, with the party of Assistant J. W. Donn, was at City Point in November, 1875, and it was then hoped that means might hold for extending the plane-table survey of the banks of the river as far as Richmond.

Several of the station-points which had been previously occupied in the triangulation of the main river near City Point could not be found, the marks having been wantonly destroyed. Mr. Donn in consequence found it necessary to begin his triangulation several miles below. During December, 1875, and January of the present year, points were selected and signals put up between Drewry and the approach to the city. Much labor was endured in prosecuting this work, as many of the lines of sight required heavy cutting through timber that abounds in the swamps bordering that part of the James River. Preliminary measurements of angles were made at all the stations, so that data might be available for topographical work, but Assistant Donn intended to make final measurements of the horizontal angles if means could be had for continuing the operations of the party during the spring. Other requirements of the service, however, made it necessary to recall the party in the Scoresby at the end of January, previous to which date twenty-three signals had been erected. During winter the vessel was docked at Richmond, there being, as against probabilities of running ice and freshets, no safe anchorage between the city and the point at which the work was resumed. Mr. Donn had been previously in Section I. On the James River he was aided by Messrs. F. C. Donn and F. H. Parsons.

Primary triangulation in Virginia.—At the opening of the fiscal year 1875-76 field-work on the series of quadrilaterals which passes southward along the eastern side of the Blue Ridge had been extended to Humpback Mountain in Nelson County, Va., at which station observations were closed on the 2d of July, 1875. Assistant A. T. Mosman, as soon as practicable, transferred his

party to Spear Mountain, and closed the series of measurements requisite there on the 29th of August. At that station the weather proved to be unusually wet and foggy.

The station in the series of points named Tobacco Row Mountain was next occupied with the theodolite, and the angular measurements there required were completed on the 22d of September. Some of the lines which converge at this station were upward of fifty miles in length. The weather was often cloudy, but, on days suitable for observing, the signal-poles on the longest lines were in full view.

Preparations were complete on Long Mountain by the 12th of October for astronomical observations and for the measurement as usual of horizontal and vertical angles. The geodetic work was much delayed by the prevalence of smoke and haze, for some days in succession the outlying signals on long lines being hid from view. The astronomical observations were less hindered by the same cause. A lamp, set as an azimuth-mark in the belfry of the court-house at Lynchburg, which is about nine miles distant from the station on Long Mountain, could be observed on at night, although the atmosphere was very seldom suitable for advancing the triangulation. The latitude observations, completed on the 28th of October, depend on two hundred and twenty-eight results found in fourteen nights with twenty pairs of stars. For value of the micrometer of the zenith-telescope, eighty-two readings were recorded, by observing on two stars. Seventeen nights were occupied in the determination of time with the meridian-telescope by observing on eighty-six stars. The azimuth was ascertained by one hundred and eighty-four pointings on Polaris, on seven nights, the observations being some direct and some reflected in mercury. The measurement of horizontal and vertical angles detained the observers on Long Mountain until the 9th of December. In addition to the series of exact angular measures recorded for the triangulation, Assistant Mosman in the course of the season observed on twenty-four subsidiary objects, mostly prominent mountain-peaks, churches, court-houses, &c., and besides recording their direction from the several stations which he occupied, determined the height of the subsidiary points by vertical angles. The statistics of the main triangulation are:

Stations occupied.....	3
Angles measured.....	11
Number of observations.....	2,978

For ascertaining the height of primary stations above the level of the sea, zenith-distances were measured with the vertical circle, and upward of two thousand observations were thus recorded.

Assistant Mosman was aided in the field and in office-work by Mr. W. B. Fairfield, and by Mr. D. S. Wolcott until the 12th of December. During part of the summer Mr. C. L. Gardner was attached to the party. The computations resulting from the triangulation were completed in the course of the spring of the present year. After turning in the records Mr. Mosman again took the field and is now pushing the triangulation across the southern boundary of Virginia, in a pre-arranged direction for joining properly with the southern part of the series of quadrilaterals, of which mention will be made further on in this report, under the head of Section V.

Reconnaissance for triangulation in Virginia.—After the return of Subassistant Edwin Smith from Chatham Island, in the South Pacific Ocean, to which place he had been assigned with a party for observing the transit of Venus, in December, 1874, and when the records of that work were complete, preparation was made for resuming his usual field-duties. Late in July, 1875, Mr. Smith commenced reconnaissance for stations to be occupied by Assistant Mosman to the southward of Lynchburg, and in doing so kept in view the necessity of selecting a course the most direct for joining with the chain of triangles which has been pushed north and east from the base-line near Atlanta, Ga. Following, in general, along the eastern flank of the Blue Ridge, a scheme for the main triangulation was laid out by Mr. Smith. This proved to be entirely acceptable, and the junction in North Carolina with the southern part of the same chain of triangles is satisfactory. The party in reconnaissance kept the field until the 3d of November. As he passed from station to station Mr. Smith made arrangements at several for subsequent occupation by Assistant Mosman.

Subassistant Smith was engaged during part of the present year in Section IV.

Mr. A. H. Scott, after his return at the end of June, 1875, from Chatham Island, in the South Pacific Ocean, where he had been on duty with the party sent to observe the transit of Venus, was

engaged, until the end of the year, in comparing with the standard the brass meters which had been constructed in the office. He made at the same time abstracts and reductions of all the recorded comparisons of the committee meter, and of the iron and steel meters, all of which are used in the final tests of the length-measures issued from the office.

Early in March, Mr. Scott had completed computations for the latitude of the station on Chatham Island at which the transit of Venus was observed in December, 1874. He then took up, under the direction of Assistant J. E. Hilgard, the computation of results from the record of magnetic observations which had been made within the year. These in graphical form, together with others, are incorporated in the illustration to Appendix No. 21, which accompanies this report.

In the latter part of the fiscal year Mr. Scott arranged the details and made an inventory of metric weights and measures and comparisons of the British yard-measures.

Reconnaissance in West Virginia.—The examination of the mountain region of West Virginia with reference to points for primary triangulation was continued during the summer of 1875 by Assistant S. C. McCorkle. West of the Gauley Mountains the country as far as the Ohio presents a succession of peaks and very short ridges, having an average and nearly equal elevation of about seven hundred feet. Hilly as the region is, it presents few natural facilities for the purpose desired, the lines of sight being generally too short for conformity with the character of the triangulation already completed to the eastward of Gauley River.

While this work was in progress the details of field-work in Northern Georgia required the recall of Mr. McCorkle for additional points there, the triangulation-party in Section VII having occupied all the practicable points that had been selected in previous reconnaissance to the westward of the Atlanta base-line. The reconnaissance in West Virginia will be completed early in the present fiscal year.

SECTION IV.

ATLANTIC COAST AND SOUNDS OF NORTH CAROLINA, INCLUDING SEAPORTS AND RIVERS.

(SKETCH No. 9.)

Hydrography of Pamlico Sound, N. C.—This work has been further advanced by a party in charge of Lient. Richard Wainwright, U. S. N., assistant in the Coast Survey, with the steamer Arago. The part sounded between the 20th of December, 1875, and the 10th of May following includes most of the interval between Gibb's Point and Stumpy Point and the middle of Pamlico Sound southward and eastward of Long Shoal Point. Before the work in this quarter had been extended eastward across the sound, the party in the Arago was transferred to Alligator River, a survey of which, beyond the limits previously reached, was requested in the interest of public improvements. Lieutenant Wainwright promptly took in hand the river-survey and traced the shore-lines southward as far as Blunt's Canal. The channel was subsequently sounded by the party and the vicinity mapped on a scale sufficient for the public uses in view when the survey was requested. Lieutenant Wainwright was assisted in this section by W. P. Ray, Master, U. S. N., and by Ensign F. H. Lefavor. Seventeen signals were erected in the course of the season. The general statistics of the work are:

Miles run in sounding	800
Angles measured	4, 517
Number of soundings	35, 663

Earlier in the fiscal year Lieutenant Wainwright conducted hydrographic work on the coast of Texas, as will be stated under Section IX.

Latitude and azimuth at Roanoke Island, N. C.—With a view of having determinations of latitude and azimuth at several stations in this section, Subassistant Edwin Smith was sent in December, 1875, with a party in the schooner Dana to observe at certain of the stations which had been occupied for the triangulation of Pamlico Sound and the adjacent waters. Bad weather and contrary winds delayed the arrival of the vessel until the 13th of January, when the Dana anchored in Oyster Creek, near Sand Island Station, which is near the southeast end of Roanoke Island.

Only a small part of the ground near the station was found to be covered with sand, and that, although the depth of the covering was eighteen inches, yielded sensibly under the pressure of the foot, so that vibrations were sensible at distances of eight or ten feet from the impression. Natural conditions being unfavorable, Subassistant Smith was constrained to put down a foundation of wood and to erect on it a platform for the meridian-instrument.

The azimuth at Sand Island was measured from the cap of the tripod which had been used in closing the triangulation of Pamlico Sound. While azimuth-observations were in progress the instrument was elevated twenty-one feet above the ground-level, a condition not favorable for great accuracy, but in this case unavoidable. Mr. Smith and the aid, Mr. J. B. Baylor, completed measurements for azimuth by the 12th of February, 1876, and recorded in the course of the work, for corrections of the sidereal chronometer, fifty-six observations on twenty-two stars with the meridian-telescope No. 13.

Latitude was determined at Sand Island Station from sixty-eight observations recorded on six favorable nights on fifteen pairs of stars. Eighty observations were made for ascertaining the value of the micrometer.

The direction of the azimuth-mark was found from eighteen sets of observations on Polaris, and the angle so determined was referred to the line passing from the observing station to the south end of the Bodie's Island base-line by thirteen sets of measurements of the horizontal angle. The records of the astronomical work, original and duplicate, contained in eight volumes, have been received at the office with the field-reductions.

Magnetic observations.—While the work noticed under the preceding head was in progress, Mr. Baylor recorded at Sand Island a complete set of observations for determining the magnetic declination, dip, and horizontal force.

Means not being available for continuing the operations of the astronomical party in this section, the schooner Dana was dispatched for Norfolk in the middle of February. Subassistant Smith and Mr. Baylor then repaired to the office and took up the computations for latitude and azimuth.

Hydrography of Core Sound, N. C.—For this work, Lieut. J. M. Grimes, U. S. N., assistant in the Coast Survey, with his party in the steamer Fathomer, reached Beaufort, N. C., on the 26th of November, 1875. The projection for the hydrography took in the west end of Core Island, and joining with work done in a previous season, extended southward to include Harbor Island Bar.

After establishing a tide-gauge in the straits, soundings were advanced by working eastward. Some of the ground-marks set when the triangulation was prosecuted had been lost by the washing away of the shore, but a sufficient number remained of points subsequently marked by the plane-table party for service in the hydrography.

Lieutenant Grimes noticed that during calm weather the rise and fall of tides in the sound was regular, as also with the wind southward or eastward; but that the tides became very irregular with the wind in any other direction. "A northeast wind, or any wind from northwest to northeast, raises the water in the sound to any height from two inches to two feet. On the contrary, any wind from south-southwest to west drives the water out the sound and lowers the water-level as much as two feet, according to the strength of the wind." In the course of the season in this section the hydrographic party set up thirty-four signals additional to field-points, which had been identified for use in soundings. The general statistics of the work are:

Miles run in sounding	526
Angles measured	4,843
Number of soundings	38,296

Having completed the hydrography of Core Sound, Lieutenant Grimes sailed from Beaufort on the 28th of May, and proceeded with the vessel to Philadelphia. He was aided in the work in Core Sound by Master T. G. C. Salter and Ensign O. W. Lowry, U. S. N.

SECTION V.

ATLANTIC COAST AND SEA-WATER CHANNELS OF SOUTH CAROLINA AND GEORGIA, INCLUDING SOUNDS, HARBORS, AND RIVERS.—(Sketch No. 12.)

Hydrography of Winyah Bay and its approaches, S. C.—For this work two sheets were projected, one to show the soundings on Georgetown Bar and at the entrance, the second to represent the hydrography of Winyah Bay and the mouths of the Pedee, Waccamaw, and Sampit Rivers, at the head of the bay. Both sheets have been completed by Lieut. C. T. Hutchins, U. S. N., assistant in the Coast Survey, with his party in the steamer Endeavor. That vessel left New York for this section on the 25th of October, 1875, and returned to port at the end of May of the present year.

For the hydrographic survey of Winyah Bay, forty-six signals were set up and determined in position by occupying thirty-five stations on the shores. In the course of the season the tides were observed at four stations, and an aggregate of nearly seven thousand observations were recorded from the tide-staff. Currents were observed in Bottle Channel (Georgetown Bar), and at the entrance to the main channel; also at three stations in Winyah Bay. Specimens of bottom found in soundings were taken at each of the current-stations. Three wrecks were determined in position and twelve buoys, and these with other customary details appear on the hydrographic sheets. Masters S. H. May and W. M. Wood, U. S. N., were attached to the party in the Endeavor at the outset of the season. The last-named officer was transferred to another section in January and was detached from Coast Survey service in March. Lieutenant Hutchins was aided in this section by Ensign H. McCrea. The hydrographic statistics are:

Miles run in sounding.....	492
Angles measured	2,627
Number of soundings	25,453

Under Section II reference has been made to work previously done by the party in the steamer Endeavor.

Hydrography of North Edisto and South Edisto Rivers, S. C.—For the purpose of sounding the sea-water channels that bound Edisto Island, and which form an important link of the inland navigation along the southern coast, Lieut. J. F. Moser, U. S. N., assistant in the Coast Survey, took the schooner G. M. Bache into the South Edisto on the 11th of April, after the completion of hydrographic work at a point which will be mentioned under the next head. Without delay a tide-staff was set up at East Landing, another in North Edisto River, and search was made for station-marks on which to base the hydrography. Stone posts had been buried out of sight some years ago at the triangulation-points, but as found from time to time by the colored inhabitants they were removed and put to use as anchors for their boats. Houses, too, marked on the hydrographic projection had been so completely carried away that their sites could not be identified. At the east end of the Edisto base-line the monument had been turned over by ignorant people in search for a supposed treasure, and no trace remained of the side-posts at the west end of the base. Fortunately, the monument at that end had not been disturbed, and was made available by Lieutenant Moser for adjusting the hydrographic work in South Edisto River. That stream was sounded upward to its connection with the Dawho. Saint Pierre Creek was sounded, the upper part of North Edisto, Dawho River and its branches, and each of the creeks passable for boats on Edisto Island. Lieutenant Moser states that the shoals that form in the middle of the rivers are invariably of hard sand, the banks at the same places being soft mud. The statistics of work are:

Miles run in soundings.....	252
Angles measured	1,738
Number of soundings.....	22,477

Hydrography of Saint Helena Sound, S. C.—Remarkable shore-line changes caused by sea-encroachment at the north end of Hunting Island were mentioned in my report of last year. In order to ascertain the corresponding alterations in depth, a projection was intrusted to Lieutenant S. Ex. 37—5

Moser, who reached the locality in the schooner *G. M. Bache* on the 21st of February, 1876. As soon as possible a few points were determined additional to those marked on the projection, and the altered shore-line was traced by the hydrographic party.

The new channel passing the north end of Hunting Island and leading into Johnson's Creek is reported by Lieutenant Moser as having eight feet at mean low water. A line of soundings was run through midchannel in Harbor River as a means for determining whether or not any alteration had been caused in the depth of that entrance. The tides were observed and recorded for one lunation at the light-house wharf, Hunting Island. In the new channel current-observations were tried, but Lieutenant Moser found that there the current was mainly induced by the wind. To his inquiries in regard to the probable rate of encroachment the replies given by the nearest residents were not consistent. It was, however, observed by the party that at one place on the exposed side thirteen feet of the bank washed away in the course of six weeks. The rate of sea-encroachments has seemed to depend on the frequency and violence of easterly storms, but is now so much lessened that comparison of the outline traced early in July, 1875, with that found in March last by Lieutenant Moser shows very little alteration corresponding to that interval of time. The statistics of the hydrographic work are:

Miles run in soundings.....	65
Angles measured.....	758
Number of soundings.....	7,543

Lieutenant Moser was assisted in this section by Master J. B. Murdock, U. S. N. After completing the work mentioned under the preceding head, the schooner was returned to Baltimore, and was there refitted for service in Section II.

Primary triangulation.—Assistant C. O. Boutelle during the course of the fiscal year occupied and completed observations at five primary stations in the mountain region of South Carolina and Georgia. Of these the most southern station was occupied first. After completing the measurement of angles at Blood Mountain and Rabun in Northern Georgia, the primary points at Pinnacle, Paris, and Mauldin, S. C., were occupied in succession, field-work for the season closing at the stations last named late in December, 1875.

The several stations mentioned above are part of the series of points selected in reconnaissance for a chain of quadrilaterals stretching northward and eastward from the base-line near Atlanta, and to be ultimately joined with a series of quadrilaterals which has been extended southward and westward along the Blue Ridge through the State of Virginia. (See sketches Nos. 10 and 11.) Blood Mountain, 4,468 feet high, was occupied by Mr. Boutelle late in June, and the measurement of horizontal angles with a 20-inch theodolite was completed by the 15th of July, 1875. Seven primary stations were observed on from Blood Mountain, and the approximate positions and elevations of twenty-three subsidiary points were noted in a separate record.

In the middle of July the party was transferred to Rabun Mountain, where observations were begun on the 27th of July. This station has a height of 4,717 feet, and is nearly forty miles distant from Blood Mountain. On reaching the station at Rabun it was found that the large signal-pole previously set up in the reconnaissance had been shattered by lightning, and that the signal left at Blood Mountain had disappeared. Subsequently, it was ascertained that two days after the party left Blood Mountain the signal-pole there had been totally destroyed by lightning, making the third instance which had occurred in the operations of this party in the course of two months. The theodolite at Rabun Mountain was protected as far as practicable by the erection of a lightning-rod, which was transferred after the 13th of August, when the party was moved. Twenty-one prominent mountains and other objects were observed on from Rabun, exclusive of eight primary signals on which the measurements were repeated, as usual, with the utmost accuracy.

Pinnacle Mountain, 3,442 feet high, in South Carolina, was occupied, and while arrangements were in progress for adjusting the theodolite there, Mr. Boutelle found it practicable to establish a tripod-signal on Wofford College, in Spartanburg. Having adjusted a structure for subsequent use on the college building, observations were begun at Pinnacle on the 25th of August, and were completed on the 8th of September. Six outlying signals were observed on, and thirty-six mountain-

peaks or other subsidiary objects, notes of which in respect of direction, though made incidentally, will be of special value hereafter for correcting the State map, or in time for the uses of the State authorities if a survey of the State should be instituted by them.

Favored thus far by good weather, corresponding progress had been made by the party when the theodolite was moved to Paris Mountain, 2,057 feet in height, and about eight miles north of Greenville, S. C. After the middle of September, however, alternating storms, and the smoky or hazy weather of autumn succeeded, and much retarded the observations at this important station. Eleven outlying signals were to be observed on, and three of them were more than sixty miles distant from the theodolite. While the geodetic work was delayed, astronomical observations were recorded for latitude and time with zenith-telescope No. 5 and transit No. 11, by Messrs. H. W. Blair and J. B. Boutelle, aids in the party. Forty-four pairs of stars were used for determining the latitude, each pair being observed on not less than five nights. In reference to the result, Assistant Boutelle remarks:

"Each observer computed the apparent place of the stars he observed, and made the field-reduction of his observations while keeping up with his field-duties. Paris Mountain is nearer the mass of mountains of North Carolina and Tennessee than any other astronomical station is in relation to similar masses. But the resulting latitude is 2".5 greater than the geodetic latitude brought forward from the mean of four astronomical stations southwest of it, and farther from the mountain masses, indicating attraction of the plumb-line in an opposite direction, or toward tide-water, precisely as was found in Maryland and Virginia."

While operations were in progress at Paris Mountain, Subassistant Edwin Smith was pushing a reconnaissance across the southern boundary of Virginia for stations to connect properly with the triangulation of Mr. Boutelle. To insure the conditions desired the two observers conferred at Paris Mountain in October, and the entire scheme was soon after perfected.

At the geodetic station near Greenville azimuth was determined by observations recorded on twelve nights between October 23 and November 20, 1875. Owing to frequent intervals of bad weather the measurement of horizontal angles was not concluded until the 1st of December. Exceptionally good weather returning some days after, Mauldin station was occupied with the theodolite, and the horizontal angles at that center were measured between the 8th and 14th of December. Before leaving the field at either of the stations, the point of observation was securely marked for identification at any time hereafter. The statistics of the triangulation of this year are:

Stations occupied.....	5
Angles measured.....	33
Number of observations.....	2, 867

Mr. Blair, when detached from the party of Assistant Boutelle, reported at the office in Washington, and during the winter tested the graduation of several of the theodolites that had been in use, and also the capacity of the dividing engine to repeat precisely in consecutive subdivisions of the same limb. During the remaining part of the fiscal year Mr. Blair was engaged in arranging matter for the publication of the transatlantic longitude work of the year 1872. At intervals, however, he was employed in making the comparisons needful for the adjustment of length-measures (meters) constructed in the office, and in computing star-places for use in future observations.

Tidal observations.—The need of a full series of tidal observations at some point on the Atlantic coast of the Southern States having been long pending, provision has been made for recording a series either at Port Royal, S. C., or at Fernandina, Fla. As the selection of the station could not be definitely made previous to the coming winter, the apparatus intended for it, and in which are combined all the later improvements for registering the tidal action continuously, was sent to the National Exhibition at Philadelphia, and there remained during the summer of the present year as one of the objects in the collection which made up the Coast Survey exhibit in the Centennial Exposition.

SECTION VI.

ATLANTIC AND GULF COAST OF THE FLORIDA PENINSULA, INCLUDING THE REEFS AND KEYS AND THE SEAPORTS AND RIVERS.—(SKETCHES NOS. 13*a*, 13*b*, AND 14.)

Hydrography of Fernandina Harbor, Fla.—For the purpose of facilitating the action of the Engineer Department, when questions in regard to the improvement of the entrance channels were under consideration, a hydrographic survey of the bar of Fernandina Harbor was directed in November, 1875. The work was begun on the 1st of December, and was prosecuted till the 3d of January following by Lieut. Commander J. C. Kennett, U. S. N., assistant in the Coast Survey, with his party, in the steamer *Bache*.

"Careful attention was given to the development of known and probable channels. Well-marked shoals and breakers and the deepest water, as shown by previous surveys, were not examined. Our work will, I think, show no decided change, except the gradual movement of the main channel to the southward."

Lieutenant-Commander Kennett traced the altered shore-line of Cumberland Island, and marked the results on his hydrographic sheet. The statistics of soundings are:

Miles run	120
Angles measured	1, 024
Number of soundings.....	10, 056

For purposes of comparison, tracings from the sheets of the last and preceding surveys were furnished to the Engineer Department.

Lieutenant-Commander Kennett was aided in this section and also in Section I by Acting Ensign George Glass.

Survey of the Saint John's River, Fla.—To provide for extending the survey of the Saint John's River above Jacksonville, a party was organized under the charge of Assistant H. G. Ogden for service with the steamer *Hitchcock*, and that vessel was dispatched from Baltimore on the 24th of October, 1875. Except between Cape Fear and Saint Helena the southern passage was made entirely through the inland waters. The steamer reached Jacksonville on the 12th of November. Without delay search was made for points at which the triangulation of the river had ceased when the survey in a former year was closed near Jacksonville. From thence to the southward a reconnaissance was conducted by Assistant Ogden to Enterprise on Lake Monroe, which is a hundred and fifty miles by the river-course to the southward of Jacksonville.

On the 1st of January, 1876, the survey of the river was taken up at limits where the work terminated some years ago. A base-line was marked out near Jacksonville, and was carefully measured, and from that vicinity a series of triangles was extended to Mandarin Point. This includes about fourteen miles of the course of the river. Azimuth was measured at the station Bluff, by forty-eight observations on Polaris near western elongation, on three different nights. The shores of the river were traced by means of the plane-table within the limits of the triangulation, but the funds available for the operations of this party did not admit of extending the hydrography above Jacksonville. Tidal observations, however, were made during one lunation. In the reconnaissance soundings were carried throughout as far as Lake Monroe. Mr. Ogden reports that the channel of the Saint John's has nine feet of water as far as Buchalon's Bluff, which is nearly eleven miles south of Pilatka, and from thence on a depth of seven feet to Volusia Bar at the southern end of Lake George. The depth on that bar is only four and a half feet, but to the southward, and as far as Lake Monroe, the channel has an average depth of seven feet. A bar, however, is met where the river passes into the last-named lake. The capacity of the channel as here mentioned refers to an average stage of the river. During freshets the depths are increased by several feet, but at the lowest stages the water is seldom as much as one foot less than the depths here reported.

Subassistant W. I. Vinal was attached to the party in the steamer *Hitchcock*, and Messrs. F. H. North and J. F. Pratt served as aids. Field-work was prosecuted until the 1st of April, when the

vessel was laid up at a station in the river, about two miles above Jacksonville, in readiness for resuming the survey hereafter. The following are statistics of the survey as far as it was advanced:

Signals erected	19
Stations occupied	19
Angles measured	148
Number of observations	4, 458
Shore-line surveyed, miles	36½
Roads, miles	12
Topography, square miles	4
Miles run, reconnaissance	204
Casts of the lead	7, 104

Twenty-four points were determined in position by the triangulation of this year on the Saint John's.

Survey of Indian River, Fla.—In continuation of this work, Assistant Charles Hosmer organized a party and resumed operations on the 4th of October, 1875, in the upper part of Indian River, where he had closed work at the end of May of the same year. Of the several branches of survey the triangulation was pushed to the southward twenty-six miles, and the topography nearly twenty miles. Soundings were completed within the plane-table limits.

The country over which the work of this season extends is similar to that passed over last year, except that the west side of Indian River, south of Titusville, is dry and sandy, and covered with a dense growth of pine, palmetto, and oak. The west bank is about ten feet above high water at Titusville and gradually attains a height of eighty to one hundred feet in the vicinity of City Point and Oleander Point. The region is very sparsely inhabited and means of communication are yet wanting.

Banana Creek, a branch of Indian River above Cape Canaveral, was included in the survey of this year. The sloop *Steadfast* was used in this work while means held out for prosecuting the survey, but in the middle of February of the present year the vessel was laid up and the party disbanded.

Assistant Hosmer was aided in the field by Subassistant Eugene Ellicott and by Messrs. W. E. McClintock and T. A. Harrison. As yet the detailed survey of the outer coast rests at a point several miles north of Cape Canaveral, but the survey of Indian River has been extended as far to the southward of the Cape. The statistics of this season are:

Signals erected	23
Stations occupied	23
Angles measured	467
Number of observations	2, 802
Shore-line surveyed, miles	186
Roads, miles	29
Area of topography, square miles	100
Miles run in sounding	579
Angles	1, 962
Casts of the lead	20, 900

Twenty-six points were determined in position by observations with the theodolite.

Hydrography of Key Biscayne Bay, Fla.—Under the head of Section II, in this report, mention has been made of the associate service of Lieut. C. A. Bradbury, U. S. N., assistant in the Coast Survey, on board the schooner *Palinurus*, and of the transfer of that vessel to his charge in December, 1875. The schooner was refitted at Norfolk and reached Charleston, S. C., on the 27th of January. Frequent storms delayed the passage of the party southward. Off the coast of Florida the damage sustained by the vessel made it necessary to return to Saint Augustine for repairs. The *Palinurus* reached Cape Florida on the 19th of March and next day passed up to the head of Key Biscayne Bay. Lieutenant Bradbury set up a tide-staff at the mouth of Miami River, and identified the ground-marks, which were set in 1855 at the ends of the base-line measured on the shore of the bay. Twenty-two signals were set up, and triangulation was carried from the light-house at Cape Florida