the bed of the Delaware, between Eridensberg and Fort Mifflin light-house. The soundings made are represented by four sheets on a scale of four hundred feet to the inch, corresponding to the sheets of the topographical sheets, the completion of which has been already mentioned. The hydrographic stationery was:

Miles run in sounding

323

Angles measured for position

19,550

Number of soundings

39,716

Permanent bench-marks were established at Five Mile Point, at Kensington water-works, at the old navy-yard, and at Leaghe Island. Each of these was referred to the others by simultaneous tidal observations. As usual, careful descriptions of the bench-marks were sent to the office.

While Assistant Marindin was at work in the Delaware, operations for improvement were in progress under the direction of Gen. J. N. Macomb, United States Engineer. At the request of that officer, Mr. Marindin was authorized to furnish the results of his survey of the bed of the Delaware, and the bench-marks of the bench-marks were sent to the office.

In presenting the general hydrography of the Delaware, absent from the city of Philadelphia, a chart was developed in the vicinity of the wharves of the American Transatlantic Steamship Company. Full particulars in regard to the obstruction were communicated in September, 1878, to the mayor of Philadelphia, in order that measures might be taken for its removal.

Assistant Marindin was added at Philadelphia by Mr. J. B. Weir. When the operations of the party about were closed in November, the hydrographic sheets were completed and results of the current observations were put in form. Assistant Mitchell in due time presented the elaborate report, in which all the results of observations are embodied.

The statistics are:

| Observing tripods and conical points erected | 4 |
| Stations occupied | 5 |
| Angular measurements | 2,109 |

When the final party closed, Professor Haupt was in readiness to resume field operations. Of these further mention will be made in my next annual report.

Pendulum observations—Experimental and mathematical studies for the determination of gravity have been continued by Assistant G. S. Peirce. Flexure, as a source of error in the ordinary support used for pendulum experiments, and the possibility of allowing for the error, as suggested by him in 1875, are now admitted by European observers to be essentials for success in the investigation. Mr. Peirce says:

"There remain a question in regard to the difference between the flexure under a force applied continuously and under one intermittent like that caused by a swinging pendulum. Experiments at Hoboken, N. J., show that "this difference is large upon a wooden support, but insignificant upon a metallic support."

In a mathematical analysis published in the "Proceedings of the American Academy of Arts and Sciences," Assistant Peirce has shewn that any difference between the statical and dynamical flexure which could possibly have an appreciable effect on the time of oscillation of the pendulum, would largely increase the rate of decrement of the amplitude of oscillation. His remarks further:

"No considerable effect of this sort exists, the rate of decrement being almost exactly the same upon the Reynolds' theory that it is upon another support of much greater stiffness. But, although the difference between the statical and dynamical flexure will be very small when good
judgment has been used in mounting the pendulum, the correction for fluctuation remains a source of anxiety and trouble in the experiments. For this reason a careful mathematical study has been made of the period of avoiding the difficulty, as proposed by M. Paye, which consists in swinging two similar pendulums simultaneously on the same support, with equal amplitudes of oscillation, but opposite phases.

The views of Assistant Peirce in this connection are fully set forth in his paper on Faye's method, communicated to the American Journal of Science.

The concluding report of the season mentions, as a special difficulty in determining gravity, the unaccountable effects of the wearing and blunting of the knife edge upon which the pendulum rolls, and of its motion upon the plane which supports it. Experimental investigations of these subjects have already been undertaken, and will be further prosecuted in the course of the coming year. The acceleration of gravity has been accurately measured by Mr. Peirce in the United States, at the Allegheny Observatory in Pennsylvania. Stations on the mountains in that State were selected for this purpose, as means for estimating the disturbing effect of the mass of the Appalachians on results for Baltimore, and for Washington, respectively.

In general reference to researches for completing the spectrum meter, Assistant Peirce thus remarks:

"The progress of the difficulties in the measurement of gravity is the circumstance that metal bars, hitherto our ultimate standard of length, probably change in length in the course of years. The confusion into which such spontaneous changes in standards of length may throw all precise measurements referred to it, is too obvious to be insisted upon. Hence search has been made for a length in nature which should be more strictly invariable than that of a metal bar."

The idea that a wave length of light would be more invariable than any substantial measure has been entertained by several distinguished physicists, such as Arago and Clarke Maxwell, but their suggestions are to be regarded as purely speculative. The means of comparing with great precision a wave length of light with a tangible object were not known when the suggestions were recorded. To reference to the basis for his subsequent development of the idea, Assistant Peirce thus observes:

"It was not until our ingenious countryman Lewis M. Rutherford, by various mechanical achievements, and especially by his manufacture of diffusing plates of extreme accuracy, had made the means available, that any one could seriously propose to measure a wave length to one-millionth part of its own length."

"The length of the wave depends, first, on the internal constitution of the chemical atoms of the object, which in turn arise to the spectral line, and this we have not yet the means of determining with the necessary accuracy that it shows, so that we are reduced to the question of how the wave might appear, our reason to suppose that they are free from influences which cause the spontaneous alterations of metallic bars."

The matter must necessarily remain tentative, but the end sought is well brought out in the paper. After many essays Mr. Peirce succeeded in manufacturing in Mr. Rutherford's laboratory, with the aid of his trained assistant, Mr. D. H. Chapman, a comparator by which a diffusing plate of one centimeter width has been compared with each one of a decimeter scale of centimeters accurately in the one-millionth part of a centimeter. The further comparison of the decimeter with such one of a meter scale of decimeters has been commenced but not completed. The whole of the paper, the subject of the investigation, the wave length of light with the breadth of the diffraction spectrum, has been successfully accomplished by means of a spectrometer of original construction, provided with a circle divided upon glass, after Mr. Rutherford's design.

In studying the various sources of error in measurements of the deviation of a line in the diffraction spectrum, Assistant Peirce observed the supplementary images, commonly called "ghosts," due to irregularities in ruling the lines. These have been found to be entirely new sources of diffraction phenomena, and that instead of their position depending on the amount of irregularity in the ruling, as heretofore supposed, only their brightness depends upon this, while their position depends solely on the period of the irregularity. After confirming the mathematical analysis of the subject by careful angular and photometric measurements, Mr. Peirce presented the results in a memoir which was read at the last meeting of the National Academy of Sciences.

UNITED STATES COAST AND GEODETIC SURVEY.

Among several forms of projection devised by Assistant Peirce, there is one by which the celestial meridian and parallel are plotted as true angles, and the angles between the angular relations of meridians and parallels are exactly preserved; and the distortion in areas is much short of the distortion incident to any other projection for the entire sphere.

SECTION III.

MARYLAND, VIRGINIA, AND WEST VIRGINIA—[Maps Nos. 9, 10, and 11.]

Longitude determinations.—For determining the longitude of a point in Statelville, N. C., of which further notice will be made under Notices IV., and also of a point in Atlanta, Ga., to be referred to under the head of Section V., the usual arrangements were made at Washington, D. C., in November, 1878. The work was under the general charge of Assistant G. W. Dean, and Assistant E. B. Ewell was directed to cooperate in the service. By permission of Rear-Admiral John Rodgers, U. S. N., Superintendent of the Naval Observatory, the station occupied by the observers in Washington for telegraphic longitude exchanges with the southern stations, was located in the Observatory Building, and the arrangements were made for erecting a temporary atmosphere. Meanwhile, Messrs. Dean and Smith were accommodated in the Transit of Venus building, and there, with Transit No. 8, each observer recorded one hundred and twenty-two observations on forty-four stars for personal equation during five nights of November and December, 1878.

Assistant Smith proceeded to Statelville, N. C., on the 13th of December accompanied by Mr. C. H. Sinclair. Between the station there selected, and the station at Washington, telegraphic exchanges were recorded by Mr. Dean during four nights in December. As usual, the observers then changed places, Assistant Dean receiving at Statelville the signals sent by Mr. Smith during three nights from Washington.

Mr. Dean transferred the instruments from Statelville, to Atlanta, Ga., and from that station exchanged signals during five nights with Assistant Smith, who remained at the Naval Observatory in Washington. Changing places as before, Mr. Smith sent from Atlanta, during six nights, signals which were recorded by Assistant Dean, at Washington.

Exclusive of details immediately connected with longitude determinations, the two observers recorded at the Naval Observatory three hundred and ninety-two observations in January and February on about nine stars for chronometer corrections. In the next section reference will be made to the determination of longitude for land stations, where the same special facilities were afforded by the officers and operators of the Western Union Telegraph Company.

In March, when Assistants Dean and Smith again met in Washington, one hundred and sixty observations were recorded by each on sixty-three stars during four nights with Transit No. 8. During January and February, Mr. F. H. Parsons aided in the work at the Naval Observatory in recording and also in computations.

Magnetic observations.—At the station established some years ago on Capitol Hill, in Washing- ton, D. C., the magnetic declination, dip, and intensity have been observed annually by Assistant Charles A. Schott. In June, 1875, the series was continued by observing on the 9th, 10th, and 11th of that month.

Assistant Schott reports that his observations show the law in regard to secular change of the magnetic declination at Washington to be as it was found by the observations of preceding years.

A third discussion of the secular change of declination (variations of the compass) in the United States and adjacent countries has been completed by Mr. Schott, and will be ready for issue at an early date.

Special photographic investigations.—Inquiry has frequently been made for such instruments as could be incidentally gathered by parties working abroad in regard to the magnetic system, which, in the mass, are commonly termed ropes, and sometimes ends. In order to meet the interest manifest by L. F. Pourtales, Eng., formerly Assistant in the Coast Survey, were given to the public in 1873, relating chiefly to vapor supply and to the manifest waste in the method employed in taking them in the waters near New York.