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REPORT OF THE SUPERINTENDENT

OF THE

UNITED STATES COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1870.

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## APPENDIX No. 16a.

REPORT ON THE ECLIPSE OF THE SUN ON THE 22<sup>d</sup> OF DECEMBER, 1870. BY BENJAMIN PEIRCE, LL.D.,  
SUPERINTENDENT UNITED STATES COAST SURVEY.

(From the Coast Survey Report for 1871.)

Certain astronomical phenomena of rare occurrence and high importance for the advancement of human knowledge have, in all civilized countries, since modern science has been cultivated, been deemed matters of national importance. Among these are total eclipses of the sun; and for many years it has been customary for the great nations to organize expeditions for the observation of them.

The first total eclipse visible in this country since the formation of the Government was that of June, 1806. This was accurately observed at several points, and a valuable painting was made of it. We were not favored with another until November 30, 1834, when the moon's shadow passed over the continent from northwest to southeast. This eclipse was observed by R. T. Paine, esq., of Boston, at Beaufort, South Carolina. A third eclipse did not visit our country until 1860; hence, at that time this wonderful phenomenon was for most American astronomers a matter of hearsay.\*

The path of the eclipse of July 18, 1860, was from Washington Territory to the northern shore of Labrador, and thence across the ocean to Spain. This eclipse was observed by expeditions organized under the Superintendent of the Coast Survey, and the results are published in the report for that year. It was also observed by the astronomers of several governments abroad, and was the first total eclipse which was photographed. In 1868 British, French, and German expeditions were fitted out for the observation of a total eclipse in India. On this occasion brilliant discoveries were made in regard to the spectrum of certain rose-colored prominences seen about the sun at such times; and these discoveries have been increasing in interest ever since. In 1869 another total eclipse was visible in the United States. It was observed by parties organized by the Coast Survey and other Government bureaus. The results were of high importance. Photographs of the whole corona were taken for the first time; the first observations were made upon the spectrum of the corona; the radial polarization of the corona was first observed with care, while the former knowledge of the subject was advanced in every direction. The results of these two eclipses were of such importance in regard to one of the chief scientific problems of our time—the constitution of the sun—as to excite the profoundest interest throughout the world. It was felt by everybody even casually interested in science that the eclipse of 1870 afforded an opportunity for removing the last obscurity from the subject of the corona, such as ought not to be let slip, the more so as no other eclipse was expected to be observed during this century.† In accordance with these views the Hon. John A. Bingham, of Ohio, introduced a joint resolution, which was approved by Congress and the Executive, authorizing the fitting out of an American expedition, such as were to be sent out by Germany, by France, by Great Britain, by Italy, and by Spain, to study the phenomena of this eclipse. The late unhappy war prevented the first two nations from sparing any of their energy for this peaceful emulation, but extensive preparations were made by all the others. The American and English parties were in co-operation, and afforded each other mutual aid. It is hoped that the good feeling thus engendered was not without influence beyond the circle of science. The observations of this eclipse had for their general result the triumphant vindication of the American observations of the year before, the novelty of which had made them somewhat

\* Mr. G. P. Bond had observed the eclipse of 1851 in Sweden.

† Nevertheless, the British government has sent out parties to another eclipse in 1871, in India and Australia; and three American astronomers have been invited, through the Superintendent of the Coast Survey, to join the expedition.

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suspected in Europe, as well as the establishment of the superior accuracy of the American lunar predictions. Some new features were observed in the corona and in the chromosphere, and other observations were multiplied. This is, however, not the place for entering upon the details of scientific proceedings, which will be given with all desirable fullness in the Appendix.

With a view of selecting localities where astronomical conditions, as well as those of the weather, might be expected to be favorable for observation, Mr. Charles S. Peirce proceeded to Europe in advance, under my direction, and after visiting Italy, Spain, and European Turkey, recommended the occupation of stations in Southern Spain and in Sicily. The country east of Italy, over which the track of the totality passed, had the sun too low for photographic purposes. Considering the probable distribution along the line of totality of the European astronomers, I decided, finally, to dispatch two parties, one to be stationed in the vicinity of Jerez, in Spain, the other, under my immediate personal direction, to occupy positions on the Island of Sicily, in the neighborhood of Catania. In selecting observers I availed myself of such as had previous experience, which, in matters pertaining to solar eclipses, is of much importance, and whose former services in the special lines of duty assigned gave full assurance that no fact that could possibly be noted under the circumstances would be lost.

The party organized for service in Sicily had the threefold duty assigned of making measures of precision, including the determination of the geographical position and local time of contact, of getting photographic impressions of the various phases of the eclipse and of the corona, and of analyzing the corona by means of the polariscope and spectroscope. Accompanying phenomena were also to be recorded. To improve as much as possible the chances of the weather the party was spread over as large an area as could conveniently be included, a precaution which proved of great value, as may be gathered from the account of the labors of the party.

A most cordial co-operation with the party of British observers, several members of which took position at Catania, was maintained throughout our stay. While in England and on the Continent, on my way to the place of observation, the opportunity was taken to procure additional instruments required for our purpose.

The party is indebted to Mr. Wilding, our vice consul at Liverpool, and to Signor Cattaneo, Italian consul at that port, for affording facilities to pass our instruments through the Messina custom-house. Our thanks are especially due, for most effective assistance rendered in receiving, storing, and forwarding our instruments and reshipping them to New York, to our consul, Mr. F. W. Behn, at Messina, and the vice-consul, Mr. Augustus Peratoner, at Catania. We were indebted, also, to Professor Lorenzo Madden and Professor Orazio Silvestri, of Catania, for assistance, and to the municipal authorities for permission to use the grounds occupied by the observers.

The distribution of the party in the vicinity of Catania, and the nature of the results secured, will be briefly mentioned.

Our principal station was in the garden of the Benedictine Convent of St. Nicola, in the western part of the city, a position selected by Assistant Charles A. Schott, who determined, early in December, the latitude and longitude, and also the local time. L. M. Rutherford, esq., of New York, provided photographic apparatus for use, by Mr. H. G. Fitz, optician; who was sent in charge of the equatorial, and was assisted by Mr. D. C. Chapman and Mr. Burgess, photographers. For determining time and latitude Mr. Schott used the portable meridian-telescope, C. S. No. 9, and sidereal chronometer, Kessels, 1287, which was rated at Washington, and checked at London, Berlin, Munich, and Naples. For local-time comparisons the party is indebted to Dr. Förster, director of the Berlin observatory; to Dr. Lamont, director of the Munich observatory; and to Professor de Gasparis, director, and Mr. Fergola, assistant, of the observatory at Cape di Monte at Naples.

Transits were recorded on five nights, and thirteen pairs of stars were observed for latitude; the longitude depends upon that of Naples and Munich. In order to secure accuracy, Mr. H. H. D. Peirce compared chronometer times at Syracuse with the party of observers from the United States Naval Observatory, thus verifying the determination for longitude of the respective stations. A number of chronometers were in advance rated for the use of observers, and a small triangulation was made, uniting the eclipse stations in the garden with the triangulation by Dr. Peters and

Baron Waltershausen, who surveyed that vicinity previous to the year 1841. It is gratifying to note the very close accordance between the earlier astronomical determinations and those taken thirty years afterward. Time signals by heliotropes were sent and received by the observers at Catania, and at the Monte-Rossi station. Mr. Schott included, in his series of geographical positions, the three places occupied in the garden of the convent, two by the English party in charge of Mr. J. Norman Lockyer, and the other by Mr. J. H. Laue, of the Office of United States Weights and Measures, who, though fully prepared for spectroscopic observations, was prevented by unfavorable weather from recording special results. The photographic party secured forty-five negatives of the sun, seventeen during the eclipse and before totality, and fourteen after it, at irregular intervals, taking advantage of breaks in the clouds. The direction of a parallel of declination was indicated by the image of a thread, so adjusted before the eclipse that a solar spot might be seen as moving along the thread during the transit. Mr. Fitz operated the equatorial and timed the pictures. An attempt was made by means of an ordinary camera to secure an impression during the momentary appearance of a portion of the corona. The time of the first contact was noted by Mr. Schott, who was apprised by a pistol fired by a member of the English party, (the report by preconcert,) indicating that Mr. Lockyer had already spectroscopically noted the approach of the moon's limb over the solar chromosphere. The dense clouds which came from the direction of Mount Etna, and to the west of it, defeated all attempts at observing the times of the inner contacts and of the last contact. Mr. Schott, however, saw, through a rift in the clouds, a part of the corona, to the northward and eastward of the sun's center, for about three seconds. It appeared in sharp outline nearly concentric with the moon's limb, of white silvery light, extending, by estimation, to about one-third of the moon's radius. The light tint of orange-yellow usually accompanying total eclipses was seen about the southern and eastern horizon. The first contact or beginning of the eclipse, as predicted from data in the American Ephemeris, was only 3.9 seconds earlier than the time actually noted in observing at Catania.

My own station was about three miles north of Catania, at the villa of the Marquis di San Giuliano, whose obliging courtesy is a subject of grateful remembrance. There the weather was more favorable than at the city, and afforded a full view of the corona, the study of which was made a special object. Mr. C. S. Peirce observed with a polariscope and obtained good results. Mrs. C. S. Peirce was successful in drawing the corona, and distinctly recognized the dark rifts which have become a subject of discussion, and which were photographed by Mr. Brothers, of the British party, at another station. Farther north were stationed Brevet Brigadier General H. L. Abbot, United States Engineers, Professor Roscoe, of England, and Signor Amerigo da Schio, Dr. Vogel, of Berlin, and others. Their object was to observe the phenomena of the eclipse at the greatest possible height on the southern slope of Mount Etna, for comparison with similar observations taken at stations near the sea-level. It is much to be regretted that this party was overtaken by a snow-storm which obscured the sky, and obliged them to descend during the time of the eclipse.

A few miles to the westward and northward of Catania, at one of the trigonometrical signals on the western peak of Monte Rossi, Dr. C. H. F. Peters, of Hamilton College, Clinton, New York and Sub-Assistant W. Eimbeck selected a position for observing the eclipse. Dr. Peters had a spectroscope apparatus, and Mr. Eimbeck a comet-seeker. This party also had unfavorable weather, but succeeded in noting the times of the first contact and of the last contact; the last through thick haze. The interior contacts were lost on account of a passing hail-storm. Mr. Eimbeck also assisted Mr. Schott in recording transits and other observations at Catania.

Professor J. C. Watson, of Ann Arbor, Michigan, occupied a station on the high ground near Carlentini. The weather there was favorable during the time of totality. Professor Watson made observations, which resulted in two colored drawings of the corona of unrivaled fullness of detail and accuracy. Dr. T. W. Parsons, at Syracuse, also made an elaborate colored representation of the eclipse.

It will thus be seen that my party in Sicily were distributed to the north of the track of total eclipse, while stations to the south of it were occupied by the party from the United States Naval Observatory. Stations on the central line were occupied by the Italian astronomers, including the Padre Secchi, Professor Cacciatores, and others.

A detailed account of the results of observations will be found in the Appendix No. 16 of the report of 1870.

I take this opportunity to mention the kindness of Henry Suter, esq., Her Britannic Majesty's vice-consul at Larissa and Volo, who, when it was contemplated to send a party to Larissa, afforded every facility for the prosecution of inquiries, and was in readiness to assist further if it had been expedient to occupy a station near that city.

P 00079