REPORT OF THE SUPERINTENDENT
OF THE
UNITED STATES COAST SURVEY,
SHOWING
THE PROGRESS OF THE SURVEY
DURING
THE YEAR 1871.

WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1874
THE UNITED STATES COAST SURVEY.

For pay and rations of engineers for the steamers used in the coast survey, no longer supplied by the Navy Department, per act of June 12, 1858 .................................................. $10,000
For continuing the publication of the observations made in the progress of the coast survey, including compensation of civilians engaged in the work, per act of March 3, 1843, the publication to be made at the Government Printing Office ................................................. 10,000
For repairs and maintenance of the complement of vessels used in the coast survey, per act of March 2, 1853 ................................................................. 45,000

The annexed table shows in parallel columns the appropriations made for the fiscal year 1871-72, and the estimates now submitted for the fiscal year 1872-73:

<table>
<thead>
<tr>
<th>Objects</th>
<th>Estimated for fiscal year 1872-73</th>
<th>Appropriated for fiscal year 1872-73</th>
</tr>
</thead>
<tbody>
<tr>
<td>For continuing the survey of the Atlantic and Gulf coasts of the United States, and Lake Champlain, including compensation of civilians engaged in the work, and including pay and rations of officers of the Army and Navy, and petty officers and men of the Navy employed in the work, per act of March 3, 1843 ..................................................</td>
<td>$301,000</td>
<td>$301,000</td>
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<tr>
<td>For continuing the survey of the western coast of the United States, including compensation of civilians engaged in the work, per act of September 26, 1856 ........................................................................................................</td>
<td>240,000</td>
<td>240,000</td>
</tr>
<tr>
<td>For extending the triangulations of the Coast Survey on the Pacific coast of the United States, and assisting in the State Surveys, including compensation of civilians engaged in the work, per act of March 2, 1853 ..................................................</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>For pay and rations of engineers for the steamers used in the Coast Survey, no longer supplied by the Navy Department, per act of June 12, 1858 ..................................................</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>For continuing the publication of the observations made in the progress of the Coast Survey, including compensation of civilians engaged in the work, per act of March 3, 1843, the publication to be made at the Government Printing Office ......................................................................</td>
<td>31,000</td>
<td>31,000</td>
</tr>
<tr>
<td>For repairs and maintenance of the complement of vessels used in the Coast Survey, per act of March 2, 1853 ........................................................................</td>
<td>43,000</td>
<td>43,000</td>
</tr>
</tbody>
</table>

Total ......................................................................................................................... 706,000 706,000

* Mr. G. P. Bond had observed the eclipse of 1871, in Sweden.

POLAR ECLIPSE OF DECEMBER 22, 1870.

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, 1854, when the moon's shadow passed over the continent from northwest to southeast. This eclipse was observed by H. T. Paine, esq., of Boston, S. C. A third eclipse did not visit our country until 1868; hence, at that time this wonderful phenomenon was for most American astronomers a matter of hearsay.*

The path of the eclipse of July 18, 1869, 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 1869, British, French, and German expeditions were fitted out for the observation of a total eclipse in India. On that 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
western part of the city—a position selected by Assistant Charles A. Schott, who determined early in the conference that the field of view of the equatorial would be the most advantageous for the eclipse, and also the most practical one for the eclipse. Mr. H. G. Fitz, photographer, was in charge of the equatorial, and was assisted by Mr. D. C. Chapman and Mr. Burgess, photographers. For determining the true latitude and longitude of the eclipse, use was made of the portable instrument of Mr. W. S. Emde, consisting of an 8-in. achromatic telescope and siderometer Kessel, 125, 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 Mr. Lord, director of the Munich observatory; and to Prof. de Gasparis, director, and Mr. Forlani, assistant of the observatory at Capo di Monte at Naples.

Truncks were recorded on five nights, and thirteen pairs of stars were observed for altitude; the longitude depends upon that of Naples and Munich. In order to secure accurate data, Mr. H. B. Peirce computed sidereal times at Synnecora with the party of observers from the United States Naval Observatory, thus verifying the determination for longitude of the respective stations. A number of stars were in advance rated for the novelty of the observation, and shots were made in the eclipse stations in the garden with the triangulation by Drs. Peters and Barnet Waltersharn, who surveyed that vicinity previous to the year 1841. It is gratifying to note the very satisfactory results between the earlier astronomical determinations and those made with the new instrument.

Time-signals, by heliostopes, were sent and received by the observers at Catalina 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. N. Lockyer, and the other by Mr. J. H. Lowe, 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 eclipse during the eclipse and the immediate vicinity, fourteen after it, at irregular intervals, taking advantage of breaks in the clouds. The direction of a parallel of declination was judged by the image of a thread so adjusted before the eclipse that a solar eclipse might be seen 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 accompanied by a pistol fired by a member of his English party, (the report being consequently indicated by Mr. Lockyer and the eclipse troseospectroscopically noted the approach of the moon's limb over the solar corona. The dense clouds which soon came from the direction of Monti Erna and to the west of it defeated all attempts at observation. In order to resume the inner corona, after the lapse of a long interval, the tripod was placed on the rocks 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 tinge of orange yellow, usually accompanying total eclipses, was seen about the eastern and western horizons. The first contact, or beginning of the eclipse, as predicted from data in the American Ephemerid, was only three and nine-tenths seconds earlier than the time actually noted in observing at Catalina.

My own station was about three miles north of Catalina, at the villa of the Marquis di Santa Giuliana, whose obliging courtesy is a subject of grateful remembrance. There the weather was much more favorable, and afforded a full view of the corona. The only serious accident which occurred was made a special object. Mr. C. S. Peirce observed with a solar spectroscopic and obtained good results. Mrs. C. S. Peirce was successful in drawing the corona, and distinctly recognized the dark rings which have become the subject of discussion, and which were photographed by Mr. Baxandall of the British party at another station. Further north were stationed Bvt. Brig. Gen. H. 1. Abbott, United States Engineers, Professor Bovee, of England, and Signor Amarego di Schon, Dr. Vogel, of Baden. This subject was to observe the phenomena of the eclipse on the heights on the northern slope of Monte Erna, 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 snowstorm, which obliged them to descend during the time of the eclipse.

A few miles to the westward and northward of Catalina, at one of the trigonometrical signals on the western peak of Monte Rossa, Dr. C. H. P. Peters, of Hamilton College, Clinton, N. Y., and Sub-Assistant W. E. Eisele, selected a position for observing the eclipse. Dr. Peters had
spectroscopic 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 thin cirrus. The latter contacts were lost on account of a passing hailstorm. Mr. Eimbeck also assisted Mr. Schott in recording transit and other observations at Cuttawa. Professor J. C. Watson, of Ann Arbor, Mich., occupied a station on the high ground near Carlsbad. 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 be seen that my party in Sicily were distributed to the extent 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 Scichi, Professor Casatelli, 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 Livorno and Vulci, who, when it was contemplated to send a party to Livorno, 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.

The general charge of the observations to be made in Spain was assigned to Professor Joseph Winlock, director of Harvard College Observatory, Cambridge, Mass., with Assistant George W. Dean, of the Coast Survey, as executive officer. The party of eleven persons from the United States was organized early in October, 1870.

Two English and one Spanish observer joined the expedition at Jeréz, and it is highly praiseworthy that notwithstanding the unfavorable weather on the day of the eclipse, most of the observers were quite successful.

It being desirable to obtain as far as practicable in advance, information in regard to the meteorological conditions of the winter of 1871 at Jeréz, Assistant Dean, before leaving England, collected statistics which proved of much value in selecting the locality in Spain for observing the eclipse. Mr. Dean was cordially assisted in his inquiries by the Astronomer Royal, and by several members of the Royal Astronomical Society.

Professor Winlock, Capt. O. E. Ernst, of the United States Engineers, Professor C. A. Young, Professor & E. Longley, Professor Edward C. Pickering, and several other members of the expedition, sailed from New York for Liverpool early in November and reached London about the middle of that month. Most of the instruments and equipments were disembarked at Liverpool for Gibralfaro, arriving at the latter port near the close of November, and from there were forwarded by steamer to Cadiz.

The information obtained from commanders and chief officers of steamers plying between England and Mediterranean ports, and regarded to be reliable, by the observations of other gentlemen, who had long resided in Southern Spain. Comparison of statements showed the prospect for fair weather on the day of the eclipse might be hoped for at points on or near the Atlantic Coast.

The geographical position of Jeréz being favorable, with good facilities for transportation by railroad from Cadiz, Professor Winlock decided to make the necessary arrangements for observing the eclipse near that place.

The principal station was located about a mile northeasterly from the city, in an olive grove belonging to Messrs. Richard H. Davies and brother. These gentlemen placed their grounds and buildings at the disposal of the expedition, and their constant kind and generous hospitality to all the observers during their stay at Jeréz is gratefully acknowledged. Some deficiencies were experienced in obtaining lumber and other materials, but all difficulties were readily met. On the 16th of December the instruments were in position, and good observations for time and latitude were made by Assistant Dean and Captain Ernst, assisted by Mr. Henry Guarnett, of Harvard College Observatory.

These observations were repeated on several favorable nights, immediately preceding the day of the eclipse, at which date the latitude and local time at the eclipse station had been well determined, completing the necessary arrangements for observing the phenomenon.

The day preceding the eclipse was unusually pleasant, but about midnight clouds began to cover the sky, and in a few hours the rain fell rapidly, with a strong wind from the southwest. The prospects for success on the morning of the 23rd of December were exceedingly doubtful; nevertheless, each observer continued to perfect his arrangements, hoping that before the beginning of the eclipse the clouds would clear, and give an opportunity to see the corona, or at least some of the bright phenomena. These hopes were in the main realized. The time of the "first contact" was successfully recorded by Assistant Dean, and a few seconds later the photographer of the expedition, Mr. C. M. Willard, of Philadelphia, obtained a good photograph of the sun. During the progress of the eclipse Mr. Willard, with the assistance of Mr. J. Maloney, took fourteen photographs of the eclipse, one of them exhibiting very satisfactorily the coronal structure during totality. The equatorial telescope used by the photographer has a focal length of about seven feet, with an aperture of six and a half inches, corrected for plate rays. This instrument showed several others for the service were furnished by Professor Winlock. The photographic telescope used by Mr. Guarnett had a focal length of about thirty-five feet, with an aperture of four inches. This telescope was firmly adjusted in a horizontal position, receiving the solar rays from a movable heliostat near the objective. Mr. Guarnett obtained five photographs in the course of the eclipse, but owing to partial obscuration by clouds they were not entirely satisfactory.

The time at which each photograph was taken was recorded by the chronograph.

Spectroscopic observations upon the sun were made by Professor Winlock with two prisms, attached to a five and a half inch achromatic telescope. Professor Winlock had devised a very complete apparatus for recording the positions of the lines seen in the spectrum as rapidly as the observer could point upon them, and, with a precision equal to measurements with a micro- meter. Before leaving America, each spectroscopic for use in Spain was provided with this apparatus, which consisted essentially of a steel point or graver, movable by a micrometer-screw, so that in pointing upon any line seen in the spectrum the exact position of the line would be recorded upon a small silver plate, when the observer pressed the graver key. Professor Winlock observed a faint continuous spectrum, without dark lines. Of the bright lines, the most conspicuous was Korshoff, λ7474, which was seen in all the spectroscopes.

Professor Young, of Hanover, N. H., used a new spectroscopic, recently designed by him, and contrasted it with the old. The results were similar. A faint continuous spectrum, without dark lines. Of the bright lines, the most conspicuous was Korshoff, λ7474, which was seen in all the spectroscopes.

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With this spectroscopic attached to the Dartmouth College equatorial, having a focal length of about six feet, and an aperture of six and a half inches, Professor Young was enabled to watch the phenomena of the precipitations of the prominence, and announce the approach of the moon several seconds before the "first contact." With the slit of the spectroscopic placed tangentially at the moment of obscuration, the field of the instrument was filled with bright lines.

Mr. Pye, a young gentleman who assisted Professor Young, saw this with a spectroscopic of one prism.

Mr. Ablay, of Washall College, Oxford, also observed with a spectroscopic, and his results were soon after published in the English journals.

Professor Langley, of Allegheny, Pa., observed the structure of the corona with a grand achromatic of four inches aperture, and a power of about one hundred and fifty. He reports that, on the 23rd, the breaking up of the corona began, with a very uniform diffused light, except that one dark ray was clearly visible at the absolute straight, and nearly radial.
Geodetic connection.—The triangulation across New Hampshire, which was commenced last year, has been continued during the present season by Prof. E. T. Quinby. As before stated, the main object of this work is to correct the survey of Lake Champlain with that of the coast, and incidentally to supply points as sanctioned by Congress for the geological and topographical operations that may be undertaken in future by the State. The last-mentioned part of the service has been greatly simplified by the wise and liberal action of the State legislature. Mention was made in my last annual report of a plan proposed for inducing the several towns in New Hampshire to erect, at their own expense, the tertiary signals requisite for the local survey. Recently, that plan has been much enlarged. Through the representations of Professor Quinby, showing the value of numerous well-established geographical positions for the future construction of a map of the State, the legislature passed an act, which was approved by the governor July 5, 1872, authorizing the assisant in charge of triangulation on the part of the Coast Survey to erect such signals as may be necessary, at an expense not to exceed $20, in any town or city of the State, and to draw upon the State treasurers for the sums so expended.

This prompt acceptance of the policy of Congress, on foresight of the benefit which must follow as well to each State of the Union as to the public service and its economical administration, will serve as an example to induce other States to co-operate with the General Government in a work of such vast importance as laying in time the sure foundation for an accurate map of our country.

Professor Quinby resumed field-work on the 1st of May, and devoted some weeks to reconnaissance and to the erection of signals for the extension of quadrilaterals in the direction of Lake Champlain, and of others to include important points in the State.

The measurement of angles was commenced on the 1st of June at Monadnock, one of the primary stations which was occupied in the survey of the coast. Work was continued at all favorable intervals. In regard to progress at that time, Professor Quinby reports, "The month of June was very unfavorable, with scarcely more than a day in a week of good observing weather. In July and August, the weather was more favorable; but still the rainy days were about equal in number to the fair ones."

Field-work was continued until the 1st of September. The following statistics result from operations conducted while occupying as stations Monadnock, Unkonomac, Battleships, Stewart's Peak, and Mount Kearsarge. Angular measurements were made with a ten-inch and with a twenty-four-inch theodolite.

<table>
<thead>
<tr>
<th>Angles observed</th>
<th>32</th>
</tr>
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<tbody>
<tr>
<td>Directions noted</td>
<td>129</td>
</tr>
<tr>
<td>Number of observations</td>
<td>4,509</td>
</tr>
</tbody>
</table>

Forty-one stations were determined in position. The expense of erecting twenty-one tertiary signals was paid by the State of New Hampshire.

Hydrography of George's Bank.—Commander John A. Howell, U. S. N., Assistant Coast Survey, after the completion of hydrographic service, which will be mentioned under the head of Section VI, and of repairs requisite on the steamer A. D. Bach, took up soundings in this section in August. The following are extracts from his report at the end of the season:

"On the 22d of August, we anchored in 8 fathoms on George's Island, off the coast of Massachusetts, intending to observe the currents, with a view to preventing other operations.

"The hand-log (a large grating) was thrown every half-hour, the ship's head being at each time noted. In twelve hours and a half, the vessel had swung about about her anchor. During this time, there was no slack water; the velocity of the tide being about ten per cent. The motion of the ship's head was uniform, passing from east through south to west, north, and east again. At intervals, unequal tide pulses moved up against the current, and those passing slowly from the north forward temporarily augmented the velocity of the current sometimes to 25 knots, and as a consequence the vessel would shear away. The rips passed ahead, disappeared gradually, and the current again diminished. Several tide-pulses were frequently in sight at the same time, the appearance being like that of agitated waves breaking in very shallow water. The surface of the sea was white and broken, and the noise, like that of breakers, was audible at a great distance."