APPENDIX No. 16.

REPORTS OF OBSERVATIONS UPON THE TOTAL SOLAR ECLIPSE OF DECEMBER 22, 1870.

(December 21, Washington astronomical time.)

COAST SURVEY OFFICE, *May* 1, 1871.

DEAR SIR: Having been appointed a member of your party for observing, in Sicily, the eclipse of the sun of December 22, 1870, I joined you at New York, on board the steamer Algeria, October 13. The special duty assigned me, besides the direct observations of the eclipse, was the determination of the geographical position of the central station occupied by the Sicilian party. For this purpose I provided myself with a meridian telescope, (as described in Appendix No. 8, Coast Survey Report of 1867,) to be used for finding the time and latitude, also for observing the eclipse; I had also a small theodolite for local triangulation, a hand-telescope, and a sidereal chronometer, rated at Washington; this box-chronometer I carried by hand, going and returning, not trusting it to the care of any one. The instruments, together with a number of cases containing the spectroscopic outfit of the English party, under the direction of Mr. J. N. Lockyer, were shipped from Liverpool direct to Messina, care of our consul, Mr. F. W. Behn. Special arrangement had been made to insure their safe transportation, and they reached their destination in good condition.

On the way from London to Florence frequent chronometer comparisons were made, with a view of testing the performance of your two pocket-chronometers. At Munich I assisted in the purchase of some hand-telescopes and other small instruments. By the courtesy of the directors of the respective observatories, I was able to obtain comparisons of my sidereal chronometer with the clocks at the observatories at Berlin, Munich, and Naples. On my return from Sicily I again compared the chronometer with the Naples clock.

For the purpose of selecting a suitable locality for our observations of the eclipse at Catania, I left you at Florence, November 29, and arrived at Catania December 5. With the assistance of the consul, the instruments arrived from Messina, by rail, the same day. On the following day no suitable locality was found, but on the 7th, with the assistance of our vice-consul at Catania, Mr. A. Peratoner, and at the suggestion of Professor Orazio Silvestri, the garden of the Benedictine monastery of Sta. Nicola, situated in the western part of the city, was found to be a most desirable location, and was accordingly selected for our station. Upon the arrival of the photographic instruments and outfit of our party, on the 11th, I mounted the transit, on the following day, in the southeastern corner of the garden, by the side of the photographic tent. Subsequently the English observers, under Mr. Lockyer, located themselves in the western portion of the garden. On the 7th Dr. C. H. F. Peters arrived, and on the 9th I visited with him Carlentini, south of Catania, and nearer to the central line of the shadow. The station was afterward occupied by Professor J. C. Watson.

The meridian instrument was mounted on its packing-box, which had been filled with blocks of lava, the weight of which was sufficient to render it sufficiently steady. At the close of each night's observation, the telescope was dismounted, but the frame was left standing, covered with a piece of oil-cloth, to protect it against rain and dust. A meridian-mark was put up, and a small geodetic survey was made to connect the station with the triangulation of this part of Sicily, executed about thirty years ago, by Dr. Peters. The position of the station is referred to the center of the dome of the church of Saint Nicholas. The elevation of the ground of the garden above the sea-level was found to be nearly 40 meters, by repeated measures with an aneroid barometer, the scale of which had been tested.

The results for local time, from observations* with the meridian telescope No. 9, are as follows:

Correction (ΔT) to sidereal chronometer, Kessel, 1287.

* In recording most of these observations, as well as those for latitude, I was assisted by Mr. W. Eimbeck, who arrived on the 15th.

Date.	Sidereal hour.	Δ T, Catania sidereal time.	Daily rate.
1870.		*h. m. s.*	*s.*
Dec. 13	0.0	+6 07 46.44	
			−0.53
15	1.7	45.35	
			−0.99
19	23.7	41.44	
			−0.42
20	1.7	40.98	
			−0.85
22	22.8	39.28	

By comparisons with Kessel 1287 other chronometers were rated as follows:

Corrections and rate of mean time chronometer Hornby 1107, *used for timing the photographic plates at Catania.*

Date.	Hour.	Correction ΔT, Catania mean time.	Difference.
1870.	*h. m.*	*s.*	*s.*
Dec. 13	2.30 p. m.	+51.2	
			−3.4
14	0.45	47.8	
			−3.8
15	1.45	44.0	
			−4.0
16	2.00	40.0	
			−3.2
17	2.30	36.8	
			−2.1
18	0.45	34.7	
			−4.1
19	0.15	30.6	
			−3.7
20	11.45 a. m.	26.9	
			−4.5
21	0.30 p. m.	22.4	
			−3.8
22	10.30 a. m.	18.6	
			−4.4
23	2.30 p. m.	+14.2	

Correction and rate of sidereal time chronometer Hutton 208, *used by Dr. Peters at the western peak of the Monte Rosso.*

Date.	Hour.	Correction Δ T, Catania sidereal time.	Difference.
1870.	*h. m.*	*s.*	*s.*
Dec. 13	20	+10.3	
			−2.9
14	18	+ 7.4	
			−2.9
15	19.30	+ 4.5	
			−4.5
16	19.30	0.0	
			−3.3
17	20.15	− 3.3	
			−2.0
18	18.30	− 5.3	
			−3.7
19	18.15	− 9.0	
			−3.5
20	17.45	−12.5	
21	} Taken to Monte Rosso.—W. P.*		
22			
23	20.30	−53.6	

These two box-chronometers were received at Catania, December 13.

* On the morning of the day of the eclipse, heliotrope signals were exchanged between Dr. Peters's and Mr. Eimbeck's station at Monte Rosso and my station in the garden at Catania, from which I deduce, Δ T (Catania sidereal time) December 22, at 16^h sidereal time $= -39^s.2$; hourly rate $-0^s.15$.

The correction and rate of your mean-time pocket-chronometer, "Parkinson and Frodsham 5389," on Catania mean time, was found as follows:

1870. December 15, $\Delta T = + 5^h\ 44^m\ 26^s.3$ $\delta T = + 0^s.2$.
December 21, $27\ .5$

This chronometer was taken to Syracuse, between the 15th and 21st, for the purpose of comparison with the time determined by the United States Naval Observatory party.

The correction and rate of your mean-time pocket-chronometer, "Frodsham 04211," on Catania mean time, was found as follows:

1870. December 15,	$\Delta T = + 0^h\ 59^m\ 18^s.2$	
19,	11.1	$\delta T = - 1^s.8$
20,	08.6	$- 2\ .5$
21,	03.1	$- 5\ .5$

[N. B.—Since its arrival at Catania, this chronometer assumed a rapidly changing rate.]

The correction to mean-time pocket-chronometer, "French Royal Exchange, London, 4136," belonging to Mr. Lockyer, was found as follows:

December 21, noon, slow of Catania mean time $1^s.3$. (Rate not known.)

The correction to Professor Watson's mean-time pocket-chronometer, (used at Carlentini,) was found as follows:

December 21, $6^h\ 32^m\ 39^s.8$
December 23, 6 32 37 .0 } Slow of Catania mean time.

For the latitude of the station, I find the following individual results from observations with meridian telescope No. 9, on December 16, 17, 19, and 20.

Pairs of stars B. A. catalogue.		Number of observations.	Latitude.
			° ′ ″
8206 and	8245	1	37 30 08.3
8289	8324	2	08.2
8344	26	1	12.2
8366	26	2	09.2
79	178	4	10.7
222	327	3	12.4
416	500	2	08.3
540	569	2	09.9
684	744	3	08.9
827	872	3	10.1
904	1006	3	11.7
1057	1127	1	07.8
1257	1293	1	10.8

Resulting, latitude 37° 30′ 09″.9 ± 0″.3. Reduction to center of dome of church of Saint Nicholas, by triangulation, + 3″.5. Resulting latitude of dome, 37° 30′ 13″.4.*

The longitude was determined by means of chronometers as follows:

1. By sidereal chronometer, Kessel, 1287, compared with the Naples clock;

Naples, December 2.....	$\Delta T = + 6^h\ 04^m\ 19^s.8$	Catania, December 13.....	$\Delta T = + 6^h\ 07^m\ 46^s.4$
Naples, December 31.....	$+ 6\ 04\ 24\ .1$	Catania, December 23.....	$+ 6\ 07\ 38.5$

Hence daily *traveling* rate $+ 0^s.64$.

And difference of longitude, $\Delta\lambda$ ..... $- 3^m\ 19^s.5$

Longitude of observatory Capo di Monte $- 6^h\ 05\ 11\ .0$

Longitude of Catania..... $- 6\ 08\ 30\ .5$ from Washington.

* An inscription on the pavement of the church, dated January, 1841, states the latitude 37° 30′ 15″.5, as determined by Sartorius of Waltershausen and Dr. Peters; the latter corrected it afterward to 37° 30′ 12″ .8 ± 0″.5 (See Atti dell' Academia Gioenia di scienze naturaly di Catania, serie seconda, tomo IV, Catania, 1847.)

2. By mean-time pocket-chronometer, "Parkinson and Frodsham, 5389," compared with the Munichclock:

Munich, November 21, $\Delta T = +5^h\ 30^m\ 28^s.6$
Catania, December 15, $+5\ 44\ 26.3$

The daily traveling rate of this chronometer, between Boston and Greenwich, was $-0^s.15$; between Berlin and Munich $-0^s.03$, and at Catania (stationary) $+0^s.20$; the rate between Munich and Catania was taken 0.00; hence:

	h.	m.	s.
Difference of longitude $\Delta\lambda$	— 0	13	57.7
Longitude of Observatory of Munich (Bogenhausen)	— 5	54	38.0
Longitude of Catania	— 6	08	35.7

3. By mean-time pocket-chronometer, Frodsham 04211, also compared at Munich:

	h.	m.	s.	
Munich, November 21	$\Delta T = +$ 0	45	41.6	Average daily rate, during 17 days,
Rate for 24 days			—20.6	between London and Munich, $-0^s.86$.
ΔT December 15	0	45	21.0	
ΔT December 15, Catania	+ 0	59	18.2	
Difference of longitude $\Delta\lambda$	— 0	13	57.2	
Longitude of observatory, Munich	— 5	54	38.0	
Longitude of Catania	— 6	08	35.2	

4. By exchange of chronometer times with the United States Naval Observatory party at Syracuse. Chronometer Negus 1228* was compared with pocket-chronometer Parkinson and Frodsham, 5389, carried to Syracuse by Mr. H. Peirce.

	h.	m.	s.
December 19. Negus, 1228, at comparison	0	37	00.0
Correction			—36.0
Greenwich, mean time of comparison	0	36	24.0
Parkinson and Frodsham, 5389	7	54	18.4
Parkinson and Frodsham, slow of Greenwich mean time	4	44	05.6
Parkinson and Frodsham, slow of Catania mean time	5	44	27.1
Catania, east of Greenwich	1	00	21.5
Difference of longitude, Greenwich and Washington	5	08	12.0
Longitude of Catania	—6	08	33.5

Recapitulation of results for longitude of Catania.†

	h.	m.	s.	
1. By Kessel, 1287, (Naples)	— 6	8	30.5	Weight, 3
2. By Parkinson and Frodsham, 5389, (Munich)	— 6	8	35.7	1
3. By Frodsham, 04211, (Munich)	— 6	8	35.2	1
4. By Negus, 1228, (Syracuse)	— 6	8	33.5	1
Weighted mean	— 6	8	32.6	
Geodetic reduction to center of dome			+ 0.4	
Longitude center of dome church of St. Nicholas	— 6	8	33.0	from Washington.‡
	[— 1	0	21.0	from Greenwich.]

*The correction on Greenwich time for this chronometer, at the time of comparison, I obtained from Professor Hall, United States Navy. The chronometer came by sea, via Malta.

†By Professor Watson's pocket-chronometer, compared at Ann Arbor, Michigan, and at Catania, the longitude of Catania was found to be $-6^h\ 08^m\ 47^s.1$, but as the time elapsed was considerable, I did not think it safe to trust to the uniformity of the rate, and consequently no use was made of this result.

‡The inscription on the floor of the church (as mentioned before) makes Catania $51^m\ 4^s$ east of Paris, (or in longitude $-6^h\ 08^m\ 36^s.5$,) and as corrected afterwards by Dr. Peters, $6^m\ 43^s$ east of Berlin, (or in longitude $-6^h\ 08^m\ 30^s.3$.)

By means of a small triangulation, a base measure, and the azimuth of the mark, the following geographical positions were determined. To these I have added Monte Rosso station and your station, "Villa del Marchese di San Giuliano," near Catania, derived from Dr. Peters's difference of latitude and longitude with the Church of St. Nicholas. The approximate altitude of the villa is 207 meters.*

Geographical positions.	Latitude.	Longitude east of Washington.
	° ′ ″	h. m. s.
Catania: meridian telescope and equatorial of photographers in southeast corner of garden of Benedictine Monastery.	37 30 09.9	6 8 32.6
Catania: dome of monastery of Sta. Nicola, center	37 30 13.4	6 8 33.0
Catania: station in garden, English equatorial	37 30 11.2	6 8 32.4
Catania: station in garden, Mr. Lockyer's, spectroscope	37 30 10.4	6 8 32.4
Catania: pavilion in northwest corner of garden, Mr. Lane's, and English photometric station	37 30 12.6	6 8 32.4
Monte Rosso: western peak, monument	37 37 07.8	6 8 16.4
Villa of the Marchese di San Giuliano, north of Catania	37 32 29.2	6 8 32.7

By means of Agnello's† map, I obtain for the position of Professor Watson's station at Carlentini, approximately, latitude 37° 16′ 16″, longitude $6^h\ 8^m\ 13^s.7$ (east).

A daily record of the weather was kept while in Sicily; it was fair enough until the day preceding the eclipse, when a change occurred, bringing on clouds and occasional rain. Early in the day, December 22, the sky, to a great extent, was clear, but as the morning advanced clouds appeared from the northward and westward, which unfortunately, during the time of the eclipse, became so dense as almost to hide the whole phenomenon from our view. Beyond noting the time of the first contact, and recording the impression of a momentary glimpse of a portion of the corona through a rent in the clouds, little more could be done. The phenomena of the two inner contacts, and of the last contact, were not observable, on account of the presence of the dark-blue clouds. Some rain fell for a short time.

A little before the predicted time of beginning, Mr. Lockyer caused a pistol to be discharged, noted by me at $12^h\ 32^m\ 11^s.0$, by Kessel 1287, and about $1\frac{3}{4}$ seconds later a second shot was heard, intended, I believe, to indicate the time of the first observed spectroscopic contact of the moon's limb with the outer chromosphere. At this time and until $12^h\ 32^m\ 25^s$ I could see no change in the sun's outline at the place where the first contact was expected, the limb being very irregular and wavy. About $12^h\ 32^m\ 25^s$ I supposed the moon had advanced upon the sun, but waited till $12^h\ 32^m\ 29^s.5$, when it was evident the moon had made a perceptible indentation; I then pulled the string connected with the photographic equatorial and exposed the first plate of the eclipse. At $12^h\ 55^m\ 26^s.5$, the moon came in contact with the umbra of the first large spot, and at $13^h\ 01^m\ 01^s.5$ with that of the second spot. At $13^h\ 30^m$ heavy clouds passed rapidly over the sun, and at $13^h\ 50^m$ drops of rain fell. At $13^h\ 55^m\ 55^s$ the sun was again obscured, but at $13^h\ 57^m\ 55^s$ a rent in the cloud revealed the eastern and northern part of the corona (about 120° of the lunar circumference) for about 3 seconds. This part of the corona had a sharp outline, nearly concentric with the moon, except on the northeast, where it extended to a greater distance; its average width was estimated at one-third of the moon's radius. There was no gradual shading off and no long rays as was noticed at Springfield, Illinois, during the total eclipse of August 7, 1869. The color was of the same silvery white. No protuberances were seen with the naked eye. The color of the sky near the southern and eastern horizon‡ was of a light orange-yellow, considerably brighter than the yellow tint as seen at Springfield; the clouds overhead were of a deep indigo blue, with purple shades; altogether the darkness was much less than that witnessed at Springfield, so that at first I could

* According to Dr. Peters.

† Sull' Ecclisse totale di sole del 22 Dicembre, 1870, visibile in Sicilia, &c., &c., da Angelo Agnello, Palermo, 1870.

‡ Other parts obstructed by trees and buildings.

hardly persuade myself that totality had set in.* A bright star in the southeast was noticed by bystanders. At $13^h\ 59^m\ 5^s$ it grew lighter, but the totality must have ended some seconds before this, as the sun was at the time thickly covered by clouds. Cleared again partially at $14^h\ 30^m$, clouded up at $15^h\ 5^m$, and remained so until after the end of the eclipse. During the progress of the eclipse no regularity in the timing of the photographs could be preserved, as they had to be taken during the temporary clear intervals. The correction of the chronometer, Kessel, 1287, is $+\ 6^h\ 7^m\ 39^s.4$ to Catania sidereal time.

The first contact of the eclipse, therefore, was observed at the Catania station at $18^h\ 40^m\ 04^s.4$ Catania sidereal time, or $3^s.9$ later than the time predicted by the data of the American ephemeris.†

The computed times I obtained as follows:

	h.	m.	s.			h.	m.	s.		
Beginning of eclipse	0	36	42.8	Catania	M. T., or	18	40	00.5	Catania	S. T.
Beginning of totality	2	01	23.0	"	"	20	04	54.6	"	"
Ending of totality	2	03	01.8	"	"	20	06	33.7	"	"
Ending of eclipse	3	20	27.2	"	"	21	24	11.8	"	"
Duration of eclipse	2	43	44.4	M. T.		2	44	11.3	S. T.	
Duration of totality		1	38.8	"			1	39.1	"	

A few transits of stars for time were observed before darkness set in. The instruments were taken to Messina, and left in charge of our consul, Mr. Behn, to be shipped to New York. We reached Boston in the steamer Tripoli, February 2, 1871, and on the 4th I reported for duty at the office here. The instruments arrived in New York in the steamer Anglia, on the 24th of February.

The records, original and duplicate, and the computations connected with the eclipse, are deposited in the archives of the office.

I remain, sir, yours, very respectfully,

CHARLES A. SCHOTT,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey,
And in charge of the United States Eclipse Expedition to Europe.

SIR: Having been invited by you to join in the United States expedition for observing the late eclipse, I sailed from New York in October last, in company with yourself and some other members of the party.

During the passage to Liverpool, reflection upon the shortness of the period of totality led me to reconsider the views I first proposed as to the plan of observation, and with your approval I concluded to undertake spectroscopic observations of the corona. I arrived in London on the evening of the 26th of October, and soon after I was placed by you in communication with Mr. J.

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* A pistol was fired off at $13^h\ 57^m\ 11^s.5$, the *estimated* time of commencement of totality. The phenomenon itself was hidden by clouds.

† The predicted times for Catania, by Agnello, (see his pamphlet,) are as follows:

First outer contact	0^h	38^m	$18^s.6$ Catania mean time.
First inner contact	2	01	01.1
Second inner contact	2	02	38.5
Last outer contact	3	20	19.5
Duration of eclipse	2	42	0.9
Duration of totality		1	37.4

$\phi = 37^\circ\ 30'\ 2''.1$; $\lambda = 3^m\ 19^s.8$ east of Naples, for Piazza del Duomo, which is east and south of the Coast Survey station.

His assumed geographical position differs but little from mine, and does not account for the defect in the predicted time of beginning, which is over 1½ minutes too late. Similar differences exist for *Augusto* $\phi = 37^\circ\ 13'\ 48''$; $\lambda = -\ 1^h\ 00^m\ 52^s.1$ from Greenwich. Beginning by American ephemeris data $0^h\ 37^m\ 38^s$; first inner contact, $2^h\ 02^m\ 18^s$; second, $2^h\ 04^m\ 06^s$; end, $3^h\ 21^m\ 26^s$, Augusto mean time. Agnello gives $0^h\ 39^m\ 17^s$, $2^h\ 1^m\ 57^s$, $2^h\ 3^m\ 47^s.5$, and $3^h\ 21^m\ 21^s$, respectively. Using the data of the English Nautical Almanac, the predicted times for *Catania* become $0^h\ 36^m\ 22^s$ and $3^h\ 20^m\ 08^s$ Catania mean time, for first and last contacts respectively.