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Report of the Observations of the Total Solar Eclipse of August 29, 1886, Made at Grenville, in the Island of Grenada

H. H. Turner

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XII. *Report of the Observations of the Total Solar Eclipse of August 29, 1886, made at Grenville, in the Island of Grenada.*

By H. H. Turner, *M.A., B.Sc., Fellow of Trinity College, Cambridge.*

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I. General Arrangements.

The eclipse party was landed at St. George's, Grenada, on Thursday, August 12. On Saturday, August 14, I proceeded with Professor Tacchini to Grenville, a village on the east coast, near which it had been decided that we were to take up our stations. Our instruments and baggage, with two huts constructed by a local carpenter at St. George's, were placed on a sloop which was towed round the coast as far as Grenville Bay by H.M.S. "Fantôme"; but, as it was unadvisable for a large ship to attempt to enter the bay, the sloop went in alone, and deposited its freight on the jetty. I proceeded to Grenville by the Grand Etang Pass, which runs nearly east and west across the island from St. George's to Grenville, being anxious to determine whether there was any chance of returning with heavy baggage by the overland route. However, it soon became evident that this would be very difficult, if not impossible, the pass being little more than a bridle-path in certain portions.

The party—consisting of Professor Tacchini and myself, Lieutenant Smith, of H.M.S. "Sparrowhawk," a quartermaster from the same ship, and an artificer from H.M.S. "Fantôme"—found very comfortable quarters at Boulogne, the house of Colonel Duncan, which is situated about two miles from Grenville Bay, along a fair road.

After some delay, caused by very heavy rain on Monday, August 16, which made the roads nearly impassable for a time, the huts and instruments were carted from the bay to Boulogne, and erected very quickly on a site close to the house, longitude 4h. 6m. 30s. W., latitude 12° 8′·5 N. One bell tent was also erected for contingencies, though this was almost unnecessary, as our instruments were unpacked and the cases left in the "buchan," a kind of superior barn for storing cocoa, which was then nearly empty and was kindly placed at our disposal by Mr. St. George, Colonel Duncan's representative.

The huts, which had been constructed before our arrival under the direction of his Excellency Governor Sendall, required very little modification. They were ten feet

square, with a gabled roof, the ridge running north and south. The door for entrance was in the western face. The eastern roof consisted almost entirely of two shutters, which could easily be thrown open with a pole; and, after this, a large portion of the eastern face (which, in my own case, was enlarged still further) could be opened, turning about hinges which ran horizontally across the face. This gave practically a clear view eastwards from the sea horizon up to the zenith, so that it was possible to work on the Sun from sunrise to midday. The instruments inside were further protected from drippings by mackintosh covers. My own instrument consisted of the Simms equatorial No. 1, with a grating spectroscope; and a 4-inch telescope by SIMMS, mounted as a part-counterpoise on the same polar axis. The whole weight was about 15 cwt.; and, as my work was not to be photographic, and no very great steadiness was necessary, it was found sufficient to place the base plate (an iron plate 3 feet in diameter) on the soil, after removing the turf.

After Tuesday, August 17, the mornings were generally fine, and everything was soon in order for observation. Lieutenant SMITH rated the chronometer (ARNOLD and DENT, 965) by sextant observations of equal altitudes of the Sun with an artificial horizon; the local time of totality was found to be correct within a few seconds.

In taking a photograph of the portion of the spectrum under observation, some difficulty was found in preventing the film from becoming detached during development or washing. I found at last that drying the plate thoroughly by the stove before taking the photograph prevented this detaching.

The night of August 28–29 was beautifully fine, but at sunrise clouds began to gather, and the observations of the eclipse were made under considerable difficulties. The following notes will give some idea of the circumstances :—

	h.	m.	s.	
From sunrise to	6	30	0	Cloudy.
	6	30	0	Sun appeared.
	6	31	30	Cloudy.
	6	33	15	Clear.
	6	34	15	Cloudy.
	6	41	20	Clear.
	6	45	30	Slight shower; Sun visible.
	6	47	0	Shower passed.
	6	48	0	Another shower.
	6	49	5	Shower passed.
	6	52	20	Showery.
	6	55	0	Shower passed.
	6	56	30	Cloudy.
	7	0	20	Clear.
	7	10	10	Cloudy for ten seconds.
	7	12	0	Totality.

h.	m.	s.	
7	14	30	Light cloud passing.
7	15	5	Quite cloudy.
7	15	50	End of totality; cloud lifted for five seconds.
7	16	0	Quite cloudy.
7	20	0	Clear.
7	23	15	Cloudy.
7	24	10	Clear.
7	25	17	Clouded up for some time.

After the eclipse the instruments were quickly dismounted, and, with the huts, were placed on board a small steamer, the "Waltham," which, on Wednesday, September 1, conveyed us back round the south coast to St. George's, stopping at Prickly Point on the way, to pick up a lighter containing the instruments and baggage of the southern party. I returned to England with some other members of the expedition by the mail which left Grenada on the following Sunday.

II. Observations.

(*a*) *The Order of Appearance of Certain Bright Lines of the Chromosphere and Inner Corona.*

In the programme arranged before the expedition left England, I was directed to attempt the confirmation of Mr. Lockyer's observations before and after totality during the Egyptian eclipse of 1882. These are described briefly, with promise of further details, in the 'Roy. Soc. Proc.' for 1882 (pp. 291 *et seq.*), and it will be sufficient here to reproduce the following paragraphs from this paper for convenience (*ibid.* p. 296, §§ 10–13). The observations were intended as a test of two rival hypotheses.

"On the old hypothesis the construction of the Solar atmosphere was imaged as follows:—

"(1) We have terrestrial elements in the Sun's atmosphere.

"(2) They thin out in the order of vapour density, all being represented in the lower strata, since the Solar atmosphere at the lower level is incompetent to dissociate them.

"(3) In the lower strata we have especially those of higher atomic weight, all together forming a so-called 'reversing layer,' by which chiefly the Fraunhofer spectrum is produced.

"The new hypothesis necessitates a radical change in the above views. According to it, these three statements require to be changed, as follows:—

"(1) If the terrestrial elements exist at all in the Sun's atmosphere, they are in process of ultimate formation in the cooler parts of it.

"(2) The Sun's atmosphere is not composed of strata which thin out, all substances being represented at the bottom; but of true strata, like the skin of an onion, each different in composition from the one either above or below.

"(3) In the lower strata we have, not elementary substances of a high atomic weight, *but those constituents of all the elementary* bodies which can resist the greater heat of these regions.

* * * * * * *

"It was stated in (6): While discussing the conditions of observation, that whether we were dealing with strata of substances extending down to the Sun, or limited to certain heights, the spectral lines would always appear to rest on the Solar spectrum, and that the phenomena would *in the main* be the same. This, however, is true in the main only; there must be a difference, and this supplies us with a test between the rival hypotheses of the greatest stringency.

"For take three concentric envelopes, A, B, C, so that only A rests on the photosphere, B rests on A, and C on B. The stratum B, being further removed from the photosphere than the stratum A, will be cooler, its lines will be dimmer, and the lines of C will be dimmer than the lines of B, and so on. So, if we could really observe the strata, *the longer a line is, i.e.*, the greater the height at which the stratum which gives rise to it lies, *the dimmer the line will be.*

"Now, our best chance of making such an observation as this is during a total eclipse. We do not see the lines ordinarily, in consequence of the illumination of our air. As during an eclipse, before totality, the intensity of this illumination is rapidly diminishing, the lines first visible should be short and bright, and should remain short, while the new lines which become visible as the darkness increases should be of gradually increasing length.

"Further, the short lines which first appear should be lines seen in prominences and not in spots, and relatively brighter in the spark than in the arc, while the longer lines added should be lines affected in spots and *not* in prominences."

The manner in which these expectations were realised is shown at once by the subjoined diagram from the same paper (fig. 1).

For convenience of reference I have used small letters to denote the lines shown in the lowest line of the diagram, beginning with *a* on the left. Thus—

The two lines at			4870–71	are called		*a* and *b*.
,,	,,	,,	,, 4890	,,	,,	*c* and *d*.
,,	three	,,	,, 4918–23	,,	,,	*e*, *f*, and *g*.
,,	two	,,	,, 4932–33	,,	,,	*h* and *i*.
,,	one	,,	,, 4956	,,	,,	*k*.
,,	,,	,,	,, 4970	,,	,,	*l*.

In this nomenclature, then, lines *g* and *l* are seen by TACCHINI in prominences,

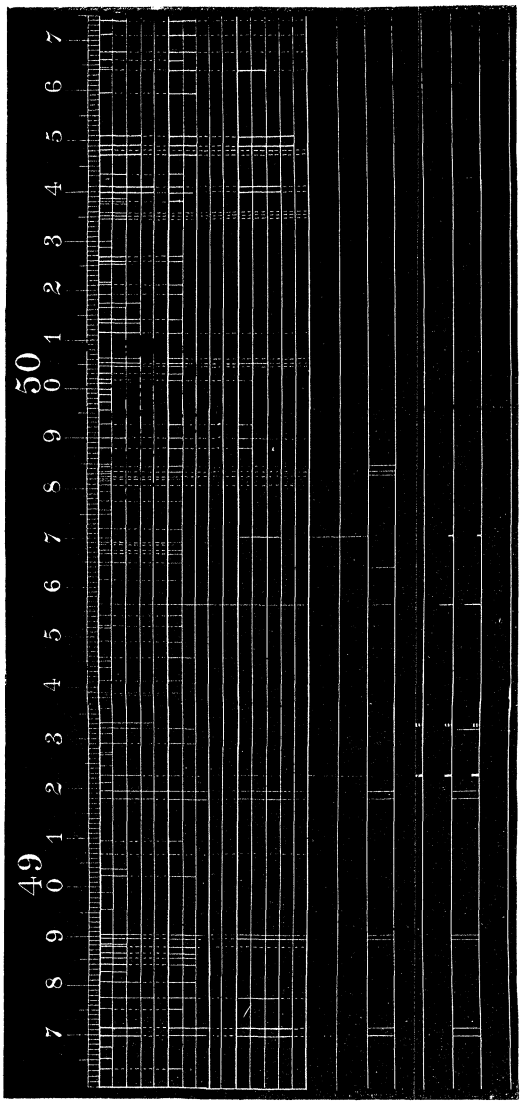


Fig. 1.

The Ba line at λ 4933·4 is a line seen thirty times by Young at the maximum spot period, and not recorded by Tacchini at the minimum. The lower longer line not seen till five minutes afterwards is a Te line λ 4932·5.

and the other lines (excepting h and i) are seen by LOCKYER in spots. In the Egyptian eclipse—

g and i	were seen	7	minutes	before	totality;
k and l	,, ,,	3	,,	,,	,,
and all the other lines	,, ,,	2	,,	,,	,,

In making my own observations, the slit of the spectroscope was placed radial to the limb at the cusp some minutes before totality. The point of the cusp was brought on to the slit, and the motion of the Sun allowed to carry it gradually away. The Solar spectrum, as seen in the spectroscope, thus became narrower as the point of the cusp approached, and finally disappeared. It was hoped to catch the bright lines just at this point, the dark lines of the vanishing Solar spectrum serving as a set of fiducial marks for the identification of the bright lines. But there was also inserted in the focus of the eyepiece a photograph of this region of the spectrum taken the day before. Some twenty minutes before totality it was suspected that, in the increasing darkness, the lines of the photograph would not be well seen, and the places of the lines were therefore carefully marked by scratching the film with a sharp penknife; the scratches were seen to accord well with the proper lines in the Solar spectrum. But in the actual observations it was not found necessary to refer to the photograph, and the identifications mentioned below were referred to the vanishing spectrum. For the period of the observations the cusp does not travel very rapidly along the limb,* so that the slit was nearly radial until a few seconds before totality. I now subjoin the observations, as recorded at the time by an assistant to my dictation.

Time by chronometer.

h.	m.	s.	
6	55	30	No bright line visible at cusp.
6	56	30	Cloudy; no bright line visible up to the time clouds appeared.
7	0	20	Clear again.
7	7	45	F line appeared.
7	8	55	g appeared; very short.
7	10	10	Cloudy for ten seconds.
7	11	30	g and i. Immediately after many lines appeared.
7	12	0	Totality.
7	15	50	End of totality; cloudy.
7	20	50	Only F, g, and i visible at times.

* The rate of motion is very nearly inversely proportional to the duration of totality. For a three-minute eclipse the angular distances of the cusp from the point of disappearance are respectively 75°, 60°, 51°, 33½°, at 4½ mins., 90 secs., 54 secs., 18 secs. before totality.

7	21	45	g still suspected, and k.
7	22	28	k certainly visible.
7	23	15	Cloudy.
7	24	10	Clear again.
7	24	42	No line visible.
7	25	17	Cloudy for some time.

In addition, I wrote the following note immediately afterwards :—

"Just before totality all the lines were glimpsed, but all were much shorter than was expected; g and i were certainly seen before this, but no others. F was very bright from time noted, and prominent after totality. After totality was over, cloud still remained for nearly a minute. Then F line only was prominent, but g and k were afterwards seen; i was not seen; k appeared to remain longest."

The telescope used was one by SIMMS, of 6 in. aperture and 6 ft. focal length. To this was attached a grating spectroscope by HILGER; collimator, $1\frac{1}{2}$ in. aperture and 18 in. focal length; telescope, $1\frac{1}{2}$ in. aperture and 9 in. focal length; magnifying power of eyepiece, 10. The grating kindly lent to me by Captain ABNEY was by RUTHERFURD, and contained 17,200 lines to the inch. The second order of spectrum was used.

It will be seen that these observations confirm Mr. LOCKYER'S in only a few points. The phenomena were apparently of greater intensity in Egypt; the bright lines g and i appeared there 7 minutes before totality, the first of which I saw 3 minutes and the second only 30 seconds before totality. The second stage of the appearance of k and l in the Egyptian observations is not represented at all in my own, being indistinguishable both from the third stage and from the general flashing out of many bright lines which took place just before totality, and is represented in my own notes by "many lines appeared."

Bright lines are recorded after totality for nearly 6 minutes; and, as the appearance of k was unexpected, it was looked at carefully, with the result noted, "k certainly visible." I could not help feeling some doubt afterwards as to the observation; and it is possible that it is really spurious, and due to the straining of the eyes, to the imagination, or other causes. But it is only differentiated from the other observations by the fact of coming rather later in a somewhat exciting half-hour, and I have left the record untouched. It is perhaps only natural that the clear atmosphere of Egypt and the great altitude of the Sun, as compared with the vapour-laden air of the West Indies and an altitude of only 18°, should modify the particular phenomena under discussion. And, again, it must be remembered that in 1882 the Sun's activity was nearly at its maximum; whereas in 1886, judging at least by the paucity of spots, the minimum was appearing somewhat prematurely. This may have had a considerable effect on these phenomena.

This diminution of the period of time over which the phenomena were distributed,

and especially the concentration of the later changes in the spectrum into the space of a few seconds, made a most essential difference in the observation. The record of the Egyptian eclipse gave rise to the hope that the observations could be made somewhat leisurely—which, indeed, is almost essential if the eye is to carefully compare faint lines (the few early lines were too faint on this occasion to be held steadily by the eye, but could be seen by glimpses in the manner familiar to observers of faint objects) in different parts of the field. Instead of this, I found that the phenomena were sudden, and, with the few exceptions mentioned, the change which the spectrum underwent was confined to what has been called "the flash," as I understand it. Mr. LOCKYER seems to have had the good fortune to see this "flash" in stages, extended for analysis. For a complete confirmation of his results it is possible that better conditions may be necessary than those of the 1886 eclipse.

III. OBSERVATIONS DURING TOTALITY.

During totality I had been directed by the Committee to examine the corona, with a view to the detection of currents. For this purpose, a 4-in. telescope by SIMMS was attached to the same mounting as the 6-in. used for the spectroscope. The power used was 140. With this instrument I made a careful examination of the corona all round the limb. It did not seem to me to vary essentially in appearance from point to point. The structure was radial, and on following the rays outwards from the limb I could not detect any appearance of curvature, to join another ray in the form of a loop. I believe such forms were represented in some of the naked-eye drawings. The great prominence was a striking feature; it seemed to me of a rosy tint throughout. Concerning the particular object of the search—indications of any sort of current—I can only report a negative result.

There was, to my eye, scarcely any distinguishing feature in *structure* by which the orientation could be recognised; though some of the rays were, of course, longer than others—that is to say, I looked specially for the structure characteristic of the poles, and failed to notice any very marked difference from the structure in other parts of the circumference.

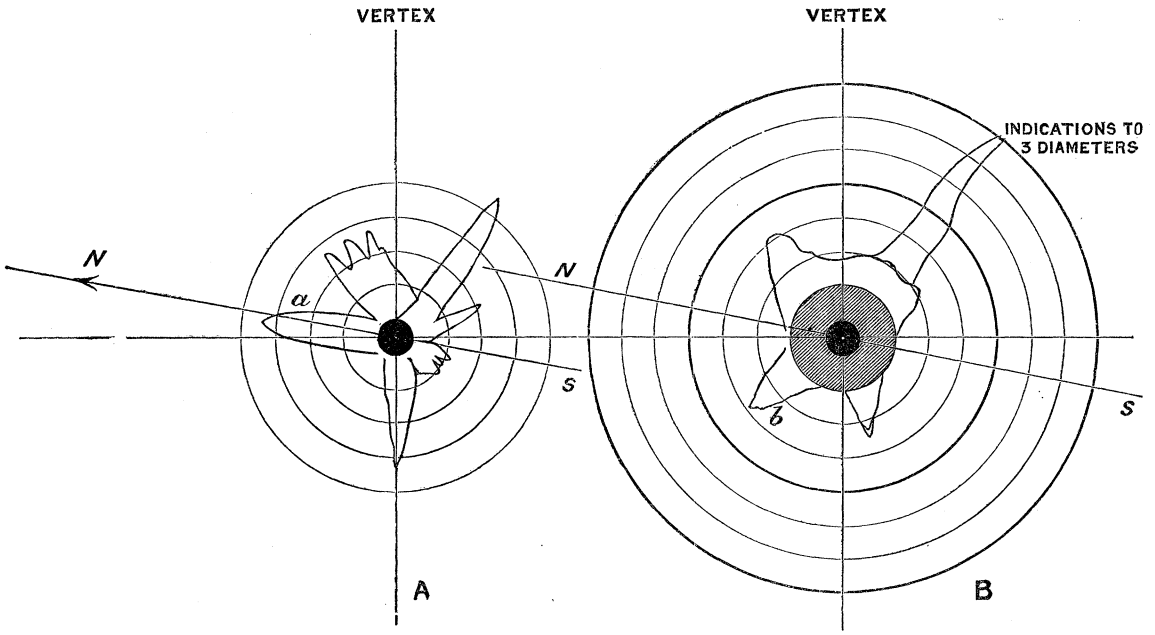
I then returned to the spectroscope, with a view to examining the brightness of the lines at different distances from the limb; but the eye examination had taken some considerable time, and the clouds which obscured the Sun for the last minute of totality were already approaching.

IV. DRAWINGS.

The drawing marked A was made by Mr. ST. GEORGE with an opera glass. His eyes were not specially made sensitive before totality.

The drawing B was made by Lieutenant SMITH, of H.M.S. "Sparrowhawk," from

naked-eye observations; but his head was wrapped in a black mackintosh 15 minutes before totality commenced.



Mr. St. George's drawing. Lieutenant Smith's drawing.

The black centre represents the Moon; the shaded circle in B represents the disk (three times size of Moon) which obscured the brighter portions of the corona.
Long. of station, 4h. 6m. 30s. W.; lat. 12° 8′·5 N.

No attempt is made in either drawing to give details, but merely the distances to which coronal extension could be traced, as estimated in diameters of the central black disk, which in the first case represents the Moon, and in the second a disk which was so placed as to screen the brighter portions of the inner corona from the observer's eyes, and subtended an angle of 3 diameters. It will be seen that the chief discrepancy in the drawings is in the orientation of the rays marked respectively *a* and *b*, in one of which there would seem to be some error; otherwise the correspondence is remarkably good, except that Lieutenant Smith obviously traced the extension much further than Mr. St. George. It may be mentioned that special rehearsals were conducted on the two days before the eclipse, in drawing on such skeleton forms of concentric circles pictures of coronæ held before the eye for $3\frac{1}{2}$ minutes. The two gentlemen mentioned above were found to reproduce the direction of the rays very accurately, and, as regards distance, Mr. St. George seemed to be liable to slightly over-estimate the extensions.