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MADRAS RECORD OFFICE.

Government of Madras.

Public DEPARTMENT.

G.O. No.	976	Press
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Dated	15-7-	19/8/37

Not to be folded or roughly handled

Public Department.

PROCEEDINGS of the MADRAS GOVERNMENT.

Read the following letter

Report of the
Govt Astronomer with reference to the Total Eclipse
of Sun on the 18 Augt last.

Here enter

Order thereon No 976-15 July/87.

The Government are
glad to learn from the
report of the Government
Astronomer that the ar-
rangements made under
his superintendence for
observing the total eclipse
of the Sun in August
1887 were on the whole
attended with success.
They however note with
regret the great delay
in the

W. J. W.

Copy of the
Journal of the
Board of the Home for the
Deaf and Dumb
for the year 1861
July 24

Vol. of 1861 and 1862.

Public

To
 The President of the Board
 of the

Dated July 15- } 1861 No 976
 Recd

Nos 94. 95.

Having ordered in the
 Report of the Board of the
 Home for the Deaf and Dumb
 for the year 1861 and 1862
 of the sum in August
 last.

To the President of the Board
 of the

29-84.
 12-12-84

With-~~es~~. 496 Sub
by 15-7-1869.

REPORT ·
OF THE
GOVERNMENT ASTRONOMER
UPON THE PROCEEDINGS OF THE OBSERVATORY, IN CONNEXION WITH THE
TOTAL ECLIPSE OF THE SUN ON AUGUST 18th, 1868, AS OBSERVED
AT MASULIPATAM, VUNPURTHY, MADRAS, AND
OTHER STATIONS IN SOUTHERN INDIA.

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OTHER STATIONS IN SOUTHERN INDIA.

To

THE HONORABLE R. S. ELLIS, C. B.,

Chief Secretary to Government,

Fort Saint George.

SIR,

Herewith I have the honor to submit my account of the proceedings undertaken by permission of Government, with reference to the Total Eclipse of the Sun on the morning of Tuesday, August 18th, 1868, and the results derived therefrom. I have to express my deep regret at the long delay which has occurred in the preparation of my report, but it was impossible for me to pay earlier attention to the subject without neglecting current duties, which could not have waited without absolute loss to science, while the eclipse results are just as useful now as immediately after the event. An unusually laborious search for the recovery of the planet Sylvia at her opposition in October and November, and the discovery and subsequent observation of the new planet Camilla, were interruptions which will, I trust, be kindly regarded as reasonable apology for such unintentional delay.

It was at first contemplated to locate observers at four points upon the line of totality, viz., on the east coast of Tenasserim, at Masulipatam or Narsipore, and near Muktul and Beejapore. The extraordinary preparations which had, however, been made, by the fitting out of no less than five separate and distinct European expeditions, rendered such precautions unnecessary, and it was ultimately, and as the result proved fortunately, decided to rest contented with three stations, viz., Vunpurthy, Masulipatam, and Narsipore. I have never been able to comprehend the peculiar ground upon which European observers justified the needless and lavish expenditure incurred in their agreeable tours, for the observation of so ordinary and nearly annual an occurrence as a total eclipse of the sun. That it was of unusually long duration was

undeniable, but with an eclipse of three instead of six minutes duration, just as much may be recorded by a judicious sub-division of labor and an increased number of observers. It might very safely have been left to the Madras, Bombay, and Dehra Doon establishments, or in fact to any one of the three, to render an account of the eclipse under consideration, and it is to be hoped that no similar rival expeditions at so great a cost, and so utterly needless in a scientific point of view, will be permitted upon future occasions of total eclipses in India. In the following reports, I think it will be found that every result was obtained that could have been expected, or that was accomplished elsewhere, except as regards photography, which we should have attempted also, had it not been undertaken so completely by Major Tennant as to render our efforts in that line perfectly unnecessary. The recent application of that most wonderful and novel invention, the spectroscope, to the analysis of the light of the red prominences and of the corona, was of course the general inducement which led so many observers so far from home, when by waiting another year or so they might have had much nearer and more convenient opportunities of witnessing similar phenomena ; but even that plea will avail no longer, as it has since been found possible to examine the spectra of these singular appendages at any time, without waiting for an eclipse to render them visible. The older class of measurements bid fair to be entirely neglected, so eager were one and all to share in the excitement of the spectroscopic investigations, and expecting such to be the case I devoted much of my own time and attention to the use of the wire micrometer, and requested two of my colleagues to do the same. It is much to be regretted that no skilful artist, with a good and quick appreciation of tints, was officially attached to any of the expeditions, at least so far as we have yet heard ; and I earnestly hope that whatever other preparations may be made for the next total eclipse in India, which will happen in the southern portion of this Presidency on December 11th, 1871, this want will be supplied, and reliable colored sketches secured, alike of terrestrial and celestial effects.

The Masulipatam party consisted of three observers ; C. G. Walker, Esq., of the Madras Civil Service ; G. K. Winter, Esq., Telegraph Engineer, Madras Railway ; and myself. I feel most deeply indebted to the two gentlemen named, who so kindly volunteered their services, and rendered me such valuable aid, but their separate reports will speak for themselves, and I shall only add my sincere hope that, if circumstances permit, we may all as cordially co-operate in 1871 as upon the recent occasion. I think we all agree in the conviction, that the experience gained in our first observation of a total eclipse will enable us to be so much better prepared for a second, as to render a totality of

only half the duration, in every respect equal to, if not better to us, than the longer interval of the 1868 eclipse. Not that we were in any degree overwhelmed by the startling nature of the phenomena, for strange and fascinating as was the scene each man attended zealously to his allotted task, and no time was lost in idle wonder or admiring inactivity, but we all felt that if we could have profited by a former experience we should have done far better in the few precious minutes available.

We left Madras on the morning of August 4th, per Steamer "Bushire," and arrived off Masulipatam about noon on the 5th. The landing at that port is anything but pleasant; and although most courteously aided by Captain Maidan, the Master Attendant, it took us five hours in an open boat to reach the shore. Fortunately, all our instruments reached their destination without injury, and after spending the 6th and 7th in looking about for the best and most suitable station for our observations, we decided upon occupying a house kindly placed at our disposal by the late Lieut.-Colonel G. V. Winscome, R. E., the verandah of which, while affording a sufficiently firm foundation for our instruments, was also a convenient shelter for them by night. I had a brick pier, about two feet broad and four high, hastily erected, on which to place a sextant stand and artificial horizon, for time and latitude determinations, and commenced operations of this nature on the morning of August 9th. It was my intention to have kept the chronometers rated solely by equal altitudes of the sun, but cloudy and windy weather so frequently prevented the corresponding afternoon sets from being taken, and still worse the unsteady rate of the chronometer was so affected by alternate exposure to day and night temperatures, that I found it necessary to treat each set separately, and to adopt interpolated rates therefrom. Owing to the rustling of adjacent palm trees under the slightest breeze, the faint beat of the only good chronometer was inaudible, and I was, therefore, compelled to employ a loud beating but very inferior time-keeper as the standard. A third and usually pretty steady going chronometer, which had just been cleaned and repaired by a Madras Watchmaker for the occasion, was returned so discredibly injured as to be only serviceable as a hack-watch. These chronometric failures rendered any trustworthy determination of the longitude impossible, but a rough approximation by the best of the three gave the station 3m. 31s. East of Madras. I have, however, assumed in preference an old Trigonometrical Survey determination of the longitude of the Masulipatam Flag-staff, which was almost exactly on the meridian line, giving a difference of time of 3m. 49s., agreeably to which the longitude was 5h. 24m. 46s. East of Greenwich.

The latitude of the station, as deduced by meridian altitudes of Fomalhaut on August 13th, and of α Gruis, α Cassiopeïæ, and Fomal-

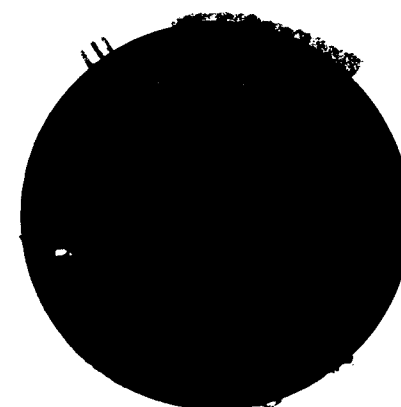
haut, on August 23rd, was $16^{\circ} 11' 33''$ North. The height above sea-level must have been inconsiderable, as it was within the limit of the great storm wave which dealt such ruin and desolation upon the occasion of the memorable cyclone of November 18th, 1864.

The morning of the eclipse was anything but propitious, the sky being covered with light clouds, which, however, gradually cleared off as the sun rose higher; but flying cirro-cumuli still rendered the chance of a fine interval during the totality very dubious. My instrument was an excellent five foot telescope of $3\frac{3}{4}$ inches aperture, by Tulley, constructed for Admiral (then Captain) W. H. Smyth, R. N., and kindly placed at my disposal by its late esteemed owner, Dr. Lee, proprietor of the Hartwell Observatory, and formerly President of the Royal Astronomical Society. The full aperture was employed throughout, the telescope being fitted with one of Mr. Cooke's admirable solar reflecting eye-tubes, which by transmitting most of the heat and light through its unclosed end, and reflecting only a small per-centage of either, renders reduction of the aperture of the object glass unnecessary. A good parallel wire micrometer, bearing a magnifying power of fifty-two, was attached; a low power being preferred to enable the entire disc of the sun to be kept in view at once. Red and green sliding shades were provided, but the former only was required, and none during the total phase. The time of first contact was lost, but it is quite certain that no trace of the moon was discernible before its entry upon the sun's disc. The remarkably serrated or notched outline of the moon's edge was strikingly conspicuous, and immediately suggestive of the true explanation of the well known appearance termed Baily's Beads, of which more hereafter. The distance between the points of intersection of the sun's and moon's discs was repeatedly measured with the wire micrometer near the beginning and end of the eclipse, and when these cusp measurements got beyond the range of the micrometer, the greatest width of the uneclipsed solar crescent, in a direction at right angles to the line joining the cusps. These cusp and lune measurements were taken with especial care, and occupied my best attention during the partial phases, both before and after the totality. The contact of the shadow with four solar spots was also recorded, and the readings of a dry bulb thermometer in the shade, and of a black bulb or solar radiation thermometer in vacuo, exposed to the sun's rays, were also noted occasionally. Nothing unusual marked the progress of the eclipse until about a quarter of an hour before the totality, when the light and heat of the sun having become sensibly diminished, I noticed the chirping of birds as at evening twilight. After this time the rapid diminution of temperature appeared to cause the formation of hazy clouds, which prevailed

THE TOTAL ECLIPSE OF THE SUN

AS SEEN BY C. G. VALDER ESQ. AT MASULIPATAM,

On Tuesday August 17th 1868.



The large prominences seen during the second minute of totality.

The upper prominences as they appeared immediately before the sun's reappearance.

Photographed by F. Cooke & Sons, London. Aperture $\frac{1}{2}$ inch. Power 35.

more or less until about a corresponding interval after the totality. Happily, however, they kept pretty clear of the sun, and interfered but little with the observations. The total extinction of sunlight was far from instantaneous. The peaks of the mountains seen along the edge of the moon's limb, divided the final thread of sunlight into unequal lengths, for more than a second before the actual commencement of totality. This was, of course, the phenomenon termed "Baily's Beads," and I can well understand why, upon the same occasion, some do and others do not see this most ordinary and inevitable appearance. The eye that can most rapidly accommodate itself to changes of intensity, (not necessarily the better vision,) will catch this brief but conspicuous inequality in the covering up of the sun's limb, while others will either entirely fail to remark it, or will receive a vague impression of beads or drops in relative motion, as the involuntary adjustment of the sight keeps pace more or less with the rapidity of the changes to be seen. At the disappearance I remarked three distinct fixed breaks in the vanishing limb, but at the reappearance a complete string of points, momentarily uniting to form the line of light at the sun's western limb. If the duration of the beads seen at immersion be assumed at a second and a quarter, I do not think that of those visible at the opposite limb exceeded a quarter of a second, so instantaneous was the formation of the complete limb at the reappearance; but with the exception of two prominent notches, the receding moon's limb was far less deeply serrated than her advancing limb, which accounted for the shorter duration described in the latter case.

Coincidentally with the last ray of sunshine flashed into view those most wonderful objects, the colored prominences; one especially, of extraordinary length and figure, conspicuous even to the naked eye, at the E. by N. point of the sun's disc, like a nearly straight finger, very slightly inclined eastward from a radial line, with a detached portion at the extremity, nearly at right angles to and a little above the trunk of the prominence. It was, at the first moment of its magical apparition, of a salmon or straw color, with the faintest idea of pale pink at its upper extremity, but the space between the trunk and bent arm was unmistakeably sky blue. I turned the micrometer upon it immediately, and at about 9h. 35m., or three-quarters of a minute after the commencement of totality, determined its height to be 199.4 seconds of arc, corresponding to 88352 miles. Its angle from the sun's north point was 77.7 degrees. During the brief time of measurement its colour was perceptibly changing to a beautiful blush rose tint, and I quitted the telescope with regret to turn to the spectroscope, my results with which instrument will be found further on. Before leaving the

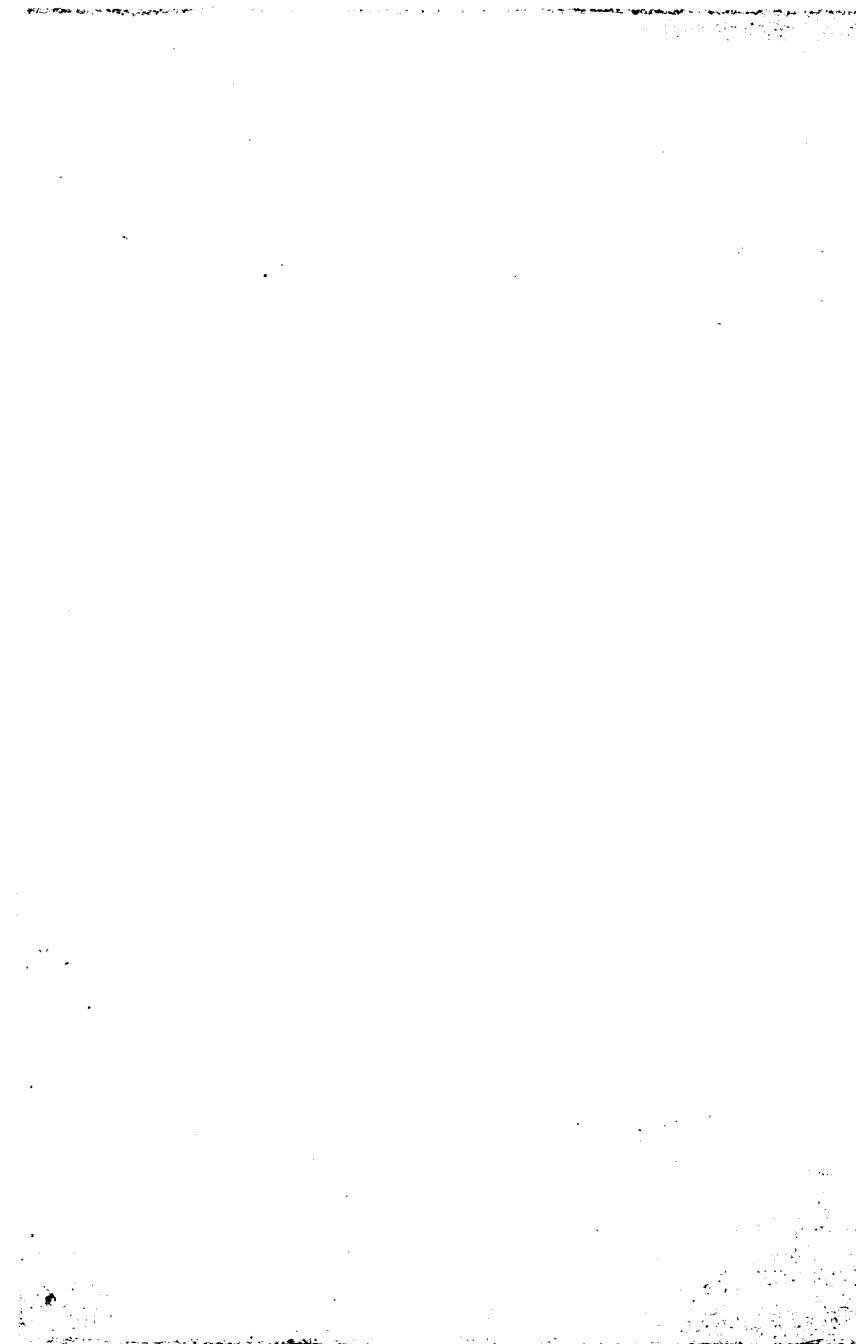
micrometer, however, I saw three other prominences : two, separated by a space of about three minutes of arc, near the S. E. by E. point of the disc, pretty conspicuous, and of a pale red colour ; and one, broad but low, of a deep rose color, at the W. by N. point, the precise position of which I also measured, 283 degrees from north point, reckoned as usual eastward round the sun's disc. Upon returning from the spectroscope about one minute before the reappearance of sunlight, I was astonished at the vividly intense crimson which all the prominences had assumed, and by the appearance of an irregular but continuous chain of them, extending northward from the one last named, over an extent of upwards of seventy degrees of the sun's disc. This ridge, or crimson fringe of prominences, was visibly increasing in apparent height as the moon receded, while the long finger one, at the opposite limb, had been encroached upon, and to a great extent covered by the advance of the moon's disc over it. Its colour though rich red was far less vivid than that of the increasing prominences on the western side of the disc. The first flash of returning sunshine obliterated all the western prominences, but after recording the time of reappearance, I still saw and again measured the height of the long eastern prominence, twenty-eight seconds after the end of the totality. It had remained apparently fixed, and time was too precious to be lost in any attempt at exact adjustment, so with the micrometer wire some few degrees eastward of being a tangent to the sun's limb at its base, *i. e.* with the angle of position 84.6 degrees, I found its height to be only 42.3 seconds of arc ; which, allowing for the 6.9 degrees of eastward inclination of the micrometer wire, would give its perpendicular height as 49.5 seconds from the moon's limb. The question as to whether these prominences belong to the sun or to the moon has long since been decided in favour of their purely solar origin ; but this observation alone, shewing the moon's encroachment upon the large eastern prominence would have established their true relationship incontestibly, had any doubt still remained upon this point.

Of the corona I regret to be able to give little or no account, my time and attention having been so completely taken up with the micrometrical and spectroscopical measurements of the prominences. I cannot even say whether it came immediately or gradually into view in the telescope, but its light was of a pure white silvery nebulous nature for two or three minutes of arc from the moon's limb, when its homogeneous appearance ceased, and it seemed to radiate from the sun's centre until lost in the surrounding hazy sky. To the naked eye, however, a hasty glance, while passing from one telescope to the other, exhibited two long and broad radial arms of unequal length,

THE TOTAL ECLIPSE OF THE SUN

AS SEEN BY G. K. WINTER ESQ AT MASULIPATAM.

On Tuesday, August 15th, 1868.



The prominences as seen during the first two minutes of totality,

Telescope by T. Cooke & Sons, London. Aperture 2½ inches. Power 40.

and two others, considerably shorter, nearly, but not quite perpendicular to the former pair; but in what direction these singular radial arms lay, I had no time to note, and recollection would not serve me safely to assert. I saw no trace of the corona, either with the naked eye or with the telescope, after the first flash of returning sunlight. Nothing surprised me more than the unexpected light, given I suppose by the corona, for it could be from no other source. I expected a very considerable amount of darkness, such at least as to render lamp-light absolutely necessary, whereas, though provided with a bull's eye lantern in readiness, I found not the slightest need of it, whether for entering my records, reading them, or taking the seconds off my chronometer dial. The lamp was only wanted to read the small divisions upon the silvered circles of the micrometer and spectroscope. I estimated the intensity of light as at least four times that of full moonlight. Distant houses, trees, and a native cooly gardener at work were never in the slightest degree indistinct. I have frequently seen a much deeper gloom cover the landscape before a storm, both in England and out in India. The animal-like apathy of a low class native was amusingly shewn in the cooly within sight. He continued his hedge operations up to the moment of totality, and was at work again immediately after, as if nothing had happened. He evidently feared no dragon eating up the sun, and had no more appreciation of the wonders of nature than the sticks he was cutting. Between the light hazy clouds many stars were visible. Venus, Mercury, Castor and Pollux caught my eye instantly, with a brilliancy which satisfied me that all stars down to the third magnitude ought to be distinctly seen wherever the sky was clear. I had a strong impression of seeing Orion also through light clouds, but had no time to verify stars, so left them for others to record.

The local mean times of all the ordinary contact phenomena of the Eclipse observed were as follows :—

1868, August 18, A. M.			
	<i>h.</i>	<i>m.</i>	<i>s.</i>
First contact of Moon's limb with large solar spot (D)*	8	33	35.4
Estimated bisection of do....	8	34	16.3
Complete obscuration of do....	8	34	41.2
Bisection of small spot (C)....	9	18	36.2
Simultaneous bisection of a considerable spot B, and of a smaller one b.	9	25	26.1

* The reference letters for the solar spots, employed throughout this report are those adopted by the Kew Observers in their photograph of the sun, taken on the day of the eclipse, and published in the Monthly Notices of the Royal Astronomical Society, Vol. XXIX, page 3.

						<i>h.</i>	<i>m.</i>	<i>s.</i>
Commencement of total phase	...	...	...	...	...	9	34	14.2
Ending of do.	...	...	...	...	...	9	40	5.8
Last measure of large prominence	...	...	...	...	...	9	40	33.7
Bisection of large spot (B) at emersion	...	...	...	...	...	10	45	4.5
Do. of small spot (b)	...	...	...	...	...	10	46	13.3
Last contact of limbs	...	...	...	...	...	11	4	47.4

The time of first contact was missed. The time of last contact given refers to the even contour of the limbs; but the two lunar mountains before named, visibly notched the moon's disc for more than a second after the time above recorded.

Measurements of the distance between the cusps, in seconds of arc, with approximate position angles; and of the greatest width of the crescent, in a direction at right angles to the line joining the cusps, called for distinction "Lune measures."

Masulipatam Mean Time, 1868, August 18, A. M.			Measure of	Corrected Distance.	Position Angle of Cusps.
<i>h.</i>	<i>m.</i>	<i>s.</i>		"	°
8	20	35.4	Cusps	406.2	—
8	22	50.1	Do.	626.1	282.1
8	27	14.4	Do.	904.1	285.2
8	30	45.8	Do.	1065.3	285.1
9	7	35.9	Do.	.....	286.0
9	26	19.0	East Lune	96.9	287.3
9	45	52.4	West Lune	113.0	285.1
9	48	2.5	Do.	193.6	285.7
10	3	34.1	Do.	548.9	287.1
10	6	31.6	Do.	613.4	287.1
10	10	37.0	Do.	710.1	287.1
10	14	12.4	Do.	790.7	287.1
10	16	23.0	Do.	839.1	287.1
10	21	59.1	Do.	968.2	287.2
10	29	25.0	Do.	1129.4	288.0
10	34	27.2	Do.	1242.2	288.0
10	36	45.8	Do.	1390.6	288.0
10	56	53.6	Cusps	806.8	288.4
10	59	50.2	Do.	645.7	289.4
11	3	3.6	Do.	387.0	289.4

The cusps were throughout sharp and well defined, and never in the least blunted or distorted during the above measures.

The small size of the Position Circle of the wire micrometer prevented me from reading off the angles beyond tenths of a degree. The value of one revolution of the screw was 32.114 seconds, as determined

by stars at night; but bearing in mind the very different circumstances under which both telescope and micrometer were employed, when exposed for hours to tropical sunshine, I considered it better to make a fresh determination by means of the sun only, and the result was 32.225 seconds, the value adopted for the cusp and lune reductions.

The positions of the four principal spots visible, were taken with the wire micrometer, immediately after the last contact of the limbs.

Large spot	D	....	157"	from 1st limb	....	659"	from south limb.
Small spot	C	....	669"	,, 2nd ,,	....	383"	,, ,, ,,
Double spot	{	B	... 509"	,, ,, ,,	....	336"	,, ,, ,,
		b	 491"	,, ,, ,,	....	348"	,, ,, ,,

Or measuring from the nearest point of the sun's limb towards his centre, and the position angles as usual from north, eastward round the disc, we have, for spot D, distance 107", position 250.2° ; and for the double spot B b, distance 194", position 140.4° .

I have now to treat of the Spectroscope, the new and deservedly popular instrumental wonder of the age, the application of which to the examination of the nature of the corona and red prominences, gave to this eclipse so extraordinary and fictitious an amount of interest. By the kind aid of the distinguished astronomer to whom science is indebted for the development of this new branch of research, W. Huggins, Esq., of London, I was placed in possession of an excellent spectroscope, constructed by Messrs. Troughton and Simms under Mr. Huggins' special superintendence. Unfortunately, it did not reach Madras until July 6th, and had then to be adapted to the telescope upon which it was to be used for the eclipse. This was a five-foot, made up at the Public Works Department, with the four-inch object glass, by Dollond, formerly used in the old Transit instrument of the Observatory, mounted on a firm portable equatorial stand by Messrs. Cooke and Sons. The weight of the spectroscope was considerable, rendering counterpoising and adapting, so as to secure perfectly smooth tangent rod motion, far from easy. This of course involved further delay, and when at last it was returned for use, what with cloudy nights and pressure of current duties, there was really no chance for me to acquire the practice which appeared indispensable to ensure success with so new and difficult an instrument. Clock motion was considered to be absolutely necessary, to retain any prominence under examination exactly in front of the narrow slit of the jaws of the spectroscope. I had none; for though two scientific friends kindly placed telescope driving clocks at my disposal, there was no time for completing their attachment at Madras before leaving, and no convenience for doing so

at Masulipatam. Mr. Huggins' instructions were, however, so explicit and intelligible, that, notwithstanding all my disadvantages, I resolved to try what could be done; not altogether in anticipation of total failure, but fully aware that at least three similar instruments were under manipulation, by men who had enjoyed every facility of preparation for the occasion. It might be partly by accident, but I believe I may safely say that I secured as good results as could have been expected under far more favorable circumstances. The points to be decided were—first, the nature of the visible spectrum, whether continuous or broken by lines; secondly, whether such lines, if visible, were black, as in the solar spectrum, or bright, indicating gaseous matter in a state of combustion; and lastly, if time permitted, to determine the positions of the lines seen, so as to verify the actual kinds of gas to which the bright lines referred. The corona and the red prominences each required examination, and as every body seemed to feel far more interested in the latter than in the former, I decided upon confining my own attention to the corona exclusively. A little before 9 A. M., when the partial phase was well advanced, I turned the spectroscope upon the Sun, and took the micrometer readings of seven known lines of the ordinary spectrum, agreeably to Mr. Huggins' instructions. I had previously taken care to have the equatorial stand in tolerable adjustment, and side by side with the Smythian telescope employed for the other class of observations. After measuring the long prominence, as before described, about one minute after the beginning of totality I directed the finder of the spectroscope telescope to a part of the corona on the sun's southern limb, as clear of any visible prominences as possible. A faint light was seen, scarcely colored, and certainly free from either dark or bright lines. While wondering at the dreary blank before me and feeling intensely disappointed, some bright lines came gradually into view, reached a pretty considerable maximum brilliancy, and again faded away. Five of these lines were visible, but two decidedly superior to the rest. A turn of the right ascension tangent rod immediately brought back the welcome lines, and by manipulating it with one hand and the spectroscope micrometer with the other, the readings of the two brightest were secured. It struck me as strange that these brightest lines should appear at a part of the spectrum not corresponding to any very conspicuous dark lines in the solar spectrum, but not having Kirchhoff's chart in my possession, I must leave it for my scientific friends at home to decide upon the interpretation of the measures obtained. The third line seen, in order of brilliancy, must have been either coincident with, or very near the place of the sodium line D, but it was much fainter than the two measured; while the fourth and fifth lines were extremely

faint, and about as close as E and *f*, but I estimated them to be somewhere near the position of Fraunhofer's F in the solar spectrum. The fact of bright lines being seen at all, shews that the red prominence which produced them was composed of incandescent gas, but whether similar to any of our known terrestrial elements or otherwise it would be premature for me to offer any opinion. The red prominence under observation in my spectroscope was not the long one which most other observers naturally singled out for examination, but one of the two seen side by side about the S. E. by E. point of the moon's black disc. I remeasured the seven ordinary lines of the solar spectrum about the same time on the following morning, and also repeatedly since my return to Madras, the extreme difference in any case being four divisions of the micrometric scale for the lines A and C. The scale numbers (a mean of the two Masulipatam readings) were as follows:—

<i>a</i> = 1513	in the deep red.
C = 1547	in the bright red.
D = 1639	in the yellow.
E = 1782	} both in the green.
<i>f</i> = 1785	
F = 1873	in the blue.
G = 2055	in the deep blue.

The two bright lines were situated, the most conspicuous at 1743, and the other at 1763. I preferred employing the micrometric scale of the spectroscope rather than the illuminated photographic scale, and felt satisfied that I had done so; for, although with the latter I might have measured the five lines in less time than the two with the former, I think it highly probable that the light of the lamp required for the illumination of the photographic scale would have over-powered the faint bluish white light of the lines, and so have prevented me from measuring, and possibly even from seeing any of them at all. The light of the corona would, however, I believe, have sufficed to have rendered the photographic scale visible without lamp illumination; but it was impossible for me to venture an opinion upon that point until after the commencement of the totality, and so perhaps it was for the best that I decided upon the slower but surer resource of the micrometric scale.

Besides the spectroscope, Mr. Huggins also sent out, at my request, a set of polarization prisms, by Mr. Ladd of London, similar to those supplied to Major Tennant and Lieut. Herschel, by the Royal Astronomical and Royal Societies. The use of these was the special task undertaken by Mr. Winter, and so completely and successfully

was it accomplished, that the like investigation need not again be attempted. Mr. Winter's account of his observations will be found in his report, and his results were fully corroborated by Captain Branfill, at Guntoor, and by Lieut. Campbell, at Jamkundi.

Mr. Walker kindly undertook to make such records of the general phenomena of the totality as were most likely to escape the notice of observers whose attention was concentrated upon special pursuits, as was the case with both Mr. Winter and myself. His interesting report will speak for itself, and I have only to express my best thanks for the valuable aid he so ably and willingly rendered.

Readings of the barometer and thermometers were taken, but with the exception of those of the black bulb thermometer in vacuo nothing unusual was indicated. The following quarter-hourly records, selected from those made upon the occasion, will suffice to show the meteorological conditions prevailing during the eclipse.

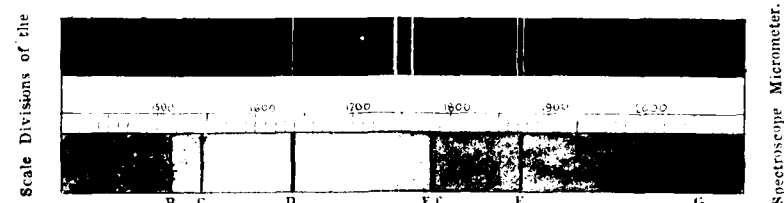
Time. A. M.	Barometer reduced to 32°.	THERMOMETERS IN SHADE.		Humidity, per cent.	Solar black bulb in vacuo.
		Dry bulb.	Wet bulb.		
8 $\frac{1}{4}$	.....	85.4	82.6	89	.....
8 $\frac{1}{2}$	.....	85.1	81.6	86	105
8 $\frac{3}{4}$	29.763	84.8	81.3	86	102
9	.....	84.6	81.0	86	98
9 $\frac{1}{4}$	29.766	84.1	80.8	87	94
9 $\frac{1}{2}$	.....	83.6	80.6	88	91
9 $\frac{3}{4}$	.....	82.8	80.1	89	87
10	.....	82.6	80.4	91	87
10 $\frac{1}{4}$	.....	83.0	81.0	92	102
10 $\frac{1}{2}$	29.772	83.8	81.4	90	110
10 $\frac{3}{4}$	.....	85.1	82.2	88	119
11	.....	86.6	83.1	86	128
11 $\frac{1}{4}$	.....	89.1	85.3	85	130

A light north-west wind prevailed before the eclipse, but a perfect calm for some time before and after the totality. A fresh westerly breeze sprung up with the increasing sunlight, and a fine solar halo continued visible for some time after the end of the eclipse. The rest of the day was chiefly overcast.

The erection of the thermometer shed at the new meteorological station, in the compound of the Small Cause Court, about half a mile from our temporary residence, served our purpose in an unexpected and rather singular manner. Our greatest fear of interruption arose from

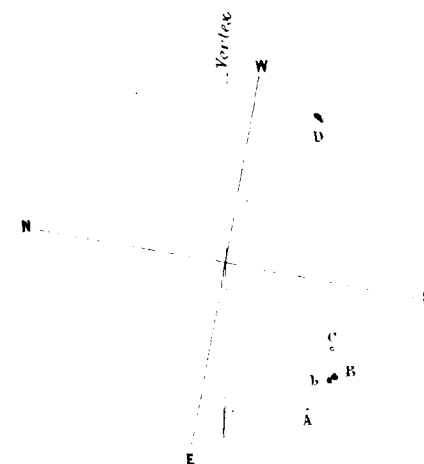
BRIGHT LINES SEEN IN THE SPECTRUM

OF THE SOUTH EAST BY EAST PROMINENCE



ORDINARY LINES IN THE SOLAR SPECTRUM

MEASURED BEFORE AND AFTER THE ECLIPSE.



PRINCIPAL SOLAR SPOTS MEASURED AT MASULIPATAM

ON TUESDAY, AUGUST 13th, 1868.

the probability of native curiosity attracting about our quarters a crowd of idle gazers, and the noise and unpleasantness of such a visitation would doubtless have proved a very serious drawback during the totality, but to our gratification we were quite unmolested, and as quiet as if in an enclosed English garden. I afterwards learned that an impression had got abroad amongst the natives, that the meteorological station was the spot at which our operations were to be conducted, and that a mob, thousands thick, had collected around the shed in anticipation of beholding some astonishing performances or ceremonies in connexion with the eclipse. This circumstance effectually secured us from the dreaded annoyance on the all-important occasion; but notwithstanding that the site selected was one of the best that could have been desired for the meteorological records, and that the Judge of the Court, S. R. Dawes, Esq., had most obligingly granted me permission to set up the instruments in his compound and on the roof of the Court, I was compelled to have all removed to another position about two miles distant, out of the reach of the too inquisitive and meddlesome loiterers about the supposed magical spot; for not contented with looking, they must needs finger the thermometers and tamper with the instruments to such an extent as to render trustworthy records impossible. To their credit, however, not an article was missing, simple curiosity, not acquisitiveness, being the sole cause of their troublesome interference. The instruments and shed were all removed to the new Civil Hospital, and the eleventh meteorological station of the Presidency was satisfactorily started in charge of Dr. D. Kearney, the Zillah Surgeon, aided by a Native assistant, whom I instructed in his duties before leaving Masulipatam.

It would be ungrateful to omit mention of the generous aid and valuable friendship, shewn us by the residents of Masulipatam during our three weeks stay in the district. We were indebted to G. Thornhill, Esq., Collector of the Kistna District, for much useful preliminary information before leaving Madras; to the late Colonel Winscome for the house in which we resided; and although his tenancy thereof expired about the day of the eclipse, the owner of the premises, the Nabob of Masulipatam, liberally permitted us to continue in undisturbed occupation, until our departure on August 25th. Our thanks are also due to the Acting Collector, W. McQuhae, Esq., and his Assistant, H. Newman, Esq., of the Civil Service; to Captains Cole and Isaac; to the Reverend John Sharp; to J. L. McAlpine, Esq., of the Public Works Department; and to Mr. M. Fruval. One and all most cordially co-operated to render our visit to the place as comfortable and agreeable as possible, and to aid us in preparing for the grand event; and the

value of such co-operation can only be duly appreciated by those who have experienced what it is to be placed in a wrecked and ruined station, such as Masulipatam has been ever since the great cyclone of 1864; destitute of hotel accommodation, shops, or anything to make life endurable to strangers.

It is much to be regretted, that, in two instances, the intended arrangements failed to realize their anticipated results. My worthy First Assistant, C. Ragoonatha Chary, whose zeal and interest in the undertaking, as evinced by his useful preliminary calculations published in the Asylum Press Almanac for 1868, merited better success, had the misfortune to experience disappointment at Gumpurthy, owing to cloudy weather during the totality. I am satisfied that no efforts were wanting on his part to carry out my instructions to the letter, and thanks to the acceptable aid rendered him by the authorities in the Nizam's dominions, in compliance with the request of the Madras Government made through the Resident of Hyderabad, as well as on the part of the Madras Railway Company, and their obliging contractor, E. W. Barnett, Esq., who helped him on his way by special transit along the yet unfinished portion of the line, he arrived at his destination, across a very awkward and difficult line of country, without injury to any of the instrumental appliances entrusted to his care.

Instruments were also prepared for Captain Edgecome, Principal of the Civil Engineering College, who had volunteered to proceed by sea to Vizagapatam, and thence to push southward, as far as time would permit, towards Narsipoor on the central line; but here again our plans were frustrated by the delay of the steamer, and Captain Edgecome's expedition had to be reluctantly abandoned.

I have the honor to be, &c.,

N. R. POGSON,

Government Astronomer.

THE TOTAL ECLIPSE OF AUGUST 18TH, 1868, AS SEEN AT MASULIPATAM,

BY C. G. WALKER, ESQ., MADRAS CIVIL SERVICE.

Before detailing my observations of the eclipse, it may be well that I should describe my equipment, which, as general phenomena were the objects of my attention, was simple.

I used a telescope by Messrs. T. Cooke and Sons of London, of $2\frac{1}{2}$ inches aperture, and 28 inches focal length, with an erecting eye-piece, having a sliding adjustment for powers from 30 to 55. I employed the 35 power, and had cause for regret that I had even thus slightly diminished my field of view.

In order to ascertain, with more accuracy than estimation would afford, the positions of the protuberances, I fitted my telescope with a simple form of micrometer, reading easily to two degrees, for measuring angles of position on the solar or lunar disc, and also with two parallel wires, giving two minutes of arc in my field. Comparison with the Astronomer's micrometer showed that this was very fairly accurate. Fine hairs were employed from fear of great darkness, but the finest spider lines would have been visible. The few angles I took are referred to the sun's north point, and reckoned, as usual, eastward round the disc.

My telescope had blue and green shades, and the light was well kept under. The stand was a firm tripod, with a tolerably stiff horizontal movement, and a vertical slow motion. This was extremely faulty, both in conception and execution, and lost me much precious time during the totality. The tangent rod was so badly arranged, that with the sun at an altitude of some 50° , it could be used only with the arm at full stretch, and at the most critical time I gave the rod three full turns without any effect, and then it jammed. A vigorous wrench extricated it, but tilted up my stand, and compelled me to look away to see that it was correctly replaced. The whole construction reflects little credit on the Public Works Workshops. I had a chronometer by Arnold and Dent, not in good order however, thanks to the fact of its having been cleaned and regulated (??) by a Madras Watchmaker; but I compared it with a reliable chronometer before and after the eclipse, and the times given are corrected to mean local time.

On a bamboo frame, I had a sensitive thermometer by Negretti and Zambra, and a black bulb in vacuo (not self-registering) by Murray and Heath. The readings of both are given corrected to the Kew standard. They were about $4\frac{1}{2}$ feet from the ground, and the black bulb thermometer was fully exposed to the sun. I had a sheet of drawing paper stretched on a board, with 6 circles, each $2\frac{1}{2}$ inches in diameter, and lightly divided into 60 degree sectors. These were for mapping the solar spots, drawing the red protuberances and corona in their relative positions, &c.: this rested on my knees. On a table beside me were, a chronometer, several pencils, a *pad* of paper for notes, and (during totality a lighted candle in a covered shade.

The morning broke cloudily, but the sun soon began to show itself, and before 8 A. M. was clear of clouds. I had my first station in a verandah beyond which projected for some 15 feet a pandal (a lightly thatched roofing). In *this* I had a broad slit cut, east and west. Before 8 o'clock I had made a map of the solar spots as then visible. The spot A was not seen until later. I put my telescope into fair adjustment.

At 8h. 2m. the thermometer read 86.7, and the black bulb in vacuo 103.9. At ten or twelve minutes past eight I began carefully to scrutinize the sun's neighbourhood, but I could see nothing of the moon's disc: while looking thus, with my eye wandering now to the sun's disc, now from it, I lost the absolute moment of first contact. But I estimated it at 8h. 19m. 22s., occurring at 283° of the sun's disc. The sky at this time was partially covered with light fleecy clouds. There was no shadow visible on the sun's disc at first contact.

At 8h. 32m. 41s. occurred the contact of penumbra of the solar spot D, and of the upper edge of the spot at 8h. 33m. 24s.

At 8h. 35m. the plain thermometer stood at 85.7, and the black bulb at 100.1.

The light was now not only diminishing, but getting paler, and as if the sun were overcast, giving one the idea of the "sickly gleam" of sunlight coming out from a thunder cloud. The wind was rising slightly.

At 8h. 43m. light clouds flitted over the sun's disc. At 8h. 44m. I detected a new spot (A) in the sun's lower limb, no doubt not seen until the diminished light permitted.

At 8h. 46m. clouds covered the sun, but it was still visible; but at 8h. 49m. it was very much obscured, and I began to have fears that the totality would be quite lost. These clouds began by being of a light fleecy character, and gradually massed together, and I feel little doubt that with an atmosphere so highly charged with moisture

they were caused by the rapid condensation of the aqueous vapor by the decreasing temperature. The wind was now more quiet.

At 9h. 0m. the light was greatly diminished, and though the sun was not obscured, the clouds were forming heavily.

I had arranged to observe the totality from the roof of the verandah under which I had hitherto sat, and I now had my telescope, removed thither. The view was over a level plain intercepted by tops of cocoanut and palmyra, and so was not very extensive. The general appearance was what painters call *sombro*, but I could not say that it struck me that there was anything very unusual in the light, or different from what is familiar to any one fond of watching cloud effects.

At 9h. 24m. 57s. occurred the contact of the upper edge of solar spot B, and at 9h. 31m. 34s. that of A. The crescent was now very small, and the telescope carefully focussed on the moon's limb showed it to have a very markedly serrated edge. Upon the most prominent of these serrations I now fixed my attention, when, beginning at the cusps, the crescent rapidly broke up into *bits*, and all was dark. Absorbed in watching and keeping my time, I had omitted to slide off my dark glasses, which, however, hardly many seconds before, I had found it impossible to dispense with. As I slid these off I lost my time and took a hurried glance up, (I am very short-sighted, and had no glass on my eye,) and the silver *cloud* which met my eye sent me at once to look at it more closely. The time lost was so short that I almost still seemed to see the phenomenon burst into view, and its sudden appearance and still beauty (for all was deadly still except one chattering bird) made me listen as one listens for the faint report of a rocket bursting, after seeing its cloud of stars fall.

The first thing which struck the eye was the long finger-like prominence, projecting from the lower (east) limb of the disc, a little to the left; and on the right side two rounded prominences, at some distance from each other. These were of the most delicate tint of blush rose colour, and were backed by the silver light of the corona. I made a rapid attempt to measure the position and magnitude of the larger prominence, and obtained the elevation well. But I found that the moon's black disc was moving rapidly over the lower protuberances, and so sketching them, the large one very carefully, I turned to the upper limb. Here occurred my mishap with the telescope, and I lost much time, besides deranging the zero of my position circle, but the protuberances on this limb were very rapidly uncovering. There were visible three peaks on the left, and a small rounded protuberance on the right, of a deeper tint of the same rose colour. The moon's apparent motion seemed to become more rapid, and the small

round mound to the right suddenly grew into a long ridge of peaks and rounded points, extending over at least 60° of the limb. This had hardly burst fully into view, when, as in a moment, all vanished; a string of glittering points burst out, in another moment coalescing into a perfect crescent of light, and a distant shout of many voices from the town welcomed the sun's return.

The angle of position of the south edge of the long lower protuberance was lost, owing to the upsetting of my telescope; but as it was some distance to the left of the lowest point of the sun's disc it could not be far from 80° . Its height was $3' 12''$, which, with the sun's apparent semi-diameter at $15' 51''$, and assuming the diameter 887000, gives 89539 miles, a little over one-tenth of the sun's diameter.

The prominences were, so far as any movement was concerned, apparently solid, but not more solid than the evening wrack usually is. Their colour in relief on the pure silver behind (for it appeared behind) gave the prominences a very beautiful effect. I have attempted to delineate them as accurately as I can, and the shape of the large one is very fairly accurate. In its head there seemed to be three holes right through, showing a clear blue behind. The large aperture was at the bend of the head almost forming a crescent, and the other two were thin slits with sides parallel to the convexity of the larger aperture. The impression made, was, that they were holes *through* the cloud or flame, or whatever it may be.

The other prominences had no peculiarities. I did not see the red flames before or after totality.

The accompanying sketch gives the appearance of the lower protuberances as they were seen about the end of the second minute of totality, and of the upper ones as seen just before the end of the totality.

The corona was of a singularly pure white light, less brilliant at its outer edges. It seemed radiant, shot out from the sun's disc; the radial character being most strongly marked as the edges were approached. I saw no apparent movement. Taking the apparent position of the disc, as before, there was a strongly projecting branch of the corona at about 35° from the centre of the upper limb on the left, and exactly opposite, *i. e.*, on the lower right-hand side, a less prominent arm or branch. At about 60° from the centre of the lower limb, there was another projection, rounded, not pointed, and a similar one exactly opposed to it. The respective angles of position I estimate at about 315° for the larger branch, 135° for the smaller one, and 40° and 220° respectively for the other two. But I speak with diffidence about the corona. As I said, I regretted the high power I had on my telescope, and it was because I could not command, as it seemed to me, the whole corona at

once. This destroyed my clear idea of its shape, although its colour and texture were well seen.

The formation of Baily's beads was very clearly seen. The excrescences on the lunar disc visibly first passed over the solar limb and obscured each its portion, while the depressions still remained clear, forming apparently rectangular *bits* of light, and in the re-appearance the phenomenon was equally clear. The disc of the moon was intensely black, and I could not detect a speck upon it.

The darkness was not great; it was rather gloom than darkness. I had a lighted candle on a table behind my right shoulder and wrote on a board on my knee, and at about 28 inches distance the candle flame threw my fingers in clear shadow on the white paper, but I wrote and read my watch by natural light.

The extensive masses of clouds no doubt accounted in a degree for the light, reflecting it, as they did, from clouds beyond the shadow curve. I saw nothing awful or unusual in the gloom. I think I have seen a full parallel on a dark day of low clouds, when a heavy black upper-stratum cloud has hid the sun.

At 9h. 40m. the thermometers were, standard 83.3 , and black bulb 84.4 , almost the same.

The sun soon became very powerful, and I retired under shade, ceasing in fact to observe the later phenomena.

At 10h. 2m. the Negretti and Zambra thermometer was 84.4 , and the black bulb 91.1 ; and at 10h. 27m. the plain thermometer was 89.8 , the black bulb 112.5 . By this time it was an ordinary morning of Indian brilliance, and it was only a glance upwards that told the sun was still partly covered.

OBSERVATIONS OF THE TOTAL ECLIPSE OF AUGUST 18th, 1868, MADE AT MASULIPATAM,

BY G. K. WINTER, ESQ., TELEGRAPH ENGINEER, MADRAS RAILWAY.

The telescope used in making the following observations was by Messrs. Cooke and Sons; its aperture being $2\frac{1}{4}$, and its focal length 28 inches. It was provided with two eye-pieces; the first an ordinary erecting eye-piece, the magnifying power of which was adjustable within the limits of 30 and 50 diameters; the power used was 40, and with it excellent definition was obtained. This eye-piece was provided with two

hairs, at right angles to each other, in the focus, and with an index corresponding with one of them. The position of this index was read upon a card-board disc, 6 inches in diameter, fixed upon the body of the telescope, and divided into divisions of 10° . The second was a negative eye-piece, adapted to be used with either a Savart's polariscope or a double image prism; the Savart's polariscope, only was, however, employed; and as its quartz prism could not be removed without some little difficulty I was unable to use it as a plain Nicols' prism. It had an index corresponding with the direction of the bands, to determine the plane of polarization. The telescope was fixed upon a small equatorial mounting.

I noticed the first contact at 8h. 19m. 15s. local mean time, but cannot speak very positively as to this being exact, though I believe it to be so within one or two seconds.

As the moon advanced the irregularities of its edge were very striking. I could not observe any penumbra on the sun's disc beyond the moon's limb.

I observed the so-called Baily's beads very carefully. Just before totality, the crescent was broken up into small spots of light; each of these spots, however, had well defined edges, and was quite stationary with respect to the moon's edge. They appeared first where the crescent was thinnest, namely, at its extremities, and disappeared as the moon advanced, successive portions being broken up as the crescent diminished.

The perfect definition of these spots, which were of irregular shape; the perfect absence of all motion with respect to the moon, and their gradual disappearance as she advanced, leave no doubt upon my mind as to their being entirely due to the irregularities on the surface of the moon, seen of course in profile.

The corona seemed to burst into being at the first moment of totality. Its colour was silvery white. It was slightly mottled near the sun, and nearer to its edges was beautifully striated, radially from the sun. At four points, namely, about N. E., N. W., S. E., and S. W., it extended to a greater distance from the sun than at other parts, the branches from the N. W. and S. E. being much the longest and most conspicuous. The accompanying drawing will give some idea of the shape and appearance of this phenomenon.

I had not time to observe the red flames properly, but my attention was especially drawn to one at the left hand lower extremity. It was long, narrow, and curved; its concave side being towards the south. Its edges were well defined, and its colour was rather deep rose. Its position angle was estimated to be about 70° from the north point of the

sun's disc. I have endeavoured to represent it as nearly as possible in the drawing, as well as another red flame I observed about 130° from the north.

After about two minutes observations with the erect eye-piece the negative eye-piece and Savart's polariscope were used. The corona was very strongly polarized in a plane passing through the centre of the sun. The bands were extremely vivid, more so than any I have observed in a clear sky. I tried several portions of the corona, and in all the white central band was brightest when it corresponded with the sun's radius, and the black band was equally marked when the bands were tangential to the limb. There was not sufficient time fairly to test the red flames for polarization.

The fact that the light from the corona was polarized, proves that it shines chiefly, at all events, by reflected light; and the plane of polarization being everywhere radial to the sun, makes it as certain that its light is derived therefrom. This being so, from the great amount of polarization observed, we may conclude that the corona is caused by an atmosphere surrounding the sun and reflecting the solar light.

I observed the last contact at 11h. 4m. 43s.

On looking carefully at the sun on the morning following the day of the eclipse, I found nothing remarkable on that part of the sun at which the large flame had been seen; but on the south-eastern limb, near the lower group of spots, about the position at which another flame had been observed of greater breadth, faculae were distinctly visible, with the telescope and power already described.

EXTRACTS FROM NOTES ON THE TOTAL SOLAR ECLIPSE OF AUGUST 18TH, 1868,

COMMUNICATED BY THE REVEREND JOHN SHARP, MASULIPATAM.

Mr. Sharp used one of the Madras Observatory telescopes, by Dollond, aperture $2\frac{1}{2}$ inches, focal length 42 inches, and with an inverting eye-piece, power about 40.

Three protuberances were noticed. The one first seen was to the right of the vertex, and it continued visible throughout, even to the naked eye. It appeared like a long knife, very brilliant and silvery, and gradually became pinkish. Another, on the left of the vertex, was

soon lost to sight. The third, a little to the right of the lowest point of the disc, only appeared towards the end of the totality; it was redder than the large one, and also visible to the naked eye. The outlines of all were well defined and varied in shade.

The corona was not of uniform brightness, and in parts the rays appeared streaming, as in the Aurora Borealis, but its appearance was not altered by the progress of the moon during the totality. Bright spots were seen on the moon's western limb, just before the sun's re-appearance. The first break of restored sunlight seemed intensely bright, and just after the re-appearance a narrow rim of shaded colours, mixing from red to yellow on the west, and merging into blue and purple on the south, appeared to surround the moon's disc on those sides. Three spots were remarked on the sun towards the south-east part of his disc, and one large one also towards the north-west.

The planets Venus and Mercury were distinctly seen; the former was very bright and visible for some time before and after the totality. One native near me saw four stars and many three. Some elsewhere counted six, and one noticed Mars, as laid down in Ragoonatha Chary's "*Map of the stars probably visible on the occasion.*" About a dozen cows and calves feeding in the compound stopped grazing as the totality came on, and hurried to the gate as at evening; but as the light returned they again dispersed over the field and began to graze as before. Some cows also tried to take refuge in the Mission Girls' School. The crows went to roost and a cock began to crow. The light before totality became of a very peculiar and pallid hue. During the totality, both it and the temperature were very pleasant, and a sensible relief from the usual glare and heat; but it was light enough to read both watch and thermometer readily throughout. The appearance of the eclipse was exceedingly interesting and beautiful. A native told me that he watched the leaves of a tamarind tree to see if they curled up as at night, but that he did not find them so affected.

THE TOTAL ECLIPSE OF THE SUN OF AUGUST 18TH, 1868, AS SEEN FROM VUNPURTHY IN THE NIZAM'S DOMINIONS,

BY C. RAGOONATHA CHARY, FIRST ASSISTANT IN THE MADRAS OBSERVATORY.

In compliance with the instructions given me by the Government Astronomer, I left Madras on the 4th August for Vunpurthy, 45 miles north of Kurnool and 12 miles south of the central line of the shadow, and reached it on the 14th, having travelled 228 miles by railway, and the remainder, about 142 miles, by bullock transit. I was accompanied by my brother C. Rungacharry, and my nephew C. Appoo Iyengar, with a view to their assisting me in the undertaking.

Vunpurthy is situated on high ground, amidst distant hills of small elevation, and the spot I selected was a small hill about sixty feet higher than the surrounding ground, which had been found to command a good view. I had it cleared of trees, a tent pitched, and all the instruments finally placed on the morning of August 17th.

From our arrival at Vunpurthy the weather had been unfavorable, and early on the morning of the eclipse day, the aspect of the sky was far from promising. It began to clear, however, towards the east about 7 A. M., but to my great sorrow clouds overspread the heavens by 8 A. M., and both before and after the time of totality the sky was almost overcast.

The instruments prepared for my use were the following.—A five foot achromatic telescope by Dollond, of four inches aperture, equatorially mounted, and provided with a wire micrometer, of which one revolution of the screw was determined, in sunshine, after my return to Madras, and found to be $34''\cdot442$. The magnifying power of the eye-piece was about fifty, and two dark glasses, easily moveable, were made to slide in front of the eyepiece. A sextant, by Troughton and Simms, with stand, and an artificial horizon. An excellent three foot telescope on stand, by T. Cooke of London, with erect eye-piece, and powers variable from 30 to 55. An aneroid barometer, two black bulb thermometers in vacuo, a standard thermometer, and two chronometers, one of which, an old pocket watch by Barraud, proved quite useless from its bad daily rate, although recently cleaned and repaired for the occasion. The other, by Arnold and Dent, was tolerably steady in its performance.

For the determination of latitude I had only one pretty clear observing night, namely, August 19th, on which I took several double altitudes of γ Draconis shortly before and after its meridian passage. Reducing these to the meridian, I found the latitude of the station to be $16^{\circ}22'18''$ north.

As I had no other means of finding the longitude of Vunpurthy, I assumed the mean daily rate of the best chronometer to be uniform throughout the interval between my departure from and return to Madras. The error of the chronometer on Vunpurthy mean time was ascertained by sextant observations of the sun, on August 16th, 18th, 19th, and 21st, and the resulting longitude obtained therefrom was 8m. 45.3s. west of Madras, or 5h. 12m. 12s. east of Greenwich.

From a comparison of the readings of the aneroid with the corresponding barometric records at Madras, the height of the station above sea level was found to be 1516 feet.

The following were all the records obtainable during the eclipse. The distances have been duly corrected for refraction :—

Vunpurthy Mean Time August 18th, 1868.			Cusp Measurements.		Remarks.
<i>h.</i>	<i>m.</i>	<i>s.</i>	Corrected Distance.	Position Angle.	
8	3	9.9 A. M.	.....	.....	First contact.
8	10	34.9 "	13 59.7	280.5	With the wire micrometer; but the distance doubtful, possibly one revolution or 34.4" too large.
8	17	5.9 "	.....	.....	Bisection of a large spot D, in the S. W. quadrant of the disc.
9	6	59.8 "	.....	.....	Spot B bisected in the S. E. quadrant.
9	17	— "	.....	.....	Large protuberance seen at upper limb.
9	57	30.7 "	29 29.4	.....	With the sextant.
10	27	50.2 "	18 57.4	281.9	With the wire micrometer.
10	29	59.7 "	17 48.3	281.9	
10	32	21.7 "	16 37.6	281.9	

The scenery during the time of totality was awfully sublime. I had previously instructed the by-standers to watch carefully if they could see the sweeping of the shadow from the west, and they unanimously cried out, just at the beginning of the totality, "darkness coming, and covering hill after hill; the shadow has come over us." At that moment it did not appear so very dark, but only a few seconds after it became so much more so, that I was unable to see some steps near me distinctly. A passing thin break in the clouds favored me with the sight of a long protuberance, but its sudden appearance and the vexatious return of heavy clouds, rendered measurement with the micrometer

impossible. The time of its visibility was, about a minute after the total extinction of the sun's limb, and its estimated position was about 10° to the right of the vertex as seen in my inverting telescope, or 90° from north point towards east, its length being about one-tenth of the sun's diameter and its breadth about one-tenth of its length. It appeared to me of nearly the same breadth except at its end, where it abruptly sloped off to a point. It was of a pale yellowish colour, and not red.

I can safely say that it was quite as dark as on a clear star-light night. I had to use lamp-light when looking for the time by the chronometer, and it was impossible to recognize the face of a person standing within a distance of three yards. Lighted candles appeared just as bright as in the night-time, and I was told that my lights were distinctly seen three quarters of a mile off. I heard loud shouting from the people at a distance during the total darkness.

My brother, C. Rungacharry, who used the smaller telescope, by Cooke of London, twenty-eight inches in focal length and two and a half in aperture, with an erect eye-piece and power forty, furnished the following particulars :—

"The first contact of the limbs (probably a little too late) was noted at 8h. 3m. 13s. The contact of the moon's limb with the centre of a large spot in the S. W. quadrant occurred at 8h. 16m. 49s. At this time the horns were pointed, and the moon's limb sharply defined. At 9h. 3m. the moon's limb was observed to be notched and somewhat undulating. The horns also appeared to be blunt. On turning from the telescope and looking towards the west and north-west I found darkness covering the horizon, and in a moment all around us was immersed in the same gloomy shadow. Between 9h. 15m. and 9h. 20m. my pencil notes and the features of persons within four feet could hardly be distinguished. Two hills, apparently close to each other, although at a distance of about twenty miles in the direction of N. W. by W., were made out with difficulty. The colour of the sky between the clouds was pale yellow. A small herd of bullocks, most of them lying down before the eclipse, began to move off, but returned to their former place just after the totality. I also heard a great noise of the people at a distance, crying out as on the approach of some great calamity."

A remarkable feature of the phenomenon was the stillness of the atmosphere during the whole time of totality, and for some time afterwards. The moderate breeze blowing at the commencement of the eclipse diminished by degrees to a dead calm, which continued for about a quarter of an hour after the sun's re-appearance.

The following are the Meteorological observations taken by C. Appoo Iyengar, before and after, as well as during the time of the eclipse:—

Vunpurthy Mean Time.	Aneroid Barometer.	Thermometer in the shade.	Solar Thermometer in Vacuo.	Clear sky.	Weather.
1868. h. m.	Inches.	°	°	Cents.	
Aug. 17—10 20 A. M.	28.33	82.3	...	40	Passing clouds.
3 50 P. M.	28.18	85.0	{ 128.3 } Max.	30	Do. do.
„ 18— 7 7 A. M.	28.32	76.3	94.8	40	Passing clouds; moderate breeze.
7 22 „	28.33	77.1	103.3	60	Do. do. do. do.
7 37 „	28.34	78.0	104.8	60	Do. do. do. do.
7 52 „	28.34	77.8	109.0	50	Do. do. do. do.
8 7 „	28.34	77.3	109.8	50	Do. do. do. do.
8 22 „	28.35	78.1	104.6	30	Do. do. do. do.
8 37 „	28.35	77.8	99.8	...	} Almost overcast with thick clouds; moderate breeze.
8 52 „	28.35	77.5	92.3	...	
9 7 „	28.35	76.8	84.3	...	} The whole sky almost covered with thick clouds, and the wind gradually abating became perfectly calm at the time of totality, regaining its strength by degrees afterwards.
9 10 „	.....	.....	80.5	...	
9 17 „	.....	.....	80.3	...	
9 24 „	.....	.....	77.8	...	
9 28 „	.....	.....	77.8	...	
9 37 „	.....	.....	79.3	...	
9 43 „	.....	76.8	83.3	...	
9 51 „	28.35	77.5	89.8	...	
10 1 „	.....	.....	97.3	10	
10 11 „	28.37	79.3	107.9	40	
10 21 „	28.35	80.8	113.3	10	Passing clouds; gentle breeze.
10 44 „	.....	79.8	113.3	...	Moderate breeze.
10 51 „	.....	80.8	112.3	10	
11 6 „	.....	.....	115.3	...	{ Passing clouds; moderate breeze.
5 40 P. M.	28.25	81.0	{ 130.3 } Max.	...	
„ 19— 9 30 A. M.	28.39	79.8	.....	20	Heavy clouds.
4 53 P. M.	28.26	88.8	{ 134.3 } Max.	...	

I was informed by the Dewan of Vunpurthy, who is a lover of science, and by other intelligent people in the neighbourhood, that at Vyaperla, a village about twenty-five miles south of Vunpurthy, red protuberances, four broad and long beams of light in the corona, and about 30 stars, were seen. Just after the totality the buds of the jessamin flower were found fully blown open as at the approach of night, and the leaves of the tamarind trees were closing. At Kurnool, Chavudappa Row, Collector's Sheristadar, who had a copy of the "Popular Description of the Eclipse," with the configuration of the stars possibly visible, assured me that he and some others, saw the star Regulus, just below the dark limb of the moon, shining as a bright point through the dim light of the corona. He also stated that he saw the planet Mercury.

I take this opportunity of gratefully acknowledging the kind assistance rendered to me by Govindu Venkoba Naik, the Dewan of Vunpurthy, during my stay in and journey through his district.

OBSERVATIONS OF THE ECLIPSE MADE AT THE MADRAS OBSERVATORY, AND AT OTHER STATIONS BEYOND THE CENTRAL LINE.

T. Mootoosawmy Pillay, the second Assistant in the Madras Observatory, made the following records with Messrs. Troughton and Simms' new ten foot equatorial, power forty-seven.

Madras Mean Time,
August 18th, 1868, A. M.

	h.	m.	s.
Beginning of the eclipse.	8	14	54.4
First contact with penumbra of the large spot D. ...	8	33	29.4
Bisection of the nucleus of do. ...	8	35	9.1
Complete covering of penumbra of spot D. ...	8	37	37.7
Small spot C touched.	9	19	35.8
The same spot covered.	9	20	4.7
Bisection of large spot B.	9	26	18.7
Do. of small spot b.	9	26	43.6
Do. of small spot A.	9	32	4.7
Do. of large spot D. at emersion.	9	33	58.4
Last contact with penumbra of spot D.	9	35	33.2
Central re-appearance of small spot C.	10	26	59.7
Bisection of large spot B at emersion.	10	35	43.3
Do. of small spot b.	10	36	22.2
Do. of spot A.	10	46	16.6
End of the eclipse.	11	0	42.8

At 9h. 15m. the south limb of the moon appeared serrated and uneven, and the south cusp was blunt and flattened.

Colonel W. K. Worster occupied himself in securing photographs of the successive stages of the eclipse by means of the old 7½ foot equatorial, by Messrs. Lerebours and Secretan. Aided by Mr. Curths, of the photographic establishment of Messrs. Nicholas and Curths, he obtained fifteen pictures, copies of which have since been on sale at Messrs. Nicholas and Curths' rooms. Colonel Worster's notes, made during leisure intervals, were as follows:—

At 8 A. M. the sun was apparently free from clouds, although he was considerably obscured on rising. Very soon after the commencement of the eclipse, the landscape was tinged with bluish neutral tint, deepening in intensity as the sun became more obscured, the march of the shadow being very clearly indicated by the tints deepening, especially on the walls of buildings to the south. About 9h. 15m. the

south limb was slightly serrated, the point of the cusp being obtuse. I also observed that the moon's limb was a faint copper colour. The landscape was now gloomy and unearthly, but very beautiful. About 9h. 30m. the light on the moon's limb had changed to a greenish bronze hue. The return of heat and light was very striking. At 10h. 24m. the sun's limb was flattened in on the cusps, confirmed by Mr. Chisholm, and by my son observing elsewhere with a forty-two inch telescope by Arnold.

In many compounds birds ceased their song, and crows flew wildly about, cawing violently.

R. F. Chisholm, Esq., who was watching the eclipse in company with Colonel Worster and other friends, chiefly with a view to recording any changes of colour, furnished the following memoranda. He was provided with one of Messrs. Cooke and Son's telescopes, of $2\frac{1}{2}$ inches aperture, and 28 inches focal length, power 30, similar to those used by Messrs. Walker and Winter at Masulipatam.

Almost immediately after the first contact there was a perceptible change in the colour of the light, but no positive diminution. As the sun advanced the yellow rays appeared to be cut off. At 9h. 15m. the south limb of the moon appeared jagged and uneven; and all round, the outline seemed bounded by small tangents, something like shallow saw-cuts. The appearance would be earthly, supposing the jagged points to be the tops of high hills intercepting each other, with the lower portions invisible. At 9h. 25m. the change in the colour of the light and its diminution were quite apparent. Roughly assuming light to be divided into six parts, and in its normal state to be composed of equal parts of the three primary colours, I should say the intensity and proportions of each at the time of greatest obscuration were, three parts blue, two red, and one yellow.

I looked carefully for any change of colour on the sun, but could not distinguish any. At about 9h. 38m., the time of greatest obscuration, I fancied the sun's cusps turned a sickly yellowish orange, but as I was observing with a warm neutral dark glass at the time, I cannot be certain of the effect, and think it probably due to the fatigued retina. About the same time I turned the bright crescent out of the field of view and removed the dark glass, but could not get the faintest indication of the dark limb of the moon upon the sky.

Colonel Worster having asked me to notice the sun about 10h. 25m., I saw a flattening in of the limb, as if the edges were slightly smoothed off at the cusps, but shortly after all was again clear and well-defined.

Magnetical and Meteorological Observations registered at the Madras Observatory during the Total Eclipse of August 18th, 1868.

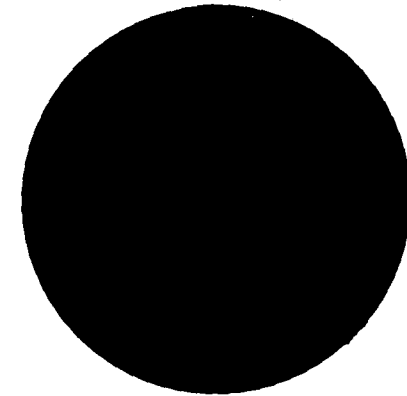
1868 August 18th, A. M.	Magnetometers.		Barometer reduced to 32°.	Solar black bulb in vacuo.	Dry bulb Thermo- meter.	Wet bulb Thermo- meter.	Humidity. Cents.	Wind.		Clear sky. Cents.	Weather.
	Declination East of North.	Bifilar $1 + \frac{\Delta X}{X}$						Hourly velocity. Miles.	Direc- tion. Point.		
h. m.	° ' "		Inches.	°	°	°	Cents.				
8 15	1 24 19	1.008609	29.824	118.4	84.0	73.4	60	12	W.	60	Hazy.
8 30	1 23 55	1.008666	29.822	119.0	84.4	73.8	60	15	W.	60	Do.
8 40	1 23 22	1.008695	29.831	110.8	84.7	74.3	59	15	W.	60	Do.
8 55	1 23 22	1.008695	29.831	107.6	84.2	73.2	61	17	W.	55	Do.
9 0	1 22 58	1.008702	29.832	104.6	84.1	73.8	61	21	W.	60	Do.
9 5			29.832	102.3	83.8	73.2	60	18	W.	60	Do.
9 10			29.832	98.4	83.6	73.2	61	17	W. by N.	60	Do. and light clouds
9 15	1 22 6	1.008666	29.837	95.3	83.2	73.0	61	17	W. by N.	65	Do.
9 20			29.837	92.0	82.9	73.2	63	18	W. by N.	70	Do.
9 25			29.836	88.2	82.6	72.6	62	14	W.	70	Do.
9 30	1 21 37	1.008695	29.836	86.8	82.7	72.5	63	14	W.	70	Do.
9 35			29.836	84.7	82.0	72.3	63	14	W.	70	Do.
9 40			29.835	85.0	81.9	72.6	64	12	W.	70	Do.
9 45	1 21 21	1.008688	29.835	85.6	82.0	72.6	64	12	W.	70	Do.
9 50			29.835	88.0	82.0	72.8	64	10	W.	70	Do.
9 55			29.831	90.1	82.3	73.2	65	8	W.	70	Do.
10 0	1 20 40	1.008688	29.831	92.7	82.6	73.4	64	10	W.	70	Do.
10 5			29.831	98.0	83.0	74.0	66	14	W.	70	Do.
10 10			29.829	101.0	83.6	74.3	65	18	W.	65	Do.
10 20			29.829	109.6	84.6	74.6	63	9	W. by S.	60	Do.
10 30	1 19 51	1.008652	29.829	116.4	85.3	74.8	61	9	W. by S.	60	Do.
10 40			29.829	123.2	86.0	74.2	58	9	W.	60	Do.
10 50	1 19 19	1.008652	29.828	129.0	86.7	74.2	55	10	W.	60	Do.
11 0			29.828	131.0	87.3	75.0	56	8	W.	60	Do.
11 10			29.828	134.1	87.8	74.7	55	8	W.	60	Do.

A solar halo appeared faintly about 9 A. M. It became pretty distinct in about a quarter of an hour, and remained so until 10h. 5m., after which time it faded away, and disappeared altogether before 10h. 40m.

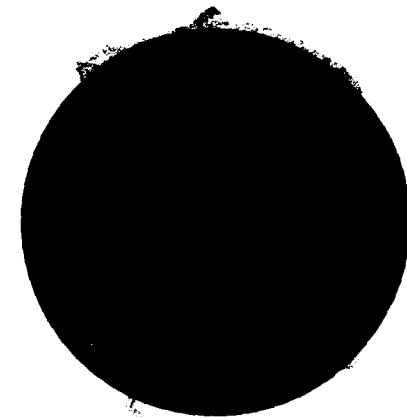
At Kodikonal, on the Pulney Hills, between seven and eight thousand feet above sea level, where the eclipse was considerably less, its effect upon the intensity of the sun's rays was relatively much greater than at Madras. The thermometer, as registered by V. H. Levinge, Esq., Collector of Madura, was 110° in the sun about 7 A. M. It fell to 62° at the middle of the eclipse, and rose to 115° when all was over. At Masulipatam the difference between the temperature of sunshine immediately after totality and at the end of the eclipse was only 43° ; at Vunpurthy 38° ; at Madras, where the eclipse though not total was very considerable, but the air much less humid, 49° ; but at Kodikonal 53° , although less of the sun was obscured. At the same elevation above the earth's surface, Mr. Glaisher, in his scientific balloon ascents in England, found the difference between the exposed black bulb and shaded thermometers to be only about three degrees; while on the other hand Professor C. Piazzi Smyth, when at Guajara, on the Peak of Teneriffe, 8900 feet above sea level, recorded a difference of 93° . From this it may be inferred that there is as much danger from the direct solar rays at a hill station as on the plains, and that the diminution of solar intensity depends far more upon elevation above the surrounding ground than above the sea level. I am indebted for this interesting observation to the kindness of Lady Napier, who was staying at the Pulney's during the eclipse, and obligingly furnished me with Mr. Levinge's records upon her return to Madras.

From the Trevandrum Observatory I am indebted to Sir T. Madava Row, K. S. I., the Devan, and to H. Newill, Esq., the Resident of Travancore, for observations of the eclipse at that station. They were taken by the head native assistant with a five foot equatoreal, and by another assistant with a smaller instrument, but the magnifying powers employed were not mentioned. The sky was generally clear, though hazy near the horizon. The clock error was found by a transit of Aldebaran, and the positions of four of the spots visible were also determined before the commencement of the eclipse. The planet Venus was conspicuous to the naked eye for nearly half an hour, and there was an indescribable change in the colour of the light during the eclipse. The cusps were seen sometimes more sharply defined than at others. The principal phenomena, recorded in Trevandrum mean time, were:—

	<i>h.</i>	<i>m.</i>	<i>s.</i>
Commencement of the eclipse ...	8	0	19.0
Contact of moon's limb with spot D. ...	8	36	5.0
Do. do. with spot B. ...	9	29	18.0
End of the eclipse (by both observers) ...	10	38	59.5



AS SEEN IMMEDIATELY AFTER THE SUN'S DISAPPEARANCE.



AS SEEN IMMEDIATELY BEFORE THE SUN'S REAPPEARANCE.

The Trevandrum Observatory is in $8^{\circ} 30' 32''$ north latitude, and 5h. 7m. 59s. east longitude. Meteorological records were also made but nothing unusual was noticed.

At Colombo, in Ceylon, observations were made by Captain Fyers, the Surveyor General, with a five foot telescope, power 60, in $6^{\circ} 56' 6''$ north latitude, and 5h. 19m. 28s. east longitude; and by I. J. Grinlinton, Esq., with a twelve-inch altazimuth, from the tower of Trinity Church, 5421 feet east, and 466 south of Captain Fyers' position, and 115 feet above sea level. Captain Fyers made the following records in local mean time :—

	<i>h.</i>	<i>m.</i>	<i>s.</i>
Commencement of the eclipse	8	17	23
First contact of moon's limb with penumbra			
of large spot D	9	57	49
Complete covering of do.	9	59	19
Last contact with penumbra of do. ...	10	23	39
End of the eclipse	10	59	20

A bluish or rather neutral tint was imparted to terrestrial objects shortly before 9h. 30m., the period of greatest obscuration. The cusps were pointed and well defined, but the jagged mountainous outline of the moon was clearly discernible throughout the eclipse. Readings of the meteorological instruments were taken at short intervals. The temperature in the sun at $8\frac{1}{2}$ A. M. was 95° . It fell to 86° at 9h. 40m. but rose again to 104° by 11 A. M.

Mr. Grinlinton's observations consisted of measurements (apparently most carefully taken) of the altitudes and azimuths of various points of the sun during the eclipse, the local mean time of each measure being duly recorded. The most important of the fourteen measures taken, namely, those relating to the cusps, were as follows :—

Point observed.	Mean Time.			Altitude.			Azimuth.		
	<i>h.</i>	<i>m.</i>	<i>s.</i>	$^{\circ}$	$'$	$''$	$^{\circ}$	$'$	$''$
Lower or north cusp ...	8	40	1.5	39	37	8	78	30	26
Upper or south cusp ...	8	46	35.5	41	28	25	78	49	33
Lower or north cusp ...	9	6	38.5	45	54	15	78	9	12
Upper or south cusp ...	9	14	32.5	48	15	33	78	15	25
Lower or north cusp ...	9	21	58.5	49	33	3	77	56	9
Solar spot (D) ...	10	17	2.0	63	19	38	74	58	23

The morning was fine, clear, and favorable at first, but passing clouds prevailed towards the time of greatest observation. Eleven

elaborately drawn sketches of the appearance of the sun at various stages of the eclipse accompanied the printed report obligingly forwarded to me by Mr. Grinlinton, out of which I have extracted the foregoing items in reference to the eclipse as seen at Colombo.

OCCULTATIONS OF STARS BY THE MOON,
OBSERVED AT MADRAS AND MASULIPATAM,
ABOUT THE TIME OF THE TOTAL ECLIPSE OF THE SUN,
IN AUGUST 1868.

At Madras the occultations were noted by T. Moottoosawmy Pillay, with the ten foot equatoreal, of eight inches aperture, by Troughton and Simms; the comet eye-piece, power 47, being always employed. Each observation was considered satisfactory.

Madras Mean Time.

	<i>h.</i>	<i>m.</i>	<i>s.</i>	
Aug. 10—12	17	7·7		Reappearance of μ Ceti at the moon's dark limb.
„ 23—	8	35	24·6	Reappearance of ξ' Libræ at the moon's bright limb.
„ 25—	8	46	17·2	Disappearance of 5579 BAC at the moon's dark limb.

At Masulipatam only two occultations were observed by the Government Astronomer, with a five foot portable equatoreal, power 52. Upon the first occasion the sky was unfavorable and the observer fatigued; but the second observation was good, and the disappearance of the star instantaneous.

Masulipatam Mean Time.

	<i>h.</i>	<i>m.</i>	<i>s.</i>	
Aug. 14—15	36	42·0		Reappearance of 12650 Lalande at moon's dark limb.
„ 23—7	21	9·5		Disappearance of ξ' Libræ at moon's dark limb.