"Total Eclipse of the Sun, January 22, 1898. Preliminary Account of the Observations made by the Eclipse Expedition and the Officers and Men of H.M.S. 'Melpomene,' at Viziadrug." By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received March 28, 1898.

LOCAL ARRANGEMENTS.

After various inquiries which I had made respecting the suitability of Viziadrug for observations of the total eclipse, I informed the Eclipse Committee that I was prepared to take charge of an expedition to that locality, and it was agreed that the observations at this station should be placed in my charge.

The latitude and longitude of the part of the fort at Viziadrug finally occupied were 16° 33′ 26″ N. and 73° 18′ 58″ E. respectively, and the duration of totality was estimated at 127 seconds.

In connection with the work at this station the Admiralty was asked for a ship of war to convey the observers from Colombo to Viziadrug, and to permit the use of the ship, if possible, as a base, to enable me to repeat the observations attempted in Norway in 1896 with the assistance of H.M.S. "Volage," which ship supplied twenty-four assistants during the eclipse and fifty volunteers for general observations.* As a result of the Royal Society's application, H.M.S. "Melpomene," in command of Captain Chisholm Batten, R.N., was told off to join the expedition.

The expedition, which left England on December 10, consisted of Mr. A. Fowler, Dr. W. J. S. Lockyer, and myself, together with the Marquis of Graham, who joined as a volunteer. Some little time after reaching Viziadrug Professor Pedler, F.R.S., joined the party from Calcutta, and shortly before the eclipse Mr. John Eliot, Meteorological Reporter to the Government of India, joined from Simla. On arrival at Colombo we found H.M.S. "Melpomene" waiting there, and at once proceeded to the selected spot of observation—Viziadrug.

During the three days' voyage to our station a call for volunteers was made by Captain Batten, and 120 came forward. Lectures and demonstrations were therefore at once commenced by Lieutenants Blackett, Colbeck, and Dugmore, second engineer Mountfield, and myself to the several parties of men who had undertaken to perform special pieces of work. Twenty-two separate groups of observers were formed. On our arrival at Viziadrug we were received very kindly by Mr. Bomanji, the collector of Ratnagiri, and an Overseer of the Public Works Department, who was on the spot in charge of

* 'Phil. Trans.,' A, vol. 190 (1897), pp. 1—21.

some most excellent masons and carpenters, picked men from Ratnagiri as we later ascertained, and plenty of material for the construction of the necessary concrete bases and huts. It was important to erect the huts as soon as possible, not only to shelter the instruments but the observers from the sun. Several screens were made which could be moved and placed in any required position; these were found to be invaluable while the instruments were being erected. A considerable number of coolies was also present to do such work as carrying packing-cases, sawing wood, clearing the camp, &c.

In the fort was also a police guard sent from Ratnagiri. The camp was watched both by day and night so effectively by them that no damage to any instrument was reported.

On the arrival of the "Melpomene" at Viziadrug, Mr. Bomanji came on board to report the arrangements which had been made for the expedition by the Government of India. As these were not quite completed, it was necessary for the first few days to return to the ship every evening, but afterwards Mr. Fowler, Dr. Lockyer, and myself took up our quarters at the Dak bungalow inside the Fort, close to the instruments. Meals were provided at the Collector's camp, which was also inside the Fort.

A party was landed at the fort on the afternoon of our arrival to inspect the site suggested by Mr. Bomanji, and it was at once evident that it would satisfy all requirements, provided the fluctuations of temperature of the great masses of masonry composing the fort had no disturbing influence on the steadiness of the air. In order to investigate this point a $3\frac{3}{4}$-inch telescope was erected, and observations of the surrounding landscape, and, at dusk, of various stars, were made, from which it appeared that the atmosphere was sufficiently steady for the observations.

Next morning the instruments were landed and the concrete bases for them were commenced. The erection of the huts was also begun by the native workmen and continued without intermission.

The instruments were set up as soon as their bases were ready, and by the end of a week all were practically in readiness for the eclipse. Constant clear skies enabled all the adjustments to be made without difficulty.

During the week preceding the eclipse the adjustments were frequently tested, and a complete system of drills was established.

As the number of volunteers was so large I pointed out to Captain Batten, who had volunteered to aid in a special branch of the work, the importance of his taking charge of the whole camp and giving all the necessary orders for conducting the operations during the general rehearsals, and the eclipse itself. He eventually agreed to this, and the procedure and time signals were arranged between us.

The groups of observers were as follows :—

1. Time.
2. 6-inch prismatic camera.
3. 9-inch „ „
4. Integrating spectroscope.
5. 6-inch equatorial.
6. Coronagraph.
7. Discs.
8. Sketches of corona without discs.
9. $3\frac{3}{4}$-inch equatorial.
10. Observations on stars.
11. Shadow-bands.
12. Meteorological observations.
13. Hand spectroscopes.
14. Prisms for rings.
15. Polariscope.
16. Landscape colours.
17. „ cameras.
18. Shadow phenomena.
19. Kinematograph for eclipse.
20. „ „ shadow.
21. Contact observations.
22. Observations on natives, animals, &c.

The observers were as follows :—

1. *Time Signals.*

Captain A. W. Chisholm-Batten, R.N.
F. Downton, Leading Seaman.
W. Woods, Yeoman of Signals.
W. Groves, Shipwright.
F. T. Marey, Private, R.M.L.I.
G. S. Fullilove, Private, R.M.L.I.
G. Cleary, Private, R.M.L.I.

2. *6-inch Prismatic Camera.*

Mr. Fowler.
Lieutenant O. de Wett, R.N.
C. Ironsides, G.M.
J. Turner, T.I.
F. Brading, A.B.
J. Innes, A.B.
G. Salt, Boy, 1st Class.

3. *9-inch Prismatic Camera.*

Dr. Lockyer.
Lieutenant Percival-Jones, R.N.R.
A. Ramage, A.B.
W. Bray, Ch. Arm.
A. Wilkins, Shipwright.
E. Ashford, A.B.
F. Fenton, A.B.
A. Carr, Boy, 1st Class.

4. *Integrating Spectroscope.*

Lieutenant G. C. Quayle, R.N.
J. Bird, Ch. E.R.A.
G. Travill, P.O., 1st Class.

5. *6-inch Equatorial with Grating Spectroscope.*

Sir Norman Lockyer, K.C.B.
Professor A. Pedler, F.R.S.
Mr. R. C. Steele, Gunner, R.N.
P. Ross, Ch. E.R.A.
G. Vanstone, Ch. E.R.A.
H. Brown, Ship's Steward's boy.

6. *Coronagraph.*

Staff-Engineer A. Kerr, R.N.
W. Holmes, E.R.A.
C. Moseley, Leading Stoker, 1st Class.
G. Collier, Stoker.

7. *Discs.*

A. Ruse, Ship's Corporal, 1st Class.
G. Pink, Qualified Signalman.
J. Henry, Boy, 1st Class.
R. Sutherland, Leading Signalman.
W. Webb, A.B.
W. Corney, Stoker.

B. Brook, Stoker.
A. McDonald, P.O., 1st Class.
A. Tull, Ship's Steward's Boy.
G. Price, A.B.
J. Jones, A.B.
F. Dibbins, Ordinary Seaman.

L. Pettingale, Leading Signalman.
W. Brooker, A.B.
S. Drew, Ordinary Seaman.
L. Gates, A.B.
R. Davis, A.B.
P. McKenna, A.B.

8. *Sketches of Corona without Discs.*

General.
A. Richardson, P.O., 1st Class.
W. Pankhurst, A.B.
H. Lack, Boy, 1st Class.

N.E.
W. Anderson, A.B.
E. Wilson, Ordinary Seaman.

N.W.
T. Wells, A.B.
H. Brinstead, A.B.

S.E.
E. Dann.
W. Evans.

S.W.
W. Clayton.
A. Penny.

9. $3\frac{3}{4}$-*inch Equatorial.*

Sir Norman Lockyer, K.C.B.
Mr. H. Willmore, Assistant Engineer, R.N.
M. Moore, Stoker.

10. *Observations on Stars.*

Lieutenant Henry Blackett, R.N.
J. McDonald, A.B.
F. Stevens, A.B.
R. Buckland, Plumber's Mate.
T. Sutton, Stoker.
J. Fitzroy, Boy, 1st Class.
G. Russell, Private, R.M.L.I.

11. *Observations of Shadow-bands.*

Staff-Surgeon C. L. Nolan, R.N.
C. Hester, Private, R.M.L.I.
A. Purkington, 2nd S. B. Steward.

12. *Meteorological Observations.*

Mr. John Eliot, C.I.E., F.R.S.
J. Russell, Chief Stoker.
C. Butt, Leading Stoker, 1st Class.
H. Rockett, Stoker.
A. Wallace, Stoker.
G. Pratt, Stoker.
H. Wallburn, Stoker.
J. Bartlett, Stoker.
T. McCarthy, Stoker.
E. Perry, Stoker.
G. Woolston, Stoker.
G. Garrard, Stoker.
C. Mintram, Stoker.
P. Keefe, P.O., 1st Class.

13. *Hand Spectroscopes.*

Lieutenant C. E. B. Colbeck, R.N.
C. Kitchingham, Private, R.M.L.I.
C. Woodley, P.O., 1st Class.
P. Manning, Ordinary Seaman.
H. Mitchell, Stoker.
J. Dobson, Sergeant, R.M.L.I.

14. *Prisms for Observations of Ring Spectra.*

Mr. J. Mountifield, Senior Engineer, R.N.	R. Coates, Stoker.
W. Morris, E.R.A.	G. Tarrant, Stoker.
A. Howe, E.R.A.	H. Warren, Stoker.
C. Stacey, Leading Stoker, 2nd Class.	J. Inch, Stoker.
H. Knight, Leading Stoker, 2nd Class.	G. Gray, Chief Stoker.
	J. Cross, Stoker.

15. *Polariscope.*

Staff-Surgeon C. L. Nolan, R.N.

16. *Landscape Colours.*

Lieutenant E. N. R. Dugmore, R.N.	P. Darvil, Boy, 1st Class.
G. Farrell, Boy, 1st Class.	H. Rhodes, Ordinary Seaman.
W. Jacobs, A.B.	H. Attree, Signalman.

17. *Landscape Cameras.*

Mr. Turner, Survey Department, Calcutta.	J. Collins, Chief Stoker.
E. Gyngell, A.B.	J. Kearney, Leading Stoker, 1st Class.
H. Childs, Chief Stoker.	E. Cross, Leading Stoker, 2nd Class.

18. *Shadow Phenomena.*

W. Keenan, Chief Carpenter's Mate.	G. Riley, Stoker.
A. Reynolds, Stoker.	B. Crunden, Stoker.
W. Weeks, Shipwright.	C. Carpenter, Stoker.

19. *Kinematograph for Eclipse.*

The Marquis of Graham.	C. Thomas, Seedie.
A. Shilcock, E.R.A.	P. King, Ordinary Seaman.
E. Green, Boy, 1st Class.	W. Cronen, Stoker.

20. *Kinematograph for Shadow.*

Mr. H. P. Barnett, Paymaster, R.N.	A. Gidney, E.R.A.

21. *Contact Observations.*

Lieutenant O. de Wet, R.N.	C. Ironsides, G.M.

22. *Observations on Natives, Animals, &c.*

W. J. C. Slocombe, Ordinary Seaman.	F. Beal, Ordinary Seaman.
G. Whittingstall, Ordinary Seaman.	

Aides-de-Camp to Sir Norman Lockyer, K.C.B., F.R.S.

Mr. W. H. P. Bourne, Midshipman, R.N.	J. Hunt, P.O., 2nd Class.

The development of the photographic plates was commenced immediately after the eclipse, and it was found that the results were on the whole very satisfactory. No results, however, were obtained with the integrating spectroscope, and the kinematograph films taken by Lord Graham were too badly fogged to serve any useful purpose.

The dismantling of the instruments was commenced very soon after the eclipse, and the packing, together with the development and copying of the negatives, kept the party fully occupied until the morning of January 25, when the expedition left Viziadrug.

Half of the negatives and glass copies of the remainder were conveyed to England in charge of Mr. Fowler, while the remaining half of negatives and positives were sent home *viâ* Bombay.

The general time signals were given by a bugler under Captain Batten's orders. The chronometer was in charge of Lieutenant de Wet, R.N.

For the work of the prismatic cameras it was important to get a signal as nearly as possible five seconds before the beginning of totality, and, in order to eliminate the possible error of the chronometer, it was arranged to determine this by direct observations. Two methods were adopted. In one of them a boat was moored at a distance of two miles from the camp, in the direction of approach of the shadow, which would pass this point five seconds before totality. This failed because of the indefinite boundary of the shadow.

The other method was to determine when the visible remaining crescent subtended an angle of 45°; calculation showed that this would occur at the desired interval from totality. This method was completely successful.

The special signals during totality were given every ten seconds, beginning at 127—the assumed period of totality—by means of the eclipse clock (which was started at the signal "go" by cutting a thread thereby releasing the pendulum), by two timekeepers, one during the first half, the other during the second half of totality.

In the system adopted not only was the time left called out every tenth second, but other signals were interpolated to guide the work in the photographic huts. In order that there might be no mistake about the calls, a spiral was drawn on the clock-face and the seconds left plainly marked at the points which the second hand would occupy during its two revolutions.

In consequence of the perfect drill acquired at the rehearsals the operations went off during the eclipse with absolute steadiness. They commenced about one and a half hours before totality, ending after a like interval after totality. Six volunteers were employed in the timekeeping, including three with lamps which were not wanted.

The Chief Instruments employed.

The Prismatic Cameras.

In the two prismatic cameras no less than fifty-seven photographs were secured, the exposures varying from one to fifty seconds. Such a result as this could only be obtained by a minute subdivision of labour. In the case of each of these two instruments six volunteers were employed, and they were distributed in the following manner:—

One observer with the finder, his duty being to keep the image

in the centre of the field of view which corresponded (by previous adjustment) to the centre of the plate in the prismatic camera. He had a timekeeper to record the times of contact.

A third acted as timekeeper to record the exact moments at which the exposures were begun and ended.

A fourth volunteer, by means of a piece of cardboard, covered and uncovered the front of the prism, from directions given by Mr. Fowler and Dr. Lockyer respectively.

In one case two, and in another three, men were required to hand and receive the large dark slides before and after exposure, taking them out or placing them back in bags made for this purpose.

Six-inch Prismatic Camera.

This instrument, the dispersion of which had been increased this year by the addition of a second prism, was worked by Mr. Fowler, with the assistance of Lieut. de Wet and five men. Mr. Fowler's programme was to begin taking a series of ten snap-shot pictures five seconds before the commencement of totality, to obtain a record every second or thereabouts of the spectrum of the chromosphere. After this he exposed eight other plates to secure photographs of the coronal rings, the exposures being of various lengths. It was also arranged that at five seconds before the end of totality he should commence another series of ten snap-shots, exposing the last of these some few seconds after totality. On developing the plates it was found that everything had gone satisfactorily. The large plates containing the ten snap-shots give the whole story of the chromosphere during twelve seconds, the time to make the ten exposures, and in one of the negatives there are as many as a thousand lines (about).

The last set of ten exposures did not come out quite as expected, for the reason that the duration of totality was a few seconds shorter than had been provided for in the time table, so that only two of the exposures were made before the end of totality. The very last exposure, however, taking about nine seconds after totality, shows many bright lines.

Nine-inch Prismatic Camera.

This instrument was in charge of Dr. W. J. S. Lockyer, who was assisted by Lieut. Percival Jones, R.N.R., and six men. This instrument was also fed by a siderostat, but the tube was not placed horizontally. It was intended with one of the prismatic cameras to so mount the tube that the arcs formed on the photographic plate should be symmetrical about the direction of dispersion, and it was decided that the 9-inch camera should adopt this plan of mounting.

The exact position of the tube to obtain this result was carefully determined by calculation. To facilitate the erection of the instrument at the station two wooden tops to carry the tube were previously made and taken out.

It is satisfactory to state that the photographs showed that the experiment was very successful, the arcs coming out exactly as forecasted.

Although this instrument was capable of only giving about half the dispersion of the 6-inch, the optical parts were better adapted for recording the ultra-violet region of the spectrum.

The programme adopted was similar to that of the 6-inch, there being two large plates ($16 \times 6\frac{1}{2}$) for recording a series of ten snapshots at and near the times of second and third contacts and nine smaller plates for exposure during totality. All the exposures were successfully made, but the lines in the spectrum are not so distinct owing to warping of the wooden tube by the heat and the consequent disturbance of the focus.

I shall refer to the results obtained by the prismatic cameras later in this preliminary report.

Integrating Spectroscope.

This instrument consisted of a large collimator, two prisms of 60°, and a receiving camera. It was entrusted to the care of Lieut. G. C. Quayle, R.N., with two assistants. The light which fed this instrument was obtained from a cœlostat, and there was still sufficient room for another instrument to be utilised, so the coronagraph was set up in the same hut. Although three exposures were made, no results were secured owing, it is feared, to an alteration of the slit, which was found closed after the eclipse.

Six-inch Equatorial with Grating Spectroscope.

This instrument consisted of a 6-inch lens mounted equatorially. The small grating employed contained 17,296 lines to the inch, and in the focus of the eyepiece was placed a small photographic spectrum of iron for comparison.

Professor Pedler, who came to take charge of this instrument was assisted by Mr. Steele, R.N., gunner, and three other volunteers. Up to the present time I have not received Professor Pedler's report of his observations, but I may say that among his observations reported at the time, he recorded the presence of arc lines of iron in the lower corona and the absence of the enhanced lines.

The Coronagraph.

All the more important instruments available for the expedition being employed in the spectroscopic work I could only use a small one for taking photographs of the corona, which were essential for me in order to make comparisons with the chromosphere and coronal rings we hoped to get in the prismatic cameras. The instrument employed, of $4\frac{5}{8}$-inch aperture, was entrusted to Staff-Engineer A Kerr, R.N., who was assisted by three volunteers.

Five photographs were taken. These on development were found to be exceedingly good, the long exposed plate showing a great amount of detail both in the polar rifts and in the streamers.

There being still a small amount of available surface of the cœlostat for other purposes, this was utilised for the 10 × 8 landscape camera which was operated by Mr. Turner. Two exposures were made during totality, with very successful results. The longest exposure shows very well the general form of the corona and the relative lengths of the extensions, the longest streamer being nearly three lunar diameters.

Discs.

The discs, six in number, were put into position by Lieutenant G. C. Quayle, R.N., and Lieutenant C. E. B. Colbeck, R.N., being ranged along the southern wall of the fort, close to the Eclipse Camp. The great altitude (53°) of the sun rendered the operation of setting them up somewhat difficult. Their sizes varied from six to two inches, and they were so placed that they cut off 3, 5, and 7 minutes of arc round the dark moon.

Each disc occupied the time of three men, so that in all eighteen volunteers were employed. Of each party of three, one volunteer kept the eye end in adjustment up to the time of totality, another who was blindfolded ten minutes before totality acted as observer, and the third wrote down the remarks of the observer.

A preliminary examination of the drawings shows that no equatorial extension was observed.

The $3\frac{3}{4}$-inch Equatorial Telescope.

This telescope was used by me to observe the exact time of second and third contacts to give the signals "go" and "over" to the time-keepers. For the first fifty seconds of totality I employed this instrument myself to minutely observe the structure of the rifts and streamers. In my absence it was used by Assistant Engineer H. H. Willmore for the examination of the structure of the corona.

Observations of Stars during Eclipse.

This party of six volunteers was in charge of Lieutenant Henry Blackett, R.N. Each observer was supplied with a photograph of a small star chart of the region near the sun, prepared by Dr. Lockyer. This was afterwards supplemented by another on a larger scale photographed at the office of the Trigonometrical Branch of the Survey of India at Dehra.

Two striking observations were made by most of the observers. First, more stars were seen just before the commencement of totality than during the actual period of totality; that is, they were logged as disappearing just before the total eclipse phase commenced. A similar observation was made by Admiral Don Ulloa in the eclipse of 1778.* Secondly: two observers noted on the chart a bright body, certainly not a star, midway between the planets Mars and Venus. It was seen only for a short time, and that before totality, being estimated as of the Second Magnitude.

Meteorological Observations.

Mr. Eliot, the Meteorological Reporter to the Government of India, brought with him several important instruments with a view of making observations similar to those he had arranged along the whole line of totality. The report of his observations I have not yet received. He was assisted by twelve volunteers.

Observations of Shadow Bands.

Staff-Surgeon Nolan, R.N., observed these phenomena with the help of two assistants. Previous to the eclipse a large white table-cloth was spread on a flat piece of ground in front of two walls intersecting at an angle of 115°, which were whitewashed. The bands were well seen before the second and after the third contact. None were seen during totality. Their direction of travelling was before totality towards the west (N. 88° W.), veering gradually round to S. 60° W. After totality they practically reversed their direction, travelling N. 60° E. They moved too quickly for their rate of motion to be determined, but it was noted that their rate of motion was not constant.

They were estimated to be about $\frac{1}{2}$ to $1\frac{1}{2}$ inches in breadth, but this also varied. The interspaces were gauged at 4 to 6 inches in breadth.

Each observer noted, one minute after totality, a long intermittency during which a large band, about 2 inches broad, passed by itself in a most striking manner.

* 'Phil. Trans.,' 1779, p. 105.

The Chief Results bearing on Solar Theory.

1. *The Spectrum of the Chromosphere.*

Considerable time must elapse before the complete discussion of the numerous photographs taken in the prismatic cameras can be completed. I therefore give here only some general results which can be gathered by a preliminary inspection of them.

I first deal with the determination of the heights of the various absorbing vapours so far as they can be gathered from the photographs, which, of course, only record for us the brightest lower portions of the different arcs, and not their complete extension.

The following table shows the results obtained in the case of some of the most typical lines:—

Lines.	Length of arcs.	Height.	
		In miles.	In secs. of arc.
Ca(K)	130°	6000	13·3
Hydrogen	112°	4500	10·0
He 4471·25	105°	4000	8·9
He 4026·3; Sr 4077·9, 4215·66	86°	2700	6·0
Ca 4226·9; Unknown, 4247 Mg ultra-violet triplet	72½°	2000	4·4
Fe triplet (4045) Strongest arc lines (4307·96, 4325·92, &c.) Al 3944·16 and 3961·67	60°	1450	3·2
Fe enhanced lines 4584, 4233 Mn quartet (4030·9, &c.)	51°	1100	2·4
Fe enhanced quartet (4523·0, &c.) and many other lines	40°	650	1·4
Carbon fluting and many lines, including arc lines of iron	35°	475	1·05

A very noticeable feature of the chromospheric spectra, which the photographs enable us to investigate at different elevations, is the difference in the behaviour of the gaseous and metallic lines. In the spectrum taken very near the moment of second contact, representing that of the lower strata with the spectra of higher ones superposed, the metallic arcs are relatively short and very bright, while in later photographs, representing the spectra of successively higher strata free from admixture with lower ones, the metallic arcs are relatively feeble. This is also indicated in another way by the varying effects seen over the tops of lunar mountains and through indentations in the moon's limb.

Some of the lines are seen to be relatively much brighter in the

upper strata than in the lower, such lines showing no notable increase of brightness at the points where lower strata are revealed through lunar valleys. Chief among these lines are those of hydrogen, helium, and calcium (H and K), but there is an additional line at wave-length 4686·2 or thereabouts, which behaves in the same way.

This line does not appear in Young's list of chromospheric lines, and all attempts to trace it in known spectra have failed. A line apparently coincident with it, however, has been found in the photographed spectrum of a tube containing helium, which is one of a series of comparison spectra being taken with the 6-inch prismatic camera to facilitate the reduction of the eclipse photographs.

The only recognised impurity in the vacuum tube used is oxygen, but besides the line to which reference has been made, there are a few faint lines for which no origins can at present be assigned.

It is worthy of remark that this line falls very near to the first line of the principal series in the spectrum of hydrogen, recently calculated by Rydberg to have a wave-length of 4687·88.*

As in the case of the photographs taken with the prismatic cameras in 1893 and 1896, the spectrum of the chromosphere in 1898 is very different from the Fraunhöfer spectrum, so that we have not to deal with a mere reversal of the dark lines of ordinary sunlight into bright ones. (See fig. 1, next page.)

Many very strong chromospheric lines, as the helium lines for example, are not represented among the Fraunhöfer lines, while many Fraunhöfer lines are absent from the chromospheric spectrum.

2. *The Spectrum of the Corona.*

The heights of the chief coronal rings as photographed are roughly as follows:—

1474 K	60,000 miles (in lower parts of inner corona).
3987·4	20,000 miles.
4231·3	More than 10,000 miles.

The coronal rings not only differ from the chromospheric ones in regard to the heights to which they extend above the photosphere, but also in appearance.

The outlines of these rings are distinctly not connected with the configuration of the chromosphere and prominences. In photographs taken near the beginning and end of totality, the 1474 ring is brightest on the same side of the moon, although the chromosphere and prominences are first visible on one side and then on the other. None of the rings give any indications of increased brightness at the places occupied by prominences. The green ring, corresponding to

* 'Astro. Phys. Jour.,' vol. 6, p. 237.

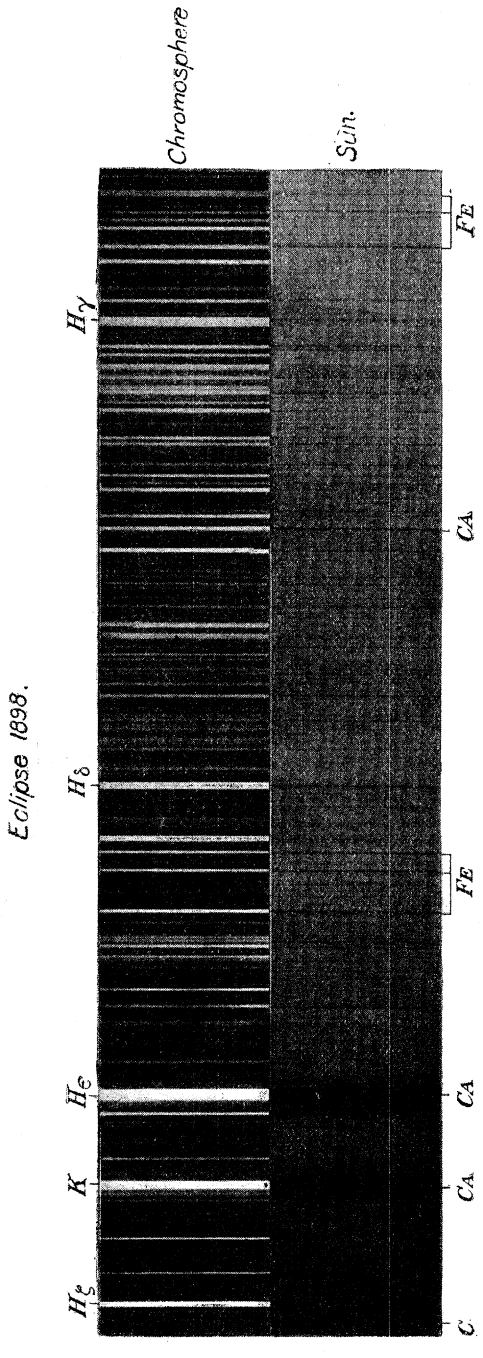

FIG. 1.—Spectrum of Chromosphere as photographed during Eclipse compared with Fraunhöfer lines.

1474 K, which is the brightest of the rings seen, can be traced completely round the limb, and while in some parts it is very feeble, in others it is bright enough to show the brightest projections of the inner corona as photographed with short exposures with the coronagraph. The other rings at 3987 and 4231 can also be traced completely round the limb, but they are fainter on the average and of much more uniform intensity than 1474 K. This latter fact suggests that the additional rings are produced by a substance which is not the same as that to which 1474 K corresponds.

It is interesting to note that the three rings photographed in 1898 were also the most conspicuous in the coronas of 1893 and 1896 as determined by the use of prismatic cameras. The following table gives a comparison of the results obtained in the three eclipses, the wave-lengths for 1898 of course being only provisional.

1893.	1896.	1898.
3987	3988	3987·4
4086	4084	
4217		
4231	4232·0	4231·3
4240		
4280		
4486		
5316·9	5316·9	5316·9

3. *Results regarding the Corona.*

I looked forward to the corona this year with the greatest interest on account of the high temperature of the sun as judged by the fact that scarcely any iron lines have been recorded as most widened in the spectrum of sun spots since the end of 1892; that is, chemically, the maximum sun-spot conditions have been retained since 1893. Hence I was not astonished to see several large spots on the sun on the days preceding the eclipse.

I pointed out in 1878, a year of minimum, that the corona of that year was vastly different from that of 1871, a year of maximum; not only was it very much dimmer, but its spectrum was continuous; there were practically no bright lines, while long equatorial extensions were seen.

Normally we should have expected an approach to the 1878 conditions this year. But both the photographs and eye observations show that the only minimum appearance noticeable was the exquisite tracery near the sun's poles.

The violent magnetic storm and bright aurora on March 15 and 16,

to which Mr. Chree has recently called attention, follow suit with the chemical and eclipse observations, and it is important to note, as Dr. Chree has informed me in a later communication, that there were less violent disturbances on January 15—18 and February 11—16, so that there have been three disturbances separated roughly by an interval of twenty-eight days.

Conclusion.

The extraordinary interest and the skill displayed by the officers and men of H.M.S. "Volage" under Captain King Hall in 1896, and of H.M.S. "Melpomene" under Captain Chisholm Batten in the present year, prove beyond all question that in eclipses in which a man-of-war can be employed the most effective and the most economical means of securing observations is to depend upon the naval personnel, one or two skilled observers being sent out to help in the final adjustments of instruments according to the number it is intended to employ.

At Viziadrug, Mr. Fowler and Dr. Lockyer were enabled to report all the fixed instruments and huts, eight in number, erected and all but the final adjustments made after six days' work, a long break being necessary in the middle of the day in consequence of the heat. Such an achievement as this is beyond all eclipse precedent and was only rendered possible by the help of a large staff of highly trained men. Of the 150 engaged in the operations only three originally formed the expedition.

It is, therefore, quite inappropriate that I, on the part of the expedition, should here tender thanks to Captain Batten, the officers and men of H.M.S. "Melpomene" for their assistance, for as matters turned out we assisted them; but we are anxious to place on record the kindness we received from them both afloat and ashore, and since the great success of the recent observations is due almost entirely to Captain Chisholm Batten and the ship's company of the "Melpomene," I trust that the President and Council of the Royal Society may be pleased to communicate this fact to the Lords Commissioners of the Admiralty.

Among those to whom thanks are specially due are the following representing the Indian Government:—

E. Giles, Esq., Director of Public Instruction, in charge of arrangements made by Bombay Government.
K. R. Bomanji, Esq., Collector of Ratnagiri.
J. L. Jenkins, Esq., Collector of Salt.
E. H. Aitken, Esq., Assistant Collector of Salt.
F. R. Bader, Esq., Assistant Engineer, P.W.D.

Gangadhar Anant Bhat, Executive Engineer, P.W.D.
Govind Goshi, Overseer, P.W.D.
Sadashi Govind Joshi, Clerk to the Overseer, P.W.D.

Thanks are also due to the Officers of the Police, Telegraph, and Customs Departments, and others representing the Bombay Government, for their unceasing efforts to help us in every way.

Everybody was struck by the admirable and smart manner in which the subordinates of the Public Works Department accomplished their respective tasks.

I took upon myself when leaving Viziadrug, to write an unofficial letter to Mr. Bomanji, thanking him, in the name of the expedition, for his great personal kindnesses to us as well as for the valuable assistance we had received from him and the other local representatives of the Government.

L. Lee, Esq., Collector of Customs for Ceylon, and other Customs officials at Colombo rendered valuable assistance to the expedition by granting special facilities and providing means for transhipping the instruments.

The Orient Steam Navigation Company very kindly conveyed the instruments free of charge to and from Colombo.

To W. H. Sinclair, Esq., a former Collector of the district (now retired), I was indebted for the supply of much valuable local information before leaving England.

My own personal thanks are due to Mr. Fowler and Dr. Lockyer, who assisted me in the preliminary work of organisation, and who, while at Viziadrug, worked hard both day and night to further the objects of the expedition; and also to Mr. Bourne, Midshipman, attached to me as Aide-de-camp, who was indefatigable in helping me to carry out the various details of the local organisation.

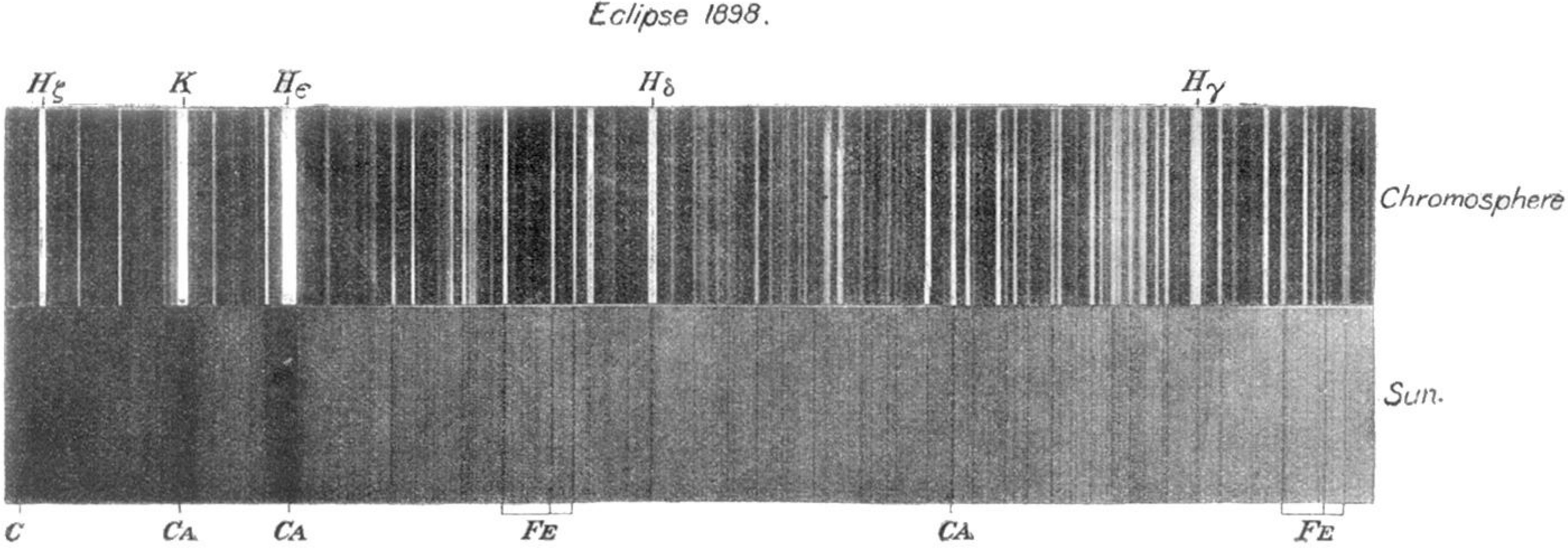

FIG. 1.—Spectrum of Chromosphere as photographed during Eclipse compared with Fraunhöfer lines.