Effect of the Eclipse on Temperature as shown by Five-Minute Readings—*continued.*

Time of day. hrs.	mins.		Dry bulb.	Wet bulb.
1	0		−1·3	−0·8
1	5		−1·9	−0·8
1	10		−2·0	−1·3
1	15		−2·2	−1·4
1	20		−2·8	−1·9
1	25		−3·4	−1·9
1	30		−4·0	−2·5
1	35		−4·0	−2·5
1	40	Totality	−5·1	−3·5
1	45		−7·2	−3·5
1	50		−7·7	−3·5
1	55		−8·3	−3·6
2	0		−8·9	−3·6
2	5		−8·5	−3·1
2	10		−7·6	−2·6
2	15		−6·7	−2·2
2	20		−5·7	−1·9
2	25		−5·1	−1·7
2	30		−4·4	−1·7
2	35		−3·4	−1·5
2	40		−3·7	−1·4
2	45		−3·5	−1·2
2	50		−3·5	−1·2
2	55		−3·1	−0·6
3	0	Last contact	−3·1	−0·6
3	30		−2·6	−0·3
4	0		−2·5	−0·2

"Total Solar Eclipse of January 22, 1898. Preliminary Report on Observations made at Ghoglee, Central Provinces." By Professor RALPH COPELAND, Astronomer Royal for Scotland. Received May 10, 1898.

In the month of August, 1897, I was invited by the Joint Permanent Eclipse Committee to take part in observing the total solar eclipse which occurred in India on 22nd January of the present year.

The preparation of the equipment, which will be described further on, was at once proceeded with, and by the sanction of the University authorities and the Secretary for Scotland I was granted the

necessary leave of absence from the University and the Royal Observatory.

Having shared in the general disappointment of the Russian eclipse of 1887, and the no less unfortunate visit to Vadsö in 1896, I resolved on this occasion to occupy a separate station at some distance from any large group of observers. My only companion was our observatory engineer (James McPherson), who on the two previous occasions had shown his skill and energy in setting up and handling the instruments.

A grant of £180 was made to me by the Committee. This would have been amply sufficient had I dispensed with the services of Engineer McPherson, but without his aid I could not have carried out my plan of occupying an independent station and using several instruments.

Our equipment consisted of—

(1) A horizontal telescope of 38 feet focus and 4 inches aperture to be used with a fixed mirror, the image being received on 18-inch plates moved by clockwork. This instrument was provided with a direct vision prism mounted on a slide in front of the object-glass, which, when drawn into position by an attendant, transformed the telescope into a prismatic camera.

(2) A small prismatic camera designed for the investigation of the ultra-violet rays of the solar appendages. To this end the object-glass was of quartz and Iceland spar, the prism being of the latter material.

(3) A slit spectroscope by Grubb, with one compound prism. (2) and (3) were carried by a 4-inch equatorial mounting, and served to balance each other.

(4) A 4-inch camera with a doublet lens, by Dallmeyer, of 33-inch focus, mounted on a 3-inch equatorial stand. Both the equatorial mountings were fitted with driving clocks.

In place of a hut we were provided with a supply of laths, boards, and brown paper, plain as well as waterproof and blackened, for building the camera of the 40-foot, which had also to serve as a dark room. The hut built with these materials served the intended purpose satisfactorily. It was ventilated by a tin chimney like that of a magic lantern.

The instruments were despatched on the 20th November, *viâ* Leith and London, to Bombay. Engineer McPherson left Edinburgh on the 2nd December to embark in London on board the P. and O. s.s. "Britannia," while I, leaving on the 8th, was able to catch the same steamer at Brindisi on the 12th December. Bombay was reached on the 26th December, and Nagpur, in the Central Provinces, two days later. Here we were most hospitably received by Colonel Henry J. Lugard (Madras Staff Corps), and with his help

and that of his son, Mr. Edward Lugard, Executive Engineer, Bhundara, a station was finally selected on the last day of the year, close to the village of Ghoglee, 16 miles north-west of Nagpur, and about 2 statute miles south-east of the line of central eclipse. On New Year's Day I observed the sun for latitude, time and azimuth, and on the 2nd January we began our camp life, having lived meanwhile at Kalmeshwar, in a bungalow belonging to the Department of Works, three miles distant, on the way to Nagpur. We found the large double tent provided by the Government most comfortable. It was pitched beside a grove of mango trees, under which was a large well with a plentiful supply of water. On the 4th January concrete foundations were begun for the fixed mirror and lens, for the plate-carrier of the long-focus telescope, and for each of the two equatorials. The latter were placed in line with the dark room of the horizontal tube, so as to bring the observers within earshot of the metronome which was used to regulate the lengths of the exposures. It is needless to give particulars respecting the adjustments of the equatorials, which were considered sufficiently accurate when within two minutes of arc of the truth.

The method pursued with the horizontal telescope was as follows :— With the theodolite placed on the proposed centre line of the tube, the azimuth of a distant tree was found from observations of the sun, and also of the pole star. Two sets of footholes for the theodolite were made in blocks of cement at different levels, but referred to a common centre. By this means the theodolite could be used either as a collimator looking through the lens of the long telescope, or as a directing telescope to bring the tube, lens, and plateholder exactly into the required line. The fixed mirror was roughly adjusted as regards azimuth with the theodolite and a reflecting eye-piece, and as to inclination by means of a gauge and spirit level. The final adjustment was given by slightly turning the slow motion screws of the mirror until the sun's image ran along a parallel of declination drawn on the cover of the plate-holder, and also crossed one or other of a set of vertical lines at a given computed time. The tube being set exactly horizontal, the plate-holder was "squared on" by viewing the image of the object glass in a mirror held against the plate-holder in reversed positions. The long-focus object glass was "squared on" with the help of one of the little centering telescopes originally designed by Fraunhofer. The inclination of the slide on which the plate-holder ran was found from the computed altitude and azimuth of the sun's centre two minutes before and two minutes after mid-totality. The same data also gave the speed at which the plate had to move—in our case 1·872 inch per minute. No provision was made to counteract the very slight effect of the rotation of the sun's image during the period of exposure. The

sliding frame was drawn forward by a wire cord and weight, the rate of motion being regulated by the speed at which the driving clock "payed out" the cord. A tendency to advance by jerks was altogether removed by thoroughly strengthening the clock seat-board and its attachment to the fixed frame. The clock, kindly lent by Lord McLaren, was made by Sir Howard Grubb. We utilised the slide motion to obtain a chronographic record of the exposures. Three pencils, in holders hinged to the standing part and moved by strings, marked the time on a slip of paper pasted on the back of the moveable frame.

The distance of the plate-holder from the cell of the lens had been found in Edinburgh to be 455·27 inches. This interval was set off in India with light wooden rods, which were compared with a Chesterman steel foot-rule. The photographic focus of the Dallmeyer 4-inch had been found to agree exactly with the visual focus. The instrument was focussed in India with the help of a focussing glass, both in the day-time on an object at a distance of 440 yards, and on stars at night, in the former case making allowance for the divergence of the rays by means of the well-known formula for conjugate foci. The two results were practically identical, but differed considerably from the scale reading used at home, owing to the shrinking of the wooden tube, in which the grain runs crosswise. The tube of the Iceland spar camera, being made of well-seasoned teak, was found unchanged in length, as proved by the linear spectra of Sirius and γ Argûs.

The greatest difficulty was experienced in filling the plate-holders of the long-focus telescope. It was only after many hours spent in paring and rasping the twisted frames that the plates were adjusted and ready for exposure. Two plates were broken in the process.

Our programme was as follows:—Eight plates, 18 inches square, to be exposed by Engineer McPherson standing in the dark room, where he had control of the cord for opening the spring shutter, were provided for the horizontal telescope, each carried in a separate holder. The prism was to be pulled into position by our native butler, Vardhya, at a signal from McPherson.

Mr. Meehan, Assistant Engineer of the Public Works Department, had kindly volunteered to work the Dallmeyer camera. He was provided with nine quarter plates, mounted in three long slides. The shutter was of the ordinary pneumatic kind.

I took charge of the ultra-violet prismatic camera, with six plates in three reversible holders. I had also one plate (Cadett) in the Grubb spectroscope, which was to be exposed by simply drawing back the slide. Cadett plates were used for the horizontal telescope and the 4-inch, while partly Lumière and partly Cadett plates were to be tried in the prismatic camera.

Mr. Meehan came in good time on the morning of the 22nd in order to have a final opportunity of practising the management of the 4-inch. Everything being prepared to the best of our ability, I anxiously watched with the finder of the prismatic camera for the first contact. The first indentation in the sun's limb was not perceived until 11 secs. after the computed time, but as the telescope only magnified thirteen times, and there was a chance that the prediction might be slightly wrong, this agreement was considered satisfactory. Ten minutes before the beginning of totality the observers took their assigned stations, and a little later the metronome was set going 2 mins. 14·6 secs. before the computed total phase, McPherson saw the following edge of the diminishing sun's image exactly on the line which had been previously marked on the sliding frame. 20 secs. later he started the clock in accordance with a signal given by me, and after about a quarter of a minute had elapsed each observer made a mark on the chronograph slip in response to the measured "one, two, three," called out by me in time with the beats of the chronometer. From this moment, which was 40·8 secs. before the computed disappearance of the sun, I watched the shortening line of light with the finder. It seemed a long time in disappearing, but the sunshade was so dark that I felt sure that nothing but the photosphere could be seen through it. I therefore refrained from giving any signal until the last trace of light had disappeared. I then called out "totality," as previously arranged, and had the satisfaction of hearing the shutter of the 38-foot (which made a rather loud noise) closing at the end of McPherson's first exposure.

The whole of the eight plates were successfully exposed in the horizontal telescope.

	Exposure.	Object.
No. 1	1·4 secs.	Corona.
2	6·7 „	Corona.
3	3·8 „	Spectrum.
4	6·7 „	Spectrum.
5	9·5 „	Corona.
6	13·2 „	Corona.
7	5·4 „	Corona.
8	1·0 sec.	Spectrum.

The five photographs of the corona are much disfigured by an exhalation thrown off by the bass wood of which the plate-holders are made, which has caused the grain of the wood to print itself in broad streaks on the pictures. By combining the various negatives in one drawing, however, there is reason to believe that the details of the brighter parts of the corona can be satisfactorily worked out. Plates 3 and 4 show very distinct spectral images

of the prominences corresponding to a number of lines in the violet region of the spectrum. On the last plate, which was exposed very shortly after the end of totality, there is a broad spectral band full of bright and dark lines of varying intensities, corresponding to irregularities in the sun's limb and the presence or absence of prominences. Many of the bright lines run out into the cusps. The scale of this photograph is such that H and K are 10 mm. apart. By an oversight the prism was not used with Plates 1 and 2 as was originally intended.

Mr. Meehan also exposed the whole of the nine plates allotted to him. Three of these show the coronal rays during totality. The fourth has the coronal streamers quite distinct, although the sun is already reappearing with a trace of Baily's heads. The fifth plate, taken several seconds later, shows the solar crescent still further disclosed, but with the whole of the moon's disc distinctly outlined against the background of corona. In the last plate there is nothing to be made out beyond the over-exposed solar crescent; the remaining three plates are blank. I am under great obligation to Mr. Meehan for his valuable assistance with this instrument, as well as for help in other directions.

In the small prismatic camera four plates proved to be as many as I could dispose of. The actual exposures attempted were 2·5 secs., 4·7 secs., 19·6 secs., and 14·0 secs. respectively. The resulting negatives show numerous rings and lines ranging from 1474 K to about W.L. 3000. The lines are sharpest in the first plate, while the 1474 K ring comes out more fully in the second and fourth negatives. The third plate is unfortunately blank.

The plate in the integrating spectroscope, which was used without a condensing lens, shows a spectrum of three strong bright lines with a number of feebler ones between them. With an exposure of about a minute, terminating just before the end of totality, the plate is decidedly under-exposed.

The makeshift chronograph, while working well for the other two observers, failed to record Mr. Meehan's signals distinctly, owing probably to the greater length of the cord required to reach his telescope.

On Wednesday, 26th January, we broke up our camp at Ghoglee and sailed from Bombay on the 29th, reaching Edinburgh on the 21st February.

I wish here to record my indebtedness to all the officials and private individuals, British and native, by whose kind aid the object of the expedition was so much furthered and our visit to Central India made so pleasant as well as scientifically interesting.