the Observatory photoheliograph, both the photographs which he took of the corona during totality and the above photographs of the partial phase. The former I myself brought home to the Royal Observatory, Greenwich; the latter will be sent at the first available opportunity.

I took no observations myself of temperature during the eclipse, the Director of the Royal Alfred Observatory having made arrangements for full meteorological observations being taken both at the Observatory and at several other stations, not only in Mauritius, but also on other islands in the Indian Ocean.

"Preliminary Note on Observations of the Total Solar Eclipse of 1901 May 18, made at Pamplemousses, Mauritius." By (Mrs.) A. S. D. Maunder. Received October 23,—Read at Joint Meeting of the Royal and Royal Astronomical Societies, October 31, 1901.

Having observed successfully the eclipses of 1898 January 22, in India, and 1900 May 28, in Algiers, and my husband having been sent to Mauritius as the representative of the Royal Observatory, Greenwich, to observe the eclipse of May 18 last, I determined to accompany him, and to take with me the instruments which we had used in 1900. By the great kindness of Mr. G. J. Newbegin, F.R.A.S., I was also furnished with a 4¼-inch Cooke photo-visual telescope of 71 inches focus.

As my husband fixed his observing station at the Royal Alfred Observatory, Pamplemousses, and as the Director, Mr. Claxton, gave me every facility, I set up my instruments in the Observatory grounds. The Newbegin telescope was mounted upon the equatorial stand of the photoheliograph which was left vacant, the Mauritius photoheliograph having been dismounted in order that it might be used in connection with the 16-inch cœlostat of the official Greenwich Expedition. The photoheliograph dome stands on the east of the Observatory grounds, and about 150 feet to the west of the dome I set up the Waters equatorial lent to my husband by the Royal Astronomical Society, which I used to carry two little cameras, each with a 1½-inch Dallmeyer Stigmatic lens. About 105 feet further west the camera belonging to the Waters telescope was firmly fixed, pointing directly to the Sun, and by its side the Niblett lens belonging to the British Astronomical Association, a photographic lens 4 inches in diameter, and of 34 inches focus. This was likewise fixed rigidly. Mr. Nevil Maskelyne, F.R.A.S., also lent me his kinematograph, and this was mounted a few feet further south. The management of these instruments during the eclipse was very kindly undertaken by several friends, and I was further helped by three non-commissioned officers who had volunteered to assist in the eclipse observations. The entire party was arranged as follows:—

Personnel.

Mr. A. Walter: Newbegin photo-visual telescope, 71 inches focus.

Bombadier A. H. Thorne: Recorder to Mr. Walter.

Mrs. Walter Maunder: Dallmeyer Stigmatic lens twin camera, 9 inches focus.

Sergeant J. H. Tyson: Recorder to Mrs. Maunder.

Lance-Corporal A. Balguè: Waters camera, 8 feet equivalent focus.

Mr. G. H. Ireland: Kinematograph. The kinematograph gave no result, the film tearing across before totality was reached.

(Mr. Ireland brought a camera of about 2 feet focus, which was mounted as a stationary camera, and six exposures were made with it by Mr. T. W. Hanning.)

I add here a brief description of the photographs obtained:

1. *The Dallmeyer Stigmatic Twin Camera.*

These lenses are each $1\frac{1}{2}$ inches aperture, 9 inches focus, and give a field nearly 40° in diameter on a plate 16 cm. square. I procured one of these lenses in 1897, on account of its great field, in order to photograph the Milky Way, and it being the only photographic lens I then possessed, I took it to India in 1898. Exposures of 20 seconds made with it upon the corona of that year, recorded the coronal extensions much further from the Sun than they had been photographed before; in one instance to a distance of 13·9 lunar radii from the Sun's centre. My purpose on this occasion was to repeat the Indian exposures of 20 seconds, and also to try the effect of exposures longer still. I therefore gave two exposures with each camera—one of 2 minutes and one of 20 seconds.

No. 1.—From 30 seconds to 150 seconds. Exposure 120 seconds. Sandell Triple-coated plate.

A fairly dense negative. The chromosphere has come up as a very brilliant ring, but the motion of the Moon across the Sun's disc during the very considerable exposure is very apparent. Of course no detail of the inner corona is seen on such a small image, except the large prominence on the east limb of the Sun, but the outer corona is fairly defined, tapering in long rod-like rays which on the east side of the corona reach a distance from the Sun of about five lunar radii, and on the west side of about six.

No. 2.—From 30 seconds to 150 seconds. Exposure 120 seconds. Imperial Special Rapid plate.

This negative is not so dense nor so well defined as No. 1. The sky glare has come up, and the extensions are not so considerable as in the former case.

No. 3.—From 170 seconds to 190 seconds. Exposure 20 seconds. Sandell Triple-coated plate.

The image of the corona is fairly dense, but the sky glare has not come up so much as in the previous cases, and it shows as great extension as No. 1.

No. 4.—From 170 seconds to 190 seconds. Exposure 20 seconds. Imperial Special Rapid plate.

This is a weak image, and has no points to recommend it.

(Nos. 3 and 4 have a double image on them, due probably to the cameras not having settled down after the plate-carriers were changed.)

2. *The Niblett Lens.*

This lens is of 4 inches aperture and 34 inches focus, fitted with a revolving drum carrying 5-inch by 4-inch plates.

No. 1.—Exposed at second contact. Exposure about $\frac{1}{4}$ second. Imperial Fine Grain plate.

This photograph was taken at second contact, and several "beads" of sunlight are seen. Nevertheless, not only is there a great deal of detail to be seen in the middle corona, but on the west side a coronal ray can be traced to two lunar radii, and on the east side to a somewhat greater distance. The image is a fairly dense one. The image is not large enough, nor was the exposure sufficiently short to show any detail in the prominences or chromosphere, but the polar rays and the "combing out" of the equatorial wings are well seen.

No. 2.—Exposed at 40 seconds. Exposure about $\frac{1}{4}$ second. Imperial Ordinary plate.

A fairly dense image, showing the polar rays and middle corona well.

No. 3.—Exposed at 80 seconds. Exposure about $\frac{1}{4}$ second. Imperial Special Rapid plate.

The image is not so dense as in the previous cases, but the coronal rays can be traced to a greater distance, as can also the polar rays.

No. 4.—Exposed at 120 seconds. Exposure about $\frac{1}{4}$ second. Imperial Special Rapid plate.

A weak faint image, under-developed. No detail shown.

No. 5.—Exposed at 160 seconds. Exposure about $\frac{1}{4}$ second Imperial Ordinary plate.

Under developed, only the chromospheric ring seen.

No. 6.—Exposed at 200 seconds. Exposure about ¼ second. Imperial Fine Grain plate.

A good image, not very dense, showing the middle corona and polar rays well.

3. *The Newbegin Telescope.*

This lens is a Cooke photo-visual objective of 4¼ inches aperture and 71 inches focus. The photographs were taken on quarter plates. They form an exceedingly fine series of fourteen, taken on different makes of plate and with differing exposures. They bear magnification well up to the limit we have yet tried, namely, to one giving 4 inches to the Sun's diameter. Every photograph in this series was successful.

No. 1.—Exposed 7 seconds after commencement of totality. Exposure instantaneous. Plate, Lumière Orthochromatic, Series A.

This is a not very dense negative, and shows the prominences on the east side of the Sun, and the very complicated structure of the corona surrounding them. From the large prominence on the Sun's east equatorial limb two very marked and irregular black rifts or streaks cross the coronal wing and seem to broaden as they get further away from the Sun. A similar single streak leaves the Sun's surface to the south of the large prominence in the south-east.

No. 2.—Exposed at 21 seconds after commencement of totality. Exposure, 2 seconds. Plate, Imperial Fine Grain Ordinary.

A denser negative than No. 1, showing great extension of the polar rays. In the northern polar rays is seen a forked dark marking cutting the rays obliquely.

No. 3.—Exposed at 32 seconds after the commencement of totality. Exposure 4 seconds. Plate, Imperial Fine Grain Ordinary.

The dark marking in the north polar rays is clearly seen. There is a greater extension on the north-western side of the corona than in the two previous photographs.

No. 4.—Exposed at 45 seconds after commencement of totality. Exposure 6 seconds. Plate, Imperial Fine Grain Ordinary.

The corona is distinctly larger than on the previous photographs, and the dark marking cutting the north polar rays is very clearly seen.

No. 5.—Exposed 1 minute after commencement of totality. Exposure 8 seconds. Plate, Imperial Fine Grain Ordinary.

A negative very similar to No. 4.

No. 6.—Exposed at 77 seconds after commencement of totality. Exposure 10 seconds. Plate, Imperial Fine Grain Ordinary.

No. 7.—Exposed at 94 seconds after totality. Exposure 6 seconds. Plate, Imperial Ordinary.

This negative is perhaps not so well defined as the others.

No. 8.—Exposed at 107 seconds after totality. Exposure 6 seconds. Plate, Imperial Ordinary.

This negative is not very dense, but the corona is very large, and it shows a greater extension of the coronal rays than any of the previous ones.

No. 9.—Exposed at 126 seconds after totality. Exposure 10 seconds. Plate, Imperial Fine Grain Ordinary.

No. 10.—Exposed at 144 seconds after totality. Exposure 8 seconds. Plate, Imperial Fine Grain Ordinary.

No. 11.—Exposed at 162 seconds after totality. Exposure 6 seconds. Plate, Imperial Fine Grain Ordinary.

On this negative it is very clearly seen that the bulbous curves at the base of the great north-east wing are laid over and across other coronal curves in the background.

No. 12.—Exposed at 176 seconds after totality. Exposure 4 seconds. Plate, Imperial Fine Grain Ordinary.

This photograph shows perhaps best the corona in the south-west region. Here there seem to be a number of synclinal groups, which give the impression of not being all in the plane of the photograph, as usually appears to be the case in coronal negatives, but in different planes.

No. 13.—Exposed at 191 seconds after totality. Exposure 2 seconds. Plate, Imperial Fine Grain Ordinary.

The corona is here very restricted. In the south-west region the exposure does not seem to have been sufficient to bring up all the synclinal groups, and in consequence the south polar rays have the appearance of encroaching on this side.

No. 14.—Exposed at 202 seconds after the commencement of totality. Exposure instantaneous. Plate, Lumière Orthochromatic, Series A.

This negative is fainter then any of the others, but shows well the detail and prominence in the south-west region of the corona.

4. *The Waters Camera.*

This is a Dallmeyer portrait combination of 2 inches aperture and 8 feet equivalent focus, a Dallmeyer telephoto lens being used as a negative enlarger. The photographs were taken on half plates. The enlargement is rather too great for detail of any importance to be shown, and there is therefore no need to describe them in detail. Exposures of about a quarter of a second were given in all cases.

No. 1.—Exposed at second contact. Plate, Imperial Special Rapid.
No. 2.—Exposed at 40 seconds. Plate, Imperial Special Rapid.
No. 3.—Exposed at 80 seconds. Plate, Imperial Flashlight.
No. 4.—Exposed at 120 seconds. Plate, Imperial Flashlight.
No. 5.—Exposed at 160 seconds. Plate, Imperial Flashlight.
No. 6.—Exposed at 200 seconds. Plate, Imperial Special Rapid.

5. *The Pinhole Camera.*

This was a camera with pinhole aperture of $\frac{1}{32}$ of an inch, and the plate was placed at a distance of 30 inches. The plate was exposed immediately before second contact, and closed immediately after third. A small arc of sunlight is thus seen both on the east and west limbs of the Moon. A coronal ring, about 4 minutes in greatest height, is seen connecting these arcs. The little photograph has of course no scientific value, but as being the only instance of a photograph of the corona taken with a pinhole, it may rank as a curiosity. The ratio of aperture to focal length was as 1 to 960, and the exposure given to the plate would correspond to one of $\frac{1}{15}$th of a second, as given with the Newbegin. The plate used was an Imperial Special Rapid.

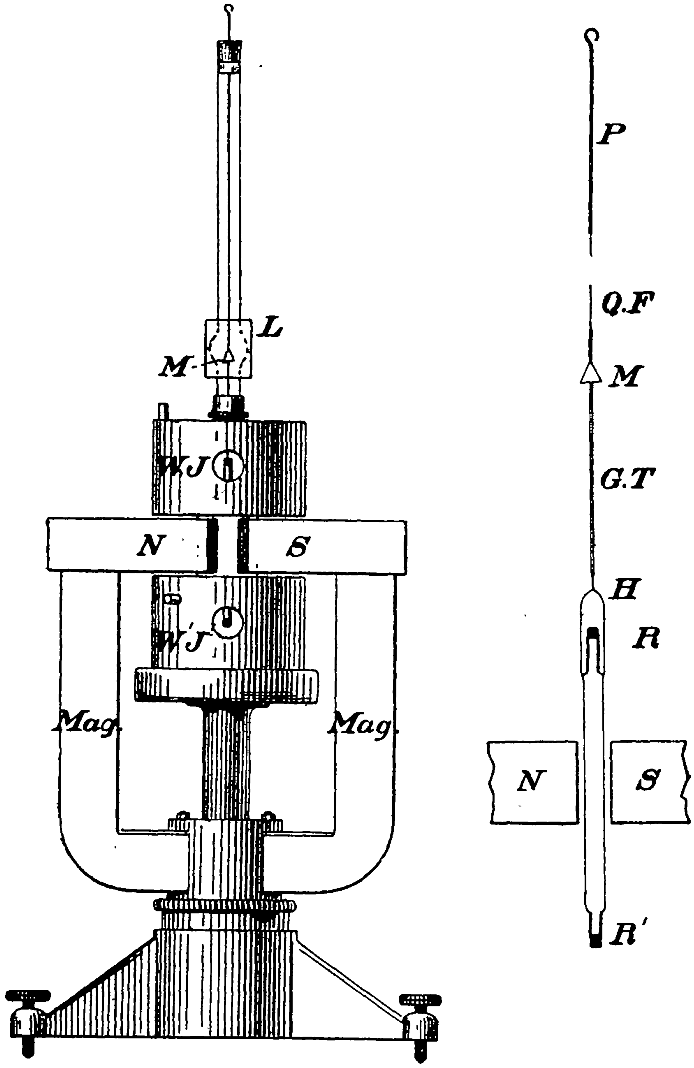
6. *Photographs of the Landscape.*

At my request M. Alexander Rambert, a professional photographer of Mauritius, took a series of photographs of the landscape during the coming on and passing off of the shadow. The same exposure was given in every instance, the plates were all from the same batch, and they were developed at one and the same time, in the same bath and for the same length of time. The exposures were made at regular intervals of 5 minutes, the first being taken 27½ minutes before mid-totality, the last 27½ minutes after. A comparison of the plates taken before totality with those taken at corresponding times after, shows a slight but appreciable increase in density in the later plates as compared with the earlier, but perhaps not more than would be accounted for by the increase in altitude of the Sun.

"The Effective Temperature of the Sun." By W. E. Wilson, D.Sc., F.R.S. Received December 5,—Read December 12, 1901.

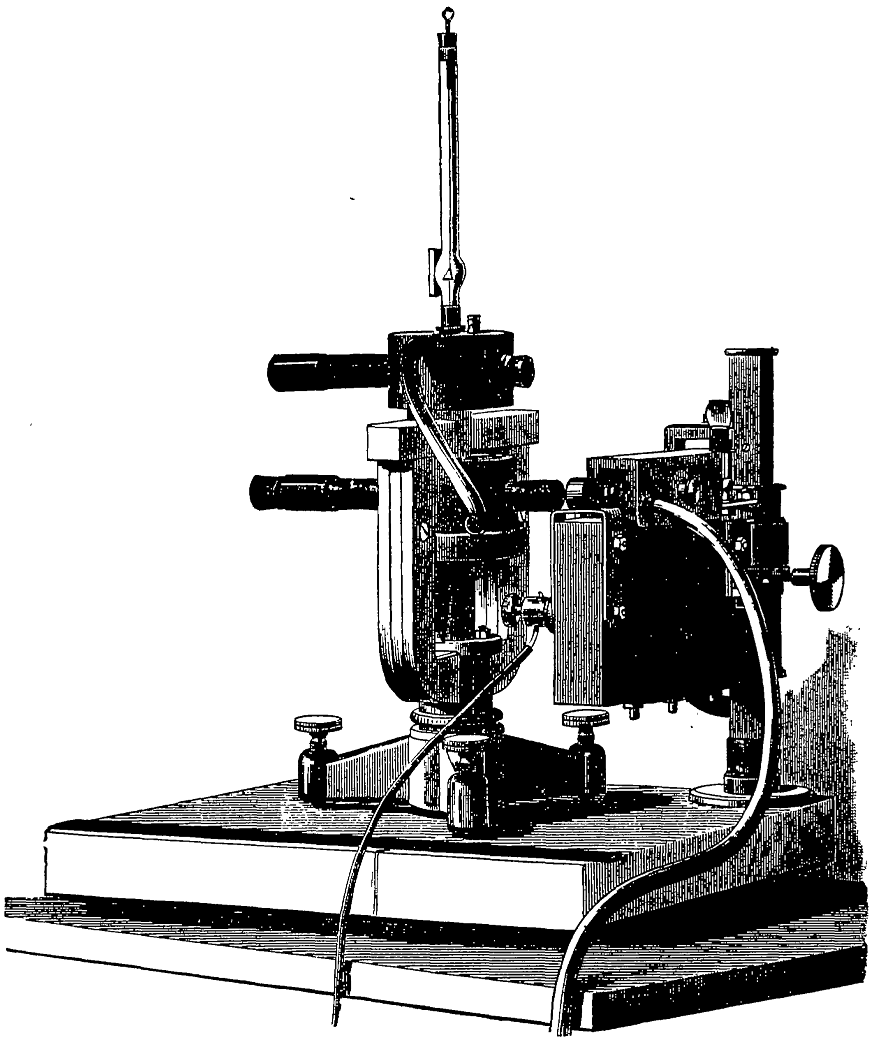
In March, 1894, Dr. G. Johnstone Stoney communicated to the Society a memoir by myself and Mr. P. L. Gray, entitled "Experimental Investigations on the Effective Temperature of the Sun," which was published in the 'Phil. Trans.,' A, vol. 185 (1894). In these investigations the method we adopted was as follows:—A beam of sunlight was sent horizontally into the laboratory by means of a Stoney single-mirror heliostat. The mirror was an optical plane of unsilvered glass, and the beam was directed into one aperture (A) of a differential Boys' radio-micrometer. The other aperture (B) received the radiation from a strip of platinum, which could be raised to any desired temperature by an electric current supplied by a battery of accumulators. The temperature of this strip was at any moment determined by its linear expansion, the instrument being previously calibrated by melting on it minute fragments of AgCl and of pure gold, as in Joly's meldometer. In front of the aperture (B) of the radio-micrometer was placed a stop with a circular hole of 5·57 mm., and the distance of this hole from the receiving surface of the thermo-couple was 60·2 mm. This gave for the angle subtended by a diameter of the aperture at the receiving surface 5°·301. Knowing then (i) the ratio which the angular diameter of this circular aperture bears to that of the sun, (ii) the temperature of the platinum strip at the moment that the radio-micrometer is balanced, (iii) the amount of the sun's radiation lost by reflection from the heliostat mirror and also by absorption in the earth's atmosphere, it is possible on any assumption with regard to the law connecting radiation with temperature, to determine the effective temperature of the sun. A series of very accordant observations were made in this way, the mean of which gave 6200° C. as the effective solar temperature.

For the details of the apparatus and the complete method of reduction of the observations, the original memoir in the 'Phil. Trans.' may be referred to.



In order to protect the incandescent strip from draughts of air it was covered with a water-jacket of gilded brass. This was provided with a circular hole in one of its longer sides, through which its radiation could reach the aperture of the radio-micrometer. The internal walls of this water-jacket being highly polished, it has occurred to me, since the publication of the memoir referred to, that possibly some of the radiation from distant parts of the platinum strip may have been reflected backwards and forwards from the polished walls and the strip itself, ultimately escaping through the aperture and reaching the radio-micrometer, thus increasing the amount of radiation which should have reached it directly from the strip alone.

In order to test this surmise I first took a number of readings at known temperatures with the walls of the water-jacket polished as before. I next smoked the surface of the walls well, and found that the amount of radiation coming from the aperture was then sensibly reduced. It is also possible that changes in the condition of the surface of the platinum strip may effect its emissivity, and in fact it is very doubtful whether it is possible to determine with any degree of accuracy what the emissivity of bright platinum is, relatively to lamp



black. In the original memoir we took Rosetti's estimate of 35 per cent. as the most probable value for this quantity, but as our former estimate of the solar temperature depends greatly on this factor, to which so much uncertainty attaches, I thought it would be a distinct advance to abolish entirely the platinum strip as a source of radiation, and to substitute in its place a uniformly heated enclosure which would radiate as an absolutely "black body."

In 1895 Mr. Lanchester pointed out to me that such an enclosure would be a theoretically perfect radiator; while Lummer, Paschen and others have shown that the law connecting temperature and radiation from such an enclosure confirms in a remarkable manner Stefan's law of radiation, viz., $R = aT^4$.* Since therefore the results of several independent investigations corroborate this law, I have felt justified in applying it to the results of my observations.

On consideration it seemed that the most convenient form of radiator would be a long tube closed at one end, and uniformly heated in a gas furnace. Accordingly a porcelain tube, 2 feet in length and 1 inch internal diameter, was fitted into a Fletcher gas-tube furnace. This was afterwards changed for an iron tube, which was employed in the observations on September 30th, given below.

A plug of asbestos was inserted in the tube at about 10 inches from the end farthest from the radio-micrometer, and resting against this plug was the end of a Callendar platinum-resistance thermometer. This was connected with one of Professor Callendar's electric recorders, so that during an experiment the temperature of the tube was registered continuously on the paper wrapped round the drum of the instrument. In front of the open end of the tube, and between it and the radio-micrometer, was placed a large brass water-screen, through which a copious supply of water passed. In front of the aperture (B) of the radio-micrometer this screen was provided with a rectangular aperture. One side of this aperture was formed by a slide moved by a micrometer screw reading to 0·01 mm. By this means the area of this aperture at any time could be measured with precision. Its fixed sides were 5 mm. apart, and as the movable side had a range of 5 mm., the maximum area of the aperture was 25 sq. mm. The distance (d) of this aperture from the surface of the thermo couple was 66·3 mm.

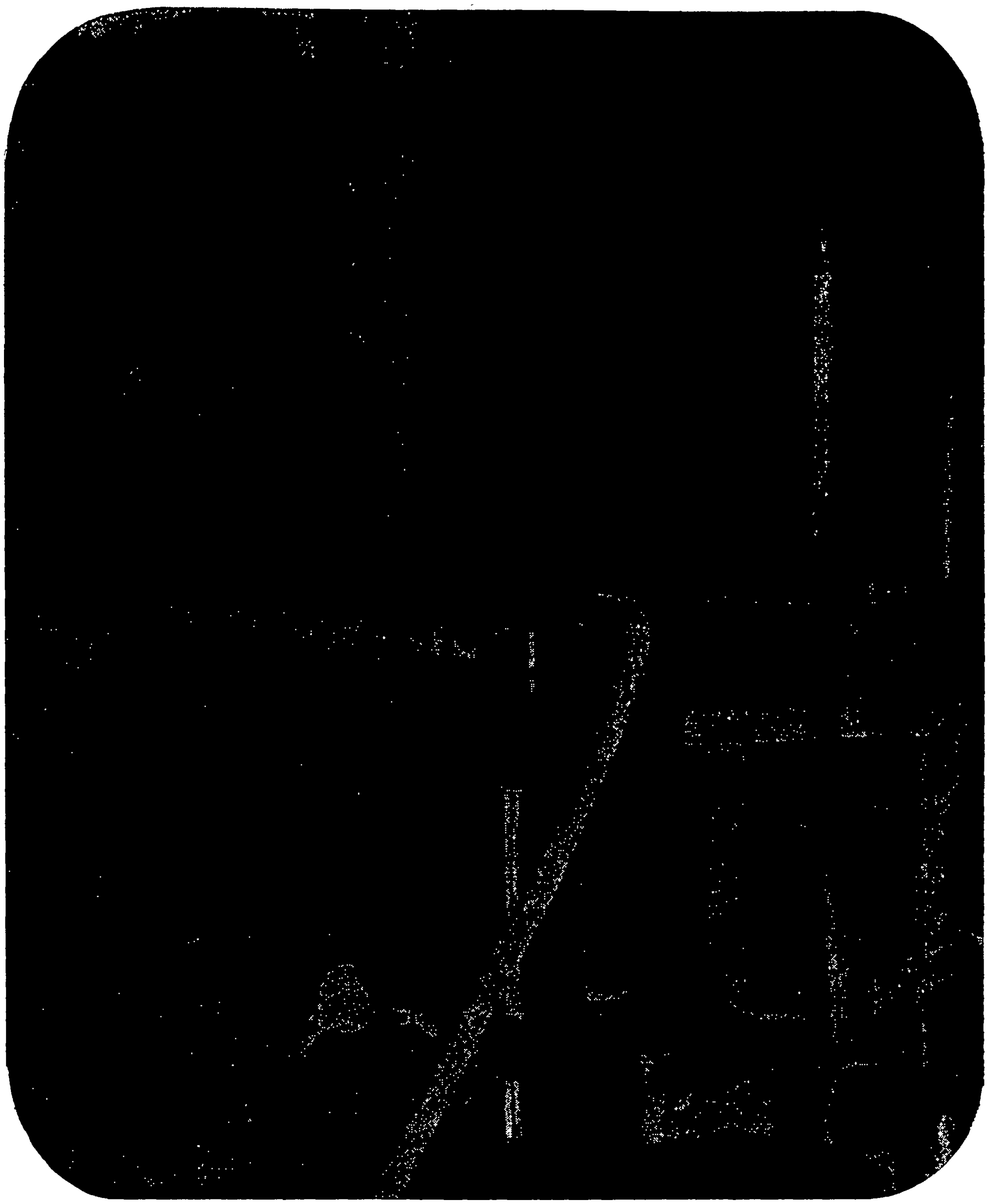
To make an observation the tube was heated to as high a temperature as the furnace was capable of, and when a steady temperature had been obtained, the amount of radiant heat coming from the interior of the hot tube and passing into the aperture (B) of the radio-micrometer was adjusted by the micrometer screw until a balance was obtained with the radiation coming from the Sun through the aperture (A).

If ρ is the angular semi-diameter of the sun, its radiation outside of our atmosphere is $K.\pi \sin^2 \rho$, where K is a constant depending on the sun's temperature.

Again, if α be the height of the slit through which the radiation from the hot tube reaches the radio-micrometer, and β its width, the radiation may with sufficient accuracy be expressed by $K\alpha\beta/d^2$. Assuming Stefan's law, the radiation of the sun outside our atmosphere is $a\theta^4\pi \sin^2 \rho$, θ being the effective temperature of the sun.

* Stefan, 'Sitzber. d. k. Akad. zu Wien,' vol. 79, 1879 (Abth. 2), p. 391; Boltzmann, 'Wied. Ann.,' vol. 22, 1884; M. Planck, 'Drude Ann.,' vol. 1, No. 1, 1900; Paschen, 'Wied. Ann.,' vols. 58, 60, 1896, 1897; Lummer and Pringsheim, 'Wied. Ann.,' vol. 63, 395, 1897.

The percentage transmitted is p, therefore the radiation before reflection from the heliostat is $\frac{ap\theta^4}{100}\pi \sin^2 \rho$.



At reflection q per cent. is transmitted, therefore the radiation received by the radio-micrometer is

$$a \cdot \frac{pq\theta^4}{(100)^2} \cdot \pi \sin^2 \rho \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1).$$

Also the radiation received from the hot tube is

$$a'(T^4 - T_0^4) \cdot \frac{\alpha\beta}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2).$$

We need not inquire what is the absorptive power of the thermo-junction, provided that we are justified in assuming that lamp-blacked surfaces absorb the radiation from the hot tube as freely as that from the sun, or that the constants in these expressions (1) and (2) for the radiation may be taken to be equal.

On balancing, these expressions must be equal, and therefore

$$\frac{pq\theta^4}{(100)^2} \cdot \pi \sin^2 \rho = (\mathrm{T}^4 - \mathrm{T}_0^4)\frac{\alpha\beta}{d^2}$$

$$= \mathrm{T}^4\left(1 - \left(\frac{\mathrm{T}_0}{\mathrm{T}}\right)^4\right)\frac{\alpha\beta}{d^2} \quad \ldots\ldots\ldots\ldots\ldots (3).$$

But $\left(\frac{\mathrm{T}_0}{\mathrm{T}}\right)^4$ may be neglected, hence we have finally

$$\theta^4 = \frac{\alpha}{\pi d^2} \; \frac{\beta}{\sin^2 \rho} \; \frac{100}{p} \; \frac{100}{q} \; \mathrm{T}^4$$

or

$$\theta = \sqrt[4]{\frac{10000\,\alpha}{\pi d^2}} \cdot \sqrt[4]{\frac{\beta}{pq \sin^2 \rho}} \cdot \mathrm{T}$$

$$= \frac{0 \cdot 13806}{\sqrt{\sin \rho}} \cdot \sqrt[4]{\frac{\beta}{pq}} \cdot \mathrm{T}.$$

The mean value of $\frac{0 \cdot 13806}{\sqrt{\sin \rho}}$ is [1·30413].

Therefore $\theta = 1 \cdot 30413 \,.\, \sqrt[4]{\frac{\beta}{pq}} \,.\, \mathrm{T}$ .... (4).

After a series of observations had been made, the furnace and tube were raised so that the radiation of the latter then passed into the aperture (A), on which the sunlight had previously fallen, while the beam of sunlight was now directed so as to be upon (B), and in this position a second series of observations was taken. The geometrical mean of the result of the two groups gives the Effective Temperature of the Sun, the effect of any difference in the sensitiveness of the thermo-junctions disappearing in the geometrical mean.

Observations were made in the manner described above on August 19th and September 30th, 1901, and reduced by means of equation (4), as exhibited in the following tables. In these the successive columns contain (1) the local mean time, (2) the value of β as read on the micrometer head, (3) the absolute temperature of the tube in the furnace, (4) the sun's altitude, (5) the percentage of the sun's radiation transmitted through the earth's atmosphere, (6) the angle of incidence on the heliostat mirror, (7) the percentage reflected from the surface of the mirror, (8) the corresponding value of θ deduced from equation (4). Of these (5) and (6) and (7) were determined as in Wilson and Gray's memoir referred to above.

Note, α = 7 mm.

Local time.	Balance. Reading.	Balance. Temp. absolute.	☉ Altitude.	Per cent. trans.	Angle of incidence.	Per cent. reflected.	☉ Temp. absolute.	Date, August 19, 1901. Blue sky.
h. m.								
11 0	1·68	1099°	47° 18′	66	62°	9	5586°	First Position (B).
11 3	1·69	1098	47 36	66	62	9	5589	”
11 7	1·70	1098	47 44	66	62	9	5598	”
11 19	1·60	1100	48 24	66	62	9	5503	”
11 22	1·55	1100	48 25	66	62	9	5459	”
11 28	1·62	1101	48 41	66	63	11	5161	”
11 30	1·70	1101	48 42	66	64	12	5223	”
11 33	1·75	1101	48 50	66	64	12	5262	”
11 36	1·77	1101	48 54	67	64	12	5278	”
11 38	1·80	1101	49 0	67	64	12	5286	”
						Mean........	5394	”
12 48	3·99	1119	48 20	67	68	15	6192	Reversed Position (A).
12 51	4·00	1119	48 13	67	68	15	6184	”
12 53	3·98	1119	48 6	67	68	15	6186	”
12 56	3·96	1119	48 0	67	68	15	6190	”
12 58	3·98	1119	47 49	66	68	15	6210	”
1 3	3·94	1119	47 39	66	68	15	6193	”
1 5	3·93	1119	47 36	66	68	15	6190	”
1 7	3·93	1119	47 24	66	68	15	6190	”
1 9	3·92	1119	47 18	66	68	15	6186	”
1 11	3·96	1119	47 13	66	68	15	6202	”
						Mean........	6192	”

Geometrical mean of A and B = $\sqrt{5394 \times 6192} = 5779°$.

Note, α = 5 mm.

Local time.	Balance. Reading.	Balance. Temp. absolute.	☉ Altitude.	Per cent. trans.	Angle of incidence.	Per cent. reflective.	☉ Temp. absolute.	Date, Sept. 30, 1901. Weather, slight haze.
h. m.		°	° ′	°			°	
10 45	2·05	1107	31 30	59	64	11	5318	First Position (B).
10 52	2·16	1112	32 0	59	64	11	5379	,,
10 55	2·17	1113	32 0	60	64	11	5364	,,
11 25	2·55	1124	33 0	61	66	12	5446	,,
11 38	2·42	1124	33 0	61	67	13	5320	,,
						Mean......	5365	
11 51	5·20	1127	33 0	61	68	14	6302	Reversed Position (A).
11 55	6·05	1127	33 0	61	68	14	6585	,,
12 0	6·02	1126	33 0	61	68	14	6570	,,
12 8	5·39	1127	33 0	61	69	15	6290	,,
12 18	5·67	1128	32 30	60	70	17	6201	,,
12 25	5·18	1126	32 30	60	70	17	6053	,,
12 32	5·25	1127	32 15	60	71	18	5992	,,
12 36	5·18	1126	32 0	60	71	18	5968	,,
12 50	5·55	1122	32 0	60	71	18	6050	,,
12 58	5·25	1122	31 30	59	71	18	5992	,,
						Mean......	6201	

Geometrical mean of A and B = $\sqrt{5365 \times 6201} = 5768°$.

In the above tables Rosetti's determination of the amount of the terrestrial atmospheric absorption has been used. It may be well, however, to give the results obtained by using other estimates of this quantity. Taking Langley's transmission coefficient when the sun is in the zenith as 59 per cent., compared to Rosetti's 71 per cent., the temperature would be multiplied by $\sqrt[4]{(71/59)}$ and thus become 5773 × 1·054, which is 6085° absolute. And, as in the previous memoir, to make the case general, if any later investigation shows the zenith transmission coefficient to be x per cent., the effective absolute temperature becomes

$$5773° \times \sqrt[4]{(71/x)}.$$

It may also be of interest to see what effect is produced if absorption in the atmosphere of the sun itself is taken into account. First, considering the falling off in radiation from the central to the peripheral parts of the sun's disc, we may deduce that, if the absorption were everywhere equal to that at the centre, the radiation would be multiplied by 4/3 and the temperature would become

$$5773° \times \sqrt[4]{(4/3)} = 5773 \times 1{\cdot}074 = 6201°.$$

Secondly, assuming Wilson and Rambaut's* result for the total loss due to absorption in the solar atmosphere as equal to one-third, our estimate of the temperature would have to be multiplied by $\sqrt[4]{(3/2)}$, and we get finally

$$6201° \times \sqrt[4]{(3/2)} = 6201° \times 1{\cdot}107 = 6863° \text{ absolute} = 6590° \text{ C.}$$

I wish to express my thanks to Dr. Rambaut for some valuable suggestions during the progress of the work.

"The Chemical Origins of the Lines in Nova Persei." By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received December 23, 1901,—Read January 30, 1902.

In the first two papers† which I communicated to the Royal Society on the observations of Nova Persei at Kensington, a general description of the spectrum in its earliest stages was given, and also a statement as to the probable origins of some of the strongest lines, depending upon a comparison of the Nova Spectrum with those of α Cygni, α Canis Majoris, γ Orionis, &c.

A table showing the results of the detailed reduction and discussion

* "The Absorption of Heat in the Solar Atmosphere," 'Proceedings Royal Irish Academy,' 1892, vol. 2, No. 2.

† 'Roy. Soc. Proc.,' vol. 68, p. 119 and p. 142.

Comparison Table of Bright Lines in the Spectra of Nova Persei and Nova Aurigæ with α Cygni Lines, Chromospheric Lines, and the Enhanced Lines of some of the Metals

Nova Persei (Kensington).		Nova Aurigæ.		α Cygni.	Chromosphere (1898 Eclipse).	Enhanced lines.		Remarks.
λ of middle of line.	Description of line.	Campbell.	Vogel.			λ.	Substance.	
3836	Very broad, weak	—	3835	—	3835 ·6	—	—	Hη.
3889	Very broad. ? Narrow reversal in centre	—	3889	3889 ·1	3889 ·1	—	—	Hζ.
3934	Broad, rather weak. Fine narrow reversal in centre	—	3934	3933 ·8	3933 ·83	3933 ·83	*p*Ca	K(Ca).
3969	Very broad and fairly strong; shows fine narrow reversal in position of H(Ca) and possibly another weaker one in position of Hε	—	3969	{ 3968 ·6 3970 ·2	{ 3968 ·63 3970 ·25	3968 ·63	*p*Ca	H(Ca) + Hε.
3982 4003 4019 4029 4067	} All these are very weak diffuse lines which can just be seen with the unaided eye, but which will not bear any magnification, and their wave-lengths can only be roughly determined	 — — —	 — — 4067	 4002 ·7 4028 ·5 4067 ·3	 — 4028 ·5 4067 ·3	 4002 ·77 4028 ·50 4067 ·30	 *p*Fe *p*Ti *p*Ni	 Strongest enhanced line of Ni.
		4082	—	4077 ·9	4077 ·9	4077 ·88	*p*Sr	
4102	Broad and strong	4095 4102 } 4108	4102	4101 ·8	4101 ·9	—	—	Hδ.

Comparison Table—*continued.*

Nova Persei (Kensington).		Nova Aurigæ.		α Cygni.	Chromosphere (1898 Eclipse).	Enhanced lines.		Remarks.
λ of middle of line.	Description of line.	Campbell.	Vogel.			λ.	Substance.	
4128	Very broad and merging into Hδ	4126	4125	{4128·1	—	{4128·1	*p*Si	
				{4131·1	—	{4131·1	*p*Si	
		4166	4158	4163·8	4163·8	4163·82	*p*Ti	
4175	Broad and fairly strong	4180	4176	{4173·5	4173·5	4173·52	*p*Fe }	Mean λ of enhanced double = 4176·23.
				{4179·0	4179·0	4178·95	*p*Fe }	
		4209						
4232	Broad, but not very strong	4227 } 4236 }	4230	4233·3	4233·3	4233·25	*p*Fe	
4247	Comparatively narrow, but merging into the broader 4232 line, slightly stronger than the latter	4246	—	4247·2	4247·0	4247·00	*p*Sc	Strongest spark line of Sc.
4262	Narrow, but fairly strong	4267	4262	4262·2	—	4262·15	*p*Cr	
			4288	4290·4	4290·2	4290·38	*p*Ti	
				{4296·7	4296·7	4296·65	*p*Fe }	
4300	Broad line, fairly strong.......	4296	—	{4300·2	4300·2	4300·21	*p*Ti }	Mean λ of enhanced Fe double = 4300.
				{4303·3	4303·0	4303·34	*p*Fe }	
4314	Comparatively narrow, merging into 4300	4316	4315	4315·1	{4314·0 } {4315·1 }	4315·14	*p*Ti	Possibly due to Sc 4314·25, one of the strongest spark lines.
4341	Broad and very strong. Doubtful reversal in centre	4331·3 } 4340·6 } 4347·8 }	4341	4340·7	4340·7	—	—	Hγ.
		4355	—	—	4355			
		4375	—	4374·9	4374·9	4374 90	*p*Ti	
		4385	4383	4385·5	4385·5	4385·55	*p*Fe	

4392	Fairly broad, rather weak.							
4411	Broad and moderately strong ...	—	—	4411 ·2	4411 ·2	4411 ·20	*p*Ti	
		4419	4417	{ 4417 ·0				
				4417 ·9 }	4417 ·9	4417 ·88	*p*Ti	
4425	Weak and rather narrow.							
4434	— —	4436	4435	4434 ·4	4435 ·5			
4444	Fairly broad, but weak	4445	4445	4444 ·0	4444 ·0	4443 ·98	*p*Ti	
4454	Rather narrow, weak.							
4470	,, ,, and weak	4471 }	4473	4468 ·7	4468 ·7	4468 ·66	*p*Ti	
4481	,, ,, fairly strong.....	4481 }	4480 }	4481 3		4481 ·30	*p*Mg	Strongest enhanced line of Mg.
				{ 4489 ·0	4489 ·3	4489 ·35	*p*Fe	
4493	,, ,, ,, ,, ...	4490 }	4495 }	4491 ·6 }	4491 ·6	4491 ·57	*p*Fe	
4509	,, ,, ,, ,, ...	4502 }	4507	{ 4501 ·5	4501 ·5	4501 ·45	*p*Ti	
				4508 ·5	4508 ·5	4508 ·46	*p*Fe	
				4515 ·5	4515 ·5	4515 ·51	*p*Fe	
4519	,, ,, ,, ,, ...	to	4520 }	4520 ·4	4520 ·4	4520 ·40	*p*Fe	
				4522 ·7	4522 ·7	4522 ·69	*p*Fe	
4535	,, ,, weak..........	4534 }	4530 }	4534 ·1 }	4534 ·1	4534 ·14	*p*Ti	
4548	,, ,, moderately strong	4549	—	4549 ·8	4549 ·7	{ 4549 ·64	*p*Fe	
						4549 ·81 }	*p*Ti	
		4554 }	4557	{ 4556 ·1	4556 ·1	4556 10	*p*Fe	
		4559 }		4558 ·8 }	4558 ·8	4558 ·83	*p*Cr	
		4564	—	4563 ·9	4563 ·9	4563 ·94	*p*Ti	
4568	,, ,, ,, ,,	4570	—	4572 ·2	4572 ·2	4572 ·16	*p*Ti	
		4576	—	4576 ·5	4576 ·5	4576 ·51	*p*Fe	
4583	,, ,, but fairly strong.	4586	4583	4584 ·0	4584 ·0	4584 ·02	*p*Fe	
4628	Broad and fairly strong	4630	4628	4629 ·6	4629 ·5	4629 ·50	*p*Fe	
4670	,, rather weak	4669						
4705	,, weak	4707	—	—	4707 ·8			
		4737	—	—	4737 ·0			
		4774						
*4822	Fairly broad, weak	—	—	4824 ·3	4824 ·3	4824 ·33	*p*Cr	Strongest enhanced line of Cr.
		{ 4851 ·2						
4862	Very broad and strong.........	4861 ·6	4862	4861 ·5	—	—	—	Hβ.
		4869 ·9 }						

Comparison Table—*continued.*

Nova Persei (Kensington).		Nova Aurigæ.		α Cygni.	Chromo-sphere (1898 Eclipse).	Enhanced lines.		Remarks.
λ of middle of line.	Description of line.	Campbell.	Vogel.			λ.	Sub-stance.	
4924	Broad and strong..............	4913 4923 4929 4969	4923 4925	4924·1	4924·1	4924·11	*p*Fe	
5019	" "	5007 5018 5095 5142	5016	5018·6	5018·6	5018·63	*p*Fe	
5169	Broad and very strong	5159 5169 5176 5200	5167	5169·1	5169·1	5169·07 5169·22	*p*Fe	Certainly not the *b*-group of magnesium.
*5224	Narrow and weak.	5234	523	—	5234·8			
*5273	" "	5276 5285	528	—	5275·1 to 5276·2	5276·17	*p*Fe	
5316	Moderately broad and strong....	5318 5329 5379	5317	5316·8	5316·8	5316·79	*p*Fe	
*5420	Weak and rather narrow.	5454						
*5475	Weak and narrow.							
*5530	Fairly strong and broad........	5535	—	—	5527·6	5527·03	*p*Sc	By far the strongest spark line of Sc in the visual region.

*5575	„ „ „	5575 5584 }					
*5686	„ „ „	5630 5685 5761 5841 5885					
*5893	„ „ „	5896	5686†	—	{ 5890·2 5896·2 }	—	—	D(Na).

† As given by Vogel (probably 5886).

Note.—The lines marked * cannot be seen in the photographs taken with the 6-inch prismatic camera, and their positions have been reduced from the spectrum photographed with the 30-inch reflector with a two-prism slit spectroscope.

of the bright lines in the best spectrum typical of the Nova in this early stage (that obtained with the 6-inch objective prism on February 25, when the star was nearly as bright as Capella), was undertaken later for inclusion in a general summary of the observations in course of preparation.

As various conclusions as to the chemical origin of some of the Nova lines have recently been published which differ widely from those arrived at from a careful study of the Kensington photographs, I think it desirable to publish the above-mentioned table at once. A detailed statement of the evidence on which these conclusions as to origin are based, will follow in the general summary before referred to.

That many of the stronger lines in the early spectra of Nova Aurigæ were chromospheric, has been pointed out by several observers, and all agree that there is little difference in the general aspect of the spectrum of Nova Aurigæ and that of Nova Persei at a corresponding stage of development. In confirmation of this it may be said that by means of direct comparison of the various Kensington photographs, the identity of most of the strong bright Nova bands with lines of α Cygni and the chromosphere—already known to be due to enhanced lines of certain metals—has been established.

With regard to the stellar relations of the Nova, I may state that in my note of February 28,* the agreement in position of its lines with those of α Cygni was pointed out. Later, Mr. McClean† confirmed this, and further stated that the bright lines of η Argus corresponded with the dark lines of the Nova; while later still, Sir David Gill‡ has shown the similarity between the spectra of η Argus and Nova Aurigæ. Hence we are led to the conclusion that the temperatures reached in the outbursts of both these Novæ were not greatly different from those of the stars named, and that in η Argus there are constant con ditions which are similar to those temporary conditions which produce the appearance of Novæ.

In the table the lines of Nova Persei are compared with those recorded by Campbell§ and Vogel‖ in Nova Aurigæ.

The probably corresponding lines of α Cygni, chromospheric lines, and enhanced lines, are also given in separate columns.

The reduction to wave-lengths and discussion of the lines in relation to those of other celestial and terrestrial spectra, has been undertaken by Mr. F. E. Baxandall, to whom my best thanks are due.

* 'Roy. Soc. Proc.,' vol. 68, p. 121.
† 'M.N., R.A.S.,' vol. 61, p. 387.
‡ 'Roy. Soc. Proc.,' vol. 68, p. 457.
§ 'Ast. and Ast. Phys.,' vol. 11, p. 808.
‖ 'Ast. and Ast. Phys.,' vol. 12, p. 912.

"On some Phenomena which suggest a Short Period of Solar and Meteorological Changes." By Sir NORMAN LOCKYER, K.C.B., F.R.S., and WILLIAM J. S. LOCKYER, M.A., Ph.D., F.R.A.S. Received June 14,—Read June 19, 1902.

In continuation of the inquiries referred to in a former paper on Indian rainfall and solar activity,* attention has more recently been devoted to an examination of the variations of pressure over the Indian and other areas.

1. It is well known that in India during the summer months (April to September) and during the winter months (October to March) low and high pressures respectively prevail. In the case of the latter, the pressure is found to exhibit very remarkable and definite variations, and is in excess, every $3\frac{1}{2}$ years, on the average, while at these times of excess of high pressure the low pressure during the other 6 months of the year is deficient; so that every $3\frac{1}{2}$ years or so the high pressure becomes higher and the low pressure is not so low as usual.

2. Further, this short-period variation, which appears in the mean variation of pressure over the whole of India, is as well defined in the mean values for individual stations, such as Bombay (fig. 1, Curve F), Calcutta, Madras, Nagpur, &c.

3. The view that the variation of pressure in question over India and its neighbourhood is not due to local causes, but is produced by some external or extra-terrestrial action, is considerably strengthened by an examination of the pressure-curve of a very distant station, such as Cordoba. Dealing with the pressure of Cordoba during the high-pressure months, April to September, the curve (fig. 2, Curves F and E), representing the variation from the mean from year to year, is exactly the *inverse* of the curve representing the Bombay and other Indian pressures for the same months over the same period of time. The cause, therefore, which raises the mean value for the low-pressure months over the Indian area would appear to lower the mean value of high-pressure months at Cordoba simultaneously. In fact, we have a see-saw.

* 'Roy. Soc. Proc.,' vol. 67, p. 409.

4. Further investigation shows that not only do the pressures of practically the whole Indian area exhibit variations from year to year, which present very similar features, but that this is the case with

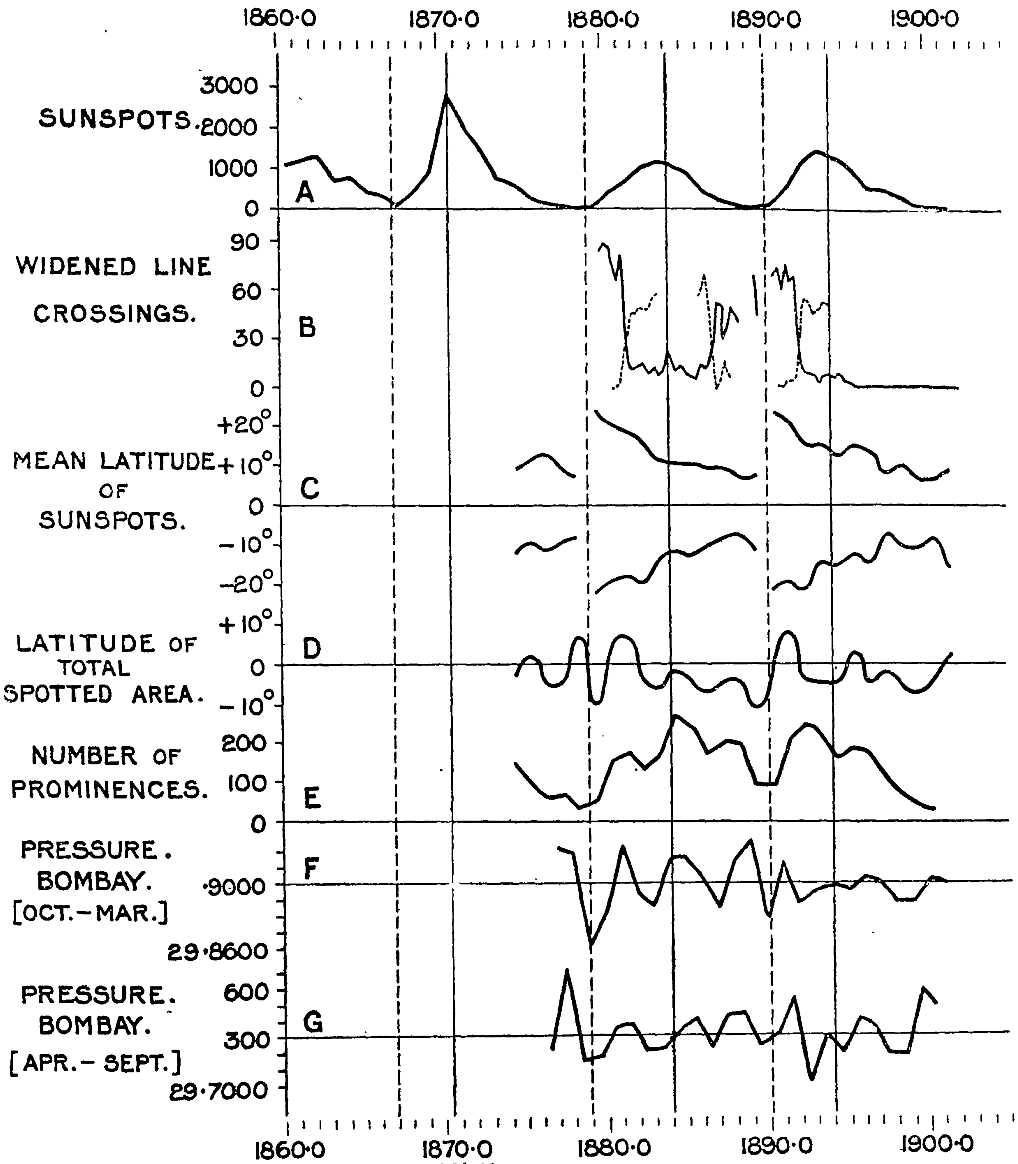


Fig. 1.

other large areas. Thus, for instance, it is found that the yearly mean pressures for Brussels, Bremen, Oxford, Valencia, and Aberdeen (the only pressures that have been at present examined) are all remarkably similar in their variations from year to year, and it might almost be said that one curve, representing the variations from the normal, would approximately define the pressures at all these places.

The probable extra-terrestrial origin of these short-period variations led to a detailed examination of the records of the phenomena con nected with solar spots and prominences, with a view of seeing whether similar variations, indicating changes in the solar activity, could be detected.

5. A preliminary reduction of the Italian observations of prominences observed on the sun's limb since 1871 was first undertaken.

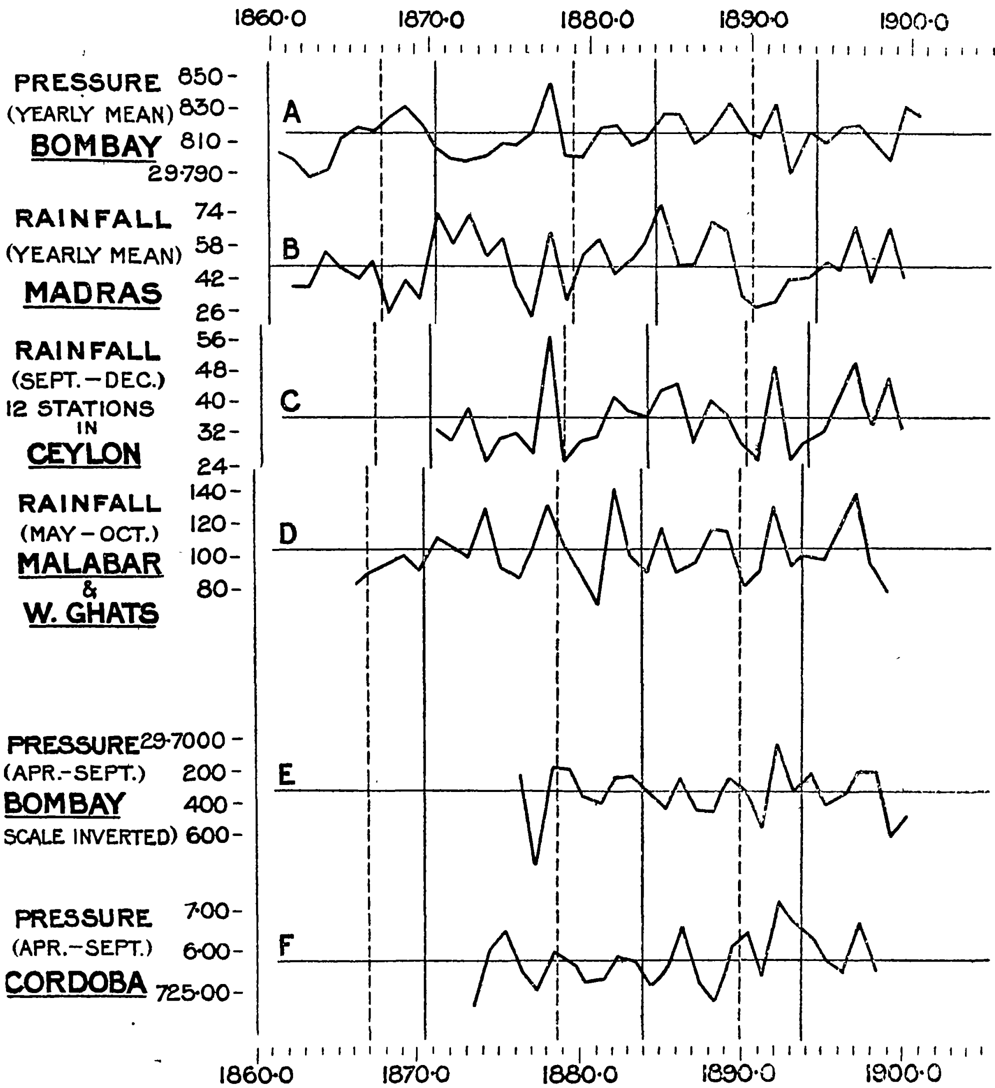


Fig. 2.

The result of this inquiry indicates that, in addition to the main epochs of maximum and minimum of prominences, which coincide in time with those of maximum and minimum of the total spotted area, there are prominent subsidiary maxima and minima having a similar short period and also coinciding in time. (Fig. 1, Curve E.)

6. Although these subsidiary prominence pulses are not distinctly duplicated in the curve representing the spotted area of the solar surface, it is to be noted that corresponding pulses are indicated in

the curves which represent the change of latitude of spotted area from year to year; and in each case an increase in prominence activity is associated with a decrease of latitude of the spotted area. (Fig. 1, Curves C and D.)

7. A comparison of these solar data with those already referred to relating to terrestrial pressures suggests that these simultaneous outbursts of prominences and changes of the latitudes in which the spots occur about every $3\frac{1}{2}$ years are the true cause of the pressure changes; and that the varying intensity of solar activity during the sunspot period of 11 years produces an effect on the pressure and circulation of our atmosphere, thus affecting the whole globe meteorologically.

8. The close correspondence between the epochs of these subsidiary pressure variations and those representing prominence frequency, suggests not only their very close relationship, but that the terrestrial pressure quickly answers to the solar changes, while so far as the work has gone it would appear that rainfall (fig. 2, Curves A, B, C, D) and snowfall are subsequent effects.

9. It may be remarked that we have already obtained evidence showing that this short-period variation is not the only one acting, but that the 11-year and 35-year periods apparently influence the short-period variations; but even this does not explain some anomalies already met with, and should the solar origin of these short-period pressure changes be subsequently confirmed, some of them not constant in all localities will have to be explained; and it is possible we may obtain in this way some new knowledge on the atmospheric circulation.

10. The period of time included in this survey begins generally with the establishment of the full records of the Indian Meteorological Department in 1875 and extends to 1895, when the regularity of the widened-line phenomena was broken, as stated in a previous communication.

ADDENDUM. Dated June 26.

In continuing the above researches we have plotted the percentage frequency of the solar prominences derived from the Italian observations for each 10° of solar latitude N. and S. of the Equator.

We find that the epochs of maximum prominence disturbance in the higher latitudes are widely different from those near the Equator. The latter are closely associated with the epochs of maximum spotted area; the former occur both N. and S. at intervening times.

We have then two sets of strongly marked prominence outbursts occurring at intervals of between 3 and 4 years.

Both sets are represented closely in the Indian pressure curves.

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