

RESULTS
OF THE
SPECTROSCOPIC AND PHOTOGRAPHIC OBSERVATIONS

MADE AT THE
ROYAL OBSERVATORY, GREENWICH,

IN THE YEAR

1892:

UNDER THE DIRECTION OF

W. H. M. CHRISTIE, M.A., F.R.S.,
ASTRONOMER ROYAL.

(EXTRACTED FROM THE GREENWICH OBSERVATIONS, 1892.)

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
By DARLING & SON, LTD., 1, 2, 3, & 5, GREAT ST. THOMAS APOSTLE, E.C.

1894.

ERRATA.

SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1891.

MEASURES OF POSITIONS AND AREAS OF SUN SPOTS AND FACULÆ, 1891.			
Page.	Column.	Line.	
39	Footnote	2	For July 16, read July 14, and insert On July 15 and 16 the cluster <i>b</i> is measured in two portions.
40	2	25	No. of Group, insert <i>b</i> after 2256.
41	1	9	No. of Group, insert <i>b</i> after 2256.
41	1	29	No. of Group, insert <i>b</i> after 2256.
41	2	10	No. of Group, insert <i>b</i> after 2256.

LEDGERS OF SUN SPOTS, 1891.

Group 2311. Oct. 9. Longitude, for 167°9, read 168°8; Means, Longitude, for 170°52, read 170°59.

SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892.

MEASURES OF POSITIONS AND AREAS OF SUN SPOTS AND FACULÆ, 1892.			
Page.	Column.	Line.	
2	2	1	Position-Angle, for 49°4, read 55°3; Longitude, for 82°8, read 36°3; Latitude, for + 24°7, read + 20°9.
3	2	15	Longitude of Centre of Disk, for 60°0, read 6°0.
	2	12	Latitude, for — 11°6, read — 11°3; Area of Umbra, for 3, read 0.
		13	Total Area of Umbra, for 82, read 56.
		14	Dele this line.
		27	Total Area of Spots, for 1861, read 1852.
6	2	6	Longitude, for 182°4, read 182°8; Latitude, for + 26°1, read 26°2.
		32	No. of Group, for 2403, read 2400; Longitude, for 194°4, read 181°4.
		35	No. of Group, for 2398, read 2397.
		36	No. of Group, for 2398, read 2397.
7	1	17	No. of Group, for 2399, read 2400; Longitude, for 179°0, read 178°1; Latitude, for + 24°9, read + 14°6.
	2	5	Position-Angle, for 11°3, read 9°3; Longitude, for 148°0, read 148°9; Latitude, for + 18°6, read + 18°8.
8	1	26	Longitude of Centre of Disk, for 152°5, read 115°8.
9	Footnote.		Group 2415, for Feb. 4, read Feb. 3.

SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892—continued.

Page.	Column.	Line.	
10	1	20	No. of Group, for 2415, read 2412; Latitude, for — 15°9, read — 18°5.
	Footnote.		Group 2420, for A regular spot on Feb. 5. It diminishes, read Two spots on Feb. 5. One has disappeared by Feb. 7 and the other diminishes.
14	2	37	Greenwich Civil Time, for 53 ^d .517, read 53 ^d .406.
14	2	37-40	} Feb. 23. Increase all Longitudes on this date by 1°4.
15	1	1-6	
15	2	30-34	} March 4. Diminish all Longitudes on this date by 3°0.
16	1	1-3	
19	1	24	Measurers, for MA, B., read M, AB.
	2	1	Measurers, for MA, B., read M, AB.
20	2	30	Total Area of Spots, for 1262, read 1258.
21	1	1	No. of Group, for 2454, read 2463.
		18	No. of Group, for 2454, read 2463.
		19	No. of Group, for 2454, read 2463.
	Footnote.		Group 2463, for March 29, read March 27 twice.
22	2	1-16	April 4. Increase all Longitudes by 0°4.
23	2	20	Greenwich Civil Time, for 101 ^d .528, read 101 ^d .538.
	Footnote.		Group 2480, for smaller than Group 2480, read smaller than Group 2479.
24	1	1	Greenwich Civil Time, for 102 ^d .402, read 102 ^d .404.
		30-41	} April 14. Increase all Longitudes by 1°0.
	2	1-8	
		22-37	} April 16. Diminish all Longitudes by 0°3.
31	1	6	
		6-40	} May 5. Diminish all Longitudes by 0°6.
		41	
		41	Greenwich Civil Time, for 126 ^d .473, read 126 ^d .401.
32	1	26	No. of Group, for 2509, read 2509*.
	Footnote.		Group 2509, for May 7-8, read May 7.
	Footnote.		Insert Group 2509*, May 8. A small faint spot.
33	1	1	Measurers, for MA, B., read M, AB.
36	2	12	Area of Spot, for 196, read 422.
		21	Total Area of Spots, for 2319, read 2545.

E R R A T A .

SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892—continued.			
Page.	Column.	Line.	
38	1	1	Area of Umbra, for 0, read 29.
		1	Area of Spot, for 93, read 144.
		22	Total Area of Umbra, for 210, read 239.
		22	Total Area of Spots, for 2003, read 2054.
45	2	1	Greenwich Civil Time, for 174 ^d .176, read 174 ^d .187.
46	2	1	Greenwich Civil Time, for 177 ^d .193, read 177 ^d .200.
49	2	13	Latitude, for — 22°0, read — 22°1.
52	1	14-16	Dele these three lines.
		24	Dele Area of Spot.
		25	Total Area of Spots, for 442, read 374.
54	2	9	Total Area of Spots, for 2259, read 2159.
59	2	32	Total Area of Spots, for 1661, read 1671.
60	1	20	Measurers, for \mathcal{A} E, read AE.
65	2	43	Total Area of Spots, for 718, read 719.
69	1	25-43	Sept. 22. Increase all Longitudes by 0°6.
70	1	3	No. of Group, for 2677, read 2676.
71	1	22	Total Area of Spots, for 1909, read 1906.
	2	1	Greenwich Civil Time, for 272 ^d .421, read 272 ^d .412.

SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892—continued.			
Page.	Column.	Line.	
74	2	28	Total Area of Spots, for 1798, read 1748.
75	1	17	Greenwich Civil Time, for 281 ^d .327, read 281 ^d .328.
80	1	19	Area of Whole Spot. <i>Insert</i> 9.
82	1	12	Total Area of Spots, for 1376, read 1276.
88	2	4	Greenwich Civil Time, for 329 ^d .202, read 329 ^d .203.
90	1	4	Greenwich Civil Time, for 333 ^d .173, read 333 ^d .200.
		37	Total Area of Spots, for 1382, read 1372.
91	1	4	Greenwich Civil Time, for 336 ^d .450, read 336 ^d .451.
	2	35	Greenwich Civil Time, for 338 ^d .478, read 338 ^d .477.
92	2	6	Latitude, for — 15°9, read + 15°9.

LEDGERS OF SUN SPOTS, 1892.

Group 2438. March 4. Longitude, for 44°3, read 41°3; Means, Longitude, for 39°95, read 38°45.

Group 2439. March 4. Longitude, for 12°3, read 9°3; Means, Longitude, for 11°60, read 10°60.

Group 2440. March 4. Longitude, for 249°9, read 246°9; Means, Longitude, for 250°26, read 250°04.

GREENWICH SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892.

INTRODUCTION.

§ 1. *Measures of Positions and Areas of Sun Spots and Faculae on Photographs taken at the Royal Observatory, Greenwich, at Dehra Dîn in India, and at the Royal Alfred Observatory, Mauritius, in the year 1892; with the deduced Heliographic Longitudes and Latitudes.*

The photographs from which these measures were made were taken either at Greenwich; at Dehra Dîn, North-West Provinces, India; or at the Royal Alfred Observatory, Mauritius.

The photographs of the Greenwich series were usually taken with the Dallmeyer Photoheliograph returned from the Transit of Venus expedition to New Zealand, which, as now adapted, gives a solar image of 8 inches diameter on the photographic plate. But a few were taken with the photographic refractor of 9 inches aperture, presented to the Royal Observatory by Sir Henry Thompson, which had been fitted with an enlarging lens and with a camera and shutter for rapid exposure in order to take photographs of the Sun on a scale of about 8 inches to the solar diameter. The enlarging lens formerly used in the Dallmeyer Photoheliograph was employed with it until December 2, when a new lens was tried. A third magnifier, by Ross, was adapted to the instrument on December 13, and as the resulting image was very free from distortion, this has been adopted for regular use. The photographs selected for measurement on February 3; September 16, 23, 26; October 14, 17, 24; November 12, 13; December 7 and 13 were taken with this instrument.

The photographs have been taken throughout the year on gelatine dry plates, either Thomas's "Thickly-coated Landscape" plates, or "Lantern" plates supplied by the same firm. A hydroquinone developer has generally been used, but occasionally the plates have been developed with pyrogallic acid and ammonia.

vi INTRODUCTION TO GREENWICH SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892.

The Indian photographs, which have been forwarded by the Solar Physics Committee to fill the gaps in the Greenwich series, were taken under the superintendence of the Deputy Surveyor General, Trigonometrical Survey of India, with a Dallmeyer photoheliograph giving an image of the Sun nearly 8 inches in diameter. In the process adopted at Dehra Dûn bromo-iodized collodion has been used in connexion with iron development.

The Mauritius photographs were taken under the superintendence of Dr. C. Meldrum, Director of the Royal Alfred Observatory, Mauritius, with a Dallmeyer photoheliograph, giving an image of the Sun about 8 inches in diameter. At the Mauritius Observatory bromo-iodized gelatine dry plates have been used with alkaline development.

Photographs of the Sun were taken at Greenwich with the Dallmeyer photoheliograph on 186 days, and with the Thompson photoheliograph on 11 days, and Indian photographs on 141 days with Mauritius photographs on 24 days have been received from the Solar Physics Committee to complete the total of 362 days for which there are either Greenwich, Indian, or Mauritius photographs of the Sun available for measurement in 1892.

The *first* column on each page contains the Greenwich Civil Time at which each photograph was taken, expressed by the day of the year and decimals of a day, reckoning from Greenwich mean midnight January 1d. 0h., and also by the day of the month (civil reckoning), which latter is placed opposite the total area of Spots and Faculæ for the day. The photographs taken in India are distinguished by the letter I, and those taken in Mauritius by the letter M.

The *second* column contains the initials of the two persons measuring the photograph; the initial on the left being that of the person who measured the photograph on the left of the centre of the measuring instrument, and that on the right being that of the person who measured on the right of the centre.

The following are the signatures of those persons who measured the photographs for the year 1892:—

E. W. Maunder	-	-	M	Annie S. D. Russell	-	-	AR
H. Appleyard	-	-	HA	C. C. Lacey	-	-	CL
Alice Everett	-	-	AE	J. S. Gillingham	-	-	JG
Edith Mary Rix	-	-	ER	A. G. Bell	-	-	AB

The *third* column gives the No. of the group, and the letter for the spot. The groups are numbered in the order of their appearance.

The *next two* columns give the Distance from the Centre of the Sun in terms of the Sun's Radius, and the Position-Angle from the Sun's Axis, reckoned from the Sun's North Pole in the direction *n, f, s, p*, both results being corrected for the effects of astronomical refraction.

The measures of the photographs were made with a large position-micrometer specially constructed by Messrs. Troughton and Simms for the measurement of photographs of the Sun up to 12 inches in diameter. In this micrometer the photograph is held with its film-side uppermost on three pillars fixed on a circular plate, which can be turned through a small angle, about a pivot in its circumference, by means of a screw and antagonistic spring acting at the opposite extremity of the diameter. The pivot of this plate is mounted on the circumference of another circular plate, which can be turned by screw-action about a pivot in its circumference, 90° distant from that of the upper plate, this pivot being mounted on a circular plate with position-circle which rotates about its centre. By this means small movements in two directions at right angles to each other can be readily given, and the photograph can be accurately centred with respect to the position-circle. When this has been done, a positive eye-piece, having at its focus a glass diaphragm ruled with cross-lines into squares, with sides of one-hundredth of an inch (for measurement of areas), is moved along a slide diametrically across the photograph, the diaphragm being nearly in contact with the photographic film, so that parallax is avoided. The distance of a spot or facula from the centre of the Sun is read off by means of a scale and vernier to 1.250th of an inch (corresponding to 0.001 of the Sun's radius for photographs having a solar diameter of 8 inches). The position-angle is read off on a large position-circle which rotates with the photographic plate. The photograph is illuminated by diffused light reflected from white paper placed at an angle of 45° between the photograph and the plate below.

The following is the process of measurement of a photograph:—By means of the screws attached to the circular plates carrying the pillars which hold the photograph, the image of the Sun is centred as accurately as possible by rotation. The position-circle is then set to the readings 0°, 90°, 180°, and 270° in succession, and the scale readings taken for the two limbs. The scale being so adjusted that its zero coincides with the centre of rotation of the position-circle, the mean of the eight readings for the limb gives the mean radius of the Sun directly.

viii INTRODUCTION TO GREENWICH SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892.

At the principal focus of the photoheliograph are two cross-spider-lines which serve to determine the zero of position-angles on the photograph.

The zero of position-angles for the Dallmeyer Photoheliograph, employed at Greenwich, has generally been determined throughout 1892 by the measurement of a plate which had been exposed to the Sun's rays twice, with an interval of about 100 seconds between the two exposures, the instrument being firmly clamped. Two images of the Sun, overlapping each other by about a fifth part of the Sun's diameter, were therefore produced upon the plate, and the exposures having been so given that the line joining the cusps passed approximately through the centre of the plate, the inclination of the wires of the photoheliograph to this line was measured with the position-micrometer, and a small correction for the inclination of the Sun's path was then applied. The following table gives the correction for zero of position for the mean of the two wires as thus determined :—

Date, Greenwich Civil Time.		Correction for Zero.
1892 March	h	° /
	5. 11	— 2. 7
	18. 10	— 1. 52
	30. 11	— 2. 3
April	7. 10	— 1. 0
	8. 10	— 0. 49
	23. 11	— 0. 57
May	25. 16	— 0. 38
	10. 12	— 0. 45
	28. 10	— 0. 48
June	7. 12	— 0. 46
	27. 12	— 0. 47
July	29. 9	— 1. 11
August	15. 12	— 0. 58
September	1. 11	— 1. 2
	8. 11	— 1. 3

MEASURES OF PHOTOGRAPHS OF THE SUN.

Date, Greenwich Civil Time.		Correction for Zero.
1892 November	8. 12 ^h	- 1. 1
	30. 11	- 1. 15
December	10. 11	- 1. 15
1893 January	11. 11	- 1. 15

The zero of position has also been determined on several occasions by allowing the diurnal motion to carry a spot or the Sun's limb along the equatorial wire, a correction for the inclination of the Sun's path being applied to the reading of the position-circle so obtained, and also by running the image along the wire by the use of the R.A. slow motion, the mean of the two determinations, further corrected for the error of the perpendicularity of the wires, being then taken. The correction for error of perpendicularity of the wires in use throughout 1892 was $- 0^{\circ}. 23'$. The following table gives the correction for zero of position of the mean of the two wires as obtained by this method :—

Date, Greenwich Civil Time.		Corrected Zero of Position-Circle from Transit.	Zero of Position-Circle obtained when using R.A. Slow Motion.
1892 April	23. 12 ^h	- 0. 45	- 0. 46
May	10. 12	- 0. 42	- 0. 48
July	29. 12	- 0. 54	- 0. 52
August	15. 11	- 0. 59	- 1. 1
September	8. 12	- 0. 56	- 0. 58
November	8. 12	- 1. 14	- 1. 3

The Dallmeyer Photoheliograph was removed on April 6 from stand No. 3 in the first floor of the New Museum building, and remounted on its own stand in the Photoheliograph dome. It was transferred back again to stand No. 3 in the New Museum on September 9.

In the use at Greenwich of the Dallmeyer Photoheliograph the position-circle has usually been set to some convenient reading near that for zero, so that the wires are

x INTRODUCTION TO GREENWICH SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1892.

respectively very nearly parallel and perpendicular to the circle of declination, and a correction for zero of position of the photoheliograph for the mean of the two wires has been applied to the zero of the position-circle of the micrometer. The position-circle was set to the reading $354^{\circ}0$ throughout 1892.

The zero of the position-circle of the micrometer has been determined from the readings of the position-circle for the four extremities of the two wires. The resulting combined correction is applied to all position-circle readings for spots and faculae, so as to give true position-angles.

The Thompson Photoheliograph is not fitted with a position-circle, and the position-angle of the wires, which, as in the Dallmeyer, are placed respectively very nearly parallel and perpendicular to the circle of declination, cannot be altered. The zero of position-angle has been determined by stopping the driving-clock immediately after the exposure of the plate, and giving a second exposure about two minutes later than the first. A second image of a small portion of the Sun is thus secured. The mean of the position-circle reading for two points on the limb of the second image, equidistant from the centre of the first image, corrected for the inclination of the Sun's path, gives the position-circle reading for the west point of the image of the Sun.

In the use of the Photoheliographs at Dehra Dûn and in Mauritius the position-circle has always been set to the zero as determined by allowing the diurnal motion to carry a spot or the Sun's limb along the horizontal wire, and the accuracy of the adjustment has been tested at short intervals. No correction for zero of position of the wires has therefore been applied for the reduction of the photographs taken in India or in Mauritius.

The uncorrected distance from the Sun's centre for spots and faculae is read off directly to 1.250th of an inch by means of a scale and vernier, the zero of the scale of the new micrometer being adjusted to coincide with the centre of the instrument.

Two sets of measures of the Sun's limb and of spots and faculae on each photograph have been taken and the mean of the two sets adopted.

No correction has been applied to the photographs on account of distortion.

The correction for the effect of refraction has been thus found, the Sun's image being assumed to be sensibly an ellipse. The refraction being sensibly $c \tan z$ where $c = \sin 57''.5 = \frac{1}{3600}$ nearly, and z is the apparent zenith distance, we shall have—

$$\frac{\text{Vertical Diameter}}{\text{Horizontal Diameter}} = \frac{1 - c \sec^2 z}{1 - c} = 1 - c \tan^2 z ;$$

and thus the effect of refraction will be to diminish any vertical ordinate y by the quantity $c \tan^2 z$. Resolving this along and perpendicular to the radius vector r , and putting v for the position-angle of the vertex, we have for δr and $\delta \theta$, the corrections to radius vector and position-angle for the effect of refraction—

$$\delta r = + c . \tan^2 z \times r . \cos^2 (\theta - v) = + c . \tan^2 z \times r \times \frac{1 + \cos 2 (\theta - v)}{2},$$

$$\delta \theta = - c . \tan^2 z . \sin (\theta - v) . \cos (\theta - v) = - c . \tan^2 z \frac{\sin 2 (\theta - v)}{2}$$

The quantity δr thus found is the correction, on the supposition that a horizontal diameter of the Sun is taken as the scale. But, as the mean of two diameters at right angles has been used, the scale itself requires the correction $\delta R = + c . \tan^2 z \times R \times \frac{1}{2} \left\{ \frac{1 + \cos 2 (\theta_0 - v)}{2} + \frac{1 + \cos 2 (\theta_0 + 90^\circ - v)}{2} \right\} = + \frac{1}{2} c R . \tan^2 z$, where R is the Sun's mean radius and $\theta_0, \theta_0 + 90^\circ$ the position-angles of the two diameters measured. Thus the final correction to r becomes—

$$\delta r = + c . \tan^2 z \times r \times \frac{\cos 2 (\theta - v)}{2}.$$

The quantities $c \tan^2 z$, $-\frac{\sin 2 (\theta - v)}{2}$, and $\frac{\cos 2 (\theta - v)}{2}$ have been tabulated for use as follows, $c \tan^2 z$ being expressed in circular measure and in arc for application to distances and position-angles respectively :—

$c \tan^2 z$.

z .	In Circular Measure.	In Arc.	z .	In Circular Measure.	In Arc.	z .	In Circular Measure.	In Arc.
80	·0089	31	70	·0021	7	60	·0008	3
79	·0073	25	69	·0019	6½	58	·0007	2
78	·0061	21	68	·0017	6	56	·0006	2
77	·0052	18	67	·0015	5½	54	·0005	2
76	·0045	15	66	·0014	5	52	·0005	2
75	·0039	13	65	·0013	4½	50	·0004	1
74	·0034	11½	64	·0012	4	45	·0003	1
73	·0030	10	63	·0011	4	40	·0002	1
72	·0026	9	62	·0010	3	30	·0001	0
71	·0023	8	61	·0009	3			

Factors for Refraction.

$\theta - v$	$\theta - v$	$\frac{\text{Sin } 2(\theta - v)}{2}$	$\frac{\text{Cos } 2(\theta - v)}{2}$	$\theta - v$	$\theta - v$	$\frac{\text{Sin } 2(\theta - v)}{2}$	$\frac{\text{Cos } 2(\theta - v)}{2}$
0	0			0	0		
5	180	— .00	+ .50	95	275	+ .09	— .49
10	185	— .09	+ .49	100	280	+ .17	— .47
15	190	— .17	+ .47	105	285	+ .25	— .43
20	195	— .25	+ .43	110	290	+ .32	— .38
25	200	— .32	+ .38	115	295	+ .38	— .32
30	205	— .38	+ .32	120	300	+ .43	— .25
35	210	— .43	+ .25	125	305	+ .47	— .17
40	215	— .47	+ .17	130	310	+ .49	— .09
45	220	— .49	+ .09	135	315	+ .50	.00
50	225	— .50	.00	140	320	+ .49	+ .09
55	230	— .49	— .09	145	325	+ .47	+ .17
60	235	— .47	— .17	150	330	+ .43	+ .25
65	240	— .43	— .25	155	335	+ .38	+ .32
70	245	— .38	— .32	160	340	+ .32	+ .38
75	250	— .32	— .38	165	345	+ .25	+ .43
80	255	— .25	— .43	170	350	+ .17	+ .47
85	260	— .17	— .47	175	355	+ .09	+ .49
90	265	— .09	— .49	180	360	.00	+ .50
	270	.00	— .50				

The position-angle of the Vertex v is readily taken from a globe.

The distance from centre in terms of the Sun's radius given in the *fourth* column is then readily found by dividing the measured distance r_0 , as corrected for refraction, by the measured mean radius of the Sun, R ; and the Position-Angle from the Sun's Axis given in the *fifth* column is obtained by applying to the Position-Angle (from the N. point) corrected for refraction the Position-Angle of the Sun's Axis derived from the "Auxiliary Tables for determining the Angle of Position of the Sun's Axis, and the Latitude and Longitude of the Earth referred to the Sun's Equator," by Warren De La Rue, F.R.S.

The *sixth* and *seventh* columns give the heliographic longitude and latitude of the spot, which are thus computed.* Let r be the measured distance of a spot from the centre of the Sun's apparent disc, R the measured radius of the Sun on the photograph, (R) the tabular semidiameter of the Sun in arc, and ρ, ρ' the angular distances of a spot from the centre of the apparent disk as viewed from the Sun's centre and from the Earth respectively. Then we have—

$$\rho' = \frac{r}{R}(R); \text{ and } \sin(\rho + \rho') = \frac{r}{R},$$

$$\text{whence } \rho = \sin^{-1} \frac{r}{R} - \rho'.$$

* Researches on Solar Physics: Heliographical Positions and Areas of Sun Spots observed with the Kew Photoheliograph during the years 1862 and 1863, by W. De La Rue, B. Stewart and B. Loewy. Phil. Trans, 1869.

Log $\sin \rho$ and log $\cos \rho$ as computed from this formula are given in "Tables for the Reduction of Solar Observations No. 2," by Warren De La Rue, F.R.S. Then, if D , λ are the heliographic latitudes of the Earth and the Spot respectively, referred to the Sun's Equator, and L , l the heliographic longitudes reckoned from the ascending node of the Sun's Equator on the ecliptic, and χ the position-angle from the Sun's axis, we have by the ordinary equations of spherical trigonometry—

$$\begin{aligned}\sin \lambda &= \cos \rho \sin D + \sin \rho \cos D \cos \chi \\ \sin (L - l) &= \sin \chi \sin \rho \sec \lambda.\end{aligned}$$

The quantities L and D are derived from Warren De La Rue's Auxiliary Tables before referred to, in the computation of which the following formulæ have been used—

$$\begin{aligned}\tan L &= \cos I \tan (\odot - N) \\ \sin D &= \sin I \sin (\odot - N)\end{aligned}$$

where I is the inclination of the Sun's Equator to the ecliptic, N the longitude of the ascending node, and \odot the longitude of the Sun.

The position-angle χ is given by the formula—

$$\chi = P + G + H$$

where P is the position-angle from the north point of the Sun, and G and H two auxiliary angles given by the formulæ—

$$\begin{aligned}\tan G &= \tan \omega \cos \odot \\ \tan H &= \tan I \cos (\odot - N)\end{aligned}$$

where ω is the obliquity of the ecliptic.

It will be seen that G is the inclination of two planes through the line joining the centres of the Earth and Sun passing through the poles of the Earth and of the ecliptic respectively, and that H is the inclination of two planes through the same line and the poles of the Sun and of the ecliptic. The values assumed for I , N , ω in the computation of the Tables are $7^\circ 15'$, $74^\circ 18'$, and $23^\circ 27'.5$ respectively.

The Heliographic Longitude of the Spot is found from l , the Heliographic Longitude from Node, by subtracting the Reduction to the Prime Meridian, which is the Longitude of the Node at the epoch of the photograph, referred to the assumed Prime Meridian, the latter being the meridian which passed through the ascending node at mean noon, 1854, Jan. 1. The period of rotation assumed is 25.38 days.

The Heliographic Longitude and Latitude of the Centre of the Sun's Disk at the time of the exposure of each photograph are also given (in brackets) in the *sixth* and *seventh* columns respectively. The Longitude of the Centre of the Disk is found by subtracting the Reduction to the Prime Meridian from L, the Longitude of the Centre from the Node. The Latitude of the Centre is of course the same as D, the Heliographic Latitude of the Earth.

The measures of areas given in the *last three* columns were made with a glass diaphragm ruled into squares, with sides of one hundredth of an inch, and placed as nearly as possible in contact with the photographic film. The integral number of squares and parts of a square contained in the area of a spot or facula was estimated by the observer, two independent sets of measures being made by two observers. The mean of the two sets of measures has been taken for each photograph. The factor for converting the areas, as measured in ten-thousandths of a square inch, into millionths of the Sun's visible hemisphere, allowing for the effect of foreshortening, has been inferred by means of a table of double entry, giving the equivalent of one square for different values of the Sun's radius, and for different distances of the spot or facula from the Sun's centre, as measured by means of the position-micrometer.

The individual spots in a group have in some cases not been measured separately, but combined into a cluster of two or three small spots close together, the position of the centre of gravity and the aggregate area of the cluster being given. The actual number of individual spots is usually stated in the Notes.

§ 2. *Ledgers of Areas and Positions of Groups of Sun Spots deduced from the measurement of the Solar photographs for each day in the year 1892.*

In these Ledgers the daily results for each group are collected together from the measures of the individual spots and given in a condensed form. The first column gives for each day, on which the group was observed, the Greenwich civil time at which each photograph was taken, expressed by the day of the month (civil reckoning) and the decimals of a day reckoning from Greenwich mean midnight. The second and third columns give the sums, for each day, of the projected areas of all the umbræ and whole spots comprised in the group, the projected area being the area as it is measured upon the photograph, uncorrected for foreshortening, and expressed in millionths of the Sun's apparent disk. The fourth and fifth columns give the sums for each day of the areas of all the umbræ and whole spots comprised in the group, corrected for foreshortening, and expressed in millionths of the Sun's visible hemisphere.

The sixth and seventh columns give the mean longitude and latitude of the group, found by multiplying the longitude and latitude of each separately measured component of the group by its area, and dividing the sum of the products by the sum of the areas. The last column gives the mean longitude of the group from the central meridian, and is found by subtracting the longitude of the centre of the disk from the mean longitude of the group. At the foot of these daily results for each group are given the mean areas of umbrae and whole spots and the mean longitude and latitude for the period of observation.

§ 3. *Total Projected Areas of Sun Spots and Faculae, for each day, and Mean Areas and Mean Heliographic Latitude of Sun Spots and Faculae, for each Rotation of the Sun, and for the Year 1892.*

This section requires no further explanation.

W. H. M. CHRISTIE.

1894 October 4.

ROYAL OBSERVATORY, GREENWICH.

MEASURES OF POSITIONS AND AREAS

OF

SUN SPOTS AND FACULÆ

ON

PHOTOGRAPHS

TAKEN WITH THE

PHOTOHELIOGRAPHS

AT GREENWICH, IN INDIA, AND IN MAURITIUS,

WITH THE DEDUCED

HELIOGRAPHIC LONGITUDES AND LATITUDES.

1892.