GREENWICH

SPECTROSCOPIC AND PHOTOGRAPHIC

RESULTS.

1894.

RESULTS

OF THE

SPECTROSCOPIC AND PHOTOGRAPHIC OBSERVATIONS

MADE AT THE

ROYAL OBSERVATORY, GREENWICH,

IN THE YEAR

1894:

UNDER THE DIRECTION OF

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

(EXTRACTED FROM THE GREENWICH OBSERVATIONS, 1894.)

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1897.

GREENWICH SPECTROSCOPIC AND PHOTOGRAPHIC RESULTS, 1894.

INTRODUCTION.

§ 1. *Measures of Positions and Areas of Sun Spots and Faculæ on Photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn in India, and at the Royal Alfred Observatory, Mauritius, in the year* 1894; *with the deduced Heliographic Longitudes and Latitudes.*

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

The photographs of the Greenwich series were taken either with the Dallmeyer or with the Thompson Photoheliograph. The Dallmeyer is an instrument used in the Transit of Venus expedition to New Zealand, and, as now adapted, gives a solar image of 8 inches diameter on the photographic plate. The Thompson is a photographic refractor of 9 inches aperture, presented to the Royal Observatory by Sir Henry Thompson, which has been fitted with an enlarging lens by Ross, and with a camera and shutter for rapid exposure, so as to take photographs of the Sun on a scale of about 8 inches to the solar diameter.

The photographs have been taken throughout the year on gelatine dry plates, "Lantern" plates supplied by R. W. Thomas and Co. being used, with hydroquinone development.

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.

Of the photographs of the Sun taken at Greenwich, those selected for measurement were taken with the Dallmeyer photoheliograph on 111 days, and with the Thompson photoheliograph on 87 days. Indian photographs on 127 days, and Mauritius photographs on 39 days have been received from the Solar Physics Committee to complete the total of 364 days for which there are either Greenwich, Indian, or Mauritius photographs of the Sun available for measurement in 1894.

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 1894 :—

E. W. Maunder - -	M	J. S. Gillingham - -	JG
H. Appleyard - -	HA	C. F. Turner - -	FT
Annie S. D. Russell -	AR	A. J. Wilkin - -	AW
C. C. Lacey - -	CL		

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.

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 been determined 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.
	d h	o ′
1893 December	21. 11	+ 0. 37
1894 January	13. 11	+ 0. 54
	19. 13	+ 0. 17
February	13. 11	+ 0. 33
June	9. 12	+ 3. 17
	14. 10	+ 3. 7
	14. 11	+ 3. 16
	14. 12	+ 3. 17
	15. 11	+ 3. 12
	16. 10	+ 2. 58
	16. 13	+ 3. 24
August	18. 11	+ 2. 53
	22. 11	+ 2. 49
September	18. 16	+ 3. 3
November	10. 12	+ 2. 47
December	27. 13	+ 3. 2

The magnifier of the Dallmeyer Photoheliograph was removed on 1894 July 20 and a Ross magnifier, supplied for use with a photoheliograph lent to the Indian Government, was temporarily inserted for trial and adjustment. The original Dallmeyer magnifier was replaced on August 15.

The wires of the Photoheliograph were found to be broken on July 21, and a new pair was inserted on July 30.

The Dallmeyer Photoheliograph was mounted on the tube of the new 28-inch refractor till April 24, when it was removed and mounted on its own stand on the terrace roof of the South wing of the new Physical Observatory.

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 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°·0 throughout 1894.

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 faculæ, 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 approximately 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 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. The Thompson Photoheliograph was dismounted on 1894 October 15, as the progress of the building operations interfered with its further use.

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 faculæ 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 faculæ 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 $c = \sin 57''{\cdot}5 = \frac{1}{3600}$ 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

$$\delta \mathrm{R} = + c \,.\, \tan^2 z \times \mathrm{R} \times \tfrac{1}{2} \left\{ \frac{1 + \cos 2 (\theta_0 - v)}{2} + \frac{1 + \cos 2 (\theta_0 + 90^\circ - v)}{2} \right\} = + \tfrac{1}{2} c \, \mathrm{R} \,.\, \tan^2 z,$$

where R is the Sun's mean radius and θ_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	180	·00	+ ·50	95	275	+ ·09	− ·49
5	185	− ·09	+ ·49	100	280	+ ·17	− ·47
10	190	− ·17	+ ·47	105	285	+ ·25	− ·43
15	195	− ·25	+ ·43	110	290	+ ·32	− ·38
20	200	− ·32	+ ·38	115	295	+ ·38	− ·32
25	205	− ·38	+ ·32	120	300	+ ·43	− ·25
30	210	− ·43	+ ·25	125	305	+ ·47	− ·17
35	215	− ·47	+ ·17	130	310	+ ·49	− ·09
40	220	− ·49	+ ·09	135	315	+ ·50	·00
45	225	− ·50	·00	140	320	+ ·49	+ ·09
50	230	− ·49	− ·09	145	325	+ ·47	+ ·17
55	235	− ·47	− ·17	150	330	+ ·43	+ ·25
60	240	− ·43	− ·25	155	335	+ ·38	+ ·32
65	245	− ·38	− ·32	160	340	+ ·32	+ ·38
70	250	− ·32	− ·38	165	345	+ ·25	+ ·43
75	255	− ·25	− ·43	170	350	+ ·17	+ ·47
80	260	− ·17	− ·47	175	355	+ ·09	+ ·49
85	265	− ·09	− ·49	180	360	·00	+ ·50
90	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 disk, 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 ρ and log cos ρ 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—

$$\sin \lambda = \cos \rho \sin D + \sin \rho \cos D \cos \chi$$
$$\sin (L - l) = \sin \chi \sin \rho \sec \lambda.$$

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—

$$\tan L = \cos I \tan (\odot - N)$$
$$\sin D = \sin I \sin (\odot - N)$$

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—

$$\tan G = \tan \omega \cos \odot$$
$$\tan H = \tan I \cos (\odot - N)$$

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° 15′, 74° 20′, and 23° 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* 1894.

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 umbræ and whole spots and the mean longitude and latitude for the period of observation.

§ 3. *Total Projected Areas of Sun Spots and Faculæ, for each day, and Mean Areas and Mean Heliographic Latitude of Sun Spots and Faculæ, for each Rotation of the Sun, and for the Year* 1894.

This section requires no further explanation.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich.
1896 *December* 18.

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.

1894.

MEASURES of POSITIONS and AREAS of SUN SPOTS and FACULÆ on PHOTOGRAPHS taken at the ROYAL OBSERVATORY, GREENWICH, at DEHRA DÛN in INDIA, and at the ROYAL ALFRED OBSERVATORY, MAURITIUS, in the Year 1894.

NOTE.—The Greenwich Civil Time at which the photograph was taken is expressed by the Day of the Year and decimals of a day, reckoning from Midnight, January 1d. 0h.

For convenience of reference the Month and Day of the Month (Civil Reckoning) are added.

The letter I. signifies that the photograph was taken in India; the letter M. that the photograph was taken in Mauritius; the time given is Greenwich Civil Time.

The position-angles are reckoned from the North Pole of the Sun's Axis in the direction N., E., S., W., N.

Greenwich Civil Time.	Measurers.	No. of Group, and Letter for Spot.	Distance from Centre in terms of Sun's Radius.	Position Angle from Sun's Axis.	Heliographic Longitude.	Heliographic Latitude.	Spots. Area of UMBRA for each Spot (and for Day).	Spots. Area of WHOLE for each Spot (and for Day).	Faculæ. Area for each Group (and for Day).
1894.				°	°	°			
Jan. 1		No photograph.							
1d.442	JG,FT		0·991	248·6	223·0	−21·7			142
			0·978	240·8	218·2	−29·3			266
			0·967	265·8	215·4	− 4·9			409
			0·949	293·3	208·8	+20·8			278
		3342	0·961	293·8	224·0	+21·7	0	4	
		3323*a*	0·862	259·0	199·6	−11·2	20	171	160*c*
		3323	0·776	259·4	190·9	−10·4	0	9	
		3323*b*	0·762	255·6	189·3	−13·2	44	342	
		3323	0·701	253·0	183·8	−14·3	0	9	
		3323*c*	0·688	253·0	182·7	−14·1	16	151	
		3325*a*	0·493	260·8	169·5	− 7·5	51	264	
		3325	0·453	254·9	166·4	− 9·8	0	2	
		3325	0·443	259·6	166·2	− 7·6	0	2	
		3328*b*	0·437	323·8	155·8	+17·3	0	7	
		3328	0·420	325·2	154·6	+16·8	0	2	
		3328	0·381	324·8	153·3	+14·7	0	7	
		3328*c*	0·394	328·7	152·5	+16·3	0	6	
		3329	0·328	247·7	158·1	−10·4	0	2	
		3329*a*	0·290	251·7	156·3	− 8·5	44	405	
		3329	0·267	242·1	154·0	−10·4	0	7	
		3329	0·248	249·8	153·7	− 8·2	0	6	
		3329	0·231	245·5	152·4	− 8·8	9	26	
		3329	0·223	238·5	151·3	−10·0	2	8	
		3337	0·296	211·7	149·6	−17·9	0	5	
		3340	0·564	99·7	106·2	− 8·3	2	17	
		3341	0·690	108·2	97·7	−14·9	0	11	
		3343	0·863	62·0	85·2	+21·9	0	15	113*c*
			0·851	68·1	84·9	+16·6			65
			0·916	105·4	74·1	−15·4			328
			0·923	95·8	72·8	− 6·7			368
			0·952	74·1	69·8	+14·0			63
Jan. 2		Centre			(140·2)	(− 3·4)	(188)	(1478)	(2192)
1894.									
2d.228	CL,JG		0·791	286·9	180·0	+11·0			20
		3323*a*	0·943	258·8	200·5	−11·8	52	221	273*c*
I.		3323	0·870	258·0	190·1	−12·1	4	27	
		3323*b*	0·866	256·1	189·5	−13·8	53	318	400*c*
		3323*c*	0·809	254·6	183·3	−14·5	34	183	
		3325	0·684	261·4	172·8	− 8·5	0	7	
		3325*a*	0·650	261·9	170·1	− 8·0	57	261	
		3329*b*	0·493	253·9	158·5	−10·9	12	104	
		3329*c*	0·464	260·3	157·1	− 7·6	44	188	
		3329*d*	0·455	256·7	156·3	− 9·1	37	167	
		3329	0·427	251·5	154·1	−11·0	0	12	
		3329	0·404	256·6	153·1	− 8·6	7	27	
		3329	0·396	249·5	151·9	−11·2	0	5	
		3329	0·381	257·7	151·8	− 7·9	0	11	
		3329	0·381	251·8	151·3	−10·1	0	9	
		3337	0·407	232·6	149·5	−17·6	0	3	
		3343*	0·308	242·0	145·8	−11·6	0	3	
		3343*	0·272	244·2	144·1	−10·2	0	3	
		3340	0·408	102·2	106·1	− 8·1	0	3	
		3343	0·760	56·9	86·6	+21·9	0	13	
		3343	0·771	58·4	85·1	+21·3	2	12	105*c*
		3343	0·803	59·2	82·0	+21·9	11	37	
		3344	0·950	98·4	57·9	− 9·1	0	25	290*c*
		3345*a*	0·985	102·9	49·4	−13·3	114	360	490*p*
			0·795	103·4	77·6	−12·7			278
			0·908	110·2	65·2	−19·8			44
			0·910	93·2	64·4	− 4·4			82
Jan. 3		Centre			(129·8)	(− 3·5)	(427)	(1999)	(2168)
3·183	CL,FT		0·875	284·7	176·5	+10·9			382
		3323*a*	0·993	258·6	200·9	−11·8	0	217	
I.		3323*b*	0·954	256·3	189·9	−14·2	30	200	
		3323	0·952	257·5	189·5	−13·0	0	14	583*c*
		3323*c*	0·913	255·9	183·0	−14·4	30	195	

The Groups of Spots are numbered in the order of their appearance. When there is no number in the third column it is to be understood that there is a Facula unaccompanied by a Spot. The positions of Faculæ relative to the Spots with which they are associated are indicated by the letters *n*, *s*, *p*, *f*, *c*, denoting respectively north, south, preceding, following, concentric. The longitude and latitude of the centre of the disk are given in brackets.

The Areas of Spots and Faculæ are expressed in millionths of the Sun's visible Hemisphere.

Group 3323, 1893 December 23–1894 January 5. A large regular spot, *a*, followed by several nebulous areas, with many small nuclei distributed through them. These areas undergo many changes. The two largest are called *b* and *c* from December 29, and have become defined into two large regular spots by January 2. *a* has a large proper motion in longitude.

Group 3325, 1893 December 25–1894 January 6. A large regular spot, *a*, with occasionally some small companions. *a* moves forward in longitude after December 29.

Group 3328, 1893 December 26–1894 January 2. A large spot, *a*, on December 26 and 27. It has broken up by December 28, the principal portions being the two spots *b* and *c*. *b* and *c*, with some small spots near them, make up an irregular stream, which diminishes from day to day.

Group 3329, 1893 December 26–1894 January 7. A large spot, *a*, with some very small companions. The nucleus of *a* is divided into two on December 29; and three separate nuclei are seen on January 2. These are seen as three distinct spots, *b*, *c* and *d*, after January 3.

Group 3337, 1893 December 30–1894 January 3. A pair of very small spots on December 30. One very small spot on January 2 and 3.

Group 3340, 1893 December 30–1894 January 4. A small spot, with a very small companion on January 4.

Group 3341, 1893 December 30–1894 January 2. A single spot, which has greatly diminished by January 2.

Group 3342, 1894 January 2. A very small faint spot.

Group 3343, January 2–11. A number of small spots in a straight stream. *a* and *b*, the first and last spots on January 4, are the largest. *b* diminishes after January 5 and has disappeared by January 10. *a* increases in size until it reaches the W. limb.

Group 3343*, January 3–4. A pair of very small spots *n* of Group 3337 and *f* Group 3329.

Group 3344, January 3. A small spot.

Group 3345, January 3–15. A large regular spot, *a*, preceded on and after January 5 by a number of small spots in a straight stream. *a* is crossed by a bright bridge on January 4, which eventually divides it into two distinct spots, which are measured separately as *b* and *c* after January 11. The preceding spots also show