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363

KODAIKANAL OBSERVATORY

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DISCUSSION OF THE RESULTS OF OBSERVATIONS OF SOLAR PROMINENCES MADE AT KODAIKANAL FROM 1904 TO 1950.

BY

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1. Introduction.

In Volume I, Part 2 of the Memoirs of the Kodaikanal Observatory Mr and Mrs. Evershed (1917) have discussed the results of solar prominence observations made at Kodaikanal during the years from 1904 to 1914 supplemented with Mr Evershed's own observations at Kenley in Surrey (England) during the period 1890-1904 Since then, a large volume of observational data relating to solar prominences has been accumulated at this observatory and several contributions relating to various aspects of the subject have appeared from time to time The object of the present paper is to give a general review and discussion of the prominence data collected at Kodaikanal during the first half of this century. The period covered comprises four sunspot cycles. The scope of the paper is restricted to prominences observed at the limb. A parallel study of the absorption markings on the disc observed in the H-alpha line is in progress.

At Kodaikanal systematic visual observations of prominences in the C line were commenced in 1903 with a six-inch Cooke Equatorial and a grating spectroscope mounted in the " South Dome " of the observatory. The grating spectroscope was replaced by a three-prism Evershed spectroscope towards the end of 1904. In October 1912 the Cooke equatorial and Evershed spectroscope were removed from the south dome and a six-inch Cooke photo-visual telescope with equatorial mounting received from the Takhtasinghji Observatory at Poona was installed in this dome. A good grating spectroscope also from the Poona Observatory was adapted for use with the telescope for visual study of solar limb and disc features

Upto 1904 February 21, the solar limb was scanned only with eight settings of the position circle ; after that date the entire limb was scanned for prominences The daily observations were entered on charts and the data comprising the heliographic coordinates, extents, heights and descriptions of the prominences were published half-yearly in the Bulletins of the Observatory. Abstracts giving mean heights, mean frequency and mean heliographic latitudes of the prominences in each hemisphere for every month as well as quarterly and half-yearly frequencies of prominences in ten-degree latitude zones for every year were also included in the Bulletins.

In August 1904 a two-prism spectroheliograph manufactured by the Cambridge Scientific Instruments Co., Ltd., was installed at the observatory and daily photographing of the limb and the disc in the H line of Ca+ was commenced from the end of that year. The limb spectroheliograms were compared with the sketchings of prominences in H-alpha at the prominence spectroscope and a complete list of all prominences recorded visually and/or photographically was included in the Bulletins In about two years the H line was discarded in favour of the K line, and since then the calcium spectroheliograms of the disc and the limb have always been taken in the K line.

Beginning from 1908 the half-yearly prominence data published in the Bulletins included a diagram giving the zonal distribution of the mean daily profile area of prominences in the two hemispheres. The publication of the detailed list of prominences was discontinued from 1912 ; since that time only a summary of the prominence observations has been published for every half year.

18 DGO/53

Price : Rs. 5-12 or 9 sh.

In 1934 a Hale spectrohelioscope was installed and from that time visual examination of the limb and the disc in the C line at specified times with this instrument has also formed part of the routine observational programme of this observatory.

Weather permitting, the routine daily solar observations with the prominence spectroscope and the spectroheliograph are made between 0730 and 1000 hrs. I. S T. (0200 to 0430 hrs U T) when the sky and seeing conditions are generally the best at Kodaikanal The results discussed in the present paper are, therefore, largely based on daily prominence observations made during this interval. Upto 1922 the available data relate to Kodaikanal observations only In accordance with the resolution of the International Astronomical Union at its first meeting in Rome in 1922, the Kodaikanal Observatory undertook the work of compilation and discussion of the statistics derived from photographs of prominences and H-alpha absorption markings Since then, the Mt. Wilson and Meudon Observatories have been cooperating with this observatory by supplying copies of their photographs for those days when Kodaikanal records are imperfect or wanting. Consequently, the number of days for which prominence data are available is somewhat greater for the years subsequent to 1922 than for the previous years.

2. Data for Analysis.

The half-yearly summaries of prominence observations published in the Bulletins of the Observatory are based on detailed tabulations maintained in the registers These registers constitute the source of the data discussed in the present paper. They contain a vast mass of prominence data derived from observations with the prominence spectroscope, the spectroheliograph and the spectrohelioscope. An account of the data available in the registers is given below :-

(*a*) *Extent of Base, Heliographic Coordinates and Heights of Prominences :—*

Tabulations giving extent of base, mean latitude and maximum height of all prominences observed at the limb are available continuously from April 1904 onwards except for interruptions caused by unfavourable weather conditions. Up to the end of 1911 these detailed data have also been published in the Bulletins of the observatory.

(*b*) *Mean Daily Profile Areas of Prominences :—*

Tabulations of the mean daily area of prominences for every month for each five degree latitude interval in the NE, NW, SE and SW quadrants based on limb spectroheliograms are available from 1905 onwards.

At Kodaikanal the prominence areas are estimated visually by superposing on the spectroheliograms a glass grid (Fig. 1). The inner circle of this grid has the same diameter as the solar disc in the spectroheliograms ($\simeq$60 mm). The diameter of the circle is equal to 100 grid divisions. Assuming the mean geocentric semi-angular diameter of the sun as 16 minutes of arc (this varies from about 16 m 18 s to 15 m 45 s), each small square on the measuring grid represents an area of 1/10 square minute of arc of the celestial sphere with a sufficient degree of accuracy. This is the unit of prominence area employed in the measurements. Areas are estimated correct to one half of a small square on the grid. The grid also contains a set of concentric circles so spaced that the interval between adjacent circles represents 30 seconds of arc on the scale employed for the sun's diameter. The heights of the prominences above the chromosphere are estimated with reference to these circles.

The international unit of prominence area employed by Arcetri, Zurich and some other observatories is different from the Kodaikanal unit. It is equal to the area of a rectangle whose height is one second of arc of the celestial sphere and whose base is one degree along the solar limb. From the old records of the Kodaikanal Observatory it is seen that this unit was tried here in 1907 but was subsequently given up in favour of the unit equal to one-tenth square minute of the celestial sphere. The prominence areas for 1907 available in the registers are in terms of the area of a unit rectangle whose sides correspond to one degree along the solar limb and 10 seconds of arc of the celestial sphere, that is 10 international units The areas for 1907 as tabulated in the registers have, therefore, to be appropriately reduced in order to make them comparable with the data for the preceding and succeeding years.

Assuming the mean geocentric semi-angular diameter of the sun as 16 minutes of arc, we see that 1° along the solar limb corresponds to $\frac{2\pi \times 16}{360}$ minutes as seen from the earth Hence the area represented by a rectangle whose sides are 1° along the solar limb and 10 seconds of arc of the celestial sphere is $0{\cdot}465 \times 10^{-1}$ sq min. As this is a smaller unit than one-tenth square minute, the areas for 1907 given in the registers have to be multiplied by 0·465 to make them comparable with those for the remaining years It is readily seen that the Kodaikanal unit of prominence area (one-tenth square minute) is equal to 21·5 international units.

In the registers the separate tabulations of prominence areas in 5° latitude intervals for all the four quadrants are available only for 1905, 1906 and for the period subsequent to August 1911 For the period January 1907 to July 1911, prominences on the east and west limbs have been combined and the data are available separately only for the north and south hemispheres.

(c) *Mean Daily Prominence Numbers :—*

For the period 1904 to 1911 the numbers of prominences observed in each ten-degree latitude zone in the two hemispheres have been published in the Observatory Bulletins for every month, every quarter, half-year and full year. From July 1912 onwards the prominence numbers for each five-degree zone have been separately tabulated in the registers month by month for all the four quadrants of the sun's disc. It has been the practice at Kodaikanal to group equatorial prominences (prominences whose mean bases lie within one degree of the solar equator) separately.

The convention which has been adopted for prominence numbers from the beginning of this observatory is as follows. The apparent mean latitude of each prominence is taken as the average of the apparent latitudes of its two extremities. From the apparent mean latitude the true latitude is found by applying a correction which varies with the heliographic latitude of the centre of the disc (correction for the tilt of the plane of the solar equator to the plane of the ecliptic). If the corrected latitude thus obtained falls within a particular five-degree interval it is reckoned as one prominence number for that interval, irrespective of the size of the prominence or its total extent

The practice followed at the Zurich Observatory for reckoning prominence numbers is somewhat different. When a large prominence extends over several degrees along the solar limb, each five-degree zone in which any part of the prominence lies gets a weightage of one for prominence number. (This is the practice followed at Kodaikanal for reckoning numbers of H-alpha dark markings in five-degree latitude zones) On the other hand, if there are two or three tiny prominences within the same five-degree interval on the same day, then it is the Zurich practice to reckon these as only one number for that zone (W. Brünner-Hagger, 1940).

The diagrams illustrating the latitudinal distribution of prominence areas and prominence numbers for the years 1936 to 1939 in the Zurich *Astronomische Mitteilungen* reveal a close parallelism On the other hand, Mr and Mrs. Evershed found that the Kodaikanal prominence number curve for the period 1905 to 1914 showed little variation of activity from year to year unlike the curve of prominence areas for the same period which showed a close resemblance to the curve of sunspot activity. They remarked that the flatness of the prominence number curve was due to the fact that at Kodaikanal " all prominences down to the smallest visible are recorded, not only those of 30″ and over as at Catania and other observatories, and small prominences are numerous at all times".

It is well known that the Greenwich sunspot areas and the Zurich relative sunspot numbers have a high degree of correlation and either of these can be employed as a representative index of sunspot activity. But prominence numbers reckoned according to the Kodaikanal practice cannot obviously constitute a good index of prominence activity since the same weightage is given to large and small prominences. It is often not possible to judge uniquely from the appearance of a prominence at the limb whether it is single or is a superposition of more than one prominence. In some cases adjacent prominences which are apparently separated may be parts of one and the same prominence. For these reasons prominence numbers cannot be regarded as indicating unequivocally the number of individual prominences Despite these limitations, the original practice has been continued at Kodaikanal for the sake of continuity

Any procedure which assigns less weightage to small prominences and more weightage to larger ones would result in better correlation betwen prominence areas and prominence numbers. The conventions followed by Zurich and Catania are steps in this direction.

It appeared to be of interest to examine the degree of correlation between prominence areas (A) and prominence numbers reckoned in two different ways (*a*) according to the existing Kodaikanal practice explained above (N), (*b*) by giving a weightage of one to each five-degree zone on all days when prominences are observed in that zone (N') The years 1949 and 1950 were chosen for this study Table I(*a*) (Appendix) gives the mean daily areas and the mean daily numbers of prominences in the five-degree zones for the north and south hemispheres Table I(*b*) (Appendix) gives the corresponding percentage frequencies We see from this table that the latitudinal distribution of prominences as represented by mean daily areas shows more pronounced maxima than when the activity is represented by numbers reckoned in the two different ways. It is also seen that the distribution given by the numbers N' obtained by method (*b*) corresponds more nearly to the distribution given by prominence areas than that given by the numbers N obtained by method (*a*).

In Figs. 2*a* and 2*b* the mean daily areas A for five-degree zones for the years 1949 and 1950 are plotted against the mean daily numbers N and N' respectively These diagrams at once reveal that N' is better correlated with A than N. For comparatively small areas the relation between A and N' is practically linear. For larger areas the trend of the points indicates that $\frac{dA}{dN'}$ is no longer constant but increases ; the correlation between A and N' also decreases at the same time as is evident from the greater scatter of the points.

The decrease of prominence activity from 1949 to 1950 as estimated by A, N and N' is given below :—

		Northern hemisphere	Southern hemisphere.
$\frac{1950}{1949}$	A	57%	64 5%
	N	69 3	82 1
	N'	63 2	75

Again we see that N' is a better index of prominence activity than N.

The numbers N' as defined above are practically identical with the Zürich prominence numbers. On account of the fairly good correlation between A and N' it is possible to derive an equation connecting these two quantities from a statistical analysis of the corresponding data for one solar cycle. It would then be possible to derive the area distribution curve from the corresponding curve for N'.

On account of the unrepresentative nature of the Kodaikanal prominence numbers as a measure of prominence activity we have made little use of this data in the present study.

(*d*) *Metallic Prominences* :—

In the visual observations with the prominence spectroscope a special record is kept of prominences which can be seen in the emission lines of sodium, magnesium, iron etc. Such prominences which are comparatively rare are designated as "metallic" in the Kodaikanal records.

3. Mean Daily Profile Areas of Prominences

It is well known that the profile area of prominences is by far the best index of prominence activity. The Kodaikanal data in this respect constitute an unbroken sequence commencing from 1905 Unfortunately, the data in the form available in the registers could not be directly made use of for the purpose of the present investigation The data for the entire period 1905-1950 were, therefore, retabulated month by month and year by year for each of the four quadrants or five-degree intervals of latitude The mean daily area for each interval was found by dividing the total area by the effective number of days of observation in the year.

Table II (Appendix) gives the mean daily profile areas of prominences year by year separately for each of the four quadrants for five-degree intervals of latitude from the equator to the poles The data for the two hemispheres north and south obtained by adding the corresponding areas for the eastern and western limbs are also given in the table In order to avoid decimals the unit of prominence area for this and other tables has been chosen as 10^{-3} square minute of arc, that is $\frac{1}{100}$ of the Kodaikanal prominence unit. (The figures in the table have to be divided by 4 65 in order to express the areas in terms of the international prominence unit) For the years 1907 to 1911 during which areas are not separately available for the four quadrants the corresponding entries are absent in the table The effective number of days of observation for each year is given in brackets under the year

Figs. 3(*a*) and 3(*b*) illustrate the variation of prominence activity in each five degree zone for the northern and southern hemispheres during the period under study The zero of the vertical scale has been appropriately displaced to avoid superposition of the curves for the different latitude zones The horizontal line against which the designation of a particular zone is written corresponds to the zero of prominence activity for that zone The scale of prominence areas is indicated for the zone 0°-5° at the bottom of each figure and is the same for all other zones. The curve of Zurich relative sunspot numbers is given at the top of each of the diagrams.

4. Four Zones of Prominence Activity.

Systematic collection of prominence statistics by visual observations was organised by the Italian school of astronomers under the leadership of Respighi, Secchi and others from about the seventies of the last century and the results have been discussed in a series of papers by Ricco (1891, 1914), Lockyer and Lockyer (1903), Bocchino (1933) and Barocas (1939) Since the invention of the spectroheliograph it became possible to make more exact measurements of prominence areas on limb spectroheliograms and collection of such data was started at Kodaikanal by Evershed who had already commenced visual study of prominences at his private observatory at Kenley in Surrey as early as 1890—seventeen years before he joined the Kodaikanal Observatory The combined observational data for the period 1890-1914 have been discussed by him and Mrs. Evershed in the Memoir already cited.

The main features of solar prominence activity brought out by these researches are as follows. There are four zones of prominence activity, two in the northern and two in the southern hemisphere. The low latitude zones extend from the solar equator to about 40° on either side while the high latitude zones extend from 40° to the poles The manner in which prominence activity manifests itself in the course of the sunspot cycle in the low and high latitude zones is different Prominences always occur in the low latitude zones although the activity is a minimum at the minimum epoch of sunspot activity. Prominence activity in the high latitude zones above latitude 60° is conspicuous only at and near the time of sunspot maximum. The activity dies down very rapidly thereafter These broad features are clearly brought out by the diagram reproduced in a note entitled " Prominence Activity and the Sunspot Cycle " by one of us (Ananthakrishnan, 1952). Figs 3(*a*) and (*b*) also illustrate these features. We now proceed to a discussion of the prominence data covered by the present study.

5. Comparison of the Northern and the Southern Hemispheres.

For a comparative study of prominence and sunspot activities in the northern and southern hemispheres, the mean daily profile areas of prominences for the two hemispheres and the mean daily areas of sunspots extracted from the Greenwich *Photo-Heliographic Results* are represented graphically in Fig. 4. Despite the general similarity of the two sets of curves, we see also some striking differences

1905-1913 —In the northern hemisphere sunspot activity reached its maximum in 1905 after which there was a progressive decrease till the minimum in 1912. For the southern hemisphere, spot maximum was reached only in 1907 although there was a temporary decrease in activity from 1905 to 1906. The southern minimum was reached in 1913 The maximum of prominence activity for both the hemispheres was reached only in 1908 by which time a decline in spot activity had already set in. The prominence minima for the two hemispheres occurred in the same years as the corresponding sunspot minima

1913-1923 —Sunspot activity in both the hemispheres attained a maximum in 1917. In conformity with the usual trend the fall was less steep than the rise, and the minimum for both the hemispheres was reached in 1923 During this cycle the behaviour of prominence activity was somewhat abnormal. After a steep rise from 1913 to 1915 there was an appreciable decline in activity in both the hemispheres during 1916, probably associated with the temporary decline in sunspot activity in the southern hemisphere and the temporary slowing down of activity in the northern hemisphere. The prominence maximum for the northern hemisphere was reached in 1917, the same year as the sunspot maximum while the southern maximum which was attained in 1918 was less marked than the southern peak in 1915 There occurred two minima of prominence activity in both the hemispheres, the first in 1919 and the second in 1922, a year before the spot minimum

1923-1934 —There was a rapid rise in spot activity in the northern hemisphere which reached a peak in 1926 There was then an appreciable decline during 1927 followed by a revival next year when the maximum of the cycle was reached. The southern maximum which was rather flat occurred in 1927. The spot minimum came six years after the maximum for both the hemispheres, in 1933 for the south and in 1934 for the north The southern minimum was the feebler of the two The interesting feature of prominence activity for this cycle is the two-peaked maximum for both the hemispheres These two peaks occur in the same years as the two peaks in the sunspot curve for the northern hemisphere However, the maximum prominence activity for the north was in 1926 and for the south in 1928 The prominence minimum for the northern hemisphere occurred two years before the corresponding sunspot minimum while for the southern hemisphere the epochs of sunspot and prominence minima coincided

1934-1944 —In this cycle the northern maximum for sunspots was reached in 1937 (three years after the previous minimum) while the southern maximum which was separated from the previous minimum by five years occurred in 1938 The fall of activity was steeper in the southern hemisphere than in the north, the minima being reached in 1943 and 1944 respectively. The peak of prominence activity for the northern hemisphere occurred a year after the sunspot maximum while for the southern hemisphere it occurred two years before sunspot maximum. The prominence activity, however, showed very little decrease in the southern hemisphere during the next two years The northern minimum for prominences came a year before and the southern minimum a year after the corresponding sunspot minima

1944-1950.—The published Greenwich sunspot areas are available only up to 1946 and hence the sunspot curves do not extend beyond that year However, according to Zürich relative sunspot numbers the peak of spot activity, taking both hemispheres together, occurred in 1947. The steep rise of activity from 1944 to 1947 surpassed the rate in the three previous cycles With a slight fall, the spot activity persisted at a high level during 1948 and 1949 after which a rapid decline set in. For the southern hemisphere prominence maximum was reached in 1947 In the northern hemisphere the activity remained at a steady level during 1946 and 1947 after which there was a fall followed by a rise to the maximum in 1949

Table III gives the mean daily areas of prominences and of sunspots for the northern and southern hemispheres and also the excess north minus south in each case. From this table we see that a northern excess or defect of sunspot activity is not always accompanied by a corresponding change of prominence activity. Such a correspondence exists only in 27 years out of 46 or in about 60 per cent. cases. The integrated activity for the entire period has been slightly more in the northern hemisphere than in the southern in respect of prominences as well as of sunspots. The percentage northern excess is about 4 per cent. for prominences and 12 per cent. for sunspots

TABLE—III.

Mean Daily Areas of Prominences and Sunspots in the Northern and Southern Hemispheres.

Year	Prominences (Mean daily Areas)			Sunspots (Mean daily Areas)		
	N	S	N—S	N	S	N—S
1905	2463	2149	+ 314	750	440	+ 310
06	2328	1657	+ 671	539	239	+ 300
07	1945	2238	— 293	488	593	— 105
08	2496	3083	— 587	316	381	— 65
09	2119	2058	+ 61	299	393	— 94
10	2055	2069	— 14	66	198	— 132
1911	1273	1636	— 363	17	47	— 30
12	946	1507	— 561	1	37	— 36
13	1075	1098	— 23	5	3	+ 2
14	1503	1597	— 94	99	53	+ 46
15	2610	2681	— 71	399	318	+ 81
16	2058	1702	+ 356	470	254	+ 216
17	2893	2273	+ 620	860	677	+ 183
18	1824	2385	— 561	609	509	+ 100
19	1727	1928	— 201	559	493	+ 66
20	2045	2262	— 217	208	410	— 202
1921	1853	2282	— 429	261	159	+ 102
22	1771	1461	+ 310	161	91	+ 70
23	2354	2009	+ 345	33	22	+ 11
24	2793	2051	+ 742	232	45	+ 187
25	3012	2600	+ 412	517	313	+ 204
26	4314	3234	+1080	663	599	+ 64
27	3507	2998	+ 509	379	679	— 300
28	3675	3444	+ 231	727	663	+ 64
29	2269	2682	— 413	656	586	+ 70
30	2112	1945	+ 67	286	230	+ 56
1931	2017	1922	+ 95	200	75	+ 125
32	1130	1020	+ 110	123	40	+ 83
33	1317	864	+ 453	86	2	+ 84
34	1832	1808	+ 24	44	74	— 30
35	2288	2569	— 281	205	419	— 214
36	3573	3463	+ 110	463	678	— 215
37	3437	3452	— 15	1317	757	+ 560
38	4384	3395	+ 989	899	1120	— 221
39	2409	2421	— 12	649	931	— 282
40	2296	2363	— 67	499	540	— 41
1941	2198	1591	+ 607	437	232	+ 205
42	1425	1782	— 357	252	171	+ 81
43	1089	1341	— 252	249	46	+ 203
44	1154	1285	— 131	42	83	— 41
45	1562	1739	— 177	121	309	— 188
46	2363	1905	+ 458	1127	690	+ 437
47	2363	3159	— 796			
48	2034	1900	+ 134			
49	2633	1643	+ 990			
1950	1506	1071	+ 435			
Total (1905-1950)	**102030**	**97722**	**+4308**			
Total (1905-1946)	**93494**	**89949**	**+3545**	**16313**	**14599**	**+1714**

6. Life History of the Low and High Latitude Prominences.

The manner in which prominence activity develops and progresses in the low and high latitude zones has been discussed by several workers. Although there is general agreement as regards the high latitude zones, there is some difference of opinion about the trend of activity in the low latitude or sunspot zones. According to Evershed the high latitude prominence zones begin to be active between 40° and 50° soon after sunspot minimum With increasing sunspot activity, the centres of high latitude prominence activity gradually move polewards until at the epoch of sunspot maximum there is a rapid rush towards the poles The high latitude prominence activity suddenly disappears soon after sunspot maximum The trend of activity in the low latitude zones is not so clear because of greater irregularities caused by the co-existence of several active centres From his observations Evershed concluded that in the sunspot zones prominence activity drifts more or less in phase with the sunspots from the higher towards lower latitudes and dies out near the equator at the time of sunspot minimum. Lockyer and Lockyer (1903) concluded from their study of the Italian prominence data for the period 1872 to 1901 that the low latitude prominence zones are centred round $\pm 24°$ where they appear shortly after sunspot minimum, wax in intensity with rising sunspot activity and finally recede and merge with the high latitude zones at about $\pm 40°$ before sunspot minimum.

The latitude of separation between the low and high latitude prominence zones is not quite clear cut. Bocchino and Barocas have taken this limit as $\pm 40°$—the boundaries of the sunspot zone. M and M^me^ D'Azambuja (1948) have remarked that while this limit is nearly correct on the mean, it varies with the phase of the sunspot cycle From their study of individual H-alpha dark markings they found that at the beginning of the sunspot cycle the majority of the important prominences of the equatorial zones whose low latitude extremities were at 30° extended without discontinuity upto 55° At the end of the sunspot cycle the extreme latitudes of such prominences lay between 10° and 35°. They have, therefore, ascribed a varying limit of demarcation ranging from 35° to 55° between the low and high latitude prominence zones, depending upon the phase of the sunspot cycle. For the discussion in the present paper we have taken a fixed limit of $\pm 40°$ between the two zones

An important finding of M and M^me^ D'Azambuja from measurements made on long-lived H-alpha dark markings over the period 1919 to 1930 is that on the average all prominences have a slow pole-ward drift in both the hemispheres The mean values for the pole-ward drift ($\Delta\varphi$) per solar rotation derived by them are.—

Lat. zone	0°-10°	11°-20°	21°-30°	31°-40°	41°-50°	51°-69°
$\Delta\varphi$	2° 3	1° 6	1°.3	1° 2	0° 9	0°.8

The rate of pole-ward drift was found to be at least twice as rapid in the ascending phase of the sunspot cycle than in the descending phase, particularly in the high latitude zone

Based on the above findings M and M^me^ D'Azambuja have advanced the view that all prominences originate in the sunspot zone and migrate towards higher latitudes. During the ascending phase of the sunspot cycle the centres of activity at which prominences originate are assumed to be round about $\pm 30°$ and the rate of pole-ward drift is high. For both these reasons prominences are able to reach high latitudes right up to the poles During the declining phase of the cycle the centres of formation are assumed to be round about $\pm 15°$ and the velocity of pole-ward migration is less. Hence prominence activity does not reach much beyond $\pm 50°$. (Attention has however been drawn by the French astronomers to the fact that in the majority of cases there is no direct correspondence between the manifestations of prominence activity in the low and high latitude zones) M and M^me^ D'Azambuja have emphasised that the observed general movement of prominences towards the poles at all latitudes indicates the probable existence of a meridional circulation on the sun which is postulated by certain solar theories.

While the results and conclusions of the French astronomers briefly outlined above are largely based on the study of long-lived hydrogen absorption markings (which are prominences seen in projection against the back-ground of the solar disc), it is interesting to see how far these are confirmed by the statistical study of limb prominences which is the scope of the present investigation. For this purpose the mean latitudes of the prominences of the low and high latitude zones were worked out in the following manner. If A_1, A_3, A_5 . . . . are the mean daily areas of the prominences for the five-degree zones 0°-5°, 5°-10°, 10°-15° . . . . . . then the mean latitudes of prominence activity for the two zones are :—

(*a*) Sunspot zone (0°-40°) .

$$\varphi_S = \left(\frac{A_1 + 3\ A_3 + 5\ A_5 + \quad\quad + 15\ A_{15}}{A_1 + A_3 + A_5 + \quad\quad + A_{15}} \right) \times 2^\circ 5$$

(*b*) High latitude zone (40°-90°) .

$$\varphi_H = \left(\frac{17\ A_{17} + 19\ A_{19} + \quad\quad + 35\ A_{35}}{A_{17} + A_{19} + \quad\quad + A_{35}} \right) \times 2^\circ 5$$

The values of φ_S and φ_H thus obtained are given in Table IV which also contains the mean daily prominence areas for the two zones. The mean daily sunspot areas and the mean heliographic latitudes of the spots extracted from the " Greenwich Photoheliographic Results" are also given in this table.

TABLE IV.

Mean Latitudes and Areas of Low and High Latitude Prominences and of Sunspots.

Year	NORTH. Sunspots		Prominences (0°-40°)		Prominences (40°-90°)		SOUTH Sunspots		Prominences (0°-40°)		Prominences (40°-90°)	
	Mean Area	Mean Lat °	Mean Area	Mean Lat °	Mean Area	Mean Lat °	Mean Area	Mean Lat °	Mean Area	Mean Lat °	Mean Area	Mean Lat °
1905	750	11 66	1518	20 6	945	59·0	440	15 55	1434	19 9	715	60 6
06	539	13·98	1521	22 5	807	60·8	239	14 01	1042	19·3	615	61·8
07	488	10 12	1319	21 3	626	53·2	593	13 77	1328	20 8	910	61 7
08	316	10·42	1878	18 6	618	52 9	381	10 34	2136	19·5	947	56 6
09	299	9 45	1432	20 2	687	51 6	393	9 92	1607	19 9	451	51 0
10	66	8 55	1267	19·6	788	53 6	198	11 18	1395	19·1	674	51·3
1911	17	7·89	879	22 6	394	52 2	47	5 99	963	23·4	673	49·5
12	1	20 53	625	23·2	321	51 6	37	7·78	830	24 2	677	49 8
13	5	24 81	573	24 4	502	51 7	3	20 08	597	25 6	501	49·7
14	99	21 11	847	23 7	656	50·4	53	23·06	816	24 8	781	49 2
15	379	17 95	1466	21 6	1144	53 4	318	19 75	1502	20 5	1179	50 3
16	470	15·14	1070	22·4	988	60·1	254	17 05	904	20·4	798	57 1
17	860	13 82	1529	20 2	1364	63·7	677	15 66	1315	19·7	958	62 2
18	609	11·97	1291	19 9	533	64·5	509	13 69	1411	21 5	974	68 0
19	559	9 85	1446	19 1	281	49 0	493	11 79	1711	20 8	217	48 0
20	208	11·31	1711	20 3	334	49·2	410	9 98	1898	19 9	364	48 5
1921	261	7·27	1349	21·8	504	46 7	159	8 92	1503	21 0	779	51·4
22	161	8 82	1065	20·9	706	49 0	91	6 62	875	23·6	586	47 8
23	33	13·88	1037	21 8	1317	51 3	22	17 32	940	22 6	1069	49 0
24	232	22 19	1242	23 0	1551	52 3	45	25 54	915	23 1	1136	51 5
25	517	20·70	1700	20·3	1312	55 4	313	19 37	1365	21 1	1235	52 6
26	663	19 27	2118	21·1	2196	62 9	599	17 98	1808	21 0	1426	61 5
27	379	17·75	1670	20·2	1837	62 7	679	13·54	1601	19 6	1397	67·0
28	727	11 93	2156	20 7	1519	62 0	663	15 23	2298	20 5	1146	56·8
29	656	10·73	1684	21 8	585	54 0	586	10 27	1907	19 6	775	54·8
30	286	10 60	1582	21 8	530	49 7	230	8 96	1706	19 1	239	50·6
1931	200	7·91	1417	21·8	600	48·5	75	9 39	1342	20·6	580	48 1
32	123	8 22	770	21 9	360	48 4	40	8 62	626	22 6	394	47 6
33	86	10 60	983	24 7	334	47 0	2	8 35	672	26 4	192	48·2
34	44	16·45	1114	24 4	718	42·0	74	28 09	1056	24 6	752	49 4
35	205	22 42	1309	21·0	979	48·6	419	23 72	1501	21·8	1068	50 8
36	463	19 36	2002	19 9	1571	53 6	678	21 02	2134	19·4	1329	57 4
37	1317	17 63	1777	19 7	1660	62·5	757	15 96	1953	19 4	1499	65 8
38	899	15 55	2478	21 0	1906	66·1	1120	14 17	2304	19 9	1091	51 2
39	649	14 64	1891	21 6	518	48 1	931	12 57	2037	20 1	384	49 4
40	499	11 65	1757	20·8	539	48·7	540	10 72	1941	21 1	422	49 1

18 DGO/53 2

TABLE IV—*contd.*

Mean Latitudes and Areas of Low and High Latitude Prominences and of Sunspots—*contd.*

NORTH. SOUTH.

Year	North Sunspots Mean Area	North Sunspots Mean Lat °	North Prominences (0°-40°) Mean Area	North Prominences (0°-40°) Mean Lat °	North Prominences (40°-90°) Mean Area	North Prominences (40°-90°) Mean Lat °	South Sunspots Mean Area	South Sunspots Mean Lat °	South Prominences (0°-40°) Mean Area	South Prominences (0°-40°) Mean Lat °	South Prominences (40°-90°) Mean Area	South Prominences (40°-90°) Mean Lat °
1941	437	11·13	1730	21·2	468	50·5	232	8·67	1375	19·9	216	47·9
42	252	9·32	1267	20·6	158	50·2	171	8·45	1397	21·2	385	47·3
43	249	9·01	909	24·0	180	47·6	46	15·87	838	20·6	503	49·2
44	42	19·00	758	28·0	396	46·1	83	22·81	688	23·6	597	48·6
45	121	20·13	867	21·9	695	49·5	309	20·26	934	22·1	805	51·0
46	1127	20·74	1332	21·6	1031	52·6	690	18·79	1120	21·0	785	52·3
47			1330	20·9	1033	59·2			1577	21·1	1582	58·6
48			1033	19·7	1001	64·1			1038	20·9	862	65·5
49			1655	21·5	978	57·6			1268	20·1	375	49·5
1950			1198	21·8	308	51·7			893	20·2	178	50·0
Total (1905-1950)			**63552**		**38478**				**62501**		**35221**	
Total (1905-1946)	**16313**		**58336**		**35158**		**14599**		**57725**		**32224**	

The mean latitudes of high and low latitude prominences and of the sunspots for the two hemispheres are graphically represented in Fig 5 Fig 6 represents the mean daily prominence areas for the low and high latitude zones and also the mean daily sunspot areas for the two hemispheres. In Fig 7 the peaks of prominence activity in the various five-degree zones have been plotted against the years The primary peaks are indicated by black dots and the secondary peaks by open circles. The history of prominence activity in the low and high latitude zones is clearly brought out by Figs. 3, 5, 6 and 7.

Prominence activity is comparatively short-lived above latitude 60°. In the polar zones from 75° to 90° its maximum phase is practically coincident with the epoch of sunspot maximum. The corresponding years of prominence and sunspot maxima are :—

Prominence maximum (75°-90°)	N	1906	1917-18	1926-27	1938	1948
	S	1907	1918	1927	1937	1948
Sunspot maximum	N	1905	1917	1928	1937	1947
	S	1907	1917	1927	1938	

The high latitude prominence activity can be traced back to latitude 40°-45° (*vide* Figs 3 and 7) where it begins to manifest itself about two years before sunspot minimum and becomes quite conspicuous immediately after the minimum of spot activity is reached. Fig. 7 indicates a progressive march of the peak of high latitude prominence activity from 40°-45° latitude belt to the poles during the ascending phase of the sunspot cycle From the trend of these peaks we may calculate the mean rate of pole-ward drift of the prominences of the high latitude zone A period of 3 to 4 years elapses between the first appearance of high latitude prominence activity near latitude 45° and the appearance of prominence activity at the poles Assuming a uniform rate of poleward drift we get a mean latitudinal movement of 11° to 15° per year or about 0°.8 to 1°.1 per solar rotation, —a value in fair agreement with that found by M and M^me^ D'Azambuja

A pole-ward drift of about 1° in 30 days was also found by Moss (1946) for high latitude prominences from a study of the Kodaikanal prominence data for the period 1905 to 1928.

A more critical examination of Figs. 3 and 7 indicates that the march of prominence activity from 70° to the poles is somewhat more rapid than the progress from 45° to 70°. There is hardly an interval of 1 year between the prominence maximum in the zone 65°-70° and the maximum activity in all the higher five-degree zones up to the poles The progress of activity from 45°-70° takes about 2 to 3 years We, therefore, get a mean pole-ward drift of 8°-12° per year (or 0° 6 to 0° 9 per solar rotation) from 45°-70° and 20° per year (or 1° 5 per solar rotation) from 70°-90° This indicates an accelerated pole-ward drift on approaching the poles The sudden appearance of prominence activity at the poles practically simultaneous with the epoch of sunspot maximum was designated by Evershed as " dash to the poles " of prominences.

In the low latitude or sunspot zone (0°-40°) no direct evidence for the pole-ward drift of the prominences can be adduced from the present study based on annual means Some interesting features are, however, brought out by Fig. 5 which depicts the variation in the mean latitudes of low and high latitude prominences and of sunspots. As is well known, the mean latitude of sunspots is lowest just before the minimum of the cycle At the minimum epoch spots of the new cycle already begin to appear at the higher latitudes between 30° and 40° so that there is a steep increase in the mean latitude of the spots, the maximum being reached shortly after the epoch of sunspot minimum The mean latitude of sunspots ranges from about 7° to 28°. The interval from minimum to maximum is seen to vary from 1 to 3 years while the corresponding interval from maximum to minimum varies from 8 to 9 years during the sunspot cycles covered by the present study.

When we consider the manner in which the mean latitude of the prominences of the sunspot zone varies, we find that the range of variation is much less than that of sunspots. The mean latitude of low latitude prominences varies from 19° to 26° which is only about a third of the range for sunspots. For most of the time the mean prominence activity is centred round about 20° which is the mean latitude of the sunspot zone. The maximum mean latitude for low latitude prominences is reached generally about a year ahead of that for sunspots, that is almost simultaneous with sunspot minimum The mean latitude of low latitude prominences attains a minimum at or near the epoch of sunspot maximum. In this connection it is interesting to see how the prominence activity in the five-degree belts of the low latitude zone varies in the course of the sunspot cycles. Examination of Figs. 3*a* and 3*b* shows that the variations are generally in phase with the sunspot cycle but the *amplitude of variation becomes less as we approach the limits of the sunspot zone* This accounts for the highest mean latitude of low latitude prominence activity at the time of sunspot minimum.

M and Mme D'Azambuja explain the lack of prominence activity beyond latitude ±50° at the declining phase of the sunspot cycle by assuming the centre of origin of prominences at about latitude ±15° and showing by rough calculation that the pole-ward drift in about 2½ years will not take such prominences beyond ±50°. We should, however, consider the fact that the origin of the prominences in the sunspot zone and their pole-ward migration take place continuously throughout the sunspot cycle in such a way that *prominence activity is always present at the boundaries of the sunspot zone where it undergoes the least variation in the course of the sunspot cycle*. Why then should there be no activity beyond 55° at the declining phase of the sunspot cycle, a fact so clearly brought out by Figs 3*a* and 3*b*. If we assume with M and Mme D'Azambuja that the high latitude prominences are transported from the sunspot zone by a meridional circulation, then the velocity of this circulation probably decreases rapidly beyond the sunspot zone and becomes vanishingly small at latitude ±55°. That is, the meridional circulation undergoes a cyclic variation in phase with the sunspot cycle. The work of the French astronomers has already furnished some evidence in this direction but as they have remarked it is necessary to undertake new measurements on the pole-ward drift of prominences in the sunspot and high latitude zones to confirm their results and establish them more precisely.

The mean latitude of high latitude prominences varies from about 42° to 68° It reaches the lowest value approximately when the low latitude prominences have their highest mean latitude, that is, at the epoch of sunspot minimum The highest mean latitude of high latitude prominences is reached almost simultaneous with the epoch of sunspot maximum The maximum mean latitude of sunspots and the corresponding latitude of high latitude prominences are separated by about 40° and a time interval of 3 to 4 years from which again we may calculate a mean pole-ward drift of 10° to 13° per year or about 1° per solar rotation for prominences of the high latitude zone if they have their origin in the sunspot zone

The comparison of the prominence areas for the low and high latitude zones with the sunspot areas (Fig 6) brings out some interesting features. For the sunspot zones, the minimum of prominence activity occurs in the same year or a year before the minimum of spot activity. The prominence maxima are characterised by multiple peaks in both the hemispheres, the peaks being generally double and at times triple indicating two or three outbursts of prominence activity The low latitude prominence activity corresponding to the sunspot cycle of 1913-23 presents some extraordinary features The northern hemisphere shows three peaks and the southern two. The highest prominence activity in both the hemispheres occurred in 1920, three years after the sunspot maximum—by which time the high latitude prominences had already attained a minimum For the next three cycles the low latitude prominence maxima occurred either simultaneously with or a year after the sunspot maxima A retardation of prominences over sunspots is thus indicated If we now consider the high latitude prominences we find that the minimum is reached 1 to 4 years before the minimum of sunspot activity while the maximum is reached in the same year as the sunspot maximum or one to two years before it Thus, generally speaking, the indications are that in the sunspot zone prominence activity slightly lags behind spot activity while in the high latitude zone prominence activity leads over the spot activity

M and M^me D'Azambuja (1948) have investigated the correlation between prominences and sunspots Their researches have revealed that an " impulse " of spot activity is generally followed by an " impulse " of prominence activity in the sunspot zone after 3 or 4 solar rotations A correlation of this nature should be brought out by a comparative study of the monthly means of prominence and sunspot areas. It is hoped to go into this question at a future date

7. Mean Daily Heights, Extents and Numbers of Prominences.

At Kodaikanal the height of a prominence is reckoned as the elevation above the chromosphere of the highest point of the prominence. The extent of a prominence is reckoned as the number of degrees along the solar limb for which the prominence appears continuous All prominences observed daily are tabulated in this manner and the mean heights and extents are worked out for each month, each quarter and each half year The mean height (in seconds of arc) and the mean extent (in degrees along the solar limb) of the prominences for the period 1915 to 1950* are listed in Table V and represented diagrammatically in Fig 8 In this figure, the mean extent of base is represented along the abscissa and the height along the ordinate. The interval between the marks corresponding to adjacent years represents an extent of base of 10° Thus the horizontal extent or thickness of each rectangular block is proportional to the extent of base while its vertical extent is proportional to the mean height of the prominences for the corresponding year. Both these parameters undergo variations generally in unison with the sunspot cycle The mean extent of base varies from 3° to 7° while the mean height varies between 30 and 50 seconds It will be seen from Fig 8 that the mean height is a maximum for the latest sunspot cycle while the mean extent of base is a maximum for the cycle just previous to it. The reason for the lower prominence activity during the latest cycle (*vide* Section 10) is to be attributed to the smaller " number " of prominences during this cycle as compared with the two previous cycles The mean daily prominence numbers from the Kodaikanal records which are also given in Table V indicate that this was actually the case For reasons explained in Section 2, these numbers do not, however, constitute a reliable index of prominence activity

*In the Kodaikanal records mean heights of prominences are available from 1904 and mean extents from 1912 onwards A scrutiny of the data, however, shows that the data prior to 1915 are not quite comparable with the subsequent data. Hence, these have not been taken into consideration in the present discussion.

TABLE—V.
Mean Daily Heights, Extents and Numbers of Prominences.

Year	Height (Seconds of Arc)	Extent (Degrees)	Number	Year	Height (Seconds of Arc)	Extent (Degrees)	Number
1915	36 8	3 50	18 68	**1933**	39 3	4 47	8 72
16	35 3	2 94	18 97	**34**	34 4	4 43	12 96
17	38 1	3 66	19 32	**35**	37 2	5 61	13 58
18	33 2	3 52	17 05	**36**	42 4	7 41	15 02
19	31 7	3 14	12 48	**37**	42·9	7 92	15 37
20	31 3	3 19	14 55	**38**	43 7	7 60	14 84
				39	38 9	6 34	13 06
1921	31 8	3 52	14 09	**40**	37 2	5 77	13 52
22	33 9	3 92	10 70				
23	33 7	3 71	15 25	**1941**	33·7	4 71	12 64
24	35 5	4 24	14 74	**42**	34 4	4 15	10 88
25	37 7	4 65	16 44	**43**	35 4	3 90	8 98
26	40 6	5 69	17 84	**44**	41 5	5 54	7 40
27	37 1	5 39	19 19	**45**	46 5	6·26	9 61
28	42·6	6 85	18 35	**46**	51 7	6 78	10 74
29	36 9	6·30	13 75	**47**	48·0	5 49	12 40
30	32 8	5 77	11 67	**48**	43 4	4 55	12·09
				49	45 3	4·74	10 23
1931	31 8	5 22	12 91				
32	32 2	3 76	9 58	**1950**	40 3	3 98	7 64

8. Metallic Prominences.

Hydrogen, helium and singly ionised calcium are the main constituents of the majority of solar prominences and prominence spectra invariably exhibit the emission lines belonging to the Balmer series of hydrogen, the D_3 line of helium and the H and K lines of Ca^{+} In fact, hydrogen and Ca^{+} are so closely interlinked in prominences that spectroheliograms taken in the H-alpha and K lines indicate that quiescent prominences have no essential differences in form in these two elements as has been shown by Dr. Royds (1932) and others. Dr Royds also found that even in the case of eruptive prominences the similarity of form persists and both the elements partake equally in the motion

It is well known from observations of flash spectra that the three elements which are most abundant in prominences are also those which rise to greater heights in the chromosphere compared with other elements According to Mitchell (1935) the H and K lines of Ca^{+} can be traced upto a height of 14,000 km. in the chromosphere, the H-alpha line upto 12,000 kms, H-beta upto 8,500 kms. and H-gamma and H-delta upto 8,000 kms. Next in order of height come helium (7,500 kms), Mg (7,000 kms), Ti^{+}, Sc^{+}, Sr^{+} (6,000 kms), neutral Ca (5,000 kms.), Al (2,000 kms) and Fe, Ti, V, Cr, Sr, Ni, Co, Mn (1,500 to 3,000 kms) Several lines belonging to the low-lying elements, neutral or ionised, are found in the spectra of prominences during total eclipses, but are ordinarily not observed Occasionally prominences do appear in which emission lines of one or more of the elements Mg, Na, Fe, Fe^{+}, Cr etc. appear conspicuously even outside an eclipse Such prominences are generally small, intense, very active and short-lived and hence they form a class by themselves In the Kodaikanal records they are classified and tabulated under the heading " Metallic Prominences ". The emission lines which are generally observed in such prominences in visual observations with the prominence spectroscope are given in the following table :—

λ	Element	λ	Element
4923 92	Fe^{+}	5275·99	Fe^{+}, Cr
5015 68	He	5316 61	Fe^{+}
5018 43	Fe^{+}	5362·86	Fe^{+}
b_4, b_3, b_2, b_1	Mg, Fe, Fe^{+}	D_2, D_1	Na
5234 62	Fe^{+}	6678 10	He, Fe
5275 25	Cr	7065·20	He

In the great majority of them the D lines of sodium, the b lines of magnesium and the enhanced lines of iron appear prominently

Table VI (Appendix) gives the frequency distribution in five-degree zones of all metallic prominences observed at Kodaikanal during the period 1904 to 1950. It is based on visual observations of the solar limb made with the prominence spectroscope generally between 8 A M and 10 A M on all clear days A casual examination of the frequency table reveals the close connection between metallic prominences and sunspots. They are most abundant in the sunspot zone and the frequency pattern resembles the well known " butterfly diagram " of Maunder The maximum frequency of metallic prominences in both the hemispheres occurs in the latitude belt 10°-20° Such prominences are often observed in the vicinity of active sunspots when they are just appearing at the east limb or disappearing at the west limb. Some of them at least may be manifestations of flares occurring at the limb

Are metallic prominences exclusively confined to the sunspot zone ? We see from Table VI that this is not the case although their frequency of occurrence falls off very rapidly outside the confines of the sunspot zone. In this respect we find that the observations of the earlier years from 1904 to 1920 indicate a somewhat greater frequency in the higher latitudes as compared with the subsequent period Hardly any metallic prominences have been recorded above latitude 60° since 1920 while we find that prior to this year such prominences have been observed upto latitude 85° Evershed analysed the metallic prominences observed at Kodaikanal during the period 1904 to 1914 and found that about 15 per cent of them occurred above latitude 40°. From the percentage frequencies for different five-degree zones given at the end of Table VI we see that about 95 per cent of metallic prominences were observed within the sunspot zone during the period 1904 to 1950.

9. Comparison of Prominence Activity on the East and West Limbs.

Since the publication of Mrs. Maunder's well known paper (1907) in which she showed that " there is a well-marked and steady preponderance of the eastern half of the sun's disc over the western half both as regards the areas of the spots and as to the numbers of the separate groups ", several investigators have sought to find if there is a similar asymmetry in the case of other solar phenomena. Towards the end of her paper Mrs Maunder showed that the unexpected asymmetry revealed by her analysis of sunspots for the period 1889-1901 existed also in the case of prominences She found that the Italian prominence observations for the period 1882 to 1904 showed a steady eastern excess of prominences for all the years The eastern excess of sunspots and prominences was interpreted as an apparent extinguishing effect of the earth on these two forms of solar phenomena.

At Kodaikanal Evershed (1912) examined the distribution of prominences on the east and west limbs for the period 1894 to 1912 and found that there was a systematic eastern preponderance of prominence numbers. In the case of prominence areas the excess was less marked than for numbers and was often in favour of the west limb. Following a different method of analysis Evershed and Chidambara Iyer (1921) were led to a conclusion " apparently opposed to the suggestion that the earth tends to extinguish a prominence in its passage across the visible disc ".

Royds and Sitarama Ayyar (1913) applied the periodogram method of Schuster for interpreting the eastern excess of prominences for the years 1904-1912 discussed by Evershed. They were led to the conclusion that the excess cannot be interpreted as due to planetary influences and that an effect due to the earth is improbable Das and Narayan (1940) made a statistical study of solar prominences observed at Kodaikanal during the period 1913-37. They found that the maximum mean daily area of prominences occurred in January and the minimum in July. This was interpreted as evidence of the existence of a tide-raising influence of the earth on the sun Recently a number of papers on " Solar Asymmetry " and " Planetary Influences on the Sun" have appeared in the *Bulletin of the Central Astronomical Institute of Czechoslovakia* by Link and his co-workers (1951, 1952 and 1953). In view of the long-standing nature of this problem we have felt it worthwhile to consider in some detail the East-West distribution of prominences during the period covered by the present study.

Table VII gives the mean daily prominence areas for the east and west limbs year by year from 1905 to 1950 The last column of this table gives the eastern excess E minus W. We see that there has been an eastern excess of prominences only in 11 years out of 41. Out of the 20 years from 1931 to 1950 prominence activity has been more pronounced on the west limb during 18 years. For the entire period of 41 years prominence activity on the west limb has been 3·5 per cent greater than that on the east limb For the period 1931 to 1950 the corresponding value is 5 5 per cent The largest western excess of 17·2 per cent occurred in 1950. For the years 1920, 1926, 1931, 1942, 1945 and 1949 the western excess amounted to over 14 per cent. We thus see that prominence activity, judged by profile area of prominences, has been more at the west limb of the sun. The western excess is more pronounced since 1920 than in previous years.

TABLE—VII.

East-West Distribution of Prominence Areas.

Year	East	West	E—W
1905	2390	2222	+168
06	2026	1959	+ 67
07			
08			
09			
10			
1911			
12	1187	1266	— 79
13	1116	1057	+ 59
14	1594	1506	+ 88
15	2598	2693	— 95
16	1889	1871	+ 18
17	2565	2601	— 36
18	2081	2128	— 47
19	1851	1804	+ 47
20	2005	2302	—297
1921	2054	2081	— 27
22	1609	1623	— 14
23	2095	2268	—173
24	2490	2354	+136
25	2727	2885	—158
26	3514	4034	—520
27	3178	3327	—149
28	3598	3521	+ 77
29	2440	2511	— 71
30	2111	1946	+165
1931	1837	2102	—265
32	1018	1132	—114
33	1032	1149	—117
34	1919	1721	+198
35	2318	2539	—221
36	3500	3536	— 36
37	3502	3387	+115
38	3871	3908	— 37
39	2371	2459	— 88
40	2322	2337	— 15
1941	1858	1931	— 73
42	1563	1644	— 81
43	1130	1300	—170
44	1175	1264	— 89
45	1542	1759	—217
46	2047	2221	—174
47	2658	2864	—206
48	1918	2016	— 98
49	1975	2301	—326
1950	1181	1393	—209
Total	**87858**	**90922**	**—3064**

For a closer study of the east-west asymmetry of prominence areas we consider the northern and southern hemispheres separately. Tables VIII (*a*) and (*b*) give the east-west distribution of mean

TABLE—VIII(*a*).

East-West Distribution of Prominence Areas (North Hemisphere).

Year	NE			NW			NE—NW		
	a	b	c=a+b	a′	b′	c′=a′+b′			
	0°-40°	40°-90°	0°-90°	0°-40°	40°-90°	0°-90°	a-a′	b-b′	c-c′
1905	794	462	1256	724	483	1207	+ 70	—21	+ 49
06	787	433	1220	734	374	1108	+ 53	+59	+112
1912	283	155	438	342	166	508	— 59	—11	— 70
13	293	257	550	280	245	525	+ 13	+12	+ 25
14	487	336	823	360	320	680	+127	+16	+143
15	767	540	1307	699	604	1303	+ 68	—64	+ 4
16	483	519	1002	587	469	1056	—104	+50	— 54
17	796	646	1442	733	718	1451	+ 63	—72	— 9

TABLE—VIII(*a*)—*contd.*
East-West Distribution of prominence Areas (North Hemisphere)—*contd.*

Yeaı	NE			NW			NE—NW		
	a	b	c=a+b	a′	b′	c′=a′+b′			
	0°-40°	40°-90°	0°90°	0°-40°	40°-90°	0°-90°	a—a′	b—b′	c—c′
1918	650	298	948	641	235	876	+ 9	+ 63	+ 72
19	619	143	762	827	138	965	—208	+ 5	—203
20	791	181	972	920	153	1073	—129	+ 28	—101
1921	680	250	930	669	251	923	+ 11	— 4	+ 7
22	524	354	878	541	352	893	— 17	+ 2	— 15
23	437	669	1106	600	648	1248	—163	+ 21	—142
24	669	789	1458	573	762	1335	+ 96	+ 27	+123
25	715	671	1386	985	641	1626	—270	+ 30	—240
26	932	1082	2014	1186	1114	2300	—254	— 32	—286
27	824	899	1723	846	938	1784	— 22	— 39	— 61
28	1061	745	1806	1095	774	1869	— 34	— 29	— 63
29	840	278	1118	844	307	1151	— 4	— 29	— 33
30	779	266	1045	803	264	1067	— 24	+ 2	— 22
1931	600	298	898	817	302	1119	—217	— 4	—221
32	347	183	530	423	177	600	— 76	+ 6	— 70
33	429	179	608	554	155	709	—125	+ 24	—101
34	583	371	954	531	347	878	+ 52	+ 24	+ 76
35	622	499	1121	687	480	1167	— 65	+ 19	— 46
36	961	791	1752	1041	780	1821	— 80	+ 11	— 69
37	798	844	1642	979	816	1795	—181	+ 28	—153
38	1227	933	2160	1251	973	2224	— 24	— 40	— 64
39	880	254	1134	1011	264	1275	—131	— 10	—141
40	808	276	1084	949	263	1212	—141	+ 13	—128
1941	800	227	1027	930	241	1171	—130	— 14	—144
42	622	61	683	645	97	742	— 23	— 36	— 59
43	418	94	512	491	86	577	— 73	+ 8	— 65
44	375	162	537	383	234	617	— 8	— 72	— 80
45	377	308	685	490	387	877	—113	— 79	—192
46	639	471	1110	693	560	1253	— 54	— 89	—143
47	649	555	1204	681	478	1159	— 32	+ 77	+ 45
48	494	522	1016	539	479	1018	— 45	+ 43	— 2
49	717	437	1154	938	541	1479	—221	—104	—325
1950	536	186	722	662	122	784	—126	+ 64	— 62
Total	27093	17624	44717	29684	17741	47425	—2591	—117	—2708

TABLE VIII(*b*).
East-West Distribution of Prominence Areas (South Hemisphere).

Year	SE			SW			SE—SW		
	a	b	c=a+b	a′	b′	c′=a′+b′			
	0°-40°	40°-90°	0°-90°	0°-40°	40°-90°	0°-90°	a—a′	b—b′	c—c′
1905	760	374	1134	674	341	1015	+ 86	+ 33	+119
06	527	279	806	515	336	851	+ 12	— 57	— 45
1912	421	328	749	409	349	758	+ 12	— 21	— 9
13	307	259	566	290	242	532	+ 17	+ 17	+ 34
14	388	383	771	428	398	826	— 40	— 15	— 55
15	756	535	1291	746	644	1390	+ 10	—109	— 99
16	481	406	887	423	392	815	+ 58	+ 14	+ 72
17	649	474	1123	666	484	1150	— 17	— 10	— 27
18	713	420	1133	698	554	1252	+ 15	—134	—119
19	963	126	1089	748	91	839	+215	+ 35	+250
20	856	177	1033	1042	187	1229	—186	— 10	—196

TABLE VIII(*b*)—*contd.*

East-West Distribution of Prominence Areas (South Hemisphere)- *contd.*

	SE			SW			SE—SW		
	a	b	c=a+b	a′	b′	c′=a′+b′	a-a′	b′—b′	c′-c′
	0°-40°	40°-90°	0°-90°	0°-90°	40°-90°	0°-90°			
1921	729	395	1124	774	381	1158	— 45	+ 11	— 34
22	397	334	731	478	252	730	— 81	+ 82	+ 1
23	454	535	989	486	534	1020	— 32	+ 1	— 31
24	456	576	1032	459	560	1019	— 3	+ 16	+ 13
25	620	721	1341	745	514	1259	—125	+206	+ 82
26	849	651	1500	959	775	1734	—110	—124	—234
27	795	660	1455	806	737	1543	— 11	— 77	— 88
28	1198	594	1792	1100	552	1652	+ 98	+ 42	+140
29	944	378	1322	963	397	1360	— 19	— 19	— 38
30	952	114	1066	754	125	879	+198	— 11	+187
1931	634	305	939	708	275	953	— 74	+ 30	— 44
32	284	204	488	342	190	532	— 58	+ 14	— 44
33	333	91	424	339	101	440	— 6	— 10	— 16
34	543	422	965	513	330	843	+ 30	+ 92	+122
35	751	446	1197	750	622	1372	+ 1	—176	—175
36	1084	664	1748	1050	665	1715	+ 34	— 1	+ 33
37	1022	838	1860	931	661	1592	+ 91	+177	+268
38	1121	590	1711	1183	501	1684	— 62	+ 89	+ 27
39	1023	214	1237	1014	170	1184	+ 9	+ 44	+ 53
40	1036	202	1238	905	220	1125	+131	— 18	+113
1941	713	118	831	662	98	760	+ 51	+ 20	+ 71
42	694	186	880	703	199	902	— 9	— 13	— 22
43	412	206	618	426	297	723	— 14	— 91	—105
44	320	318	638	368	279	647	— 48	+ 39	— 9
45	448	409	857	486	396	882	— 38	+ 13	— 25
46	537	400	937	583	385	968	— 46	+ 15	— 31
47	783	671	1454	794	911	1705	— 11	—240	—251
48	516	386	902	522	476	998	— 6	— 90	— 96
49	608	213	821	660	162	822	— 52	+ 51	— 1
1950	405	57	462	488	121	609	— 83	— 64	—147
Total	**27482**	**15659**	**43141**	**27590**	**15907**	**43497**	**—108**	**—248**	**—356**

daily prominence areas for the two hemishperes. The data are given separately for the sunspot zones and for the high latitude zones. An examination of these tables reveals the following facts :—

(*a*) *Sunspot zone* (0°—40°)

(i) For the entire period of 41 years prominence activity at the east limb has been slightly more in the southern hemisphere than in the north, the magnitude of the excess $\frac{S-N}{N}$ being 1·44 per cent. At the west limb, however, prominence activity has been appreciably less in the southern hemisphere compared with the north, the deficit $\frac{S-N}{N}$ being 7·05 per cent.

(ii) There has been western excess of prominences in both the hemispheres, the magnitude of the excess $\frac{W-E}{E}$ being 9·56 per cent. for the north hemisphere, and 0·39 per cent for the south Thus the hemisphere with smaller total prominence area at the east limb shows larger western excess.

(iii) There has been western excess of prominence activity for 31 years in the northern hemisphere and for 24 years in the southern hemisphere during the total period of 41 years.

(*b*) *High Latitude Zone* (40°—90°).

(i) On the whole, prominence activity at the east and west limbs has been less in the southern hemishpere, the deficit $\frac{S-N}{N}$ being 11·14 per cent. and 10·33 per cent. respectively for the two limbs.

(ii) There has been western excess of prominence activity in both the hemispheres, the magnitude of $\frac{W-E}{E}$ being 0 66 per cent for the north and 1·58 per cent for the south Again we find that the hemisphere with smaller total prominence area at the east limb shows larger western excess.

(iii) There has been western excess of prominence activity for 18 years in the northern hemisphere and for 20 years in the southern hemisphere during the total period of 41 years

Judged by profile areas, the aggregate prominence activity for the high latitude zones has been 60 per cent of that for the sunspot zones.

The main feature brought out by the above analysis is that during the period covered by the present study the east-west asymmetry has been more conspicuous for the sunspot zone than for the high latitude zone. The asymmetry has been most pronounced for the sunspot zone of the northern hemisphere despite the fact that the total prominence area at the east limb of this zone has been less compared with the southern hemisphere

Indeed over 85 per cent of the total observed western excess for the sun as a whole arises from the sunspot zone of the northern hemisphere. Since neither the observational technique nor the method of evaluation of prominence areas from the photographs gives a preferential bias to either hemisphere, the observed "asymmetry" between the two hemisphere as brought out by the east-west distribution of prominence areas appears to be an intrinsic feature of prominence activity during the period under consideration It does not seem possible to explain the observed facts on the basis of terrestrial or planetary influences on the sun.

In this connection a recent study of the eastern excess of sunspots by Romaña and Torroja (1948) appears to be of interest. From one of the tables presented in their paper it is seen that the eastern excess of sunspots has been much less conspicuous since 1930 than during the half century prior to this year. As a matter of fact, the integrated spot activity for the period 1930 to 1947 shows a western excess. It is also seen that the eastern excess of sunspots was particularly well marked in the solar cycle investigated by Mrs. Maunder. This change in trend has been interpreted by them as a slow periodic variation of the inclination of the axes of sunspots with an amplitude of 3° around a mean position of 1° 15′ towards the west. From a short note by M. Hotinli (1952) in the *Publications of the Istanbul University Observatory*, it is seen that during each of the years 1948, 1949 and 1950 more spots were observed on the western half of the sun's disc than on its eastern half, the western excess being about 6 to 7 per cent.

10. Solar Activity during the Latest Sunspot Cycle.

It is well known that judged by spot activity the latest solar cycle which attained its maximum in 1947 is one of the most active on record. This cycle has also the unique distinction of having been characterised by some of the biggest spot groups ever observed. But even a casual examination of Figs. 3 and 4 which illustrate this paper shows that prominence activity has been less pronounced during the latest solar cycle as compared with the two previous ones with maxima during 1937 and 1928. In this connection it is worth recalling that Behr and Sidentopf (1952) and Kleczek (1953) have found from their analyses of solar flare data that flare activity has also been less during the latest cycle as compared with the previous one. These facts tend to confirm the result which is repeatedly brought home by solar researches that the broad correlation between sunspots and other solar phenomena does not mean that there is one to one correspondence among them and that no single factor can furnish an adequate measure of solar activity.

11. Acknowledgement.

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SUMMARY.

The paper contains a discussion of the results of solar prominence observations made at Kodaikanal during the first half of this century The first two sections give an account of the observational procedure and the nature of the available data on which the rest of the paper is based The distribution of mean daily profile areas of prominences according to heliographic latitude for the period 1905-1950 is given in Table II (Appendix) The variation of prominence activity in the course of the sunspot cycle for the northern and southern hemispheres is illustrated by Figs. 3(*a*) and 3(*b*). Comparison of prominence and sunspot activities in the two hemispheres shows that a northern excess of spot activity is not always accompanied by a corresponding excess of prominence activity The life history of the low and high latitude prominence zones is considered A mean poleward drift of about 1° per solar rotation has been found for the prominences of the high latitude zone in fair agreement with the value found by M and M^me^ D' Azambuja by measurements made on long-lived H-alpha dark markings. There is some evidence of an accelerated poleward drift as the prominences approach the poles. The mean heliographic latitudes and the mean daily areas have been worked out for the prominences of the sunspot and high latitude zones and compared with the mean latitudes and mean daily areas of sunspots. Generally speaking, prominence activity in the sunspot zone attains its highest mean latitude (about 26°) at the time of sunspot minimum and the loswet mean latitude (about 19°) at the time of spot maximum. High latitude prominences, on the other hand, attain their lowest mean latitude (about 42°) at sunspot minimum and highest mean latitude (about 68°) near spot maximum. Prominence activity undergoes the least variation at the boundaries of the sunspot zone (±40°) during the course of the solar cycle. The highest prominence activity occurs near ±50° during the ascending phase of the sunspot cycle.

The mean daily heights, extents and numbers of prominences undergo variations more or less in unison with the sunspot cycle. The frequency of "metallic prominences" during 1904 to 1950 indicates their close association with sunspots , 95 per cent of such prominences were observed within the sunspot zone. Comparison of prominence activity on the east and west limbs indicates a western preponderance, the western excess being most pronounced in the sunspot zone of the northern hemisphere. It is found that the aggregate prominence activity has been less during the latest solar cycle as compared with the previous two cycles despite the fact that judged by spot activity the latest cycle is one of the highest on record.

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KODAIKANAL OBSERVATORY,
NOVEMBER, 1953.

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APPEN

TABLE

Comparison of Prominence Areas

NORTH.

Year	Total	85—90	80—85	75—80	70—75	65—70	60—65	55—60	50—55	45—50	40—45	35—40	30—35	25—30	20—25	15—20	10—15	5—10	0—5
1949 A	2633	35	47	55	52	91	103	115	101	148	231	229	240	250	225	179	187	183	153
N	5990	12	163	178	160	246	339	261	345	279	446	369	461	425	532	371	480	454	469
N′	10992	151	228	217	252	422	466	526	507	594	707	814	867	891	892	892	880	861	825
1950 A	1506	0	5	8	10	29	18	18	32	83	105	139	209	224	143	120	99	138	126
N	4173	3	27	45	54	89	83	74	128	258	331	241	500	456	394	328	376	372	414
N′	6984	6	51	65	68	131	113	116	229	407	482	572	765	791	649	643	601	690	605

TABLE

Percentage

NORTH.

Year	Total	85—90	80—85	75—80	70—75	65—70	60—65	55—60	50—55	45—50	40—45	35—40	30—35	25—30	20—25	15—20	10—15	5—10	0—5
1949 A		1 3	1 8	2 1	2 0	3 5	3 9	4 4	3·8	5 6	8 8	8 7	9 1	9 8	8 5	6 8	7 1	6 9	6 1
N		0 2	2 7	3 0	2 7	4 1	5 7	4 4	5 7	4 7	7 4	6 2	7 8	7 1	8 9	6 2	8 2	7 6	7 8
N′		1 4	2·1	2 0	2 3	3·8	4·2	4 8	4 6	5 4	6 4	7·4	7·8	8 1	8 1	8·1	8 0	7 8	7·5
1950 A	.	..	0 3	0 5	0·7	1 6	1 2	1 2	2 1	5 5	7·0	9·2	13 9	14 9	9·5	8 0	6 6	9 1	8 4
N	.		0 6	1 1	1 3	2 1	2 0	1 8	3 1	6·1	7 9	5 8	12 0	10 9	9 4	7 9	9 0	8 9	9·9
N′		0 1	0 7	0 9	1 0	1 9	1 6	1 7	3 3	5 9	6 9	8 2	11 0	11·3	9 3	9 2	8 6	9 9	8·7

TABLE

Distribution of Prominence Areas According

NORTH.

Year (No of days)	Total	85—90	80—85	75—80	70—75	65—70	60—65	55—60	50—55	45—50	40—45	35—40	30—35	25—30	20—25	15—20	10—15	5—10	0—5
1905 NE	1256	7	7	22	56	80	65	30	44	64	81	67	96	127	127	101	107	90	79
(284) **NW**	1207	7	6	15	59	86	76	24	61	73	76	98	97	94	113	96	93	65	68
N	**2463**	**14**	**13**	**37**	**115**	**172**	**141**	**54**	**105**	**137**	**157**	**165**	**193**	**221**	**240**	**197**	**200**	**155**	**147**
1906 **NE**	1220	24	36	52	58	19	13	25	57	60	80	86	117	135	149	112	85	58	45
(253) **NW**	1108	19	25	40	47	19	9	22	56	74	63	71	134	148	112	87	72	68	42
N	**2328**	**43**	**61**	**92**	**105**	**38**	**22**	**47**	**113**	**143**	**143**	**157**	**251**	**283**	**261**	**199**	**157**	**126**	**87**
1907 NE											.					.			.
(296) **NW**	..																	.	.
N	1915	**3**	**4**	**5**	**8**	**15**	**60**	**133**	**191**	**110**	**97**	**145**	**170**	**238**	**209**	**164**	**153**	**123**	**117**
1908 NE		.																	
(298) **NW**					.														
N	2466	**3**	**6**	**8**	**12**	**26**	**65**	**97**	**115**	**121**	**160**	**199**	**265**	**265**	**212**	**207**	**264**	**243**	**223**

DIX.

I (*a*).

and Prominence Numbers.

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year
154	157	153	164	176	137	170	157	140	101	45	50	27	10	2	1	0	0	1643	A 1949
416	333	446	315	424	294	448	362	312	249	199	167	116	28	28	6	9	0	4153	N
718	707	749	659	689	620	689	645	591	430	258	243	169	46	15	15	9	3	7264	N′
116	104	90	109	148	131	104	91	69	34	23	36	10	3	2	0	1	0	1071	A 1950
417	247	310	292	464	325	283	259	253	158	146	143	45	9	33	6	12	3	3405	N
574	515	491	552	657	607	506	449	342	227	170	202	98	21	27	6	15	3	5461	N′

I (*b*).

Frequencies.

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year
9 4	9 6	9·3	10 0	10 8	8 4	10 4	9 6	8 5	6·2	2 7	3 1	1 6	0 6	0 1				.	A 1949
10 0	8 1	10 8	7 6	10 3	7 1	10 8	8 8	7·5	6 0	4 8	4 0	2 8	0 5	0 5	0 1	0 2			N
9·8	9 7	10 2	9 0	9 4	8 5	9·4	8 8	8 1	6 0	3·5	3 3	2 3	0 6	0 2	0 2	0 1			N′
10 8	9 7	8 4	10 3	13 8	12 3	9·6	8 5	6 4	3 2	2 1	3·4	0·9	0 3	0 2	0·1	0·1			A 1950
12 3	7 3	9 1	8 6	13 6	0 5	8 3	7 6	7 4	4 6	4 3	4 2	1 3	0 3	1 0	0 2	0 4	0 1	..	N
10 5	9 4	9 0	10 1	12 0	11 1	9 3	8 2	6 3	4 1	3·1	3 9	1 8	0·4	0·5	0 1	0 3			N′

II.

to Heliographic Latitudes.

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year (No of days)
77	84	87	109	142	121	77	63	72	44	27	17	53	70	43	19	18	11	1134	**SE 1905**
79	103	83	58	97	102	87	65	56	33	22	19	59	85	35	12	9	11	1015	**SW** (*284*)
156	**187**	**170**	**167**	**239**	**223**	**164**	**128**	**128**	**77**	**49**	**36**	**112**	**155**	**78**	**31**	**27**	**22**	**2149**	**S**
60	81	63	57	72	89	65	40	30	40	37	41	12	12	27	40	23	17	806	**SE 1906**
67	63	58	65	93	77	60	32	38	48	61	49	23	13	19	33	33	19	851	**SW** (*253*)
127	**144**	**121**	**122**	**165**	**166**	**125**	**72**	**68**	**88**	**98**	**90**	**35**	**25**	**46**	**73**	**56**	**36**	**1657**	**S**
																			SE 1907
																		..	**SE** (*296*)
105	**142**	**209**	**180**	**193**	**161**	**189**	**149**	**183**	**109**	**90**	**70**	**67**	**79**	**81**	**93**	**72**	**66**	**2238**	**S**
																		.	**SE 1908**
																			SW (*298*)
245	**257**	**289**	**321**	**305**	**271**	**253**	**195**	**166**	**183**	**203**	**108**	**67**	**47**	**34**	**37**	**55**	**47**	**3083**	**S**

APPEN

TABLE

Distribution of Prominence Areas According

NORTH.

Year (No of days)	Total	85–90	80–85	75–80	70–75	65–70	60–65	55–60	50–55	45–50	40–45	35–40	30–35	25–30	20–25	15–20	10–15	5–10	0–5
1909 NE																			
(296) NW																			
N	**2119**	**10**	**9**	**9**	**11**	**10**	**18**	**94**	**185**	**194**	**147**	**140**	**191**	**212**	**210**	**178**	**160**	**155**	**186**
1910 NE																			
(305) NW																			
N	**2055**	**16**	**10**	**13**	**16**	**17**	**60**	**174**	**160**	**164**	**158**	**131**	**138**	**171**	**193**	**167**	**149**	**153**	**165**
1911 NE																			
(286) NW																			
N	**1273**	**12**	**11**	**7**	**11**	**13**	**24**	**31**	**51**	**99**	**135**	**123**	**125**	**138**	**159**	**121**	**85**	**68**	**60**
1912 NE	438	4	3	6	4	3	5	12	18	53	47	53	53	46	42	29	20	24	16
(273) NW	508	5	5	4	3	4	5	9	27	42	62	58	51	48	38	43	43	35	26
N	**946**	**9**	**8**	**10**	**7**	**7**	**10**	**21**	**45**	**95**	**109**	**111**	**104**	**94**	**80**	**72**	**63**	**59**	**42**
1913 NE	550	4	5	5	7	7	8	20	51	73	77	53	51	46	49	34	21	21	18
(282) NW	525	5	6	7	6	5	7	21	48	76	64	56	49	46	38	40	20	18	13
N	**1075**	**9**	**11**	**12**	**13**	**12**	**15**	**41**	**99**	**149**	**141**	**109**	**100**	**92**	**87**	**74**	**41**	**39**	**31**
1914 NE	823	2	3	3	4	7	7	20	85	112	93	86	109	74	49	42	42	52	33
(271) NW	680	3	3	4	7	3	11	28	86	100	75	65	59	59	50	40	31	20	27
N	**1503**	**5**	**6**	**7**	**11**	**10**	**18**	**48**	**171**	**212**	**168**	**151**	**168**	**133**	**99**	**82**	**73**	**81**	**60**
1915 NE	1307	2	2	2	2	14	69	154	120	74	101	123	114	103	99	111	75	55	87
(285) NW	1303	1	1	2	3	19	76	153	140	115	85	91	86	116	100	84	81	79	62
N	**2610**	**3**	**3**	**4**	**5**	**33**	**145**	**307**	**269**	**189**	**186**	**214**	**200**	**219**	**199**	**195**	**156**	**134**	**149**
1916 NE	1002	4	10	22	57	93	116	65	38	53	61	63	81	75	67	59	50	41	47
(311) NW	1056	2	3	8	40	99	108	77	44	37	51	82	107	97	87	64	43	45	62
N	**2058**	**6**	**13**	**30**	**97**	**192**	**224**	**142**	**82**	**90**	**112**	**145**	**188**	**172**	**154**	**123**	**93**	**86**	**109**
1917 NE	1442	32	58	71	85	73	53	62	68	71	73	76	120	128	109	94	91	72	106
(277) NW	1451	29	49	83	100	97	81	60	64	87	68	74	99	96	100	99	74	74	108
N	**2893**	**61**	**107**	**154**	**185**	**170**	**134**	**122**	**132**	**158**	**141**	**150**	**219**	**224**	**218**	**193**	**165**	**146**	**214**
1918 NE	948	41	54	30	16	17	15	18	21	31	55	61	94	104	79	67	79	83	83
(273) NW	876	33	33	21	7	5	17	16	22	37	44	68	77	94	87	78	87	69	81
N	**1824**	**74**	**87**	**51**	**23**	**22**	**32**	**34**	**43**	**68**	**99**	**129**	**171**	**198**	**166**	**145**	**166**	**152**	**164**
1919 NE	762	3	4	2	3	1	2	4	23	36	65	69	70	65	77	73	71	84	110
(274) NW	965	2	4	1	2	2	1	1	17	47	61	119	92	72	96	123	111	111	103
N	**1727**	**5**	**8**	**3**	**5**	**3**	**3**	**5**	**40**	**83**	**126**	**188**	**162**	**137**	**173**	**196**	**182**	**195**	**213**
1920 NE	972	2	3	3	3	3	3	8	19	56	81	95	105	107	100	97	103	88	87
(288) NW	1073	2	3	6	3	2	3	6	16	45	67	89	109	145	138	131	109	85	114
N	**2045**	**4**	**6**	**9**	**6**	**5**	**6**	**14**	**35**	**101**	**148**	**184**	**214**	**252**	**247**	**228**	**212**	**173**	**201**
1921 NE	930	3	2	2	2	3	5	4	17	67	145	127	80	69	80	92	82	71	70
(293) NW	923	3	3	2	3	3	2	4	14	79	141	131	86	95	73	86	71	63	64
N	**1853**	**6**	**5**	**4**	**5**	**6**	**7**	**8**	**31**	**146**	**286**	**258**	**166**	**164**	**153**	**178**	**153**	**134**	**143**

DIX—*contd*

II—*contd.*

to Heliographic Latitudes—*contd.*

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year (No of days)
																			SE 1909
																			SW (*296*)
167	**203**	**229**	**213**	**229**	**205**	**177**	**184**	**162**	**121**	**59**	**34**	**28**	**12**	**9**	**9**	**9**	**8**	**2058**	**S**
																			SE 1910
																			SW (*305*)
156	**200**	**204**	**193**	**178**	**186**	**163**	**115**	**151**	**224**	**173**	**55**	**13**	**12**	**13**	**10**	**11**	**12**	**2069**	**S**
																			SE 1911
																			SW (*286*)
80	**89**	**94**	**94**	**121**	**126**	**154**	**205**	**224**	**241**	**124**	**26**	**11**	**10**	**11**	**9**	**8**	**9**	**1636**	**S**
18	35	46	55	40	66	73	79	100	117	69	21	5	1	3	4	4	4	740	**SE 1912**
11	27	40	63	64	61	73	70	102	130	69	17	4	7	5	6	4	5	758	**SW** (*273*)
29	**62**	**86**	**118**	**113**	**127**	**146**	**149**	**202**	**247**	**138**	**38**	**9**	**8**	**8**	**10**	**8**	**9**	**1507**	**S**
12	18	26	25	41	50	57	78	100	77	38	17	9	4	5	2	2	5	566	**SE 1913**
8	24	30	24	39	47	53	65	85	78	41	15	6	4	4	4	3	2	532	**SW** (282)
20	**42**	**56**	**49**	**80**	**97**	**110**	**143**	**185**	**155**	**79**	**32**	**15**	**8**	**9**	**6**	**5**	**7**	**1098**	**S**
31	25	40	38	44	47	67	96	109	127	87	36	8	4	4	3	3	2	771	**SE 1914**
31	33	33	33	43	62	96	97	143	131	78	23	8	2	4	3	4	2	826	**SW** (*271*)
62	**58**	**73**	**71**	**87**	**109**	**163**	**193**	**252**	**258**	**165**	**59**	**16**	**6**	**8**	**6**	**7**	**4**	**1597**	**S**
101	85	82	82	92	122	104	88	71	120	189	116	26	6	1	3	1	2	1201	**SE 1915**
83	91	87	85	99	108	105	88	94	161	200	141	31	10	3	2	1	1	1300	**SW** (*285*)
184	**176**	**169**	**167**	**191**	**230**	**209**	**176**	**165**	**281**	**389**	**257**	**57**	**16**	**4**	**5**	**2**	**3**	**2681**	**S**
53	62	64	50	56	65	72	59	49	33	51	100	97	49	15	6	6	0	887	**SE 1916**
52	63	55	44	46	56	53	54	56	38	41	120	96	30	6	3	1	1	815	**SW** (*311*)
105	**125**	**119**	**94**	**102**	**121**	**125**	**113**	**105**	**71**	**92**	**220**	**193**	**79**	**21**	**9**	**7**	**1**	**1702**	**S**
116	98	73	59	53	73	86	91	78	54	33	16	50	87	75	48	23	10	1123	**SE 1917**
99	91	75	67	60	67	97	110	82	49	23	14	77	93	74	42	21	9	1150	**SW** (*277*)
215	**189**	**148**	**126**	**113**	**140**	**183**	**201**	**160**	**103**	**56**	**30**	**127**	**180**	**149**	**90**	**44**	**19**	**2273**	**S**
75	79	66	75	83	101	127	107	57	48	52	10	3	3	20	55	82	90	1133	**SE 1918**
88	87	75	67	73	95	116	97	83	69	47	11	3	11	56	93	89	92	1252	**SW** (*273*)
163	**166**	**141**	**142**	**156**	**196**	**243**	**204**	**140**	**117**	**99**	**21**	**6**	**14**	**76**	**148**	**171**	**182**	**2385**	**S**
90	94	103	119	133	165	153	106	62	32	20	4	2	1	1	1	2	1	1089	**SE 1919**
88	91	90	90	102	129	100	58	36	27	14	7	1	2	3	0	0	1	839	**SW** (*271*)
178	**185**	**193**	**209**	**235**	**294**	**253**	**164**	**98**	**59**	**34**	**11**	**3**	**3**	**4**	**1**	**2**	**2**	**1928**	**S**
86	91	114	143	109	117	101	95	79	52	27	5	3	1	2	2	3	3	1033	**SE 1920**
109	135	151	169	119	117	135	107	85	56	25	5	4	2	3	2	3	2	1229	**SW** (288)
195	**226**	**265**	**312**	**228**	**234**	**236**	**202**	**164**	**108**	**52**	**10**	**7**	**3**	**5**	**4**	**6**	**5**	**2262**	**S**
77	68	62	96	131	124	79	92	78	82	135	75	12	3	2	2	3	3	1124	**SE 1921**
68	87	99	99	117	134	91	79	86	87	140	47	6	3	3	3	4	5	1158	**SW** (*293*)
145	**155**	**161**	**195**	**248**	**258**	**170**	**171**	**164**	**169**	**275**	**122**	**18**	**6**	**5**	**5**	**7**	**8**	**2282**	**S**

APPEN

TABLE

Distribution of Prominence Areas According

NORTH.

Year No of days	Total	85–90	80–85	75–80	70–75	65–70	60–65	55–60	50–55	45–50	40–45	35–40	30–35	25–30	20–25	15–20	10–15	5–10	0–5
1922 NE	878	1	1	1	3	2	2	15	89	149	91	70	64	63	67	72	66	65	57
(*276*) **NW**	893	0	1	1	1	1	2	21	126	131	68	86	69	81	66	54	68	67	50
N	**1771**	**1**	**2**	**2**	**4**	**3**	**4**	**36**	**215**	**280**	**159**	**156**	**133**	**144**	**133**	**126**	**134**	**132**	**107**
1923 NE	1106	5	5	5	9	9	16	93	209	222	96	72	72	60	45	59	46	39	44
(*274*) **NW**	1248	2	6	5	3	8	22	112	221	165	104	83	73	93	90	78	73	60	50
N	**2354**	**7**	**11**	**10**	**12**	**17**	**38**	**205**	**430**	**387**	**200**	**155**	**145**	**153**	**135**	**137**	**119**	**99**	**94**
1924 NE	1458	4	4	5	4	7	49	169	229	193	125	108	88	95	102	101	83	53	39
(*323*) **NW**	1335	3	2	5	3	11	52	185	225	161	115	111	79	92	78	76	55	41	41
N	**2793**	**7**	**6**	**10**	**7**	**18**	**101**	**354**	**454**	**354**	**240**	**219**	**167**	**187**	**180**	**177**	**138**	**94**	**80**
1925 NE	1386	4	3	3	8	45	114	169	123	105	97	87	108	109	98	75	69	88	81
(*315*) **NW**	1626	1	4	5	15	51	146	146	107	76	90	112	124	127	127	125	129	121	120
N	**3012**	**5**	**7**	**8**	**23**	**96**	**260**	**315**	**230**	**181**	**187**	**199**	**232**	**236**	**225**	**200**	**198**	**209**	**201**
1926 NE	2014	70	67	107	144	132	85	99	112	131	135	133	127	120	118	100	106	105	123
(*343*) **NW**	2300	64	80	120	148	126	87	83	101	126	179	197	167	149	153	133	113	132	142
N	**4314**	**134**	**147**	**227**	**292**	**258**	**172**	**182**	**213**	**257**	**314**	**330**	**294**	**269**	**271**	**233**	**219**	**237**	**265**
1927 NE	1723	58	88	98	80	49	89	119	109	111	98	106	106	98	108	125	105	83	93
(*321*) **NW**	1784	77	83	85	61	80	103	100	101	117	131	116	95	86	107	131	112	103	96
N	**3507**	**135**	**171**	**183**	**141**	**129**	**192**	**219**	**210**	**228**	**229**	**222**	**201**	**184**	**215**	**256**	**217**	**186**	**189**
1928 NE	1806	45	57	74	93	84	66	64	64	91	107	139	155	151	133	121	122	121	119
(*312*) **NW**	1869	47	46	59	83	94	69	70	72	113	121	136	146	151	130	145	139	126	122
N	**3675**	**92**	**103**	**133**	**176**	**178**	**135**	**134**	**136**	**204**	**228**	**275**	**301**	**302**	**263**	**266**	**261**	**247**	**241**
1929 NE	1118	10	9	13	10	7	7	16	32	85	89	89	126	149	139	90	78	88	81
(*326*) **NW**	1151	11	14	21	19	15	19	12	16	75	105	117	118	146	124	99	89	86	65
N	**2269**	**21**	**23**	**34**	**29**	**22**	**26**	**28**	**48**	**160**	**194**	**206**	**244**	**295**	**263**	**189**	**167**	**174**	**146**
1930 NE	1045	2	3	3	3	1	5	18	71	79	81	118	127	124	91	82	80	71	86
(*325*) **NW**	1067	3	3	1	3	2	9	19	61	83	80	90	107	141	129	108	95	77	56
N	**2112**	**5**	**6**	**4**	**6**	**3**	**14**	**37**	**132**	**162**	**161**	**208**	**234**	**265**	**220**	**190**	**175**	**148**	**142**
1931 NE	898	3	2	4	5	4	4	11	54	105	106	101	74	68	86	74	69	67	61
(*332*) **NW**	1119	3	1	2	3	5	4	7	47	110	120	135	126	100	100	105	84	83	84
N	**2017**	**6**	**3**	**6**	**8**	**9**	**8**	**18**	**101**	**215**	**226**	**236**	**200**	**168**	**186**	**179**	**153**	**150**	**145**
1932 NE	530	1	1	2	2	1	5	11	31	58	71	54	40	62	46	37	40	37	31
(*339*) **NW**	600	1	1	1	1	2	4	8	33	55	71	69	46	69	56	59	50	38	36
N	**1130**	**2**	**2**	**3**	**3**	**3**	**9**	**19**	**64**	**113**	**142**	**123**	**86**	**131**	**102**	**96**	**90**	**75**	**67**
1933 NE	608	1	3	2	2	2	1	2	16	61	89	87	69	63	82	52	31	21	24
(*327*) **NW**	709	2	2	1	1	1	2	2	11	43	90	116	90	93	89	61	36	37	32
N	**1317**	**3**	**5**	**3**	**3**	**3**	**3**	**4**	**27**	**104**	**179**	**203**	**159**	**156**	**171**	**113**	**67**	**58**	**56**
1934 NE	954	5	4	6	4	4	3	15	53	131	146	130	112	74	63	64	64	44	32
(*316*) **NW**	878	5	6	3	3	4	3	12	53	130	128	105	96	83	61	61	55	42	28
N	**1832**	**10**	**10**	**9**	**7**	**8**	**6**	**27**	**106**	**261**	**274**	**235**	**208**	**157**	**124**	**125**	**119**	**86**	**60**

DIX—*contd.*

II—*contd.*

to Heliographic Latitudes—*contd.*

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year (No. of days)
44	38	38	42	45	46	59	85	103	120	73	16	5	2	1	2	1	2	731	**SE 1922**
26	27	51	62	57	78	83	94	101	86	41	12	3	3	2	1	2	1	730	**SW** (*276*)
70	**65**	**89**	**104**	**102**	**124**	**142**	**179**	**204**	**215**	**114**	**28**	**8**	**5**	**3**	**3**	**3**	**3**	**1461**	**S**
33	44	42	50	42	68	68	107	159	194	120	28	7	3	3	6	3	3	989	**SE 1923**
40	57	62	75	57	56	52	87	184	187	97	25	9	8	7	7	5	5	1020	**SW** (*274*)
73	**101**	**104**	**125**	**99**	**124**	**120**	**194**	**343**	**381**	**226**	**53**	**16**	**11**	**10**	**13**	**8**	**8**	**2009**	**S**
35	42	40	63	59	68	63	86	115	142	151	98	37	15	11	4	1	2	1032	**SE 1924**
41	36	33	60	65	69	64	91	111	155	161	89	18	7	5	5	4	5	1019	**SW** (*323*)
76	**78**	**73**	**123**	**124**	**137**	**127**	**177**	**226**	**297**	**312**	**187**	**55**	**22**	**16**	**9**	**5**	**7**	**2051**	**S**
72	70	65	66	59	80	89	119	129	162	143	162	99	18	2	1	2	3	1341	**SE 1925**
112	106	71	62	73	93	116	112	101	103	115	125	49	12	5	2	1	1	1259	**SW** (*315*)
184	**176**	**136**	**128**	**132**	**173**	**205**	**231**	**230**	**265**	**258**	**287**	**148**	**30**	**7**	**3**	**3**	**4**	**2600**	**S**
115	110	109	112	96	107	97	103	72	45	62	92	107	135	80	29	15	14	1500	**SE 1926**
145	132	99	101	100	137	130	115	68	71	77	116	146	134	91	34	21	17	1734	**SW** (*343*)
260	**242**	**208**	**213**	**196**	**244**	**227**	**218**	**140**	**116**	**139**	**208**	**253**	**269**	**171**	**63**	**36**	**31**	**3234**	**S**
114	110	95	97	90	96	97	96	73	84	73	35	23	29	65	112	101	65	1455	**SE 1927**
99	112	103	96	91	98	107	100	72	66	64	51	31	53	96	111	103	82	1543	**SW** (*321*)
213	**222**	**198**	**193**	**181**	**194**	**204**	**196**	**145**	**150**	**137**	**86**	**62**	**82**	**161**	**223**	**204**	**147**	**2998**	**S**
103	136	196	204	141	130	147	141	99	81	99	102	106	58	20	13	8	8	1792	**SE 1928**
102	113	148	167	153	133	147	137	78	69	87	107	89	59	28	15	12	8	1652	**SW** (*312*)
205	**249**	**344**	**371**	**294**	**263**	**294**	**278**	**177**	**150**	**186**	**209**	**195**	**117**	**48**	**28**	**20**	**16**	**3444**	**S**
119	126	129	141	130	115	101	83	53	62	62	72	66	41	12	4	3	3	1322	**SE 1929**
92	109	121	144	161	126	108	102	83	81	65	72	54	20	7	8	5	2	1360	**SW** (*326*)
211	**235**	**250**	**285**	**291**	**241**	**209**	**185**	**136**	**143**	**127**	**144**	**120**	**61**	**19**	**12**	**8**	**5**	**2682**	**S**
93	117	114	144	152	154	104	74	49	34	12	6	1	3	1	3	2	3	1066	**SE 1930**
83	95	118	135	117	97	63	46	45	35	16	8	5	3	4	3	2	4	879	**SW** (*325*)
176	**212**	**232**	**279**	**269**	**251**	**167**	**120**	**94**	**69**	**28**	**14**	**6**	**6**	**5**	**6**	**4**	**7**	**1945**	**S**
75	72	70	85	88	81	77	86	137	116	29	5	2	1	4	3	4	4	939	**SE 1931**
90	84	88	74	83	84	102	103	123	93	25	8	7	3	6	3	4	3	983	**SW** (*332*)
165	**156**	**158**	**159**	**171**	**165**	**179**	**189**	**260**	**209**	**54**	**13**	**9**	**4**	**10**	**6**	**8**	**7**	**1922**	**S**
30	33	25	21	29	54	50	42	67	95	32	3	2	1	1	1	1	1	488	**SE 1932**
32	29	31	38	49	49	51	63	73	79	23	5	3	1	2	1	1	2	532	**SW** (*339*)
62	**62**	**56**	**59**	**78**	**103**	**101**	**105**	**140**	**174**	**55**	**8**	**5**	**2**	**3**	**2**	**2**	**3**	**1020**	**S**
25	21	18	20	29	56	90	74	48	25	7	1	2	2	2	1	1	2	424	**SE 1933**
26	24	24	19	32	54	79	81	54	27	6	4	2	2	1	2	2	1	440	**SW** (*327*)
51	**45**	**42**	**39**	**61**	**110**	**169**	**155**	**102**	**52**	**13**	**5**	**4**	**4**	**3**	**3**	**3**	**3**	**864**	**S**
25	42	53	64	85	94	81	99	141	130	79	35	12	9	3	3	5	5	965	**SE 1934**
22	26	44	55	78	85	92	111	124	115	52	15	4	4	5	4	2	5	843	**SW** (*316*)
7	**68**	**97**	**119**	**163**	**179**	**173**	**210**	**265**	**245**	**131**	**50**	**16**	**13**	**8**	**7**	**7**	**10**	**1808**	**S**

APPEN

TABLE

Distribution of Prominence Areas According

NORTH.

Year (No of days)	Total	85–90	80–85	75–80	70–75	65–70	60–65	55–60	50–55	45–50	40–45	35–40	30–35	25–30	20–25	15–20	10–15	5–10	0–5
1935 NE	1121	2	3	1	3	4	10	22	120	196	138	102	87	78	66	75	67	79	68
(311) NW	1167	2	1	2	2	3	5	19	117	195	134	111	85	82	79	85	72	83	90
N	2288	4	4	3	5	7	15	41	237	391	272	213	172	160	145	160	139	162	158
1936 NE	1752	3	2	5	7	17	93	242	178	123	121	120	116	109	110	116	120	133	137
(317) NW	1821	3	7	4	5	16	78	243	176	121	127	140	140	122	130	125	123	131	130
N	3573	6	9	9	12	33	171	485	354	244	248	260	256	231	240	241	243	264	267
1937 NE	1642	22	45	57	103	177	147	84	61	64	84	91	90	110	100	87	89	99	123
(329) NW	1795	17	25	48	94	175	144	93	56	73	91	113	126	134	124	109	106	127	140
N	3437	39	70	105	197	352	291	177	117	137	175	204	225	244	224	196	195	226	263
1938 NE	2160	123	137	113	81	57	47	68	80	112	115	149	167	193	169	146	134	139	130
(314) NW	2224	132	152	131	68	39	41	60	94	116	140	156	168	186	188	166	126	114	147
N	4384	255	289	244	149	96	88	128	174	228	255	305	335	379	357	312	260	253	277
1939 NE	1134	3	3	4	3	2	2	7	32	87	111	119	139	123	104	98	101	95	101
(300) NW	1275	3	2	3	5	2	3	5	32	90	119	150	179	148	117	102	103	101	111
N	2409	6	5	7	8	4	5	12	64	177	230	269	318	271	221	200	204	196	212
1940 NE	1084	4	3	3	4	5	5	10	48	91	103	101	108	105	106	109	118	92	69
(334) NW	1212	2	3	4	2	4	2	7	42	88	109	133	138	103	110	130	123	118	94
N	2296	6	6	7	6	9	7	17	90	179	212	234	246	208	216	239	241	210	163
1941 NE	1027	2	3	3	3	2	5	17	60	57	75	85	131	123	122	99	83	74	83
(307) NW	1171	2	4	4	5	3	6	32	55	69	61	101	132	137	158	121	95	98	88
N	2198	4	7	7	8	5	11	49	115	126	136	186	263	260	280	220	178	172	171
1942 NE	683	1	1	2	2	3	4	3	10	10	25	57	82	96	106	70	60	71	80
(329) NW	742	2	2	1	3	1	2	6	13	20	47	82	96	98	85	69	58	78	79
N	1425	3	3	3	5	4	6	9	23	30	72	139	178	194	191	139	118	149	159
1943 NE	512	1	1	1	2	1	3	1	3	22	59	80	84	66	57	40	33	26	32
(297) NW	577	1	1	2	1	1	2	2	3	22	51	65	101	97	72	47	36	30	43
N	1089	2	2	3	3	2	5	3	6	44	110	145	185	163	129	87	69	56	75
1944 NE	537	1	1	1	1	1	1	2	12	48	94	120	110	48	16	19	27	21	14
(299) NW	617	1	1	3	0	0	4	4	19	71	131	131	102	45	24	23	21	18	19
N	1154	2	2	4	1	1	5	6	31	119	225	251	212	93	40	42	48	39	33
1945 NE	685	1	2	1	1	2	3	31	95	107	65	62	63	48	37	36	34	46	51
(293) NW	877	0	0	0	1	1	6	39	121	127	92	98	73	61	61	40	49	53	55
N	1562	1	2	1	2	3	9	70	216	234	157	160	136	109	98	76	83	99	106
1946 NE	1110	0	0	2	4	18	47	112	98	86	104	107	102	87	71	74	66	71	61
(307) NW	1253	0	1	6	7	15	51	137	136	97	110	112	100	80	76	86	88	71	80
N	2363	0	1	8	11	33	98	249	234	183	214	219	202	167	147	160	154	142	41
1947 NE	1204	8	17	26	57	74	79	69	62	75	88	107	103	68	73	71	72	83	72
(316) NW	1159	5	5	14	43	84	107	66	40	47	67	72	103	101	97	75	74	89	70
N	2363	13	22	40	100	158	186	135	102	122	155	179	206	169	170	146	146	172	142

DIX—*contd.*

II—*contd.*

to Heliographic Latitudes—*contd.*

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year (No of days)
49	70	92	77	86	117	141	119	101	122	133	67	12	5	2	2	1	1	1197	SE 1935
76	97	99	95	93	87	101	102	100	167	204	124	18	3	2	1	2	1	1372	SW *(311)*
125	167	191	172	179	204	242	221	201	289	337	191	30	8	4	3	3	2	2569	S
145	149	145	151	134	122	118	120	116	99	65	79	121	87	49	26	12	10	1748	SE 1936
133	131	137	141	127	120	134	127	101	88	92	123	119	70	32	20	11	9	1715	SW *(317)*
278	280	282	292	261	242	252	247	217	187	157	202	240	157	81	46	23	19	3463	S
140	135	123	109	109	121	139	146	127	94	76	57	37	51	136	123	76	61	1860	SE 1937
148	132	110	117	112	101	111	100	89	50	42	29	14	55	125	113	83	61	1592	SW *(329)*
288	267	233	226	221	222	250	246	216	144	118	86	51	106	261	236	159	122	3452	S
123	157	151	149	134	124	140	143	165	152	130	81	22	4	5	10	11	10	1711	SE 1938
137	147	155	170	141	149	128	156	149	156	93	42	18	3	4	7	15	14	1684	SW *(311)*
260	304	306	319	275	273	268	299	314	308	223	123	40	7	9	17	26	24	3395	S
103	122	138	149	143	127	124	117	79	65	30	16	7	3	5	3	3	3	1237	SE 1939
117	126	129	121	135	148	127	111	82	50	14	7	2	3	2	3	3	4	1184	SW *(300)*
220	248	267	270	278	275	251	228	161	115	44	23	9	6	7	6	6	7	2421	S
71	108	128	149	151	163	155	111	72	56	57	11	1	1	1	1	1	1	1238	SE 1940
88	105	100	126	139	138	121	88	67	62	55	20	5	4	2	2	2	1	1125	SW *(334)*
159	213	228	275	290	301	276	199	139	118	112	31	6	5	3	3	3	2	2363	S
71	79	90	102	101	114	89	67	51	34	20	4	2	1	2	1	1	2	831	SE 1941
81	86	85	93	88	93	74	62	53	26	7	4	2	2	1	2	1	0	760	SW *(307)*
152	165	175	195	189	207	163	129	104	60	27	8	4	3	3	3	2	2	1591	S
67	77	87	93	99	101	95	75	85	70	17	5	1	3	2	1	1	1	880	SE 1942
66	76	75	82	88	100	129	87	85	78	20	5	2	2	2	2	2	1	902	SW *(329)*
133	153	162	175	187	201	224	162	170	148	37	10	3	5	4	3	3	2	1782	S
38	42	57	62	57	37	39	80	73	61	41	22	4	1	2	1	1	0	618	SE 1943
54	56	53	55	46	49	55	58	67	106	76	34	7	2	2	2	1	0	723	SW *(297)*
92	98	110	117	103	86	94	138	140	167	117	56	11	3	4	3	2	0	1341	S
24	30	34	27	34	47	57	67	87	121	66	29	8	1	3	2	1	0	638	SE 1944
24	33	43	34	49	52	65	68	88	120	47	13	6	1	1	1	1	1	647	SW *(299)*
48	63	77	61	83	99	122	135	175	241	113	42	14	2	4	3	2	1	1285	S
43	47	47	49	60	60	63	70	85	105	108	60	26	15	5	2	2	1	857	SE 1945
47	52	54	65	50	56	69	93	108	103	90	64	22	4	2	0	2	1	882	SW *(293)*
90	99	101	114	110	116	132	172	193	208	198	124	48	19	7	2	4	2	1739	S
53	63	67	65	67	71	76	75	70	96	101	90	31	9	3	0	0	0	937	SE 1946
73	65	60	73	69	74	83	86	81	82	101	73	29	8	5	4	2	0	968	SW *(307)*
126	128	127	138	136	145	159	161	151	178	202	163	60	17	8	4	2	0	1905	S
84	93	95	90	80	113	120	108	95	79	87	82	126	106	54	19	15	8	1454	SE 1947
88	95	76	67	60	99	145	164	147	136	94	83	143	161	81	39	18	9	1705	SW *(316)*
172	188	171	157	140	212	265	272	242	215	181	165	269	267	135	58	33	17	3159	S

APPEN

TABLE

Distribution of Prominence Areas According

NORTH.

Year (No of days)	Total	85—90	80—85	75—80	70—75	65—70	60—65	55—60	50—55	45—50	40—45	35—40	30—35	25—30	20—25	15—20	10—15	5—10	0—5
1948 NE	1016	28	58	103	87	38	25	31	42	56	54	56	63	61	66	64	50	63	71
(326) **NW**	1018	28	50	66	61	51	21	36	44	57	65	70	70	80	71	55	53	67	73
N	**2034**	**56**	**108**	**169**	**148**	**89**	**46**	**67**	**86**	**113**	**119**	**126**	**133**	**141**	**137**	**119**	**103**	**130**	**144**
1949 NE	1154	16	17	17	20	51	63	54	42	63	94	88	107	112	96	79	77	88	70
(337) **NW**	1479	19	30	38	32	40	40	61	59	85	137	141	133	147	129	100	110	95	83
N	**2633**	**35**	**47**	**55**	**52**	**91**	**103**	**115**	**101**	**148**	**231**	**229**	**240**	**259**	**225**	**179**	**187**	**183**	**153**
1950 NE	722	0	4	5	8	21	12	9	16	50	61	64	90	98	57	53	48	69	57
(336) **NW**	784	0	1	3	2	8	6	9	16	33	44	75	119	126	86	67	51	69	69
N	**1506**	**0**	**5**	**8**	**10**	**29**	**18**	**18**	**32**	**83**	**105**	**139**	**209**	**224**	**143**	**120**	**99**	**138**	**126**

TABLE

Frequency Distribution of

NORTH.

Year	Total	85—90	80—85	75—80	70—75	65—70	60—65	55—60	50—55	45—50	40—45	35—40	30—35	25—30	20—25	15—20	10—15	5—10	0—5
1904	15					1		1					1	4	3	2	2	1	
05	26											1		2	6	4	6	4	3
06	30									1	1	1	2	4	4	6	7	2	2
07	55								1		1	1	1	6	5	9	12	15	4
08	23					1						1	1	1	1	3	9	4	2
09	16															1	6	5	4
10	5								1			1				1	1		1
1911	10	1								1						1	1	5	1
12	4			1									1					1	1
13	2													2					
14	12								1	1	1			1	5	2	1		
15	26								1				1	1	10	10	3		
16	34											1	2	2	10	9	8	1	1
17	32											1	1	7	8	6	6	1	2
18	34											1		3	5	6	12	2	5
19	72				1		1				1	1	2	4	5	17	18	18	4
20	58				1				1	1	4	3	2	6	6	14	10	5	5
1921	20															4	9	4	3
22	32													1	4	4	10	11	2
23	7												2		1	2	2		
24	10												1	5	3	1			
25	33											1	7	7	11	6	1		
26	96									2	3	6	20	20	19	18	4	4	
27	37										2	2	6	5	4	10	3	3	2
28	39												1	1	3	15	12	5	2
29	37												1	3	1	5	13	11	3
30	25										1		1	2	2	5	7	4	3
1931	21															3	2	9	7
32	1															1			
33	2																	2	
34	2													2					
35	3												1	1	1				
36	22													3	7	7	3	2	
37	36											2		2	7	4	15	4	2
38	20													5	2	5	6	1	1
39	22													4	3	3	8	2	2
40	10														1	2	3	3	1
1941	11											1			2	2	2	1	3
42	15													2		1	4	7	1
43	2																1		1
44	0																		
45	2											1		1					
46	23								8			2	5	5	5	2	1		
47	14									1			1	2	5	1	4		
48	10													2	1	2	4	1	
49	19									1		1	6	2	4	2		3	
1950	11											1	4		5	1			
Total	**1036**	**1**	**—**	**1**	**2**	**2**	**1**	**1**	**8**	**8**	**14**	**29**	**70**	**118**	**159**	**197**	**216**	**141**	**68**
Per cent. Frequency	100·0	0·1	—	0·1	0·2	0·2	0 1	0 1	0 8	0·8	1·4	2·8	6·8	11 4	15·3	19·0	20·8	13 5	6 6

DIX—*contd.*

II—*contd.*

to Heliographic Latitudes.

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year (No of days)
62	57	51	57	83	79	71	56	40	62	44	19	9	26	54	69	40	23	902	SE 1948
53	58	65	53	72	76	85	60	42	55	57	27	8	33	84	76	63	31	998	SW (*326*)
115	**115**	**116**	**110**	**155**	**155**	**156**	**116**	**82**	**117**	**101**	**46**	**17**	**59**	**138**	**145**	**103**	**54**	**1900**	**S**
67	66	81	83	79	64	86	82	73	55	28	31	17	8	1	0	0	0	821	SE 1949
87	91	72	81	97	73	84	75	67	45	17	19	10	2	1	1	0	0	822	SW (*337*)
154	**157**	**153**	**164**	**176**	**137**	**170**	**157**	**140**	**100**	**45**	**50**	**27**	**10**	**2**	**1**	**0**	**0**	**1643**	**S**
52	36	36	52	77	63	49	40	25	13	4	10	4	0	0	0	1	0	462	SE 1950
64	68	54	57	71	68	55	51	44	21	19	26	6	3	2	0	0	0	609	SW (*336*)
116	**104**	**90**	**109**	**148**	**131**	**104**	**91**	**69**	**34**	**23**	**36**	**10**	**3**	**2**	**0**	**1**	**0**	**1071**	**S**

VI.

Metallic Prominences.

SOUTH.

0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	Total	Year
		1	3	3	2	2	2	1		3	3	5	6	1				32	**1904**
1	4	9	7	6	2		1	1			1							32	**05**
	2	1	4	2	1									1	1			12	**06**
5	12	14	13	3	3	1	1	1	2	1	1	1	2	4	1			65	**07**
9	10	10	13	6	2	3	1	2	1	1	1				1			63	**08**
1	4	8	2	1														16	**09**
4	5	4	2	1	1	1							1					19	**10**
1	3	2	1	1			1		2	1				1				13	**1911**
	2	4	1			1				1								9	**12**
								2	1									3	**13**
		1				1		1	1				1					5	**14**
		1	4	8	4	1				1								19	**15**
	1	4	9	2	2	2		2					1					23	**16**
1	1	4	6	5	1													18	**17**
	5	4	10	5	3	2	1											30	**18**
5	12	14	14	7	11	3	4	2	1		1	1		1	2	2		80	**19**
4	15	15	11	5	11	3	3											67	**20**
4	4	7	3	6	6													30	**1921**
2	3	2				1												8	**22**
2																	2	2	**23**
					2													2	**24**
		1	5	4	4	1	2											17	**25**
1	1	6	12	13	10	6	1	2										52	**26**
4	5	13	9	7	5	1												44	**27**
	4	15	15	3	1	1												39	**28**
4	8	12	6	2		3												35	**29**
	1	5	5	1	1													13	**30**
2	1	1																4	**1931**
		1																1	**32**
	1																	1	**33**
				2	1	3												6	**34**
			3	2	7	5												17	**35**
	1	2	15	7	9	6				1		1	1					43	**36**
	1	1	6	4	4	3	1											20	**37**
1	5	5	4	6	6		1											28	**38**
3	9	9	8	4	2	2												37	**39**
5	2	4	3	2	1													17	**40**
4	3	4	2	2														15	**1941**
2	5	2	2															11	**42**
																		0	**43**
																		0	**44**
			1	1	2													4	**45**
	2	1		3	2		1			1								10	**46**
1	1		3	4	2	1	1		1	1								15	**47**
1	1	3	2			2												9	**48**
		1	2	3	1	1												8	**49**
					1													1	**1950**
67	**134**	**191**	**206**	**131**	**110**	**56**	**21**	**14**	**12**	**11**	**7**	**8**	**12**	**8**	**5**	**2**	**—**	**995**	**Total**
6·7	13 5	19 2	20 8	13 2	11·1	b·6	2 0	1 4	1·2	1·1	0 7	0 8	1 2	0·8	0 5	0·2	—	100·0	Per cent Frequency

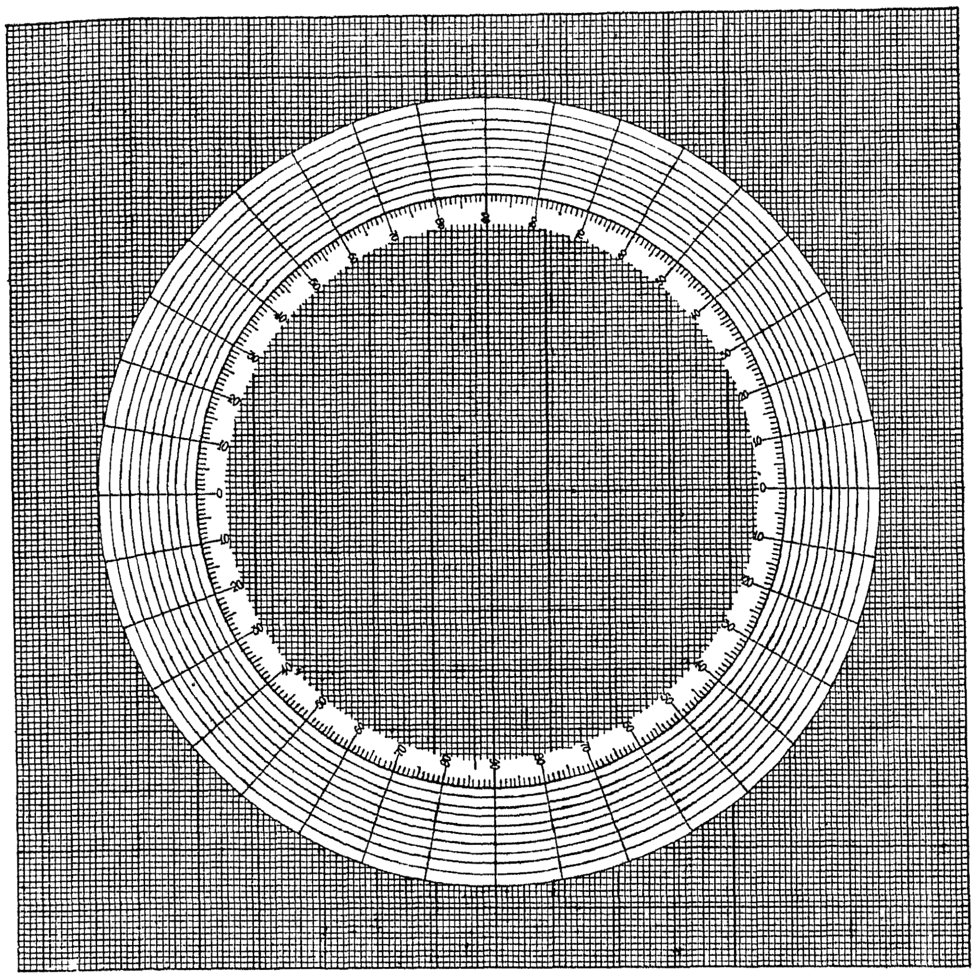


Fig. 1
GRID FOR MEASURING PROMINENCES

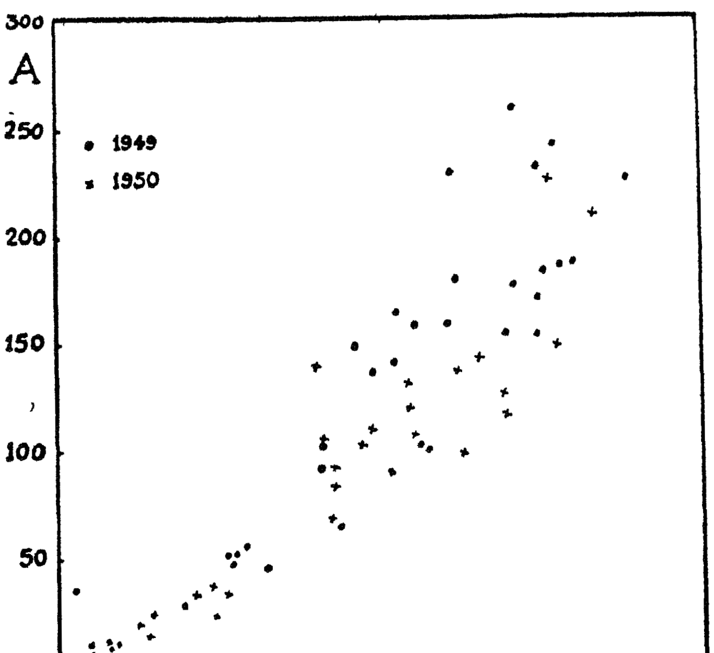


Fig. 2(*a*)

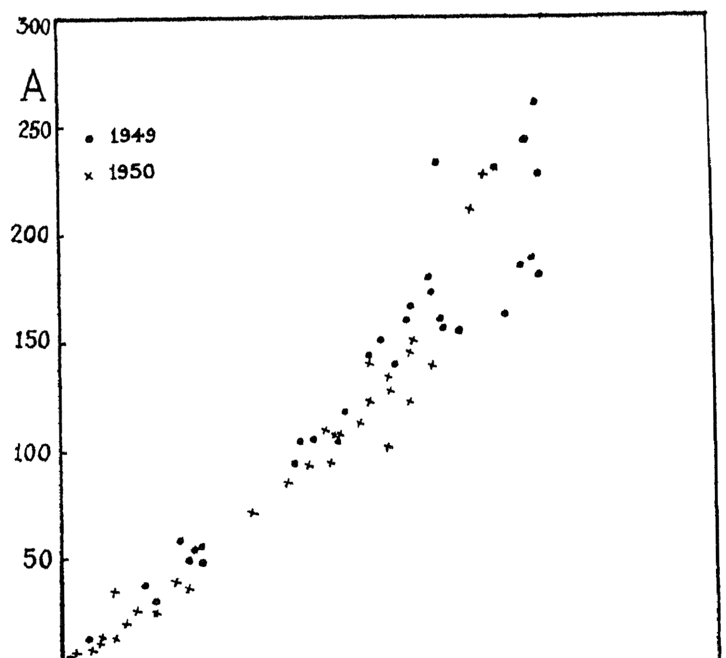
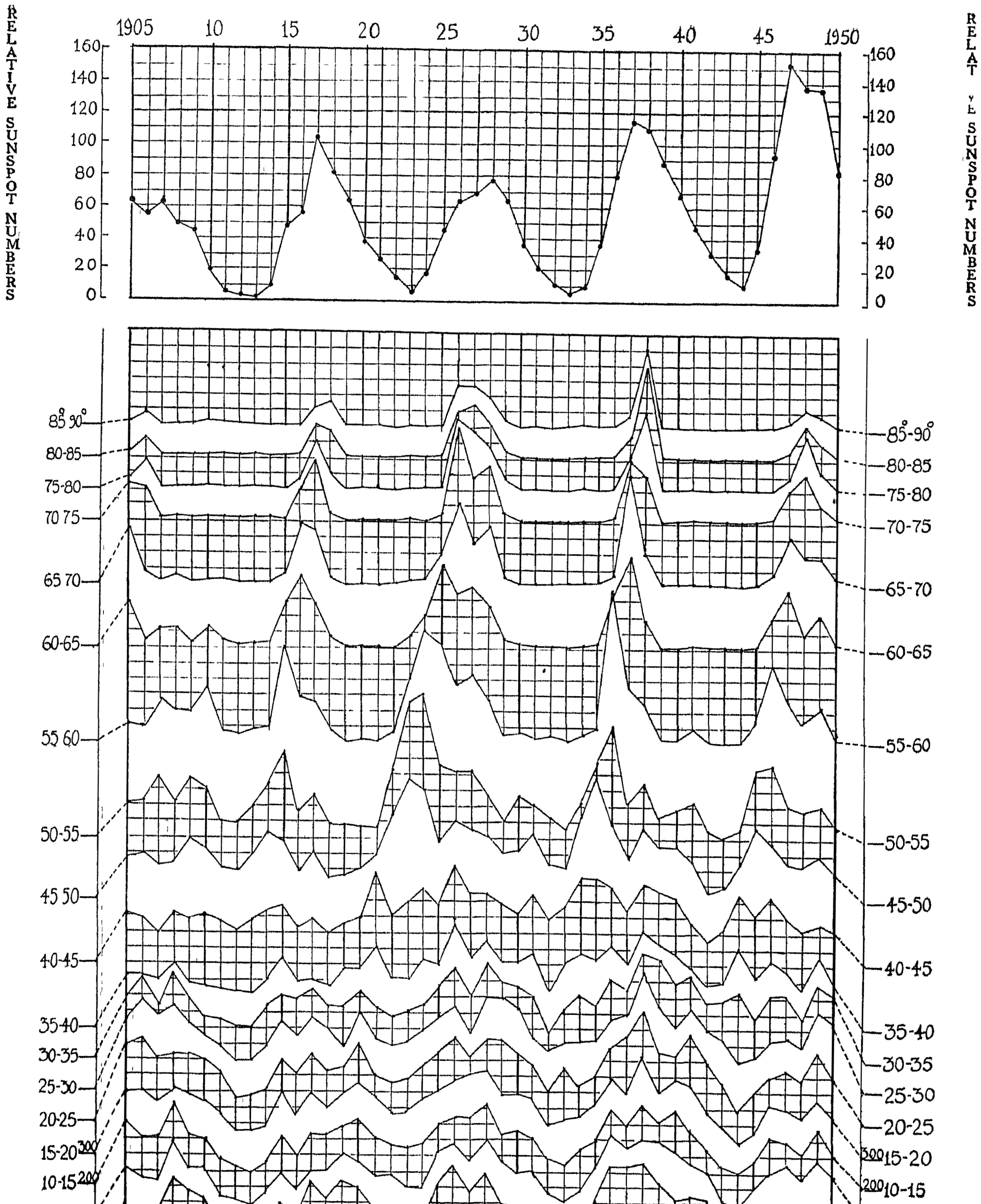


Fig. 2(*b*)

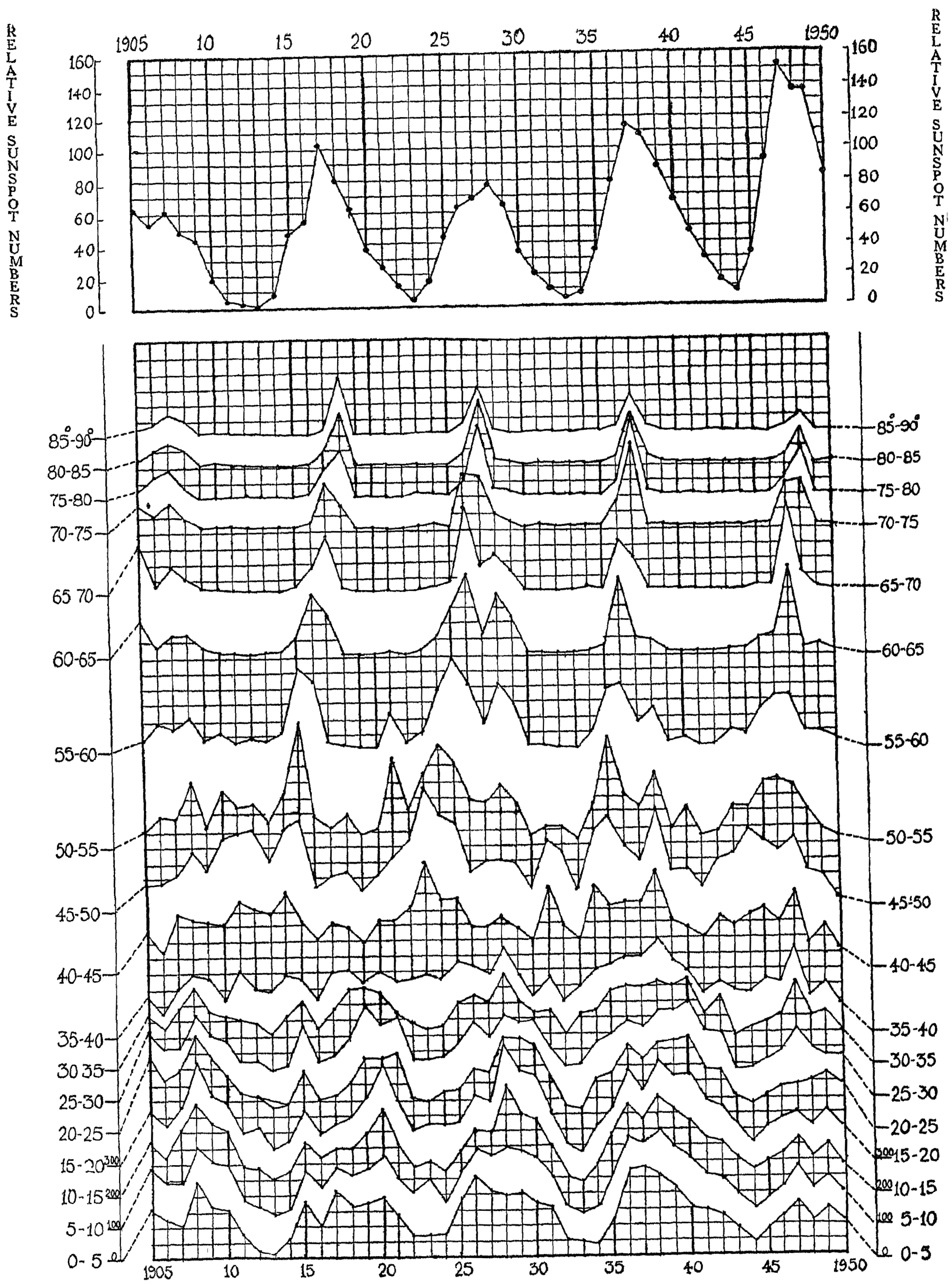
CORRELATION BETWEEN PROMINENCE AREAS AND PROMINENCE NUMBERS



PROMINENCE ACTIVITY AND SUNSPOT CYCLE

NORTHERN HEMISPHERE

Fig. 3(*a*)



PROMINENCE ACTIVITY AND SUNSPOT CYCLE
SOUTHERN HEMISPHERE

Fig. 3(*b*)

Mean Daily Areas of Sunspots : Greenwich
(Unit : 10^{-6} of sun's Visible Hemisphere.)

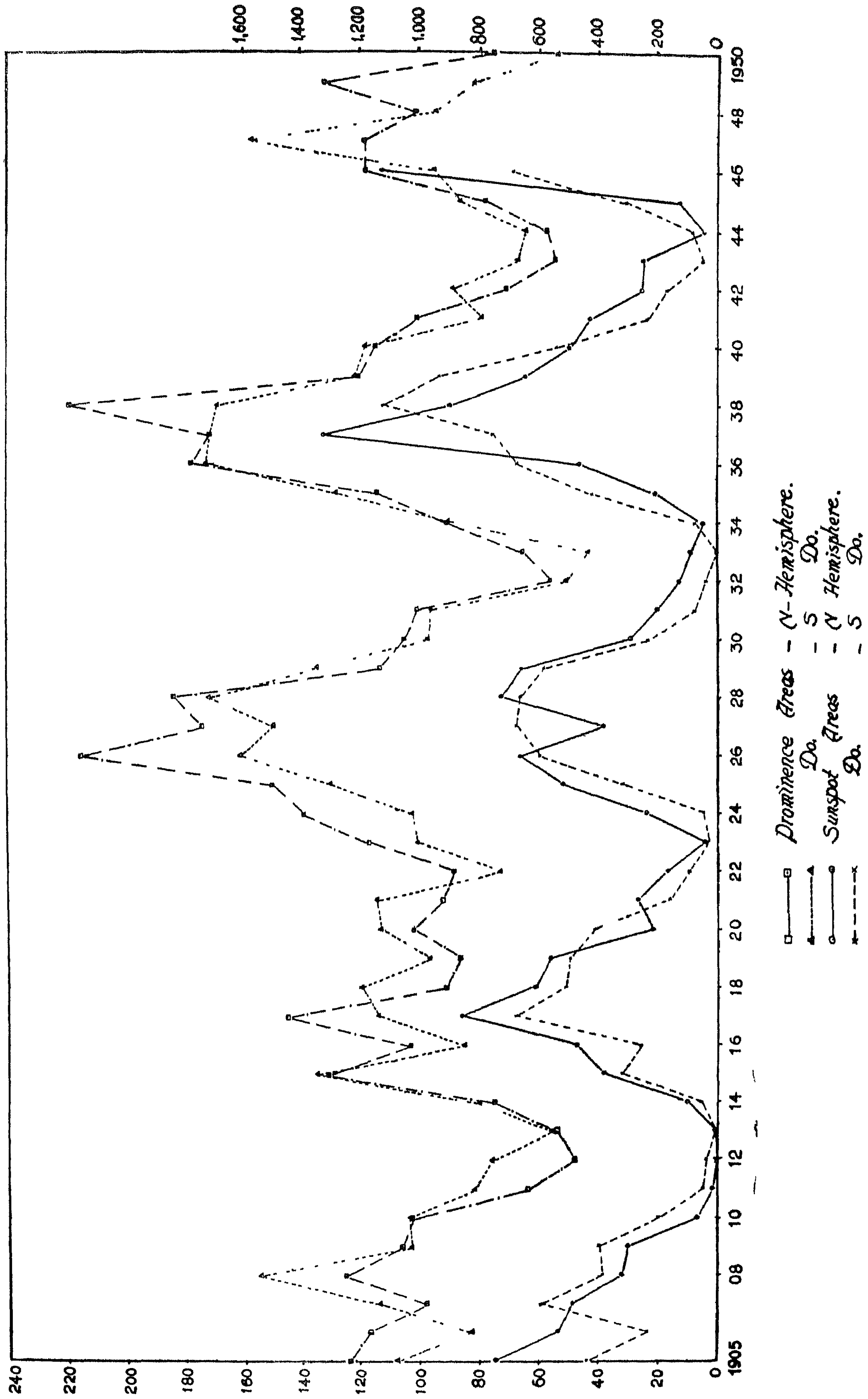
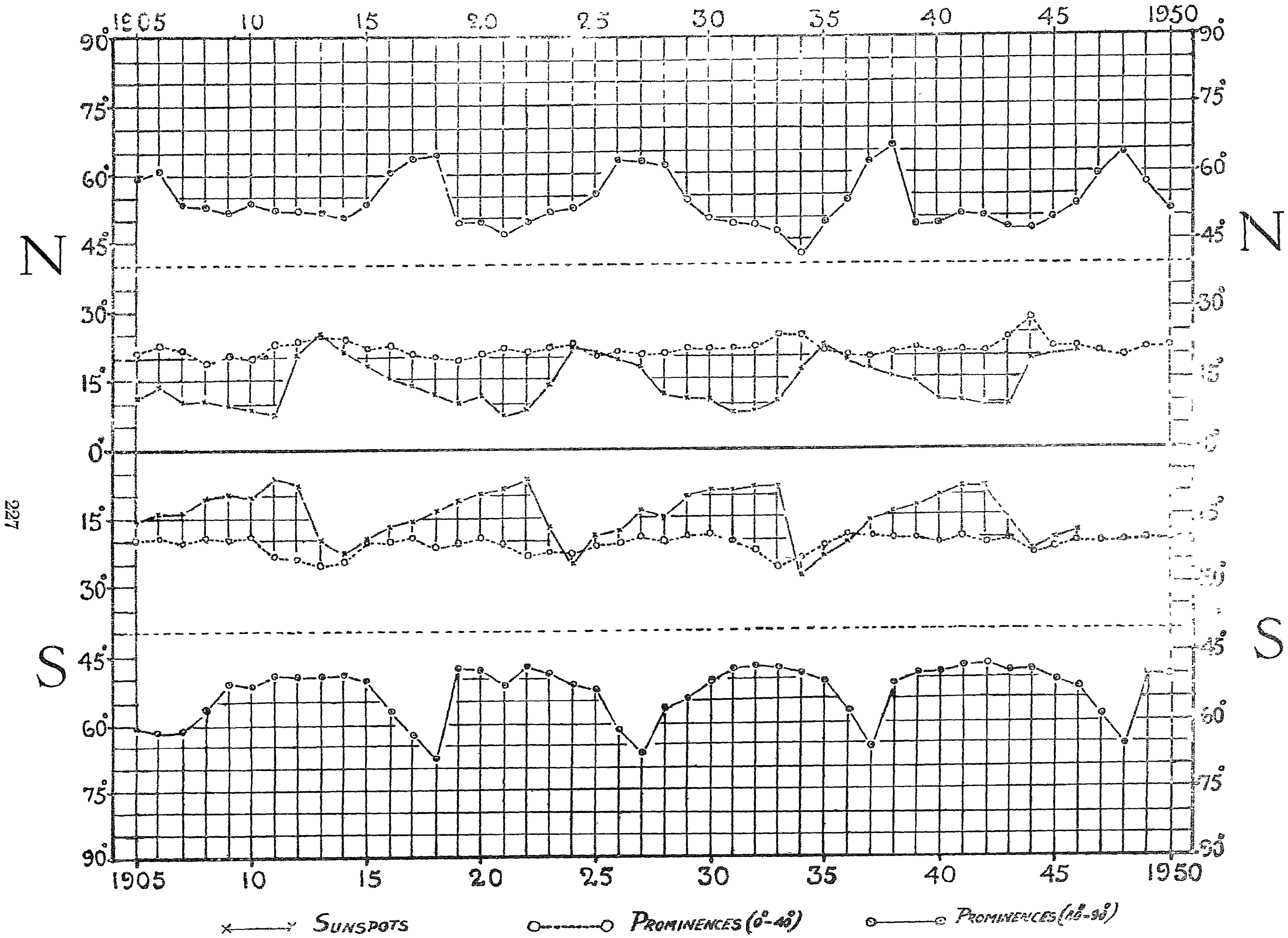


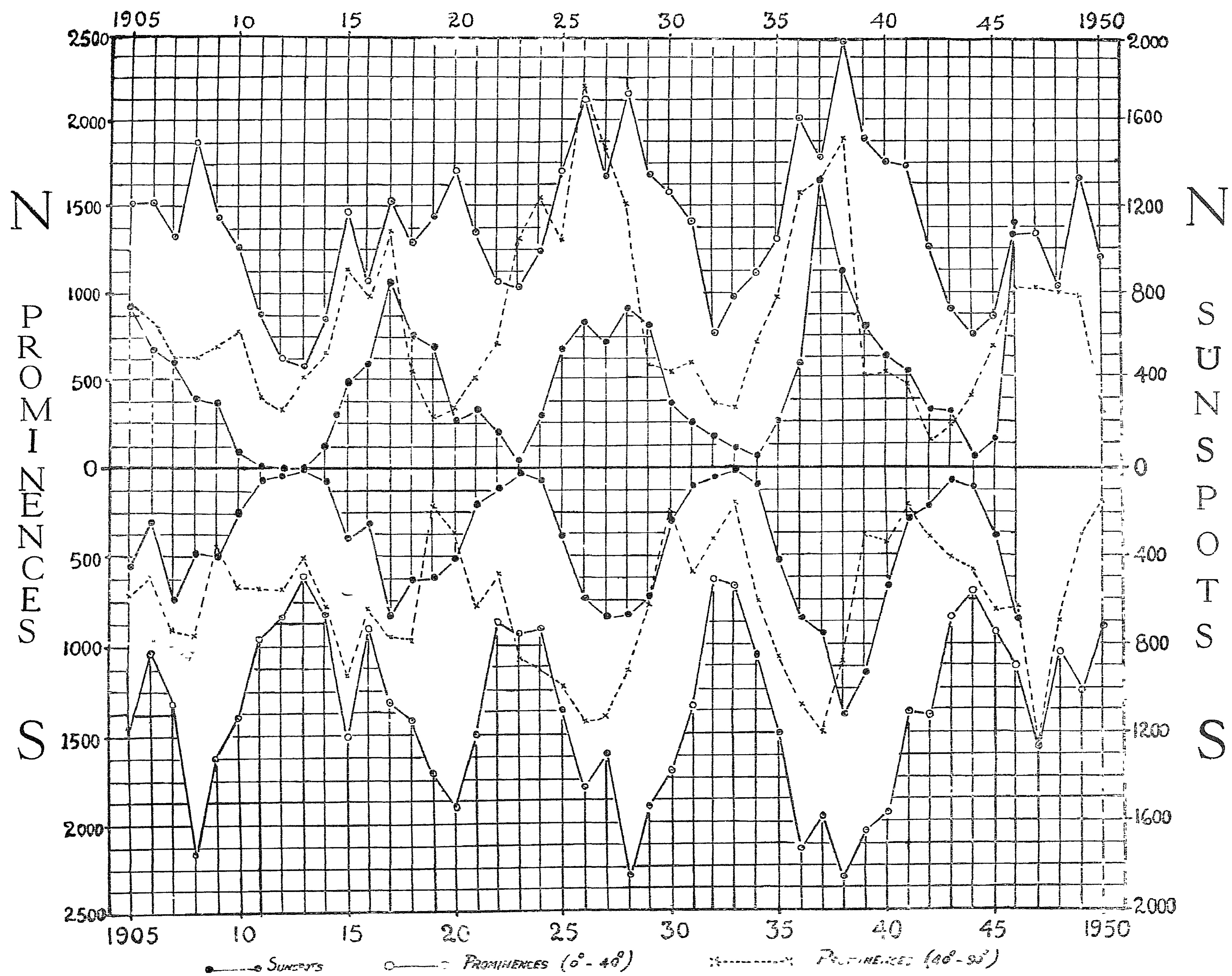
Fig. 4

PROMINENCE AND SUNSPOT ACTIVITIES IN THE NORTH AND SOUTH HEMISPHERE



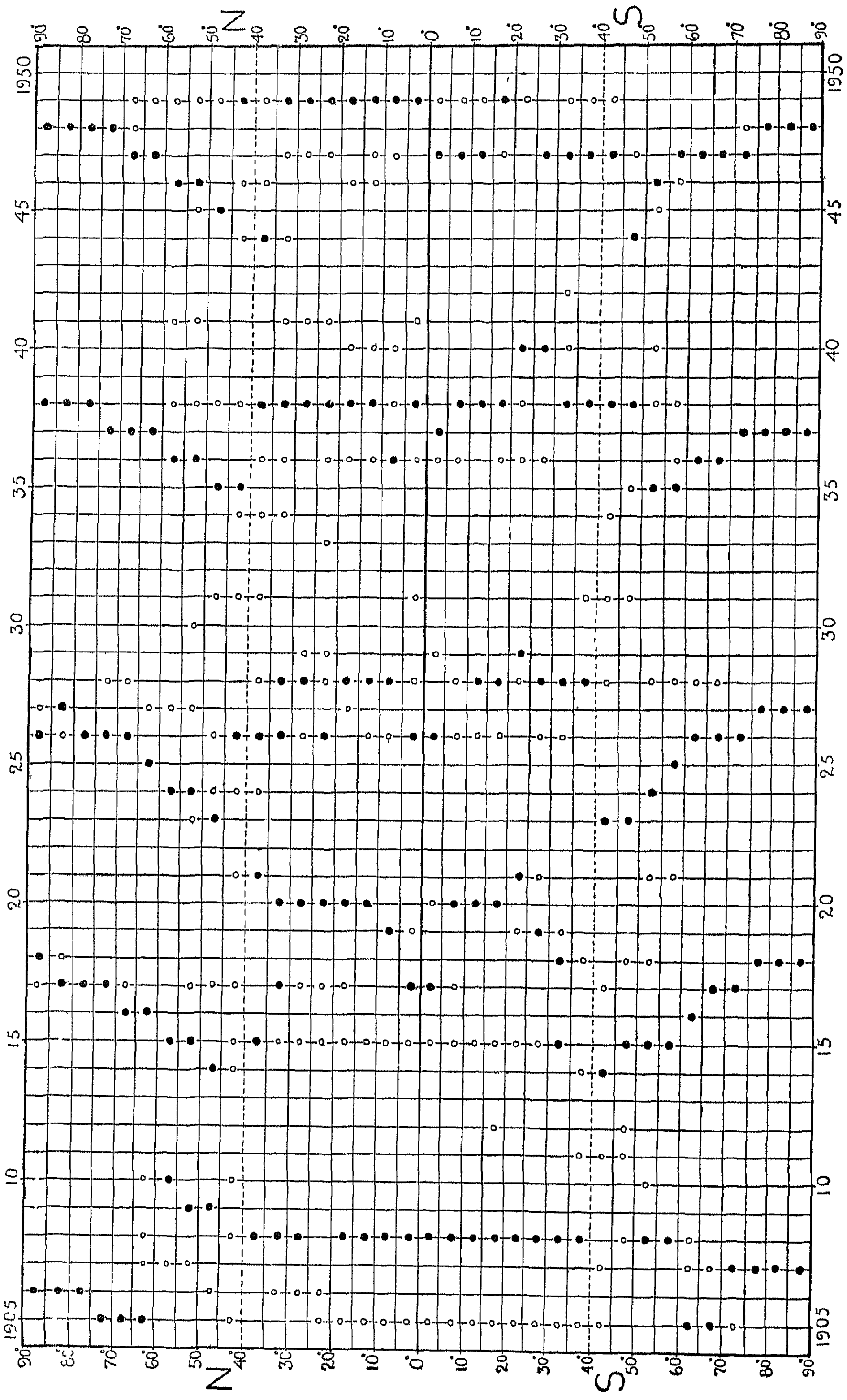
MEAN LATITUDES OF SUNSPOTS AND OF LOW AND HIGH LATITUDE PROMINENCES

Fig. 5

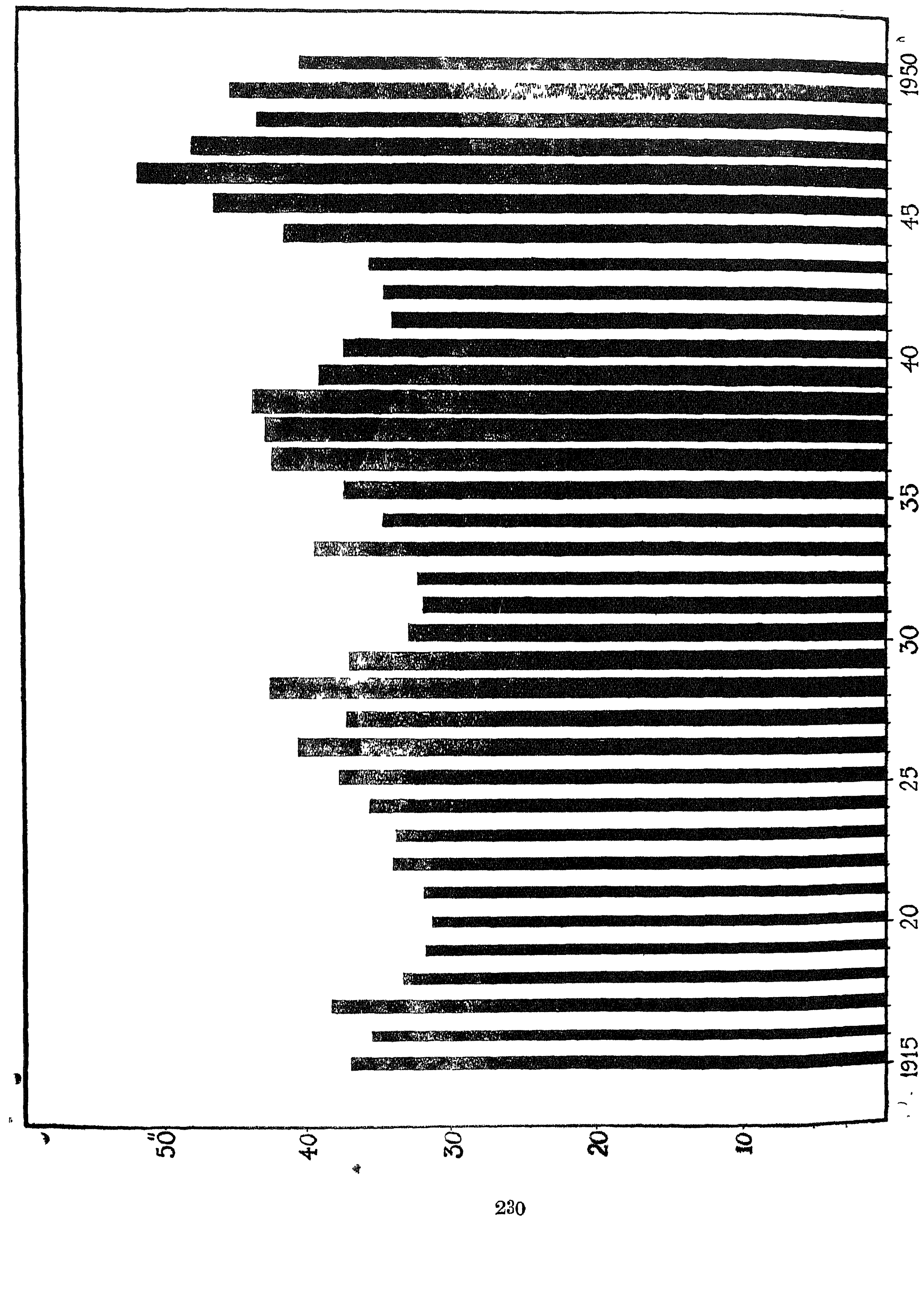


MEAN DAILY AREAS OF SUNSPOTS AND OF LOW AND HIGH LATITUDE PROMINENCES

Fig. 6

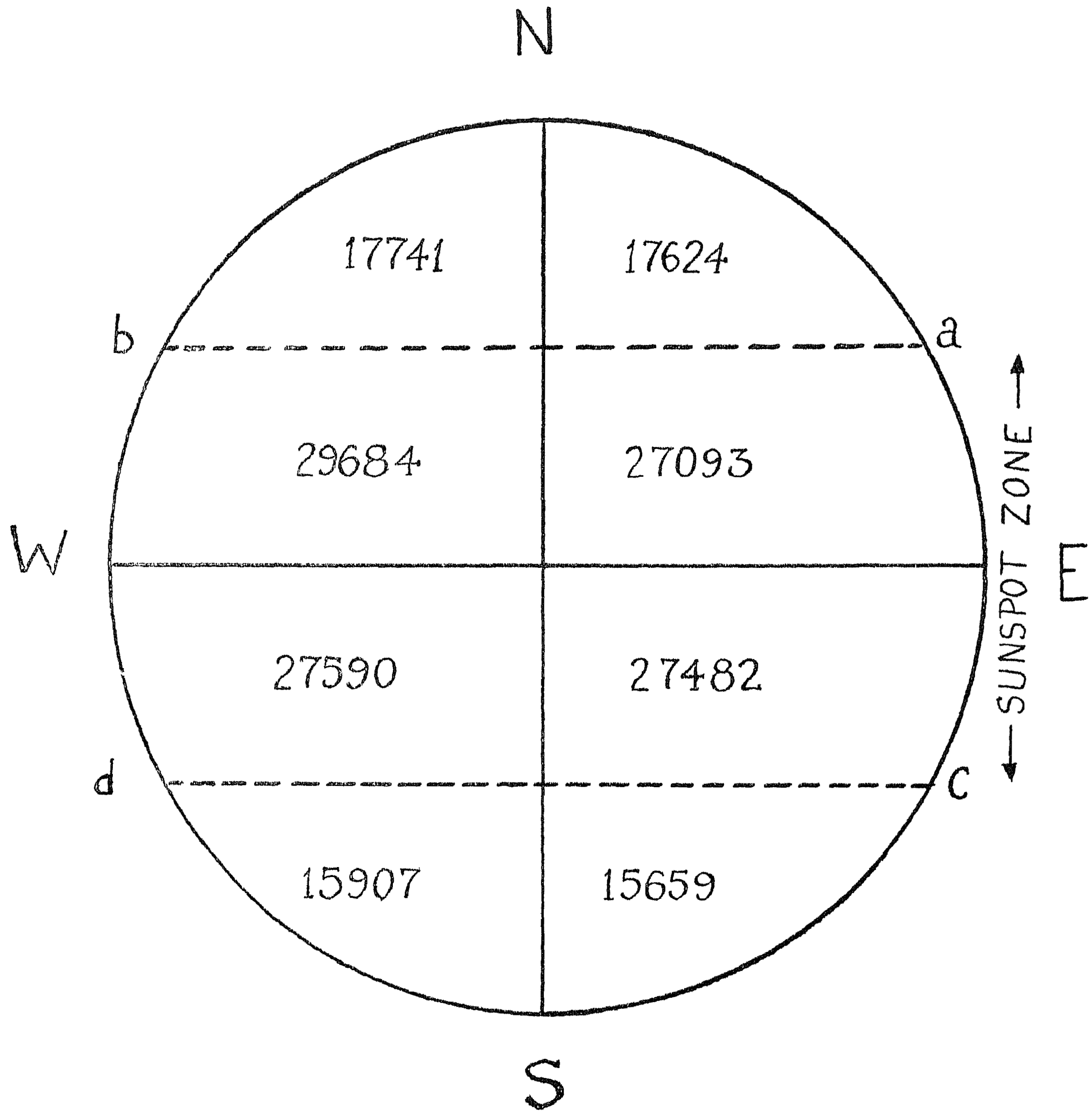


PEAKS OF PROMINENCE ACTIVITY IN FIVE DEGREE LATITUDE ZONES



MEAN DAILY HEIGHTS AND EXTENTS OF PROMINENCES (1915-1950)

Fig. 8



NW = b = 17741 + 29684 = 47425
NE = a = 17624 + 27093 = 44717
SW = d = 15907 + 27590 = 43497
SE = c = 27482 + 15659 = 43141

DISTRIBUTION OF PROMINENCE AREAS IN DIFFERENT QUADRANTS AND ZONES

Remarks on the foregoing paper.

One of the conclusions which the authors reach in the above paper is that " it does not seem possible to explain the observed facts on the basis of terrestrial or planetary influences on the sun" This conclusion, which relates to the western preponderance of prominence areas, seems to me to be a little too facile to be convincing

I had in fact casually suggested to the authors that they might explore the possibility of the tidal influence of the earth on solar prominences (combined with a slightly higher prominence activity in the northern compared with the southern hemisphere, which I imagined might be found to exist) being responsible for the western preponderance of prominence areas and for the western excess being greater in the northern hemisphere than in the southern as their statistics of available Kodaikanal data on limb prominences indicate. As the authors offer no explanation of the points, which emerge from the statistical examination, but nevertheless decide against the fore-going suggestion, it seems worthwhile to examine this suggestion a little more closely in order to see whether the statistical results presented in the paper are indeed unquestionably contrary to it.

From the data utilised in the paper it is evident that, whatever may be the reason, prominence activity has actually been more in the northern than in the southern hemisphere during the period under examination, in fact, if we divide the limb into quadrants, it becomes also apparent that prominence activity in the NE quadrant has been more than in the SE quadrant, and similarly the NW quadrant has been more active than the SW. This is obvious from the accompanying diagram (page 38) which summarises the total prominence areas in the different quadrants and zones It is also apparent that prominence activity in the NW quadrant has been greater than that in the NE, while prominence activity in the SW has been higher than in the SE quadrant. Furthermore, the difference NW-NE is greater than the difference SW-SE.

Let us consider whether these broad statistical results are consistent with the foregoing suggestion. For convenience of presentation let us call the prominence areas in the NE, NW, SE and SW quadrants a, b, c and d respectively. The observational data show that

$$a > c \text{ and } b > d \qquad \ldots (1)$$

Now assume that the earth exercises a tide-generating force on solar prominences, then we should expect

$$b > a \text{ and } d > c \qquad \ldots (2)$$

From (1) and (2) we see at once that

$$b + d > a + c \text{ always} \qquad \ldots (3)$$

$$b - a > d - c \text{ sometimes} \qquad \ldots (4)$$

So long as we accept the initial premisses, (3) is always true and represents the excess of prominence activity in the western compared to the eastern hemisphere. The relation (4) however is not invariably valid, but it does hold under certain circumstances consistently with the initial premisses. Now, since the tide-generating force must have a greater effect on larger and taller prominences than on smaller prominences, we should expect the ratio b/a to be greater than d/c. Thus under all circumstances the following relations should also be valid

$$\frac{b - a}{a} > \frac{d - c}{c} \qquad \ldots (5)$$

$$b - a > d - c \qquad \ldots (6)$$

Therefore, the broad statistical results concerning the western preponderance of prominence areas are consistent with the idea suggested above. The authors, however, mainly emphasize that the fact that the western excess is most conspicuous for the sunspot zone of the northern hemisphere is against the idea of a tidal effect due to the earth. But I consider that, so far from contradicting the idea of tidal effect, this statistical result does indeed support it, for the earth is approximately in the equatorial plane of the sun, and therefore, the earth's tidal influence ought to be most conspicuous on the prominences of the sunspot zone. It seems to me that no salient statistical result, so far as it is discussed in the paper in relation to the western excess of prominence areas, can be regarded as contrary to the foregoing idea at least qualitatively. From the diagram accompanying this note one can, nevertheless, see one or two minor discrepancies which the authors do not stress There is, however, one discrepancy which the authors do stress, namely that in the northern hemisphere the total prominence area in the sunspot zone of the east limb is actually smaller than that in the southern hemisphere. This, I think, is not necessarily contradictory to the idea of a terrestrial tidal influence on prominences. For instance, the *heights* of prominences on the east limb in the sunspot zone may have actually been greater in the northern hemisphere than in the southern, despite the fact that the corresponding prominence *areas* are smaller in the northern compared to the southern hemisphere. The terrestrial tidal influence would surely be greater on taller prominences than on those of smaller heights, and in fact, in this matter of tidal influence it is the height of a prominence which is the more important of the two factors that determine the area of the prominence Considered from this standpoint, the few minor discrepancies which are obvious from the accompanying diagram may turn out to be only apparent, but further work is necessary to settle this point. In any event, before these can be considered to be decisively contradictory to the idea of a tidal influence of the earth one ought to establish that they are statistically significant even though they appear to be quantitatively small.

I should, however, stress that, because of certain complicating factors, a truly quantitative estimate of the earth's tidal influence on prominences is extremely difficult to make One of these disturbing factors is that the prominences of the equatorial regions are more or less parallel to the meridians, but with increasing latitude they tend to become progressively more and more parallel to the parallels of latitude, this well known behaviour of prominences will generally make prominence areas appear smaller in high latitudes than in the sunspot zone. Another disturbing factor, which must contribute to the uncertainty of a quantitative estimate of the earth's tidal influence, is that prominence matter on the sun behaves in a way suggesting that, for some yet obscure reason, solar gravity is practically ineffective on prominences. This fact could make the tide-generating force due to the earth (and other planets also) on the highly deformable prominences far more effective than if the sun exerted its full force of gravity on prominence matter. As matters stand at present, it would seem, therefore, that there is no compelling reason at all for ruling out the earth's tidal effect as a possible explanation of the different salient aspects of the observed western excess of prominence areas, including the north-south asymmetry. Unless indisputable evidence is furnished to prove its inadequacy, or until a more satisfactory theory is evolved, the tidal effect of the earth on prominencees ought not to be dismissed as an untenable working hypothesis, even though it seems for the present to be somewhat lacking in quantitative definiteness, the resultant tidal influence of the other planets will, on the whole, *be* comparatively small for reasons discussed in a previous paper by Mr. B. G. Narayan and myself (Ind. Journ. Phys., Vol 14, pp. 311-23, 1940).

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