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# KODAIKANAL OBSERVATORY

## BULLETIN No. CXXXVII

## 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.

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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 $0\cdot465 \times 10^{-1}$ 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—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 |
| 1921 | 31 8 | 3 52 | 14 09 | 39 | 38 9 | 6 34 | 13 06 |
| 22 | 33 9 | 3 92 | 10 70 | 40 | 37 2 | 5 77 | 13 52 |
| 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 |
| 1931 | 31 8 | 5 22 | 12 91 | 49 | 45 3 | 4·74 | 10 23 |
| 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 |

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 | 120 | 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 | 40 | 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 | 99 | 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 |