VERTICAL IONOSPHERIC SOUNDINGS AT AHMEDABAD DURING TOTAL SOLAR ECLIPSE ON 30th JUNE 1954

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Received October 18, 1957

(Communicated by Dr. Vikram A. Sarabhai, F.A.SC.)

On June 30, 1954, there occurred a solar eclipse at Ahmedabad (23° 02′ N., 72° 38′ E.). Ahmedabad lay to the south of the shadow track. As the eclipse occurred late in the evening it was considered that the characteristics of the eclipse would not be the same at different levels above the ground. The times and phases of the eclipse at heights of 0, 100, 200 and 300 km. above Ahmedabad were therefore calculated. The results are given in Table I.

TABLE I

Characteristics of the eclipse of 30 *June* 1954 *at Ahmedabad*

Height above the ground	0 km.	100 km.	200 km.	300 km.
Time of the beginning of the eclipse	1807·4	1808·4	1809·5	1810·7
Time of maximum phase of the eclipse	1859·3	1858·3	1857·2	1856·2
Magnitude of the eclipse	93%	94%	97%	99·8%
Time of Sunset	1859	1944	2004	2021

The times are given as 75° E.M.T.

It is seen that though there was not much difference in the times of the various phases of the eclipse at different heights, the eclipse at 300 km. was almost total whereas at ground level it was only 93%. The times of sunset at different heights were, of course, different. At ground level the sun had set at the time of maximum obscuration, but at greater heights, the sun had begun to be uncovered before it went below the horizon.

The British N.P.L. type automatic ionospheric height recorder installed in the laboratory was used for all the measurements. On the control days, P′-*f* records were taken every fifteen minutes from 16 hr. to 21 hr.

75° E.M.T. On the eclipse day, once every fifteen minutes observations were started at 1030 hr.; the recordings were more frequent afterwards and during the eclipse, records were taken once every five minutes.

The lower layers.—As during the eclipse the solar altitude was very low, the ionisation of the lower layers was decreasing rapidly with decreasing cos χ of the sun. The eclipse therefore could not be of much use to study the lower layers of the ionosphere. The critical frequencies of E, E_2 and F_1 layers, and the minimum virtual heights of the F_1 layer on the eclipse day and on the control days are shown in Fig. 1. The E layer reflection traces on the eclipse day were often merged with those of E*s* and so *h*′E is not shown on the diagram. As expected, the critical frequencies of E and F_1 decreased at a faster rate after the start of the eclipse. The E_2 layer showed changes similar to F_1, but the effect of the eclipse is not very clear.

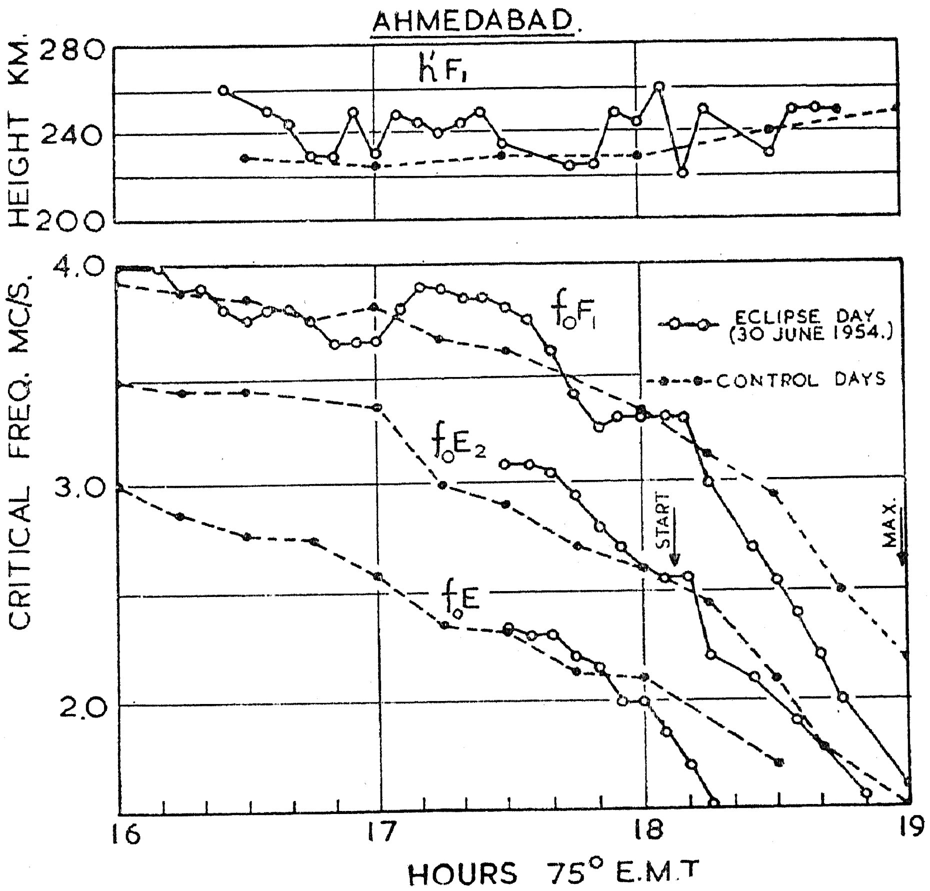

FIG. 1. The variations of f_0E, f_0E_2, f_0F_1 and $h'F_1$ on the control days and on the eclipse days.

An interesting feature was noted in the F_1 layer at about 1745 hr. The relevant P′-*f* records are redrawn in Fig. 2 and a few P′-*f*

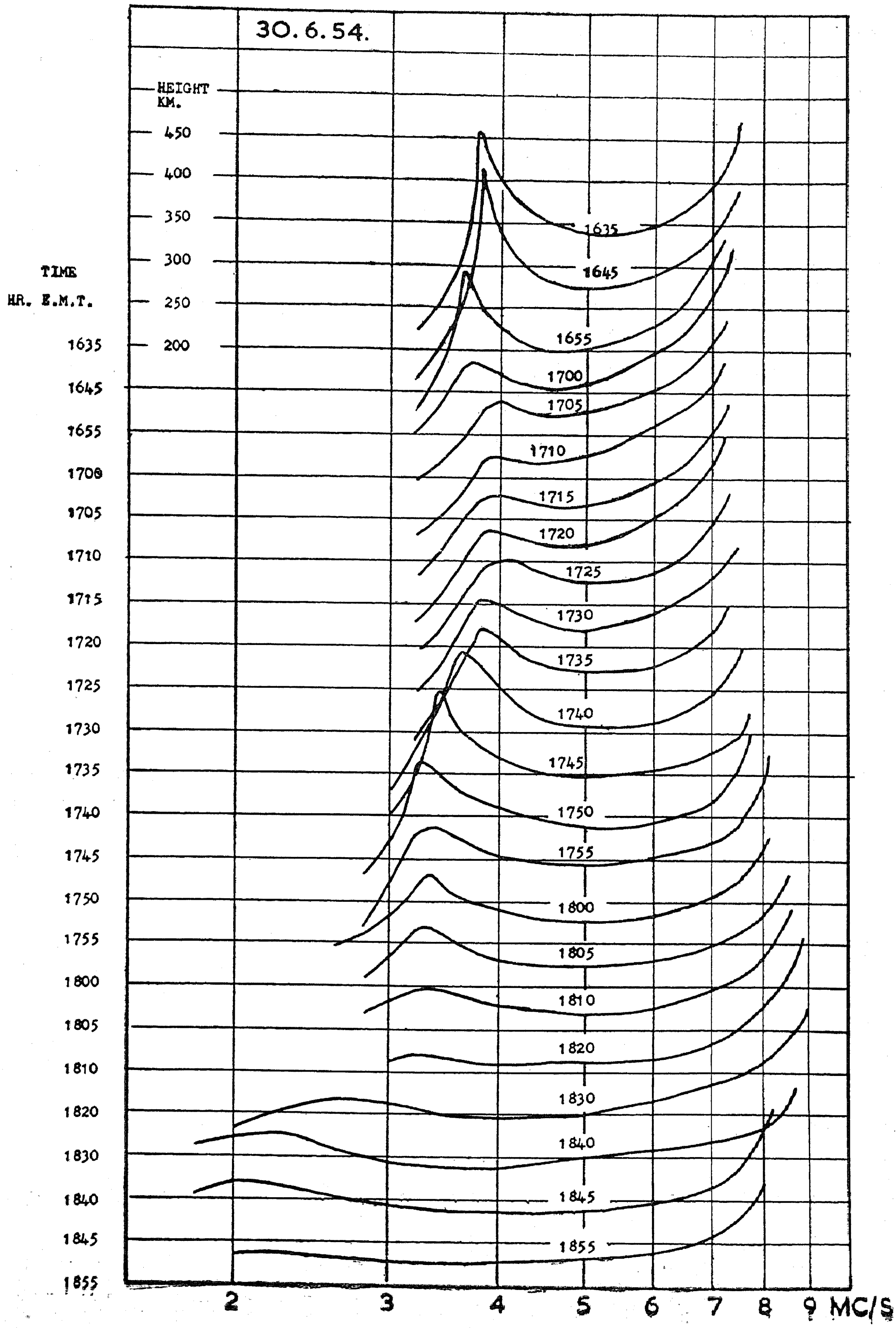

FIG. 2. Few redrawn P′-*f* records on the eclipse day.

records are reproduced in Fig. 3. On normal days with the lowering of the sun, the cusp corresponding to F_1 critical frequency gets flatter as the critical frequency decreases, and the identity of the F_1 layer gets lost with vanishing inflection on the F_1-F_2 layer trace. On the 30th June 1954, on the other hand, the F_1 layer trace continued to get flatter with the time as on normal days upto about 1720 hr. after which it suddenly increased in sharpness. At 1745 hr. it had a very sharp cusp, and later the cusp died out slowly. During this period, the F_1 reflections were very strong and many M reflections were recorded. Curiously, however, the phenomenon occurred about half an hour before the beginning of the eclipse at Ahmedabad.

F_2 layer.—The variations of the critical frequency (f_0F_2) and the height of maximum ionisation (h_pF_2) of the F_2 layer on the eclipse day and on the control days are shown in Fig. 4. f_0F_2 values were higher on the eclipse day than on the control days. Curiously again, the increase in f_0F_2 above the

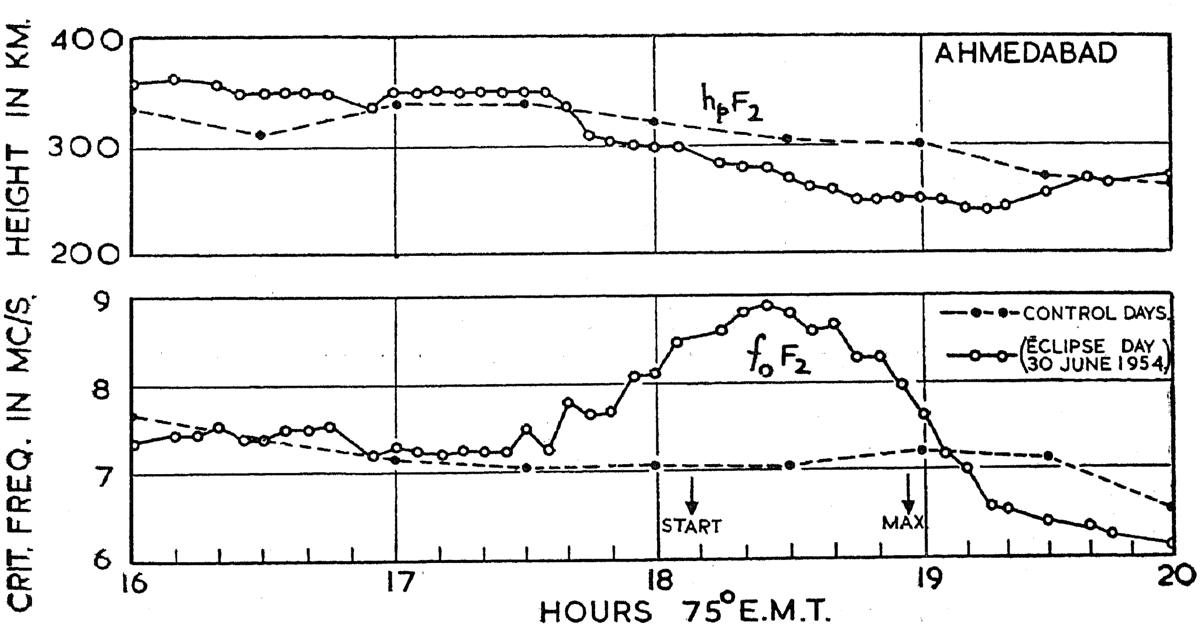

FIG. 4. The variation of h_pF_2 and f_0F_2 on the control days and on the eclipse day.

normal day values started about half an hour before the beginning of the eclipse. Similar sharp increases of f_0F_2 before the start of the eclipse were also noted at some other ionospheric stations, *e.g.*, DeBilt,[1] Tromoya, Kjeller and Tromso,[2] (Landmark *et al.*, 1956) at Slough and Inverness[3] (Minnis, 1956) at Lindau[4] (Becker, 1956). The variations of f_0F_2 on a few individual days round the day of the eclipse are shown in Fig. 5. The behaviour on the eclipse day was significantly different from that on normal days.

In order to find how the changes in the critical frequency of the F_2 layer were associated with changes in the electron density distribution, the heights of h_oF_2, h_mF_2 and semi-thickness (TF$_2$) were calculated by Booker and

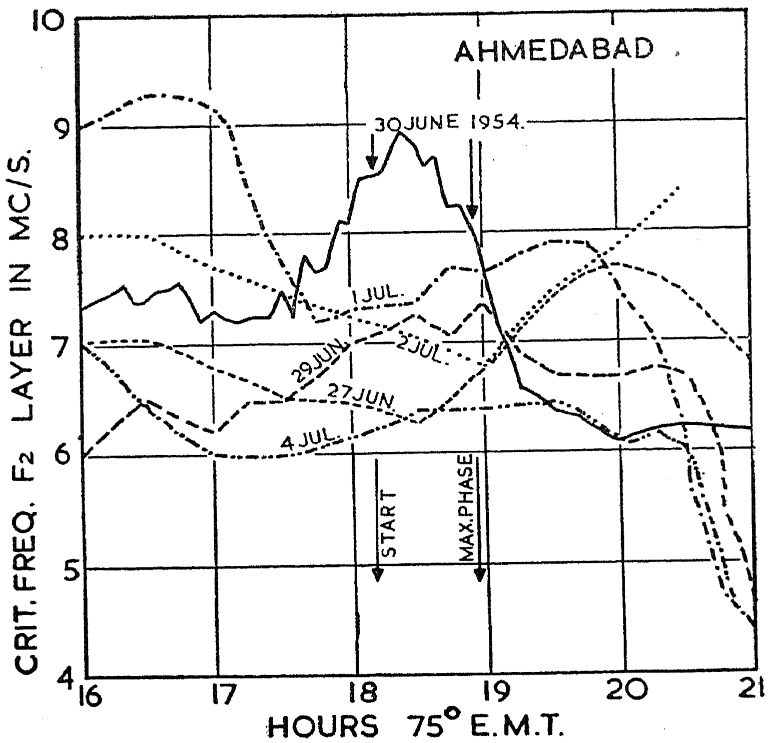

FIG. 5. The variation of f_oF_2 on the eclipse day and on the individual control days.

Seaton's method.[5] These are plotted in Fig. 6. The values of the maximum electron density (N_mF_2) and total electron content in a vertical column of the F_2 layer upto the height of maximum ionisation density (nF_2) are also plotted in the same diagram. It is seen that the semi-thickness of the F_2 layer increased in the early part of the eclipse period. This increase was mainly due to a lowering of h_oF_2. The total electron content therefore showed an increase during the eclipse period.

Another noteworthy change in the F_2 reflection traces during the eclipse was the appearance of multiple splitting of the critical frequency and the appearance of range duplication on the first order reflection trace. At 1840 hr., $1 \times F_2$ trace became very broad near the end showing a number of critical frequencies, whereas $2 \times F_2$ and $3 \times F_2$ traces showed clear critical frequencies. A few P'-f records during the period are shown in Fig. 7. At 1845 hr., the broadening of the F_2 trace extended to lower frequencies. At 1850 hr., two parallel F_2 traces very close to each other were recorded and these were very clear at 1855 hr. The range duplication was observed till 1920 hr.

At 1930, $1 \times F_2$ trace was weak and diffused, while $2 \times F_2$ was strong and clear, further the critical frequencies of $1 \times F_2$ and $2 \times F_2$ traces were very different. After 1940 hr. the reflections were again normal. Such abnormal records are not uncommon at Ahmedabad, and these are generally observed later

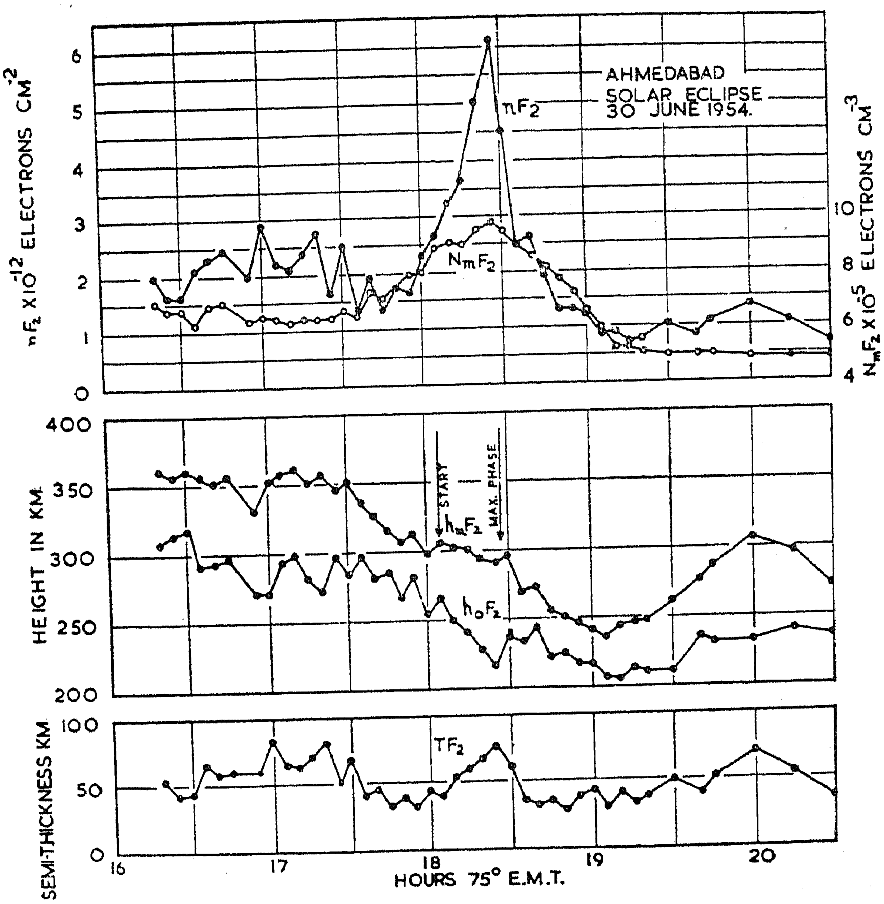

FIG. 6. The variation of h_mF_2, h_oF_2, TF_2, NmF_2 and nF_2 on the eclipse day.

in the night[6] (Rastogi, 1956). The phenomena can, however, be explained on the basis of a travelling discontinuity or a hump on the surface of the F_2 layer. Depending on the position and shape of the discontinuity a particular order of reflections may arrive from different directions and so with slightly differing time delays, and this would give rise to multiple splitting of the critical frequencies and parallel F_2 traces. Further, the reflections of a particular order may be selectively focussed by the curved surface of the ionosphere giving rise to anomalous intensity distribution of echoes of different orders[7] (Rastogi, 1956). It may be mentioned that Mitra, S. N.[8] (1955) reported a similar effect in the F_2 layer at Delhi round 1905 hr. and described it as triple splitting. Recently, Munro and Heisler[9] (1956) have pointed that if we look at the special situation at any instant during a solar eclipse, then the resultant distribution of ionisation will be very similar to that caused by a travelling disturbance and would produce anomalies in both F_2 and F_1 regions. Bramley[10] (1956) has reported that the solar eclipse on 30th June 1954 at Slough, reaching 72% of totality, produced a tilt in the F layer and the direction varied with time as expected from the geometry of the eclipse.

Sporadic E layer.—Sporadic ionisations in the E region are more frequent and stronger during summer months at Ahmedabad. During the days of these observations E*s* was abnormally high and often blanketted all the higher reflections extending even above 15 Mc/s. The variations of maximum frequency of E*s* reflections (*f*E*s*) on the eclipse day and on the controlled days are shown in Fig. 8. *f*E*s* increased soon after the start of the eclipse and remained higher than the normal values upto 1900 hr. Very high *f* E*s* can be seen in the P′-*f* records for 1825, 1040 and 1850 hr., reproduced in Fig. 7.

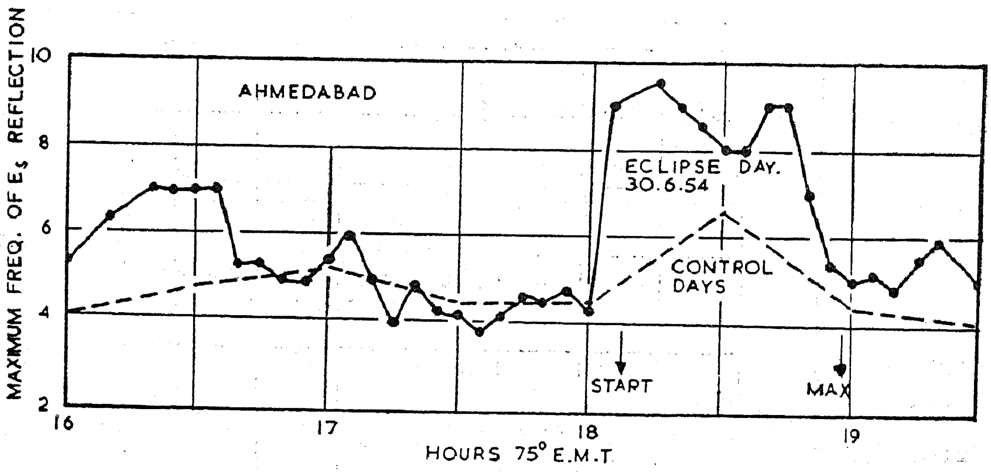

FIG. 8. The variation of maximum frequency of E*s* reflections on the eclipse day and on the control days.

CONCLUSION

The vertical ionospheric soundings at Ahmedabad during the solar eclipse on 30th June 1954 presented some interesting results. The ionisation of the lower layer E and F_1 decreased during the eclipse. Half an hour before the eclipse, the F_1 layer showed a sharp cusp with a number of multiple and M reflections. It is difficult to say that this was due to the eclipse. The F_2 critical frequencies, as well as the total ion content of the F_2 layer during the eclipse, were above normal. The semi-thickness of the F_2 layer increased during the eclipse. This was due to a lowering of the base of the F_2 layer. It seems that the lower portion of the F_2 layer was more affected by the withdrawal of solar radiation than at the level of maximum ionisation. Multiple splitting, range duplication and other effects of the curvature of the ionos-

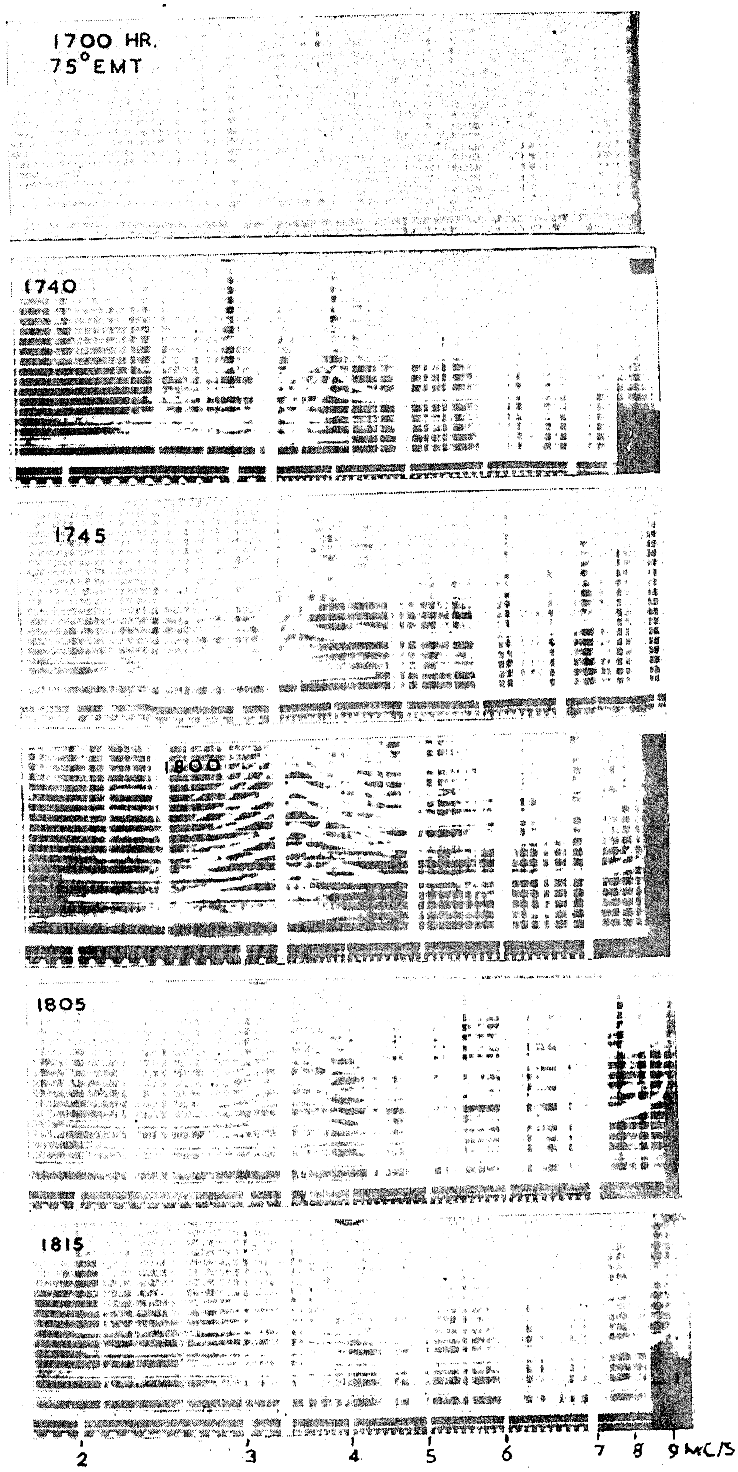

FIG. 3. Few P′′-f records showing the sudden sharpening of the F_1 cusp and appearance of large number of multiple reflections slightly before the start of the eclipse.

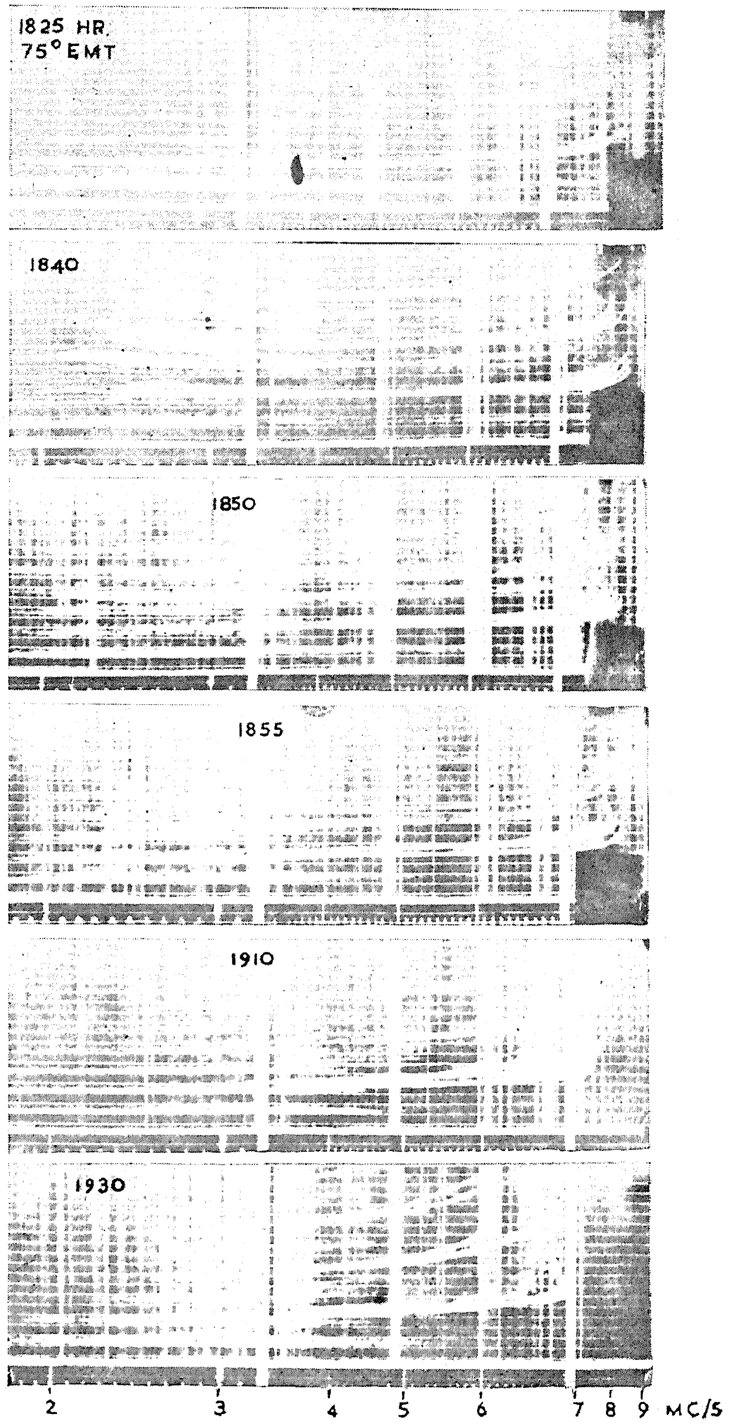

FIG. 7. A few P″-f records taken during the eclipse showing range duplication at 1850 to 1920 hr. and anomalous strengthening of 2nd order F_2 reflections at 1930.

pheric surface were observed during the eclipse. Maximum E*s* frequencies were higher during the eclipse period.

ACKNOWLEDGEMENTS

The work described is a part of the studies of the ionosphere during solar eclipses undertaken by the author in the laboratory. The author is greatly indebted to Professor K. R. Ramanathan for his valuable guidance and encouragements. The Council of Scientific and Industrial Research (India) is supporting the SIonospheric tation with financial assistance.

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