THE DISAPPEARANCE OF EQUATORIAL E_s AND THE REVERSAL OF ELECTROJET CURRENT

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ABSTRACT

Based on simultaneous observations of the horizontal geomagnetic field component H, sporadic E (E_s) and E-W electron drifts at stations close to the dip equator within the equatorial electrojet region, it has been found that on quiet days and sometimes on disturbed days, when there is an abnormal large decrease in H during daytime, there is a simultaneous disappearance of E_s and a reversal of the direction of drift of electrons from westward to eastward. This suggests that the disappearance of equatorial E_s during daytime is due to a temporary reversal of the electrojet current, which is caused by the imposition of an additional electrostatic field opposite in direction to that of normal S_q field.

INTRODUCTION

THERE are three major zones of occurrence of sporadic E (E_s) in the ionosphere namely (1) the auroral zone in which the E_s is predominantly a night-time phenomenon with little seasonal variation, (2) mid-latitude zone in which E_s is predominantly a summer-time phenomenon occurring both during day and night but more intensively during day and (3) the equatorial zone in which the E_s is a daytime phenomenon with little seasonal variation.

Matsushita (1951) showed that there was a close relation between the maximum frequency (fEs) reflected from daytime E_s and the solar daily range of horizontal geomagnetic field (H) in low latitudes; both showing a sharp peak over the magnetic equator suggesting that the equatorial E_s is associated with the equatorial electrojet. Knecht and Mcduffie (1962) showed that the equatorial E_s occurs in a belt having a width of about 700 Km which agrees very well with the width of the equatorial electrojet as deduced from geomagnetic field observations.

Skinner and Wright (1957) found that the fEs at Ibadan during the daylight hours is lower on magnetically disturbed days than on quiet days. On 2 or 3 occasions in each month, a series of abnormally low values of fEs with the simultaneous decrease in H were also reported. Bhargava and Subrahmanyan (1961) observed that E_s at Kodaikanal disappeared for several hours during the main phase of the magnetic storm.

In this note are presented a few simultaneously observed short-time decreases in H, disappearance of E_s and a reversal of direction of drift of electrons at equatorial stations.

The daily variation of H at an equatorial station on a quiet day is known to be a steady rise of the field from the night-time level following sunrise, reaching a maximum around 1100–1200 hr and a steady decrease till sunset. The examination of magnetograms at the equatorial station, Kodaikanal, revealed that during the low-sunspot years of 1954 and 1964 on some apparently magnetically quiet days, significant depressions in the daily variation of H were noticed either a few hours after sunrise or a few hours before sunset; and these depressions in H were found to be correlated with the disappearance of E_s.

In Fig. 1 are reproduced the H magnetogram and a sequence of ionograms at Kodaikanal on 27 January 1964. This day was one of the five international quiet days of the month, the daily-sum K_p index being only 7 +. It is seen that the magnetogram trace is very smooth with no short-period fluctuations superposed on the daily variation. However on the same day, a significant depression in H is noticed around 1500 hr. Referring to the ionograms, one finds a very strong E_s at 1300 hr, the value of fEs being about 11 MHz. Also at 1330 hr, strong E_s can be seen in the ionogram. At 1400 hr the E_s echoes are weak and the normal E echo traces appear at a height slightly greater than that of $h'E_s$. At 1415 hr, no evidence of E_s is seen on the ionogram. This no-E_s condition continues in each of the 15-minute ionograms till 1515 hr. At 1530 hr although F traces were recorded clearly, the reflections from sporadic E_s or the normal E are not seen, probably due to low frequency absorption. The effect of a seemingly minor solar flare was recorded at about the same time on the field-strength observations of Tashkent 164 KHz radio waves received at Ahmedabad. At 1600 hr, E_s is seen fairly strong with fEs at about 6 MHz. Similar strong reflections from E_s region are seen at 1630 hr and 1700 hr. Thus the absence of E_s between 1415 hr and 1515 hr is not an early disappearance of E_s in the evening, but a temporary disappearance of E_s linked with the decrease in H field. This day being exceptionally quiet, it is reasonable to assume that the depression in H was due to a decrease of the electrojet currents and was not due to any non-ionospheric currents.

In Fig. 2 are shown the magnetogram at Kodaikanal (dip 3·7° N) and the inograms at Thumba (dip 0·6° S) on 13 September 1967. The daily sum of K_p for this day was 31_o, and C_p was 1·3. Further a moderately severe magnetic storm with its Sudden Commencement around 0345–0348 hr (U.T,) was reported both at Trivandrum and Kodaikanal Observatories. This can be seen in the magnetogram reproduced here. One of the major features on this day was that after about 1330 hr there was a sudden drop in H amounting to about 177 γ within 55 mins. Referring to the ionograms for the same day, the occurrence of E_s are clearly seen at 1300 hr and 1330 hr; while at 1345 hr, distinct O and X components of normal E layer reflections are seen, but there is no evidence of sporadic E reflections. This no-E_s condition prevailed till 1645 hr, while at 1700 hr, very distinct E_s reflections can be seen. The heights of E_s are seen to be slightly lower than the heights of the normal E layer.

In Fig. 3 are shown the variations of H, fEs and horizontal F-region electron drift at Thumba/Trivandrum for 13 Septermber 1967 together with the average variations for the whole month; E region drifts were not available on the particular day due to experimental trouble. It is seen that the normal H variation is fairly symmetrical around 1100 hr. The diurnal variation of H on 13 September 1967 was very similar to the monthly mean curve till about 1330 hr, after which there was an unusual large decrease for a few hours. While the value of fEs averaged for the whole month exceeded 7 MHz between 0700 to 1700 hr, on 13 September 1967, fEs was very close to the normal monthly mean value upto 1330 hr after which there were no E_s reflections on the ionograms, *i.e.*, fEs was less than 1 MHz, the latter being the minimum frequency limit of the ionosonde. This no-E_s condition remained upto 1645 hr and fEs revived to about 7 MHz at 1700 hr. The direction of the horizontal drift on normal days was Westward during the period between 0700 to 1900 hr and Eastward between 1900 hr and 0700 hr. On 13 September 1967, the drift was fairly similar to that of a normal day upto about 1300 hr but at about 1330 hr, the drift changed to Eastward and remained so upto about 1800 hr. It is seen that the depression in the magnetic field H, the disappearance of E_s and the Eastward F-region drift all coincide in time indicating that these phenomena are strongly associated with each other.

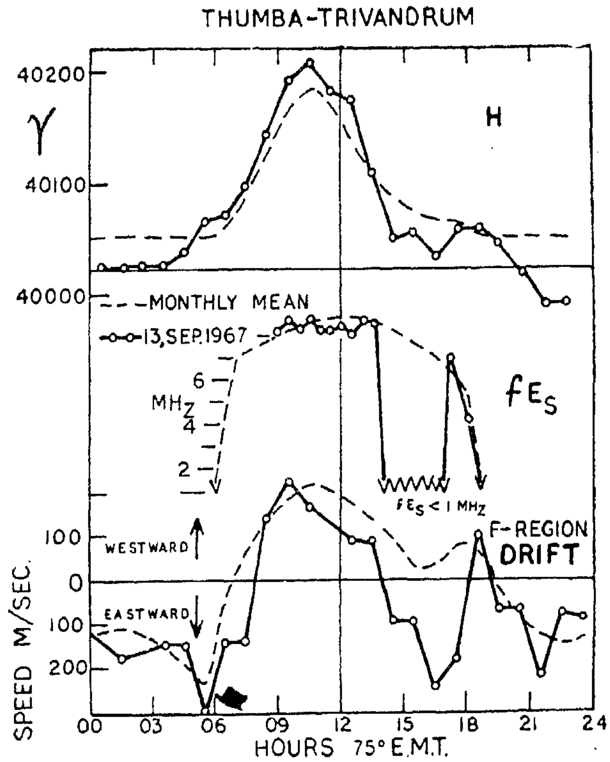

FIG. 3. Daily variations of H, fEs and East-West F-region drift at Thumba/Trivandrum on 13 September 1967 along their monthly mean variations showing the depression in H, disappearance of E_s and reversal of drift occurring simultaneously.

In Fig. 4 are reproduced the magnetograms at Kodaikanal on 20 November and 23 November 1964. It is seen that the variation of H was very smooth on 20 November, while on 23 November large depressions in H were seen between 11 and 16 hr. The variation of f_0E_s on 20 November shows that the value of f_0E_s is above 7 MHz between 0800 and 1600 hr. On 23 Nov, f_0E_s was close to 9 MHz from about 0800 hr to 1100 hr. There were no E_s reflections from 1130 to 1400 hr, and fEs is revived to a value of about 7 MHz at 1530 hr. The E-W component of E-region drift at close-by station Thumba on 20 November showed a maximum around 0800 hr and a minimum around 1400 hr but the direction was all the time towards West. On 23 Nov, there is a peak of drift speed at 0830 hr, but the direction became Eastward between 1130 hr and 1530 hr coinciding in time with that of the depression in H. Thus, it is concluded that the disappearance of E_s and the depression in H during the daylight hours at an equatorial station are associated with the reversal of the E and F region drifts from Westward to Eastward direction.

The variation of E and F region drifts at Thumba are shown to be similar in nature and are closely associated with the horizontal magnetic field variations (Rastogi *et al.*, 1970). The magnetic field variations observed at the ground level are found to be due to the ionospheric currents at E-region around 106 Km by direct rocket measurements (Sastry, 1968). The equatorial electrojet current is given by the product of E-W electrostatic field

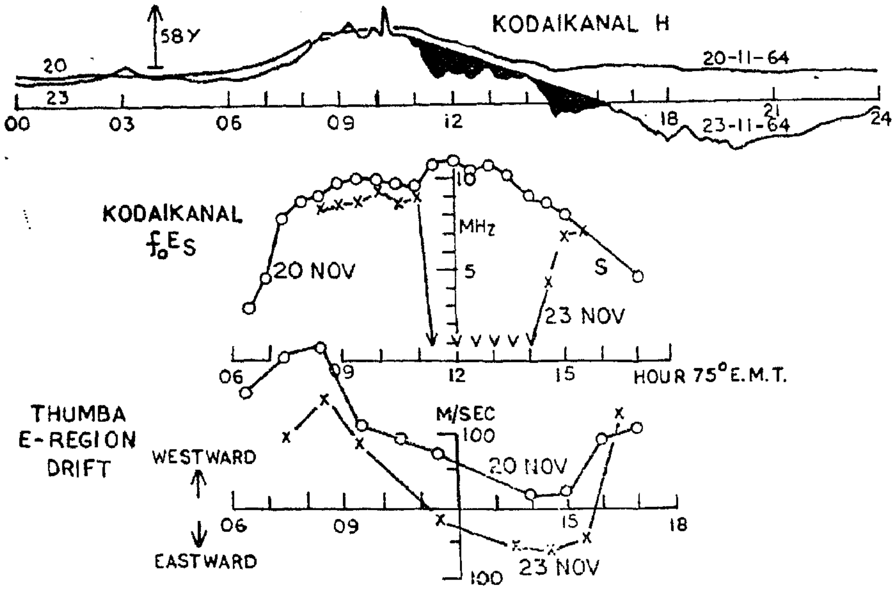

FIG. 4. Daily variations of H (Kodaikanal) f_0E_s (Kodaikanal) and E-W E-region drift (Thumba) on a quiet (20–11–1964) day and a disturbed (23–11–1964) day. Note the depressions in H disappearance of E_s and the Eastward E-region drifts occur simultaneously in time.

and the cowling conductivity. During solar flares the magnetic field variations on the ground are known to be due to the changes in the E-region ionisation and thereby in conductivity, but during relatively, quiet conditions (*i.e.*, without solar wave disturbances) the short period fluctuations in H would be more likely due to corresponding variation of electric field in the E-region. It is thus suggested that the disappearance of equatorial E_s is due to the temporary reversal of equatorial electrojet currents. This reversal of currents may be taking place due to the imposition of an electrostatic field opposite in direction to the ambient S_q field.

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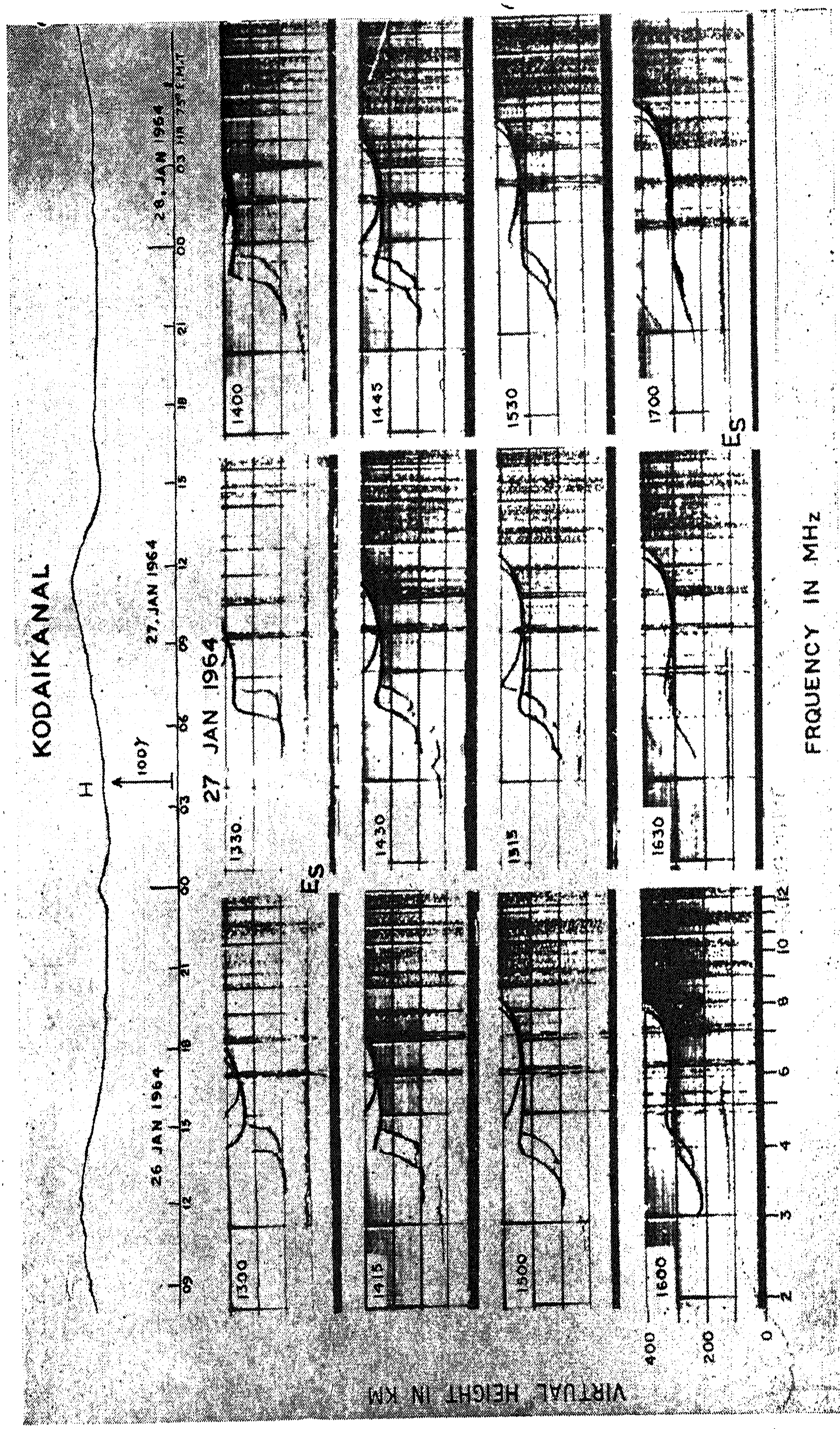

FIG. 1. Magnetograms and ionograms at Kodaikanal on a magnetic quiet day (27 January 1964) showing a temporary decrease in H and disappearance of E_s.

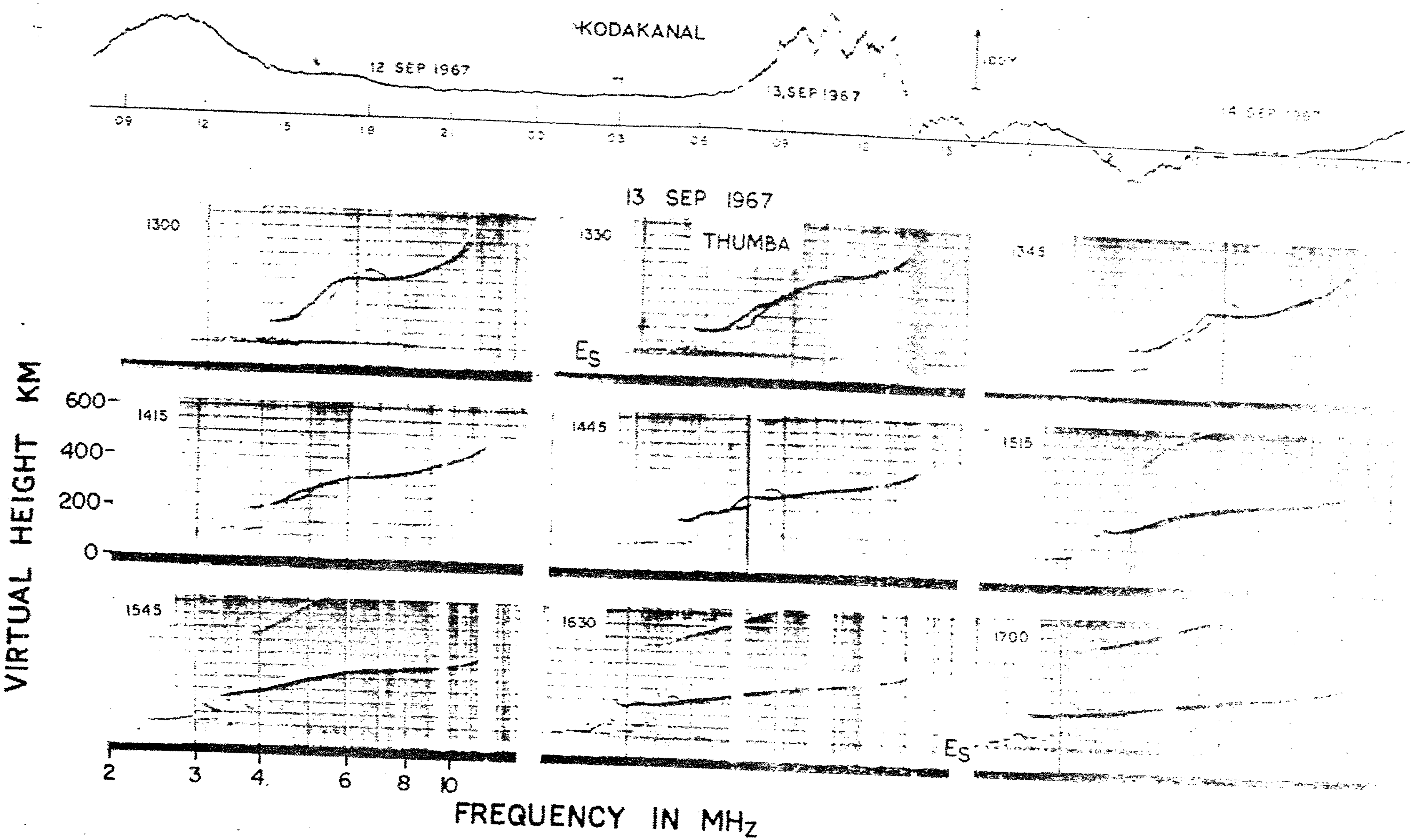

FIG. 2. Magnetograms at Kodaikanal and ionograms at Thumba on a magnetic disturbed day (13 September 1967) showing the disappearance of F_1 at the time of a sharp decrease of H.

magnetrograms and ionograms. Thanks are also due to Mrs. Girija Rajaram for assistance during the study of the ionograms at Kodaikanal.

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