TOPSIDE REFRACTIVE IRREGULARITIES AND TRAVELLING IONOSPHERIC DISTURBANCES*

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Munro (1950) deduced from ground-based observations that travelling ionospheric disturbances (T.I.D.'s) are large-scale distortions of the electron density contours, which travel through the ionosphere, and Calvert and Schmid (1964) attributed extra traces and distortions of the main echo traces, which occur near the critical frequency of topside ionograms, to refractive effects associated with large-scale irregularities. In an examination of topside and sub-peak ionograms recorded close in position and time, it was found that on a number of occasions refractive effects occurred on topside ionograms, when manifestations of T.I.D.'s were observed on sub-peak ionograms (Dyson 1967*b*).

A sequence of topside ionograms, which were recorded at Woomera from the Satellite Alouette I and in which a number of the ionograms exhibit refractive effects, is shown in Figure 1. For each of these ionograms electron density profiles have been calculated using a lamination method (Dyson 1967*a*) and assuming that the main ionogram traces are the result of vertical propagation. The results (Fig. 2) show that a large distortion in the electron density contours exists near the peak of the F_2 layer. Actually, the distortion of the electron density contours is probably less than that shown in Figure 2 because the main ionogram traces do not arise from truly vertical propagation. It is also apparent from Figure 2 that the amplitude of the disturbance decreases with increasing height and is no longer evident above a height of about 800 km. The distortions in the electron density contours are similar to those found by Munro (1950) to be associated with T.I.D.'s observed below the peak of the F_2 layer.

Manifestations of T.I.D.'s on sub-peak ionograms usually occur at different times on the o- and x-ray traces as a result of the divergence of the o- and x-rays in the magnetic meridian plane (Munro and Heisler 1956*b*). A similar effect is noticeable in the sequence of ionograms in Figure 1 where the first effect of the irregularity is to produce a cusp on the o-ray trace. This sequence of ionograms was recorded as the satellite moved northward and as it approached the irregularity; the o-ray would first be affected because, in the southern hemisphere topside ionosphere, the lateral deviation of the o-ray is northward and that of the x-ray southward. Further evidence of a close relation existing between T.I.D.'s and refractive irregularities is the similarity in the times of occurrence of these phenomena (Calvert and Schmid 1964; Dyson 1967*a*).

Hines (1960) showed that the properties of T.I.D.'s determined from ground-based observations could be interpreted in terms of internal atmospheric

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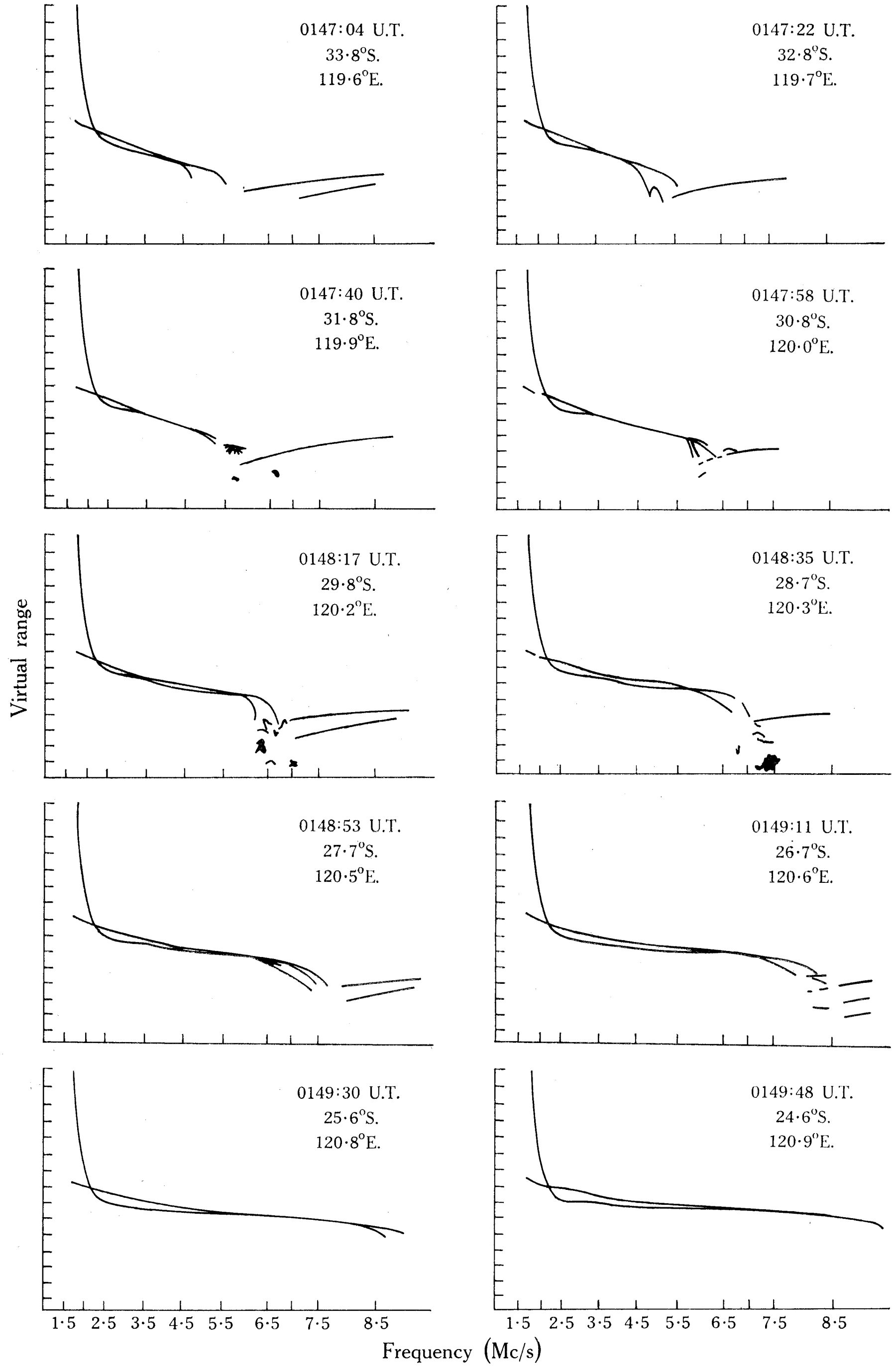

Fig. 1.—Tracing of a sequence of Alouette I ionograms containing refractive effects, which was recorded at Woomera on October 2, 1962. In each tracing the vertical scale represents virtual range and is divided into 100 km intervals.

gravity waves. These waves tend to increase their amplitudes of oscillation with increasing height but this is modified by damping effects due to energy dissipation, which also increases with height. Therefore the amplitude of the distortion in the electron density produced by a T.I.D. would be expected first to increase with height to some maximum value and then to decrease with further height increases. The observation reported here and those of Munro (1950) and Munro and Heisler (1956*a*) show this behaviour and suggest that the maximum amplitude of distortion in the F_2 layer occurs at about the height of the layer peak. Observations of T.I.D.'s by the incoherent scatter technique have also shown that the amplitude of these disturbances decreases above the F layer peak and that the maximum amplitude occurs near the height of the maximum density of the F region (Thome 1964).

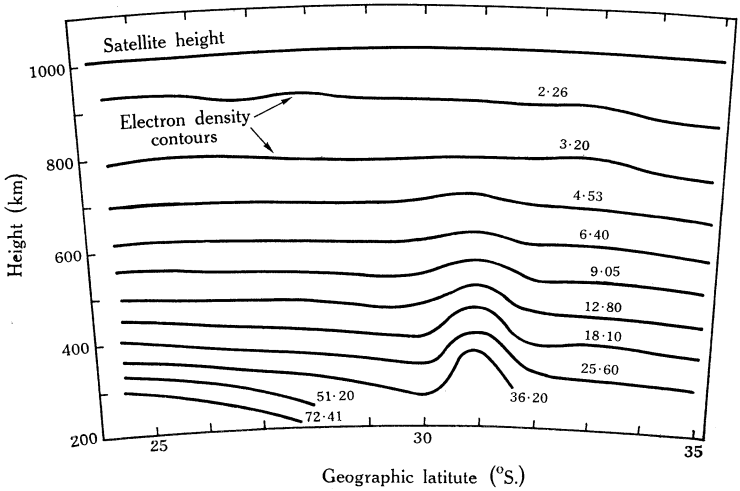

Fig. 2.—Electron density (10^4 electrons/cm^3) contours calculated from the ionograms of Figure 1.

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