The work presented in this thesis was carried out by the author at the Physical Research Laboratory (PRL), Ahmedabad under the guidance of Prof. R. Raghavarao.

The sounding of the topside ionosphere by means of satellites is one of the established techniques for studying the F2 region and the topside ionosphere. An experimental setup has been established at PRL for receiving the telemetry data from the ISIS (International Satellites for Ionospheric Studies) satellites at 136.08 and 136.59 MHz frequencies. The 136.08 MHz telemetry signal contains the video data (in the FM mode) of the ionospheric sounder experiment, in the range of 0.1 to 20 MHz frequency, on board the ISIS satellites. The topside sounder data are retrieved from the telemetry signal and recorded on a magnetic tape. The data signals are later processed through a locally built signal analyzing unit to produce the ionograms on 35 mm film.

The location of Ahmedabad (+18°.6 dip latitude, 72°.3 E geog. longitude) is suitable for studying the low latitude ionospheric phenomena, for example the equatorial anomaly. The establishment of a satellite telemetry station at Thumba (-0°.3 dip latitude, 76°.9E geog. longitude) provides the much needed information about the F2 region on
The author has actively participated in the recording as well as reproducing the topside data. The reduction of the topside ionogram data to N(h) profiles was carried out by the author by using the IBM 360 Computer at PRL. The present thesis describes the results obtained from the topside sounder data recorded at PRL, Ahmedabad during 1972-1975. The study concerns the equatorial ionospheric phenomena: the ionisation ledge, the ionisation and the neutral anomalies, the electrojet, the spread F, and their interrelationship.

A Chapterwise break up of the thesis is as follows:

Chapter I

The first chapter describes the present knowledge of the equatorial ionosphere. The composition and the dynamical processes in the ionosphere are briefly discussed.

A brief description of the earlier work on the equatorial ionisation anomaly, especially its behaviour in sunspot minimum and maximum periods, is presented. The dynamical interaction of the ionisation anomaly with the neutral atmosphere, through the ion drag force, is known to produce a similar anomaly in the neutral temperature and density at the F2 region altitudes known as "neutral anomaly".
The neutral anomaly in turn modifies the distribution of ionisation through partial inhibition of the diffusion of plasma that is lifted up at the magnetic equator due to the $E \times B$ force, thus leading to the formation of the ionisation ledge. The high crest to trough ratio of the ionisation anomaly in the forenoon hours in solar minimum period helps to build up the neutral anomaly and consequently the ionisation ledge.

Chapter II

Two ionospheric phenomena occurring at the equatorial magnetic latitudes and caused by the eastward electric field ($\mathbf{E}$) interacting with the horizontal magnetic field ($\mathbf{B}$) of the earth, are: (1) the ionisation anomaly in the F region extending into the topside ionosphere and (2) the electrojet in the E region. Both these phenomena are understood to be caused by the $E \times B$ force on the plasma. In the E region, only the electrons move under the influence of this force giving rise to an upward Hall polarisation electric field that in turn causes the eastward electrojet current. In the F region, however, both the electrons and the ions drift upward under the influence of the $E \times B$ force and the subsequent plasma diffusion along the magnetic field lines creates the crests of ionisation on either side of the magnetic equator. The correlation between
the two phenomena has been investigated by a number of authors using different parameters for representing the electrojet and the ionisation anomaly strengths. A discussion of the earlier work is given and a new method of analysis, that takes into account the time integrated strength of the electrojet intensity, is shown to exhibit better correlation between the two phenomena than obtained by other workers. It is shown that this method of approach shown here for evaluating the electrojet strength provides more clear insight in understanding the basic process responsible for the formation of ionisation anomaly.

Chapter III

The observations and interpretations of ledge formation in the topside ionosphere by earlier authors are critically discussed in view of several new characteristics revealed by our observations on the ledge formation. A brief discussion of the new mechanism for the formation ledge, due to Raghavarao and Sivaraman (1974), is given. The mechanism invokes the presence of neutral anomaly in the neutral temperature and density. A method for calculating the neutral anomaly is described and the anomaly in the neutral atomic oxygen is calculated on a few occasions. The diurnal variation of the neutral anomaly appears to be similar to the observed diurnal behaviour of the ionisation anomaly.
Chapter IV

The procedure for delineating the spatial structure of ionisation ledge is described. It is seen that the structures during equinoxes are symmetric in their latitude extent in the two hemispheres around the magnetic equator. However, during solstices the spatial structures are physically shifted to the winter hemisphere. These observations reveal the presence of neutral wind across the magnetic equator from summer to winter hemisphere. The magnitudes of these winds are calculated from the excess length of the ledge in the winter hemisphere over that in the summer hemisphere. The wind magnitudes obtained in this manner represent average winds and are found to be of the same order as hypothesised for explaining the observed solstice asymmetry of the ionisation anomaly crests (in the topside as well as bottomside ionosphere) in the numerical simulations by various workers.

Chapter V

The occurrence and intensity distribution of more than 200 ledge occurrences (during 1972-75) when plotted against lunar age, shows two broad peaks around 0300 and 1500 hours lunar age. This behaviour is explained on the basis of modulation of the diurnal Sq electric field (due to solar tide) by the semidiurnal L electric field (due to lunar tide).
The modulation enhances the electric field in the forenoon hours for the above lunar ages. The effect of the enhancement in the electric field is to create strong ionisation anomaly around the noon hours by which time the neutral flow reverses its direction of motion from west to east at F region altitudes. The ion drag force thus becomes effective around noon and the existence of strong ionisation anomaly provides resistance to neutral flow in proportion to the ionisation density, leading to the formation of neutral anomaly. The occurrence of ledge is thus related to the strength of the ionisation anomaly by the time the neutral wind reverses its direction around noon. The modulation of L field at 0300 and 1500 lunar ages, on Sq field is shown to provide the explanation for the observed results.

Chapter VI

The results of comparison of the occurrence of two phenomena in the equatorial ionosphere, (1) the ionisation ledge in the topside ionosphere and (2) the counter electrojet in the E region, are presented. About 170 ionisation ledge observations on magnetically undisturbed days when compared with the diurnal variation of \((\Delta H_T - \Delta H_A), \Delta H_T\) and \(\Delta H_A\) are increments from the night time base level in the horizontal components of earth's magnetic field at Trivandrum and Alibag respectively during the days of ledge observation, reveal that
the counter electrojet, either partial or full, during the afternoon hours occurred on 70 per cent of these days. The other morphological features which the ionisation ledge exhibits are: (1) more frequent occurrence in solar minimum than solar maximum period, (2) two maxima in the occurrence and intensity distribution around 0300 and 1500 hours lunar age, (3) tendency to occur on a series of days in succession and (4) occurrence in a narrow longitude belt on certain occasions. The counter electrojet was known to exhibit the same morphological features in its occurrence, as shown by a number of authors. 

All these similarities in the morphological features of both ledge and counter electrojet together with the high correlation (70%) in their occurrence on a day to day basis indicate that the two phenomena could have been caused by the same source. As neutral anomaly is now known to be the cause for the ionisation ledge formation, it is suggested that the same anomaly might also cause the counter electrojet at the E region heights. A brief description of the mechanism for causing the counter electrojet by the vertical winds, in a narrow region (± 2° dip latitude) on either side of the magnetic equator, generated by the pressure bulges associated with the neutral anomaly crest formations (around ± 15° dip latitudes), on the basis of the work of Raghavarao (1976) is given.