CHAPTER 2

GROUND BASED TECHNIQUES OF IONOSPHERIC EXPLORATION

2.0 INTRODUCTION :

Investigation with radio waves has remained the prime tool for studying the properties of the ionosphere. With the development of the so called "**pulse sounding**" technique due to Breit and Tuve , a great deal of information on the height, reflecting and absorbing power, ionization density, etc. of the ionized regions has been accumulated from the network of stations distributed throughout the world. In this method, instead of sending out continuous waves of a particular frequency, the transmission is "**keyed**" to produce packets of pulse of these waves having a duration of a few hundred microseconds separated by periods of no transmission. The rate of keying (termed the pulse repetition frequency) is usually of the order of 50 per second. In this way, adequate time is allowed following the transmission of any given wave packet for the reception of reflected signals from the ionosphere before the next packet is transmitted. Cathode ray tube recording readily enables the measurement of the time taken for the pulse to travel to the ionosphere and back. This method of echo sounding is essentially similar to that used in radar. Most experimental work of this kind is carried out using signals at vertical incidence, i.e. the ionosphere is sounded overhead and the receiver and transmitter being at the same site. The modern development of this technique has led to the construction of so called ionosonde an automatic machine which will sound the ionosphere and produce records photographically displaying the variation of echo return time with the frequency of the radio wave as the latter is continuously increased over a preselected range. From this ionogram record it is possible to determine the height at which a particular frequency is reflected, and in this way a great deal is learned about the vertical structure and temporal changes of the ionized regions. The advent of instrumented rocket and satellite vehicles capable of entering the upper regions of the atmosphere has enabled direct observations to be made within the ionosphere.

In ground based techniques of ionospheric exploration number of experiments are carried out for determination of D region parameters, absorption measurements and wave interactions These include experiments with the several kilometers in wavelength, which are reflected from the D region and experiments with shorter waves which penetrate the D region and are reflected in the E and F regions. These methods are supplemented by rocket experiments, using both radio wave and direct measurement techniques. The experiments are carried out either at a fixed frequency or at swept frequencies.

2.1 FIXED FREQUENCY STUDIES :

The data obtained from radio waves actually reflected in the D region consists of phase and amplitude measurements of signal in the range of 10-200 kHz, propagated over distances of up to about 1000km. One of the most basic parameter obtained from the phase of the received signal, is the "equivalent height of reflection", which depends on wave frequency ´f´ and on the angle of incidence at the ionosphere, i. The comparison of different data is often simplified by using an approximation known as Martyn's theorem, which states that in a plane stratified ionosphere the reflection height of an obliquely incident wave is equal to that of a vertically incident wave of frequency fcosi. The equivalent height for vertical incidence is found to show considerable diurnal changes; for 16 kHz. wave it is of order 70-75 km. by day, and roughly 90 km. by night. The equivalent height is reduced during ionospheric disturbances of various types, and provides a useful indicator of disturbed condition.

Further an important information is obtained from the amplitude and polarization of the reflected signals. If a plane polarized wave transmitted from the ground, the downcoming wave reflected from the ionosphere is, in general, elliptically polarized. It may be resolved into two plane polarized components, whose electric vectors are respectively parallel to and perpendicular to the electric vector of the upgoing wave. The ratio of the amplitudes of the upgoing and downcoming components, with similar polarization, gives a "reflection coefficient"; the ratio of the amplitudes of the upgoing wave and the perpendicular downcoming component gives a "conversion coefficient". At vertical incidence the "reflection and "conversion" coefficients are generally similar and the downcoming wave is generally circularly polarized. At oblique incidence, two pairs of "reflection" and "conversion" coefficients are defined, one pair for upgoing wave polarized parallel to the plane of incidence, on the ionosphere, the other for the an upgoing wave polarized perpendicular to this plane.

Absorption Measurement :

The absorption measurement of radio wave has been used as a means of investing the lower ionosphere. There are three types of experiments known by the following conventional designations, and the frequency ranges which are most generally used.

A1: vertical incidence pulse absorption 1.5-6 MHz.

A2: Cosmic noise absorption (riometer) 5-30 MHz.

A3: Field strength of C.W. signals 0.01-5MHz.

The pulsed signals used in the A1 experimental are reflected from E or F layers, at which level they suffer from some 'deviative' absorption, which is particularly severe if the wave frequency is close to the one of the frequency of the E or F layer critical frequencies. This absorption to which equation of the absorption coefficient of high frequency waves under "nondeviative " conditions does not apply. The relative size of the 'deviative ' and 'nondeviative' components may be in question at times, though in principle their different frequency dependence enable the two components to be separated, as explained below.

The absorption is often expressed in terms of the "apparent reflection coefficient", ρ , defined as the ratio of the amplitude actually received to that which would have been received with no absorption present. This definition implies that the effects of spatial attenuation are removed before ρ is calculated. for a signal reflected at vertical incidence, which traverses the D region twice the quantity known as "the absorption" is

$$-\ln \rho = 2\int_{0}^{h} k\,dh$$

in which integration is taken upto the reflection height and k is the absorption coefficient. The symbol L is often used to denote the absorption in decibels, so that $L = -8.68 \ln \rho$. Under normal condition in the D region, particularly all the absorption occurs at heights where $\nu << \omega$ and $\mu \simeq 1$; so that for the ordinary mode, which is generally observed i practice, the absorption is

$$L = \frac{2.33\ 10^{-6}}{(f + f_1)^2} \int_0^{h_r} N\nu dh = \frac{A}{(f + f_1)^2}$$

in which L is in decibels and the numerical constant is appropriate for m.k.s. units and $f_L = \omega_L/2\pi$; Hence a graph of $L^{1/2}$ verses f should give the straight line, with a slope $A^{-1/2}$ and intercept $-f_1$. The experimental data generally follow a relation of this type, except where f is near one of the critical frequencies foE foF1, at which deviative absorption is important (see fig 2.1). This provides evidence that nondeviative absorption is dominant, away from the critical frequencies.

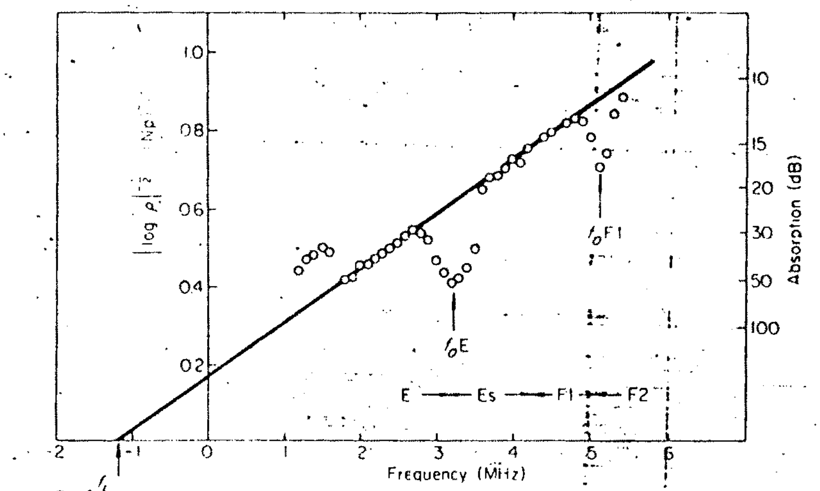


Fig 2.1: Variation of absorption with radio-wave frequency, observed at Slough, England (52°N, 1°W) near noon on 11 July 1950. The measured values are shown by open circles, and the straight line shows the theoretical frequency variation (see text). As frequency increases, reflection takes place successively in the E, Es, F1, and F2 layers (Es is sporadic E.

A2 method was developed by Mitra and Shain (1953). ionospheric absorption measurements are carried out by the use of cosmic radio noise. It is observed at a frequency of 18 MHz. The cosmic radio noise flux incident on the ionosphere varies with direction in space, and thus with sidereal time. To determine the ionospheric absorption at a given local time, the noise level is compared with the level observed at the same sidereal time. With the same antenna system, at a time when no absorption is present (i.e. at night under magnetically quiet condition), the difference gives the ionospheric absorption. An instrument called a riometer is used for routine absorption measurements. It is designed to reject inference from broadcasting stations, by scanning across a bandwidth of order 100 kHz and determining the minimum noise level observed. At frequencies of 25-30 MHz generally used for riometer operation, the normal D and F regions typically contribute about one decibel each to the total daytime absorption period of greater absorption are mostly due to increase of D region electron concentration, such as occurs during auroral and polar cap absorption events and sudden ionospheric disturbances. However it has been shown that at low latitudes F region attenuation can exceed D-region absorption even during magnetically quiet condition. (Bhonsle R. V.)

Field Strength Measurement:

Field strength measurements of CW signals from distant low frequency and medium frequency transmitter constitute the A3 method of absorption. The transmission paths are typically a few hundred kilometers. The receiving antenna system must be capable of distinguishing between the "ground wave ", received direct from the transmitter, and the "sky-wave" reflected from the ionosphere. Within certain assumption, the amplitude of the sky wave can be used to determine an equivalent value of absorption at vertical incidence, by use of Martyn's theorem. Great care must be taken to avoid ambiguity, whenever there is possibility of more than on ionospheric propagation path from the transmitter to the receiver.

Partial reflections

Partial reflections occur of a wave passing through the ionospheric irregularities which change the refractive index from μ to $\mu + \Delta\mu$ in a distance small compared with the wavelength. Reflections of this kind are very weak and hence, are observed only with a high powered transmission (~50 KW) of radio waves. The procedure is as fallows:-

The pulsed radio waves are emitted circularly polarized, first with left handed sense and immediately afterwards with right handed sense and are received after weak partial reflection at vertical incidence. The amplitudes Ex and Eo of the echoes are measured and their ratio plotted as a function of height as shown in fig.2.2. The wave frequency(~2 MHz) is chosen so that total reflection occurs at heights greater than those to be explored. It is assumed that the partial reflections are produced by $d\mu/dh$ and that the reflection coefficients by $R = \Delta\mu/2\mu$. The refractive index μo and μx for the two modes have the functional forms

$$\mu_o = fo[\omega,\omega_H,\ \nu(h)].N(h)$$

$$\mu_x = fx[\omega,\omega_H,\ \nu(h)].N(h)$$

where ν = collision frequency of electrons with neutral particles and the ratio of the reflection coefficients Rx and Ro is obtained from

$$\frac{Rx}{Ro} = \frac{fo\,[w, w_H,\ \nu(h)].N(h)}{fx\,[w, w_H,\ \nu(h)].N(h)}$$

which is independent of N(h) distribution. Therefore, height variation of Rx/Ro can be calculated assuming $\nu(h)$ distribution as shown in fig. 2.2. Because of the different amount of absorption the two waves suffer in going up to the reflection level and back, the ratio Ex/Eo will not, in general, be the same as that of Rx/Ro but are equal at heights below 65 km.

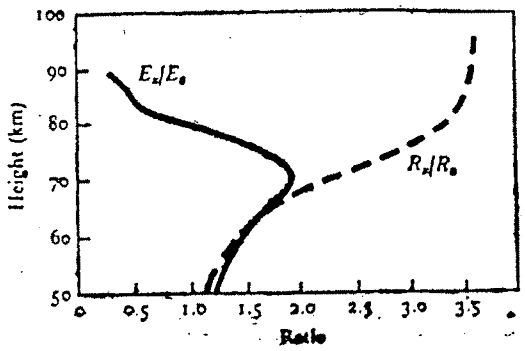


FIG: 2.2

Typical curves obtained from partial reflection. The continuous curve denotes the ratio Ex/Eo of received electric fields of the waves and the dashed curves shows that the ratio Rx/Ro of the reflection coefficients as a function of height from 50 to 100 km. where absorption are negligible. Comparing the observed magnitude of Ex/Eo with the computed magnitude of Rx/Ro, one can deduce the ratio a_x/a_o of the absorption suffered by the two waves partially reflected from a series of different heights h_1. Since absorption is given by

$$a = \exp \left| -2 \int_0^{h_1} \alpha(h)\, dh \right|$$

Where $\alpha(h)$ is the absorption per unit path length equal to the product of g(h) and N(h) where g(h) is a function of ω, ω_H and $\nu(h)$. The functions g(h) can be known for O and X modes assuming $\nu(h)$ distribution and hence, N(h) can be determined from a_x/a_o. The accuracy in determining N(h) is better the shorter the radio pulse used for transmission (~25 µs) but then the rf power needed is also high.

Ionospheric drifts:

If instead of measuring the amplitude of the reflected pulse received by one antenna as above, we receive it on three spaced antennas usually dipoles fixed at three points of a right angled triangle and record the fading pattern of the signals at each of the frequencies, we can obtain from measuring the time delays between the similar fades at each of the antennas, the direction and the speed of the electron cloud drifts in the horizontal plane in the E and F regions. As electron movements are connected with the dynamo fields in the low latitude region, it may be possible to map these fields if drift measurements are carried out simultaneously at different latitudes including the magnetic equator.

The MESOSPHERE, STRATOSPHERE, TROPOSPHERE (MST) RADAR:

The Mesosphere, Stratosphere, Troposphere (MST) Radar is a high power ,coherent, pulsed Doppler radar operating at 53 MHz. The MST radar is capable of providing continuous data on atmospheric winds, waves and turbulence with very high temporal and spatial resolution. It is also possible to carry out upper atmospheric plasma studies using the additional ionospheric beam at 14.8^0 N. Recently, the MST radar has become operational in India near Tirupati as a national facility. The detailed description of the MST radar which is primarily meant for the study of the middle atmosphere (1km. to 100 km.) is beyond the scope of the present work.

2.2 SWEPT FREQUENCY STUDIES:

Swept frequency ground based experimental technique of exploration of the ionosphere with radio wave is most important experimental method to get the knowledge of the ionospheric structure i.e electron density as a function of height. In ionospheric sounding by total reflection, waves are reflected form the ionosphere by the process similar to the total reflection of light waves and the time interval between the emission of a wave and its return to the sending point is measured. The radio frequency of the emitted pulse is altered smoothly and echo time is recorded as a function of frequency. The record is called IONOGRAM. The apparatus is called an IONOSONDE (variable frequency pulsed radar). When it is on the ground it is used to explore the lower region of ionosphere divided by peak electron concentration. When it is in space vehicle it is used to explore the outer region or top side of the ionosphere. It is then called Top Side Sounder.

It is known that reflection of radio wave in the ionosphere takes place when the refractive index reduces to 0 at $w = w_N$. (when collisions & magnetic field are ignored). In the presence of magnetic field the emitted wave is split into two waves namely ordinary and extra ordinary. Each having different penetration frequency. From the penetration (critical) frequency of the O mode, we can obtain the peak electron density in the E, F1 and F2 region with the help of ionogram.

Electron density profiles:

Since the ionogram is the record of the echo time which is a measure of heights of reflection vs the radio wave frequency, it is possible to deduce from it the true height distribution of electrons as follows. At any height 'h' in the ionosphere the

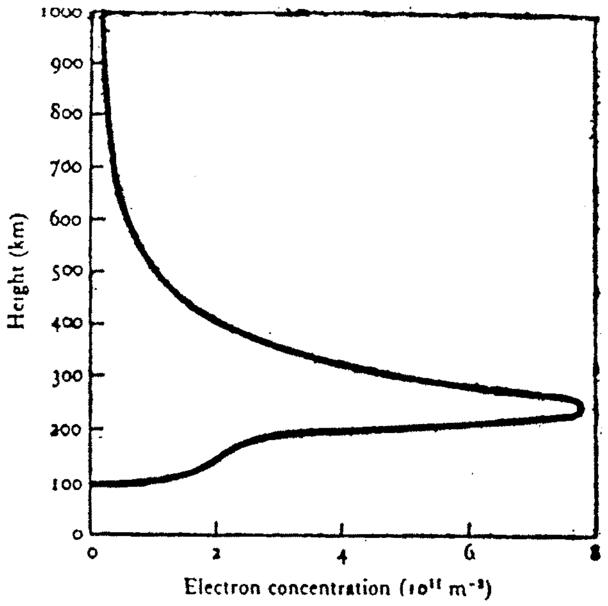


FIG: 2.3 Electron density versus true height during daytime.

wave travels with a group refractive index U′(h) related to the local electron density N(h) in a known way and is reflected at a height h1 where the wave refractive index is 0. the travel time ′t′ of echo is give by

$$t = 2/c \int_0^{h_1} \mu'(h)dh \quad S$$

and can be calculated for any distribution N(h) and any frequency. The inverse calculation can be made to deduce the N(h) profile from the ionogram and example which is shown in fig. 2.3 above, obtained from top side and bottom side ionograms.

Real height analysis:

Conventional ionograms contain a direct measure of the electron densities of the ionosphere within a range determined by the lowest and highest radio frequencies employed in the sounding. The total retardation depends upon the unknown electron density profile. However, it is not immediately obvious how the actual height of reflection of each frequency is to be determined, for the reason that the apparent (virtual) height depends in an involved way on the group retardation imposed on the probing pulses at each point below the level of reflection.

The group height h′ is given by the integral of group refractive index p′ along the ray path. In the case of vertical propagation this is given by

$$h' = \int_0^{h_1} \mu' dh = \int_0^{h_r} \mu' \, dh/_{d\phi} \, d\phi \qquad (1)$$

where h_r is the real height of reflection and Ø is an arbitrary monotonic function of the electron density distribution; for instance, in Budden′s method Ø is f_N where as in King′s method Ø is log f_N. It is not possible to solve this integral analytically, except under certain limiting conditions(transverse and longitudinal). However, a solution can be found by dividing the range of integration into n small intervals within each of which dh/d0 is assumed constant. Equation (1) can then be replaced by

$$h' = \sum_{m=1}^{n} \left(\frac{dh}{d\phi}\right)_m \int_{\phi_{m-1}}^{\phi_m} \mu' \, d\phi \qquad (2)$$

Since the integrals are now dependent on μ' and ϕ and the interval width, they may be evaluated once and for all as a set of coefficients. A equation (2) then represents a set of linear equations in $dh/d\phi$. By dividing the observed h′f curve into intervals of equal ranges of ϕ, this system of equations can, in principle, be solved and the real height intervals obtained.

In the above theory, it was assumed that ϕ increase monotonically with height. It does not give us any information about a "valley" which may exist in the profile between the E and F layers. Some information on the existence of a valley can be inferred from the extraordinary wave trace.

Diurnal variations:

The sample day and night N(h) profiles for middle latitudes are shown in fig 2.4.(a) and (b) respectively. Large diurnal changes occur particularly in lower ionosphere. The daytime structure may be thought of as a single bank of electrons beginning around 100 km. and having a peak density around 300 km. The lower 'layers' E and F1 may be only inflections, or ledges, in the electron distribution.

At night, all vestige of the F1 layer disappears and the E-layer densities drop by a factor of 100 or so, thus producing a simpler structure. The electron density in the D region is not directly observable by the conventional ionosonde and probably falls from about 10^2 per cm^3 at 80 km at noon to much less than 10^2 per cm $^{-3}$ at night.

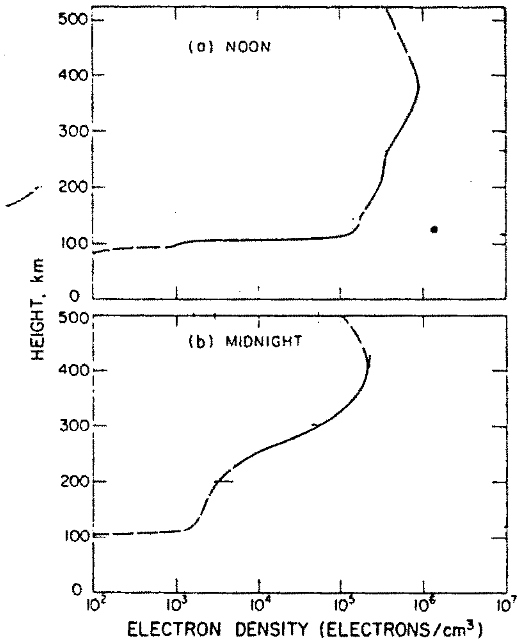


FIGURE 2.4 *Sample electron density profiles at White Sands, New Mexico, April 1961.*

(a) Noon; (b) midnight. (*After* R. W. Knecht, unpublished.)

Additional features of the diurnal variations in ionospheric structure are illustrated in fig.2.5. Note that the E layer appears promptly at sunrise and disappears promptly at sunset. The electron densities are greater at all heights by day than by the night axcept at Huancayo, where the density continues to increase for a few hours after sunset.

There is general tendency for the for the height of the F2 peak, h_mf_2, to fall at dawn, and then rise during the afternoon or evening. In low latitudes, h_mf_2 reaches a very high level by about 1900 and then falls such that at midnight it is about 100

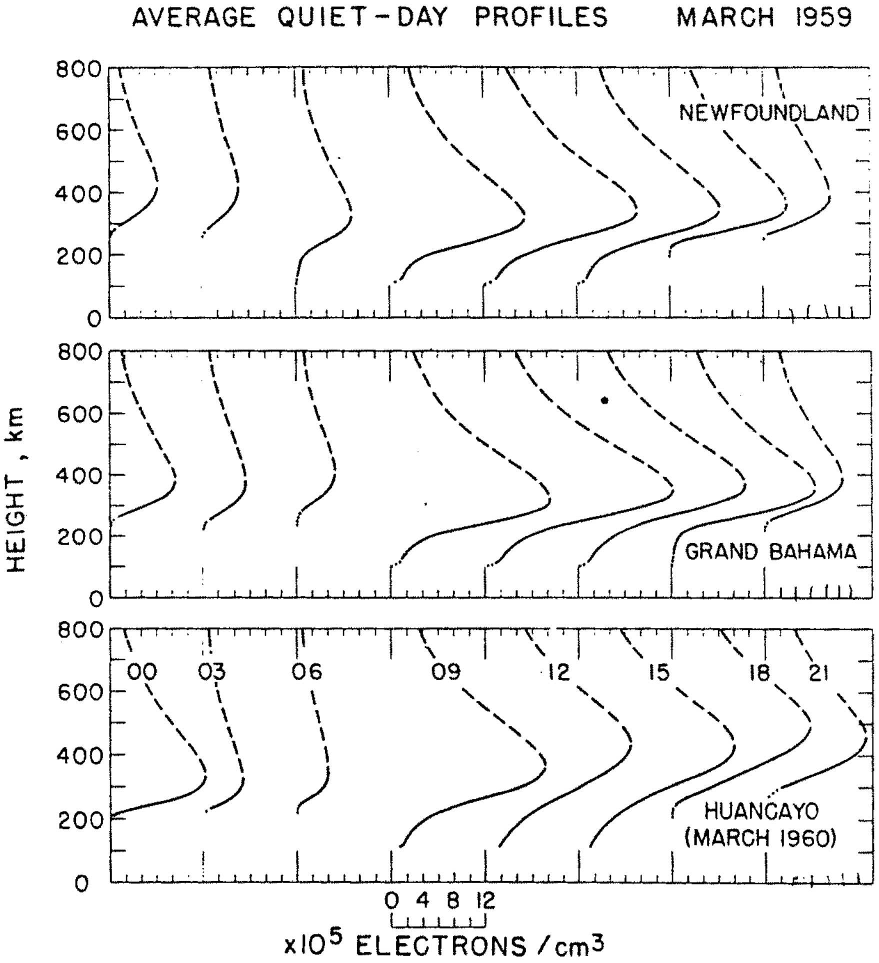


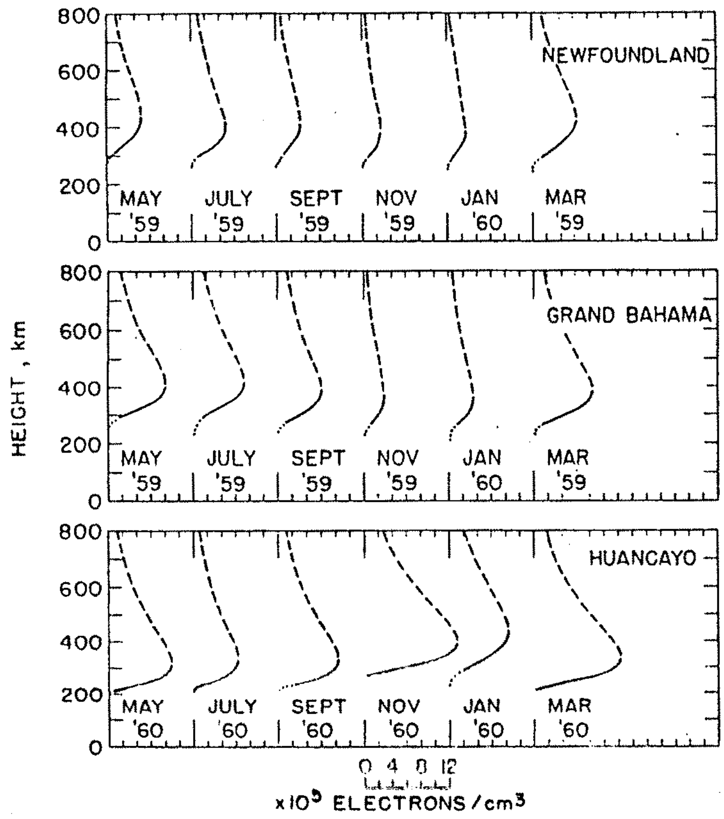
FIGURE 2.15 *Diurnal changes in ionospheric profiles.*

km lower than at noon. In middle latitude, h_mf_2 rises after sunset and is 50 to 100 km higher at midnight than at noon.

At the highest latitudes, the ionosphere may be in continuous sunlight or darkness for long periods, depending upon the season. In these circumstances the ionosphere will be typical of daylight and nighttime conditions, respectively. A moderate diurnal variation due to small variation of the solar zenith angle, but diurnal variation is still detectable at the south pole, where the solar zenith angle is diurnally constant, confirming that, at high latitudes at least, other factors besides solar illumination play a role in determining the diurnal variations of the ionosphere. The topside profiles are represented on the basis of a Chapman type distribution.

Seasonal variations:

The seasonal variation in N(h) profiles is illustrated in fig.2.6 and 2.7 for midnight and noon •conditions respectively. The nighttime F layer tends to be at higher heights in summer than in winter, the tendency being accentuated in lower latitudes. The nighttime F layer tends to be thicker when higher. In general the maximum electron density and the total electron content of the nighttime F region are greater in summer than in winter. Turning to the noon profiles, the most distinctive feature is that the peak density is considerably larger in the winter than in summer; this is called the seasonal anamoly.



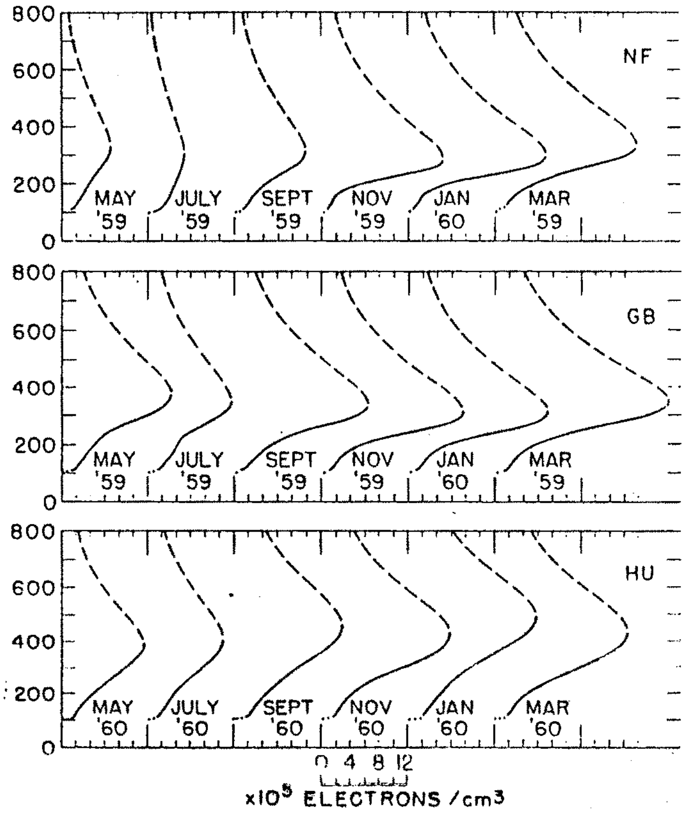


FIGURE 2.6 *Seasonal changes in midnight N(h) profiles*

FIGURE 2.7 *Seasonal changes in noon N(h) profiles.*

Solar cycle variations:

The long term variation in sunspot activity has a profound effect on the noon electron distribution, as can be seen from fig.2.8. The graphs are arranged to show increments in ionization corresponding to increments of 100 in sunspot number. The electron densities above the peak are extrapolated. A striking feature of this variation is that the most significant increases in electron density occur at successively higher heights.

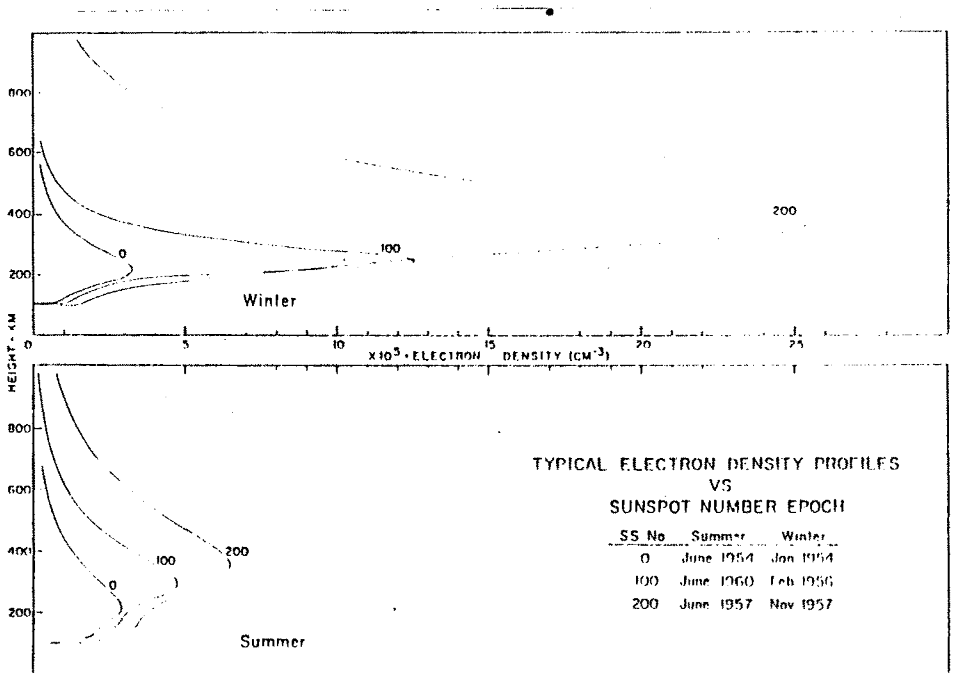


FIGURE 2.8 *Solar cycle changes in noon N(h) profiles.*

Geographical variation:

The idea of the latitudinal variations can be obtained from the iso-ionic contours obtained at CRPL, examples of which are shown in fig.2.9. Profile data taken near the 75° west geographic meridian were used and the iso-ionic contour are for fixed values of plasma frequency. The height of the F_2 maximum is shown by a dotted line. The following features are important:

1) The F layer is much thicker near the magnetic equator than elsewhere.

2) There are regions of high electron concentration at geomagnetic latitudes of about +20^{0} during the afternoon and early evening. This distortion of the ionosphere is of importance in transequatorial radio propagation.

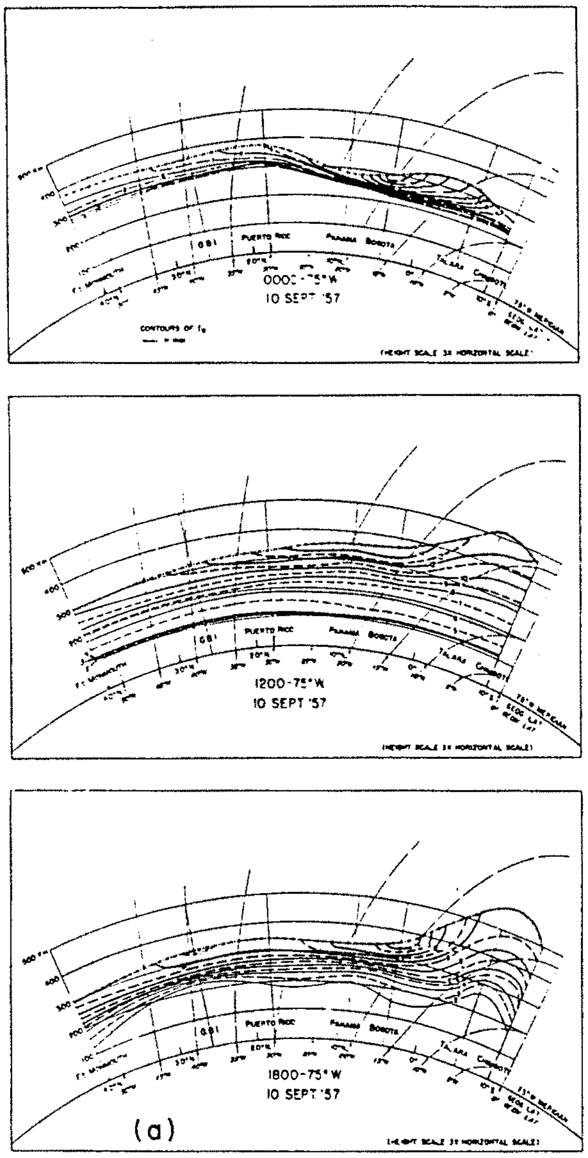
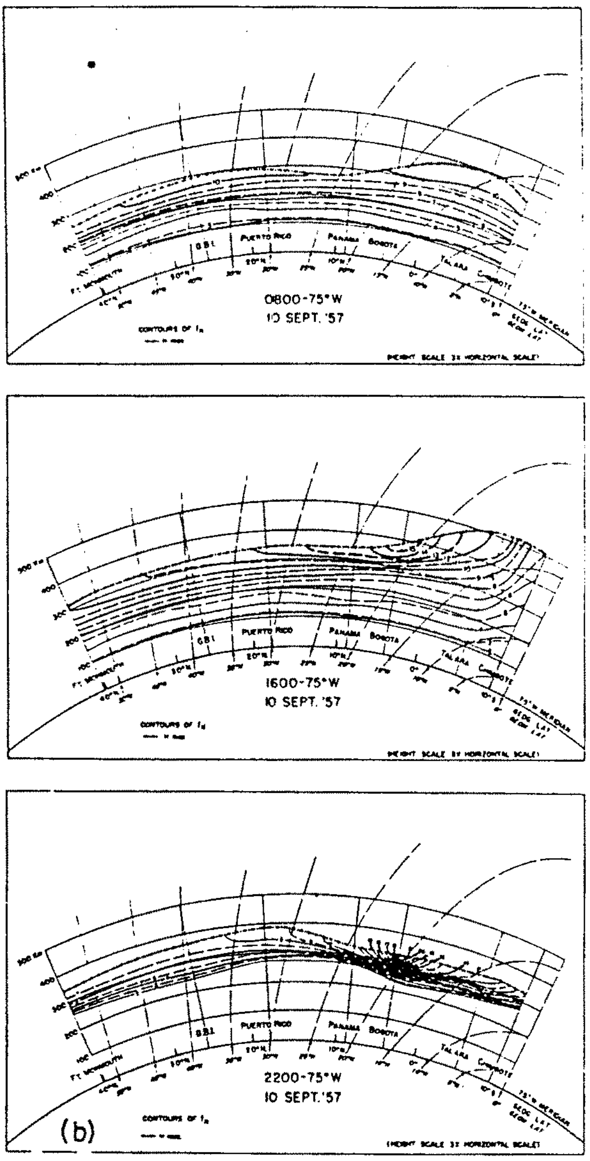


FIGURE 2.19 *Ionospheric sections along the 75th geographical meridian.*



–Continued. *Ionospheric sections along the 75th geographic meridian.*

2.3 ANALOG IONOSONDE:

The operation of analog ionosonde is very much similar to the radar. Normally in the radar the frequency is fixed and the transmitting and receiving antennas are kept in the direction of target by suitable tracking, where as in ionosonde the frequency is swept through a typical range of the order of few hundred kHz. to few MHz. The direction of transmission is vertically upward. The reflection of the radio wave from the ionosphere is recorded on the photographic film with respect to time. Various types of recordings of the reflected signals and description of system are discussed in the article 4.1. along with the typical model of IONOSONDE model 1005 W (Swedish make).

2.4 DESCRIPTION OF ANALOG IONOSONDE :

The system 1005 W is a highly sophisticated valve oriented vertical incidence ionospheric recorder that represents state of the art performance in accuracy and reliability.

It is intended as a stationary or trailer mounted recorder for programmed recording of the ionosphere at regular intervals, as well as for special investigation by manual operation.

2.4.1 CHARACTERISTICS

FREQUENCY COVERAGE

Frequency Range : 0.25 - 20.25 MHz

Frequency Covering Bands :	Band I	0.25 - 0.75 MHz
	Band II	0.75 - 2.25 MHz
	Band III	2.25 - 6.75 MHz
	Band IV	6.75 - 20.25 MHz

Frequency Scale : Logarithmic

Frequency Markers : Every 0.25 MHz(0.25-2.0 MHz)
Every 1 MHz (3-20 MHz)

The frequency markers are derived from harmonic X-tal oscillator with an accuracy of 0.1%.

TRANSMITTER :

Output Peak Pulse Power : Minimum 25 KW at 600 Ohms

PULSE REPETITION FREQUENCY :

Internal Trigger : Line frequency or scaled by two
External Trigger : 25 - 50 Hz
Pulse Width : 70 - 100 micro sec.
Pulse Rise Time : 7 micro sec
Duty Cycle : 0.0042

RECEIVER

First IF

Band I, II and IV : 4 MHz
Band III : 8 MHz

Second IF : 455 MHz

Tangential Sensitivity : 2 micro Volt
IF-Bandwidth ; selectable : 10,20,35 and 75 KHz
Video Differentiation : 10,20,50 and 100 micro sec.

RECORDING SYSTEM

The original recording set up is replaced by the use of Personal Computer (PC AT).

Three alternatives are there

(1) ´A´ scope (fix frequency)

(2) 'B' scope (fix frequency)

(3) 'PANORAMIC' (Operating mode : Automatic)

Printing selectable for above.

ON LINE HEIGHT MEASUREMENT FEATURES

Height Range : 0 - 250 Km
: 0 - 1000 Km
: 0 - 2000 Km

Height Scale : Linear

Height Markers : 100 Km and 20 Km

POWER CONSUMPTION : 2 KW

SIZE

Length : 2400 mm

Height : 1700 mm

Width : 590 mm

WEIGHT : 750 Kg

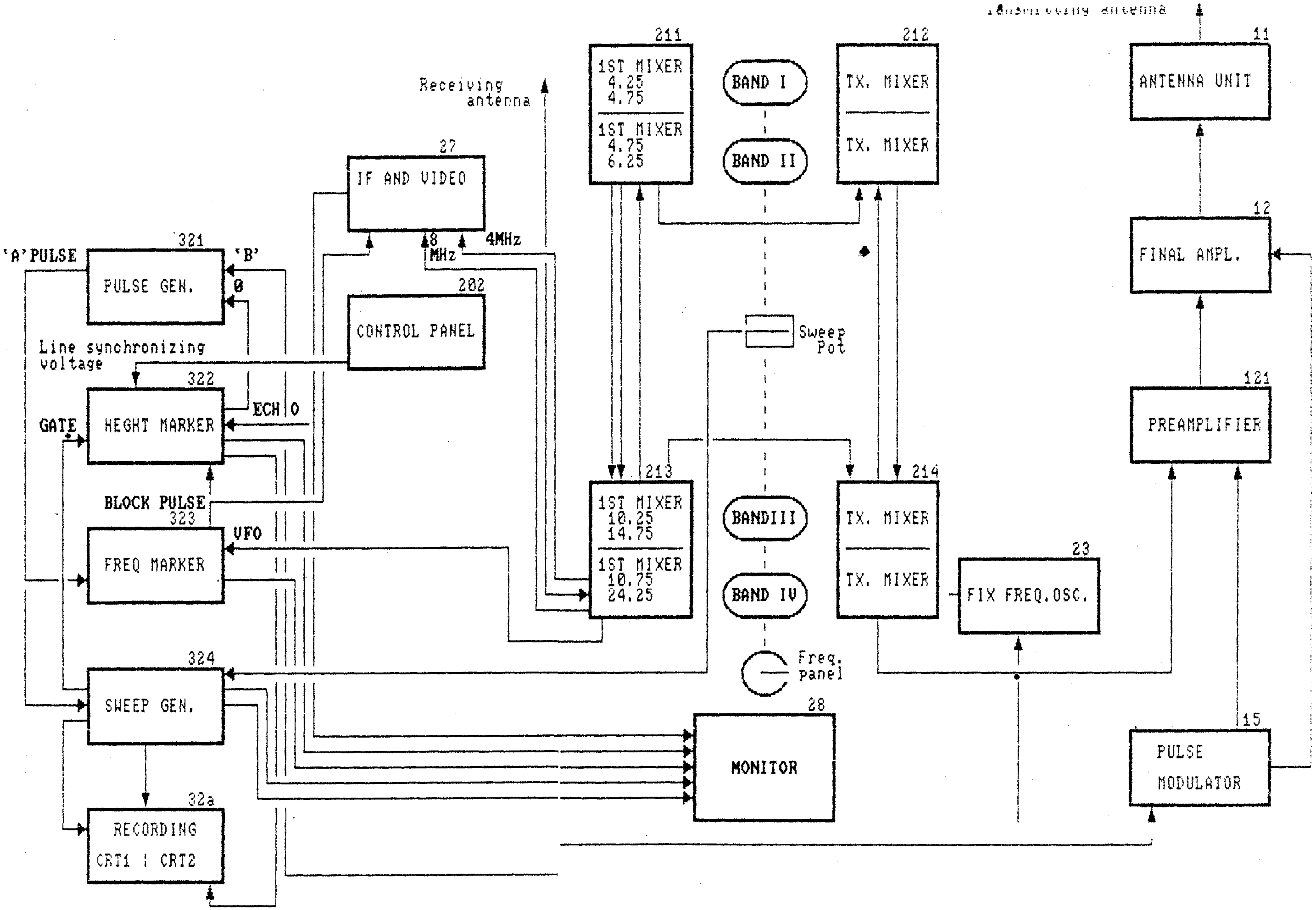
2.4.2 PRINCIPLES OF OPERATION :

The principles of operation of the transmitter, the receiver and recording systems can be understood from the block diagram, No. 1.

The units in the block diagram are oriented almost in the same way as they are located in the ionosonde seen from the rear side.

At the center of the diagram the mixer units 211-214 are shown. The first receiver mixer and the transmitter mixer utilize the same VFO which consists of one oscillator for each frequency band.

The continuous running oscillator (VFO) signal is fed to the



NO. 1 BLOCK DIAGRAM OF IONOSONDE

Transmitter mixer units 212 and 214 , where it is mixed in a balanced mixing system together with a pulsed signal from the Fix Frequency Oscillator (FFO) unit 23. The FFO frequency is 4 MHz on Band I, II, and IV. On Band III it is 8 MHz.

From the Transmitter mixers the pulsed transmitter frequency is fed to the preamplifier, unit 121 in the transmitting cabinet. In this unit the signal is untuned amplified up to an amplitude of 300 - 400 V peak to peak. The signal is further amplified in the final amplifier , unit 12, consisting of two 4PR60C in push pull parallel as final power amplifier.

The transmitted signal is fed to the antenna output terminal via a broadband transformer which is provided with various taps.

Incoming signal from the receiver antenna is fed to unit 211 and 213 which also contain separate RF-amplifier and first mixer for each band.

4 and 8 MHz IF signals are fed from unit 213 to the IF amplifier, unit 27. This unit contains the first IF-amplifiers for 4 and 8 MHz. After the mixer the second IF-signal, 455 KHz is amplified, detected and fed to the video amplifier, which also is located in this unit. The unit is provided with two separate echo outputs. The echo signal is fed to the signal mixing circuits in the Height markers unit (322) and to the Monitor (28).

Cabinet 3 contains the pulse and sweep circuits as well as calibration units for height and frequency markers.

The transmitter pulses and the oscilloscope sweeps are synchronized from the Pulse Generator unit 321. The oscilloscope is started by means of an undelayed pulse called 'A' pulse. The A-pulse generator can be synchronized to the line frequency or by externally triggered.

One with regard to the A-pulse delayed pulse, B-pulse, controls the time for the outgoing transmitter pulse. This pulse modulates the FFO unit (23). Hence the front of it triggers the Pulse Modulator, unit (15).

In order to synchronize the height markers to the sweep, a sweep gate controls the Height Markers Oscillator. The first 100 Km pulse in the height pulse train is called the '**zero**' pulse works as a ground reference. This is fed to the Pulse Generator (321).

The VFO signal is fed to the frequency markers, unit 323, where it is mixed with harmonic oscillators from crystal controlled oscillator. These are producing 0.25 and 1MHz harmonics. Zero bit notes trigger a multivibrator thus producing the frequency markers. This unit is also contains a block pulse generator triggered by A pulse train. The block pulse is fed to the IF-unit (27) in order to block the receiver. It is also utilized in the height marker generator to keep the part of the height sweep, which is located below the zero level, free from the height markers.

The monitor also has the ability to display the ionogram as a panaromic display. In order to produce the frequency sweep, the VFO rotating capacitor system is provided with the rotating potentiometer, rotating one turn for a frequency sweep. This potentiometer produces a linearly varying voltage with respect to the rotating angle. This voltage is fed to the sweep unit where it is amplified in a differential amplifier to a symmetrical frequency sweep voltage. Hence it is applied to monitor for the purpose of frequency deflection when the frequency is sweeping the entire frequency range.

2.4.3 VISUAL DISPLAY :

The monitor on front panel of cabinet No. 2 can be used to observe the ongoing reflection phenomenon in addition with the scale marks of height. By changing the selector switch to recording P left or recording P right one can have an idea of an ionogram.

2.4.4 RECORDING MODE

For normal frequency recording RECORDING MODE switch should be in NORMAL position. In position FIX FREQUENCY the VFO motor is turned off. This mode is intended for recording at one arbitrarily set frequency.

The Pilot lamp labeled SWITCHES IN NORMAL POSITION is lighted when the switches PLATE VOLTAGE , RECORDING MODE, TIME DISPLAY and TRANSM. TRIGGER is turned to normal and when the three main switches on the panel of unit 25 is turned to 1.

For above two modes 1) Normal frequency 2) Fixed frequency mode executable file gives options for the above mentioned modes of recording to the user. User selected mode will be the active one. Computer will access and execute programs Accordingly data is stored & displayed as a result along with the option of printing for hard copy.

Digital ionosonde is a ionosonde where the front panel of ionosonde is a PC. The menu driven software is written for the controlled operations of ionosonde, in which all the interfacing modules are designed for measurements of the status of the ionosonde and to control operations of the various functional blocks of ionosonde.

Recently the C4 ionosnde dating back to pre IGY period, with film recording has been replaced by a modern KEL digital ionosonde since March 1993 at PRL Ahmedabad. Digital ionosonde has on line ionogram print out facility along with digital recording of data on magnetic cartridges. See fig.2.10. Typical example of an evening ionogram over Ahmedabad from the newly installed KEL Digital ionosonde.

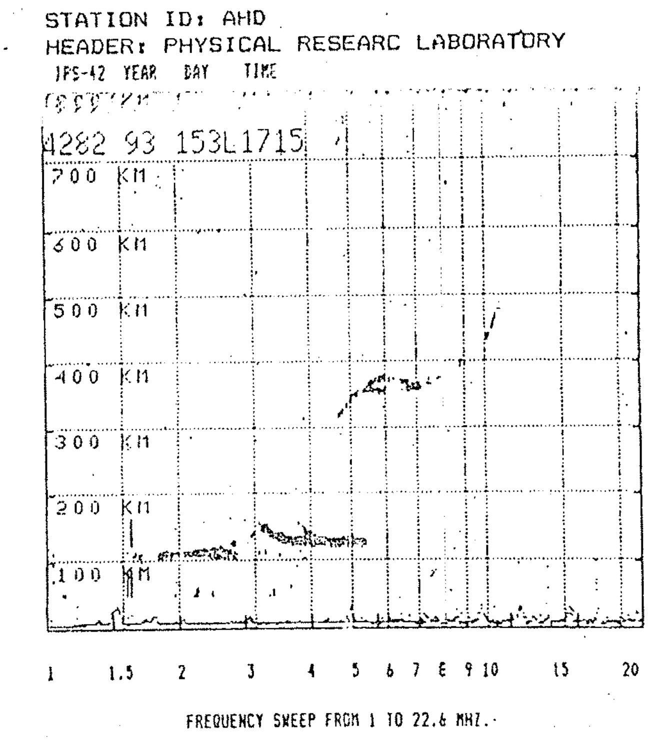
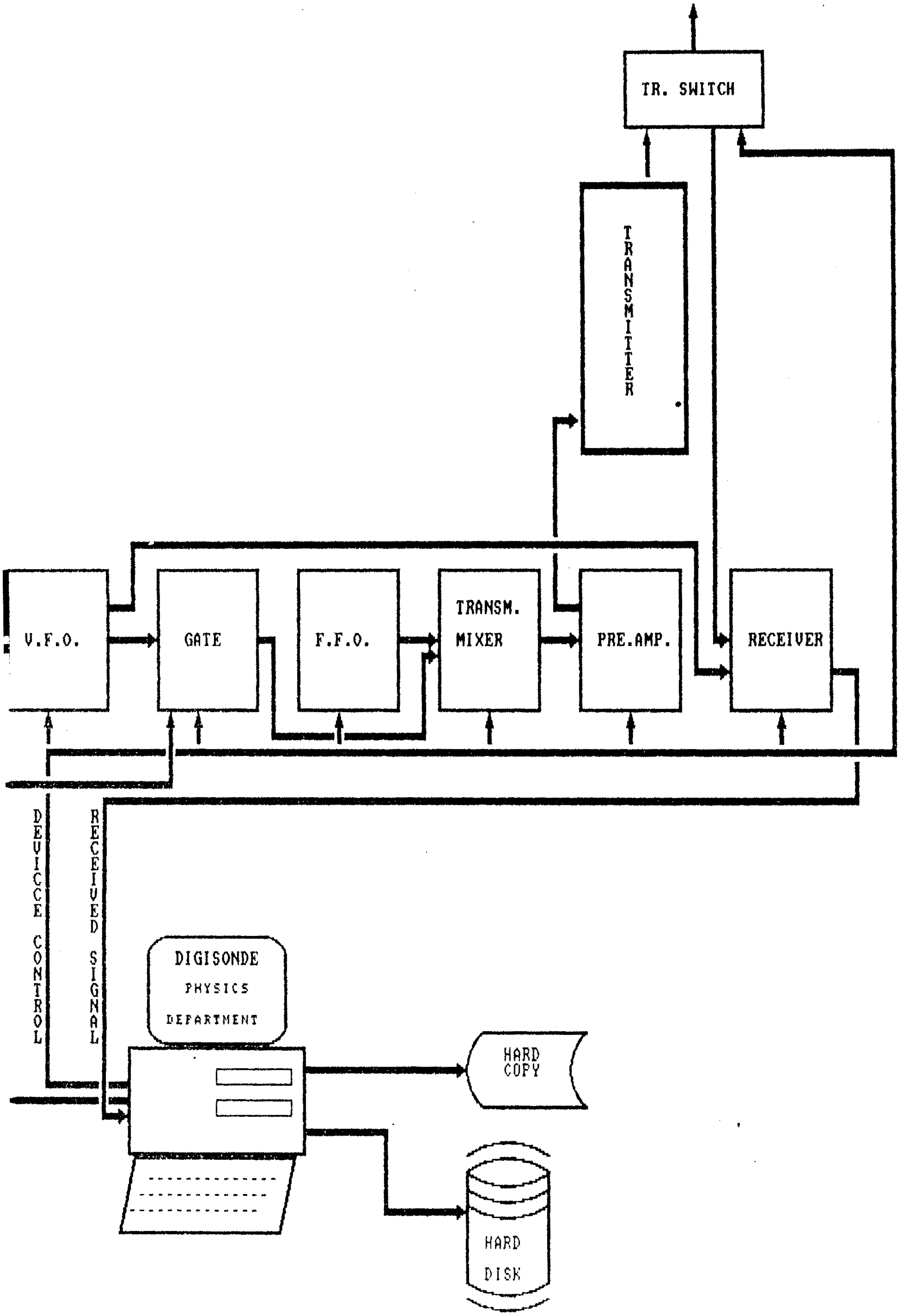


Fig 2.10 Typical example of an evening ionogram over Ahmedabad from the newly installed KEL Digital Ionosonde

2.6 DEFINITION OF PROBLEM:

In the conventional ionosonde the ground pulse and ionospheric echoes of the radio pulses are recorded on a CRO photographically. The recording film, separate cabinet, the need of very high voltages for CRT and film processing are the basic problems. There is inevitable delay in obtaining final ionograms for analysis. To avoid such time consuming photographic method which is expensive it is proposed to digitize the amplitude of second detector voltage which represents the strength of the ionospheric echo. The Department of Physics, Shivaji University has acquired an ionosonde from the Indian Institute of Geomagnetism, Bombay. It has a frequency range of 0.25 to 20.25 MHz. divided into four bands and operates with a peak power of 25 KW. It is a sweep frequency radar with vacuum tube electronics. The performance of the radar is tested with a dummy antenna. It has three types of displays; the "**A**" scope for visual monitoring and, "B" scope and the "**PANORAMIC**" recording of signals for photographic recording of the film. The latter two types of display are digitized and stored on the PC-AT 286,from which an ionogram is constructed. Thus it is proposed to replace the original method of recording ionograms using photographic film and camera by digitizing the receiver output (2nd detector DC output) and storing it in PC. For this purpose the specified block diagram of the digital ionosonde is shown in fig.2.11. The necessary hardware and software is developed to produce ionograms, which forms the subject matter of this dissertation.



G.2.11 BLOCK DIAGRAM OF DIGISONDE

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