STUDIES ON THE PROPAGATION OF RADIO WAVES:

CHAPTER I.

INTRODUCTION AND SCOPE OF THE WORK.

1. Introduction.

The radio wave, in any frequency range, has to propagate from the transmitter to the receiver or target and a study on the propagation conditions and characteristics of radio waves as well as properties of the relevant media is of prime importance in any pract problem of radio communication or radar. A radio wave can propagate from one point to another in either one or more than one of the following modes:

1) Ground wave propagation: In this mode of propagation, the radio waves glide over the ground from transmitter to receiver. as the ground losses (both conduction loss and dielectric loss) incre very rapidly with frequency, this mode of propagation is taken help of only in long and medium wave communication and primarily in medium wave broadcasting. Even then, the service range is very much limited with reasonable transmitter power and this mode of propagation is of n use except for local broadcasting purposes. Extensive studies on this mode of propagation as well as the ground losses have been carried out in different countries, the result of which are available in any standard book on the subject. Studies on the field strength at different positions for the medium wave transmitter at Calcutta was carried out much earlier by H. Rakshit (Phil.Mag. Vol.12, p 97, 1931). Further work on the subject for this transmitter was not considered

necessary and was not carried out by the author. Recently a high power medium wave transmitter has been installed at Amtola (near Calcutta) and it will be worth carrying a fresh field strength survey, specially because of the new site and considerable changes in the surrounding terrain.

2) Space wave propagation: As the name implies this mode of propagation gives the straight propagation between the transmitting and the receiving points by the direct and earth-reflected rays and is more or less a straight line or 'line of sight' propagation. This mode of propagation is most useful for VHF, UHF and microwave ranges where other modes (viz. ground wave and sky wave) fail. Although longer waves in the medium and short wave ranges can bend round obstacles more easily, they can propagate much more easily by the other modes and hence the space wave propagation is not of much importance for them. For the VHF and UHF ranges, there is no appreciable reflection, refraction or absorption in the lower atmosphere(=troposhere) and they are not reflected back from the ionosphere also. Only effects to be considered are those of obstacles in the path of propagation and reflections from the surrounding media. Some studies were carried out in this regard with a VHF television transmitter and are described in chapter II. Also, conveyance of message in these frequency bands is almost invariably done by frequency or phase modulating the propagated signal. This is because a wide band frequency/phase modulation system gives a large improvement in signal to noise ratio and even this wide band is a very small fraction of carrier frequency in the VHF/UHF range and gives no problem in circuit design or channel consumption. As the service area is small there is also less chance of interference with

other stations. New methods of phase/frequency modulation and demodulation with simple and easy circuit techniques were devised by the author and are described in Chapters III and IV. These methods can be conveniently used for communication in the VHF/UHF band.

Unlike the above mentioned frequency ranges, microwaves suffer appreciable absorption (and sometimes refraction) in the lower atmosphere and hence the range of a microwave transmitter is quite often rendered much less than the 'line of sight' distance. Limited ranges of propagation of microwave radar under different weather conditions are calculated and discussed in Chapter V. As microwaves are almost always used for point to point propagation (as in microwave relay or radar applications), beamed transmission is always used. Beaming is generally done by a parabolic reflector with a dipole antenna or a waveguide radiator as its primary feed. A new method for solving parabolic reflector problems was devised by the author and is discussed in Chapter VI. Radiations from apertures in imperfectly conducting wave guides have also been calculated and discussed in the same chapter.

3) Sky wave propagation: This is the only mode of propagation by which long distance radio linkages (in the short wave band) are established. As mentioned earlier, ground wave propagation is of very limited ranges and space wave propagation is limited to a still shorter range due to the curvature of the earth. Only the sky waves, which are reflected from the ionized regions (the ionosphere) situated high up in earth's atmosphere, can establish radio linkage between distant points. Studies on the propagation characteristics of these sky waves in the ionospheric regions have been and are being carried on in different countries. The author of this thesis also carried out a number of investigations on the same, taking the effects

of earth's magnetic field into consideration. Studies on the absorption of waves in propagating through the ionospheric regions have also been made. These are described in Chapters VII and VIII respectively. Also a knowledge of the structure and properties of the reflecting regions in the ionosphere is essential for utilising the sky wave mode of propagation in an efficient manner. A number of studied have been carried out in different parts of the globe in understanding the behaviours of these regions and the present author's contribution to the same are discussed in Chapters IX and X. Studies were carried out only on the F regions of the ionosphere, as they are the main reflecting regions for long-distance propagation of sky waves.

2. Scope of the work:

1) Investigations were carried out on the effects of obstacles and reflections from surrounding regions on the propagation of space waves in the VHF range. A television transmitter with its carrier frequency at 175.25 Mc/s was used for the purpose [1]. 2) New systems for producing phase/frequency modulation and demodulation were devised with simple circuit techniques [2, 3] and they may be profitably used for improved propagation in the VHF/UHF range. An accurate phase meter was also devised for measuring performances of the above system. [4,5]. 3) Limitations of microwave radars under different weather conditions were calculated and discussed [6]. Suggestions were also made for a new treatment of parabolic reflector problems in the microwave region [7]. An analysis was carried out for slot radiators (for microwave propagation) in an imperfectly conducting waveguide [8]. 4) Effects of magnetic field on the

propagation of sky waves were investigated [9, 10] and studies were made on the ionospheric absorption of radio waves [11].

5, Investigations were carried out on the structure and properties of the F regions [12, 13, 14, 15, 16] of the ionosphere. These are the main reflecting regions for long-distance propagation of radio waves in the short wave range.