MOTION OF A SINGLE CLOUD IN THE IONOSPHERE

By S. N. MITRA

All India Radio, New Delhi

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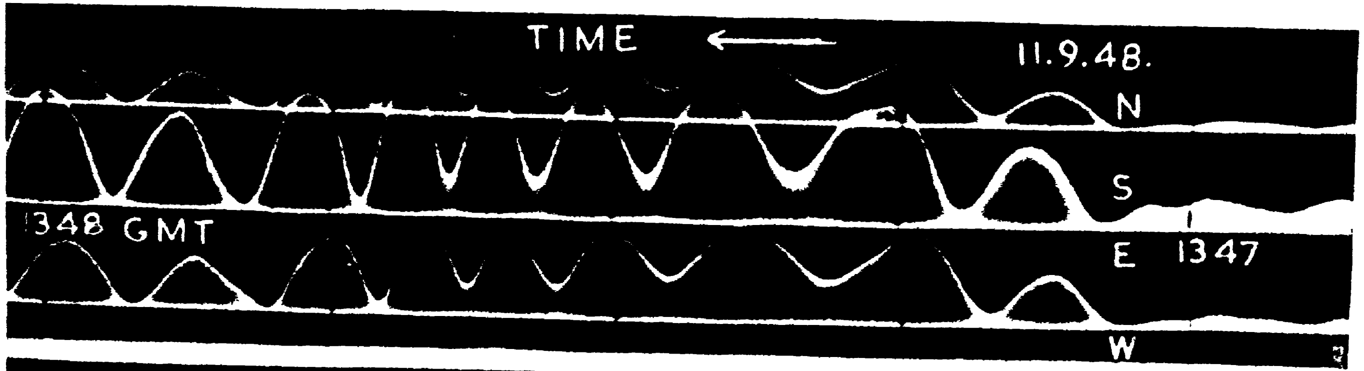
Plate XX

ABSTRACT. The fading on pulsed transmission is known to be due to interfernce between waves scattered from local irregularities in the ionosphere, the irregularities having both random and steady motion. The nature of the fading pattern indicates that a large number of irregularities is involved in the process. But, under favourable conditions, it is possible to detect a single cloud in the ionosphere, the fading of the received signal being caused by its bodily motion with the existing wind velocity.

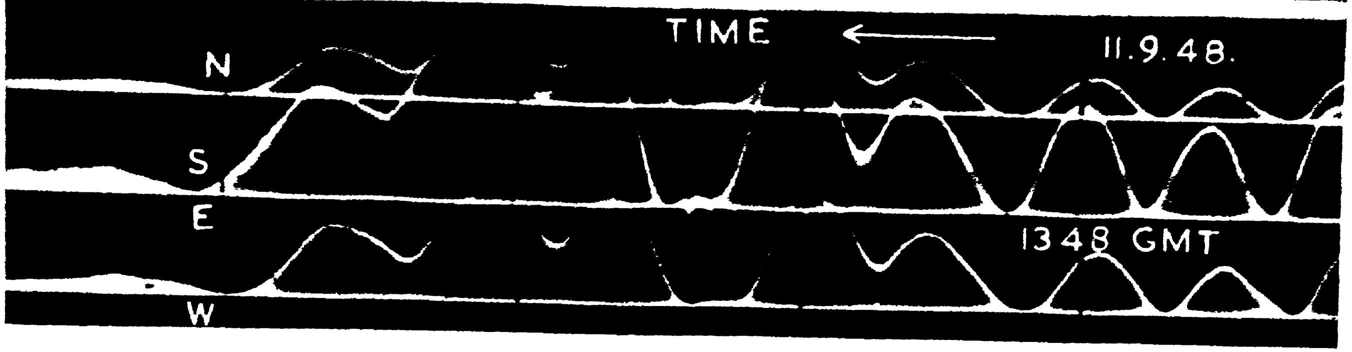
In a previous communication the author (Mitra, 1949) has described how the wind in the ionosphere could be investigated by a study of fading on pulsed transmissions as recorded simultaneously on a system of spaced receivers. The fading is supposed to be due to interference between a large number of wavelets diffractively scattered from local irregularities in the ionosphere. A wind in the ionosphere causes these irregularities to be bodily moved and the fading patterns as recorded in a system of spaced receivers are similar in nature but show a time-shift with respect to one another. The velocity of the wind could be obtained from the time-shift. A random motion of the irregularities amongst themselves causes the fading patterns to be dissimilar and when the random motion predominates, the time-shift caused by the wind is difficult to be determined due to the dissimilarity between fading patterns. Experiments have indicated that when the distance between any two receivers is of the order of a wavelength, the presence of a wind could usually be detected from the fading patterns except when the fading becomes too rapid under disturbed ionospheric conditions. The investigation of fading by pulsed transmission has shown that under favourable conditions, it is possible to deduce from the fading pattern, the motion of a single cloud in the ionosphere.

The nature of fading pattern caused by the interference of scattered wavelets is usually random without any noticeable periodicity. But in the absence of irregularities in the ionosphere, the down-coming wave will not 'fade' and the received amplitude will not vary with time. Let us assume such an idealised condition when the echo amplitude remains steady. We then enquire what happens if a single cloud comes within the receiving zone and moves past with the existing wind velocity. There will be interference between the wave reflected from the 'smooth' ionosphere and the wave scattered from the cloud. The resultant amplitude at any instant

Fig.



Fig



Fading records indicating the motion of a single cloud in the ionosphere. Frequency = 4 Mc/sec., reflection from the F-layer. Figure 2 is the continuation of figure 1 will depend upon the phase difference between the scattered wave and the wave reflected from the ionosphere.

The problem may be studied in another way. A single scattering cloud behaves as a radiating antenna and will have a characteristic polar diagram. The polar diagram, however, will depend upon the dimension of the cloud in relation to the wavelength. The situation is simplified if the back-ground reflection is due to the radiation emitted by such an antenna in that case the polar diagram becomes the same as that of a horizontal antenna radiating some distance above the ground and the ground is regarded as a perfect reflector. In our case, the ionosphere is the 'ground' and the radiating cloud becomes the 'horizontal wire antenna'. In such a case, the polar diagram will consist of several minor lobes placed symmetrically round a major lobe in the centre. Now, if this pattern is being moved bodily, the intensity of the radiation at the receiver will go through a series of maxima and minima roughly equally spaced and the variation of intensity with time will be periodic. When the radiating cloud goes out of the "contributing zone" for the receiver, the intensity at the receiver will again become steady. Thus, if a periodic fading pattern is observed preceded and followed by steady signal, the pattern may be interpreted as due to a cloud moving past in the ionosphere. It should, however, be ensured by using polarised receiving aerial that the periodic fading pattern is not due to an interference between the two magneto-ionic components (Mitra, 1950).

Such types of rather ideal fading patterns have been observed in the author's (Mitra, 1949) spaced receiver experiment on only a few occasions. It has been observed that for some time the echo amplitude was remaining more or less steady and no shift was being shown between the fading patterns at the spaced receivers. Then the periodic fading started which lasted for a short time and then the amplitude became steady again. Figures 1 and 2 (Plate XX) show a typical example. (Figure 2 is the continuation of the fading pattern shown in figure 1). It will be noted from these figures, that the echo amplitude was small but steady before the periodic fading started. The periodic fading lasted for a little more than one and a half minute and after that the fading became steady. The three patterns at the three receivers are very much similar in nature and the steady shift between the fading patterns could be easily noticed from the record. The velocity of the wind can also be calculated from the shift which comes to about 80 m/sec., its direction being towards SSE.

An ideal condition of a horizontal radiating antenna representing a scattering cloud cannot be realised in practice. Complications will arise due to the back-ground reflection and the true polar diagram for such a system. Nevertheless, some useful informations, although approximate, can be obtained from such a periodic pattern.

It is known that the number of lobes in such a system of horizontally adiating antenna is equal to the total number of half-wavelengths contained within the length of the antenna. In the present example, the total number of maxima (each maximum corresponds to a lobe) is 14. Thus, the horizontal length of the cloud is about one kilometre (wavelength used was 75 metres). Moreover, the total time of the periodic fading gives an idea of the diameter of the "contributing zone," by which is meant the horizontal distance the cloud will have to go before the radiation from the cloud ceases producing any effect on the received intensity of the down-coming wave. Knowing the speed with which the cloud is moving (wind speed), the horizontal distance comes out to be about 10 km. The height of reflection was about 250 km ; the diameter of the first Fresnel zone for a 75-metre wave is of the order of 9 km. Thus, the assumption that when a scattering centre is outside the first few Fresnel zones, it has negligible contribution to the intensity fluctuation of a down-coming wave (Pawsey, 1935) is approximately satisfied.

In the course of his investigations on fading using pulsed transmissions and a system of spaced receivers (Mitra, 1949), the author has found that such types of periodic fading of the down-coming wave, implying the motion of a single cloud in the ionosphere, are rarely observed. Most of the fading patterns do not show such effects and are mainly caused by interference of waves scattered from a number of irregularities. The presence of a single irregularity in the form of an ion cloud within the "contributing zone" is rather a rare occurrence. But when such phenomenon is observed, it gives information regarding the size of the cloud and the area of the "contributing zone" which otherwise would be difficult to determine. The origin of an ion cloud is not yet definitely established but the ionized trail left by the passage and evaporation of a meteor may constitute such an irregularity in the ionosphere.

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