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AN AUTOMATIC INSTANTANEOUS INDICATOR OF SKIP DISTANCE AND MUF

The past five years have seen much progress in the techniques of prediction and use of ionospheric data in radio communications and direction finding. Insofar as operations are concerned, however, the use of ionospheric data has been largely on a statistical basis. For example, we can predict, with reasonable accuracy, frequencies which will be usable over specific paths on a certain number of days during the month, but it has so far not been practicable to predict just which days those will be.

For certain applications, notably in d.f. or distance ranging operations, it is important to know at the time what ionospheric conditions actually are over given paths, not what they are predicted to be or have a reasonable chance of being. The purpose of this note is to describe a relatively simple equipment which will give an instantaneous measure of the skip distance on any frequency, or the muf for any distance, over any azimuth from a given station. If such equipment were installed at the various stations of a d.f. network, the muf information obtained simultaneously with the bearings could be sent at once to the plotting center, and thereby serve as an indication, when taken together with other bearings and muf data from the network, of which bearings are untrustworthy because of skip.

The instrument proposed is a pulse transmitter of not less than 50-kw peak power, a rotating beam antenna for scanning, a receiver and a PPI oscilloscope for either visual or photographic recording. The principle of operation may be seen by reference to Fig. 1. When the operating frequency of a transmitter is above the vertical-incidence critical frequency, all waves incident upon the ionosphere more steeply than a certain critical angle ϕ_c penetrate through the ionosphere and do not return to earth. Waves incident at ϕ_c, however, are reflected and hit the E layer at a distance from the transmitter nearly equal to the skip distance on the given frequency. Scattering patches in the E layer send a small amount of the incident energy back toward the transmitter and they arrive there with a retardation equal to the time necessary to travel to the E layer via the F2 layer and back. Waves incident upon the ionosphere less steeply than ϕ_c are also scattered back to the transmitter, but with greater retardation times.

If pulses are emitted from the transmitter and the returning echoes viewed upon an oscilloscope the pattern looks something like Fig. 2. The leading edge of the scattered pulse trace is fairly well defined and its retardation is a direct measure of the skip distance on the operating frequency.

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If now the pulse transmissions are made with a slowly rotating directional antenna, synchronized with the trace rotation on a PPl oscilloscope, the resultant pattern will look like Fig. 3. The distance from the center to the bright region at any azimuth is a direct measure of the skip distance for the given frequency at that azimuth. The skip distance for any other frequency can be obtained to a fair degree approximation from a graph derived from known muf-distance relations.

By the use of a non-linear sweep on the oscilloscope, using appropriate range markers, the skip distance may be scaled directly from the oscilloscope, or photographic records could be made of the pattern. Alternate linear and non-linear sweeps can be used, the first for the range markers, the second for the pulse echoes. The appearance of the PPl oscilloscope, with range markers on, is seen in Fig. 4.

The automatic recording azimuthal skip-distance indicator described here may be of direct operational use in d.f. networks, with possible applications also to communications or enemy intercept work. In its d.f. operation either all or certain selected stations of a d.f. network would be equipped with a skip distance indicator, and each bearing reported to the central plotting location would be accompanied by the value of skip distance at the azimuth of the bearing. The plotting room will thus be in a position to evaluate each bearing, in the light of the others and of possible fixes to know whether it is good, bad, or doubtful. Instantaneous ionospheric data would thus be obtained, and the application of ionospheric data to d.f. operation could be made free from the great uncertainties of predicted average data, in that these data would be neither predicted nor average data, but actual observations in the direction in which information is needed.

At different times of day different frequencies will need to be used, such that the skip distance will always be greater than zero and less than 2500 miles. At Washington, in January 1945, for example, 5 Mc should be used at night and about 13 Mc during the day.

The installation required is not a large one; a high-power pulse transmitter, receiver, and oscilloscope occupies but little space, and the rotating directional antenna is the most cumbersome piece of equipment, especially at the lower frequencies. It should be possible to obtain a satisfactory antenna arrangement, however, with a 50-foot pole and a 100-foot horizontal rotating element, since the requirements for a narrow beam are not at all stringent.

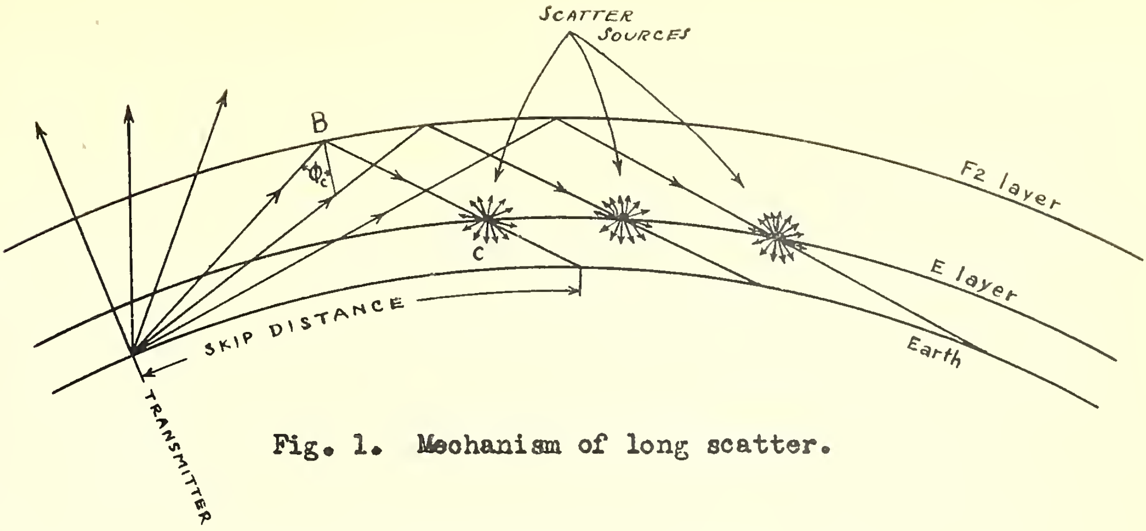

Fig. 1. Mechanism of long scatter.

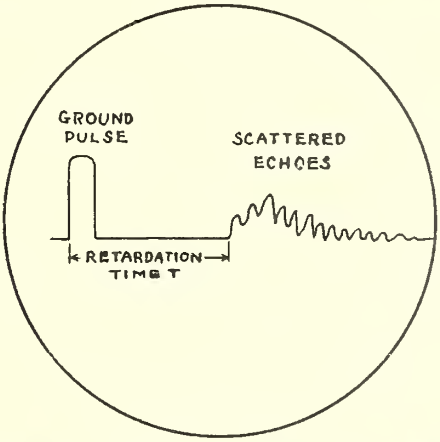

Fig. 2. A type oscillator pattern showing long scatter. T is time necessary for pulse to travel over paths ABC and back in Fig. 1.

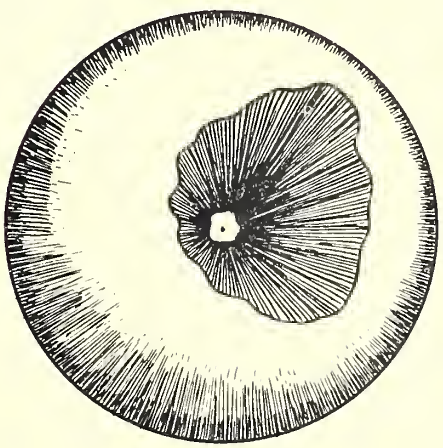

Fig. 3.

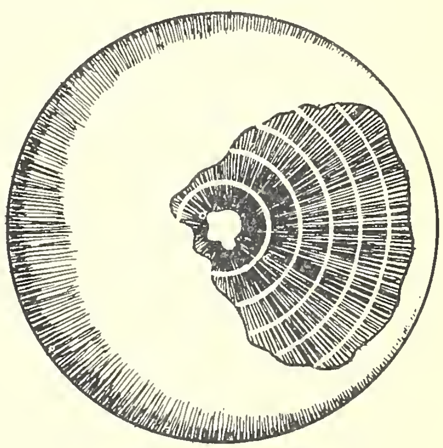

Fig. 4.

Fig. 3,4. PPl oscilloscope as automatic azimuthal skip-distance indicator, with and without range markers.