REMARKS ON THE ERDANTENNE

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"Erdantenne" is an unconventional aerial consisting of merely two electrodes inserted into the earth. Grosskopf (1956) studied the electric characteristics of this aerial in detail, while Liebermann (1956) applied this aerial termed ground dipole to the observations of waveforms of the extremely low frequency atmospherics.

Now the horizontal electric field component of the traversed wave should diminish as the conductivity of the earth approaches to the infinity. In the case of the finitely conducting earth, the horizontal electric field component appears as the forward tilt of the traversed wave having the vertical polarization. Therefore, the voltage proportional to the forward tilt on the earth's surface is induced between a pair of electrodes of the Erdantenne. This aerial system, however, is expected to have the following distinguishing characteristics, i. e. 1) simplicity of the structure, 2) wide frequency band and 3) good S/N ratio of the amplifier because of the low impedance of the aerial itself.

As to the directional sensitivity of the Erdantenne, it is clear that the sensitivity must reach its maximum value in the direction of a pair of electrodes, and it decreases in proportion to $\cos\theta$ with increasing angle θ between the direction of the traversed wave and that of a pair of electrodes. Authors have investigated this fact employing a VLF transmitter, and suggested the possibility of the direction finding techniques. A very long wave transmitter (NDT Yosami station) is situated about 36 km from the receiving point in the direction of 297° from the north, and its output power is 500 W at a frequency of 17.442 kc/s. As regards the Erdantenne, a pair of brass rods of 25 cm in length and 5 mm in diameter were used. One rod was fixed at a point and another one was rotated round the fixed one. The induced voltage between the two electrodes measured at every 10 degrees were fed into the amplifier through a shielded concentric cable. In this case, because the contact resistance between the mobile electrode and the earth were expected to vary to some extent at respective measuring points, the value of the input resistance of the amplifier adopted was large so as to avoid the effect of the earth's contact resistance. Thus the so-called eight-figure characteristics of the aerial shown in Fig. 1 were obtained, and it is easily seen that the error of bearing deduced from the figure seems to be within a few degrees. From this experimental result it follows that an aperiodic direction finder may be easily realised by arranging a couple of aerials of this type at right angles. But it is to be noted that the neighbouring soil around the Erdantenne must be of uniform conductivity. Because further measurements were not made, we have no idea about

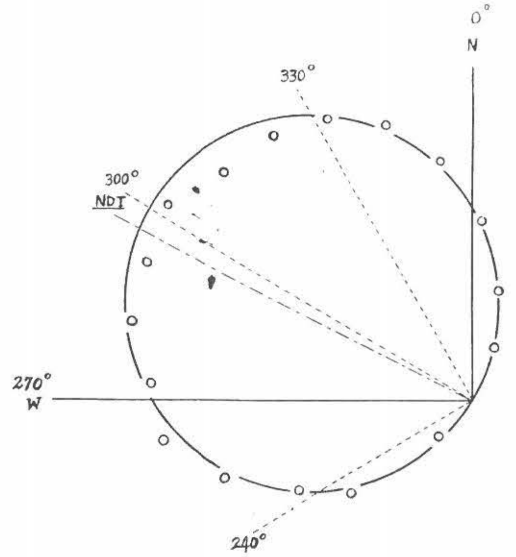

Fig. 1. The eight-figure characteristics of the Erdantenne
(◦ measured value)

the accuracy of this aerial. Provided that the error of the order of a few degrees is permissible, the Erdantenne may be used as the direction finding aerial in the case of near thunderstorms, because the bearing error of this order is of less importance for the sferics fixing of near origings.

Next, since this aerial is aperiodic, the frequency, in fact, can be freely adopted according to the need. In other words, this aerial can be used in the lowest frequency band. The authors (1963) observed the waveforms of the extremely low frequency atmospherics at a frequency of a few 10's c/s with the Erdantenne. Here, some considerations of the usual vertical aerial may be necessary for observations at frequencies under consideration. First of all, in the case of the very long radio wave the wide band amplifier must be connected to the vertical aerial by a condenser, because the electric characteristics of the vertical aerial is equivalent to a capacitor. However, since the value of this equivalent capacity of the vertical aerial is much smaller than that of the coupling condencer, the gain of the aerial-amplifier system must be extremely small. The second trouble may be the error resulting from the variation of the electro-static capacity of the aerial due to the mechanical vibration by wind. The third problem is that the vertical electric field due to the variation of the space charge in the atmosphere may introduce the unwanted effect to the vertical aerial. These factors may be the possible errors in the observations of electric field strength with the usual vertical aerial. Taking into consideration the above factors, the Erdantenne may be concluded as a useful aerial to the observations of waveforms of atmospherics at frequencies of a few 10's c/s.

Some other interesting results are obtained from the observations of the waveforms of near lightning discharges with the Erdantenne. The authors observed the waveforms of near origins with the Erdantenne and the usual vertical aerial simultaneously. Now in the case of an incident wave or any surface wave, the ratio of the horizontal electric field component to the vertical electric field component is, in general, written as follows at any incident angle of ψ, where σ denotes the conductivity of the earth, ε_0 the dielectric constant in vacuo, and ω the angular frequency of the wave.

$$\frac{E_h}{E_v}=\frac{1}{\sin\psi}\sqrt{\frac{\varepsilon_0\,\omega}{\sigma}}\cdot e^{-j\frac{\pi}{4}} \quad \cdots\cdots\cdots\cdots\cdots \quad (1)$$

From the expression (1), it is clear that the horizontal component of the electric field

E_h decreases with decreasing frequency of $\omega/2\pi$ in comparison with the vertical component E_v. Thus the lower frequency components radiated from the lightning flashes are scarcely received with the Erdantenne. In other words, the higher frequency components dominate. Now, as is well known, in the nearest point from the source the magnitude of the electro-static component exceeds in comparison with the other (induction or radiation) components, and it decreases with increasing distance from the origin. This fact was justified from the observations of waveforms by Appleton and Chapman (1937). However, in order to study the waveform of the radiation pulse in more detail, it must be observed in the nearest point from the origin. In this case the Erdantenne is the most useful one, because this aerial has less response of the electro-static component owing to its lower frequency spectra. In other words, only the radiation pulse having, in fact, higher frequencies can be observed in large amplitude with the Erdantenne. Fig. 2 shows results obtained both with the vertical aerial and with the Erdantenne simultaneously. This photograph was taken continuously by two beam cathode ray tubes with time sweep 3 ms. The left figure is the waveform observed with the vertical aerial, while the right one is that with the Erdantenne. The slight radiation pulse on the rising part of the large amplitude electro-static waveform on the left side is considered to the pulsive waveform in the right photograph. Hence, studies of the radiation pulse at lightning flashes may be made exact with the Erdantenne.

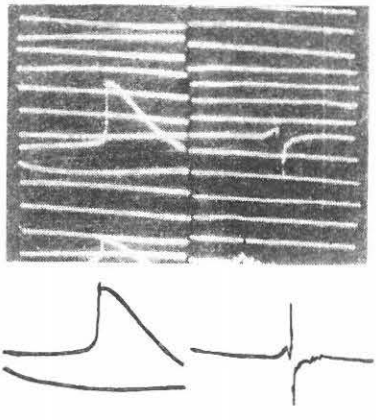

Fig. 2. Waveforms of the near lightning flash observed simultaneously
left: vertical aerial
right: Erdantenne

Finally it may be concluded that the Erdantenne is a very useful and convenient aerial for the measurements of the very low and extremely low frequency radio waves.

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