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ACTIVITY REPORT

Section 1. Propagation of Atmospherics and ELF Radio Noise

Further improvements on the real time lightning locator have been made in the electronic devices to reject the subsequent strokes of a multiple lightning stroke. Originally, it was required to investigate the electrical nature of the radiation of the first stroke compared with that of higher order strokes in both VLF and ELF components. Later on, it was required to determine what causes inaccuracies in obtaining distance to each source, for some of them may be ascribed to the nature of lightning discharges and some of them to the nature of propagation.

Polarisation was studied both theoretically and experimentally. One type of the polarisation error is produced by the effect of the Earth's magnetic field. The bearing errors for ELF and VLF waves below 10 KHz were investigated theoretically as a function of propagation distance. It was found that the bearing error at 10 KHz changes randomly from positive to negative values corresponding to the traversing distance because of propagation mode interference. But, the bearing error for ELF remains constant irrespective of the traversing distance, because propagation is by the quasi-TM zero order mode and no higher order modes exist. As to the polarisation error due to the inclined electrical dipole such as the cloud discharge, there is essentially no polarisation error for ELF. The bearing error at 10 KHz, however, depends on the inclination and the height of the dipole, configuration between the dipole and the observing point, and the conductivities of the ionosphere and the ground. Thus, if direction finding could be operated at a frequency in the ELF range, it would be very interesting to compare this with 10 KHz direction finding in view of the polarisation error. To experimentally investigate the polarisation of VLF c. w. signals, NWC (22.3 KHz, 1 MW, propagation path 6,400 Km) was measured. Absolute value of H_ϕ/H_ρ was found to be 0.08 in the daytime, and 0.11 at night. Analysis of the polarisation by the wave guide mode theory for N-S propagation shows that the absolute value of polarisation in each mode reaches its maximum at fifth or sixth order modes.

ELF and VLF TM-mode waves in the inhomogeneous ionosphere were studied theoretically in terms of a modified refractive index N consisting of n, dn/dz and d^2n/dz^2. ELF electric field components were explicitly different from that computed by the "multi-homogeneous-layer" approximation. Such a difference may be referred to the effect of singularity of wave equation at $n=0$. Taking account of the electromagnetic field patterns and the variations of the modified refractive index, the reflection and penetration heights in the ionosphere can be estimated, that is, TM-mode waves are mostly reflected near the level where $\omega = \omega_\gamma$ and can penetrate to where $\omega_\gamma \sim 3\gamma^2 c^2/\omega^2$ (γ is the conductivity gradient and c the velocity of light). Moreover, it would be significant that the amplitude of the ionospheric reflection coefficient for ELF decreases as the conductivity grandient increases for grazing incidence. The attenuation and phase velocity for ELF radio wave propagation below an inhomogeneous ionosphere depend strongly upon the gradient of electron density in the region of $\omega_\gamma = 10^4 \sim 10^6\ s^{-1}$, though the effect of the gradient is slight at VLF. As the electron density gradient in that region increases, ELF wave attenuation decreases whileVLF wave attenuation increases.

An experiment was made by rocket K-9M-43 launched on August 21, 1973 at Kagoshima Space Center in Japan. Although this experiment was designed to examine both the antenna impedance in the VLF band and the field strength of wave radiated from the ground station in the ionospheric plasma, and also to check on the phenomena which were observed at the past rocket experiments, this observation, unfortunately, ended in failure.

So as to study both the ionospheric propagation characteristics in the VLF band and the property of the lower ionosphere, observations of the intensity and the phase variations of radio waves transmitted from VLF stations are being carried out simultaneously at Toyokawa and at Syowa station in Antarctica for frequencies of 17.4 and 22.3 KHz. For this study, Rubidium frequency standard is used which has a frequency accuracy of 2×10^{-11}/day. Additionally, preparation are being made to observe OMEGA transmissions to augment this study.

For the provision of a future satellite experiment, theoretical works on the wave phenomena in a space plasma have been devoted to the radiation of electrostatic waves from an antenna.

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