# RADIATION FROM LIGHTNING DISCHARGE*

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## 1. Introduction

Streamers of diverse nature, size and complicated structure being supposed to construct a lightning discharge will be a good transmitter antenna carrying an impulsive current of various waveform on it.

Therfore, a lightning discahrge is a strong pulsive, atmospheric radio noise source whose frequency spectrum spreads over an extremely wide range ELF through UHF. This paper describes briefly the experimental results based on our atmospherics observations in a very wide frequency range during a few recent years.

## 2. Atmospheric frequency spectrum 100 Kc/s through 500 Mc/s on thunderstorm conditions

The intensity and the detailed waveform of atmospherics were measured within 30km distance from the source thunderstorm in two summers 1962, 1963, the frequency range of which extended from 100 Kc/s to 500 Mc/s (Takagi and Takeuchi, 1963).

The field intensity of the quasi-peak indication, using charging time constant 1 ms, discharging time constant 600 ms, reached the order of 0.1 v/m at 100 Kc/s on 10 Kc/s IF band-width. Up to several megacycles the spectral characteriscs were found roughly to be subjected to the inverse proportion law to frequency.

Beyond that frequency, the decrease rate turns gradually to increase and begins to fluctuate much from a storm to another. So that sometimes we did not succeed to record any atmospheric radio noise at all beyond 200 Mc/s using the receiver with 3 v/m equivalent internal noise level.

The intensity attenuation due to propagation, being indicated by the intensity difference between overhead flashs and 20 km distant flashes, amounts statistically to 4 db at 100 Kc/s, 7 db at 1 Mc/s, 14 db at 10 Mc/s and 13 db at 120 Mc/s.

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The values seem to be too large to be expected from the dielectric influence of the earth's surface on the propagation because the several kilometer altitude of the source antennas is not too much smaller than the propagating distances. Therefore we would suggest here some attenuation processes like scattering, absorption of radio noise-waves in a thundercloud body and on the surface of it, being significant even in a lower frequency range than the range of radiometeorology.

It is interesting to see the spectral difference between ground and cloud discharges. The ground discahrges predominated over the cloud discharges by 5 to 10 db in the frequency range lower than 10 Mc/s while no significant difference was found between them in the range higher than this.

The difference is supposed to result principally from the leader process and not from the return process.

The change in spectrum characteristics could not be found in any appreciable manner with respect to the development stages of a thunderstorm activity notwithstanding the supposed change in sort and scale of discharge (Takagi, Ishikawa and Takeuchi, 1959).

## 3. Fine structure of atmospherics

To relate a spectrum to a discharge mechanism, the output from a superheterodyne receiver and a VLF electrostatic field change recorder were displayed simultaneously on a dual beam oscilloscope, and the waveforms were recorded continuously on a 16 mm running film.

The radiation from a stepped leader process of a ground discharge was remarkable over the whole frequency range. B, I and L stages in the first leader process (Clearance and Malan, 1957) could also be noticed on the high frequency record. On average, the intensity is the strongest on L and the weakest on I. High frequency radiation from the leader to a subsequent ground stroke did not essentially predominate over that of J prosess, which sometimes occupied almost all of an interstroke period.

The band-width 10 Kc/s adopted for the spectral measurement is too narrow correctly to reproduce the pulsive waveform due to a return stroke and to resolve it from the preceeding leader part on the record. However, the radiation from a return stroke seems to be somewhat smaller than the maximum amplitude on the leader waveform.

In the interstroke period and the period after the last stroke, the radiation was sometimes found to continue for several tens of milliseconds or to indicate intermittent short pulses in several groups superposed on the former continuation.

The latter groups actually correspond each to a small electrostatic pulse on the VLF waveforms. Immediately after a return stroke, the radiation marks a rest for 5 to 20 ms. (Malan, 1958). Therefore the J process looks to start its progress after waiting for the regeneration of electric field being made weak by the preceding return stroke.

The radiation characteristic from a cloud discharge is similar to that from a J process. The continuing radiation unlikely comming from a stepped leader process were found to be recorded along with intermittent pulse groups. When a cloud lightning occurred within 5 km distance, a continuing radiation that goes with a weak continuous luminosity often continued more than 0.1 sec, and the VLF field change correspondingly indicated the complicated variation continuing for a long period. In the frequency range lower than 10 Mc/s, usually intermittend pulsive radiations predominate over the continuing radiations, however the difference was found to tend to vanish as the frequency goes beyond 10 Mc/s.

## References


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