ON THE NATURE OF FREQUENCY SPECTRUM OF ATMOSPHERIC SOURCE SIGNALS

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Abstract

The peak intensity spectra of atmospheric source signals have been investigated in a high frequency range to see the influence of different processes involved in lightning discharge on the nature of an intensity spectrum. It has been shown that a return stroke is the strongest source of an atmospheric source signal below a few Mc/s, while it tends to be a weaker source as the frequency is increased beyond 15 Mc/s. The recoil process which is responsible for a K-change becomes predominant beyond several Mc/s. It has been found that the break-down process preceding a leader process is not predominant in the frequency range investigated.

1. Introduction

There have been many investigations hitherto made on the frequency spectrum of atmospheric intensities. However, the frequency range of them principally concerned with was limited mainly to the low frequencies.(1)~(11) Recently, some workers come interested in the problem of waveforms and frequency spectrum of individual atmospherics in high frequency ranges and have made various studies for their practical purposes.(12)~(18) It had been quite an important problem for telecommunication systems to know the effect of atmospheric disturbances in the frequency range lower than HF band to discover a means of over-coming it until the opening of space age. However, in the present days when rockets and artificial satellites have been brought to practical use, the atmospheric noise disturbances would become an important problem in a higher frequency range than it was in the previous days for a telecommunication system with transmitter of limited weight and size and accordingly of very limited radiating power.(16) On the other hand, the mechanism of a lightning discharge has been extensively studied, using every possible means of approach.(19) In this regard the atmospheric source signals would provide an effective way of approach, if they are recorded within a distance roughly 10 km from a lightning discharge.

Generally speaking, the electric field change due to a lightning discharge consists of the three components, i. e., electrostatic field, induction field and radiation field, whose amplitudes are generally recognized to be inversely proportional respectively to the third, second, and first power of the distance from the origin lightning discharge. There appears to be some misunderstanding existing in the physical meaning of the induction components.[20]

We have adopted a method of electro-static field meter and a radio noise receiver to observe atmospheric source signals in the present series of our experiment.[17][21] The use of electro-static field meters and VLF atmospheric waveform recorders have provided a convenient way to know the nature of an individual lightning discharge recorded roughly within a distance 10 km from it.[22] At high frequencies, a few to 10 km distance from lightning discharge would be sufficiently larger than the wavelength of the source signals concerned to be considered for this paper. Therefore it is very reasonable that the atmospheric source signals we have recorded really consisted only of the radiation field. The observation of atmospheric source signals in a high frequency range was started, using a mobile station in 1962 to study the nature of a lightning discharge as origin of high frequency atmospherics[17] and it was continued until 1963, keeping the same field site at Takasaki in Gumma Prefecture.[23] In 1964 we moved it to Funyu in Tochigi Prefecture where the Office of the Experimental Plantation, Utsunomiya University is located, in order to eliminate the acoustic town noise disturbing the thunder observation and mobil ignition noise disturbing the radio noise beyond VHF range.

2. Measuring techniques

The basic principle of atmospheric source signal measurements has remained the same throughout our series of storm observations in the past several years,[17] the block diagram of which is indicated in Fig. 1 showing the techniques adopted for the years 1963 and 1964. The instruments consisted of the two radio noise field intensity meters Type K-485 and Type K-487 supplied by Kyoritsu Electric Works. We recorded the source signals at various frequencies changing from time to time the receiving frequencies of the two radio noise field intensity meters, while we continued our observation in the event of thunderstorm outbreak. But the data thus obtained were found to be insufficient, because it was difficult to effectively make the storm observation so that a sufficiently large number of the data could be secured on an occasion of a thunderstorm observation.

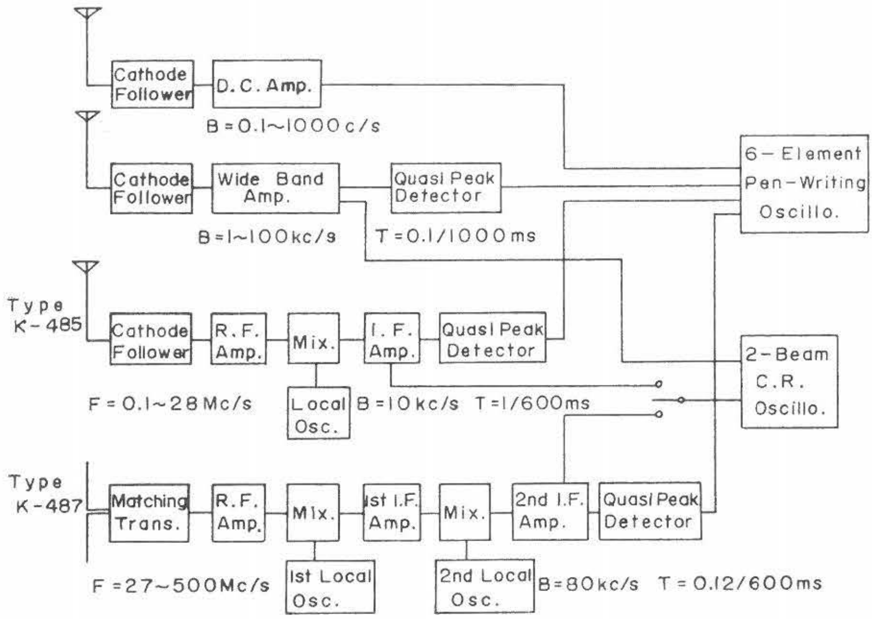

Fig. 1. Block diagram of the instrument. **F**=receiving frequency, **B**=bandwidth of the receiver and **T**=time constant of quasi-peak detector written as (charging time constant)/(discharging time constant).

3. Results

The amplitude of IF waveform of atmospheric source signals has been measured on a 16 mm film where the waveforms, IF and VLF, were recorded all together with a continuous recording camera. The use of this technique has made it possible to evaluate the IF peak intensity of a part of source signals which exactly corresponds to some definite discharge process in a lightning, e. g., breakdown, leader, return stroke etc., because it is not a very puzzling problem to tell a certain discharge process involved in a lightning flash from others on a photographic record of VLF waveforms of source signals. Since we have had to do with a two beam oscilloscope for the purpose of waveform recording, it has been always impossible to get photographic waveforms at more than one frequency in one instance. The peak IF intensity spectrum thus obtained for a certain discharge process is in no-way the result of a frequency spectral measurement made on a same lightning discharge. Fig. 2 indicates the effect of an individual lightning process on the spectral distribution of peak IF intensity of the source signals, where we see that despite a very wide dispersal of

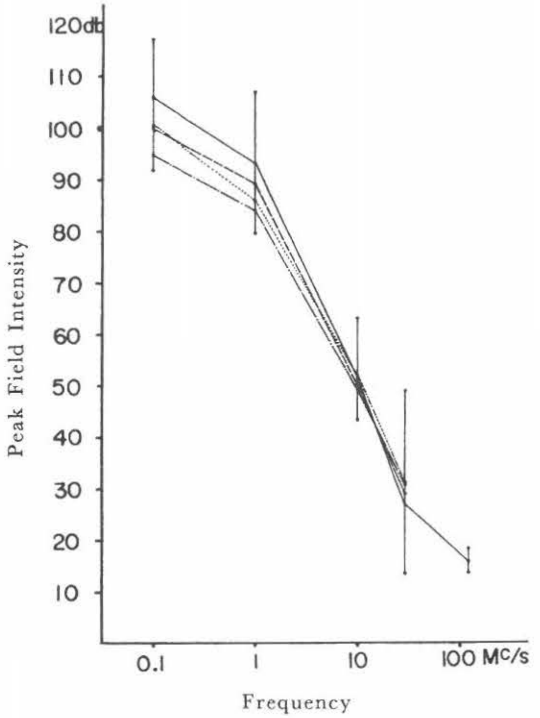

Fig. 2. Frequency spectrum in different process.

——— Return Stroke

- - - - Break Down Process

······ Recoil (K-Change)

—·—·— Stepped Leader

Field Intensity 0 db = 1 μV/m at B = 10 kc/s

Upper Decile, Median, Lower Decile of Return Stroke

individual measured values, the curve connecting the mean values seems to be quite significant. It can be stressed that a return stroke is the strongest cause of an atmosheric source signal roughly below a few Mc/s, while it tends to be a weaker cause of it as the frequency is increased roughly beyond 15 Mc/s and the recoil process producing a K-change [24] as well as the stepped leader [25] clearly become to be predominant a little over others roughly beyond several Mc/s. However the break-down process is found not to be the strongest source in the frequency range examined.

4. Conclusion

The spectrum of atmospheric source signals has been investigated on the photographic IF waveforms taken together with VLF waveforms to see the influence of a discharge process on the spectral distribution of atmospheric source signal intensities. It is shown that the strongest cause of atmospheric source signals is attributed to the return stroke below a few Mc/s, however beyond 15 Mc/s it turns to be a weaker source. Recoil and leader processes tend to be predominant roughly beyond several

Mc/s while the break-down process is not a strong cause of the source signals in every frequency range investigated.

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