ON THE SPECTRUM OF THUNDER

Minoru NAKANO and Tosio TAKEUTI

The pressure variations associated with thunder were observed first by Schmidt (1914). Recently, Bhartendu (1968) observed thunder in the frequency range from infrasonic to sonic and reported that most of the energy was concentrated in the low frequencies. On the other hand, Few et. al. (1967) obtained a dominant peak near 200 Hz in the acoustic spectrum of thunder and showed that the corresponding wavelength gave the distance between the axis of a lightning channel and the region where the shock degenerated into the acoustic wave.

Though the main purpose of the present investigation is to estimate the energy of a lightning discharge by means of the spectrum of thunder and to study the influence of the channel shape on the spectrum, in this note we will discribe some of the preliminary results obtained in the summer of 1969 at the Imaichi Observatory. Some of the waveforms of thunder obtained with a non-directional dynamic microphone that has an almost flat frequency response between 80 Hz and 1500 Hz, are shown in Fig. 1. From an examination of the corresponding electrostatic fieldchanges, we could identify the nature of the discharge. Thus the spectrum in Fig. 1 (a) is due to a cloud to ground discharge and that in (b) is due to an intra-cloud discharge. It was, however, not possible to identify the discharge for the spectrum shown in (c) because of the complicated nature of the field changes. A series of 'pearls' can be easily seen in the three figs. It can be further noted that the pearls in Fig. 1 (b) are nearly of the same intensity.

Broadly speaking, the occurrence of pearls depends on the spatial distribution of the acoustic energy at the source and on the propagation of the sound waves. Reflections at the ground and at the cloud may have some influence on the propagation of the sound waves but the investigation of Latham (1964) have shown that they can be neglected. Thus the occurrence of the pearls would seem to depend on the zig-zag character of the channel, the branchings and on the non-uniformity of the energy distribution along the parent discharge channel. In the case of C-G discharge the branching would seem te be less intense and their influence on the pearls can perhaps be neglected. In Fig. 1 (b) it is seen that the pearls are individually of nearly the same intensity. These may have been caused by the zig-zag nature of the channel and/or by the branchings of nearly the same source intensity, but a more thorough and detailed analysis of the various processes should be made to understand their relative significance. The calculation of acoustic pressure variation for cylindrical and for spherical geometry are in progress and are expected to be communicated in the near

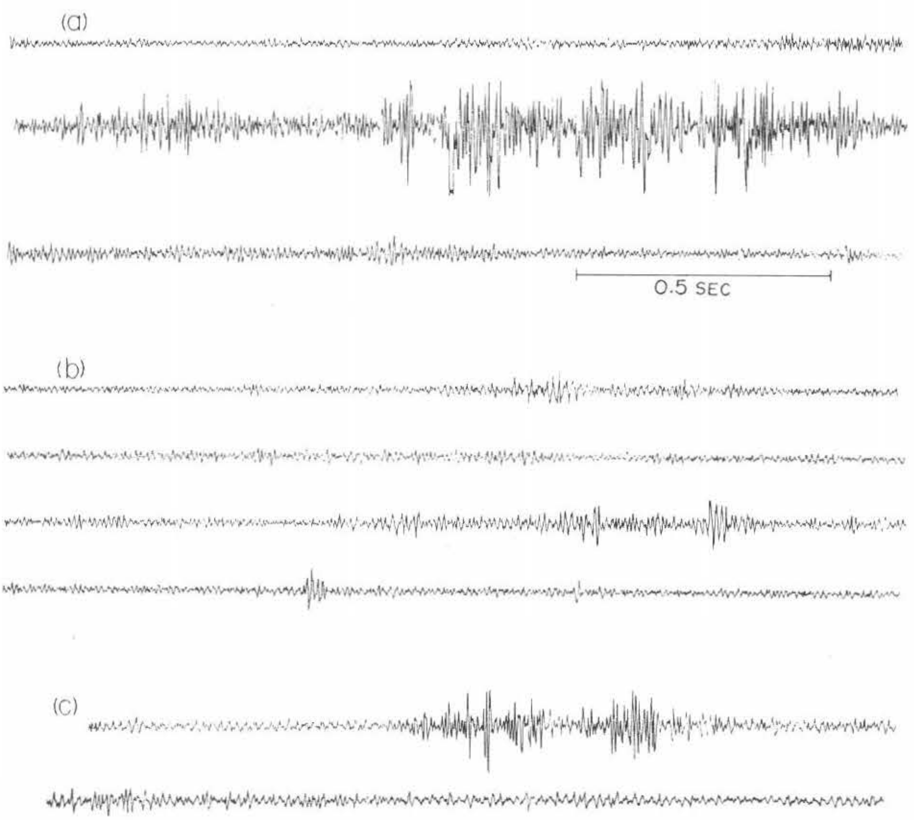

Fig. 1. Thunder records on July 26, 1969, (a) cloud to ground discharge, (b) intra-cloud discharge, (c) unidentified discharge. The distance from the source to the observatory is about 10 km.

future.

An example of the dynamic spectrum of thunder is shown in Fig. 2 where some peaks of intensity can be seen. This record has been obtained with a sound spectrograph, and the duration of thunder is about 10 seconds. The peaks occuring at 200 Hz are in accord with the results of Few et. al. (1967). The temperature, the pressure and the ion density are likely to change along the channel and are dependent on the nature of the lightning discharge. Thus we can expect the dynamic spectra to be different between C-G and C discharge. Furthermore, a change in the frequency of the peaks can also be expected, even though the spectrum in Fig. 2 does not show any such a change.

It is hoped that more extensive data will be obtained next summer to enable us to study more quantitatively the various processes.

Acknowledgement —— We wish to thank Professor H. Ishikawa, Drs. T. Nakai and

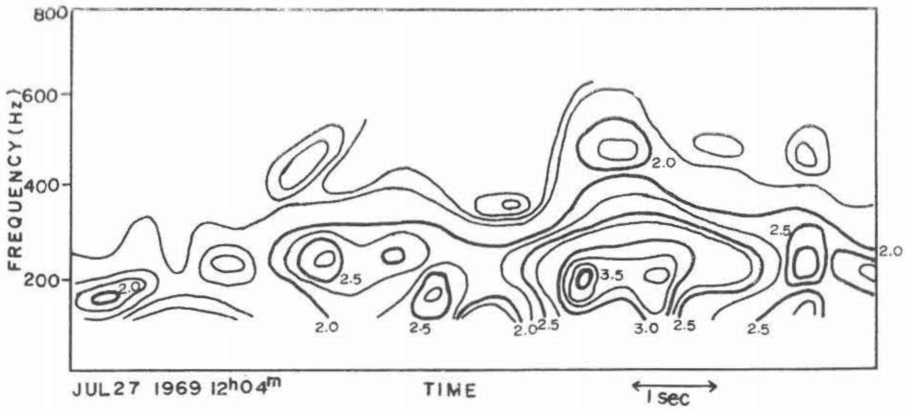

Fig. 2. Dynamic spectrum of thunder records on July 27 1969, solid lines represent relative iso-intensity contours of sound pressure.

M. Takagi for their valuable discussions. Thanks are also due to Messrs. M. Nagatani and A. Nakada for their help in the instrumetation.

References

Bhartendu : A study of Atmospheric Pressure Variations from Lightning Discharges, Can. J. Phys., **46**, 269 (1968)

Few, A.A., A.J. Dessler, Don J. Latham and M. Brook : A dominant 200-Hz Peak in the Acoustic Spectrum of Thunder, J. Geophys. Res., **72**, 6149 (1967)

Latham, D.J. : A Study of Thunder from Close Lightning Discharges, M.S.thesis, Physics Department, New Mexico Institute of Mines and Technology (1964)