SHORT NOTES

FIELD CHANGE DUE TO LIGHTNING DISCHARGE*

Haruji ISHIKAWA and Toshio TAKEUCHI

1. Introduction

It is well known that a set of simultaneous recordings at seven points on the ground is a theoretical demand for analyzing a dipole cloud discharge assumed for the interpretation of a field change. Workman et. al. (1942) recorded it at seven points in 1939-40 and at eleven points in 1952 (Reynolds, 1955), Hatakeyama (1946) at five points, and Tamura (1958) at eight points. However the slow time response of the instruments they adopted limited their analysis only to finding the charge distribution dissipated in an individual lightning as a whole, and did not concerned with any detail of the process. Later, Smith (1957) measured the field change with much higher time response at two points aiming more detailed analysis of the dipole discharge. Following the latter idea we carried out the field change measurement at three points using the ELF tape recording technique. The flash-thunder time-interval measurement and the watching out the flash appearing direction compensated the disadvantage of short commnig of the recording points. Moreover the waveform of the field change helped us in some way in estimating the distance of the pertinent discharge.

2. Analysis of dipole discharge in thundercloud

(1) Three types of thundercloud: Analysis so far being done indicates the existence of three types of thunderclouds. Type I cloud mostly produced the vertical dipole cloud discharge with upper positive polarity; type II the discharge with an

* Short Contribution to World Conference on Radio Meteorology 1963, NBS, Boulder Colorado, U.S.A.

orientation inclining to the vertical direction; type III the discharge between the positive electricity on the cloud top and the negative electricity in the upper atmosphere.

(2) Field change: The field change due to a cloud discharge can be assorted with respect to the cloud type.

Type I cloud produced the field changes whose polarity were positive when they occured at short distances, and it turned out to negative when the distances were long enough. Transition from positive to negative happened to be recorded in the intermediate range of the distance, which strongly fluctuated from a discharge to another. Here we may introduce the idea of a field reversal zone which spread out in a statistical sense, tha is 1.5 to 17 km from a discharge for this type of the cloud. In type II cloud, no simple relation could be found between the field change polarity and the distance. Type III cloud showed the reverse relation to that of type I, and the lower positive electricity located from 7 to 9 km above the ground, whereas the altitude of the upper negative electricity distributed from 9 to 11 km. Hence the field reversal zone here stretched out from 10 to 16 km distance.

The electricity dissipated by a cloud discharge was found to fluctuate very much for the cloud type I and II. Indeed it was a few coulombs for a cloud discharge and a few hundred coulombs for another, even within one thundercloud. Therefore the amplitude-distance relation is not simple for the two types of the cloud. The electricity neutralized by each cloud discharge in type III cloud was maintained remarkably constant within a relevant cloud and here we can see a simple amplitude-distance relation.

In the field reversal zone the waveform of field change due to a cloud discahrge should show an extremum, if the discharge process can be replaced by a movement of either of a pair of opposing electricities composing a dipole in the cloud. Applying the principle we can determine the streamer polarity performing a dipole cloud discharge. Smith (1957) reported the occurrence rate of positive streamer relative to negative to be 18 : 36 on average, whereas our measurement showed the ratio 25 : 17. However the ratio individually fluctuated in a wide range from a cloud to another, and sometimes it did not reach unity.

(3) Partial discharge: It is remarkable that the field change originating from a cloud discharge was sometimes superposed by a few very large step-wise variations, indicating partial discharge occurring on the way of a cloud discharge.

The electricity being neutralized by a partial discharge was comparable with the average total electricity producing a cloud discharge as a whole.

Hence a partial discharge may be brought about, when a complex cloud discharge streamer, which must be assumed to explain the field change due to a dipole discharge (Ishikawa 1961), reaches an extremely large sized local charge center lying on the way of the discharge channel. In the ordinary case as a contrast, the local charge centers invole each about 1 coulomb on average and they are roughly separated esch by 200 m lying on the channel of a cloud discahrge, thus produce ten to twenty successive local discharge without showing any appreciable step-wise field change. However it will be a matter of future problem to interpret the detailed mechanism of the discharge.

References

(1) Hatakeyama, H : Kishogijitsukan Yoseijyo Kenkyuhokoku, **1**, 33 (1946)

(2) Ishikawa, H : Proc. Res. Inst. Atmospherics, Nagoya Univ., **8A**, 122—252 (1961)

(3) Reynolds, S. E. and Neil, H. W : J. Met., **12**, 1 (1955)

(4) Smith, L. G : Quart J. Roy. Met. Soc. **83**, 103—109 (1597)

(5) Tamura, Y., Ogawa, T. and Okawati, A : J. G. G., **10**, No. 1, 27 (1958)

(6) Workman, E. J., Holzer, R. E. and Pelsor, G. T : Tech. Notes N. A. C. A. No. 864 (1942)