ON THE CLOUD DISCHARGE PRECEDING THE FIRST GROUND STROKE

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Summary—As to the beginning stage of a ground discharge, the following facts have been obtained by a field meter with the aid of a radio receiver and a flash intensity recorder. About 50% of the ground discharges are preceded by a "pre-preliminary discharge" which occurs within 500 ms before the first ground stroke, so the discharge precedes also "the preliminary discharge" which is named by Clarence and Malan "the B I L change".(1) The term "B I L" is used in this paper to avoid confusion of the preliminary with the pre-preliminary. In some thunderclouds the greater part of the first ground stroke is preceded by the pre-preliminary discharge, however, in others, the strokes are preceded only by the B I L discharge. On the average the ground discharge preceded by the pre-preliminary discharge have fewer ground strokes than those preceded only by the B I L discharge, so, the pre-preliminary discharge must neutralize the negative charge concerning the ground stroke. The relation between the pre-preliminary discharge and the B I L discharge is not obvious at this stage.

I. Introduction

It has been reported by Clarence and Malan(1) that a ground discharge usually has the B I L discharge which occurs between a lower negative charge in a thundercloud and a positive charge in the lowest part of it and leads to a ground stroke. Pierce(2) has reported on the long duration discharge occurring before the first ground stroke. The discharge is named by him "the initial L change". Authors have also recorded a long duration discharge before the first ground stroke and concluded that those long duration discharges recorded by Pierce and authors are composed of B I L discharges and those of other types. In this paper the later discharge is named pre-preliminary discharge and authors intend to discuss it.

II. Apparatus

Apparatuses employed for the observation of lightning discharge concerned in this paper are as follows:

1. The mill type electric field meter.(3) A metal electrode earthed through a high resistor is alternately shielded and exposed to the electric field due to a lightning charge, and an alternating voltage proportional to the field appears on the resistor. The voltage is recorded with a tape-recorder.

2. The flash intensity recorder.(4) A flash accompanied by lightning discharge is changed into voltage by photo-multiplier and the voltage is recorded with a tape-recorder.

3. Medium frequency wave radio receiver. As the amplitude of the atmospherics radiated from a near lightning discharge is far larger than that of a broadcast wave, the atmosphrics is received with a radio receiver without interference by a broadcast wave. The atmospheric signal received with the radio receiver is rectified and is recorded with a tape-recorder.

III. Duration of discharge occurring before the first ground stroke

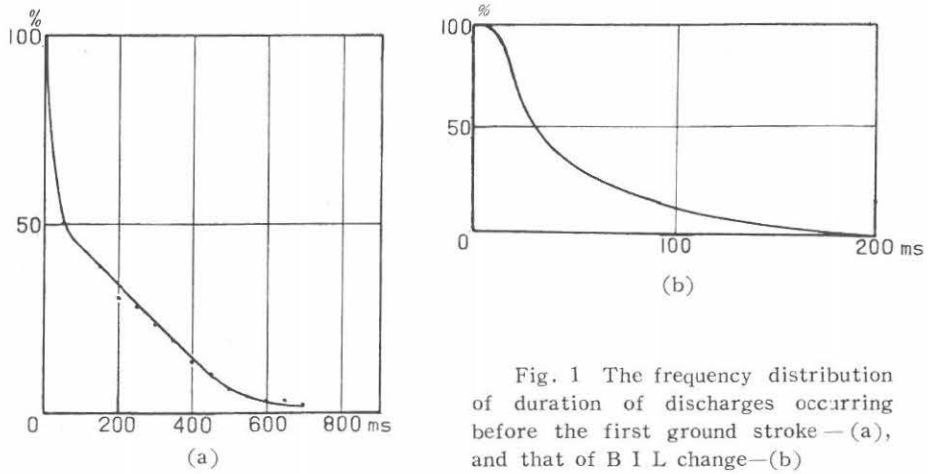
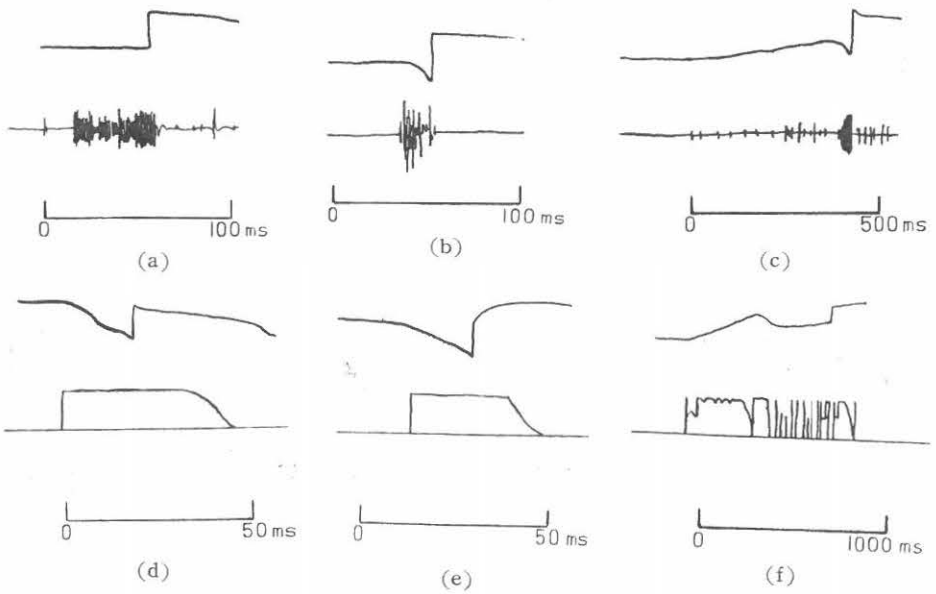
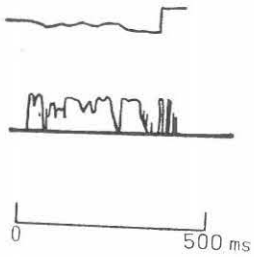


Fig. 1 The frequency distribution of duration of discharges occurring before the first ground stroke — (a), and that of B I L change—(b)

Fig. 1 (a) shows the frequency distribution of duration of discharges occurring before the first ground stroke. The figure is the summary of records of the field meter through four years since 1956. On the other hand Fig. 1 (b) shows the frequency distribution of duration of B I L discharge reported by Clarence and Malan. A comparision of the two figures cleary shows that about 50% of the discharges recorded by the authors can not be explained with the simple B I L discharge, while the other 50% are simple ones. Therefore, it is evident that one half of the ground discharges must be preceded by pre-preliminary discharges.

IV. Example of record of pre-preliminary discharge





(g)

Fig. 2 Records of ground strokes explained in chapter IV. Above parts on each couple represent field change. When flash intensity excesses some level, a flash record becomes flat owing to character of flash intensity recorder.

Some examples of record of ground discharrges obtained with apparatuses are shown in Fig. 2. Corelated records obtained with the field meter and the radio receiver are shown in (a), (b) and (c). Ground strokes which are preceded by nothing except the B I L discharge are shown in (a) and (b), while what is preceded by the pre-preliminary discharge followed by the B I L discharge is shown in (c). Owing to a lower degree of amplification of field meter the field record in (a) does not show any change. In the same figure, (d), (e), (f) and (g) show correlated records obtained with the flash intensity recorder and the field meter, and (d) and (e) represent the case of a non-pre-preliminary type discharge, while (f) and (g), the case of a pre-preliminary type.

V. Type of discharges observed in a certain period of a thunderstorm

The distribution of the duration of discharge occurring before the first ground stroke in a period of a thunderstorm is shown in Figs. 3 to 6. The periods are defined tentatively. These figures show that one of the two types, pre-preliminary or non-pre-preliminary, predominates the other in one case, while the situation is

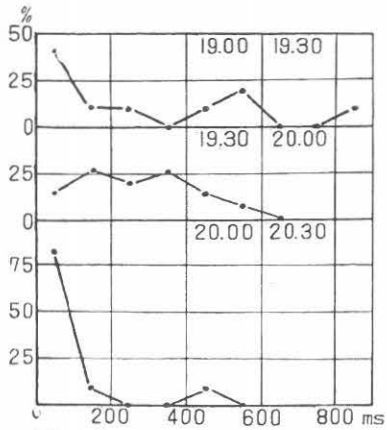


Fig. 3 The distribution of the duration of discharges occurring before the first groud strokes in the thunderstorm at Aug. 16 1956. Number of data; 19.00-19.30, 10; 19.30-20.00, 16; 20.00-20.30, 11.

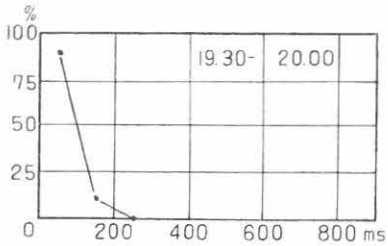


Fig. 4 The distribution of the duration of discharges occuring before the first ground strokes in the thunderstorm at July 7 1957. Number of data; 9.

reversed in another. In the thunderstorm, shown in Figs 4 and 6, the non-pre-preliminary type is more frequent than the pre-preliminary type, while the pre-preliminary type is more frequent in Fig. 5.

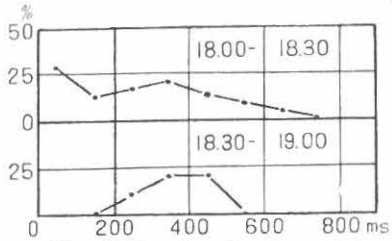


Fig. 5 The distribution of the duration of discharges occuring before the first ground strokes in the thunderstorm at Aug. 1 1957. Number of data; 18.00-18.30, 25; 18.30-19.00, 5.

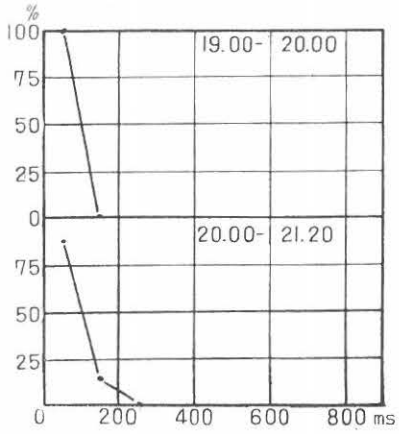


Fig. 6 The distribution of the duration of discharges occurring before the first ground strokes in the thunderstorm at Aug. 18 1959. Number of data; 19.00-20.00, 12; 20.00-21.00, 30.

Fig. 3 indicates that the either of the two types of discharge predominates the other in the respective periods separated at twenty o'clock. This may come from the character of a thundercloud, that is, the distribution of charges in the thundercloud, volume of charged region and so on, but it is not clear at present what type of clouds can actually cause the pre-preliminary discharge.

VI. Relation of pre-preliminary discharge to multiplicity of ground strokes

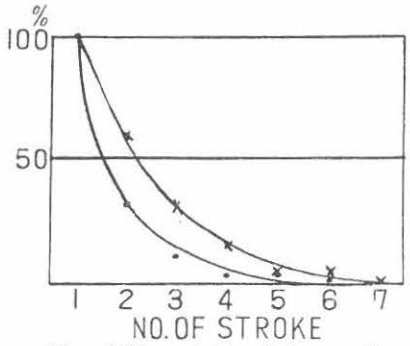


Fig. 7 The relation between the multiplicity of ground strokes and the duration of discharge occurring before the first ground strokes.

- ● Duration of a discharge is over 100 ms
- × Duration of a discharge is within 100 ms.

The relation between the multiplicity of ground strokes and the duration of discharge occurring before the first ground stroke is shown in Fig. 7, in which the duration of discharge is divided into two parts, that is, the one longer than 100 ms, and the other shorter. The former contains a predominant number of pre-preliminary discharge, while the latter does not. It is evident from the figure that a ground discharge preceded by the pre-preliminary discharge has on the average fewer ground strokes than a discharge preceded only by the B I L discharge. This may mean that the pre-preliminary discharge neutralizes the charge which would be neutralized by any ground stroke if the pre-preliminary discharge did not occur.

VII. Relation of pre-preliminary discharge to discharge occurring after the last ground stroke

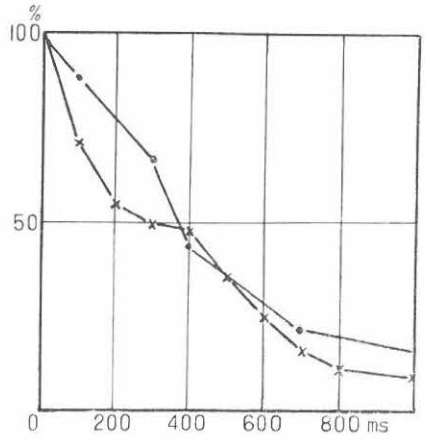


Fig. 8 The frequency distribution of duration of discharges occurring after last ground stroke.

- ● Duration of a discharge is over 100 ms
- × Duration of a discharge is within 100 ms

Fig. 8 shows the probabilty curve of the duration of discharge occurring after the last ground stroke and the two curves are classified according to the duration of discharge preceding the first ground stroke as is done in Fig. 7. So Fig. 8 shows the relation of the pre-preliminary discharge to a discharge occurring after the last ground stroke. It is obvious from Fig. 8 that there is no relation between the two, so that the pre-preliminary discharge probably occurs at an independent place of an after-discharge. Though the duration of the after-discharge is measured on the records of flash intensity variation and not measured on the field change records, it will be reasonable to consider that our after-discharge measured on flash intensity recorder may have the same meaning as the "final slow field change" reported by Malan,[5] that is, the discharge occuring in the upper part of a negative-charged column. Therefore authors may concluded that the pre-preliminary discharge occurs in the lower part of a negative-charged portion of a thundercloud.

VIII. Comparison of author's result with other reports

The pre-preliminary type discharge likely corresponds to the discharge reported independently by Malan[6] and Sourdillon,[7] that is, the chronophotographic record of a long duration of discharge before the first ground stroke by Malan and the "ground discharge having a horizontal top" by Soudillon. Soudillon reported the record of a ground flash photorgraph with Boy's camera and described that some cloud discharge which occurred simultaneously with the ground discharge had still emitted light after the finish of the first ground stroke. If Soudillon's case is applicable to the author's case, some of the pre-preliminary discharges may still continue itself after the first ground stroke, though the discharge is certain to start before the first ground stroke.

IX. Conclusion

It is concluded from above discussion that: (1) there are two types of thundercloud; one is that, in which the majority of ground discharges are preceded by the pre-preliminininary discharge; the other is that, in which most ground discharges are preceded merely by the B I L discharge.

(2) Most of the pre-preliminary discharges occur within 500 ms before the first ground stroke, and neutralize the negative charge concerned with the ground stroke. It is a problem to be submitted to future investigation to know the position of the pre-preliminary discharge in the cloud and to clear the relation between the pre-preliminary discharge and the B I L discharge.

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