OBSERVATION OF PRECEDING LEADER AND ITS DOWNWARD
TRAVELING VELOCITY IN UTSUNOMIYA DISTRICT

Y. Nagai

Sagami Institute of Technology, Fujisawa 251

S. Kawamata and Y. Edano

Faculty of Engineering, Utsunomiya University, Utsunomiya 321

Abstract: A downward traveling leader in lightning flash is observed for the first time in Utsunomiya district where lightning occurs usually in bad weather conditions. The results show that the average downward velocity of the leader front is 1.7×10^5 m/sec near the cloud base, then it is accelerated up to 4.7×10^5 m/sec with traveling the leader front to the ground. The leader seems neither to be α -type nor β -type (Schonland et al., 1938), because its downward traveling velocity increases gradually along with approaching the ground.

1. Introduction

In Utsunomiya district, almost all flashes occur in precipitation area. The base of clouds are about 1 km above the ground level or lower: the lowest case is about 300 m. The visual range becomes about 3 km or less. Hence it is very difficult to take the photograph of the lightning discharge channel with a high-speed frame or a streak camera. Hence it was seldom to take the photograph of the stepped leader by the use of any image scheme, except for upward-moving stepped leader at another observing spots in winter season (Miyake et al., 1981).

However, after try and error, on June 24 of 1981 at 21h 56m 58.6s (Japan Standard Time) the authors succeeded in taking a photograph showing faint leader preceding to the lightning return stroke, when we had favoured conditions for photography. The conditions are as follows: (1) lightning occurred in night, (2) it occurred at relatively close distance, and (3) it had little rainfall at the observing area.

From the photographic data the average downward velocities are obtained.

2. Measurement Apparatus

Apparatus used in this observation is a still camera and a streak camera. The streak camera is an improved version of oscillographic camera which makes record continuously for sufficiently long time and its optical scheme is for 35 mm film. The driving speed of film is changeable as 5, 10, 20, 50, 100 and 200 mm/sec. Errors involved in the speed of driving the film are less than 2 %, including those due to power source variations. The still camera with 35 mm film is mounted on a common metal base for viewing the same field as that of the moving-film one.

3. Results and Discussion

Fig. 1-a is shown the photograph which is taken by the streak camera and Fig. 1-b an illustrated sketch from the original photograph along with scaling in meters and time in milliseconds. In this experiment the sensitivity of the used film was ASA 100 (DIN 21) and the film-driving speed was 50 mm/sec. Time passes

Fig. 1-a. Photograph on moving-film.

Fig. 1-b. Sketch from original along with scaling in meters and time in milliseconds.

from right to left. The scaling of the discharge channel was estimated by the use of triangulation using photographic data and the time interval between the flash and the first thunder clap.

From Figs. 1-a and b, it is obvious that this flash is composed of a single stroke.

In Fig. 1-a, the right channel became to be luminous trunk which was caused by return stroke, but the channel on the left was failed behind the channel on the right and was remained as the branch. From the fact that the luminous trunk has many downward branches as shown in Fig. 1-a, hence it seems that the downward leader stepped for its approaching the ground.

The dotted lines near by the luminous channels in Fig. 1-b indicate the lateral positions of the faint leader image at each moment. Each lateral distance between the luminous channel and the dotted line is corresponding to a time interval between the moments in which the luminous front travels through that point downward in the first time, then upward in the second time. The velocity of the return stroke is much higher than that of the stepped leader (Uman, 1969), hence the lateral distances seem to be corresponding to the average downward traveling times from those points to the ground. Their times are as same as actual age termed by Schonland (1938).

For this reason, the characteristics of the average downward leader front velocity versus the height of the leader front may be obtained. The results show that the average downward velocity of the leader front is 1.7×10^5 m/sec near the cloud base, then it is accelerated up to 4.7×10^5 m/sec with traveling the leader front to the ground, as shown in Fig. 2. The leader seems neither to be α -type nor β -type, because its downward traveling velocity increases gradually along with approaching the ground. The characteristics of the velocity increasing along with traveling downward can not be compared with the results obtained by Schonland et al. (1938).

Fig. 2. Characteristics of the average downward leader velocity versus the height of front of the leader tips.

be compared with the results obtained by Schonland et al. (1938).

References

- Miyake, K., S. Yokoyama, H. Mitani, and M. Kumagai, Observation of Lightning Stroke Phenomenon in Winter Season (Part 1), Report of Central Research Institute of Electric Power Industry, CRIPI No.181008, 1981. (in Japanese)
- Schonland, B.F.J., Progressive Lightning, IV, Proc. Roy. Soc. A, 164, 132-150, 1938.
- Schonland, B.F.J., D.J. Malan, and H. Collens, Progressive Lightning, VI, Proc. Roy. Soc. A, 168, 455-469, 1938.
- Uman, M.A., Lightning, McGraw-Hill, New York, 1969.

(Received November 10, 1981;
revised March 12, 1982;
accepted March 31, 1982)