THE LIGHTNING TRIGGERING: A TECHNIQUE FOR ACTIVE PROTECTION OF A SITE

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Abstract. The technique of lightning triggering that we have developed is well mastered after numerous campaigns in France and in USA. It consists mainly of firing a small rocket carrying a thin metallic wire from the ground toward a thundercloud when the electrostatic field rises above the critical value (4 to 7 kV/m). The chances of success reach 94% under favorable conditions.

This is why it is now possible to conceive the utilization of this means of lightning control for an active protection of important installations such as spacecraft launching sites. The aim is to drive electricity generated within storm clouds to the ground through artificial lightning.

Analysis of the feasibility of this technique is given. For a thunderstorm of 40 minutes duration, a total of 120 rockets is found necessary for efficient protection. The Lightning Rocket System (LRS) technique can also be used to test electrical stability of the atmosphere before a missile launch in order to avoid the accident which happened to Apollo 12 in 1969.

1. INTRODUCTION

The feasibility of lightning triggering was demonstrated for the first time by Newman and others after many attempts by predecessors: Frankline, D'Alibard Beccaria, etc.

This means of creating lightning was then developed in France since 1973 by Commissariat a l'Energie Atomique and Electricite de France to which ONERA, CNET, IOPG and LPA joined later. At the present time, more than 250 lightning strikes for studies were triggered in France (St-Privat d'Allier 1973-1983) and in USA as well (Socorro, New Mexico, 1979, 81, 82; Florida, Melbourne 1983 and Kennedy Space Center 1984, 85).

2. TECHNIQUE OF LIGHTNING TRIGGERING

The system consists of launching from the ground toward a thundercloud (cumulonimbus) a small rocket carrying a thin metallic wire. At the upper end of the wire an upward moving "leader" takes place. At that time a current of some ten amps appears in the wire which is then rapidly heated and vaporized, thus creating an ionized channel for one or more return strokes (Fig 1.).

Although the critical process of triggered lightning is different from natural lightning, the return strokes are quite similar to those generated by natural dart leaders. It is worth noting that the current intensity of triggered lightning never exceeded 70 kA, while for natural lightning it can reach 200 kA (peak current).

From this principle, two systems have been developed. First, the so-called "classical system" used from 1973 to 1983, and second, the LRS technique tested for the first time in Florida in 1983. The LRS technique is patented. The two main components of this technique are the rocket and the conducting wire. We shall only present here the main characteristics of the LRS. Information about the classical system previously utilized may be found in the listed references (2, 3, 4).

In both cases, the delivery system is an ordinary rocket utilized by farmers mainly for hail prevention by seeding thunderstorm clouds with silver iodide (AgI). The major characteristics of the seeding rocket are:

Length:	97 cm
Total mass:	2700 g.
Black powder:	930 g.
Explosives:	400 g.
Silver iodide:	18 g.
Speed max:	250 m/s
Thrust max:	90 daN
Normal range:	1700 m.

In the LRS, explosives and AgI are removed and a spool for winding wire is fitted at the tail on the fins. The wire is made of copper Kevlar sheathed 0.2 mm diameter. Its resistance is 0.45 ohms per meter and the yield point 25 daN. With such a load the rocket weight is 2500 g. In practice, the LRS is a real improvement compared to the classical system in which the spool is at the ground. The improvement raises the probability of success to 94%.

2.1 Criteria of triggering

The main criterion for a rocket launch is the value of the electrostatic field which is recorded continuously at the ground by a field mill. When the sky is clear and the surroundings uniformly flat without trees, its strength is +100 V/m. In case of atmospheric disturbances the field can reach +500 to +1000 V/m. When a thundercloud is approaching (its lower part carries mostly negative charges), the electric field at the ground surface changes its sign from positive to negative and begins to decrease. The effect can be easily detected at 10 km distance. Just before the electric discharge, the field reaches -5000 to -10000 V/m with strong fluctuations.

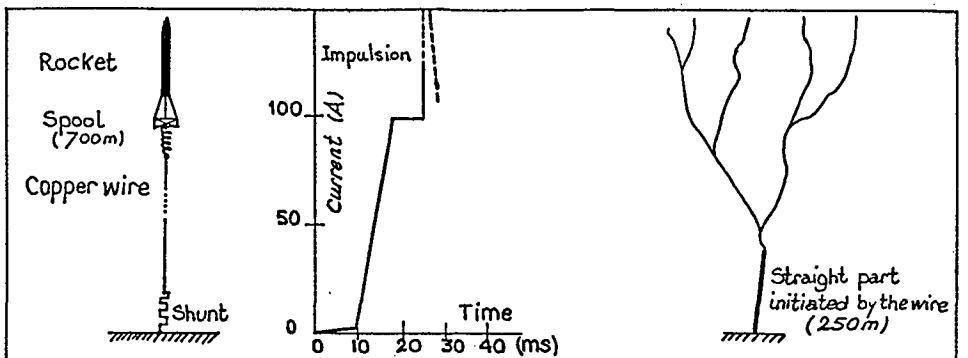

Fig.1 LRS CHARACTERISTICS

Fig.4 TRIGGERED LIGHTNING (From a Photograph)

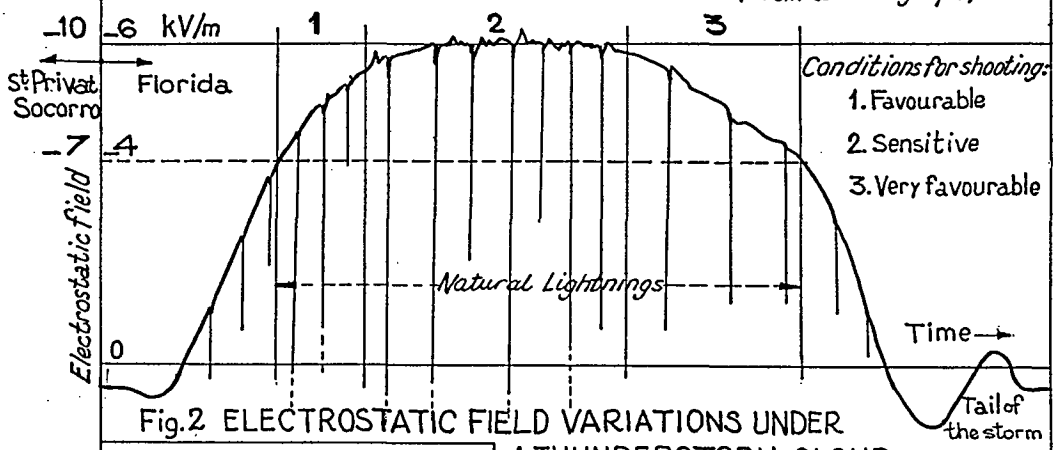

Fig.2 ELECTROSTATIC FIELD VARIATIONS UNDER A THUNDERSTORM CLOUD

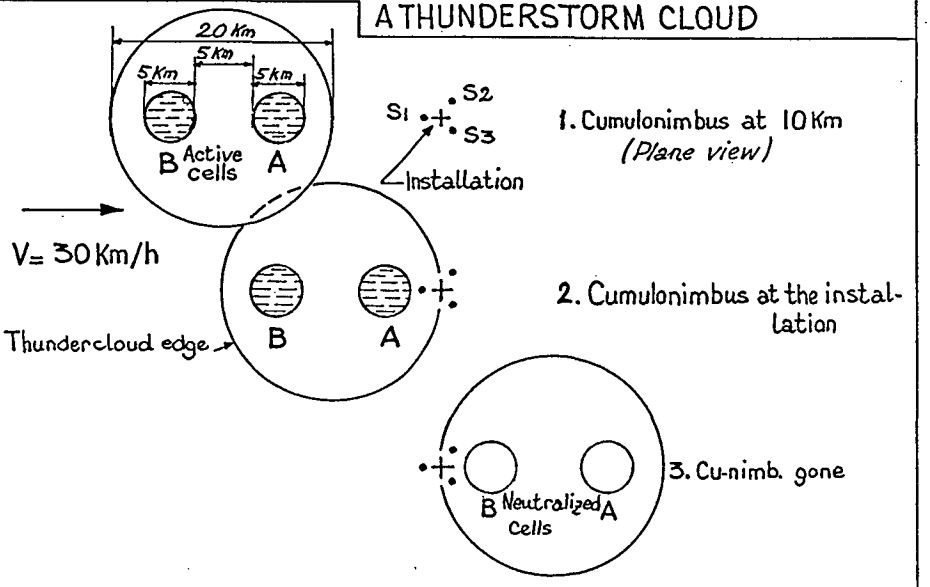

Fig. 3 ACTIVE PROTECTION OF A SITE BY LRS

3. ACTIVE PROTECTION OF AN INSTALLATION BY LRS

The aim is to neutralize the electric charge generated within the thundercloud by driving them to the ground by artificially triggered lightning. The total charge amounts 1000C in average. A lightning discharge affects the cloud within a radius of 2 km from the striking point although the time of recharging in the center of the storm is estimated at 1 minute.

3.1 Hypothesis

Let us consider a thundercloud of 20 Km diameter, moving at a speed of 30 Km/h in the direction of the installation to be protected. In the cloud two active cells are present. They are each 5 km diameter and located 5 km apart.

Around the installation three stations equipped with the LRS are in place at 1 km distance, each ready for operation. A field mill at each station records the electrostatic field. All information on the situation is gathered in a control-room with the help of a computer.

At 10 km distance, the thundercloud is detected and it will be above the installation within 20 minutes. The alarm is given when the first cell arrives. Firing the LRS starts as commanded by the control-room according to the strength of the electric field. A little later this rate is 2 or 3 per minute at maximum storm intensity and will decrease to zero when the cell is gone. The alarm ends as soon as the field has recovered its normal value. Total duration of the operation is 40 minutes. The number of 120 rockets seems to be a maximum requirement.

The hypothesis taken is an extreme case, because we considered that both active cells pass above the installation one after the other. In many cases a less favorable situation may be found (e.g. when cells are passing along the border or already in the process of discharging by natural lightning).

Another simpler procedure of lightning control may also be used. It consists of shooting a rocket at regular time intervals (say 4 to 5 per minute) without paying any attention to the field mill measurements. In this case, the necessary number of rockets is assumed to be higher.

In addition to the cost of rockets at about 1500 F ($20) each, other equipment is necessary. This includes launching devices, shelter for control-room, control desk, electrostatic field mills, TV camera, radio communication and computer as well as safety systems.

4. CONCLUSIONS

Thus, the active protection by the LRS, a direct application of the triggered lightning studies, seems to be a feasible operation. Obviously, because of its relatively high cost, this technique of lightning control is only applicable for important installations such as missile launch pads. In order to verify its real efficiency, experiments are recommended. The tests would determine the probability for natural random lightning to strike the protected area and reveal how many rockets are required.

Finally, when some doubts arise about the electrical stability of the atmosphere before launching a spacecraft, firing some of the LRS would clarify the situation. This may help avoid the accident which happened to Apollo 12 (14 November 1969, ref. 1) which was struck twice by lightning a short time after launch when the electrostatic field was less than critical strength. This particular phenomenon of electrical discharge was confirmed during the last Rocket Triggered Lightning Project (RTLP) at KSC when an application of the LRS at storm's end under a weak field (+ 2 kV) triggered a lightning discharge.

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