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Atmospheric Electricity Problems

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ATMOSPHERIC ELECTRICITY PROBLEMS AT KENNEDY SPACE CENTER

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ABSTRACT

The problems encountered when protecting rockets and launch operations from the dangers of lightning are discussed. This reveals the need for a mesoscale network for observing important parameters that indicate lightning danger, as well as the need to develop a set of rules for forecasting potential lightning danger. Before developing methods to inhibit the generation of electricity inside thunderclouds, it is imperative that the charge separation mechanism be thoroughly understood. The present state-of-the-art of lightning suppression uses either metallic chaff fibers to produce a continuous discharge current or rocket propelled projectiles to discharge the thundercloud with artificially triggered lightning.

PRESENTATION

Lightning, either by direct hits or by electric or magnetic induction, endangers launch vehicles as well as ground support operations. Nearby lightning strikes, through induced currents, can easily affect complex electronic equipment and cause time-consuming checking and repair procedures. Explosives can also be ignited by electrical sparks and strong currents. Last but not least, lightning endangers people.

There are three ways to cope with these dangers: protection, prediction, and modification. Protection against lightning is an engineering problem. Usually equipment as well as people are considered to be sufficiently protected against lightning currents as well as against electrical induction when they are inside a Faraday cage. Such shielding is usually insufficient protection against magnetic induction, unless special precautions are used. The problems of protection become particularly difficult if a direct hit by lightning must be anticipated. Electrical currents of lightning strokes are in the order of 10,000 to 100,000 A and last for about 100 microseconds. Even a small fraction of this current can burn out switches, cables, and connectors, not to speak of sensitive components of electronic circuitry, as semiconductors, capacitors, or induction coils. Although engineering techniques can cope with many of the protection problems, one must realize that there are limits in the procedures to protect against lightning.

For predicting lightning danger, one needs, as in weather forecasting, a network to survey a suitable set of parameters and, additionally, a set of rules based either on physical laws or on a history of observations. Then, when potential lightning danger is forecast, equipment and people can be moved to a safe place and the operation delayed until the danger is over. The effectiveness of this approach is limited, because delays are often intolerable or very costly, and equipment sometimes cannot be moved or only moved very slowly. Furthermore, forecasts of lightning danger are not very accurate with the present state-of-the-art, which leads to a high rate of false alarms as well as to insufficient warning of real danger.

The design of a prediction system for lightning danger is not a straightforward engineering task, because some of the instrumentation needed is not commercially available and needs to be designed; also the forecast rules still need to be developed either empirically from observational data or from the physical laws that govern the development of thunderstorms and lightning. In contrast to the prediction system for large scale weather phenomena, thunderstorms have lifetimes of only about 1 hour and extend over only about 5 miles. This makes it necessary to establish a mesoscale observational network with sensors spaced about 2 to 5 miles apart and to gather a set of data for each 10-minute period. This necessitates a rapid data processing and analysis system which has not been developed yet.

Once a good system for surveying and forecasting lightning danger exists, it is necessary to ask whether we must let nature take its course or whether we can purposefully modify and influence that what causes danger to life and equipment. Here we go to the root of the problem by treating the cause. This approach is relatively new, if we neglect all the attempts to modify lightning danger by praying or by wishful thinking. Unfortunately, the cause for lightning and high electric fields inside clouds is as yet unknown. Therefore, our efforts to eliminate or diminish occurrences of lightning should be directed strongly towards basic research on the fundamental processes of the generation of electricity inside clouds. Such an approach, however, is not likely to be favored by an organization like the Kennedy Space Center, in which launch operations, engineering, and technology are the major theme. Yet, without basic research, there can be no significant progress toward eliminating lightning danger to launch vehicles and launch support installations.

We should therefore attempt to explore the mechanism by which electrical charges are generated in clouds. This 200 year old problem has persistently resisted a solution despite the sincere efforts of many noted scientists. A strongly mission oriented research project is necessary; it must be founded on sound physical concepts and make use of modern philosophies and technologies. Such a research effort should be well directed by competent management and should involve the major U.S. centers of competence in atmospheric electricity. As is generally true in basic research, one cannot predict with certainty success as well as time and money expenditures. But I believe the time is right to solve the problem of charge generation and to find a means to eliminate charge accumulations.

At present, the approach to diminish lightning strikes at KSC is also a mission oriented one. Whenever hazardous conditions exist inside a cloud, e.g., electric fields of such a magnitude that they cause natural lightning or lightning that can be triggered by a rocket and thereby endangering the rocket, the cloud or some portion of it should be discharged artificially.

To discharge a cloud one can disperse small metallic fibers, which produce electrical corona currents in strong electric fields. Such corona currents will dissipate the cloud charges and will inhibit the buildup of dangerous conditions. Preliminary field tests by the Atmospheric Physics and Chemistry Laboratory of NOAA have shown the feasibility of suppressing lightning by this method (1). The disadvantage of this method is that such metallic fibers scatter certain electromagnetic waves, which can interfere with vital communications between a rocket and the ground. Using this method therefore requires good coordination between communication engineers and cloud physicists in the design of a workable lightning suppression system.

Other schemes that promise success include the use of projectiles to trigger lightning in a controlled manner, such that no natural or unintended lightning occurs. Feasibility studies were made using small rockets that were connected to the ground during flight by a wire which triggered lightning (2).

One project conducted by Atmospheric Physics and Chemistry Laboratory of NOAA, under NASA sponsorship, uses a small rocket, "Mighty Mouse," that triggers, at will, lightning inside clouds. Tests conducted in 1970 at Socorro, N. M., (3) showed very encouraging results not only to discharge some portion of the thundercloud but also to study, in general, the mechanism by which rockets trigger lightning. Such studies are necessary to assess the danger of large rockets, like the Saturn V, unintentionally triggering lightning. The Apollo 12 lightning incident showed the necessity to understand fully the physcal conditions that lead to lightning.

It is certain that in the future more concepts will be proposed and tested to harmlessly dissipate electricity that is produced and stored in a thunderstorm. It is also certain to me that the atmospheric electric problems at KSC will be solved sufficiently only when the physics of the charge separation process inside clouds is well understood, and a means to control this process is found.

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