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NASA TECH BRIEF

Lewis Research Center

A Test and Measurement Technique for Determining Possible Lightning-Induced Voltages in Aircraft Electrical Circuits

The Problem:

When lightning stroke currents flow through an aircraft, rapidly changing magnetic fields and structural voltage drops are created which cause transient voltages to arise in internal electrical wiring. Even if the aircraft is metallic, its non-cylindrical geometry and finite structural resistivity result in hazardous voltages being induced into aircraft electrical systems. As a result, interference or damage has occurred to electrical and avionics components in aircraft struck by lightning. Transient voltage protection devices are available which can prevent such effects but, before they can be applied, it it usually necessary to determine the level of induced voltage possible in particular circuits. However, existing laboratory facilities are not capable of passing full scale simulated lightning currents through an airframe at the required waveshapes; and such tests, if even possible, might damage on-board equipment.

The Solution:

Conducted laboratory tests on a major airframe component (wing) to confirm that induced voltages are directly proportional to simulated lightning current amplitude. Once the basic linearity of the lightning-induced voltage relationship was confirmed, a low energy lightning current generator, called a Transient Analyzer, was designed and proof tested.

How It's Done:

The transient analyzer consists of four 0.5 μf capacitors chargeable by a self-contained solid state 50 kV dc power supply operating from standard 110 Vac line voltage. Also included are control and waveshaping circuitry, and push-button or remote triggering capability. The transient analyzer is housed in a steel cabinet with safety-interlocked doors. The unit can circulate unidirectional current impulses of up to 500 amperes through an aircraft at waveshapes similar to those of natural lightning strokes. Variations in test current amplitude or waveshape are easily made with simple changes in impedance or control settings.

Output and return connections to the transient analyzer are intentionally isolated from ground so that the aircraft itself may be grounded during tests without permitting test current to flow off the aircraft via the ground connection. This enhances safety and greatly reduces measurement system interference. Connections to the aircraft are made at logical lightning attach points by alligator clips or other convenient means. Since lightning strikes occur randomly at different entry and exit points, the test current is applied between several representative pairs of attachment points (i.e., nose-to-tail, wing tip-to-wing tip, etc.). The basic test arrangement is shown in Figure 1.

Oscilloscopes, in a nearby shielded enclosure, displayed the applied test current and the resulting induced voltages. A twin-axial shielded cable brings the induced voltages, appearing at points of interest in the aircraft, to the oscilloscopes. The basic measurement system is shown in Figure 2.

In most cases, the induced voltages resulting from the scaled-down test currents may be extrapolated linearly to correspond with full scale lightning current amplitudes.

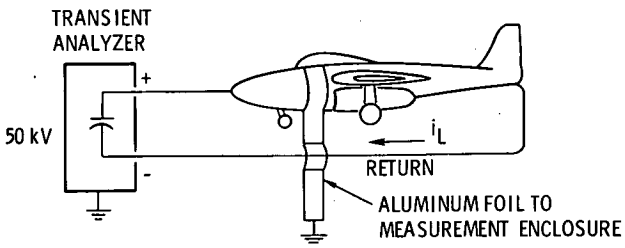

Fig. 1. Basic Test Circuit.

(continued overleaf)

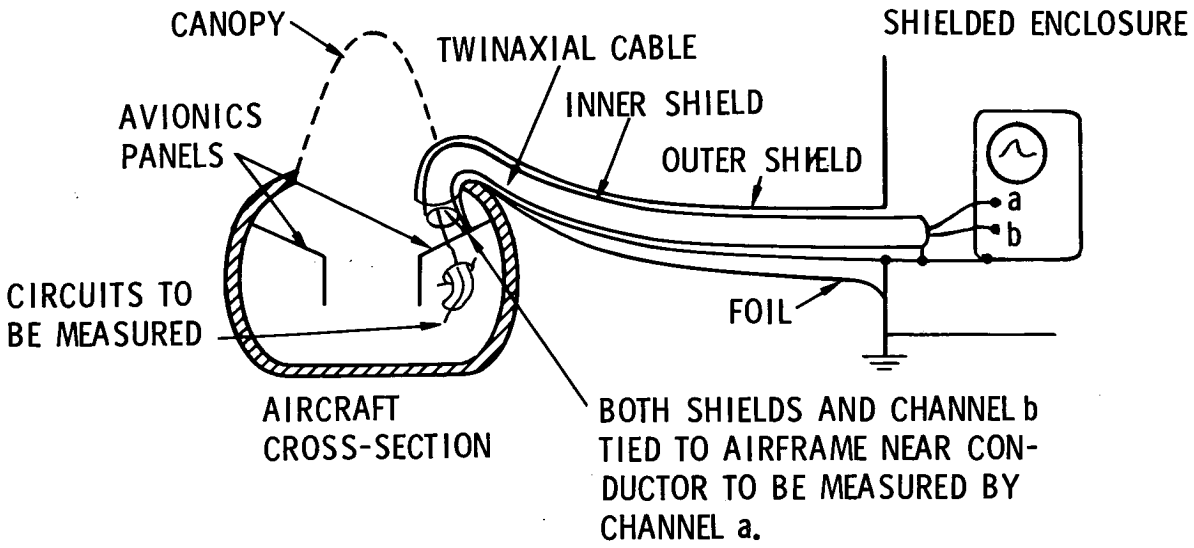

Fig. 2. Attachment of Instrument Cable to Aircraft.

Notes:

1. This test and measurement technique has the following advantages:
   a. Test currents with fast rates of change, representative of natural lightning, can readily be generated at scaled-down amplitudes.
   b. Voltages induced by these scaled-down currents typically range between several millivolts and several volts, so they are not likely to upset or damage connected avionics.
   c. The aircraft is grounded at all times while being tested. Personnel may be in or on the aircraft while tests are conducted and aircraft systems may be operated if desired.
   d. The measurement system is free from the troublesome interference commonly associated with full-scale lightning test facilities.
   e. The equipment is easily transportable to the aircraft, and may be set up quickly.
2. Application of this method of extrapolating induced voltages from test currents to anticipated currents from lightning strikes on ground structures, electrical equipment, etc., will require specific experiments to adapt the equipment.
3. Further information is available in the following report:
   NASA CR-2348 (N74-16716), A Test Technique for Measuring Lightning-Induced Voltages on Aircraft Electrical Circuits

   Copies may be obtained at cost from:
   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B75-10068
4. Specific technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
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Patent Status:

NASA has decided not to apply for a patent.

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