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FIELD ENHANCEMENT OF UHF-VHF AIRCRAFT ANTENNAS

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Final Report

AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base, NM 87117-6008

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This final report was prepared by the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico under Job Order 12091501. Mr Raymond W. Nethers (NTAO) was the Laboratory Project Officer-in-Charge.

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This technical report has been reviewed and is approved for publication.

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Results of high voltage electrical discharge tests of various electrode enhancement geometries are reported along with test conduct. Four antennas (collins, unknown 2- and 3-ft rods) were tested with both positive and negative voltages. It was found that on the negative electrode in large gaps, a large enhancement is needed to degrade the gap holdoff.

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INTRODUCTION

The purpose of these tests was to determine how much electric field enhancement is produced by blade type UHF-VHF* aircraft antenna mounted on the underside of an aircraft fuselage or wing when the aircraft has a high voltage charge with respect to ground.

*Ultrahigh frequency - very high frequency

BACKGROUND

The proposed trailing wire antenna (TWA) electromagnetic pulse (EMP) tests would require a negative voltage of up to 4 mV with a rise time of 1.6 μs and a decay time of 50 μs to be applied to an aircraft that is insulated from the ground without arcing between the aircraft and ground. The UHF-VHF blade antennas mounted on the bottom of the aircraft may enhance the electric field in the vicinity and may arc to ground.

TEST CONDUCT

The Ferranti Impulse Generator (FIG) which is located on the TRESTLE EMP test site was configured to produce the TWA waveshape. The Mobile Upper Electrode (MUE), which is designed to produce a uniform electric field between it and the ground plane (GP), was used for these tests. The donut-shaped MUE is about 26 ft in diameter and is covered with 1-in wire mesh. The MUE was spaced 8 ft 4 in above the GP. This spacing was chosen because it is the same spacing used in the previous "charred beam" test.

A Collins-type 37R-2V aircraft antenna was mounted on the center of the MUE. Another aircraft antenna of unknown type was also tested. These antennas were mounted on the GP also to test the positive polarity breakdown effects.

After the antenna tests were performed, it was found that the antennas did not affect the negative charge breakdown voltage. To further investigate this effect, a 1/2-in square rod was projected from the center of the MUE at distances of 2 and 3 ft. This was tested and the breakdown voltage recorded. The MUE (sans rod) was lowered to these two spacings and the breakdown voltage recorded.

The FIG output voltage was then changed to positive. The MUE-GP spacing was set at 8 ft 4 in and the flashover voltage measured. The Collins antenna was mounted on the GP and the flashover voltage measured. The antenna was then mounted on the MUE and the flashover voltage measured. This test was made to determine if the effect of the antenna was due to voltage polarity effects or the field distortion caused by the MUE.

The "up-down" method was not used to determine the breakdown voltages as the breakdown voltages observed were repeatable within a few percent.

CONCLUSIONS

Equipotential plots were computed for the MUE being 8 ft 4 in from the GP with (1) no projections, (2) a 1-ft projection, and (3) a 3-ft projection (Figs. 1, 2, and 3). These plots show the projections should have a considerable effect on the breakdown voltage. These plots are the same for either polarity.

The actual breakdown data (Table 1) shows the 1-ft antenna and the 2-ft rod did not affect the breakdown voltage for the negative polarity. The 3-ft rod greatly affected the breakdown which went from 1.31 MV to 0.8 MV. This would imply that the equipotential line spacing near the center of the MUE is not linear or that higher fields near the negative electrode do not promote breakdown.

The antennas mounted on the GP (positive charge) do effect the breakdown voltage (1.31 MV without the antenna to 1.06 MV with).

A positive FIG output test was performed to see if the enhancement results observed with the negative FIG output tests were due to enhancement by the antenna or were due to the distortion of the electric field by the MUE. This test shows a 10 percent enhancement of an antenna on the positive and no enhancement by the antenna on the negative electrode. This supports the results found from the negative FIG output tests, so the effect is not due to MUE field distortion.

If the effect observed in these tests is correct, then a fairly flat aircraft surface such as the bottom of the wing or fuselage could have projections of up to perhaps 2 ft without degrading the breakdown voltage if the aircraft is supported at least 8 ft above a flat ground plane (negative voltage on aircraft).

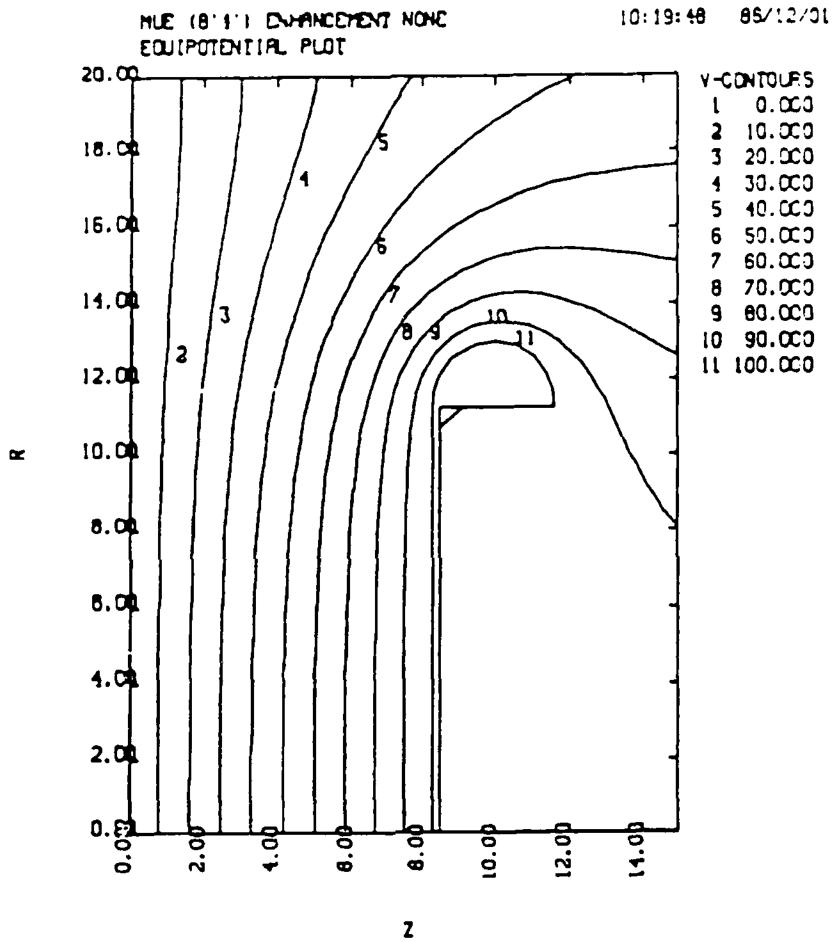

Figure 1. Equipotential plot MUE with no enhancement.

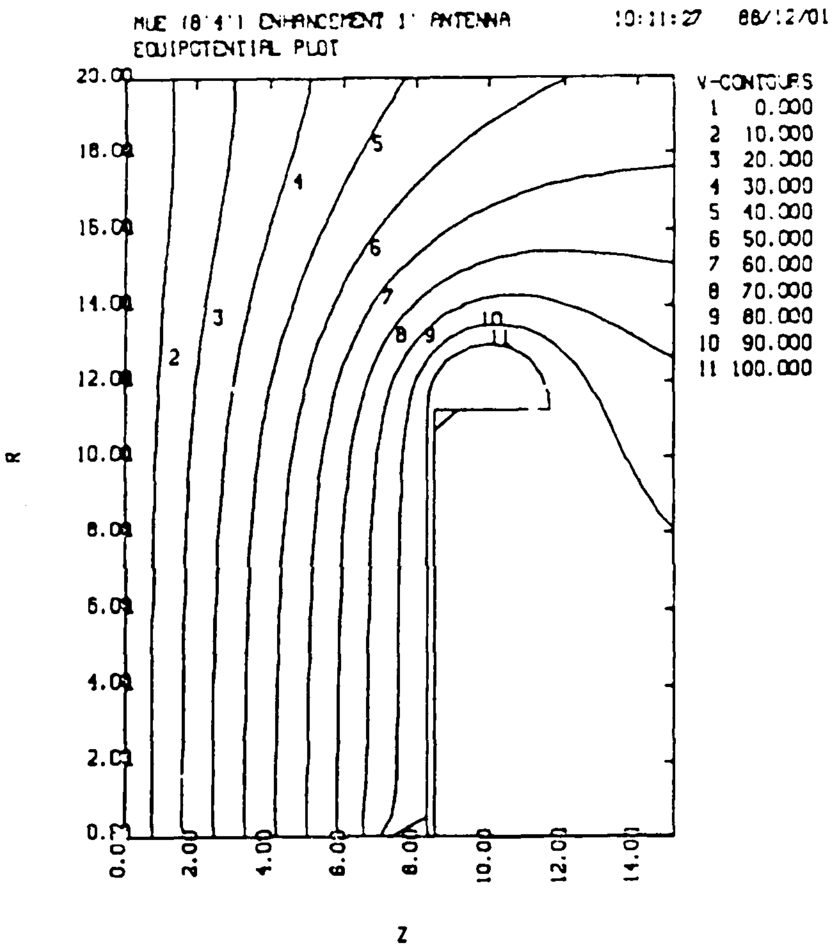

Figure 2. Equipotential plot MUE with 1-ft enhancement.

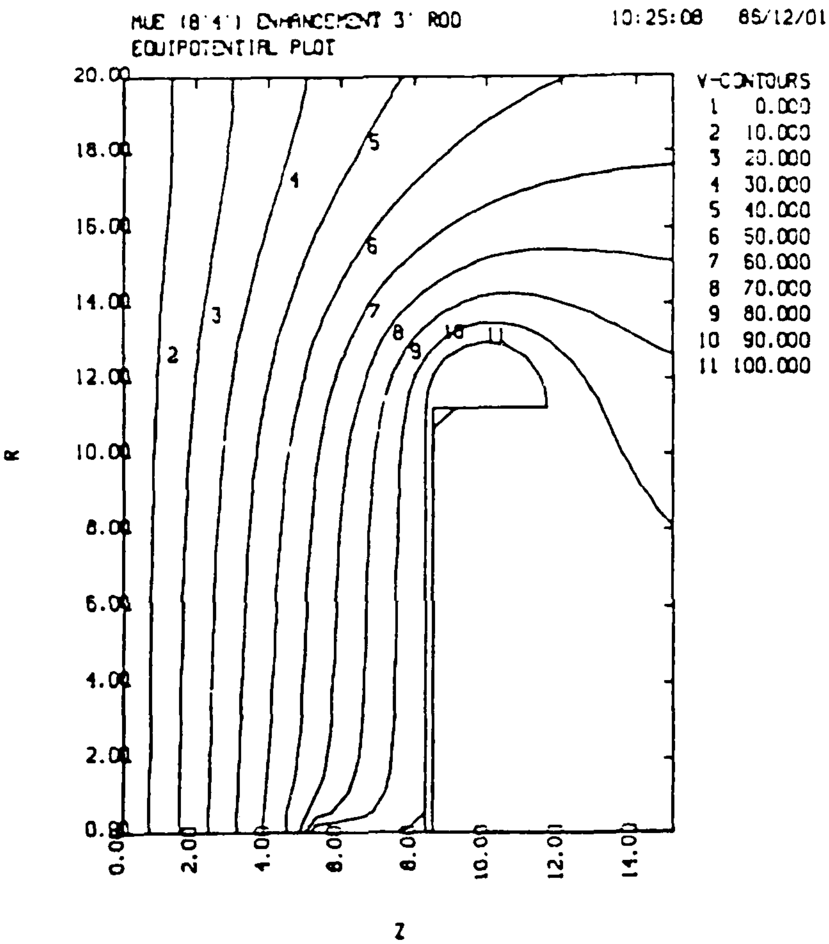

Figure 3. Equipotential plot MUE with 3-ft enhancement.

TABLE 1. Breakdown data of VHF-UHF antennas.

MUE height	Enhancement	Breakdown Voltage (MV)
Negative FIG output Enhancements on negative electrode (MUE)		
8 ft 4 in	Collins (1 ft)	1.31
8 ft 4 in	Unk. (1 ft)	1.38
8 ft 4 in	1/2-in sq rod (2 ft)	1.36
8 ft 4 in	1/2 in sq rod (3 ft)	0.80
Enhancements on positive electrode (GP)		
8 ft 4 in	Collins (1 ft)	1.06
8 ft 4 in	Unk (1 ft)	1.06
No enhancements		
8 ft 4 in	-	1.33
6 ft 4 in	-	1.06
5 ft 4 in	-	0.90
Positive FIG Output		
8 ft 4 in	No enhancements	1.17
8 ft 4 in	Collins (1 ft) on GP	1.15
8 ft 4 in	Collins (1 ft) on MUE	0.96