ESL-TR-81-45

(4)

AD A114558

TESTING OF TRITIUM-POWERED RUNWAY DISTANCE AND TAXIWAY MARKERS

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AUGUST 1981

FINAL REPORT
OCT 1980 - MAY 1981

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ESL-TR-81-45	2. GOVT ACCESSION NO.: AD-A114 558
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Testing of Tritium-Powered Runway Distance and Taxiway Markers	5. TYPE OF REPORT & PERIOD COVERED: Final Report: Oct 1980 - May 1981
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): K. W. Haff, F. N. Case, J. A. Tompkins, F. J. Schultz	8. CONTRACT OR GRANT NUMBER(s): Interagency Agreement N-80-50
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Operations Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Program Element: 72894, JON: IECSDF02
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Engineering and Services Center, Tyndall Air Force Base, Florida 32403	12. REPORT DATE: August 1981
	13. NUMBER OF PAGES: 24
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution unlimited approved for public release.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Availability of this report is specified on verso of front cover

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Tritium-Powered Runway Distance Markers
Tritium-Powered Taxiway Markers

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Isotope Technology Group of the Oak Ridge National Laboratory's Radioisotopes Department was asked by the U.S. Air Force to test tritium-powered runway distance and taxiway marker signs. The tests were selected by mutual agreement of the U.S. Air Force and Oak Ridge National Laboratory and were designed to test the serviceability of these signs under adverse weather and handling conditions, determine their limiting factors, and determine their service life. The testing program results indicate that the signs will exceed strength and durability requirements for their intended purpose. This report

is a discussion of the testing program and the results of those tests.

PREFACE

The work described in this report was performed by the Radioisotope Technology Group, Oak Ridge National Laboratory, Post Office Box X, Oak Ridge, Tennessee 37830 under Interagency Agreement N-80-50. The work was initiated at the request of the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida 32403 and was performed over the period October 1980 to May 1981. The US Air Force Project Officer for this program was Mr. Walter C. Buchholtz.

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INTRODUCTION

The currently used runway and taxiway markers used on U.S. Air Force bases use incandescent bulbs for lighting. These bulbs require frequent maintenance and replacement in addition to electric power costs. The runway distance marker signs have four 45-watt bulbs per sign and the taxiway marker signs have one 45-watt bulb per letter or number. These incandescent bulbs have a life span of approximately three months and cost $18.00, plus labor (FY 1980 dollars), per bulb to replace.[1] A suggestion was submitted by the 76th Civil Engineering Squadron at Andrews Air Force Base, Maryland, to construct runway distance and taxiway marker signs using tritium-filled phosphor coated pyrex glass tubes (similar to those used in commercial emergency exit signs) as a light source instead of incandescent bulbs and electric power. The potential savings in maintenance and operational costs would be significant.[2] Energy savings were another consideration in the decision to test the tritium signs.

In August 1980, the U.S. Air Force Engineering&Services Center (USAFESC) at Tyndall Air Force Base, Florida, requested the Isotope Technology Group of the Oak Ridge National Laboratory (ORNL), Radioisotope Department to test tritium-powered runway distance and taxiway marker signs. The tests were selected by mutual agreement of the AFESC and ORNL and were designed to test the serviceability of these signs under adverse weather and handling conditions, determine their limiting factors, and determine their service life.

Four runway distance markers (FIGURE 1) were furnished by AFESC. Oak Ridge National Laboratory installed tritium-filled tubes (FIGURE 2) in three of the signs and installed empty tubes in the other sign. FIGURE 3 is a drawing of source mounting of signs. FIGURE 4 shows the front face of the complete sign. Oak Ridge National Laboratory then tested the four signs in accordance with the prescribed test sequence and procedures.

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[1]W. C. Buchholtz, U.S. Air Force Military Interdepartmental Purchase Request N-80-50, Statement of Work, August 14, 1980.

[2]R. E. Nelson, U.S. Air Force, 76th CES, Andrews Air Force Base, Maryland, private communication.

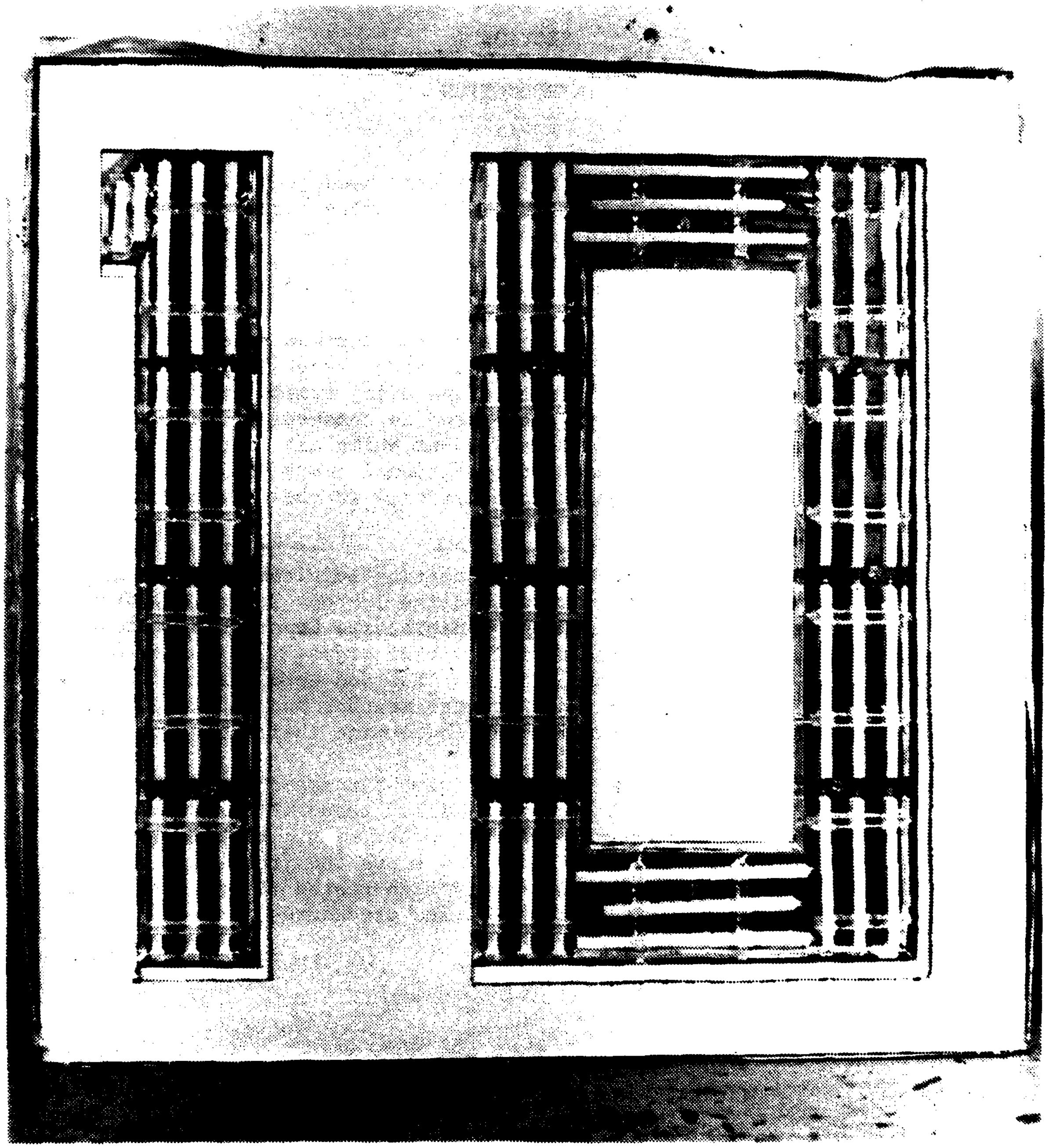

FIGURE 1. Runway Distance Marker With Front Face Removed to Show Tritium-Filled Phosphor Coated Tubes

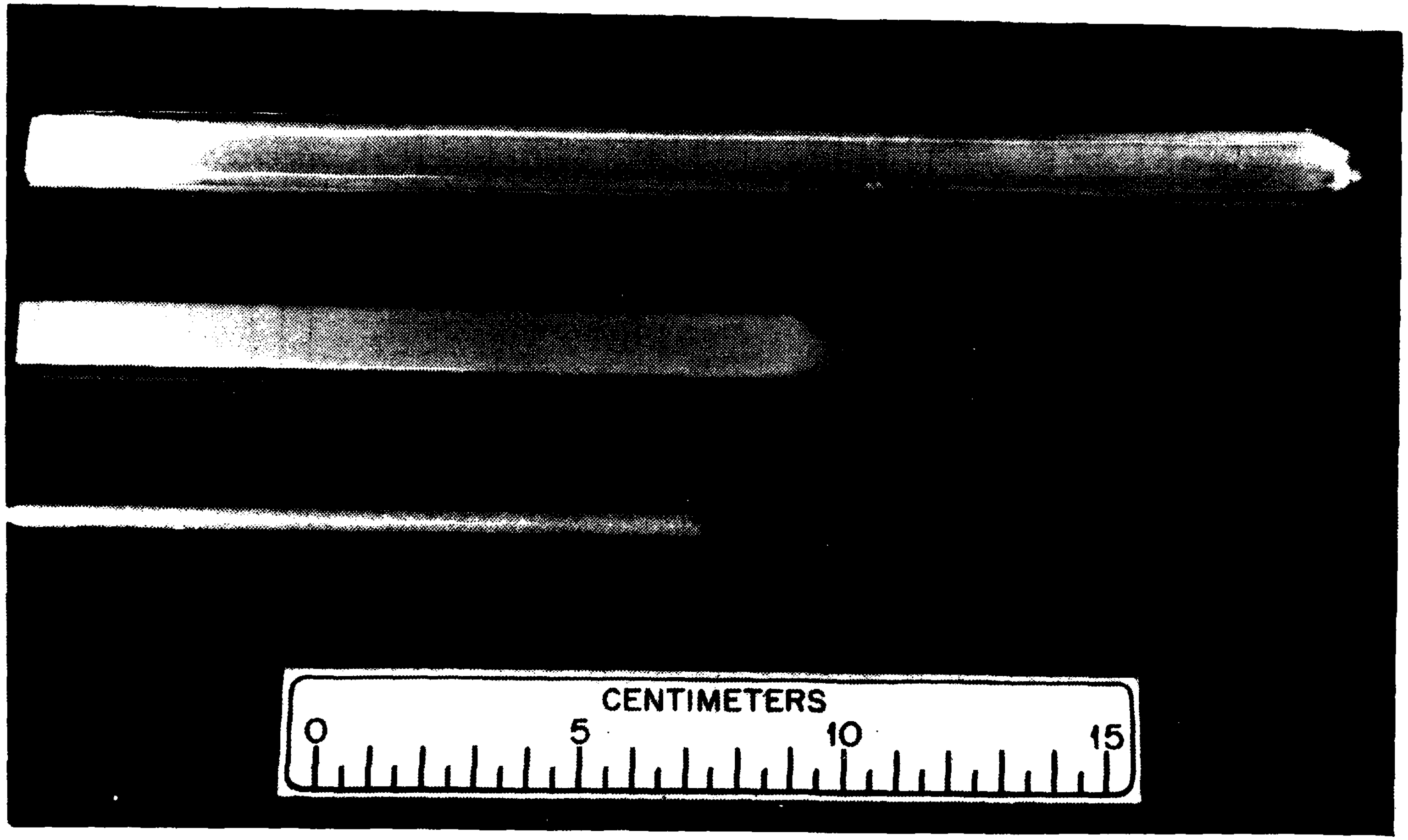

FIGURE 2. Phosphor Coated Tritium-Filled Pyrex Glass Tubes. (Top two are tubes typical of those used in Air Force Runway Distance Marker signs.)

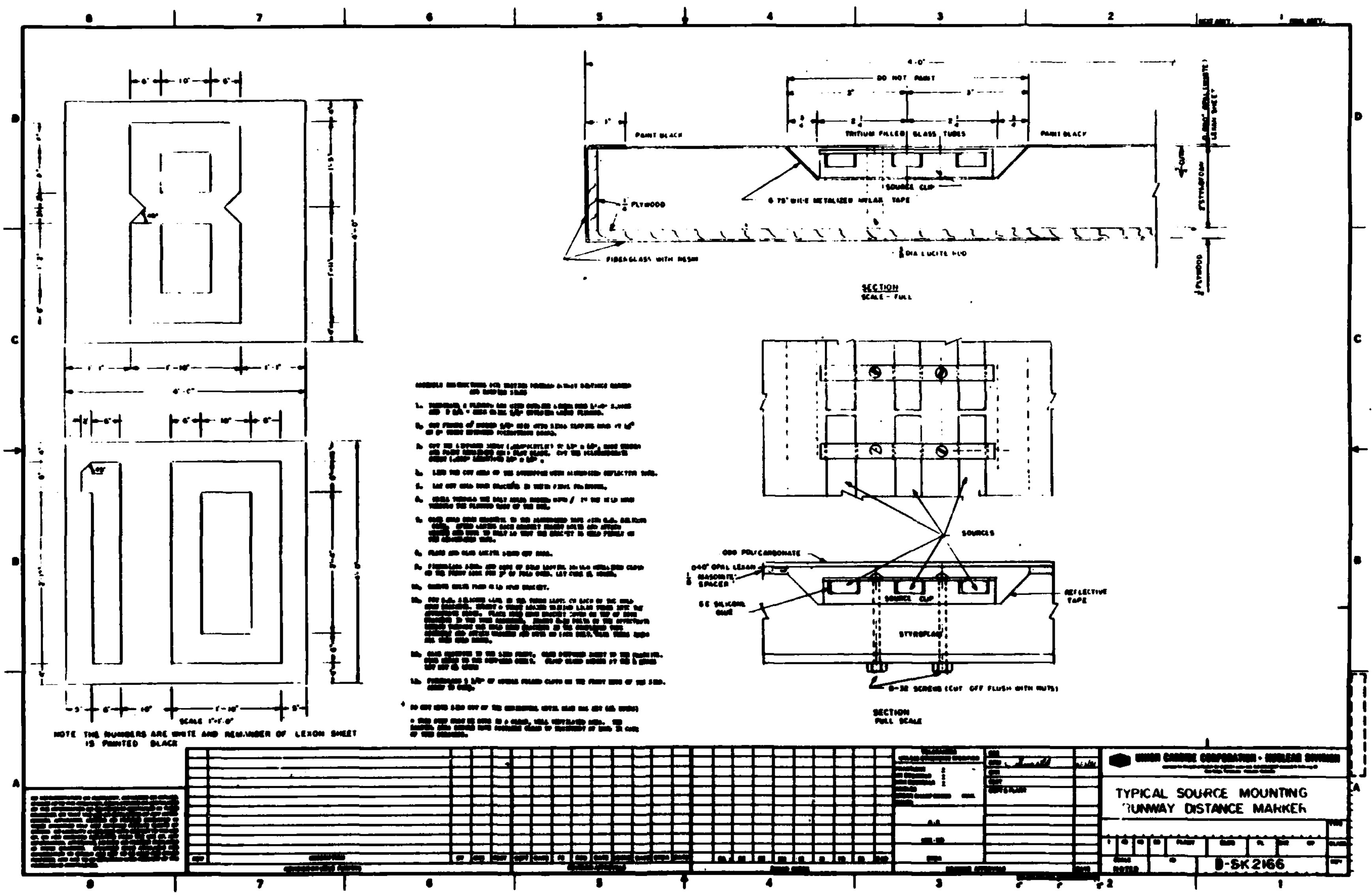

FIGURE 3. Source Mounting Detail of Runway Distance Marker

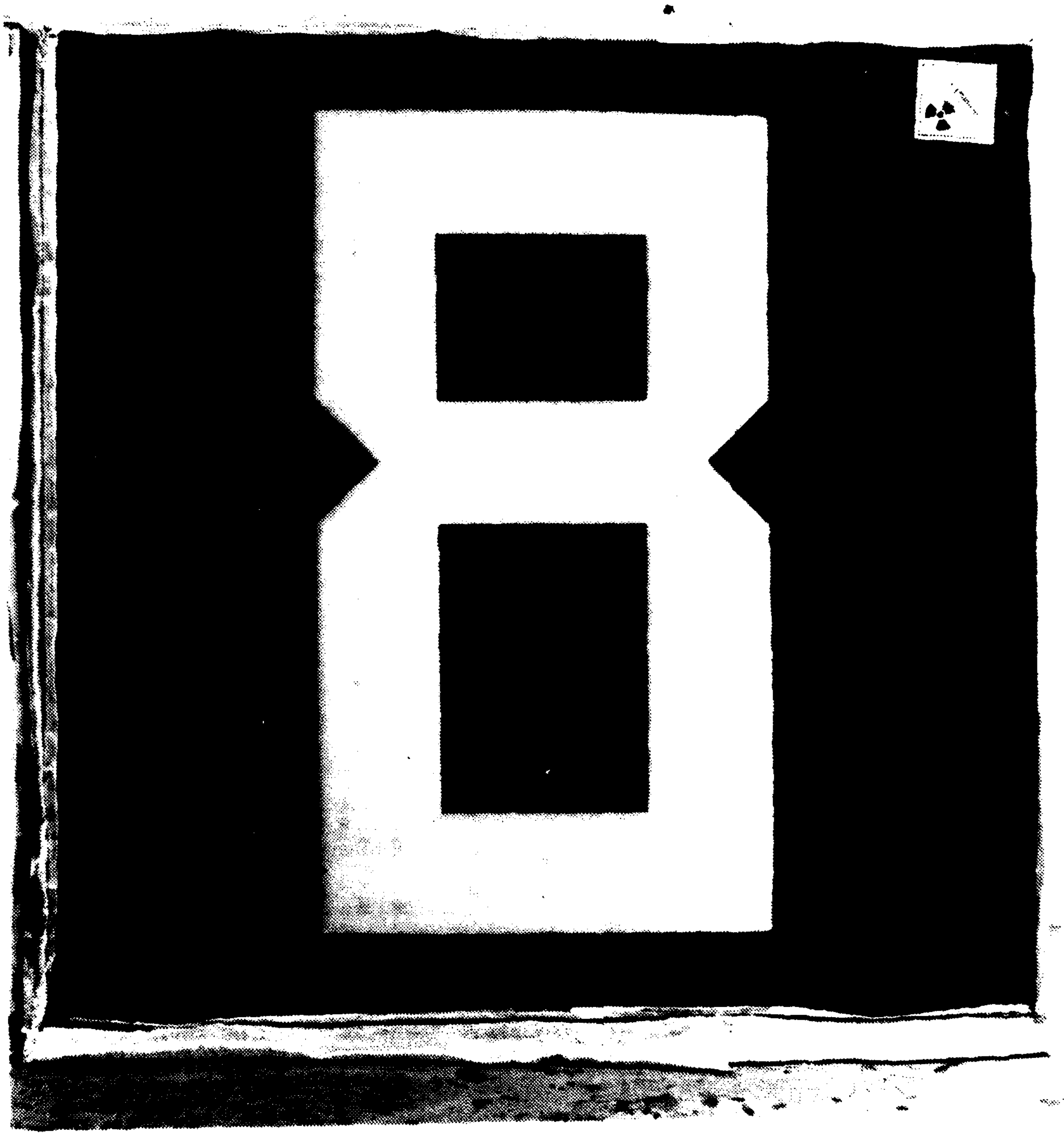

FIGURE 4. Front Face of Assembled Runway Distance Marker

SECTION II

DESCRIPTION OF TESTING PROGRAM

The Statement of Work[1] provided by the U.S. Air Force Engineering Service Center (AFESC) requested the Department of Energy (DOE), Oak Ridge National Laboratory (ORNL) at Oak Ridge, Tennessee, to perform work as follows: install empty pyrex glass tubes in one of the signs (FIGURE 5) and tritium-filled pyrex glass tubes coated on the inside with phosphor in three of the signs, test the signs and tubes per the previously agreed-upon test sequence, and evaluate the tubes, signs, and materials used in the runway distance marker signs. The AFESC constructed and provided to ORNL four runway distance marker signs, two with the number eight (8) and two with the number ten (10). Oak Ridge National Laboratory installed the tubes in the signs and completed the assembly.

The following testing program was required of the full signs and tubes to determine the capability of the signs to protect the tritium-filled glass tubes in the signs and the service life of the tubes.

1. Illumination Intensity. The intensity of light emitting from the runway marker signs should be such that readability is ensured from a minimum distance of 500 feet (150 meters) in a meteorological visibility of 3,000 feet (900 meters). The sign shall be illuminated to ensure readability at night and in adverse weather conditions.

2. Discoloration Test. Oak Ridge National Laboratory shall perform the discoloration test in accordance with NBS Handbook 116, "Classification of Radioactive Self-Luminous Light Sources."[3] The test will note the visibility, discoloration, and other effects to the sign during the test.

3. Temperature, Thermal Shock, Pressure, Impact, Vibration, and Immersion Tests. Oak Ridge National Laboratory shall perform these six tests on the assembled signs and tubes in accordance with NBS Handbook 116.[3] The temperature test, shock test, and reduced pressure test shall be conducted on the tritium-filled glass tubes. Impact, vibration, and immersion tests shall be carried out on the complete sign assembly. The evaluation of these tests is to determine the potential loss of radioactivity during or after the tests due to a failure of the glass tubes.

4. Service Life. Oak Ridge National Laboratory shall determine the service life of the signs based on the readability of the signs at the half-life of the tritium in the signs. Oak Ridge National Laboratory can calculate the amount of tritium required in a tube to determine that which will

[3]National Bureau of Standards, Handbook 116, American National Standard N540; Classification of Radioactive Self-Luminous Light Sources, 1975.

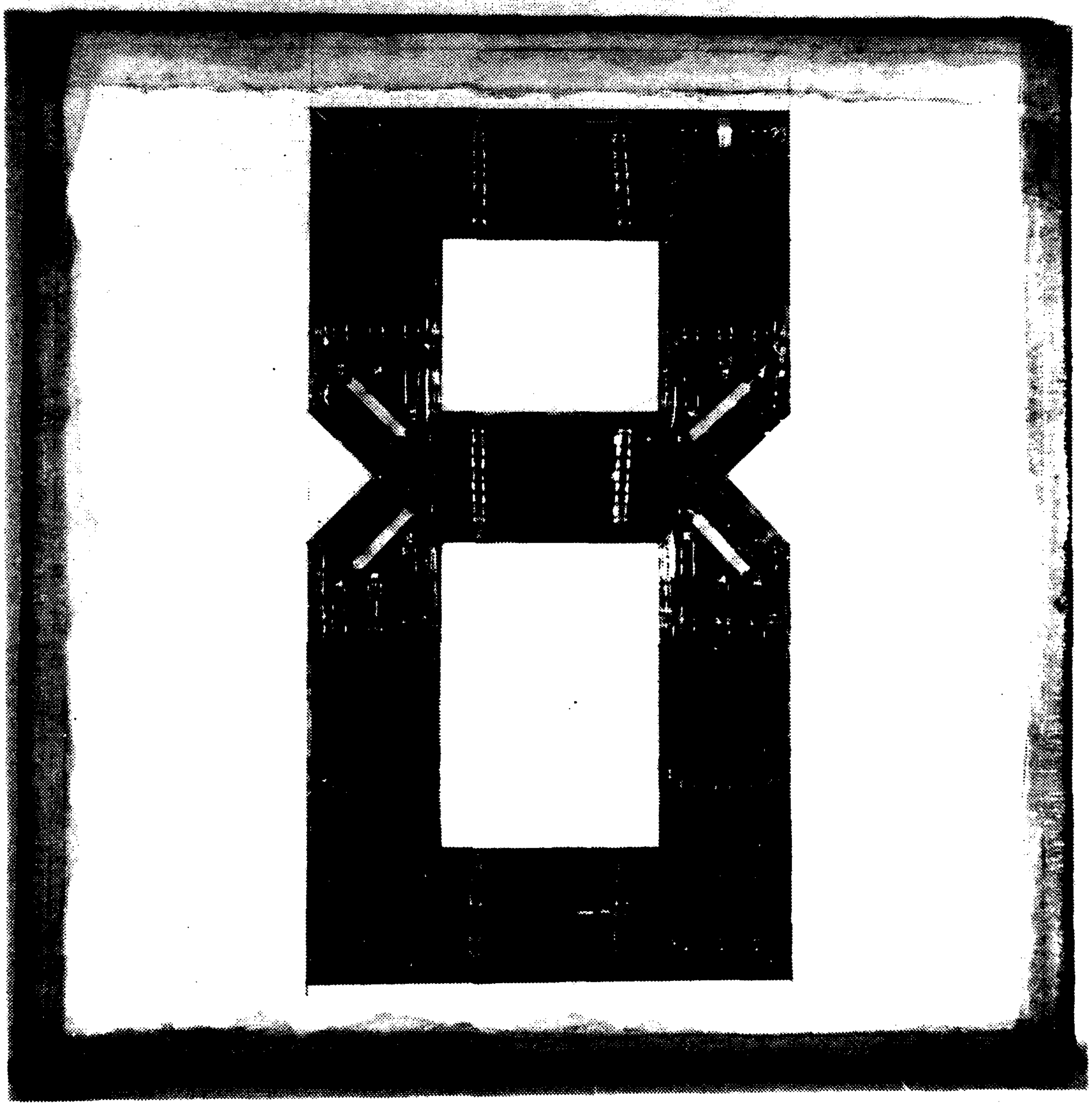

FIGURE 5. Runway Distance Marker With Empty Pyrex Glass Tubes With Front Face Removed

be present at the end of the expected life of the tritium-filled glass tubes which is 12.3 years.

5. Temperature and Humidity Cycle Test. Oak Ridge National Laboratory shall conduct this test in accordance with Military Standard 810C, "Environmental Test Methods."[4] Method 518.1, "Temperature-Humidity-Altitude." The altitude portion of the test will not be conducted as the signs will be at ground level. The signs shall be subjected to cycle of tests at 160 degrees Fahrenheit at 69-percent humidity to minus 65 degrees Fahrenheit at zero percent humidity.

6. Blowing Sand Test. Oak Ridge National Laboratory shall conduct this test in accordance with ASTM-D658, "Test for Abrasion Resistance of Coatings of Paint, Varnish, Lacquer, and Related Products with the Abrasion Tester."[5] The polycarbonate sheet should be capable of protecting the sign against adverse effects on its surface.

7. Rough Handling Test. Oak Ridge National Laboratory shall conduct this test in accordance with ASTM-D775, "Droptest for shipping Containers."[6] The purpose of this test is to determine the sign's capability to withstand rough handling and the ability of the sign as a container to protect the tritium-filled glass tubes.

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[4]MIL-STD-810C, Environmental Test Methods, U.S. Department of Defense, March 10, 1975.

[5]American Society for Testing Materials, ASTM-D658, Standard Test Method for Abrasion Resistance of Coatings of Paint, Varnish, Lacquer, and Related Products with the Air Blast Abrasion Tester, 1970.

[6]American Society for Testing Materials, ASTM-D775, Standard Method of Drop Test for Shipping Containers, 1973.

SECTION III

TEST RESULTS

1. Illumination Intensity. Several tests were conducted to verify the illumination intensity of the taxiway marker signs. In one test a barrier sign fabricated in a 3 foot diameter circle was taken to McGee Tyson Air Force Base (Air National Guard) for an illumination intensity test. The sign was loaded with tritium-filled tubes containing 1 curie/linear-inch of length. The sign was clearly visible at 1,000 feet in a meteorological visibility condition (as determined by the FAA tower at Knoxville, Tennessee Municipal Airport) of 1/4 mile (1,320 feet - 402 meters). Weather conditions which were rainy and severely overcast at the start of the observation tests, lifted to 1/2 mile (2,640 feet - 804 meters) at the conclusion of the test (approximately 2 hours elapsed time). The sign was clearly visible at 1,000 feet distance under these adverse weather conditions.

In a second test two signs were observed at ORNL. These signs were both numeral "10" and one sign was loaded with 1 curie/linear-inch of tube length and the other loaded with 2 curie/linear-inch of tube length. The 1 curie/linear-inch represents the loading at one half-life of the tritium material which is the expected service life of the signs (∿12 years). Both signs were clearly visible and readable at up to 2,000 feet. Meteorological visibility conditions were 1/2 mile during this test.

In a third test three of the signs (two numeral 10 and one numeral 8) were taken to McGee Tyson Air Force Base. One 8 and one 10 contained a tritium loading of 1 curie/linear-inch of tube. The other 10 contained a tritium loading of 2 curie/linear-inch of tube. The meteorological visibility was estimated at 50 miles by the FAA tower at the Knoxville Municipal Airport. All three of the signs were clearly visible and readable at 1,000 feet. This test further verified that the 2 curie/linear-inch initial loading is adequate for an approximate 12-year life of the signs.

2. Discoloration Test. The discoloration test requires exposure of the sign with tritium-filled tubes for 12 hours to the light of a S-4 lamp, filtered by a Corex D filter, at a distance of 20 centimeters from the lamp. Tests were performed in air at 75°F and a relative humidity of 95 percent. The sign was visually examined before and after the test. No evidence of discoloration or deterioration was observed. The light output of the sign was measured (in the area of the test) before and after the test also, and no deterioration or reduction of light output was measured. The identical test was also performed on an individual tube without a Lexan cover with the same results as observed with the assembled sign; i.e., no deterioration, discoloration, or measurable reduction of light output.

3. Temperature, Thermal Shock, Pressure, Impact, Vibration, and Immersion Tests. The temperature, thermal shock, and reduced pressure tests were conducted on single glass tubes that were not mounted in the sign. Maximum test impact was achieved by this method.

a. Temperature Test. The sources were subjected to temperatures of -30°C and 65°C for one hour at each temperature. No leakage of radioactive tritium gas occurred as a result of these tests.

b. Thermal Shock. The sources were heated to 65°C in water held at temperature for 15 minutes, transferred to a bath of trichloroethylene and dry ice at -30°C, held at that temperature for 15 minutes, transferred back to the hot (65°C) water, and held for 15 minutes. This cycle was repeated 10 times. No leakage of radioactive tritium gas occurred as a result of these tests.

c. Pressure (Reduced) Test. The sources were placed in a chamber and the pressure reduced to 175 mm Hg absolute and held at this pressure for 15 minutes. The test was repeated four times. No evidence of leakage of tritium gas could be determined as a result of these tests.

The impact, vibration, and immersion tests were conducted on the completed signs.

d. Impact Test. The completed signs were allowed to fall onto a 1/4-inch-thick steel plate supported by an 8-inch-thick reinforced concrete pad 20 times from a height of 1 meter and 2 times from a height of 2 meters.

The sign, as originally constructed, failed this test because the front face flexed and broke a tube (the tubes had been elevated higher than called for in the original design to increase reflected light output of the sign). The sign was redesigned and modified to raise the front face an additional 1/8 inch above the tubes and to place some support posts between the plastic cover and the back of the sign to prevent the front cover from flexing into the tubes and breaking them (FIGURE 3). The modified sign easily passed the impact of dropping 20 times from a height of 1 meter and two times from a height of 2 meters with no damage to the glass tubes. The signs were randomly dropped on corners, edges, and front and back faces. The only damage to the signs was some cracking of the fiberglas cloth binding the front face to the body. No damage was observed to the tubes which contain the radioactive material.

e. Vibration Test. This test consisted of subjecting the assembled sign to simple harmonic motion having an amplitude of 0.075 centimeter (0.03 inch) and a maximum total excursion of 0.15 centimeter (0.06 inch), the frequency being varied uniformly between the approximate limits of 10 and 55 Hertz (Hz). The entire frequency range, between 10 and 55 Hz and return to 10 Hz, was traversed in 1 minute. The total time of the test was 60 minutes. No damage resulted to the sign or to any individual tubes as a result of this test.

f. Immersion Test. In this test the sign was immersed in a cold water bath at 0°C for 15 minutes, immediately (<1 minute maximum) transferred to a hot water bath at 80°C and held for 15 minutes, and immediately (<1 minute maximum) transferred back to the cold bath. This cycle was repeated 5 times. The sign was inspected for damage to the tubes. No damage to the tubes was observed, nor were any leaking tubes found.

4. Service Life Test. This test was conducted by loading one sign with one-half the normal tritium loading, which represents the tritium remaining after one half-life. The observation of the signs is discussed under the Illumination Intensity Test. We conclude that the 2 curie/linear-inch tritium loading is more than adequate for a 12-year design life of the signs.

5. Temperature and Humidity Cycle Test. The sign was subjected to four cycles of tests at 70°C (160°F) at approximately 69 percent humidity for 2 1/2 hours to -54°C (-65°F) at approximately 0 percent humidity for 2 1/2 hours. No adverse effects to the sign were noted. No leaks were detected in any of the tubes.

6. Blowing Sand Test. The blowing sand test prescribed for these signs is actually a test for paints and varnish coatings for metals. In the procedure[5] the equipment is loaded with a prescribed loading of the abrasive material and is blown onto the surface to be tested. The results of the test are evaluated by the number of seconds required to abrade through the coating. The situation in this case was somewhat different. Our objective was to determine if blowing sand would cause a sufficient abrasion to the front surface of the sign to cause loss of light transmittance through the front face. We, therefore, loaded the abrasion test apparatus with its full load of abrasive material and allowed it to run until the full load was expended. This was repeated 10 times, and light transmittance measurements made through the Lexan cover were compared to those made before the test. No loss of light transmittance was observed as a result of these tests.

7. Rough Handling Test. It was concluded that the signs would never be subject to a drop in excess of 3 meters in routine handling situations. Therefore, the tests were conducted at this height. Six drops were made, one onto each corner and one each onto the back and front faces of the signs. The only damage to the signs was some abrasion and breakage of the fiberglas edges of the sign. No damage or breakage was sustained by the tubes. Therefore, we conclude that no tritium would have been released.

The results of the tests were minimal and may be seen in the photographs in FIGURES 6 through 13.

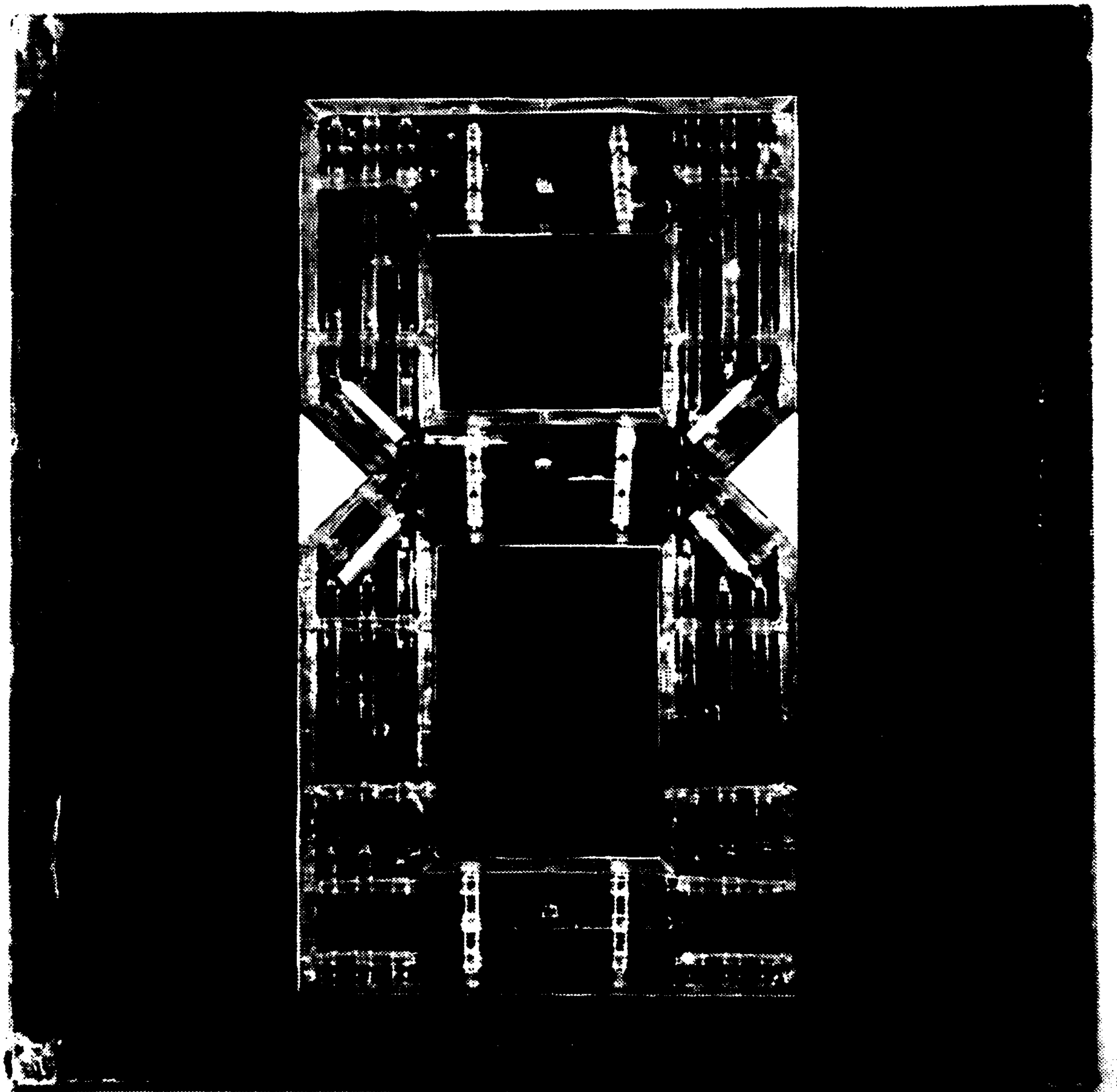

FIGURE 6. Runway Distance Marker After Test Series. Front View.

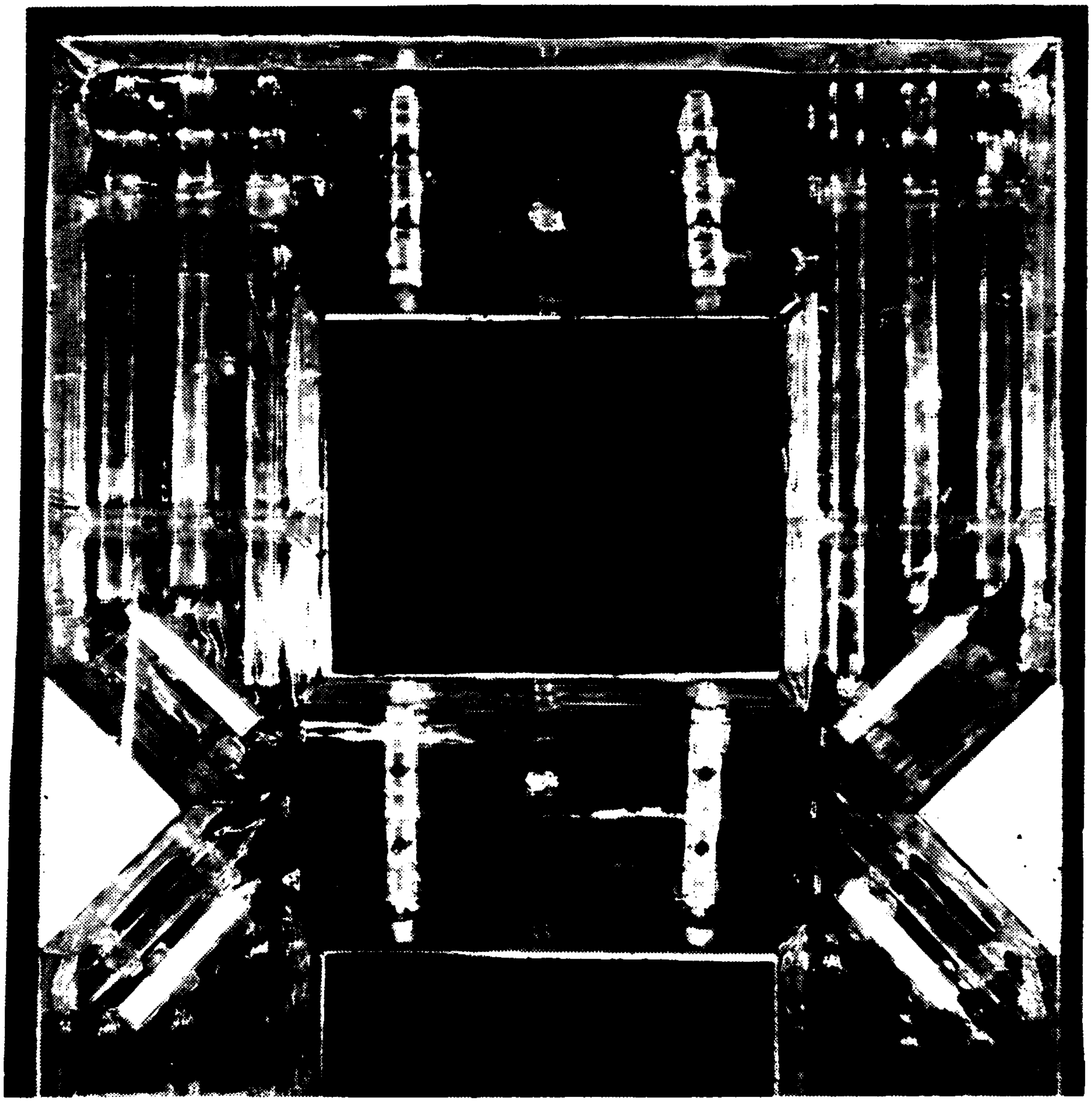

FIGURE 7. Runway Distance Marker After Test Series. Front View, Upper Half.

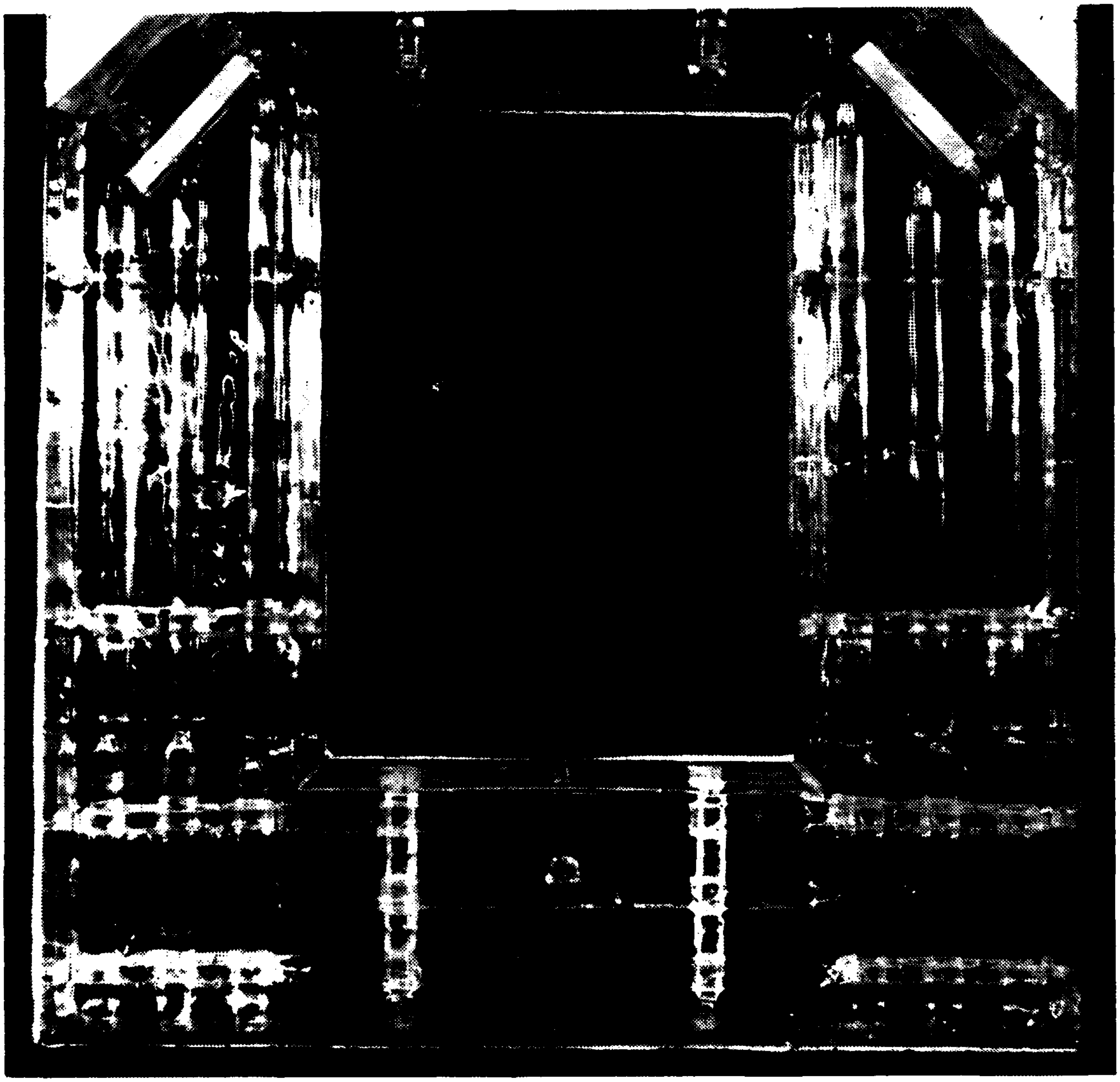

FIGURE 8. Runway Distance Marker After Test Series. Front View, Lower Half.

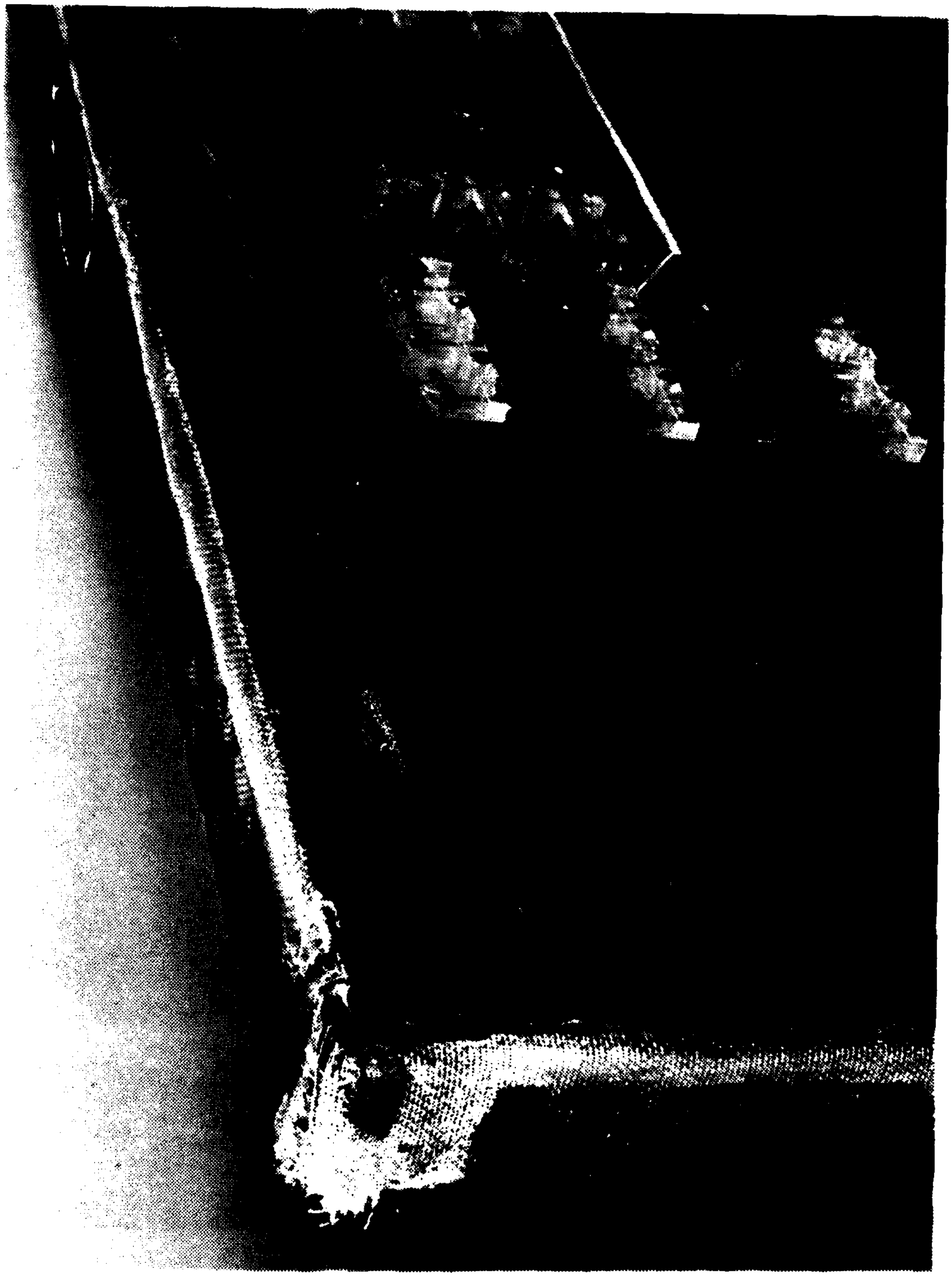

FIGURE 9. Runway Distance Marker After Test Series. Front View, Upper Left Quadrant.

FIGURE 10. Runway Distance Marker After Test Series. Front View, Upper Right Quadrant.

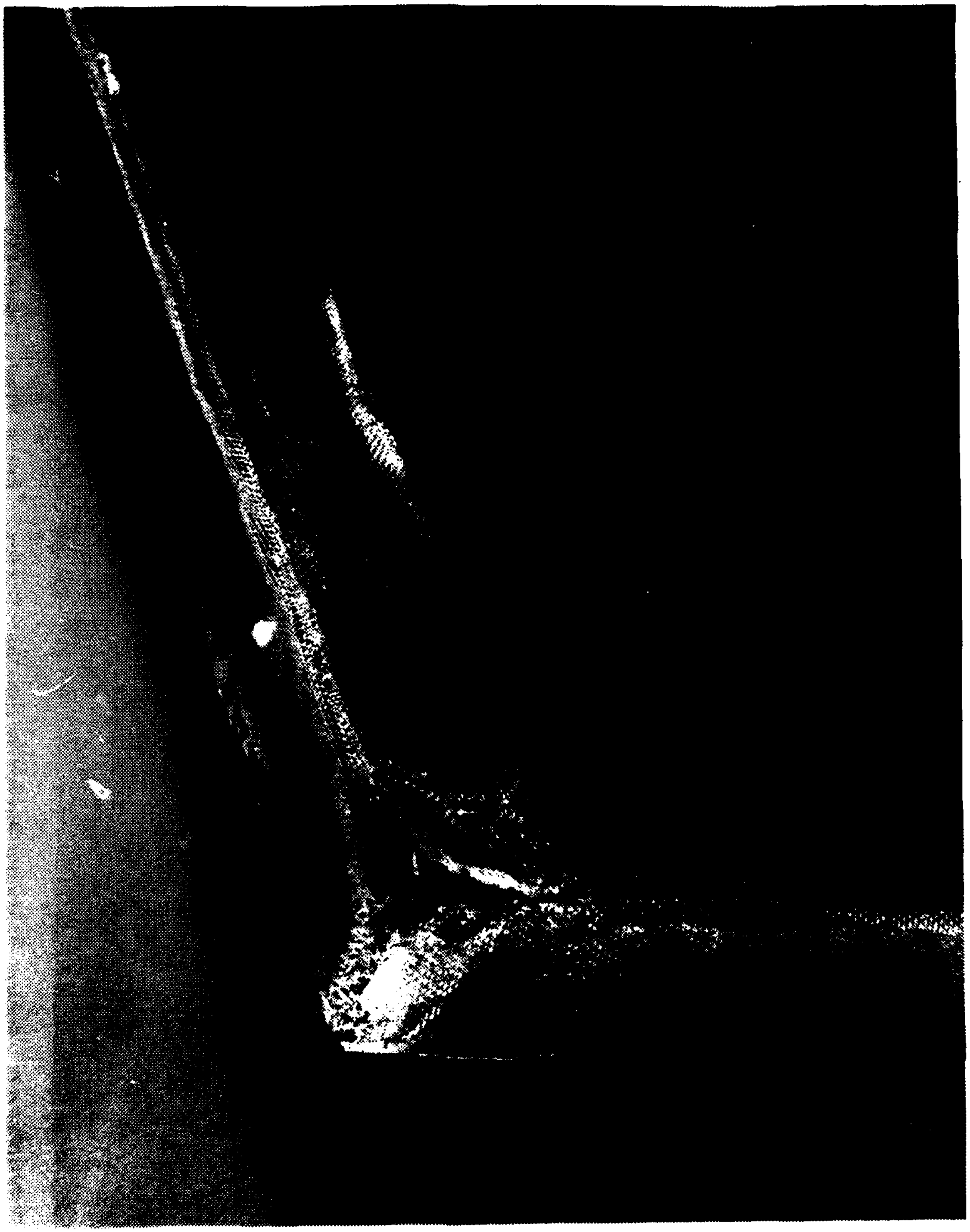

FIGURE 11. Runway Distance Marker After Test Series. Front View, Lower Left Quadrant.

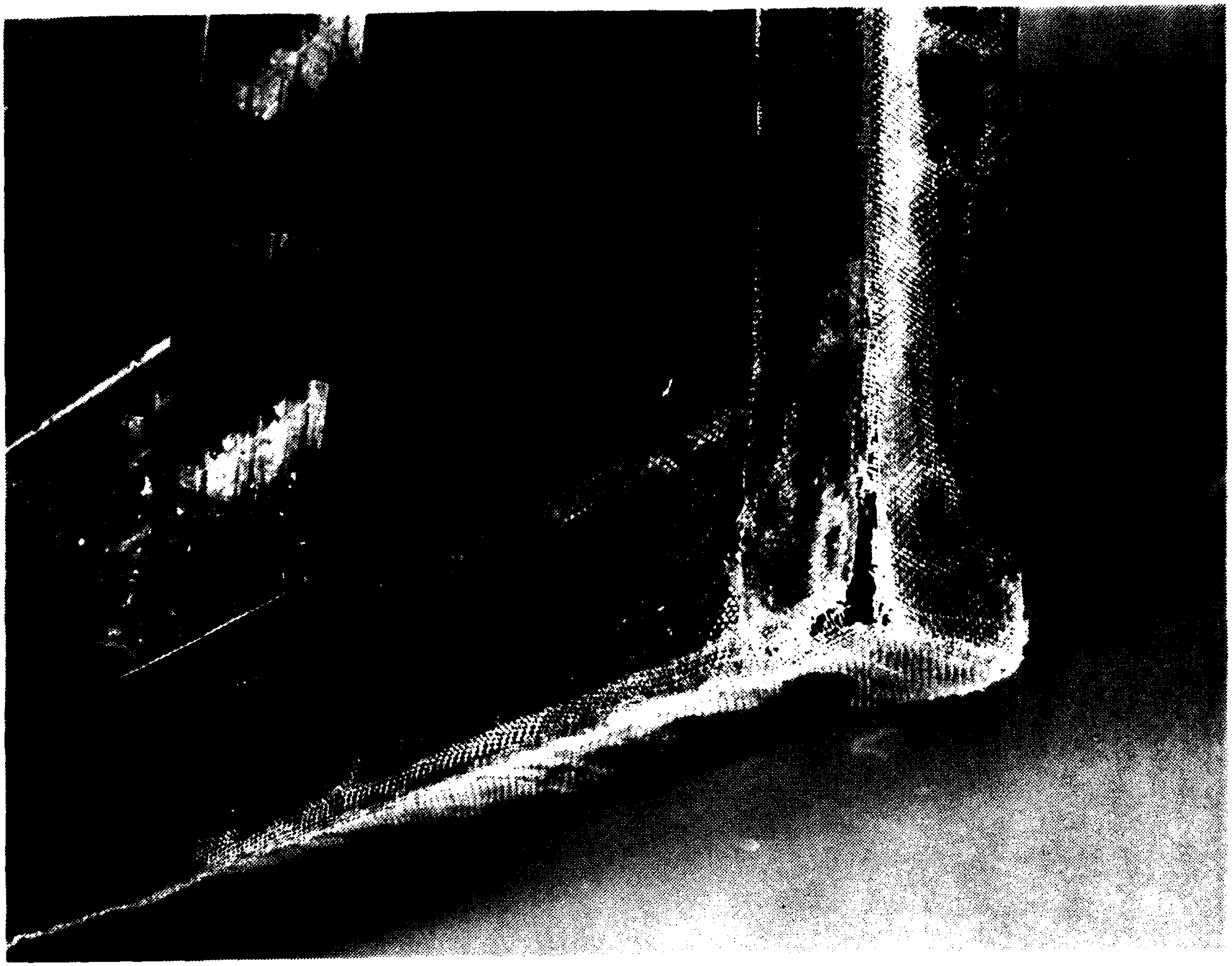

FIGURE 12. Runway Distance Marker After Test Series. Front View, Lower Right Quadrant.

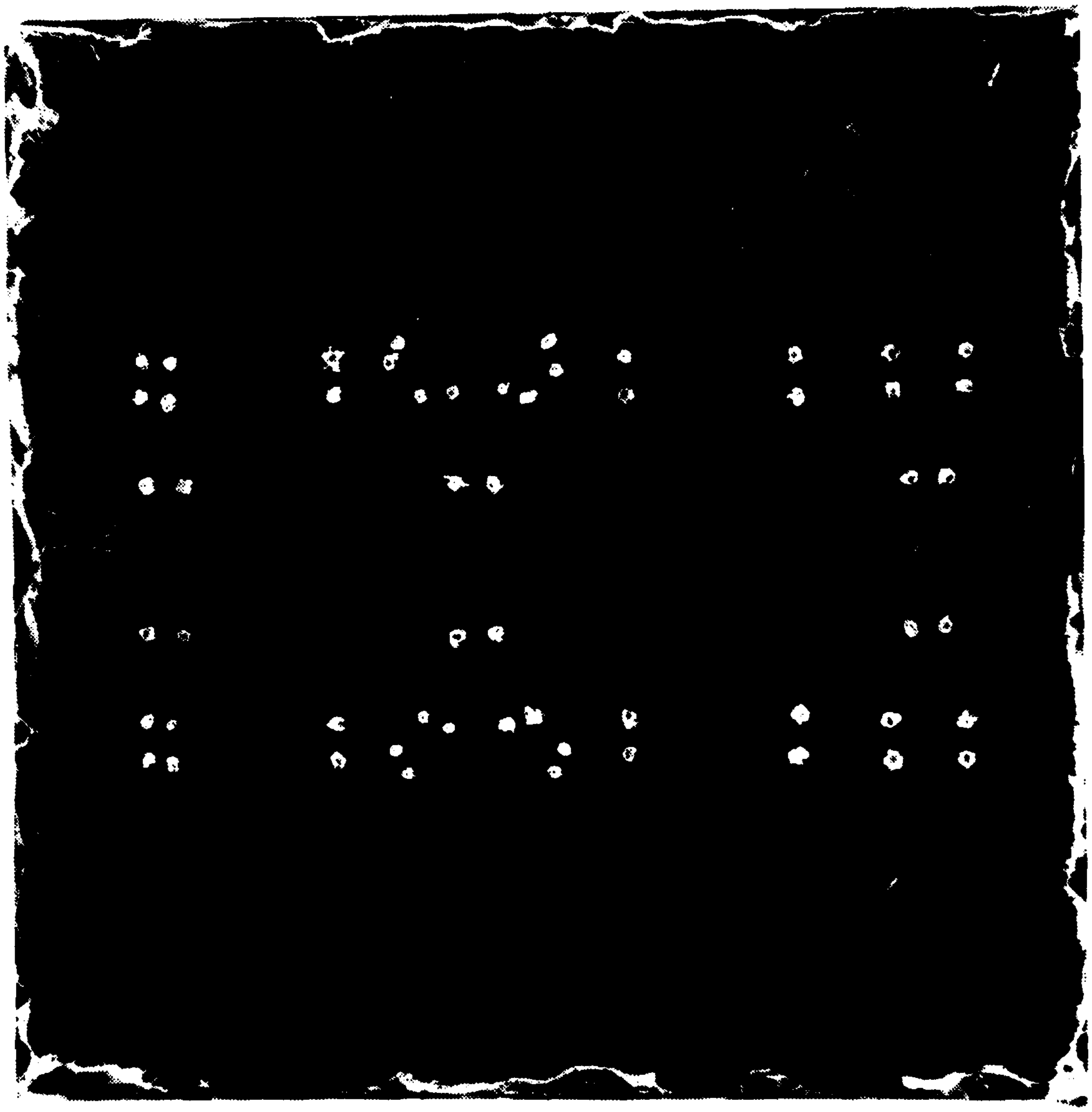

FIGURE 13. Runway Distance Marker After Test Series. Rear View.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the tritium-powered runway distance and taxiway marker signs, as redesigned as a result of this testing program, would be a satisfactory replacement for the presently used incandescent lighted signs. The authors believe that these signs would be a beneficial adjunct to present airfield lighting programs in that potential savings in energy and maintenance costs would result from their use.

It is recommended that the U. S. Air Force follow up this testing program with a full-scale test on an airfield to have pilot, maintenance personnel, and other operation personnel evaluation.

REFERENCES

W. C. Buchholtz, U. S. Air Force Military Interdepartmental Purchase Request N-80-50, Statement of Work, August 14, 1980.

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