# Polyurethane foam radome tests at C-band

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# POLYURETHANE FOAM RADOME TESTS AT C-BAND

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## ABSTRACT

A polyurethane foam radome, 26 feet in diameter, was tested at 6000 mc/s over a large antenna ( 12' × 17' ). Transmission loss produced by the radome varied from 1 to $3\frac{1}{2}$ percent for different antenna-radome aspects. Boresight error caused by the radome was measured to be ±.09 milliradian.

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# POLYURETHANE FOAM RADOME TESTS AT C-BAND

- W. Lavrench -

## INTRODUCTION

Early tests on stressed skin, space frame, and foam radomes showed that foam was superior at the higher microwave frequencies. The first foam radome tested at the National Research Council was made of expanded Dylite with a density of $2\frac{1}{2}$ pounds per cubic foot, and was assembled by gluing adjacent panels. Performance of this radome at S-band proved to be very satisfactory when tested for its effects on antenna radiation patterns and transmission. At X-band, however, the drop in transmission and increase in side lobes were not acceptable. This was largely brought about by the abrupt discontinuities formed in the radome wall by the glued joints. This unsatisfactory performance at X-band, coupled with the more exacting boresight requirements for radomes used in the guided missile application, indicated a need for further work on the foam radomes. A new design was, therefore, initiated wherein special attention was paid to the method of joining the panels.

## THE POLYURETHANE FOAM RADOME

The 26 foot diameter radome, shown in Plate I, is constructed mainly of diamond shaped panels made of Hooker's Hetron 10, a polyurethane foam. The panels are $3\frac{1}{2}$ inches thick, and measure 56 by 83 inches on the diagonals in a typical case. After the panels had been formed, the edges were machined to form a cavity between adjacent panels (see Plate II). The complete radome was assembled dry, and held together by special tapered pins. A chemical mixture was next introduced into the cavities between the panels to form a foam bond. The density of the foam in the joints was made to match the density in the panels — 6 pounds per cubic foot — as closely as possible, to reduce discontinuities in the radome wall. Test samples later removed from the joints showed that actual densities realized were within 5% of 6 pounds per cubic foot.

The radome was erected on a concrete pad on the ground, and later transported to the test site and lifted into position.

## RADOME TESTS

When the radome was completed and ready for tests, prime interest was in C-band frequencies. Thus the radome was first tested at 6000 mc/s. These tests are described in this brief report. Subsequent tests carried out at X-band are the subject of a second report (ERB-551).

Since a standard C-band antenna was not available an S-band reflector 17 feet wide by 12 feet high was used (see Plate III). A pair of C-band horns were placed at the focus to produce two overlapping beams. One of the horns was used alone for the transmission test, and both were used to simulate an amplitude comparison monopulse system for boresight tests. No antenna radiation patterns were plotted as a suitable turntable was unavailable.

a) Transmission Loss Tests

Variations in transmission loss were measured by rotating the radome about the antenna and noting the received signal. An absolute figure for the loss was obtained by removing the radome. The transmission loss varied from 1 to $3\frac{1}{2}$ percent (field strength).

b) Boresight Error Tests

Boresight measurements were made in the following manner. Signals from a distant 90-cycle square-wave-modulated source were received by a pair of horns at the focus of the receiving antenna. The two horns were separated to produce two beams which crossed at approximately the half-power points. The two signals picked up by the horns were individually detected and then subtracted in a transformer. At the start of the test the receiving antenna was positioned to produce equal signals in the two horns. This resulted in zero output from the transformer. Subsequent rotation of the radome about the antenna produced a beam shift which caused an increased signal in one horn and a reduced signal in the other horn. A beamshift in the opposite direction produced opposite results. The output of the transformer thus consisted of a 90-cycle square wave whose amplitude was proportional to beam shift and whose phase was determined by the direction of the beam shift. This error was plotted by an automatic recorder as the radome was rotated. Calibrations were made by moving the transmitting antenna known amounts transverse to the line of sight and noting the pen deflection. Results of such a test are shown in Fig. 1. The total beam shift amounts to 0.18 or ±0.09 milliradian .

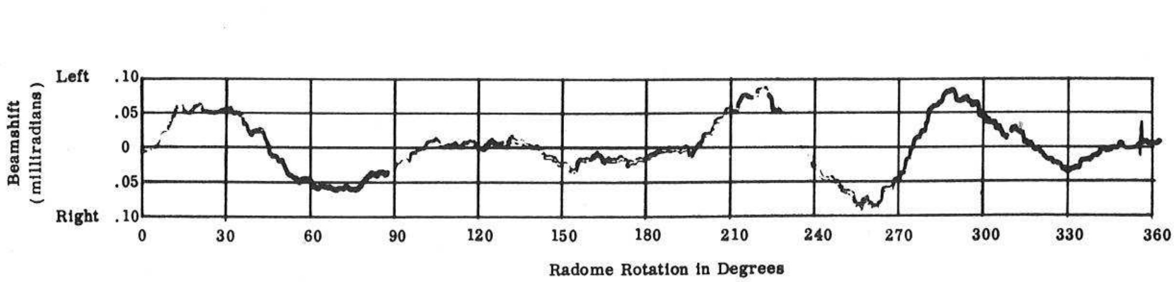



FIG. 1 BEAMSHIFT PRODUCED BY THE POLYURETHANE RADOME

The bottom edge of the antenna used in these tests was about $1\frac{1}{2}$ feet above the base of the radome, and at one time it was thought that some of the beam shift could be attributed to the stand supporting the radome. The radome was repositioned by moving it 45° on the stand and further boresight plots were made. No change could be seen in the patterns. This indicated that the shift shown in Fig. 1 is caused entirely by the presence of the radome.

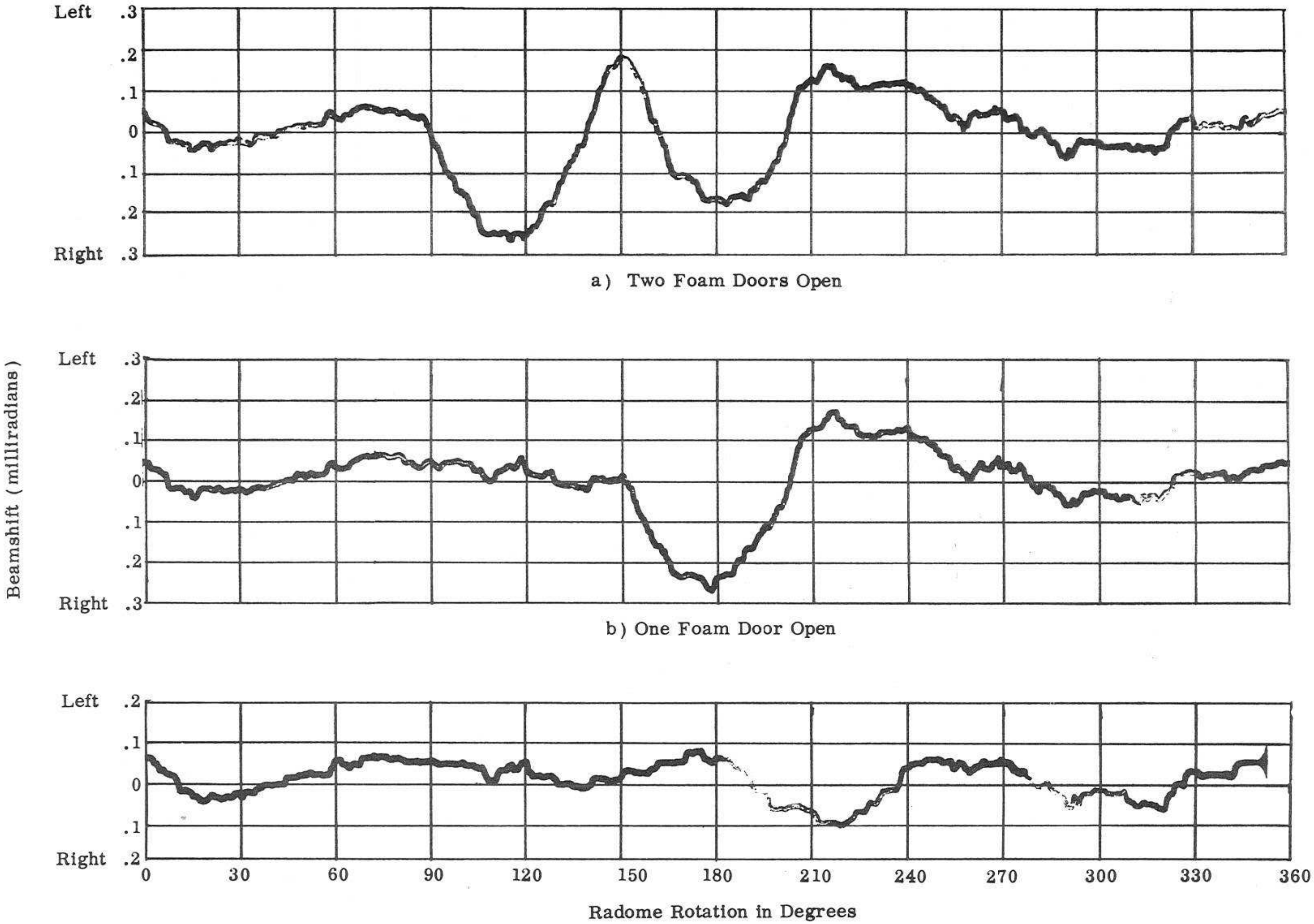
This radome has a pair of foam doors, 60° apart, in the bottom row of panels. At the start of the tests both foam doors were absent. It was found that an open door produced a sizeable boresight error. Patterns obtained with both doors open, one door open, and both doors closed, are shown in Fig. 2. It is evident that the presence or absence of a piece of foam, 6 pounds per cubic foot in density, makes an appreciable difference in the results obtained.

Tests carried out at X-band on much smaller antennas showed a 30 degree period in the boresight shift. This indicated that the shift was caused by the joints. No such period is evident here since the antenna is so large. This would tend to integrate the errors, thereby eliminating any periodicity. This radome will be cut into large sections and transported to a different site. At that time insertion phase delay measurements will be made on the intact joints to obtain more information on the radome.

## RESULTS OF TESTS

The polyurethane foam radome was found to cause a transmission loss of 1 to $3\frac{1}{2}$ percent in field strength when used over an antenna operating at a frequency of 6000 mc/s.

The maximum beamshift measured was ±.09 milliradian. This shift is believed to be caused by slight irregularities in the foam joints. More information will be available after insertion phase delay measurements have been made on this radome.




a) Two Foam Doors Open

b) One Foam Door Open

c) Both Doors Closed

FIG. 2 EFFECT OF DOORS ON BORESIGHT

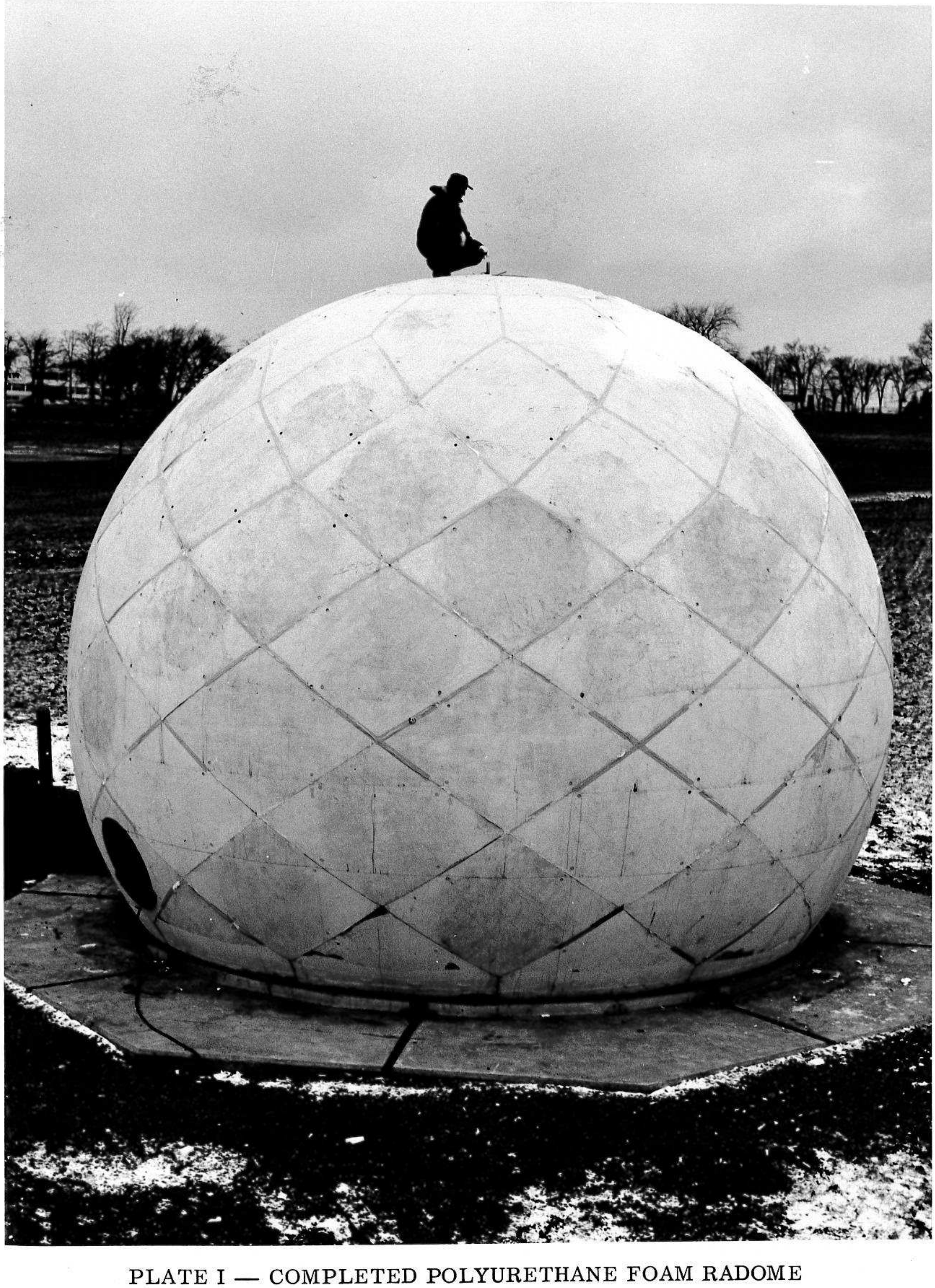


PLATE I — COMPLETED POLYURETHANE FOAM RADOME

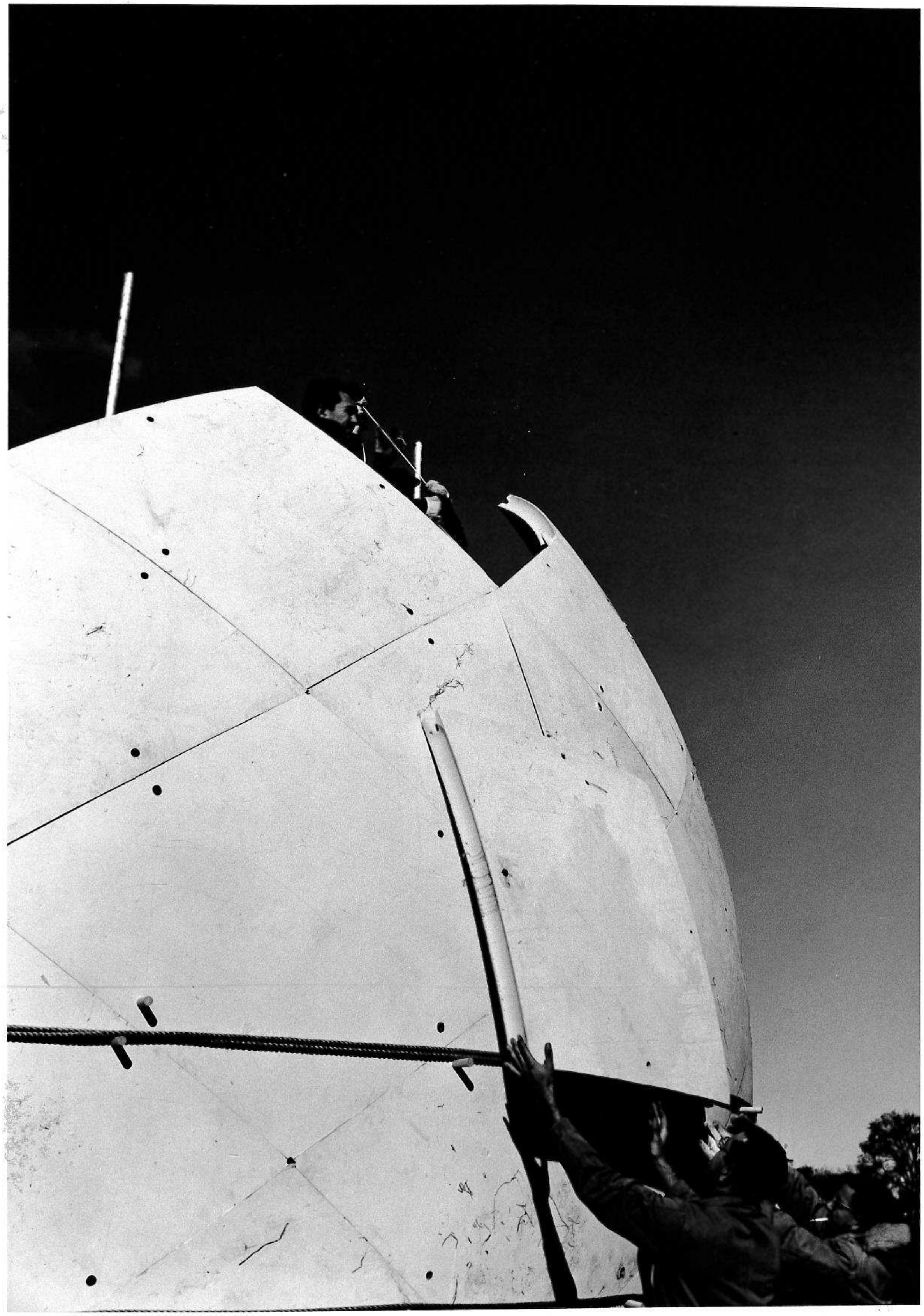


PLATE II — ASSEMBLY OF PANELS

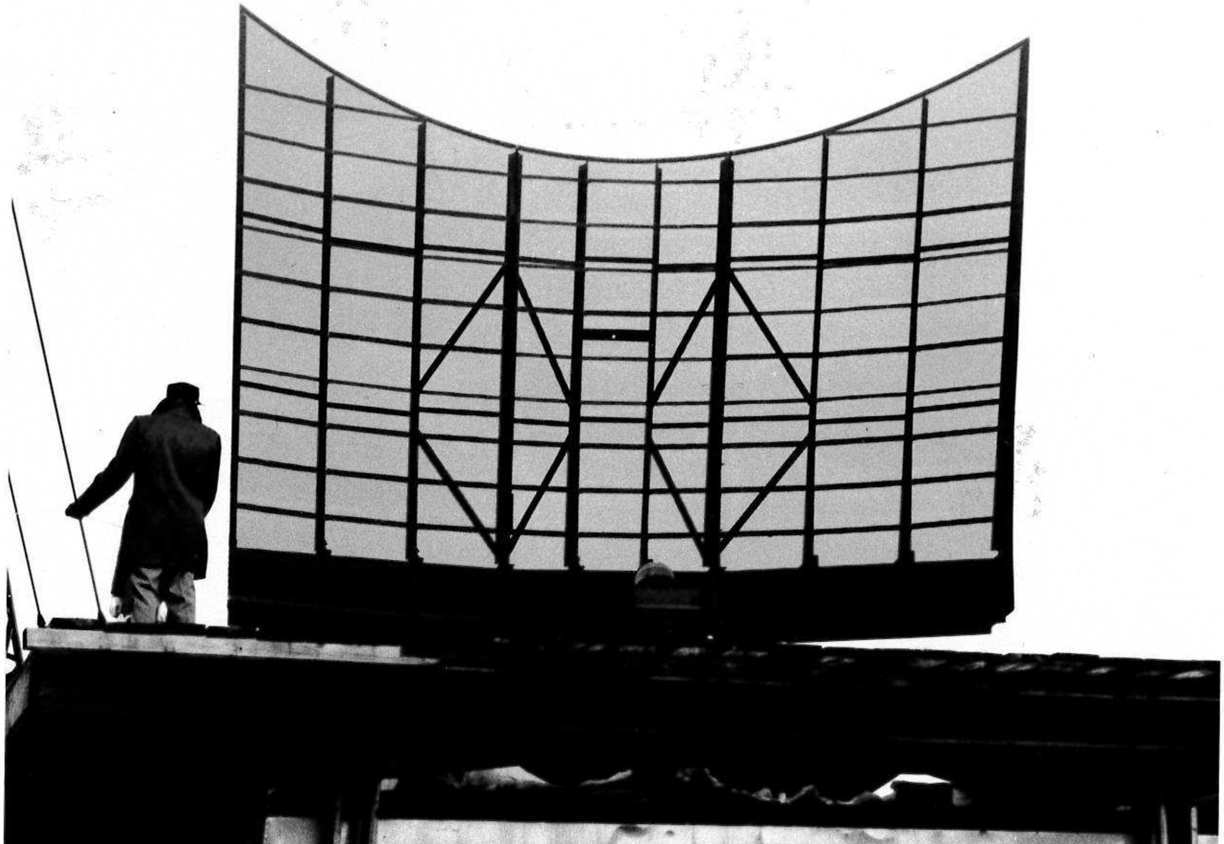


PLATE III — REFLECTOR USED IN TESTS