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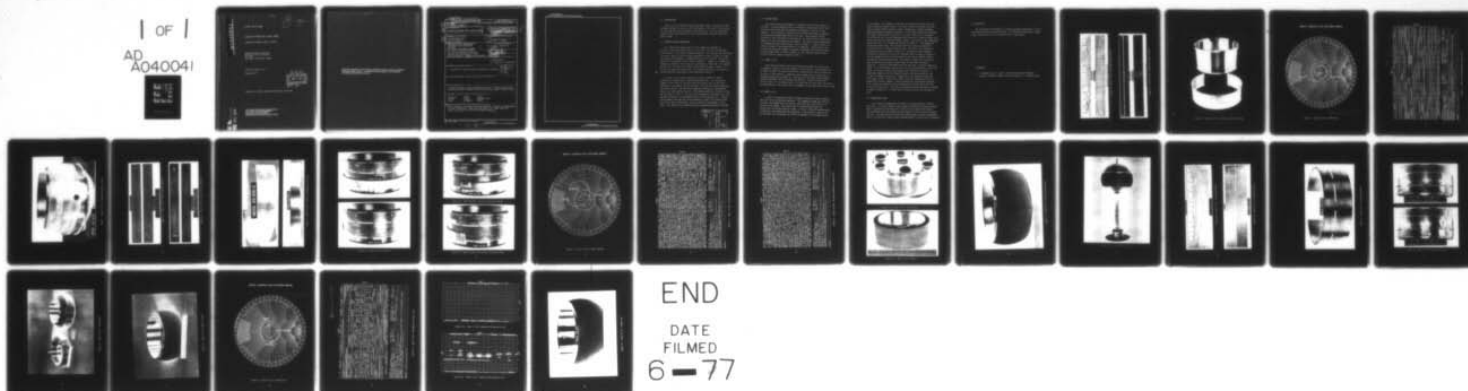
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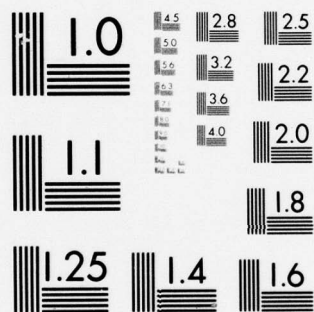
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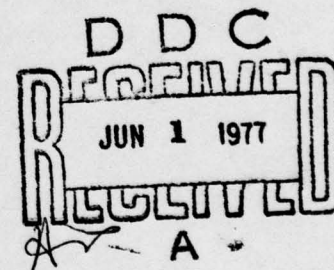
STRIPLINE ANTENNAS FOR A SMALL SPHERE

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Scientific Report No. 2

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Stripline S-band Beacon Antenna C-band Corporate Feed Array Telemetry Sphere			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The development of a stripline S-band telemetry array and a C-band beacon antenna is presented. Both units are mounted in a small area just under the surface of a 10.12 inch diameter sphere.			

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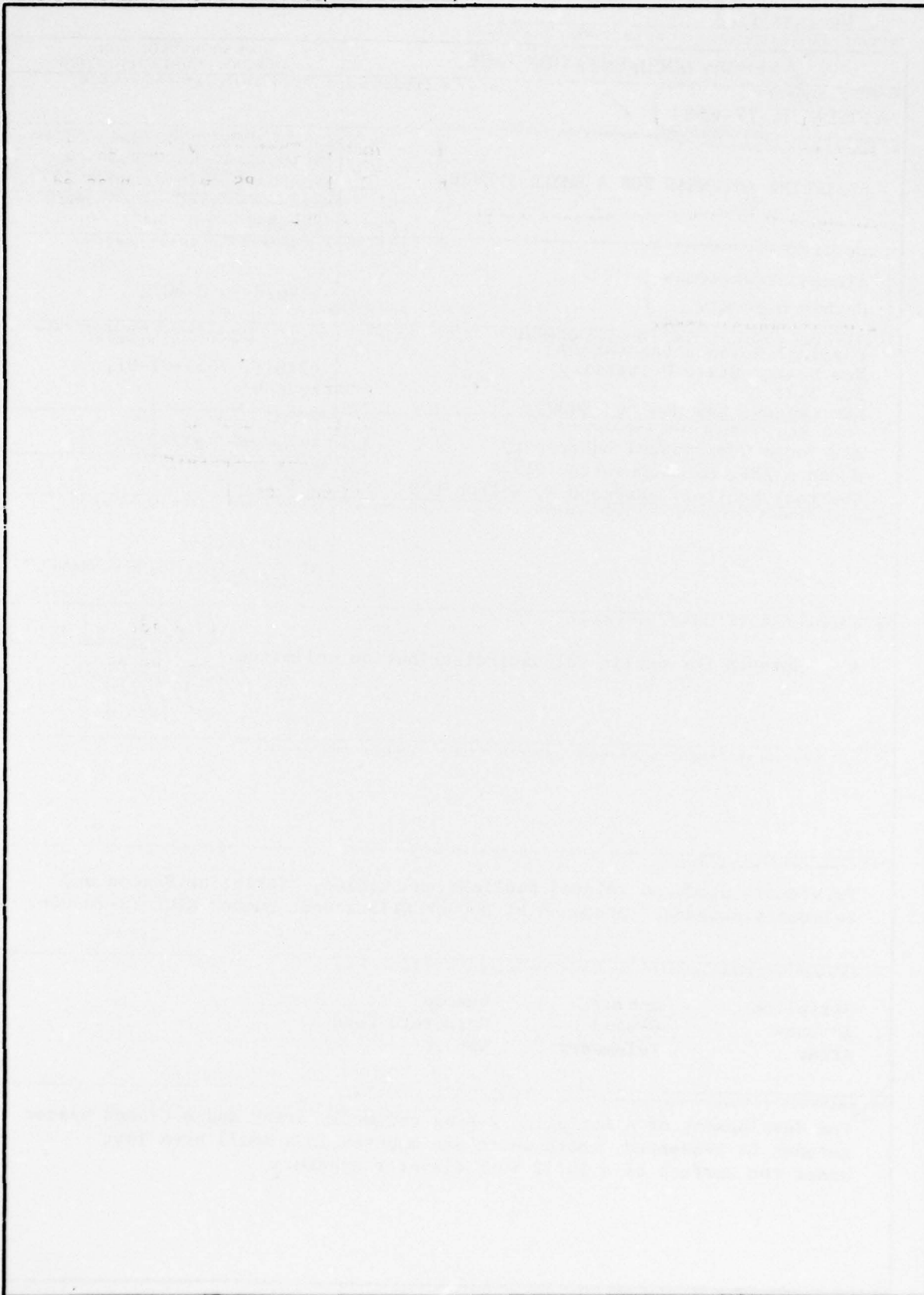
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1.0 INTRODUCTION

Late in 1972 the Physical Science Laboratory (PSL) developed an S-band stripline antenna for use in a 10.12 inch sphere. That array in the telemetry (TM) band was used successfully until early 1976. PSL was then asked to add a C-band beacon antenna to the system without using any additional sphere volume.

2.0 TELEMETRY ARRAY DEVELOPMENT

The original TM antenna array for this sphere was designed to operate in the S-band region from 2.2 to 2.3 GHz. The unit was PSL Model No. 55.509 and it used twelve radiating elements. The corporate feed structure is shown in Figure 1a and the radiating element surface is Figure 1b. When the antenna was assembled it weighed 487g and was 8.9 cm wide. This array along with its mounting ring is shown in Figure 2. Figure 3 is a VSWR curve showing the frequency of interest for this model as 2.2695 GHz. For simplification the 1.5:1 and the 2:1 VSWR circles have been drawn. Figure 4 is a copy of the radiation contour plot. It indicates that 96% of the sphere is covered by power levels greater than 10dB below isotropic.

In order to add a beacon antenna in a short a period of time as possible the original TM unit was modified physically. The antenna was trimmed to the center of the outer edge rivet lines, and no rivets were installed in the central area of the array. The unit was copper plated and then nickel plated. The edge and through hole plating were accomplished using an in house plating facility. The antenna weight was reduced to 425g and its width to 7.65 cm. The unit was redesignated as PSL Model No. 55.510 and was installed on the outermost portion of the mounting ring. A beacon feed clearance hole was then drilled through an area of the antenna which was free of circuit feed lines. Figure 5 shows the development to this point. The VSWR curve and radiation pattern remained essentially the same.

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3.0 BEACON DESIGN

The C-band beacon was designed to transmit at 5.8 GHz and receive at 5.68 GHz. It was determined that two orthogonal elements placed 180° apart and fed in phase would provide adequate coverage for a vehicle of this diameter. It was decided to make the unit as light and narrow as possible. The light model weighed 88g and was 2.7cm wide. The stripline circuit harness for this array which is PSL Model No. 55.510C is shown in Figure 6a. Figure 6b is the radiating surface elements. Two views of the antenna prior to trimming, drilling and plating are shown in Figure 7. Figure 8 shows two different views of the antenna after it is installed. The vertically and horizontally polarized elements are shown in Figures 9a and 9b respectively. A typical VSWR curve is shown in Figure 10. The radiation contour plots for E_θ and E_ϕ are shown in Figures 11 and 12.

4.0 MODEL 55.510

After some preliminary electrical tests are performed the entire unit is foamed to conform to an outer diameter of 10.12 inches. The potting mold is shown in Figure 13a and the unit prior to machining is shown in Figure 13b. The unit is then turned to a spherical outer diameter and is shown prior to filling and painting in Figure 14. The sphere is then ready for preliminary radiation patterns, and is installed on a mock-up. Figure 15 shows this mock-up ready for the antenna range. The final data is taken after the surface has been painted. Two spheres with the piggyback C-band units were flown in 1976.

5.0 MODEL 55.511

In order to overcome some minor packaging deficiencies further development work on the system was undertaken. The piggyback package was difficult to mount, and brought the outer edge of the C-band unit very close to the surface of the sphere. The method used to foam and then machine the potting left the surface much too rough. In order to make the system easier to fabricate and aesthetically more pleasing, it was decided to improve the potting mold, and concentrate our effort on redesign of the S-band portion

of the system. All attempts to compress the feed structure and still keep twelve radiating elements failed. In order to reduce the width of the TM array a design tradeoff between a better package and a slightly degraded radiation pattern was deemed acceptable. A new S-band antenna was developed with eight radiating which was only 7.4 cm wide. This unit is PSL Model No. 55.511 and its stripline corporate feed structure is shown in Figure 16a. Figure 16b shows the radiating element surface. The array is then fabricated¹ and is shown prior to trimming and plating in Figure 17. The trimmed and plated unit weighs 405g. The narrower width now allows the S-band and C-band arrays to be installed side by side. Two views of the antennas on the mounting ring are shown in Figure 18. The sphere surface roughness problem was corrected by the use of a new mold which is shown in Figure 19. The unit emerges from the potting mold with the correct diameter thereby eliminating the machining process. The surface is harder and less porous than the previous units and is shown ready for the final painting in Figure 20. A typical S-band VSWR curve for this model is shown in Figure 21. Figure 22 is the radiation contour plot, and it is estimated that 90% of the sphere is covered by power levels greater than 10dB below isotropic. A simplified comparison of the original S-band to the one presently in use is shown in Figures 23a and 23b. Figure 23a is the original S-band only array model 55.509. Figure 23b is model 55.511 the S-band portion of the present two frequency sphere. On both figures the cross hatched areas are 10 to 14dB below isotropic and the shaded areas are those which are 14dB or more below isotropic. The final configuration painted and ready to deliver is shown in Figure 24. At least three of these units will be available in 1977.

6.0 RERADIATING SLOTS

In the launch configuration the sphere is installed within a vehicle nose cone. In order to ensure correct sphere TM operation during pre-launch tests a resonant slot had been cut in the nose cone opposite the sphere. The reradiating slot also enables the TM stations to lock on prior to sphere ejection. The addition of the C-band has added another resonant reradiating slot to the nose cone which allows tracking radar to lock on prior to ejection.

7.0 CONCLUSION

The chronological development of various stripline antennas for a 10.12 inch diameter sphere has been discussed. The system has grown from a single S-band telemetry array to a TM antenna with a C-band beacon.

REFERENCES

1. A. Waterman and D. G. Henry, "Stripline Beacon and Telemetry Antenna," AFGL-TR-76-0066, Scientific Report No. 1, February 1976.

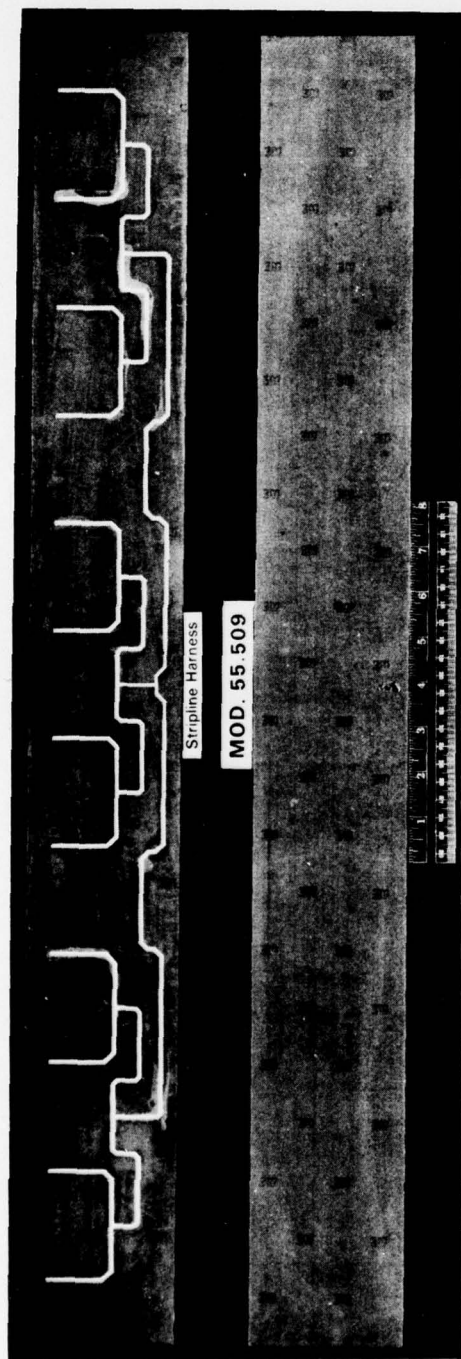


Figure 1a. Model 55.509 Corporate Feed Structure



Figure 1b. Model 55.509 Radiating Element Surface

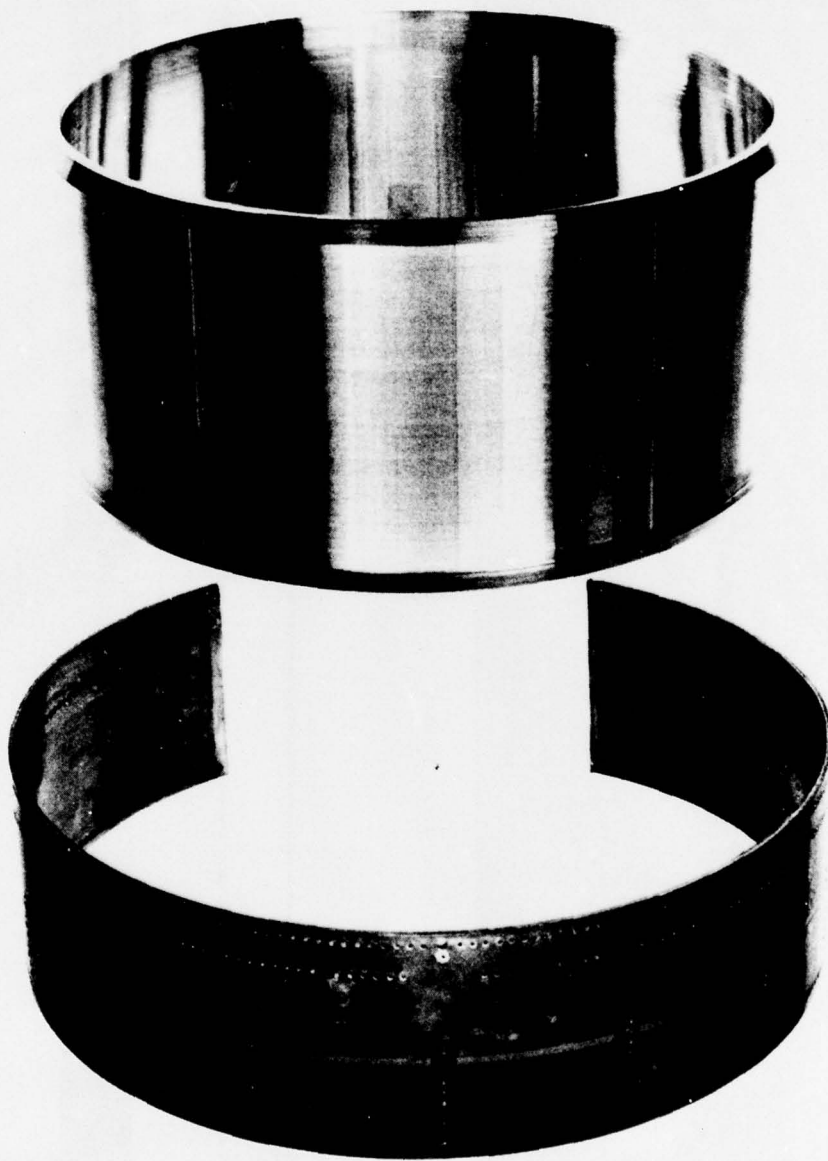
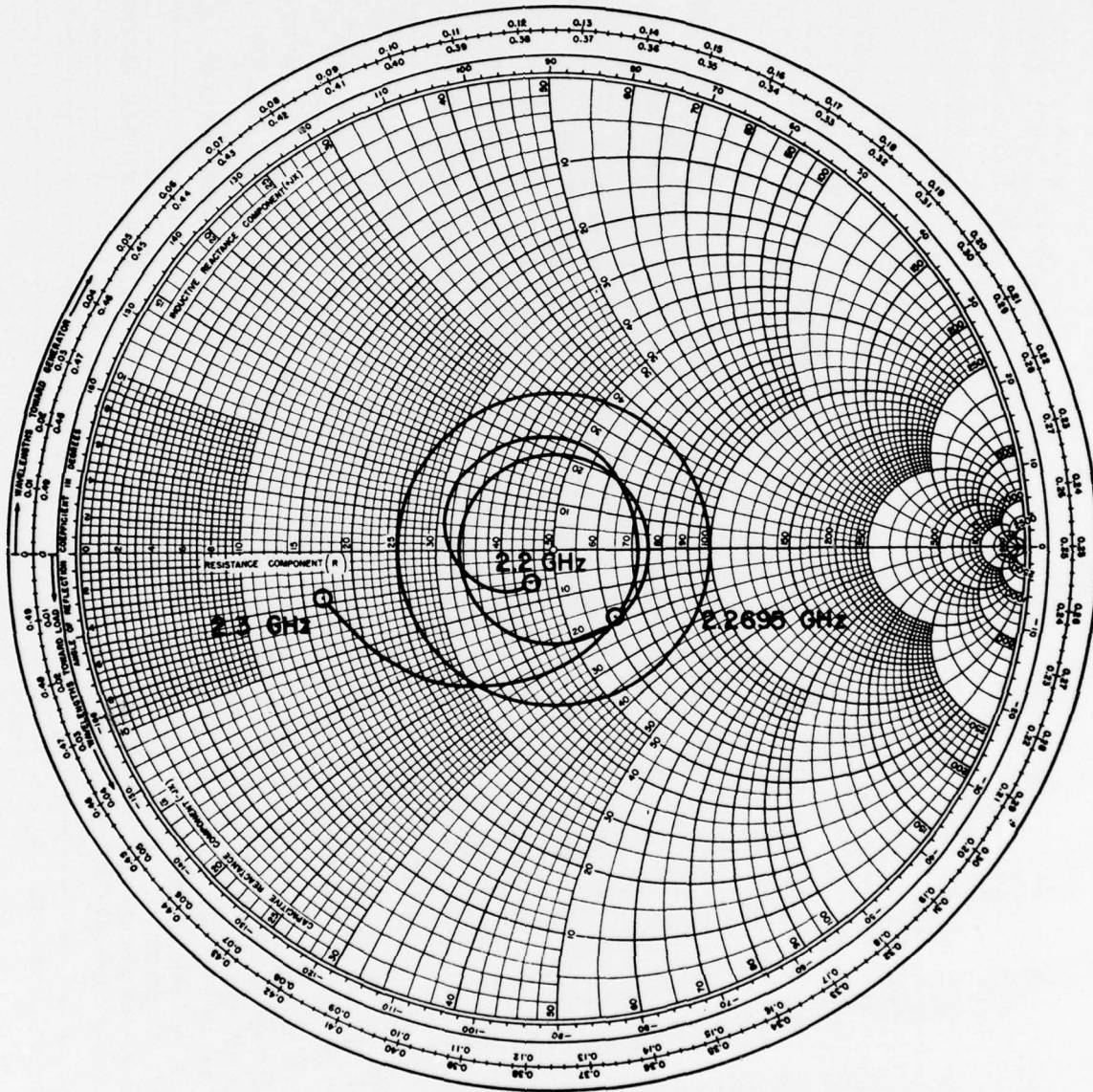


Figure 2. Model 55.509 TM Antenna and Mounting Ring

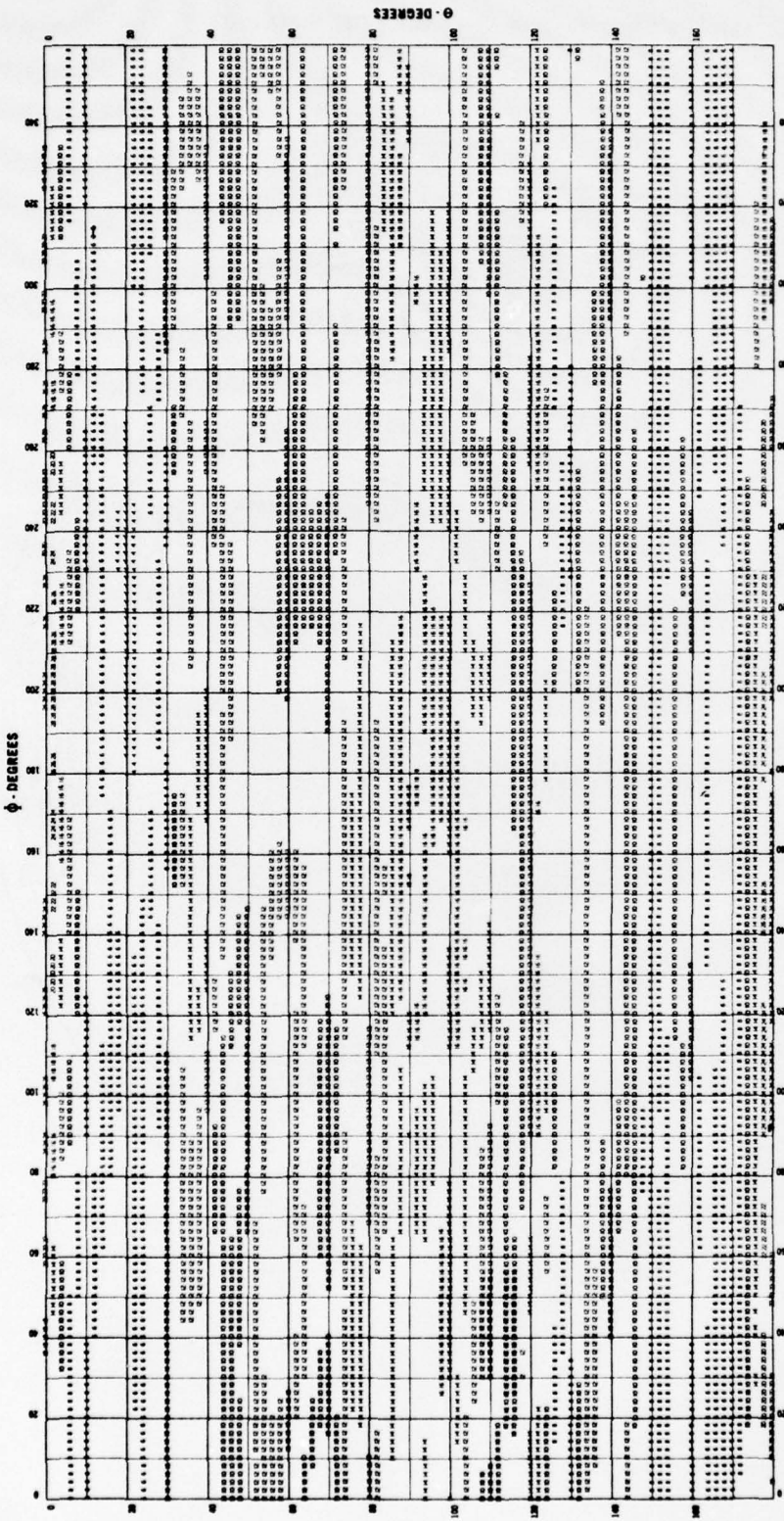
IMPEDANCE COORDINATES—50-OHM CHARACTERISTIC IMPEDANCE



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Figure 3. Model 55.509 TM VSWR Curve

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CONTRACT NO: AF-19628-75-C-0065 PSL FUND NO: 17501 RANGE REQUEST NO: 1955 DATE: 26 October 1972
PATTERN MEASUREMENT FREQUENCY: 2.295 GHz PSL PHOTO NO: N/A ANTENNA MODEL NO: 55.509 MODEL SCALE: 1:1
POLARIZATION COMPONENT RECORDED: EQ ARRAY NO: N/A ARRAY PHASING: N/A
GAIN REFERENCE ANTENNA: TYPE AND S/N: SGR 1.7 S/N 203 GAIN OF THE REFERENCE ANTENNA: +16 dB
DESCRIPTION OF TEST ANTENNA: 10" Sphere with a 9" Stripline Array, Ecofoam and Plastic Finish
DESCRIPTION OF VEHICLE MOCKUP: 10" Spherical Aluminum End Caps to Simulate Flight Configuration
THE NUMBER 10 IN THE POWER CONTOUR GRAPH CORRESPONDS TO 16 dB WITH RESPECT TO THE GAIN REFERENCE ANTENNA.
DESCRIPTION OF THE GAIN MEASUREMENT: Reference PSL Gain Pattern Number 110370

REMARKS: The Array Feed Point is Designated as 90°

Figure 4. Model 55.509 TM Radiation Contour Plot

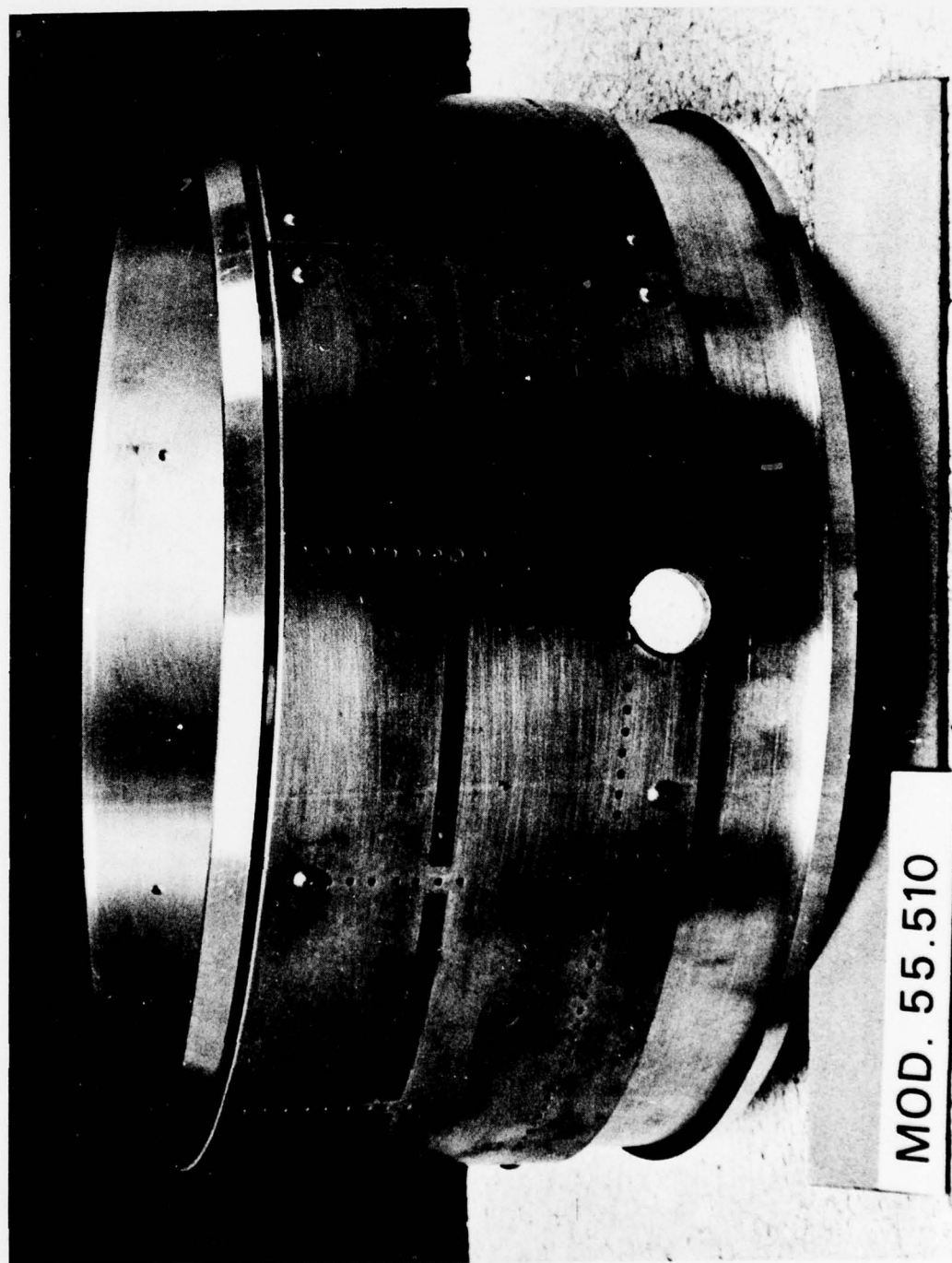


Figure 5. Model 55.510 TM Antenna Mounted on Ring

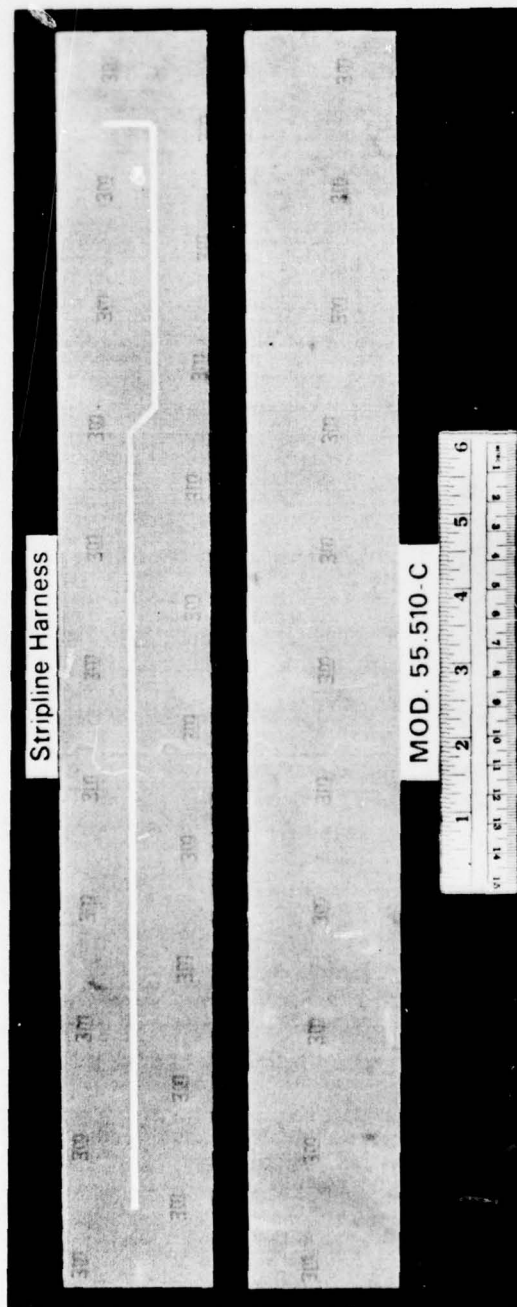


Figure 6a. Model 55.510C Beacon Antenna Circuit

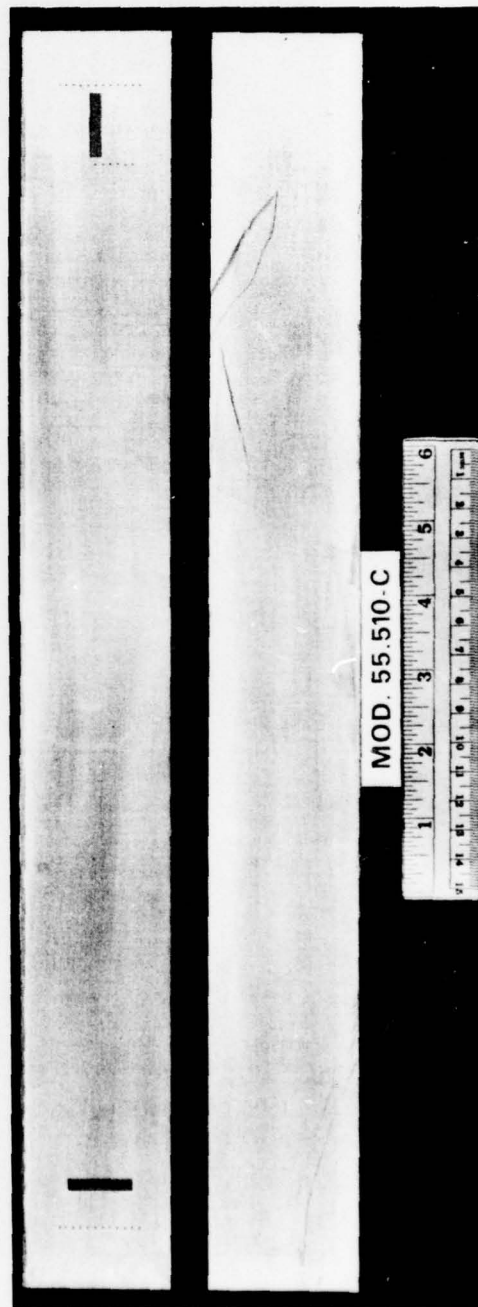


Figure 6b. Model 55.510C Beacon Antenna Elements

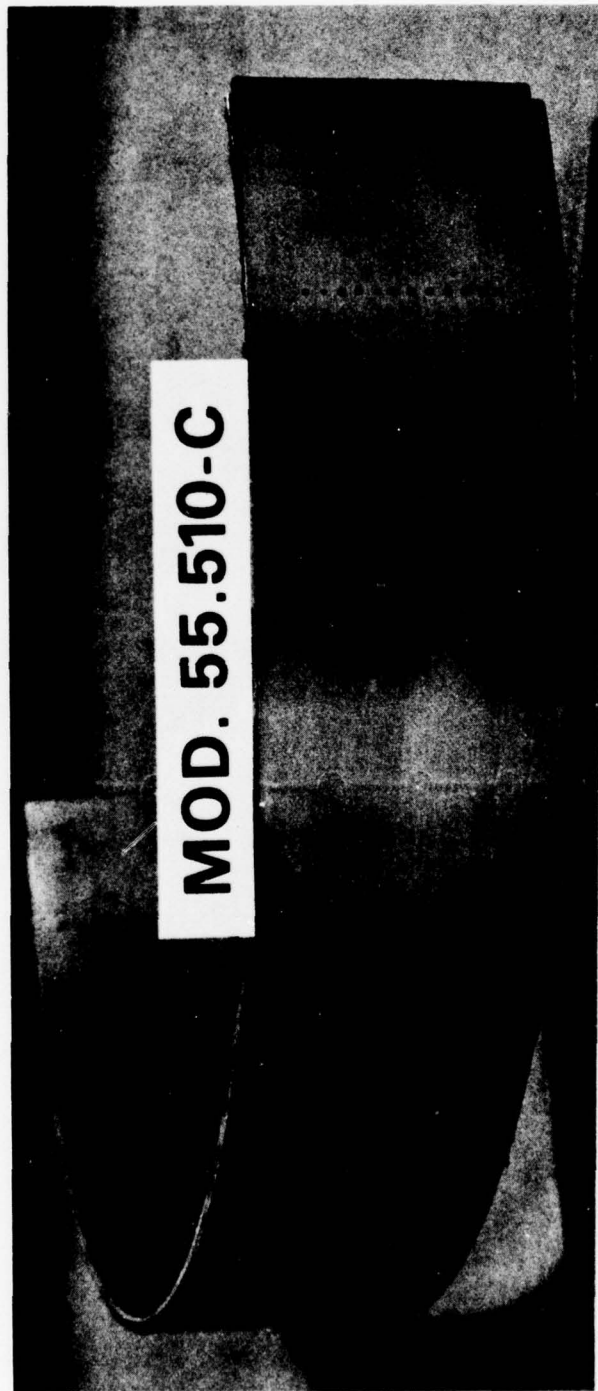


Figure 7. Model 55.510C Prior to Trimming and Plating

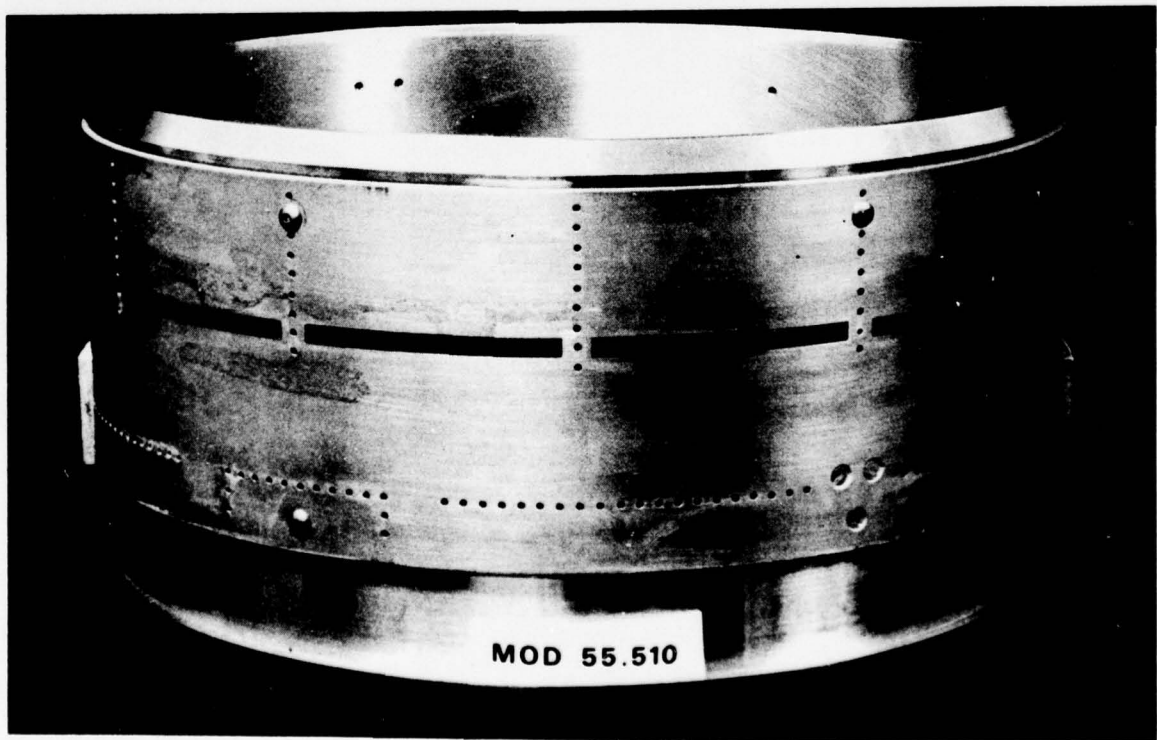
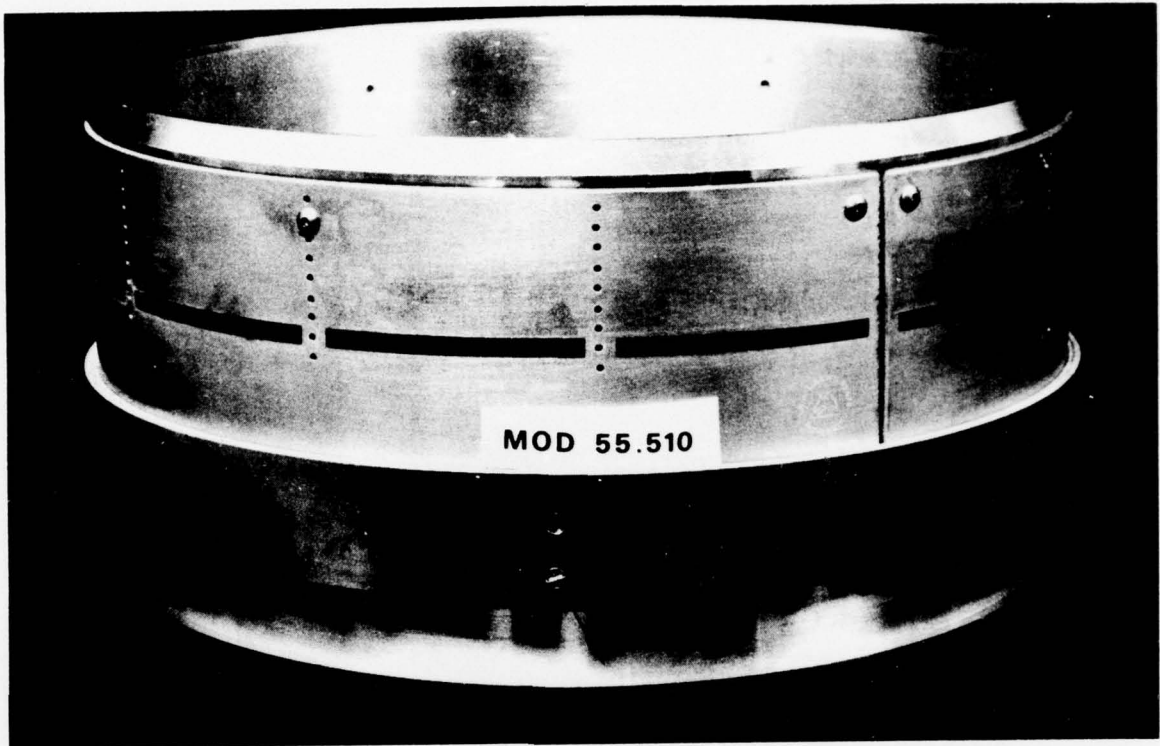


Figure 8. Model 55.510 Installed

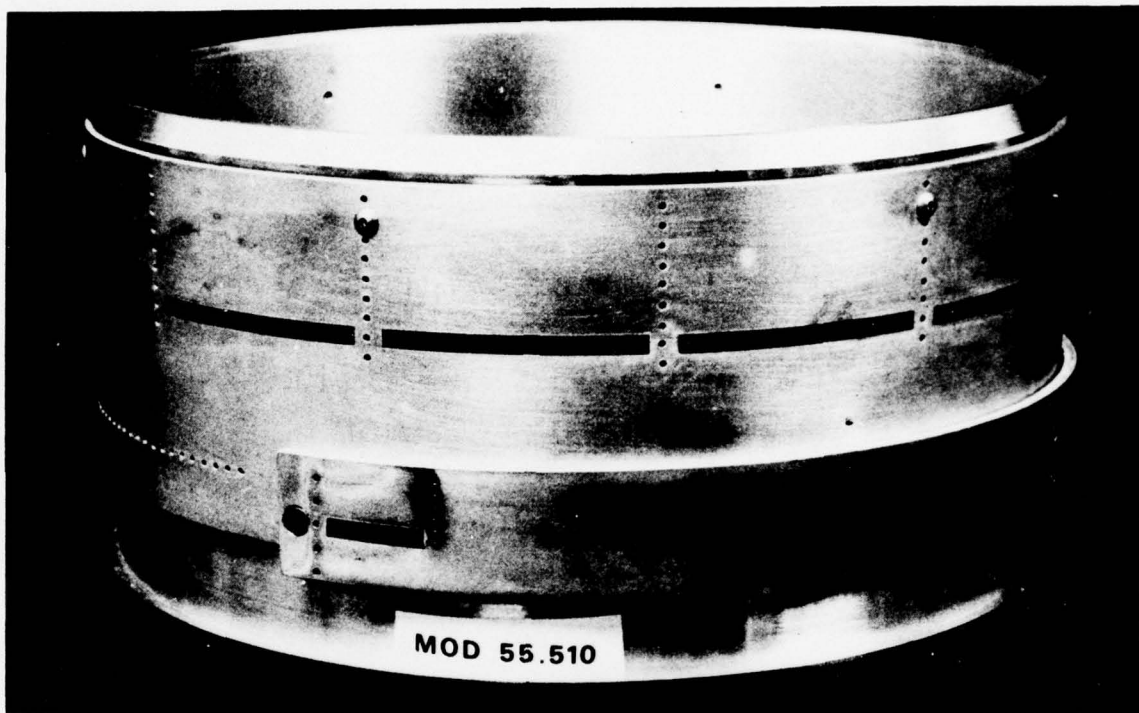


Figure 9a. Model 55.510C Vertically Polarized Element

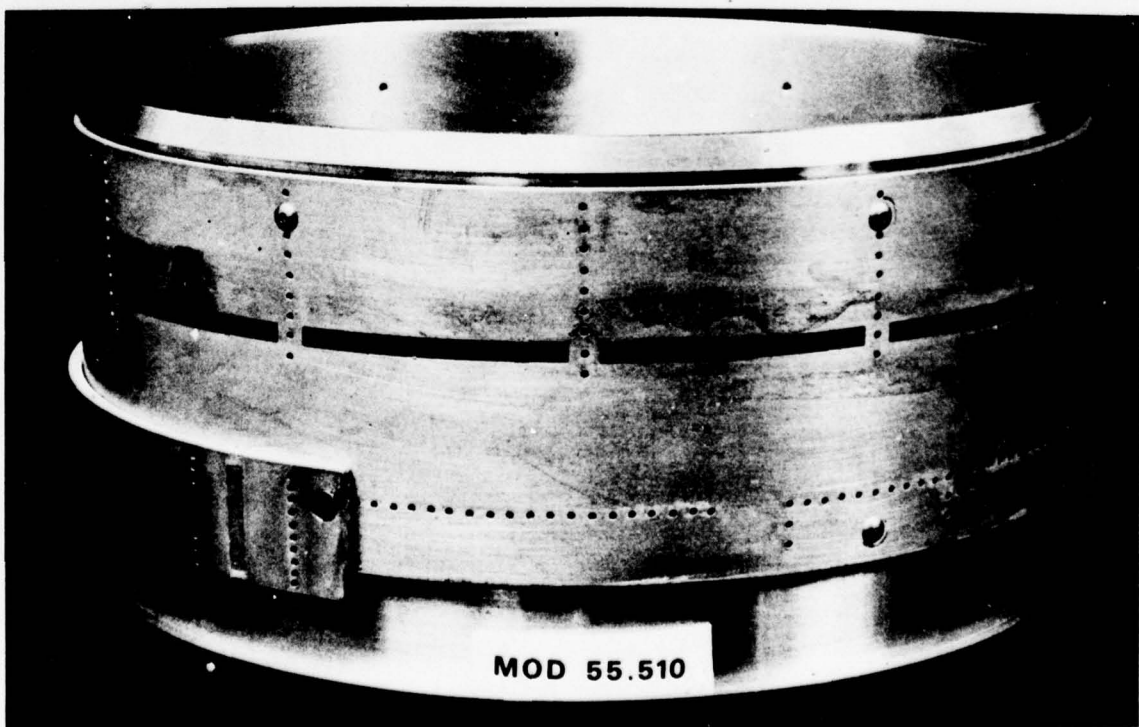


Figure 9b. Model 55.510C Horizontally Polarized Element

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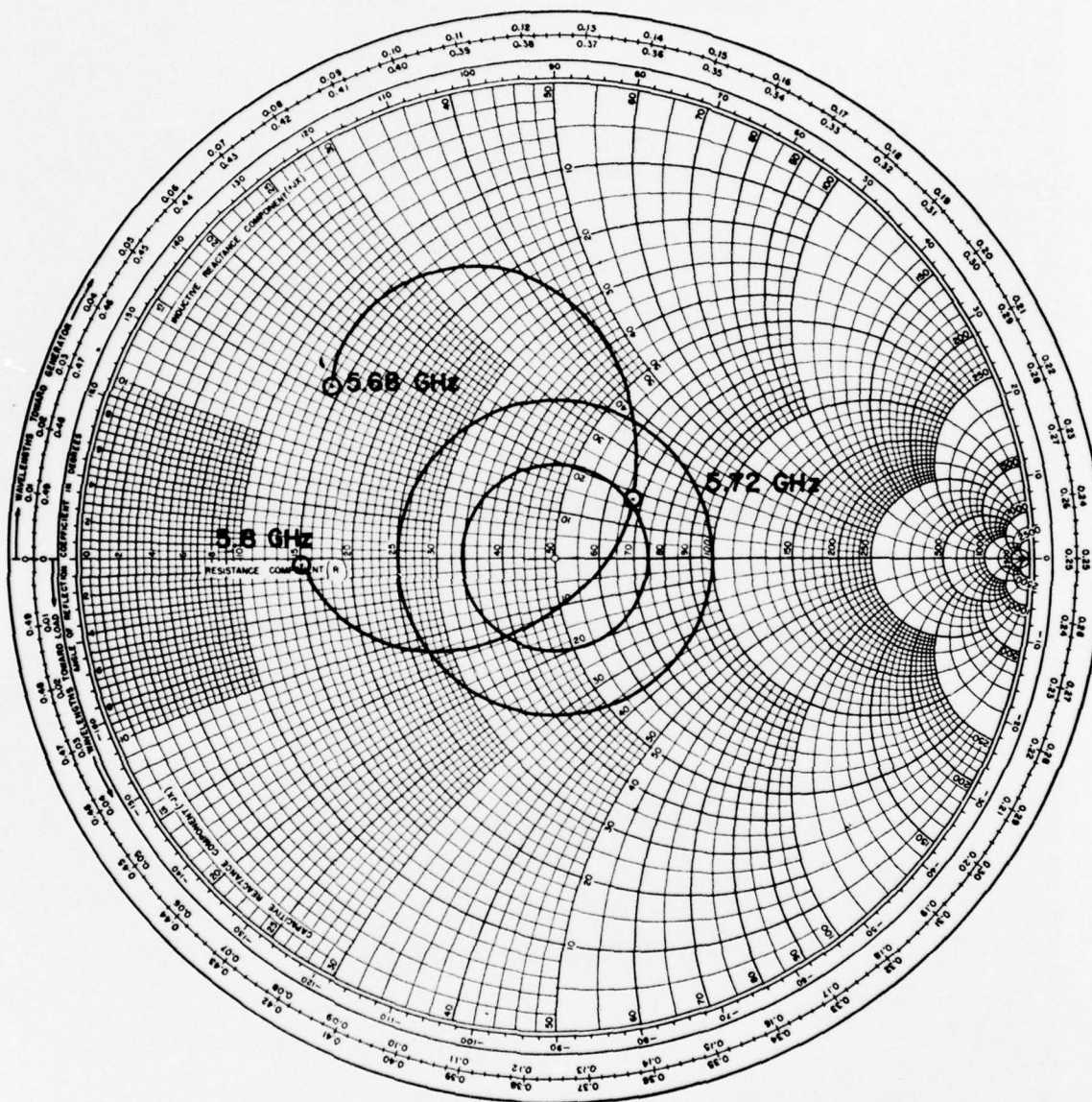
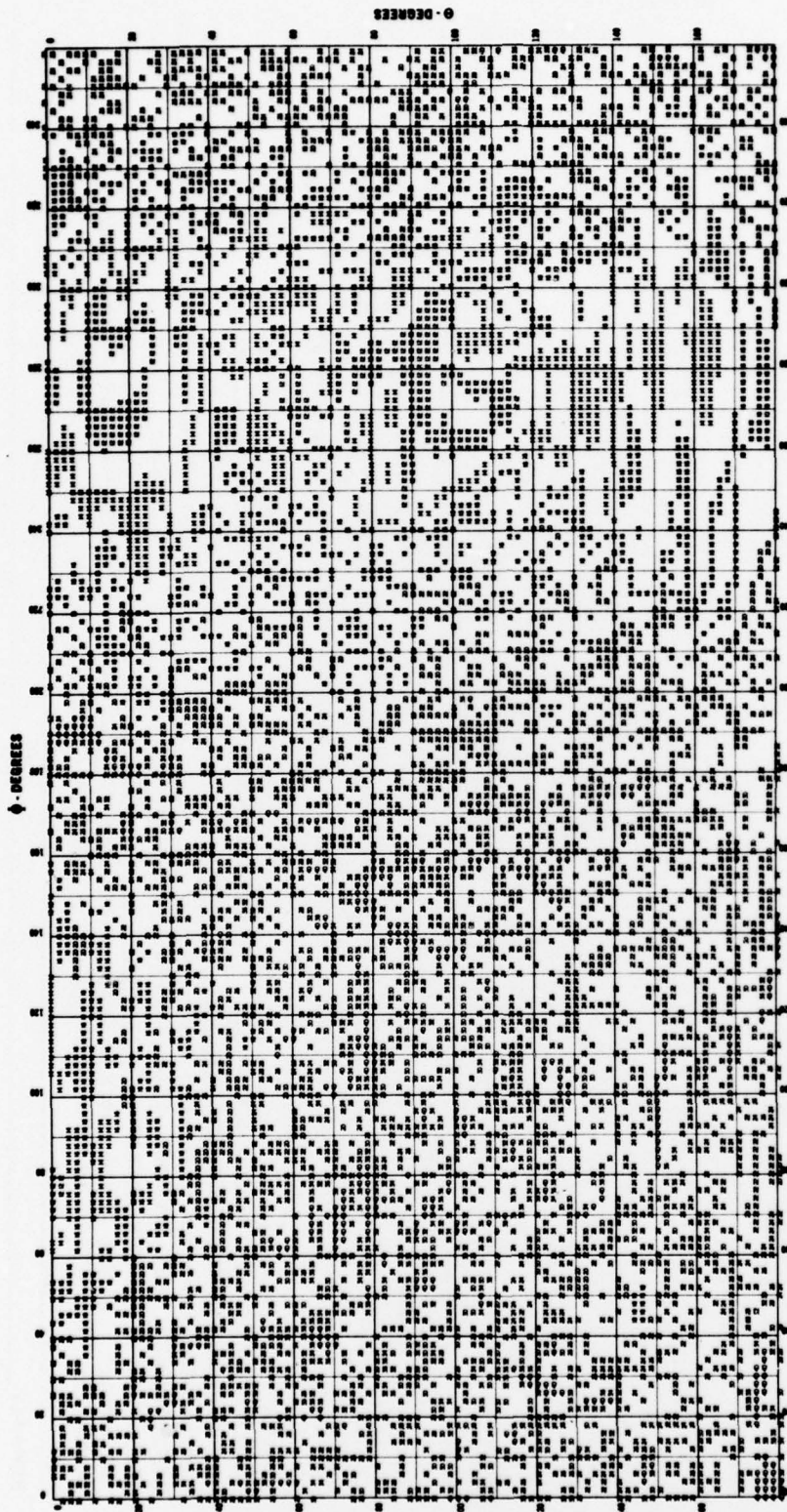
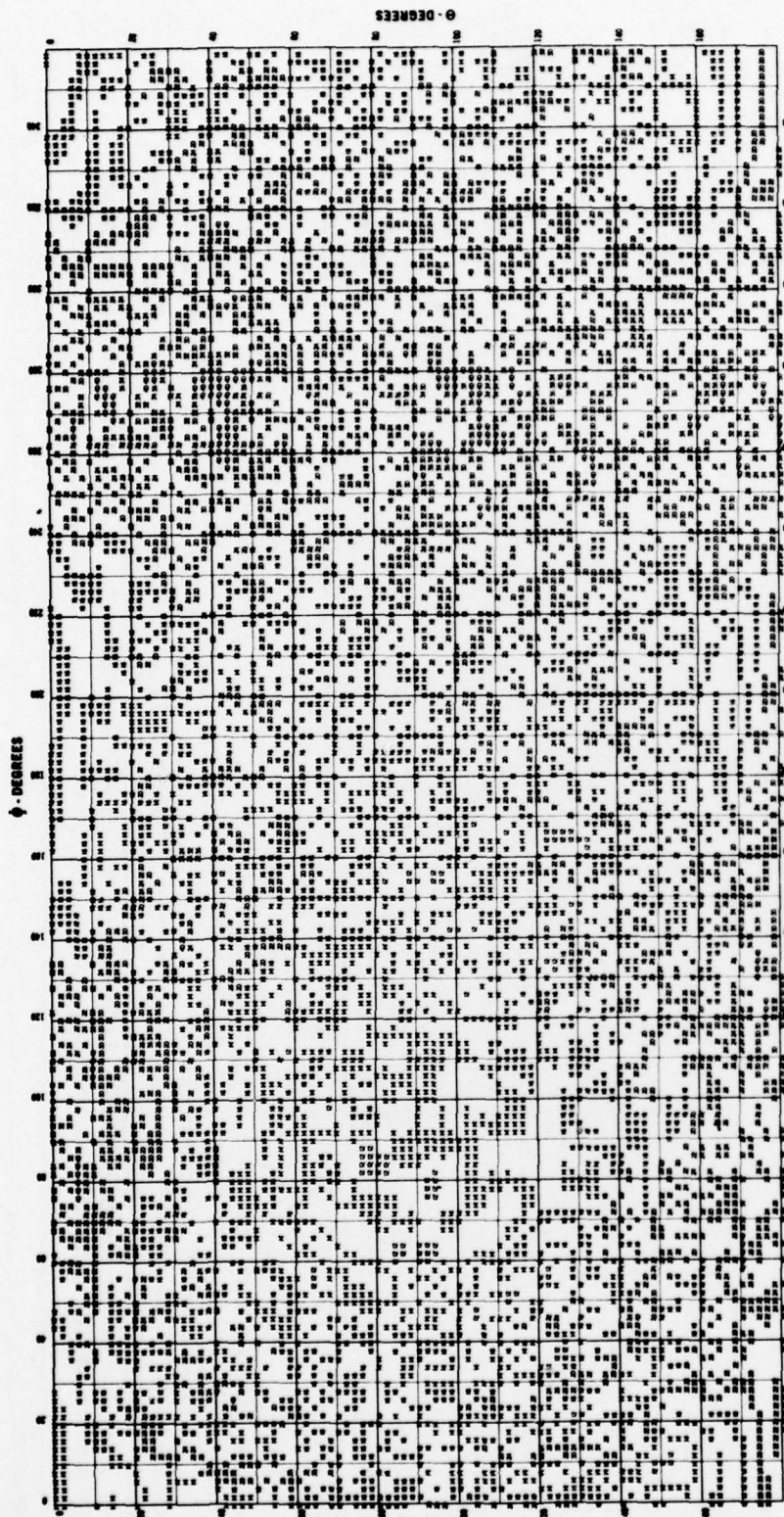


Figure 10. Model 55.510C Beacon Antenna



CONTRACT NO: # 19628-75-C-0072
 PSL FUND NO: 13201
 RANGE REQUEST NO: 2332
 DATE: February 17, 1977
 PATTERN MEASUREMENT FREQUENCY: 5.72 GHz
 PSL PHOTO NO: N/A
 ANTENNA MODEL NO: 55.510C
 MODEL SCALE: 1:1
 POLARIZATION COMPONENT RECORDED: 80
 ARRAY PHASING: N/A
 GAIN REFERENCE ANTENNA: TYPE AND S/N: S/N 3.9
 GAIN OF THE REFERENCE ANTENNA: -15dB
 DESCRIPTION OF TEST ANTENNA: Two element C-band Beacon; one element for each polarization.
 DESCRIPTION OF VEHICLE MOCKUP: 10.12 inch sphere flight unit
 THE NUMBER 10 IN THE POWER CONTOUR GRAPH CORRESPONDS TO -19 dB WITH RESPECT TO THE GAIN REFERENCE ANTENNA.
 DESCRIPTION OF THE GAIN MEASUREMENT: Reference PSL gain pattern No. 092218
 REMARKS:

Figure 11. Model 55.510C E0 Beacon Radiation Contour Plot



CONTRACT NO: P 19628-75-C-0072 PSL FUND NO: 13201 RANGE REQUEST NO: 2372 DATE: February 17, 1977
 PATTERN MEASUREMENT FREQUENCY: 5.72 GHz PSL PHOTO NO: N/A ANTENNA MODEL NO: 55.510C MODEL SCALE: 1:1
 POLARIZATION COMPONENT RECORDED: HP ARRAY PHASING: N/A
 GAIN REFERENCE ANTENNA: TYPE AND S/N: SGR 3.9 GAIN OF THE REFERENCE ANTENNA: +19dB
 DESCRIPTION OF TEST ANTENNA: Two element C-band Beacon, one element for each polarization.
 DESCRIPTION OF VEHICLE MOCKUP: 10.12 inch sphere flight unit
 THE NUMBER ₁₀ IN THE POWER CONTOUR GRAPH CORRESPONDS TO -19 dB WITH RESPECT TO THE GAIN REFERENCE ANTENNA.
 DESCRIPTION OF THE GAIN MEASUREMENT: Reference PSL gain pattern No. 092218
 REMARKS:

Figure 12. Model 55.510C Eθ Beacon Radiation Contour Plot

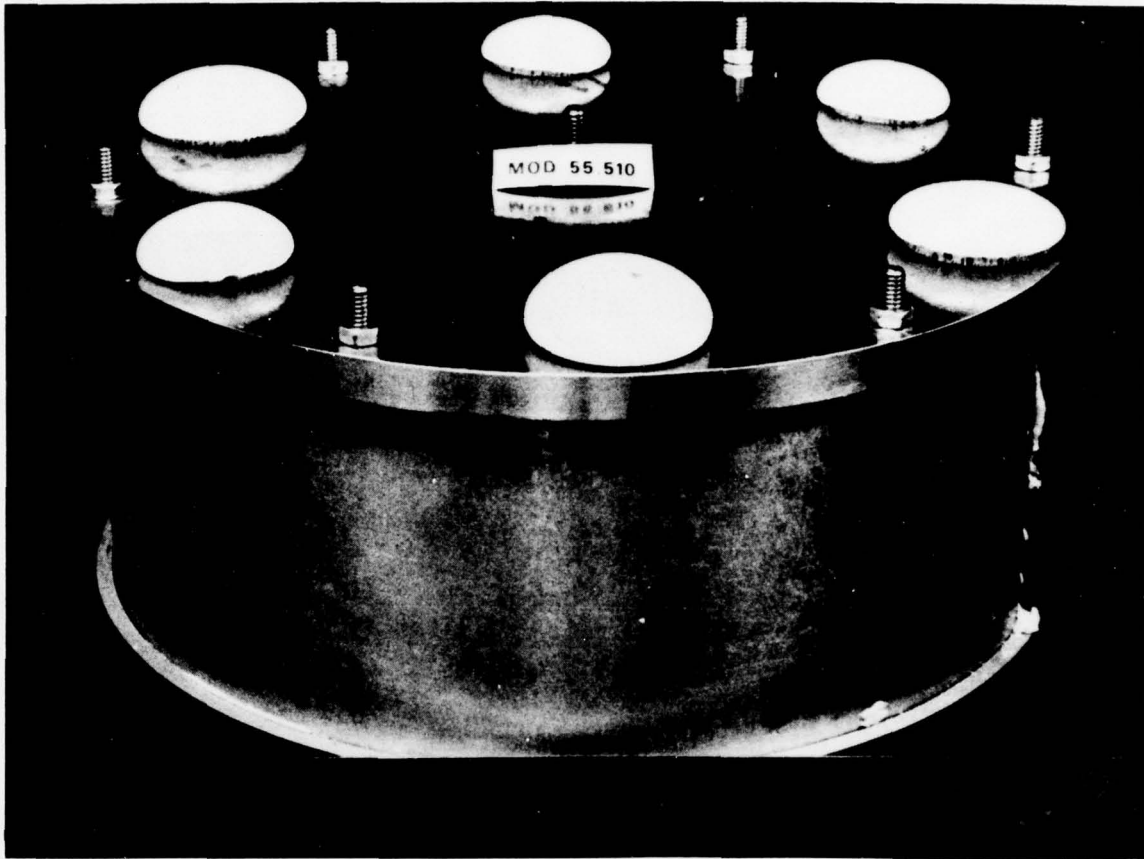


Figure 13a. Model 55.510 Potting Mold

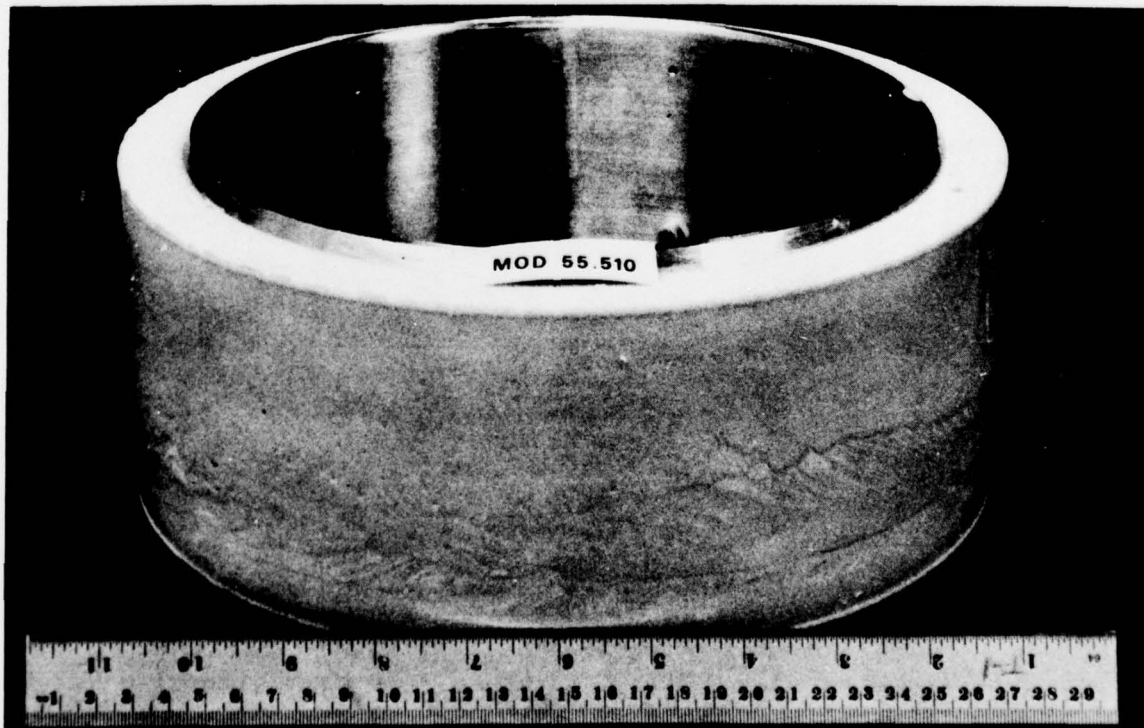


Figure 13b. Model 55.510 Foamed

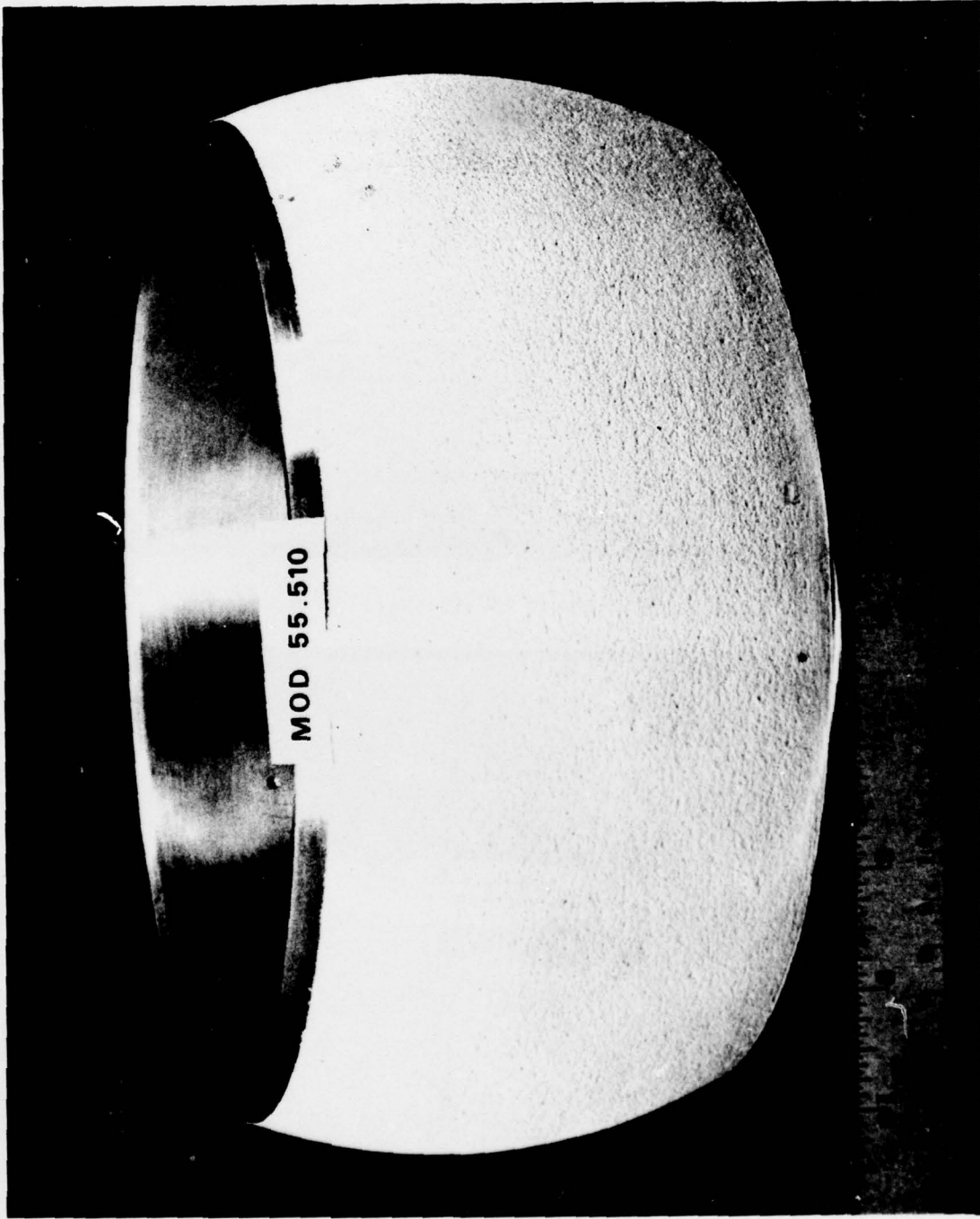


Figure 14. Model 55.510 After Being Machined

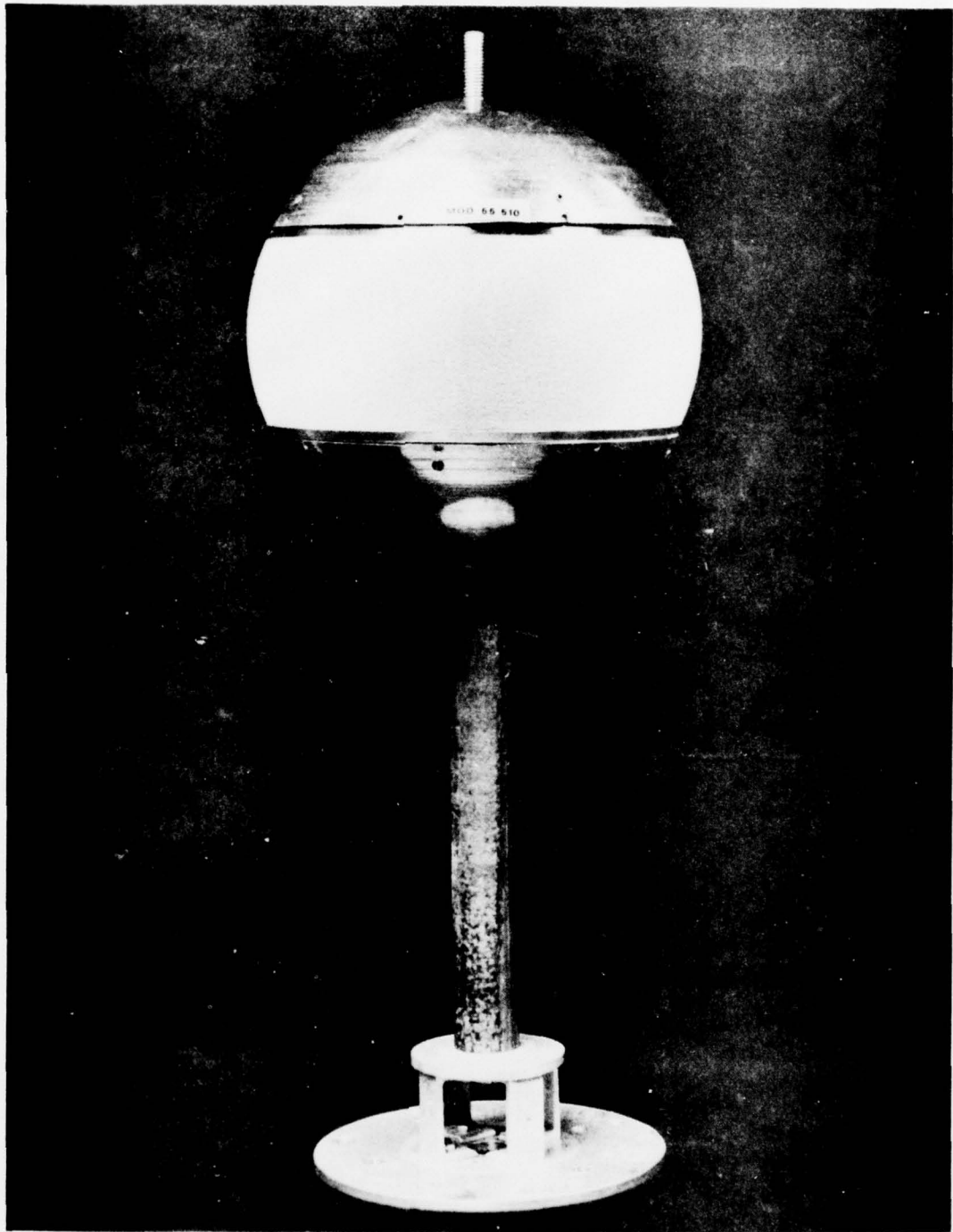


Figure 15. Model 55.510 Mock-up

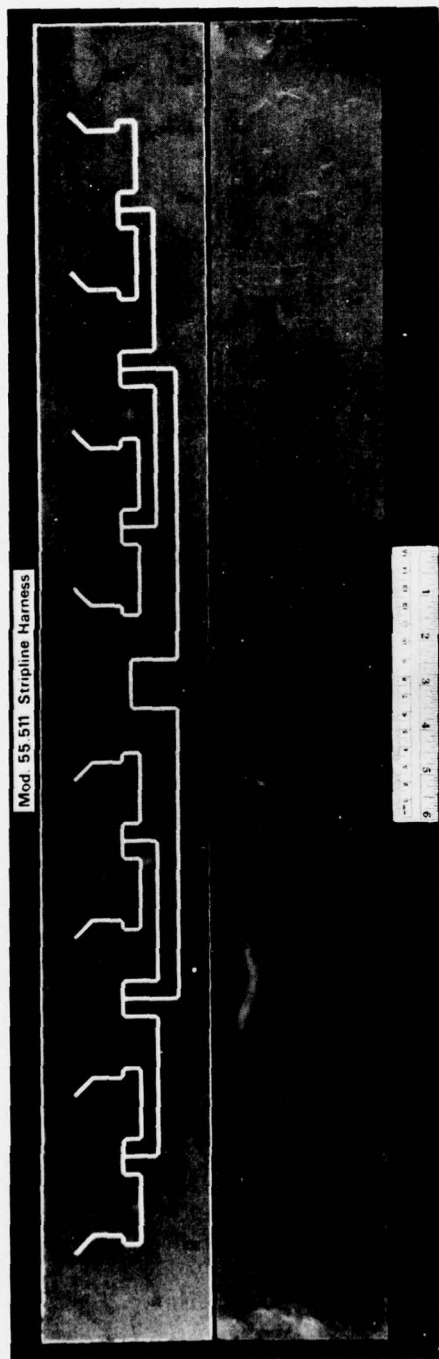


Figure 16a. Model 55.511 Stripline Harness

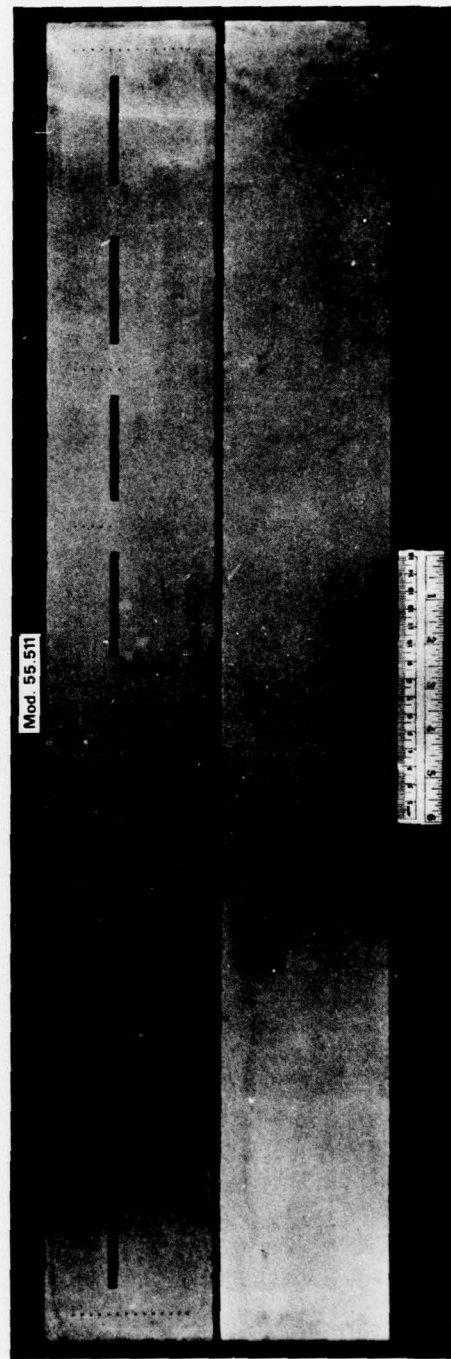


Figure 16b. Model 55.511 Radiating Surface

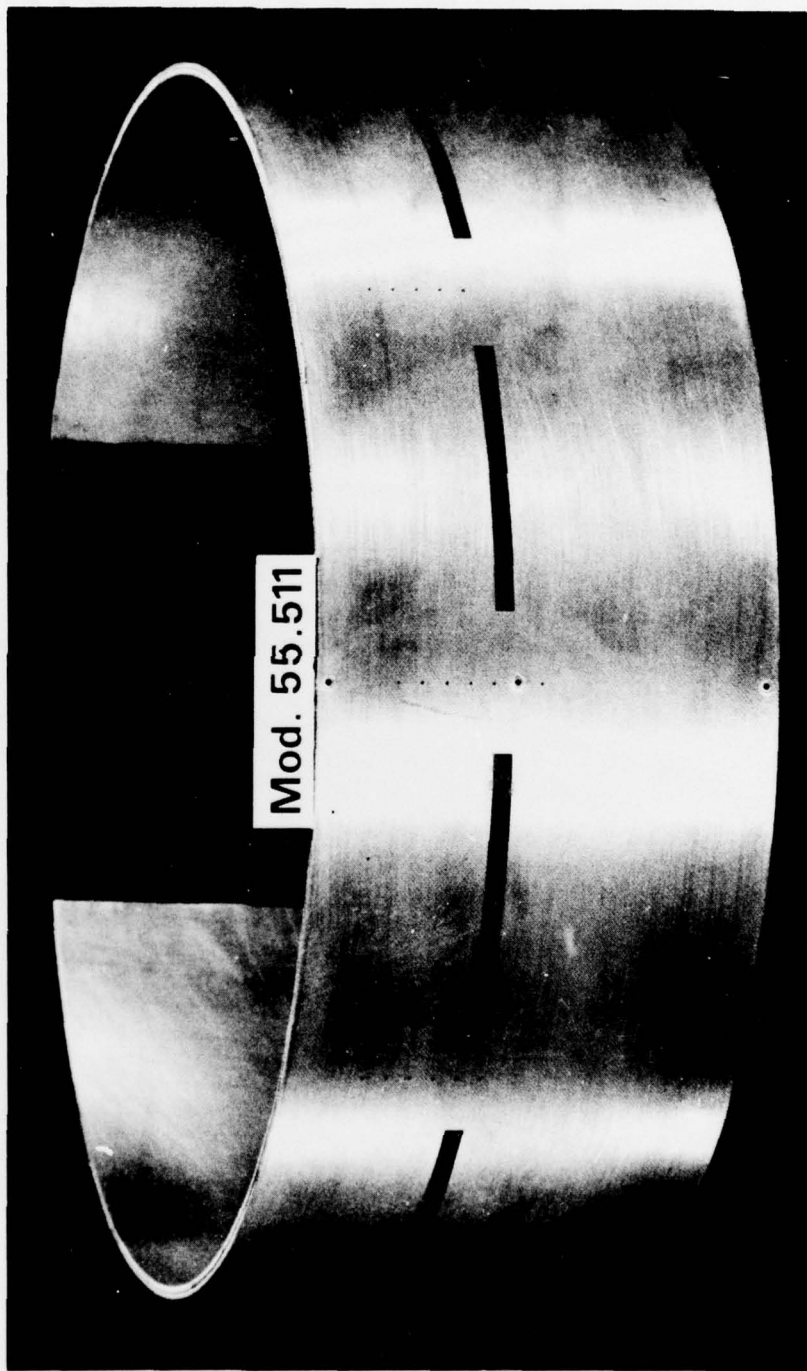


Figure 17. Model 55.511 S-band TM Antenna

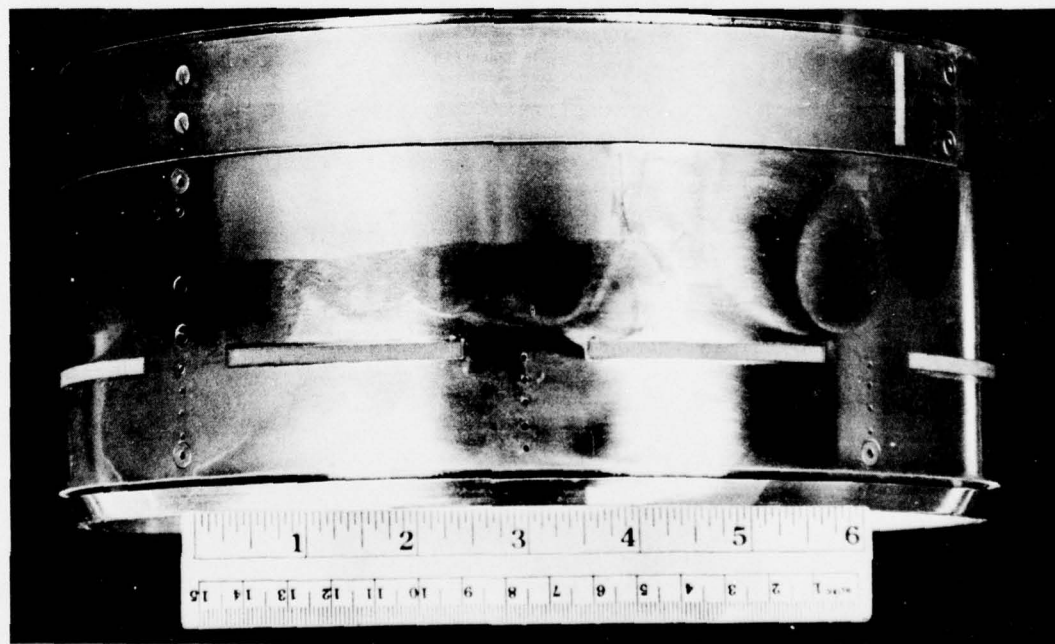
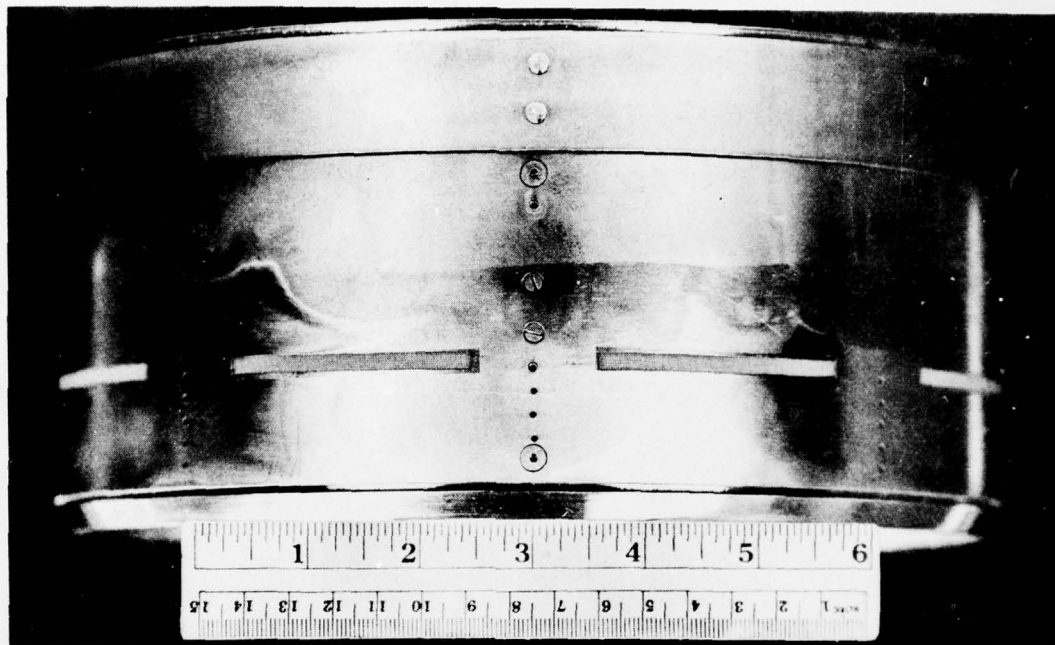


Figure 18. Model 55.511 S-band and C-band

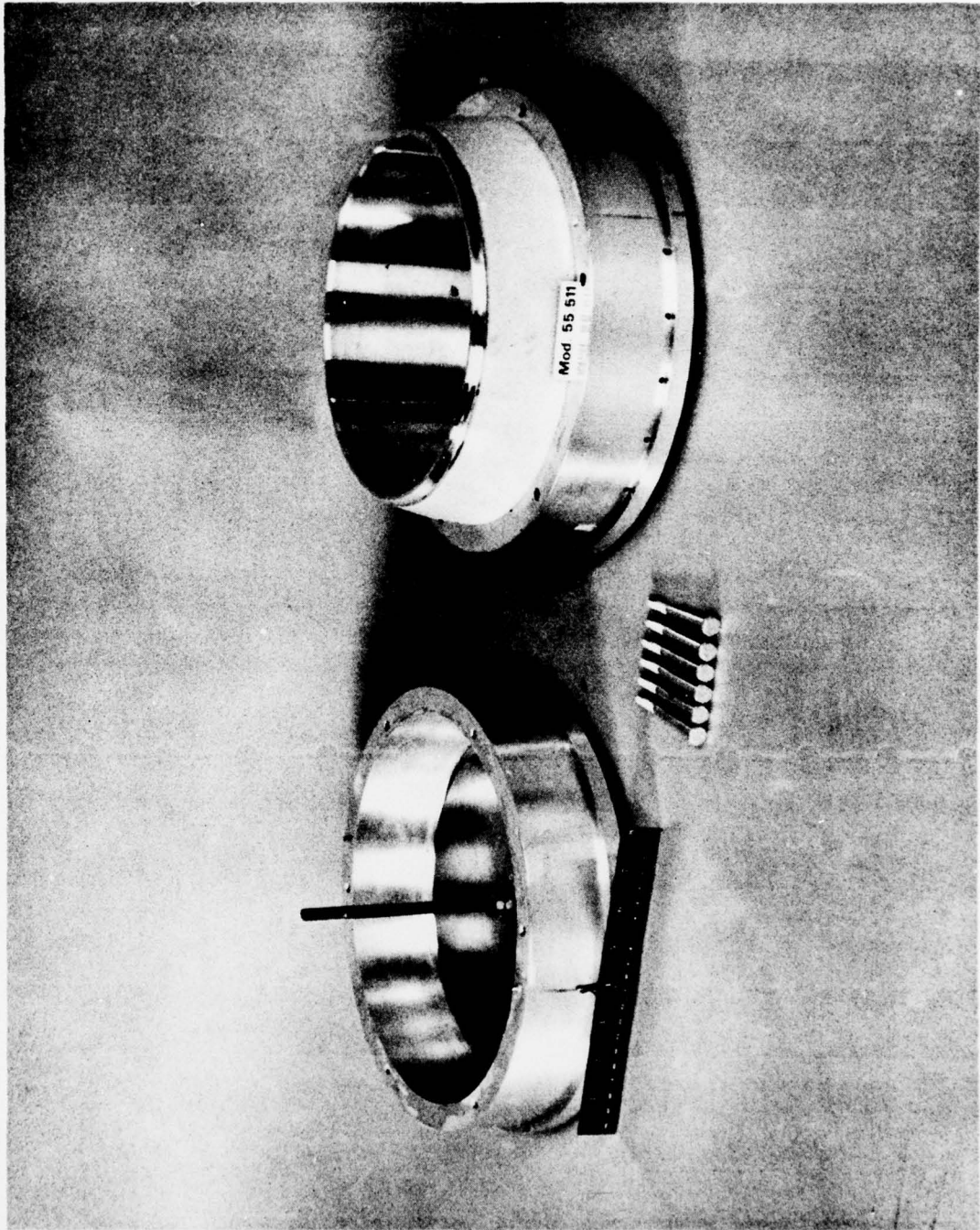


Figure 19. Model 55.511 Potting Mold

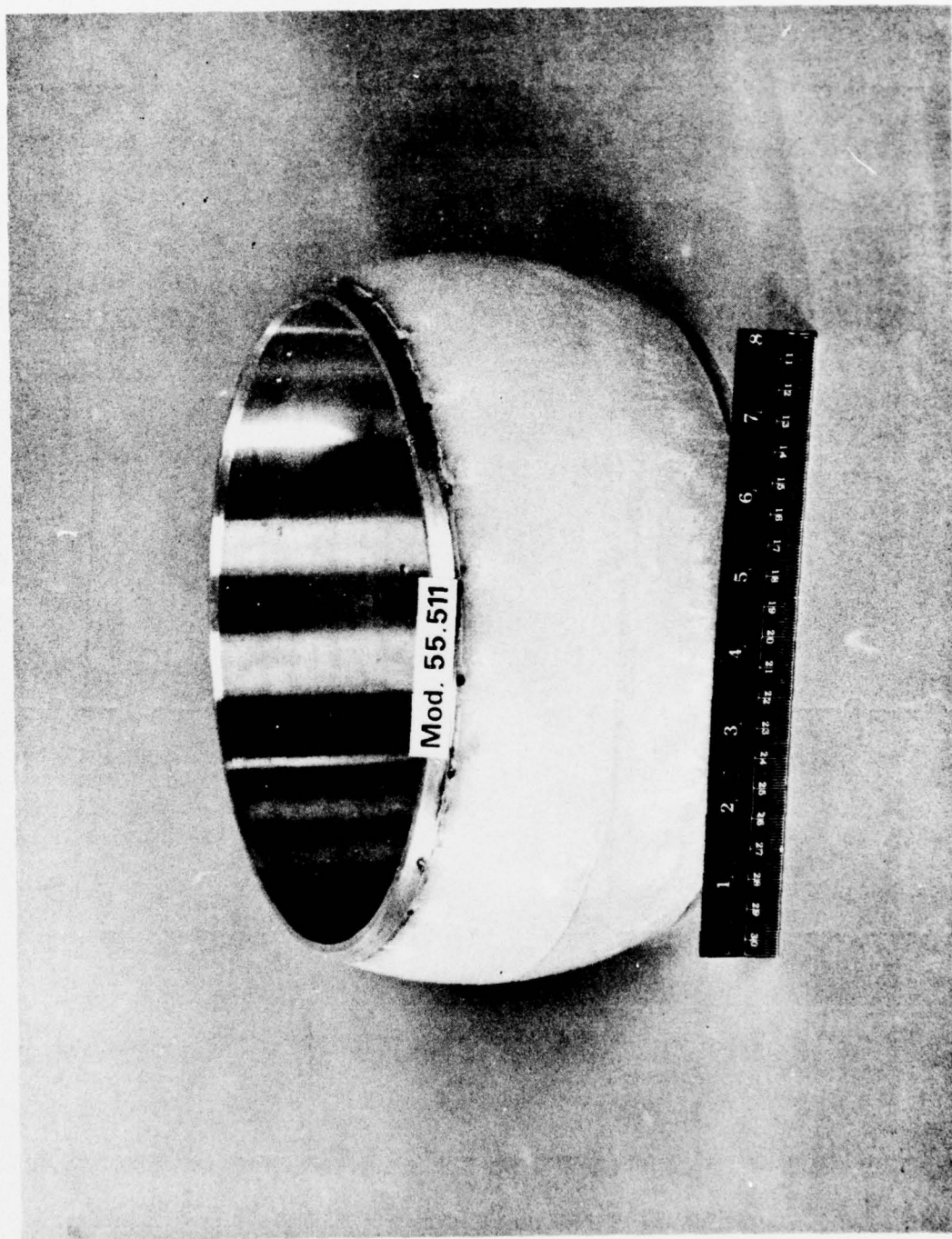


Figure 20. Model 55.511 Ready to Paint

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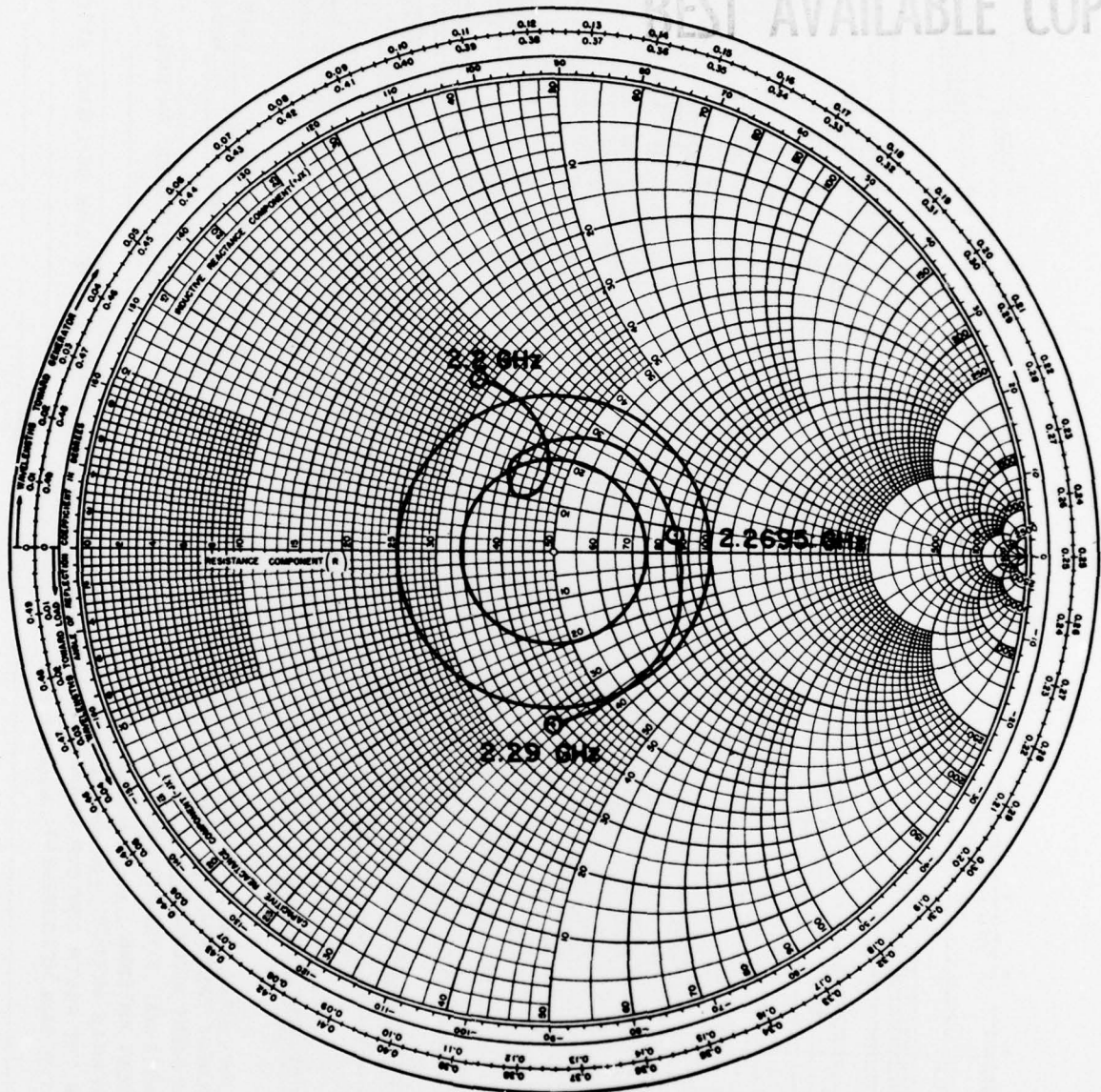
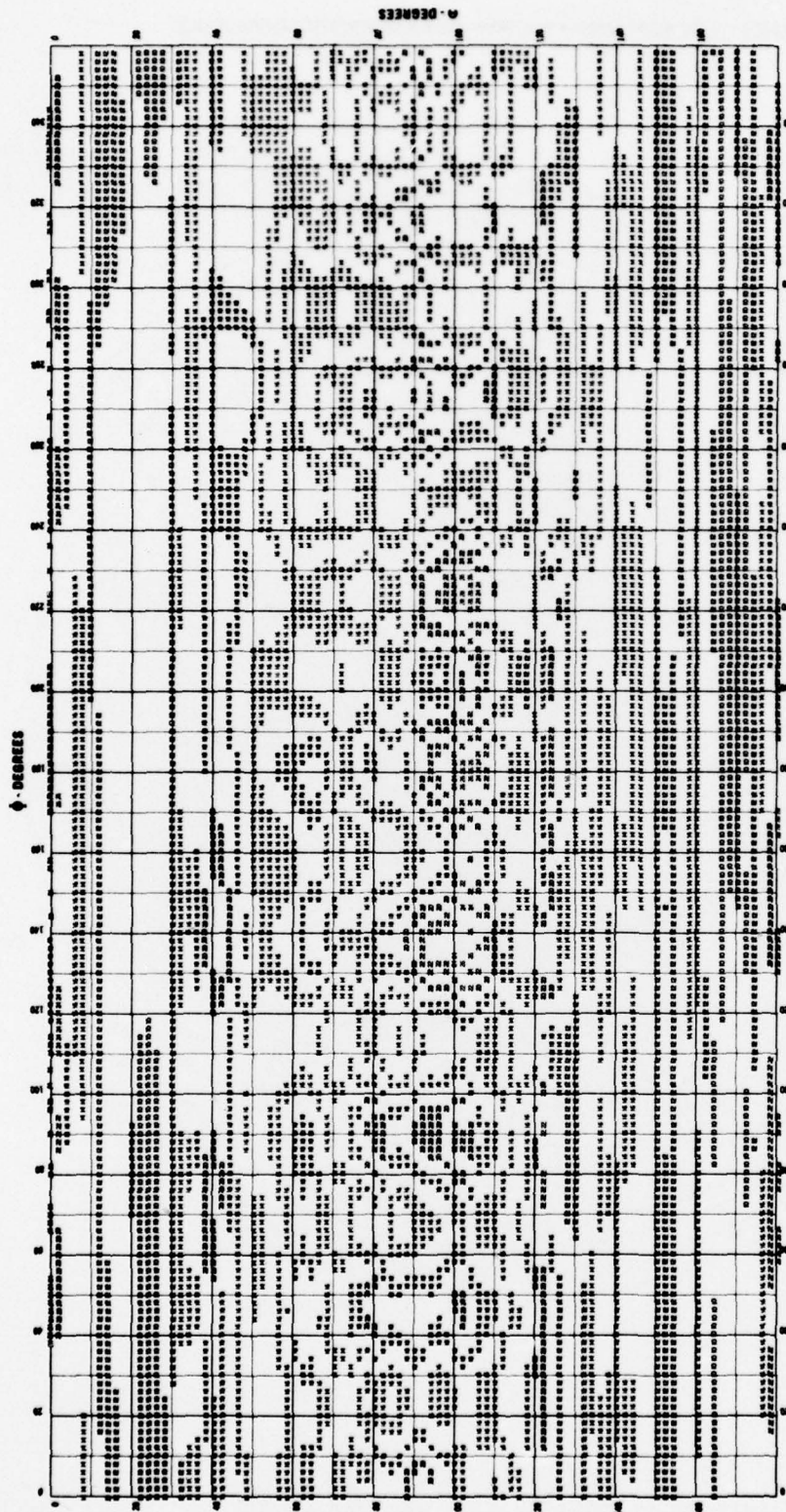


Figure 21. Model 55.511 TM VSWR Curve

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CONTRACT NO: W 19638-75-C-0072 PSL FUND NO: 13201 RANGE REQUEST NO: 2323 DATE: Jan. 5, 1977
 PATTERN MEASUREMENT FREQUENCY: 2.2695 GHz PSL PHOTO NO: W/A ANTENNA MODEL NO: 55.511 MODEL SCALE: 1:1
 POLARIZATION COMPONENT RECORDED: E ARRAY NO: W/A ARRAY PHASING: W/A
 GAIN REFERENCE ANTENNA: TYPE AND S/N: SCR 1.7 GAIN OF THE REFERENCE ANTENNA: +16 db
 DESCRIPTION OF TEST ANTENNA: S-band TM and C-band beacon tripole antennas
 DESCRIPTION OF VEHICLE MOCKUP: 10 inch sphere flight unit
 THE NUMBER 10 IN THE POWER CONTOUR GRAPH CORRESPONDS TO -16 db WITH RESPECT TO THE GAIN REFERENCE ANTENNA.
 DESCRIPTION OF THE GAIN MEASUREMENT: Reference PSL gain pattern No. 04528
 REMARKS: The feedpoint of the array was designated as $\theta = 0^\circ$

Figure 22. Model 55.511 TM Radiation Contour Plot

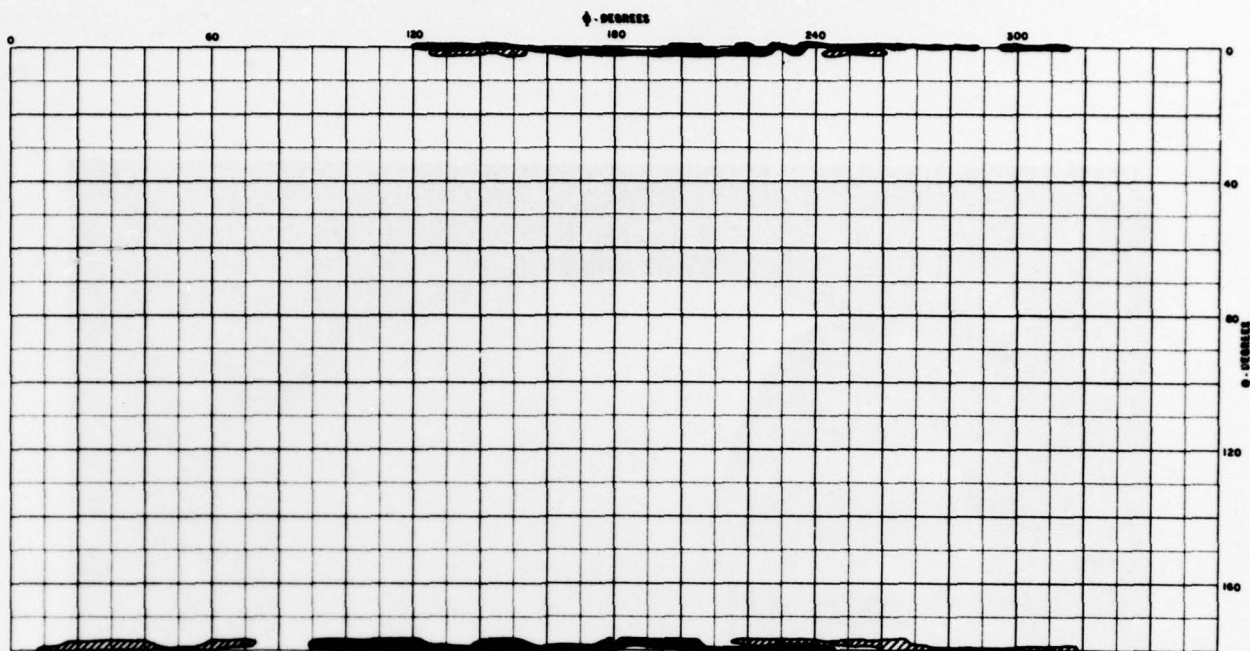


Figure 23a. Model 55.509 Simplified TM Radiation Plot

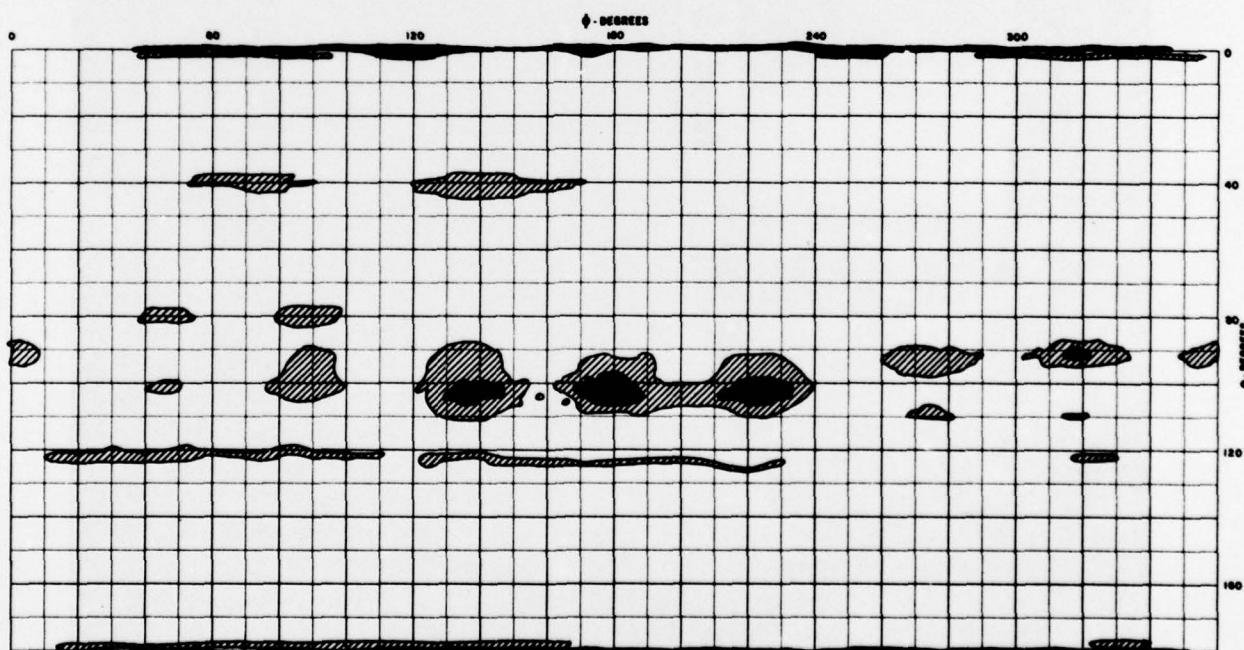


Figure 23b. Model 55.511 Simplified TM Radiation Plot

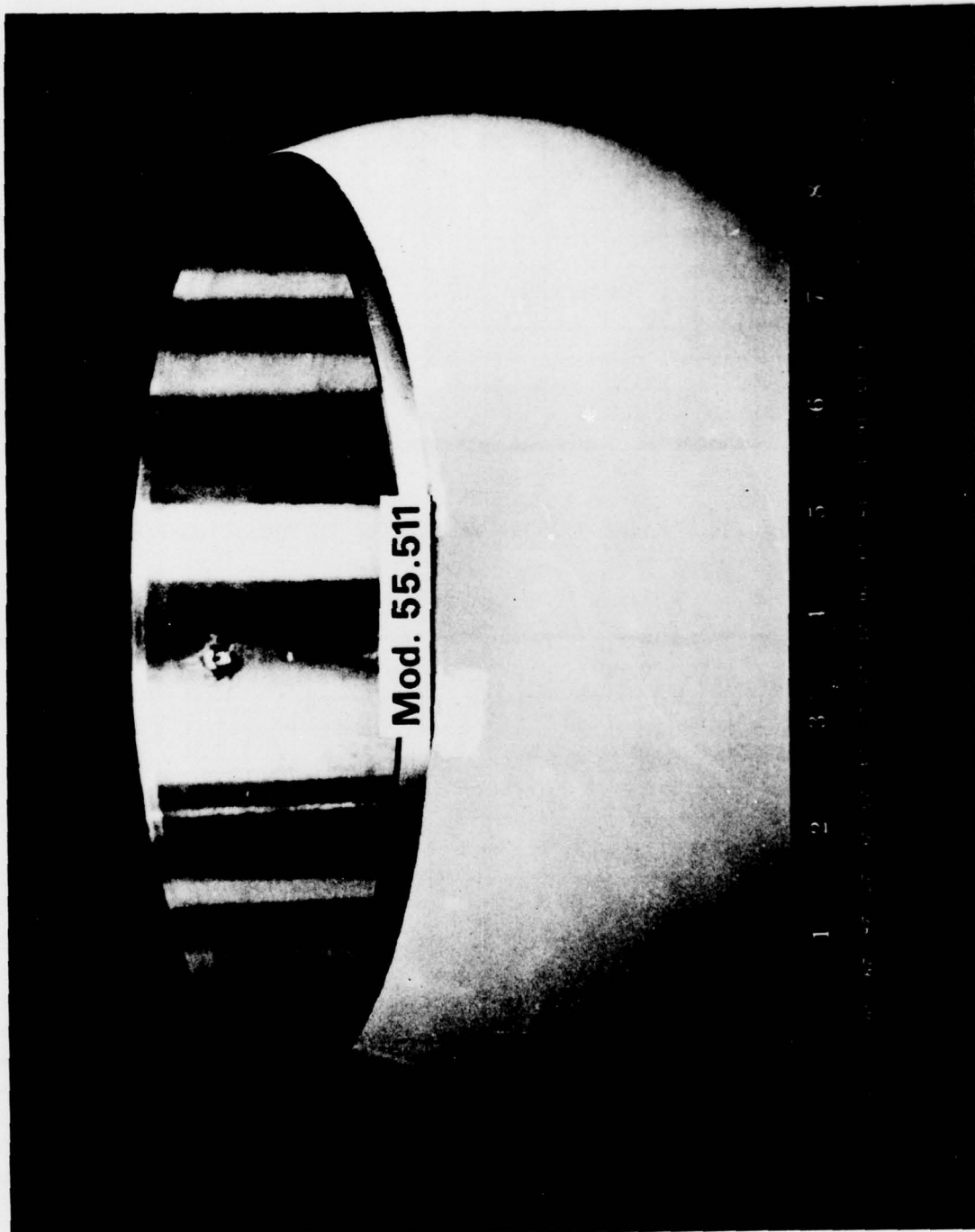


Figure 24. Model 55.511 Flight Unit