6144
P-23

NASA Technical Memorandum 102632

Experimental Measurements of Space Station Antenna Patterns at 60 GHz for EM Analysis Verification

W. Robert Young, Berkley A. Langford, Jr., and Roger K. Vaughan

October 1991

National Aeronautics and Space Administration

Langley Research Center
Hampton, Virginia 23665-5225

NASA Technical Memorandum 102632

ANTENNA SCATTERING AT 60 GHz
MEASURED IN A COMPACT RANGE

W. Robert Young, Berkley A. Langford, Jr.,
and Roger K. Vaughan

October 1991

Attached is a corrected copy of NASA Technical Memorandum 102632. An incorrect title was shown on the report which was previously sent to you. The title of the report should be "Experimental Measurements of Space Station Antenna Patterns at 60 GHz for EM Analysis Verification." Please destroy all copies of the report that you previously received.

Issued January 1992

EXPERIMENTAL MEASUREMENTS OF SPACE STATION
ANTENNA PATTERNS AT 60 GHZ FOR EM ANALYSIS VERIFICATION

SUMMARY

In 1985, the Antenna and Microwave Research Branch (AMRB) at the Langley Research Center initiated a research effort to develop the analytical methods for predicting the radiation performance of antennas on various structural concepts being considered for Space Station operations. Since the design, development, and subsequent performance of spacecraft antennas is largely dependent upon the antenna concept, size of the vehicle in wavelengths, mounting location, and potential obscuration effects, due to line-of-site blockage, it was expected that the availability of a special analysis code which could include these design parameters would be very valuable for Space Station configuration studies. So, in that regard, AMRB initiated a research program which included the development of analytical methods for radiation pattern predictions as well as an experimental program to verify the EM analytical methods through actual antenna measurements. The analytical effort has been reported previously (ref. 1) and was developed by the Ohio State University ElectroScience Laboratory as part of the Langley research program.

Therefore, the purpose of this report is to document the experimental pattern test approach, present some typical experimental data, and to show a comparison between selected experimental and analytical data. Several other antenna types and locations were investigated, but only representative results are discussed in this report.

INTRODUCTION

To satisfy all the communication, navigation, and tracking requirements of the proposed Space Station, several onboard antennas will be needed. Due to the large physical size of the Space Station, making full-scale antenna pattern measurements is not practical, therefore, methods must be developed that can be used to predict the performance of these antennas. One such method, a computer program for analyzing antenna performance on complex structures such as the Space Station, was recently developed through a joint effort between the Ohio State University ElectroScience Laboratory and Langley Research Center, Antenna and Microwave Research Branch.

The computer program, the Numerical Electromagnetic Code - Basic Scattering Code (NEC-BSC), was used to calculate the far-field radiation patterns for a 60 GHz broadbeam slot antenna mounted on a 1/30 scale model of the middle section of the Space Station. A 2 GHz frequency on the full-scale Space Station was simulated in this manner. Measurements were made at 60 GHz in the Compact Range Pilot Facility using a precision 1/30 scale model of the Space Station to provide experimental data used for verification of the NEC-BSC analytical results.

The purpose of this report is to document the methods used to make these measurements, present some typical experimental, and show a comparison between selected experimental and analytical data. The pertinent details of the test configuration and measurement procedures are presented as well. Several other antenna types and locations were investigated, however, the results are not discussed herein.

TEST CONFIGURATION

The Space Station model (fig. 1) was mounted on a Scientific Atlanta model 53 positioner in the AMRB Compact Range Pilot Facility (fig. 2). The positioner is configured in a manner to allow the making of both azimuth and roll patterns. The test signal is transmitted from a low gain feed antenna, Scientific Atlanta part no. 253342, located at the focal point of the compact range reflector.

A model 1783 Scientific Atlanta receiver with the addition of Scientific Atlanta model 1784/1785 down converters extended the frequency range of the receiver to 60 GHz. One of the down converters was used to provide a sample of the transmitted signal so the receiver could be phase locked to the source. The other down converter was used in the received signal path and was located as close as possible to the receive horn to minimize waveguide loss (see the block diagram in fig. 3).

A Varian model 2101A16 Klystron was chosen as the signal source for noise considerations. It was found that at least 100 mW of source power was required for an acceptable noise level near the -40 dB signal level. Unfortunately, the residual FM modulation on this Klystron made it impossible to use the automatic data acquisition feature of the Scientific Atlanta 2080 antenna/radar cross section analyzer. The incidental FM caused the receiver to occasionally loose phase lock which in turn causes the automatic data acquisition to abort the data file being generated. Loss of phase lock would occur on an average of three or four times during the time required to generate a single pattern cut.

TEST ANTENNAS

The antenna used for these measurements was fabricated from a section of open ended WR-15 waveguide which was terminated in a 2-in. square ground plane (fig. 4). This antenna was selected because it has a broad radiation pattern which simulates the class of antennas that is being considered for use as the Space Station communications antenna.

Figure 1 shows the location on the Space Station model chosen for mounting the antenna. Antenna patterns were measured with the antenna in the position shown and in the 90° rotated position relative to the Space Station model. Each time the Space Station antenna was rotated 90°, the source antenna was also rotated 90° for copolar operation (fig. 5). The extra vertical and horizontal lines shown on the drawing are used to indicate the axis of rotation. The arrows around these lines indicate the direction the model rotates to increase the indicated angle. This illustration shows the Space Station with the axlmuth angle at +90° and the roll angle at 23°. In this position, the front surfaces of the model are perpendicular to the received signal path.

RESULTS

Measurements were made in the Compact Range Pilot Facility at the Langley Research Center. These measurements were made at 60 GHz using a broadbeam slot antenna. Experimental data from the measurements are presented in figures 5 thru 11. In addition, the analytical results from the computer program (NEC-BSC) are also shown (figs. 12-16 and ref. 1).

By making a comparison of the analytical and experimental data, one can see that there is a close agreement between these data that were generated by different methods.

CONCLUSION

In conclusion, our test showed that there was a very good comparison between the measured and calculated patterns, and figure 12 compares the measured and calculated results from the antenna measurements. It is also noted that the large reflector of this facility was used at 60 GHz for the first time with these tests.

REFERENCES

1. Bracalente, E. M.; Gilreath, M. C.; and Marhefka, R. J.: Development of Numerical Electromagnetic-Basic Scattering Code for Space Station Applications: A Description and Antenna Chamber Evaluation. Published at the IEEE AP-S International Symposium and URSI Radio Science Meeting, Paper No. 75-1, Dallas, Texas, May 7-11, 1990.

Component/Parts List

M1, M3 - Mixers, Hughes Model 47444H1002A

M2, M4 - Mixers, Scientific Atlanta Model 14-5

AT1, AT2 - Attenuators, TRG Model V510

K1 - KLYSTRON, Varian Model VRE-2101A16

PS1 - KLYSTRON, Power Supply, Polytechnic Institute of New York Model 819-A

C1 - Converter, Scientific Atlanta Model 1785

C2 - Converter, Scientific Atlanta Model 1784

LO Unit - Scientific Atlanta Model 1780

Receiver - Scientific Atlanta Model 1783

DC1 - Directional Coupler, Hitachi Model M2101 10dB

Transmit Antenna - Scientific Atlanta Part 253342 40.0 - 60.0 GHz

Receive Antenna - See Fig. #1

* Ref. is a 949.22 MHz signal used to phase lock the 1784/85.

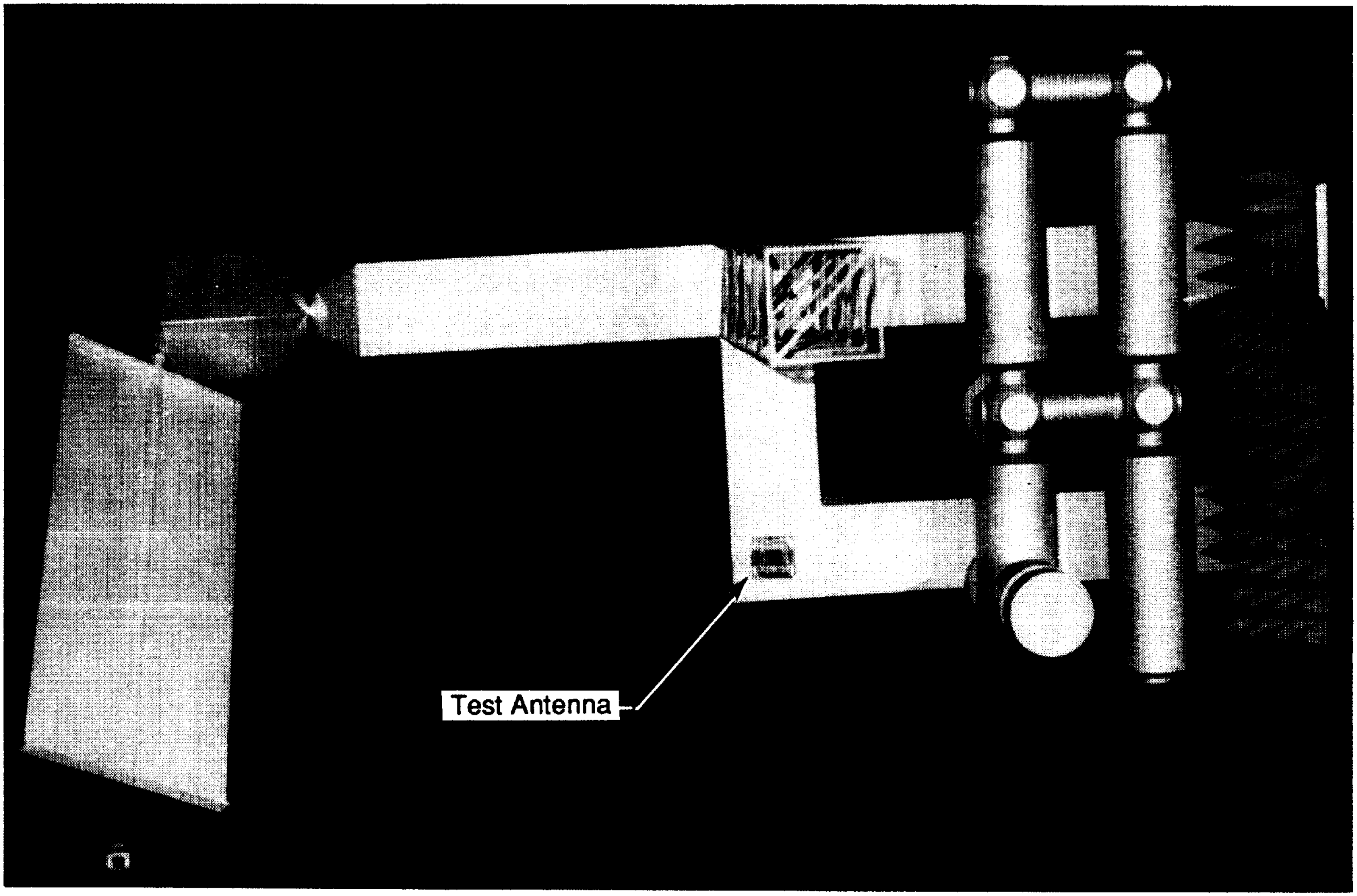


Figure 1.- 30:1 Scale model of Space Station.

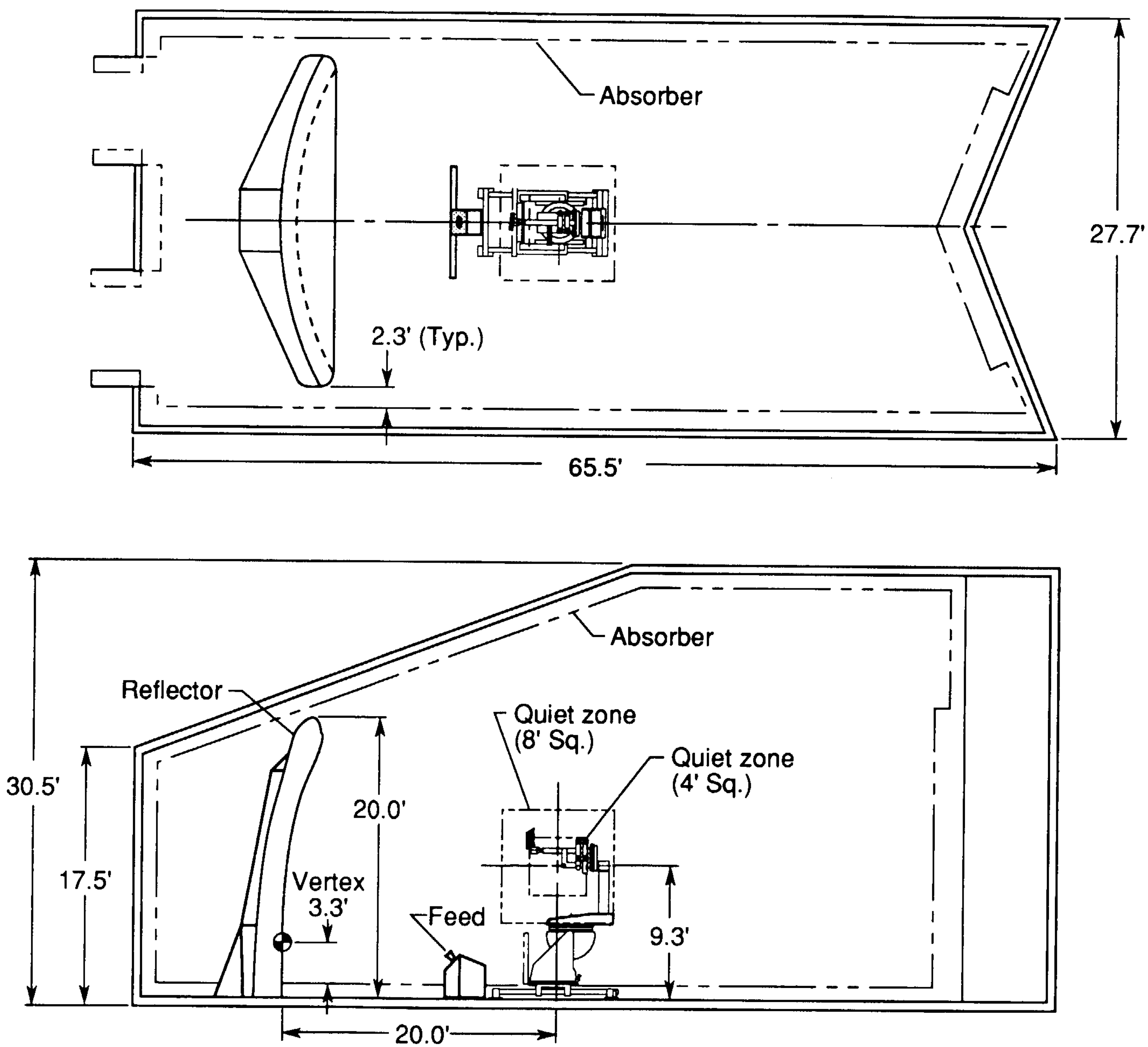


Figure 2.- AMRB compact range test facility.

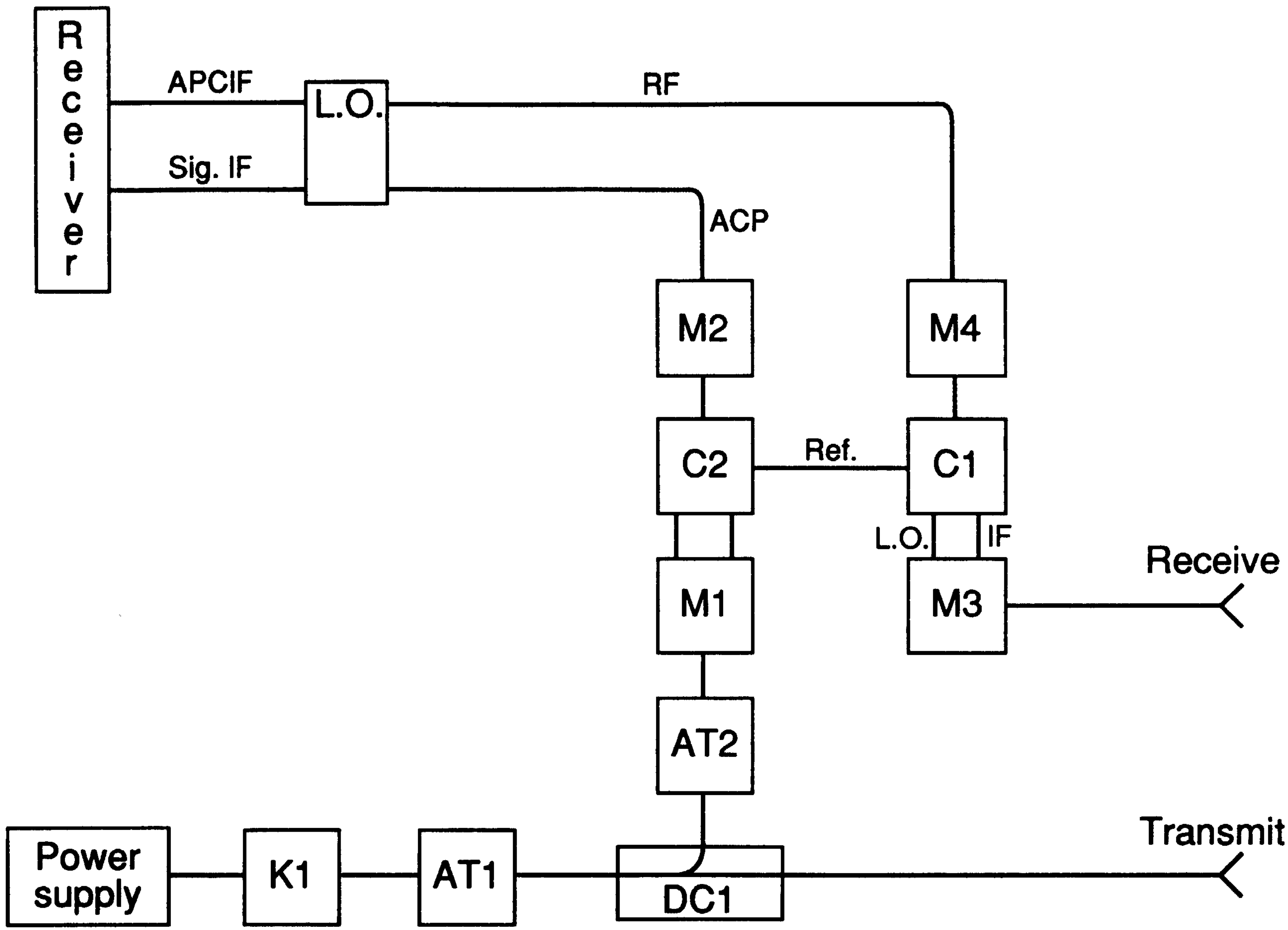


Figure 3.- Block diagram of 60GHz antenna system.

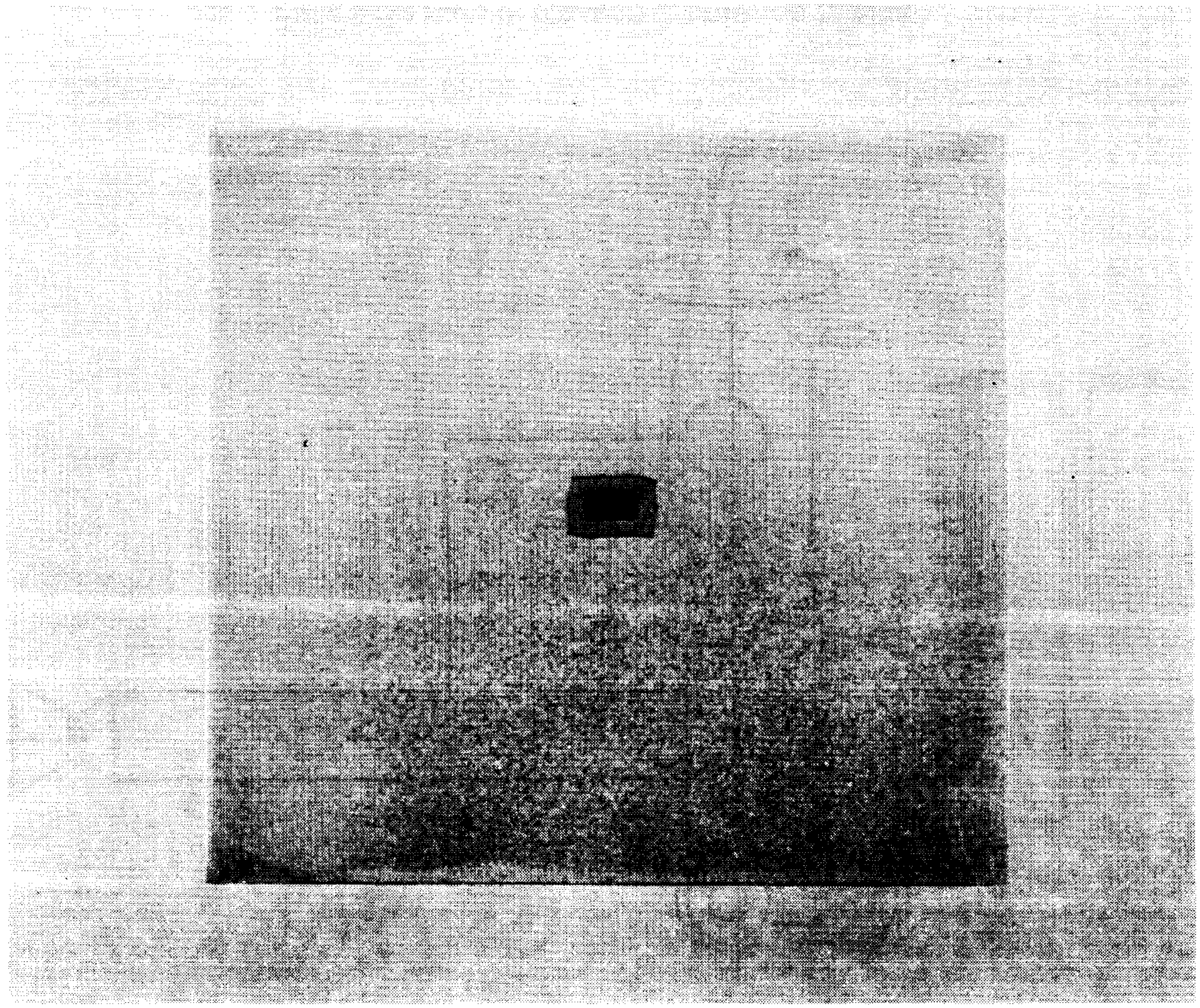


Figure 4.- 60GHz antenna used in test.

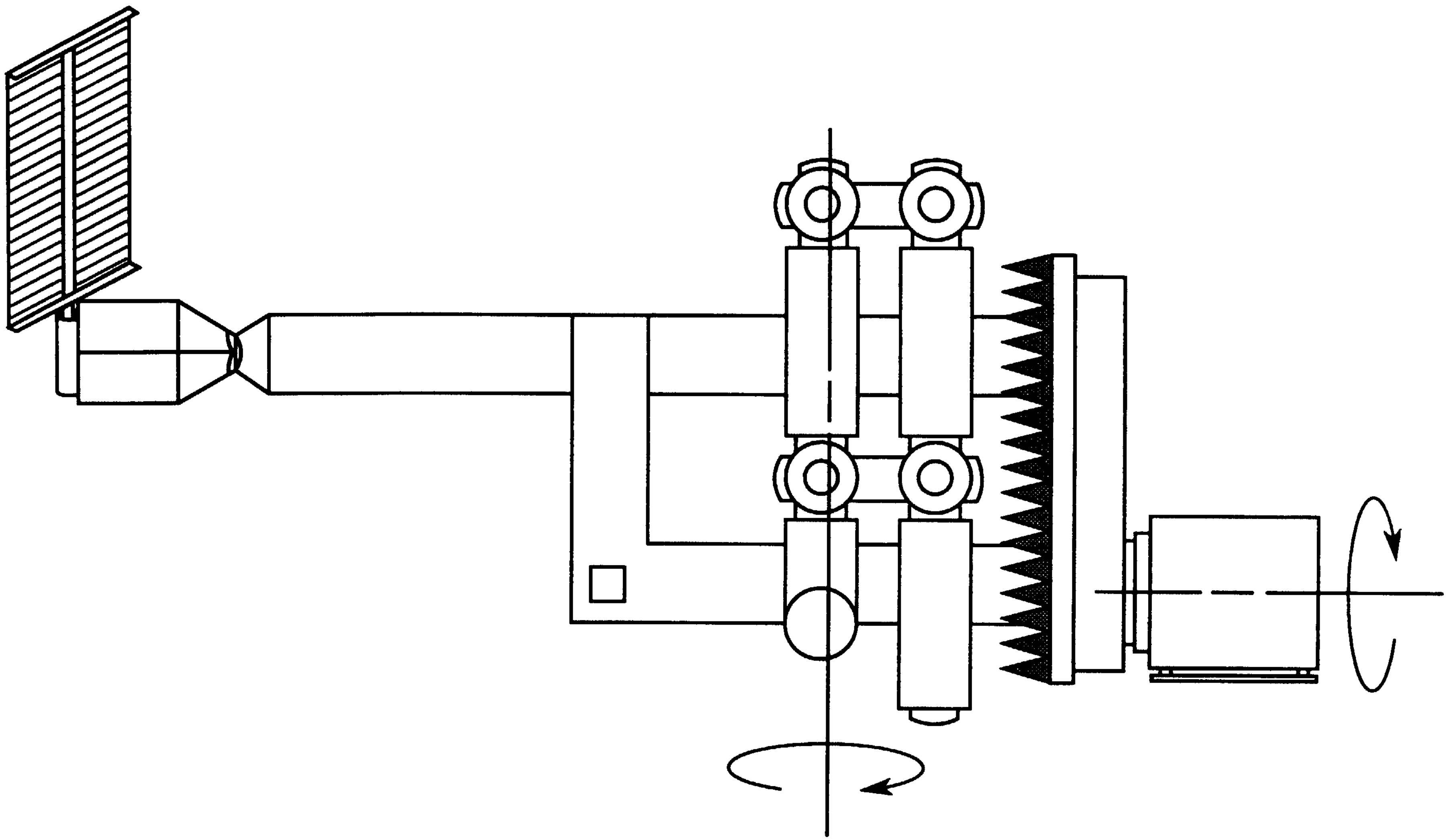


Figure 5.- Axis of rotation & antenna position.

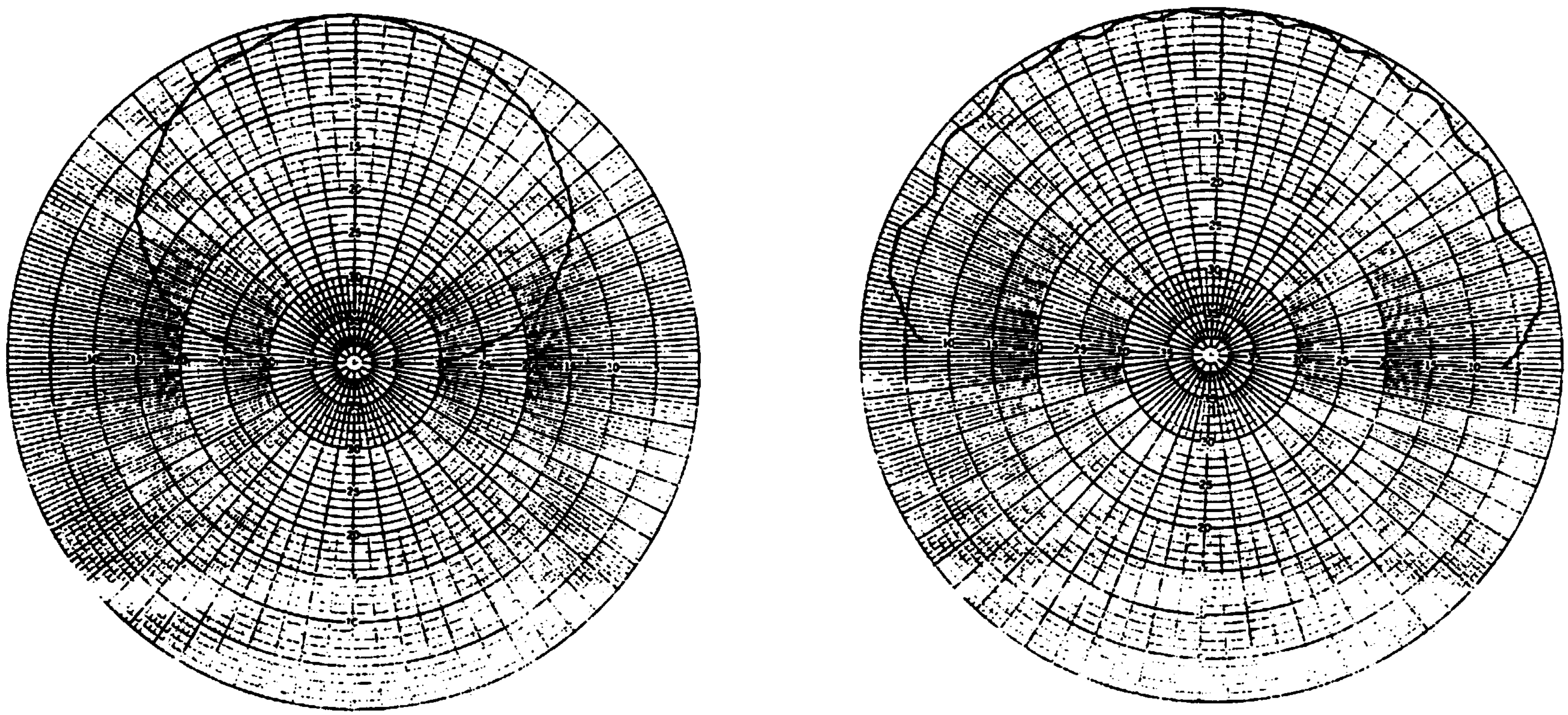


Figure 6.- Azimuth and roll cuts of open-ended wave guide horizontal polarization, w/o Space Station.

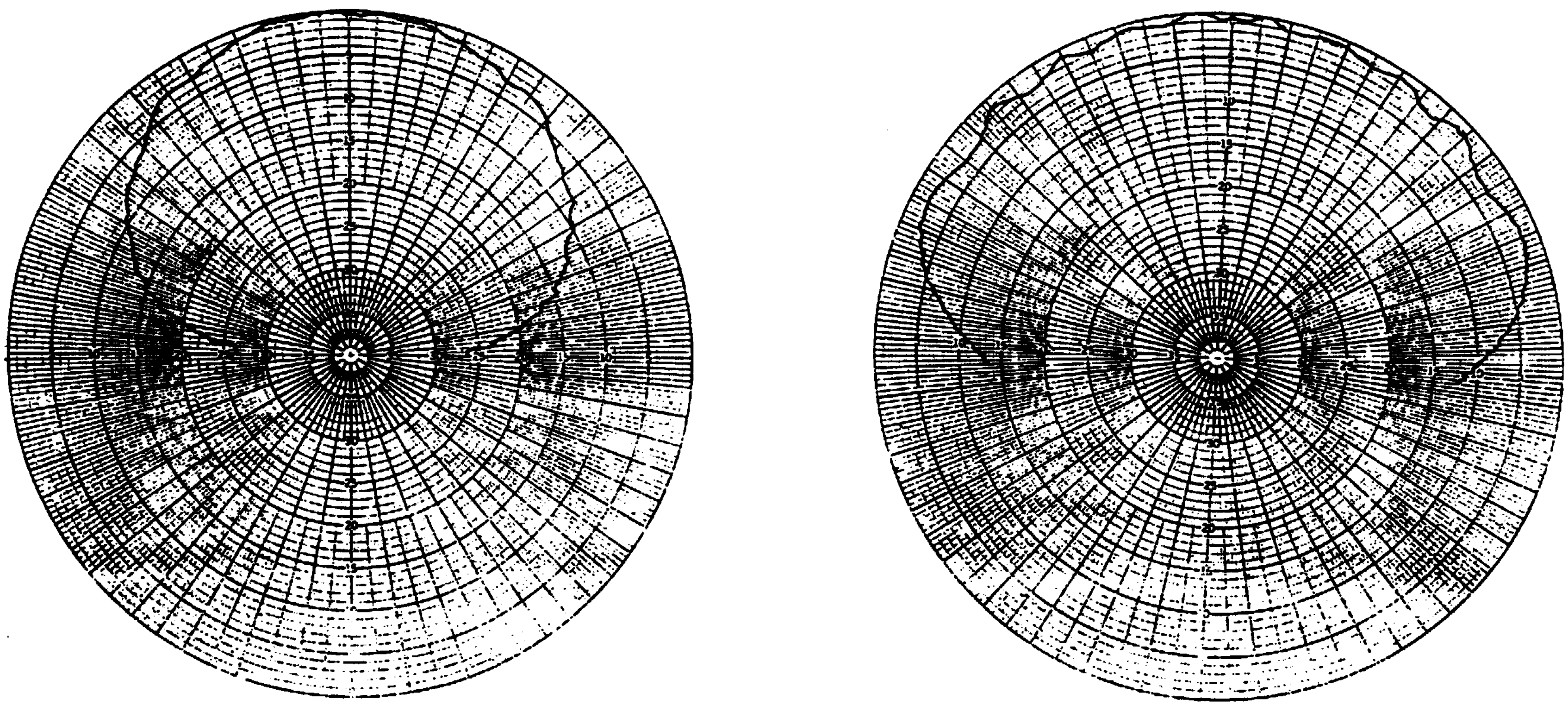


Figure 7.- Azimuth and roll cuts of open-ended wave guide vertical polarization, w/o Space Station.

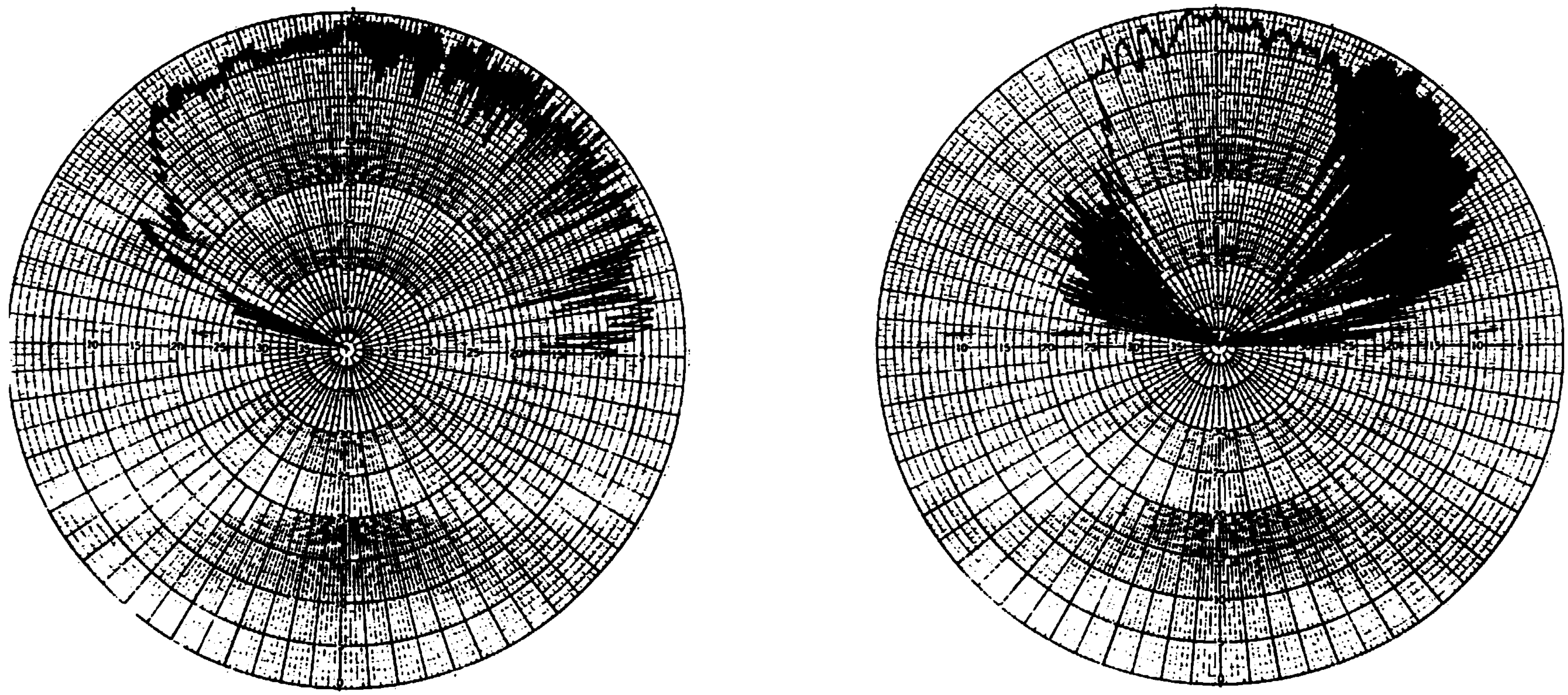


Figure 8.- Azimuth and roll cuts of open-ended wave guide on Space Station model horizontal polarization.

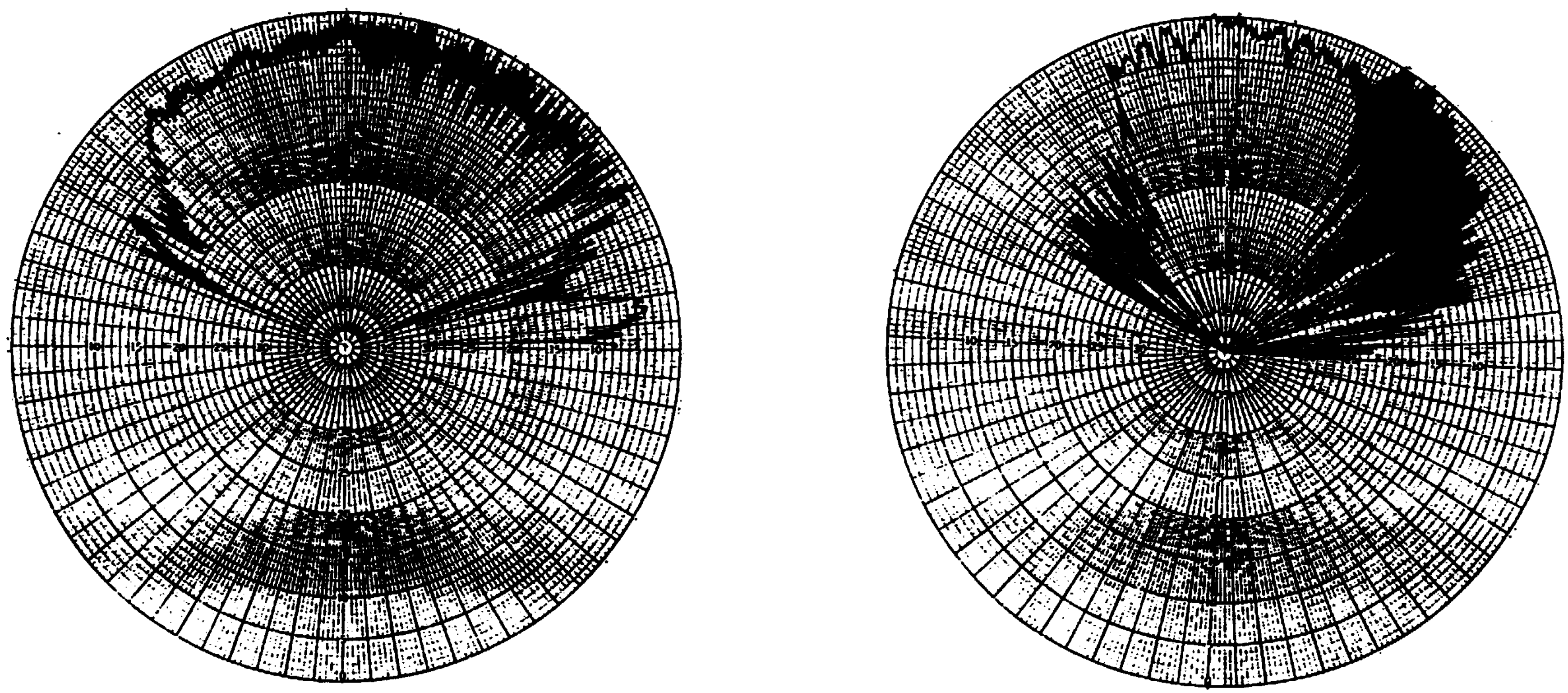


Figure 9.- Azimuth and roll cuts of open-ended wave guide on Space Station model horizontal polarization.

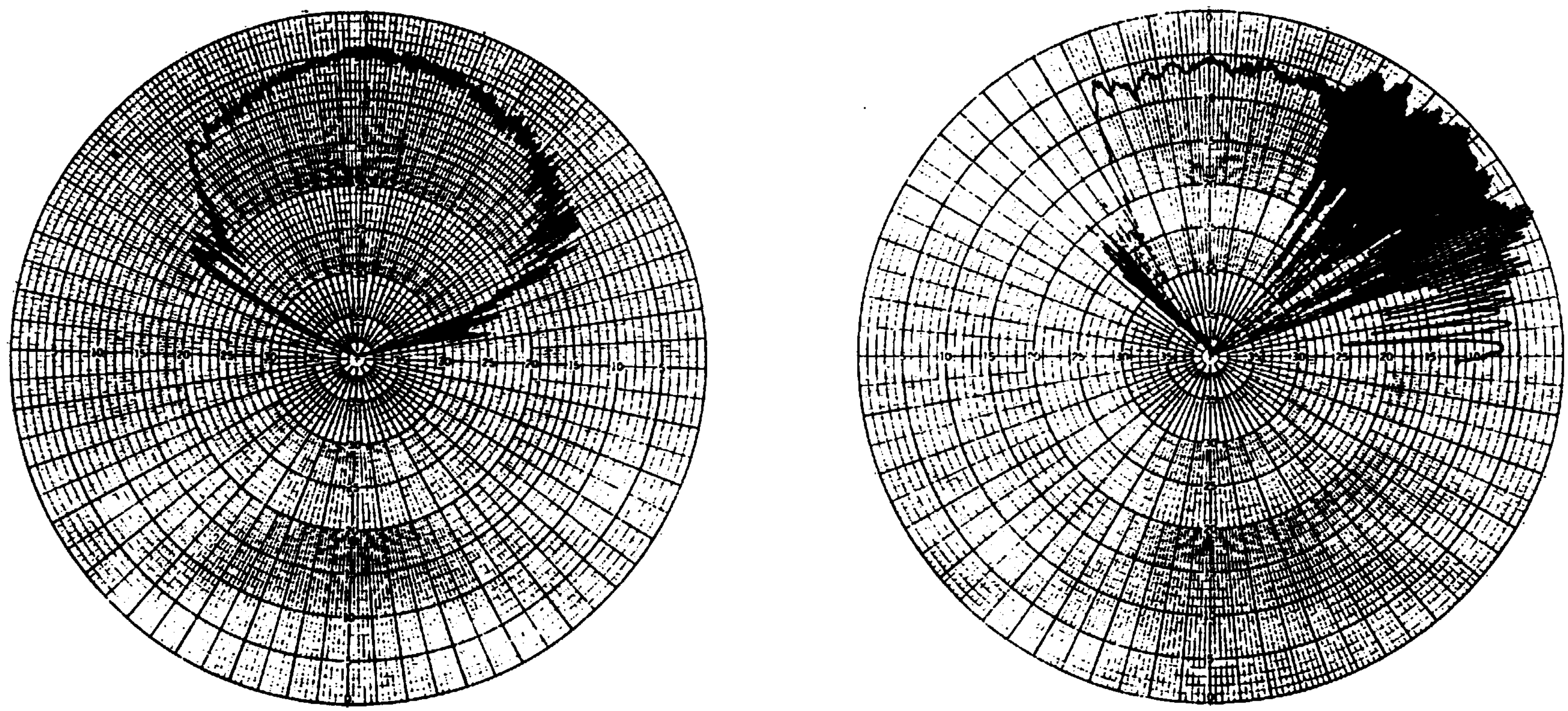


Figure 10.- Azimuth and roll cuts of open-ended wave guide on Space Station model vertical polarization.

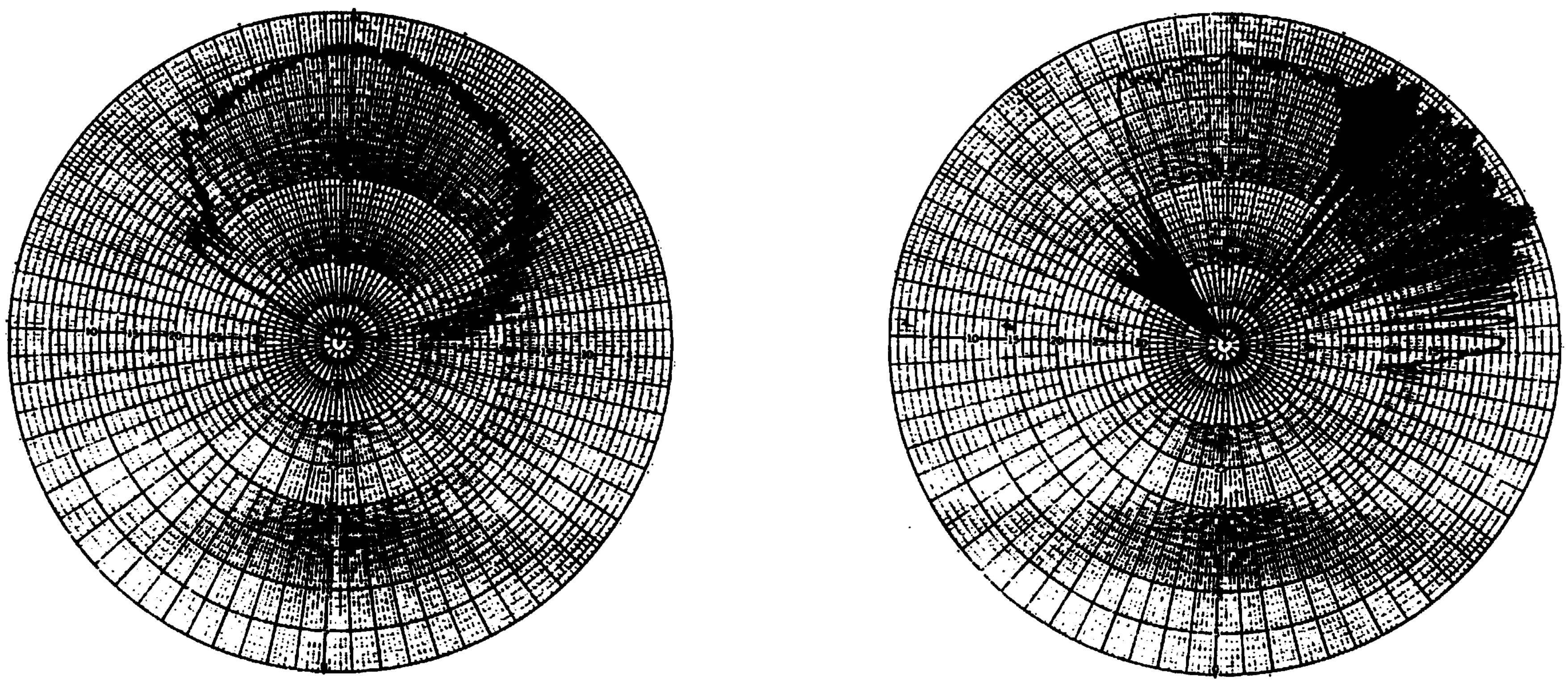


Figure 11.- Azimuth and roll cuts of open-ended wave guide on Space Station model vertical polarization.

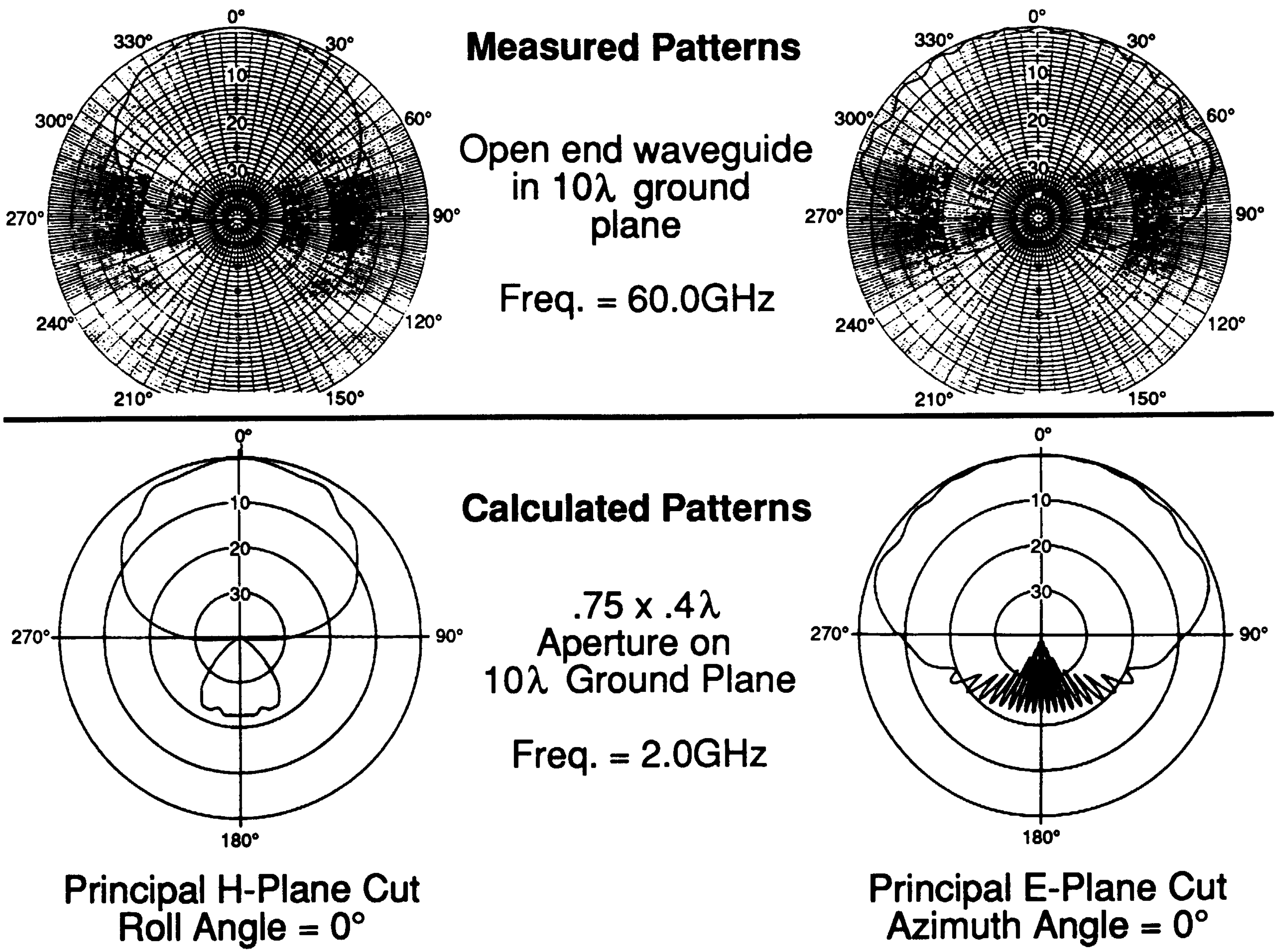


Figure 12.-Antenna patterns without space station structure.

390.0607.016.008/A

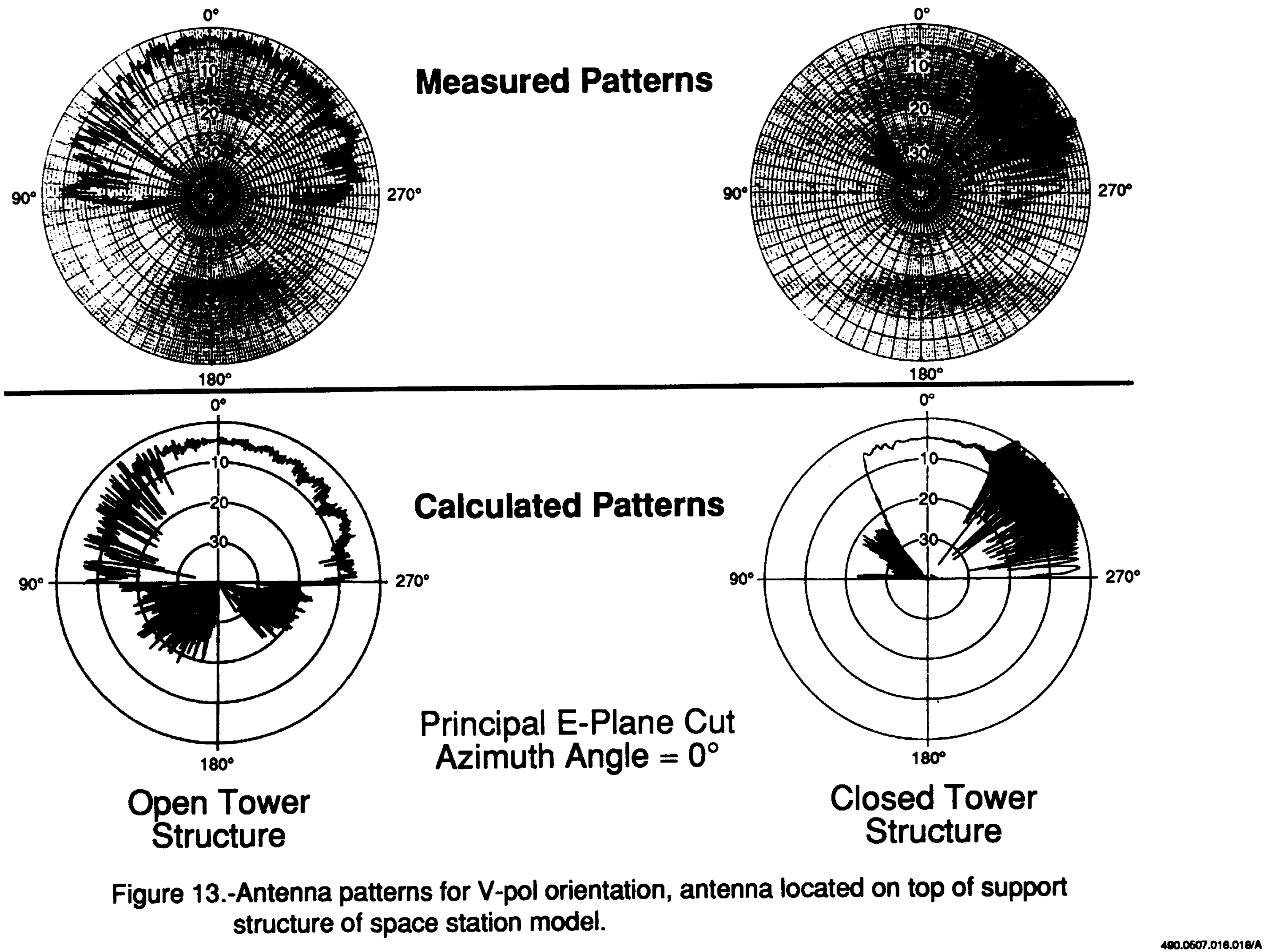


Figure 13.-Antenna patterns for V-pol orientation, antenna located on top of support structure of space station model.

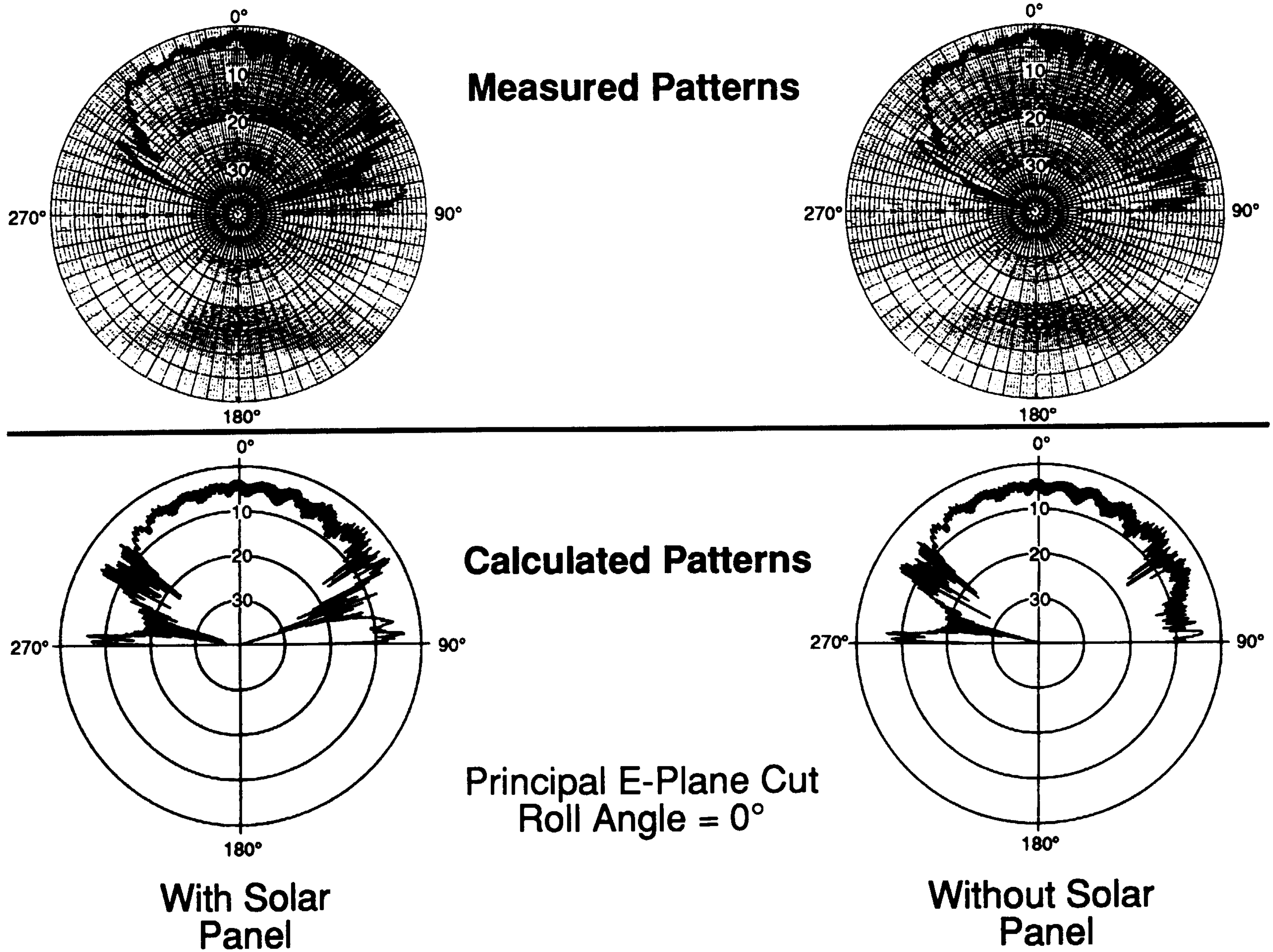
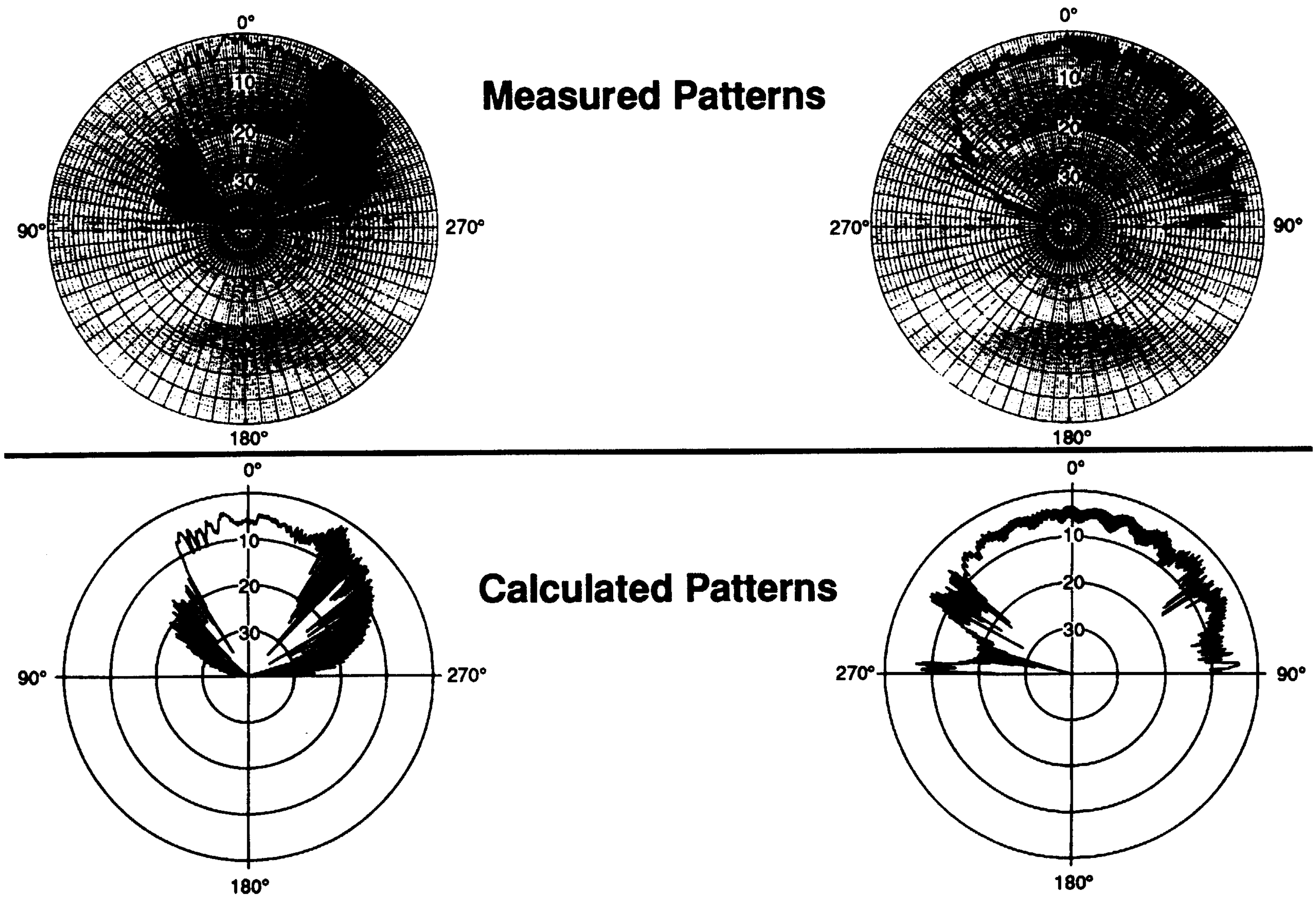


Figure 14.-Antenna patterns for H-pol orientation, antenna located on top of support structure of space station model.

390.0507.016.019/A



Principal H-Plane Cut
Azimuth Angle = 0°

Principal E-Plane Cut
Roll Angle = 0°

Figure 15.-Antenna patterns for H-pol orientation, antenna located on top of support structure of space station model.

390.0507.016.013/A

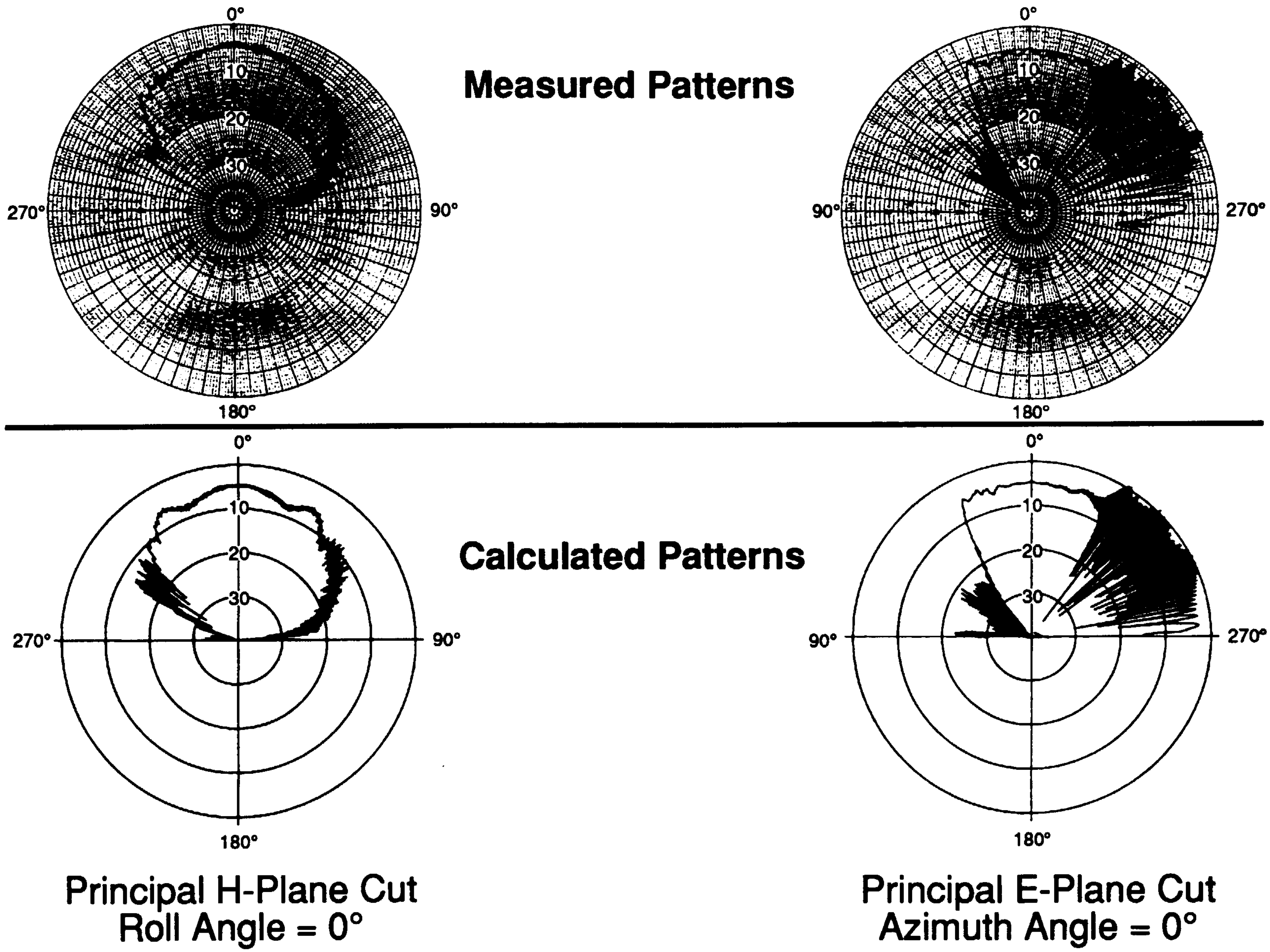


Figure 16.-Antenna patterns for V-pol orientation, antenna located on top of support structure of space station model.

390.0507.016.009/A

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
October 1991

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
Experimental Measurements of Space Station Antenna Patterns at 60 GHz for EM Analysis Verification

5. FUNDING NUMBERS
WU 505-64-70-01

6. AUTHOR(S)
W. Robert Young, Berkley A. Langford, Jr., and Roger K. Vaughan

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23665-5225

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National and Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM-102632

11. SUPPLEMENTARY NOTES
Young and Langford: Langley Research Center, Hampton, VA.
Vaughan: Lockheed Engineering & Sciences Company, Hampton, VA.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
unclassified - unlimited

subject category 32

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Complex body scattering is a major problem facing the electromagnetic researcher today. Computer codes are one important method for predicting such scattering. With funding from Langley, the Ohio State University has developed such a code. A 30:1 scale model of the Space Station was constructed to be used as a scattering target in the verification of this code. The purpose of this report is to document the methods used to make these measurements and present the results which will be used by others for code verification.

14. SUBJECT TERMS
Space Station; EM Analysis Code; Compact Range Pilot Facility

15. NUMBER OF PAGES
22

16. PRICE CODE
A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unclassified	unclassified		