

UNCLASSIFIED

AD _ 405 487 _

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA



UNCLASSIFIED

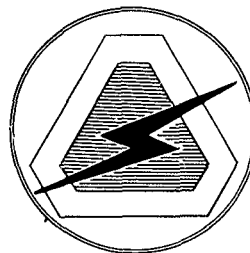
NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

63-3-5

USAELRDL Technical Report 2343

LOGARITHMIC PERIODIC ANTENNA AS -1089(XE-1)/ML

Peter Bodnar



January 1963

UNITED STATES ARMY
ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, N.J.

405 487

405 487

U. S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY

FORT MONMOUTH, NEW JERSEY

January 1963

USAEIRD Technical Report 2343 has been prepared under the supervision of the Director, Surveillance Department, and is published for the information and guidance of all concerned. Suggestions or criticisms relative to the form, content, purpose, or use of this publication should be referred to the Commanding Officer, U. S. Army Electronics Research and Development Laboratory, Attn: Chief, Advanced Techniques Branch, Electronic Warfare Division, Fort Monmouth, New Jersey.

J. M. KIMBROUGH, JR
Colonel, Signal Corps
Commanding

OFFICIAL:

HOWARD W. KILLAM
Major, SigC
Adjutant

DISTRIBUTION:

Special

QUALIFIED REQUESTERS MAY OBTAIN COPIES OF THIS REPORT FROM ASTIA.

THIS REPORT HAS BEEN RELEASED TO THE OFFICE OF TECHNICAL SERVICES,
U. S. DEPARTMENT OF COMMERCE, WASHINGTON 25, D. C., FOR SALE TO THE
GENERAL PUBLIC.

LOGARITHMIC PERIODIC ANTENNA AS-1089(XE-1)/ML

Peter Bodnar

DA Task No. 3E54-01-001-02

Abstract

↓
The electrical and mechanical characteristics of Antenna AS-1089(XE-1)/ML, a small, lightweight, broadband antenna of the broadly directional, pyramidal log-periodic type, are ~~described~~ ~~and~~ discussed. The antenna covers the frequency range of 200 to 800 mc, and has moderate gain and a medium power-handling capability. Data on impedance, gain, pattern characteristics, and power-handling capability have been obtained experimentally and are presented in this report. Although designed specifically for transmitting operations in the frequency range of 275 to 600 mc, the antenna can efficiently transmit over the 200- to 800-mc band, and can receive over the 200- to 1200-mc range. ↗

U. S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

CONTENTS

	<u>Page</u>
ABSTRACT	1
INTRODUCTION	1
DESIGN REQUIREMENTS	1
DESCRIPTION	1
Mechanical	1
Electrical	2
TESTS AND EVALUATION	2
Voltage Standing Wave Ratio (VSWR)	3
Pattern Characteristics	3
Gain	3
Power-Handling Capability	4
APPLICATIONS	4
CONCLUSIONS	4
RECOMMENDATIONS	5
ACKNOWLEDGMENTS	5
REFERENCES	5

FIGURES

1. Log Periodic Antenna AS-1089()/ML in Open Position	7
2. Log Periodic Antenna AS-1089()/ML in Closed Position	8
3. Tapered Line Cable Balun, Fully Encased	9
4. Tapered Line Cable Balun, Prior to Being Encased	10
5. VSWR of Log Periodic Antenna AS-1089(XE-1)/ML	11
6. Pattern No. 1, Polar Chart (Linear) (H-Plane, 225 Mc)	12
7. Pattern No. 2, Polar Chart (Linear) (E-Plane, 225 Mc)	13
8. Pattern No. 3, Polar Chart (Linear) (H-Plane, 250 Mc)	14
9. Pattern No. 4, Polar Chart (Linear) (E-Plane, 250 Mc)	15
10. Pattern No. 5, Polar Chart (Linear) (H-Plane, 300 Mc)	16
11. Pattern No. 6, Polar Chart (Linear) (E-Plane, 300 Mc)	17

CONTENTS (CONTD)

	<u>Page</u>
12. Pattern No. 7, Polar Chart (Linear) (H-Plane, 350 Mc)	18
13. Pattern No. 8, Polar Chart (Linear) (E-Plane, 350 Mc)	19
14. Pattern No. 9, Polar Chart (Linear) (H-Plane, 400 Mc)	20
15. Pattern No. 10, Polar Chart (Linear) (E-Plane, 400 Mc)	21
16. Pattern No. 11, Polar Chart (Linear) (H-Plane, 450 Mc)	22
17. Pattern No. 12, Polar Chart (Linear) (E-Plane, 450 Mc)	23
18. Pattern No. 13, Polar Chart (Linear) (H-Plane, 500 Mc)	24
19. Pattern No. 14, Polar Chart (Linear) (E-Plane, 500 Mc)	25
20. Pattern No. 15, Polar Chart (Linear) (H-Plane, 550 Mc)	26
21. Pattern No. 16, Polar Chart (Linear) (E-Plane, 550 Mc)	27
22. Pattern No. 17, Polar Chart (Linear) (H-Plane, 600 Mc)	28
23. Pattern No. 18, Polar Chart (Linear) (E-Plane, 600 Mc)	29
24. Pattern No. 19, Polar Chart (Linear) (H-Plane, 660 Mc)	30
25. Pattern No. 20, Polar Chart (Linear) (E-Plane, 665 Mc)	31
26. Pattern No. 21, Polar Chart (Linear) (H-Plane, 700 Mc)	32
27. Pattern No. 22, Polar Chart (Linear) (E-Plane, 700 Mc)	33
28. Pattern No. 23, Polar Chart (Linear) (H-Plane, 750 Mc)	34
29. Pattern No. 24, Polar Chart (Linear) (E-Plane, 800 Mc)	35
30. Pattern No. 25, Polar Chart (Linear) (H-Plane, 800 Mc)	36
31. Half-Power Beamwidths in 3 Planes, Log Periodic Antenna AS-1089(XE-1)/ML	37
32. Front-to-Back Ratios in 3 Planes, Log Periodic Antenna AS-1089(XE-1)/ML	38

LOGARITHMIC PERIODIC ANTENNA AS-1089(XE-1)/ML

INTRODUCTION

Antenna AS-1089(XE-1)/ML has been developed at the U. S. Army Electronics Research and Development Laboratory to provide an antenna for use with receiving and transmitting equipments in the ultra-high frequency range. The unit was designed to meet a requirement for a lightweight, broadband, broadly directional antenna capable of handling moderate power. It was to have the desirable electrical and physical characteristics of the trapezoidal-tooth, logarithmically periodic type of structure. The antenna is required for use with countermeasures electronic equipments for the transmission and reception of vertically, horizontally, and 45-degree polarized signals. Although designed specifically for transmitting operations in the frequency range of 275 to 600 megacycles, the antenna can efficiently transmit over the 200- to 800-mc band and can receive over the 200- to 1200-mc range.

This report describes the mechanical and electrical characteristics of the AS-1089(XE-1)/ML, and discusses the results of an evaluation of the antenna to determine its compliance with the established requirements.

DESIGN REQUIREMENTS

The antenna design was based on the following requirements:

- | | |
|---------------------------------|-------------------------------------|
| (1) Frequency range | 275-600 mc |
| (2) Impedance | 50 ohms input |
| (3) Voltage standing wave ratio | <2:1 |
| (4) Gain | 8 db |
| (5) Loss (including VSWR) | 1 db |
| (6) Power-handling capability | 400 watts peak (duty factor of 1/2) |
| (7) Size | Minimum |

DESCRIPTION

Mechanical

The antenna is a trapezoidal-tooth, log-periodic, pyramid-shaped structure (see Figures 1 and 2). Two sides of the pyramid consist of printed-circuit antenna elements imbedded in fiberglass. The fiberglass sides are connected by supporting arms to a nylon collar that can slide up and down

the central boom of the antenna. The sliding collar folds and unfolds the antenna with an action similar to that of a bellows. A tapered-line cable balun (shown in Figures 3 and 4) is housed within the central boom of the antenna. A small, watertight compartment near the apex of the pyramid provides weather protection to the antenna feed point and balun terminals. The compartment has a removable plate that permits inspection and repair in the event of malfunction.

The entire antenna weighs five pounds. In the open position, its dimensions are 26 inches by 18.5 inches at the base of the pyramid; in the collapsed position, the base of the pyramid measures 26 inches by 4.75 inches. In either position, the distance from the apex to the end of the boom is 25 inches.

Mechanical strength and durability were provided by the use of such nonmetallic materials as fiberglass, nylon, and teflon. The antenna elements, supporting arms, and central boom are made of fiberglass, and the hinges and knuckles throughout the unit are made of either nylon or teflon. In addition, the printed-circuit antenna elements are coated with an epoxy mixture to prevent corrosion. The weight of the antenna and its wind resistance were decreased by the removal of large rectangular sections of fiberglass from between most of the antenna elements (see Figures 1 and 2).

Electrical

A logarithmically periodic configuration was selected for this antenna because of its promising advantages in view of the design requirements. Trapezoidal-tooth, pyramid-shaped, logarithmically periodic antenna configurations are characterized by moderate and constant gain over large frequency ranges with minimum impedance variations, low side- and back-lobe levels, and small beam tilt.

The AS-1089(XE-1)/ML was designed to provide an average beamwidth of 80 degrees in both the horizontal and vertical planes over the required frequency range of 275 to 600 mc, with a maximum back-lobe level of -10 db. This design was achieved by use of a periodicity ratio of 0.85 for the element spacing, an element-included angle of 71 degrees, and an angle of 45 degrees between the two element groups.¹⁻⁴

TESTS AND EVALUATION

A series of tests was performed on the antenna to determine its electrical characteristics. The procedure used was similar to that described in Reference 6.

The following test equipments were used:

Hewlett Packard: Signal Generator Models 608A and 512A
Slotted Line Model 805A
VSWR Meter Model 415A
VHF Bridge Model 805A
VHF Detector Model 417A

Scientific Atlanta Inc.: Antenna Pattern Recorder Model 122B
Control and Indicator Univ. Model 142-2
Wide Range Receiving System Series 402
Range Tower with extension section

The results were evaluated and are summarized below.

Voltage Standing Wave Ratio (VSWR)

When referred to a 50-ohm line, the voltage standing wave ratio of the antenna is 2.46 to 1 or less, as shown in Figure 5. The average VSWR across the frequency range of 275 to 600 mc is 1.51 to 1.

The tapered line balun (Figures 3 and 4) has handled 400 watts of continuous RF power with no deterioration of its electrical performance. Its average VSWR over the 200-to 1200-mc range is 1.57 to 1.

Pattern Characteristics

The polar charts in Figures 6 through 30 show the variation in the amplitude or antenna response as a function of azimuth and elevation angle for several typical frequencies. The pattern characteristics, such as beamwidth, beam tilt, and front-to-back ratios, are reasonably uniform throughout the frequency range. The pattern response is smooth at all frequencies, with no significant side lobes or spurious nulls within the main lobe.

1. Half-Power Beamwidth. Measured data show that, within the 275- to 600-mc frequency range, the half-power beamwidths average 92 degrees in the vertical plane and 72.5 degrees in the horizontal plane. In either plane, the widest beamwidth measured was 112 degrees, and the narrowest was 64 degrees. Figure 31 gives this information in further detail.

2. Front-to-Back Ratio. The measured radiation patterns have an average front-to-back ratio of 11.16 db in the vertical plane and 11.27 db in the horizontal plane. The highest value of the front-to-back ratio is 20 db, and the lowest is 7.2 db. These data can be seen in Figure 32.

3. Beam Tilt. The radiation patterns show that the beam tilt average is 4.15 degrees in the vertical plane and 2.65 degrees in the horizontal plane. The most pronounced beam tilt in either plane is 7.5 degrees.

Gain

The AS-1089(XE-1)/ML has an average gain of 7.7 db over an isotropic source and 5.73 db over a half-wave dipole antenna. These figures are computed gains based on the beamwidth averages obtained in both the vertical and horizontal planes and the resulting average directivity of the measured patterns. Comparative gain measurements with respect to a half-wavelength dipole were not made; however, based upon these calculated gain figures and previous evaluations of log periodic antennas, the difference between the computed gain and the measured gain can be assumed to be less than 1 db.

Power-Handling Capability

The power-handling capability of the AS-1089(XE-1)/ML exceeds 400 watts of CW power with no degradation of performance. In a test at 369.5 mc, 415 watts of power was applied to the antenna for a period of ten minutes. The reflected power at this frequency was 13 watts. At 480 mc, with the same type of power applied for the same length of time, the reflected power was only 2 watts, indicating an extremely low VSWR with a very high propagation efficiency factor. Increasing the applied power to 450 watts did not affect the performance of the antenna. The VSWR of the antenna at 369.5 mc is 1.7 to 1; at 480 mc, 1.2 to 1.

APPLICATIONS

Although the AS-1089(XE-1)/ML was designed as a transmitting antenna for the frequency range of 275 to 600 mc, it can be used for receiving operations over the frequency range of from 200 mc to approximately 1200 mc. Within this wider band the VSWR is less than 2.5 to 1. In the 825- to 1230-mc region, however, the propagation patterns show a slight deterioration; the main lobes are not completely symmetrical, and the rear lobes are more pronounced. At a few of the frequencies measured, the beam tilt becomes significant, particularly in the vertical plane where a maximum of 18.5 degrees was encountered at 1150 mc.

CONCLUSIONS

Mechanically, Antenna AS-1089(XE-1)/ML has met the specified design requirements. It is a lightweight, rugged unit featuring a small silhouette with low wind resistance. When not in use, the antenna folds into a small, compact unit. The entire antenna weighs less than five pounds.

The polarization adjustment of the AS-1089(XE-1)/ML provides horizontal, vertical, or 45-degree operation, depending upon the tactical requirements. To change the polarization, the operator simply adjusts a thumbscrew and rotates the antenna on its axis to the desired mode of operation.

The antenna has also met the specified electrical design requirements with the following characteristics:

1. The effective frequency range for transmitting purposes is 200 to 800 mc, which exceeds the original design requirement (275 to 600 mc) at both ends of the frequency range. For receiving operations the antenna can be used over the extended range of 200 mc to approximately 1200 mc.

2. The antenna can capably handle 400 watts of CW power within the frequency range of 200 to 800 mc. This power-handling capability exceeds the original requirement.

3. The average VSWR over this frequency range is under 2 to 1, which meets the requirements (see Figure 5).

4. The average gain is 7.7 db, which closely approaches the original requirement of 8 db.

RECOMMENDATIONS

Although Antenna AS-1089(XE-1)/ML is satisfactory for the purpose intended, the following changes are recommended for improved performance in other applications:

1. The overall structure could be improved significantly by elimination of the folding feature. The advantage of collapsibility is questionable since the antenna is small and compact even when expanded. Without this feature, the antenna could be fabricated more easily and less expensively, and its performance would be more efficient both electrically and mechanically.

2. The present power-handling capability of 400 watts of RF power could be increased considerably by (a) replacing the present balun, which is made of RG-9/U coaxial cable, with a newer type made of RG-17/U cable;⁵ and (b) using sheet metal for the antenna elements near the apex of the pyramid instead of the thin copper printed circuits now used. With the new type balun, which was developed for higher power equipment, and the sheet metal antenna elements, which can withstand high temperature, the antenna should be capable of handling approximately 1000 watts of RF power.

ACKNOWLEDGEMENTS

Acknowledgement is made to Mr. Anthony R. Siracusano, Engineering and Drafting Branch, Engineering Design Division, for the mechanical design of the antenna; and to Mr. Joseph G. Garvey, Machine Shop, Electronic Warfare Division, for the fabrication of the antenna.

REFERENCES

1. R. H. DuHamel and D. E. Isbell, "Broadband Logarithmically Periodic Antenna Structures," 1957 IRE National Convention Record, Part I, pp 119-128.

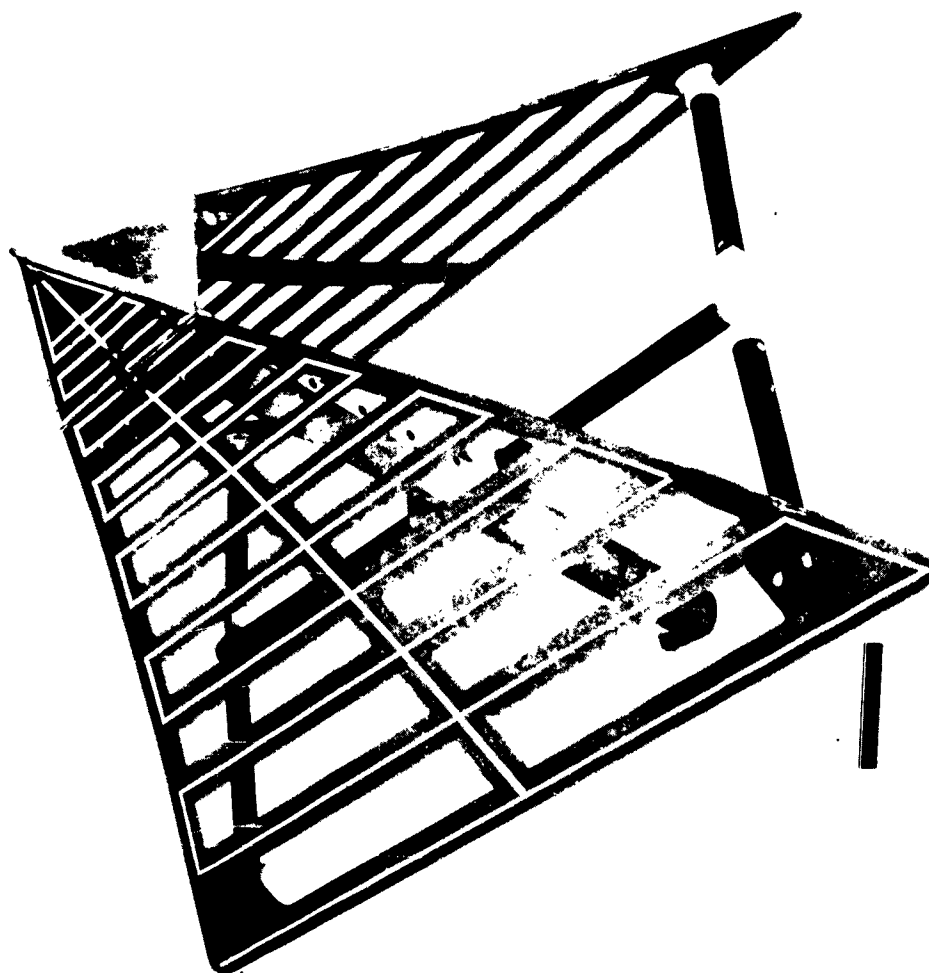
2. V. H. Rumsey, "Frequency Independent Antennas," 1957 IRE National Convention Record, Part I, pp 114-118.

3. J. D. Dyson, "The Equiangular Spiral Antenna," University of Illinois, Antenna Laboratory Technical Report #2, 15 September 1957, Contract A.F. 33 (616)-3220.

4. R. H. DuHamel and F. R. Ore, "Logarithmically Periodic Antenna Designs," Collins Radio Company, CTR-198, 31 March 1958.

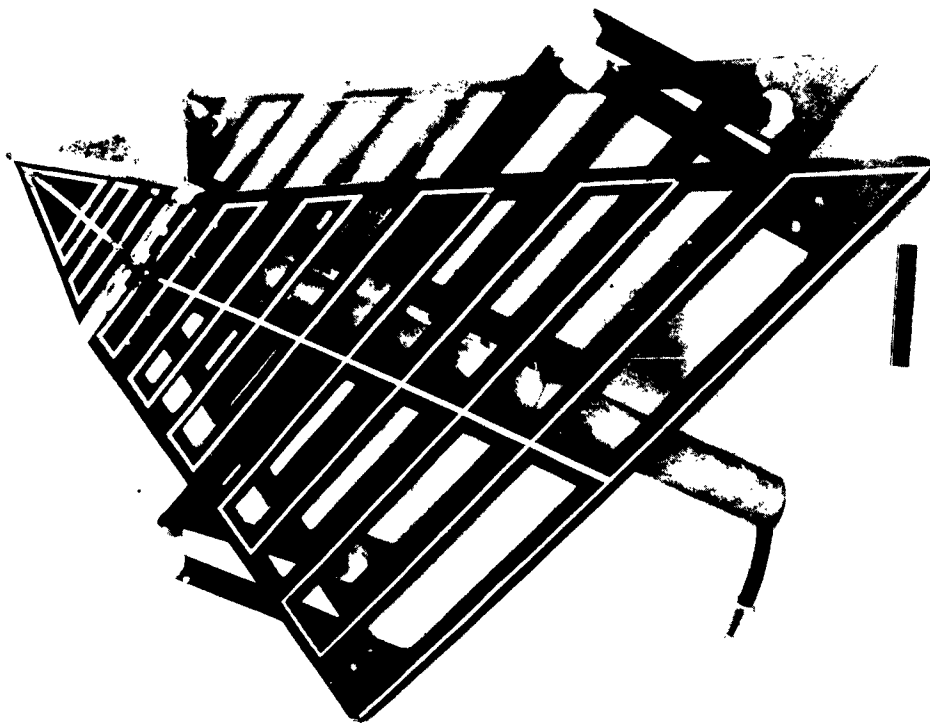
5. J. W. Duncan and V. P. Minerva, "100:1 Bandwidth Balun Transformer," Proceedings of the IRE, pp 156-164, February 1960.

6. J. D. Kraus, Antennas, McGraw-Hill Inc. 1950, pp 444-487.



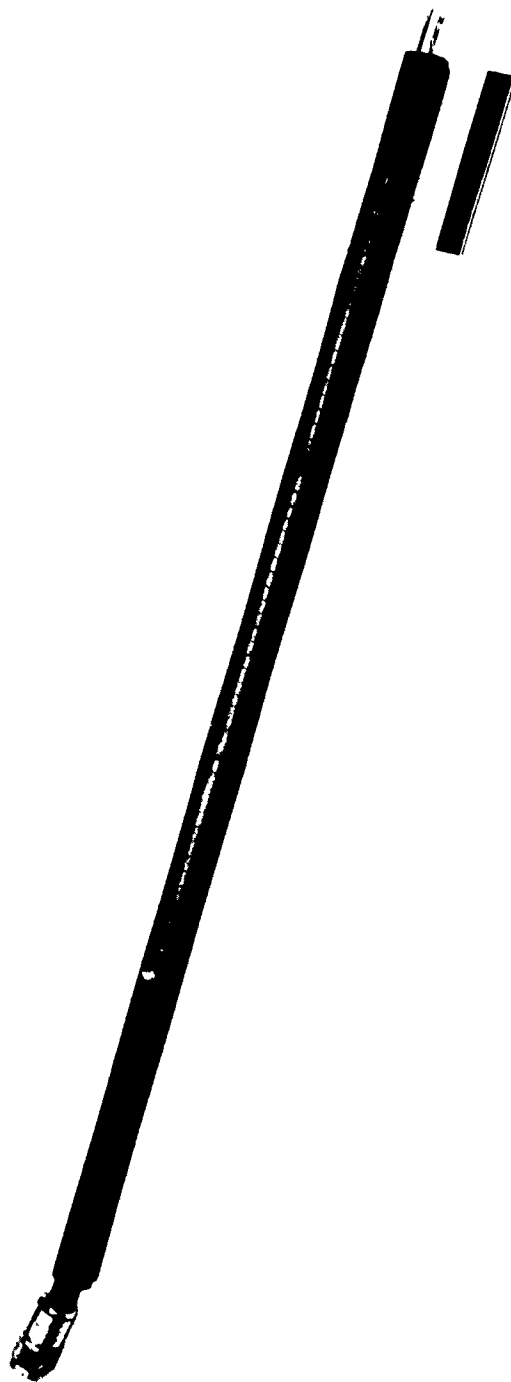
LOG PERIODIC ANTENNA AS-1089()/ML IN OPEN POSITION

FIGURE 1



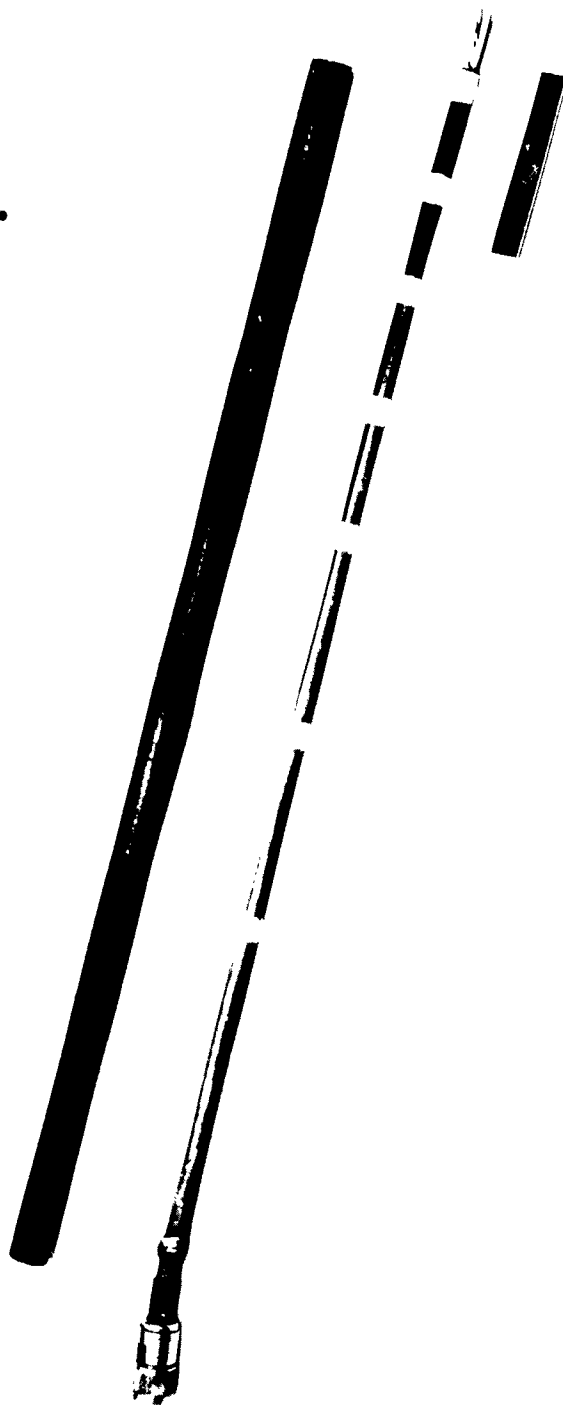
LOG PERIODIC ANTENNA AS-1089()/ML IN CLOSED POSITION

FIGURE 2



TAPERED LINE CABLE BALUN, FULLY ENCASED

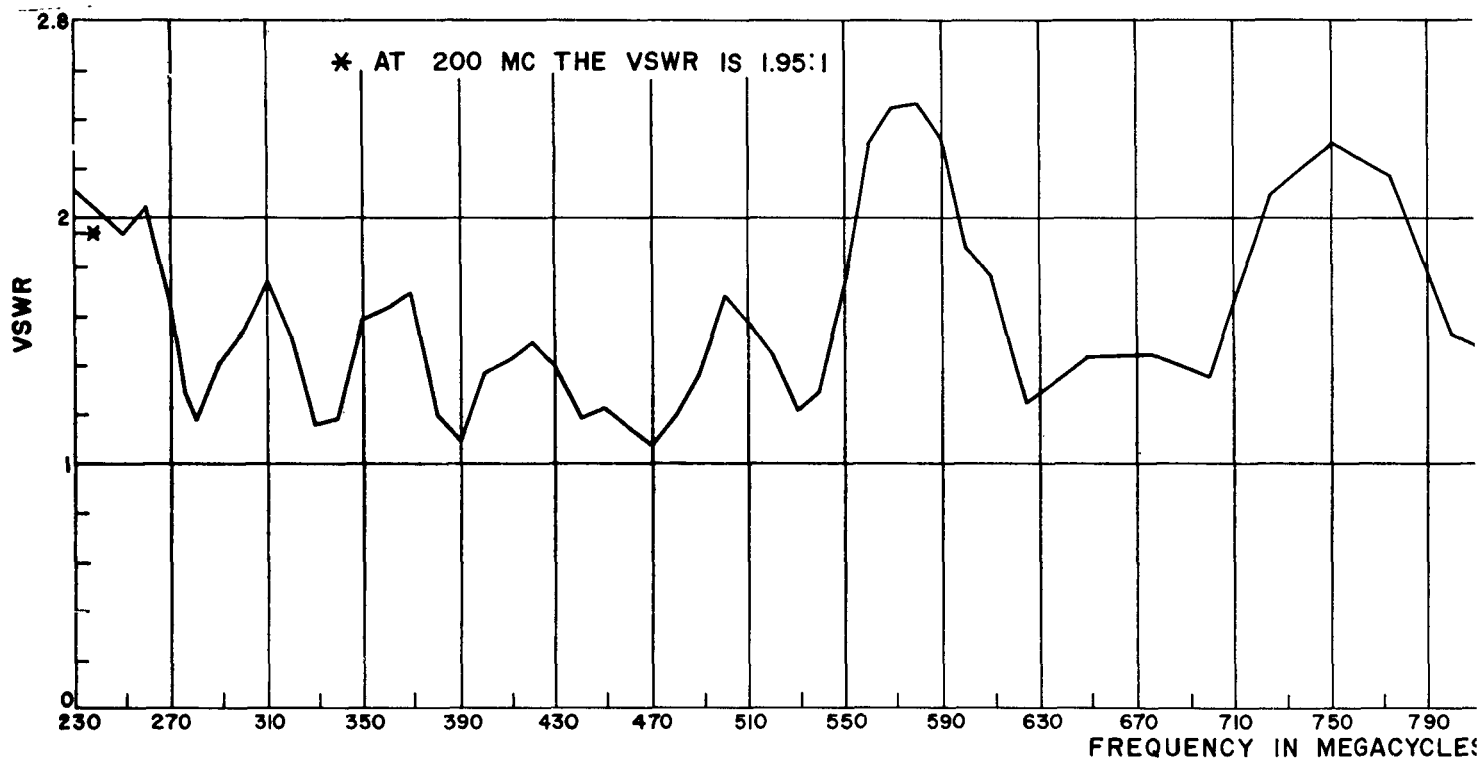
FIGURE 3



TAPERED LINE CABLE BALUN, PRIOR TO BEING ENCASED

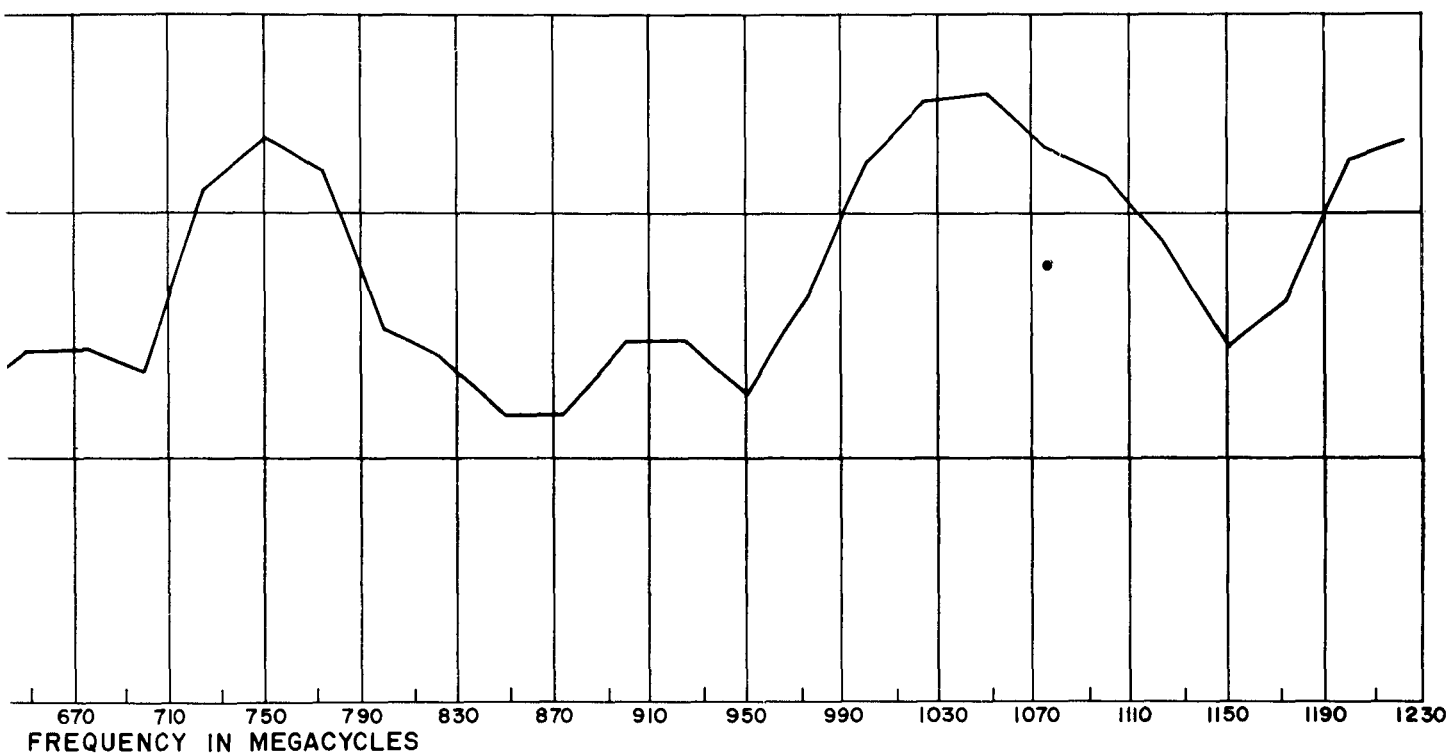
FIGURE 4

1



VSWR OF LOG PERIODIC ANTENNA
FIG. 5

2

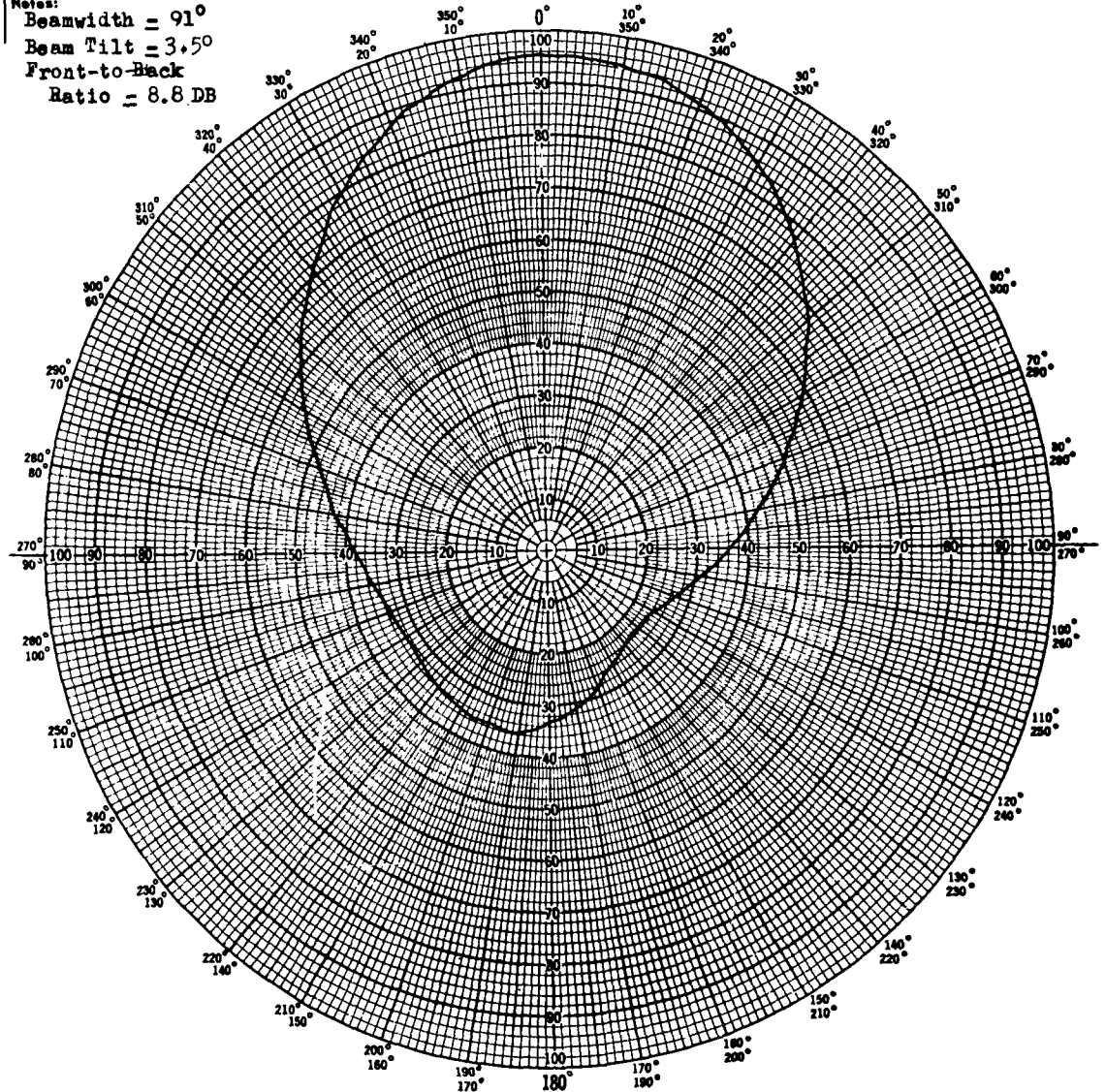


PERIODIC ANTENNA AS-1089 (XE-I)/ML
FIG. 5

FINAL MODEL AS-1089 (XE-1)/ML

FREQUENCY: 225 Mc		TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐	VOLTAGE ☒	VERTICAL ☒	HORIZONTAL ☐	VERTICAL ☒	HORIZONTAL ☐	AZIMUTH ☒	ELEVATION ☐	E-PLANE ☐	H-PLANE ☒
PERSONNEL: Peter Bodnar								AXIAL RATIO ☐	

Notes:
 Beamwidth = 91°
 Beam Tilt = 3.5°
 Front-to-Back
 Ratio = 8.8 DB

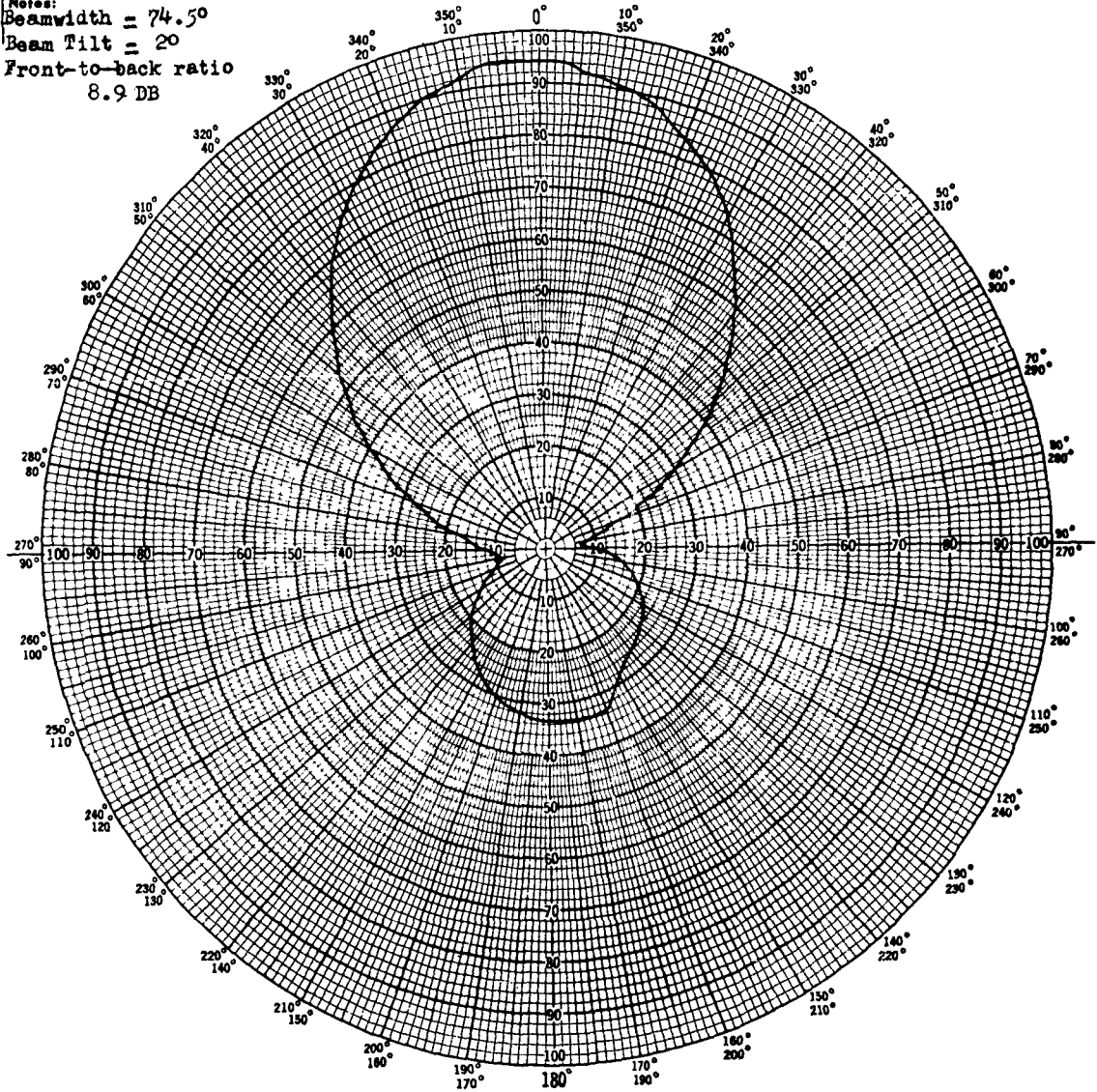


PATTERN NO. 1
 POLAR CHART - (LINEAR)
 FIGURE 6

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 225 Mc		TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐	VOLTAGE ☒	VERTICAL ☐	HORIZONTAL ☒	VERTICAL ☐	HORIZONTAL ☒	AZIMUTH ☒	ELEVATION ☐	E-PLANE ☒	H-PLANE ☐
PERSONNEL: Peter Bodnar								AXIAL RATIO ☐	

Notes:
 Beamwidth = 74.5°
 Beam Tilt = 2°
 Front-to-back ratio
 8.9 DB

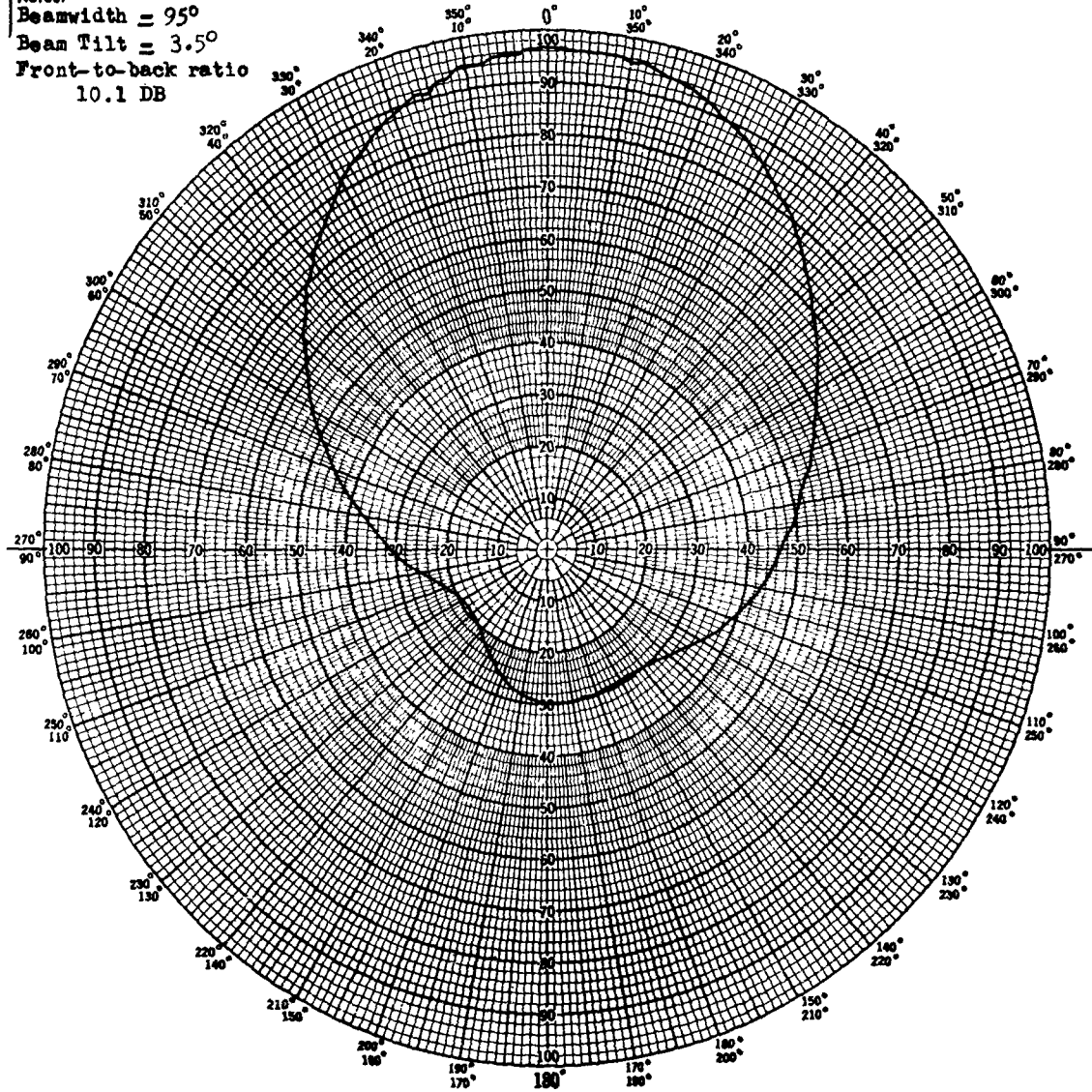


PATTERN NO. 2
 POLAR CHART - (LINEAR)
 FIGURE 7

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 250 Mc	Polarization		Pattern	
SCALE: POWER ☐ VOLTAGE ☒	TRANSMITTER	RECEIVER	ROTATION	E-PLANE ☐
PERSONNEL: Peter Bodnar	VERTICAL ☒ HORIZONTAL ☐	VERTICAL ☒ HORIZONTAL ☐	AZIMUTH ☒ ELEVATION ☐	H-PLANE ☒ AXIAL RATIO ☐

Notes:
 Beamwidth = 95°
 Beam Tilt = 3.5°
 Front-to-back ratio
 10.1 DB

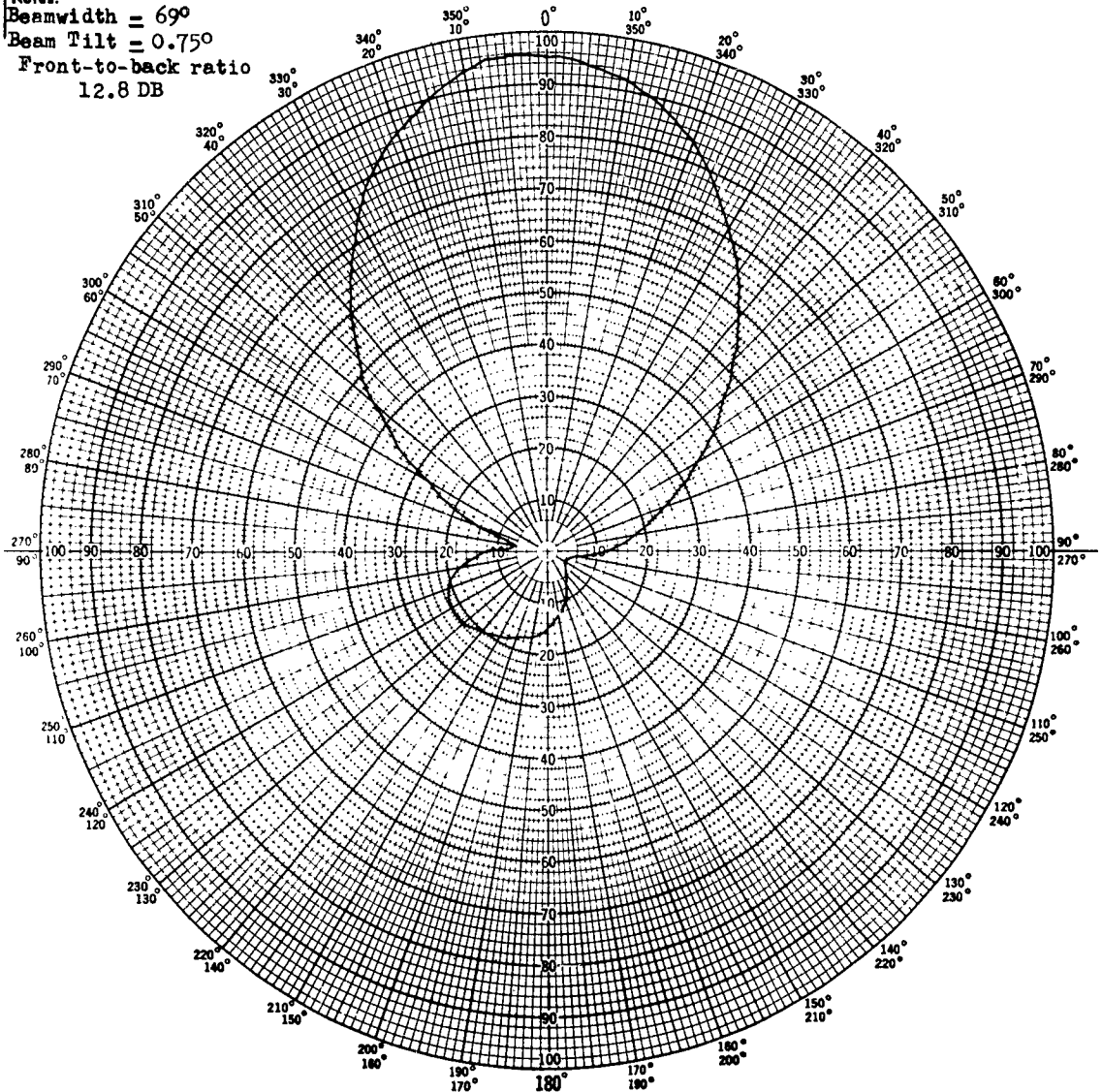


PATTERN NO. 3
 POLAR CHART - (LINEAR)
 FIGURE 8

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 250 Mc	TRANSMITTER		POLARIZATION		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☐	HORIZONTAL ☒	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☒
PERSONNEL: Peter Bodnar	VERTICAL ☐	HORIZONTAL ☒	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐
	VERTICAL ☐	HORIZONTAL ☒	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐

Notes:
 Beamwidth = 69°
 Beam Tilt = 0.75°
 Front-to-back ratio
 12.8 DB

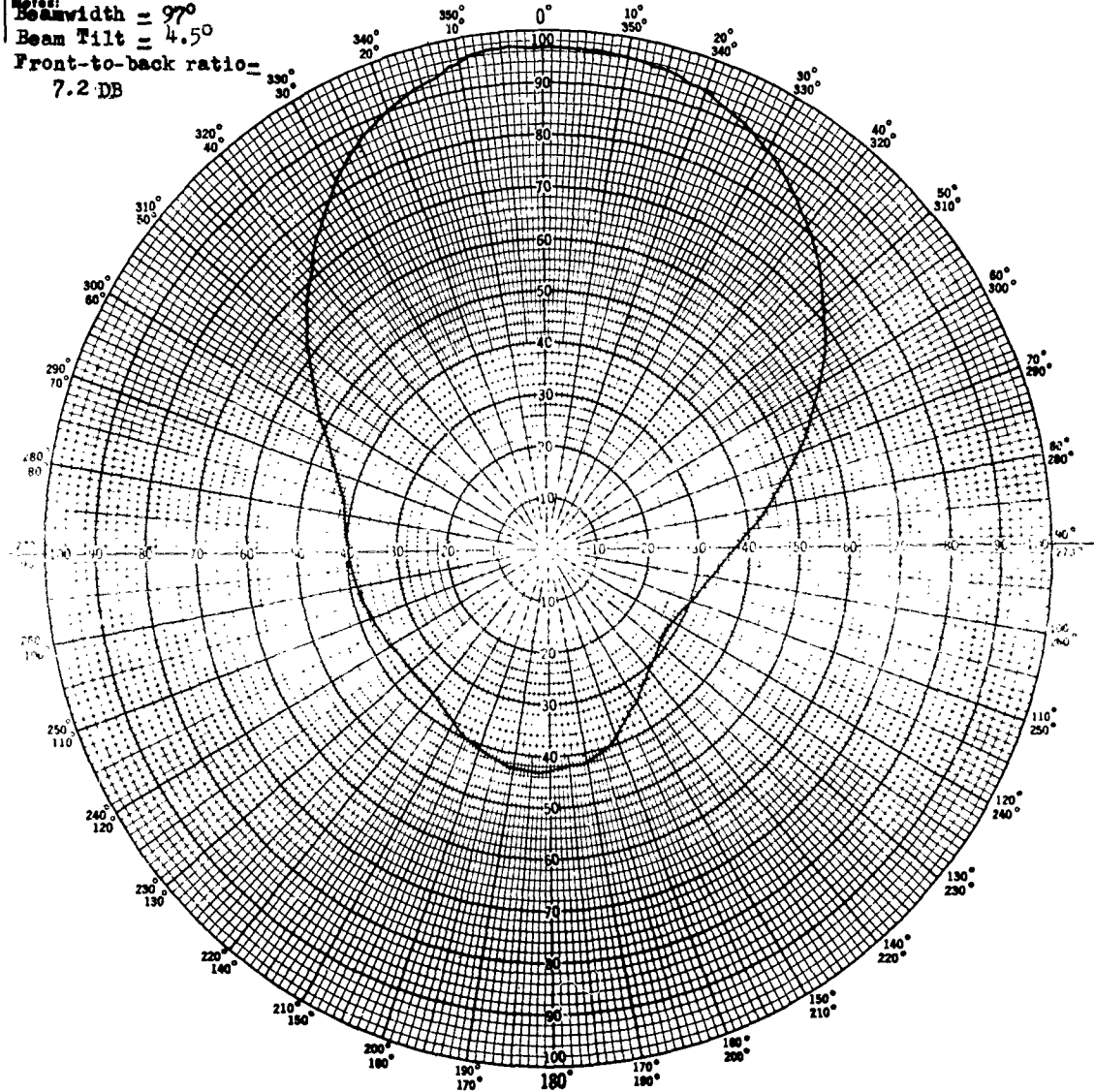


PATTERN NO. 4
 POLAR CHART - (LINEAR)
 FIGURE 9

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 300 Mc.	TRANSMITTER	POLARIZATION	RECEIVER	ROTATION	PATTERN
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☒	VERTICAL ☒	VERTICAL ☒	AZIMUTH ☐	E-PLANE ☐
PERSONNEL: Peter Bodnar	HORIZONTAL ☐	HORIZONTAL ☐	HORIZONTAL ☐	ELEVATION ☐	H-PLANE ☒
					AXIAL RATIO ☐

Notes:
 Beamwidth = 97°
 Beam Tilt = 4.5°
 Front-to-back ratio =
 7.2 DB

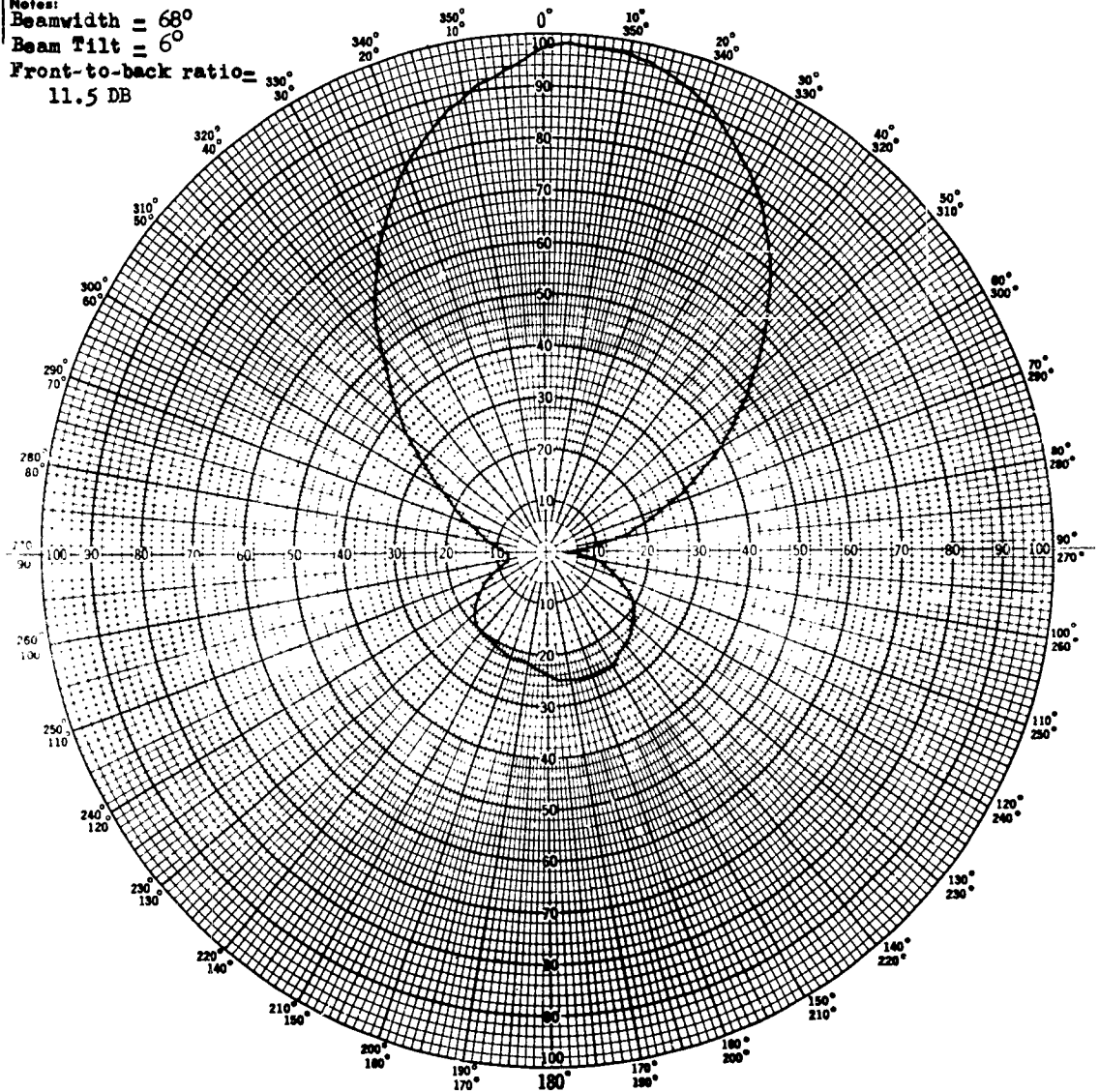


PATTERN NO. 5
 POLAR CHART - (LINEAR)
 FIGURE 10

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 300 Mc	TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☐	HORIZONTAL ☒	VERTICAL ☐	HORIZONTAL ☒	AZIMUTH ☒	ELEVATION ☐	E-PLANE ☒	H-PLANE ☐
PERSONNEL: Peter Bodnar	AXIAL RATIO ☐							

Notes:
 Beamwidth = 68°
 Beam Tilt = 6°
 Front-to-back ratio = 11.5 DB

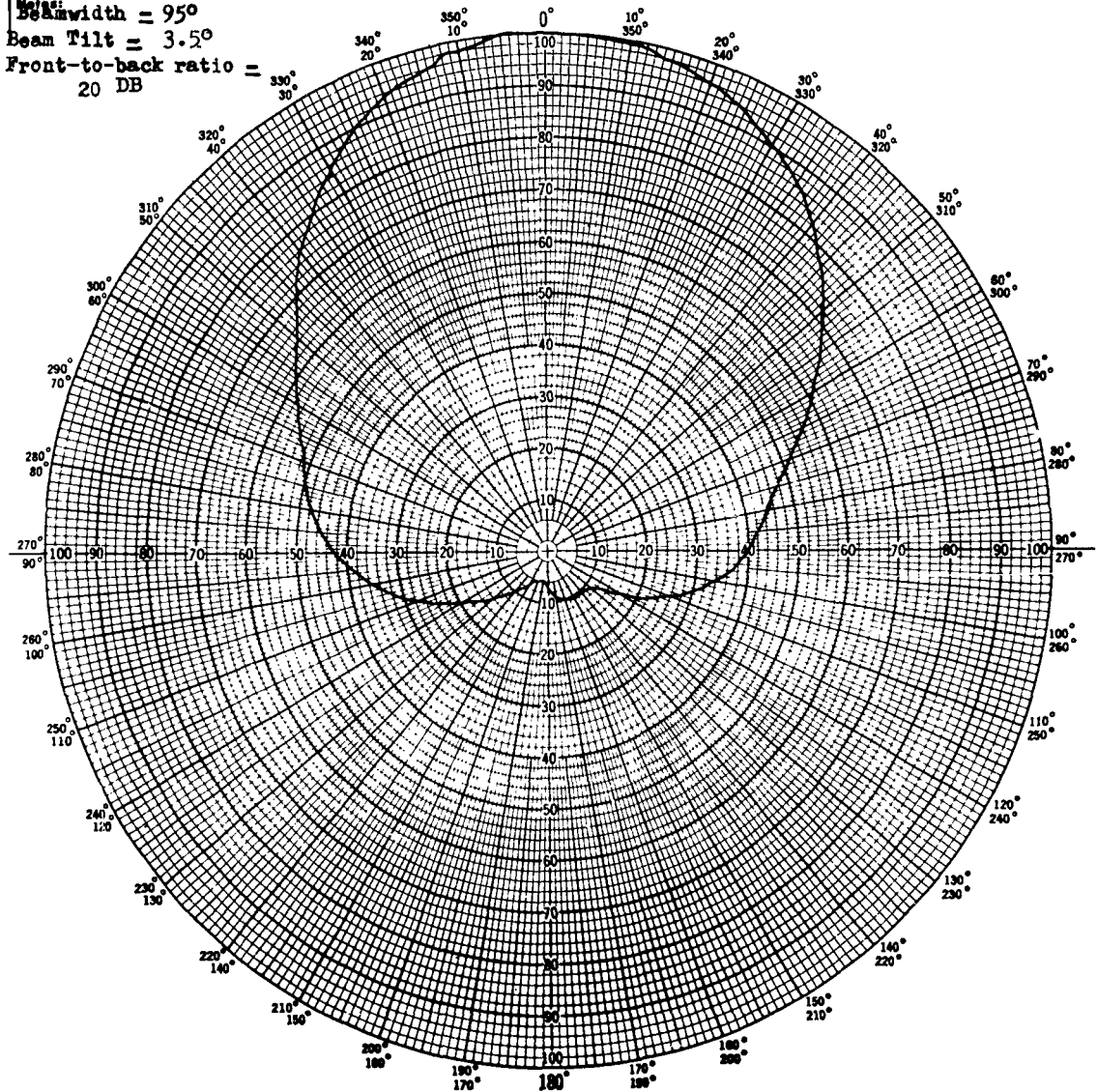


PATTERN NO. 6
 POLAR CHART - (LINEAR)
 FIGURE 11

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 350 Mc	TRANSMITTER	POLARIZATION		RECEIVER		ROTATION	PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☒	VERTICAL ☒	VERTICAL ☒	VERTICAL ☒	VERTICAL ☒	AZIMUTH ☒	E-PLANE ☐	H-PLANE ☒
PERSONNEL: Peter Bodnar	HORIZONTAL ☐	HORIZONTAL ☐	HORIZONTAL ☐	HORIZONTAL ☐	HORIZONTAL ☐	ELEVATION ☐	AXIAL RATIO ☐	

Notes:
 Beamwidth = 95°
 Beam Tilt = 3.5°
 Front-to-back ratio =
 20 DB

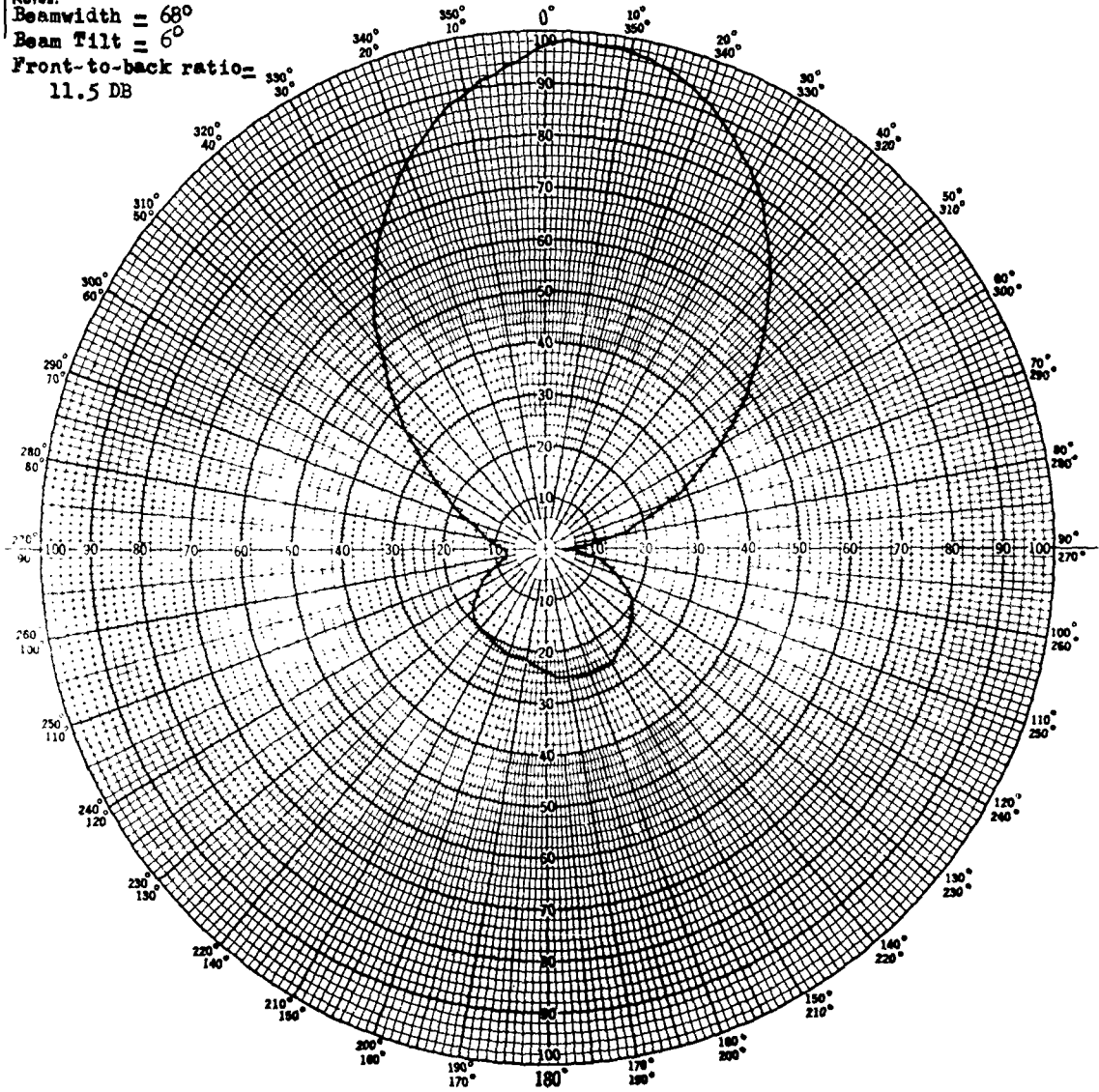


PATTERN NO. 7
 POLAR CHART - (LINEAR)
 FIGURE 12

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 300 Mc	TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☐	HORIZONTAL ☒	VERTICAL ☐	HORIZONTAL ☒	AZIMUTH ☒	ELEVATION ☐	E-PLANE ☒	H-PLANE ☐
PERSONNEL: Peter Bodnar	AXIAL RATIO ☐							

Notes:
 Beamwidth = 68°
 Beam Tilt = 6°
 Front-to-back ratio = 11.5 DB



PATTERN NO. 6
 POLAR CHART - (LINEAR)
 FIGURE 11

FINAL MODEL AS-1089(XE-1)/ML

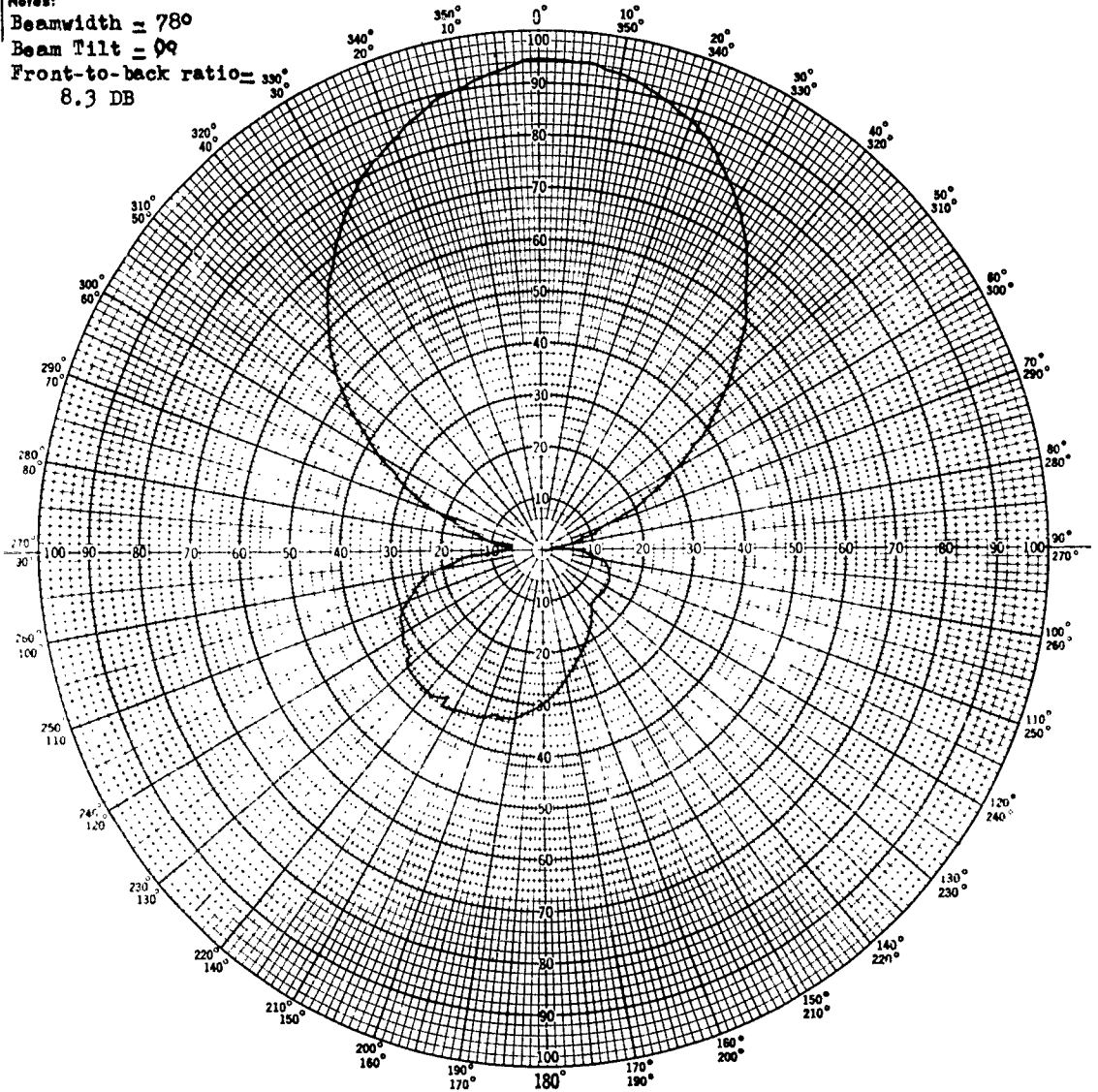
FREQUENCY: 350 Mc	TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL	☐	VERTICAL	☐	AZIMUTH ☒	E-PLANE	☒	
PERSONNEL: Peter Bodnar	HORIZONTAL	☒	HORIZONTAL	☒	ELEVATION ☐	H-PLANE	☐	
						AXIAL RATIO	☐	

Notes:

Beamwidth = 78°

Beam Tilt = 0°

Front-to-back ratio = 330°
8.3 DB

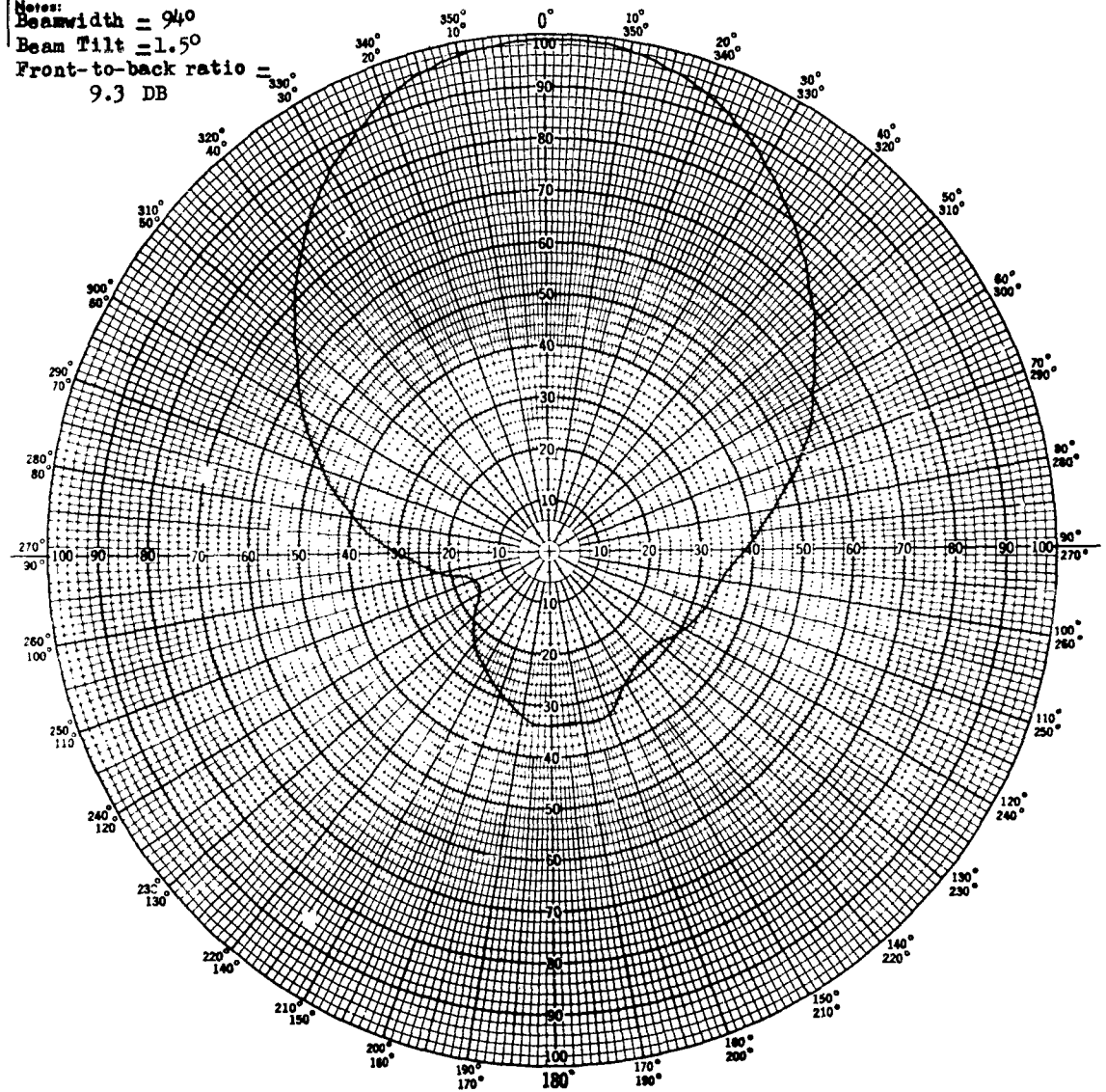


PATTERN NO. 8
POLAR CHART - (LINEAR)
FIGURE 13

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 400 Mc.	POLARIZATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	TRANSMITTER	RECEIVER	ROTATION	E-PLANE ☐
PERSONNEL: Peter Bodnar	VERTICAL ☒	VERTICAL ☒	AZIMUTH ☒	H-PLANE ☒
	HORIZONTAL ☐	HORIZONTAL ☐	ELEVATION ☐	AXIAL RATIO ☐

Notes:
 Beamwidth = 94°
 Beam Tilt = 1.5°
 Front-to-back ratio = 9.3 DB



PATTERN NO. 9

POLAR CHART - (LINEAR)

FIGURE 14

FINAL MODEL AS-1089(XE-1)/ML

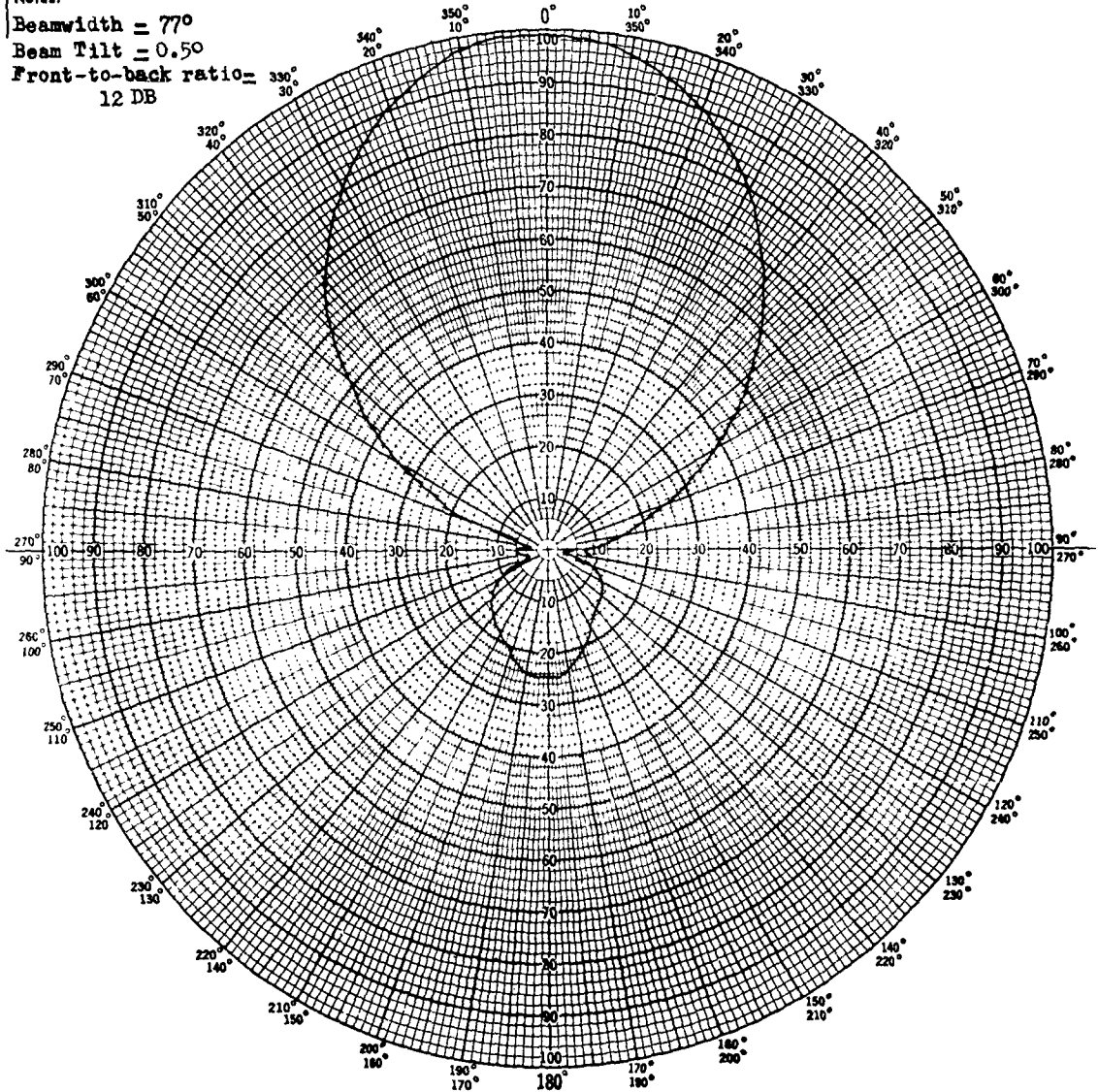
FREQUENCY: 400 Mc	POLARIZATION		PATTERN
SCALE: POWER ☐ VOLTAGE ☒	TRANSMITTER	RECEIVER	E-PLANE ☒
PERSONNEL: Peter Bodnar	VERTICAL ☐	VERTICAL ☐	H-PLANE ☐
	HORIZONTAL ☒	HORIZONTAL ☒	AXIAL RATIO ☐
		ROTATION	
		AZIMUTH ☒	
		ELEVATION ☐	

Notes:

Beamwidth = 77°

Beam Tilt = 0.5°

Front-to-back ratio = 12 DB

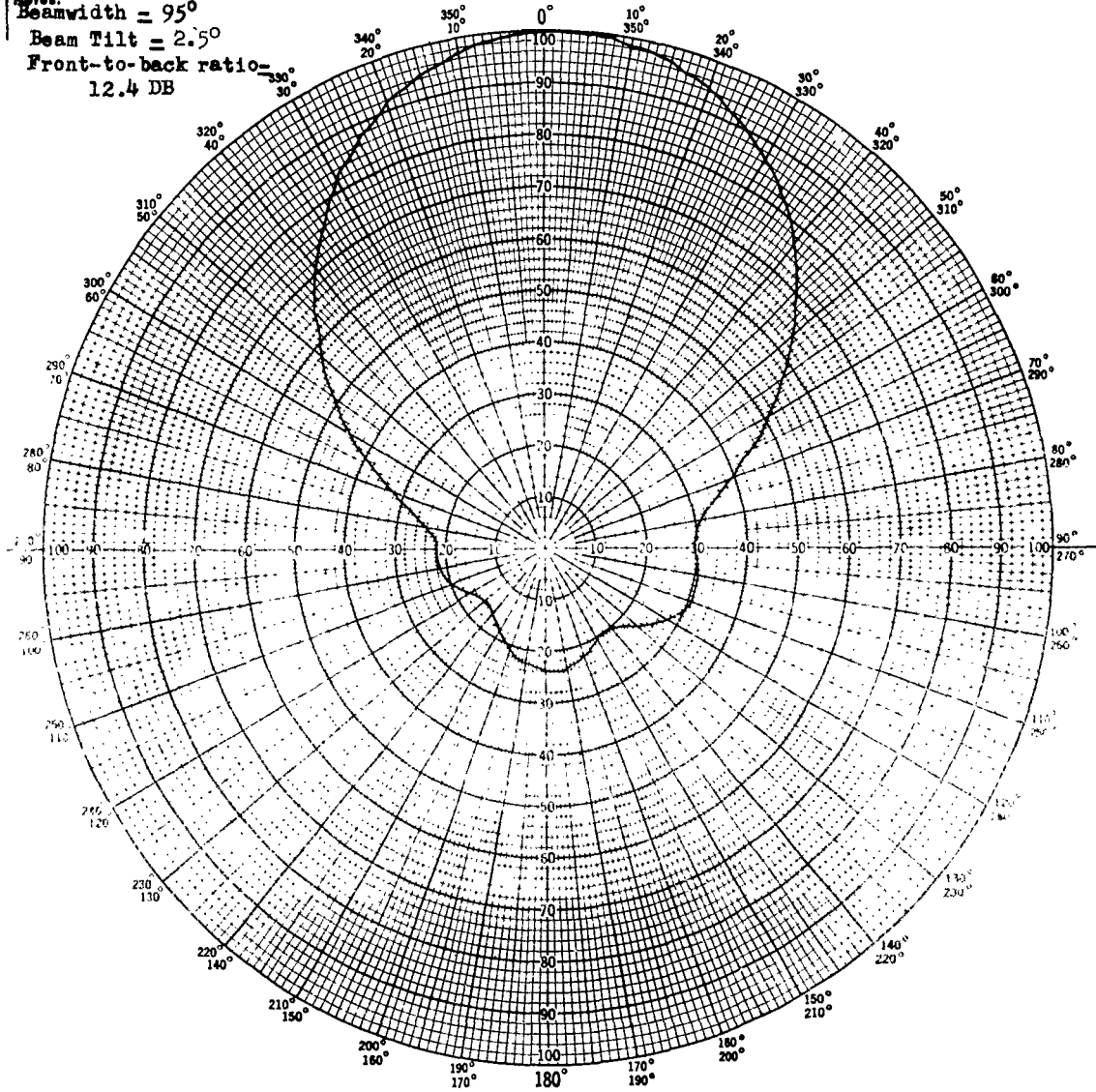


PATTERN NO. 10
POLAR CHART - (LINEAR)
FIGURE 15

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 450 Mc	POLARIZATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	TRANSMITTER	RECEIVER	ROTATION	E-PLANE ☐
PERSONNEL: Peter Bodnar	VERTICAL ☒	VERTICAL ☒	AZIMUTH ☒	H-PLANE ☒
	HORIZONTAL ☐	HORIZONTAL ☐	ELEVATION ☐	AXIAL RATIO ☐

Notes:
 Beamwidth = 95°
 Beam Tilt = 2.5°
 Front-to-back ratio = 12.4 DB



PATTERN NO. 11

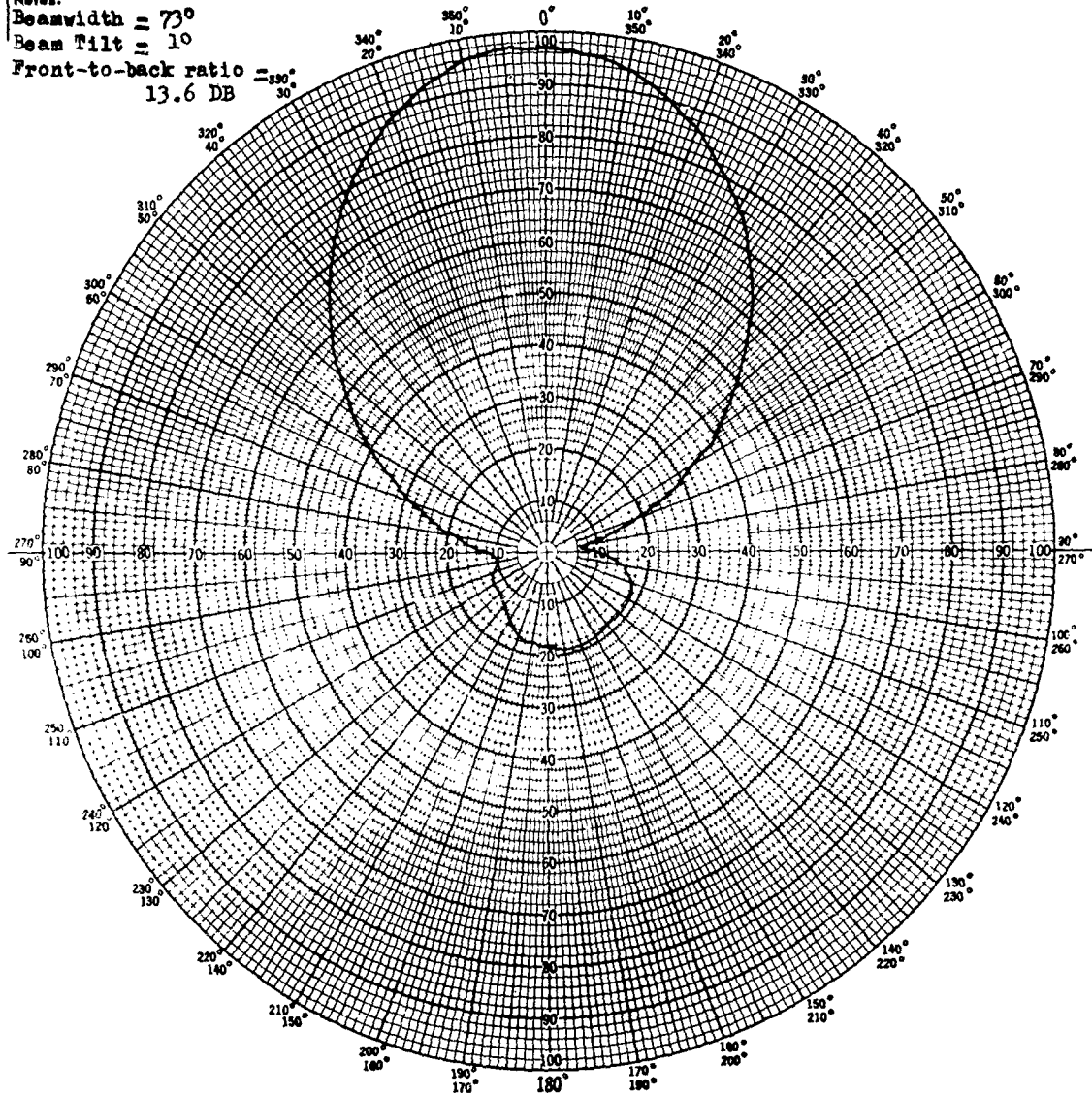
POLAR CHART - (LINEAR)

FIGURE 16

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 450 Mc	TRANSMITTER	POLARIZATION	RECEIVER	ROTATION	PATTERN
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☐	VERTICAL ☐	VERTICAL ☐	AZIMUTH ☒	E-PLANE ☒
PERSONNEL: Peter Bodnar	HORIZONTAL ☒	HORIZONTAL ☒	HORIZONTAL ☒	ELEVATION ☐	H-PLANE ☐
					AXIAL RATIO ☐

Notes:
 Beamwidth = 73°
 Beam Tilt = 1°
 Front-to-back ratio = 330°
 13.6 DB



PATTERN NO. 12

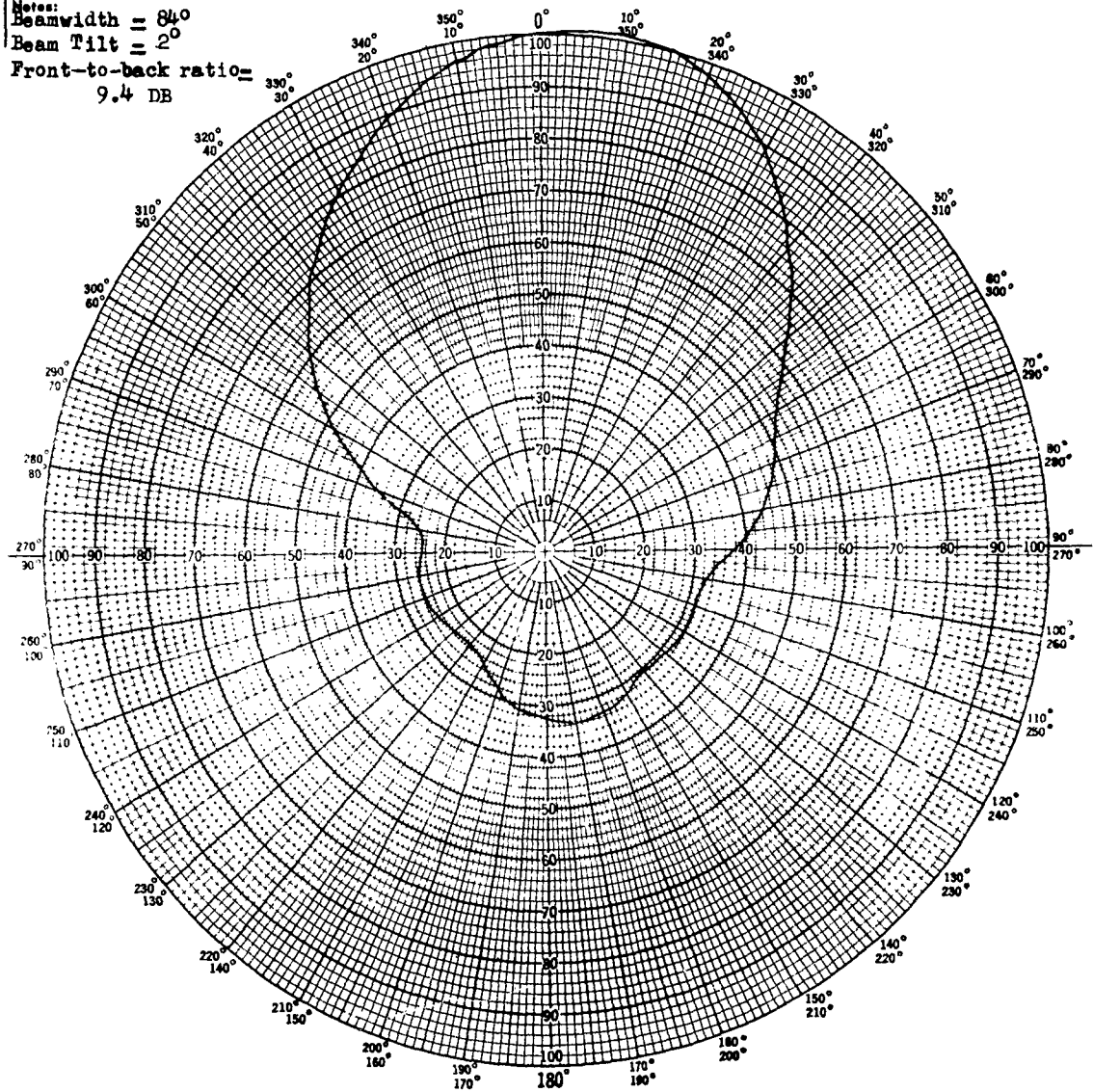
POLAR CHART - (LINEAR)

FIGURE 17

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 500 Mc	TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☒	HORIZONTAL ☐	VERTICAL ☒	HORIZONTAL ☐	AZIMUTH ☒	ELEVATION ☐	E-PLANE ☐	H-PLANE ☒
PERSONNEL: Peter Bodnar							AXIAL RATIO ☐	

Notes:
 Beamwidth = 84°
 Beam Tilt = 2°
 Front-to-back ratio = 9.4 DB

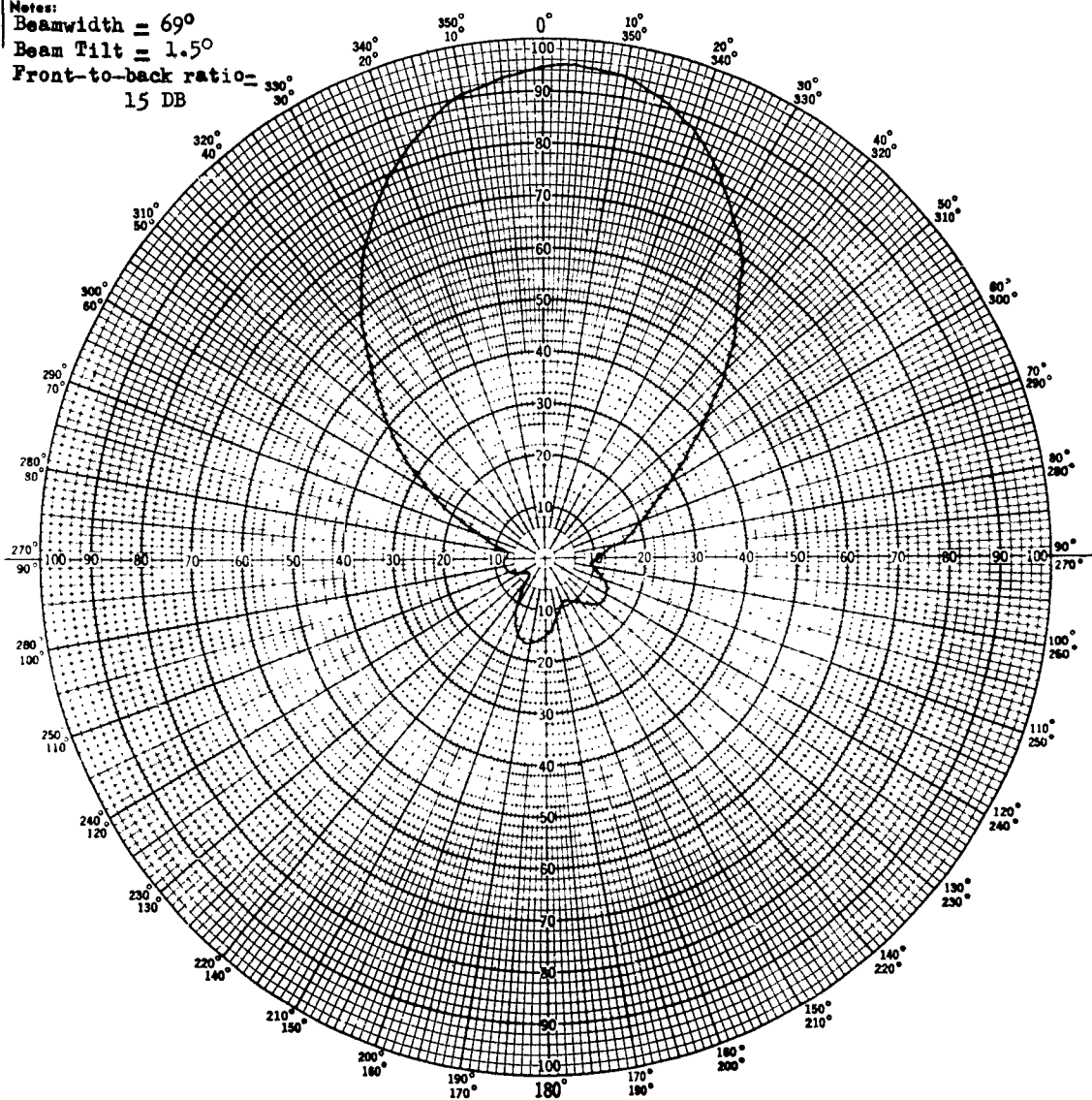


PATTERN NO. 13
 POLAR CHART - (LINEAR)
 FIGURE 18

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 500 Mc.		TRANSMITTER		POLARIZATION		RECEIVER		ROTATION		PATTERN	
SCALE: POWER	☐	VOLTAGE	☒	VERTICAL	☐	VERTICAL	☐	VERTICAL	☐	AZIMUTH	☒
PERSONNEL: Peter Bodnar		HORIZONTAL	☒	HORIZONTAL	☒	HORIZONTAL	☒	ELEVATION	☐	AXIAL RATIO	☐

Notes:
 Beamwidth = 69°
 Beam Tilt = 1.5°
 Front-to-back ratio = 15 DB



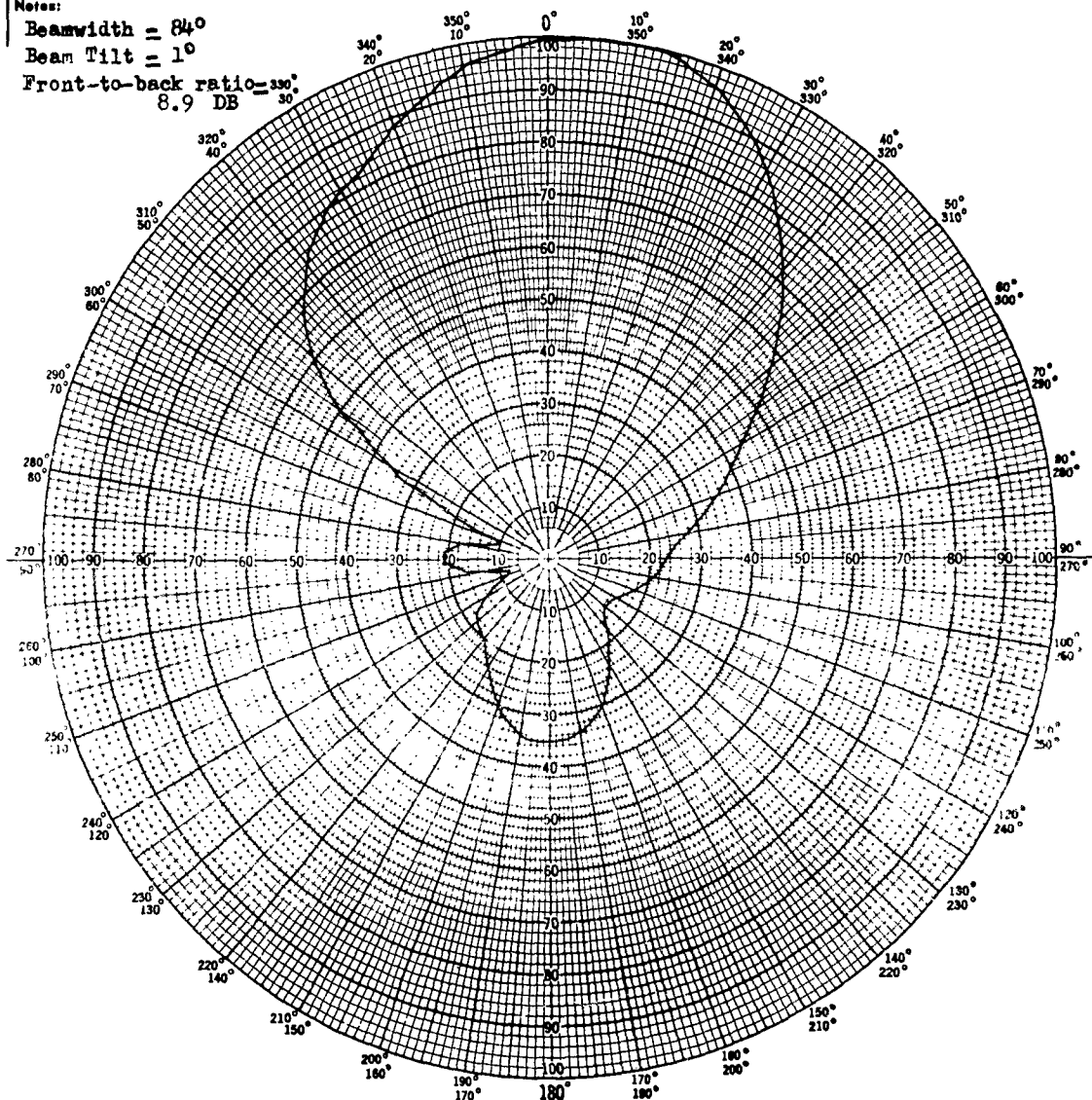
PATTERN NO. 14
 POLAR CHART - (LINEAR)
 FIGURE 19

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 550 Mc	TRANSMITTER		POLARIZATION RECEIVER		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☒	VERTICAL ☒	ROTATION	E-PLANE ☐		
PERSONNEL: Peter Bodnar	HORIZONTAL ☐	HORIZONTAL ☐	AXIMUTH ☐	H-PLANE ☒		
			ELEVATION ☐	AXIAL RATIO ☐		

Notes:

Beamwidth = 84°
 Beam Tilt = 1°
 Front-to-back ratio = 39°
 8.9 DB

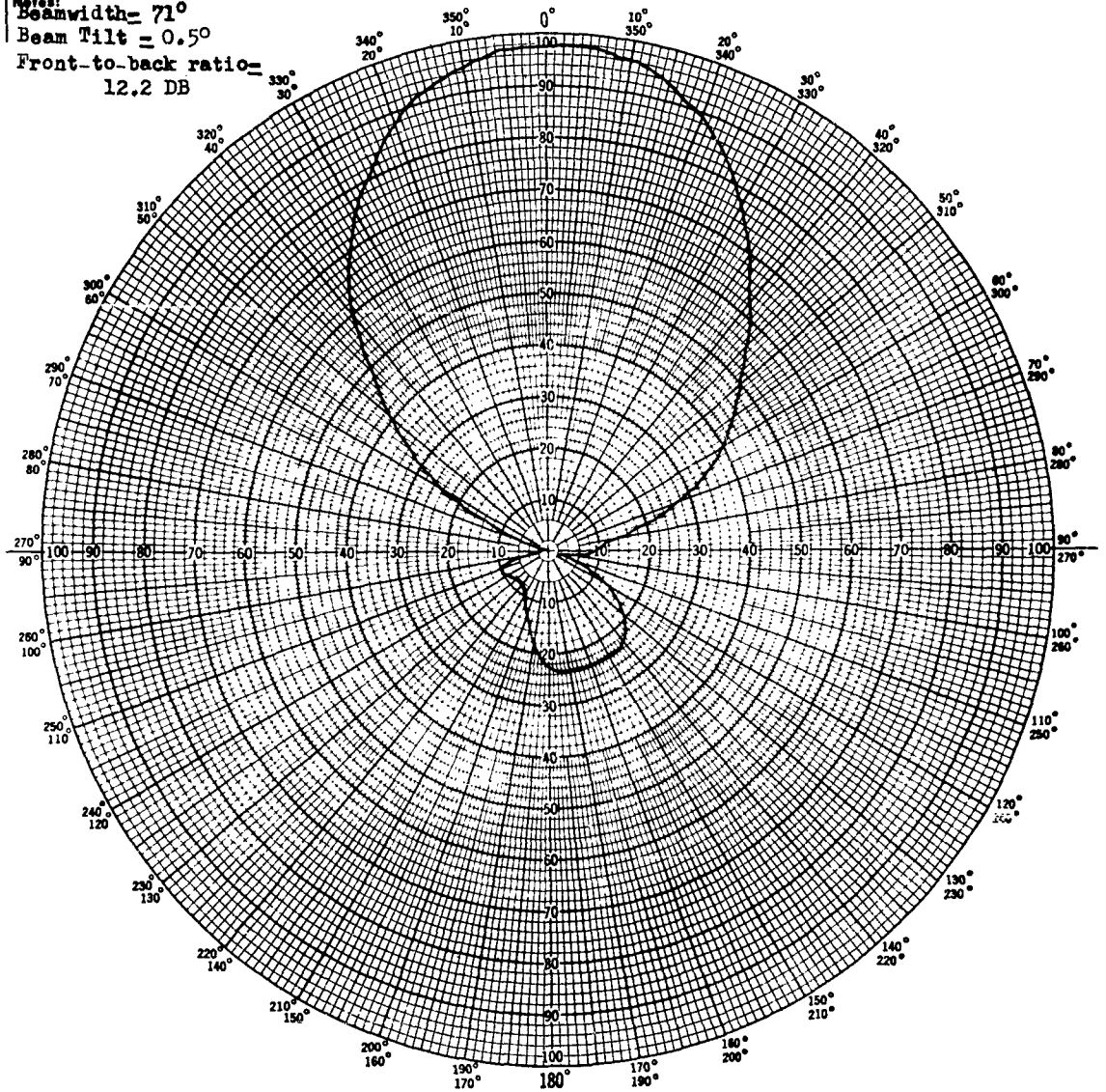


PATTERN NO. 15
 POLAR CHART - (LINEAR)
 FIGURE 20

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 550 Mc.	Polarization		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	TRANSMITTER	RECEIVER	ROTATION	E-PLANE ☒
PERSONNEL: Peter Bodnar	VERTICAL ☐	VERTICAL ☐	AZIMUTH ☒	H-PLANE ☐
	HORIZONTAL ☒	HORIZONTAL ☒	ELEVATION ☐	AXIAL RATIO ☐

Notes:
 Beamwidth = 71°
 Beam Tilt = 0.5°
 Front-to-back ratio =
 12.2 DB

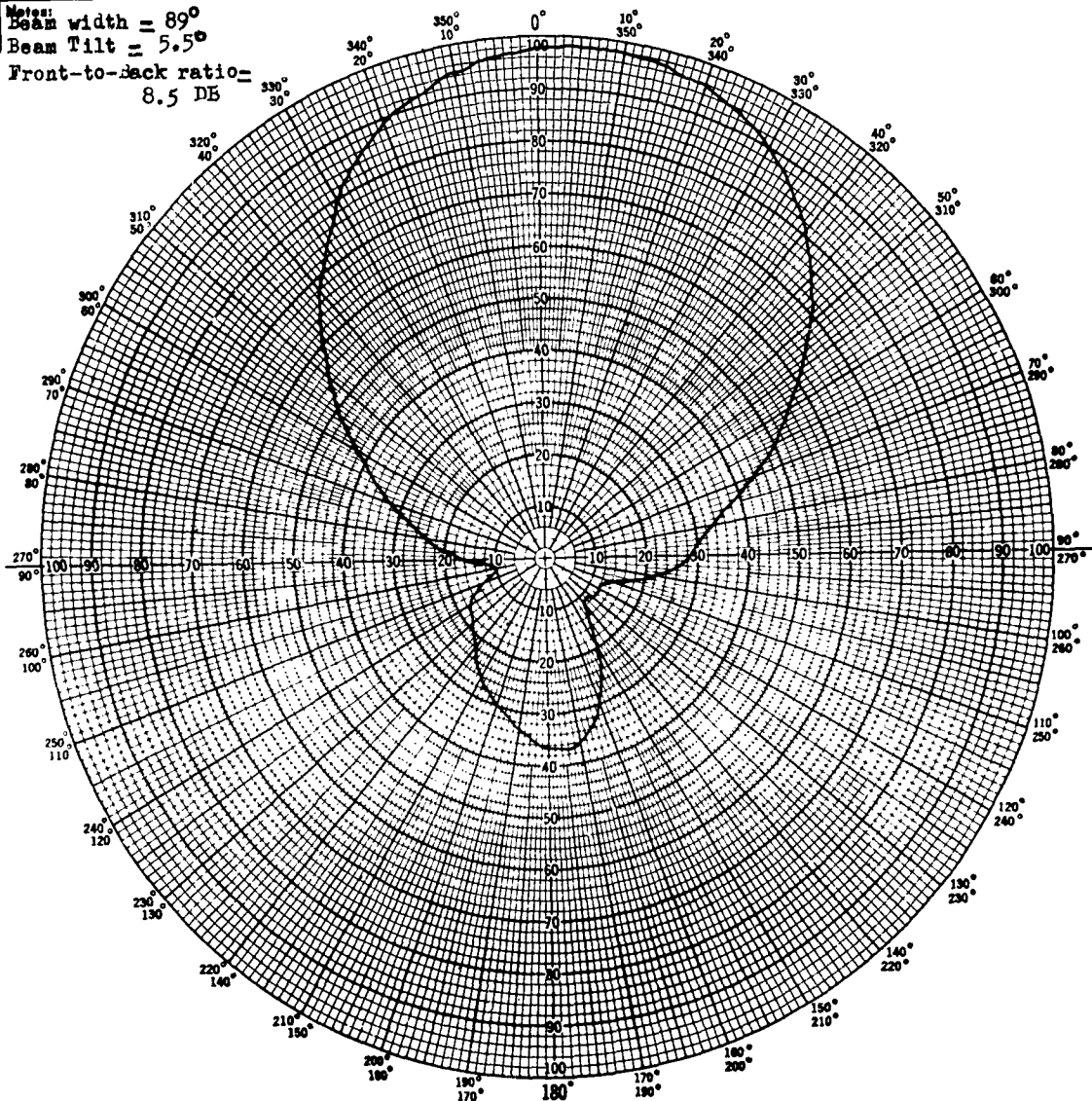


PATTERN NO. 16
 POLAR CHART - (LINEAR)
 FIGURE 21

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 600 Mc		TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER ☐	VOLTAGE ☒	VERTICAL ☒	HORIZONTAL ☐	VERTICAL ☒	HORIZONTAL ☐	AZIMUTH ☒	ELEVATION ☐	E-PLANE ☐	H-PLANE ☒
PERSONNEL: Peter Bodnar								AXIAL RATIO ☐	

Notes:
 Beam width = 89°
 Beam Tilt = 5.5°
 Front-to-back ratio = 8.5 DB



PATTERN NO. 17
 POLAR CHART - (LINEAR)
 FIGURE 22

FINAL MODEL AS-1089(XE-1)/ML

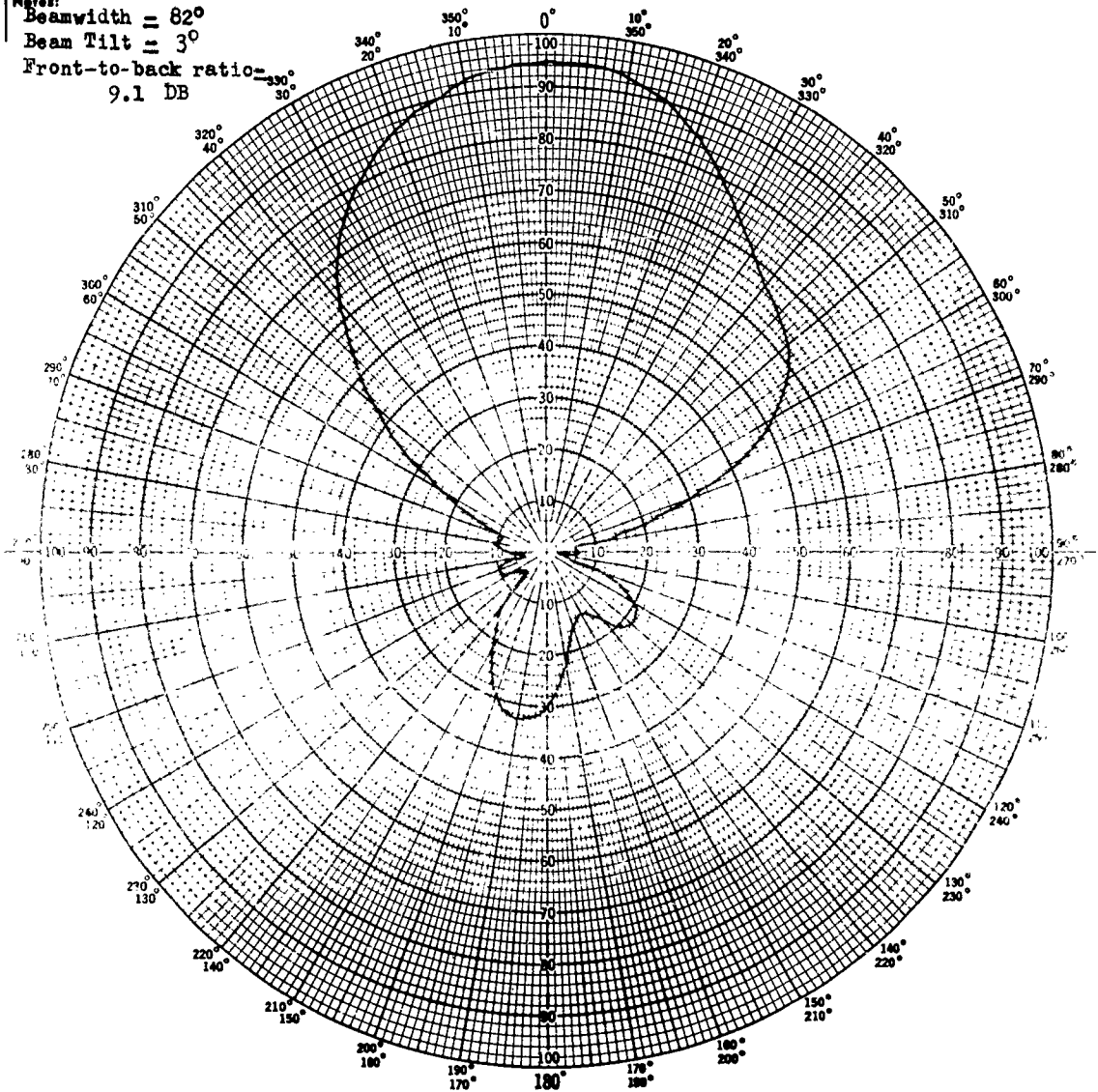
FREQUENCY: 600 Mc		TRANSMITTER		RECEIVER		ROTATION		PATTERN	
SCALE: POWER	☐ VOLTAGE	☒ VERTICAL	☐ HORIZONTAL	☐ VERTICAL	☒ HORIZONTAL	☐ AZIMUTH	☒ ELEVATION	☒ E-PLANE	☐ H-PLANE
PERSONNEL: eter Bodnar								AXIAL RATIO	

Notes:

Beamwidth = 82°

Beam Tilt = 3°

Front-to-back ratio = 9.1 DB



PATTERN NO. 18
POLAR CHART - (LINEAR)

FIGURE 23

FINAL MODEL AS-1089(XE-1)/ML

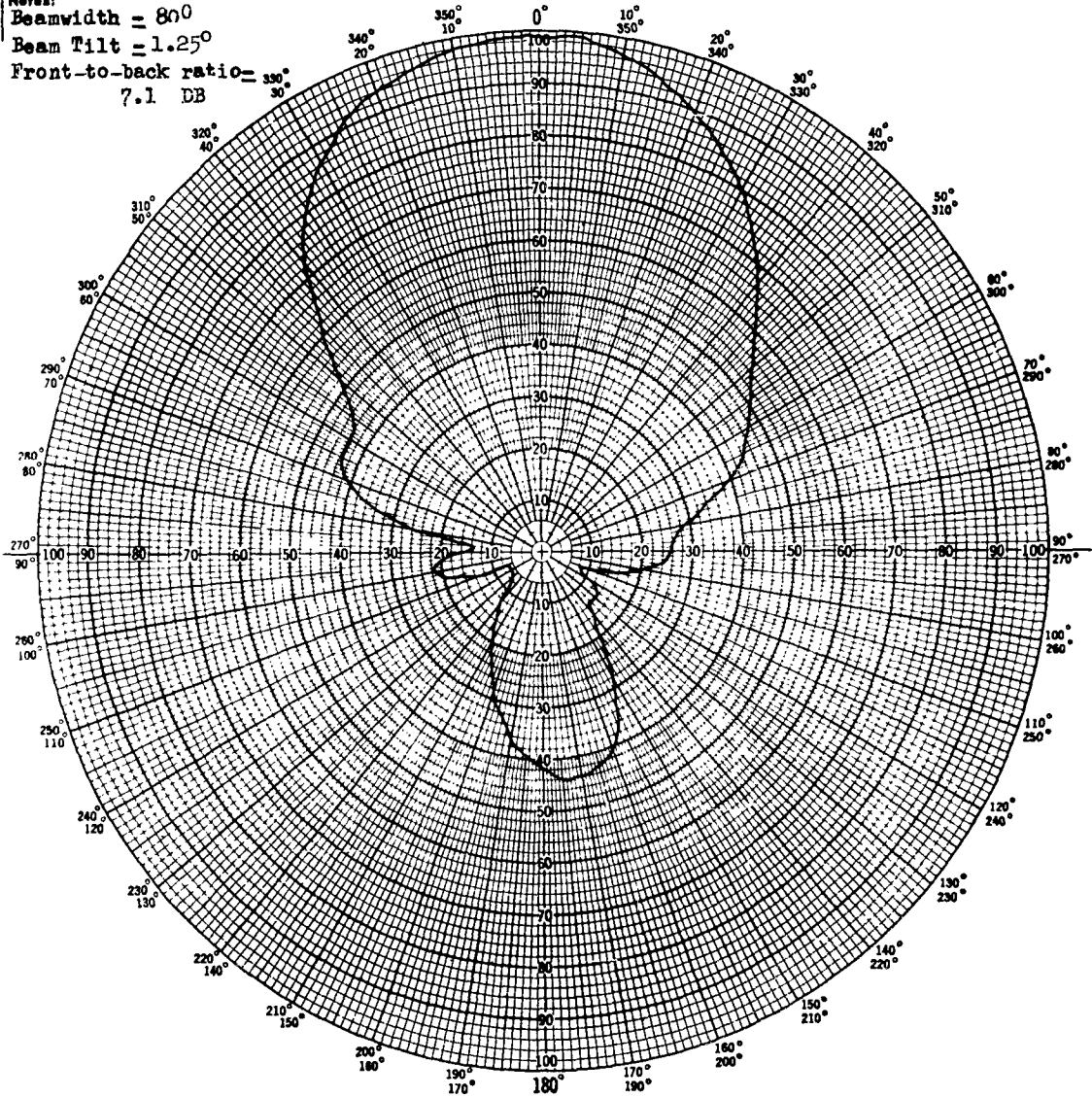
FREQUENCY: 660 Mc	TRANSMITTER	POLARIZATION	PATTERN
SCALE: POWER ☐ VOLTAGE ☒	RECEIVER	ROTATION	E-PLANE ☐
PERSONNEL: Peter Bodnar	VERTICAL ☒ HORIZONTAL ☐	VERTICAL ☒ HORIZONTAL ☐	AZIMUTH ☒ H-PLANE ☐
		ELEVATION ☐	AXIAL RATIO ☐

Notes:

Beamwidth = 80°

Beam Tilt = 1.25°

Front-to-back ratio = 7.1 DB

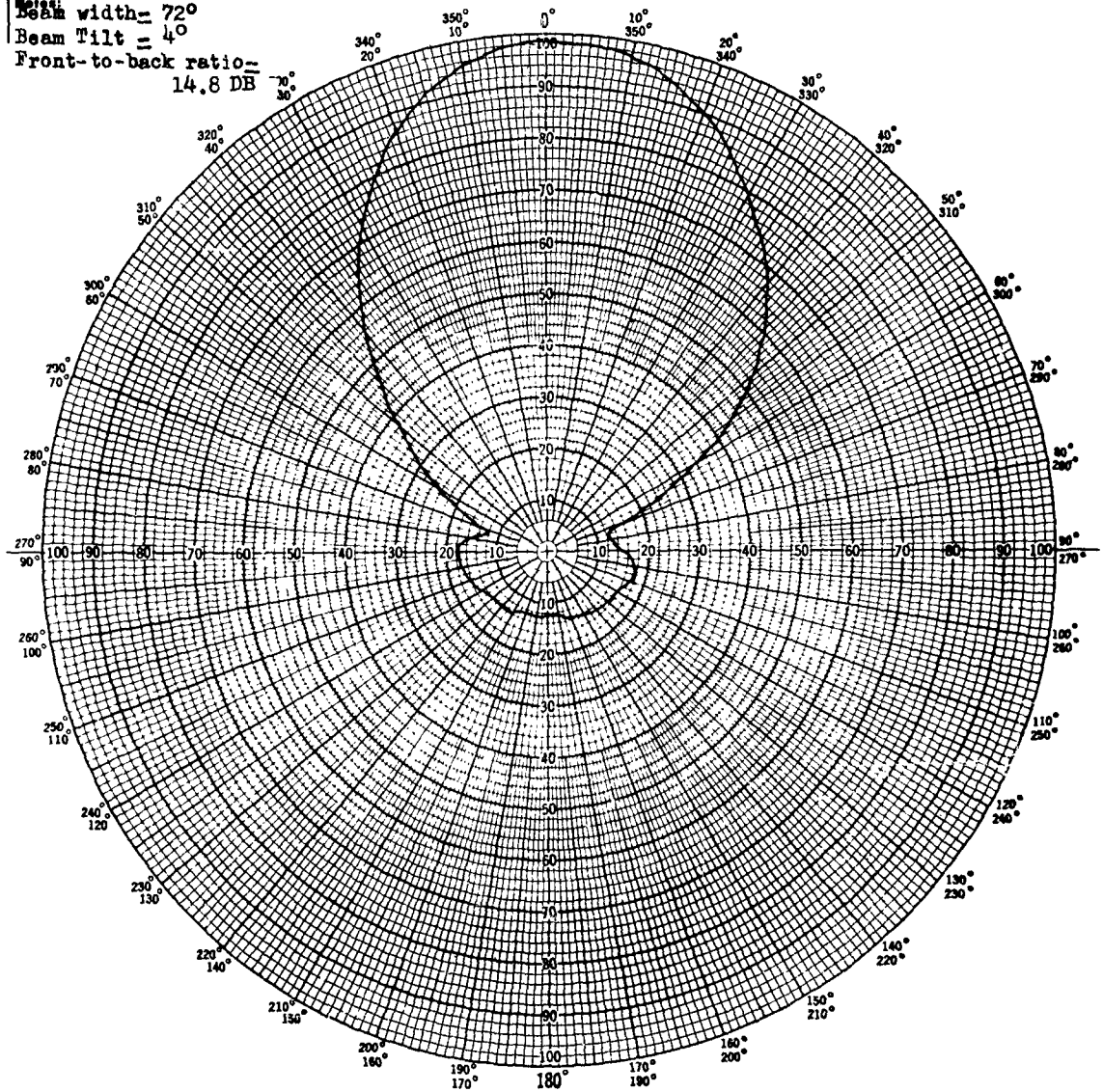


PATTERN NO. 19
POLAR CHART - (LINEAR)
FIGURE 24

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 665 Mc.	POLARIZATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	TRANSMITTER	RECEIVER	ROTATION	E-PLANE ☒
PERSONNEL: Peter Bodnar	VERTICAL ☐	VERTICAL ☐	AZIMUTH ☒	H-PLANE ☐
	HORIZONTAL ☒	HORIZONTAL ☒	ELEVATION ☐	AXIAL RATIO ☐

Beam width = 72°
 Beam Tilt = 4°
 Front-to-back ratio = 14.8 DB



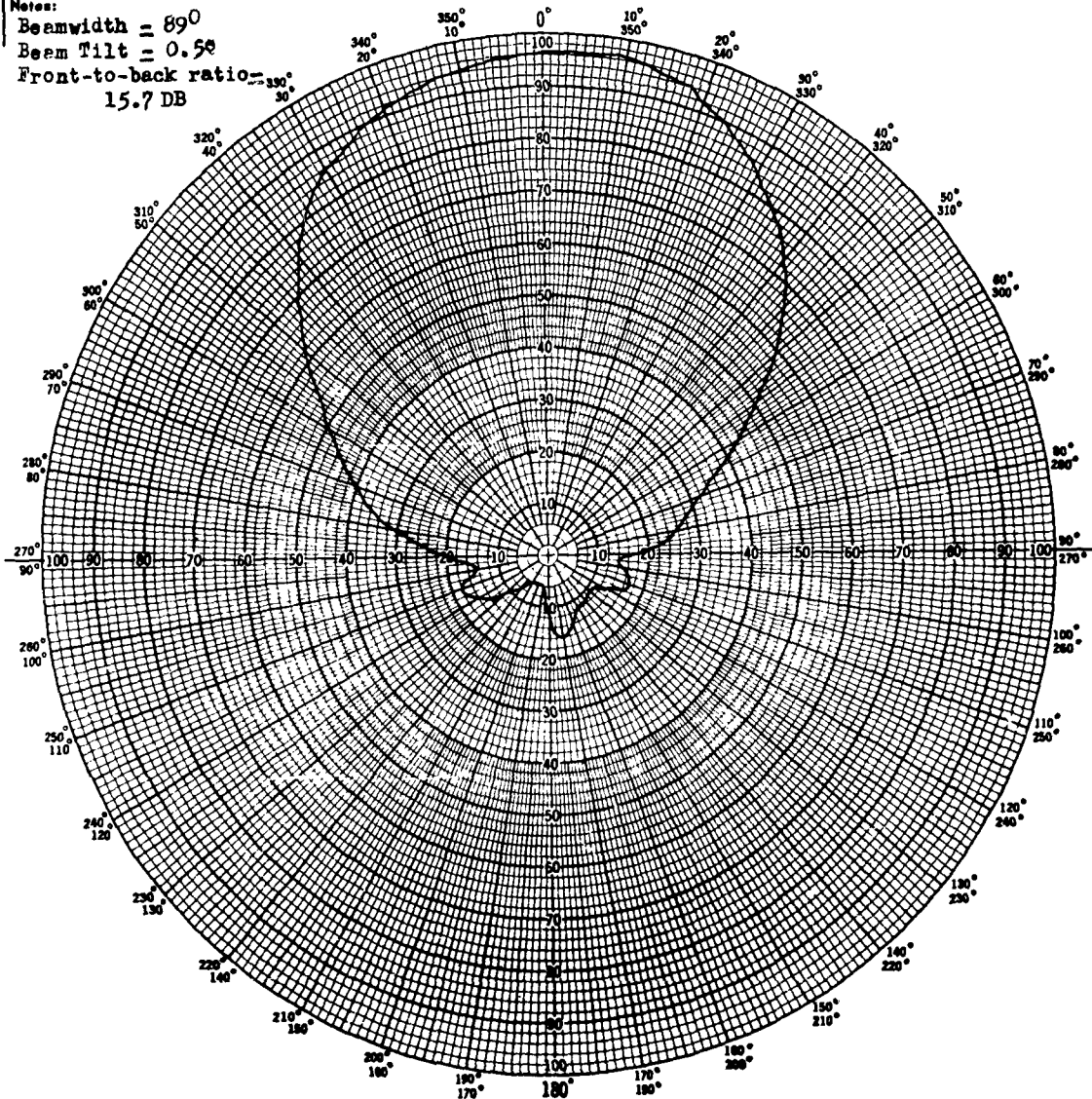
PATTERN NO. 20
 POLAR CHART - (LINEAR)
 FIGURE 25

FINAL MODEL AS-1089(XE-1)/ML

FREQUENCY: 700 Mc.	TRANSMITTER	POLARIZATION	RECEIVER	ROTATION	E-PLANE	☐
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☒	VERTICAL ☒	VERTICAL ☒	AZIMUTH ☒	H-PLANE	☒
PERSONNEL: Peter Bodnar	HORIZONTAL ☐	HORIZONTAL ☐	HORIZONTAL ☐	ELEVATION ☐	AXIAL RATIO	☐

Notes:

Beamwidth = 89°
 Beam Tilt = 0.5°
 Front-to-back ratio = 15.7 DB



PATTERN NO. 21

POLAR CHART - (LINEAR)

FIGURE 26

FINAL MODEL AS-1089(XE-1)/ML

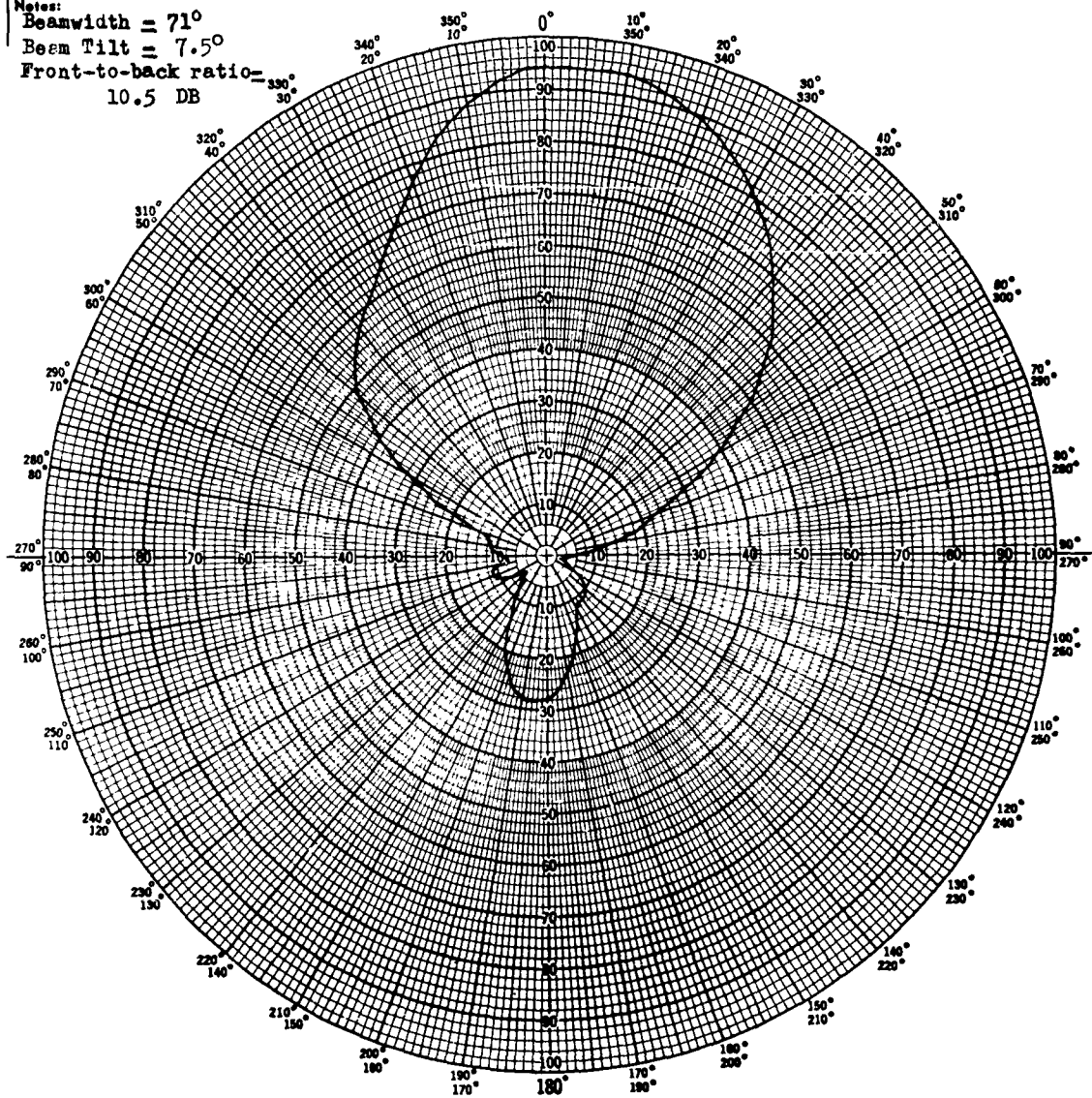
FREQUENCY: 700 Mc.	POLARIZATION		PATTERN
SCALE: POWER ☐ VOLTAGE ☒	TRANSMITTER	RECEIVER	ROTATION
PERSONNEL: Peter Bodnar	VERTICAL ☐ HORIZONTAL ☒	VERTICAL ☐ HORIZONTAL ☒	AZIMUTH ☒ ELEVATION ☐
			E-PLANE ☒ H-PLANE ☐ AXIAL RATIO ☐

Notes:

Beamwidth = 71°

Beam Tilt = 7.5°

Front-to-back ratio =
10.5 DB



PATTERN NO. 22
POLAR CHART - (LINEAR)
FIGURE 27

FINAL MODEL AS-1089(XE-1)/ML

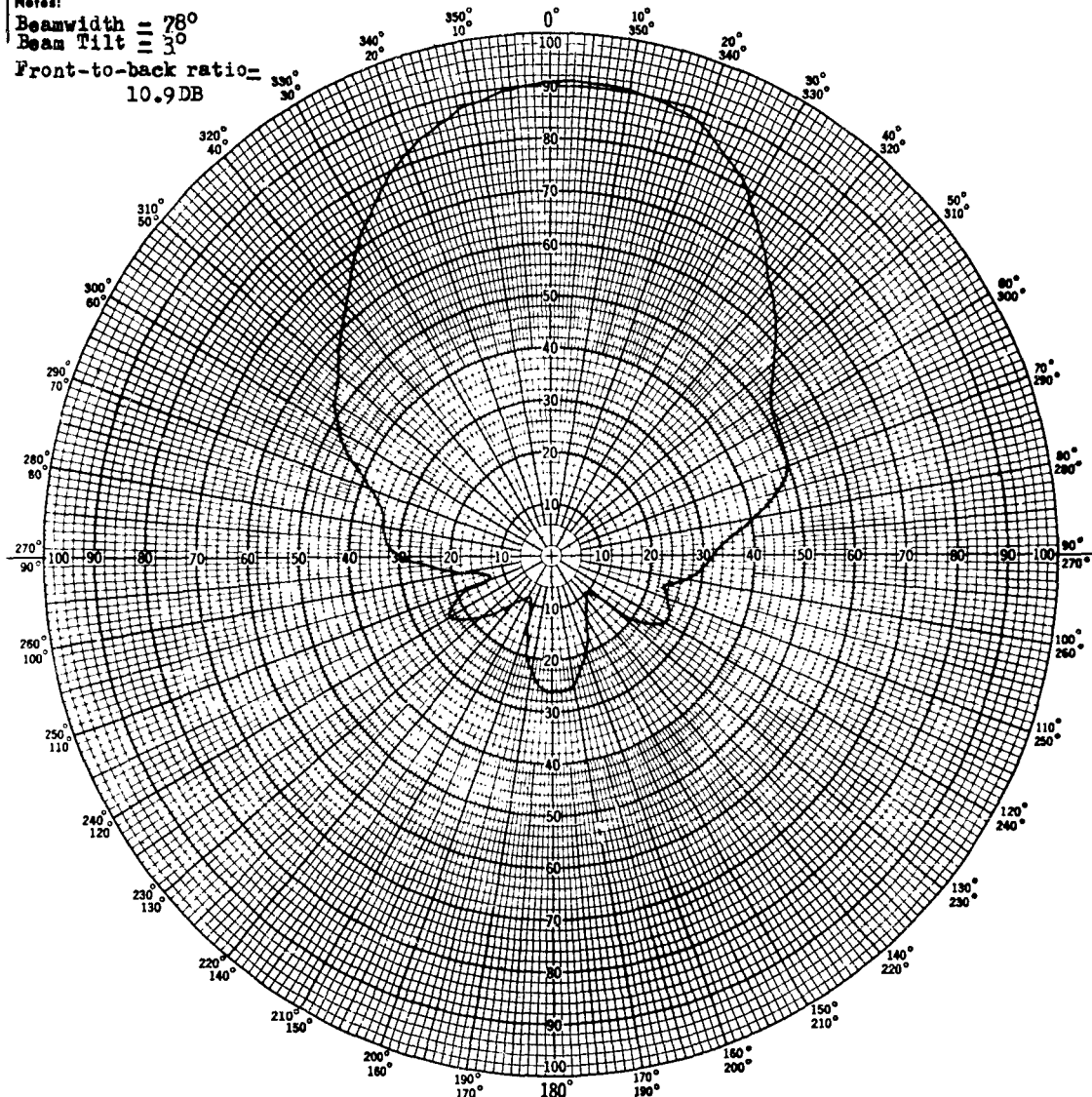
FREQUENCY: 750 Mc		POLARIZATION		PATTERN	
SCALE: POWER ☐	VOLTAGE ☒	TRANSMITTER	RECEIVER	ROTATION	E-PLANE ☐
PERSONNEL: Peter Bodnar		VERTICAL ☒	VERTICAL ☐	AZIMUTH ☒	H-PLANE ☒
		HORIZONTAL ☐	HORIZONTAL ☐	ELEVATION ☐	AXIAL RATIO ☐

Notes:

Beamwidth = 78°

Beam Tilt = 3°

Front-to-back ratio = 10.9 DB



PATTERN NO. 23

POLAR CHART - (LINEAR)

FIGURE 28

FINAL MODEL AS-1089(XE-1)/ML

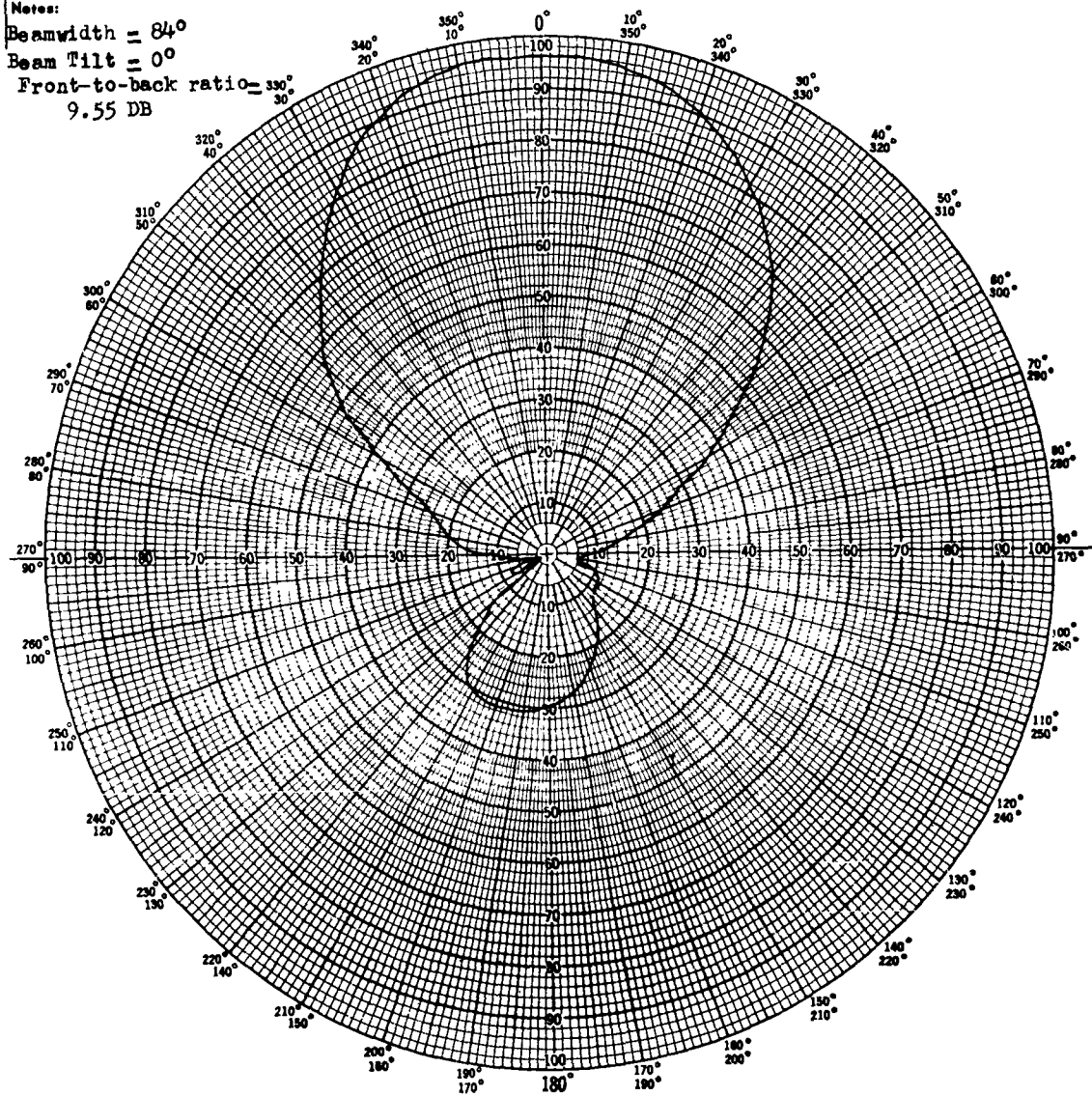
FREQUENCY: 800 Mc	TRANSMITTER	POLARIZATION		PATTERN	
SCALE: POWER ☐ VOLTAGE ☒	VERTICAL ☐	RECEIVER	ROTATION	E-PLANE	☒
PERSONNEL: Peter Bodnar	HORIZONTAL ☒	VERTICAL ☐	AZIMUTH ☒	H-PLANE	☐
		HORIZONTAL ☒	ELEVATION ☐	AXIAL RATIO	☐

Notes:

Beamwidth = 84°

Beam Tilt = 0°

Front-to-back ratio = 330°
9.55 DB

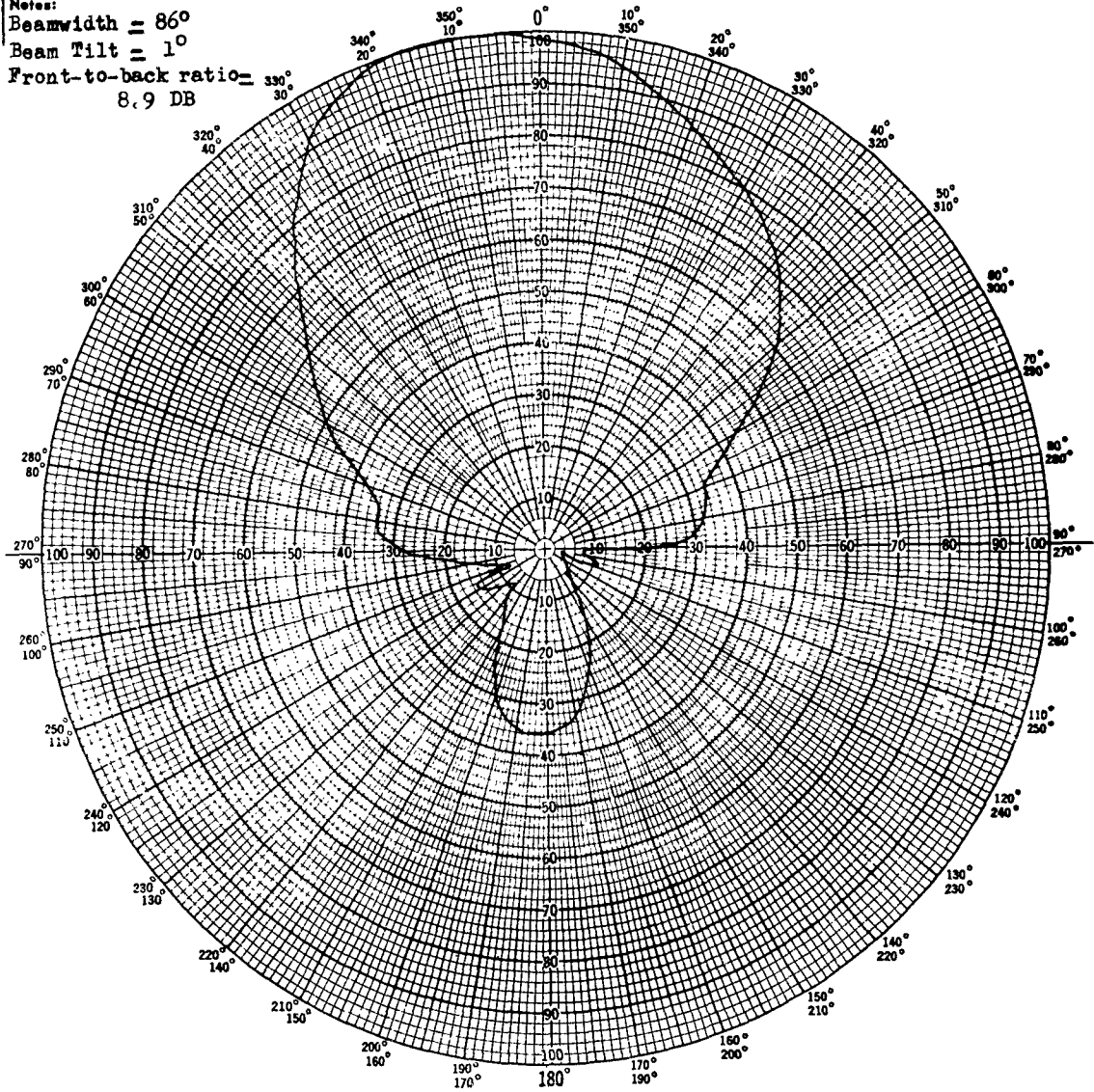


PATTERN NO. 24
POLAR CHART - (LINEAR)
FIGURE 29

FINAL MODEL AS-1089(XE-1)/ML

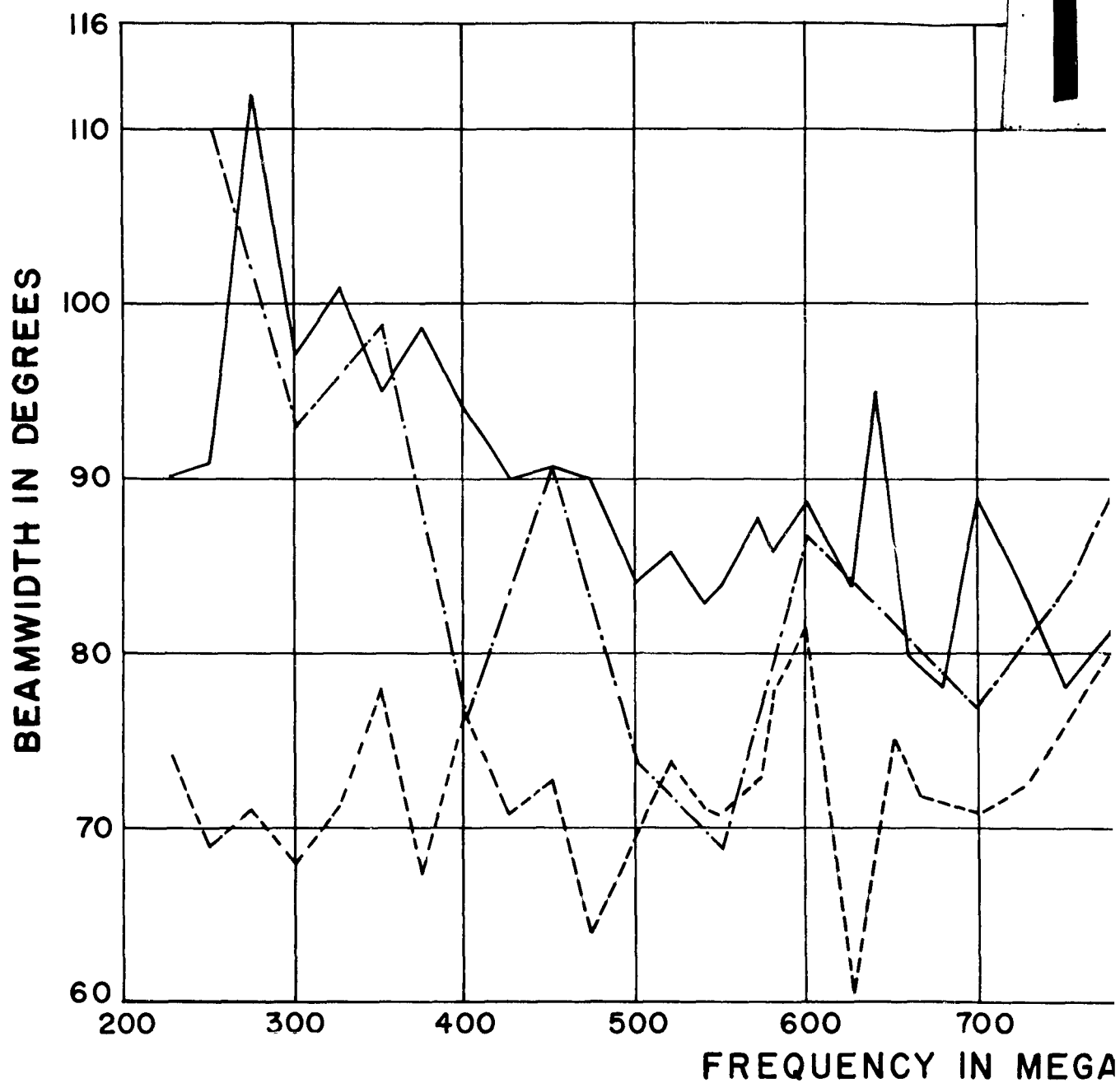
FREQUENCY: 800 Mc		TRANSMITTER		POLARIZATION		PATTERN	
SCALE: POWER ☐	VOLTAGE ☒	VERTICAL ☒	HORIZONTAL ☐	RECEIVER	ROTATION	E-PLANE ☐	H-PLANE ☒
PERSONNEL: Peter Bodnar		VERTICAL ☒	HORIZONTAL ☐	VERTICAL ☒	HORIZONTAL ☐	AXIAL RATIO ☐	

Notes:
 Beamwidth = 86°
 Beam Tilt = 1°
 Front-to-back ratio = 8.9 DB



PATTERN NO. 25
 POLAR CHART - (LINEAR)

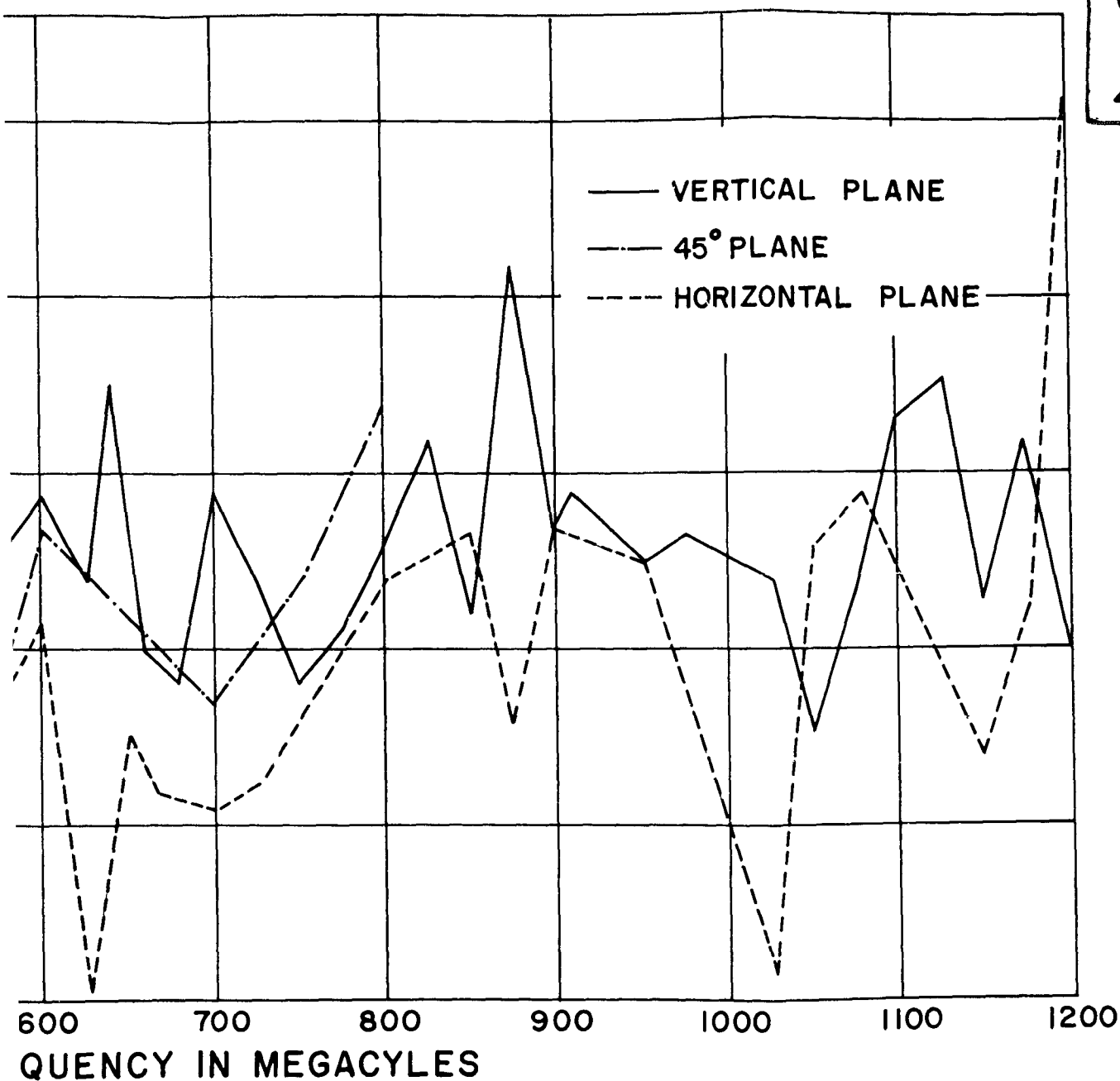
FIGURE 30



HALF-POWER BEAMWIDTH IN 3 PLANES, LOG PI

FIG. 31

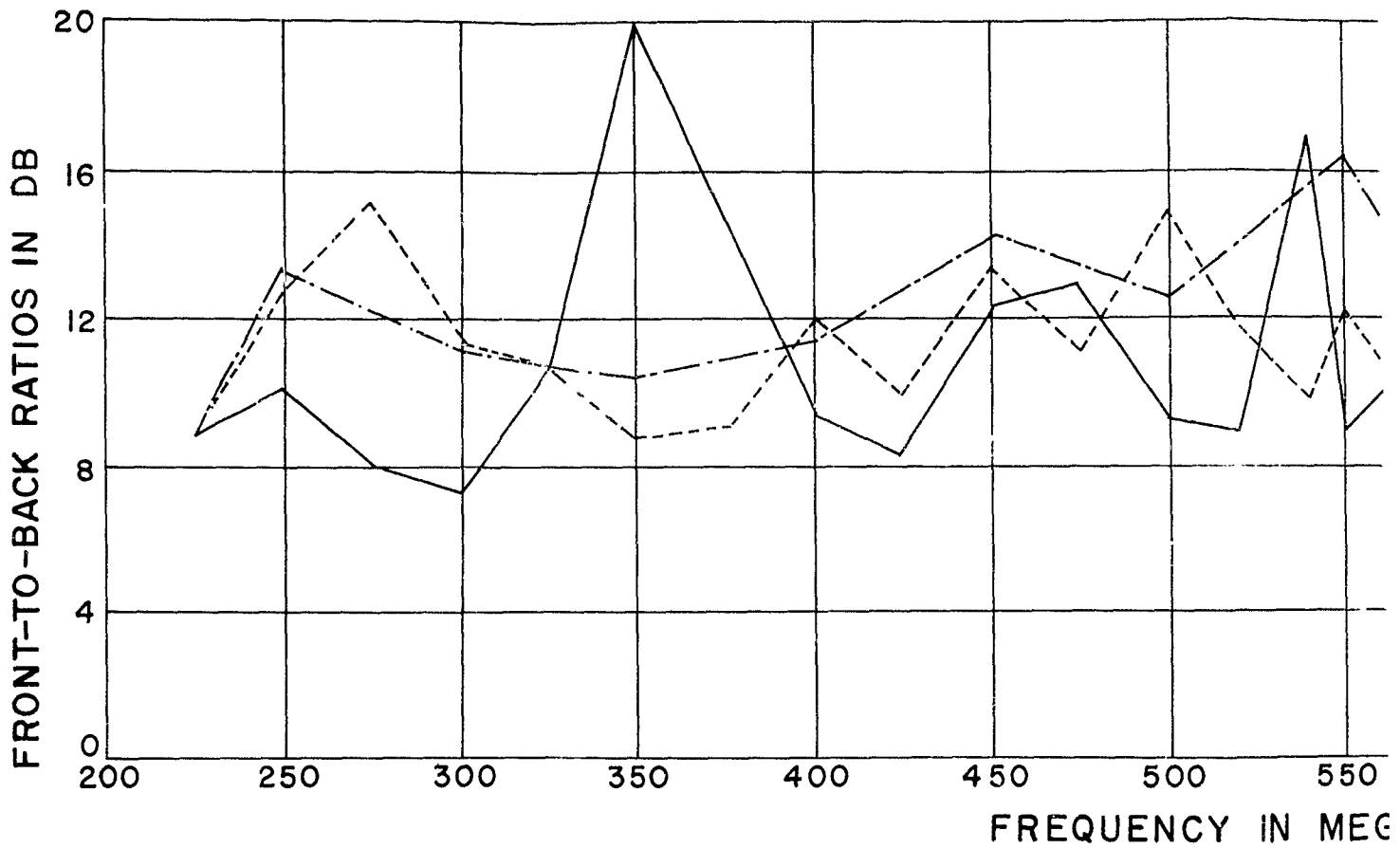
2



PLANES, LOG PERIODIC ANTENNA AS-1089(XE-1)/ML

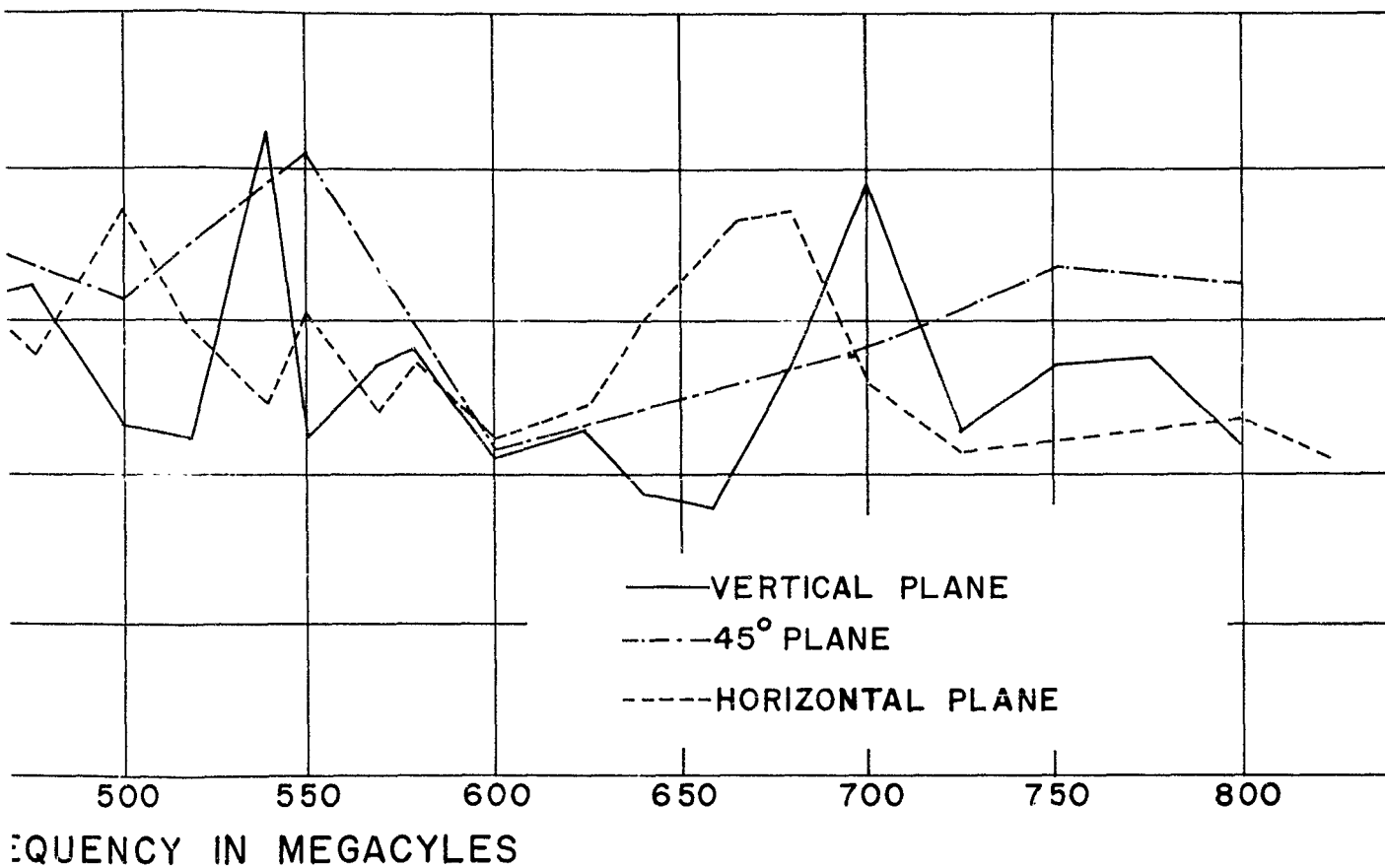
FIG. 31

1



FRONT-TO-BACK RATIOS IN 3 PLANES, LOG PE

FIG. 32



ANES, LOG PERIODIC ANTENNA AS-1089 (XE-1)/ML

FIG. 32

DISTRIBUTION LIST

<u>Addressee</u>	<u>No. of Copies</u>	<u>Addressee</u>	<u>No. of Copies</u>
Commanding General U. S. Army Electronics Command ATTN: AMSEL-AD Fort Monmouth, New Jersey	3	Commanding Officer U. S. Army Chemical Warfare Laboratories ATTN: Technical Library, Bldg 330 Army Chemical Center, Maryland	1
Office of the Assistant Secretary of Defense (Research and Engineering) ATTN: Technical Library Room 3E1065, The Pentagon Washington 25, D. C.	1	Commanding Officer Harry Diamond Laboratories Connecticut Ave. & Van Ness St., N.W. Washington 25, D. C.	1
Chief of Research & Development Department of the Army Washington 25, D. C.	2	Headquarters, United States Air Force ATTN: AFCIN Washington 25, D. C.	2
Chief, U. S. Army Security Agency ATTN: ACoS, G4 (Technical Library) Arlington Hall Station Arlington 12, Virginia	1	Rome Air Development Center ATTN: RAALD Griffiss Air Force Base New York	1
Commanding Officer U. S. Army Electronics Research & Development Activity ATTN: SELWS-AJ White Sands, New Mexico	1	Headquarters Ground Electronics Engineering Installation Agency ATTN: ROZMEL Griffiss Air Force Base, New York	1
Commanding Officer U. S. Army Electronics Research Unit P. C. Box 205 Mountain View, California	1	Commanding General U. S. Army Materiel Command ATTN: R&D Directorate Washington 25, D. C.	2
Commanding Officer U. S. Army Electronics Materiel Support Agency ATTN: SELMS-ADJ Fort Monmouth, New Jersey	1	Aeronautical Systems Division ATTN: ASAPRL Wright-Patterson Air Force Base, Ohio	1
Commanding General U. S. Army Satellite Communications Agency ATTN: Technical Documents Center Fort Monmouth, New Jersey	1	U. S. Air Force Security Service ATTN: ESD San Antonio, Texas	1
Director U. S. Army Engineer Research & Development Laboratories ATTN: Technical Documents Center Fort Belvoir, Virginia	1	Headquarters Strategic Air Command ATTN: DOCE Offutt Air Force Base, Nebraska	1
		Headquarters Research & Technology Division ATTN: RTH Bolling Air Force Base Washington 25, D. C.	1

DISTRIBUTION LIST (CONTD)

<u>Addressee</u>	<u>No. of Copies</u>	<u>Addressee</u>	<u>No. of Copies</u>
Air Proving Ground Center ATTN: PGAPI Eglin Air Force Base, Florida	1	Commander U. S. Naval Ordnance Laboratory White Oak Silver Spring 19, Maryland	1
Air Force Cambridge Research Laboratories ATTN: CRXL-R L. G. Hanscom Field Bedford, Massachusetts	2	Commander Armed Services Technical Information Agency ATTN: TISIA Arlington Hall Station Arlington 12, Virginia	20
Headquarters Electronic Systems Division ATTN: ESAT L. G. Hanscom Field Bedford, Massachusetts	2	USAELRDL Liaison Officer U. S. Army Tank-Automotive Center Detroit Arsenal Center Line, Michigan	1
AFSC Scientific/Technical Liaison Office U. S. Naval Air Development Center Johnsville, Pennsylvania	1	USAELRDL Liaison Officer Naval Research Laboratory ATTN: Code 1071 Washington 25, D. C.	1
Chief of Naval Research ATTN: Code 427 Department of the Navy Washington 25, D. C.	1	USAELRDL Liaison Officer Massachusetts Institute of Technology Building 26, Room 131 77 Massachusetts Avenue Cambridge 39, Massachusetts	1
Bureau of Ships Technical Library ATTN: Code 312 Main Navy Building, Room 1528 Washington 25, D. C.	1	USAELRDL Liaison Office Aeronautical Systems Division ATTN: ASDL-9 Wright-Patterson Air Force Base Ohio	1
Chief, Bureau of Ships ATTN: Code 454 Department of the Navy Washington 25, D. C.	1	U. S. Army Research Liaison Office Lincoln Laboratory P. O. Box 73 Lexington, Massachusetts	1
Chief, Bureau of Ships ATTN: Code 686B Department of the Navy Washington 25, D. C.	1	USAELRDL Liaison Officer Rome Air Development Center ATTN: RAOL Griffiss Air Force Base, New York	1
Director U. S. Naval Research Laboratory ATTN: Code 2027 Washington 25, D. C.	1		
Commanding Officer & Director U. S. Navy Electronics Laboratory ATTN: Library San Diego 52, California	1		

DISTRIBUTION LIST (CONTD)

<u>Addressee</u>	<u>No. of Copies</u>	<u>Addressee</u>	<u>No. of Copies</u>
USAEMSA Liaison Engineer	1	Commanding Officer	1
USASCAJ		U. S. Army Security Agency	
APO 343		Processing Center, Deal Area	
San Francisco, California		Bldg. 5001	
Technical Dir. , SELRA/CS	1	Chief, Technical Information	6
Headquarters, USAELRDL		Division	
USAELRDA-White Sands Liaison Office	1	Headquarters, USAELRDL	
SELRA/LNW, USAELRDL		(FOR RETRANSMITTAL TO Accredited	
AFSC Scientific/Technical Liaison	1	British Govt Representative (1); Accre-	
Office		ditated Canadian Govt Representative (2);	
SELRA/LNA, USAELRDL		Library of Congress (2))	
Corps of Engineers Liaison Office	1	USAELRDL Technical Documents Center	1
SELRA/LNE, USAELRDL		SEIRA/ADT, Hexagon	
Marine Corps Liaison Office	1	File Unit #2 (Evans Area)	1
SELRA/LNR, USAELRDL		USASA Technical Representative	3
USACDC Liaison Office	2	Evans Area	
SELRA/LNF, USAELRDL		Director, Electronic Warfare	30
National Security Agency	1	Division, Surveillance Dept	
ATTN: Code C-124		Evans Area	
Fort George G. Meade, Maryland		ATTN: Ch, Advanced Techniques Br	(15)
National Aeronautics and Space	1	Ch, Jamming & Deception Br	(3)
Administration		Ch, Special Devices Br	(1)
Goddard Space Flight Center		Ch, EW Systems Engineering	(1)
ATTN: Mr. A. Kampinsky		Ch, Tech Staff(Rpts Group)	(10)
Greenbelt, Maryland		Director, Radar Division	1
National Bureau of Standards	1	ATTN: SELRA/SRD (Mr. Gelernter)	
Boulder Laboratories		Director, Transmission Facilities	1
ATTN: Mr. H. V. Cottony		Division	
Boulder, Colorado		ATTN: SELRA/NRA (Mr. Triolo)	
Chief, Bureau of Naval Weapons	1	Commander	1
ATTN: RAAV-4121		U. S. Naval Ordnance Laboratory	
Washington 25, D. C.		ATTN: Code 523	
Director	1	Corona, California	
U. S. Navy Underwater Sound		Commander	1
Laboratory		U. S. Army Ordnance Ballistics	
ATTN: Mr. R. W. Turner		Research Laboratory	
Fort Trumbull		ATTN: ORDEG-BRL-M	
New London, Connecticut		Aberdeen Proving Ground, Maryland	
		Chief Scientist	1
		U. S. Army Electronics Command	
		Attn: AMSEL-SC, Fort Monmouth, N.J.	

[illegible]