Final Report

# ANTENNA EVALUATION OF FORD EXP WITH METAL VS. PLASTIC FENDERS

by

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## 1. Introduction

The purpose for conducting this investigation was to evaluate the antenna performance (antenna pattern and VSWR) in the FM band (88 to 108 MHz) of an automobile antenna mounted on a plastic fender vs. a metallic fender. To carry out this investigation two automobiles were employed. One a pool car from Ford Motor Co. and the second a test car. The pool car was identified as P109 and the test vehicle as 677. The pool car was a red Ford EXP and the test car was a white hybrid Mercury LN7 Ford EXP. With the entertainment antenna mounted on a plastic fender, it was found that its electrical performance (VSWR and radiation pattern) was sensitive to a ground plane configuration. To achieve antenna electrical performance, using a plastic fender, comparable to that obtained using a metallic fender it was necessary to back the plastic fender with a ground plane 14 x 5 inches. Data to substantiate this conclusion is presented in Appendix A.

## 2. Technical Discussion

A Ford Motor Co. pool car was used to represent a standard production line car and no changes were made to the geometry of this vechicle. However, the test car was reconfigured to represent four different model configurations. The four configurations represented were a standard production line car with steel fenders, a car having

plastic fenders with no ground plane and plastic fender with both a small and a large ground plane. The small ground plane employed was a small piece of metal setting directly underneath the antenna base and was approximately an inch and a half in diameter and had a short pigtail that was attached to the car frame. The large ground plane consisted of a metallic sheet approximately 14 inches long and 5 inches wide with the antenna mounted at its center. Large ground plane pattern data were collected for two different configurations of attachment to the car. Initially a screw was used to mount the ground plane to the car body and the second configuration used a ground strap but no screw to attach it to the car body.

VSWR and pattern data were collected at the following five frequencies within the FM band: 88, 93, 98, 103 and 108 MHz. The antenna used was a standard production line fixed AM/FM entertainment antenna used on Ford EXP and Mercury LN7 1981 automobiles.

VSWR data for the two large ground plane configurations noted above were basically the same and therefore only one set of data is shown in Table 1. From the test data of Table 1 it can also be seen that the VSWR data for the pool car, test car production line version, test car with plastic fender and large ground plane exhibit similar VSWRs. However, the test car with plastic fender and small ground plane or no ground plane exhibit a slightly higher VSWR. However, this higher VSWR would not severely degrade the performance of the antenna. It should be noted the VSWR characteristics will provide some insight as to the efficiency of the antenna. Nominally, a VSWR of 2:1 would suggest a 10 percent reduction in the efficiency of the

antenna. This inefficiency is not believed to be detrimental to the overall system performance. We would suspect system performance could begin to become degraded if the VSWR becomes greater than 3:1 (which implies a 20 percent reduction in antenna efficiency). From Table I it can be seen that at a frequency of 108 MHz, both the small ground plane and the no ground plane configurations have a VSWR of 3:1.

Antenna pattern data were also collected at the five frequencies noted above for the five car configurations. These data are presented in Appendix A of the report. In addition to collecting automobile pattern data for the car antennas, data was also collected for a quarter-wave monopole (quarter-wavelength long at 98 MHz) mounted over a five-foot diameter ground plane. These data were collected for the five frequencies previously noted. These data were recorded at the beginning and end of each days operation to provide assurance of the stability of the test setup. The test setup used is shown in Fig. 2. The transmitting antenna is a 50 to 500 MHz log periodic dipole located nominally 24 feet above ground and 150 feet from the vehicle under test. All pattern data for the automobile are arranged such that when the front of the car is facing the transmitting antenna as shown in Fig. 2 this is noted as zero degrees (top of the pattern paper) on the pattern charts. Further, as the car is rotated in a clockwise direction, pattern data was also plotted in a clockwise direction. All pattern data has been normalized so that the reader may hold the patterns over a light source and obtain a comparison between the various car configurations at each frequency of interest.

From the pattern data presented in the appendix the reader will observe that the data for the pool car, test car with metallic fender and test car with plastic fender and two large ground plane configurations (mounting screw and pigtail grounding arrangement) all exhibit the same pattern characteristics. However, the data obtained with the plastic fender, using the small ground plane or no-ground plane, exhibit some discrepancies and are not in good agreement with the other data. Further pattern data for the small ground plane or no ground plane typically have a lower gain than the other configurations tested.

From a review of the pattern data it may be seen that there is a null at the right rear of the vehicle. This null tends to become more pronounced as the frequency is increased. We have made no study to explain why this phenomenon is occurring.

# APPENDIX A

In this appendix are presented the pattern data for the six vehicle test configurations. Patterns A.1 through A.5 are a typical set of calibration data that were collected daily for the five-foot ground plane and the monopole. It should be noted that this data was used to set up the test equipment and to assure that the same system gain was obtained on a daily basis. Patterns A.6 through A.10 are for the production line car with no alterations. A.11 through A.15 are for the test car with steel fenders. These two sets (A.6 through A.15) of data tend to show good agreement. The pattern data of Fig. A.16 through A.20 are with the plastic fender installed and the large ground plane being attached to the car chassis by means of a ground strap. Figures A.21 through A.25 are for the same condition as noted above however, the grounding strap has been removed and small screw used to attach the ground plane to the car chassis. Again, these data are also in good agreement with the first two sets of data. The pattern data of A.26 through A.30 are for the plastic fender with the small ground plane and here we see the patterns have become distorted from the previous data. The final set of data, Figs. A.31 through A.35 provide insight as to the pattern performance if no ground plane is used with the plastic fender. Again, we see that there are discrepancies between this data and all the previous data.

Table I

VSWR Test Car and Frequency

| Frequency | Pool Car | Test Car | GP1 | SGP | NGP |
|---|---|---|---|---|---|
| 88 | 1.9 | 1.4 | 1.4 | 2.0 | 2.2 |
| 93 | 1.3 | 1.7 | 1.6 | 2.2 | 1.3 |
| 98 | 1.5 | 1.6 | 1.5 | 1.5 | 1.4 |
| 103 | 1.6 | 1.3 | 1.3 | 2.0 | 2.0 |
| 108 | 1.4 | 1.8 | 1.9 | 2.8 | 3.3 |

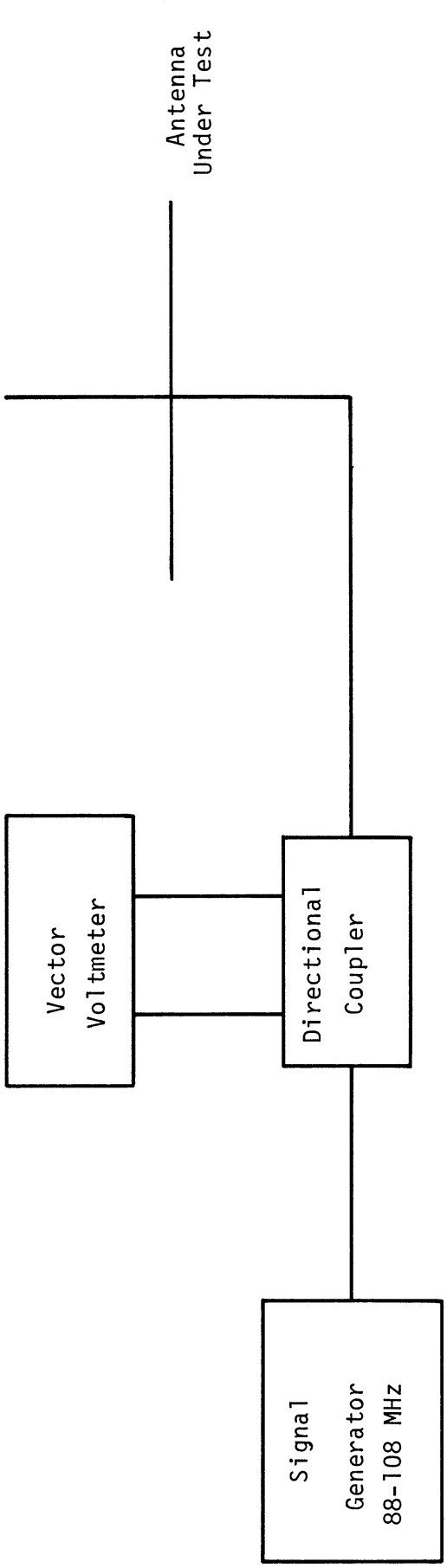


Fig. 1: VSWR Test Setup.

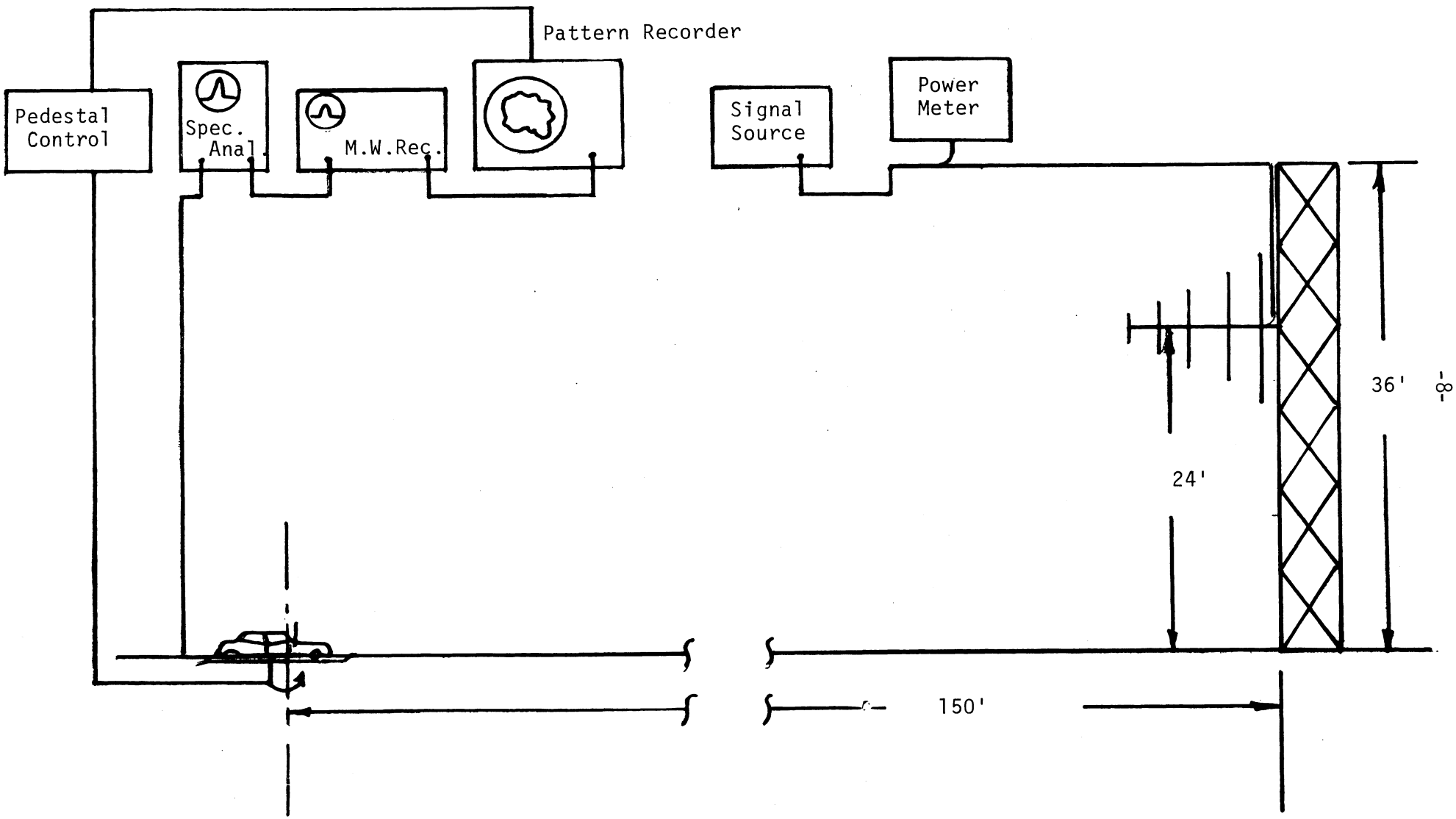


Fig. 2: Antenna Pattern Test Setup.

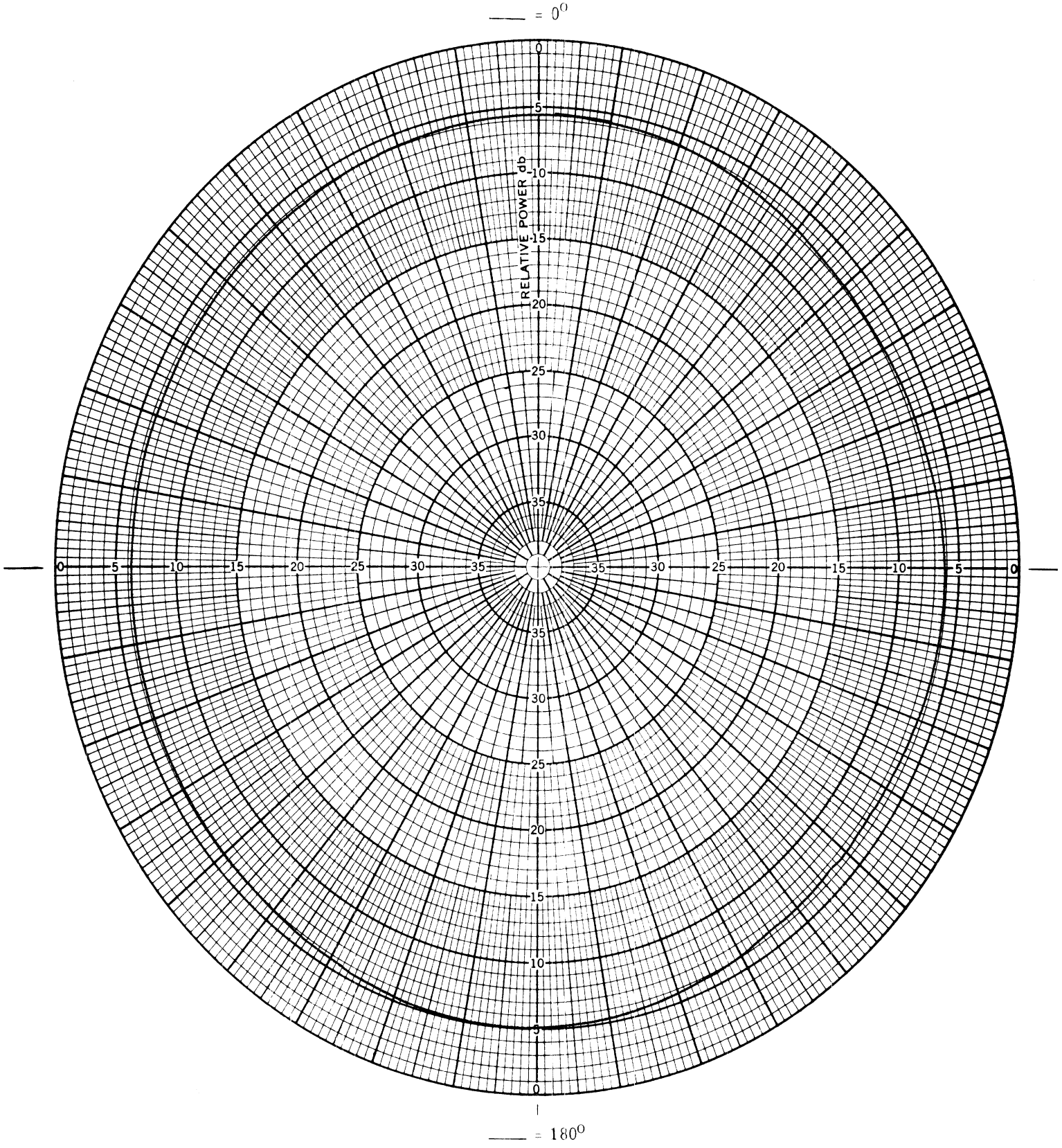


Fig. A.1 Quarter Wave Monopole (f = 98 MHz) Mounted over a Five-Foot Diameter Ground Plane. (Polarization = Vertical, Frequency = 88 MHz)

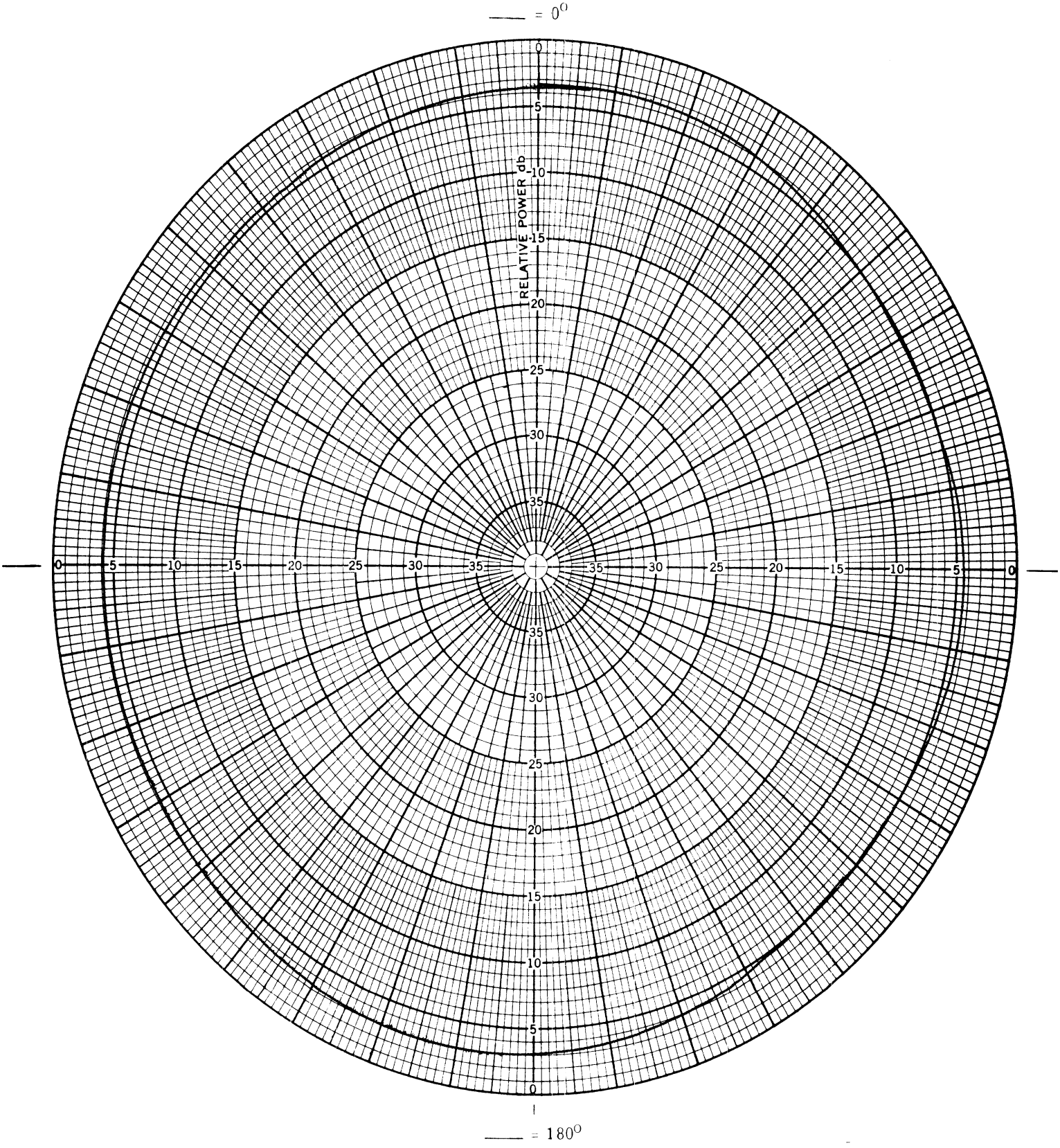


Fig. A.2 Quarter Wave Monopole (f = 98 MHz) Mounted over a Five-Foot Diameter Ground Plane. (Polarization = Vertical, Frequency = 93 MHz)

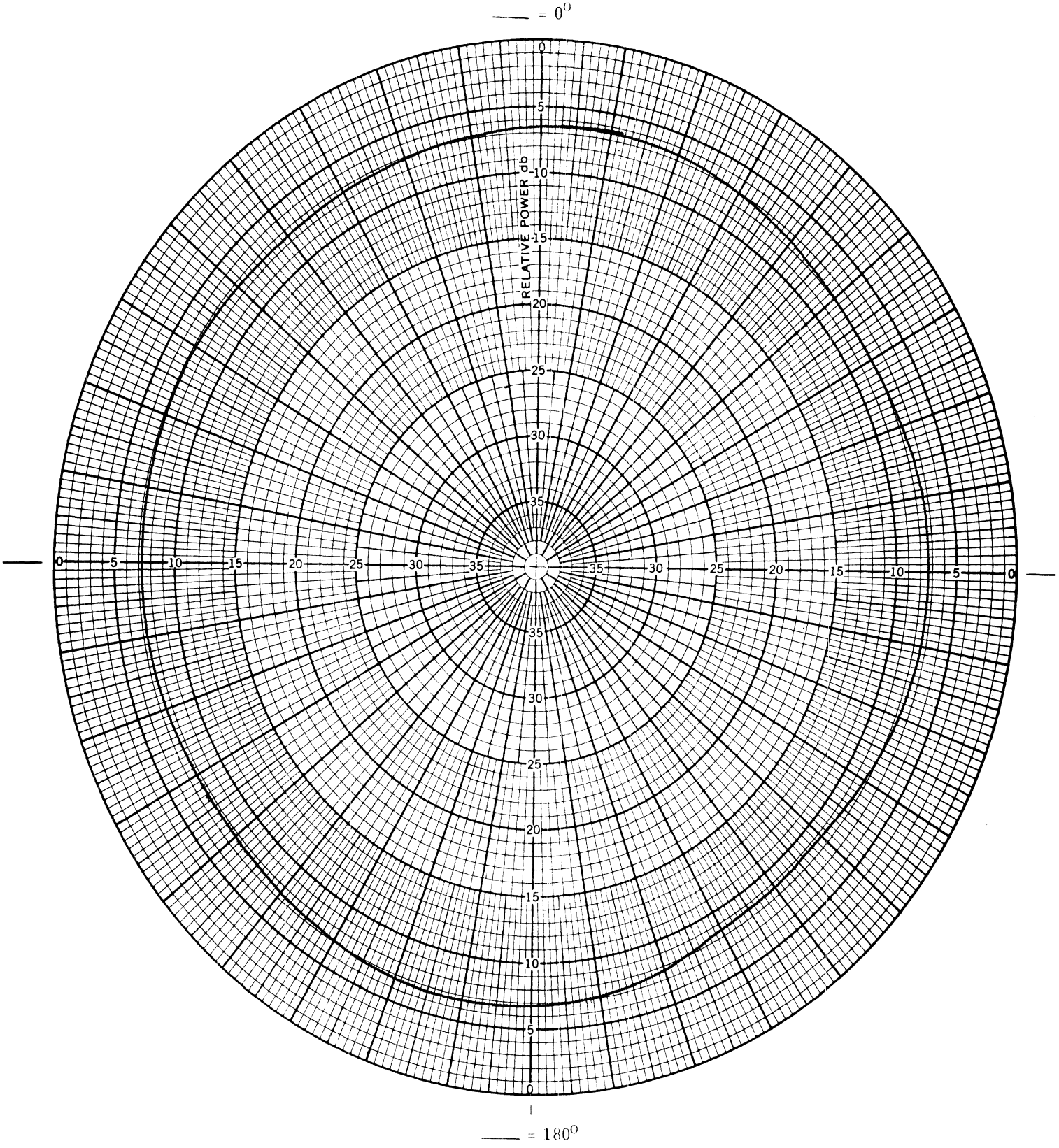


Fig. A.3 Quarter Wave Monopole (f = 98 MHz) Mounted over a Five-Foot Diameter Ground Plane. (Polarization = Vertical, Frequency = 98 MHz)

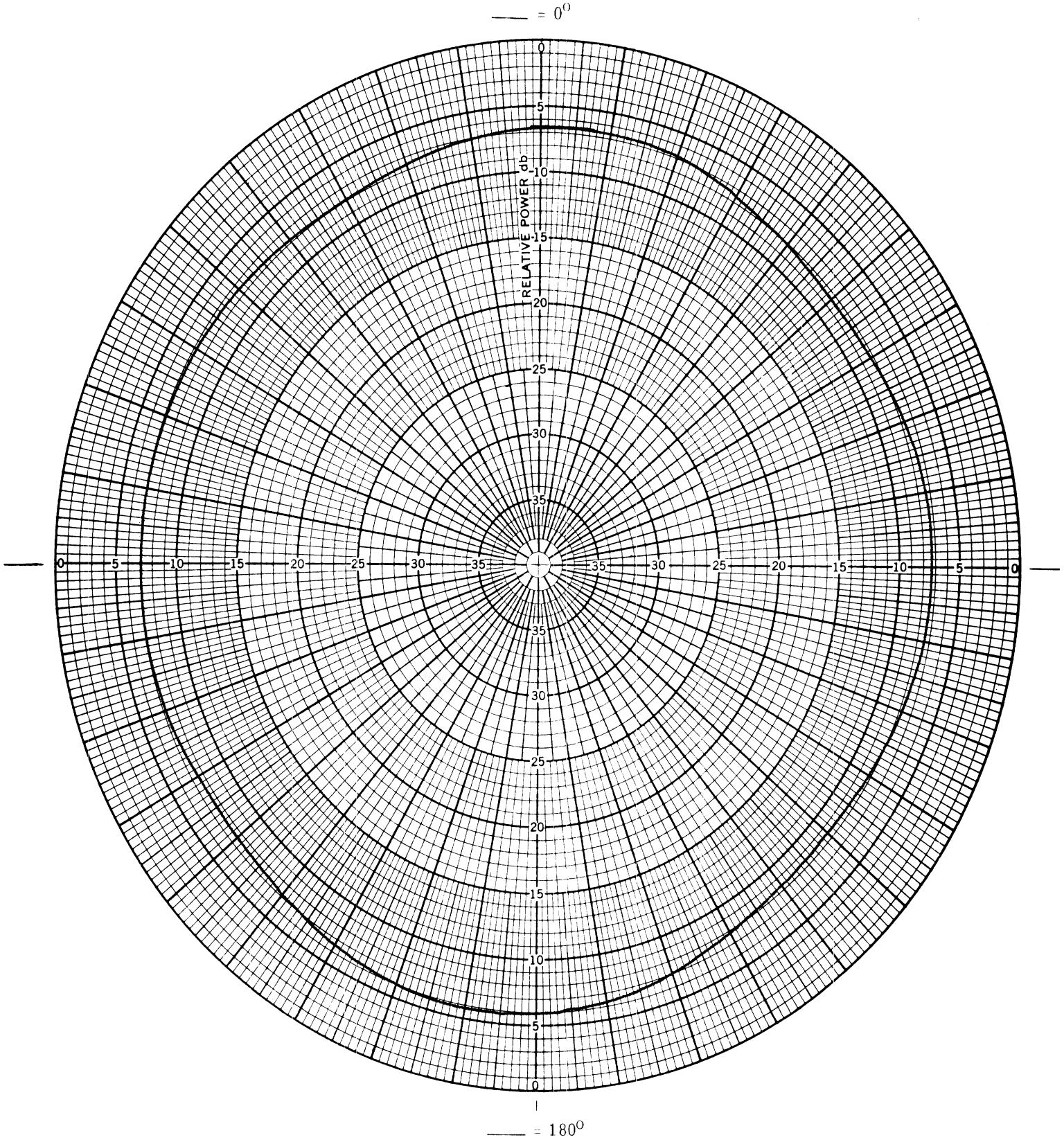


Fig. A.4 Quarter Wave Monopole (f = 98 MHz) Mounted over a Five-Foot Diameter Ground Plane. (Polarization = Vertical, Frequency = 103 MHz)

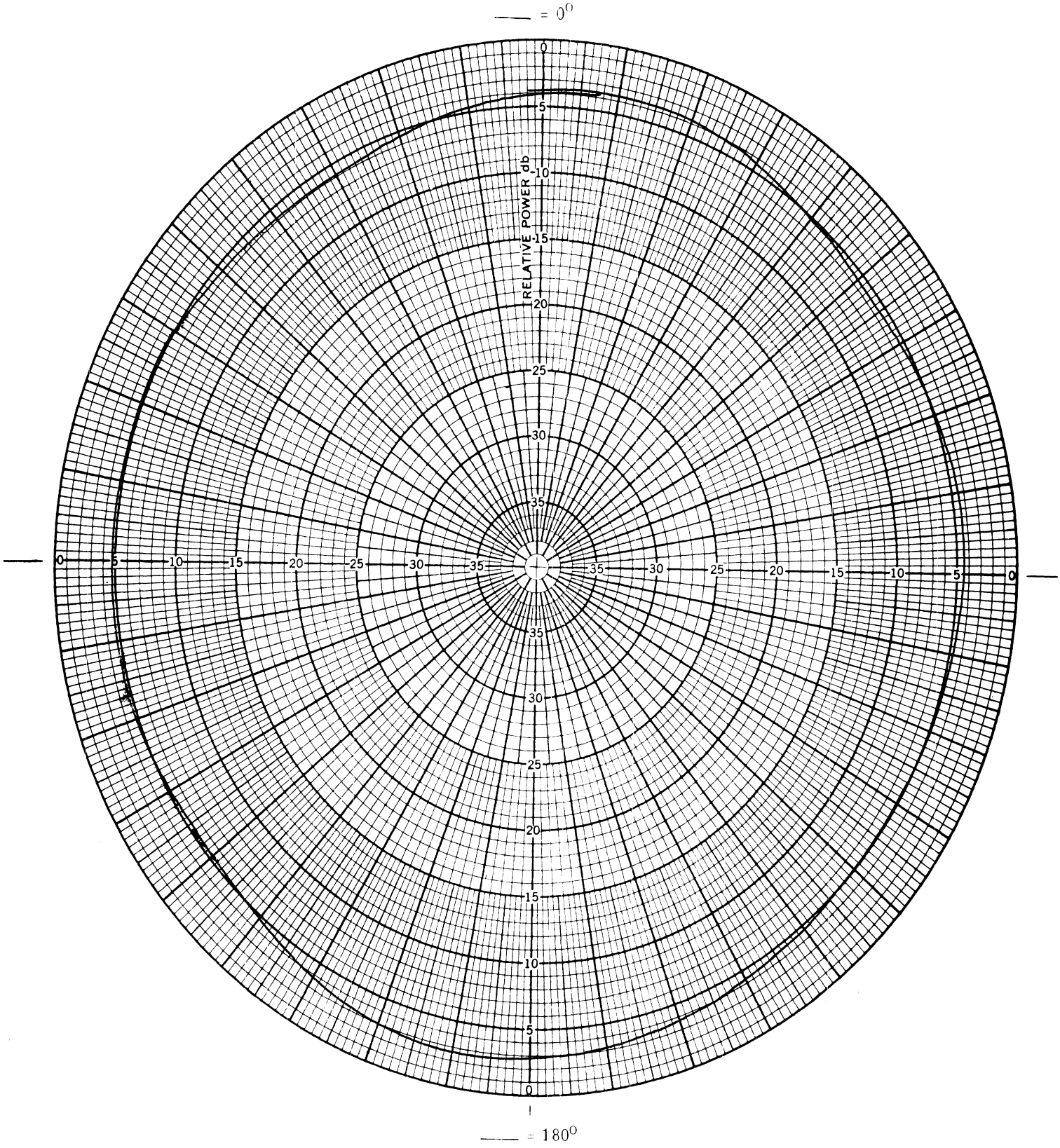


Fig. A.5 Quarter Wave Monopole (f = 98 MHz) Mounted over a five-Foot Diameter Ground Plane. (Polarization = Vertical, Frequency = 108 MHz)

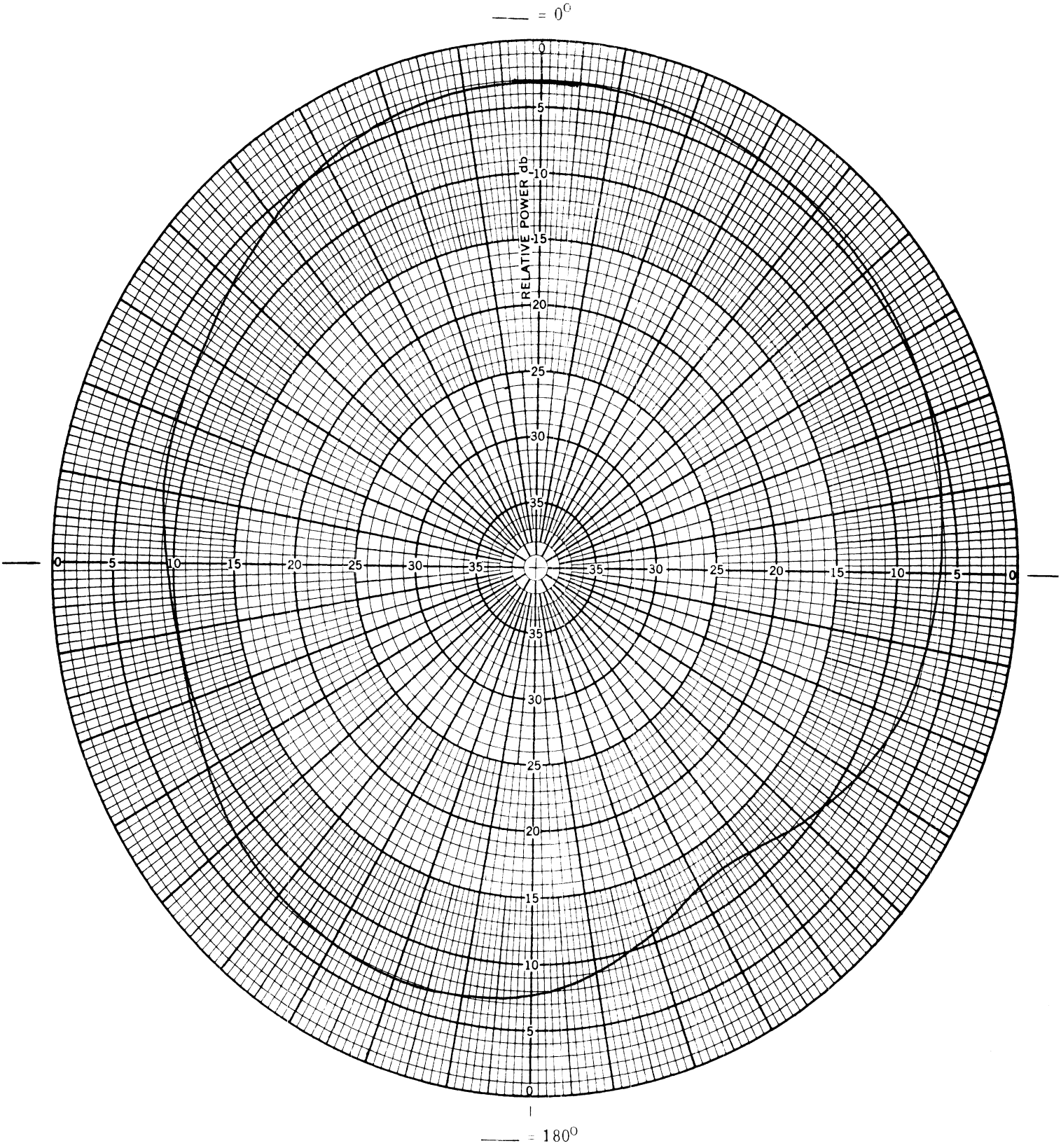


Fig. 6: Pool Car (No. 109). (Frequency = 88 MHz, Polarization = Vertical)

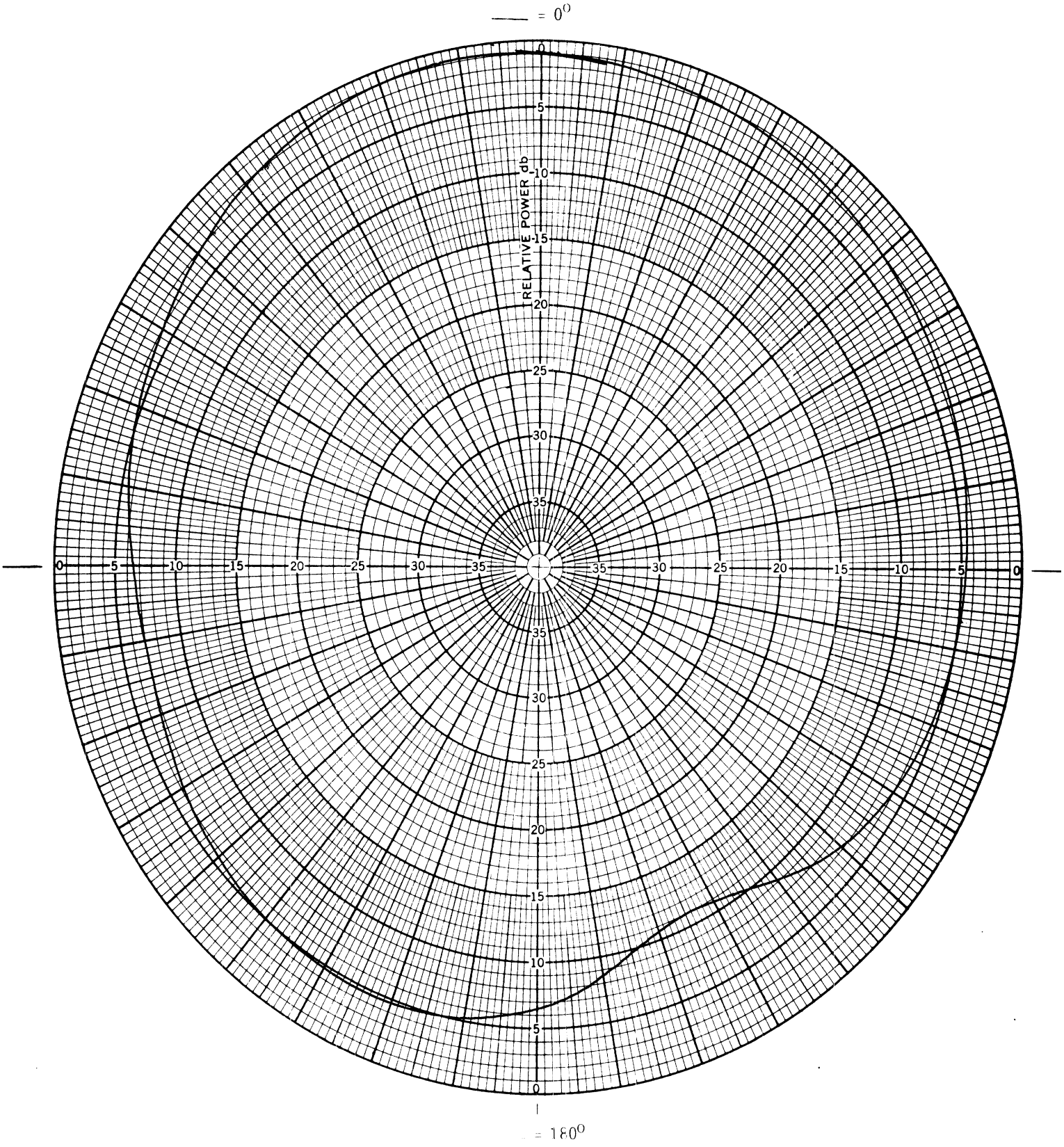


Fig. 7: Pool Car (No. 109). (Frequency = 93 MHz, Polarization = Vertical)

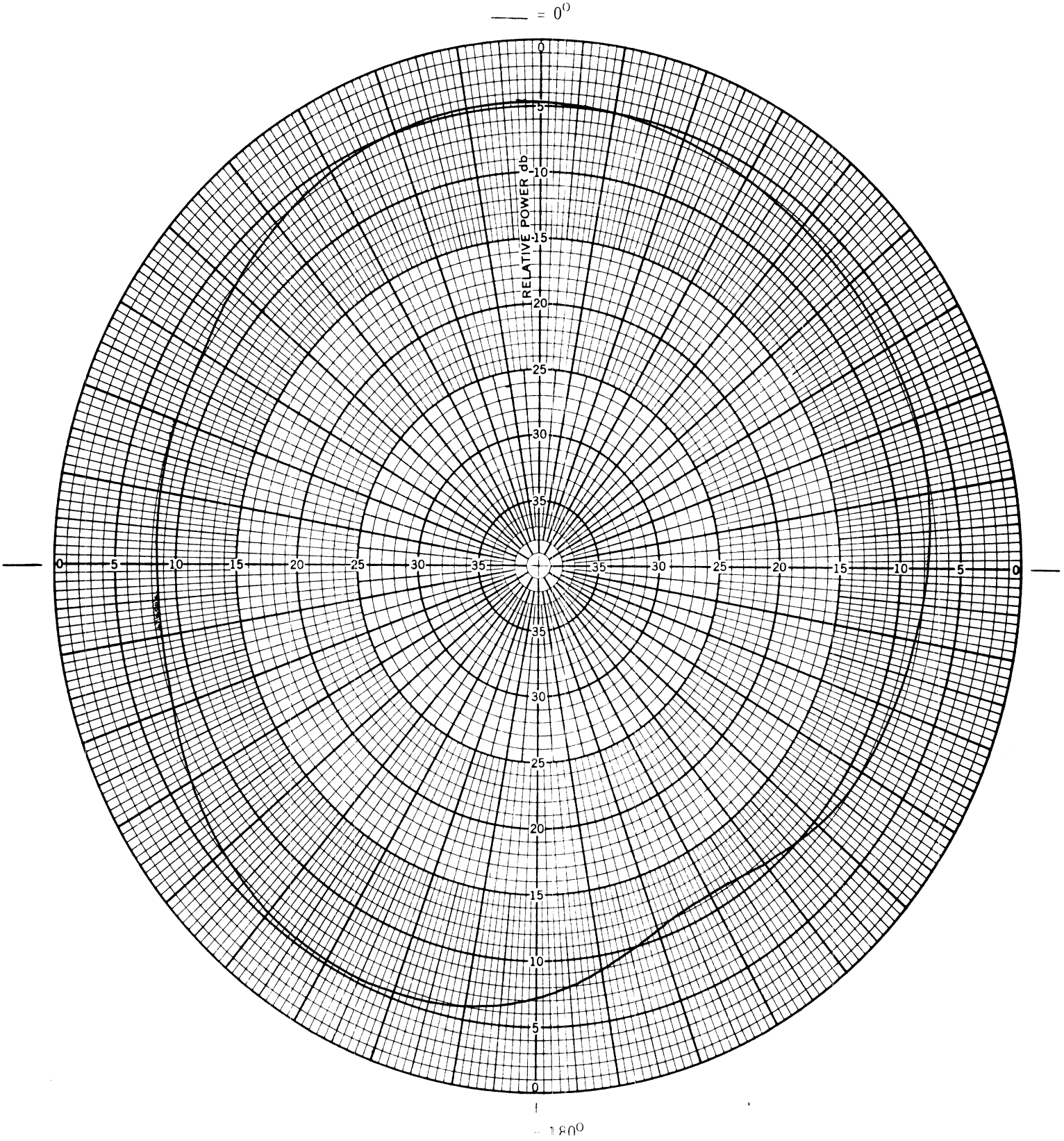


Fig. 8: Pool Car (No. 109). (Frequency = 98 MHz, Polarization = Vertical)

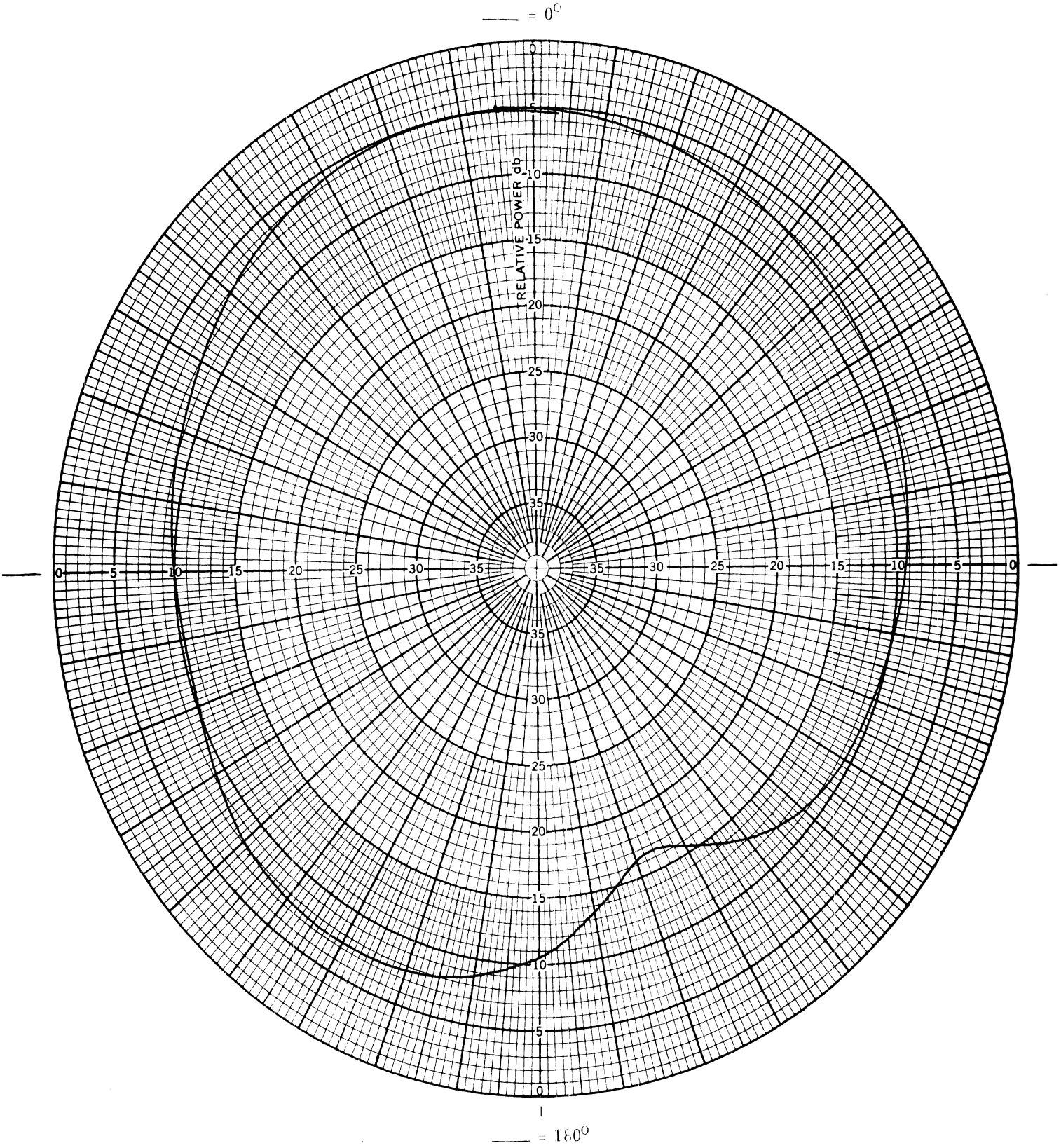


Fig. 9: Pool Car (No. 109). (Frequency = 103 MHz, Polarization = Vertical)

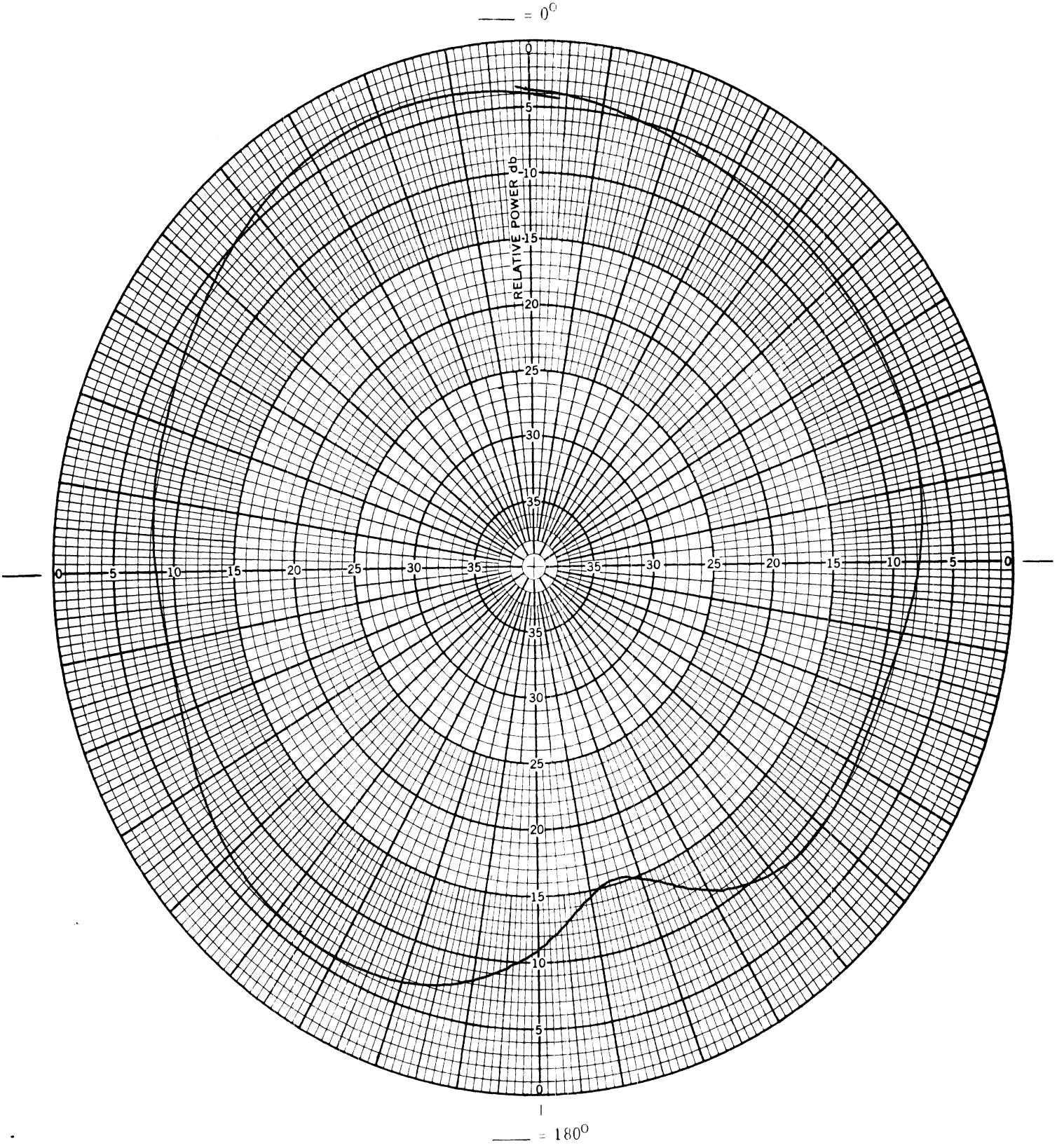


Fig. 10: Pool Car (No. 109). (Frequency = 108 MHz, Polarization = Vertical)

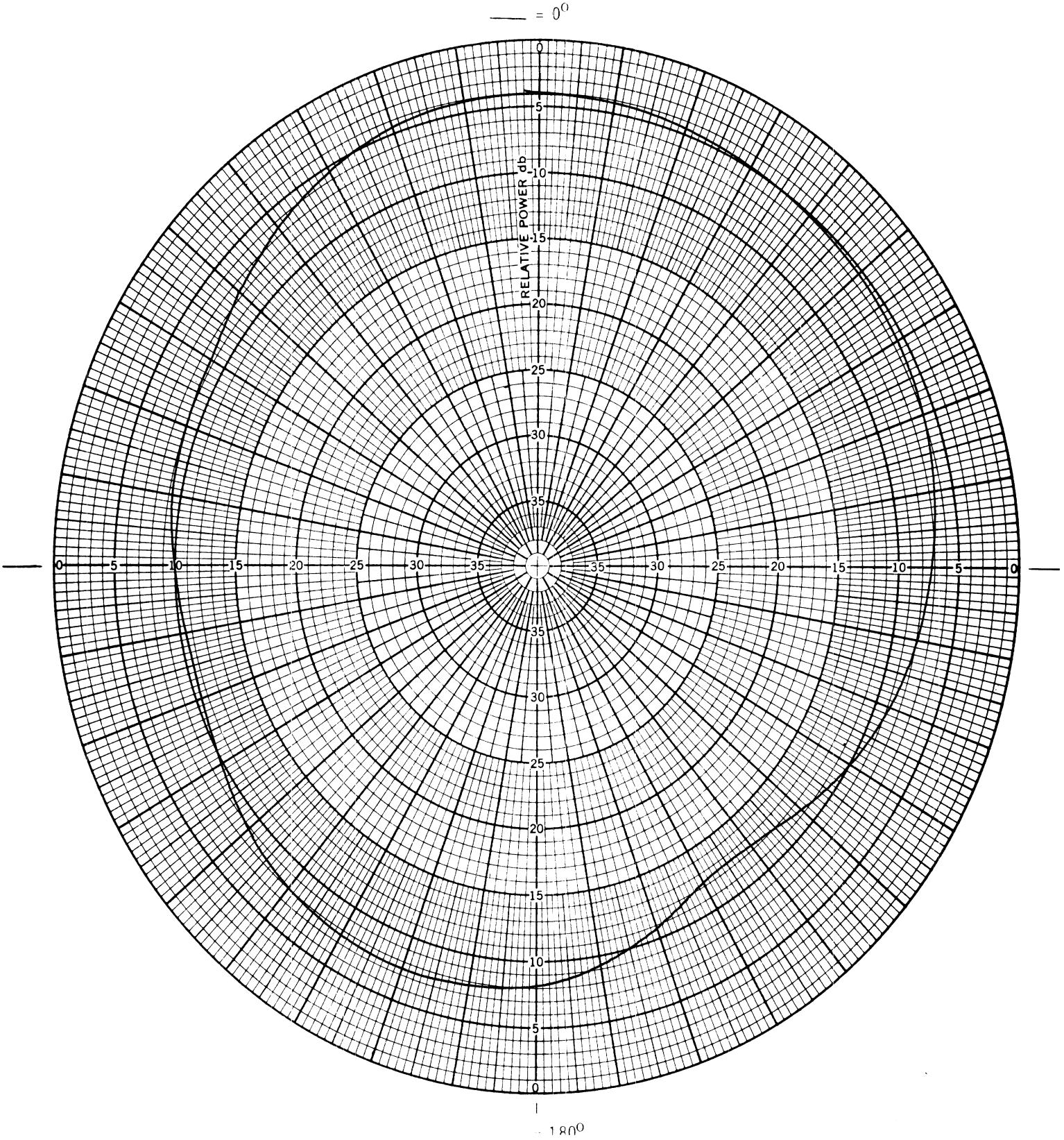


Fig. 11: Test Car with Steel Fender. (Frequency = 88 MHz, Polarization = Vertical)

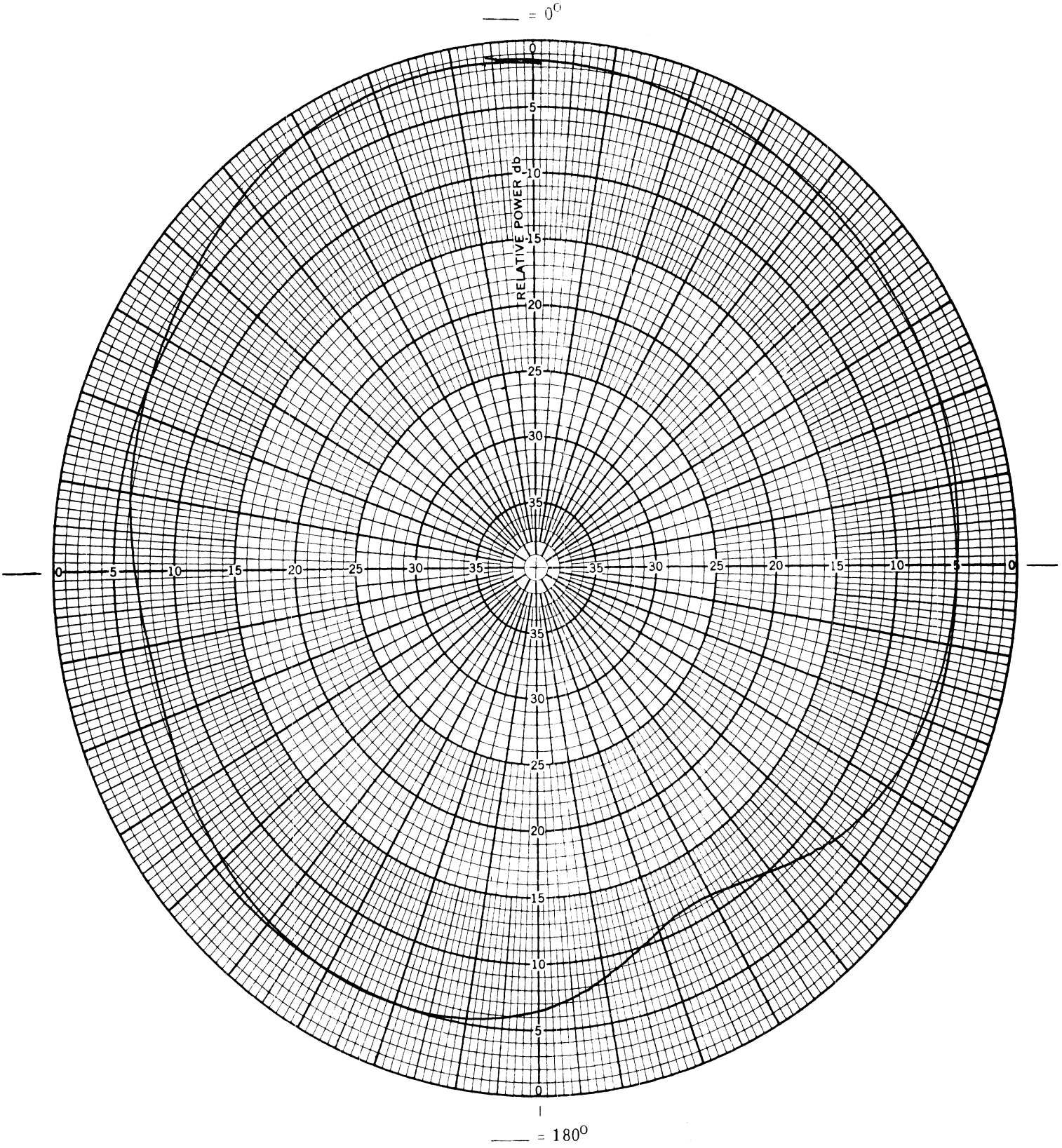


Fig. 12: Test Car with Steel Fender. (Frequency = 93 MHz, Polarization = Vertical)

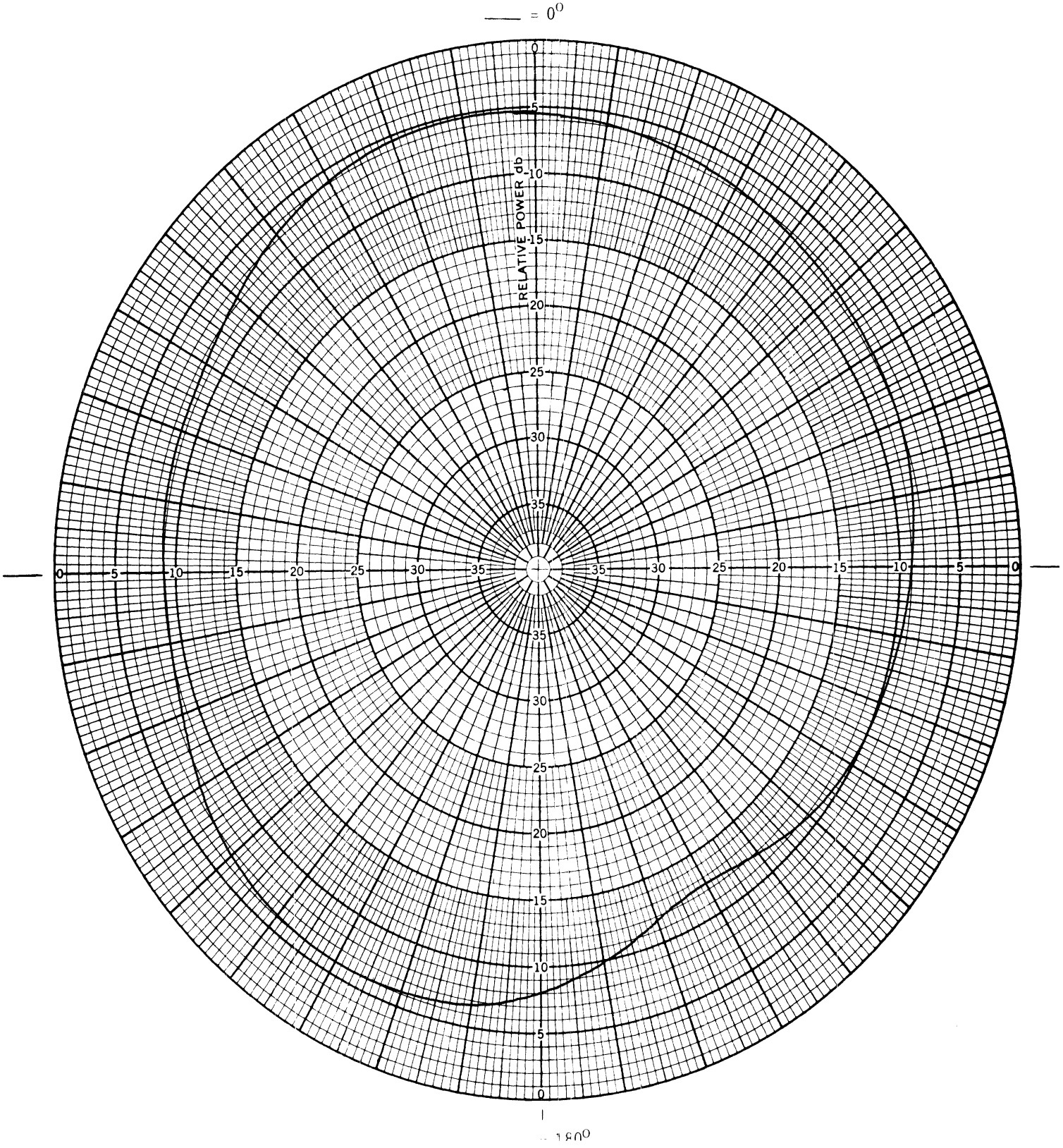


Fig. 13: Test Car with Steel Fender. (Frequency = 98 MHz, Polarization = Vertical)

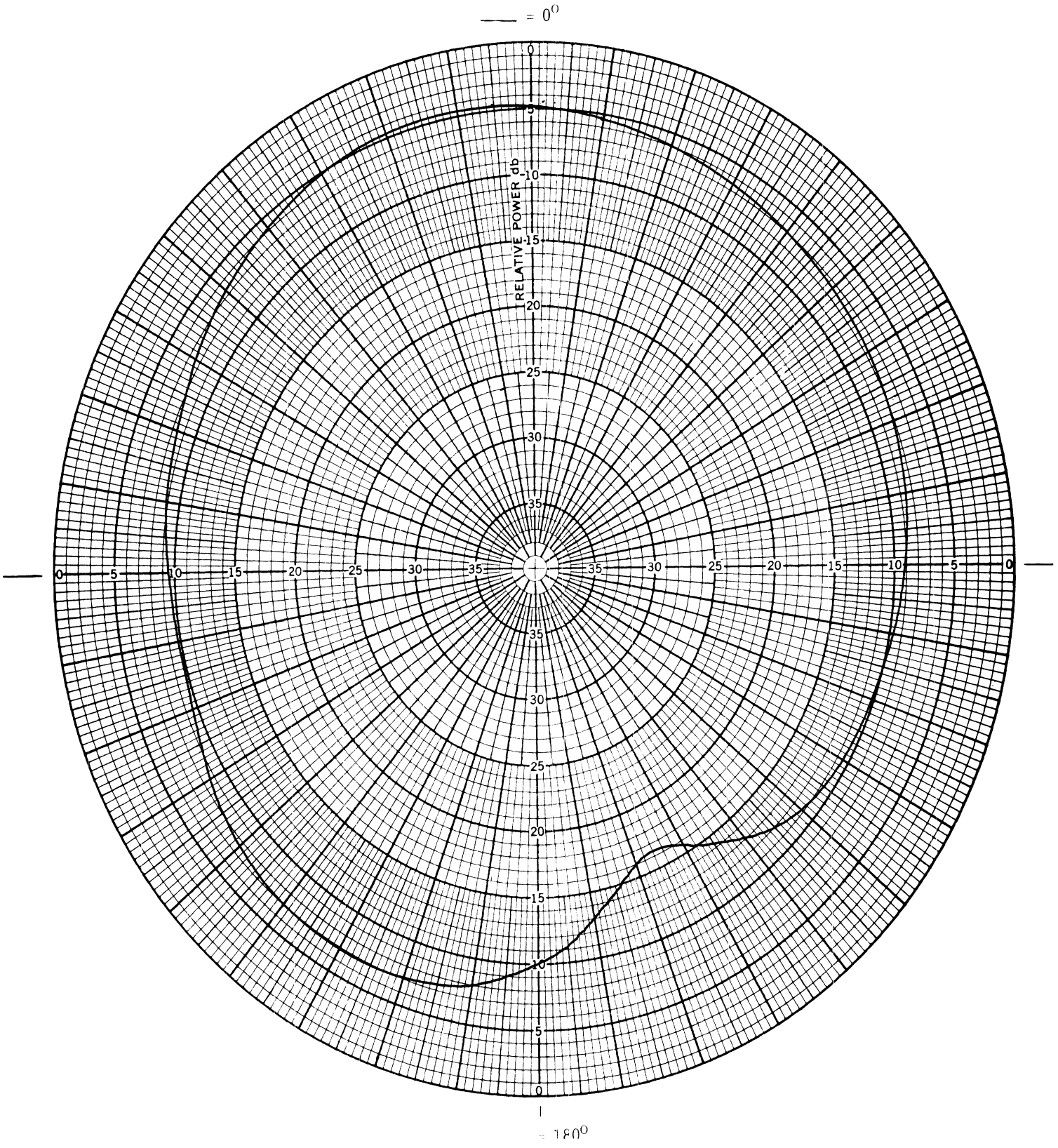


Fig. 14: Test Car with Steel Fender. (Frequency = 103 MHz, Polarization = Vertical)

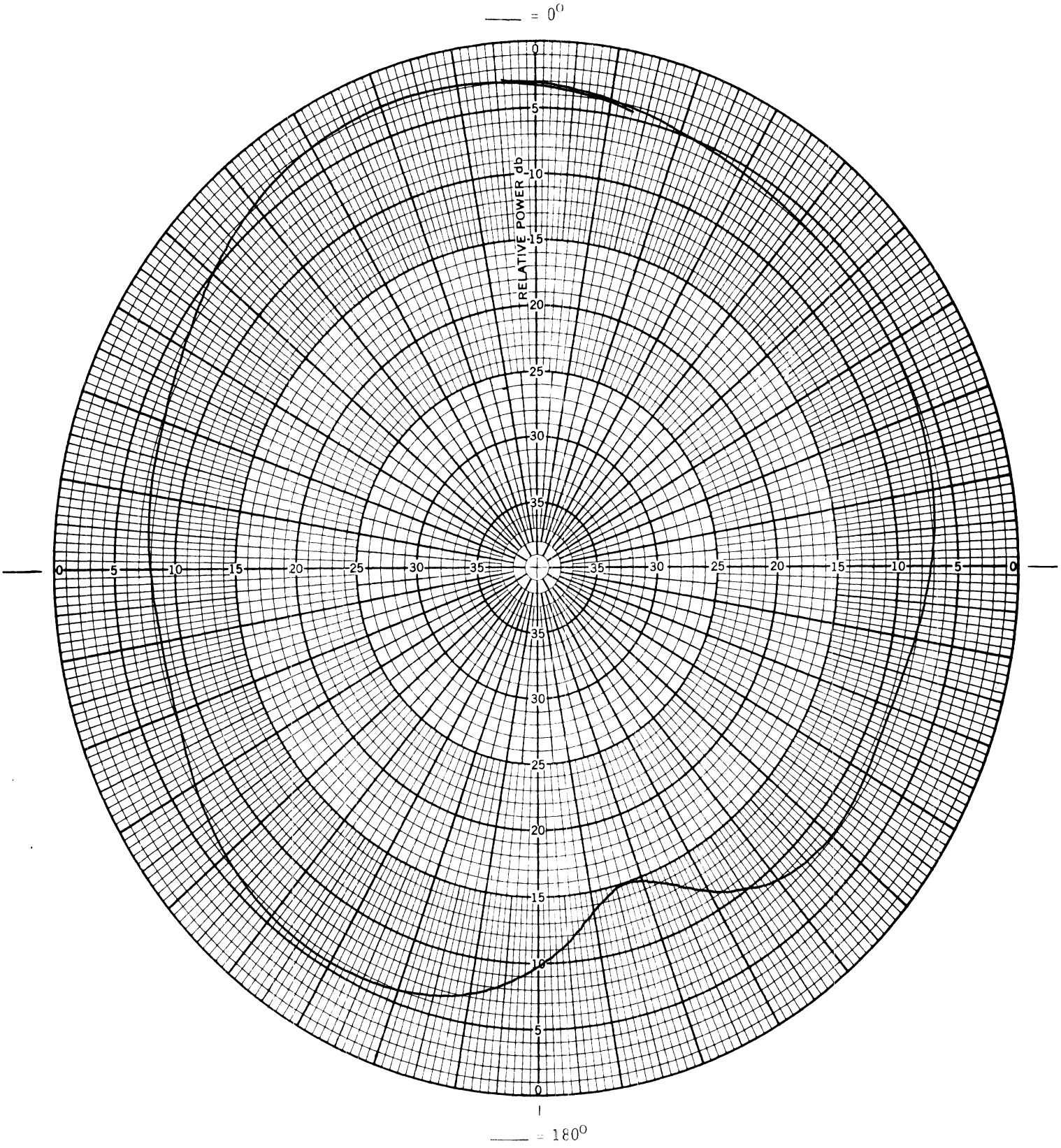


Fig. 15: Test Car with Steel Fender. (Frequency = 108 MHz, Polarization = Vertical)

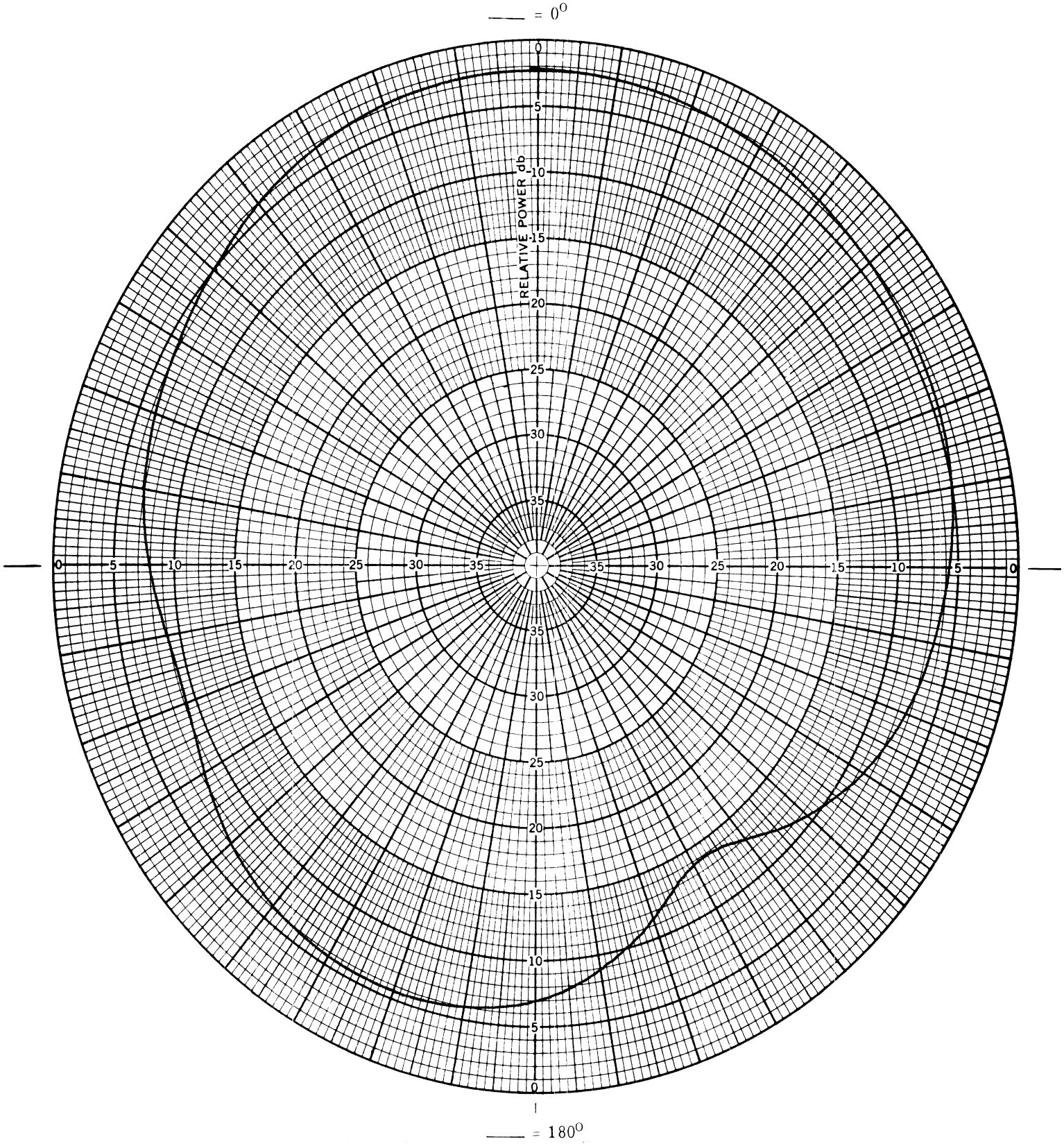


Fig. 16: Test Car (No. 677) Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Pigtail. (Frequency = 88 MHz, Polarization = Vertical)

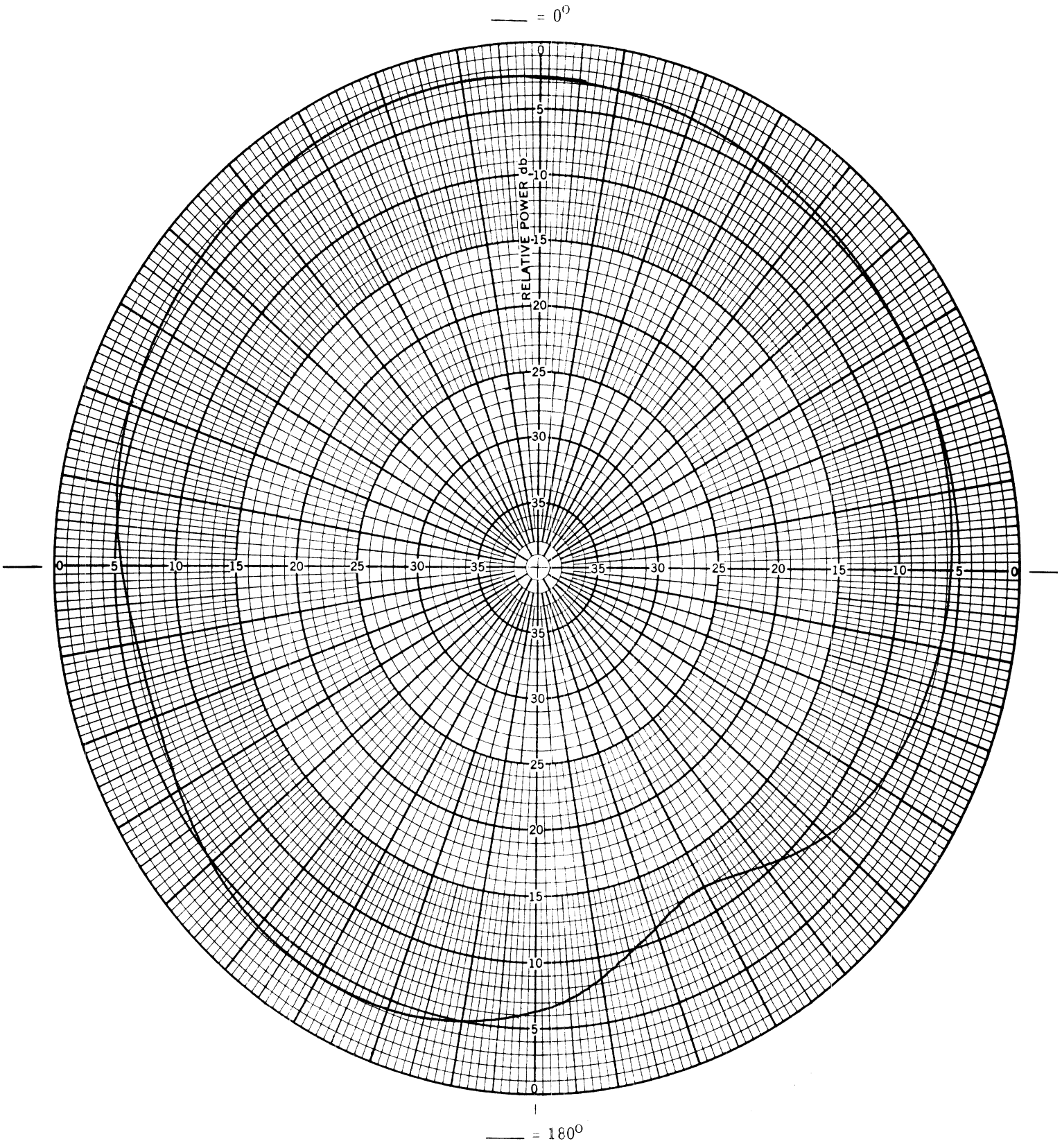


Fig. 17: Test Car (No. 677) Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Pigtail. (Frequency = 93 MHz, Polarization = Vertical)

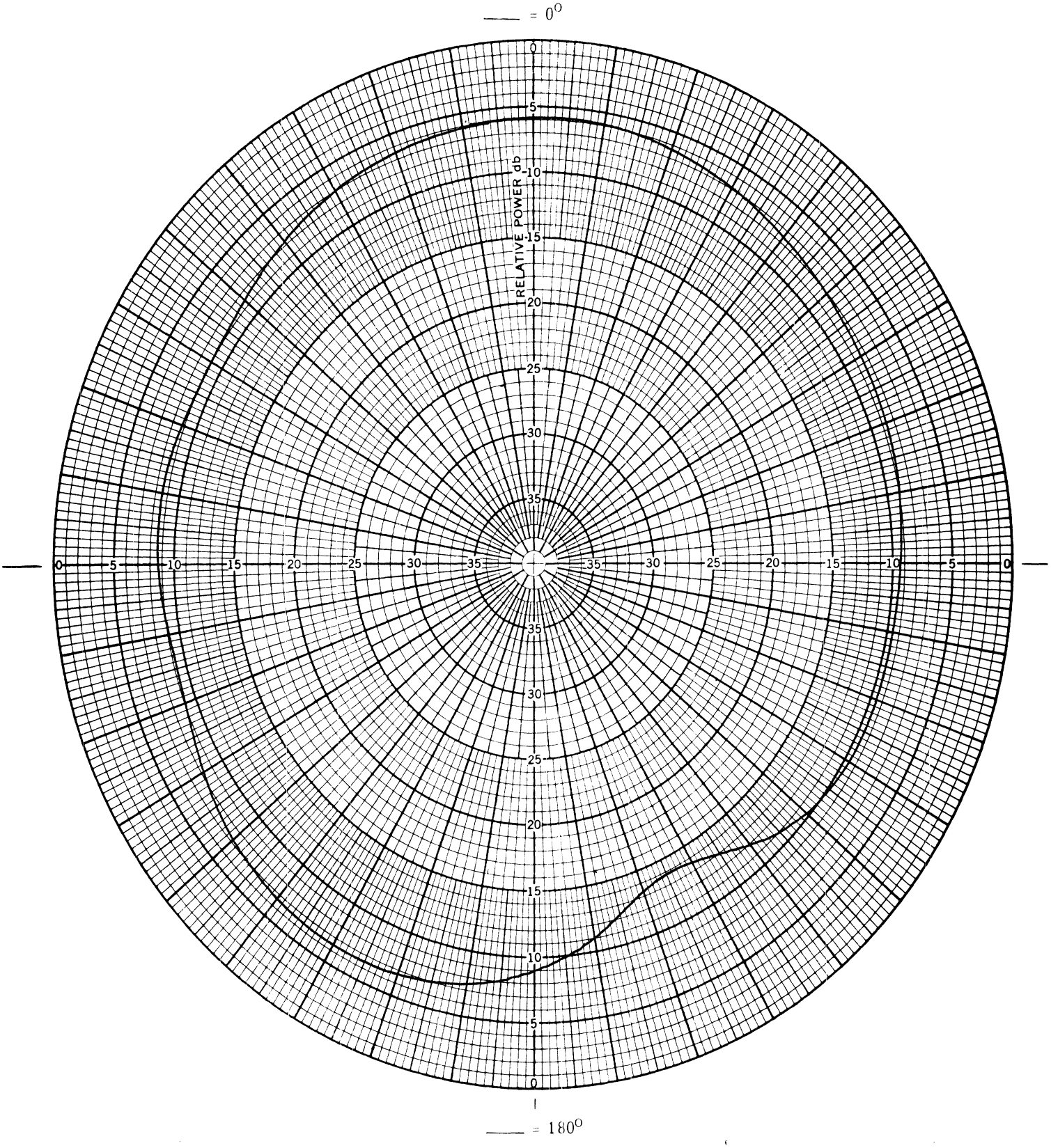


Fig. 18: Test Car (No. 677) Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Pigtail. (Frequency = 98 MHz, Polarization = Vertical)

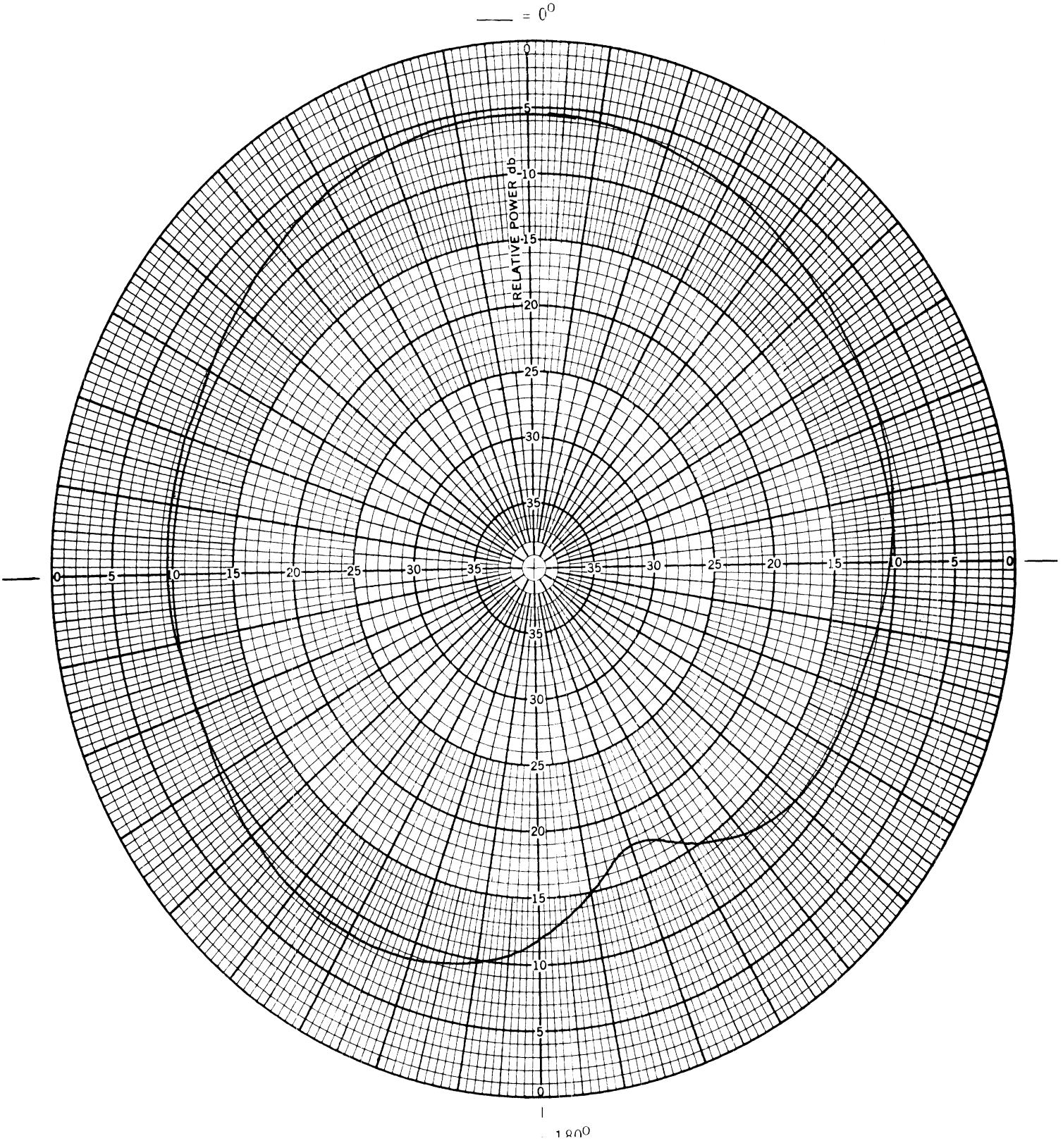


Fig. 19: Test Car (No. 677) Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Pigtail. (Frequency = 103 MHz, Polarization = Vertical)

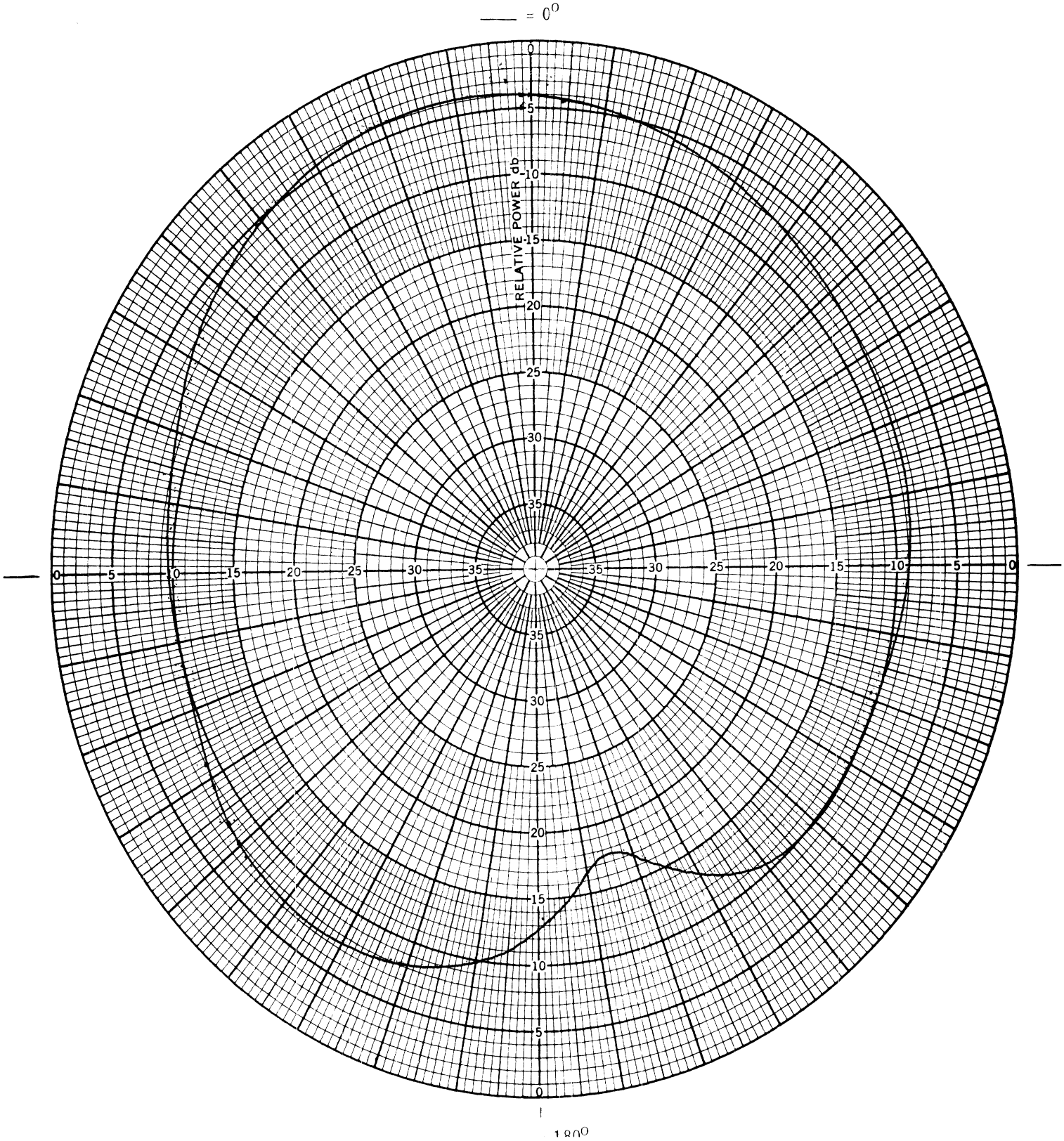


Fig. 20: Test Car (No. 677) Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Pigtail. (Frequency = 108 MHz, Polarization = Vertical).

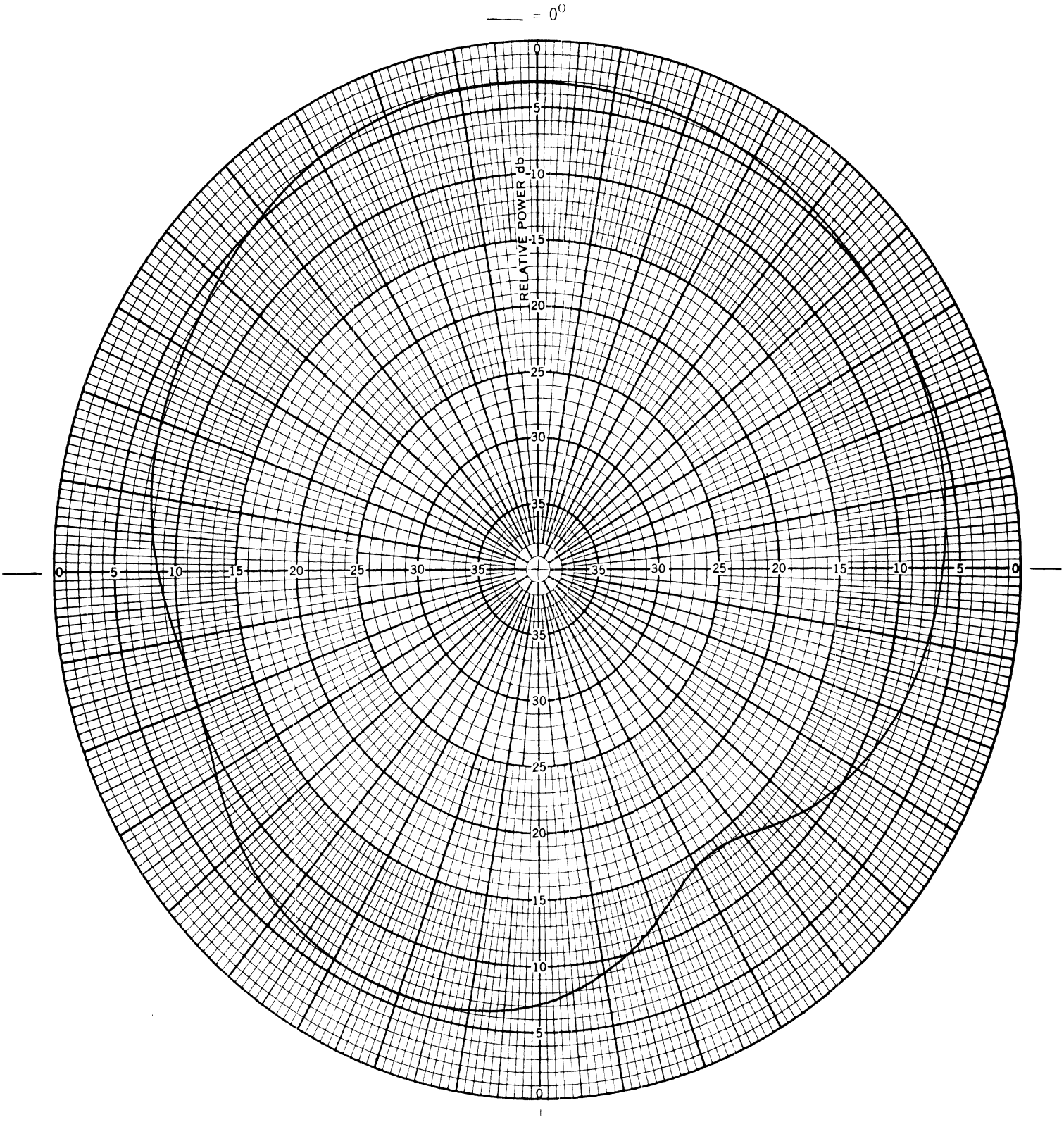


Fig. A.21 Test Car (No. 677) with Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Mounting Screw. (Frequency = 88 MHz, Polarization = Vertical)

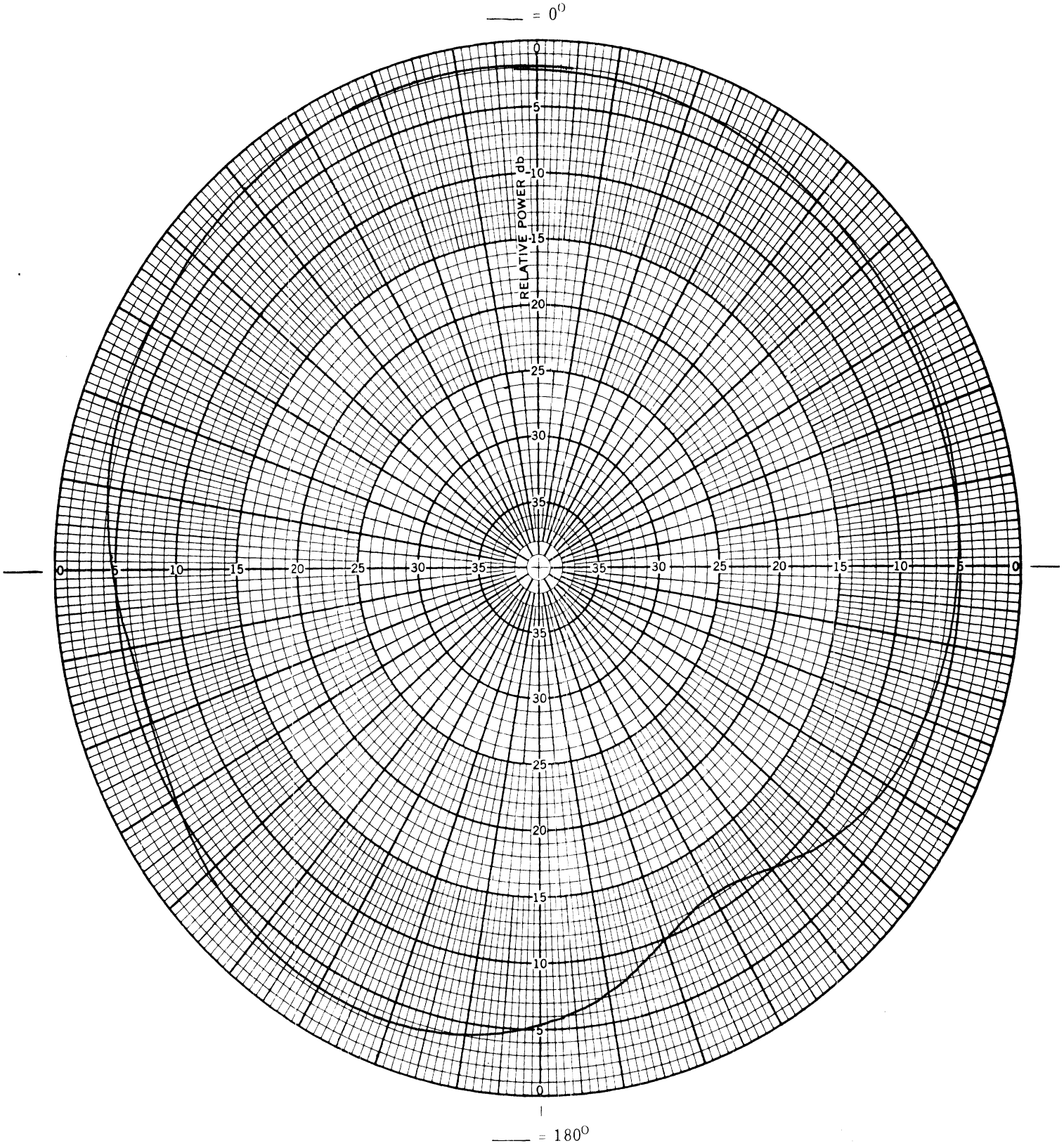


Fig. A.22 Test Car (No. 677) with Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Mounting Screw. (Frequency = 93 MHz, Polarization = Vertical)

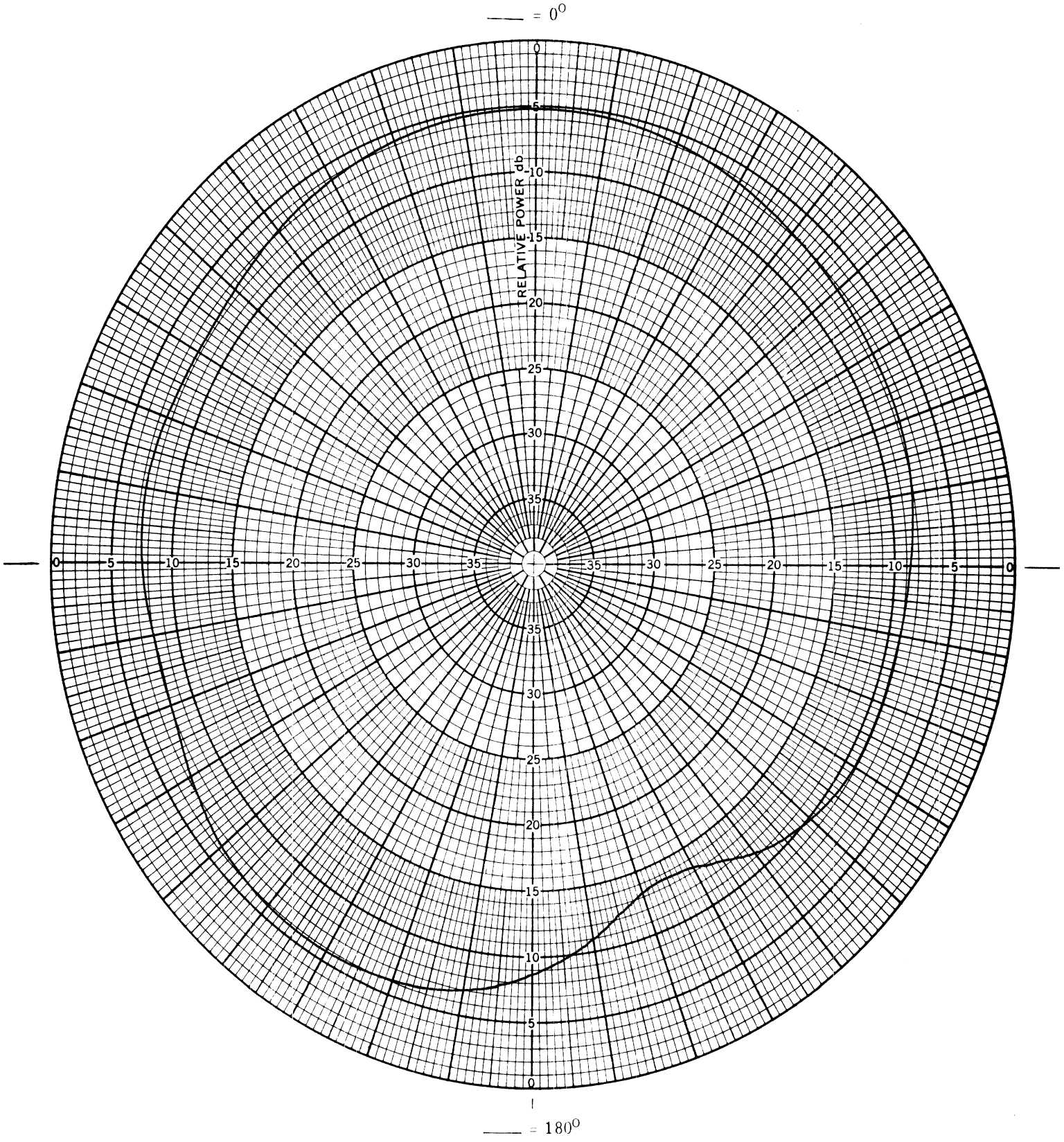


Fig. A.23: Test Car (No. 677) with Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Mounting Screw. (Frequency = 98 MHz, Polarization = Vertical)

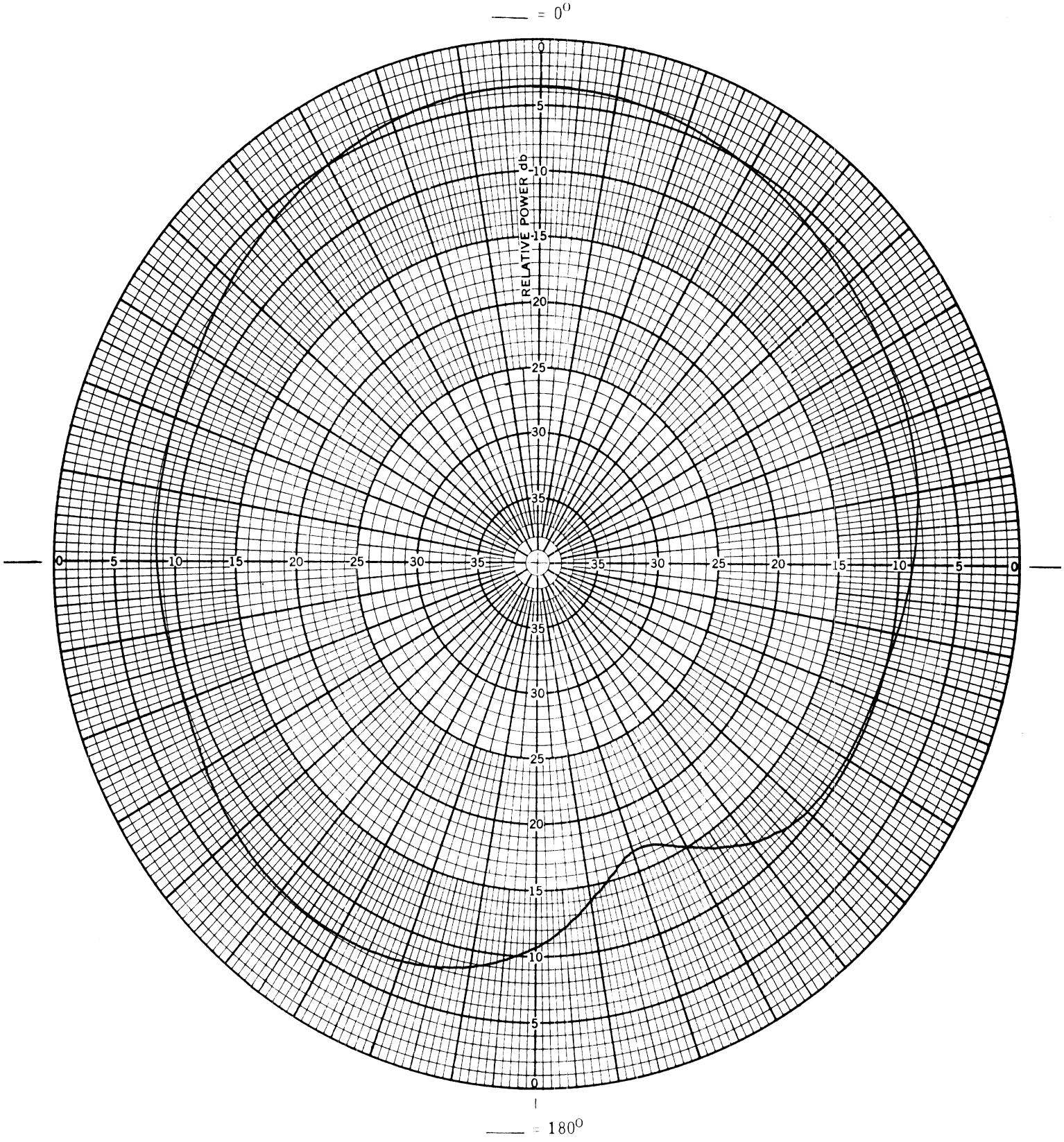


Fig. A.24: Test Car (No. 677) with Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Mounting Screw. (Frequency = 103 MHz, Polarization = Vertical)

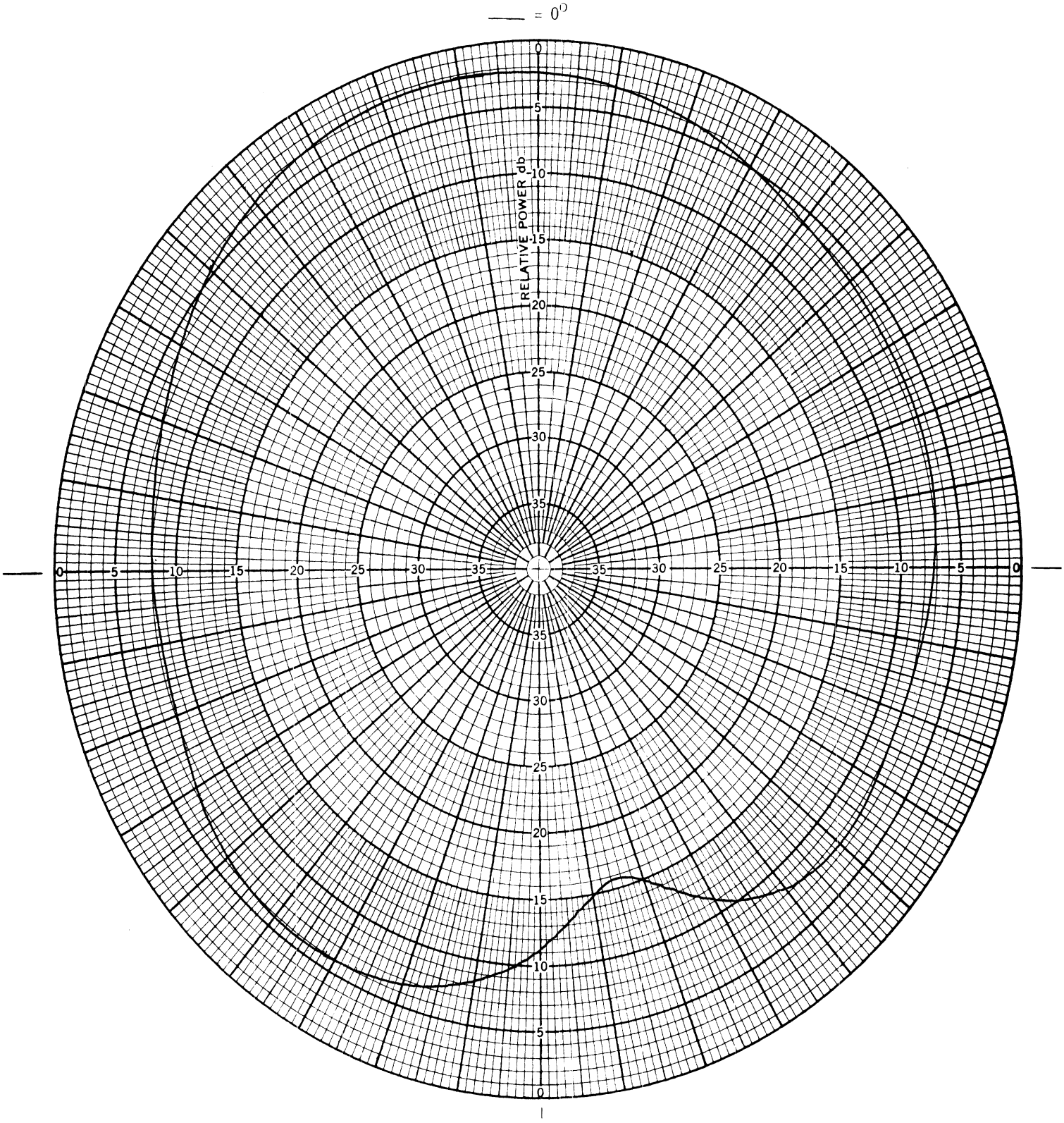


Fig. A.25: Test Car (No. 677) with Plastic Fender and 5 x 14 inch Ground Plane Attached to Car Body with a Mounting Screw. (Frequency = 108 MHz, Polarization = Vertical)

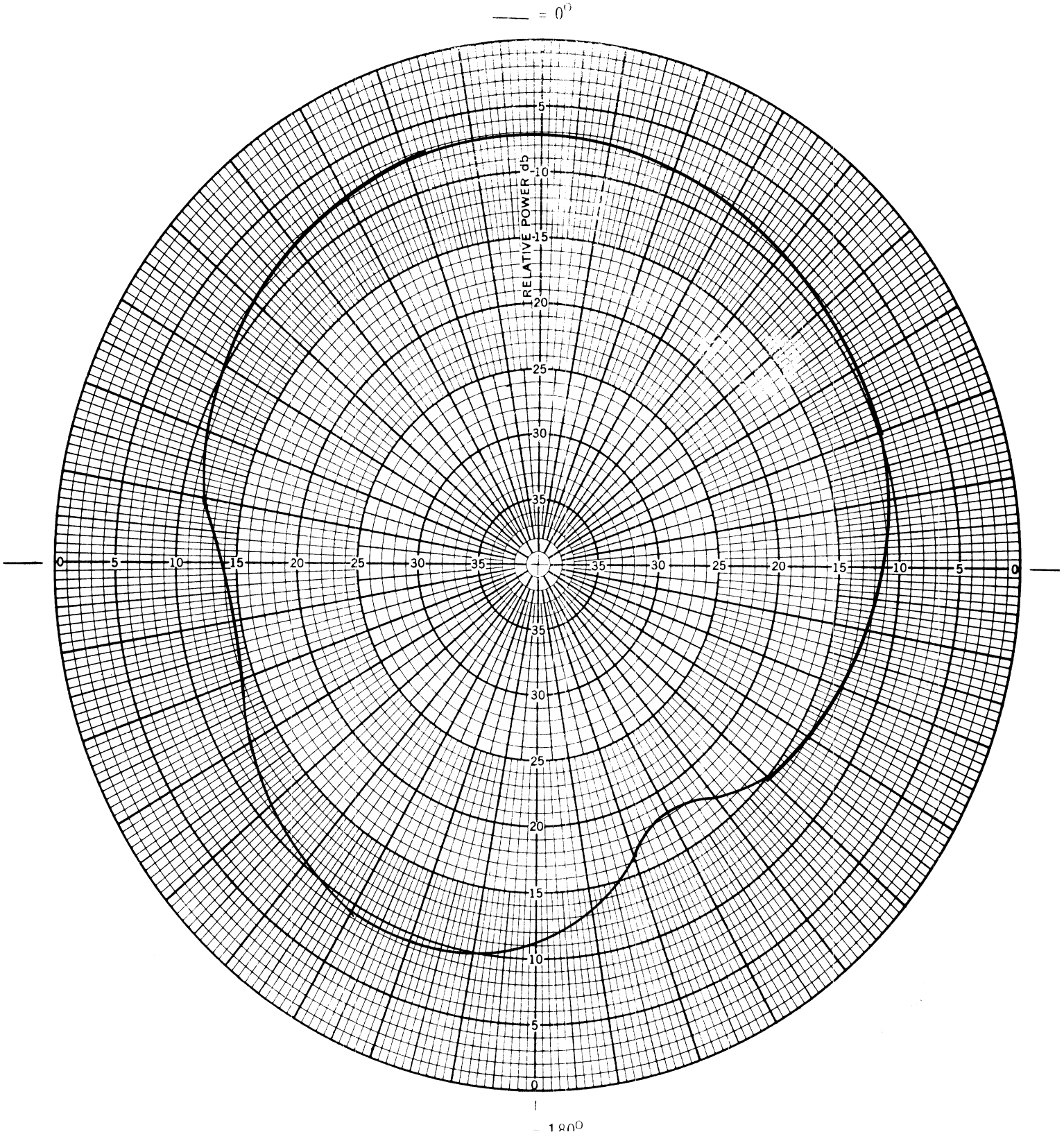


Fig. A.26: Test Car (No. 677) with Plastic Fender and 1.5 inch Diameter Ground Plane Attached to the Car Body with a Pigtail. (Frequency = 88 MHz, Polarization = Vertical)

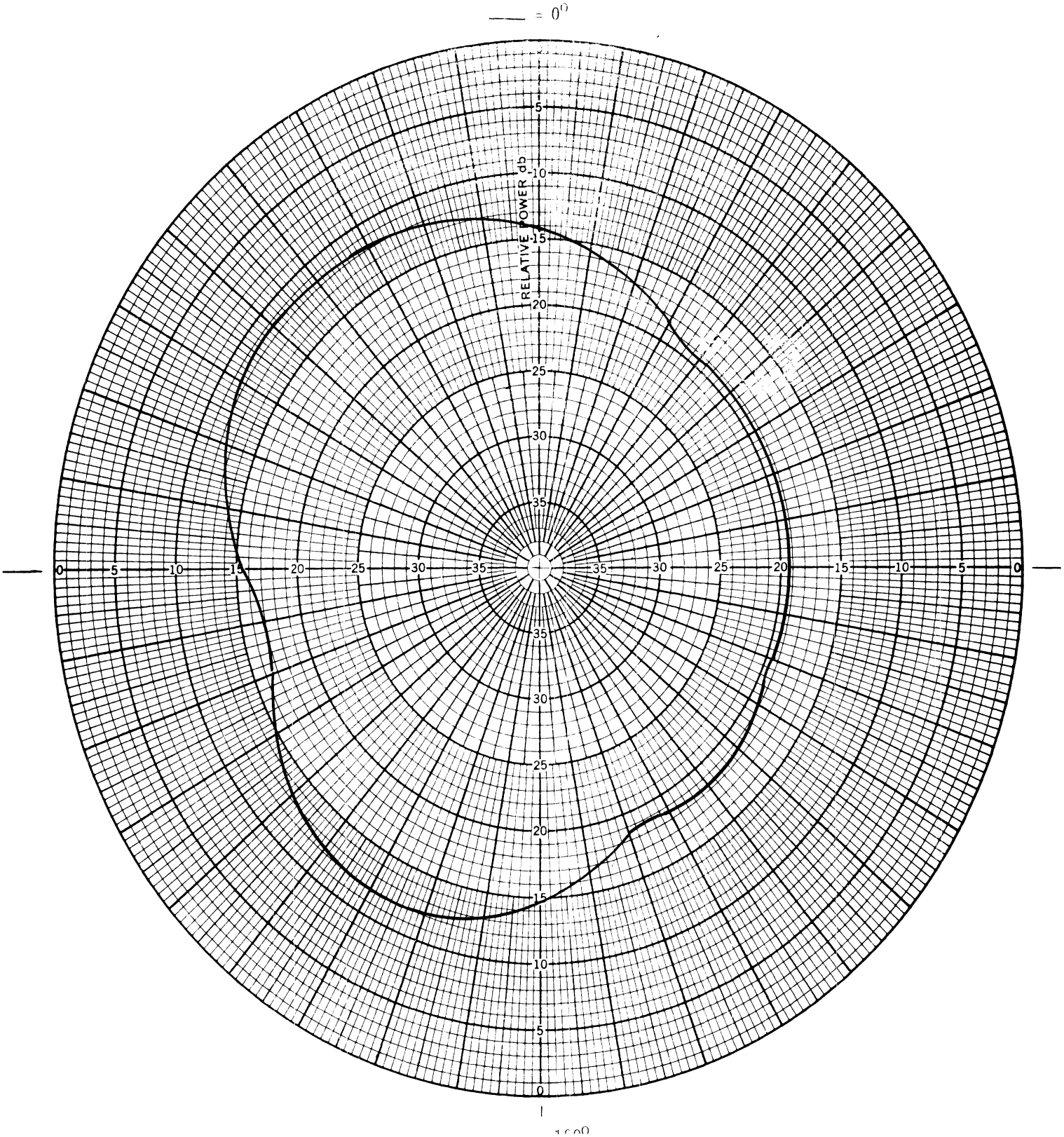


Fig. A.27: Test Car (No. 677) with Plastic Fender and 1.5 inch Diameter Ground Plane Attached to the Car Body with a Pigtail. (Frequency = 93 MHz, Polarization = Vertical)

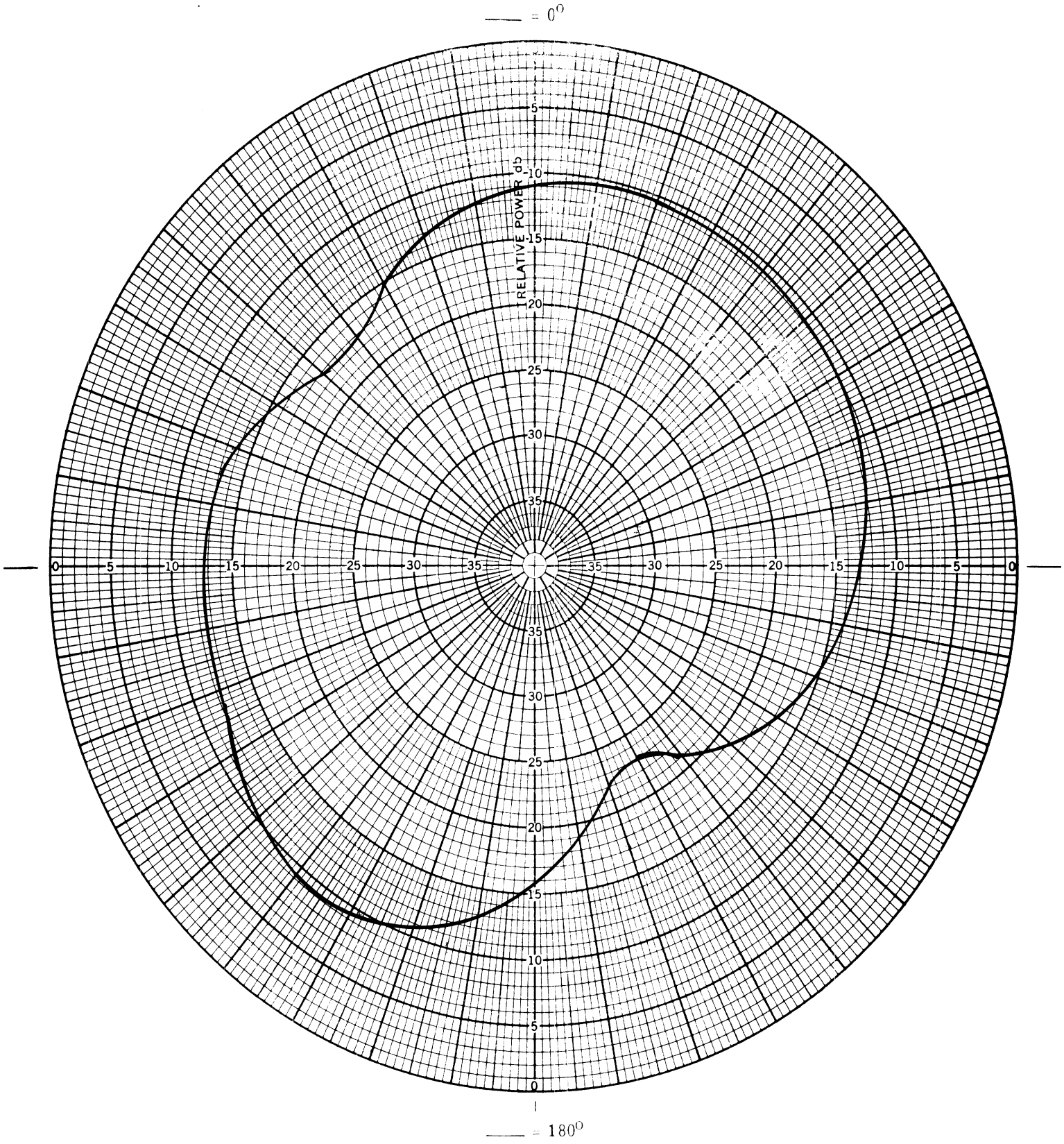


Fig. A.28: Test Car (No. 677) with Plastic Fender and 1.5 inch Diameter Ground Plane Attached to the Car Body with a Pigtail. (Frequency = 98 MHz, Polarization = Vertical)

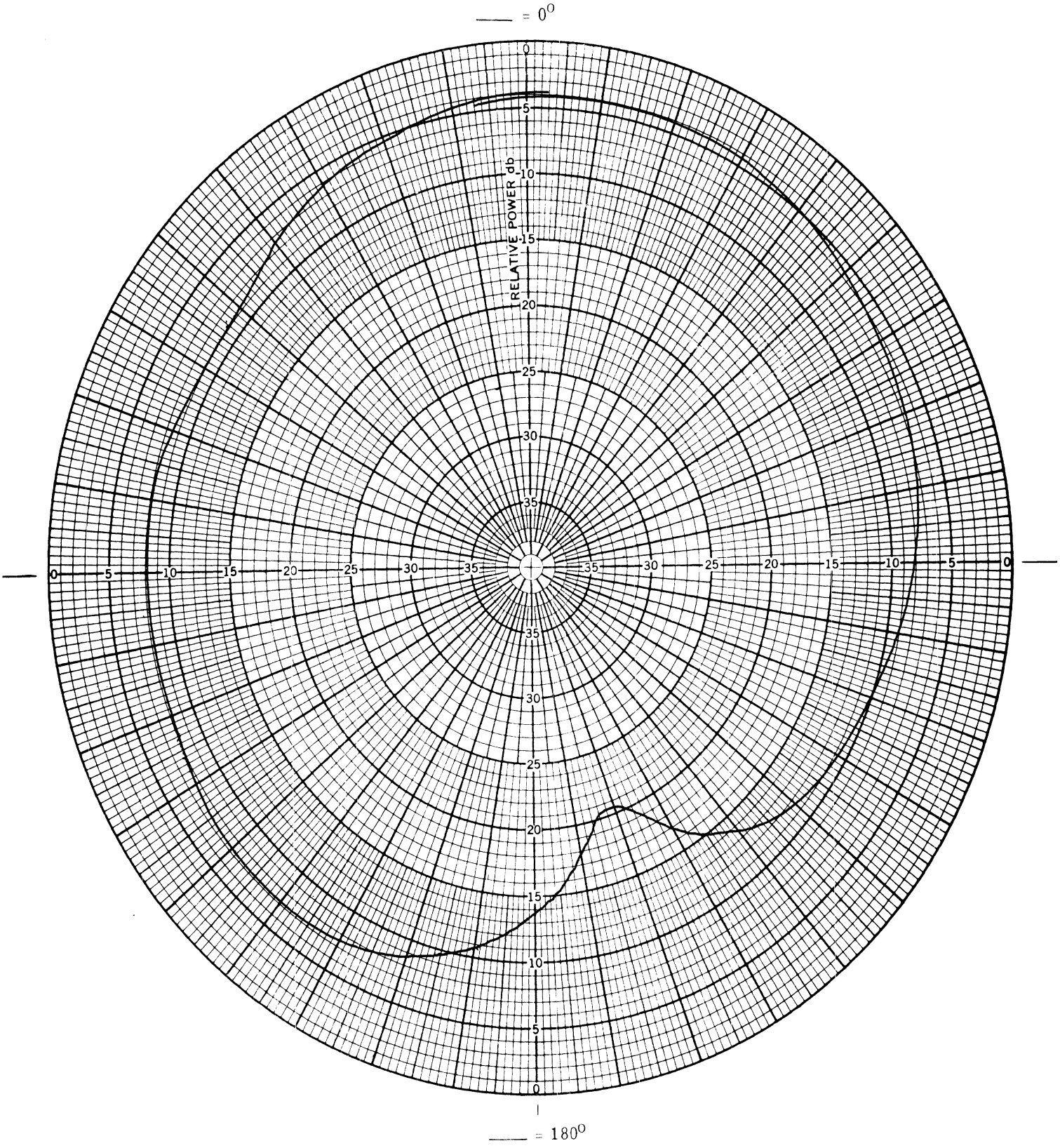


Fig. A.29: Test Car (No. 677) with Plastic Fender and 1.5 inch Diameter Ground Plane Attached to the Car Body with a Pigtail.
(Frequency = 103 MHz, Polarization = Vertical)

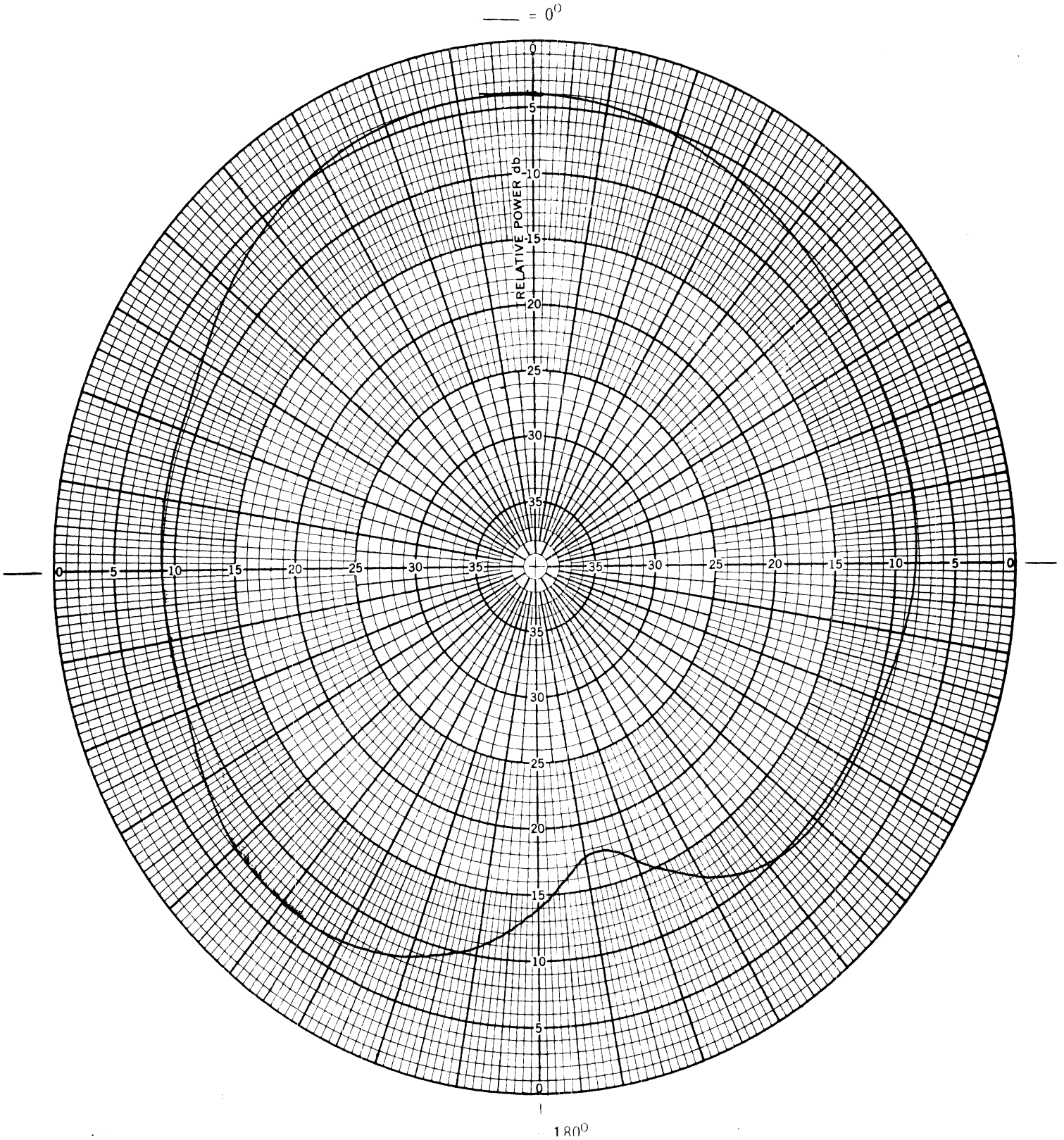


Fig. A.30: Test Car (No. 677) with Plastic Fender and 1.5 inch Diameter Ground Plane Attached to the Car Body with a Pigtail. (Frequency = 108 MHz, Polarization = Vertical)

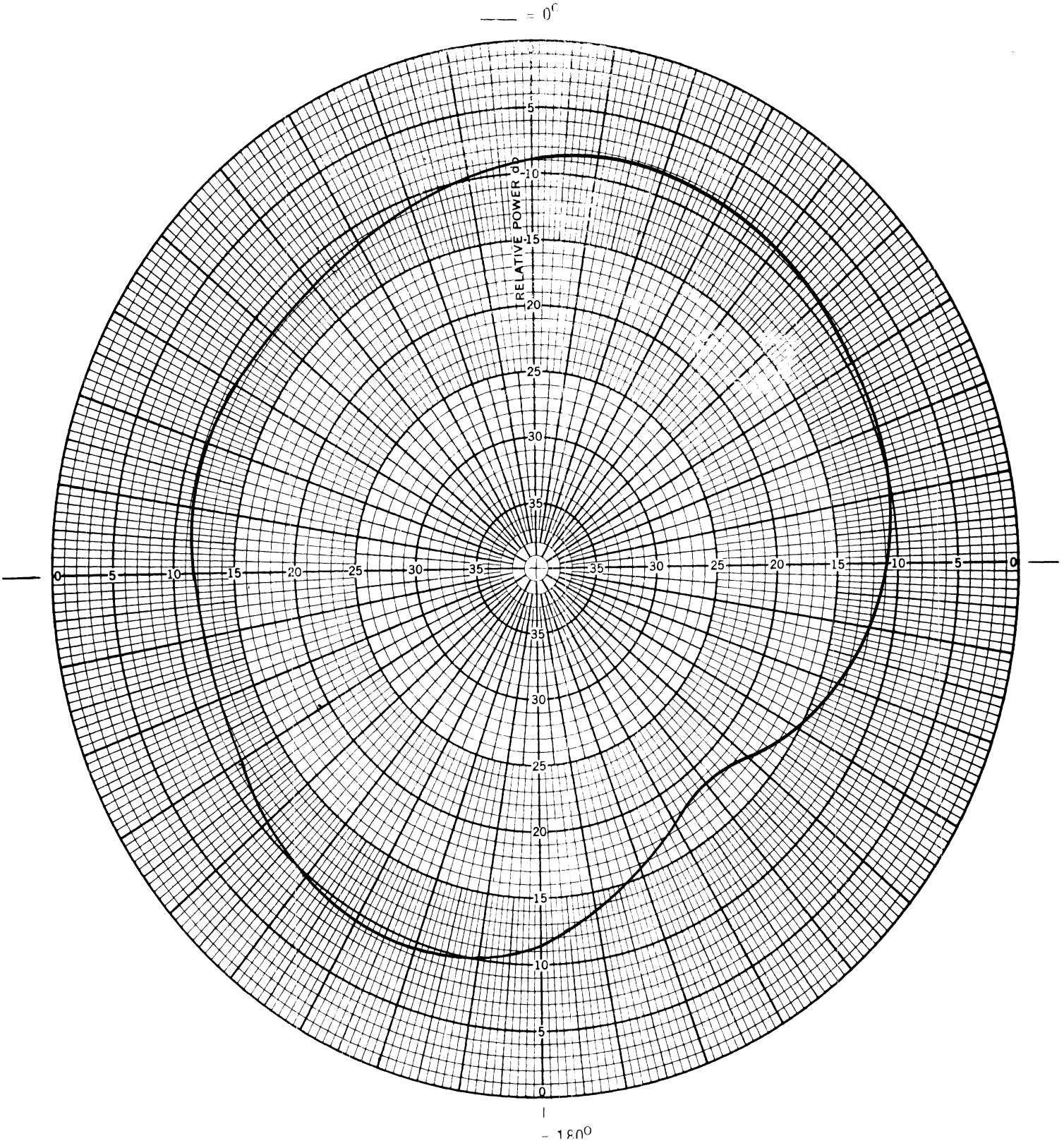


Fig. A.31: Test Car (No. 677) with Plastic Fender. (Frequency = 88 MHz, Polarization = Vertical)

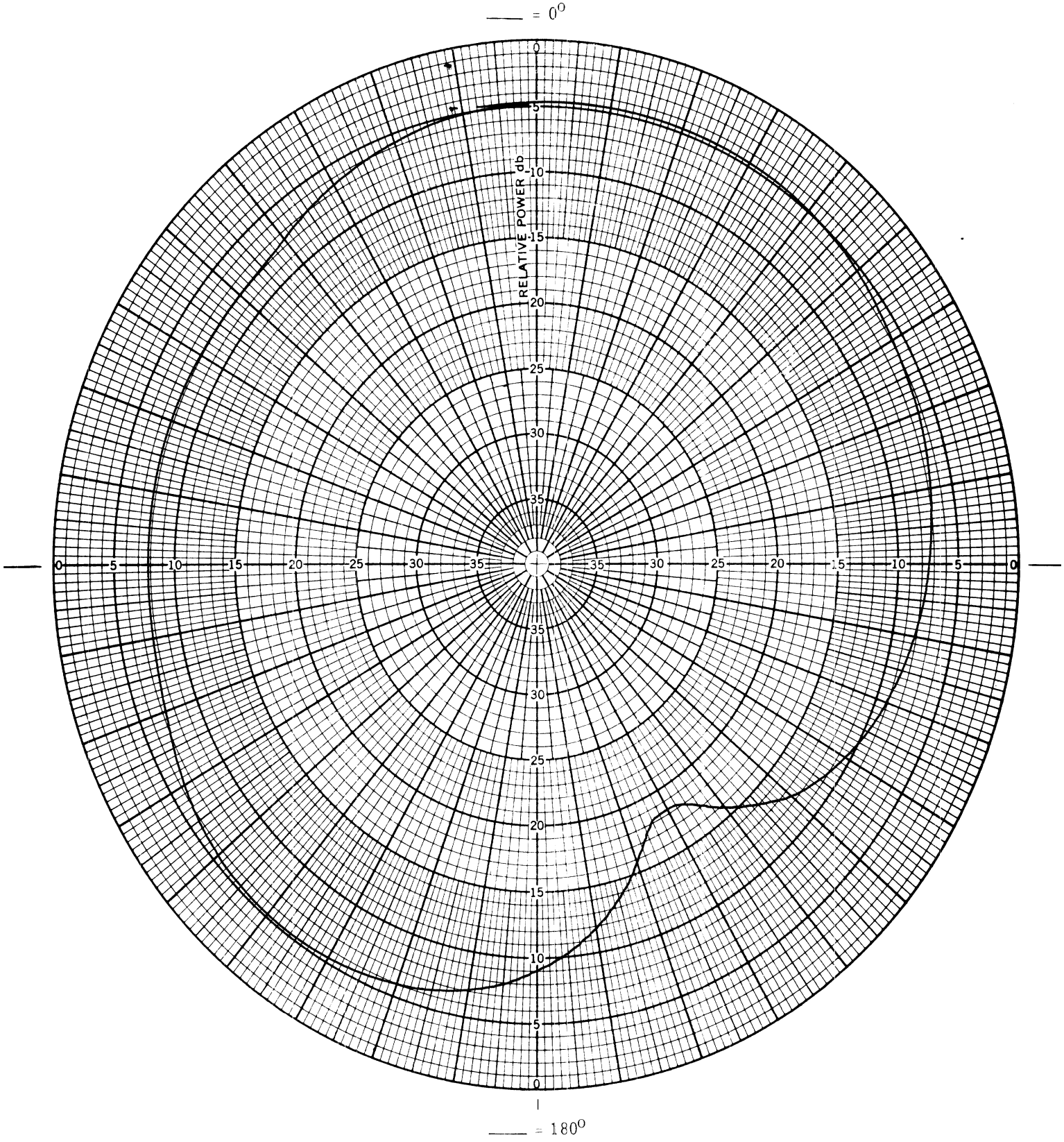


Fig. A.32: Test Car (No. 677) with Plastic Fender. (Frequency = 93 MHz, Polarization = Vertical)

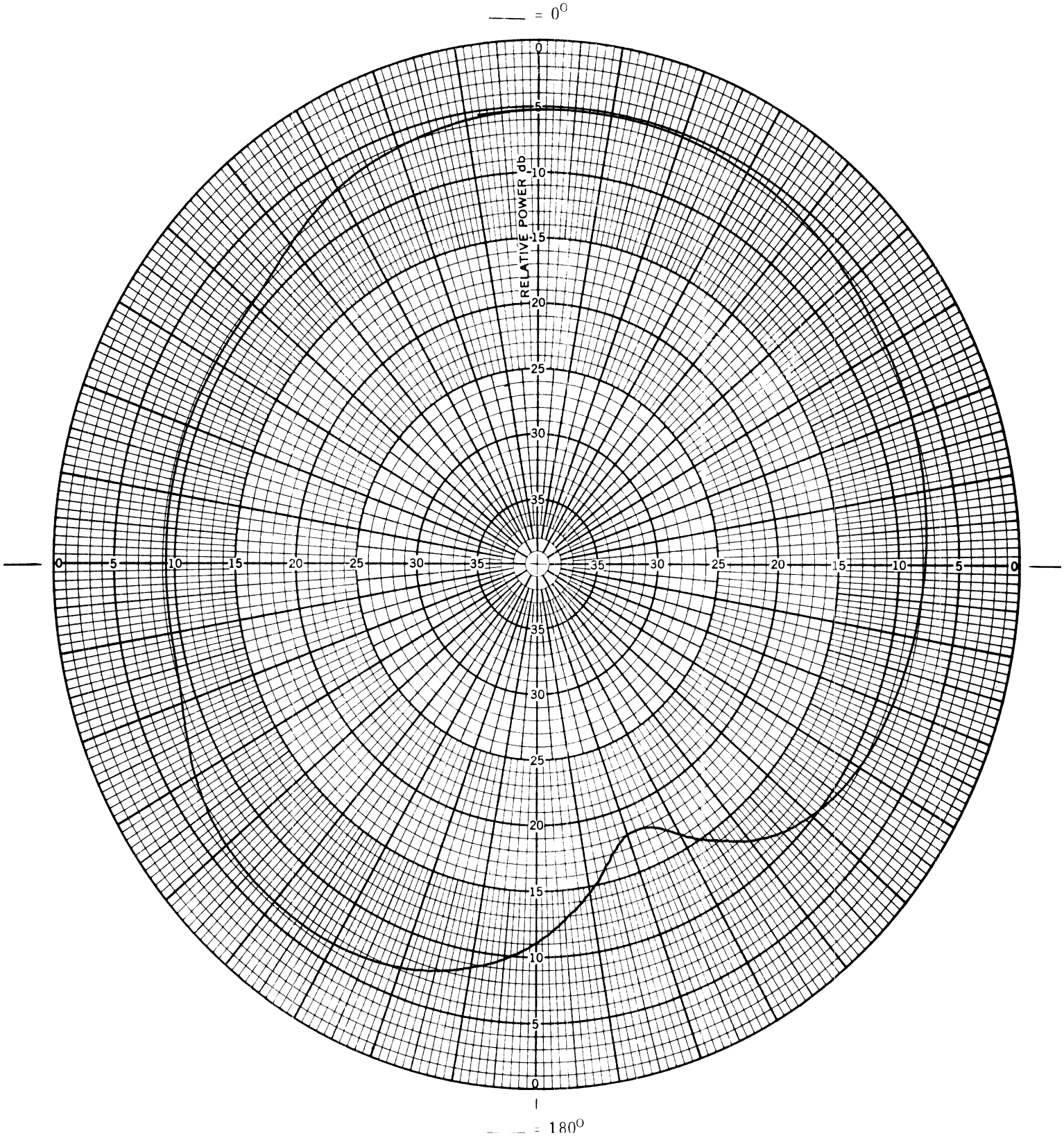


Fig. A.33: Test Car (No. 677) with Plastic Fender. (Frequency = 98 MHz, Polarization = Vertical)

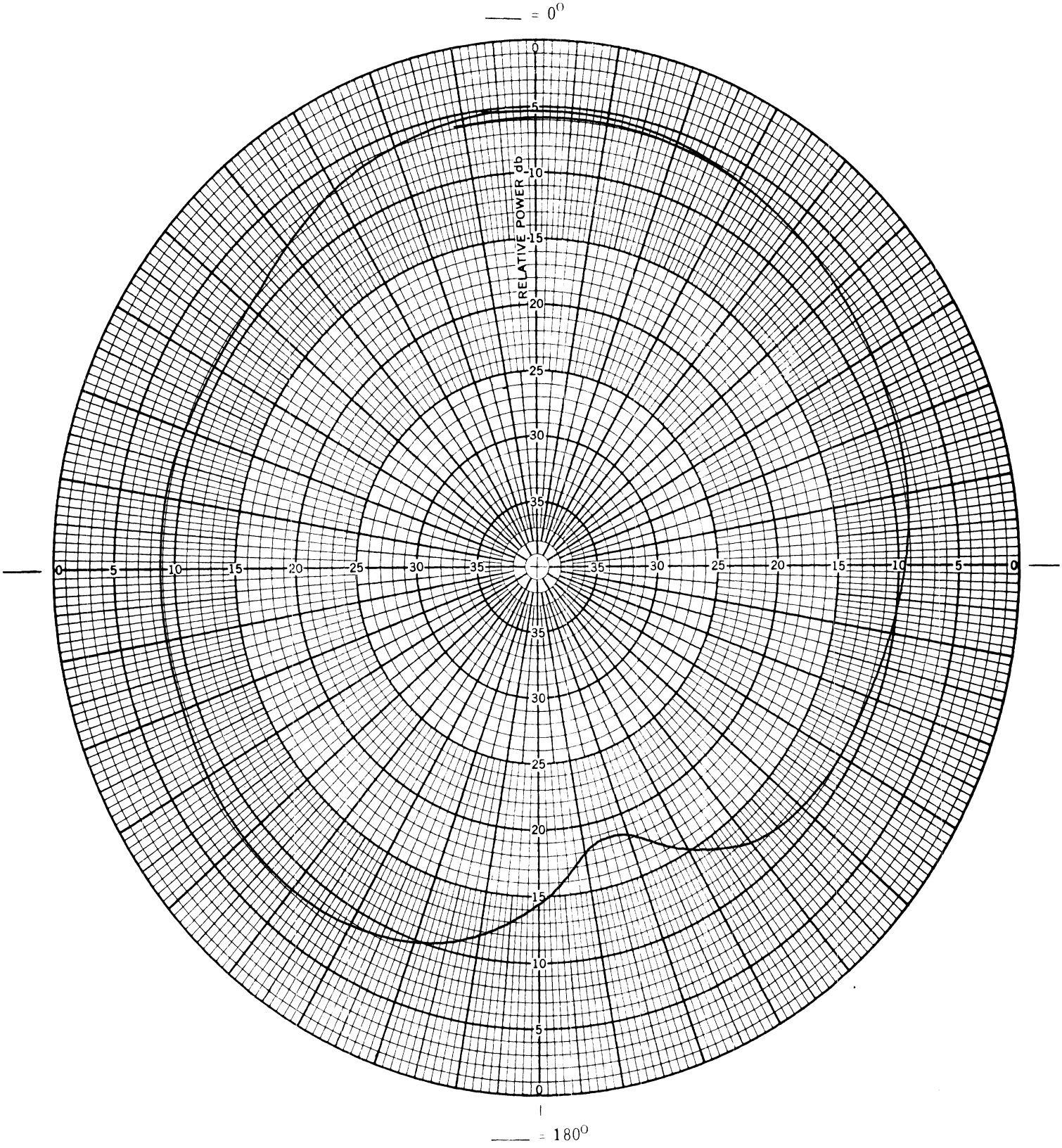


Fig. A.34: Test Car (No. 677) with Plastic Fender. (Frequency = 103 MHz, Polarization = Vertical)

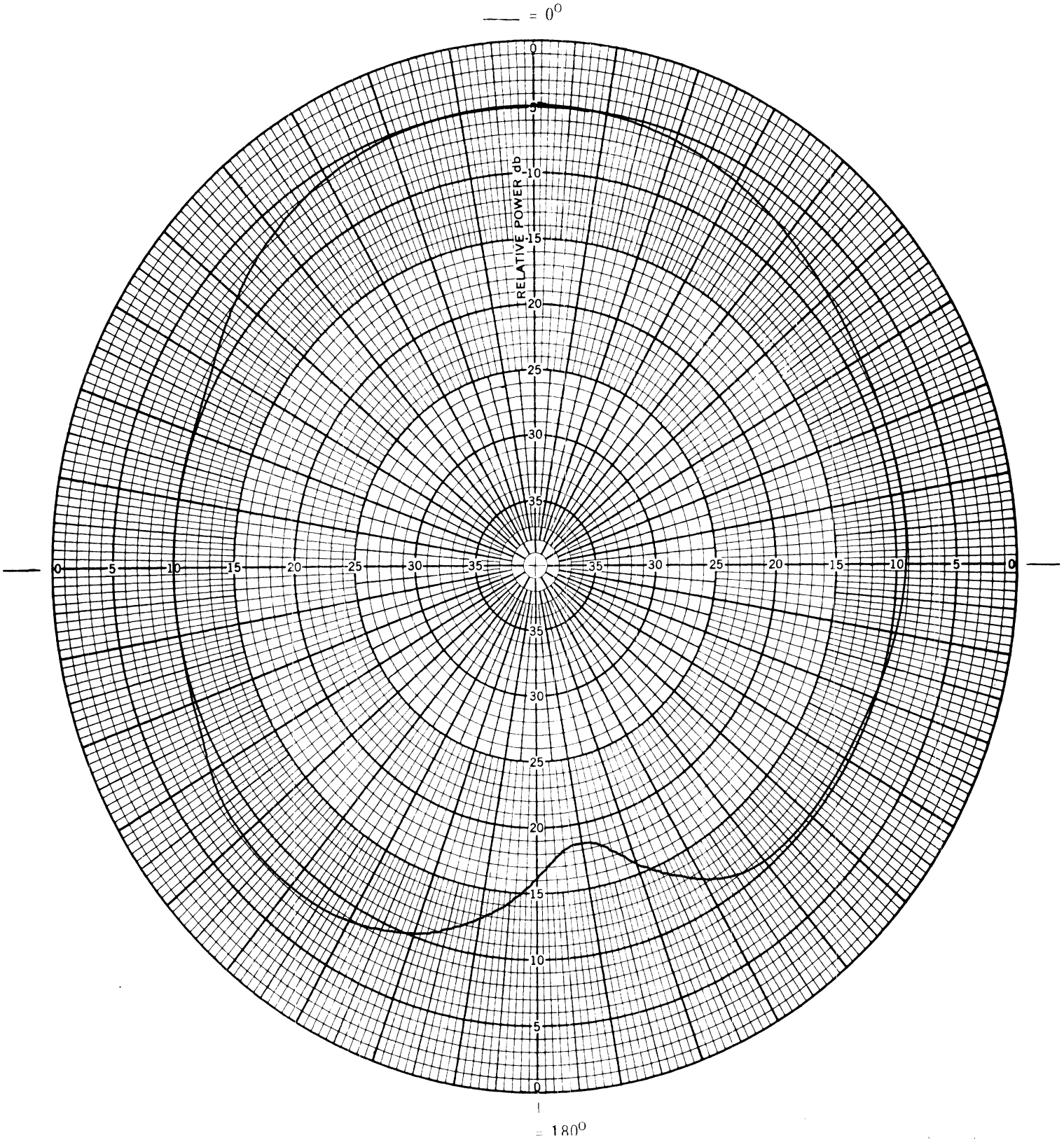


Fig. A.35: Test Car (No. 677) with Plastic Fender. (Frequency = 108 MHz, Polarization = Vertical)