# Design of an improved antenna system for the Department of Transport range positioning system

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# DESIGN OF AN IMPROVED ANTENNA SYSTEM FOR THE DEPARTMENT OF TRANSPORT RANGE POSITIONING SYSTEM

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## ABSTRACT

Preliminary field trials of a 3.2-cm Motorola range positioning system used by the Department of Transport for the positioning of sounding vessels have revealed that the system suffers from range limitation, and interference from marine radars. In an attempt to overcome both these deficiencies the design of a higher-gain transponder antenna and a shipboard omnidirectional antenna was carried out.

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# DESIGN OF AN IMPROVED ANTENNA SYSTEM FOR THE DEPARTMENT OF TRANSPORT RANGE POSITIONING SYSTEM

– J.Y. Wong and A. Grunwald –

## Introduction

The St. Lawrence Ships Division of the Department of Transport (DOT) recently acquired a complete range positioning system from Motorola for use in the positioning of sounding, sweeping, and ice-breaking vessels of the department. The system consists of a shipboard interrogator system which operates at a frequency of 9410 MHz and two shore transponders. The shipboard antenna is a horizontally polarized omni-directional slotted array having a nominal gain of 4 db. The transponders transmit on frequencies of 9310 MHz and 9410 MHz. The antenna consists of an H-plane sectoral horn having a gain of about 10 db. Limited field trials of the system carried out by DOT have revealed two major areas of weakness, namely, range limitation and interference from marine radars. It was felt that both these deficiencies could be overcome by the use of higher-performance antennas and by changing to vertical polarization.

## Design Considerations

The following parameters characterize the Motorola range positioning system.

| | |
|---|---|
| Power output | 400 watts |
| Receiver sensitivity | -65 dbm |
| Shipboard antenna gain | 4 db |
| Transponder antenna gain | 10 db |

The theoretical or calculated range of the system based on these system parameters is 8 miles, assuming free space conditions. Results of field tests, however, gave a range of only 6 miles. In order to increase the useful range of the system to 12 miles, it is necessary to increase the over-all gain by an additional 6 db. This extra gain can best be obtained by employing higher-gain antennas.

## Transponder Antenna

The Motorola system employs two transponders which are suitably deployed at different sites on shore such that the sounding vessel can be continuously tracked. This requirement dictates that the transponder antenna must have a fairly broad radiation pattern, and the design objective was a half-power beamwidth of 90 degrees. In the elevation pattern a 10-degree beamwidth was considered desirable.

The basic antenna consists of an E-plane sectoral horn. There was virtually no difficulty in meeting the elevation pattern requirement; however, in order to obtain a broad azimuth pattern, it was necessary to modify the aperture of the horn. Part of

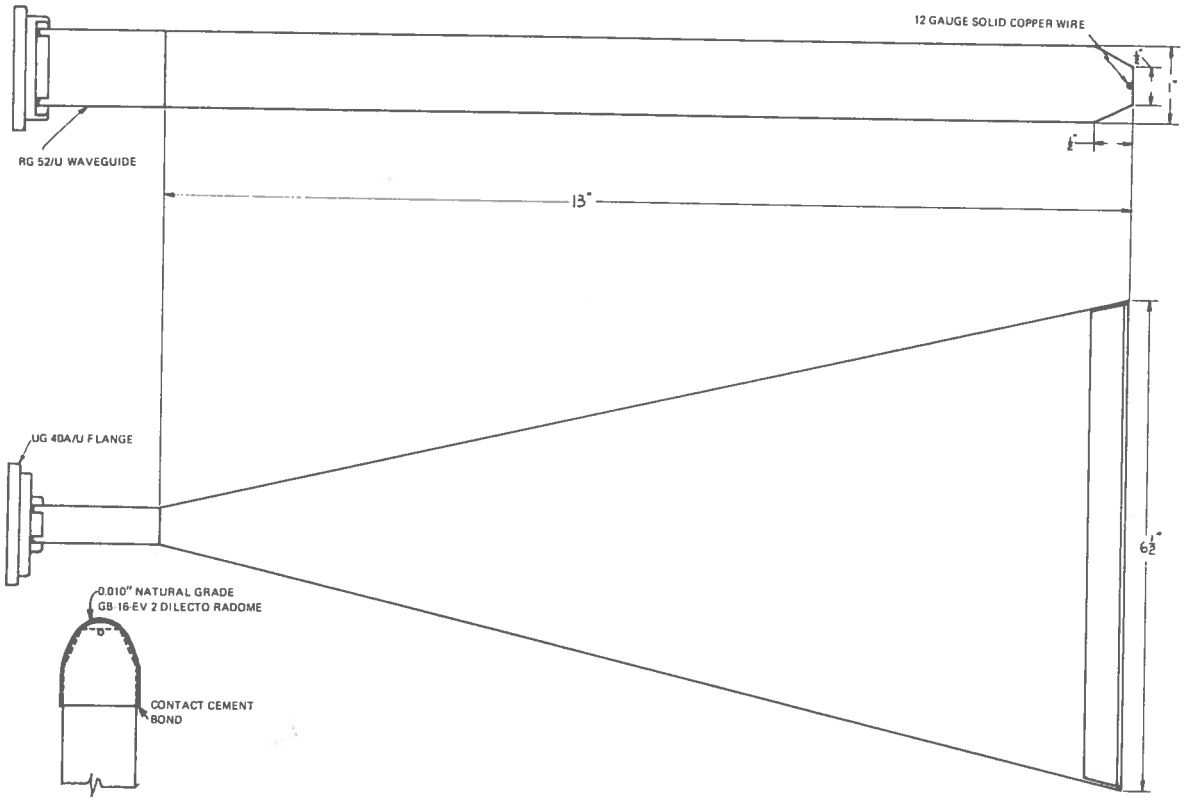



*Figure 1 Drawing of transponder horn antenna*

the side walls of the horn were removed and a scattering post was placed in the mouth of the aperture [1]. The amount of beveling and the size of post were determined strictly by experiment. A drawing of the horn showing the critical dimensions is given in Fig. 1. To protect the antenna from rain and snow, a fiber glass window was placed over the horn aperture. Radiation patterns of the antenna at frequencies of 9.3 GHz, 9.4 GHz, and 9.5 GHz are given in Figs. 2, 3, and 4, respectively. Inspection of the patterns reveals that the azimuth beamwidth is very close to the design figure of 90 degrees. The gain based on the measured patterns gives a figure of about 15 db at 9.4 GHz. This figure compares with a value of 10.4 db obtained for the Motorola antenna.

**Omnidirectional Antenna**

One of the simplest types of antenna used in practice for providing vertically polarized omnidirectional coverage is a biconical horn. A vertical half-power beamwidth of 15 degrees was our design objective. Curves given in Fig. 10-3 of Reference 2 were used in the initial design. The following horn dimensions were obtained; aperture – 4 inches, slant length – 6 inches. For these horn parameters, the gain is estimated to

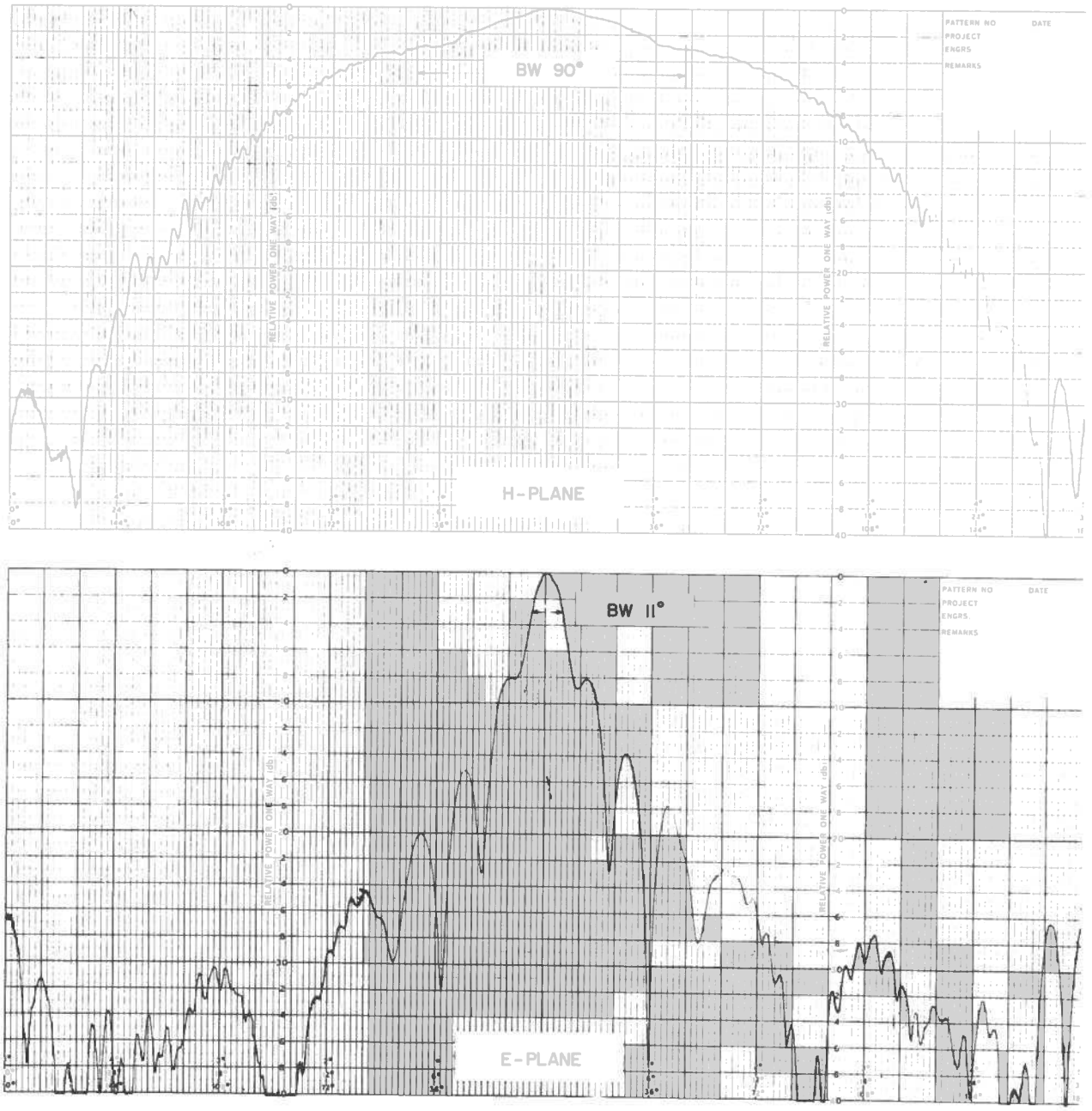



*Figure 2 Radiation pattern of transponder antenna at 9.3 GHz*

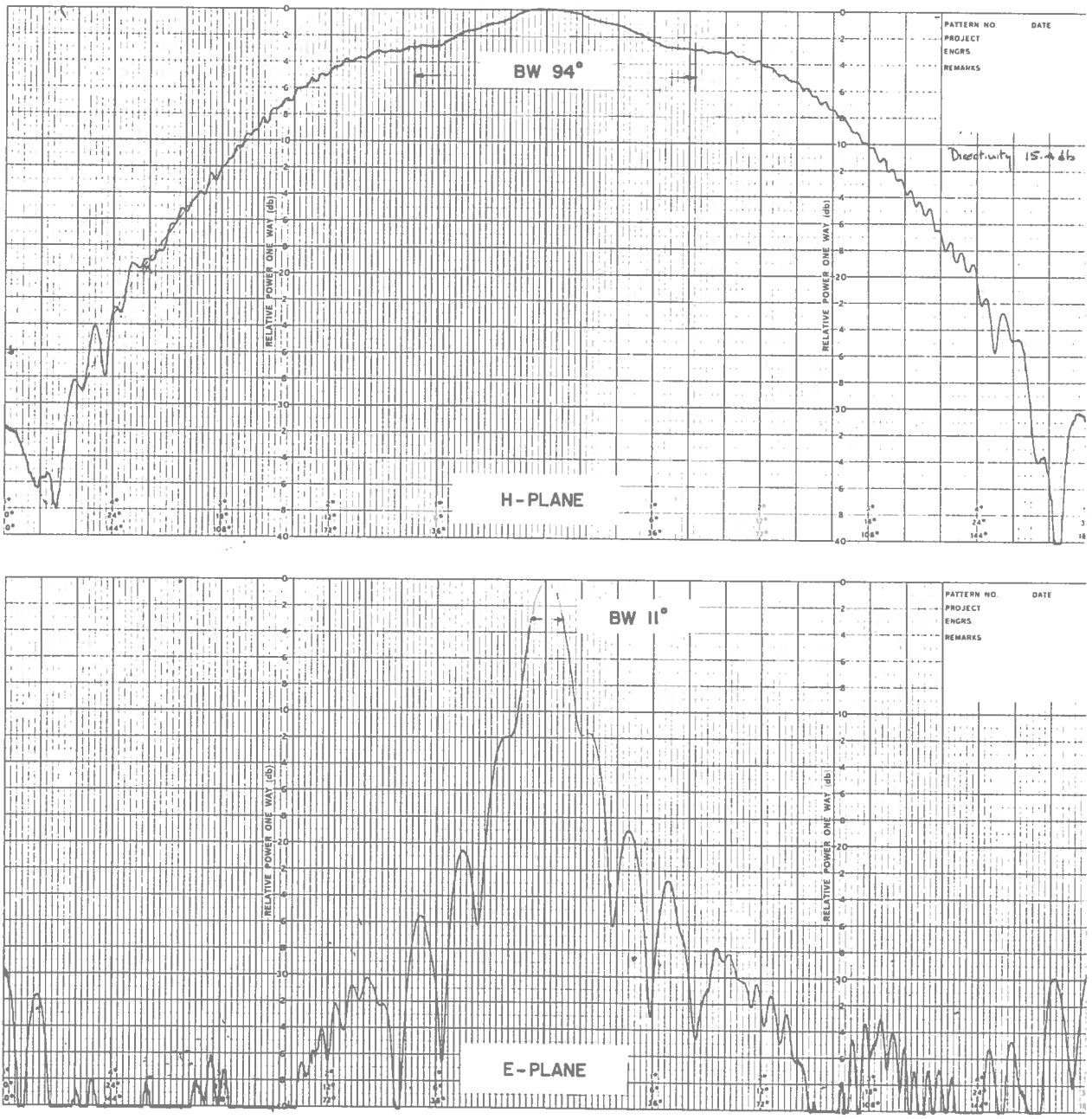



*Figure 3 Radiation pattern of transponder antenna at 9.4 GHz*

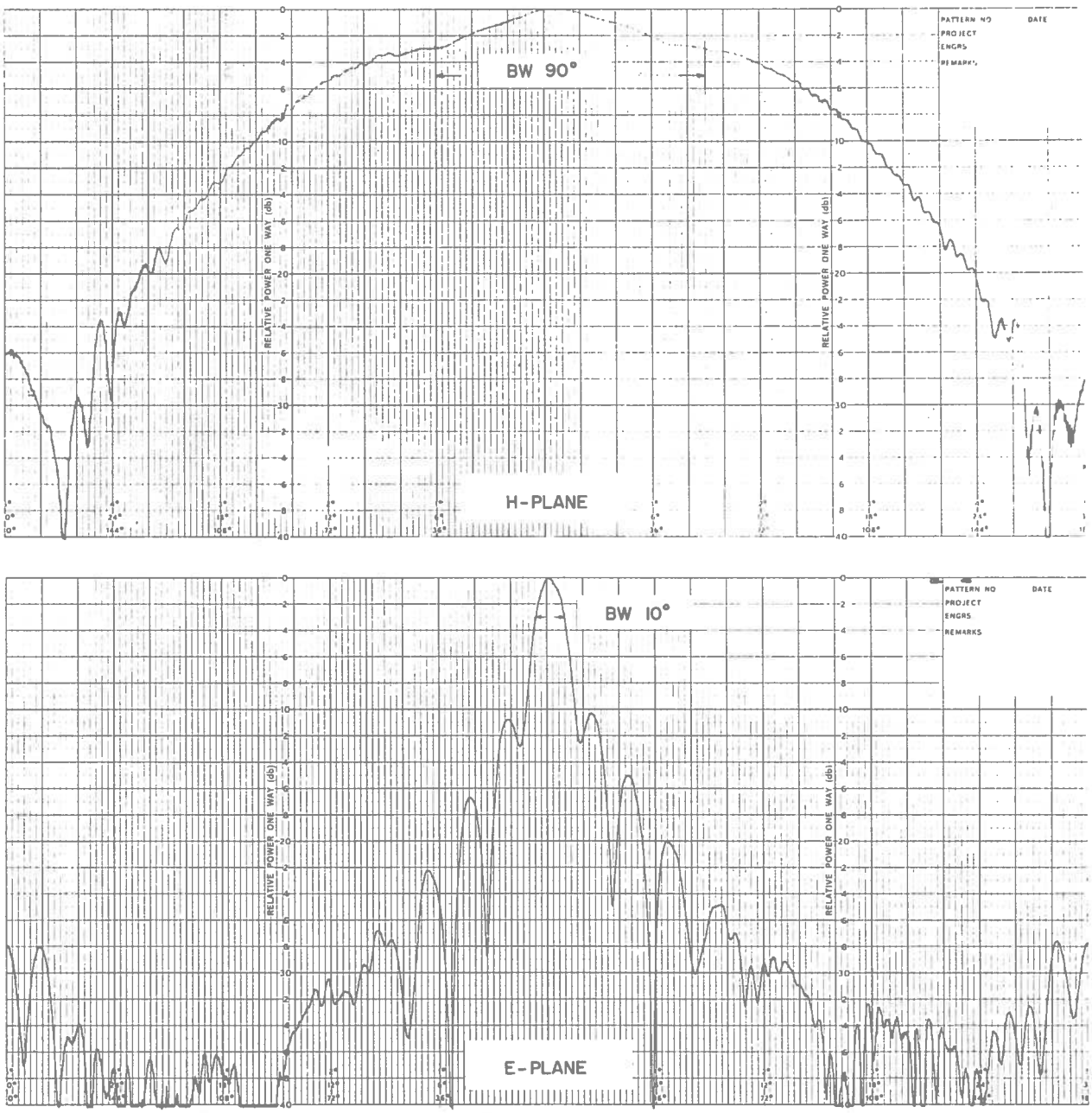



*Figure 4 Radiation pattern of transponder antenna at 9.5 GHz*

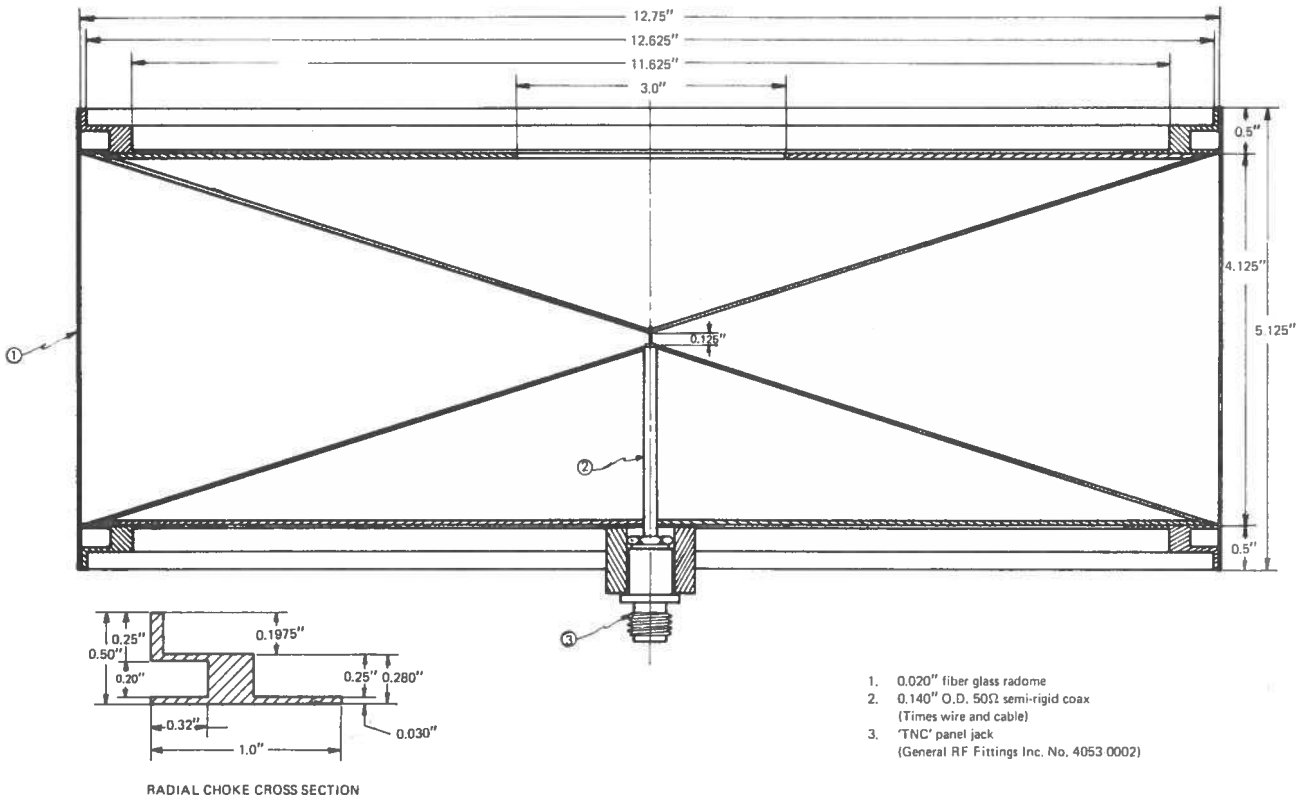



*Figure 5 Drawing of biconical horn antenna*

be 6.9 db. Figure 5 shows a drawing of the final horn configuration and a photograph of the antenna is given in Plate I. Note the quarter wave radial chokes on the top and bottom surfaces of the horn. Without the chokes, the level of the spurious lobes off the top and bottom were impractically high. Addition of the chokes reduced the level by as much as 8 db. Measured radiation patterns of the antenna are given in Figs. 6, 7, and 8. Calculated gain based on the measured patterns gives a value of 7 db at 9.4 GHz. Swept VSWR measurements of the antenna are shown in Fig. 9. Over the operating band of the antenna, the VSWR is less than 1.8 to 1.

## Conclusion

In an effort to overcome range limitation and radar interference higher-gain vertically polarized antennas have been designed for the Motorola range positioning system. Operational trials of the system using the improved antennas is expected to be carried out early in the spring.

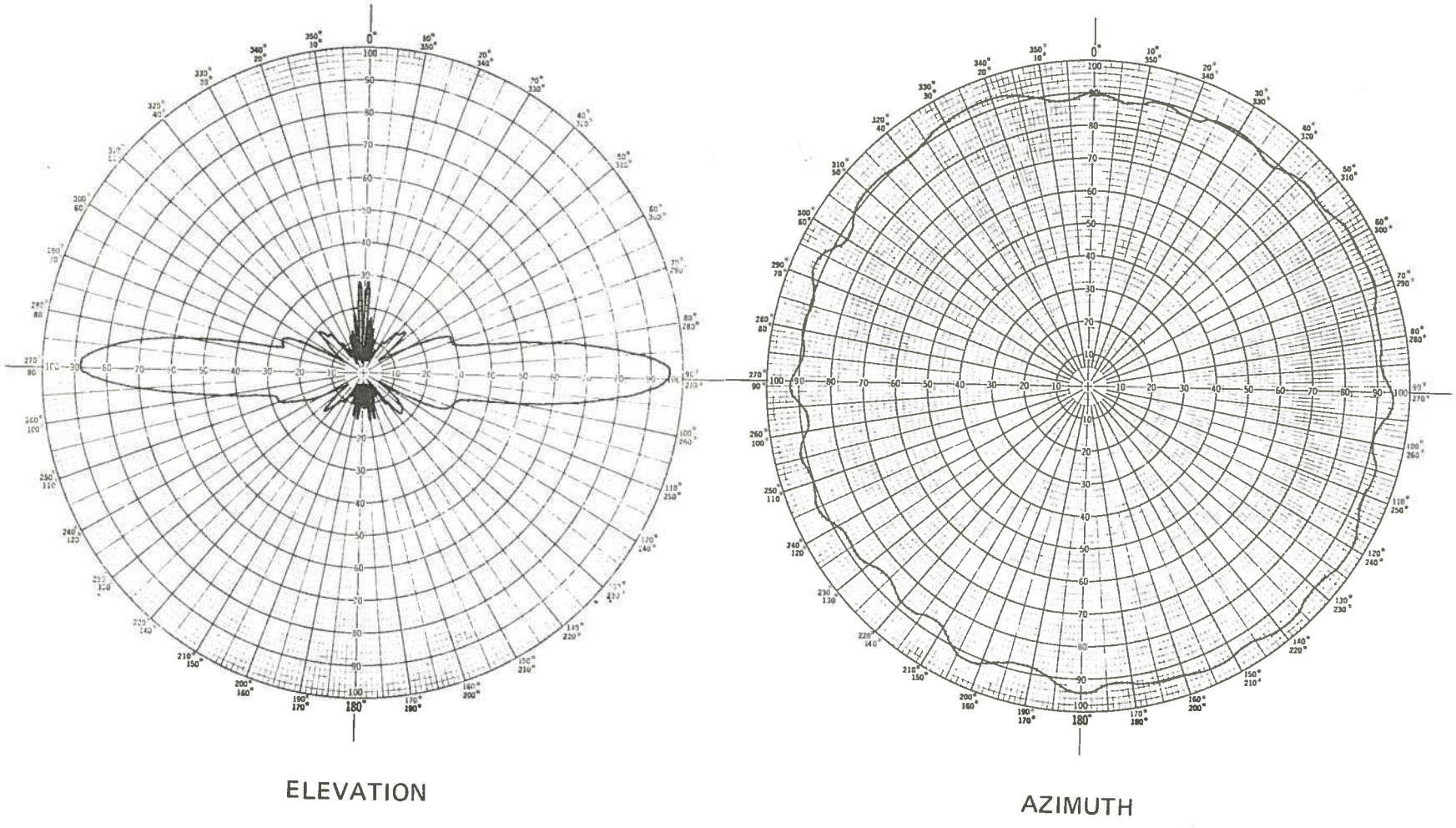
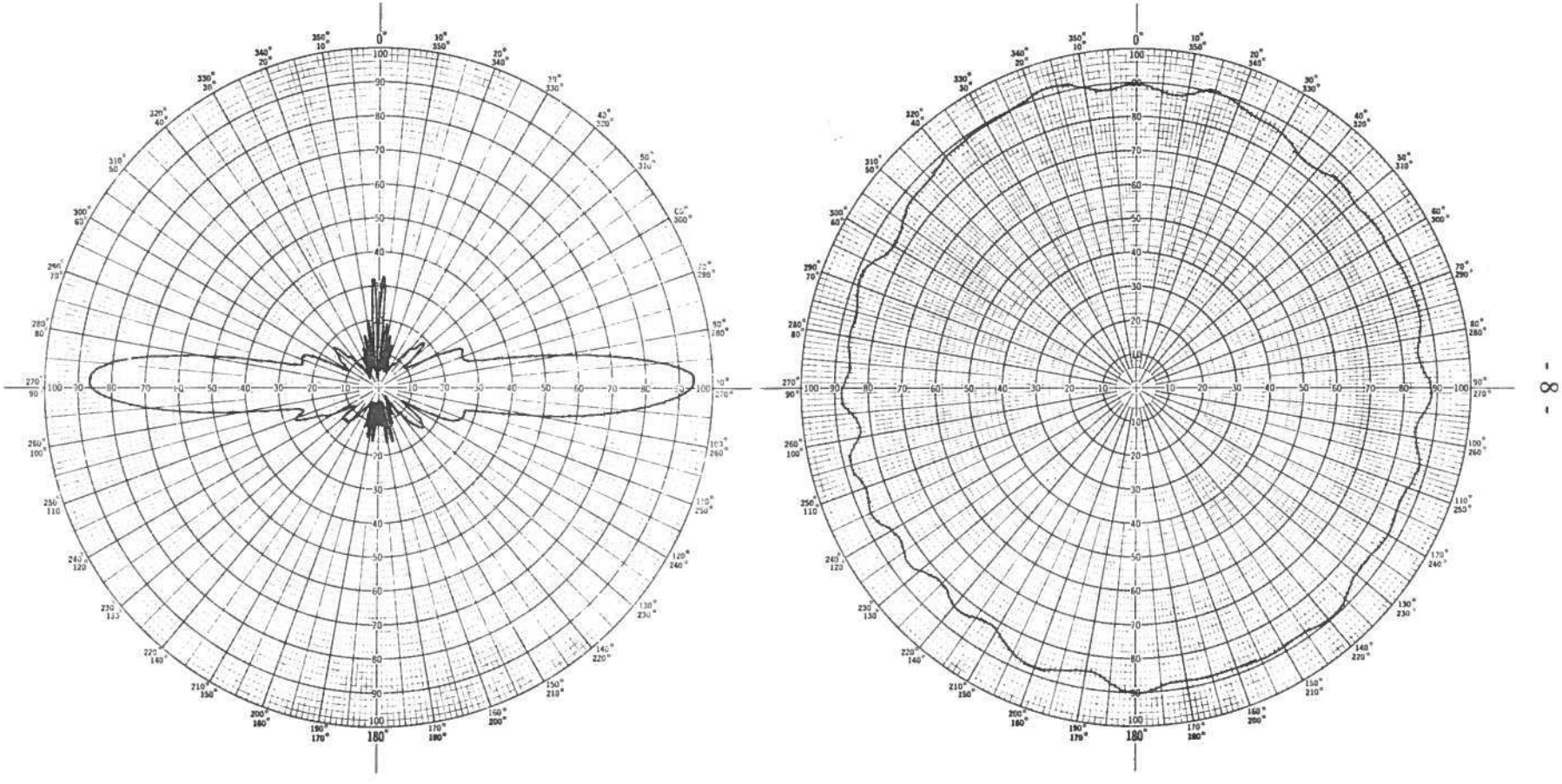


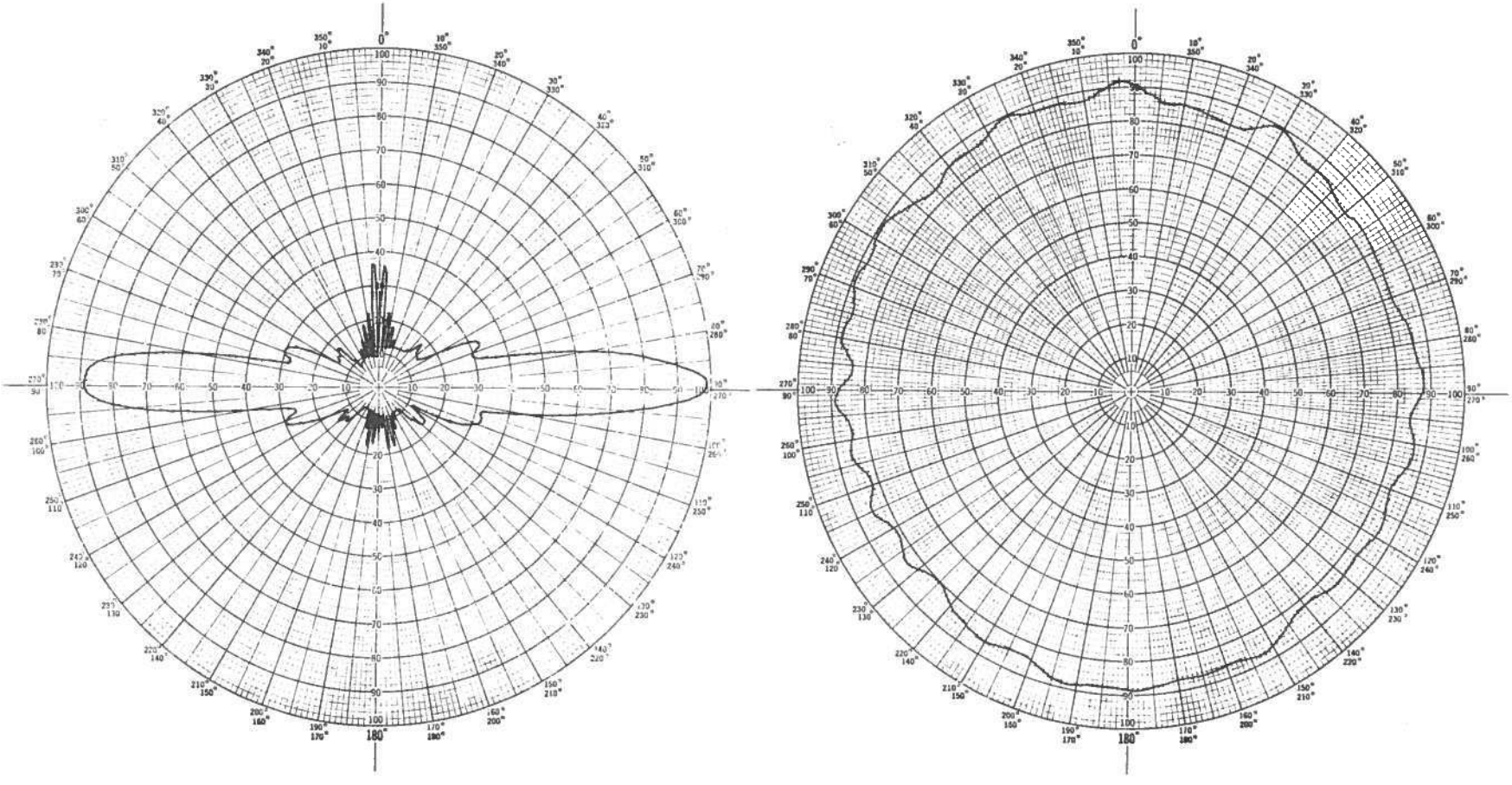

*Figure 6 Radiation pattern of biconical horn at 9.3 GHz*



ELEVATION

AZIMUTH

*Figure 7 Radiation pattern of biconical horn at 9.4 GHz*



ELEVATION

AZIMUTH

*Figure 8 Radiation pattern of biconical horn at 9.5 GHz*

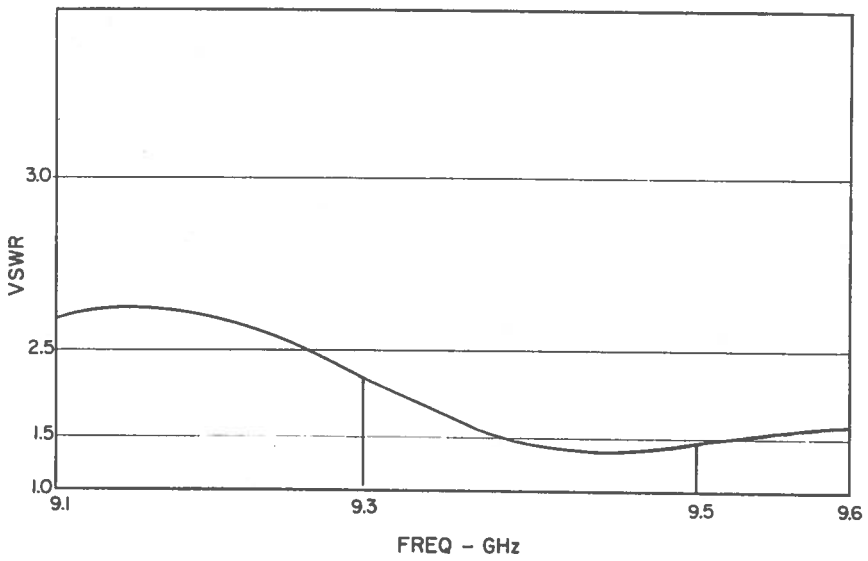



*Figure 9 Swept VSWR measurement of biconical horn antenna*

## References

1. Silver, S. Microwave Antenna Theory and Design, Vol. 12, McGraw-Hill Book Inc. 1949, p. 381.

2. Jasik, H. Antenna Engineering Handbook. McGraw-Hill Book Co. Inc. 1961, p. 10–14.

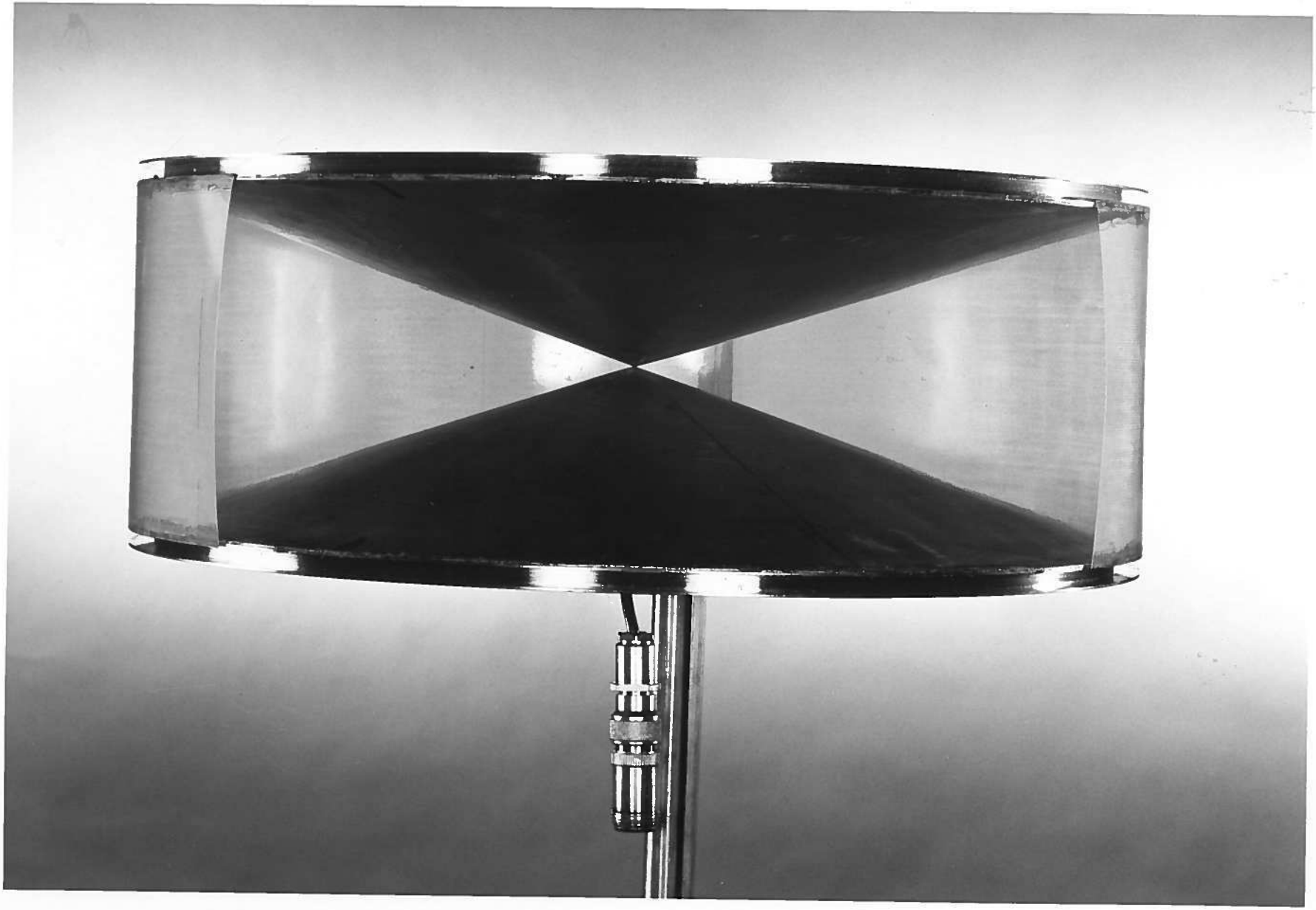


PLATE I BICONICAL HORN ANTENNA