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DESIGN OF A GAP-FILLER ANTENNA FOR AN/FPS-503

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ABSTRACT

This report presents the design and results of a gap-filler antenna for use in conjunction with the AN/FPS-503 McGill Fence doppler detection antenna. The antenna is basically a sectoral electromagnetic horn capable of producing a rectangular-type pattern in the elevation plane and a semi-circular pattern in the azimuthal plane. The respective patterns are achieved by means of a metallic post located in the mouth of the horn and a set of metal flanges attached to the long sides of the antenna aperture. The maximum gain of the antenna relative to an isotropic radiator is about 8.4 db.

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- J.Y. Wong -

INTRODUCTION

The AN/FPS-503 antenna employed in the McGill Fence doppler detection system is of the horn-reflector type. The reflector consists of a doubly curved surface designed to produce a cosecant-squared type of pattern in the elevation plane. Measured radiation patterns [1] reveal that the coverage in a sector over the antenna is inadequate and fails to meet the system's requirement.

A request was received from the Special Contract Department, Trans-Canada Telephone System, Montreal, to design an antenna which would be used in conjunction with the AN/FPS-503 for the purpose of providing adequate overhead coverage.

This report presents the design and results of a horn-type gap-filler antenna developed for this purpose.

ELECTRICAL REQUIREMENTS

The antenna is to possess horizontal polarization and operate over a band of frequencies from 482 mc/s to 492 mc/s. The specifications require a coverage diagram which is approximately semicircular in the azimuthal plane and rectangular in the elevation plane. The field strength at any angle must not be 3 db below the ideal patterns shown in Fig. 1. The antenna is to have a maximum forward gain relative to an isotropic radiator of not less than 8 db and the back lobe must be at least 20 db down.

DESIGN CONSIDERATIONS

Examination of the elevation plane pattern shown in Fig. 1 leads one to suspect that perhaps this type of coverage can be approximated by an antenna (with certain modifications) producing a conventional beam-shaped pattern. If one superimposes a conventional pattern on the ideal pattern so that the maxima are coincident, it is apparent that, in order to satisfy the pattern requirements, the sector from about 50° to 90° must be filled in.

The wide-angle coverage in the azimuthal plane suggests an antenna having a narrow aperture in this plane. Considering these factors, pattern measurements were carried out on an H-flare sectoral electromagnetic horn.

The aperture dimensions of the basic horn configuration were approximately 0.35λ in the E-plane and 2λ in the H-plane. It is known that a certain degree of beam-shaping can be achieved by the use of obstacles placed in horn and waveguide

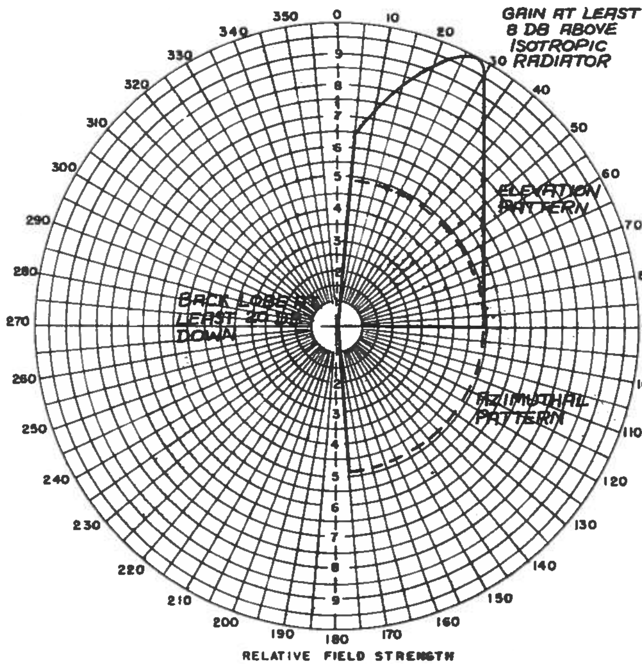

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FIG. 1 IDEAL RADIATION PATTERNS FOR GAP-FILLER ANTENNA apertures [2]. Applying this technique to our problem, H-plane pattern measurements were conducted with circular metallic posts of various sizes placed in the mouth of the antenna. Post diameters ranging from 2 inches to $3\frac{1}{2}$ inches were investigated. It was found that the amount of beam-shaping was dependent on two parameters, namely, the size of post, and the position of the post along the aperture of the horn. However, no pair of parametric values could be found which gave the required amount of beam-shaping.

In order to create additional phase distortion of the wavefront and hence further beam-shaping, it was believed this result could be accomplished by cutting off a corner of the aperture. An arbitrary diagonal cut subtending an angle of 30° with the face of the aperture was made. A good approximation to the ideal pattern was achieved finally, utilizing a post $3\frac{1}{2}$ inches in diameter placed $2\frac{1}{2}$ inches from the center of the aperture. However, the back lobe was of the order of about 25 percent. In order to reduce rear radiation to an acceptable value, the horn was fitted with a pair of quarter-wavelength parallel-plate chokes.

Patterns of the antenna in the azimuthal plane were measured with the horn tilted so that the nose of the beam was at an angle of 30° from the vertical. Preliminary measurements revealed that energy was being radiated in only a small sector along the horizon. The horn did not possess the expected wide-angle coverage.

In a paper by Owen and Reynolds [3], results of experiments are given on horns having rectangular apertures, one dimension of which is of the order of a quarter of a wavelength, the other being of the order of a wavelength or more. The polarization is parallel to the smaller dimension. Results are shown which demonstrate the types of radiation patterns resulting when various symmetrical systems of metal flanges are attached to the long sides of the aperture. In particular, it is shown within what limits the form of the radiation pattern can be regulated by this means, and to what extent it is possible to obtain patterns possessing wide-angle coverage.

Applying their results to the present design, and after a series of measurements involving flanges of various configurations, acceptable patterns were obtained for a set of flanges having the dimensions shown in Fig. 2. Again, in order to satisfy the back lobe requirements, parallel-plate chokes attached to the flanges were required.

Constructional details of the experimental horn antenna are given in Fig. 2. Fig. 3 is a photograph of the antenna tilted at 30° from the vertical and in position for azimuthal plane pattern measurements. Radiation patterns of the antenna are given in Figs. 4 and 5 for frequencies of 482 mc/s and 492 mc/s, respectively. The dotted curve in each case is the ideal pattern, and it is observed that the antenna satisfies the pattern requirements as outlined under "Electrical Requirements".

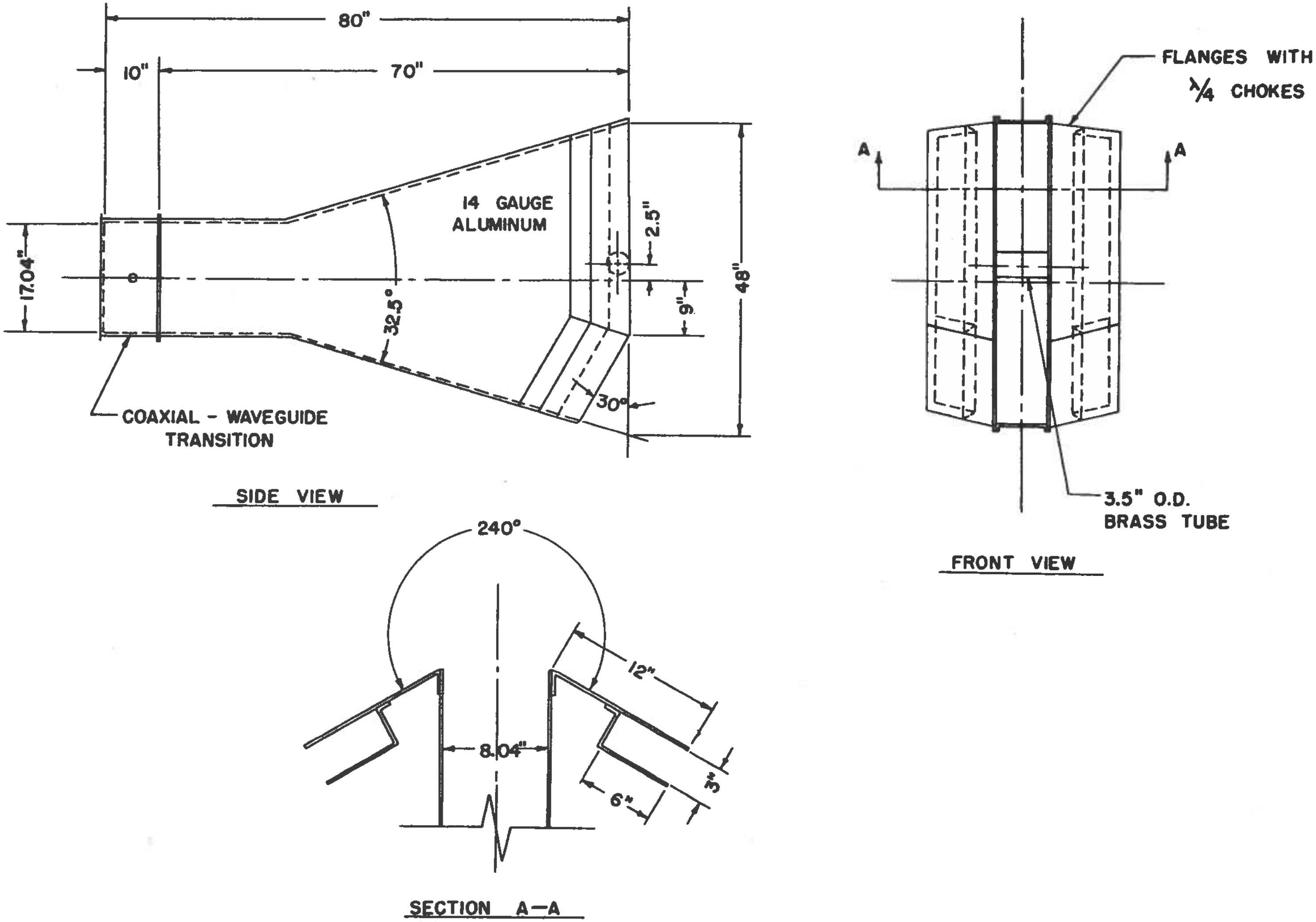

FIG. 2 CONSTRUCTION OF EXPERIMENTAL HORN ANTENNA

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FIG. 3 VIEW OF ANTENNA IN POSITION FOR AZIMUTHAL PATTERN MEASUREMENT

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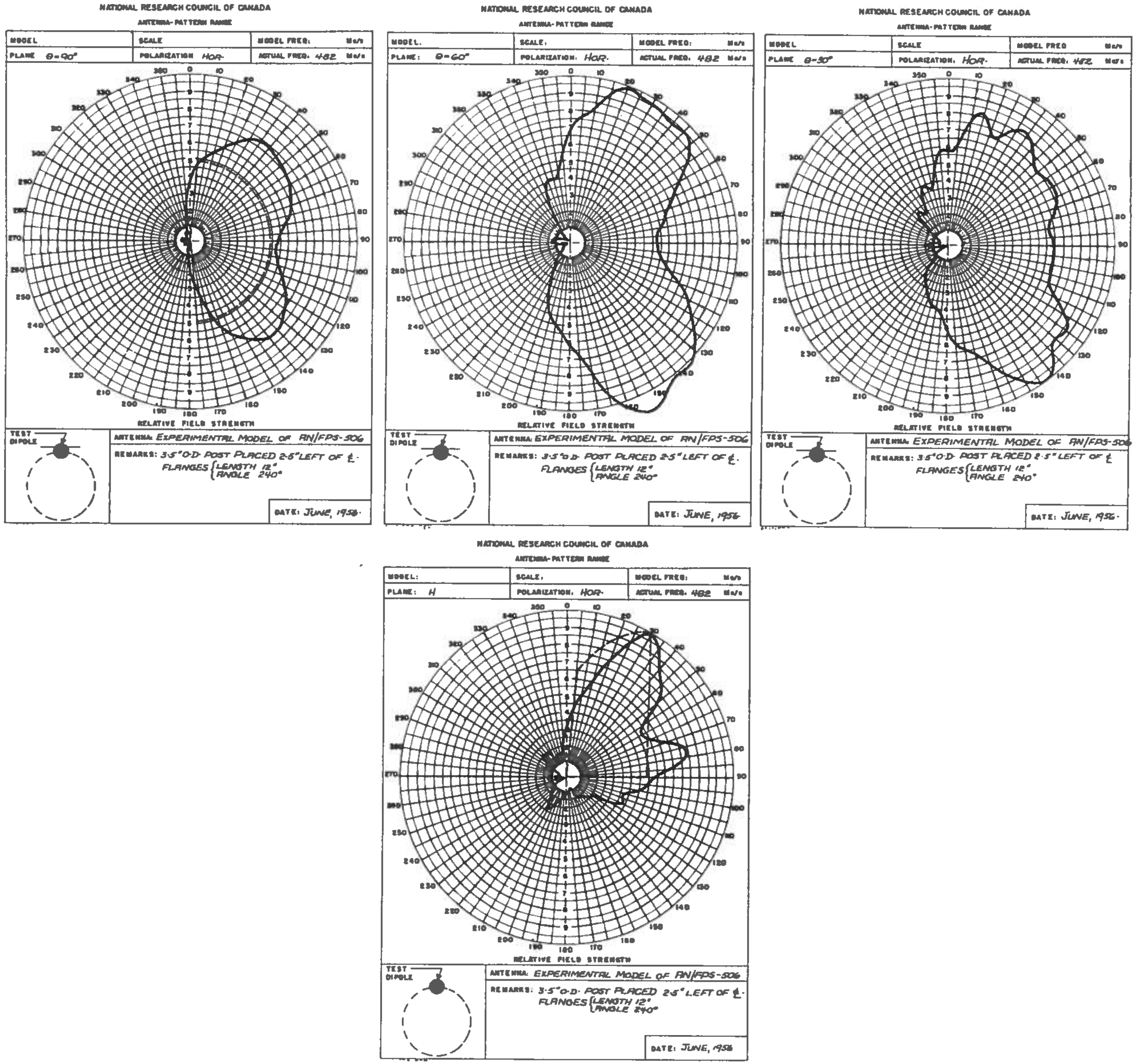

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FIG. 4 RADIATION PATTERNS OF ANTENNA AT 482 mc/s

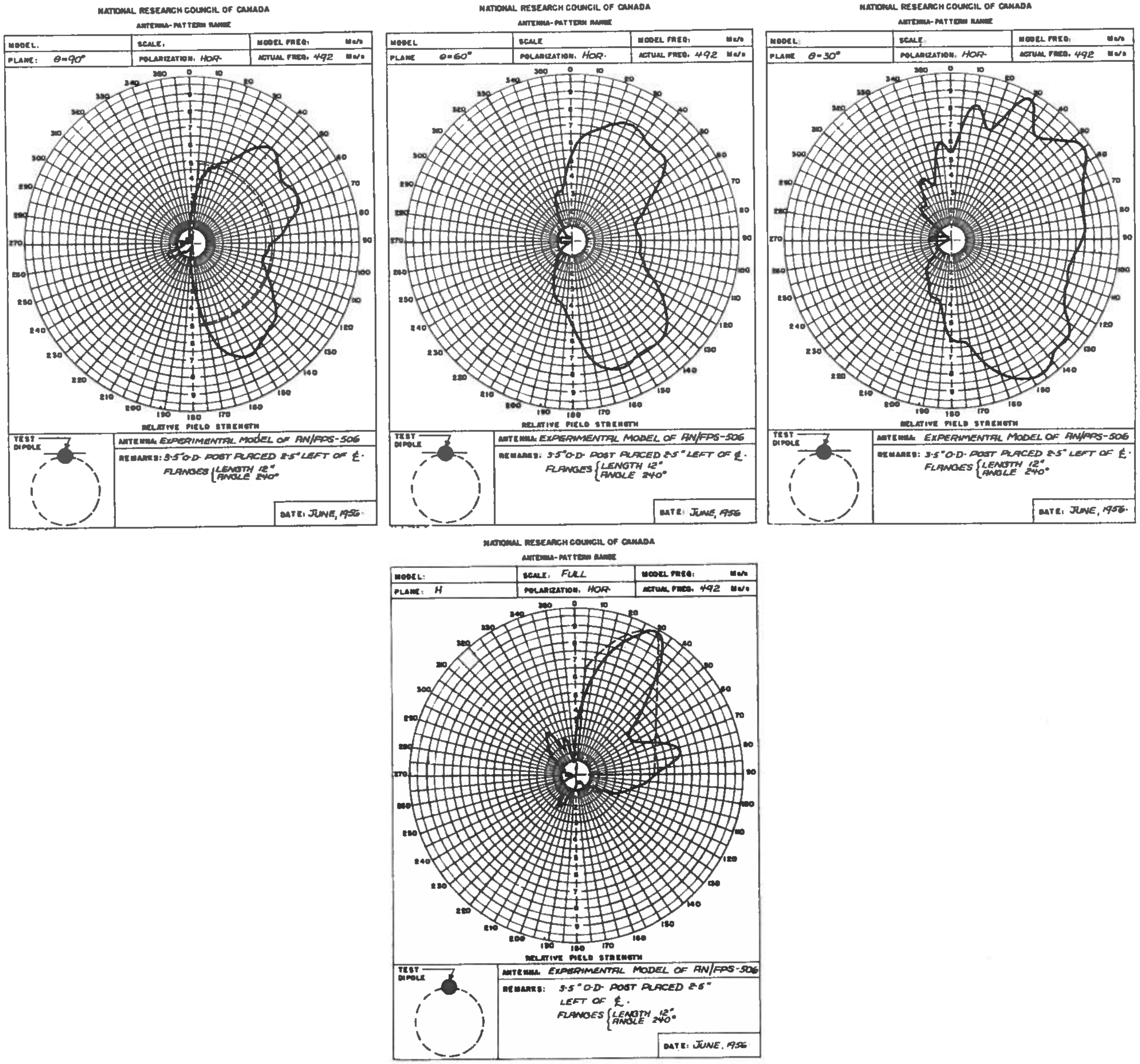

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FIG. 5 RADIATION PATTERNS OF ANTENNA AT 492 mc/s

The coaxial-to-waveguide transition employs a conventional probe-type feed. The actual probe used was from the feed horn of the AN/FPS-503 antenna. Tests were carried out to determine the position of the probe with respect to the backing plate in order to achieve the best possible match. A distance of 6-1/16 inches was found to give the lowest standing-wave ratio over the operating band of the antenna. Fig. 6 shows a plot of VSWR as a function of frequency for the horn antenna.

The gain of the antenna was measured at a frequency of 485 mc/s. Using the comparison method, the measurements yielded a figure of about 8.4 db above an isotropic radiator.

CONCLUSIONS

The antenna was found to be acceptable by the Special Contract Department, Trans-Canada Telephone System, and production units based on the design reported herein have been placed on order. The horn antenna has been designated officially as the "AN/FPS-506".

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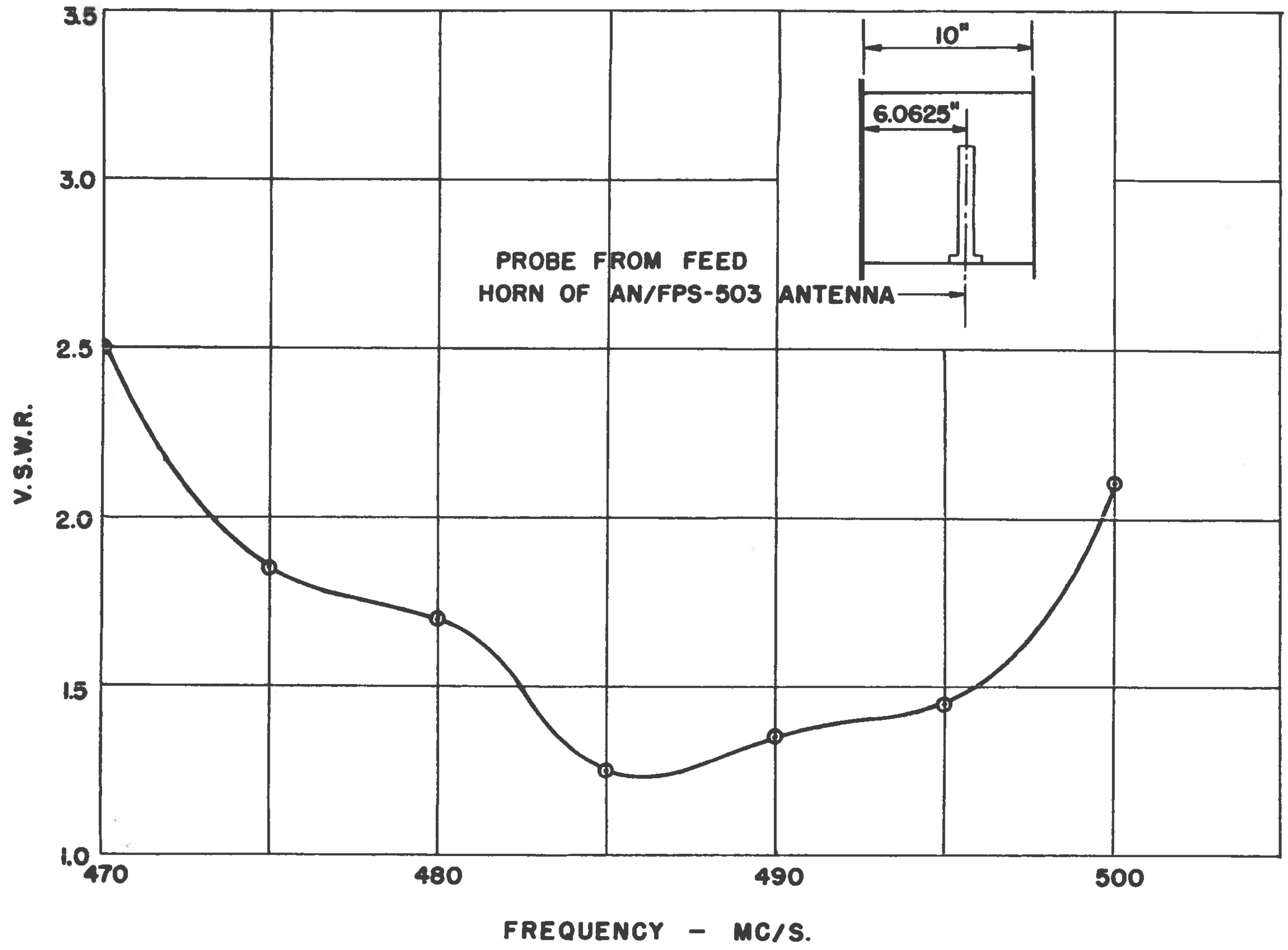

FIG. 6 VSWR CURVE OF HORN ANTENNA