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NAVAL RESEARCH LABORATORY REPORT

MODIFIED M6807 ANTENNA FOR 2200-3800 MEGACYCLE FREQUENCY RANGE

BY
Henry K. Weidemann
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- Report R-2827 -

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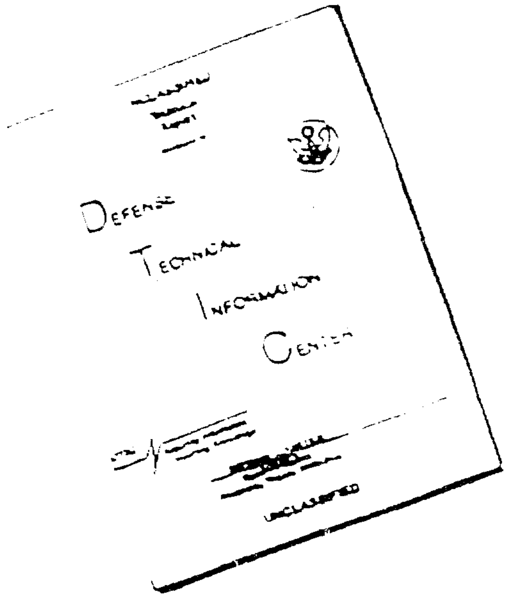

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ABSTRACTED BY OP-413-BB1

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SHIP-SHORE RADIO DIVISION
RADIO COUNTERMEASURES SECTION

7 May 1946

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MODIFIED M6807 ANTENNA FOR
2200-3800 MEGACYCLE FREQUENCY RANGE (C)

BY
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BuShips Problem S1259 R-3

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ABSTRACT

This report describes the modification of the M6807 Antenna, adapting it for use with the Type B Signal Generator (MBE-JAN 2C43) developed under NRL Problem Number S877.3R-C. The antenna described herein covers the frequency range from 2200 to 3800 megacycles per second. The development of this antenna is part of the broad problem concerned with the design and development of target pulse transmitters for calibration of DBM-1 direction finding equipment.

The modification developed for this antenna consists of a small pyramidal horn, mounted on a special flange, drilled for direct mounting on the face of the M6807 antenna in place of the curved spacer usually provided with this assembly. The modified antenna provides a beam type radiation pattern, which varies in the electric plane from a beam width of approximately 61 degrees at the half power points and a gain of 9.8 decibels at 2200 megacycles per second to a beam width of approximately 38 degrees at the half power points and a gain of 16.0 decibels at 3800 megacycles per second. Antenna to transmission line matching is satisfactory, the standing wave ratio being not greater than 2.25 to 1 on a 50-ohm line.

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INTRODUCTION

1. This work was done in accordance with Bureau of Ships letter C-A22.1 (920-Db), C-920-7565, under Problem S1259R-C (see reference 1). The entire equipment to be developed under this problem is to consist of a series of low-power pulse transmitters continuously variable in frequency, with directional antennas, to be used for calibrating DBM-1 direction finding equipment over the range from 90 to 5000 megacycles per second. The authorisation given above provides for the development of an antenna for the frequency range from 2200 to 4200 megacycles, but by later verbal agreement on 11 April 1946, between Lt. Comdr. J.K. Sterrett, BuShips, Code 925, and H.K. Weidemann of NRL, this bandwidth was decreased to a range from 2200 to 3800 megacycles. This conforms with the frequency range of one of the transmitters. The antenna as developed for this frequency range is presented in this report.

ANTENNA SYSTEM

2. The antenna consists of the M6807 "Slot" antenna with a pyramidal horn added. This horn is four inches in axial length, and has a rectangular aperture measuring six inches parallel to the magnetic plane and four inches parallel to the electric plane of the radiation. The throat of the horn conforms to the inside dimensions of the "slot" of the M6807 antenna, permitting direct mounting of the horn throat against the "slot" by means of a suitable adapting flange. Photographs of the horn attached to the M6807 antenna are given on Plates 1 and 2. A sketch, showing the principal dimensions is shown on Plate 3.

3. The M6807 antenna consists of a shallow box-like cavity open on one side and provided with a mounting flange. The aperture of the box is covered by a thin sheet of fiberglas. Input to the antenna is made through a modified UG-101/U connector mounted in the side of the cavity.

DEVELOPMENT

4. It was indicated in the original verbal statement of the desired characteristics for the horn to fit the M6807 antenna, that it was to be designed for a minimum frequency of 2030 megacycles per second, to have a maximum beam width in the electric plane of roughly 60 degrees between half power points and a minimum gain of 6 decibels over an isotropic radiator. It was indicated that sufficient time was not available to permit exhaustive investigation of the electrical characteristics of such an adapter system.

5. Since it is generally true for a given horn, that the beam width of the radiated pattern decreases and the gain increases as the frequency of operation is increased, it was decided that approximate dimensions for the horn should be determined for the conditions of minimum frequency and gain and maximum permitted beam width.

6. No design information was found to be available, which would cover the conditions outlined above. After a search of references it became apparent that the methods of design outlined in Terman's Radio Engineers' Handbook (see reference No. 2) might be used as a guide, providing the specified beam width might be converted to a beam width measured between 20 decibel points and the horn dimensions might be estimated by extrapolation beyond the limits of the graphical data presented in this reference.

7. To determine a crude relationship between beam width between the half power points and beam width between the 20 dodibel points the field intensity pattern of an M-4907 antenna fitted with an M-4902 coax to wave guide adaptor was measured at 3000 megacycles per second. In the electric plane this pattern had a beam width between the half power points of approximately 31.0°. The beam width between 20 dodibel points was approximately 76°. It was noted that the ratio of these two beam width measurements was 2.45 to 1.

8. As a very crude estimate of the beam width between 20 decibel points for the antenna in process of design, the given width of 60° between half power points was multiplied by 2.45 giving a value of 147°, which was "rounded off" to 150°.

9. Entering the graph of Figure 69, reference No. 2, using 150° as argument, the horn aperature parallel to the electric field was roughly estimated as seven tenths of a wavelength or approximately 4 inches at 2030 megacycles per second. From Figure 73(a) of reference No. 2 by extrapolation beyond the left hand limit of the graph it was estimated that an aperature one wavelength by one wavelength would give a power gain ratio of about 7. Since 6 decibels represents a power gain ratio of approximately 4 and the dimension parallel to the electric field was already estimated as seven tenths of a wavelength it was decided to try an aperature of one wavelength (i.e. 6 inches) parallel to the magnetic field, indicating an estimated power gain ratio of approximately 5 (i.e. approx. 7 db).

10. Since the design information given in reference No. 2 is quite inadequate for specification of flare angle for beams as broad as the one under consideration it was somewhat arbitrarily decided to try a flare angle in the electric plane of about 40°. From this, the dimensions of the M6807 antenna, and the horn aperature already estimated, an axial length of 4 inches from throat to mouth was decided upon for the first horn to be constructed.

11. After construction, the field pattern for the horn attached to the M6807 antenna was measured at 2000 megacycles per second. The beam width between half power points was found to be 76 degrees with a gain of slightly more than 9 decibels.

12. From the above results it is clear that the above design procedure can be considered to be hardly more than a crude first approximation.

13. The frequency limits of operation for this antenna were finally redefined as stated in paragraph 1 of this report. Within this frequency range the performance of the antenna was considered acceptable. The specific results are detailed below.

RESULTS OBTAINED

14. The standing wave ratio of the M6807 antenna with the horn added is given by the graph on Plate 4. Over the frequency range from 2200 to 3800 megacycles per second the maximum standing wave ratio is approximately 2.25 to 1. For comparison, the standing wave ratio of the M6807 antenna alone was also measured, and is given on this same graph. It is seen that the addition of the horn to the antenna did not greatly change the reflection characteristics.

15. Relative field intensity patterns in the electric and magnetic planes of the modified antenna at 2200 megacycles, 3000 megacycles, and 3800 megacycles are given by Plates 5, 6, and 7 respectively. These plates show that at 2200 megacycles the beam width at the half power point is 61 degrees in the electric plane and 51 degrees in the magnetic plane; at 3000 megacycles the beam width is 54 degrees in the electric plane and 43 degrees in the magnetic plane; and at 3800 megacycles the beam width is 32 degrees in the electric plane and 30 degrees in the magnetic plane. It is seen that the patterns in the electric plane are somewhat broader than those in the magnetic plane, and that the patterns become narrower as frequency is raised.

16. The gain of the antenna relative to an isotropic source was computed by integration of the power as indicated by the patterns over the surface of a sphere with center at the antenna. At 2200 megacycles the gain was found to be 9.8 decibels, at 3000 megacycles the gain was found to be 12.4 decibels, and at 3800 megacycles the gain was found to be 16.0 decibels over an isotropic source.

CONCLUSIONS

17. The results given in the preceding section indicate that this modified M6807 antenna should be acceptable in this direction-finder calibration application over the frequency range from 2200 to 3800 megacycles per second.

1. BuShips ltr. C-A22.1(920-Db), C-920-7565 of 28 November 1945 to Dir. NRL: Request for Assignment of Problem S1259R-C.

2. Terman - Radio Engineers' Handbook.

Original data recorded in NRL Log Books 6017 and 5367.

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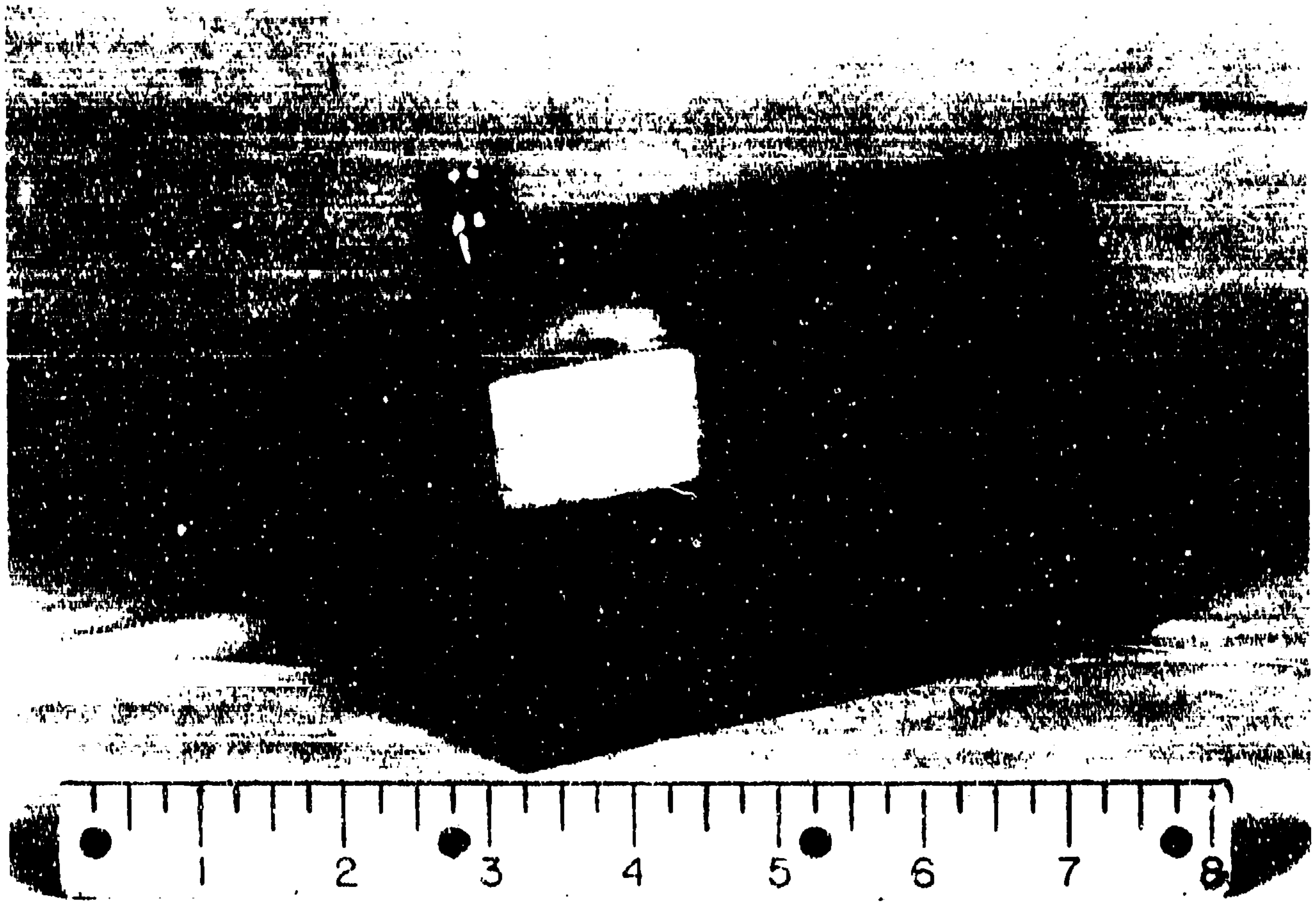
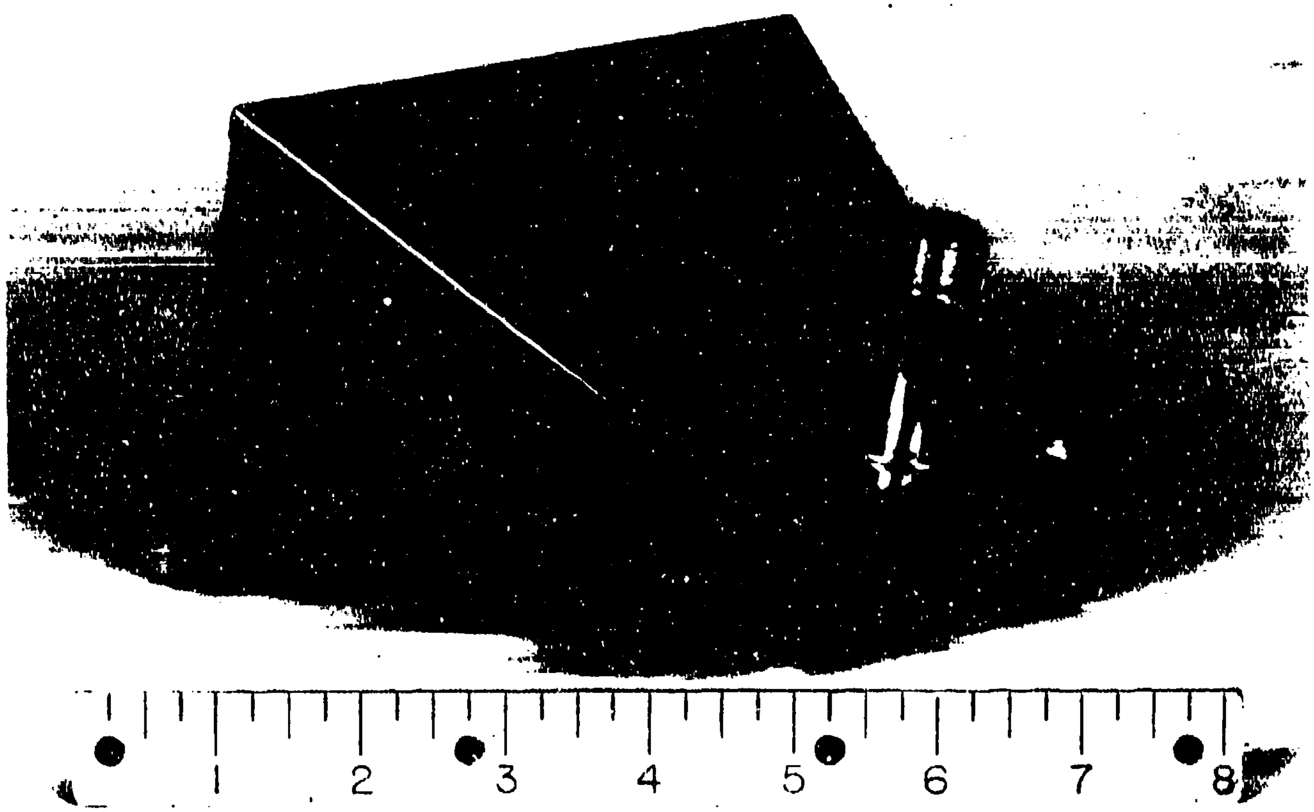
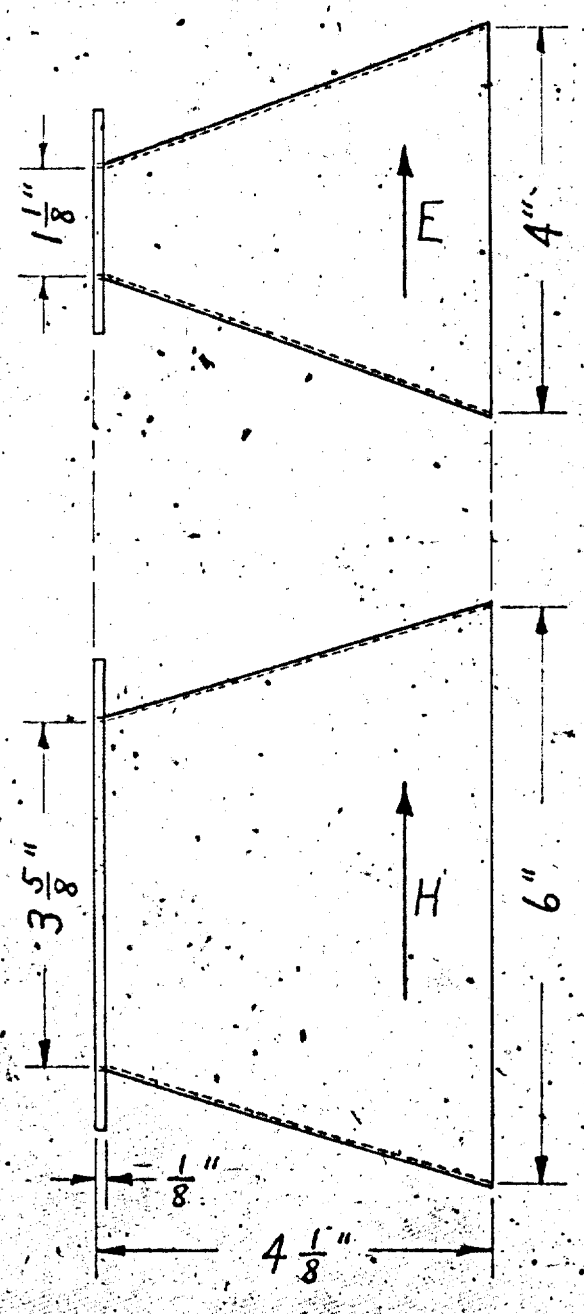


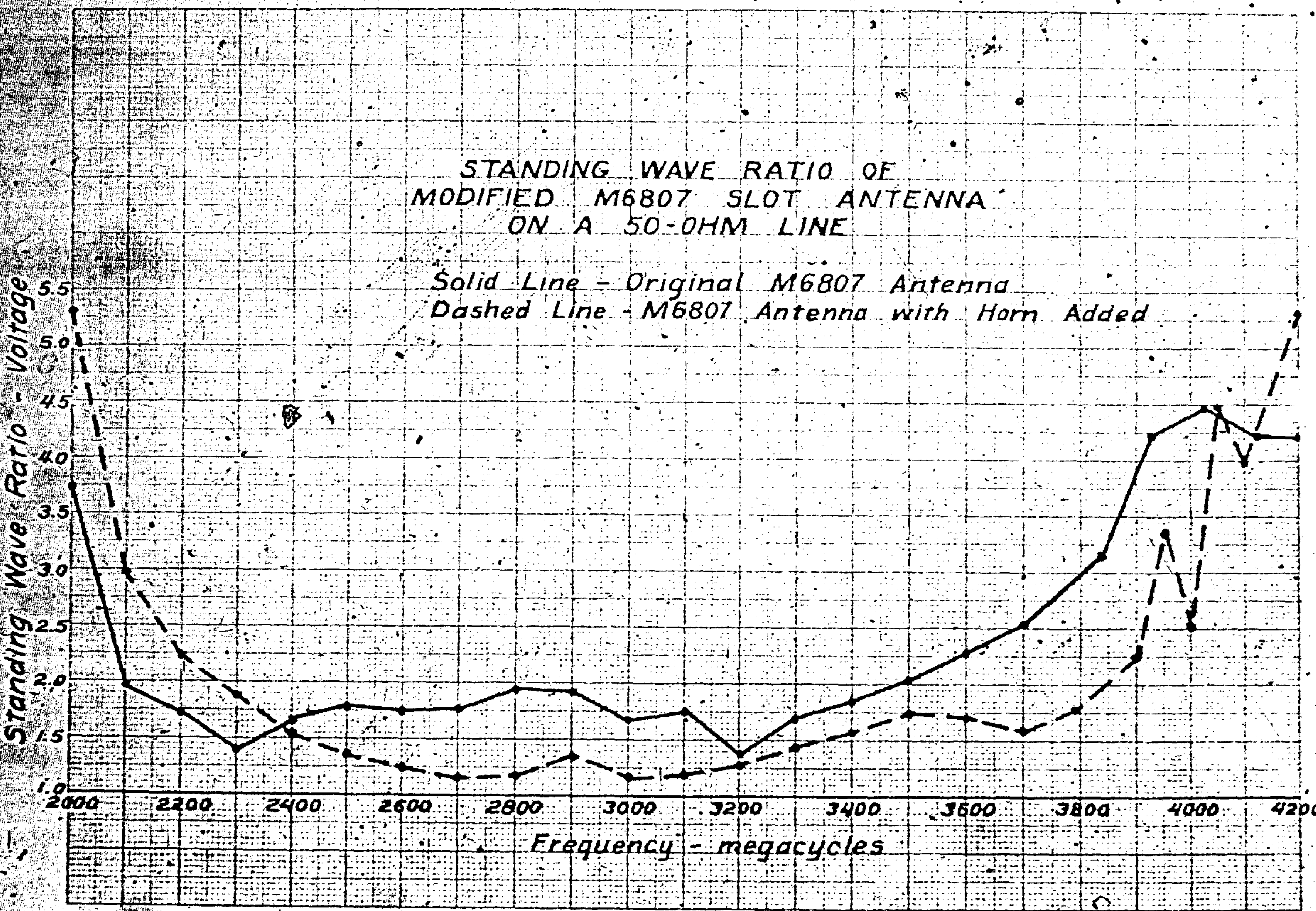
MODIFIED M6807 ANTENNA - FRONT VIEW

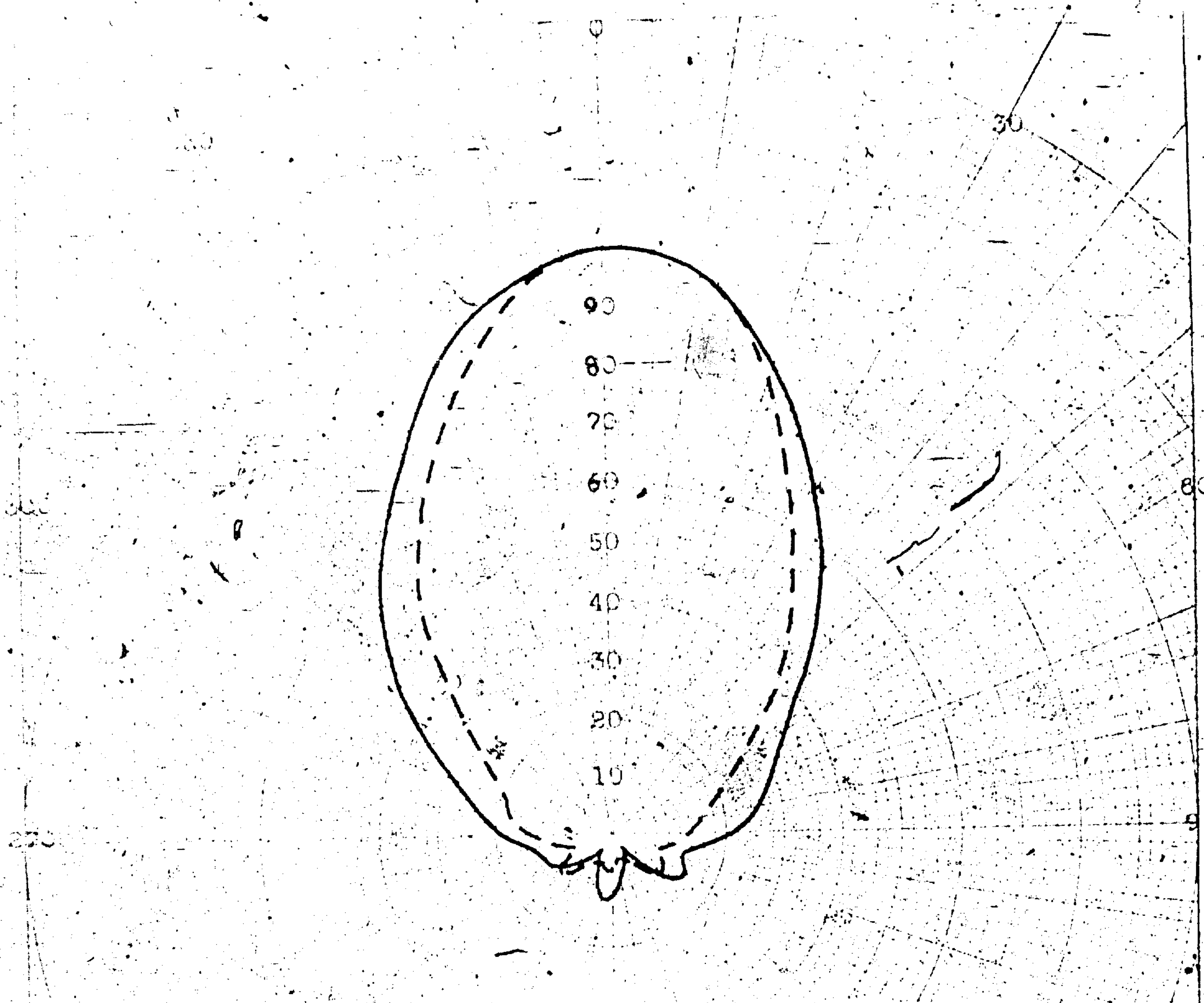


MODIFIED M6807 ANTENNA - REAR VIEW



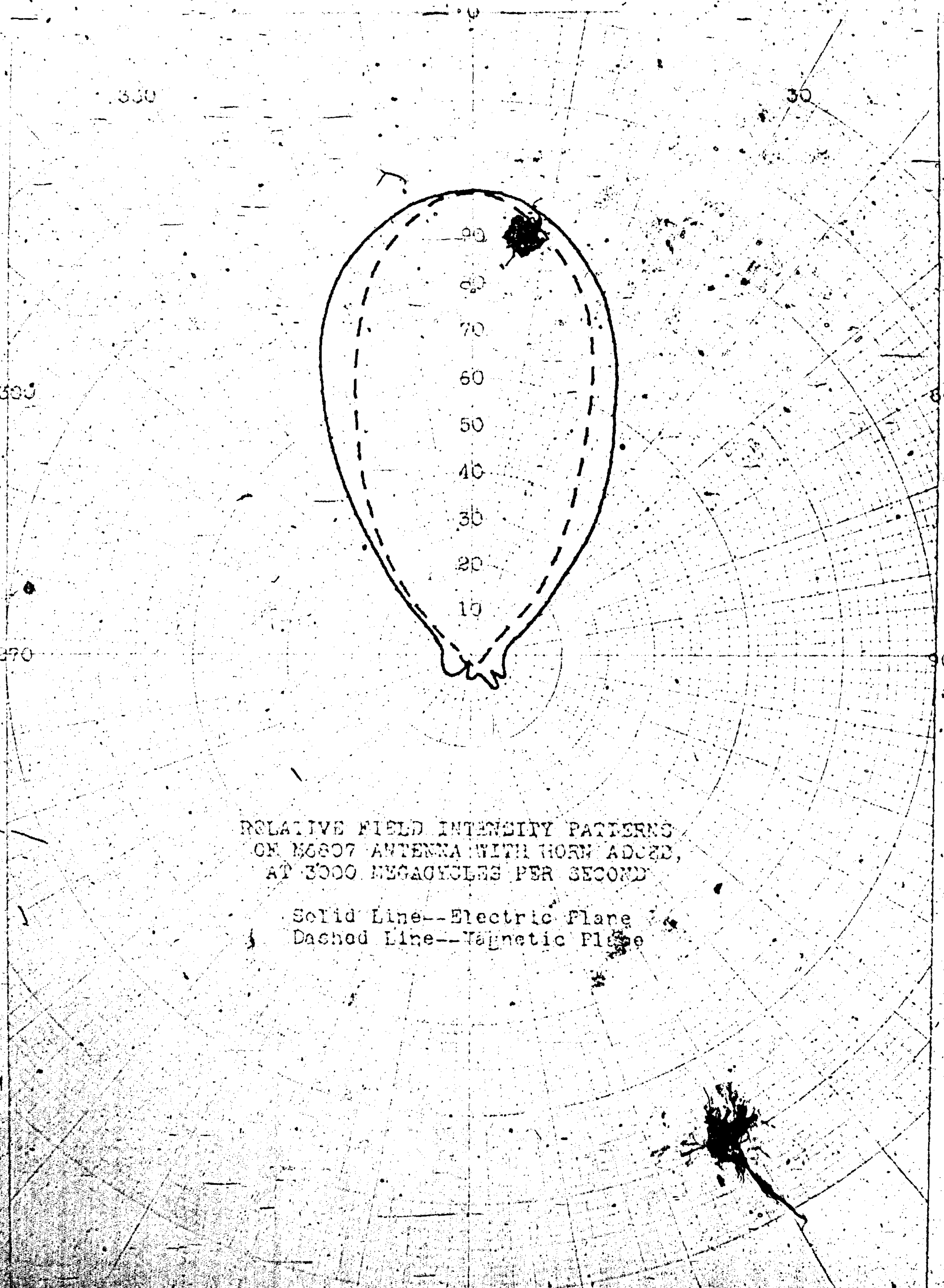
Sketch Showing Principal Dimensions of
Horn for M-6807 Antenna


STANDING WAVE RATIO OF
MODIFIED M6807 SLOT ANTENNA
ON A 50-OHM LINE
Solid Line - Original M6807 Antenna
Dashed Line - M6807 Antenna with Horn Added
Standing Wave Ratio - Voltage
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
Frequency - megacycles



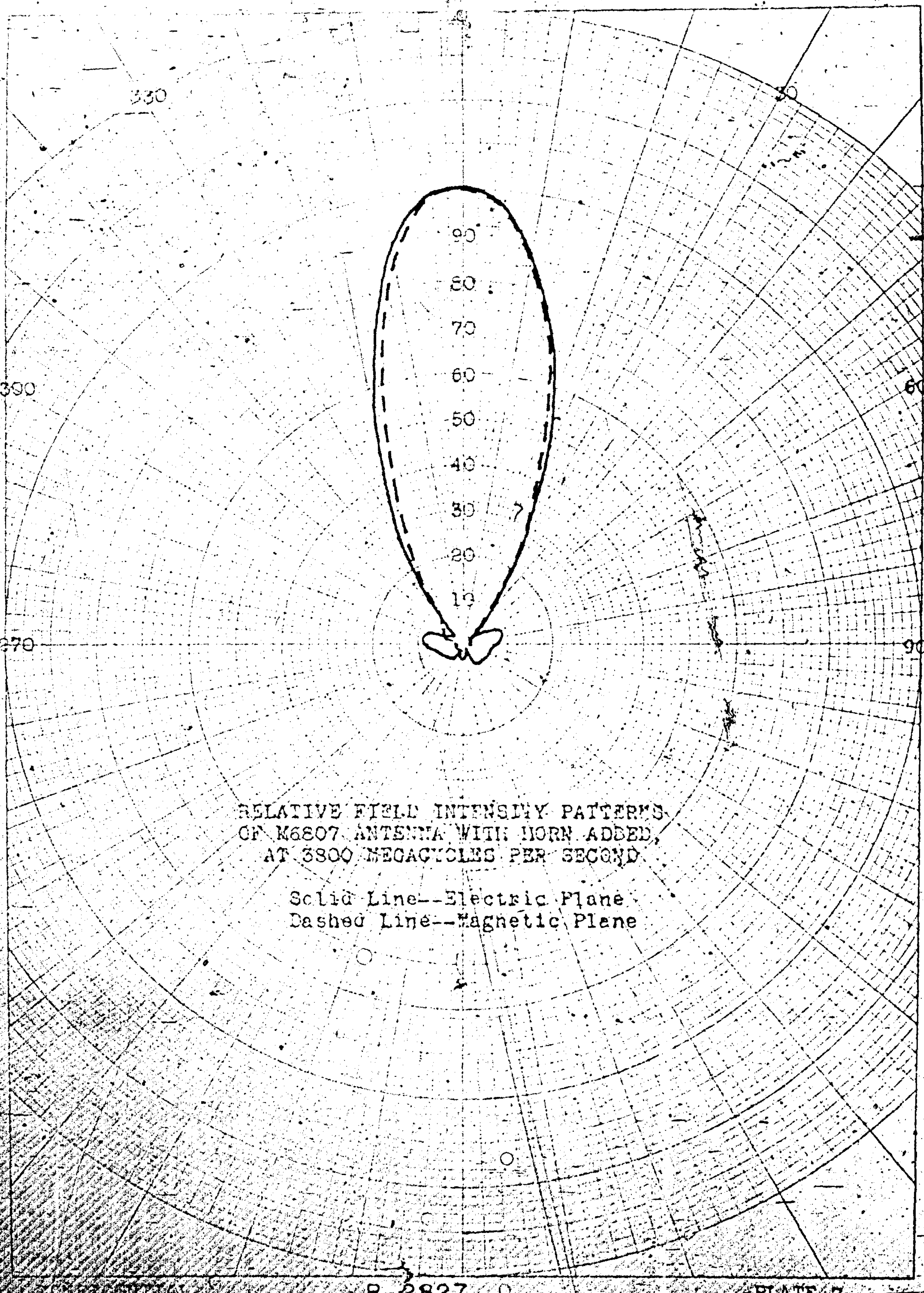
RELATIVE FIELD INTENSITY PATTERNS OF
M6007 ANTENNA WITH HORN ADDED,
AT 2000 MEGACYCLES PER SECOND

Solid Line--Electric Plane
Dashed Line--Magnetic Plane



RELATIVE FIELD INTENSITY PATTERNS OF M6807 ANTENNA WITH HORN ADDED, AT 3000 MEGACYCLES PER SECOND

Solid Line--Electric Plane
Dashed Line--Magnetic Plane



RELATIVE FIELD INTENSITY PATTERNS
OF M6807 ANTENNA WITH HORN ADDED,
AT 3800 MEGACYCLES PER SECOND

Solid Line--Electric Plane
Dashed Line--Magnetic Plane

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