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RADIO AND ELECTRICAL ENGINEERING DIVISION

CANADA INSTITUTE FOR S.T.I.
N R C C

FEB 23 1992

INSTITUT CANADIEN DE L.I.S.T.
C.N.R.C.

AN HF TRANSMITTING ANTENNA SYSTEM FOR THE
UNCONVERTED DDE 257 CLASS

- J. Y. WONG, A. GRUNWALD, AND G. GIBSON -

ANALYZED

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Authority:..... S. A. MAYMAN

Date:..... NOV 26 1992

OTTAWA

MAY, 1971

NRC # 35693

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AN HF TRANSMITTING ANTENNA SYSTEM FOR THE
UNCONVERTED DDE 257 CLASS

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OTTAWA

MAY, 1971

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ABSTRACT

An HF transmitting antenna system has been developed for the unconverted Restigouche or DDE 257 destroyer escort class. The system consists of one broadband 2 to 6 MHz monocone antenna and three 35-foot whips. This report contains the results of impedance and radiation pattern model studies.

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- I. $\frac{1}{20}$ scale mock-up of DDE-257 used in impedance measurements

RADIATION PATTERNS

Monocone antenna – patterns 1–5

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AN HF TRANSMITTING ANTENNA SYSTEM FOR THE UNCONVERTED DDE 257 CLASS

Confidential

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Introduction

In 1965, a reconstruction program was initiated to modernize the Restigouche or DDE 257 destroyer escort class. Insofar as the external modifications were concerned, the program involved principally a foremast change and the addition of an ASROC weapons system. To date only the Terra Nova has been completely converted, although plans call for the conversion of an additional three ships. As part of the modernization an improved HF antenna system was developed which made use of a broadband antenna—multicoupler arrangement for the 2 to 6 MHz band. A description of the proposed antenna system is given in Reference 1.

Although there has been no firm requirement for providing the remaining three ships in the class with an improved HF transmitting antenna system, we were requested to investigate the feasibility of developing a broadband 2 to 6 MHz antenna utilizing the ship's foremast. Our previous experience with the DDH 205 class [2] led us to conclude that a monocone antenna would be the most logical and practical configuration. In addition to the broadband monocone, the HF antenna system includes three 35-foot whips, two of which are mounted aft of the foremast and the third is located forward and center on the flag deck. The antenna arrangement is shown in Fig. 1.

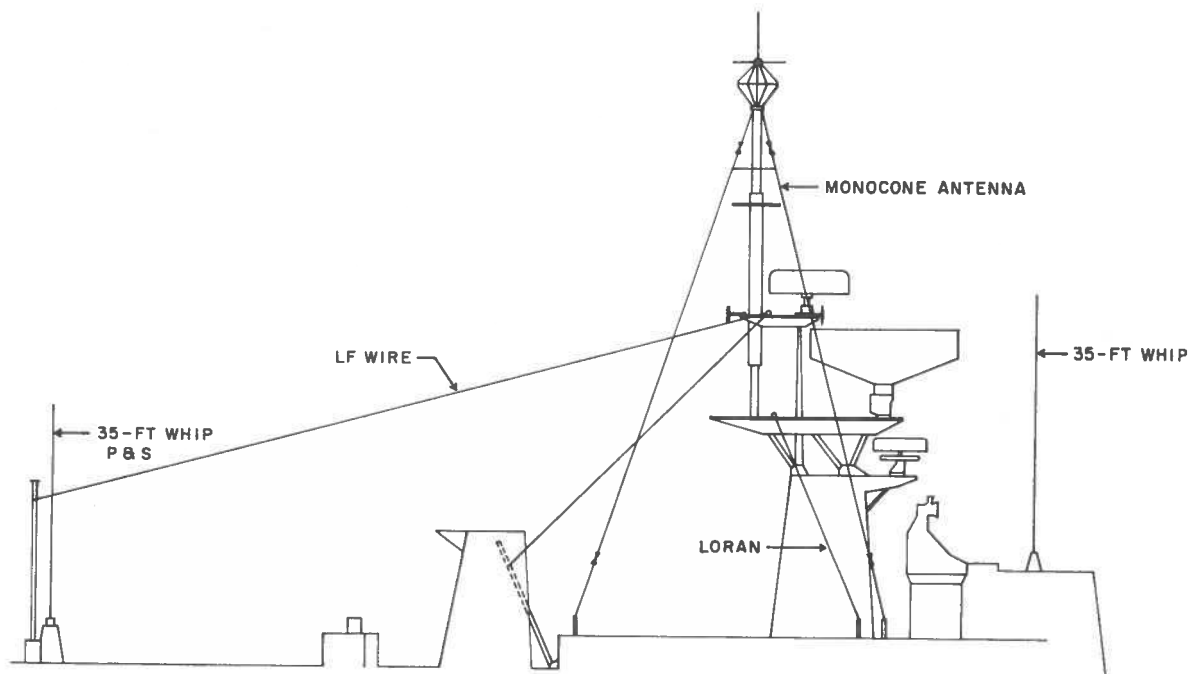


Figure 1 HF antenna arrangement for DDE 257

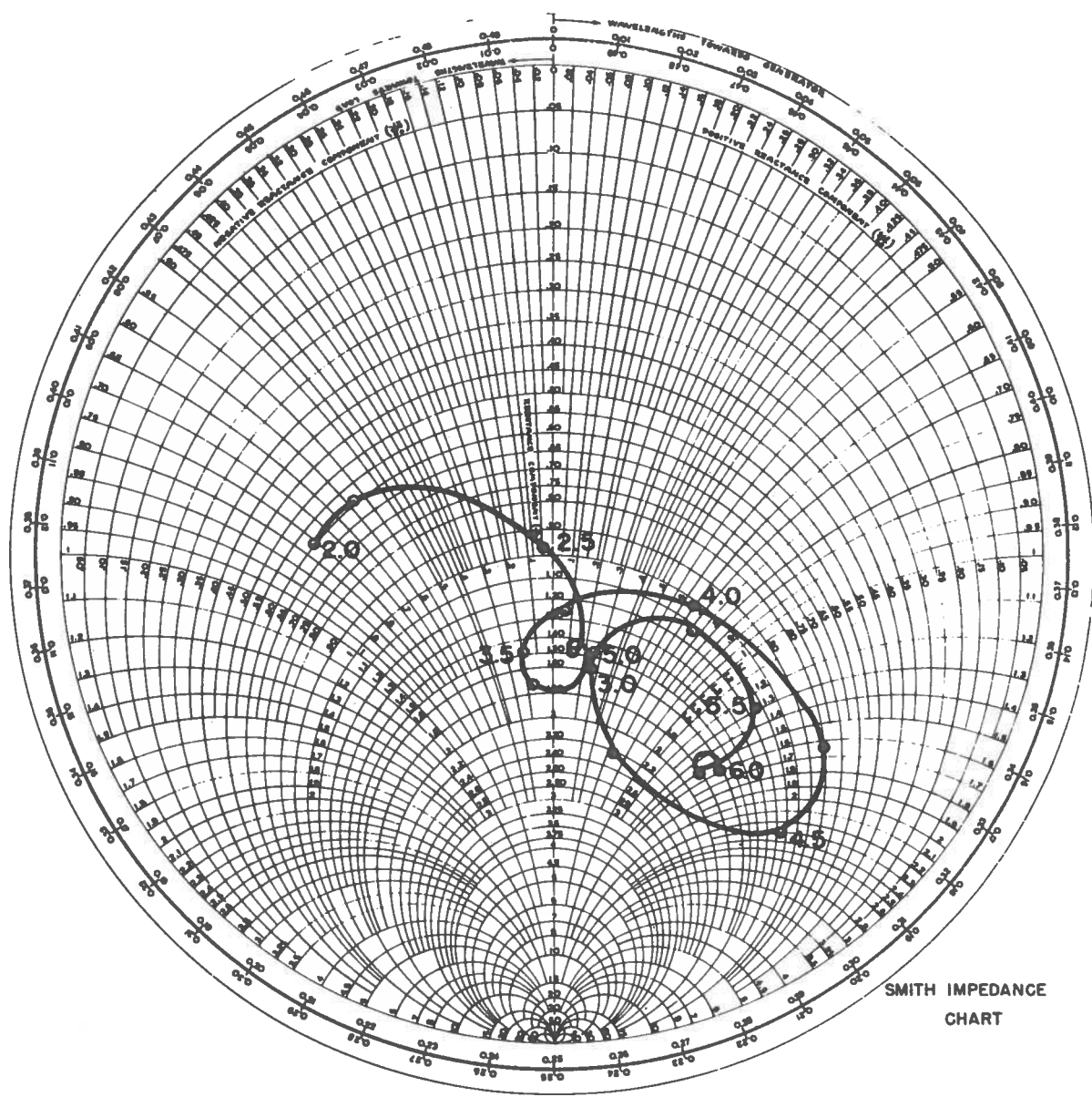


Figure 2 Smith-chart impedance of monocone antenna

Impedance Measurements

Monocone Antenna

The monocone antenna consists of four ungrounded wires which form a simulated cone around the ship's foremast. The four wires are joined together near the apex of the cone by a feed ring. This ring is fed by the center conductor of a coaxial cable and the outer conductor is grounded to the foremast. Impedance measurements were carried out on a 1/20 scale mock-up of the superstructure portion of the DDE 257 in order to determine the optimum configuration. A photograph of the impedance model is shown in Plate I. The following antenna parameters were found to give optimum impedance values from 2 to 6 MHz – leg length 45 feet, diameter of feed ring 2.5 feet.

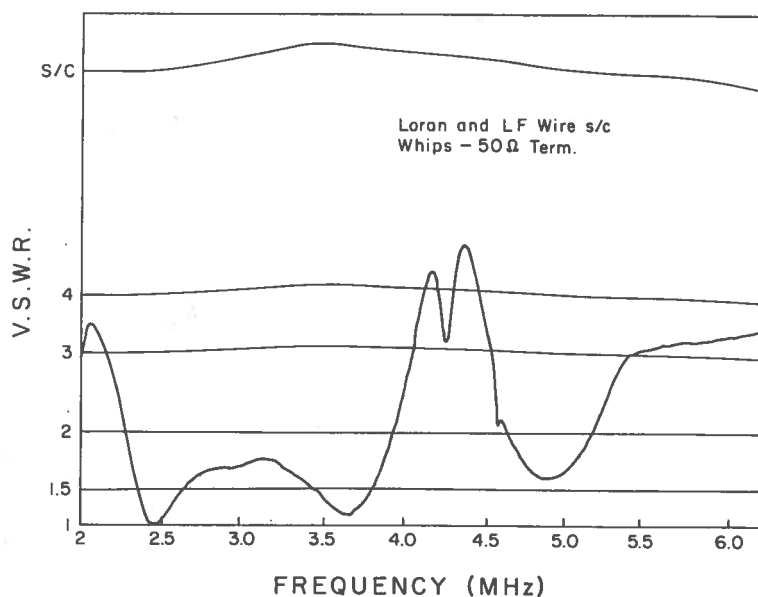


Figure 3 Swept frequency VSWR measurements of monocone

A Smith impedance chart of the optimum antenna configuration is given in Fig. 2. The measurements were carried out with the LF wire and Loran antenna installed, and both terminated in a short circuit. The three whips were terminated in 50 ohms. A swept frequency VSWR curve of the monocone is illustrated in Fig. 3. Note that the VSWR increases rapidly below 2 MHz.

35-Foot Whips

A Smith-chart plot of the forward whip is given in Fig. 4. The impedance appears to be quite well behaved. The impedance of the starboard aft whip which is given in Fig. 5 shows, on the other hand, the effects of coupling with its adjacent whip. The effect is particularly apparent between about 6 MHz and 10 MHz.

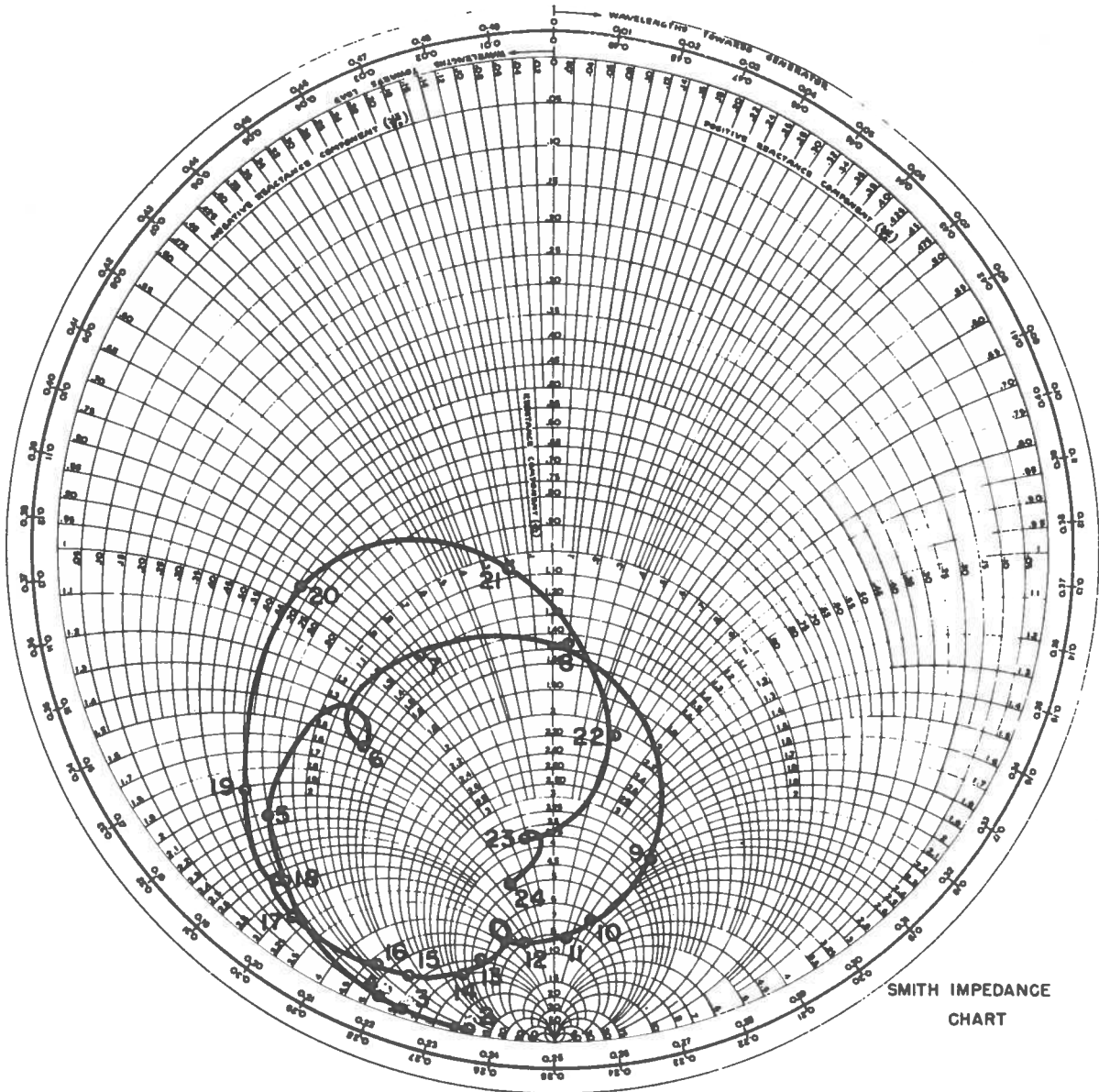
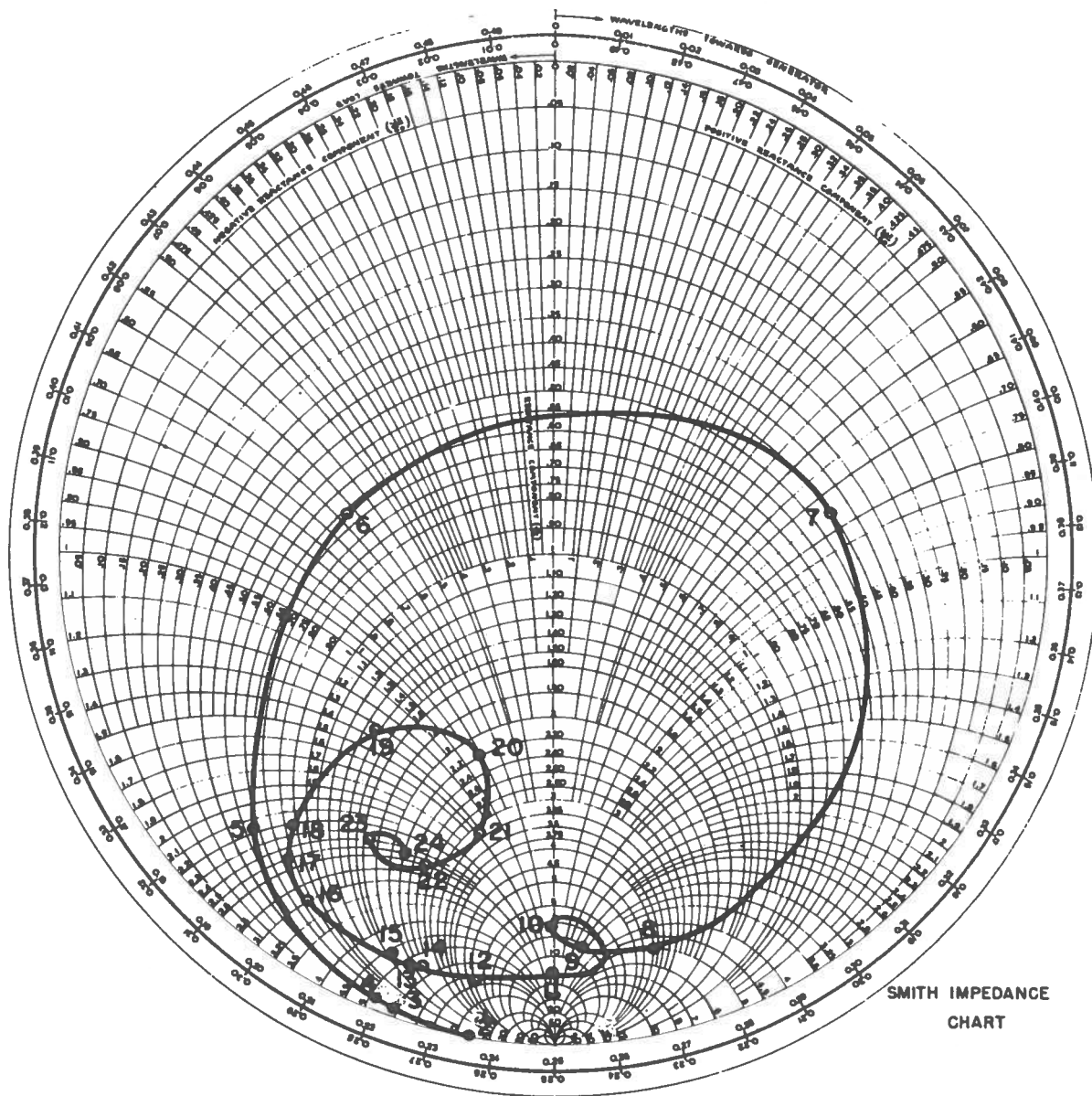


Figure 4 Smith-chart impedance of forward 35-foot whip



SMITH IMPEDANCE CHART

Figure 5 Smith-chart impedance of starboard aft 35-foot whip

Radiation Pattern Measurements

Three-dimensional patterns were obtained for all antennas. For each frequency both E_θ and E_ϕ components were measured for a 5-degree increment in θ but only the principal-plane patterns are included in this report.

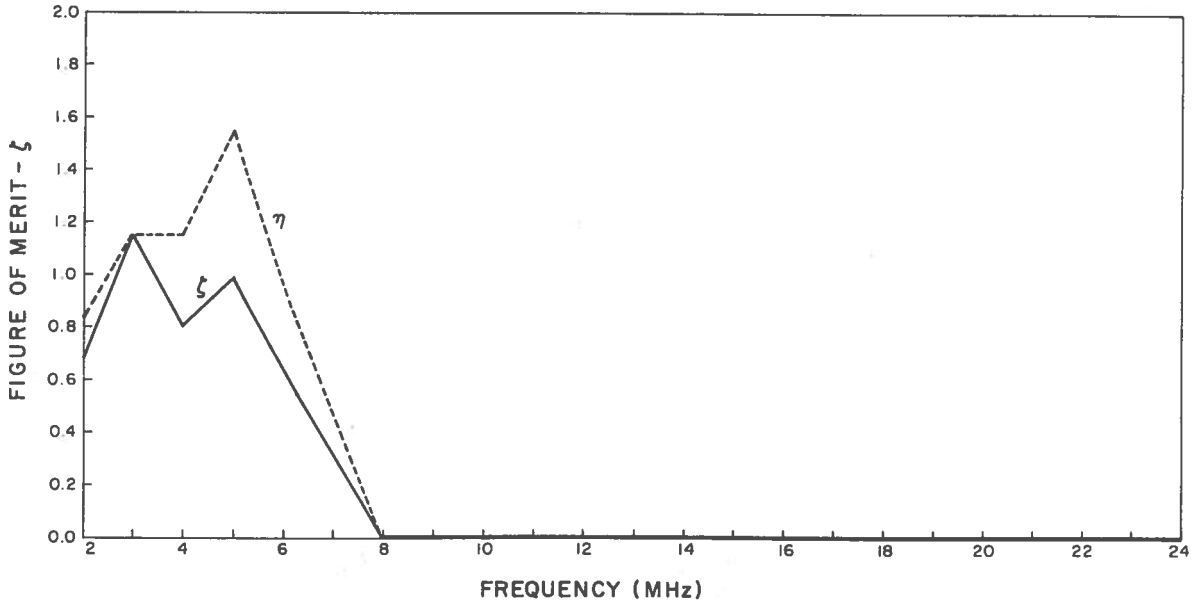


Figure 6 Figure of merit of monocone antenna

To facilitate the pattern analyses the patterns were recorded both digitally on paper tape and graphically on polar chart paper. The antenna figure of merit was determined, based on the method given in Reference 3. For all cases the figure of merit ζ is compared with that of a quarter-wave base-fed monopole which is assumed to have a value of unity. The figure of merit of the monocone antenna is plotted in Fig. 6. On the same figure is a curve labeled η . The difference between these two curves is a measure of the amount of azimuth pattern degradation. From Fig. 6 and from an inspection of the radiation patterns we see that there is a considerable amount of pattern deterioration between 4 and 6 MHz.

The figure of merit of the forward whip is given in Fig. 7 and for the starboard aft whip in Fig. 8. Owing to symmetry, Fig. 8 is applicable for the port aft whip as well.

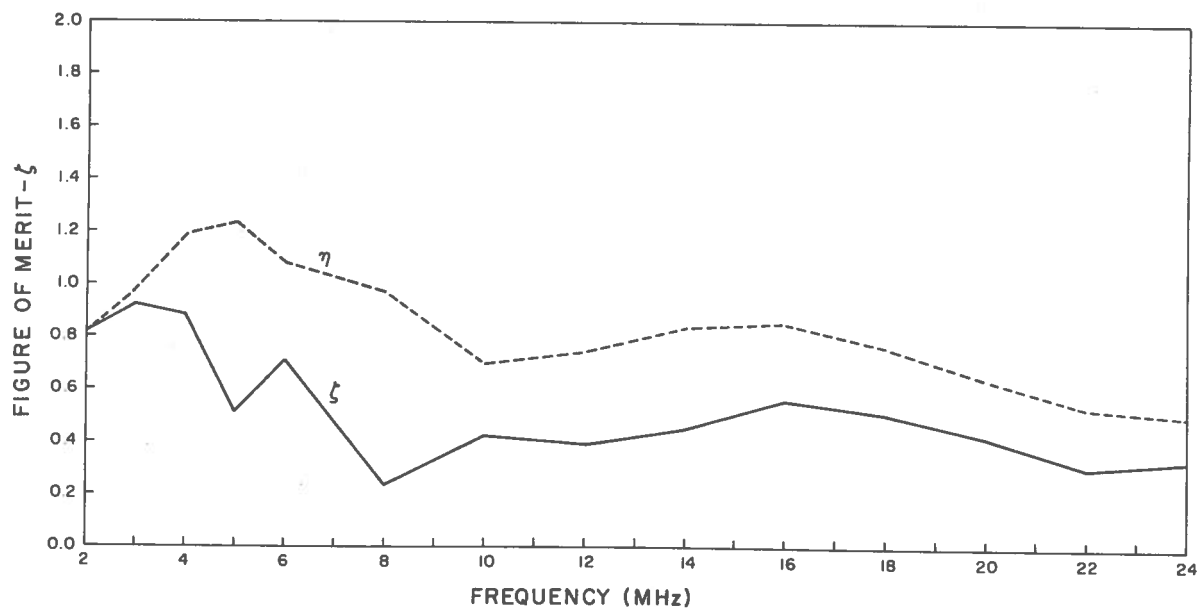


Figure 7 Figure of merit of forward whip

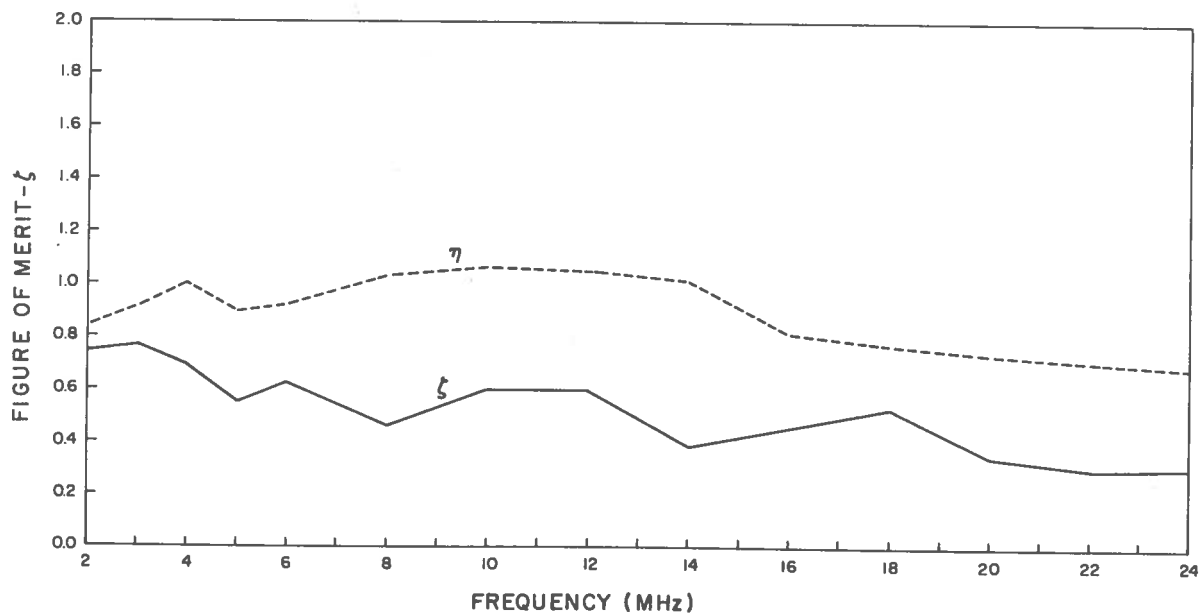


Figure 8 Figure of merit of starboard aft whip

Conclusions

Using scaled model techniques, a broadband 2 to 6 MHz monocone antenna has been developed for the unconverted DDE 257 class. Results of impedance and radiation pattern measurements are given for the monocone and the three 35-foot whips.

References

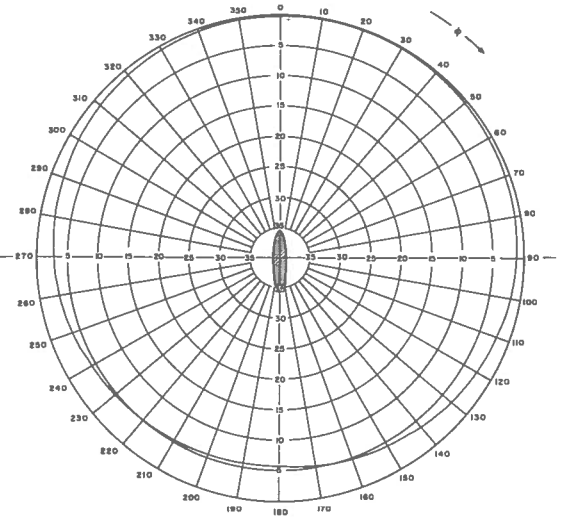
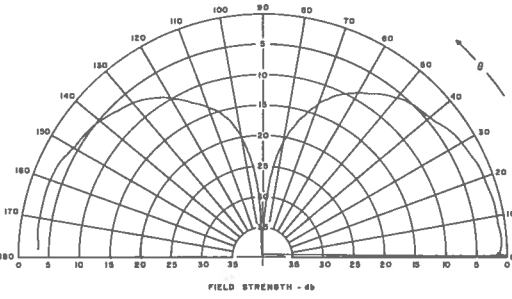
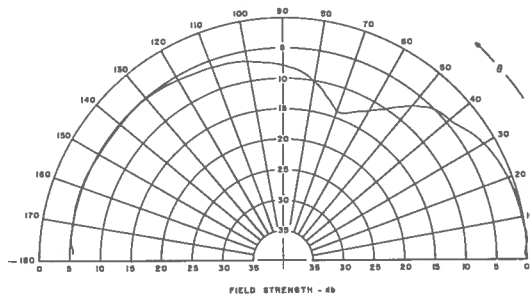
1. Wong, J.Y. Development of a broadband HF antenna system for the Restigouche DDE 257 destroyer escort conversion class. NRC Report ERB-734, April 1966 (Confidential).
2. Wong, J.Y. A broadband HF antenna system for the St. Laurent destroyer escort conversion class DDE 205C, NRC Report ERB-707, May 1965 (Confidential).
3. Wong, J.Y. An improved method for calculating the figure of merit of a non-uniform radiation pattern (Supplement to ERB-647). NRC Report ERB-829, July 1969.

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RADIATION PATTERNS

Monocone antenna – patterns 1–5

E_{θ}

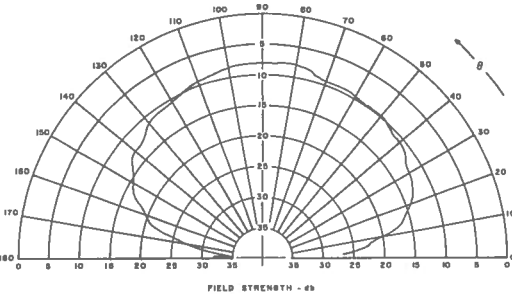
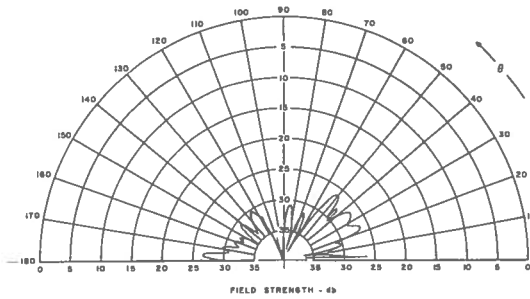


FWD-AFT

PORT-STBD

$\theta = 0^\circ$

E_{ϕ}



ANTENNA : MONOCONE

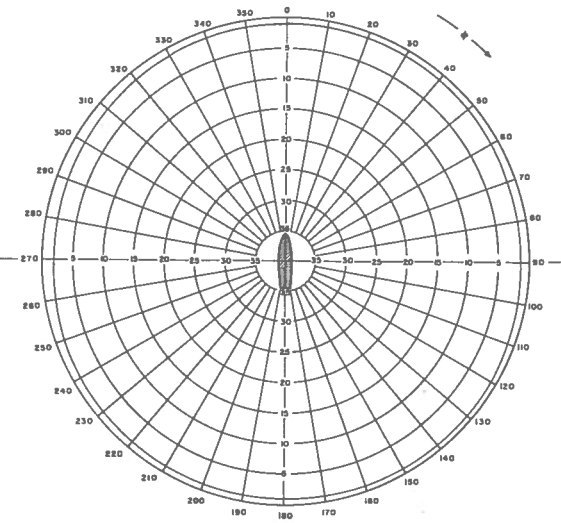
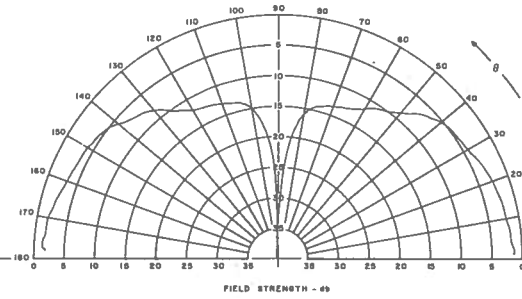
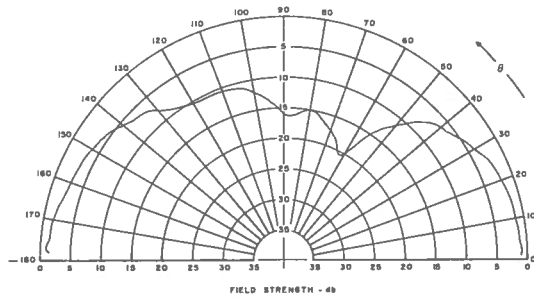
FREQ : 2 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50 Ω

$\xi = .666$

$\eta = .824$

E_{θ}

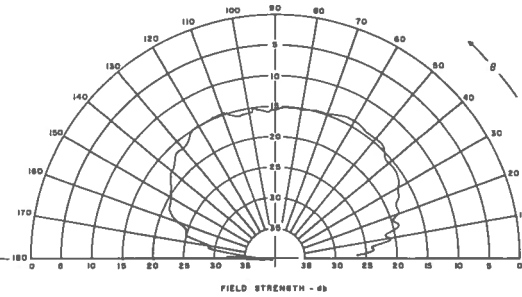
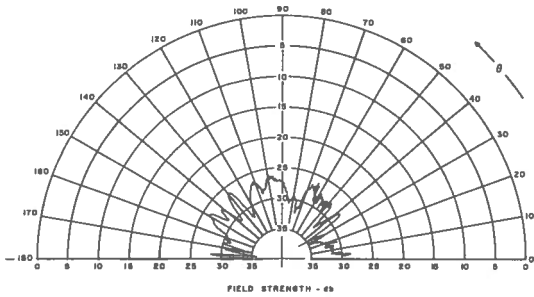


FWD-AFT

PORT-STBD

$\theta = 0^\circ$

E_{ϕ}



ANTENNA : MONOCONE

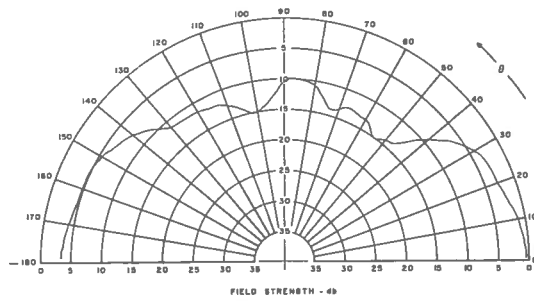
FREQ : 3 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

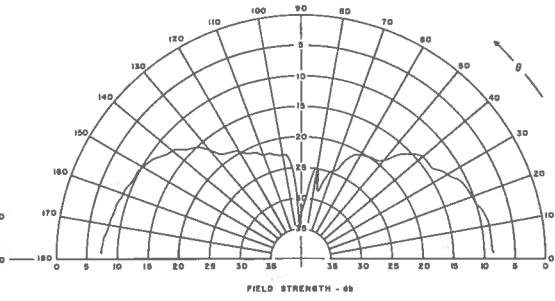
$\xi = 1.150$

$\eta = 1.150$

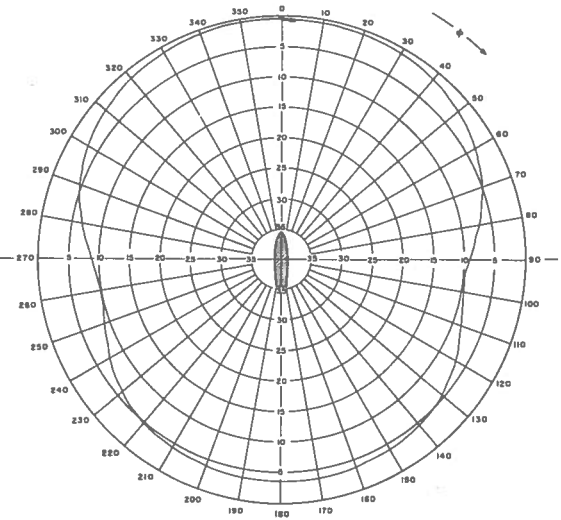
E_{θ}



FWD-AFT

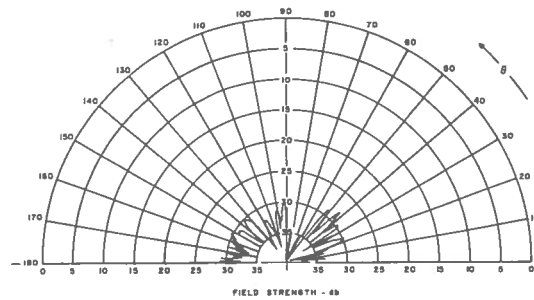


PORT-STBD

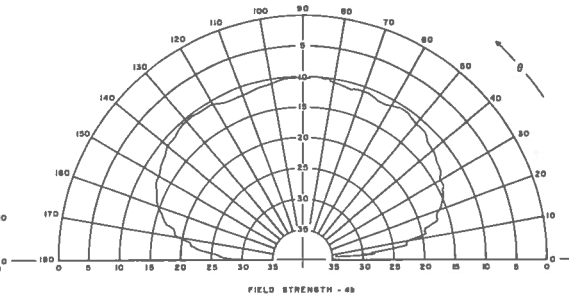


$\theta = 0^\circ$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : MONOCONE

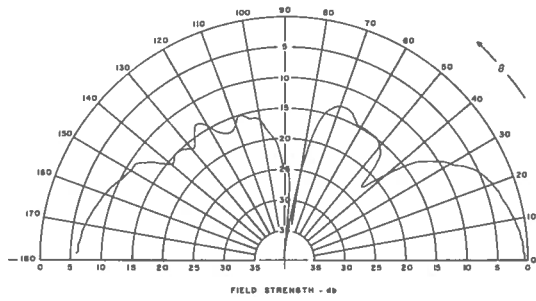
FREQ : 4 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50 Ω

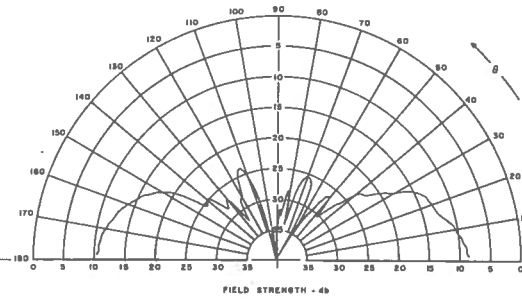
$\xi = .803$

$\eta = 1.151$

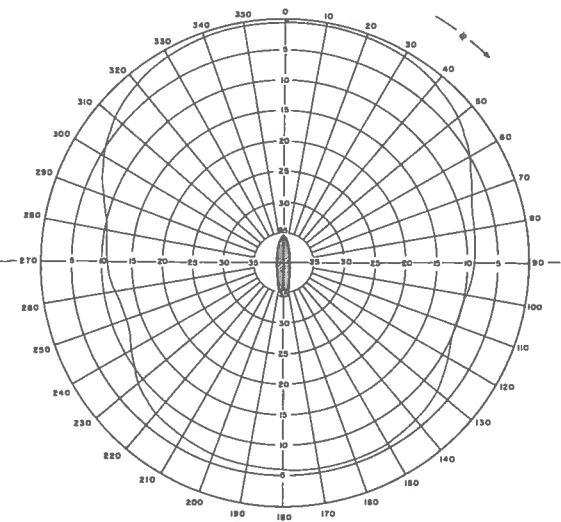
E_{θ}



FWD-AFT

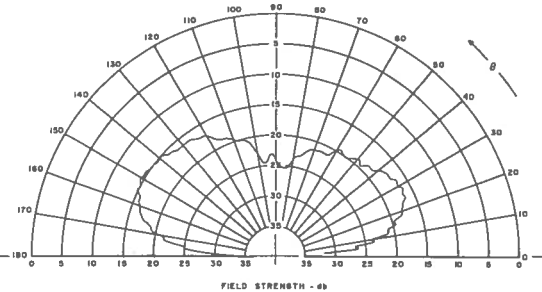
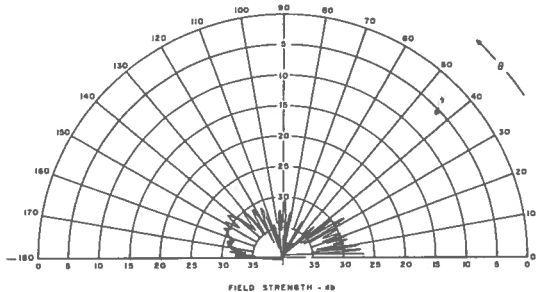


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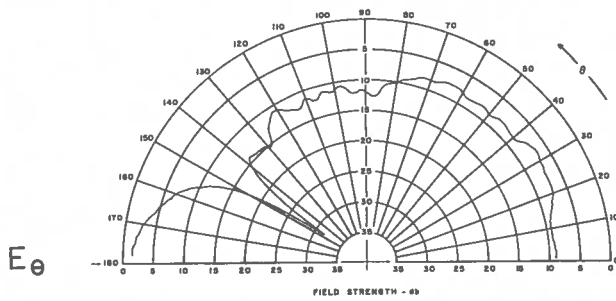


$\theta = 0^{\circ}$

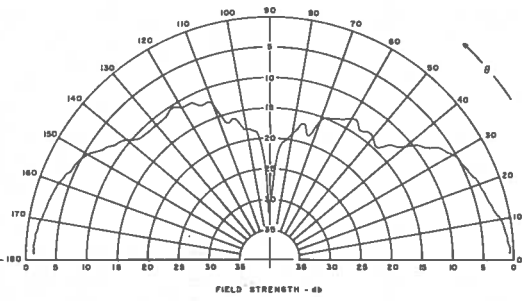
E_{ϕ}



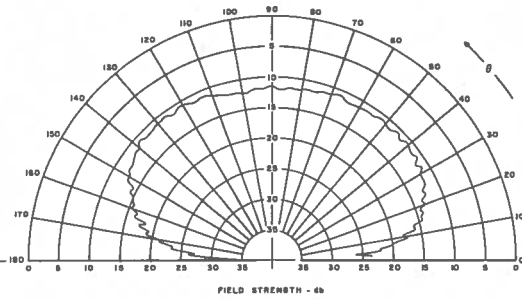
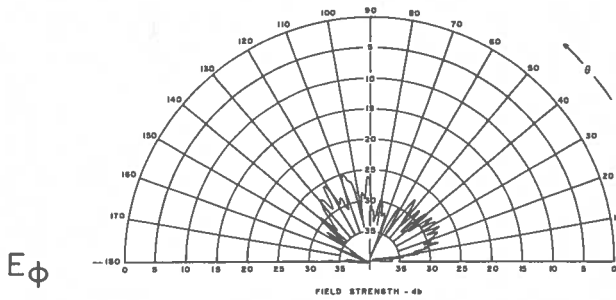
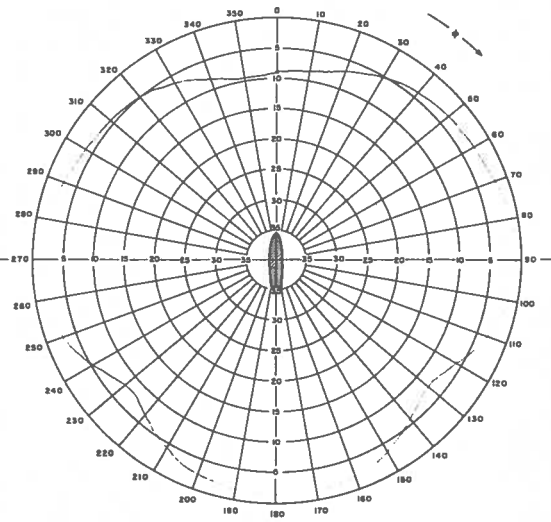
ANTENNA : MONOCONE
FREQ : 5 MHz
REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω
 $\xi = .985$
 $\eta = 1.547$



FWD-AFT



PORT-STBD



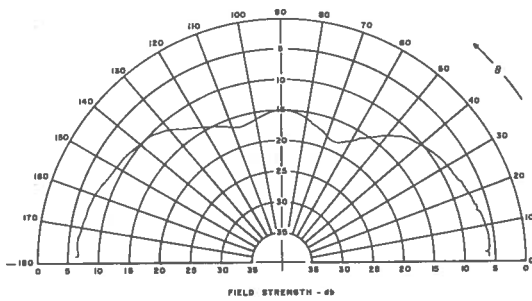
ANTENNA : MONOCONE
 FREQ : 6 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω
 $\xi = .641$
 $\eta = .954$

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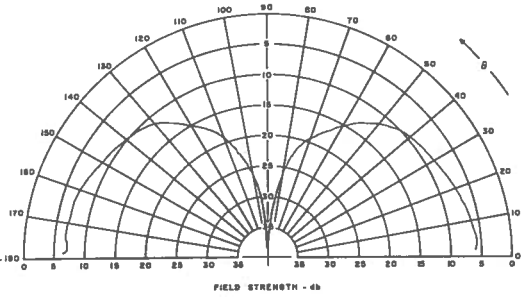
RADIATION PATTERNS

Forward 35-foot whip – patterns 6–19

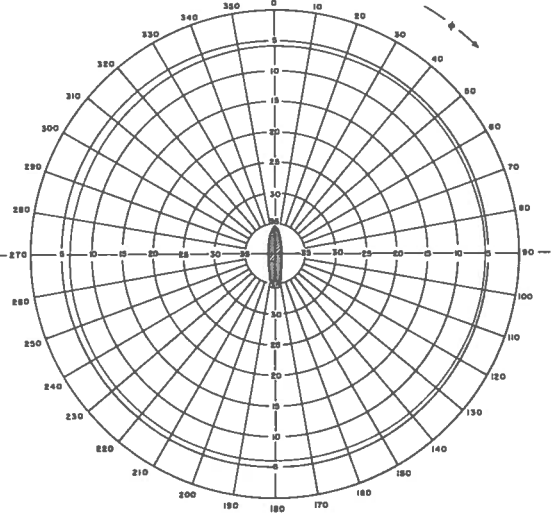
E_{θ}



FWD-AFT

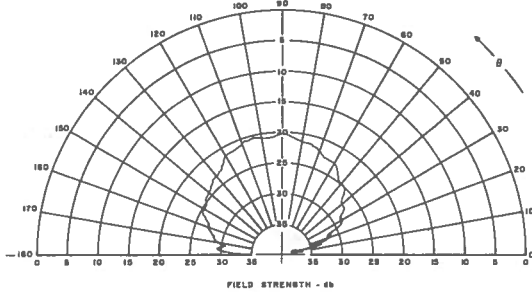


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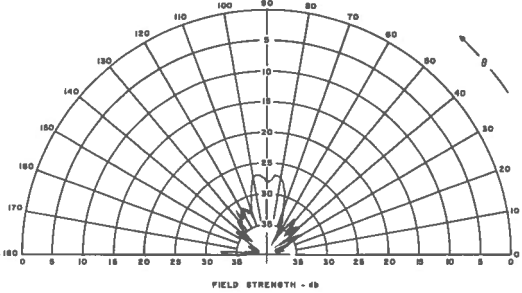


$\theta = 0^{\circ}$

E_{ϕ}



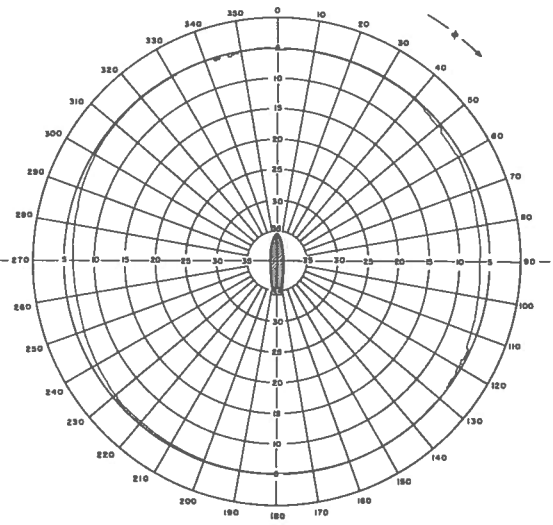
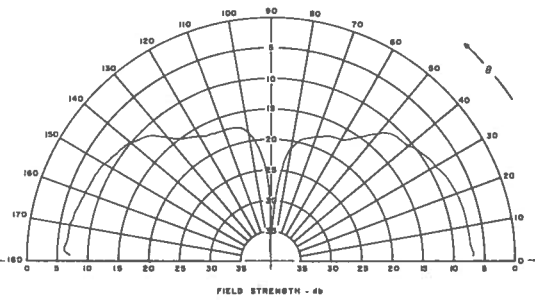
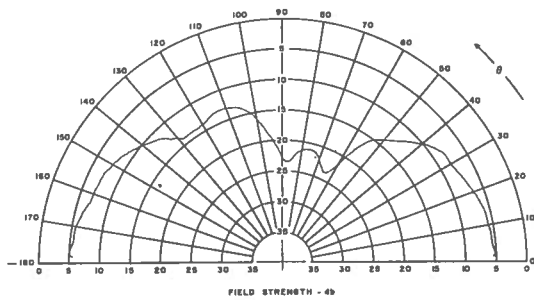
FWD-AFT



PORT-STBD

ANTENNA : FWD WHIP
 FREQ : 2 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω
 $\beta = .819$
 $\gamma = .818$

E_{θ}

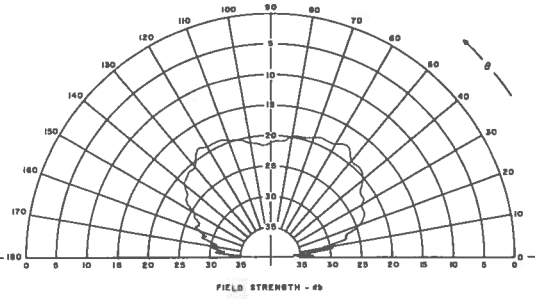
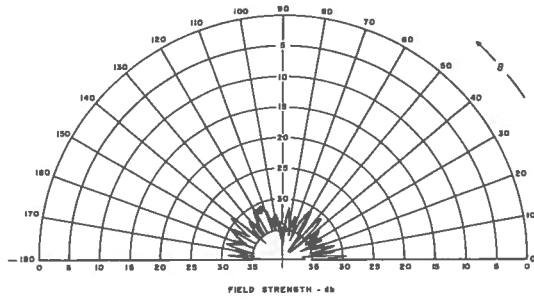


FWD-AFT

PORT-STBD

$\theta = 0^{\circ}$

E_{ϕ}

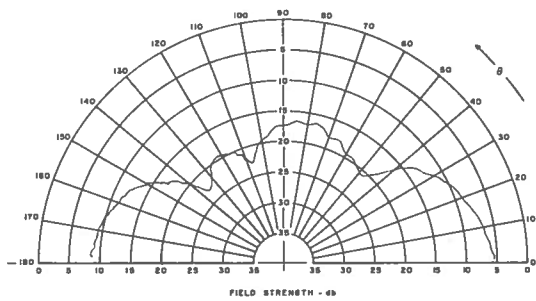


ANTENNA : FWD WHIP
 FREQ : 3 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω

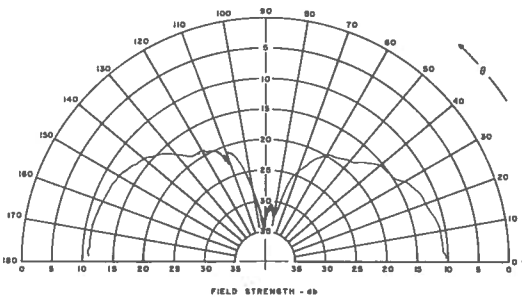
$\delta = .925$

$\eta = .979$

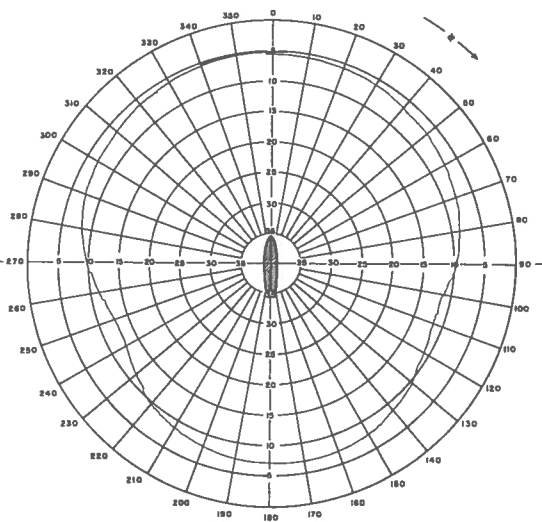
E_{θ}



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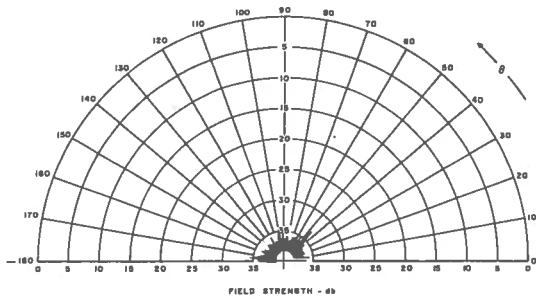


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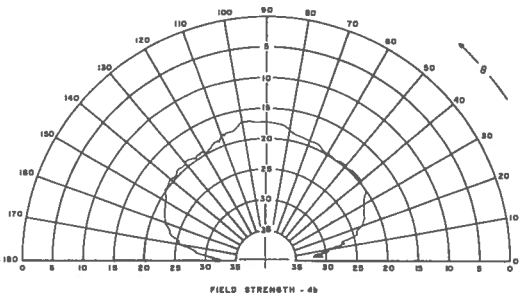


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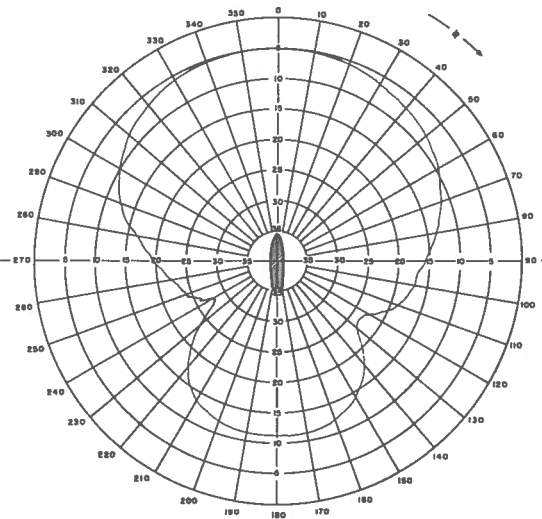
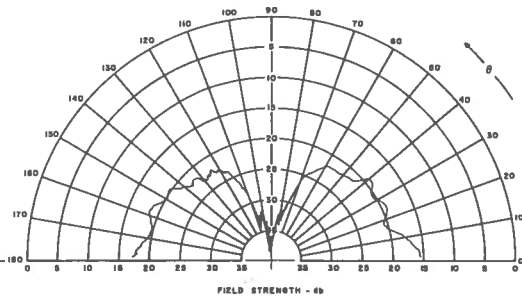
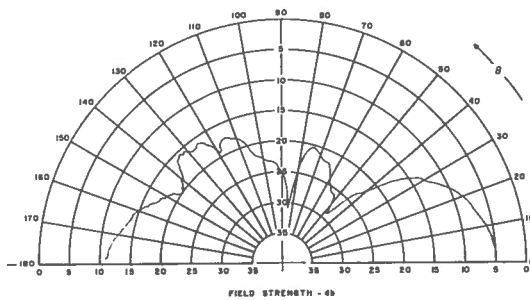
FWD-AFT



PORT-STBD

ANTENNA : FWD WHIP
 FREQ : 4 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω
 $\beta = .883$
 $\eta = 1.187$

E_{θ}

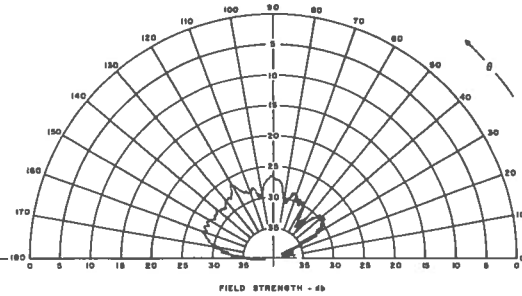
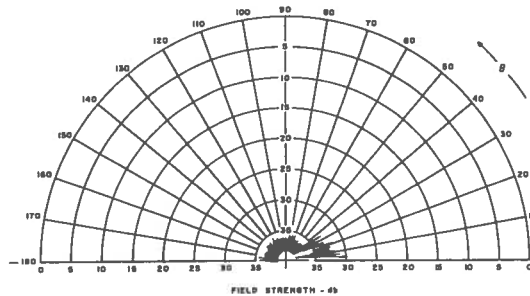


FWD-AFT

PORT-STBD

$\theta = 0^{\circ}$

E_{ϕ}



ANTENNA : FWD WHIP

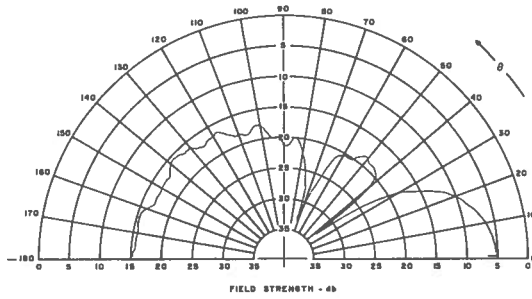
FREQ : 5 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

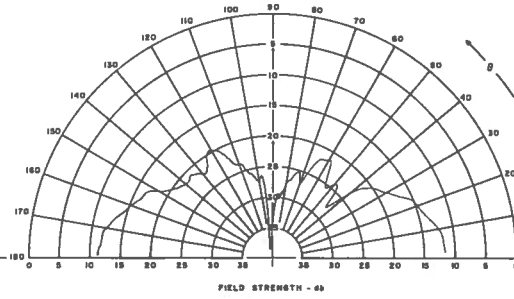
$\beta = .512$

$\gamma = 1.233$

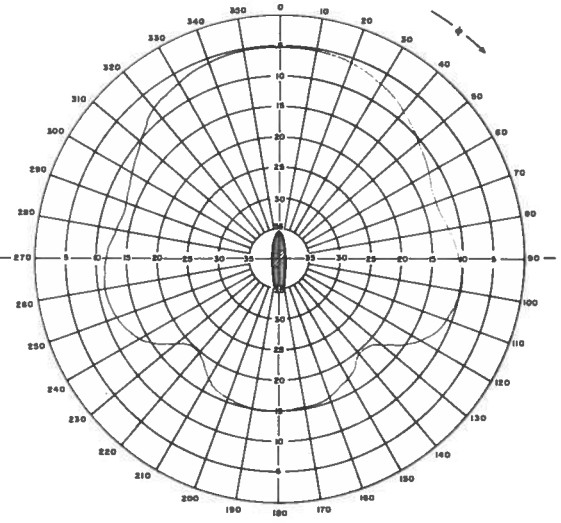
E_{θ}



FWD-AFT

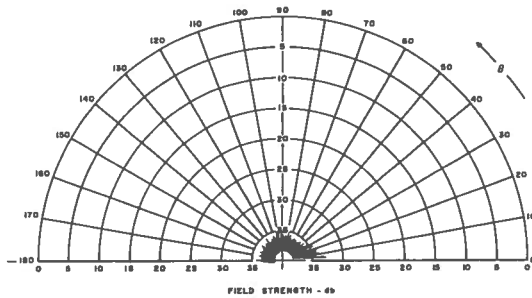


PORT-STBD

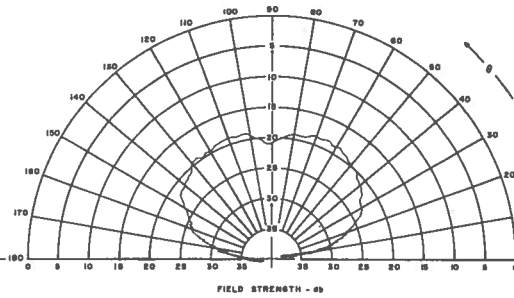


$\theta = 0^\circ$

E_{ϕ}



FWD-AFT

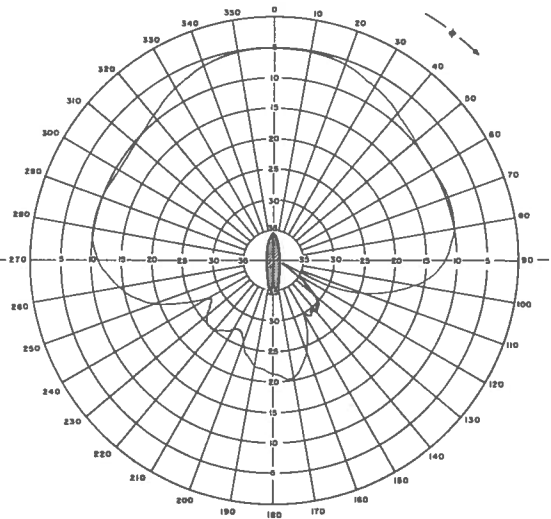
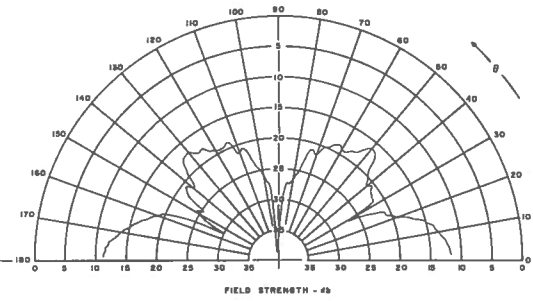
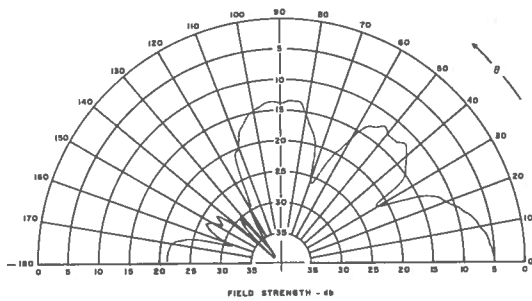


PORT-STBD

ANTENNA : FWD WHIP
 FREQ : 6 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω

$\delta = .711$
 $\eta = 1.081$

E_{θ}

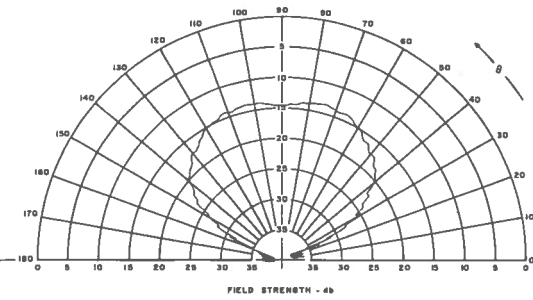
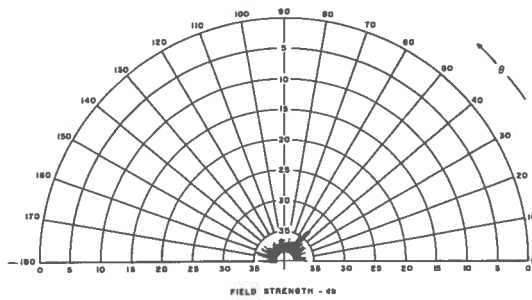


FWD-AFT

PORT-STBD

$\theta = 0^\circ$

E_{ϕ}



ANTENNA : FWD WHIP

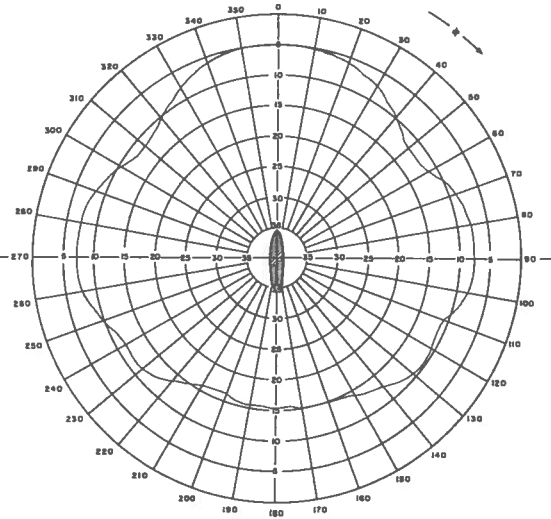
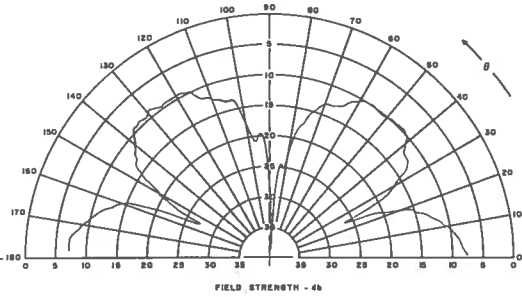
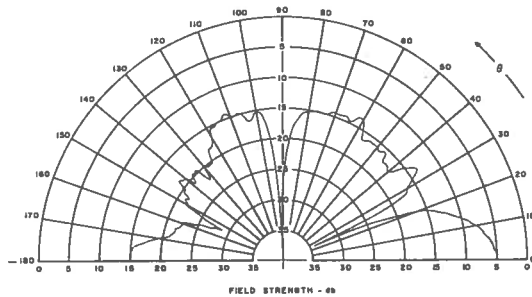
FREQ : 8 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50 Ω

$\xi = .236$

$\eta = .970$

E_{θ}

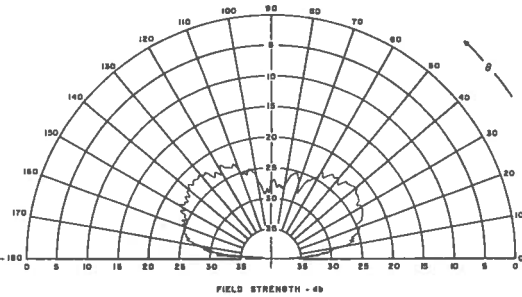
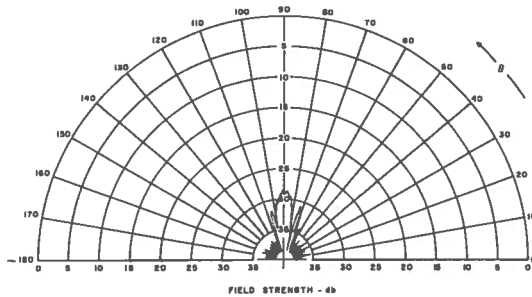


FWD-AFT

PORT-STBD

$\theta = 0^{\circ}$

E_{ϕ}



ANTENNA : FWD WHIP

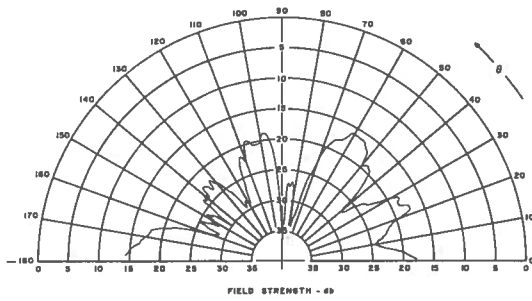
FREQ : 10 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

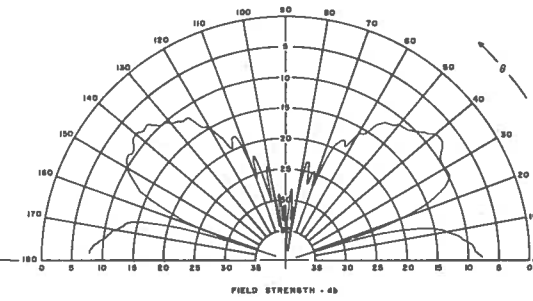
$\beta = .424$

$\eta = .698$

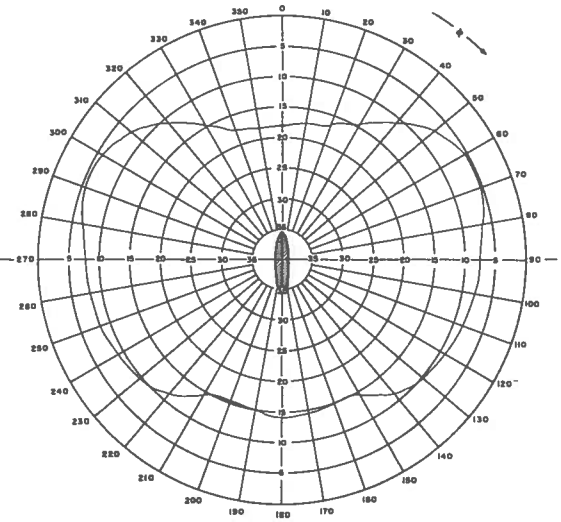
E_{θ}



FWD-AFT

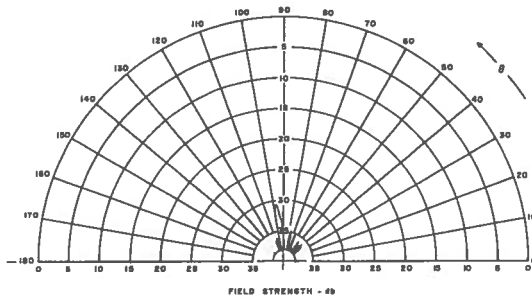


PORT-STBD

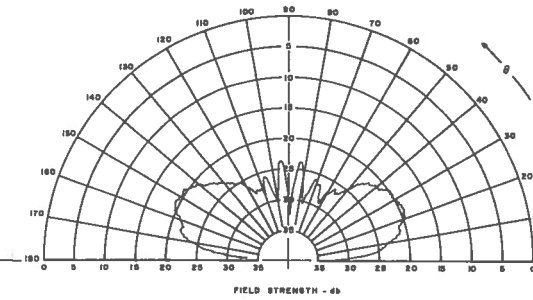


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : FWD WHIP

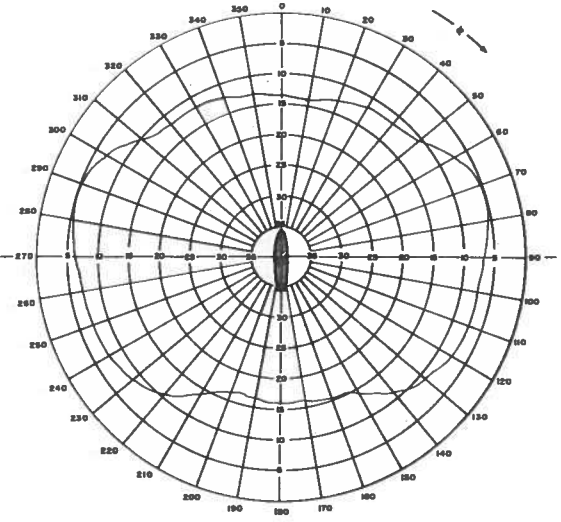
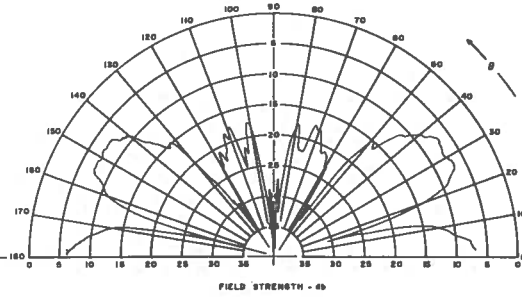
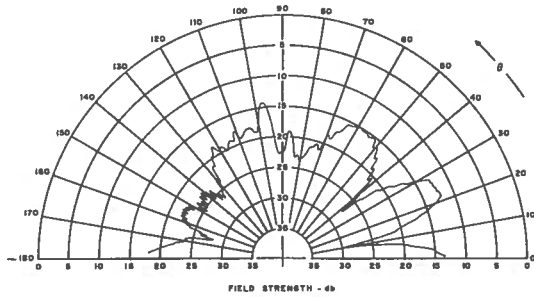
FREQ : 12 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$\beta = .392$

$\eta = .745$

E_{θ}

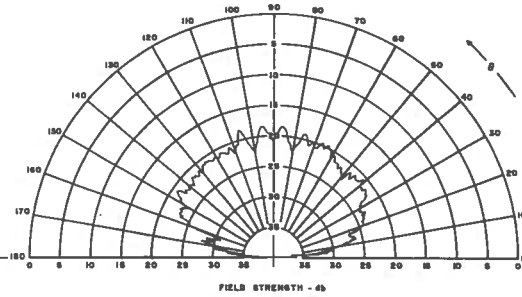
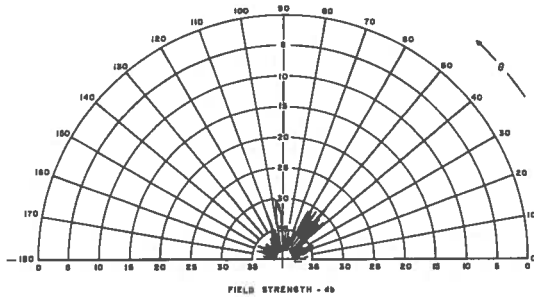


FWD-AFT

PORT-STBD

$\theta = 0^\circ$

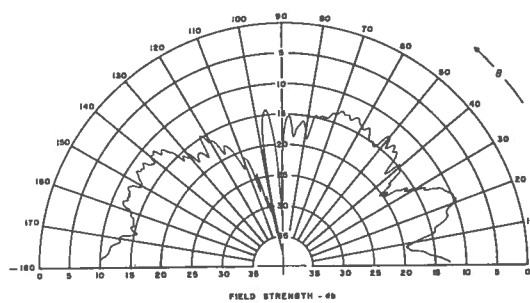
E_{ϕ}



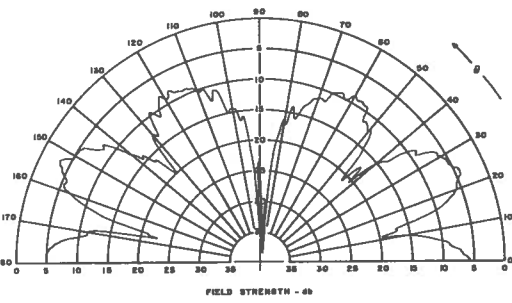
ANTENNA : FWD WHIP
FREQ : 14 MHz
REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50 Ω

$\beta = .454$
 $\eta = .836$

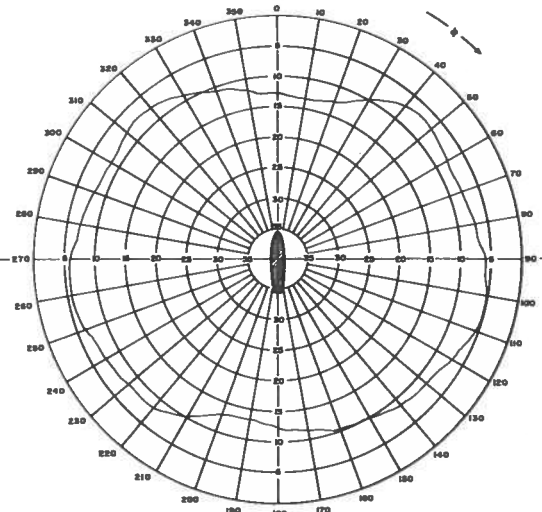
E_{θ}



FWD-AFT

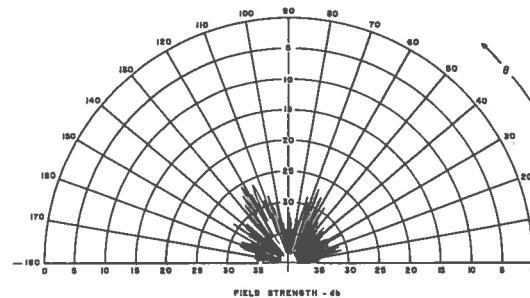


PORT-STBD

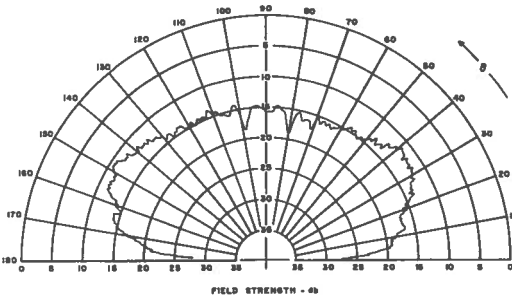


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : FWD WHIP

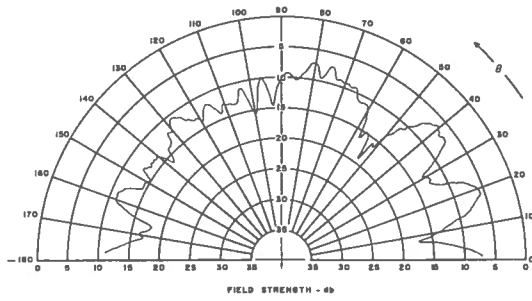
FREQ : 16 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

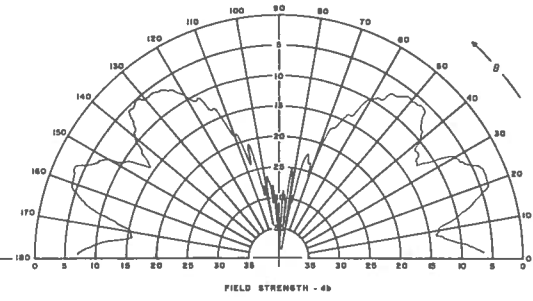
$\beta = .560$

$\eta = .853$

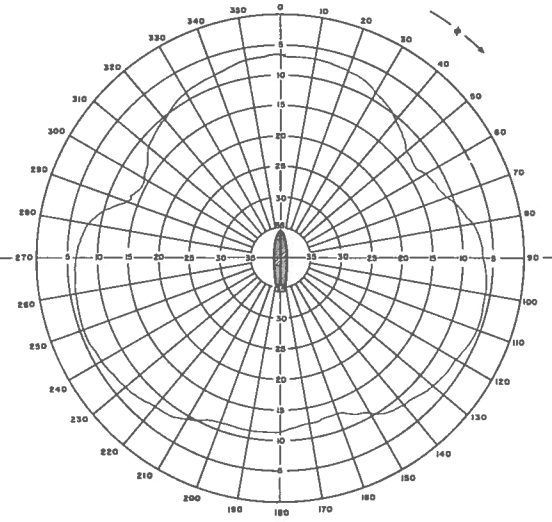
E_{θ}



FWD-AFT

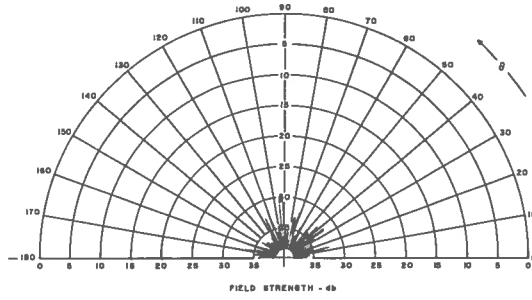


PORT-STBD

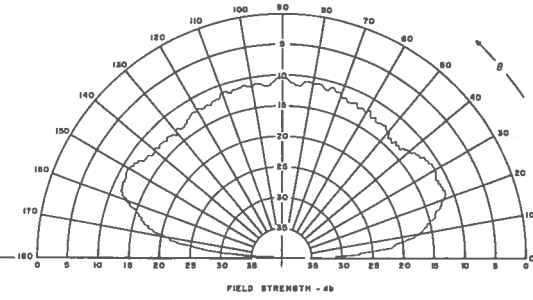


$\theta = 0^\circ$

E_{ϕ}



FWD-AFT

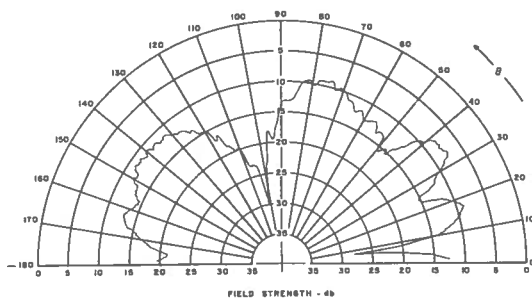


PORT-STBD

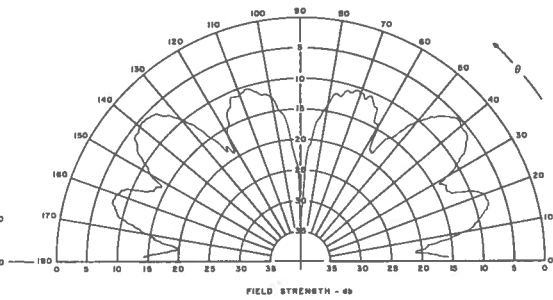
ANTENNA : FWD WHIP
 FREQ : 18 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω

$\beta = .510$
 $\eta = .764$

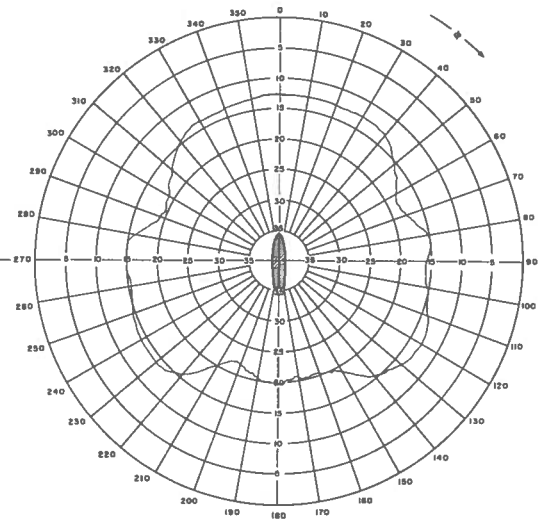
E_{θ}



FWD-AFT

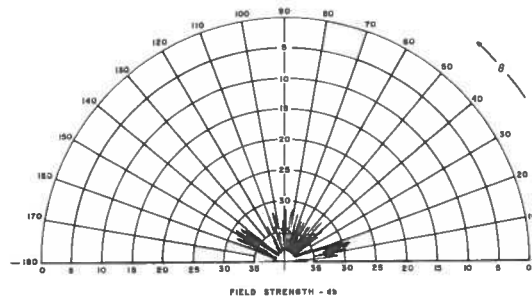


PORT-STBD

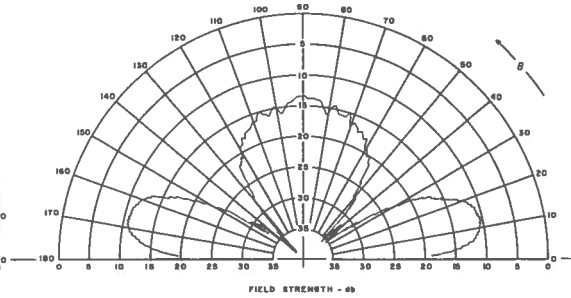


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



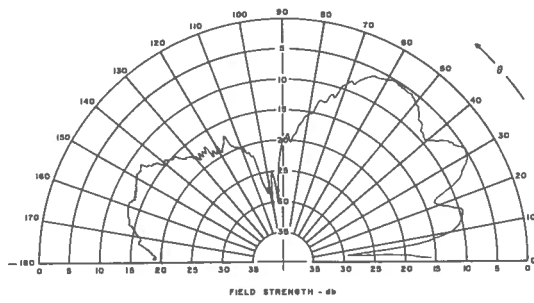
PORT-STBD

ANTENNA : FWD WHIP
 FREQ : 20 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω

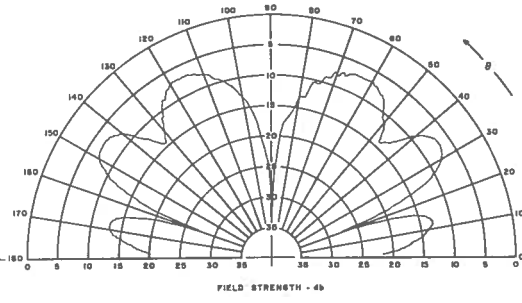
$$\xi = .422$$

$$\eta = .643$$

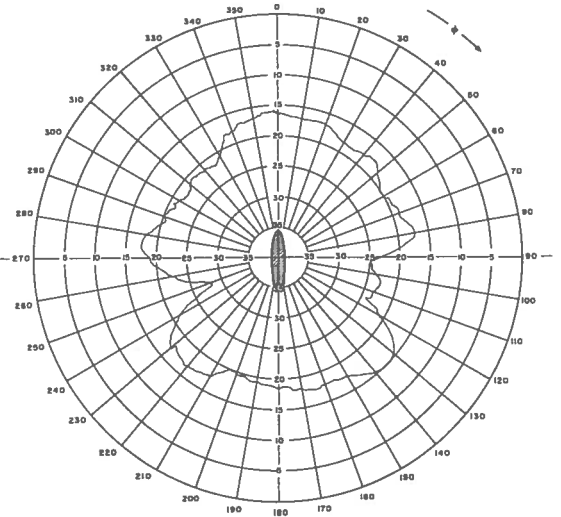
E_{θ}



FWD-AFT

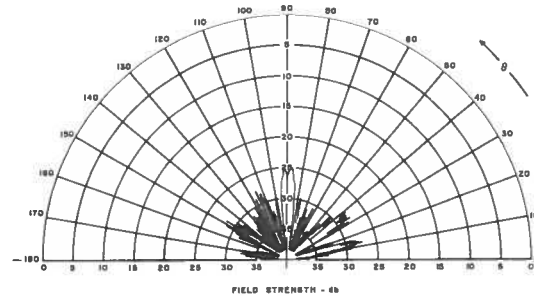


PORT-STBD

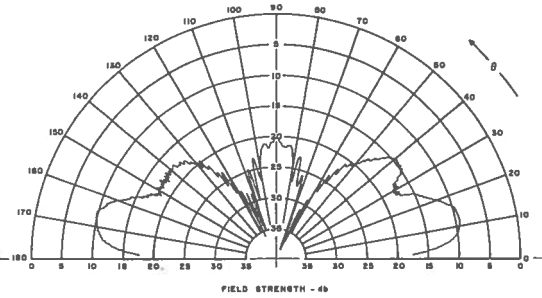


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : FWD WHIP

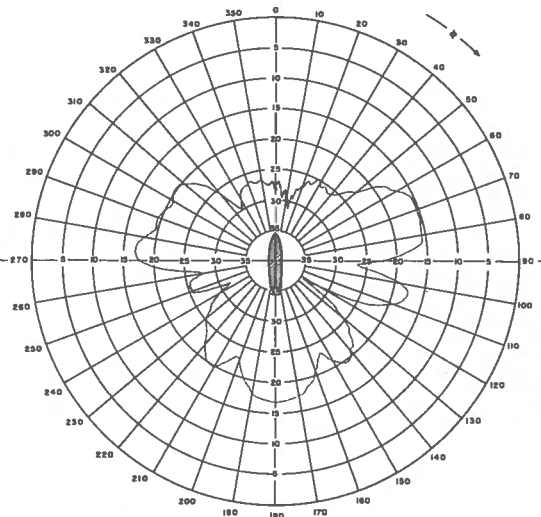
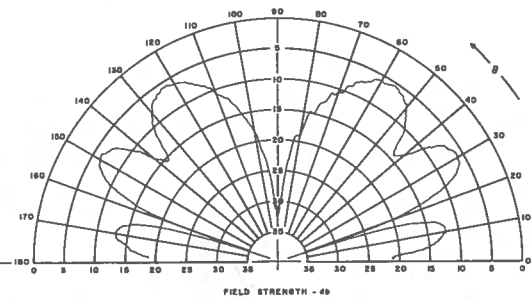
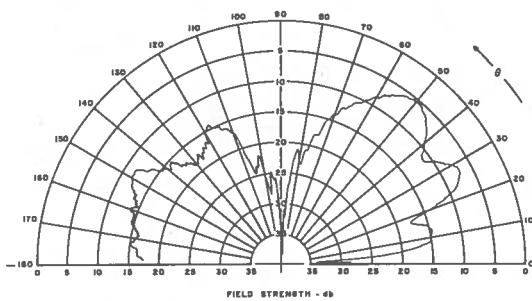
FREQ : 22 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$\beta = .307$

$\eta = .535$

E_{θ}

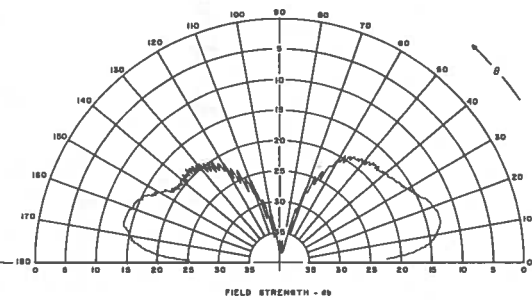
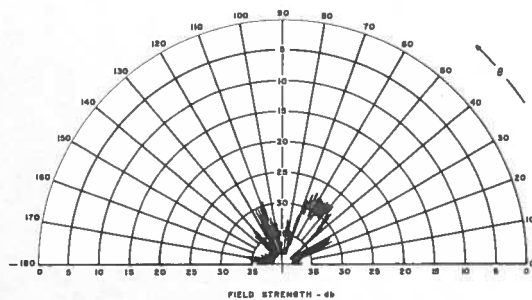


FWD-AFT

PORT-STBD

$\theta = 0^{\circ}$

E_{ϕ}



ANTENNA : FWD WHIP

FREQ : 24 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$f = .338$

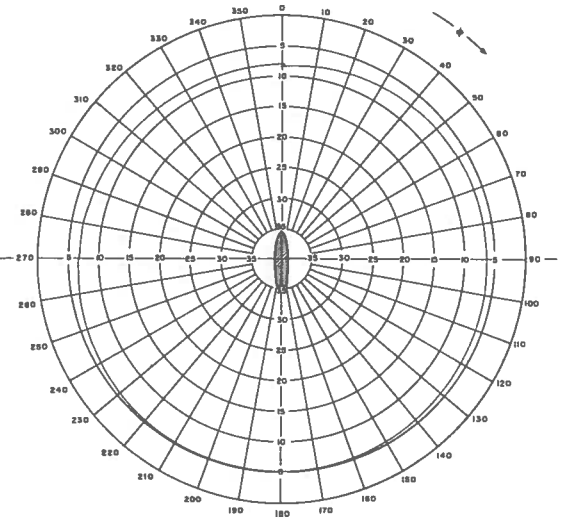
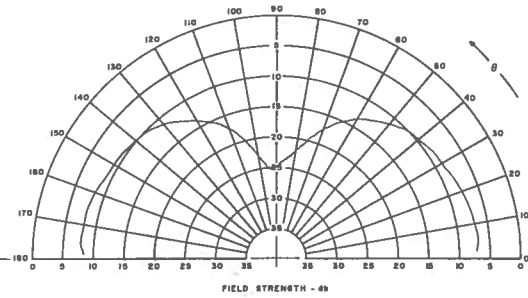
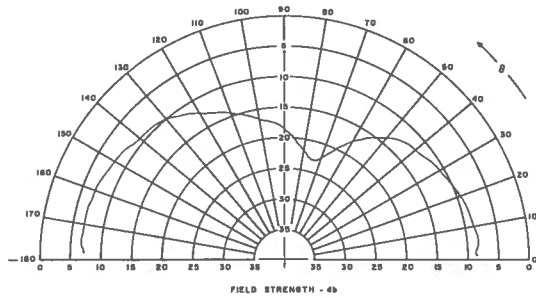
$\eta = .506$

Confidential

RADIATION PATTERNS

Starboard aft 35-foot whip – patterns 20–33

E_{θ}

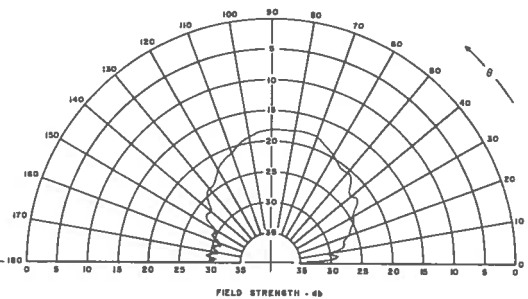
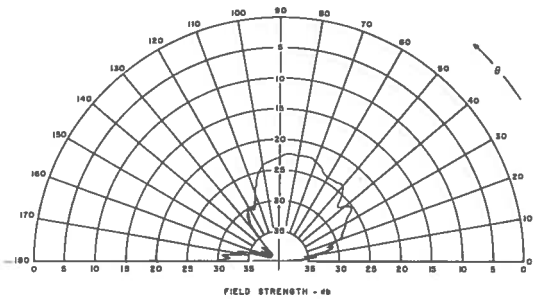


FWD-AFT

PORT-STBD

$\theta = 0^\circ$

E_{ϕ}



ANTENNA : STBD AFT WHIP

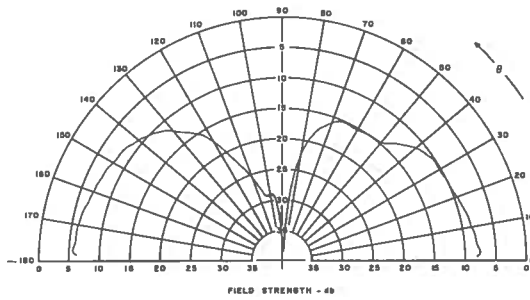
FREQ : 2 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50 Ω

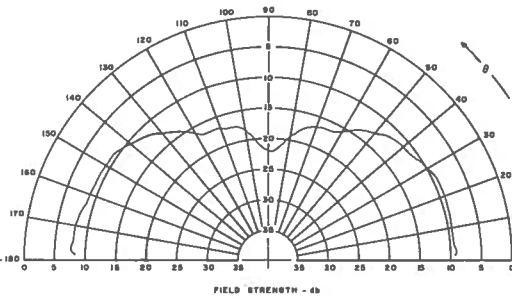
$\delta = .742$

$\eta = .838$

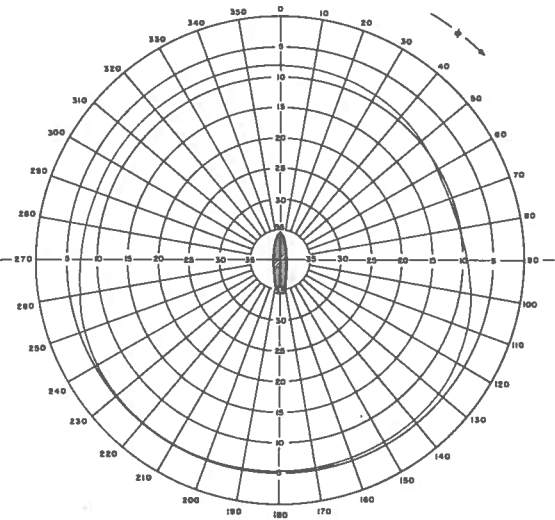
E_{θ}



FWD-AFT

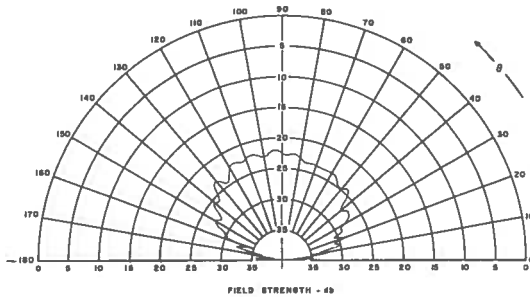


PORT-STBD

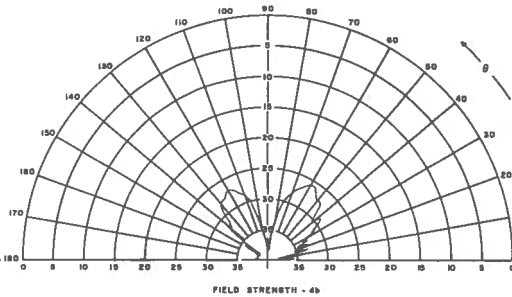


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : STBD AFT WHIP

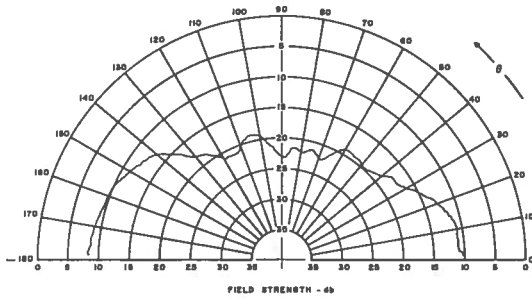
FREQ : 3 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

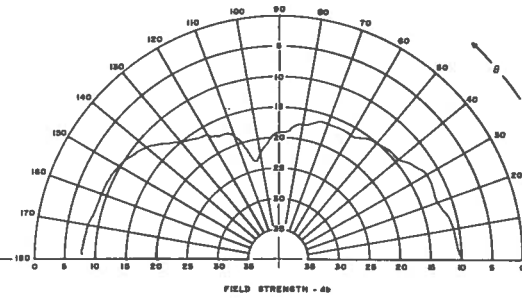
$\delta = .765$

$\eta = .909$

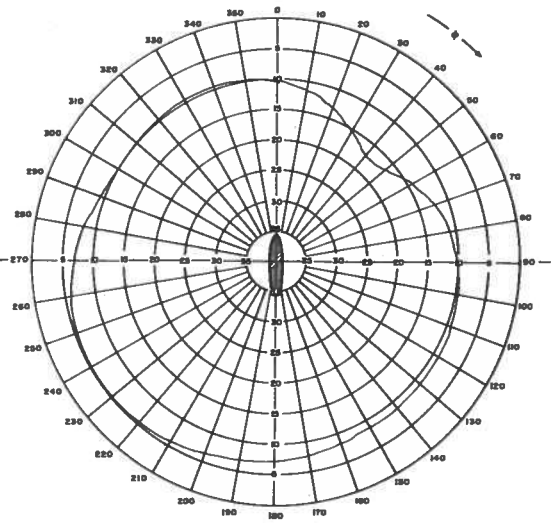
E_{θ}



FWD-AFT

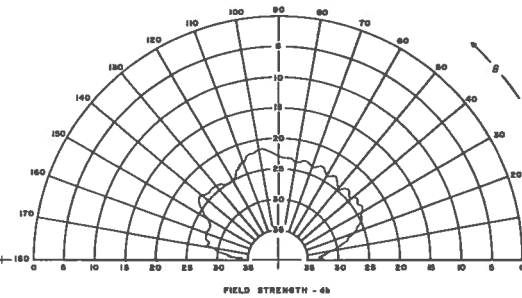
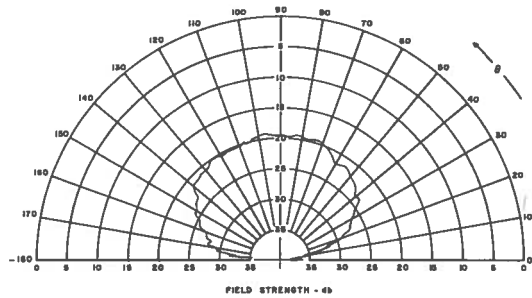


PORT-STBD



$\theta = 0^\circ$

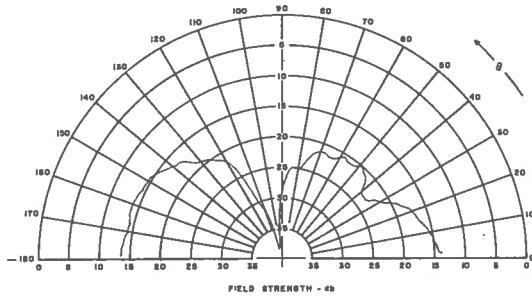
E_{ϕ}



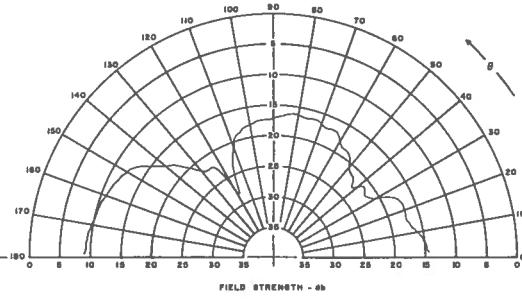
ANTENNA : STBD AFT WHIP
FREQ : 4 MHz
REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$\xi = .688$
 $\eta = .999$

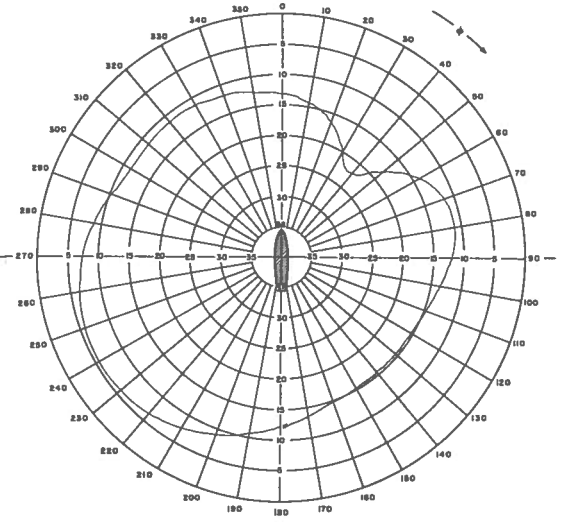
E_{θ}



FWD-AFT

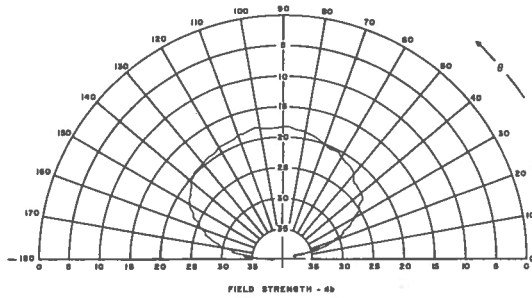


PORT-STBD

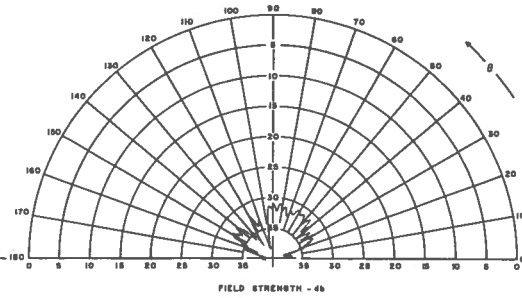


$\theta = 0^\circ$

E_{ϕ}



FWD-AFT

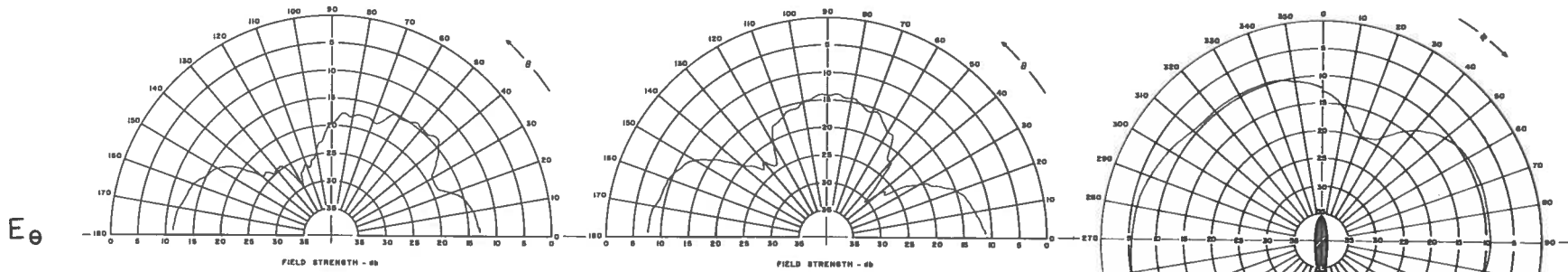


PORT-STBD

ANTENNA : STBD AFT WHIP
 FREQ : 5 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω

$$\xi = .548$$

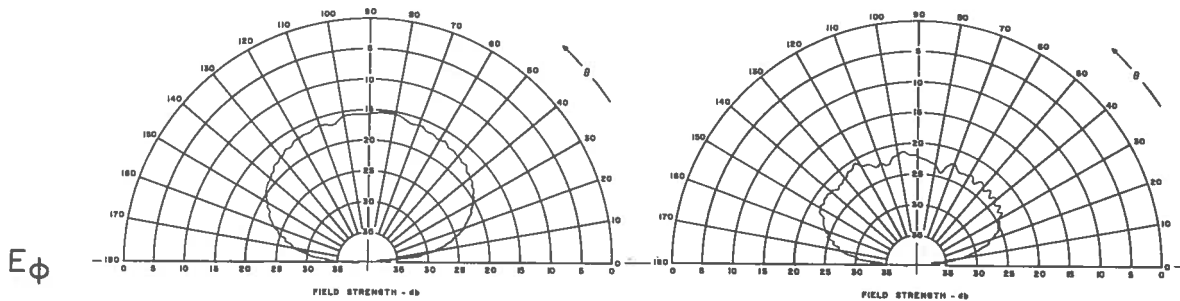
$$\eta = .895$$



FWD-AFT

PORT-STBD

$\theta = 0^{\circ}$



ANTENNA : STBD AFT WHIP

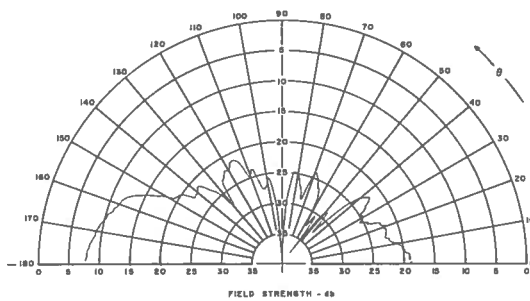
FREQ : 6 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50 Ω

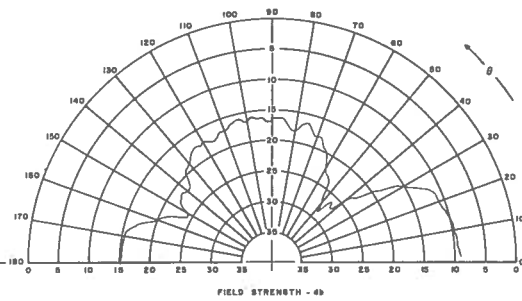
$\beta = .624$

$\eta = .920$

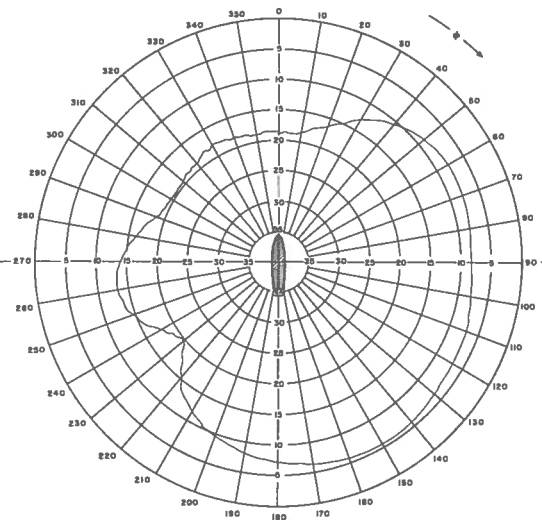
E_{θ}



FWD-AFT

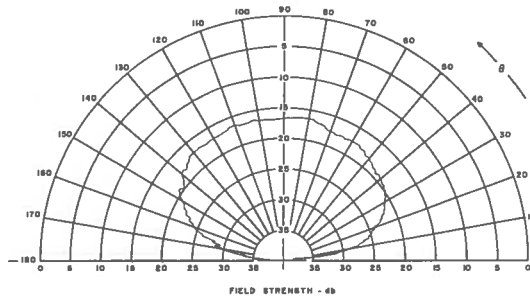


PORT-STBD

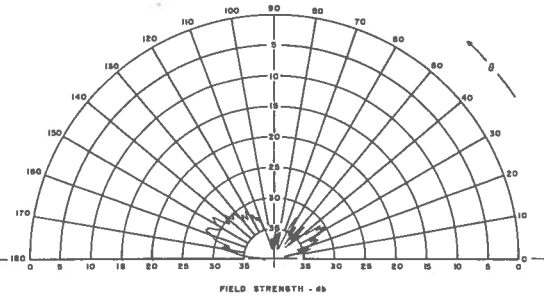


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : STBD AFT WHIP

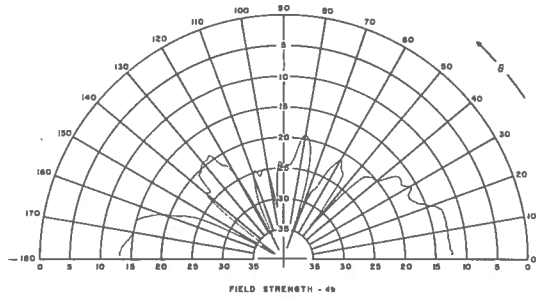
FREQ : 8 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

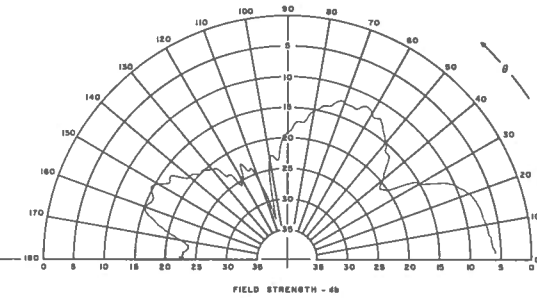
$\delta = .460$

$\eta = 1.032$

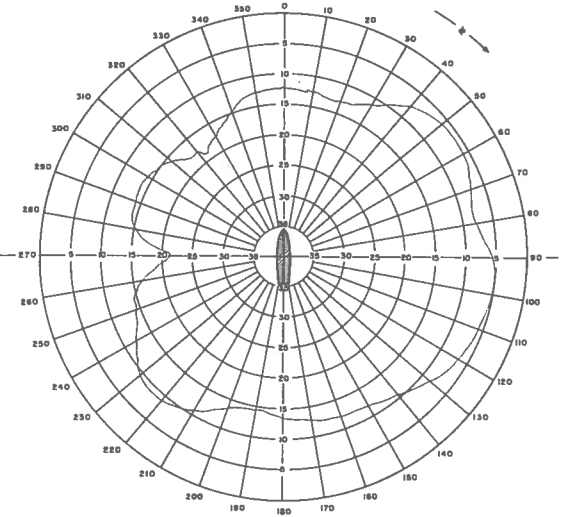
E_{θ}



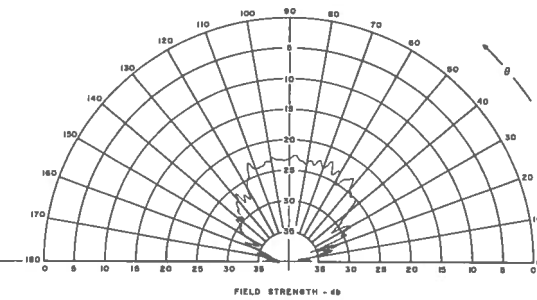
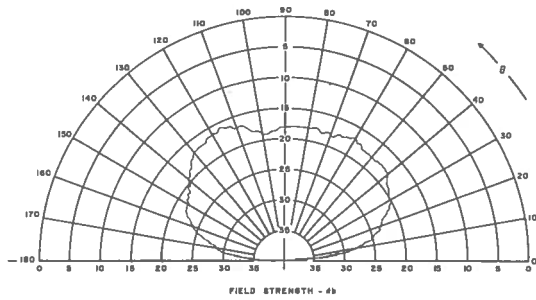
FWD-AFT



PORT-STBD



E_{ϕ}



ANTENNA : STBD AFT WHIP

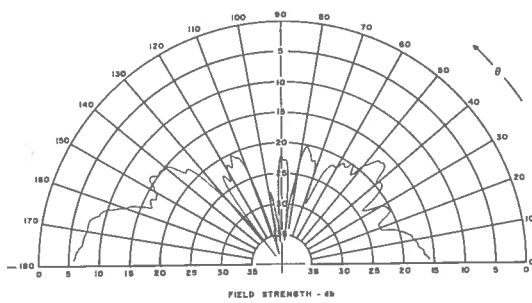
FREQ : 10 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

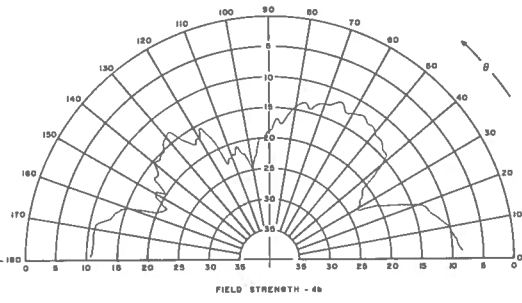
$\delta = .599$

$\eta = 1.064$

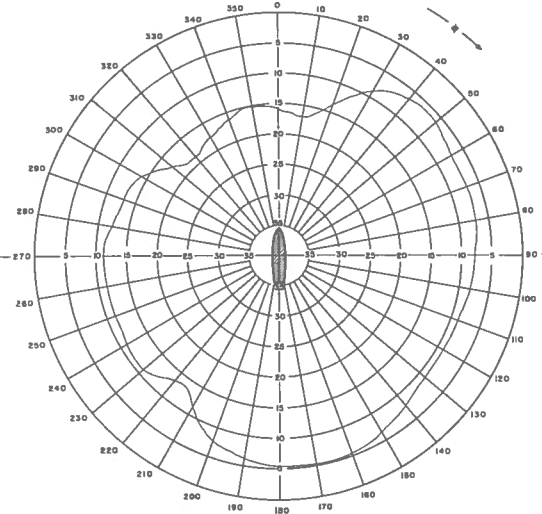
E_{θ}



FWD-AFT

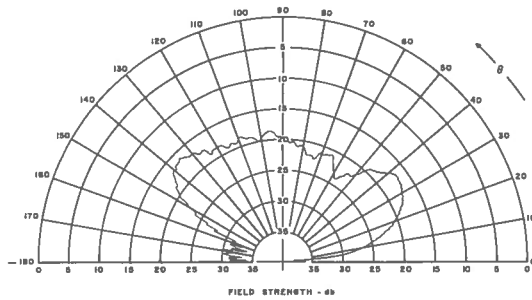


PORT-STBD

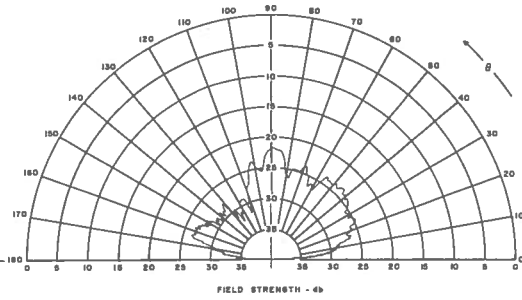


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

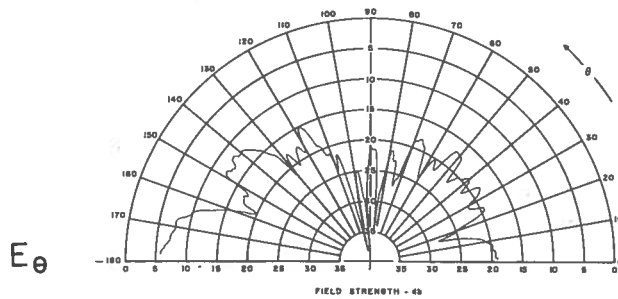
ANTENNA : STBD AFT WHIP

FREQ : 12 MHz

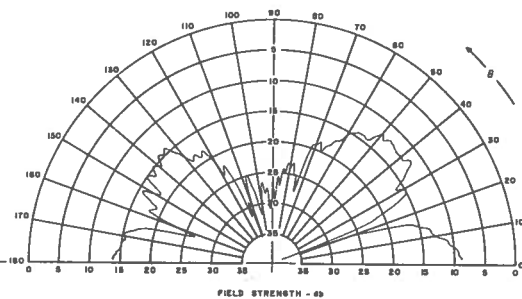
REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$\xi = .594$

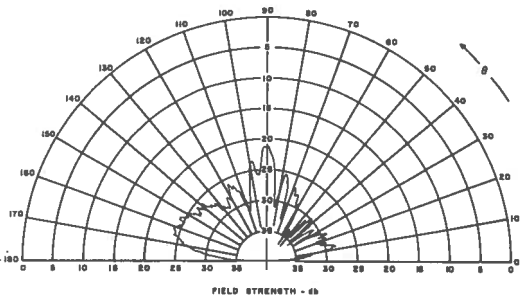
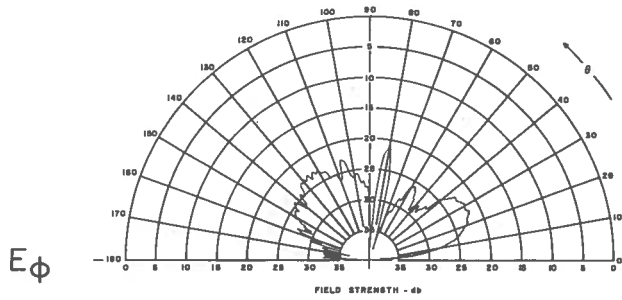
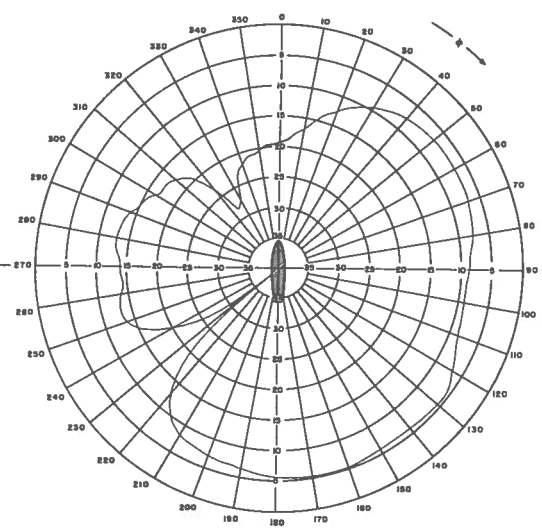
$\eta = 1.050$



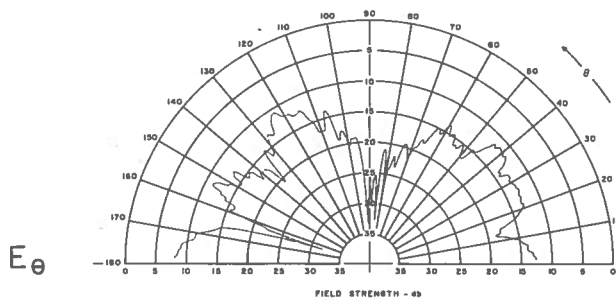
FWD-AFT



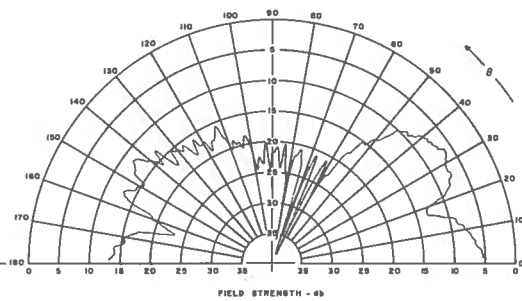
PORT-STBD



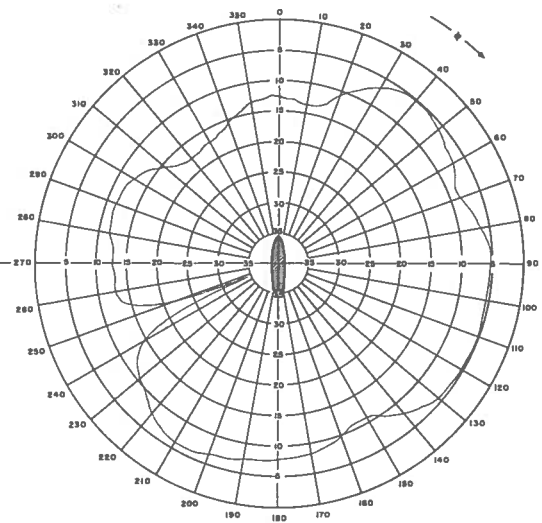
ANTENNA : STBD AFT WHIP
 FREQ : 14 MHz
 REMARKS : ALL OTHER ANTENNAS
 TERMINATED IN 50Ω
 $\delta = .363$
 $\eta = 1.010$



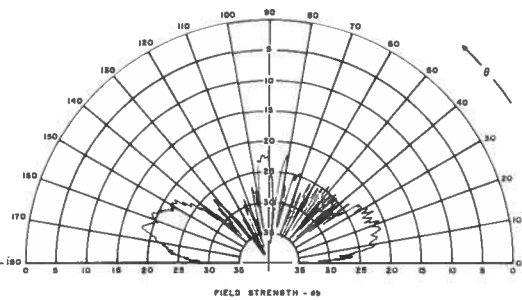
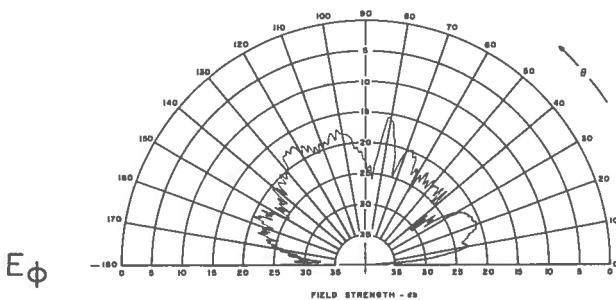
FWD-AFT



PORT-STBD



$\theta = 0^{\circ}$



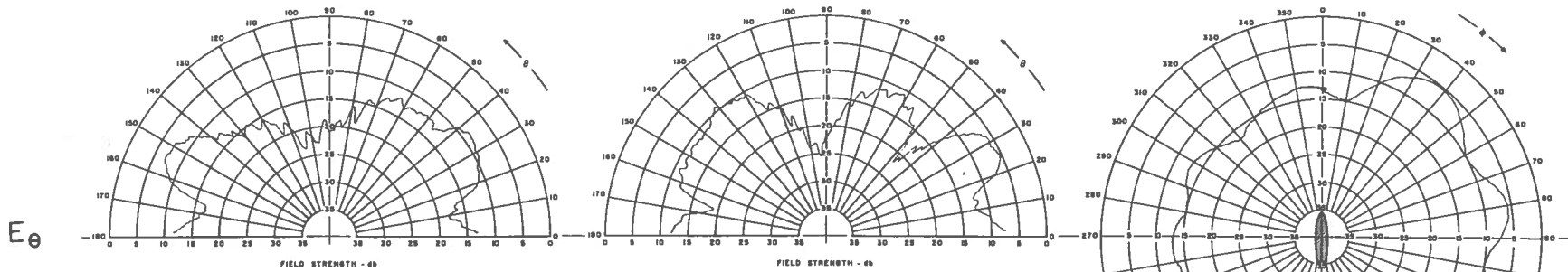
ANTENNA : STBD AFT WHIP

FREQ : 16 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$\delta = .453$

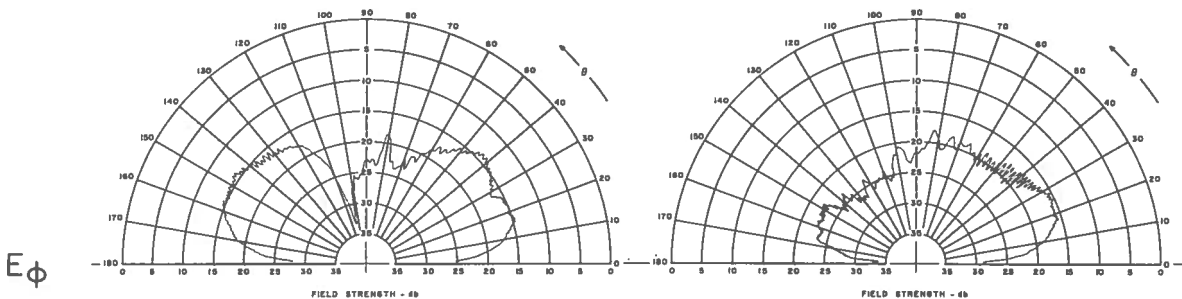
$\eta = .812$



FWD-AFT

PORT-STBD

$\theta = 0^{\circ}$



ANTENNA : STBD AFT WHIP

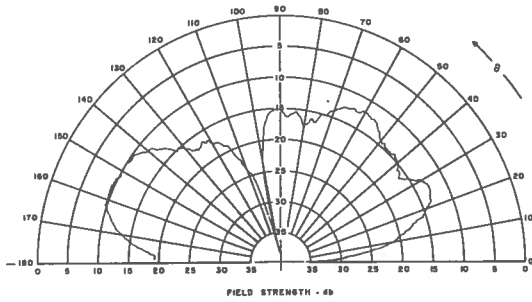
FREQ : 18 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

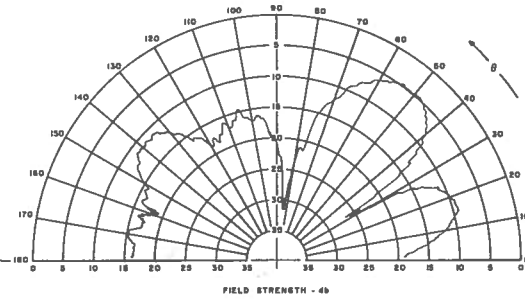
$\delta = .529$

$\eta = .768$

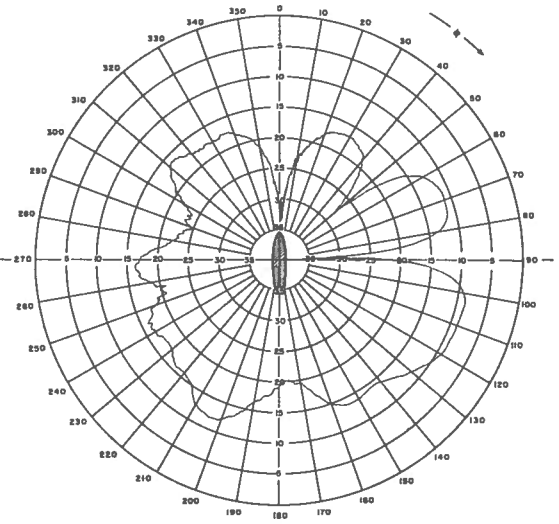
E_{θ}



FWD-AFT

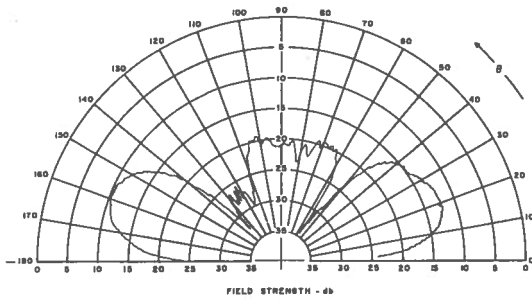


PORT-STBD

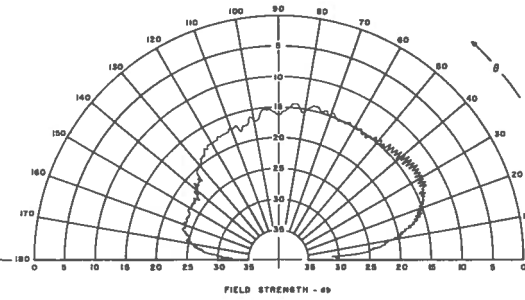


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : STBD AFT WHIP

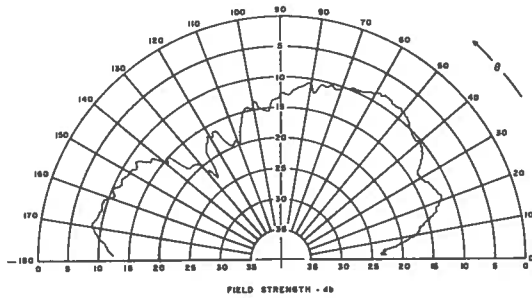
FREQ : 20 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

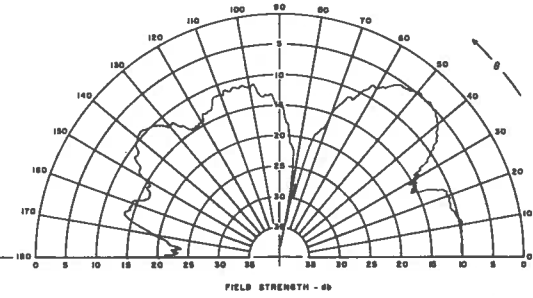
$\delta = .345$

$\eta = .734$

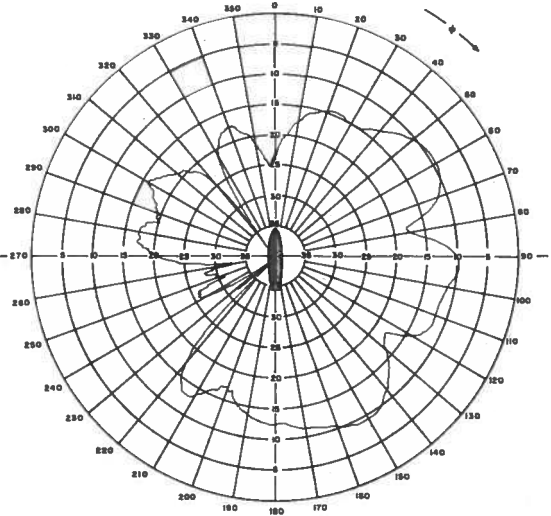
E_{θ}



FWD-AFT

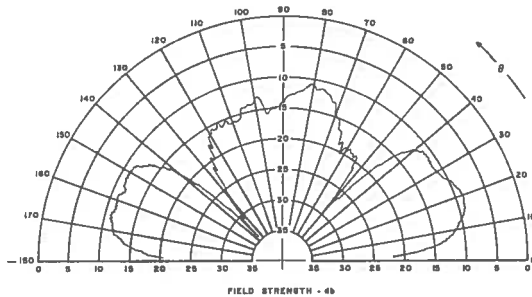


PORT-STBD

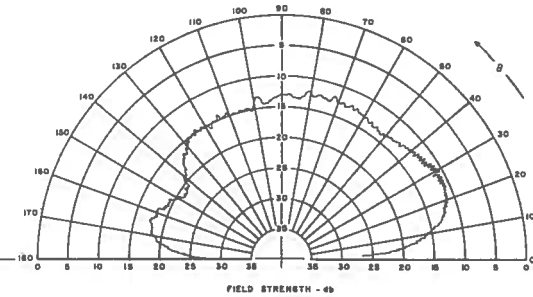


$\theta = 0^{\circ}$

E_{ϕ}



FWD-AFT



PORT-STBD

ANTENNA : STBD AFT WHIP

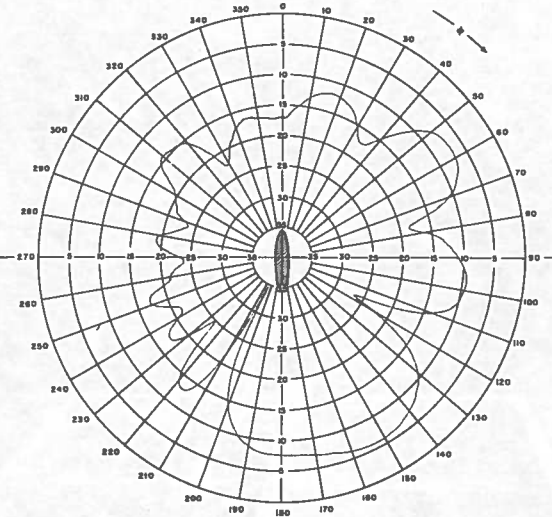
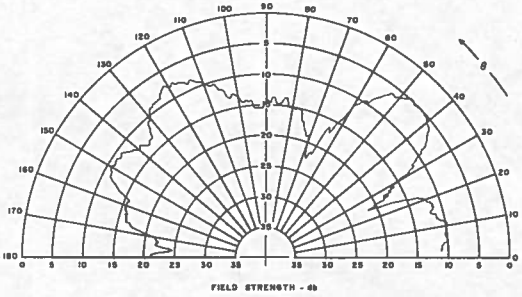
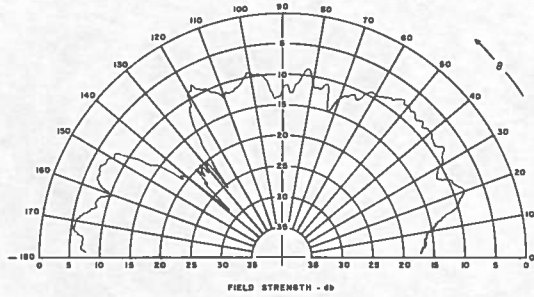
FREQ : 22 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$\delta = .301$

$\eta = .709$

E_{θ}

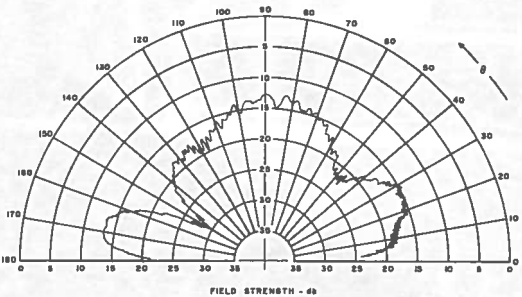
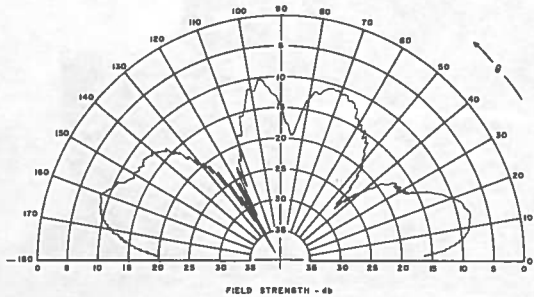


FWD-AFT

PORT-STBD

$\theta = 0^{\circ}$

E_{ϕ}



ANTENNA : STBD AFT WHIP

FREQ : 24 MHz

REMARKS : ALL OTHER ANTENNAS
TERMINATED IN 50Ω

$\delta = .307$

$\gamma = .685$

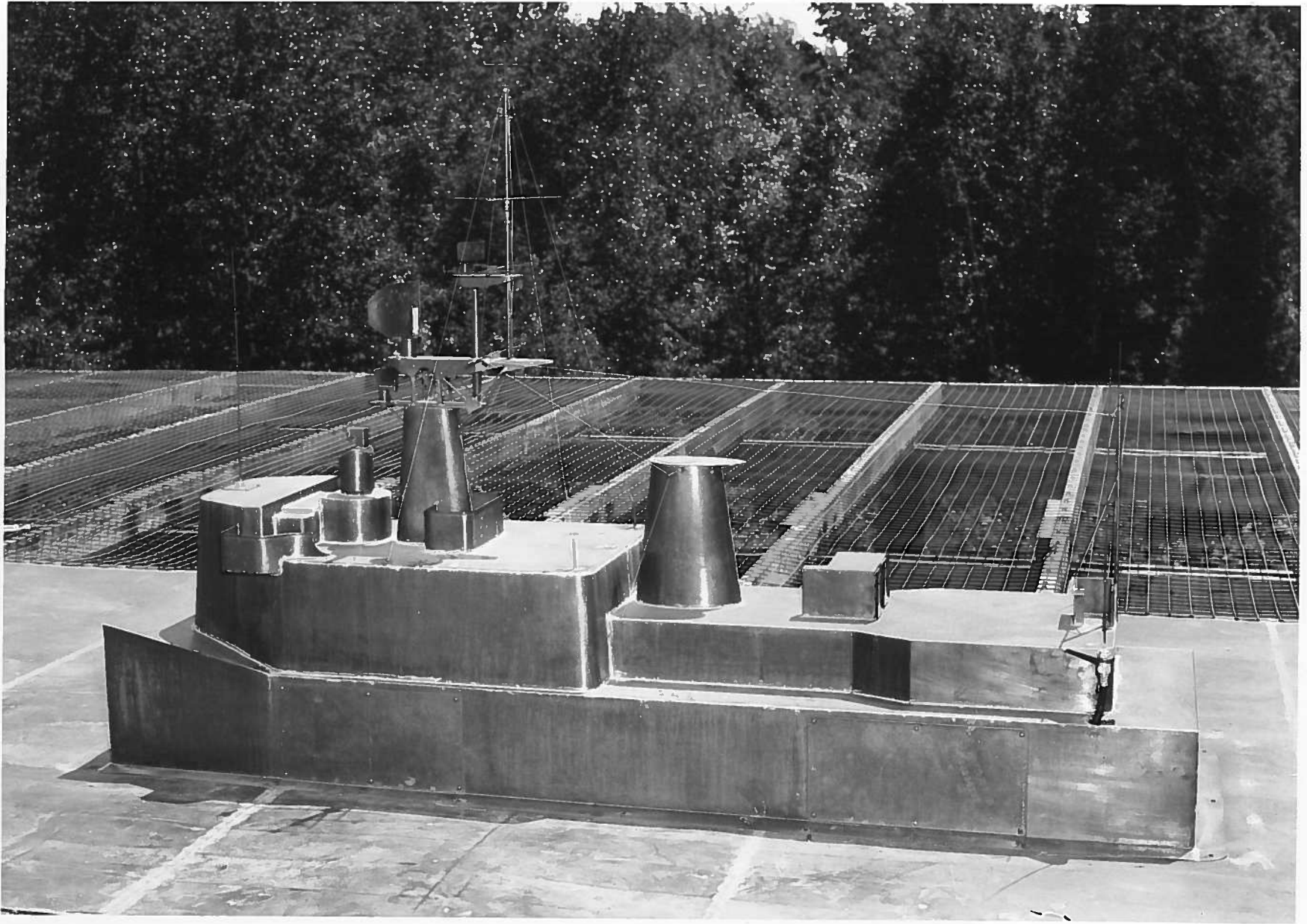


PLATE I $\frac{1}{20}$ SCALE MOCK-UP OF DDE-257 USED IN IMPEDANCE MEASUREMENTS