[redacted] DECLASSIFIED

UNCLASSIFIED

NRL REPORT 3515

FR-3515

BROADBAND COMMUNICATION ANTENNAS FOR DESTROYERS OF THE USS 693 CLASS

DECLASSIFIED: By authority of NRL ... Change Notice No. 19-21 dated 2 May 61
Duida Jean Lambert 2028
Entered by NRL Code

DECLASSIFIED by NRL Contract Declassification Team
Date: 12 JAN 2017
Reviewer's name(s): [redacted]
Declassification authority: NAVY DECLASS GUIDE/NAVY DECLASS MANUAL, 11 DEC 2012, 06 SERIES

[redacted]
Entered by NRL Code

NAVAL RESEARCH LABORATORY

WASHINGTON, D.C.

UNCLASSIFIED

DISTRIBUTION STATEMENT A APPLIES.
Further distribution authorized by UNLIMITED only.

[redacted]

DECLASSIFIED

DECLASSIFIED

[redacted] UNCLASSIFIED

NRL REPORT 3515

BROADBAND COMMUNICATION ANTENNAS FOR DESTROYERS OF THE USS 693 CLASS

A. W. Walters and H. B. Janes

UNCLASSIFIED

August 1, 1949

Approved by:

R. B. Meyer, Head, Communications Branch

L. A. Gebhard, Superintendent, Radio Division II

NAVAL RESEARCH LABORATORY

CAPTAIN F. R. FURTH, USN, DIRECTOR

WASHINGTON, D.C.

UNCLASSIFIED

DECLASSIFIED

[redacted]

DECLASSIFIED

DISTRIBUTION

ONR	
Attn: Code 427	2
Attn: Code 470	2
BuAer	
Attn: Code EL-51	1
Attn: Code TD-4	1
BuOrd	
Attn: Code Re4f	1
BuShips	
Attn: Code 833	2
Attn: Code 853	2
Attn: Code 980	2
Attn: Code 981	2
CNO	
Attn: Code 413	1
Attn: Code 413C	1
Attn: Code 413D	1
ComOpDevFor	1
CO, ONR, Boston	1
Dir., USNEL	
Attn: Code 300	2
CDR., USNOTS	
Attn: Reports Unit	2
CO, USNUSL	1
CO, NADS, Aeronautical Electronic & Electrical Lab.	
Attn: Dr. H. Krutter	1
Attn: Mr. E. Steele	1
Attn: Mr. E. R. Schlieben	1
CDR., NATC	
Attn: Mr. L. S. Marquardt	1
OCSigO	
Attn: Mr. J. J. Kelleher	1
Attn: Mr. A. A. Beach	1
Attn: Ch. Eng. & Tech. Div., SIGTM-S	1

DECLASSIFIED

DECLASSIFIED

[redacted]

UNCLASSIFIED

CONTENTS

[redacted]

DECLASSIFIED

DECLASSIFIED

Confidential

ABSTRACT

Scale-model techniques have been applied to the design of broadband communication antennas for destroyers of the USS 693 Class. Three antennas have resulted which are of the modified sleeve type. They cover the complete frequency range of 3.3 to 30 Mc, and have individual ranges of 3.3 to 9.5 Mc, 4.2 to 12.0 Mc, and 10 to 30 Mc.

The forward and aft stacks of the ship act as the sleeve section of the two lower-frequency antennas; a relatively small separate structure is utilized for the 10 to 30 Mc antenna. Throughout the operating frequency range, a standing wave ratio of 0.3 or better has been maintained and vertical field patterns are satisfactory for low-angle radiation.

PROBLEM STATUS

This report completes one phase of the problem; work on other phases continues.

AUTHORIZATION

NRL Problem R09-01R

DECLASSIFIED

Confidential

[redacted]

DECLASSIFIED

BROADBAND COMMUNICATION ANTENNAS FOR DESTROYERS OF THE USS 693 CLASS

INTRODUCTION

A brief investigation has been made of the USS 693 Class Destroyer to determine design considerations for broadband communication antennas to operate in the high-frequency range. According to a previous study,[1*] the stacks of a destroyer are well adapted for use as part of a broadband sleeve antenna and this type of design has definite advantages over simple vertical antennas.

Basically any broadband antenna, as compared with a simple antenna, has certain desirable qualifications when considered for shipboard applications. These are: (1) The impedance characteristic is such that a better match to the terminating equipment is obtained over a wide frequency range, (2) variations in field patterns vs frequency are generally less than in simple radiators, and (3) it is possible to accommodate a number of simultaneously operating equipments by means of the "Common Antenna Working" principle.[2,3,4,5]

The modified sleeve antenna considered for this class of vessels has one advantage in addition to those listed above for the general case of a broadband antenna in that, at frequencies where the antenna becomes an appreciable portion of a wavelength, the field propagated along the horizon is near the maximum value. A brief analysis showing the importance of low-angle radiation in the range 500 to 2500 miles has been published previously.[1]

Assuming that the stacks were to be used as the sleeve sections of the two low-frequency antennas, it was then necessary to determine the possible operating frequency ranges and bandwidths using various upper radiating sections. A study of the ship's dimensions, together with the results of previous investigations,[1,6,7] indicated that, with the proper choice of upper radiating sections, the frequency range of approximately 3.5 to 13.0 Mc could be covered. The expected frequency range for each antenna would be approximately 2.5 to 1 in this band. In the frequency range 10 to 30 Mc, no structure was available for the sleeve section of the antenna and a separate structure was devised for this purpose.

**References will appear at the end of this report.*

[redacted]

DECLASSIFIED

DECLASSIFIED

 Confidential

METHOD OF MEASUREMENT

Methods of impedance measurement used for modified sleeve antennas have been previously reported.[1,5] The physical arrangement for making measurements is shown in Figure 1. Briefly, the antenna to be measured was

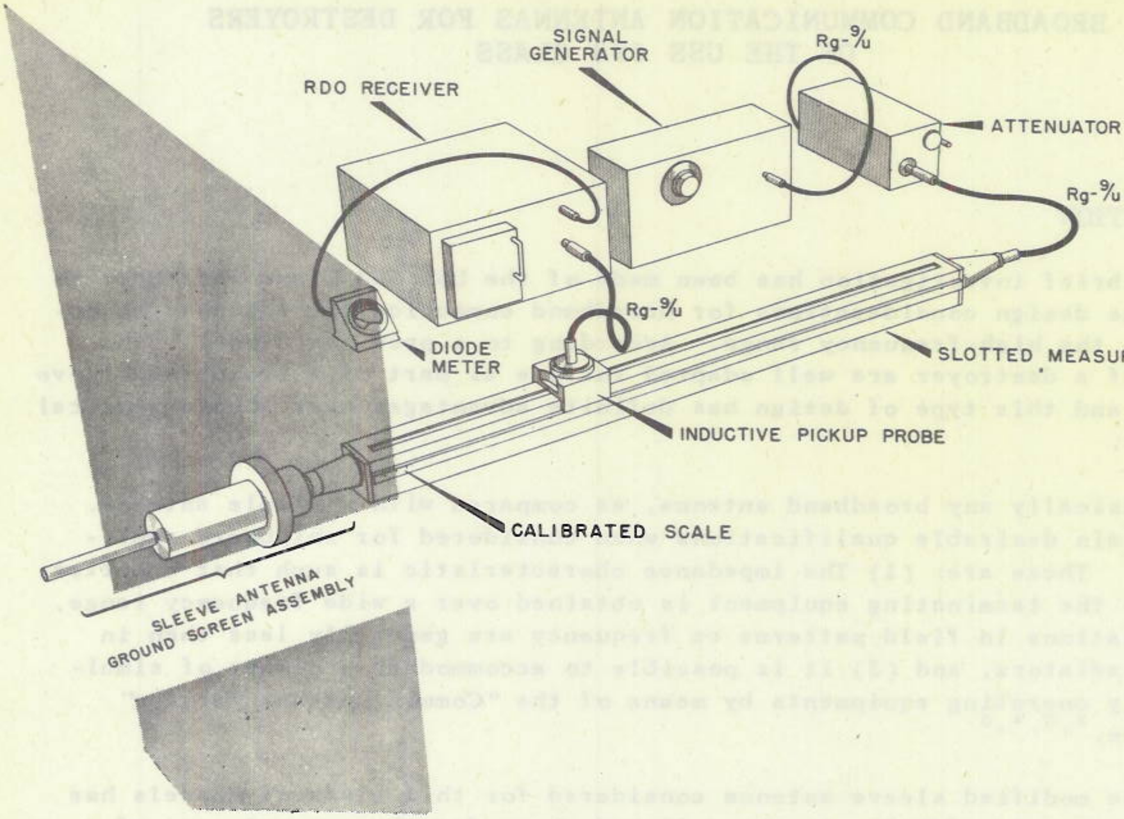


Figure 1 - Arrangement for making impedance measurements

placed in the system as shown in Figure 1, and at each measuring frequency the position of the current minimum and the ratio of current maximum to minimum were recorded. These quantities, together with the position of the current minimum when the line is shorted at the antenna terminals, and the characteristic impedance of the slotted measuring line, determine the impedance which exists at the antenna end of the line.

A sketch of the circuit used for measurement of vertical patterns is shown in Figure 2. With the model antenna inserted in the system, measurements were made at selected frequencies, the necessary r-f power being supplied by a Model LAF signal generator. Radio-frequency power received by the loop antenna was amplified, rectified, and applied to a polar recorder which rotated in synchronism with the loop antenna. Thus a continuous recording of field strength was obtained over the range of 0 to 180 degrees. The system sensitivity was limited to about 25 db in the average case and system errors were in general less than ±2 db.

Confidential

DECLASSIFIED

Confidential

DECLASSIFIED

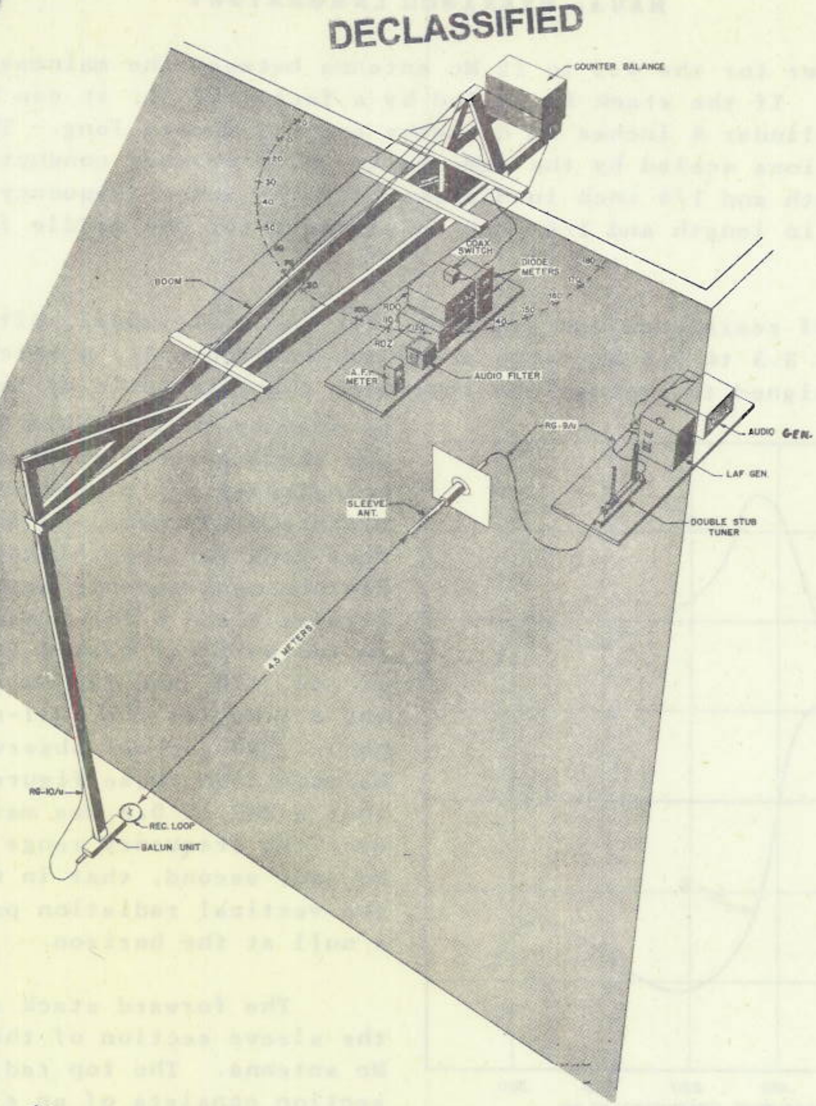


Figure 2 - Arrangement for making pattern measurements

EXPERIMENTAL RESULTS

Three antennas were designed covering the frequency ranges 3.3 to 9.5 Mc, 4.2 to 12.0 Mc, and 10 to 30 Mc. In order to use the available measuring system, it was necessary to scale these antennas. A factor of 31 was used for scaling the two lower frequency antennas and a factor of 9 for the higher frequency one. The scale-model frequencies obtained ranged from 90 to 370 Mc.

As previously stated, the two lower frequency antennas use the stacks as the sleeve sections. The top radiating section of the 3.3 to 9.5 Mc antenna would be 46 feet in length and 7.8 inches in diameter, and that of the 4.2 to 12.0 Mc antenna would be 33 feet in length and 3.9 inches in diameter. To provide the upper radiators, a wire cage or multiple wires could be used with either antenna. The top radiating section for the 3.3 to 9.5 antenna would be connected between the after stack and the mainmast,

Confidential

DECLASSIFIED

DECLASSIFIED

and the radiator for the 4.2 to 12 Mc antenna between the mainmast and the forward stack. If the stack is scaled by a factor of 31, it can be approximated by a cylinder 4 inches in diameter and 9.5 inches long. The top radiating sections scaled by the same factor will produce conductors 18 inches in length and 1/4 inch in diameter for the lower frequency antenna and 13 inches in length and 1/8 inch in diameter for the middle frequency antenna.

Values of resistance and reactance for the scale-model, after-stack antenna in the 3.3 to 9.5 Mc range are shown in Figure 3. A matching transformer was designed to improve the impedance characteristic of this antenna as seen by the 51.5-ohm line, with the results shown in Figure 4. This transformer has a characteristic impedance of 95 ohms and would be 35 feet long for the shipboard antenna. Pattern measurements are shown in Figures 5 and 6 for field strength in two vertical planes at frequencies of 140, 170, and 250 Mc (4.5, 5.5, and 8.1 Mc for the full-scale antennas). Two general observations can be made from these figures: First, that a SWR of 0.3 was maintained over the frequency range 100 to 290 Mc and, second, that in no case does the vertical radiation pattern show a null at the horizon.

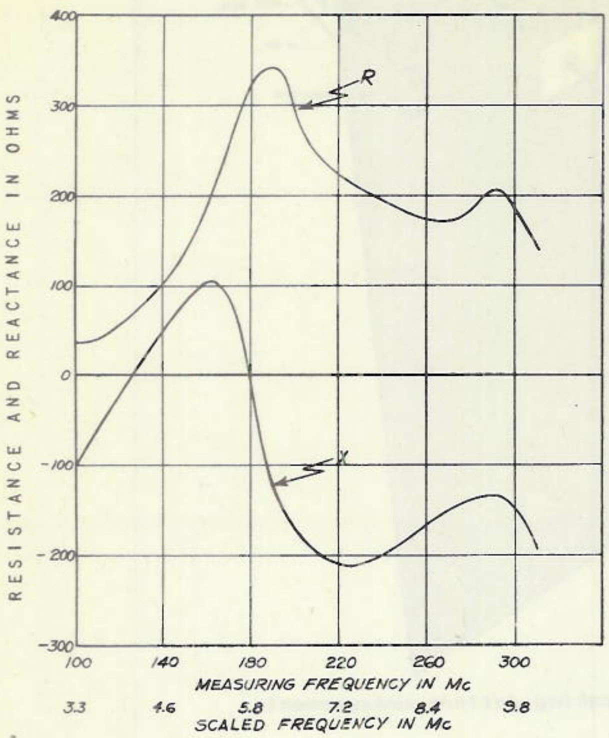


Figure 3 - Resistance and reactance vs frequency for scale model (Full-scale antenna, 3.3 to 9.5 Mc)

The forward stack serves as the sleeve section of the 4.2 to 12 Mc antenna. The top radiating section consists of an element 13 inches long and 1/8 inch in diameter. Values of resistance and reactance for this scaled antenna are shown in Figure 7. The transformed characteristic showing the impedances presented to a 51.5-ohm line is given in Figure 8. Here it can be noted that, using a 102-ohm transformer, a SWR of 0.3 or better was obtained over the frequency range 130 to 370 Mc (4.2 to 12.0 Mc for full-scale antenna). The length of this transformer for the full-scale shipboard antenna would be about 29 feet. Pattern measurements were conducted in a vertical plane and are shown in Figure 9 for frequencies of 170, 250, and 350 Mc (5.5, 8.1, and 11.6 Mc for the full-scale antennas).

No structures were available on the DD693 to act as sleeve sections for antennas in the frequency range 10 to 30 Mc. Thus it was necessary to design a specific antenna for this frequency range. It has been previously shown[1] that a satisfactory antenna operating in this range can be designed with a sleeve section 3 feet in diameter and 7-1/2 feet long, and a top radiating

DECLASSIFIED

[redacted]

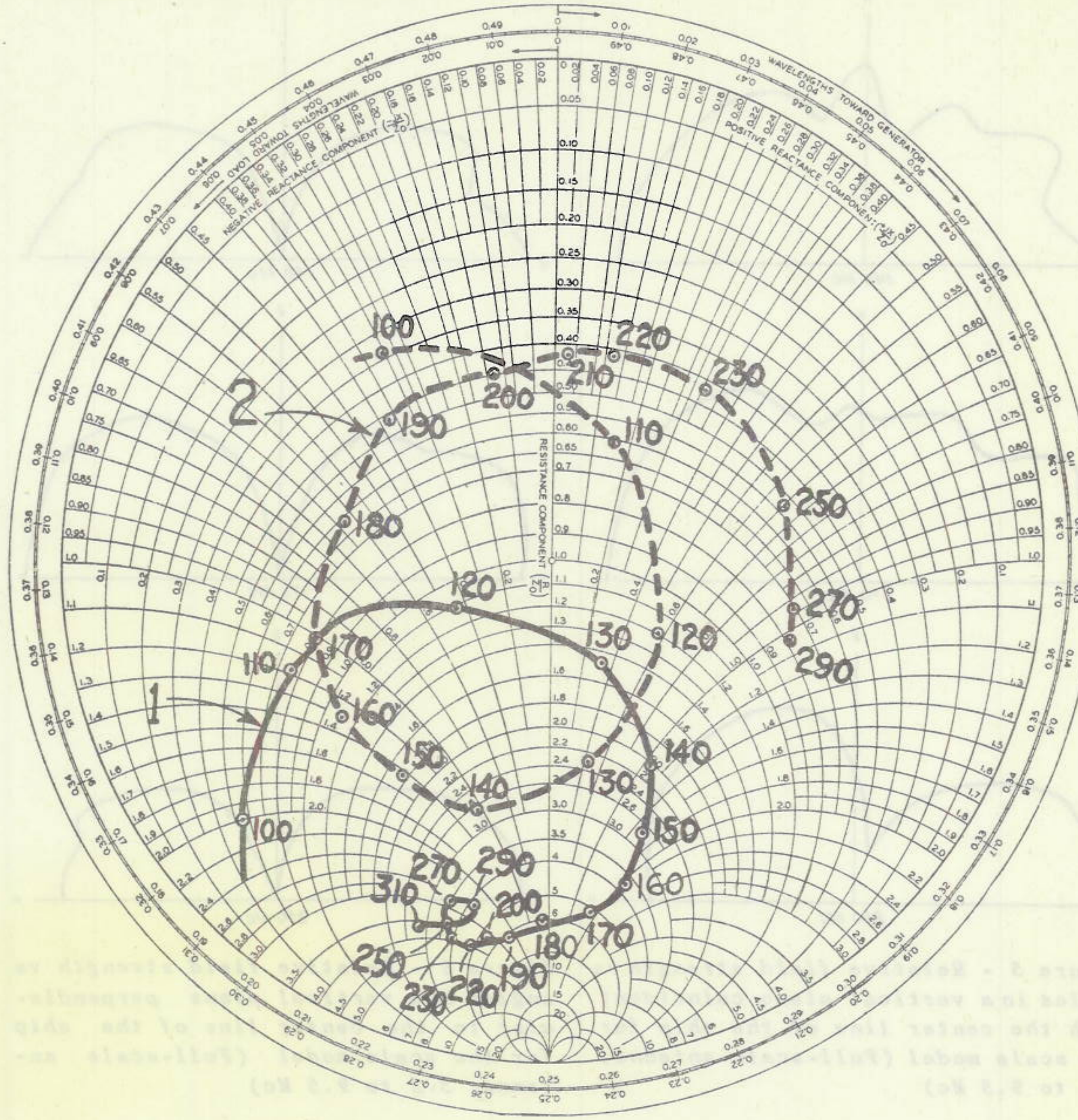


Figure 4 - Impedance characteristic for scale model (Full-scale antenna, 3.3 to 9.5 Mc); Curve (1) impedance characteristic; Curve (2) transformed impedance characteristic

[redacted]

DECLASSIFIED

Confidential

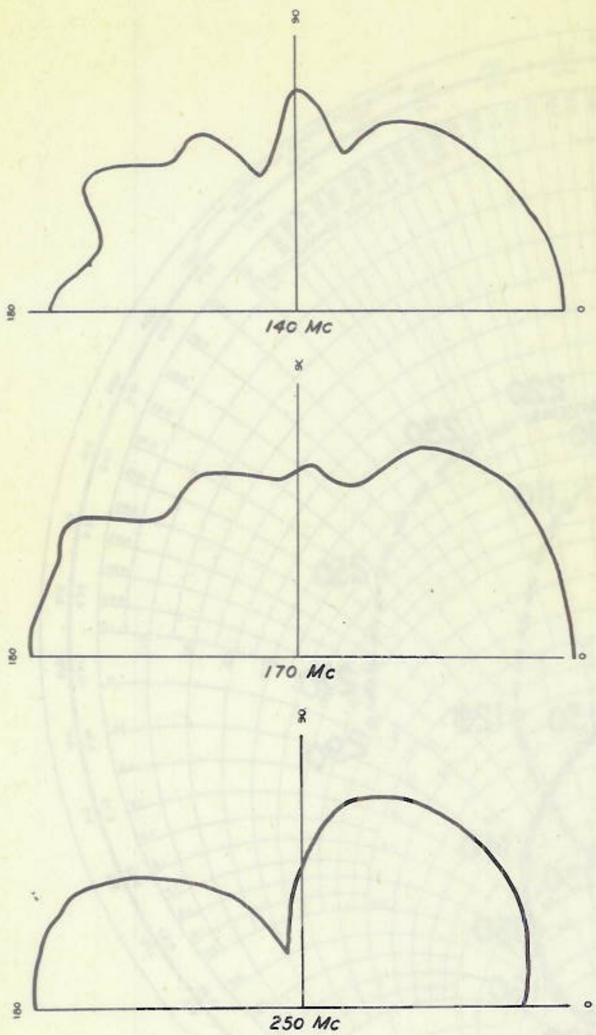


Figure 5 - Relative field strength vs angles in a vertical plane coincident with the center line of the ship for the scale model (Full-scale antenna, 3.3 to 9.5 Mc)

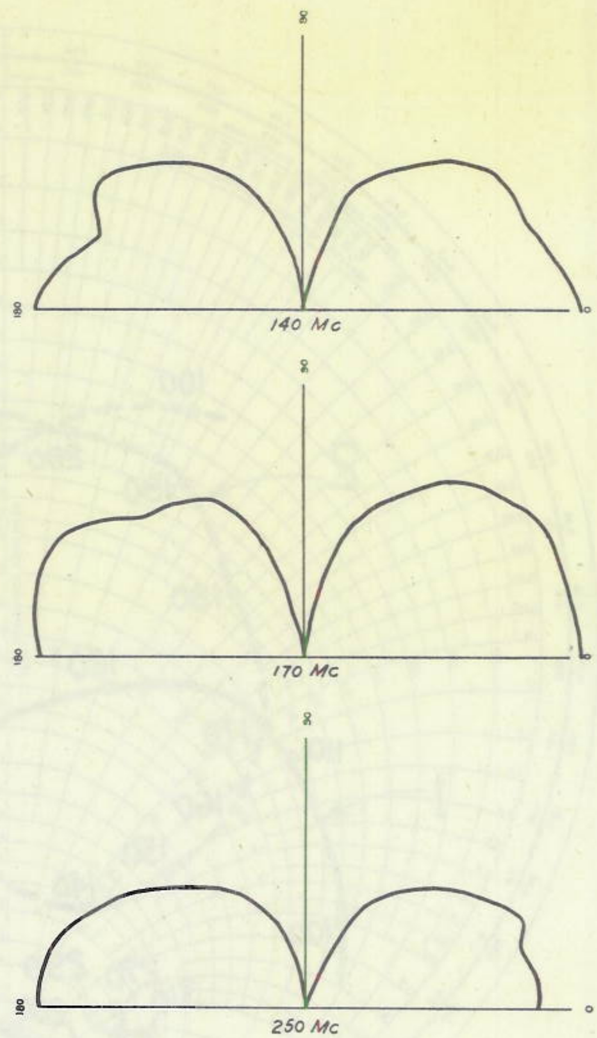


Figure 6 - Relative field strength vs angles in a vertical plane perpendicular to the center line of the ship for the scale model (Full-scale antenna, 3.3 to 9.5 Mc)

section made of a whip 2-1/4 inches in diameter and 15 feet long. To facilitate shipboard installation it may be advantageous to construct the lower (sleeve) section of this antenna in the form of a cage, which will reduce wind resistance and topside weight and produce results comparable to that of a solid structure. Values of resistance and reactance for the 10 to 30 Mc antenna are shown in Figure 10. To improve the standing wave ratios as seen by a 51.5-ohm line, a transformer of 114 ohms is used, and the impedance curves are shown in Figure 11. For the shipboard antenna in the 10 to 30 Mc range the length of this transformer would be 11.1 feet. Vertical pattern measurements for this scale model antenna have been made at frequencies of 157,200, and 270 Mc and are shown in Figure 12. It should be noted here that

Confidential

DECLASSIFIED

DECLASSIFIED

UNCLASSIFIED

no serious null occurs in the vertical pattern, and standing wave ratio values of better than 0.32 are maintained over the frequency range 90 to 270 Mc (10-30 Mc for the full-scale models).

CONCLUSIONS AND SUMMARY

Modified sleeve antennas have been developed which, when scaled by appropriate factors, will produce usable broadband communication antennas in the frequency range 3.3 to 30 Mc for use on destroyers of the USS 693 Class. The impedance characteristics and patterns are near optimum but probably will not be fully realized in a shipboard installation. The coupling between broadband antennas and the ship's superstructure will affect the impedance and pattern characteristics of the antennas. However, with careful placement, these effects can be minimized and results comparable to those reported herein can be obtained.

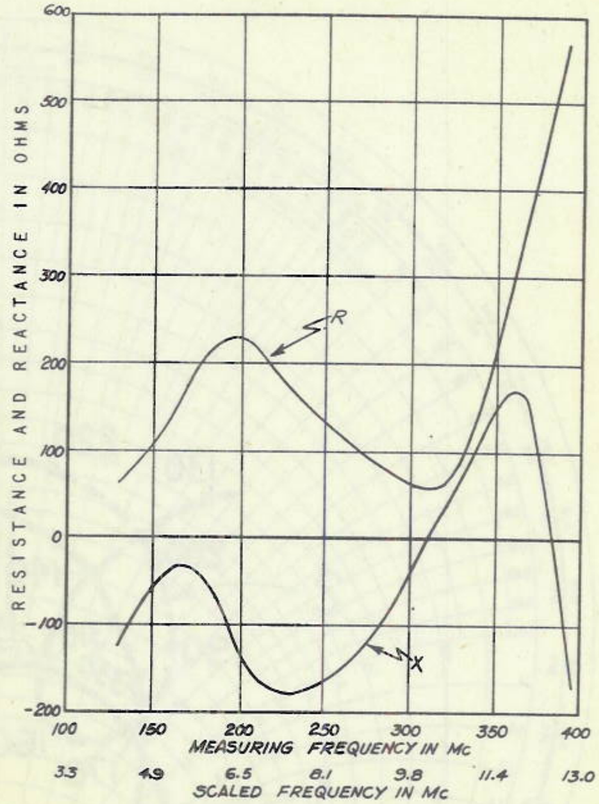


Figure 7 - Resistance and reactance vs frequency for scale-model (Full-scale antenna, 4.2 to 12.0 Mc)

The broadband characteristics of these antennas permit their use in a Common Antenna Working system. This system allows the simultaneous operation of several equipments on a common antenna. Thus the number of antennas can be reduced, permitting greater spacing between antennas as well as improving the impedance and pattern characteristics.

* * *

DECLASSIFIED

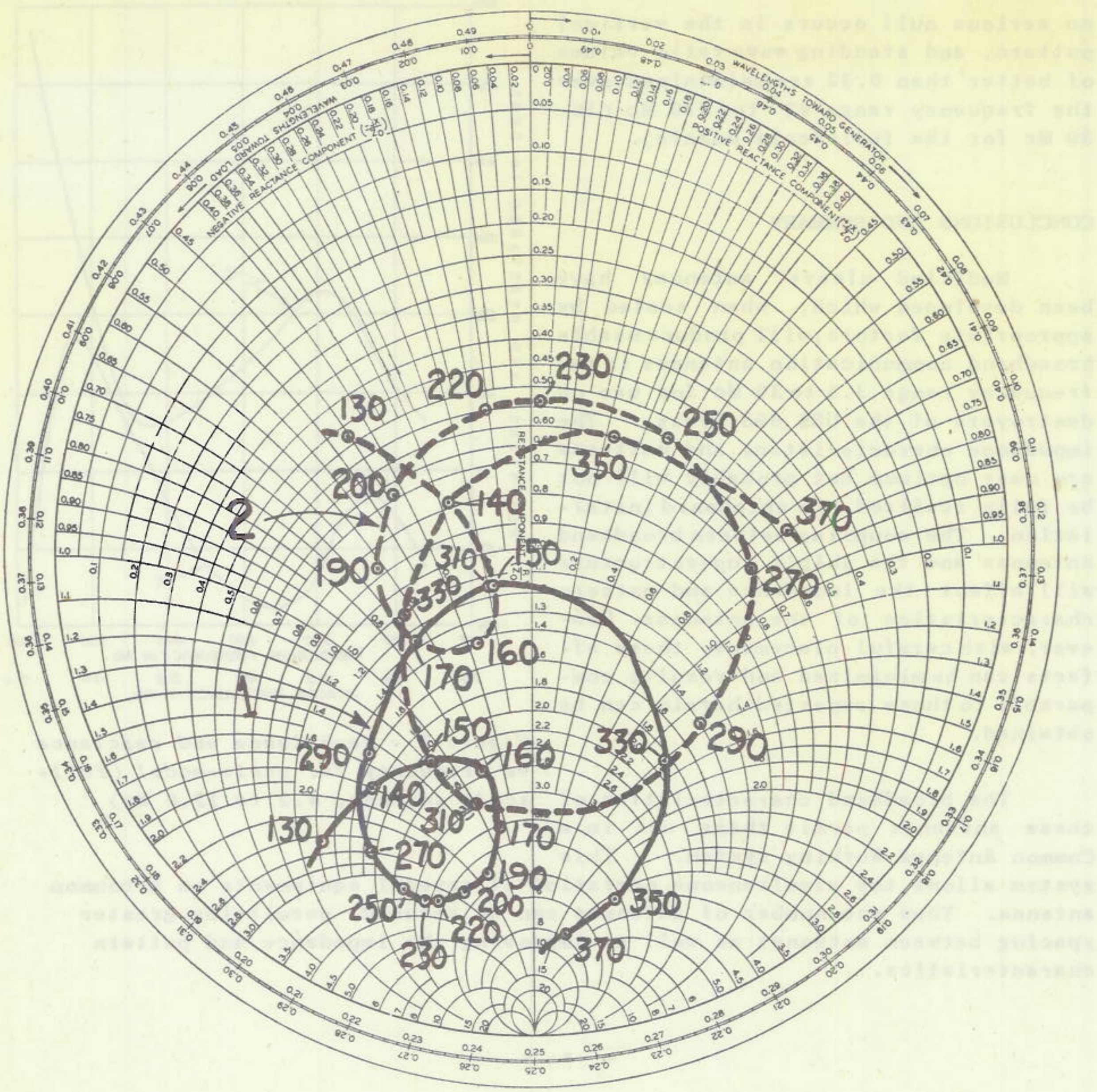


Figure 8 - Impedance characteristic for scale model (Full-scale antenna, 4.2 to 12.0 Mc); Curve (1) impedance characteristic; Curve (2) transformed impedance characteristic

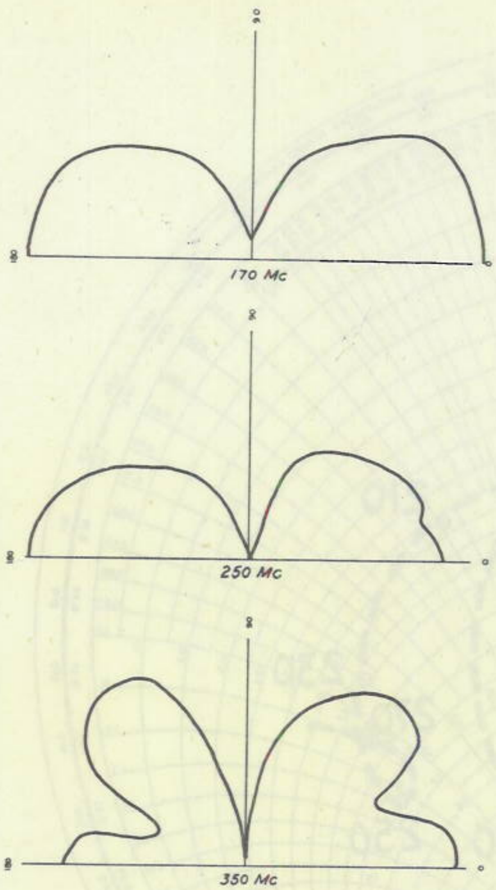


Figure 9 - Relative field strength vs angles in a vertical plane coincident with the center line of the ship for the scale model (Full-scale antenna, 4.2 to 12.0 Mc)

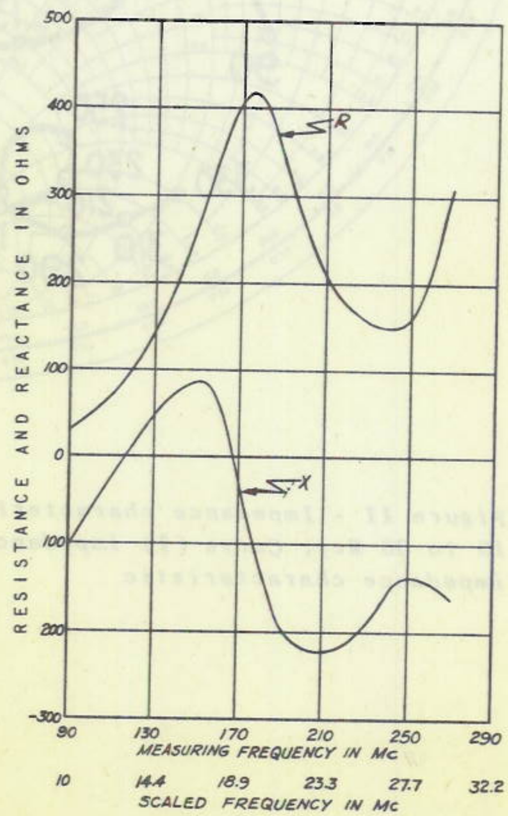


Figure 10 - Resistance and reactance vs frequency for scale model (Full-scale antenna, 10 to 30 Mc)

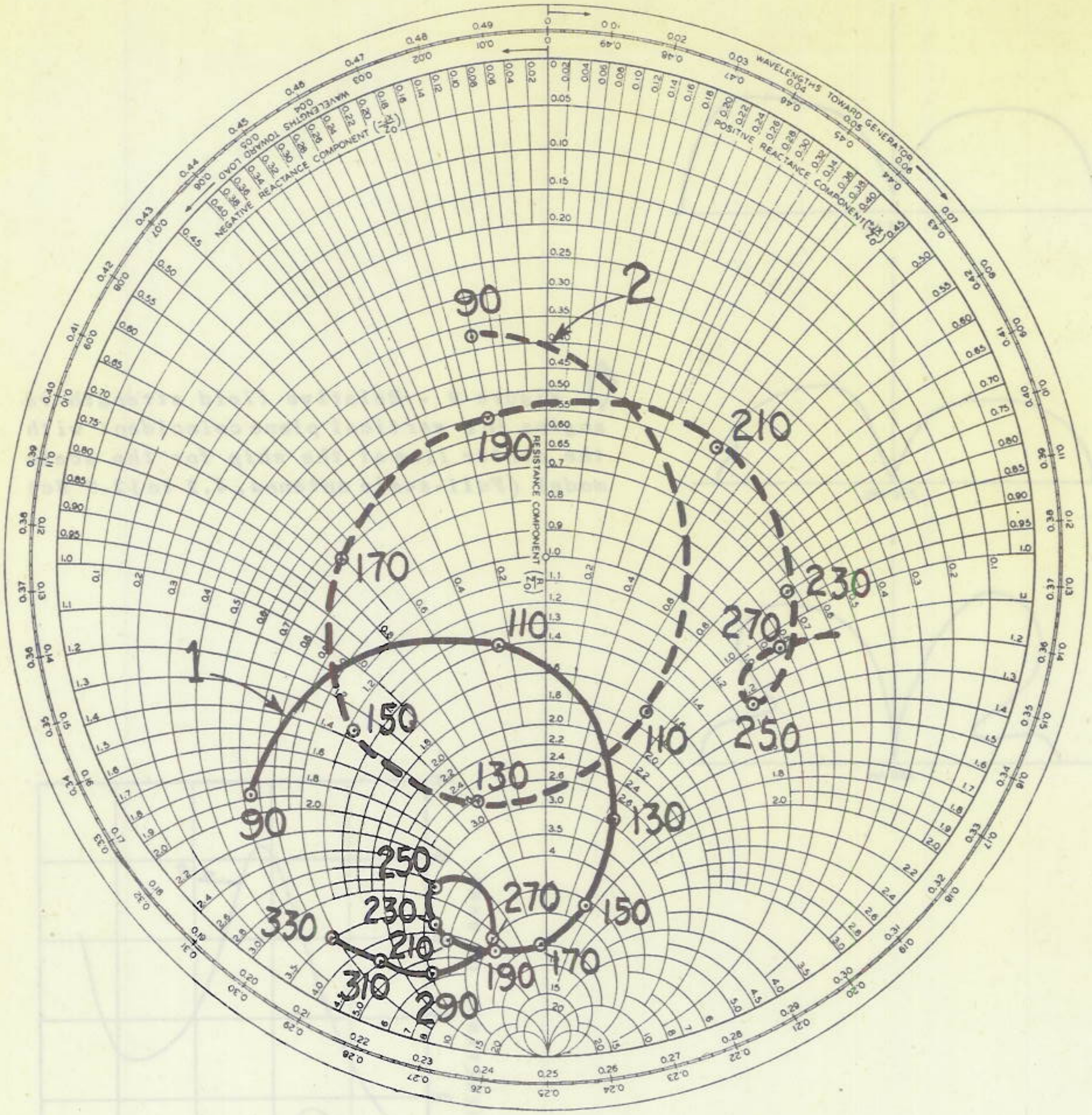
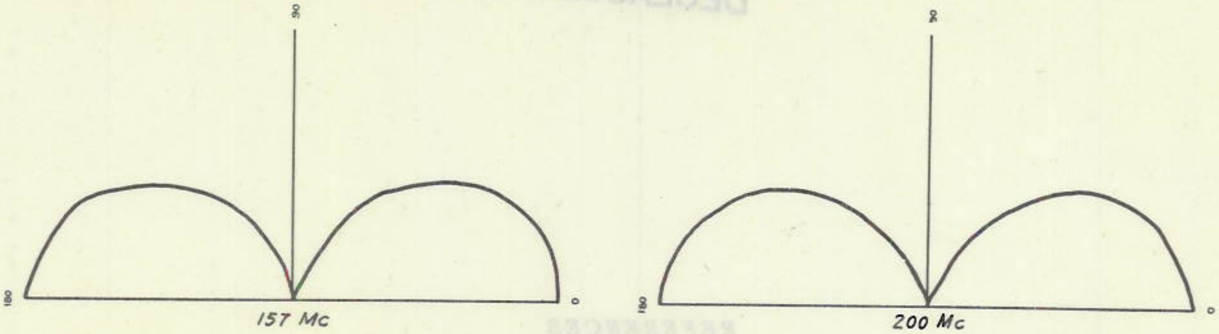


Figure 11 - Impedance characteristic for scale model (Full-scale antenna, 10 to 30 Mc); Curve (1) impedance characteristic; Curve (2) transformed impedance characteristic

Confidential

DECLASSIFIED



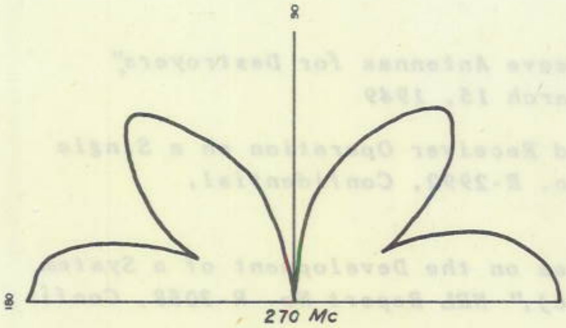


Figure 12 - Relative field strength vs angles in a vertical plane coincident with the center line of the ship for the scale model (Full-scale antenna 10 to 30 Mc)

* * *

Confidential

DECLASSIFIED

DECLASSIFIED

REFERENCES

1. Walters, A. W., "Broad-band Modified Sleeve Antennas for Destroyers," NRL Report No. R-3431, Confidential, March 15, 1949

2. White, L. R., "Multiple Transmitter and Receiver Operation on a Single Antenna (225 to 390 Mc)," NRL Report No. R-2992, Confidential, December 10, 1946.

3. Robbins, L. G. and Norgorden, O., "Notes on the Development of a System for Common Antenna Working (320-390 Mc)," NRL Report No. R-3058, Confidential, June 26, 1947

4. Robbins, L. G., "Common Antenna Working Coupler for 230 to 390 Mc," NRL letter report C-3910-96/48, Confidential, November 2, 1948

5. Leppert, M. L. and Meyer, R. B., "Common Antenna Working Coupler of High Frequency Range," NRL Progress Report April 1949, pp 58, Confidential

6. Huffman, L. C. and Walters, A. W., "Experimentally Determined Characteristics of Cylindrical Sleeve Antennas," NRL Report No. R-3354, Restricted, September 13, 1948

7. Walters, A. W. and Huffman, L. C., "Vertical Patterns of Cylindrical Sleeve Antennas," NRL Report No. R-3411, Restricted, February 2, 1949

DECLASSIFIED