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# SLEEVE ANTENNA CONSIDERATIONS FOR TASK FLEET FLAGSHIP (CLC-1)

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NRL REPORT R-3494

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# SLEEVE ANTENNA CONSIDERATIONS FOR TASK FLEET FLAGSHIP (CLC-1)

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#### ABSTRACT

An investigation has been conducted on the design of broad-band modified sleeve antennas for Task Fleet Flagships in the high-frequency range. Model techniques have been employed, using part of the ship's superstructure as the sleeve portion of these antennas and multiple wires supported by the masts as the upper radiating section.

Experimental data indicate that the model antennas have satisfactory characteristics over the measured frequency ranges. If scaled by appropriate factors, these antennas will operate in the frequency ranges 1.9 to 5.7 Mc and 2.8 to 7.2 Mc, and when used with matching networks, will have standing-wave-ratio values of 0.3 or better on a 50-ohm line. Two additional scale-model sleeve antennas which do not employ parts of the ship's superstructure as antenna parts have been designed for use in the 5 to 15 Mc and 10 to 30 Mc ranges. Representative patterns in a vertical plane are shown for all these antennas.

#### PROBLEM STATUS

This report completes one phase of the problem; work is continuing.

#### AUTHORIZATION

NRL Problem 39R09-01R

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SLEEVE ANTENNA CONSIDERATIONS FOR  
TASK FLEET FLAGSHIP (CLC-1)

## INTRODUCTION

A brief study has been made of Task Fleet Flagship (CLC-1) to determine optimum design considerations for broad-band sleeve antennas to operate in the high-frequency range. Modified sleeve antennas were considered as one of the more desirable types of design since structures on the ship could act as part of the antenna. Since this design incorporates structures which could normally distort the field pattern, a number of advantages over conventional antennas are obtained; namely, very effective broad-band antenna operation with very little increase in topside weight and improvement in patterns in all planes.

There are two other factors of considerable importance, although essentially unrelated, which support the use of broad-band sleeve antennas. The first of these is the operation of several equipments simultaneously on the same antenna system by use of the "Common Antenna Working" principle.<sup>\*1,2,3,4</sup> The second factor relates to transmission at frequencies where the antenna is a considerable portion of a wavelength long. At these frequencies, the vertical patterns of a sleeve antenna are inherently better than for a simple vertical antenna, as the field propagated is either a maximum or within several db of the maximum along the horizon. The importance of low-angle radiation in long distance communication is well known and general references can be found in the literature. A brief analysis showing the importance of low-angle radiation has been reported in the range of 500 to 2500 miles.<sup>5</sup>

It has been previously shown that a satisfactory broad-band antenna could be constructed using a relatively short sleeve section having a large diameter in conjunction with a long upper radiating section having a small diameter.<sup>6,7</sup> A previous investigation<sup>5</sup> has shown that (1) the stack of a ship can be used as the sleeve section of a broad-band sleeve antenna, and (2) the upper radiating section need not be vertical for satisfactory operation. Thus it was considered that the stack of CLC-1 would provide a satisfactory element for one or more antennas.

Assuming that the stack were to be used as the sleeve section of an antenna, 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, coupled with a knowledge of sleeve antenna design,<sup>6,7</sup> indicated that the general type of sleeve antenna most promising consisted of antennas having radiator length to sleeve length ratios ranging from 1.2/1 to 2/1. The ratio of the radiator diameter to sleeve diameter should be about 1/16. The expected frequency range for this antenna design would be of the order of 2.5 to 1 in the frequency band 2 to 8 Mc.

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\* A list of references will be found at the end of this report.

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## METHOD OF MEASUREMENT

Methods of impedance measurement used for modified sleeve antennas have been previously reported<sup>5,6</sup>. The physical arrangement for making measurements is shown in Figure 1. Briefly, the antenna to be measured was 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.

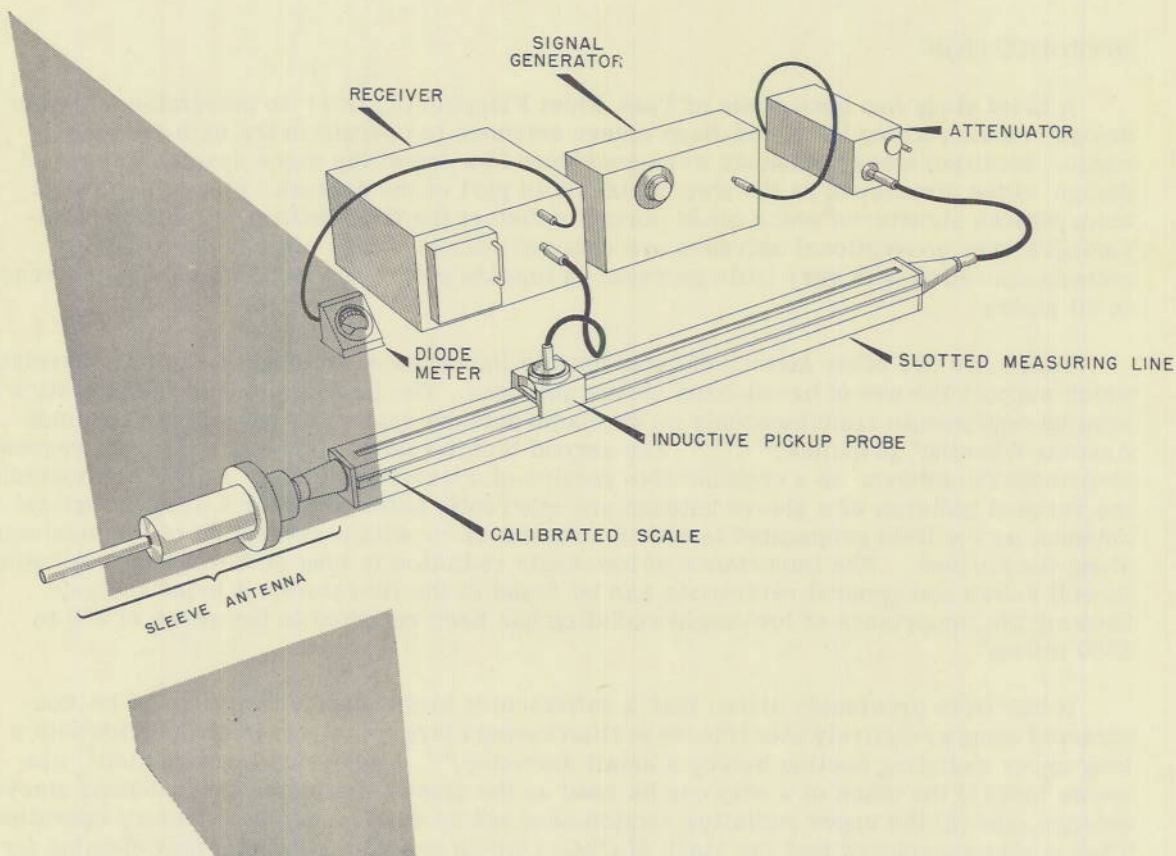


Fig. 1 - Arrangement for making impedance measurements

A sketch of the system for measurement of vertical patterns is shown in Figure 2. The method used was as follows: At each frequency the transmitting antenna was placed in the system and radio-frequency power 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 with the loop antenna. Thus a continuous recording of field strength was obtained from 0 to 180 degrees. The system sensitivity was limited to about 25 db in the average case, and system errors in general were less than 2 db.

## EXPERIMENTAL RESULTS

In order to use an available measuring system it was necessary to scale the shipboard antennas to fit the system. The antennas covering the ranges 1.9 to 5.7 Mc and 2.8 to 7.2 Mc

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were scaled by a factor of 60, and the antennas in the 10 to 30 Mc and 5 to 15 Mc ranges by factors of 9 and 18, respectively. By applying these scaling factors to the model antennas, the frequencies used ranged from 90 to 430 Mc.

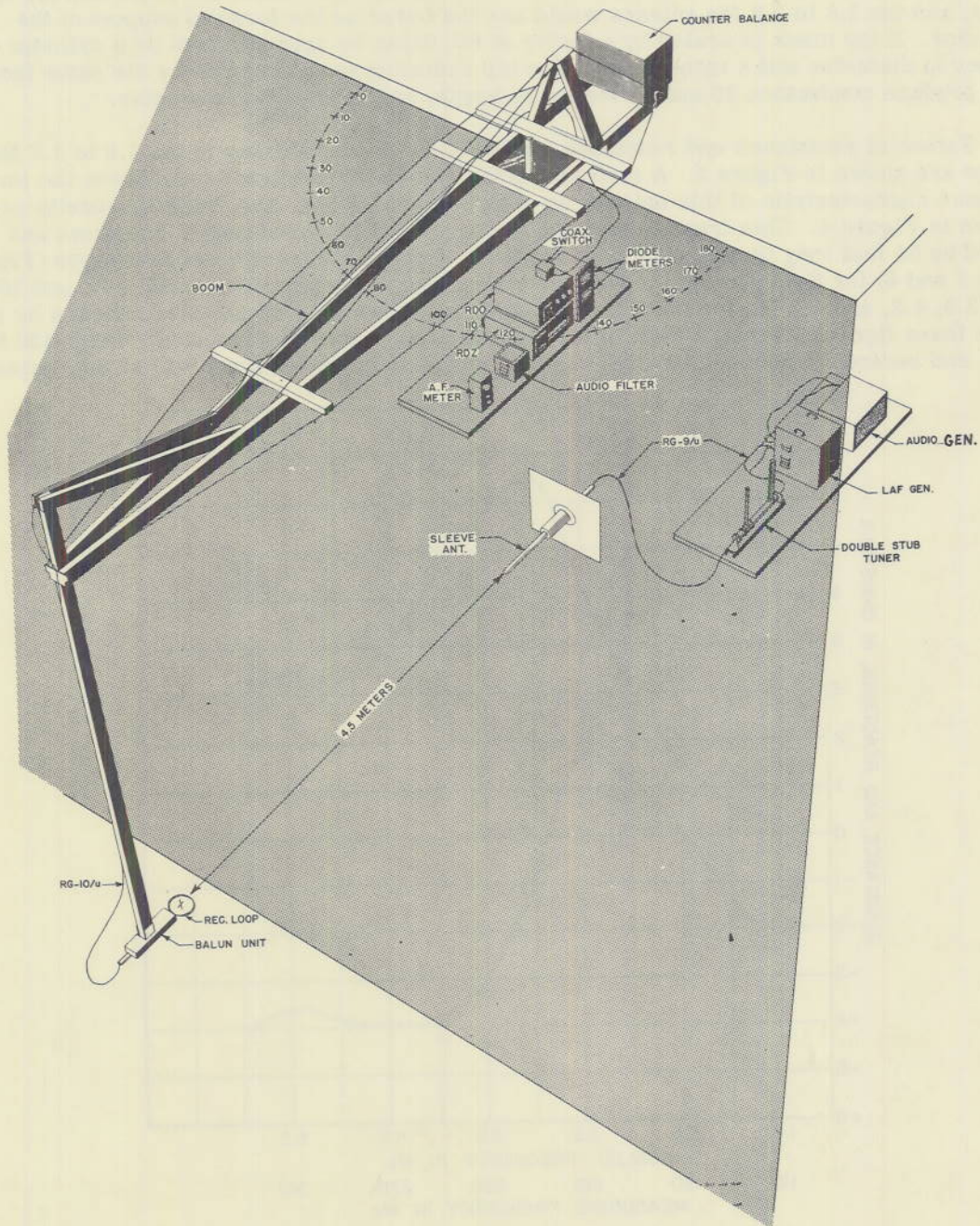


Fig. 2 - Arrangement for making pattern measurements

As previously stated, the two lower frequency antennas use the stack as the sleeve section of the antenna, and the top radiating sections of these full-scale antennas would be 80 and 50 feet in length, and 6 inches in diameter. To approximate the 6-inch diameter radiator, a wire cage or multiple wires could be used with either antenna. The top radiating section of the 1.9 to 5.7 Mc antenna would be connected between the stack and the mainmast; and the 2.8 to 7.2 Mc antenna would use the tower as the forward support of the radiator. If the stack is scaled by a factor of 60, it can be approximated by a cylinder 4 inches in diameter and 8 inches long. The top radiating section scaled by the same factor will produce conductors 16 and 10 inches in length, and 0.10 inch in diameter.

Values of resistance and reactance for the scale-model antenna in the 1.9 to 5.7 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 as shown in Figure 4. This transformer has a characteristic impedance of 110 ohms and would be 54 feet long for the shipboard antenna. Pattern measurements are shown (Figures 5 and 6) for field strength in two vertical planes at frequencies of 140, 250, and 290 Mc (2.3, 4.2, and 4.8 Mc for the full-scale antenna). Two general observations can be made from these figures. First, a SWR of 0.3 was maintained over the frequency range 130 to 310 Mc, and second, in no case does the vertical radiation pattern show a null at the horizon.

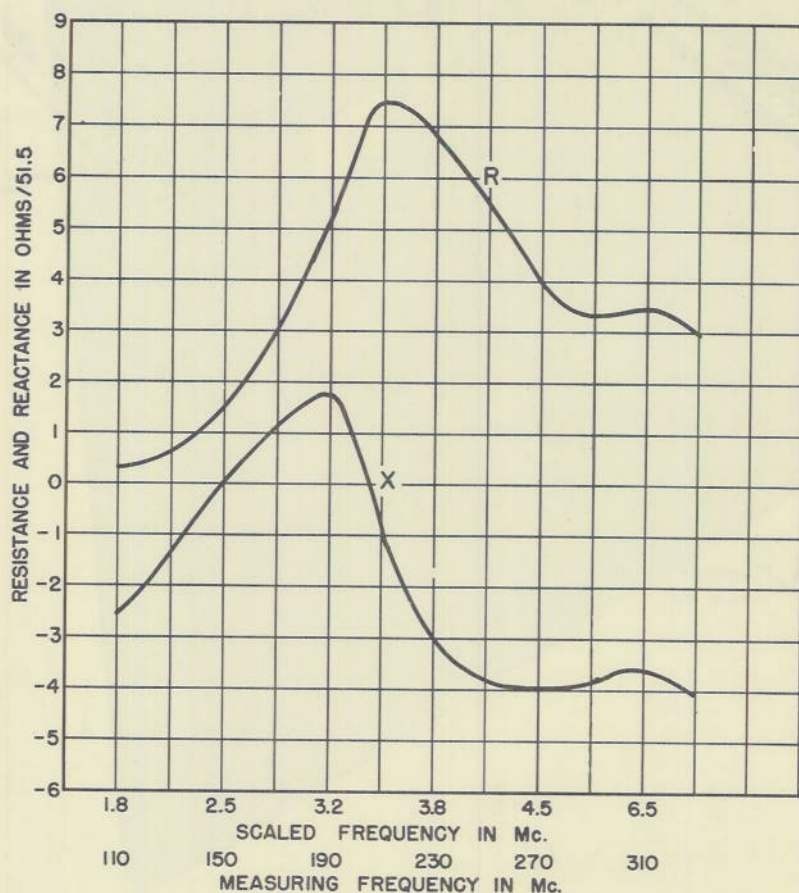


Fig. 3 - Resistance and reactance vs frequency for scale model. (Full scale antenna, 1.9 to 5.7 Mc)

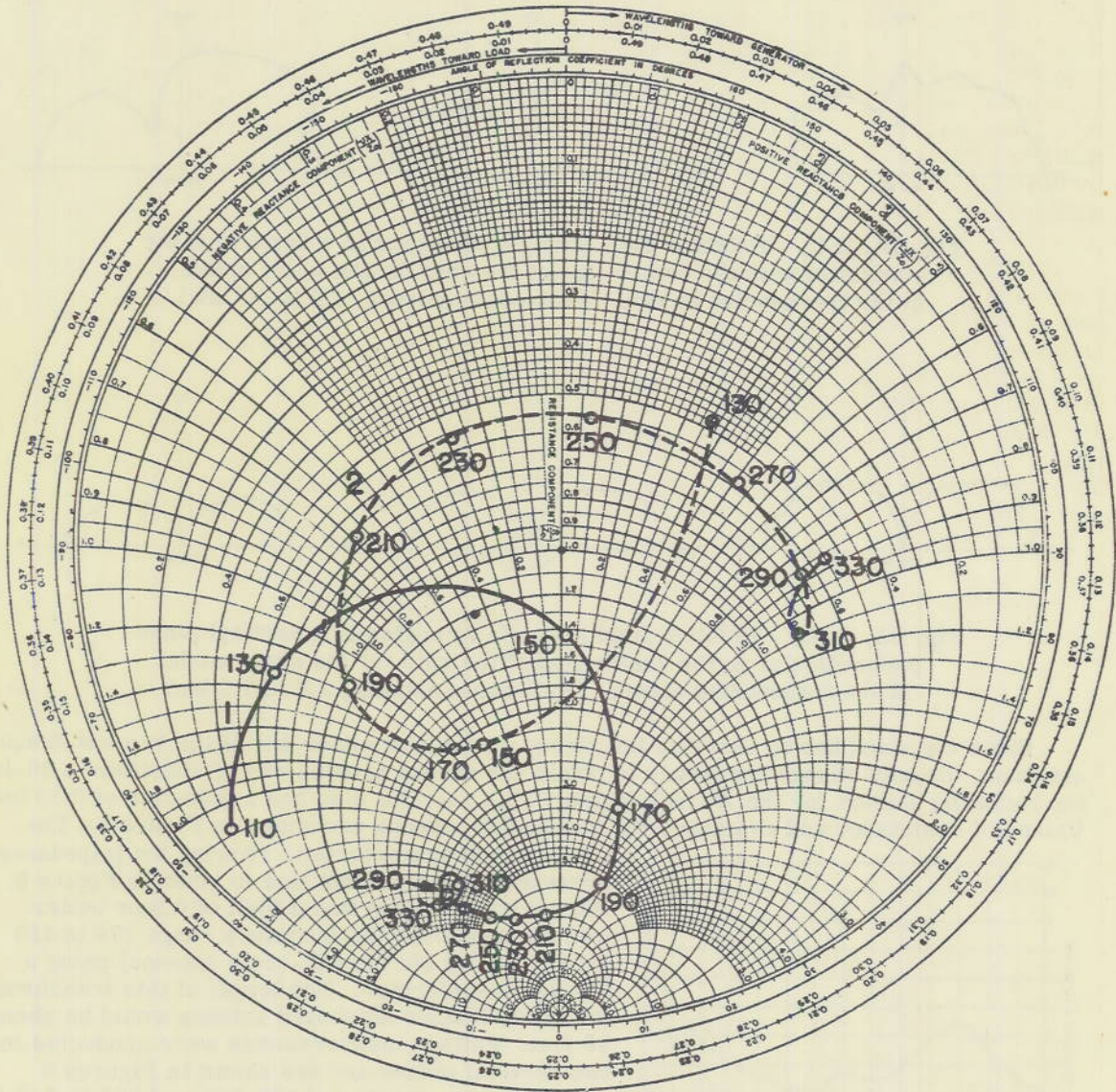


Fig. 4 - Impedance characteristic of scale model. (Full-scale antenna, 1.9 to 5.7 Mc) antenna. Curve (1) Impedance Characteristic. Curve (2) Transformed Impedance Characteristic

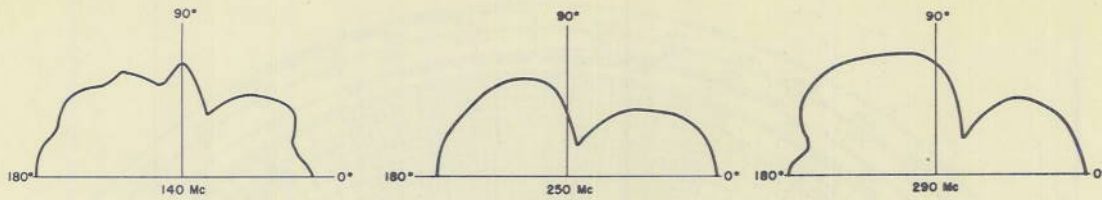


Fig. 5A, B, C, - Relative field strength vs angles in a vertical plane coincident with the center line of the ship for the scale model at the frequencies shown. (Full-scale antenna, 1.9 to 5.7 Mc)

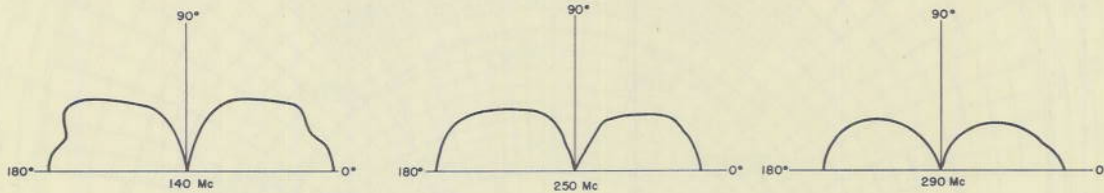


Fig. 6A, B, C, - Relative field strength vs angles in a vertical plane perpendicular to the center line of the ship for the scale model at the frequencies shown. (Full-scale antenna, 2.8 to 7.2 Mc)

Since the stack has to serve as the sleeve section for either one of the two low-frequency antennas, the only change necessary to obtain the second antenna was to substitute a 10-inch top radiating section for the 16-inch length. This radiator also had a diameter of 0.10 inch. Values of resistance and reactance for this scaled antenna are shown in Figure 7. The

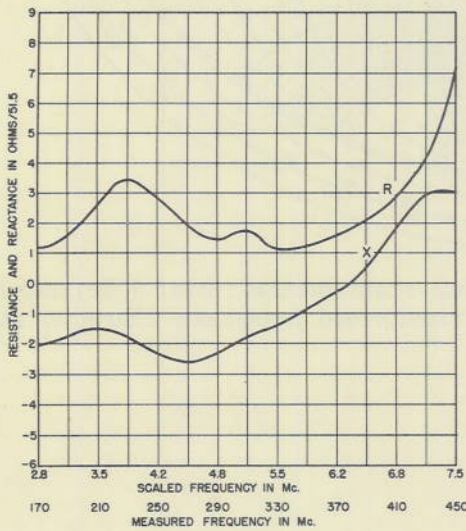


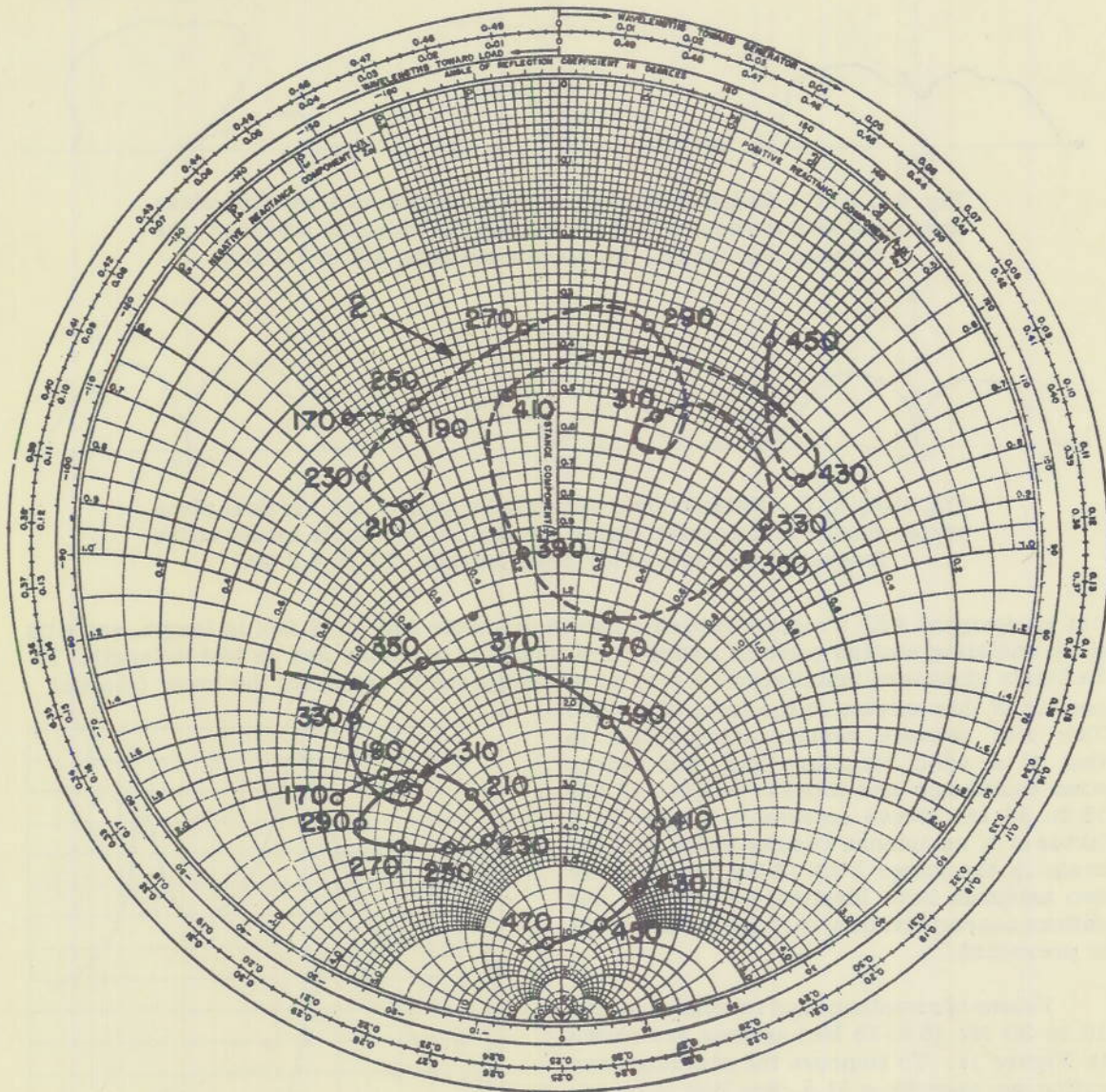
Fig. 7 - Resistance and reactance vs frequency for scale model. (Full-scale antenna, 2.8 to 7.2 Mc)

transformed characteristic showing the impedances presented to a 51.5-ohm line is given in Figure 8. Here it can be noted that a SWR of 0.3 or better was obtained over the frequency range 170 to 430 Mc (2.8 to 7.2 Mc for full-scale antenna) using a 75-ohm transformer. The length of this transformer for the full-scale shipboard antenna would be about 40 feet. Pattern measurements were conducted in two vertical planes and are shown in Figures 9 and 10 for frequencies of 170, 295, and 390 (2.8, 4.9, and 6.5 Mc for the full scale antennas).

No structures were available on this ship to act as sleeve sections for antennas in the frequency range 7 to 30 Mc. Thus in view of the stringent communication requirements placed on this ship, antennas in this range were designed using separate structures. Two antennas were designed to cover this frequency range, one from 5 to 15 Mc and another from 10 to 30 Mc.

It has been previously shown that a satisfactory antenna operating in the frequency range 10 to 30 Mc

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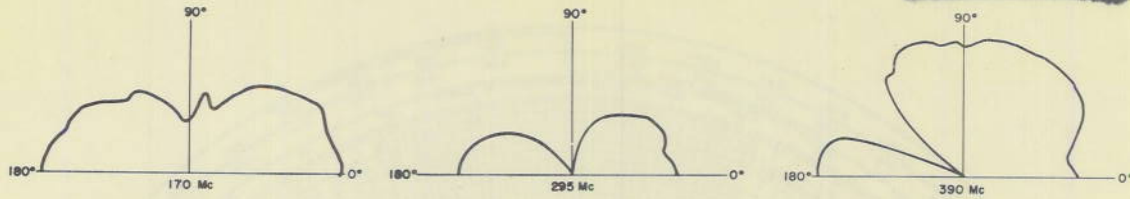


Fig. 9A, B, C - Relative field strength vs angles in a vertical plane coincident with the center line of the ship for the scale model at the frequencies shown. (Full-scale antenna, 2.8 to 7.2 Mc)

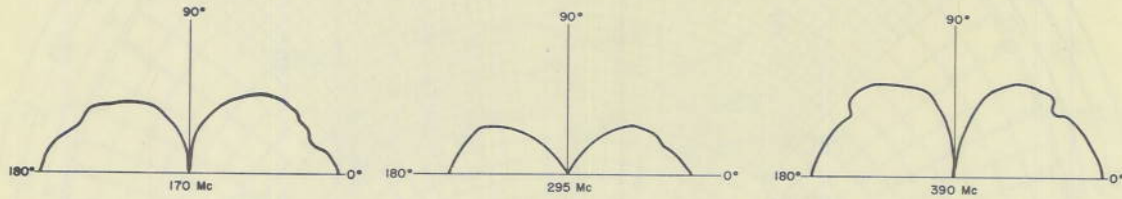


Fig. 10A, B, C - Relative field strength vs angles in a vertical plane perpendicular to the center line of the ship for the scale model at the frequencies shown. (Full-scale antenna, 2.8 to 7.2 Mc)

can be designed with a sleeve section 3 feet in diameter and 7-1/2 feet in length, and with a top radiating section made of a whip 2-1/4 inches in diameter and 15 feet in length.<sup>5</sup> To facilitate shipboard installation, it may be advantageous to construct the lower (sleeve) section of this antenna in the form of a cage. This will produce results comparable to that of a solid structure and thus reduce wind resistance and topside weight. If the 10 to 30 Mc sleeve antenna is scaled by a factor of 2, an antenna results which will operate in the range 5 to 15 Mc. Since these two antennas have identical impedance and pattern characteristics, only one set of curves is presented.

Values of resistance and reactance for the 10 to 30 Mc (5 to 15 Mc) antenna are shown in Figure 11. To improve the standing wave ratios as seen by a 51.5-ohm line, a transformer of 114 ohms is used, and these data are shown in Figure 12. For the shipboard antenna in the 10 to 30 Mc range, the length of this transformer would be 11.1 feet. A length of 22.2 feet is required for 5 to 15 Mc antenna. Vertical pattern measurements have been made and are shown in Figure 13 at frequencies of 157, 200, and 243 Mc. It should be noted here that 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 to 30 Mc and 5 to 15 Mc for the full-scale antennas).

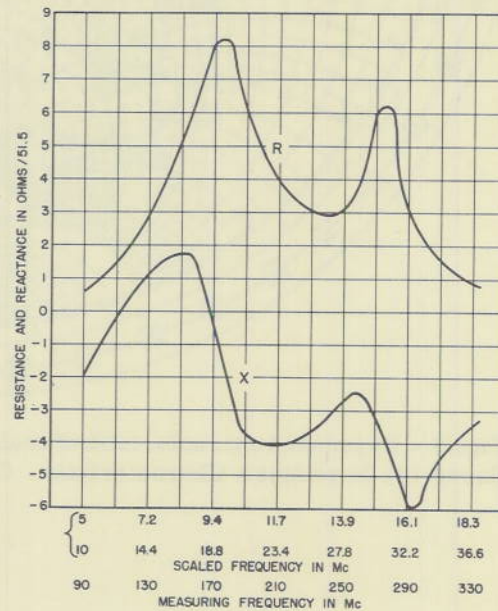


Fig. 11 - Resistance and reactance vs frequency for scale model. (Full-scale antenna 10 to 30 or 5 to 15 Mc)

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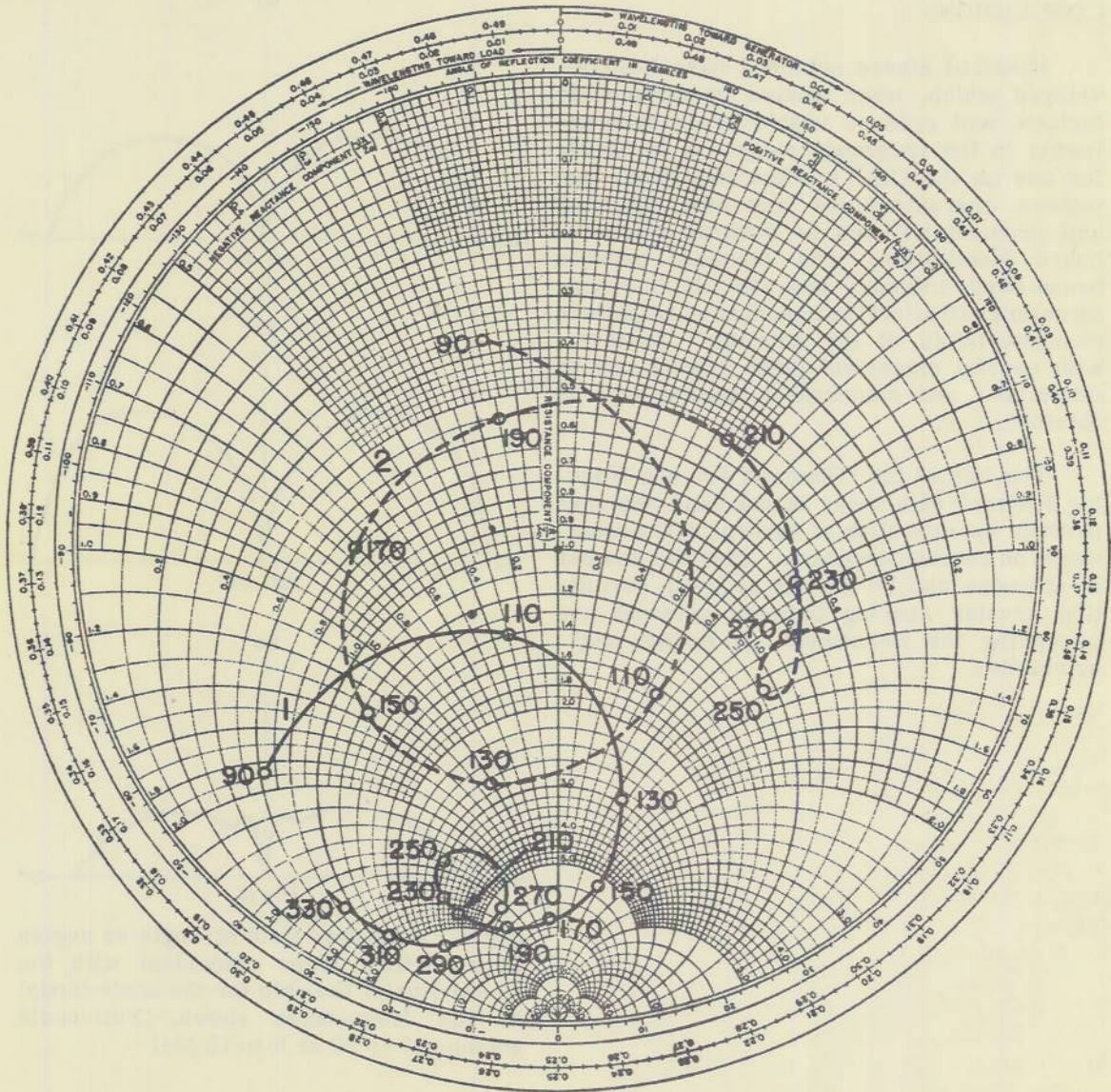


Fig. 12 - Impedance characteristic of scale model. (Full-scale antenna, 10 to 30 or 5 to 15 Mc)  
Curve (1) Impedance Characteristic. Curve (2) Transformed Impedance Characteristic

CONCLUSIONS

Modified sleeve antennas have been developed which, when scaled by appropriate factors, will produce usable broad-band antennas in the frequency range 1.9 to 30 Mc for use on the CLC-1. The impedance and pattern characteristics are near optimum and probably will not be obtained in a ship-board installation. The coupling between broad-band 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 comparable results can be obtained.

The use of the "Common Antenna Working System" with these broad-band antennas permits the operation of several radio equipments on a common antenna. Thus the number of antennas can be greatly reduced, permitting greater spacing between antennas and improving the impedance and pattern characteristics.

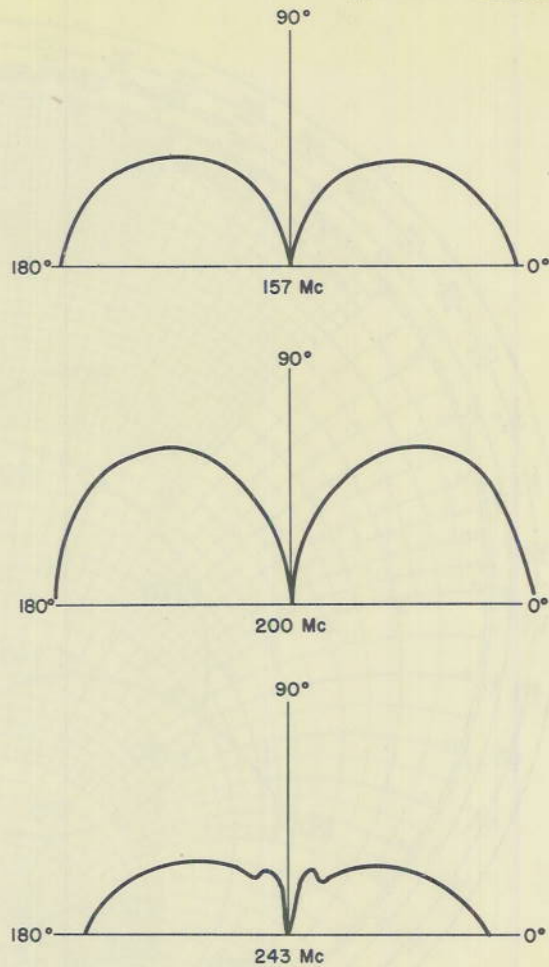


Fig. 13 - Relative field strength vs angles in a vertical plane coincident with the center line of the ship for the scale model at the frequencies shown. (Full-scale antenna 10 to 30 or 5 to 15 Mc)

\* \* \*

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