## Evaluation of the HF antenna system for HMCS "Bonaventure" by model radiation pattern measurements

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# NATIONAL RESEARCH COUNCIL OF CANADA

## RADIO AND ELECTRICAL ENGINEERING DIVISION



# ÉVALUATION OF THE HF ANTENNA SYSTEM FOR HMCS "BONAVENTURE" BY MODEL RADIATION PATTERN MEASUREMENTS



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OTTAWA

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## ABSTRACT

The performance of the HF antenna system for HMCS "Bonaventure" is evaluated by model radiation pattern measurements. The significant information from the patterns is obtained by the method developed at the U.S. Naval Research Laboratory. The performance of each of the 26 antennas evaluated is presented in graphical form on two figures.

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# EVALUATION OF THE HF ANTENNA SYSTEM FOR HMCS "BONAVENTURE" BY MODEL RADIATION PATTERN MEASUREMENTS

- J.Y. Wong -

## INTRODUCTION

The ideal horizontal radiation pattern of an HF shipboard communication antenna is one in which the signal strength is constant as a function of the ship's bearing. This ideal pattern is seldom, if ever, achieved because of deleterious effects caused by mutual coupling between antennas and between the antenna and adjacent superstructure. A typical pattern, therefore, would be one which is characterized by variations in signal strength, with the resultant maxima and minima. This undesirable directivity of the pattern may or may not affect the performance of the antenna adversely. This will depend upon the character of the maxima and minima.

In the evaluation of the performance of a shipboard antenna system by model studies, the large number of radiation patterns involved makes it extremely difficult, and often impracticable, to ascertain the performance of an antenna by inspection and comparison of the radiation patterns. A satisfactory method [1] for analyzing a pattern characterized by undesirable directivity has been developed and employed at the U.S. Naval Research Laboratory. Their method is employed to assess the performance of the HF antenna system on the aircraft carrier, HMCS "Bonaventure". A brief description of the method of analysis is given in the following section.

## METHOD OF ANALYSIS

In the analysis of the patterns of a communications antenna for the purpose of obtaining a "figure of merit", the primary problem to be investigated is the loss in performance due to the undesirable directivity. The pertinent information contained in the pattern is considered to be the following:

1) depth of the minimum field strength below a reference level,
2) width in angular degrees of the minima,
3) direction or bearing of the minima,
4) variation of the minima with frequency,
5) variation of the minima with respect to the terminating impedance of adjacent antennas.

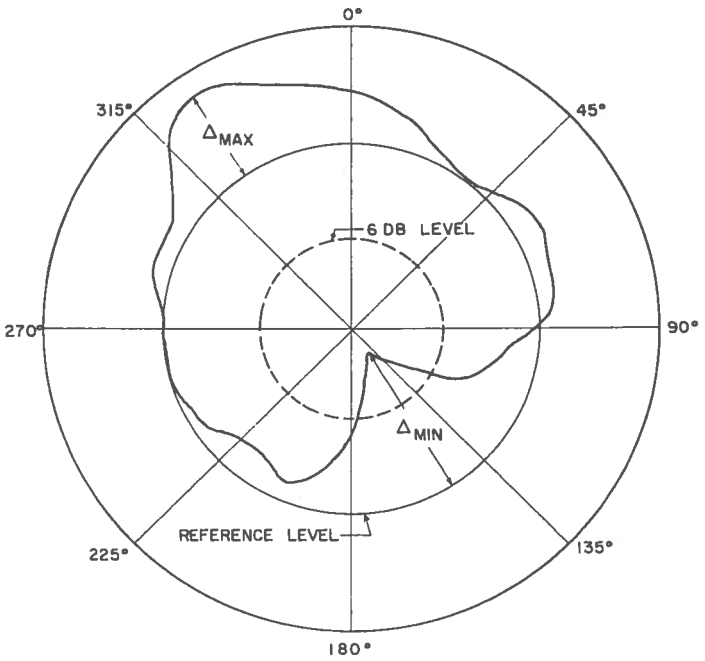



FIG. 1. TYPICAL RADIATION PATTERN USED IN ANALYZING THE PERFORMANCE OF AN HF ANTENNA

A typical radiation pattern of an HF antenna is shown in Fig. 1. The equivalent power radiated by an omnidirectional antenna is determined by measuring the area under the pattern with the aid of a planimeter. The reference level is thus established. The maximum and minimum signal levels above and below the reference level, $\Delta_{max}$ and $\Delta_{min}$, respectively, are obtained and plotted on a graph as a function of frequency.

In addition to the magnitude of a minimum, the angular width of a minimum with respect to the reference level must also be considered as a contributing factor to the loss in antenna performance. In this case the pattern is divided into 12, 30° sectors. The angular width in degrees for which the signal level is, say, 6 decibels below the reference level is tabulated for each of the 30° sectors. This information is recorded for each frequency. From the data in this table, the probability of a loss in signal of more than 6 decibels below the reference level in one 30° sector is computed. The average value of the probability for the 12 sectors can be obtained and this quantity is referred to as the "figure of merit" of the antenna. By this analysis, a numerical rating can be obtained for comparing the pattern characteristics of several antennas.

## MODEL RADIATION PATTERN MEASUREMENTS

The HF antennas on HMCS "Bonaventure" consist mainly of standard 35-foot

whips located on the island and around the flight deck. A photograph of the $\frac{1}{48}$-scale model used in the radiation pattern measurements is shown in Fig. 2. The antennas on the model are used for receiving, and the illuminating antenna — a corner reflector — can be seen in the background. Radiation patterns are plotted automatically in polar coordinates showing signal strength as a function of the ship's bearing.

A total of 26 antennas were evaluated and patterns were measured for a frequency interval of 2 mc/s (actual) from 2 to 30 mc/s. In the initial measurements radiation patterns were taken for each antenna with short-circuited terminations on all the other antennas. The measurements were then repeated with the antennas open-circuited. In this manner the effect of mutual coupling between the antenna under test and the parasitic antennas could be determined. In actual operation, there may be a wide range of terminating impedance on the parasitic antennas and it is impossible to duplicate the exact conditions in our model measurements. By terminating the parasitic antennas with open and short circuits, it is believed that the actual condition will be bounded by these two extreme cases. In the presentation of the results, only the worst case is given.

## DISCUSSION OF RESULTS

The HF antennas which were evaluated are identified in Figs. 3 and 4. Fig. 3 shows the antennas located around the flight deck and Fig. 4 shows the antennas located on the island. The performance of each antenna is presented on two graphs: one graph shows the variation of $\Delta_{max}$ and $\Delta_{min}$ as a function of frequency, and a second graph shows the probability of a loss in signal more than 6 decibels below the reference, plotted as a function of the 30° sectors. In general it is observed that the performance of the island antennas is inferior to that of those around the flight deck. This result is not surprising since there are large structures in the immediate vicinity of the radiators. From examination of Figs. 5 to 30, it is possible to determine qualitatively with relative ease the performance of the HF antenna system.

## ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of Mr. J. R Dawson who was largely responsible for the radiation pattern measurements.

## Reference

1. "Analysis of Antenna Patterns with Undesirable Directivity", O. Norgorden, R.F. Schmidt, and M.L. Musselman, NRL Report 4211, August 21, 1953 (Confidential)

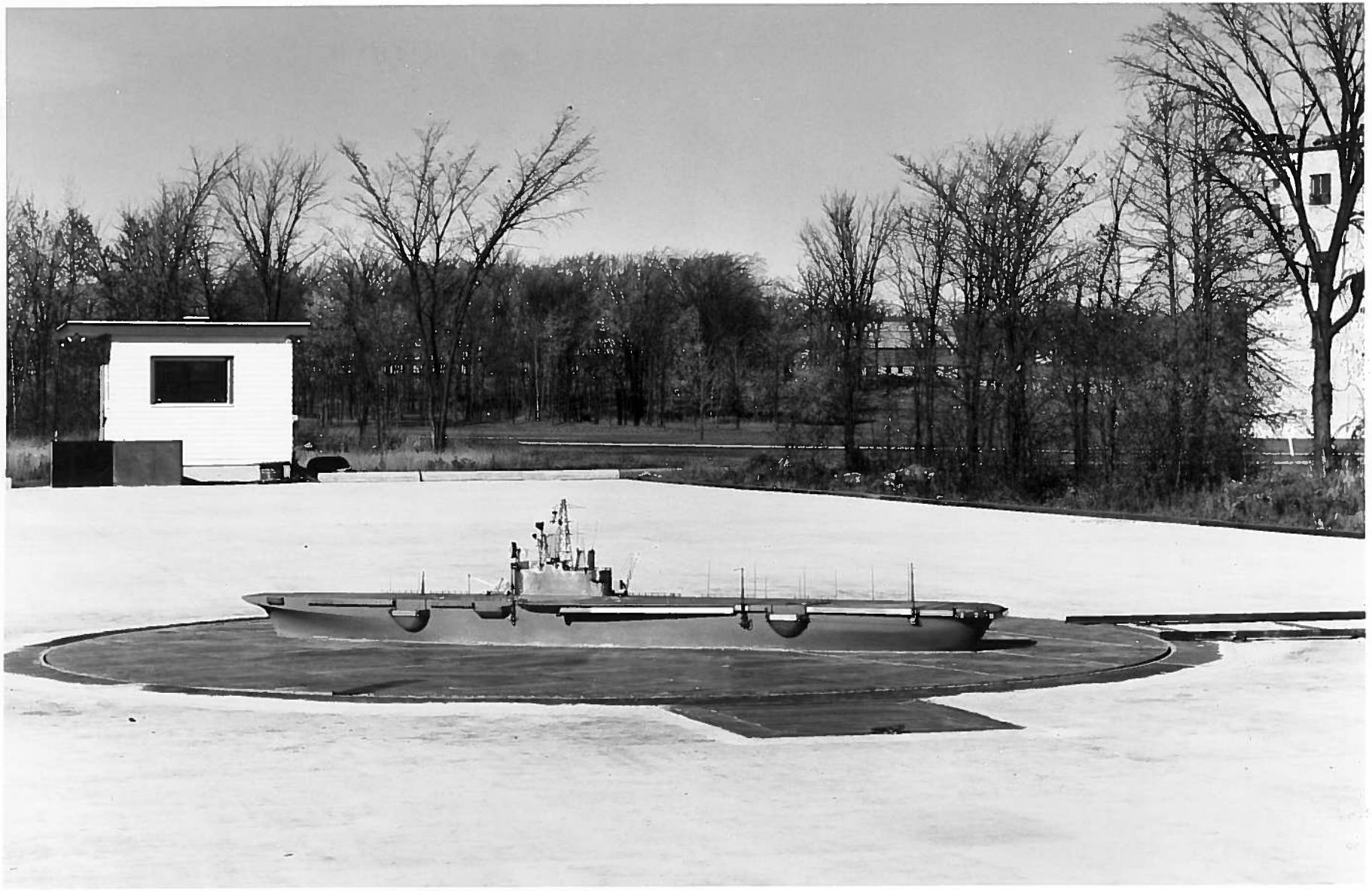
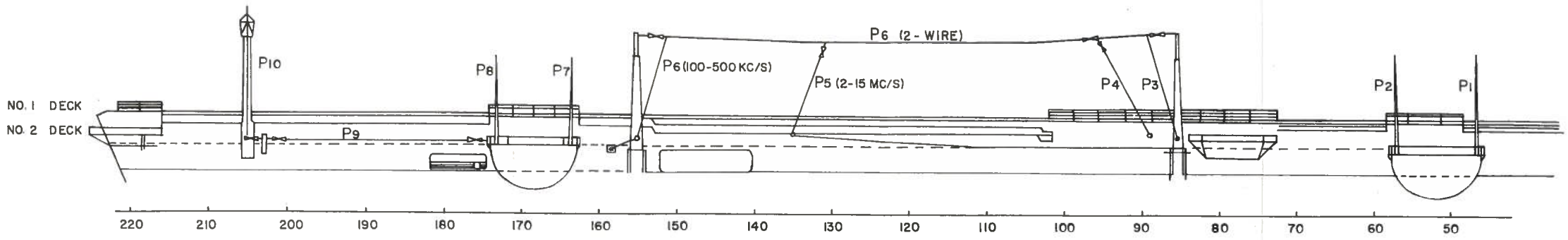
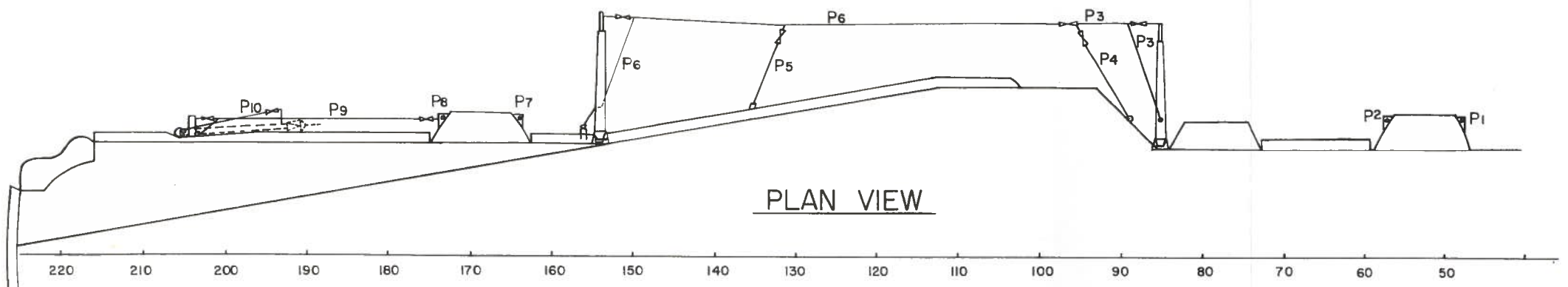


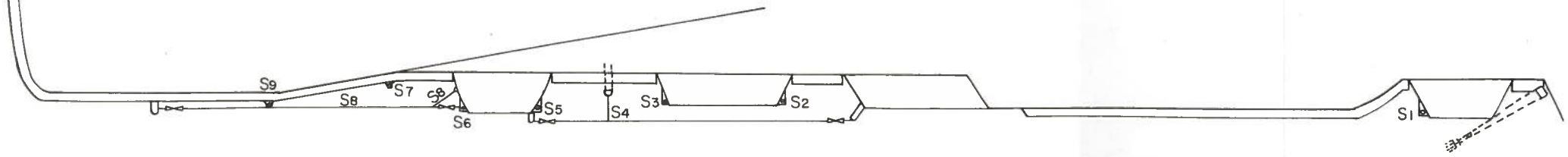
FIG. 2. SCALE MODEL OF HMCS "BONAVENTURE" LOCATED ON HF ANTENNA PATTERN RANGE

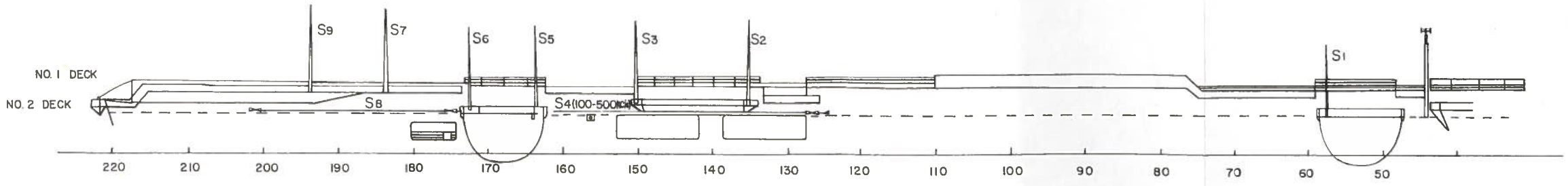



PORT ELEVATION




PLAN VIEW




STARBOARD ELEVATION

**FIG. 3. LOCATION OF HF ANTENNAS AROUND THE FLIGHT DECK**

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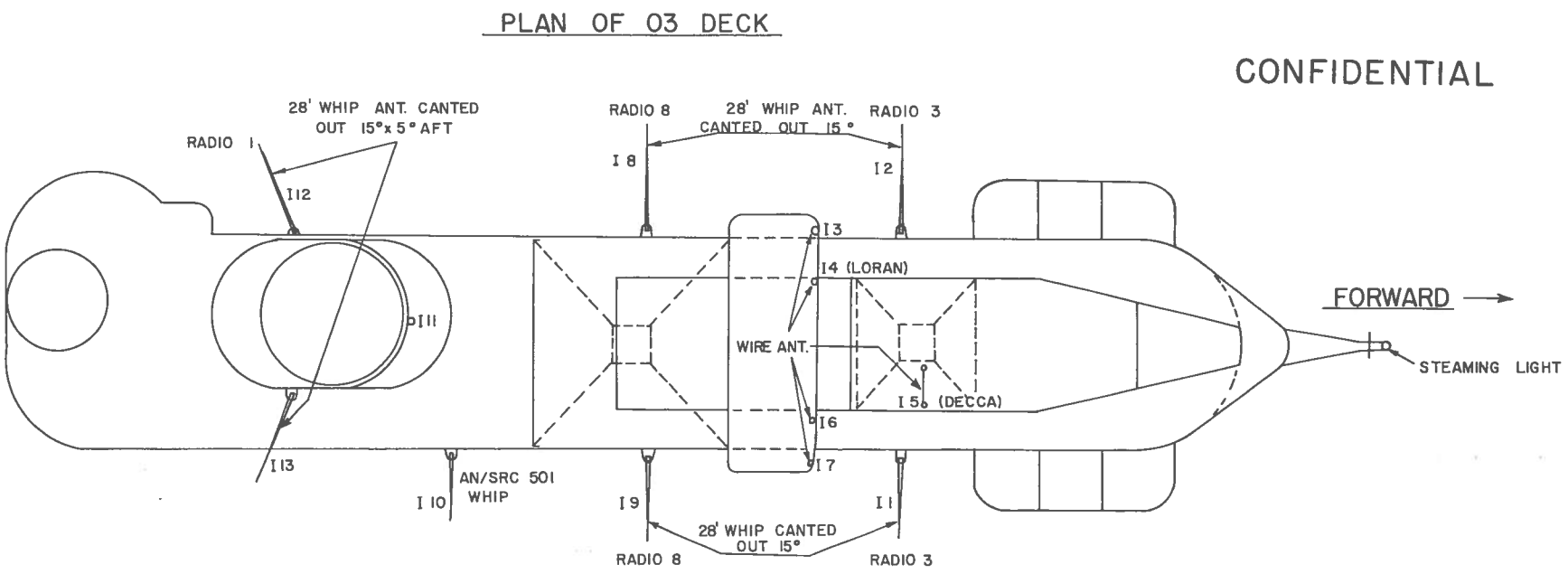
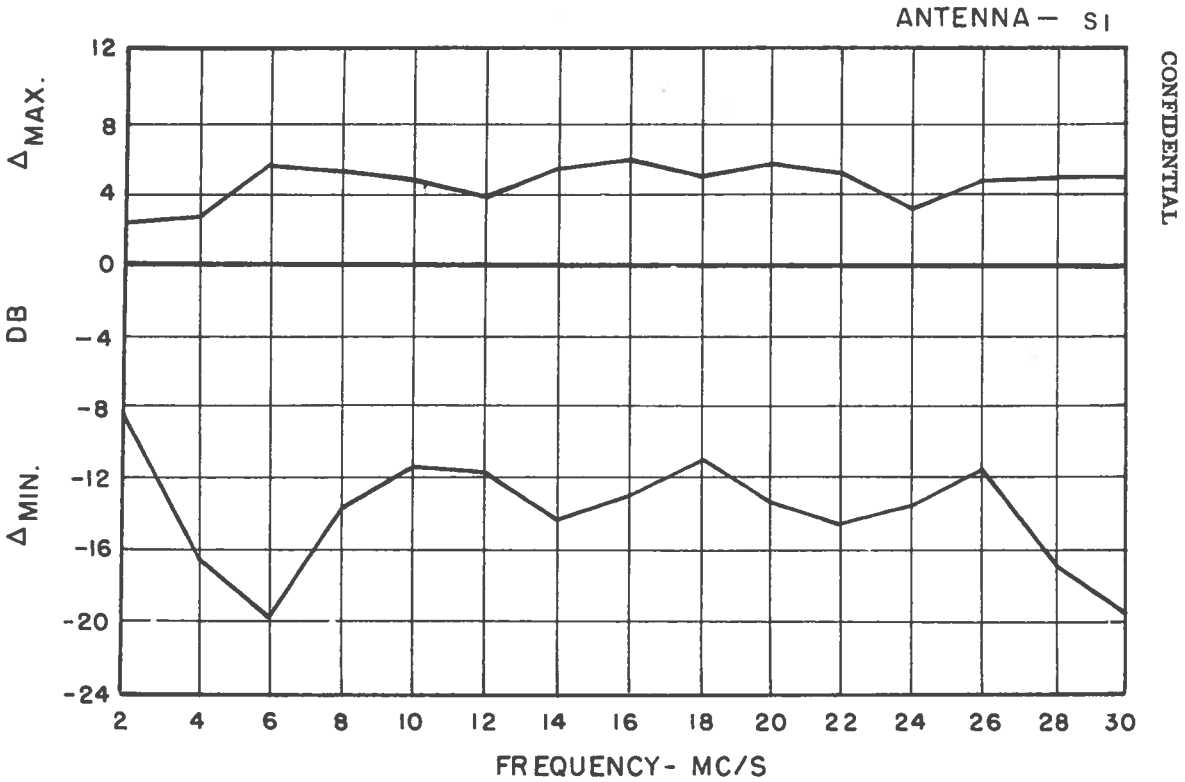
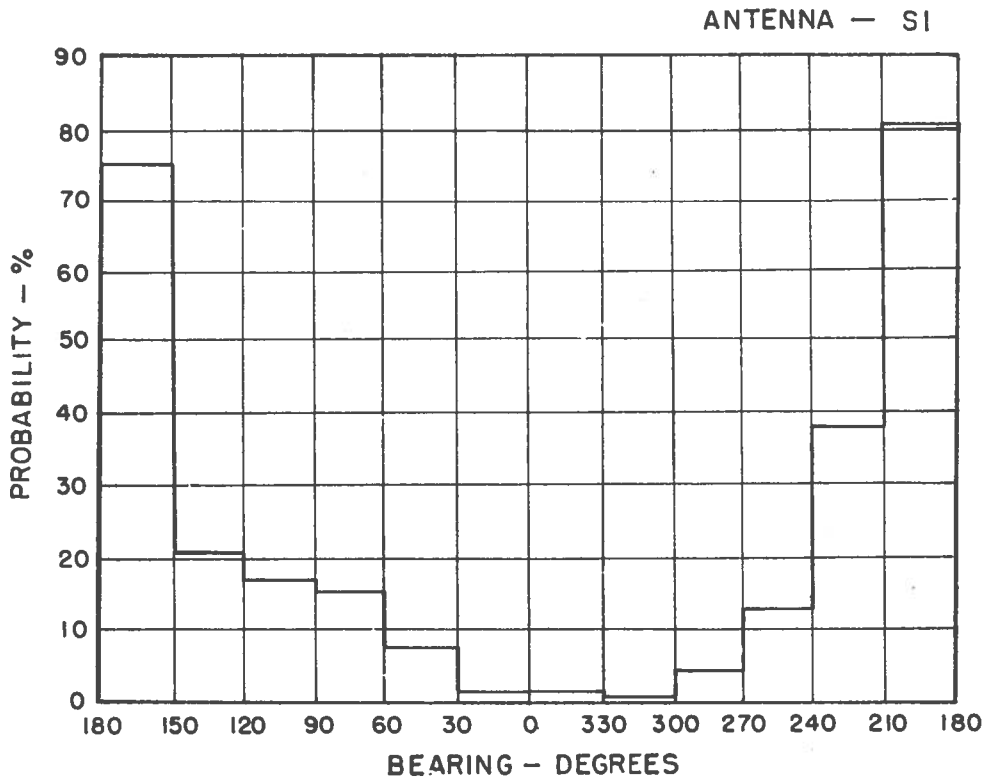



FIG. 4. LOCATION OF HF ANTENNAS ON THE ISLAND

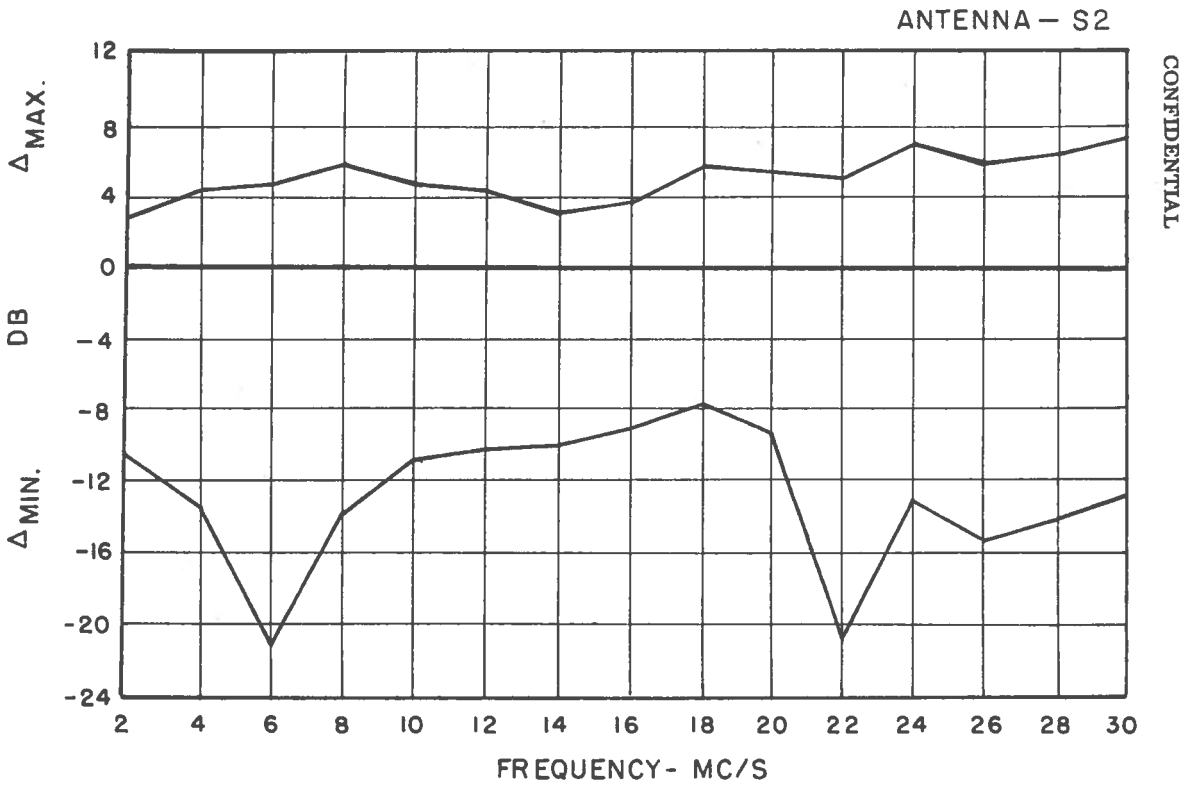



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY




(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 5

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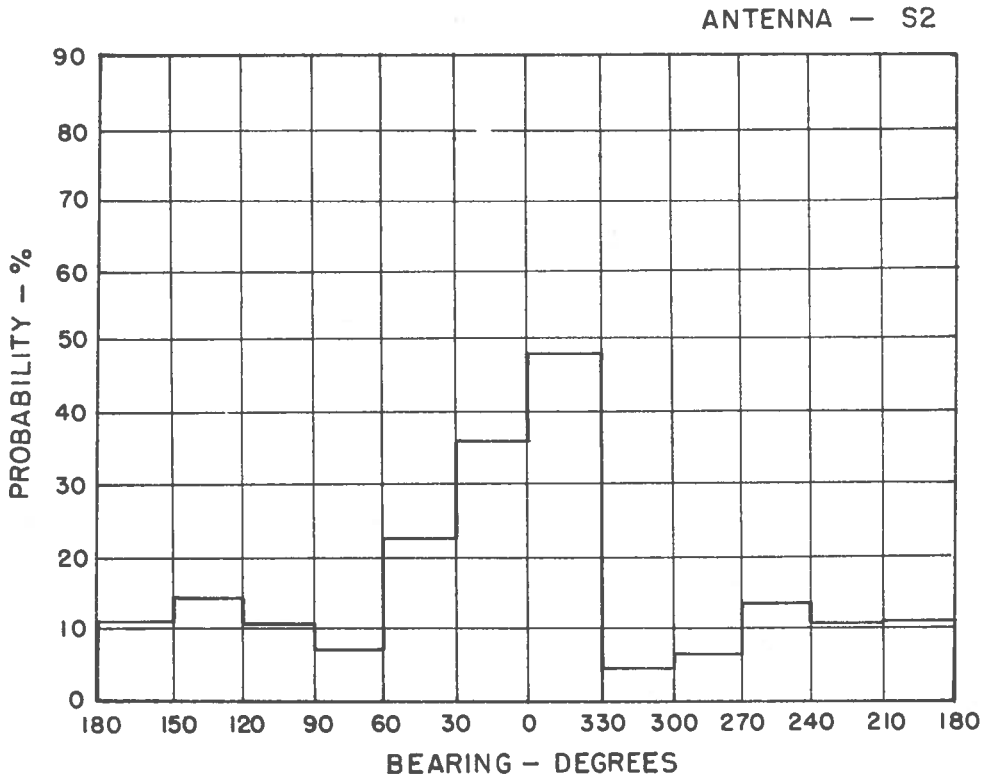


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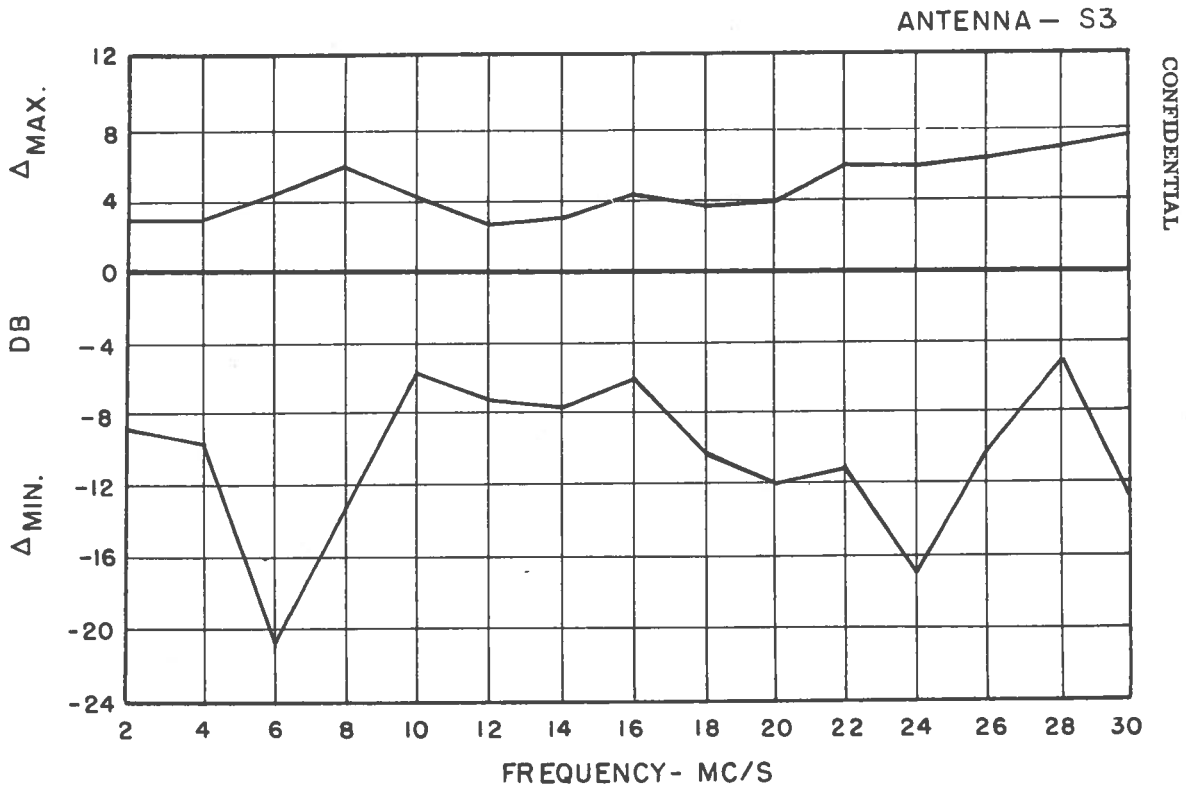
FIG. 6

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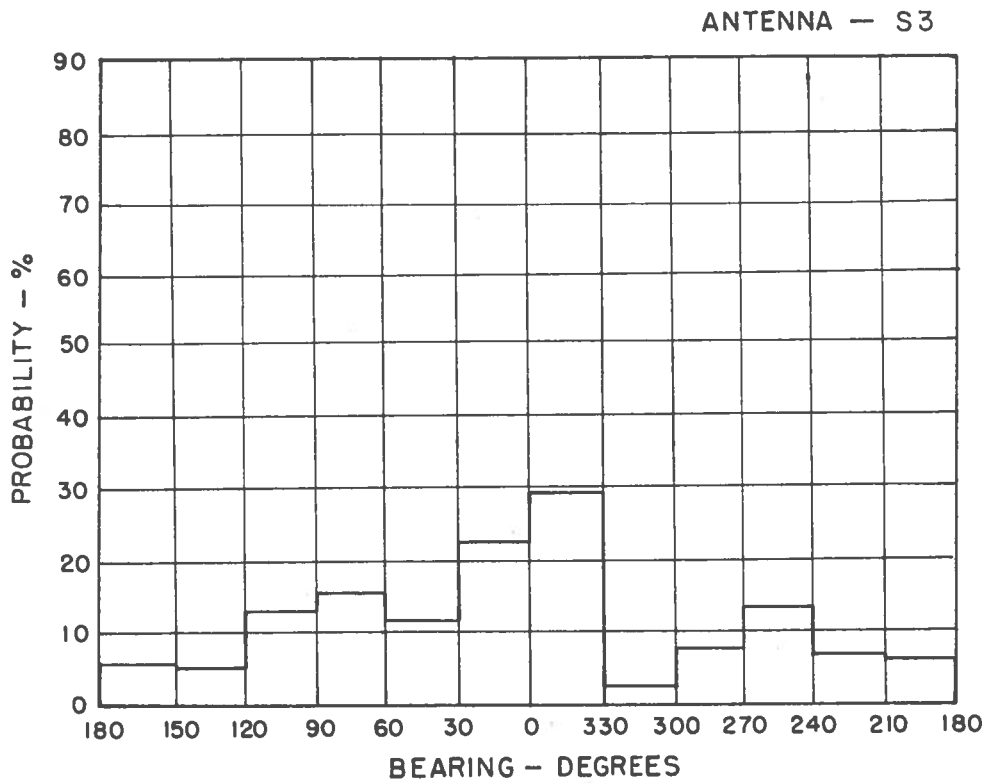
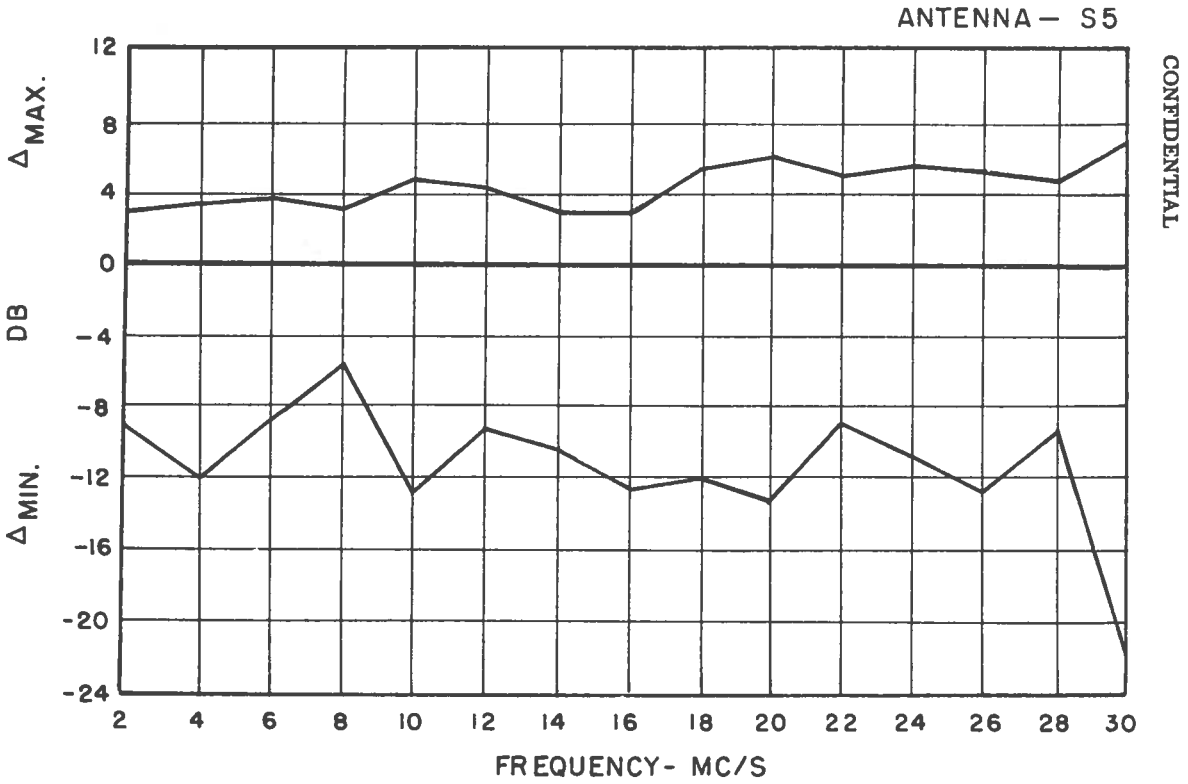



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 7

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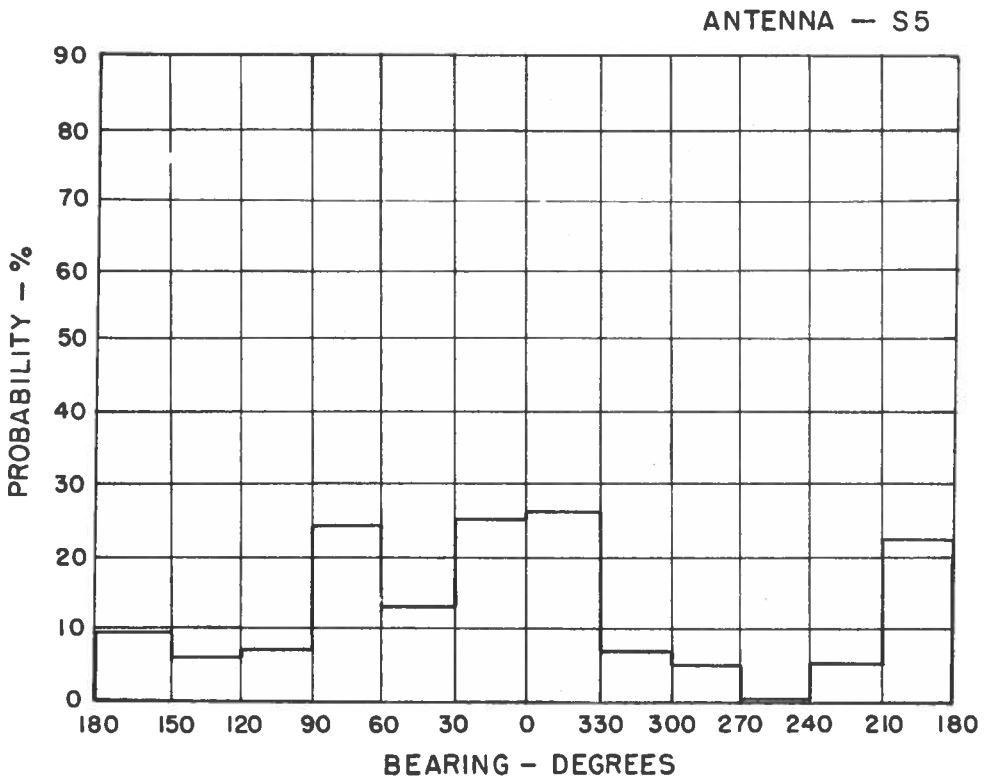
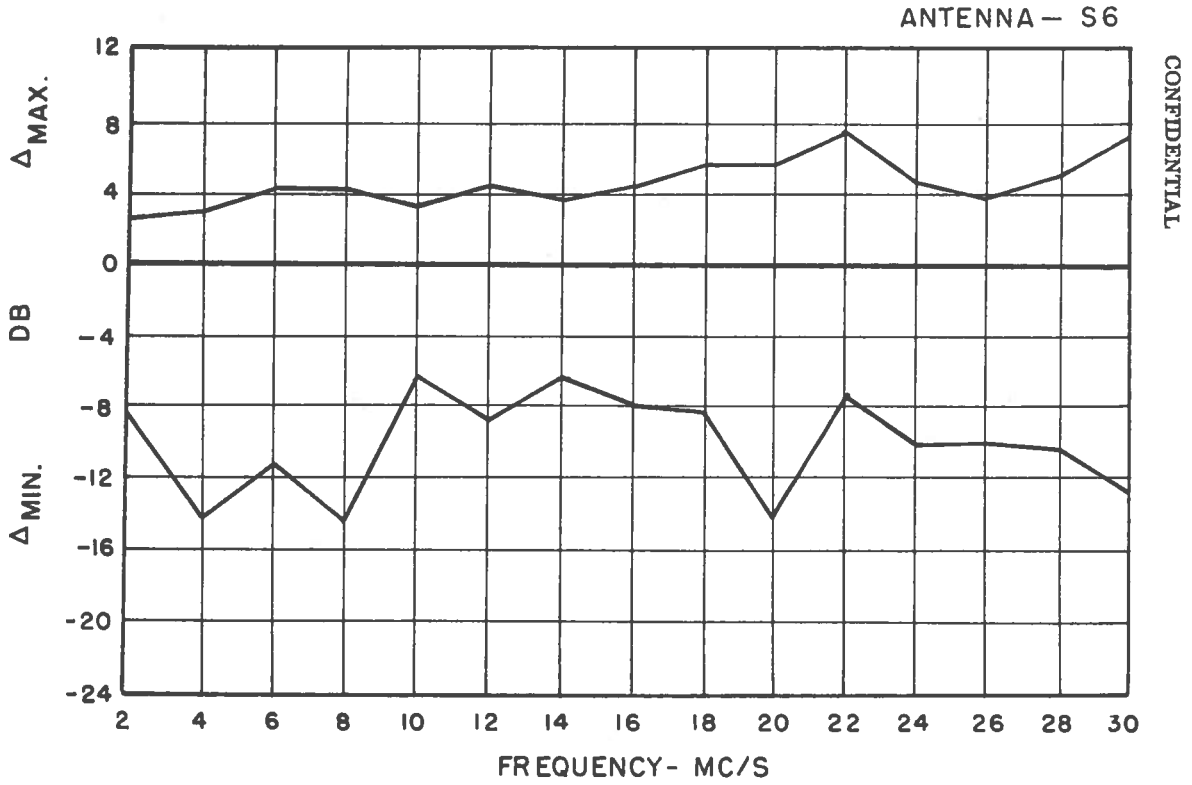



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 8

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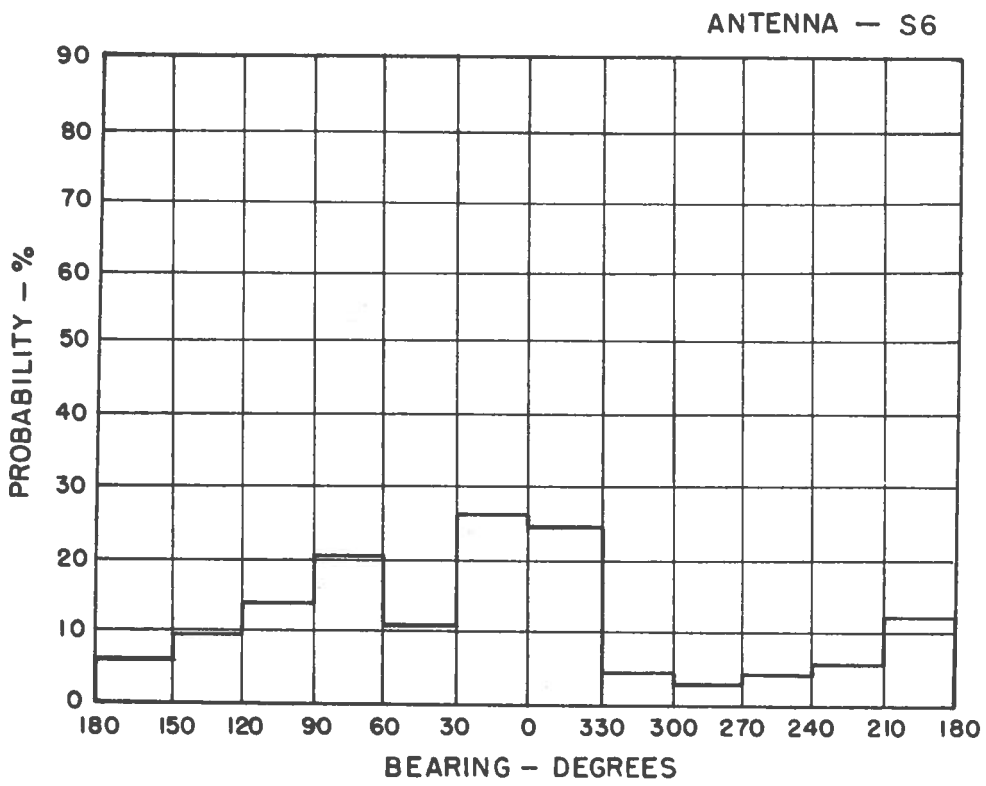


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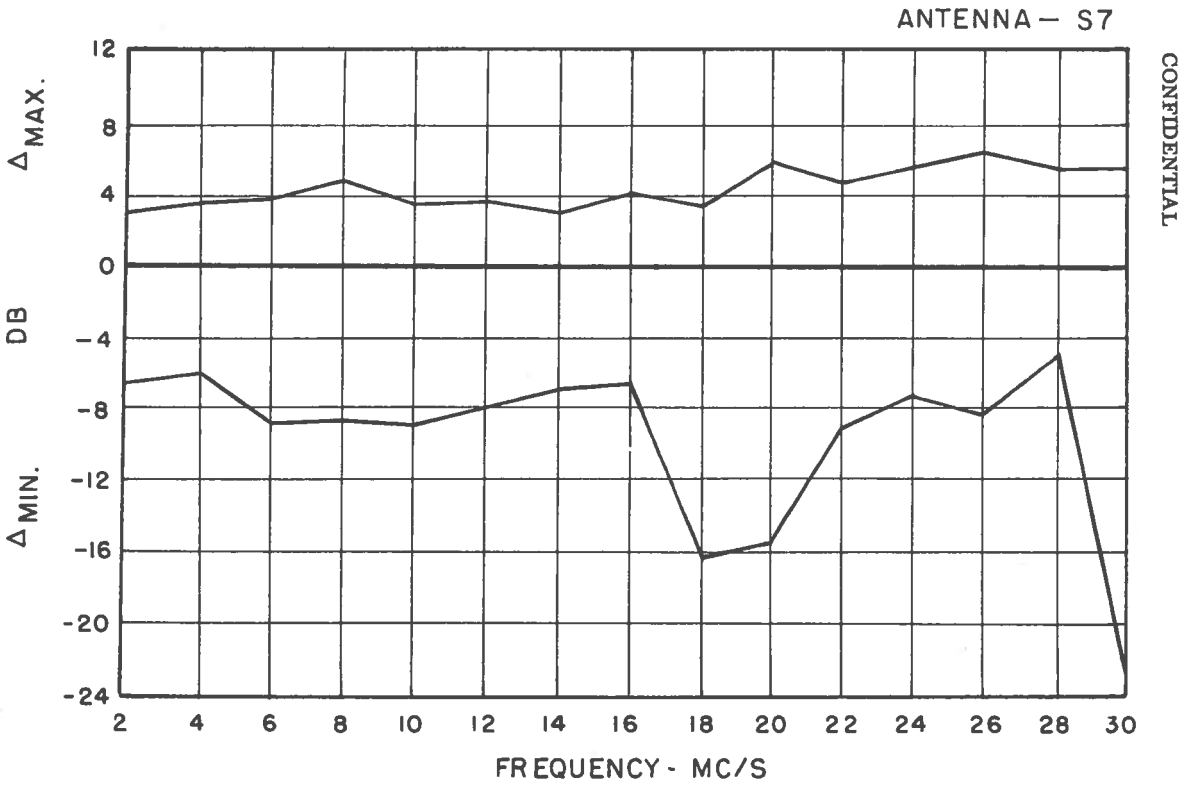
FIG. 9

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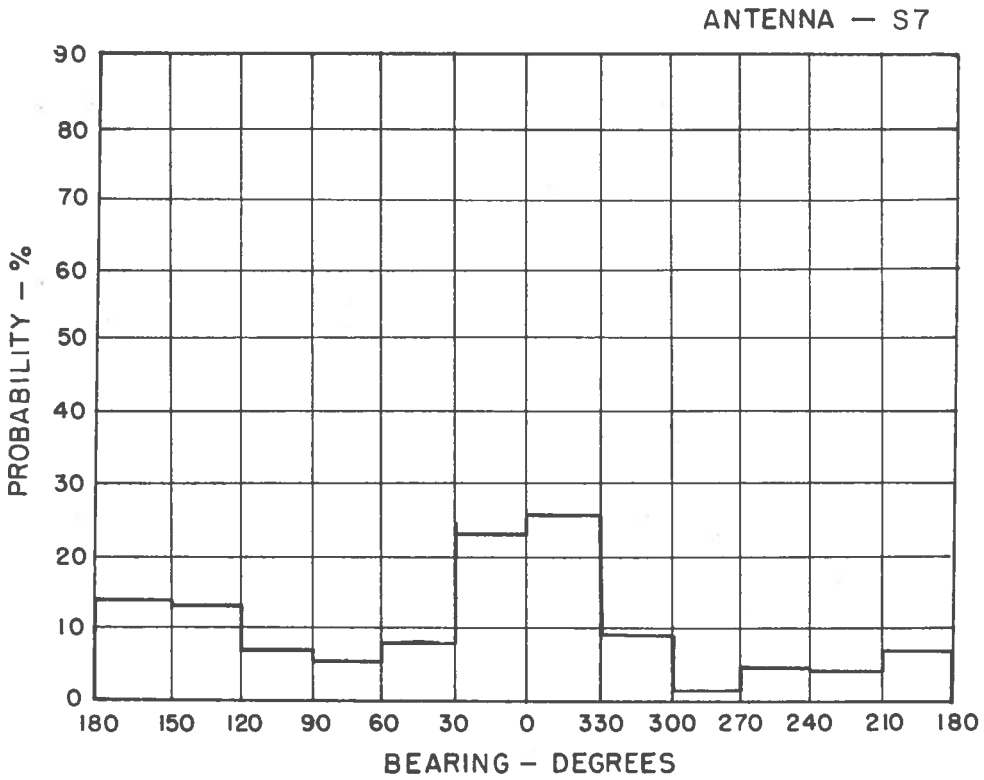
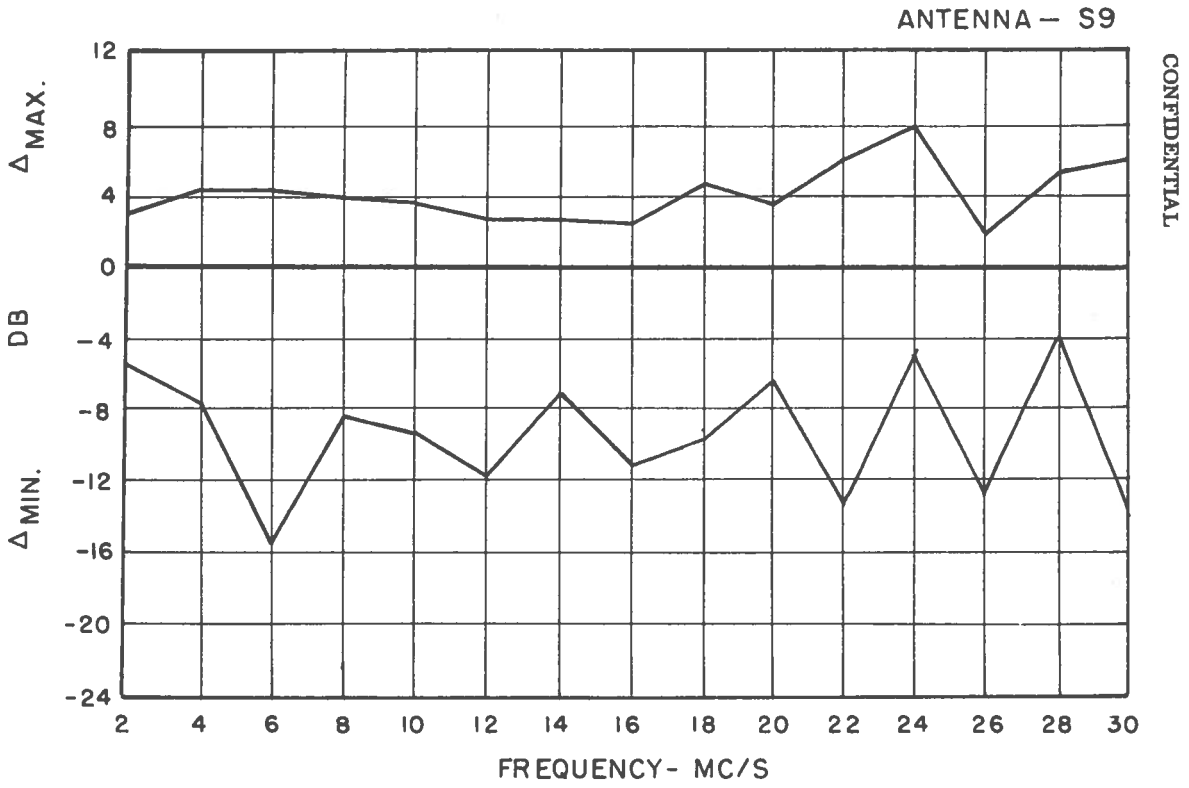



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 10

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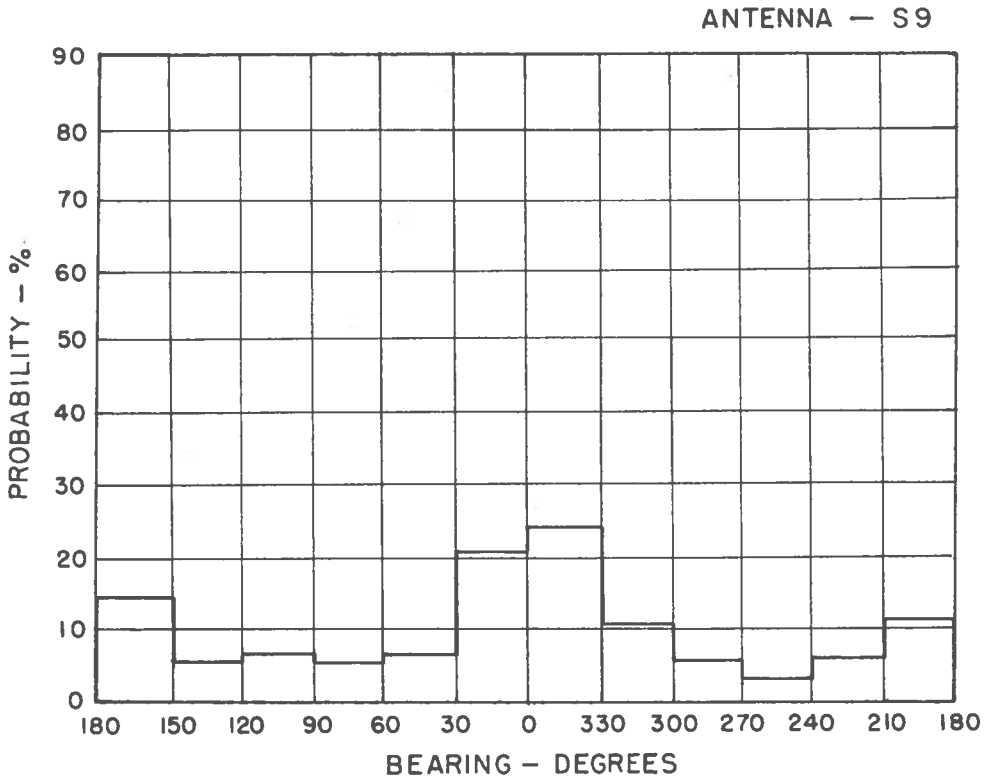


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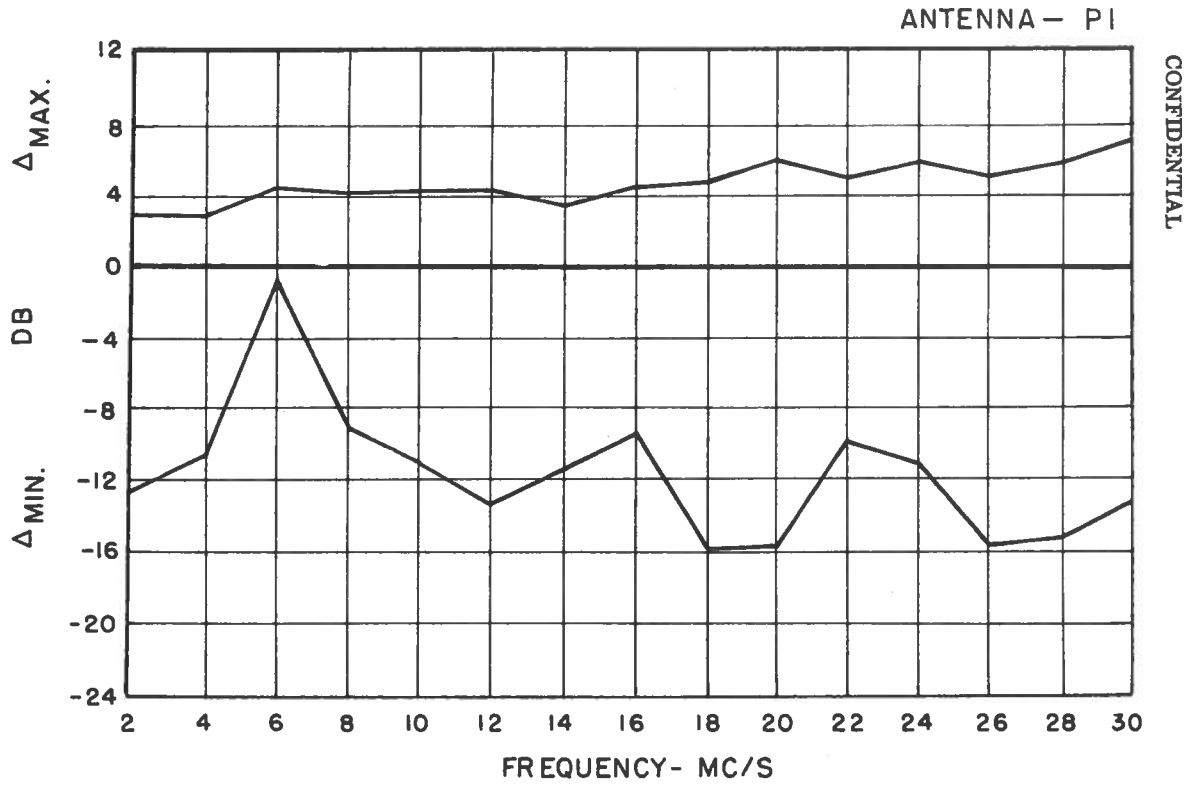
FIG. 11

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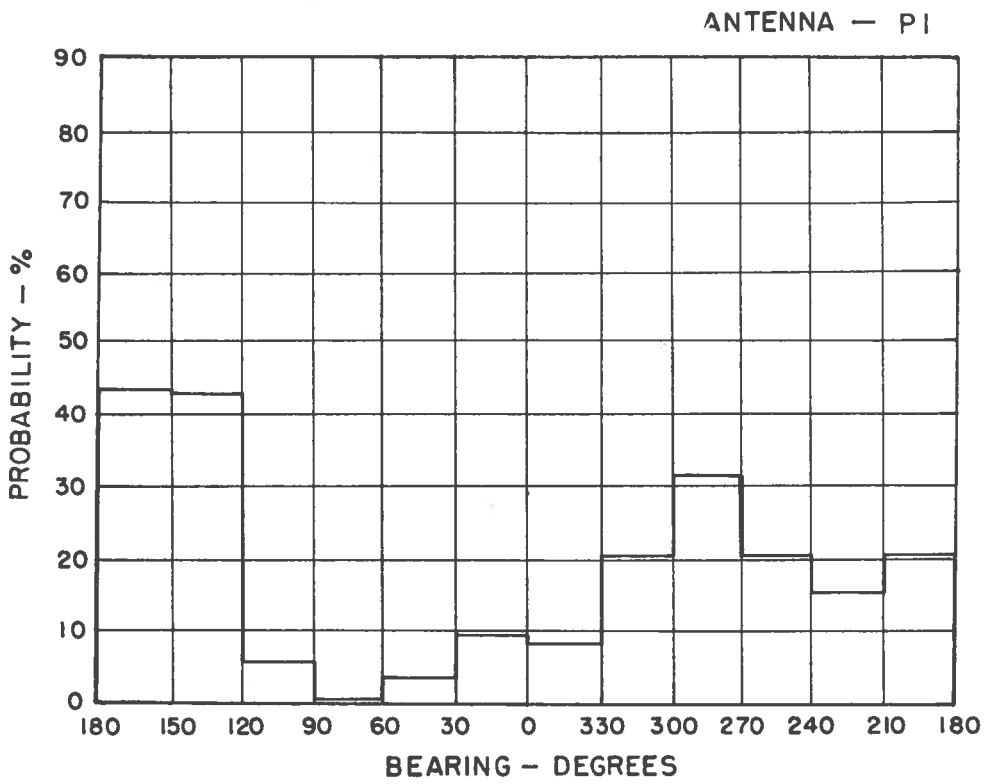
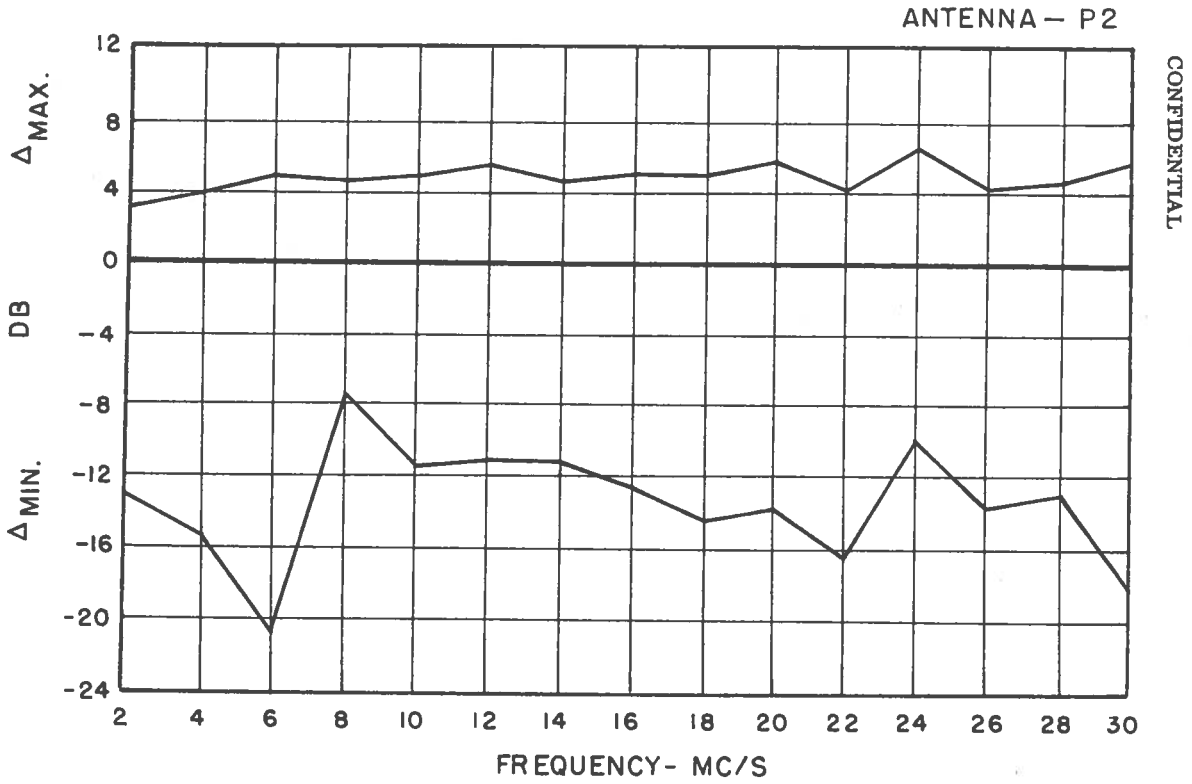



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 12

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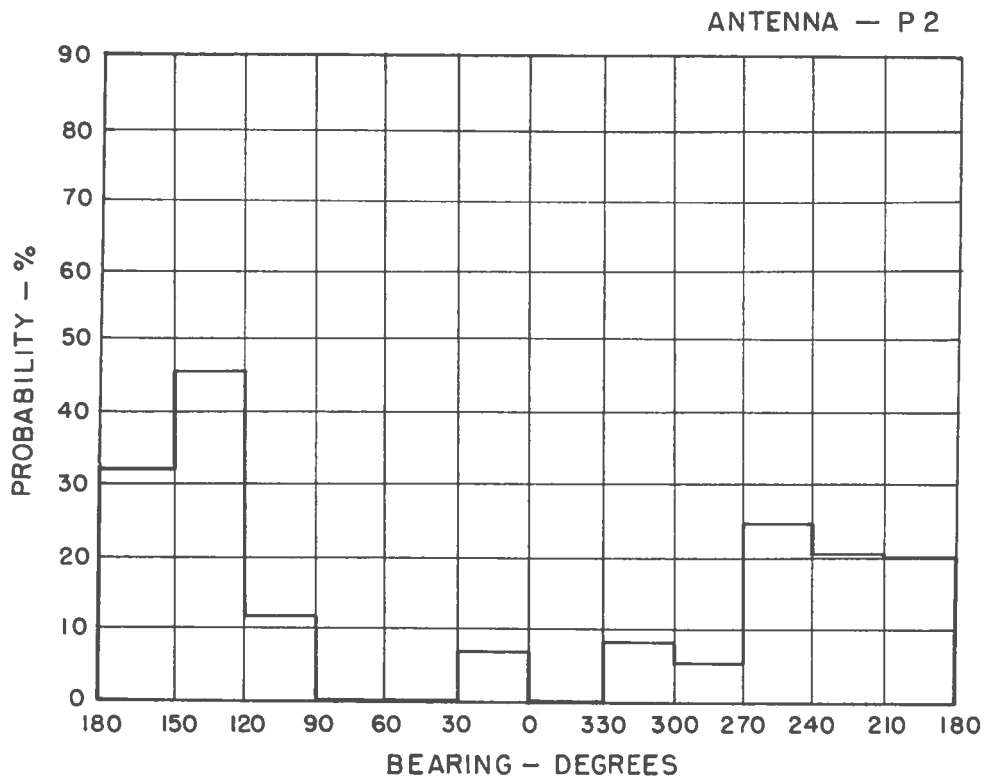
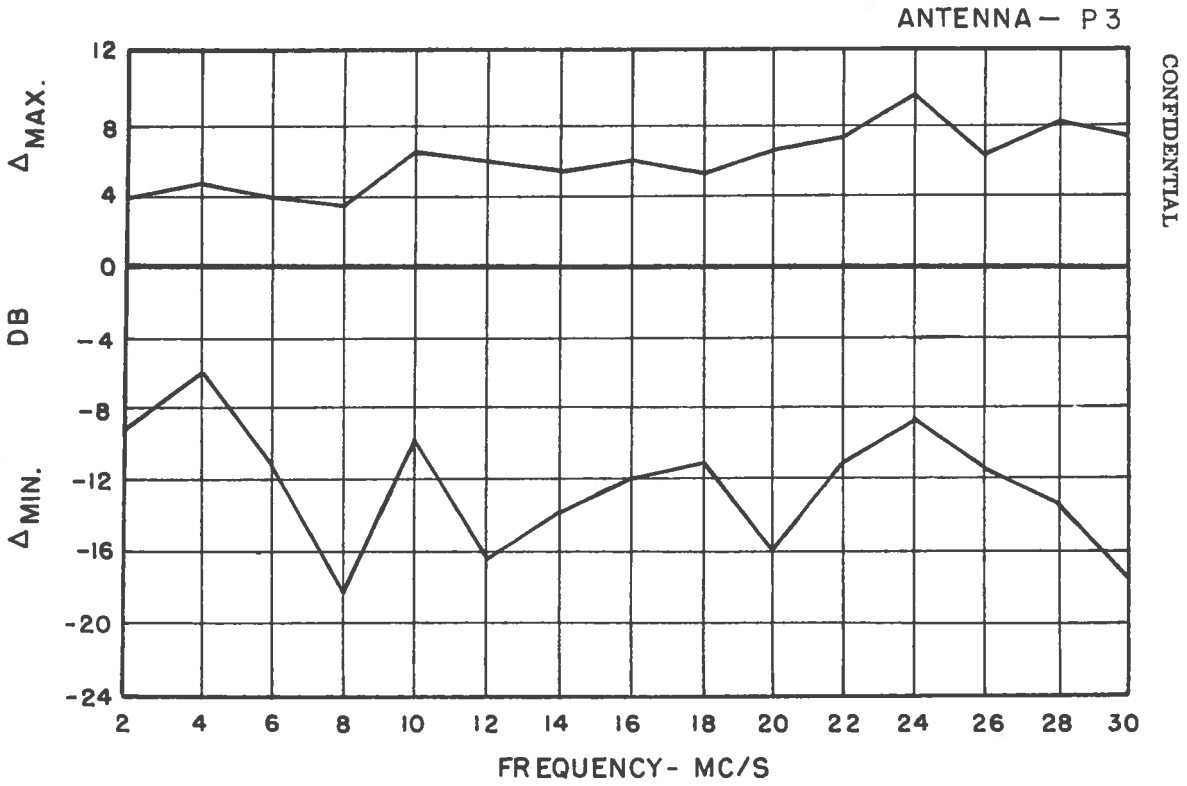



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 13

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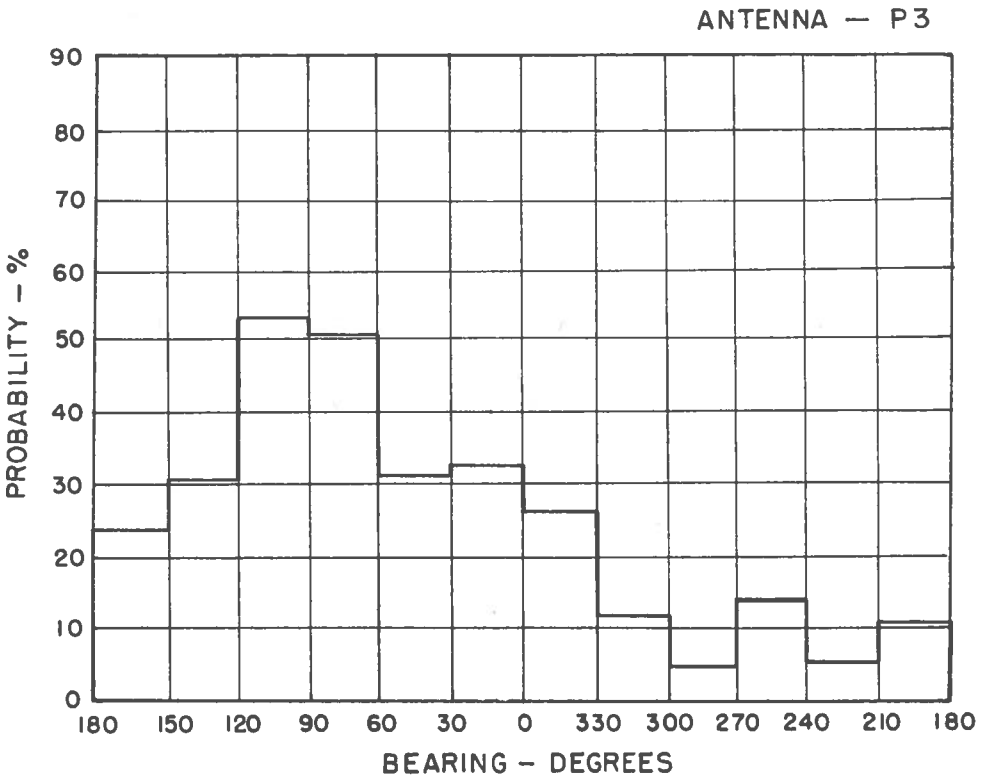
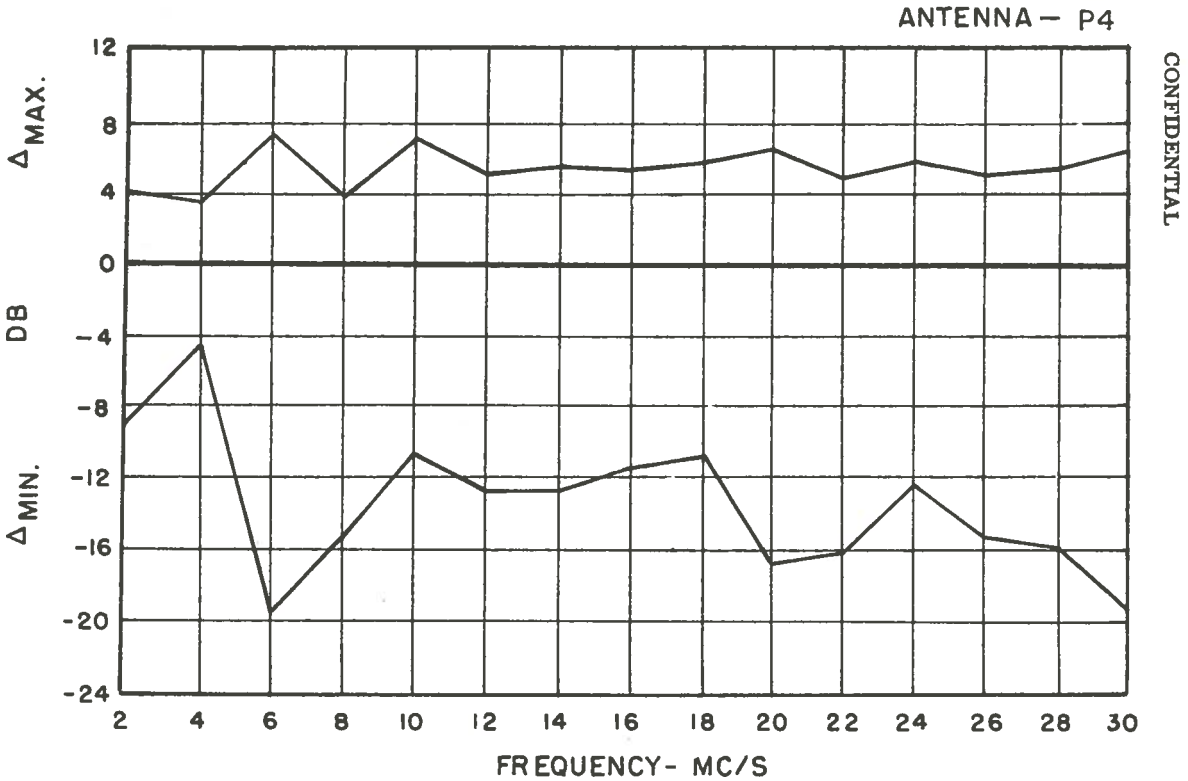



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 14

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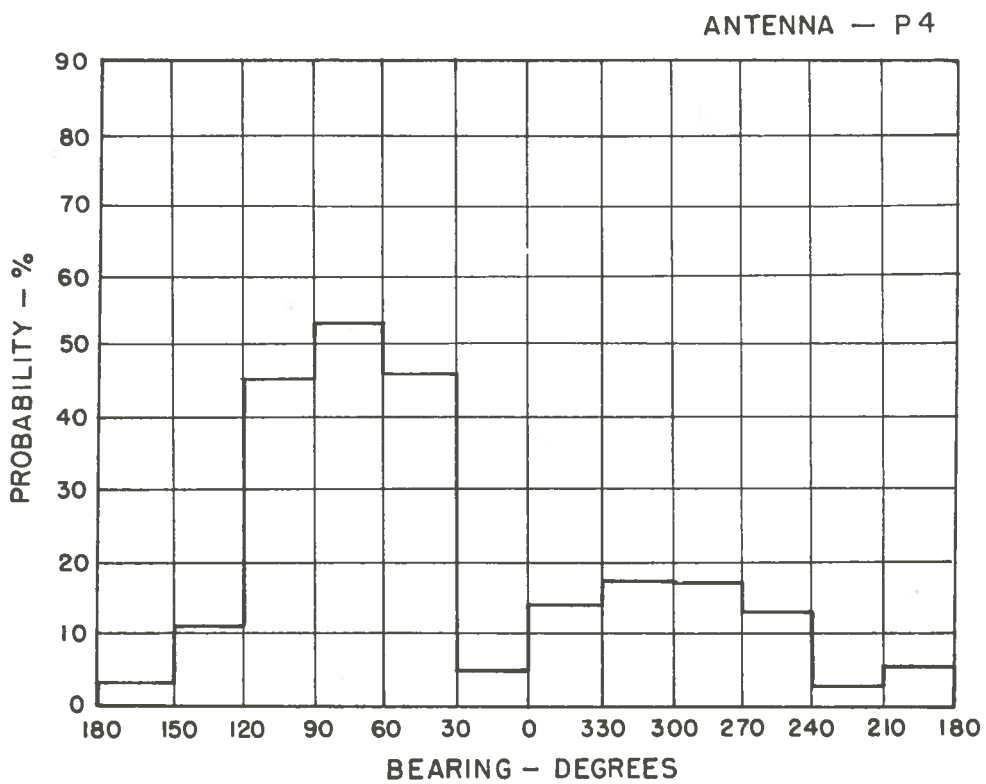
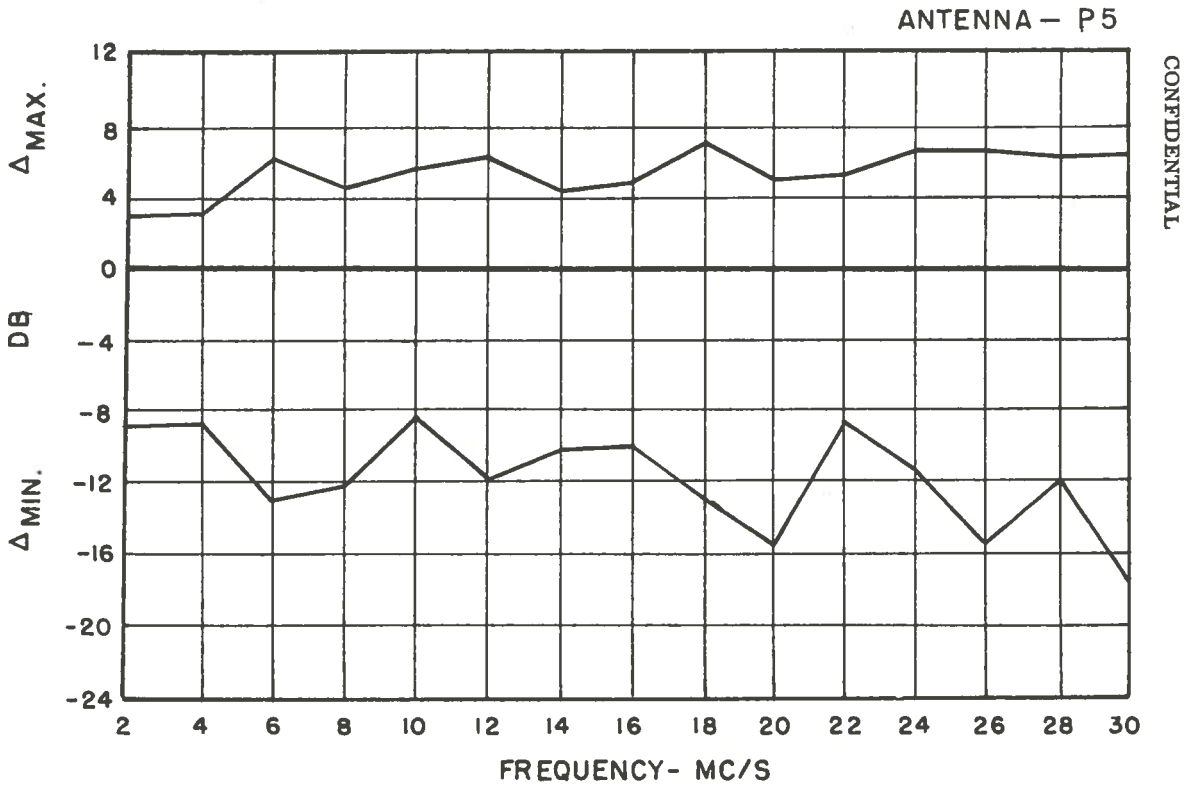



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 15

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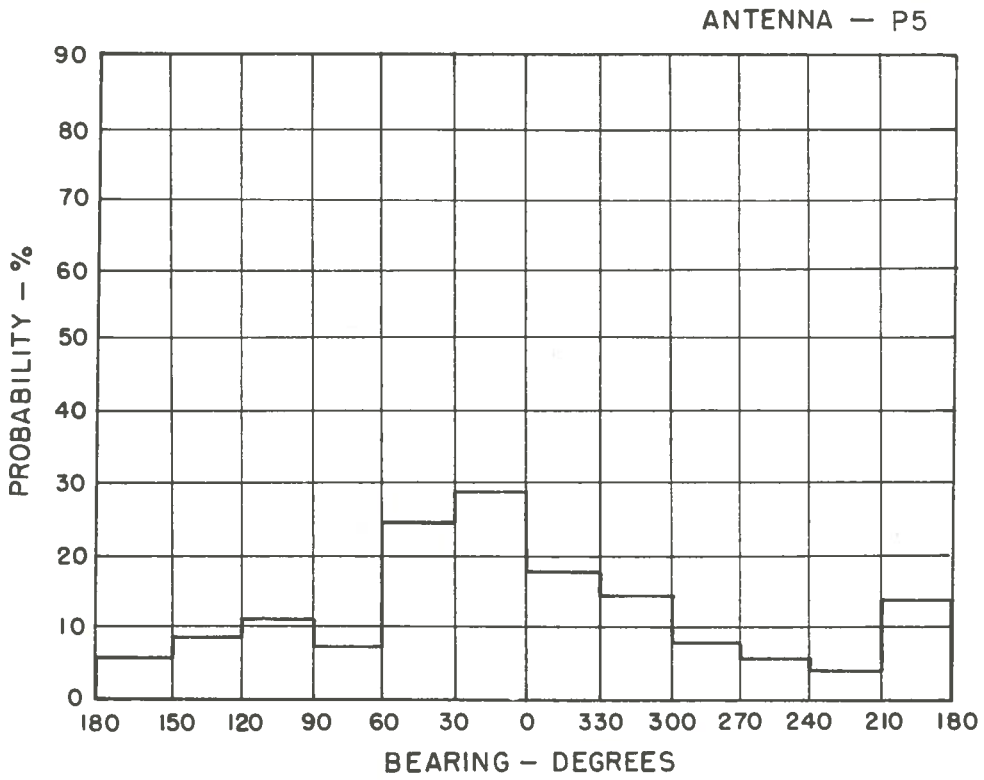


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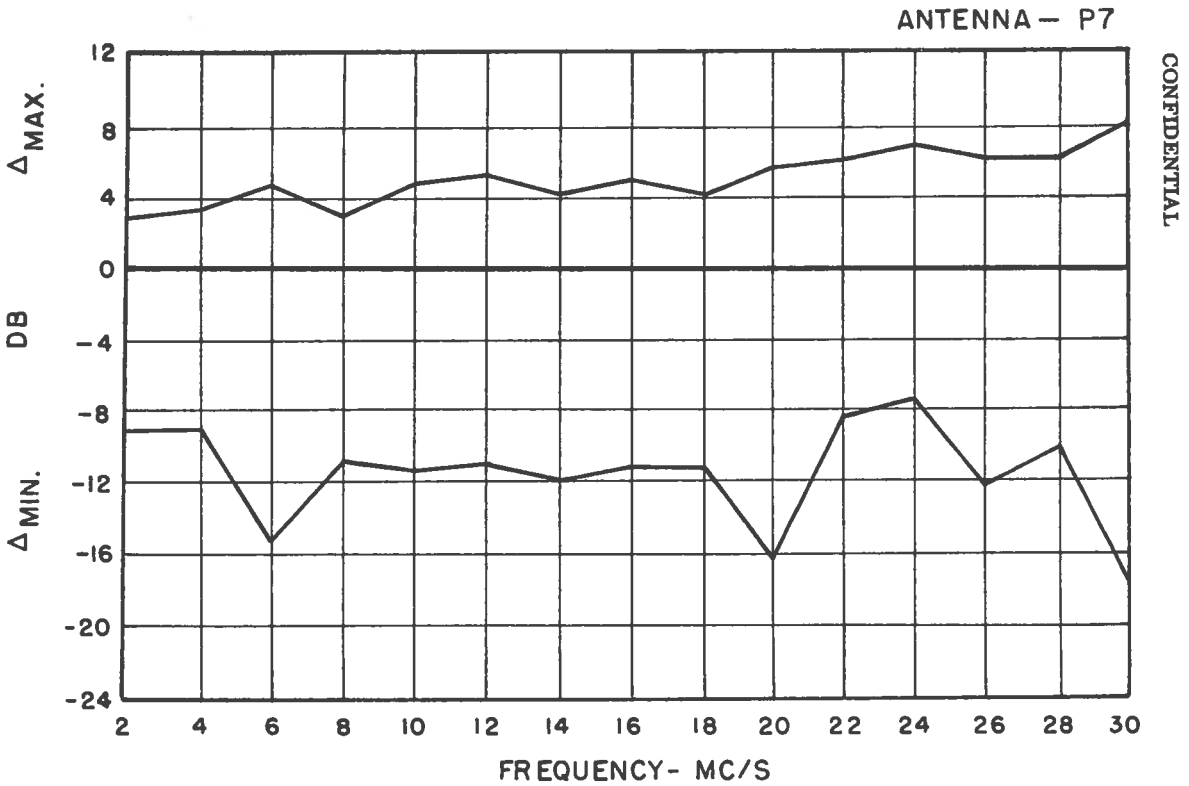
FIG. 16

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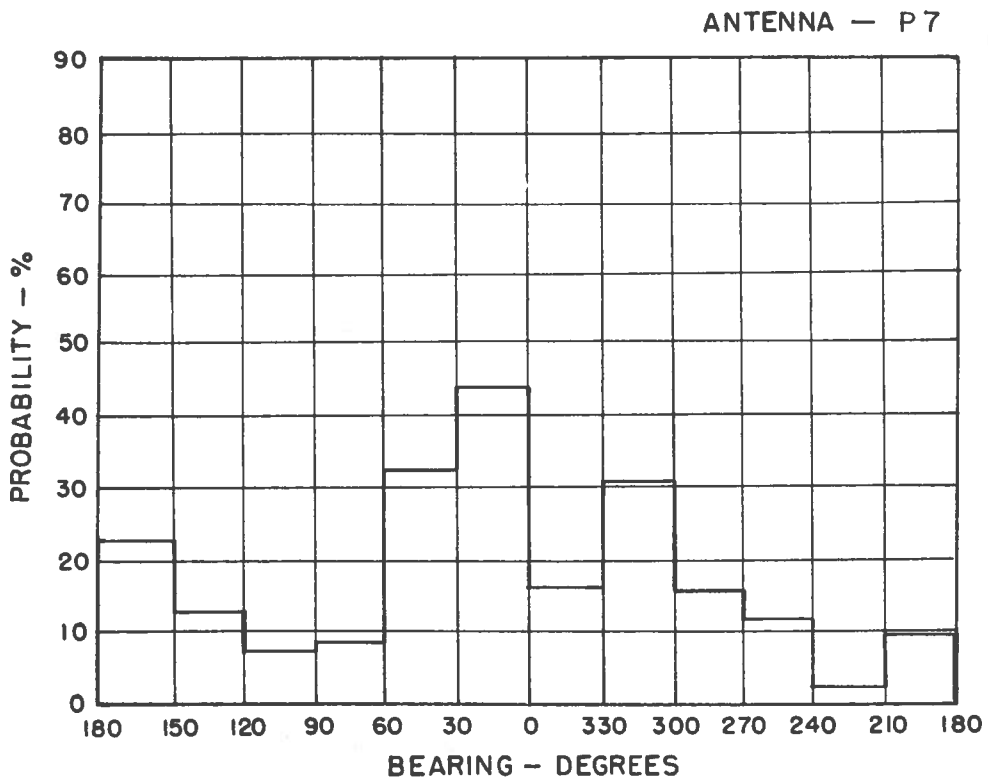
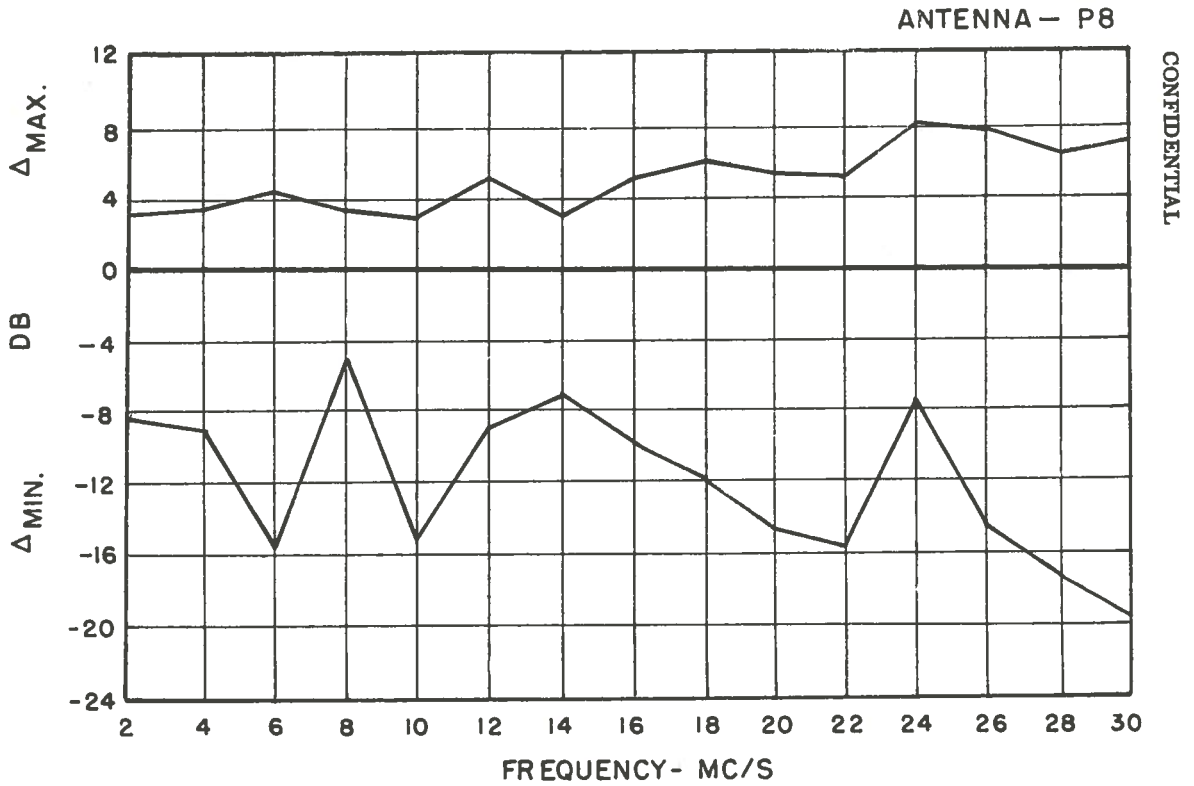



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 17

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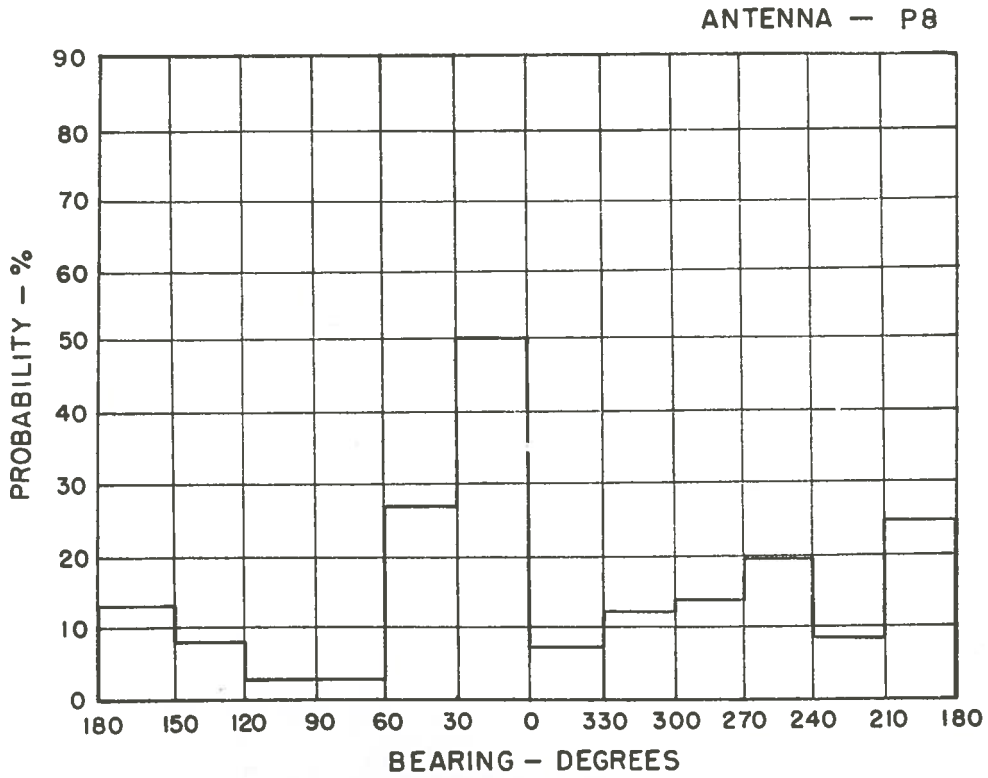
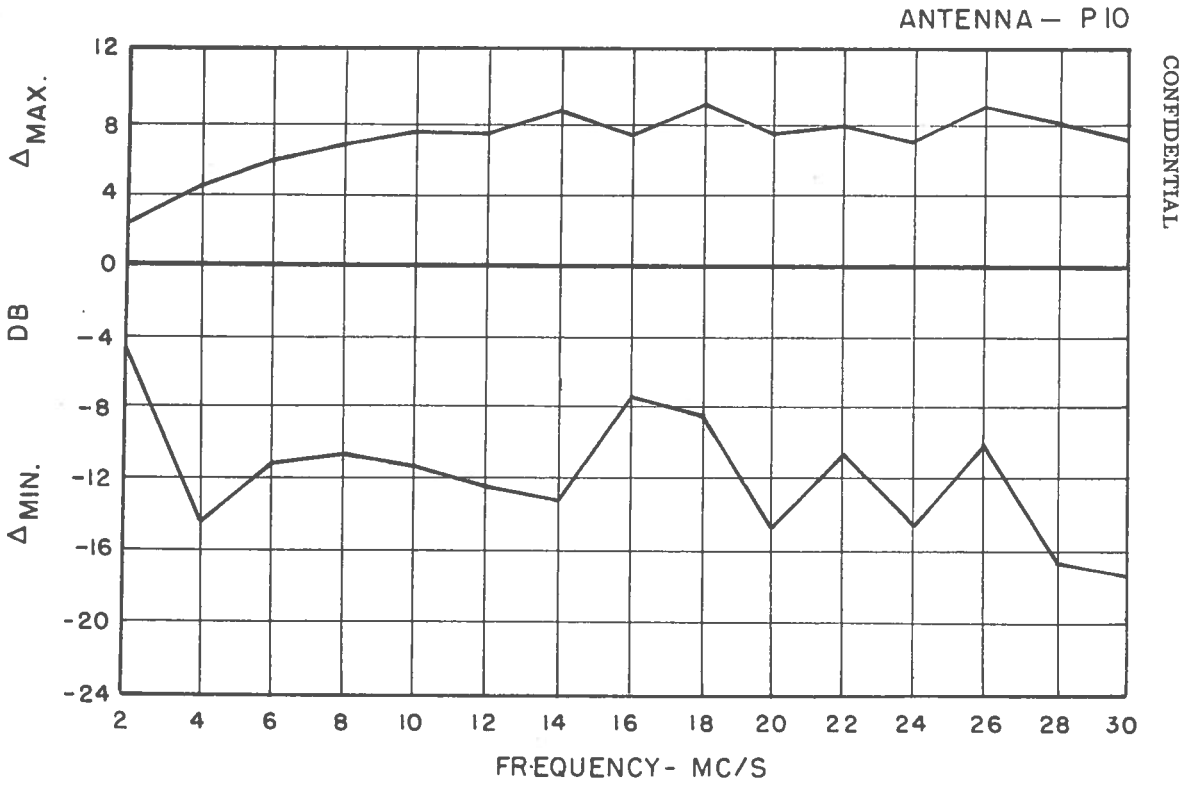



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 18

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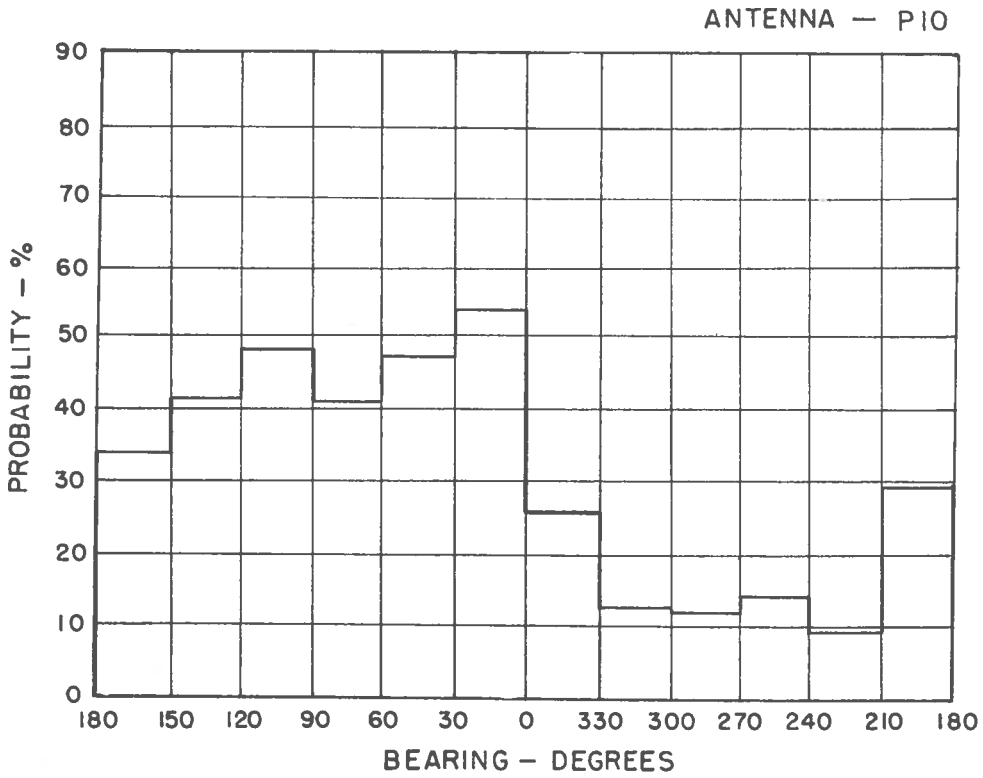
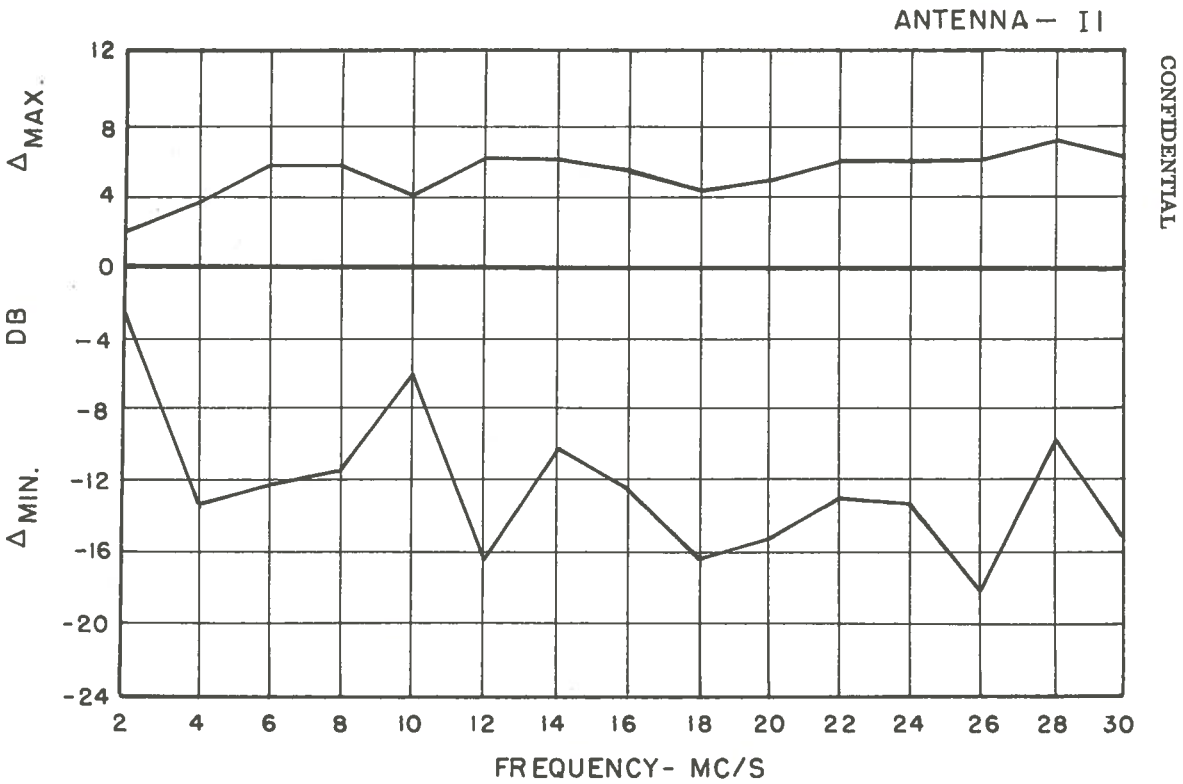



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 19

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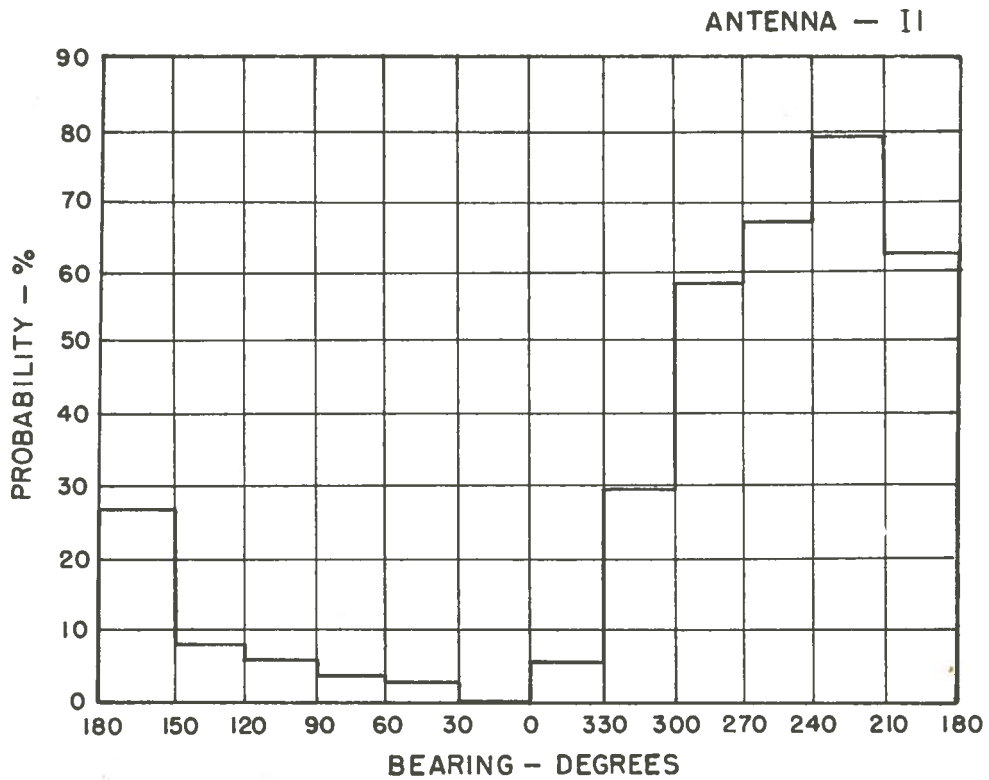
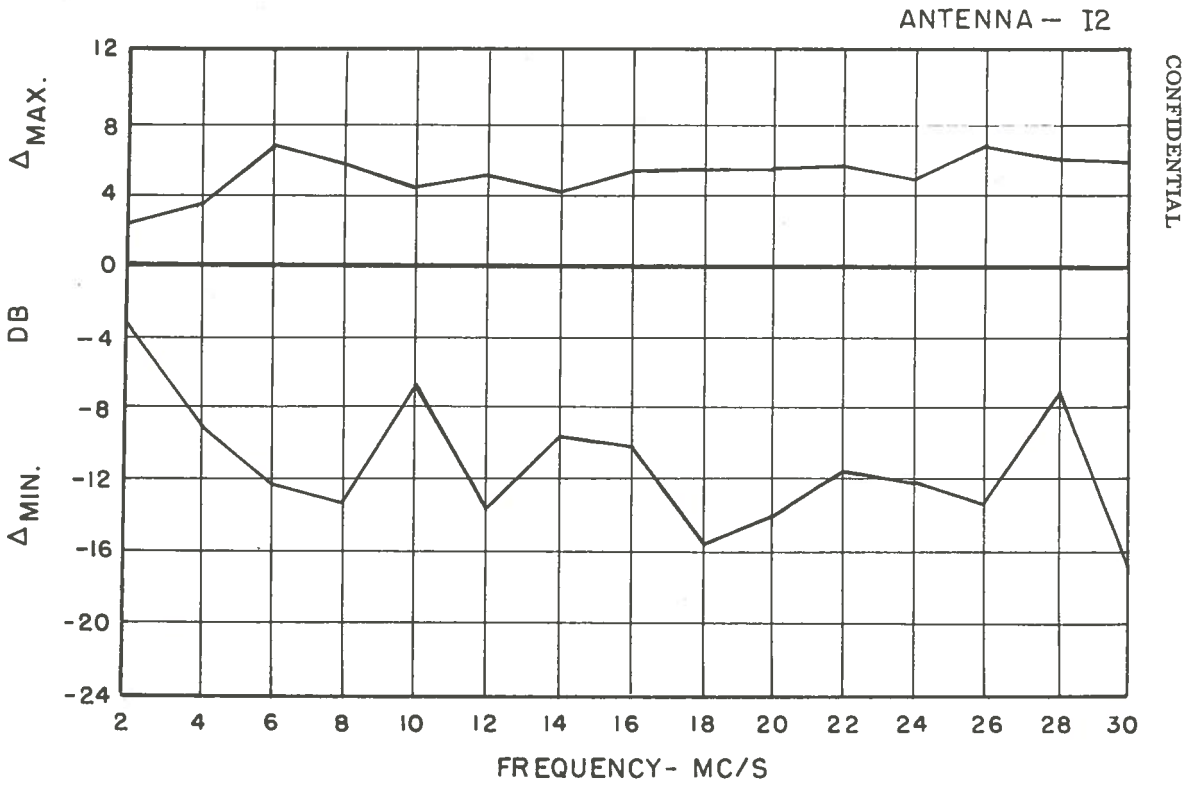



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 20

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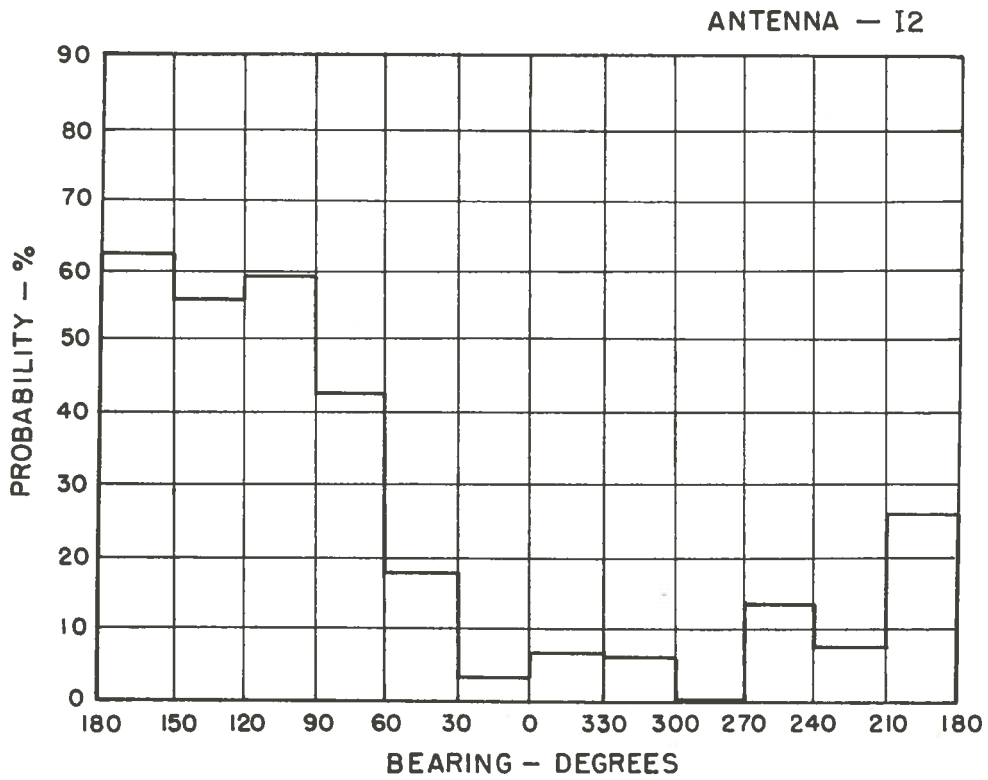
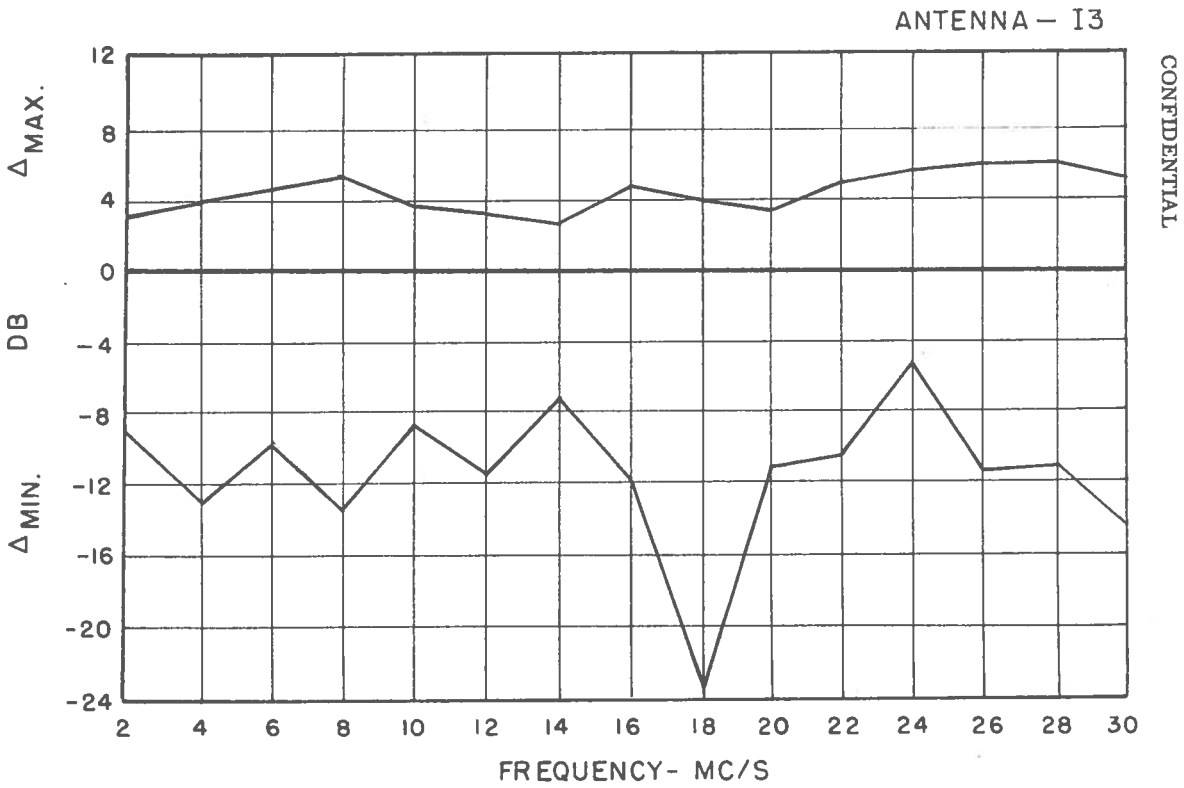



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 21

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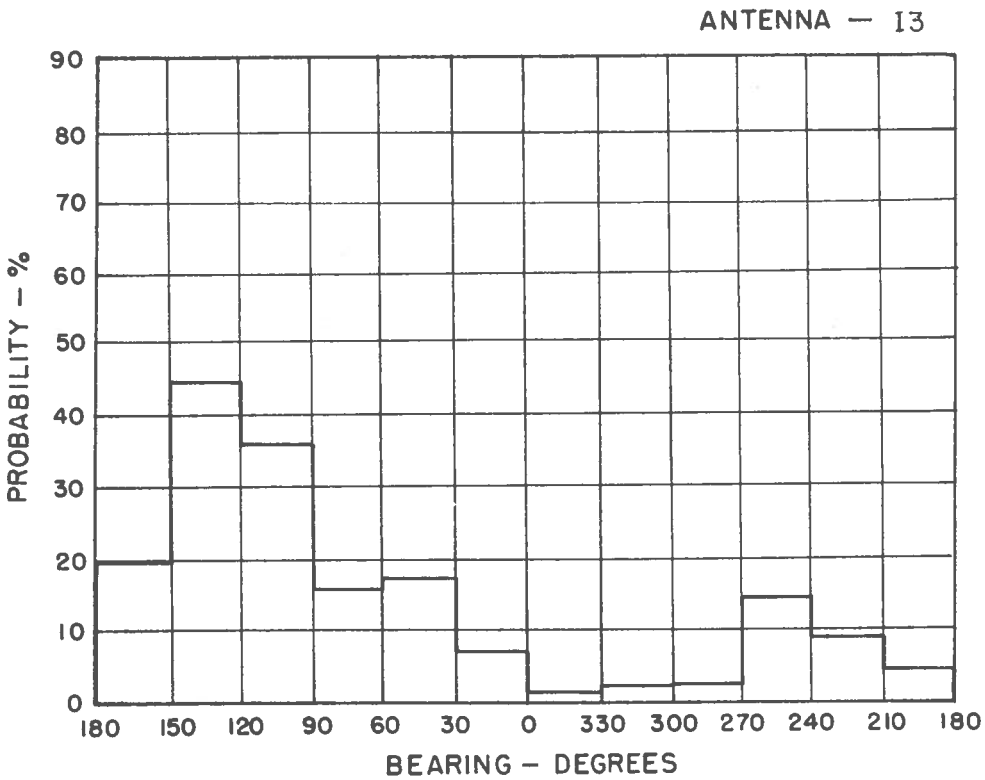
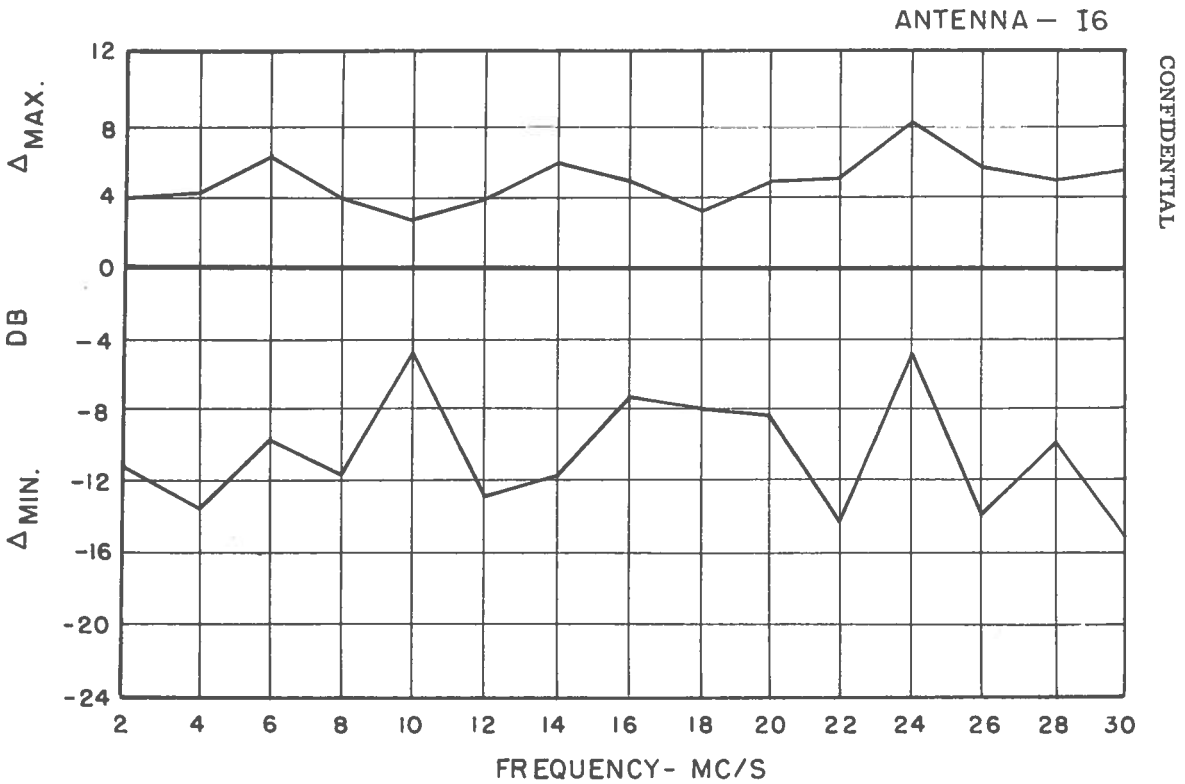
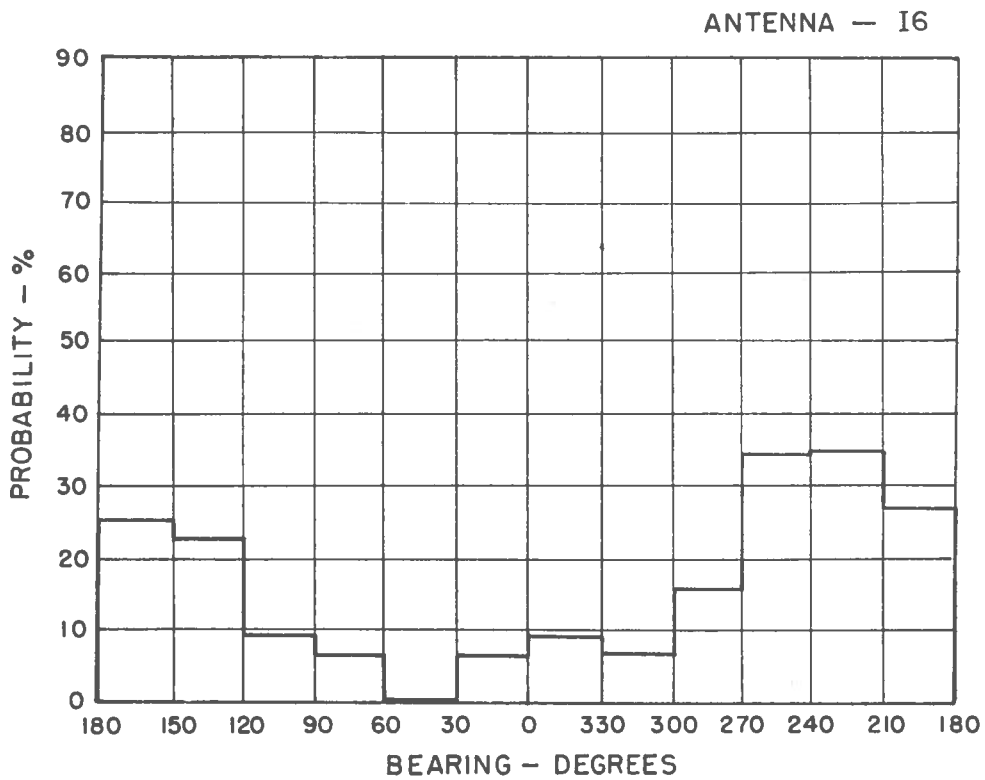



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 22

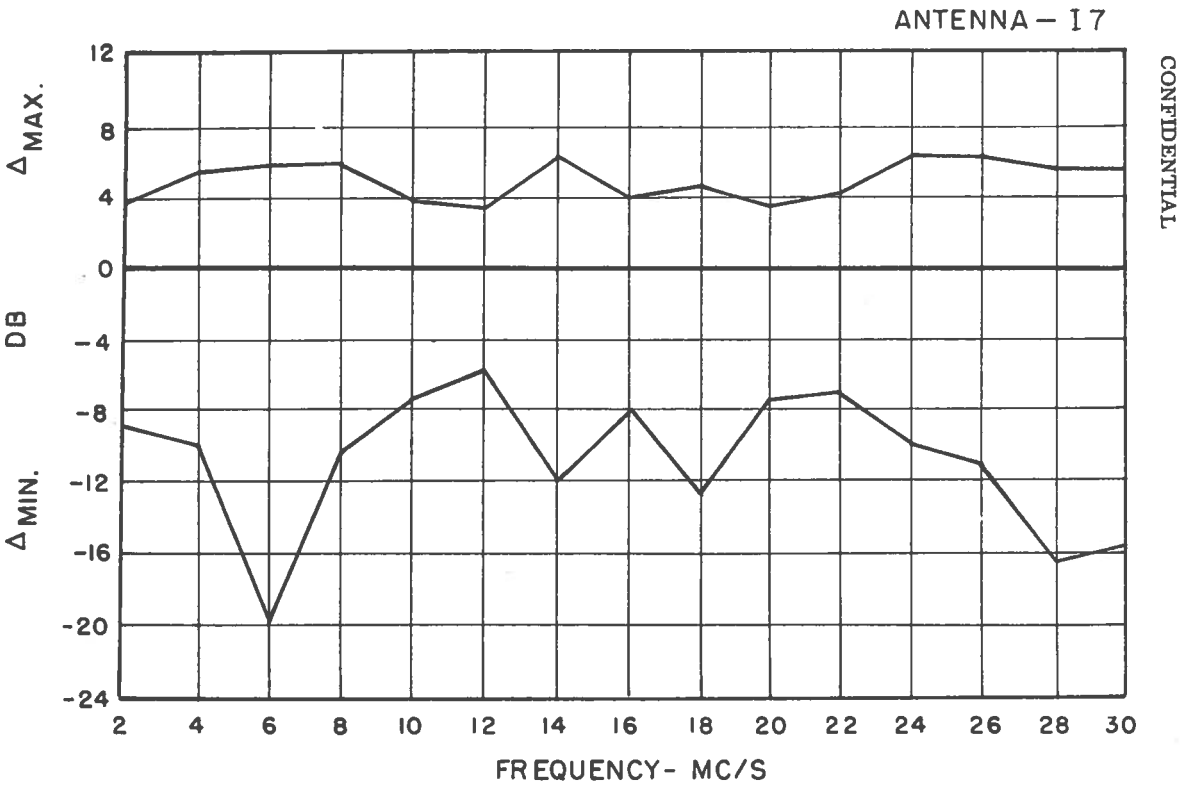



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY

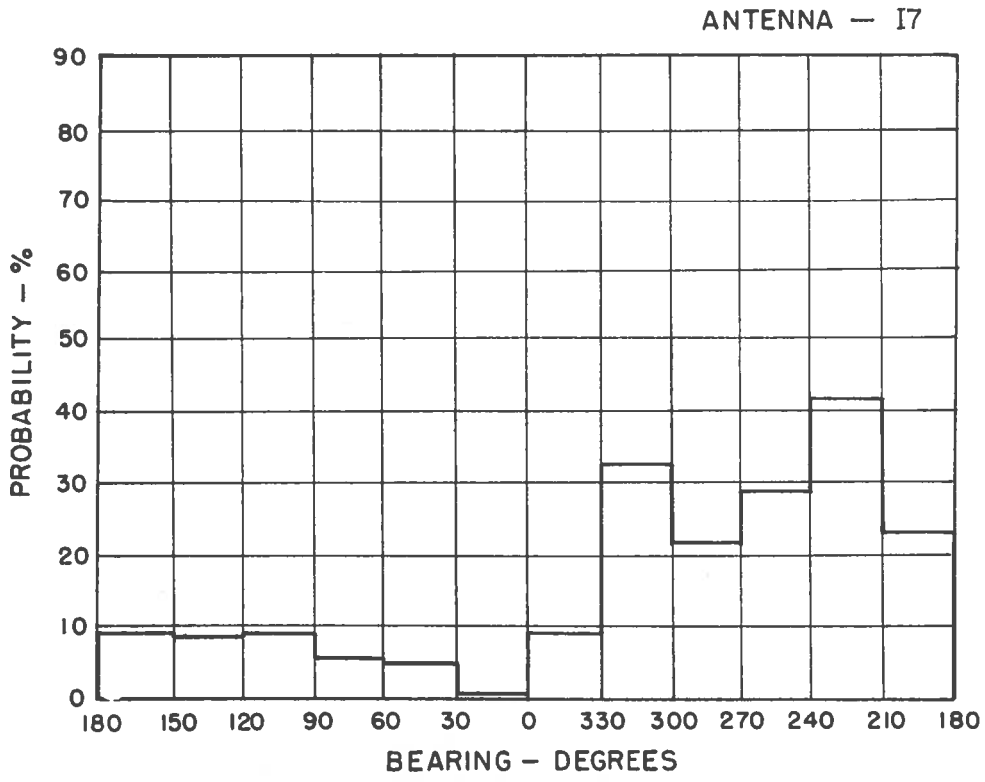



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 23

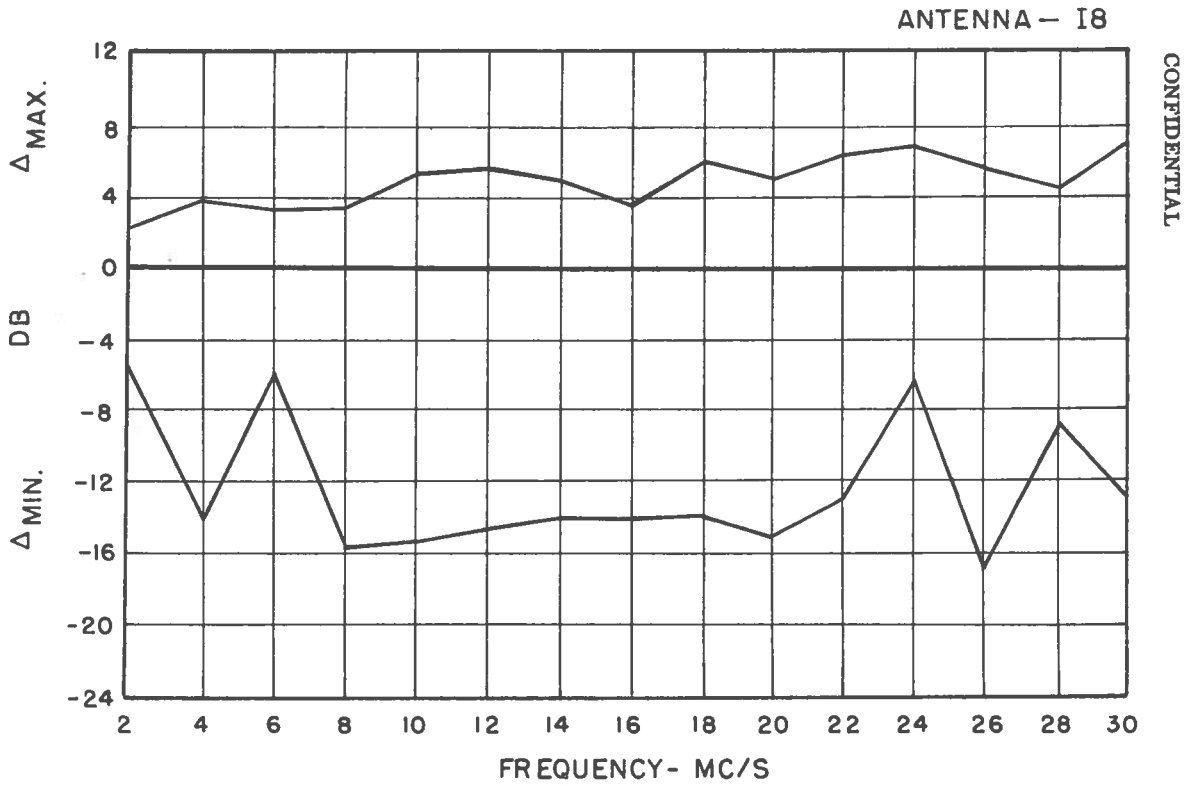



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY

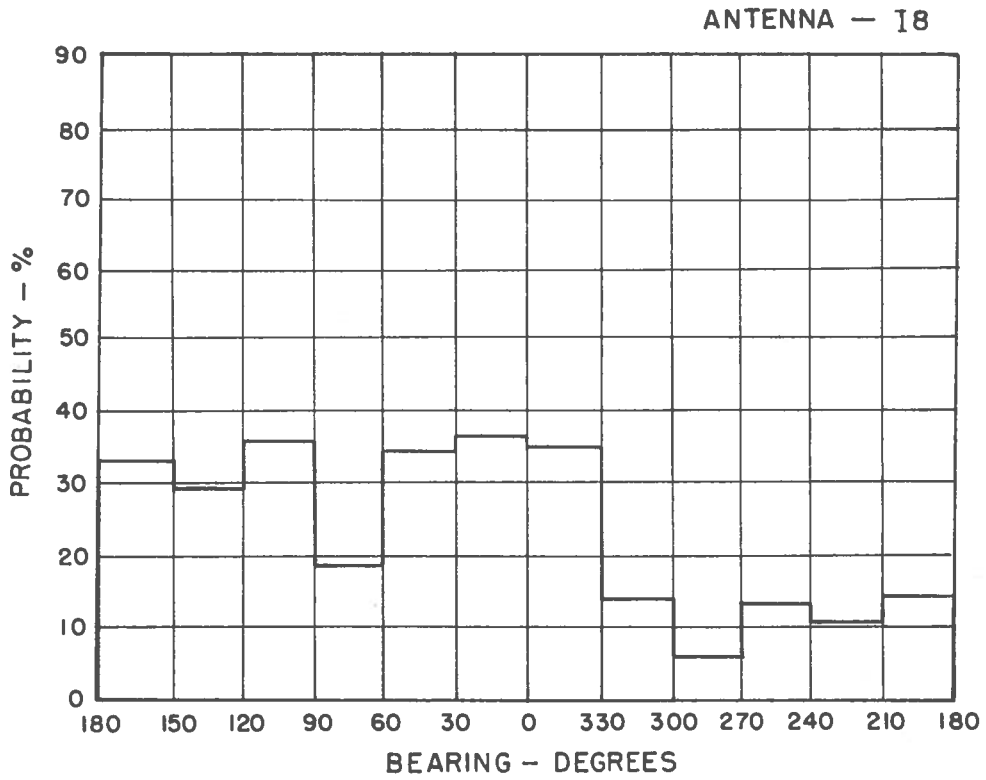



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 24

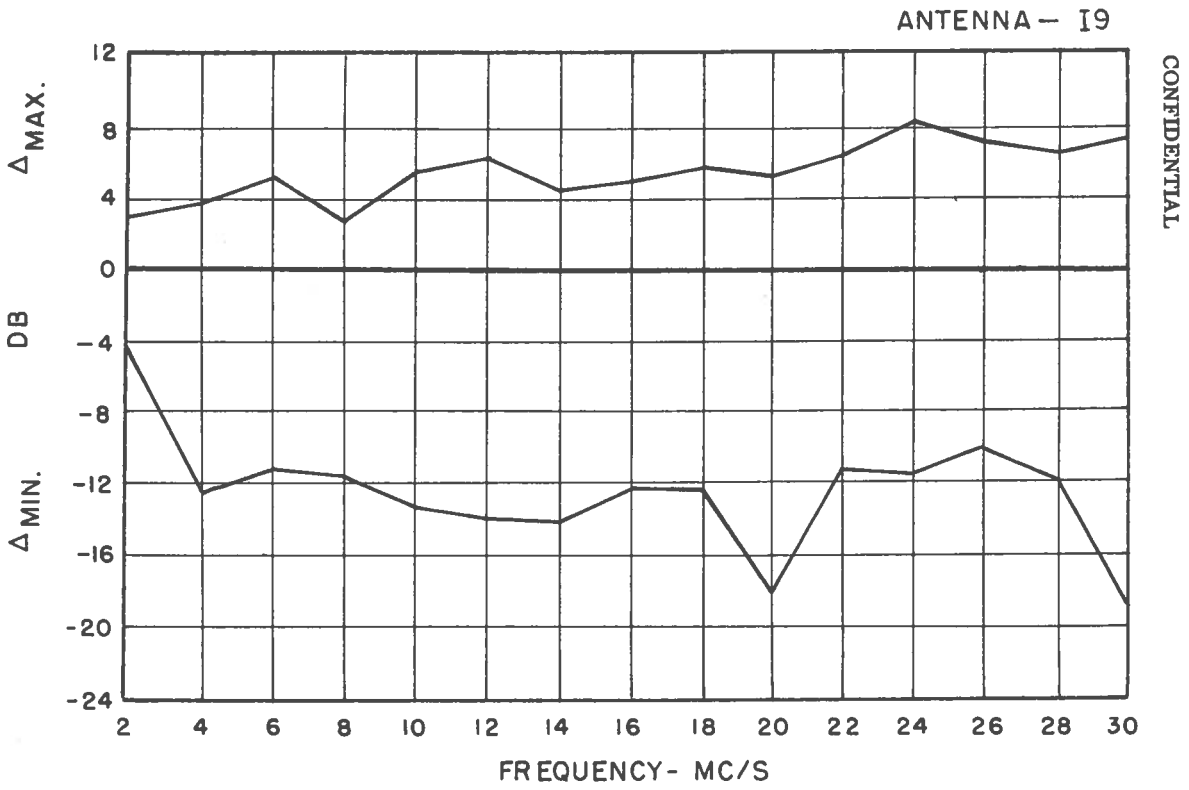



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY

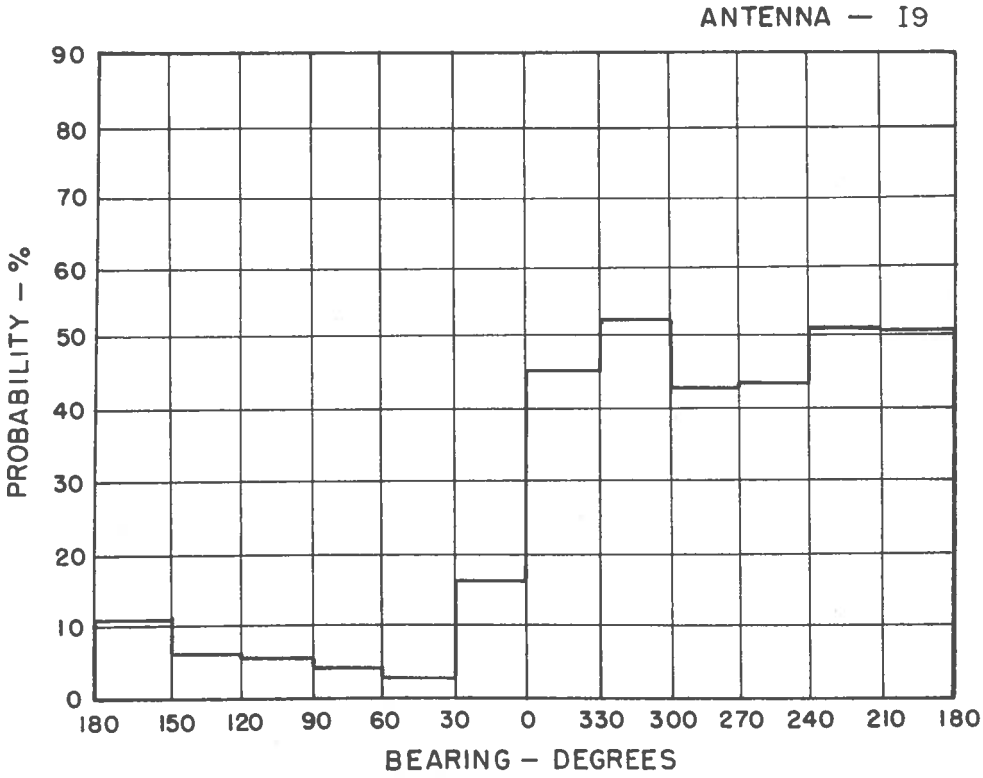



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 25

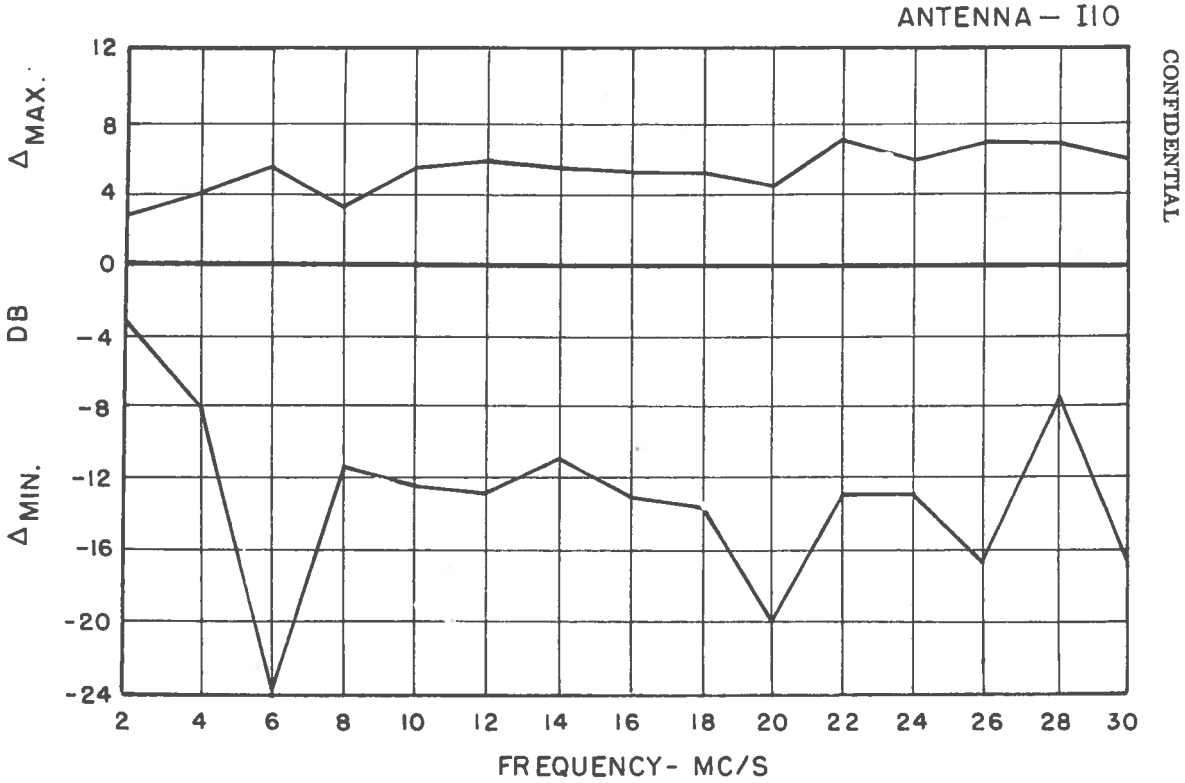



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY

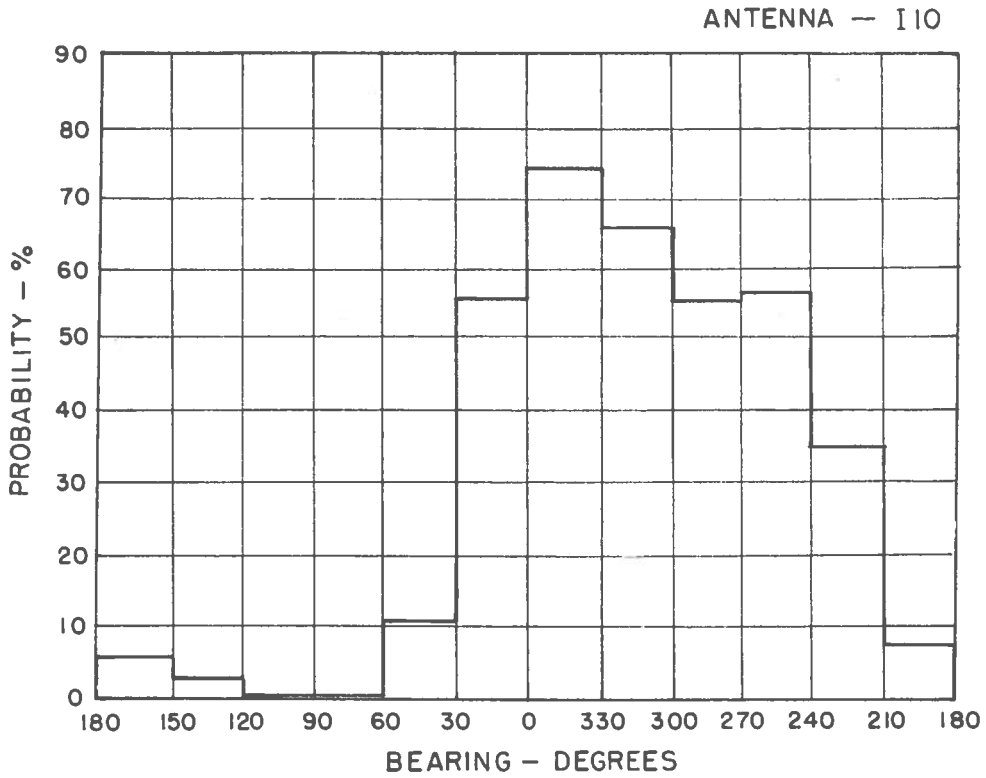



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 26

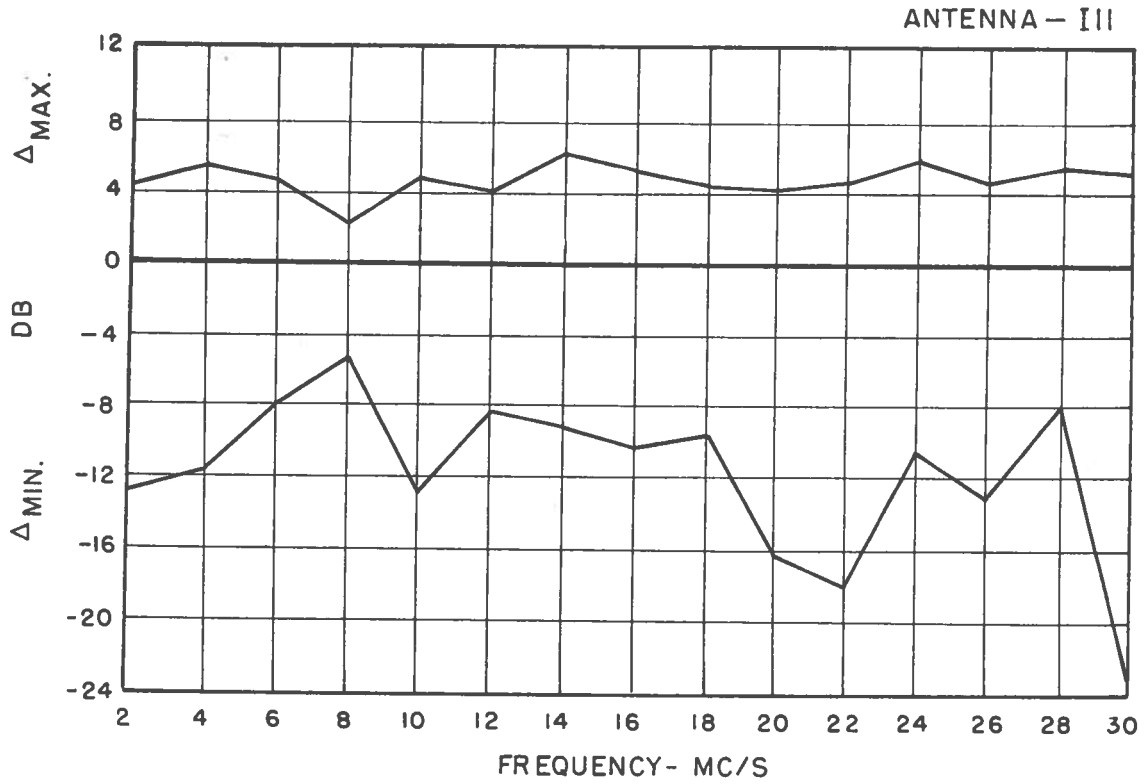



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY

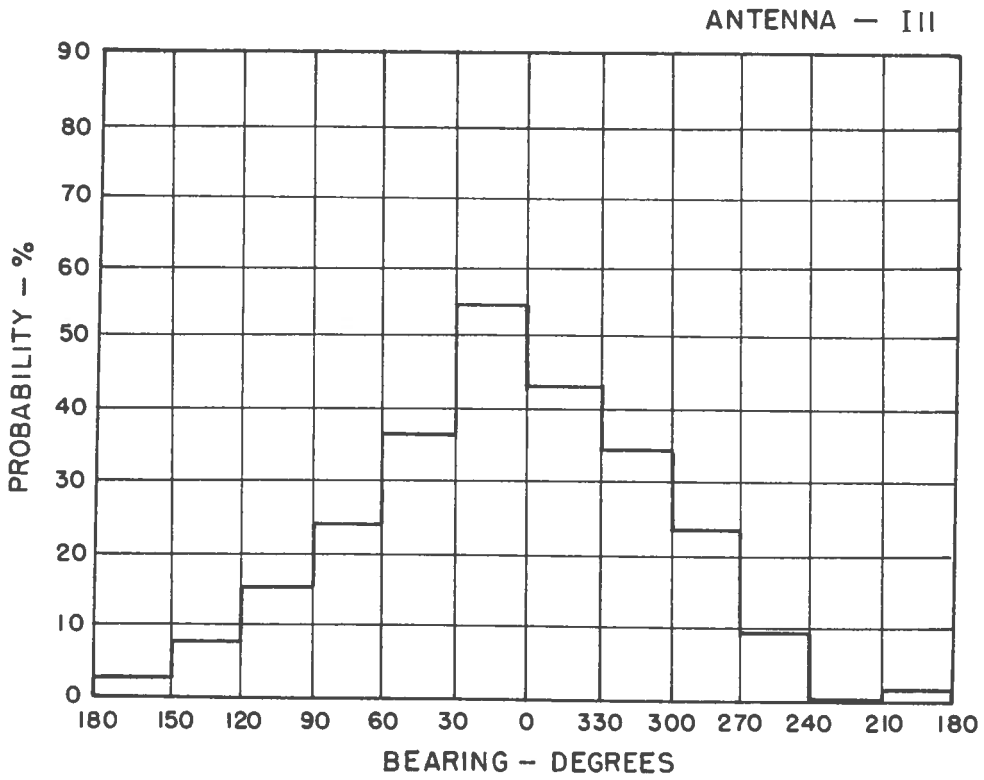



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 27

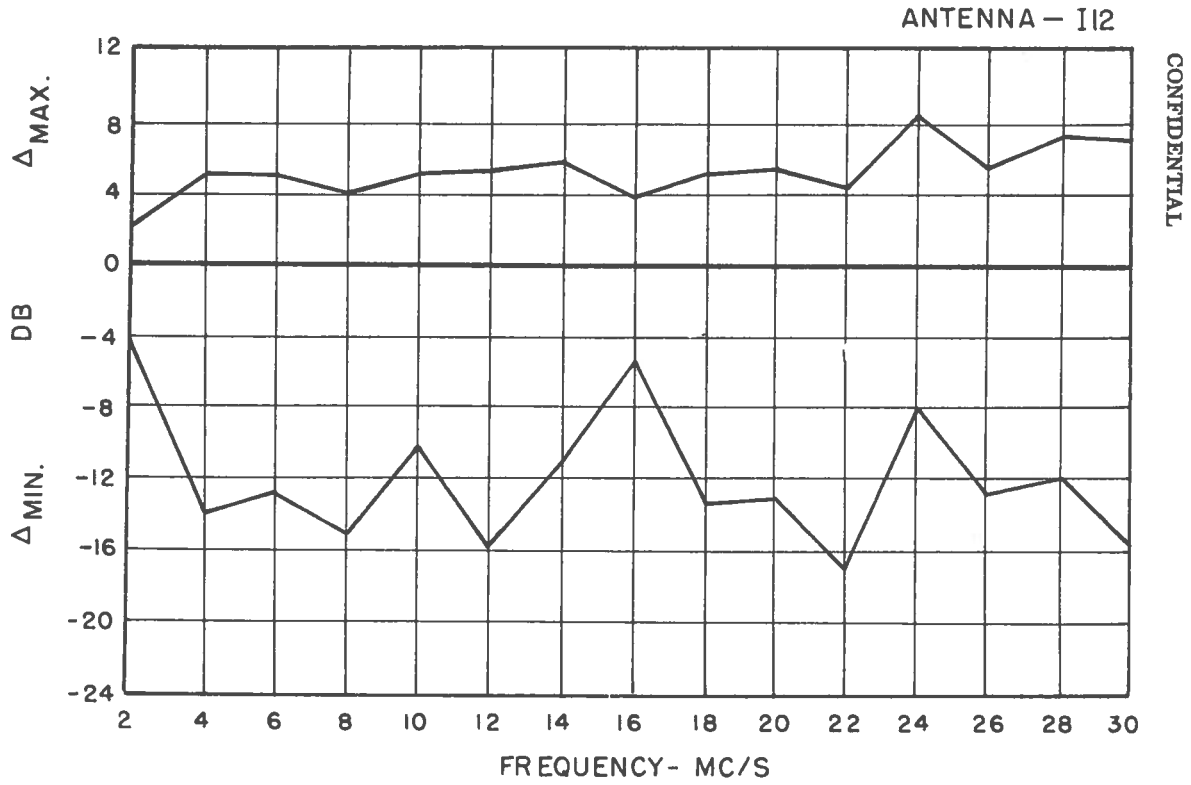



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY

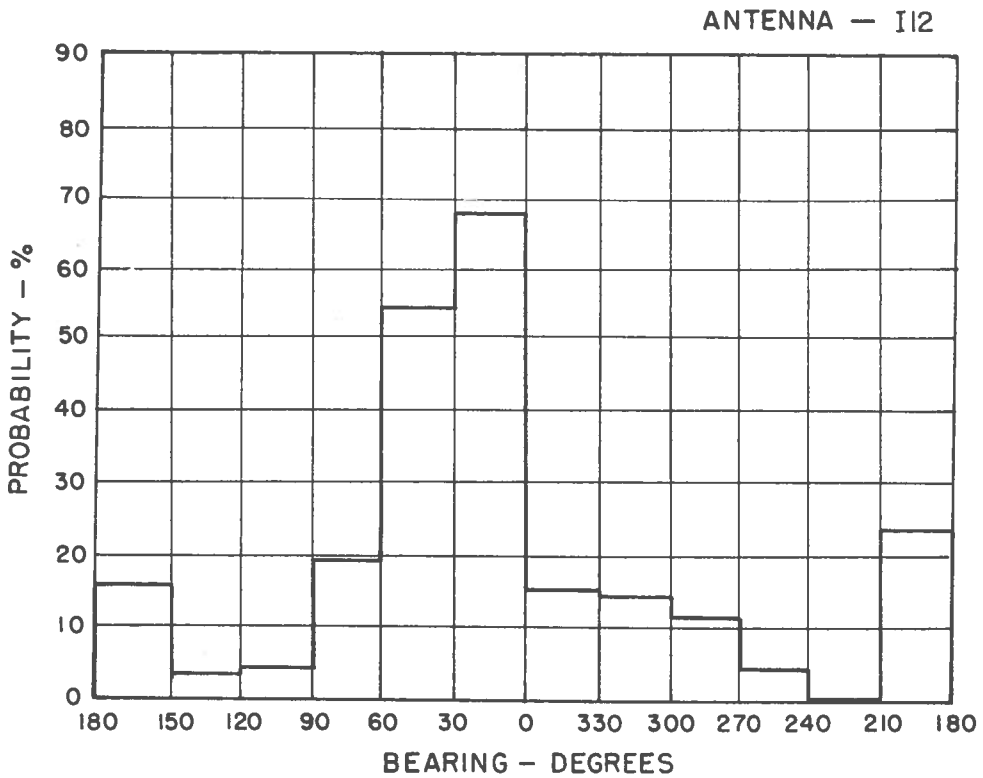



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 28

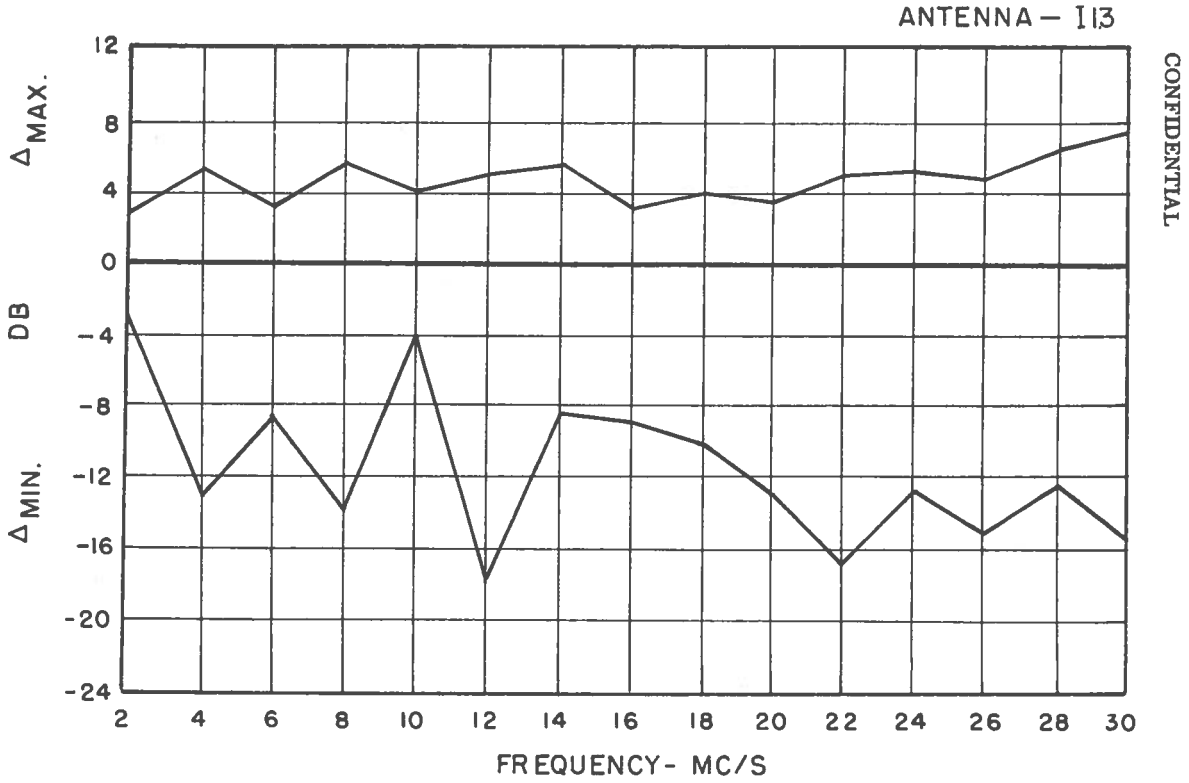



(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY

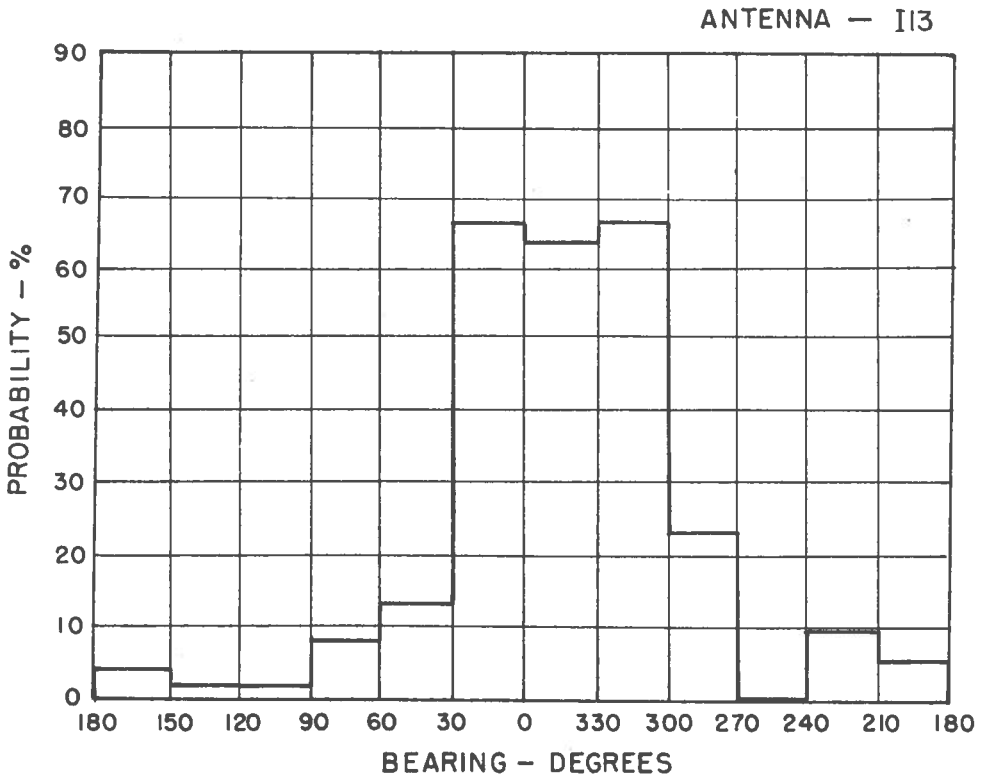



(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 29




(a) VARIATION OF $\Delta_{max}$ AND $\Delta_{min}$ AS A FUNCTION OF FREQUENCY




(b) PROBABILITY OF A LOSS IN SIGNAL 6 DB BELOW THE REFERENCE

FIG. 30