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22 December 1946

REMOVAL OF LAST REFLECTIONS BY HARP IN THE SG INSTALLATION ABOARD DESTROYERS

R. W. WRIGHT AND E. H. JOHNSON

Report R-3036

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RADIO DIVISION I

ABSORBENT MATERIALS FOR RADIO WAVES SECTION

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Preliminary Pages . . . a-d
Numbered Pages 5
Plates 12

NRL Problem N-41-R-S

ABSTRACT

A study has been made of the antenna patterns for the SG radar installation aboard a destroyer. The reflector and feed were of an improved design with side lobes approximately the same as those of the SG now under development (below 30 db). It is shown that side lobes as high as 21 db are introduced by mast reflections and that they may be eliminated by covering the illuminated section of the mast with Harp. The influence of such side lobes on the PPI presentation when large targets are nearby has also been studied and a marked improvement found with the mast reflections removed by Harp. It is concluded that the benefit derived from lower side lobes in an improved SG antenna can only be realized if provision is made to remove the mast reflections by Harp.

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REFERENCE:

I. NRL ltr, C-S67-5/25(1340), C-1300-17/46, to Chief of Research and Inventions, dated 11 February 1946.

1. INTRODUCTION

1-1. In reference I, tests made on the SG-1 antenna system aboard DD-836 are described. They were directed to isolating the effects caused by reflections from the mast and removing these effects with a Harp absorber. Such reflections occur when the antenna, located on a pedestal, four feet forward of the mast, is pointed in the backward direction. Three effects were studied.

(a) Reactions on the transmitter.

(b) Side lobes in the antenna pattern.

(c) Blind spot in the backward direction.

1-2. The following results, as reported in reference I, were obtained:

(a) Reflections from the mast into the antenna caused no appreciable pulling of the magnetron (less than 0.5 Mc).

(b) Reflections from the mast produced side lobes in the antenna pattern when the antenna was trained backwards. These side lobes were about 20 db down from the center of the main beam and were reduced below 30 db when the illuminated section of the mast was covered with absorbing Harp. Other side lobes, also about 20 db down, were produced by the reflector and feed of the SG-1 antenna itself.

(c) The obstruction of the mast caused a 12 db loss in radar performance, corresponding to a 6 db loss in antenna gain, when the antenna was trained directly backward.

1-3. It is evident that little is gained in eliminating side lobes from an antenna pattern unless all the side lobes are reduced below the desired level. Hence it was concluded in reference I that, if an improved antenna were installed for the SG radar, provision should also be made to remove the mast reflections. Similarly it was concluded that removal of the mast reflections could not effect a substantial improvement in the present SG unless an improved antenna were also installed.

1-4. The antennas of SG systems now under development are expected to have side lobes below 30 db. Consequently, it is desirable to examine directly the effects of mast reflections on this antenna and substantiate the above conclusion. The present

study, undertaken for that purpose was made on the SG radar of DD-849 at the Chesapeake Bay Annex of the Naval Research Laboratory from November 25th through November 28th, 1946. A special MTI antenna, whose side lobes were approximately the same as those of the SG antennas now under development, was rigged in place of the SG-1 antenna.[1] All the results reported herein were obtained on this installation.

1.5. It was considered unnecessary to repeat the experiments on magnetron pulling (Item (a) of paragraph 1.1). The main part of the study is concerned with the side lobes in the antenna pattern (Item (b) of paragraph 1.1). The blind spot in the backward direction has also been examined (Item (c) of paragraph 1.1).

2. INSTALLATION AND PROCEDURE

2.1. A sketch of the pedestal and mast for the SG on DD-849 is shown in Plate A. Aside from the location of handholds, etc. on the mast, the difference between this installation and that on DD-836 is the platform (marked A) on the port side of the mast which is partially illuminated by the main beam for backward positions of the antenna. A left - right asymmetry is thereby introduced which was not present in the tests described in reference I. The area covered when the Harp absorber was in place is indicated by dotted lines in Plate A.

2.2. The antenna patterns were taken by the method developed in the course of the previous tests. The shore SG was used as a signal source. A signal generator, coupled into the duplexer of the ship's SG, and the ship's receiver were tuned to the frequency of the shore transmitter.[2] A convenient signal level was reached with the ship about 20 miles south of the Chesapeake Bay Annex. Receiving pattern measurements were made by watching the pulse height of the signal generator as it appeared on the A scope against the line of pulses (unsynchronized) from the shore transmitter. Signal strengths were measured at 2° intervals of antenna bearing for a fixed orientation of the ship (Plates 1 to 8, incl.) or at 2° intervals of the ship's bearing with a fixed orientation of the antenna relative to the ship (Plate 9). The signal strength with the antenna trained on the shore station was measured before and after each run and generally

[1] The cooperation of Comdr. J. R. Oliver and of the officers and men under his command in this operation as well as in the other phases of the work was an essential factor in the successful outcome of these tests.

[2] Installation of the signal generator and modification of the ship's SG were under the direction of Mr. A. S. Grovesnor of CBA whose assistance was an important contribution to the present study.

showed less than 1 db variation. In a similar way the ship's pattern was determined by measuring the signal strengths for various bearings of the ship while the antenna was continuously trained on the shore transmitter (Plate 10).

2.3. A line of cliffs about 15 miles south of the Chesapeake Bay Annex provided a large target which might be expected to produce false echoes from the side lobes in the antenna pattern. With the ship about 2 miles off shore, PPI photographs were taken with and without the Harp absorber to show the presence of such false targets.

3. ANTENNA PATTERNS

3.1. Receiving antenna patterns were taken with the ship's head at 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315° bearing with respect to the signal source. These curves are shown as the solid lines in Plates 1 to 8, inclusive. A similar set of patterns were taken with Harp on the illuminated portion of the mast and are shown as the dotted lines in the same plates. Each curve is drawn from a set of points taken at 2° intervals for relative bearings of the antenna with respect to the ship between 90° and 270°. The radial coordinate is db down from the center of the main beam so that the center of the main beam is represented by the radius corresponding to 0 db. A solid circle has been drawn at 30 db down and represents a "danger line". A satisfactory antenna system should have side lobes below this line.

3.2. Sizable mast reflections which are removed by Harp appear in Plates 2 and 5.

Plate No.	Bearing of Source	Antenna Bearing	Height of Side Lobe	Height After Harp Installation
2	45° off port bow	185	22 db	35 db
5	90° off starboard bow	160	26 db	50 db

3.3. It will be noticed that the patterns do not exhibit the left - right symmetry that might be expected and was found in the previous tests. This is probably caused by the platform mentioned in paragraph 2.1 and marked by A in Plate A. This metallic structure intercepting a part of the beam on the port side of the mast can cause a substantial difference in the mast reflections on the port and on the starboard sides.

3.4. The pattern with the target directly off the stern (Plate 5) shows clearly the effect of the mast obstruction both in widening the beam and in causing a minor lobe to appear at 6° from the center of the main beam on both sides. The distortion of the main beam causes a serious loss in antenna gain for this position

of the antenna (See paragraph 3.7). It should be remembered in considering the side lobes in this pattern that, because of the decreased antenna gain, the center of the main beam is 11 db below the center of the main beam for antenna positions in which the reflector is not obstructed by the mast.

3.5. An antenna pattern with the reflector trained directly at the mast while the ship's head turned through 360° is shown in Plate 9. The points on this curve should correspond to points on the curves of Plate 1 to Plate 8, inclusive, at antenna bearing of 180°. Sizable mast reflections appear as follows:

Bearing	Height of Side Lobe	Height After Harp Installation
55°	23 db	32 db
125°	24 db	33 db
135°	24 db	33 db
240°	24 db	33 db
305°	21 db	35 db

These side lobes are measured with respect to the main beam when there is no obstruction between the antenna and signal source.

3.6. Study of these patterns reveals that side lobes from the mast reflections appear in many positions and are sometimes as high as 21 db down. When the illuminated section of the mast is covered with Harp, however, all side lobes of the antenna system are reduced below 27 db.

3.7. The ship's pattern was taken with the antenna trained directly on the signal source and the ship's head at various bearings between 90° and 270° relative to the signal source. As there was no significant difference when Harp was in place, only one curve has been plotted in Plate 10. (It should be noted that the radial scale has been changed in this figure). A loss of 11 db appears when the mast is directly between the signal source and the reflector and a loss of 5 db or more is present in a sector of 40° centered in the backward direction. The 11 db loss corresponds to a 22 db loss in radar performance and is approximately twice (in db) as great as that found on DD-836. This undoubtedly arises from the improved design of the MTI antenna for reduction in side lobes from the reflector is obtained by illuminating the center of the reflector more strongly and tapering the illumination to zero at the edges. Hence, close to the antenna, the radiated energy is more concentrated at the center of the beam and therefore is more strongly affected by an obstacle (the mast) of a fixed size.

4. PPI PHOTOGRAPHS

4.1. The presence of mast reflections from large targets is quite evident directly on the PPI. This may be seen by studying the two PPI photographs in Plate B. The shore on the left hand side of these photographs are cliffs approximately two miles from the ship. The upper photograph is the PPI when the mast is uncovered, the lower photograph is the PPI after Harp has been installed. In both photographs all the SG controls have been left unchanged and the same camera exposures used. The SG was left in operation in the fifteen-minute interval between the photographs when the Harp installation was made.

4.2. A "cloud" marked by an arrow appears in the upper photograph for antenna positions in the backward direction. It extends in range over the ranges of the strong land targets and is caused by the side lobes from mast reflections. When the illuminated section of the mast was covered with Harp, it can be seen in the lower photograph that these signals have disappeared and the general appearance of the PPI for directions toward the stern markedly improved.

4.3. Other differences between the two photographs are the result of changes in the target around the ship in the interval between the photographs.

5. CONCLUSIONS

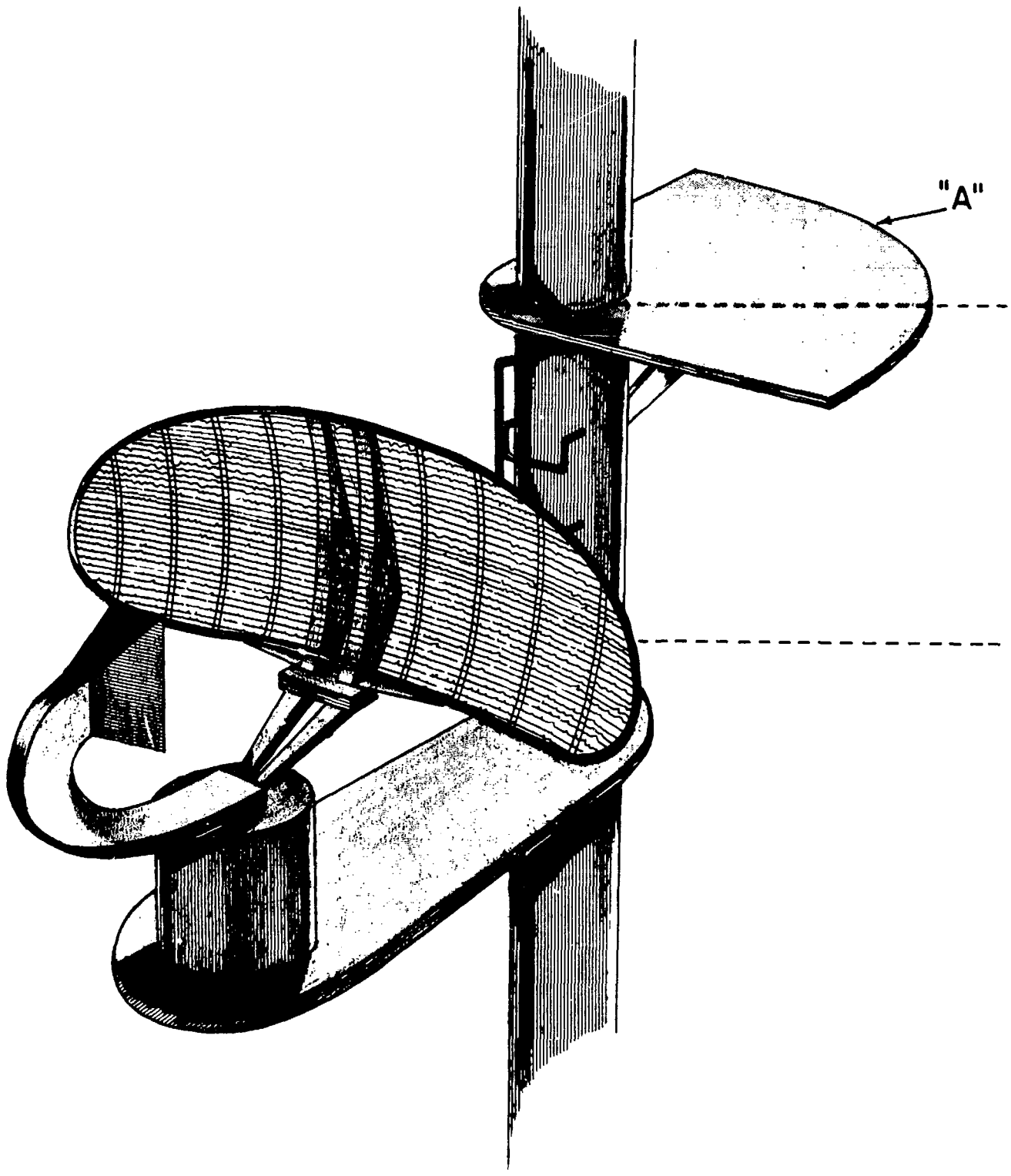
5.1. With an antenna whose side lobes are below 30 db on an SG aboard a destroyer, the mast reflections cause side lobes as high as 21 db down from the main beam. The presence of these side lobes can be clearly seen on the PPI for large, nearby targets.

5.2. All side lobes are reduced below 27 db by covering the illuminated section of the mast with Harp. There is a corresponding improvement of the PPI presentation when large targets are nearby.

5.3. From the previous two paragraphs it follows that benefit derived from lower side lobes in an improved SG antenna can only be realized in practice if provision is made to remove the mast reflections with Harp.

5.4. With the same antenna there is an 11 db loss in gain with the antenna trained directly backwards which is not affected by Harp.

SKETCH OF SG ANTENNA INSTALLATION ABOARD DD-849



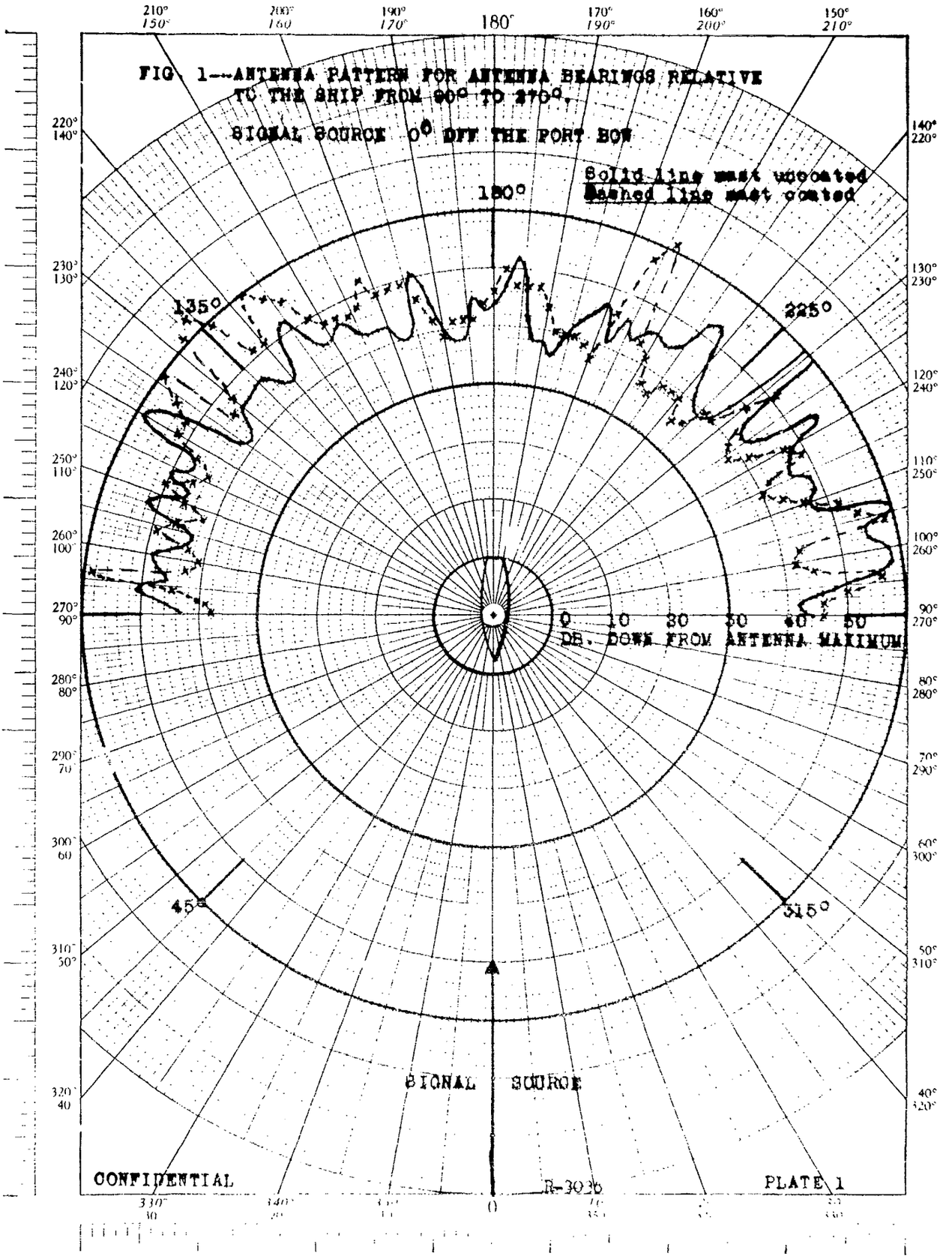
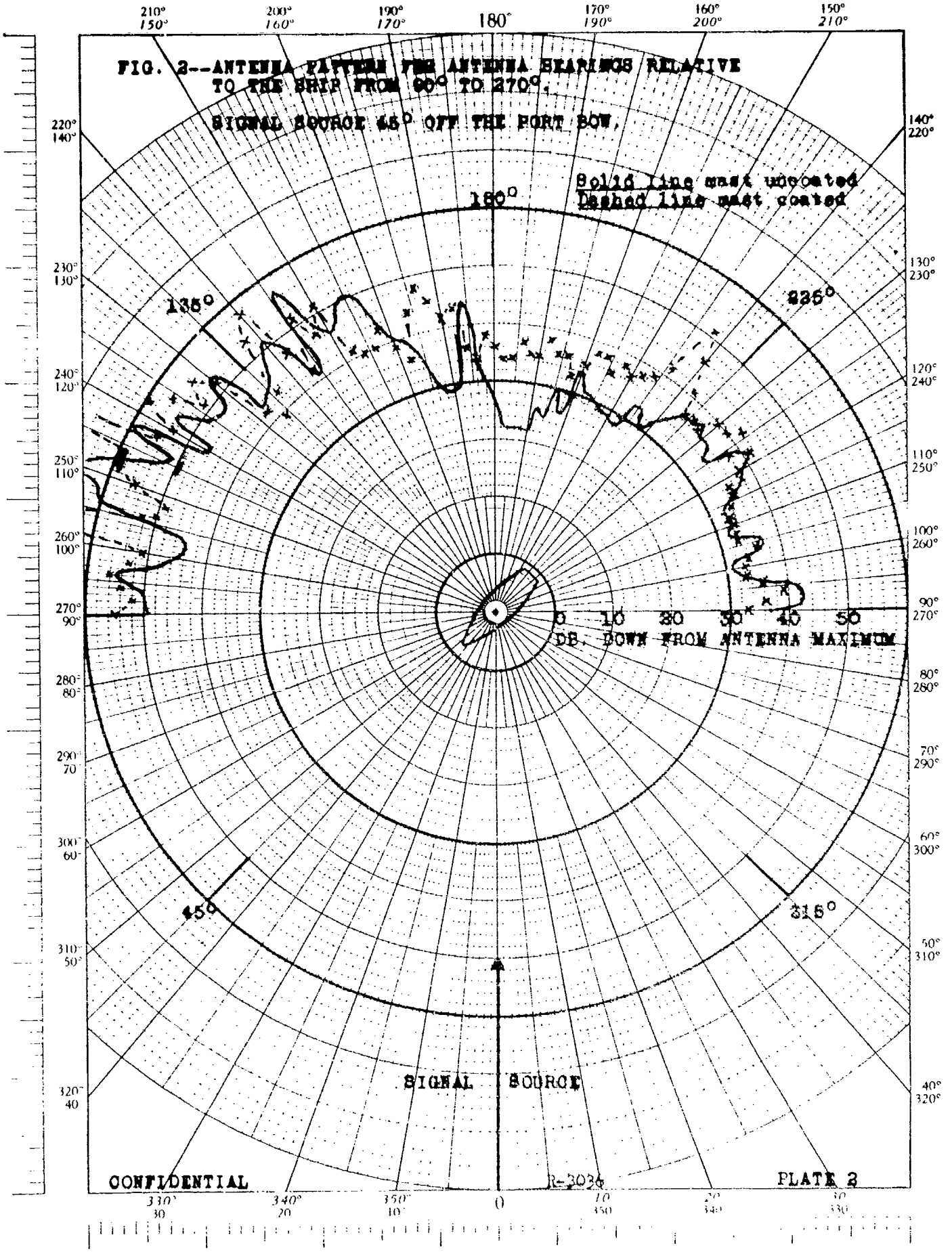


FIG. 1—ANTENNA PATTERN FOR ANTENNA BEARINGS RELATIVE TO THE SHIP FROM 90° TO 270°.
SIGNAL SOURCE 0° OFF THE PORT BOW
Solid line meat mounted
Dashed line meat mounted
180°
135°
225°
45°
315°
0 10 30 50 40 50
DB. DOWN FROM ANTENNA MAXIMUM
SIGNAL SOURCE
CONFIDENTIAL
R-3036
PLATE 1

FIG. 2--ANTENNA PATTERN FOR ANTENNA BEARINGS RELATIVE TO THE SHIP FROM 90° TO 270°.

SIGNAL SOURCE 45° OFF THE PORT BOW.



CONFIDENTIAL

R-3036

PLATE 2

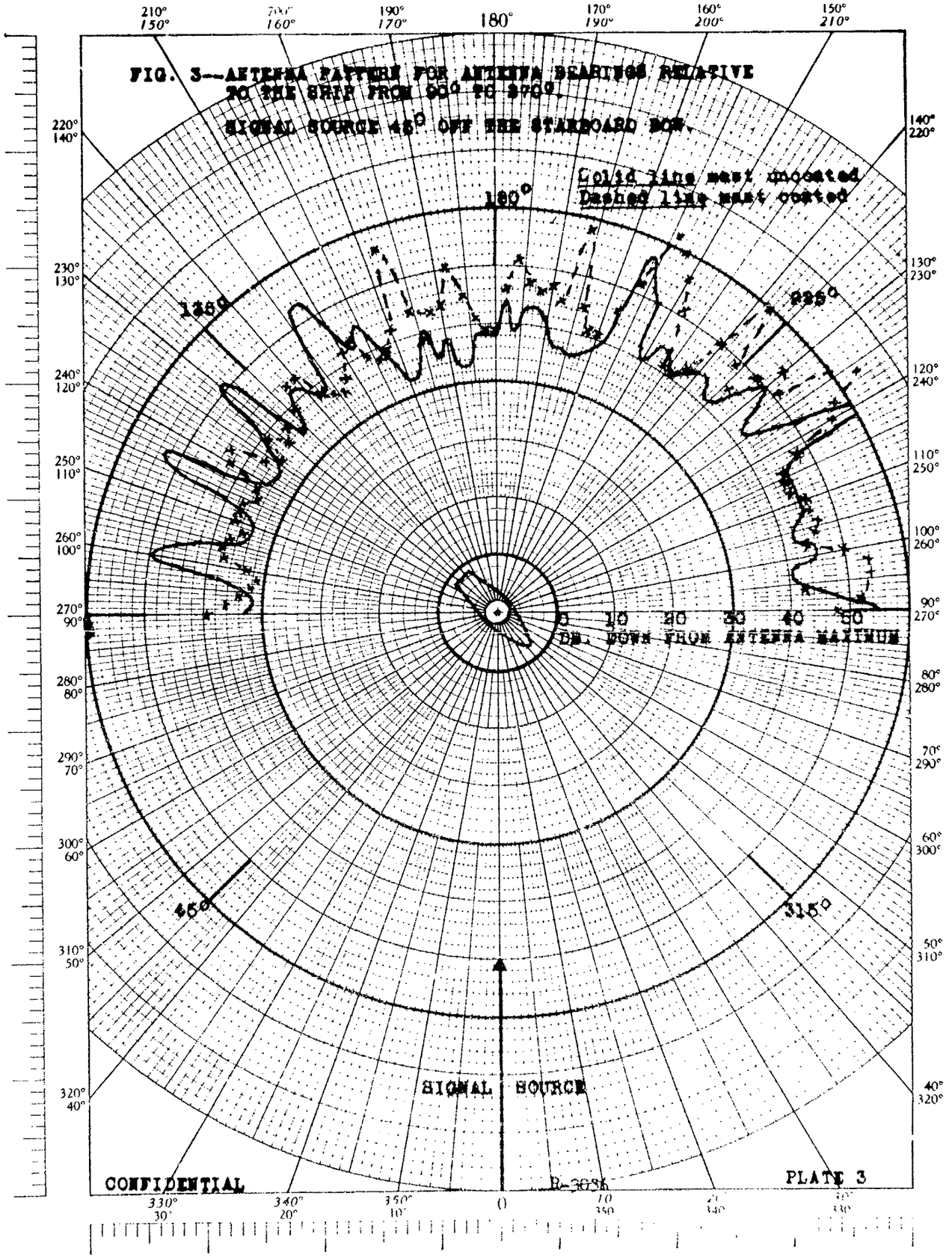


FIG. 3—ANTENNA PATTERN FOR ANTENNA BEARINGS RELATIVE TO THE SHIP FROM 000° TO 360°.
SIGNAL SOURCE 45° OFF THE STARBOARD BOW.
Solid line meat uncoated
Dashed line meat coated
180°
135°
225°
45°
315°
0 10 20 30 40 50
DB. DOWN FROM ANTENNA MAXIMUM
SIGNAL SOURCE
CONFIDENTIAL
R-3056
PLATE 3

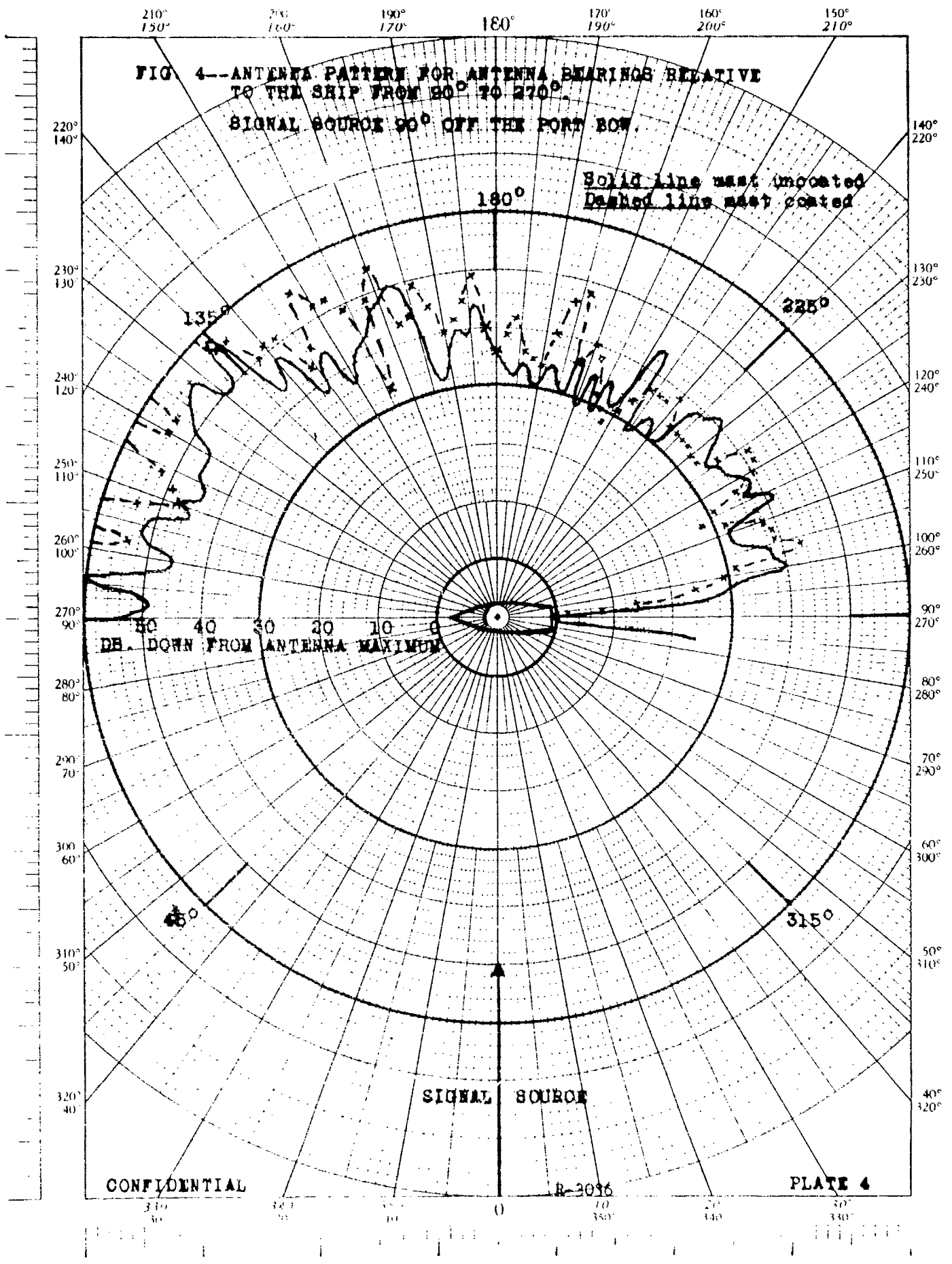


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PLATE 4

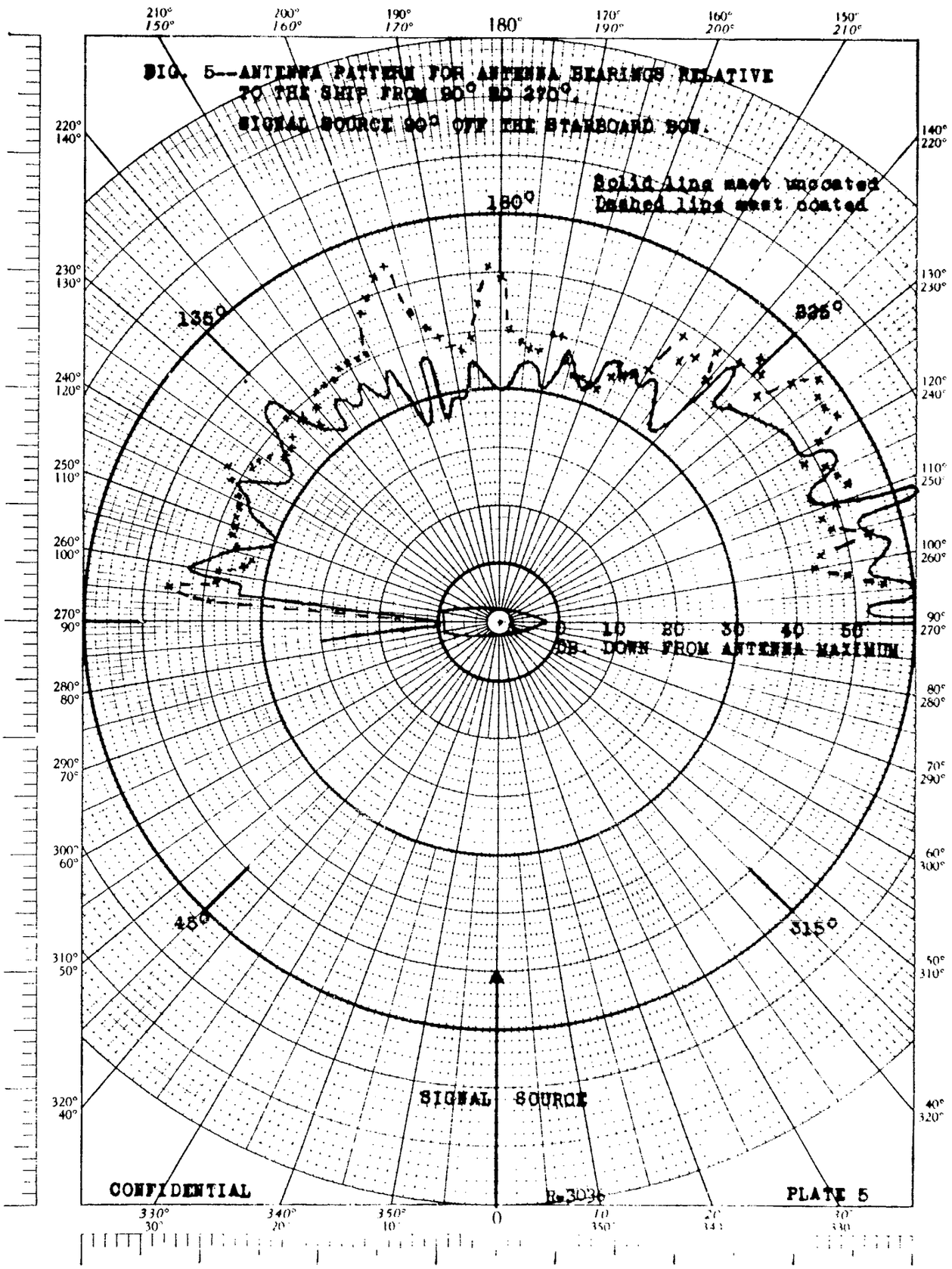
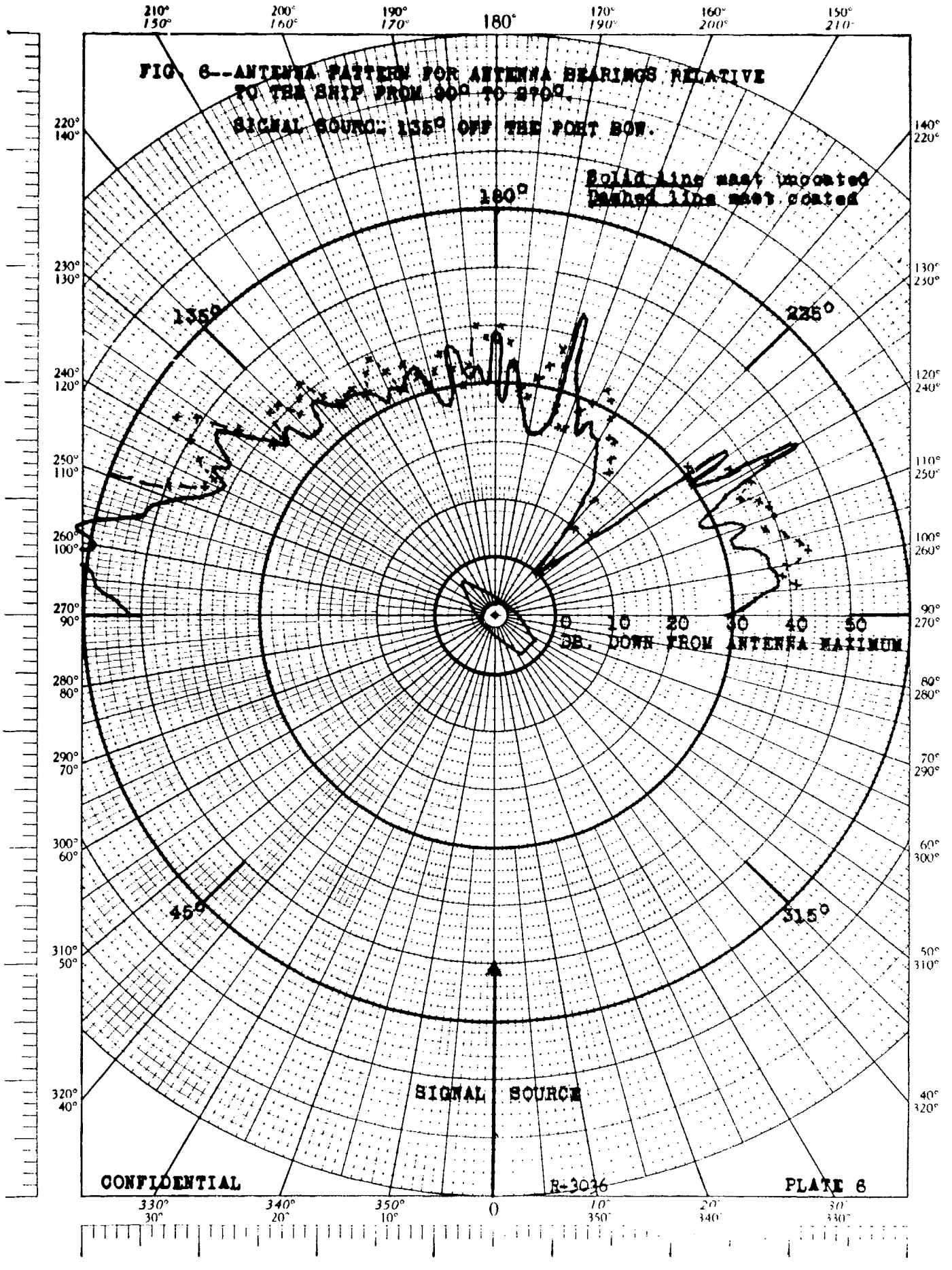


FIG. 5--ANTENNA PATTERN FOR ANTENNA BEARINGS RELATIVE TO THE SHIP FROM 90° TO 270°.
SIGNAL SOURCE 90° OFF THE STARBOARD BOW.
Solid line most uncoated
Dashed line most coated
180°
135°
225°
45°
315°
0 10 20 30 40 50
DB DOWN FROM ANTENNA MAXIMUM
SIGNAL SOURCE
CONFIDENTIAL
R-3036
PLATE 5

FIG. 6--ANTENNA PATTERN FOR ANTENNA BEARINGS RELATIVE TO THE SHIP FROM 90° TO 270°.

SIGNAL SOURCE: 135° OFF THE PORT BOW.

Solid line mast uncoated
Dashed line mast coated



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R-3036

PLATE 6

FIG. 7--ANTENNA PATTERN FOR ANTENNA BEARINGS RELATIVE TO THE SHIP FROM 90° TO 270°.

SIGNAL SOURCE 135° OFF THE STARBOARD BOW.

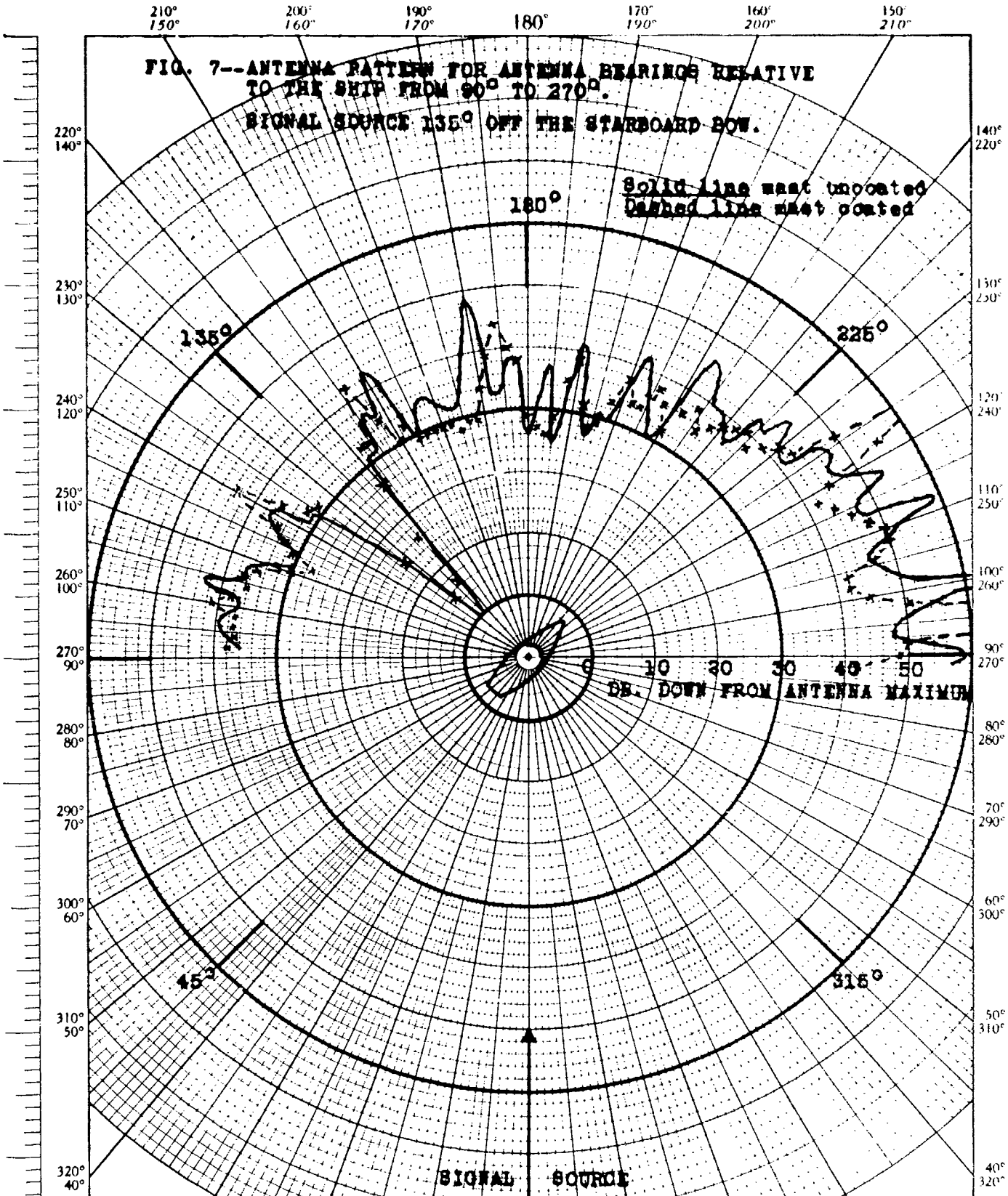

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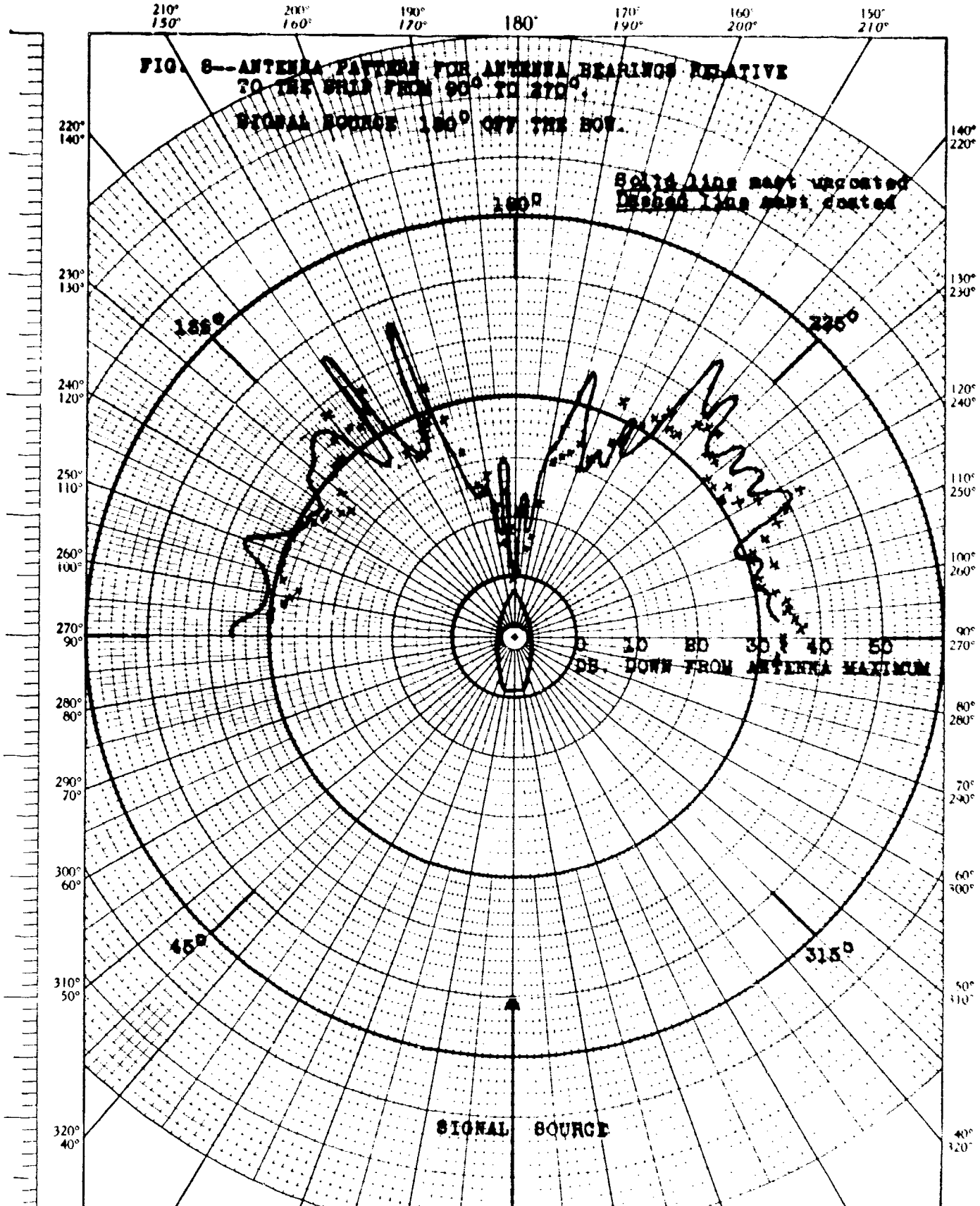
PLATE 7



CONFIDENTIAL R-3036 PLATE 8

FIG. 9—ANTENNA PATTERN WITH THE ANTENNA CONSTRUCTIONALLY POINTED AT THE BOW AND THE SHIP ROTATED THROUGH 360°.

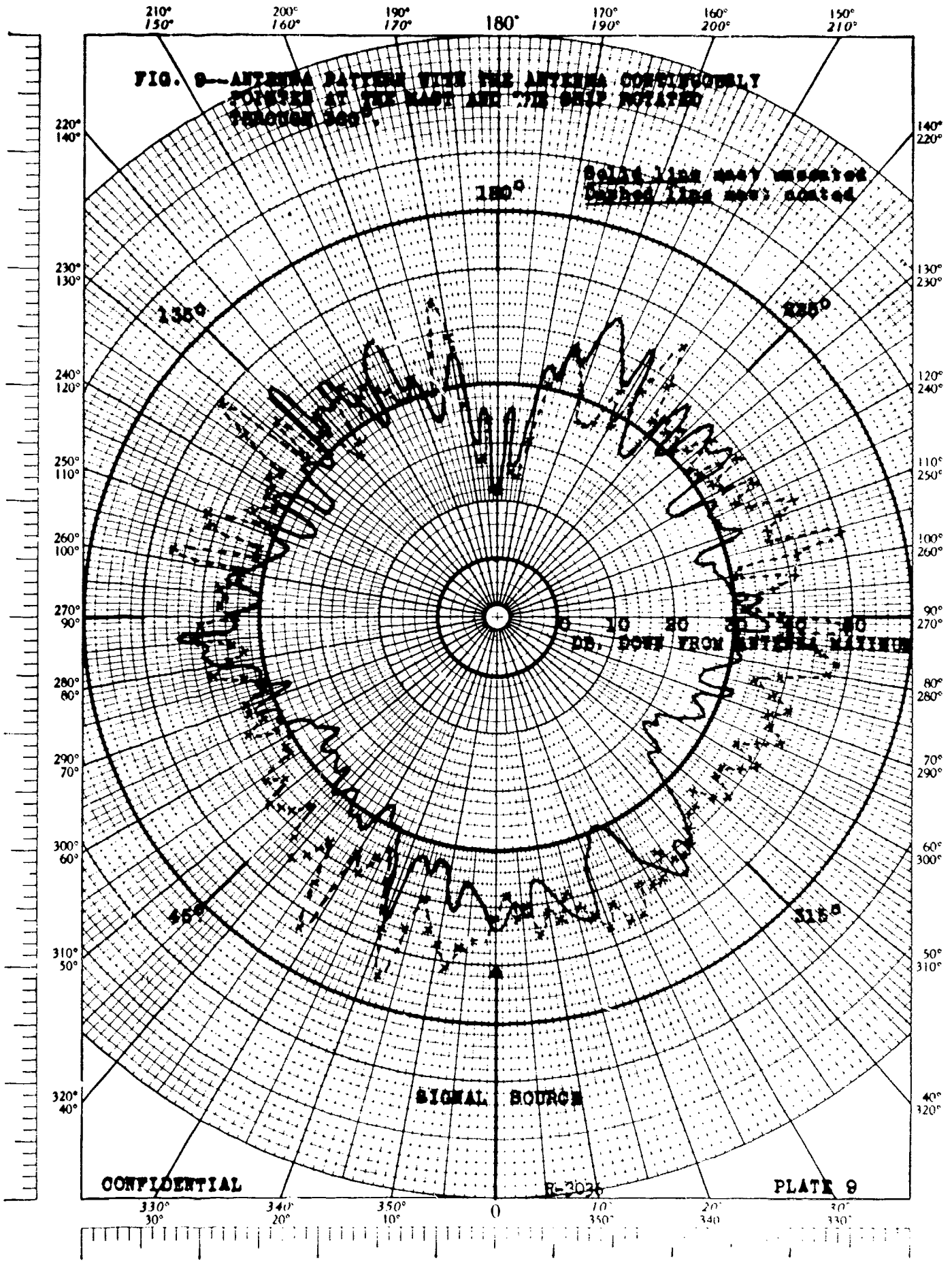
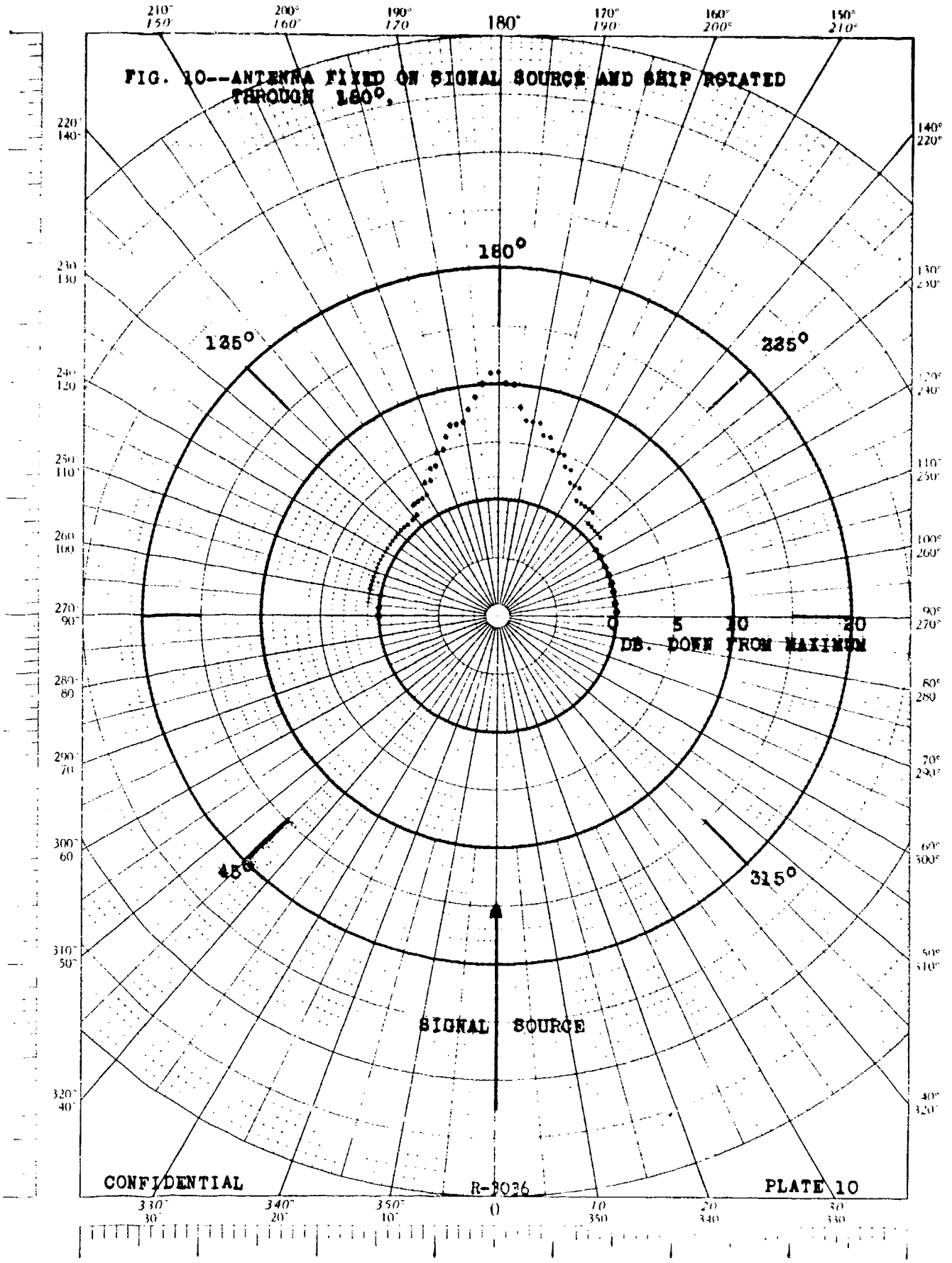
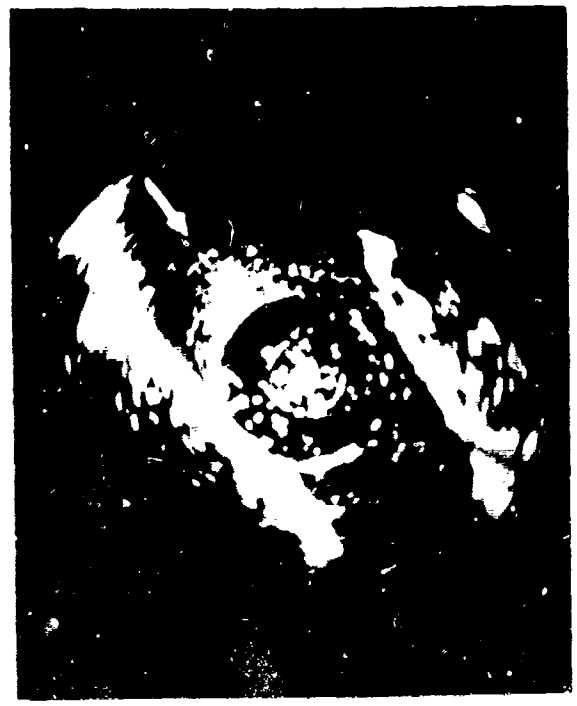


FIG. 10--ANTENNA FIXED ON SIGNAL SOURCE AND SHIP ROTATED THROUGH 180°.



CONFIDENTIAL R-3036 PLATE 10

PHOTOGRAPHS OF THE P.P.I. PRESENTATION OF S.G. RADAR



A. WITHOUT HARP

B. MAST COVERED WITH HARP

THE ARROWS POINT TO REGIONS OF FALSE ECHOES FROM MAST REFLECTIONS

Date: 15 September, 1999

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To: Dr. Trunk
Code 5300

CC: Chuck Rogers
Code 1221.1

on 9/16/99

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Thank you,

Mary Templeman

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