THE ANTENNA LABORATORY

RESEARCH ACTIVITIES in ---

Automatic Controls *Antennas* *Echo Area Studies*
Microwave Circuits *Astronautics* *E M Field Theory*
Terrain Investigations *Radomes* *Systems Analysis*
Wave Propagation *Submillimeter Applications*

Pattern Handbook
Volume VI: Far-Field Patterns of a Linear Antenna Radiating in the Presence of Circular Cylinders

C. H. Brenner

Contract No. N123(953)-31663A

1522-16 1 August 1965

Prepared for:
U. S. Navy Electronics Laboratory
Code 3300b
San Diego, California

Department of ELECTRICAL ENGINEERING

THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION
Columbus, Ohio

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Government has the right to reproduce, use, and distribute this report for governmental purposes in accordance with the contract under which the report was produced. To protect the proprietary interests of the contractor and to avoid jeopardy of its obligations to the Government, the report may not be released for non-governmental use such as might constitute general publication without the express prior consent of The Ohio State University Research Foundation.

Qualified requesters may obtain copies of this report from the Defense Documentation Center, Cameron Station, Alexandria, Virginia. Department of Defense contractors must be established for DDC services, or have their "need-to-know" certified by the cognizant military agency of their project or contract.

REPORT 1522-16

REPORT
by
THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION
COLUMBUS, CHIO 43212

Sponsor	U. S. Navy Electronics Laboratory Code 3300b San Diego, California
Contract No.	N123(953)31663A
Investigation of	Study Program Related to Shipboard Antenna System Environment
Subject of Report	Pattern Handbook Volume VI: Far-Field Patterns of a Linear Antenna Radiating in the Presence of Circular Cylinders
Submitted by	C.H. Brenner Antenna Laboratory Department of Electrical Engineering
Date	1 August 1965

PREFACE

The prediction of fields radiated by shipboard antennas is complicated by the presence of parasitically excited superstructure which warps and deteriorates the far-field patterns. If antennas are to be located in some logical manner on the ship, or if the ship design itself is to take account of the primary radiating elements, then some guides must be found to account for the influence of superstructure on antenna patterns. To this end, a handbook has been compiled, giving patterns of a thin, linear, vertical antenna radiating in the presence of cylindrical conducting structures of various cross-sectional shape. The model used to approximate this configuration is that of an infinite line source, representing the dipole, radiating in the presence of an array of thin, infinite wires parallel to each other and outlining the surface of the offending cylindrical structure. It has been shown [1] that such a wire approximation is electrically similar to the solid metallic surface if at least 5 wires per wavelength of perimeter are used. It has also been shown[2] that the patterns obtained from the infinitely tall model in the plane normal to the cylinder axis are good approximations to those obtained from the actual finite height configuration so long as the offending structure is taller than the source antenna, preferably twice as tall[3].

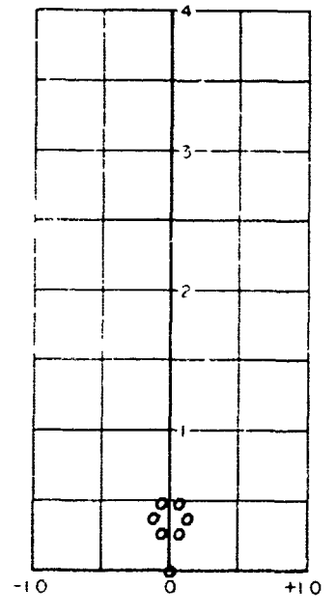
Because long distance communication systems aboard ship usually operate at wavelenghts between 10 and 100 meters, structures which have rather sizeable physical dimensions are not very large in terms of wavelength. For this reason, only offending structures up to 2 wavelengths on a side are considered. It has been found from sample calculations that patterns for objects larger than 2 wavelengths on a side do not differ radically from those for the largest objects presented in this handbook.

The computer program used to calculate the patterns in this handbook is an automated version of the SCATRAN program described in Reference 2. Certain innovations were incorporated to improve efficiency of operation.

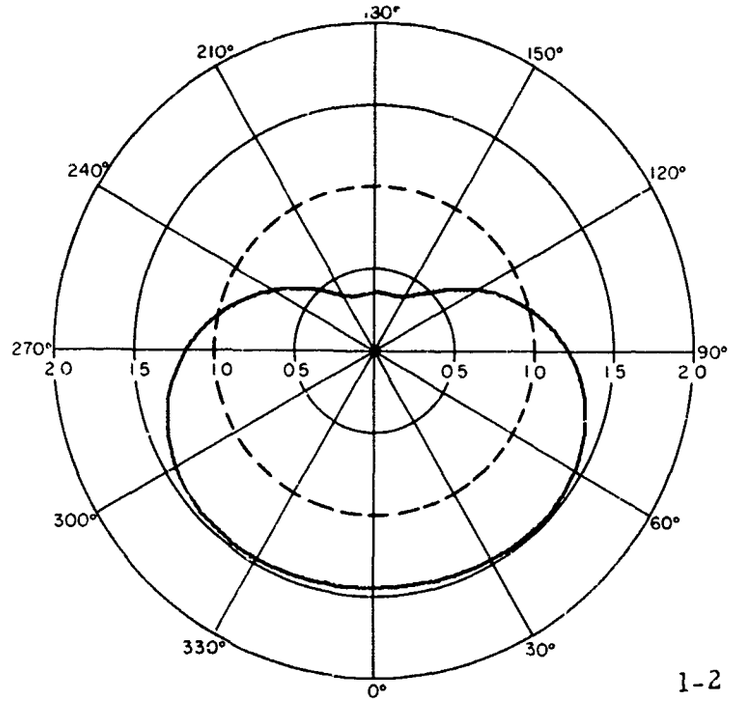
ACKNOWLEDGEMENT

The author wishes to acknowledge the assistance of Mr. G. A. Thiele in modifying the computer program and in preparing this handbook.

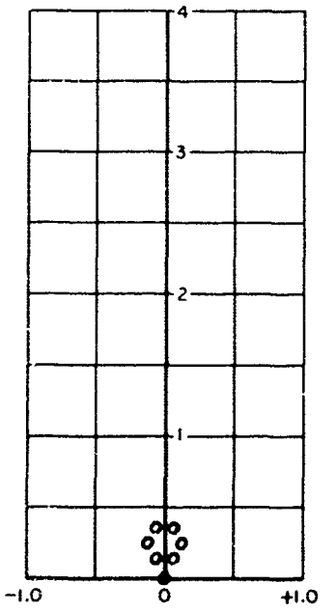
TABLE OF CONTENTS



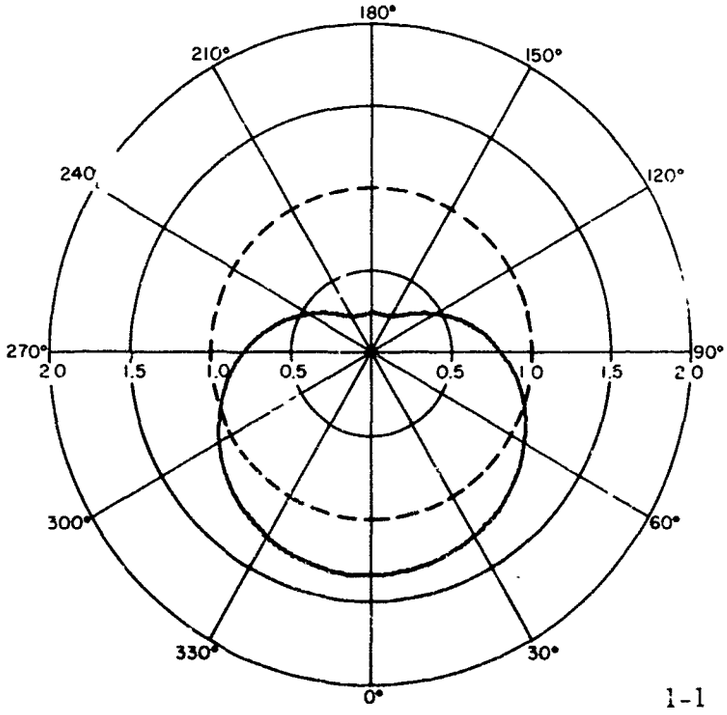
DISTANCE ~ WAVELENGTHS



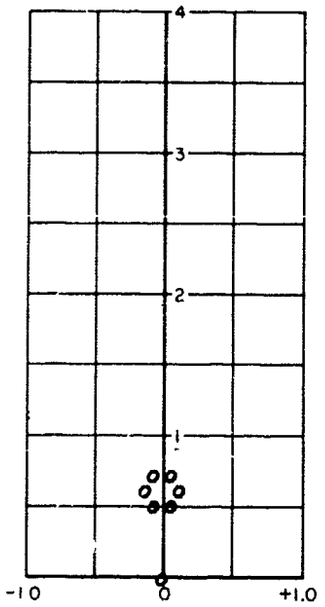
1-2



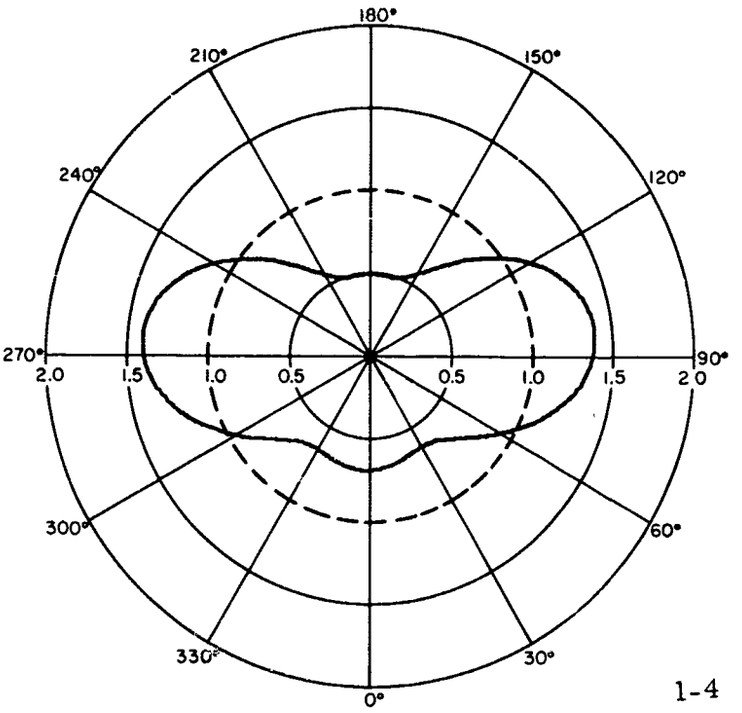
DISTANCE ~ WAVELENGTHS



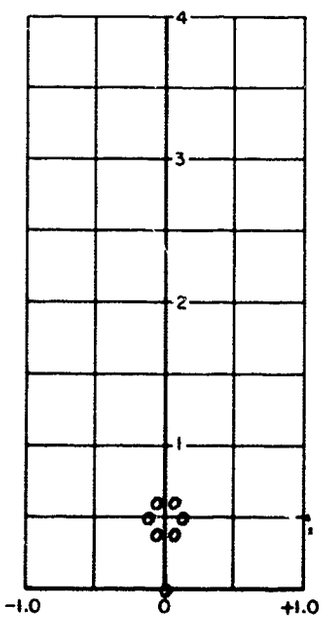
1-1



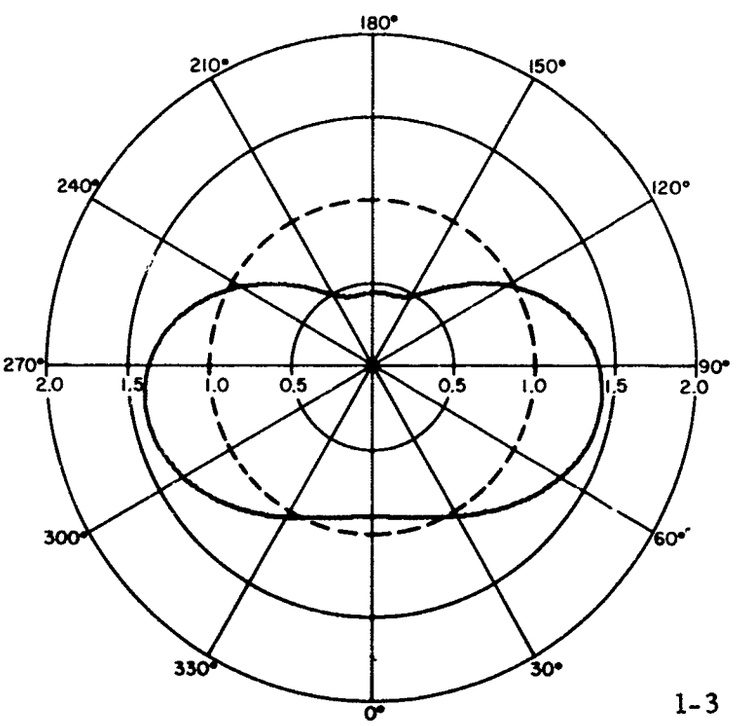
DISTANCE ~ WAVELENGTHS



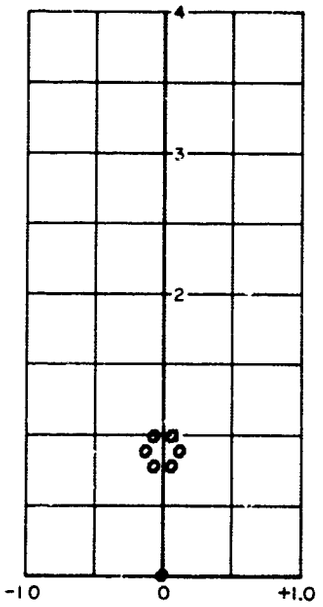
1-4



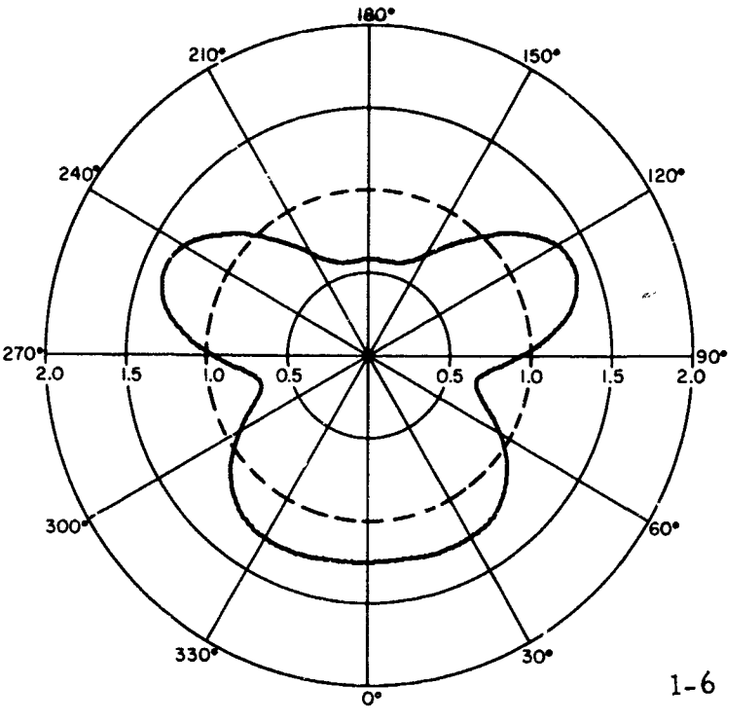
DISTANCE ~ WAVELENGTHS



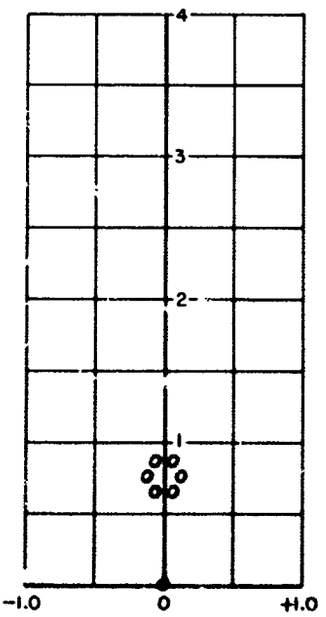
1-3



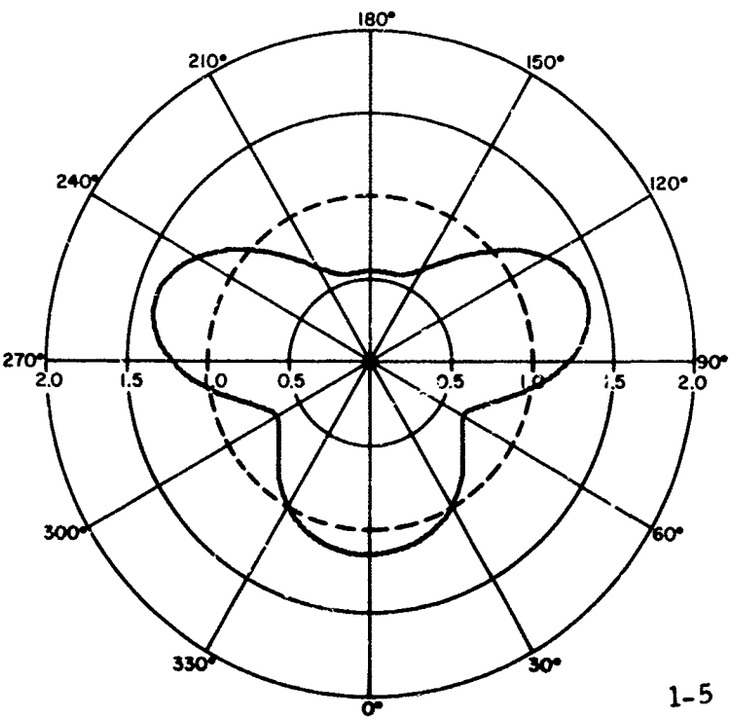
DISTANCE ~ WAVELENGTHS



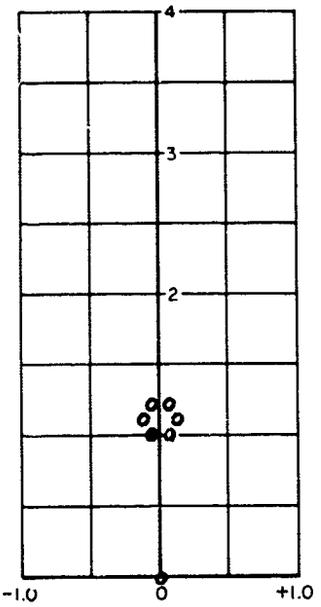
1-6

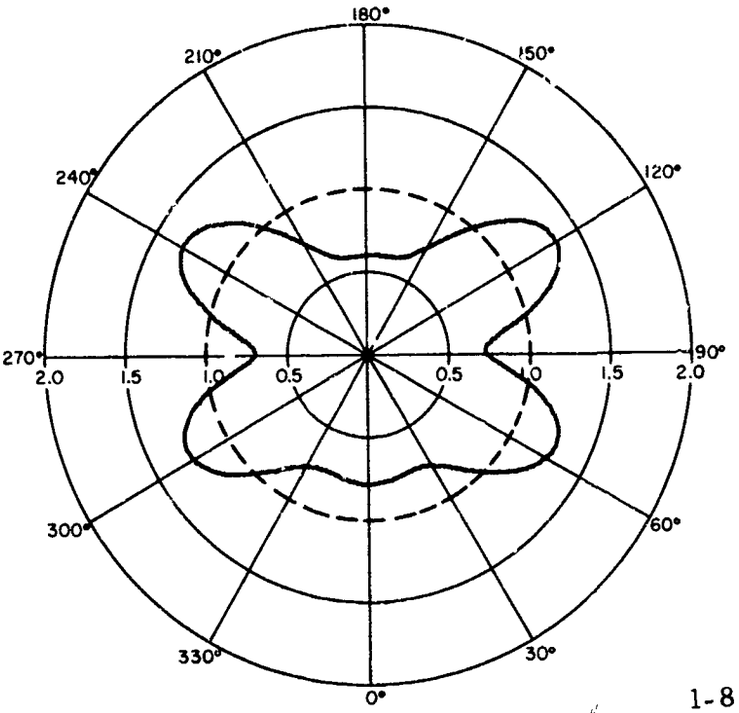


DISTANCE ~ WAVELENGTHS

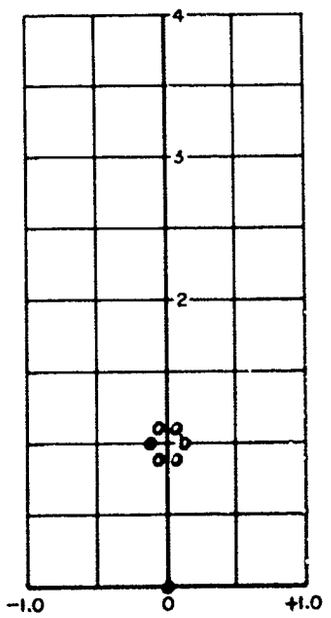


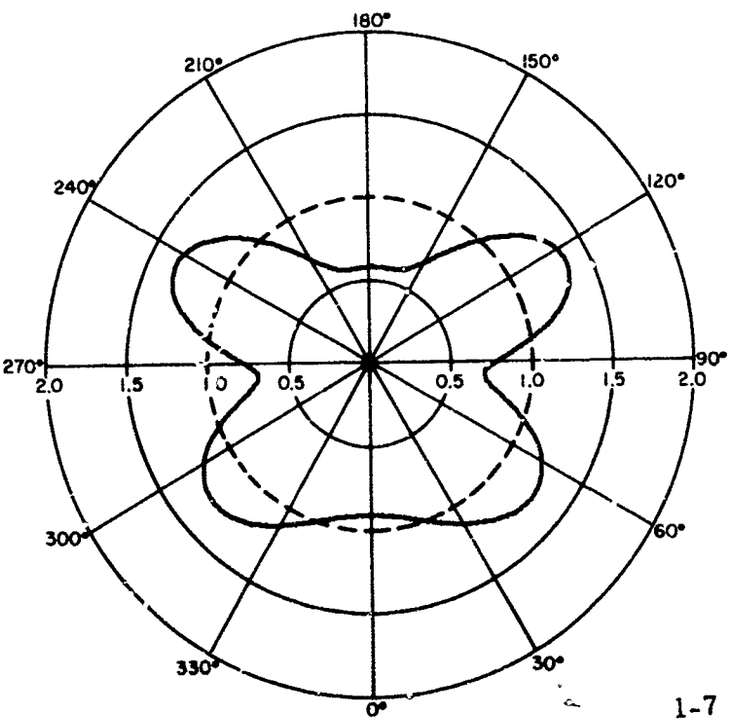
1-5


4
3
2
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

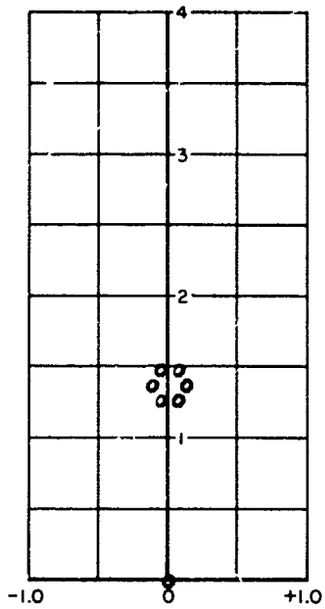

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

1-8

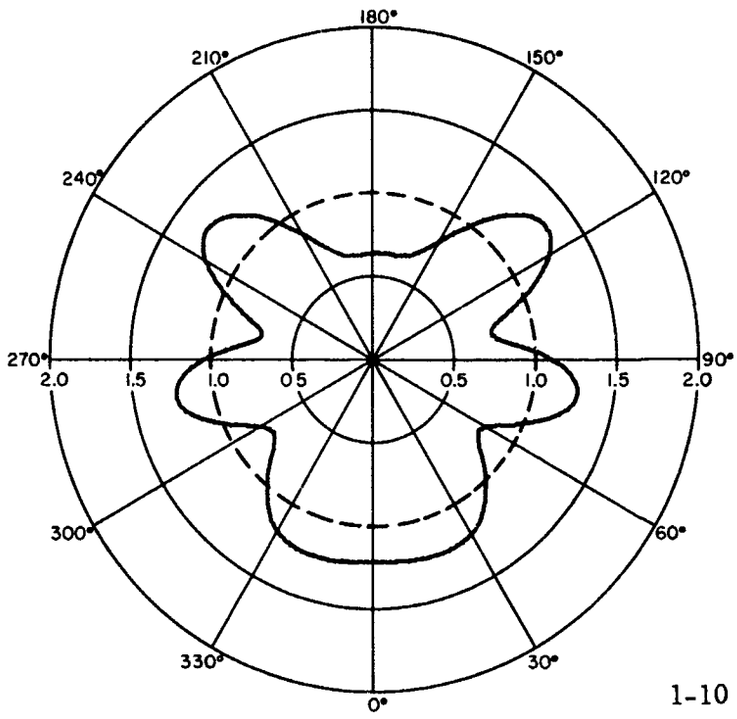

4
3
2
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

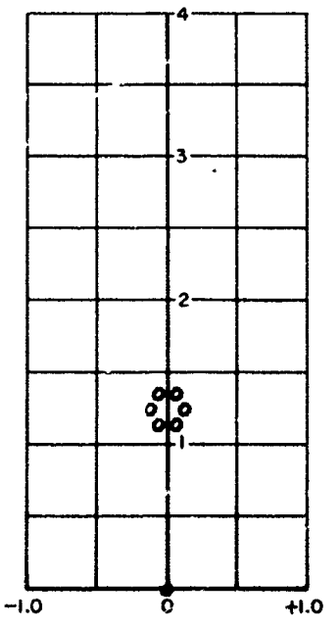
1-7



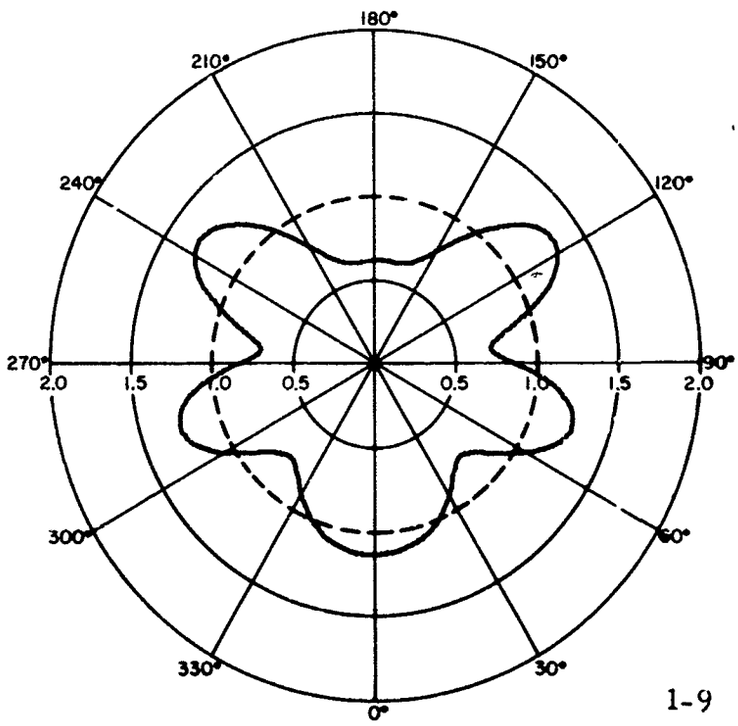
DISTANCE ~ WAVELENGTHS



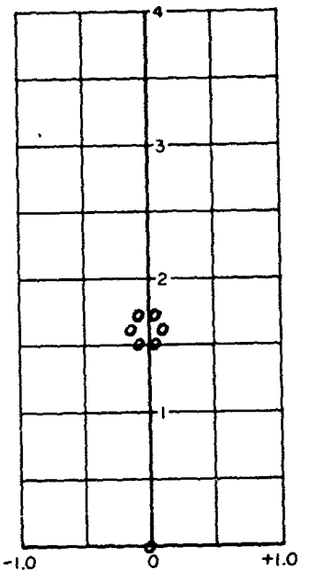
1-10

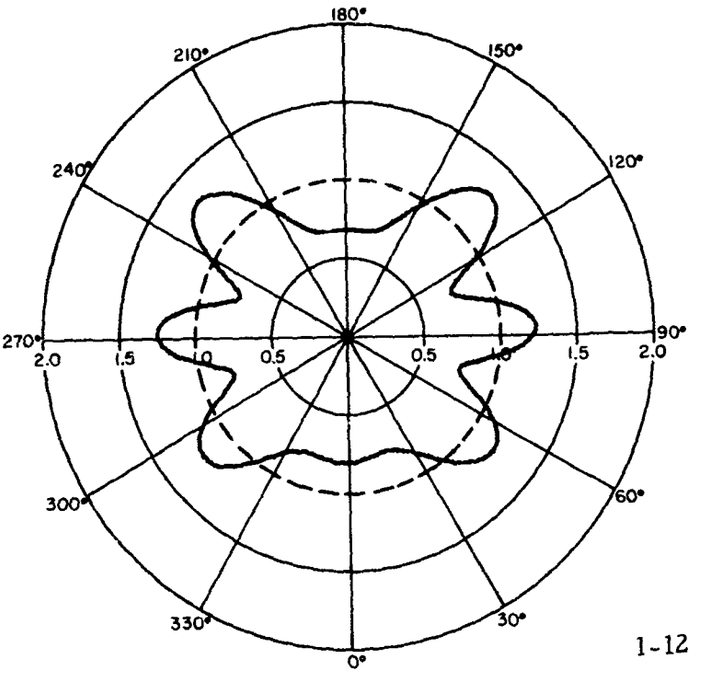


DISTANCE ~ WAVELENGTHS

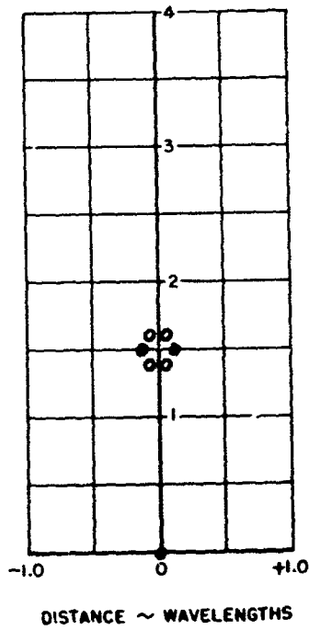


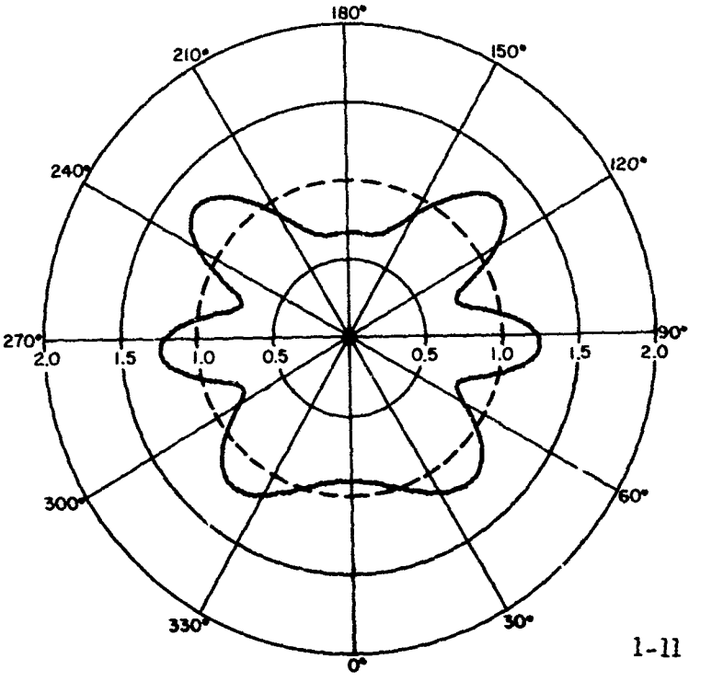
1-9


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

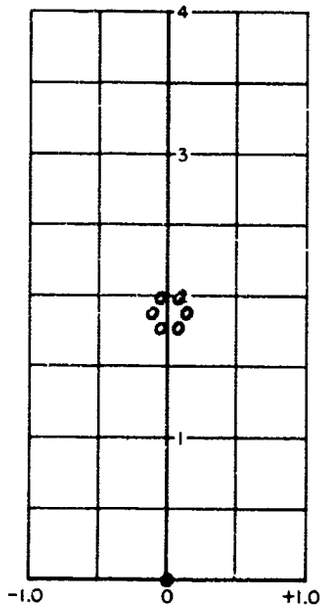

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

1-12

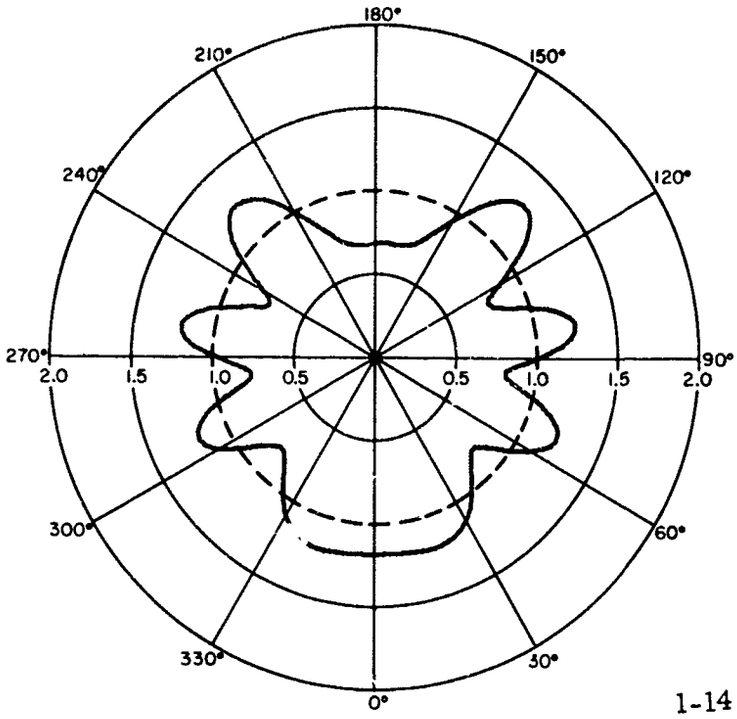

4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

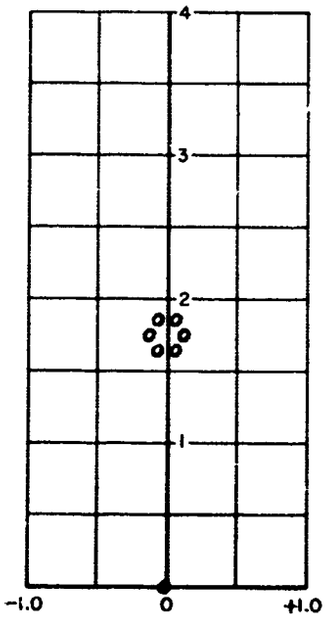
1-11



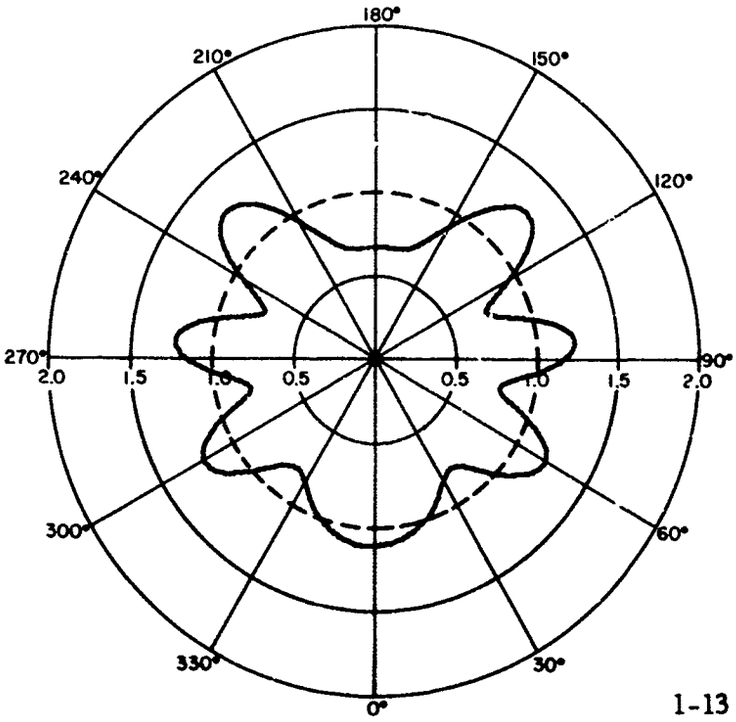
DISTANCE ~ WAVELENGTHS



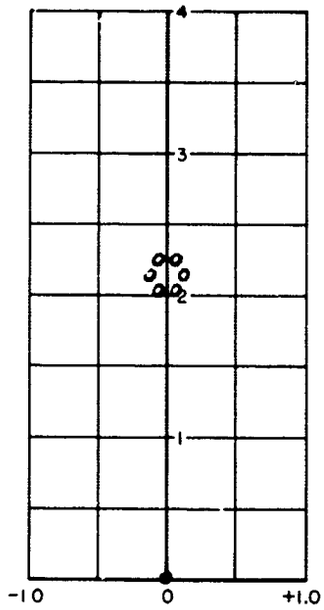
1-14

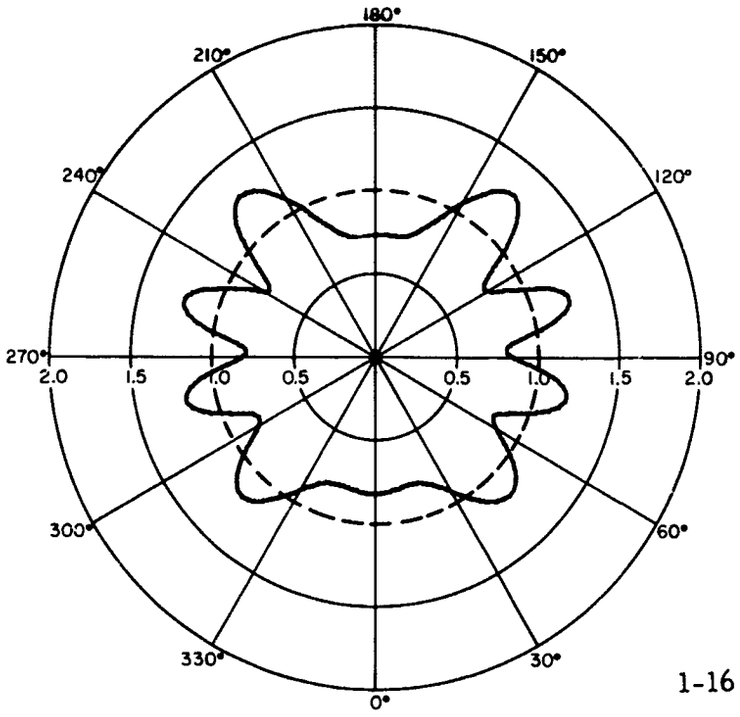


DISTANCE ~ WAVELENGTHS

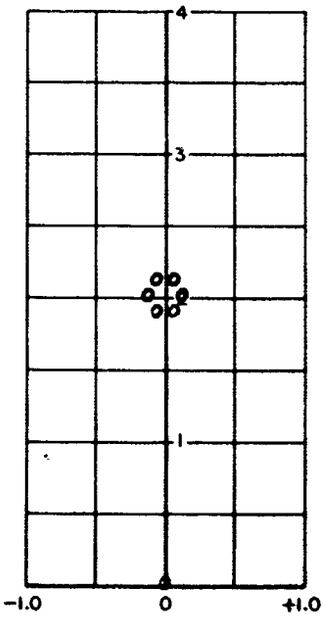


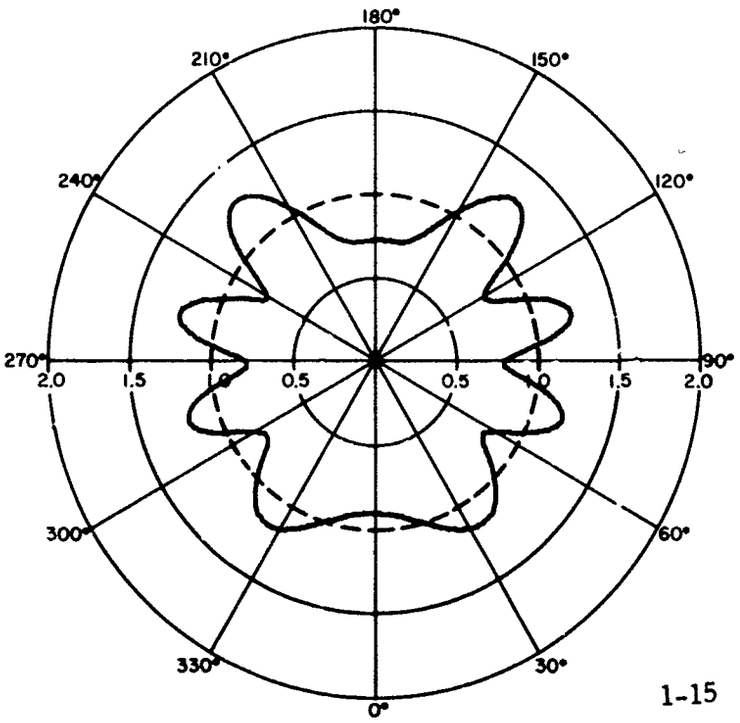
1-13


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

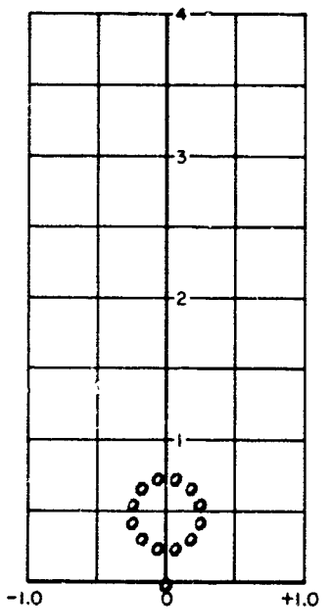

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

1-16

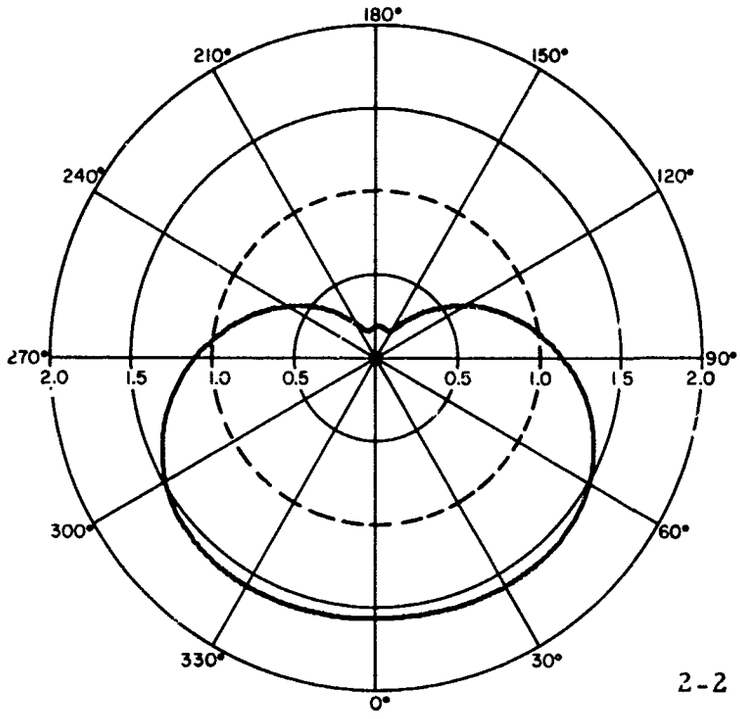

4
3
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

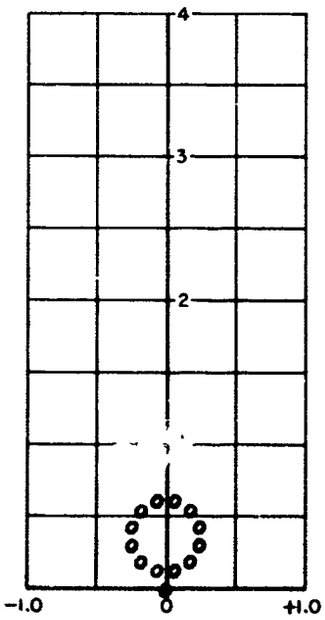
1-15



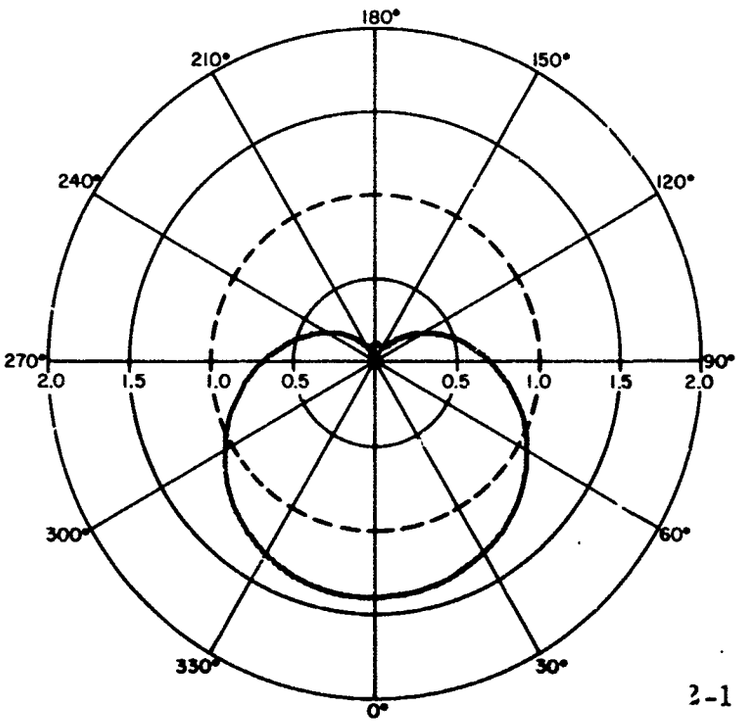
DISTANCE ~ WAVELENGTHS



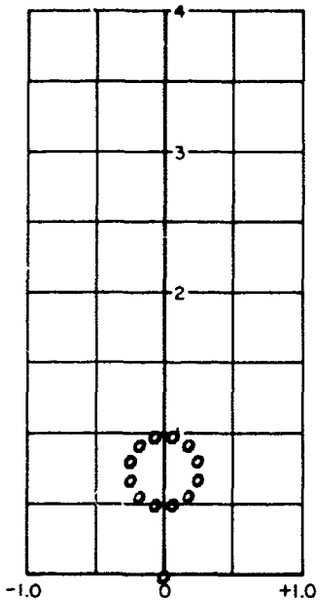
2-2



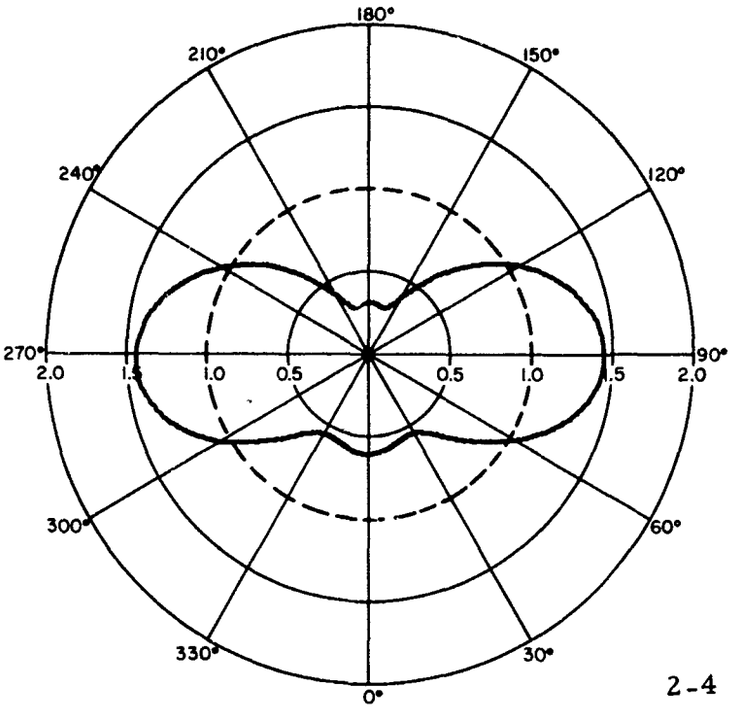
DISTANCE ~ WAVELENGTHS



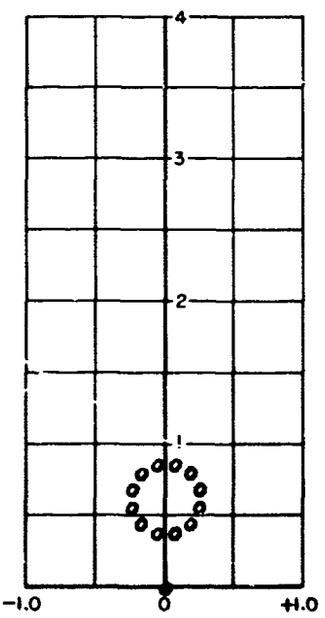
2-1



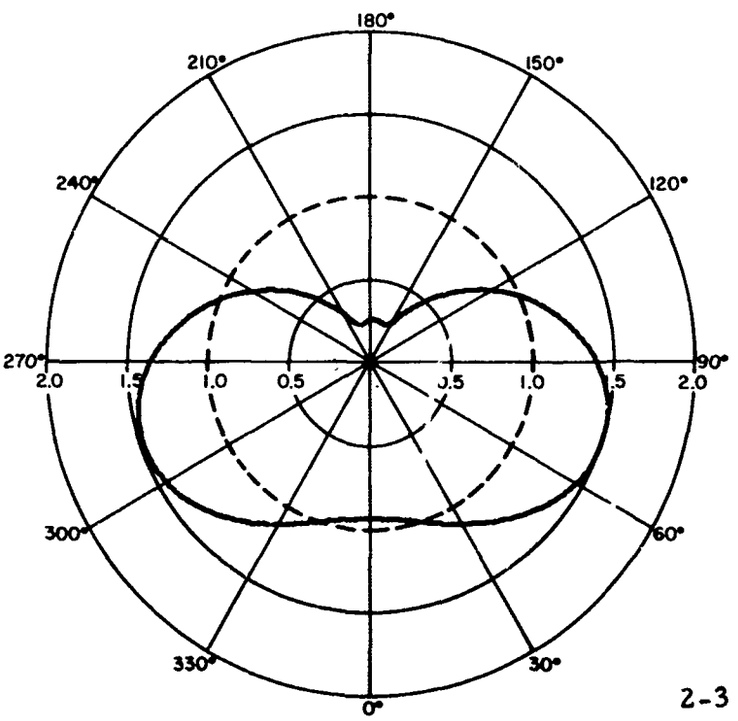
DISTANCE ~ WAVELENGTHS



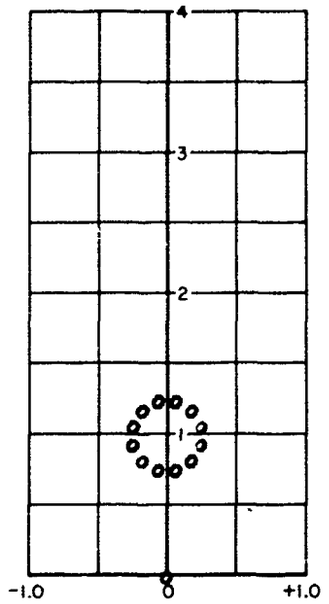
2-4



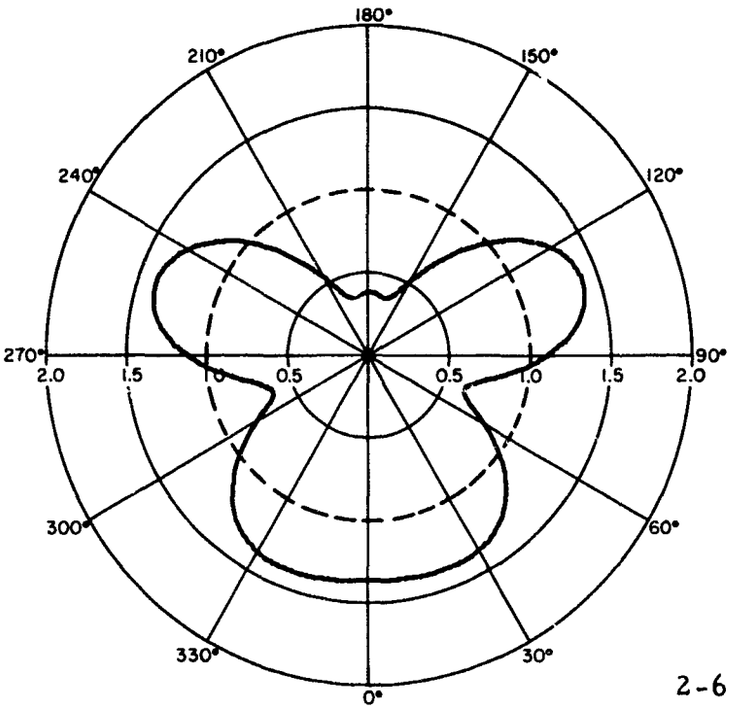
DISTANCE ~ WAVELENGTHS



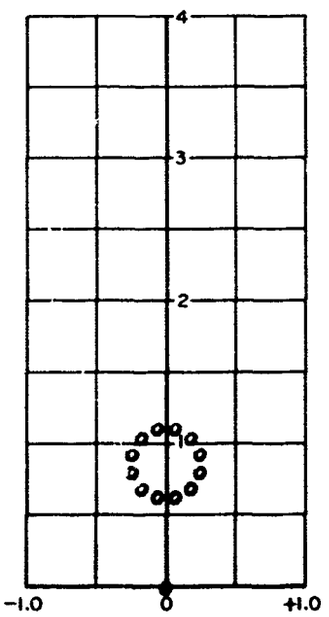
2-3



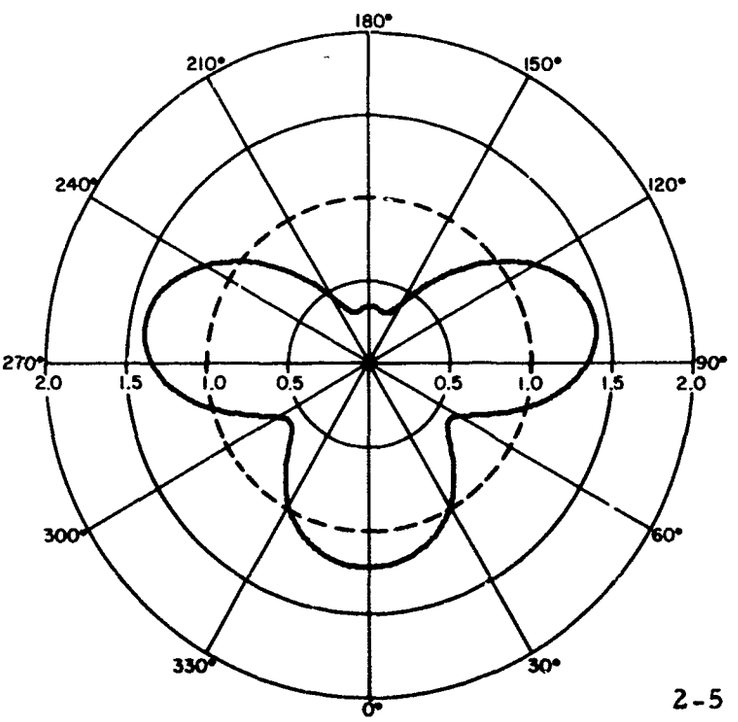
DISTANCE ~ WAVELENGTHS



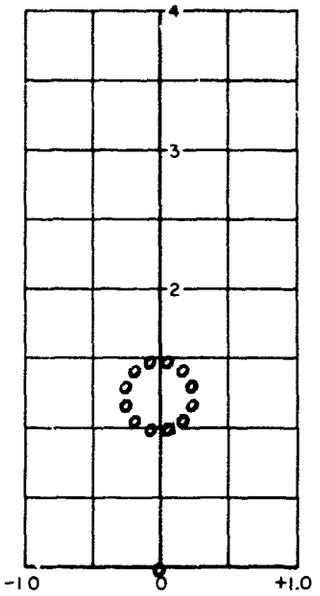
2-6



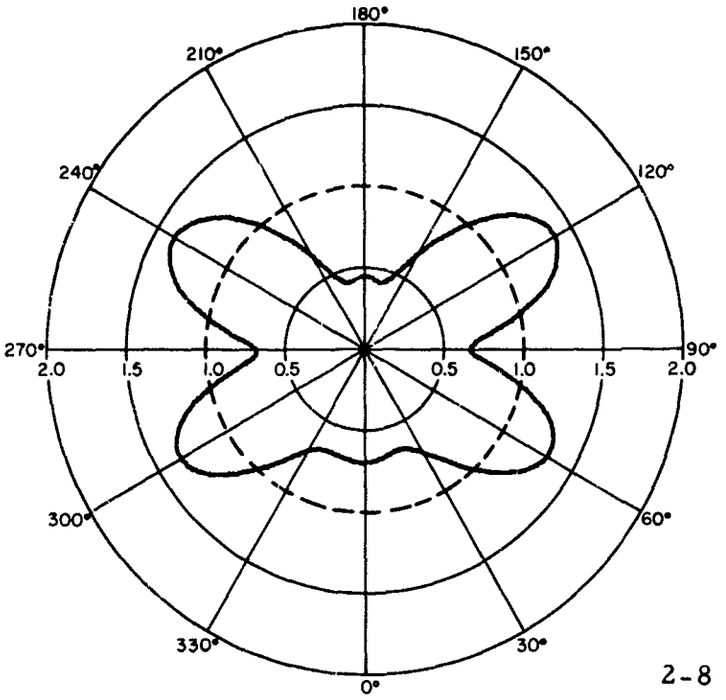
DISTANCE ~ WAVELENGTHS



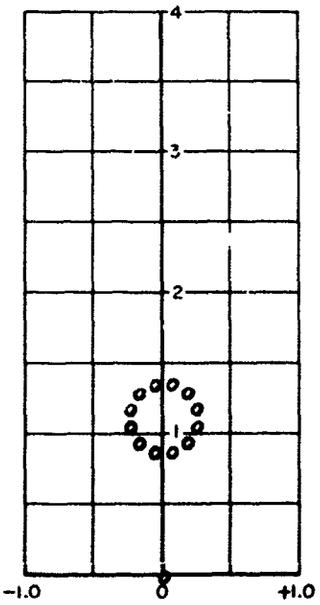
2-5



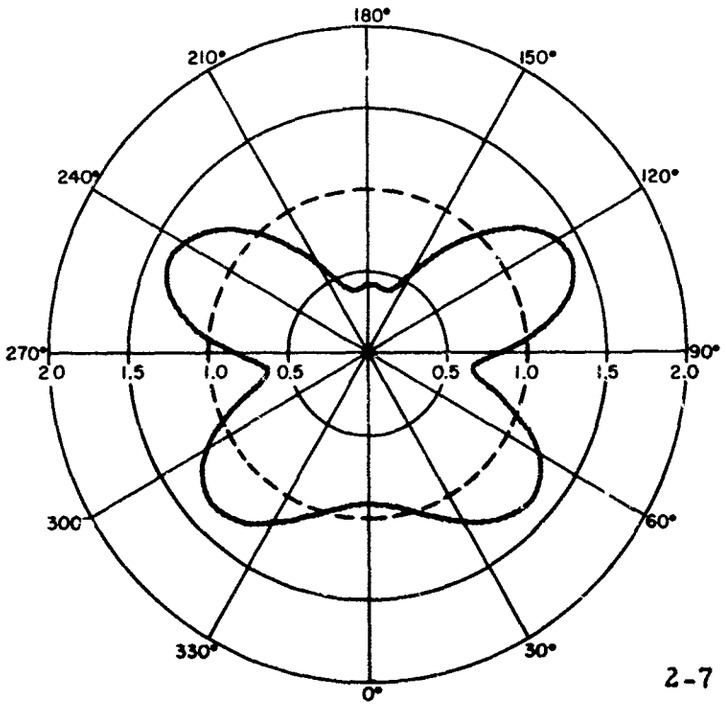
DISTANCE ~ WAVELENGTHS



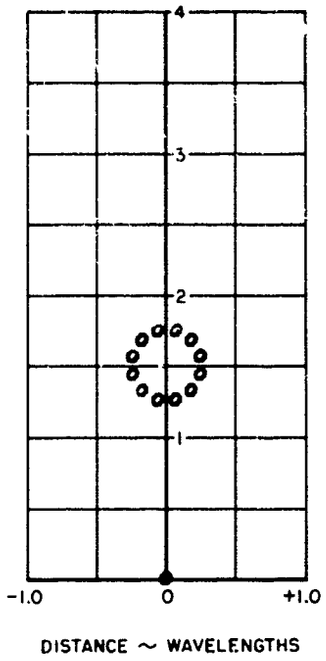
2-8

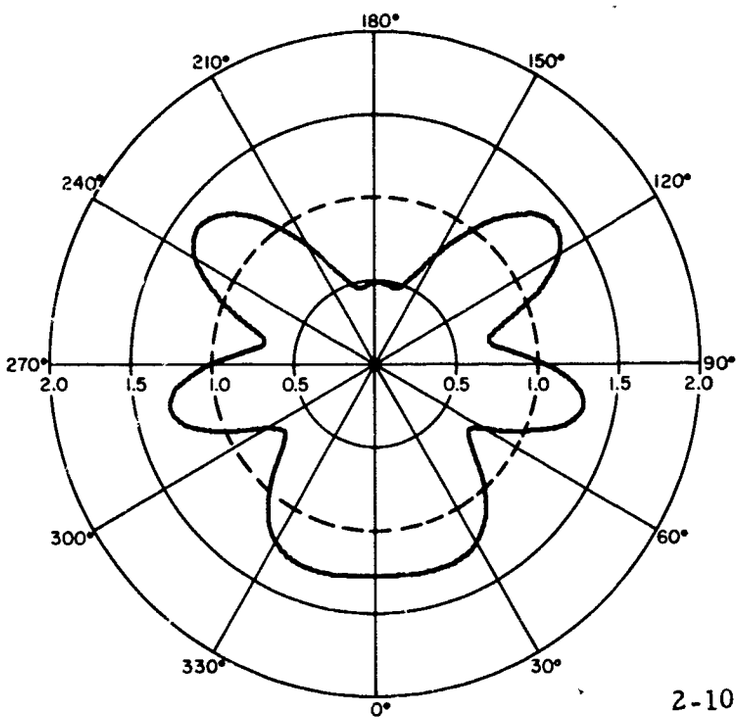


DISTANCE ~ WAVELENGTHS

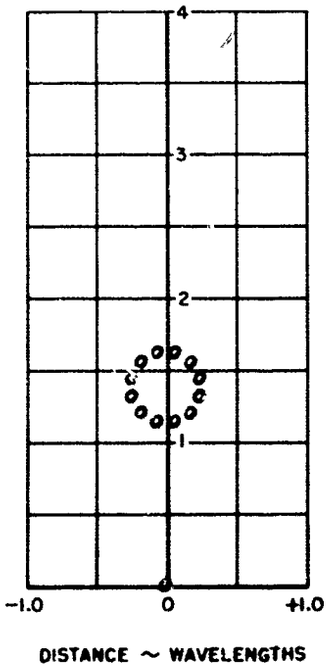


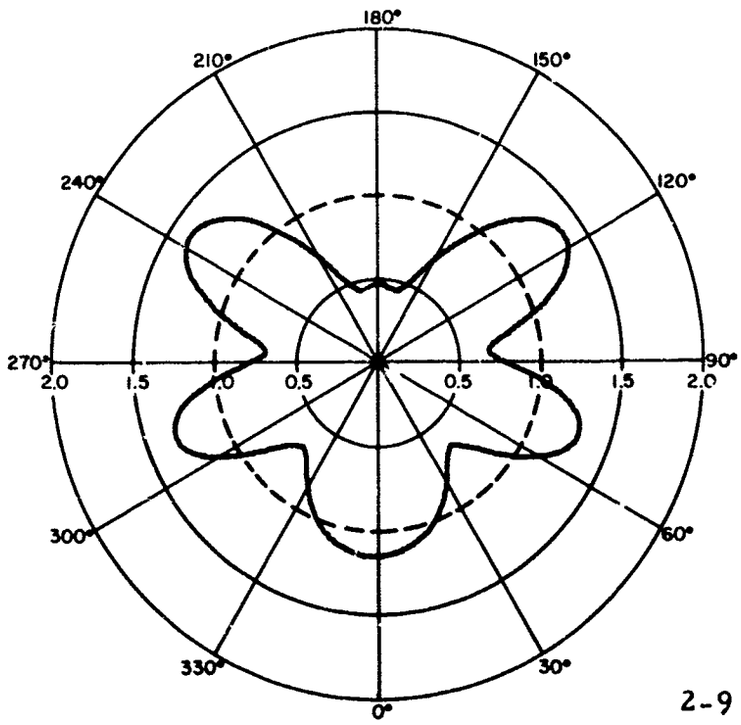
2-7


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

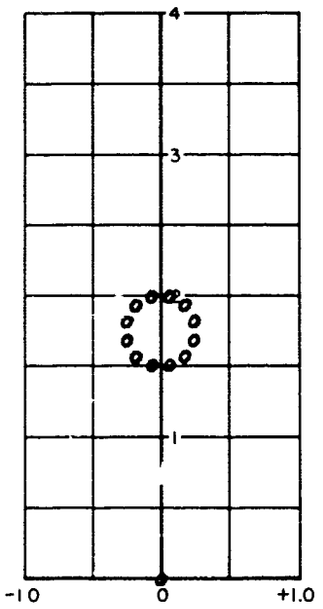

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

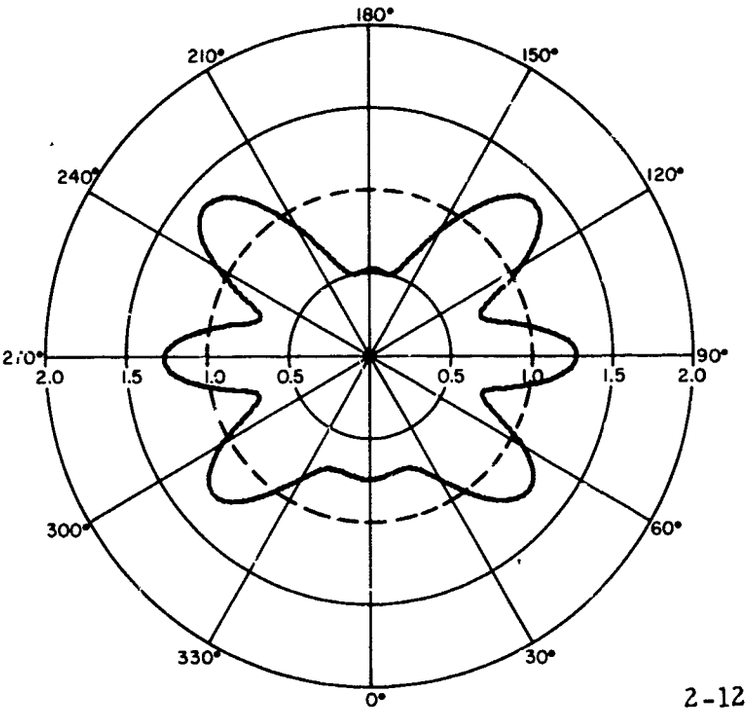
2-10


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

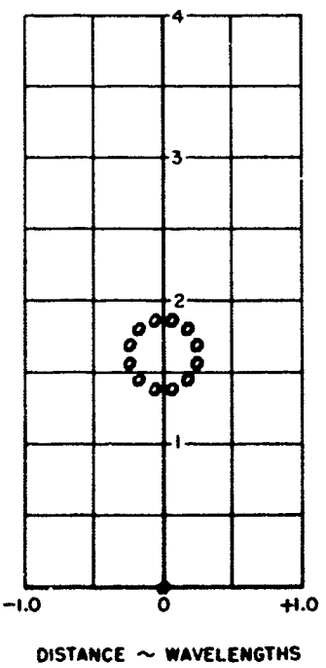

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

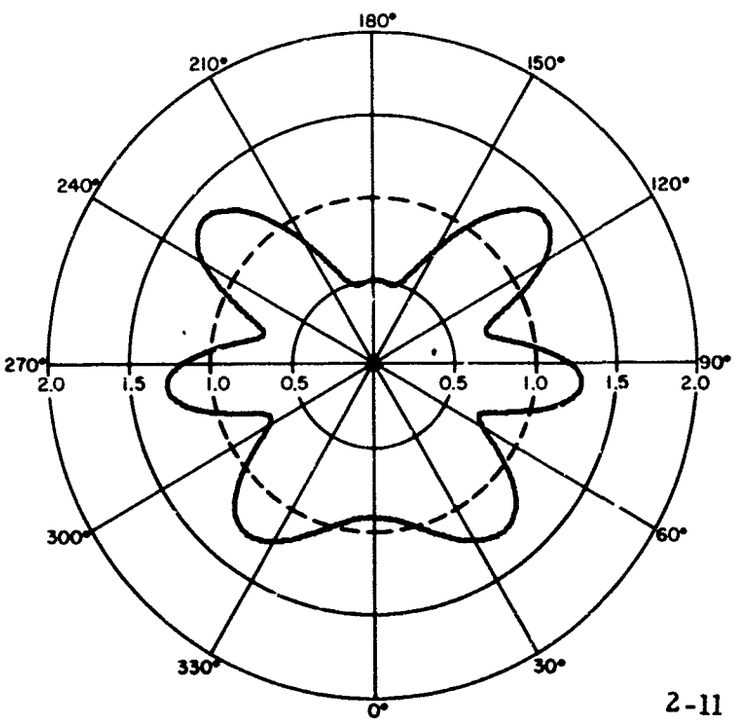
2-9


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

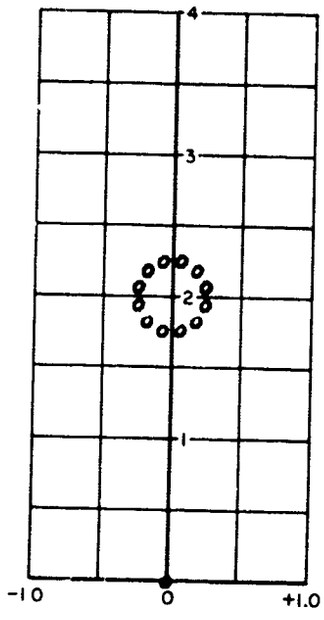

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

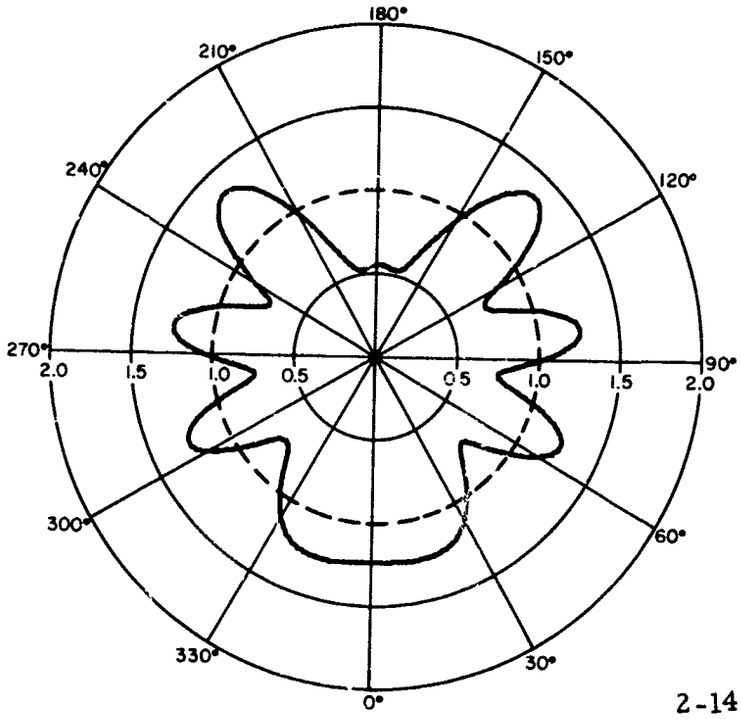
2-12


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

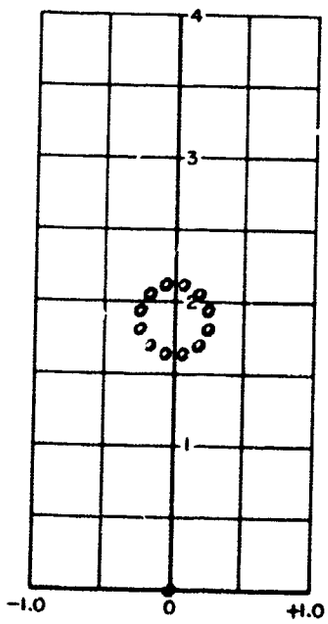

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

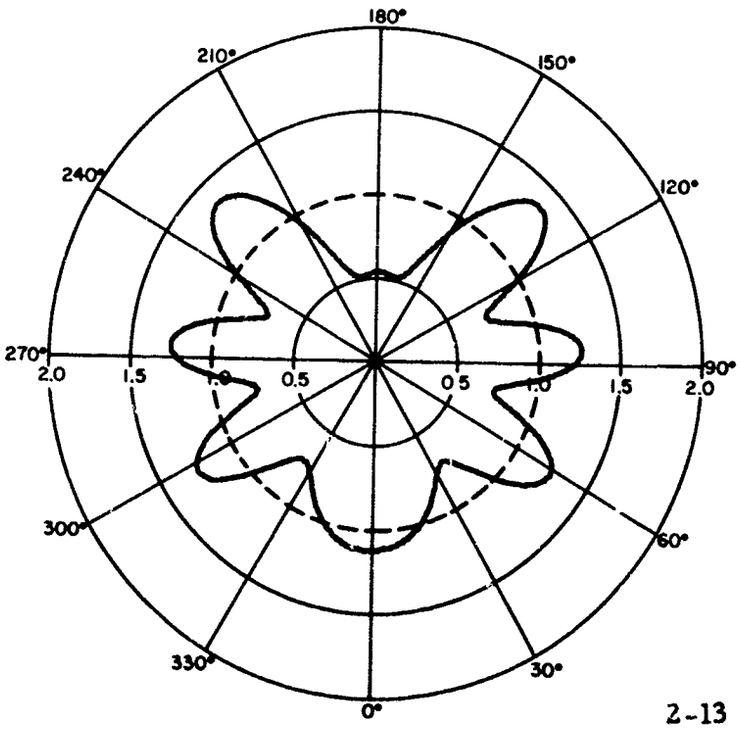
2-11


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

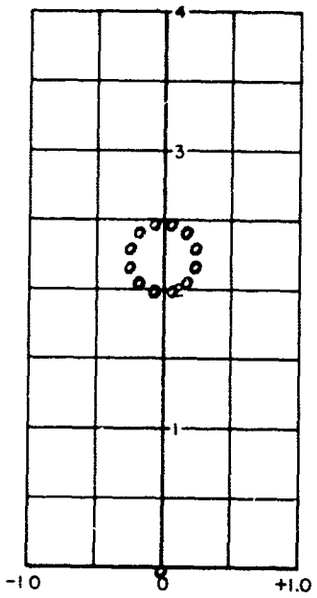

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

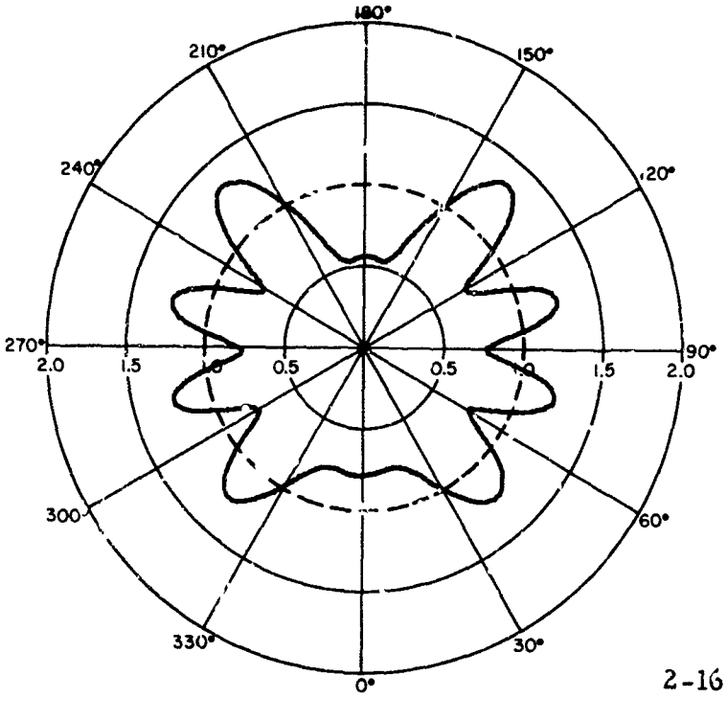
2-14


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

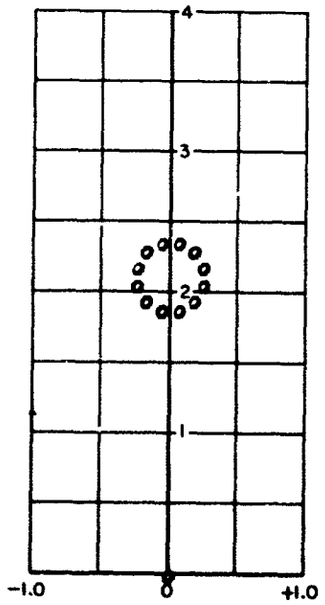

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

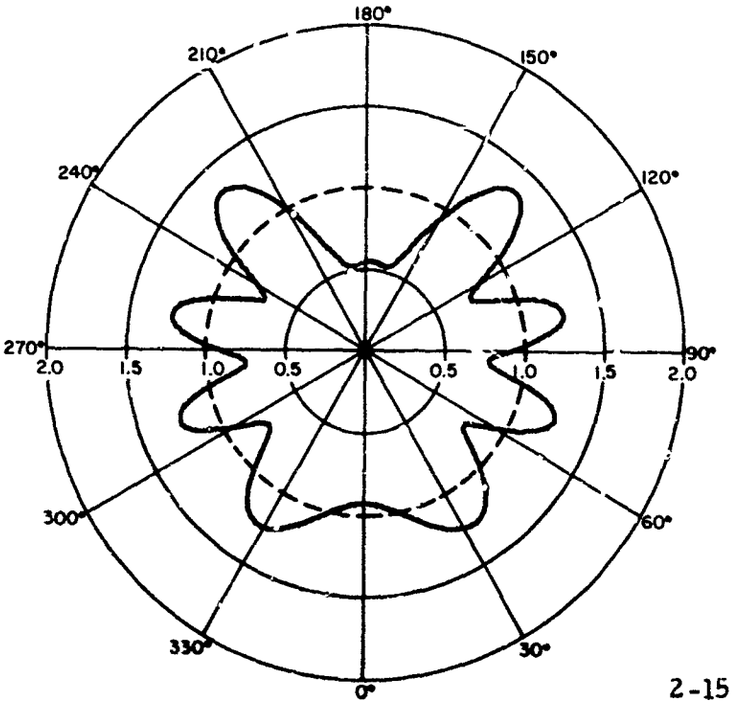
2-13


4
3
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

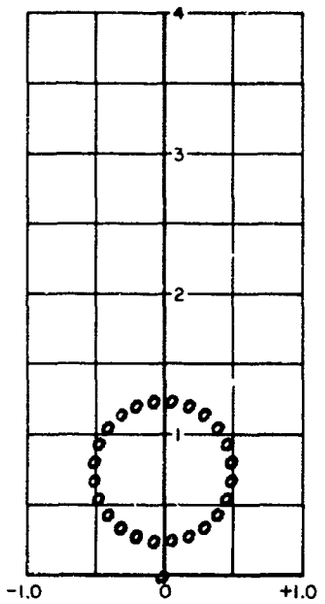

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

2-16

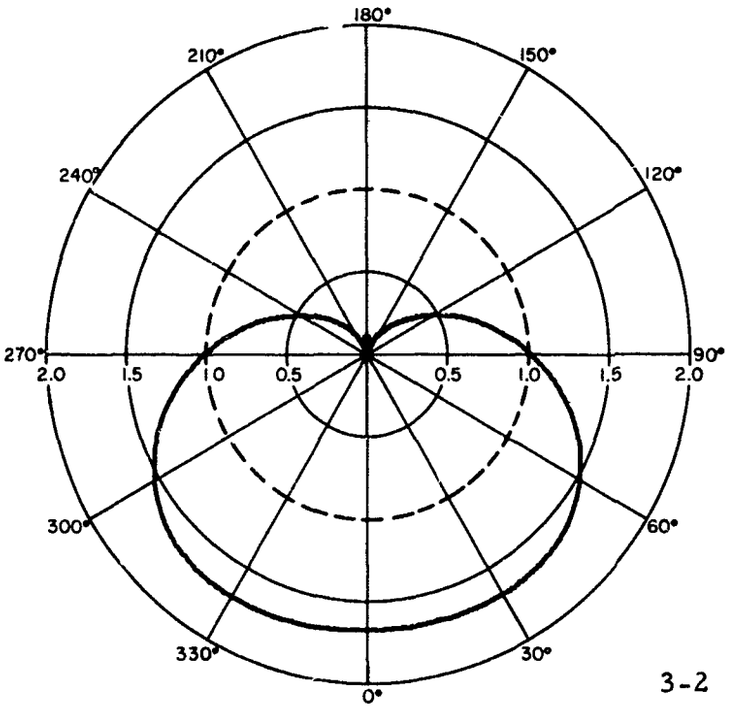

4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

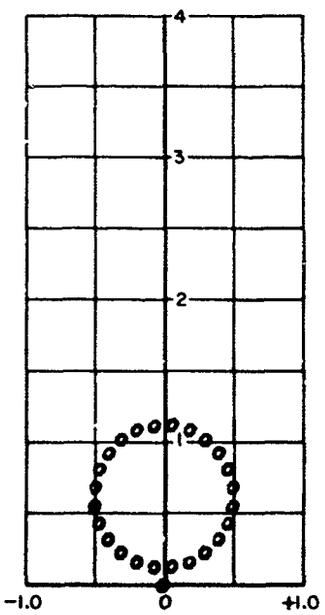
2-15



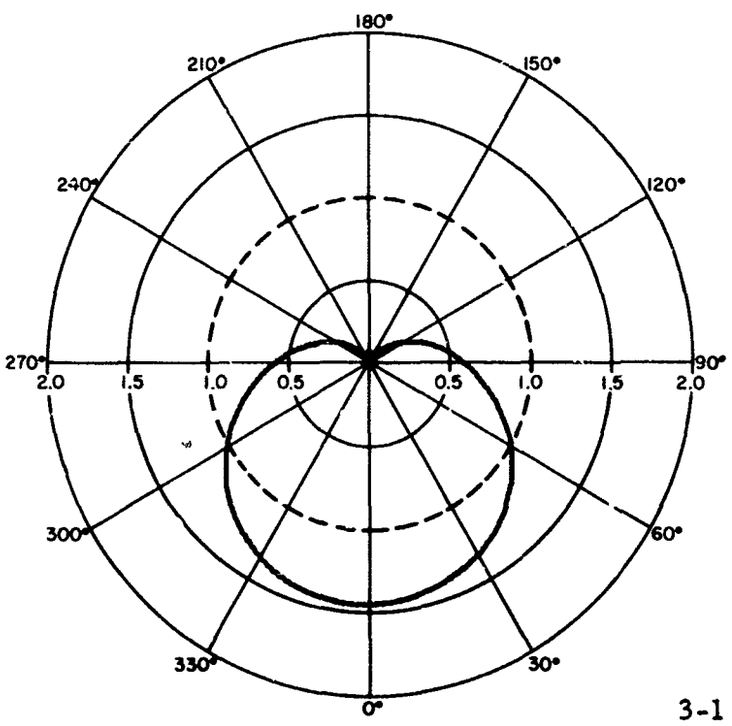
DISTANCE ~ WAVELENGTHS



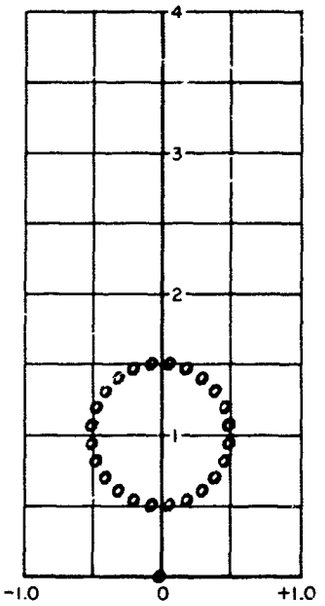
3-2

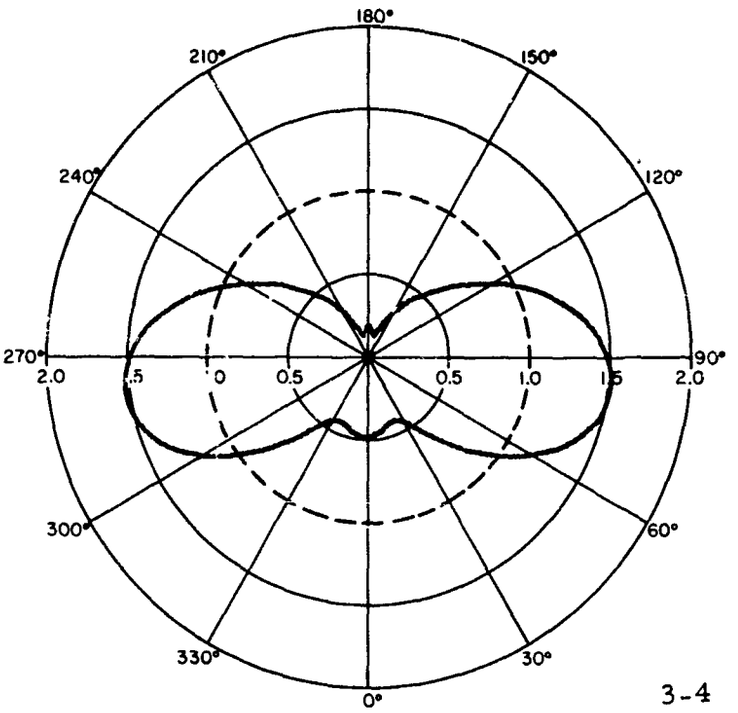


DISTANCE ~ WAVELENGTHS

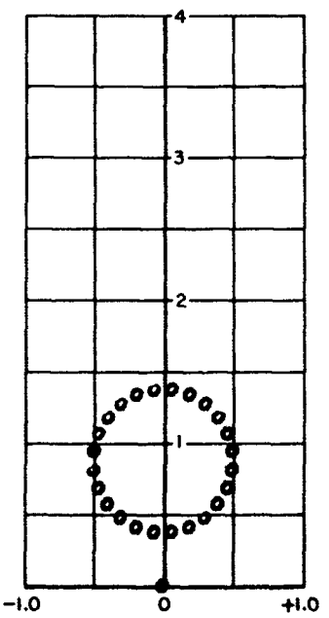


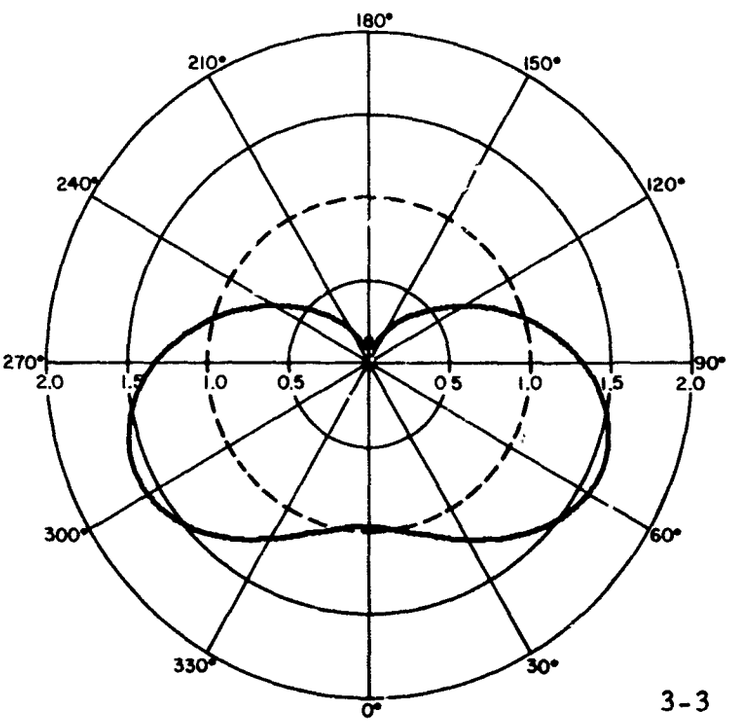
3-1


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

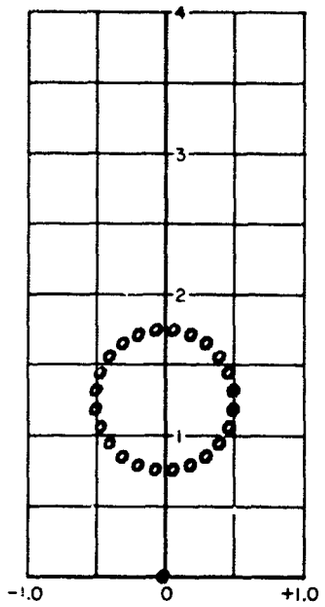

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

3-4

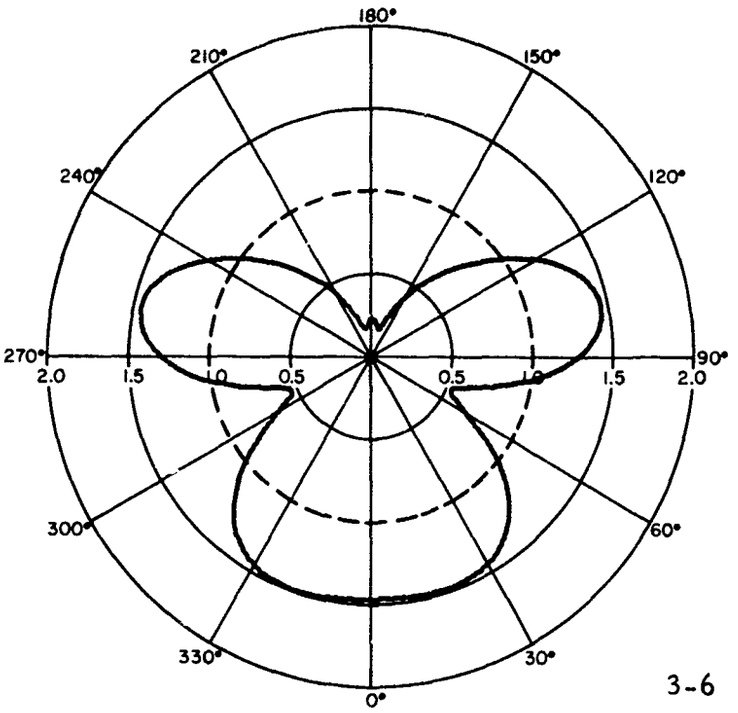

4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

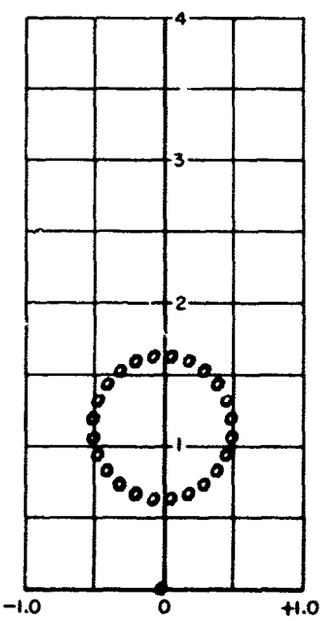
3-3



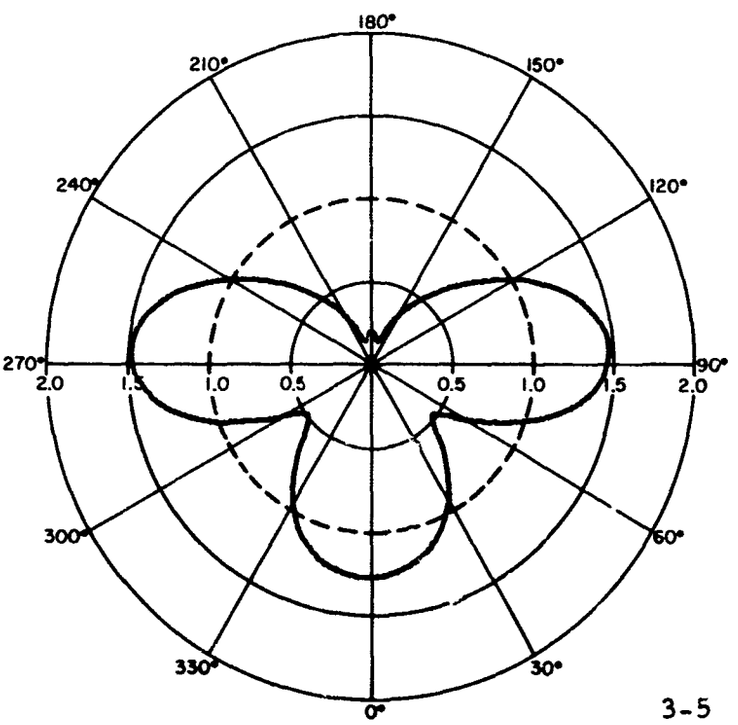
DISTANCE ~ WAVELENGTHS



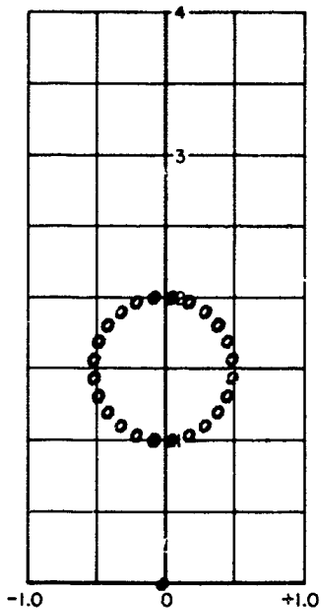
3-6

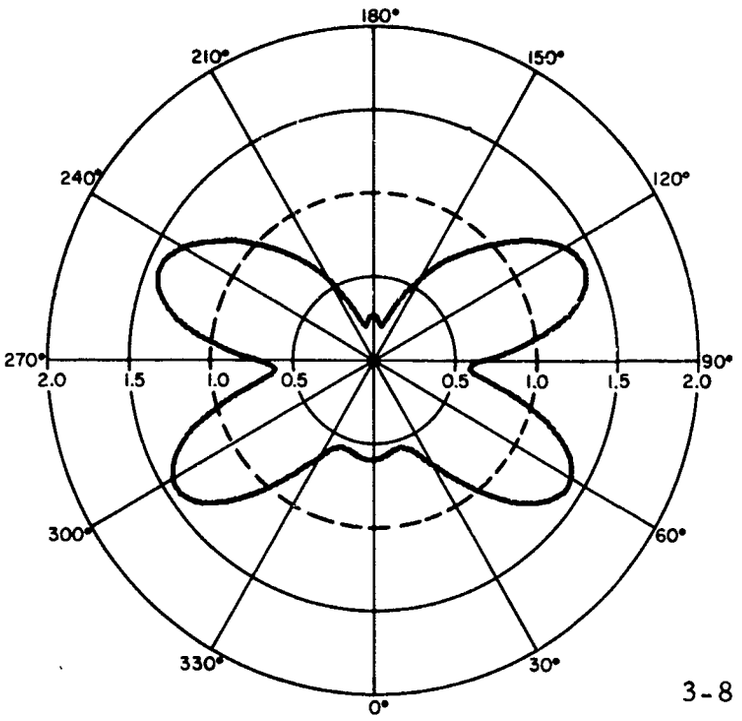


DISTANCE ~ WAVELENGTHS

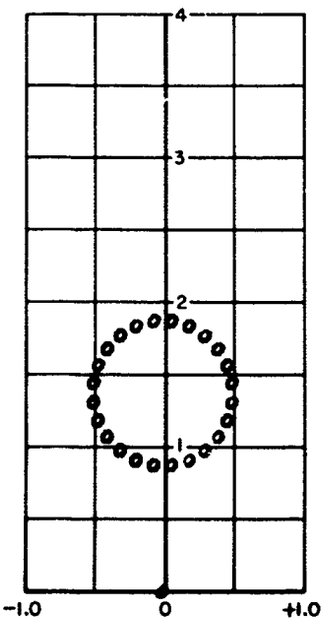


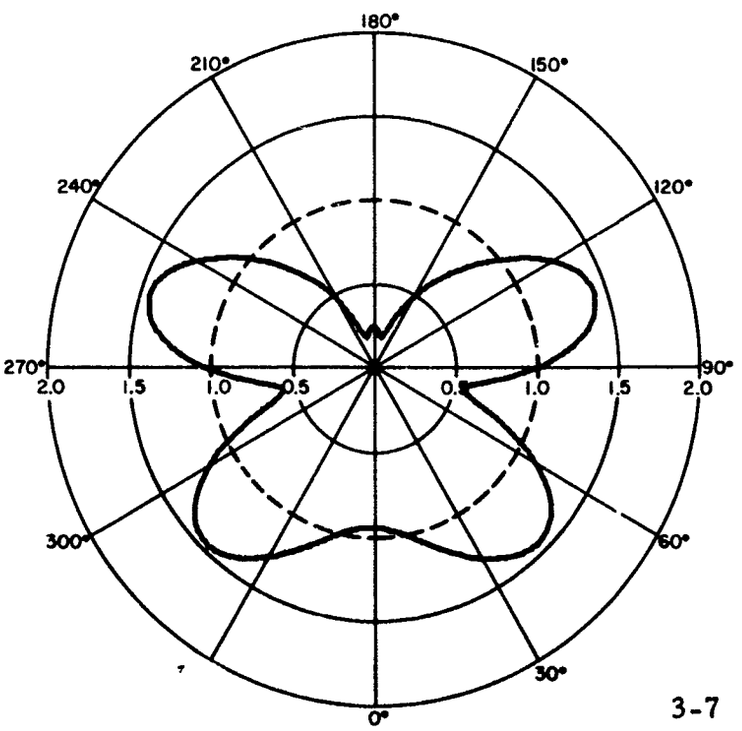
3-5


4
3
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

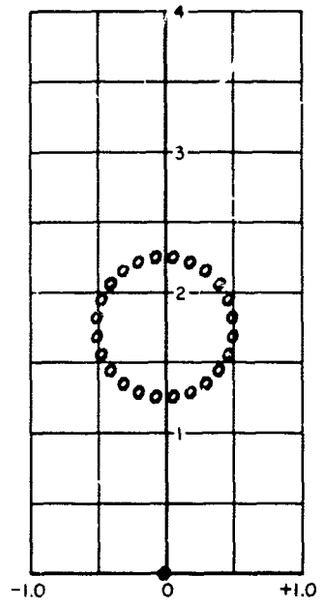

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

3-8

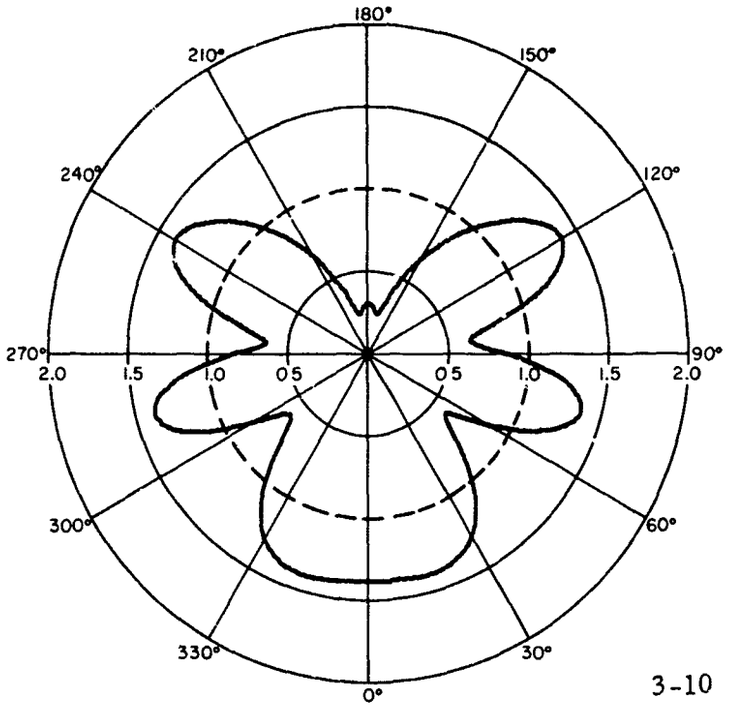

4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
30°
0°

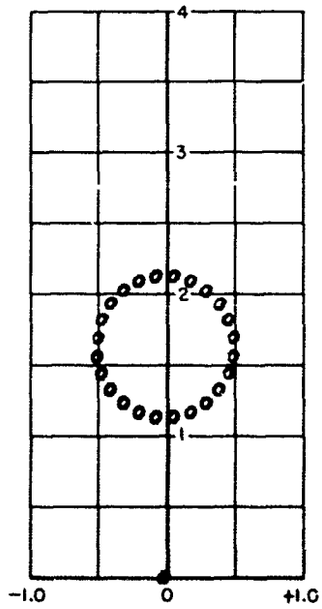
3-7



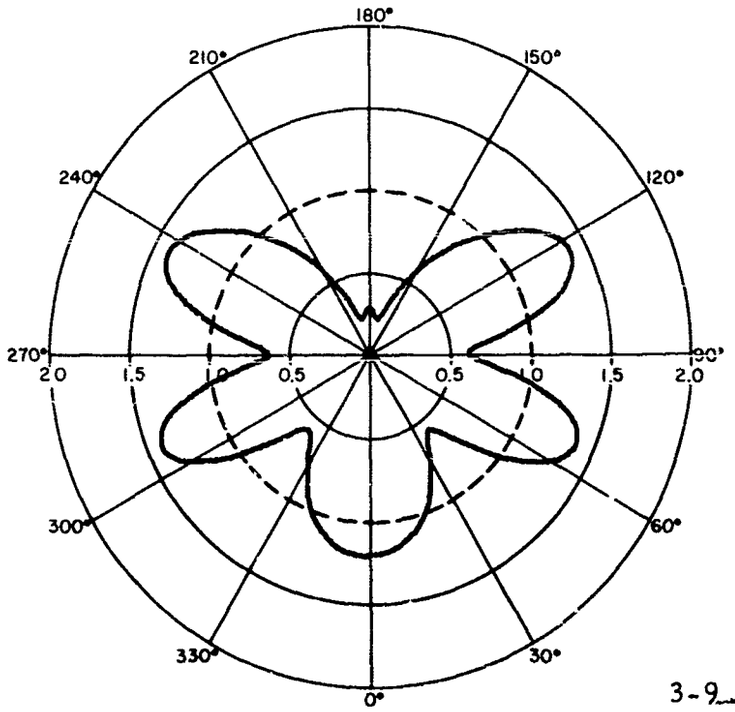
DISTANCE ~ WAVELENGTHS



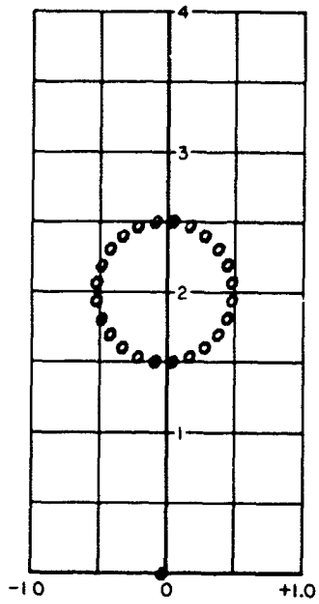
3-10

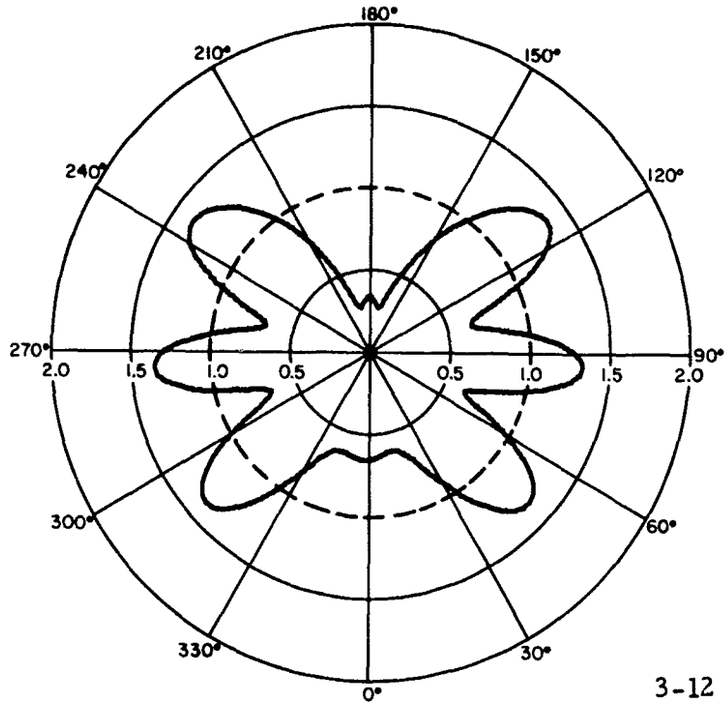


DISTANCE ~ WAVELENGTHS

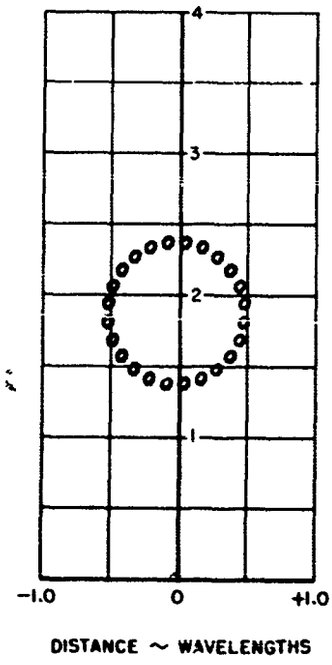


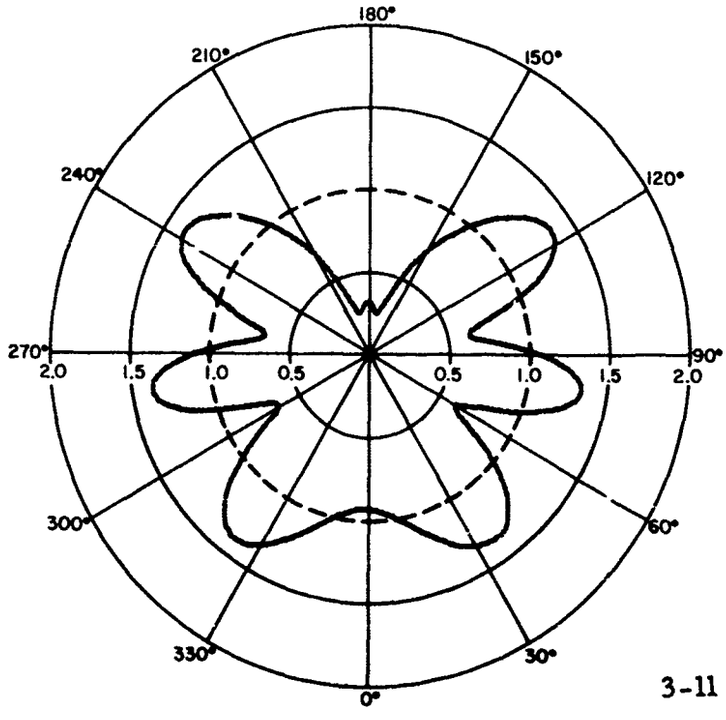
3-9


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

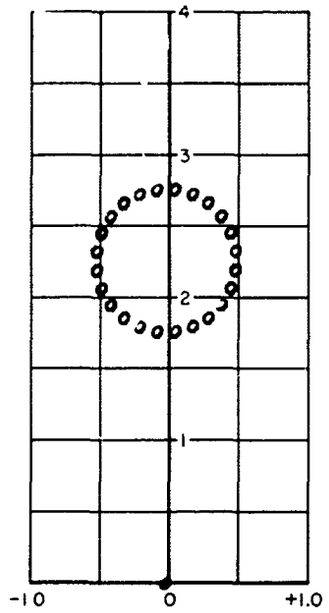

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

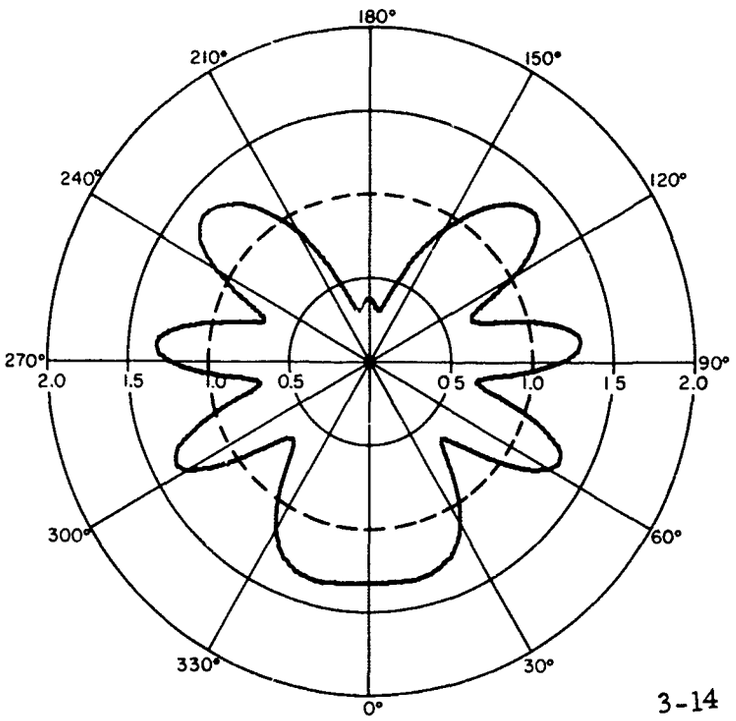
3-12


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

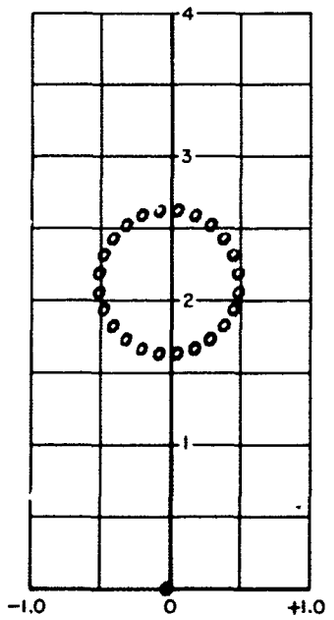

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

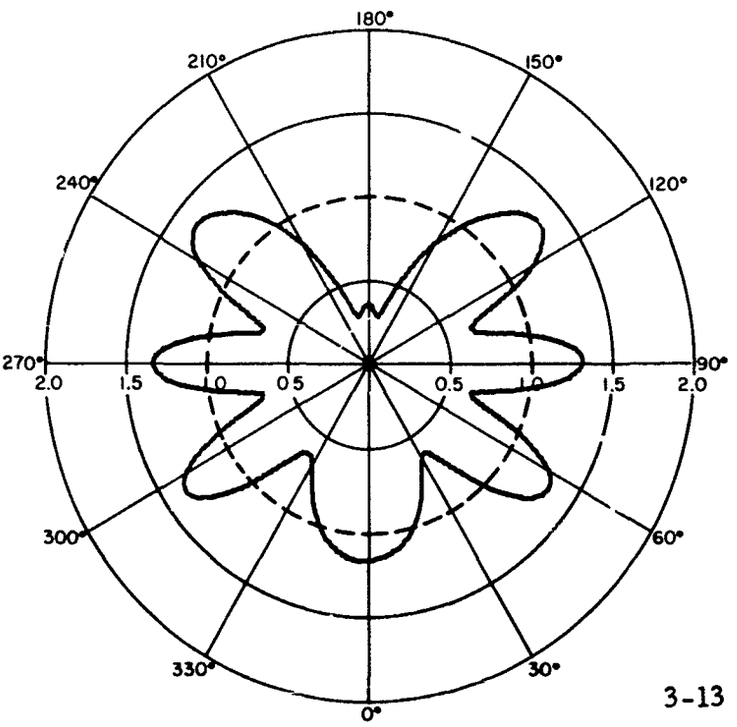
3-11


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

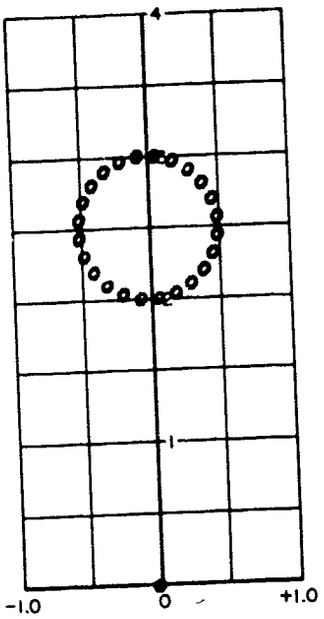

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

3-14

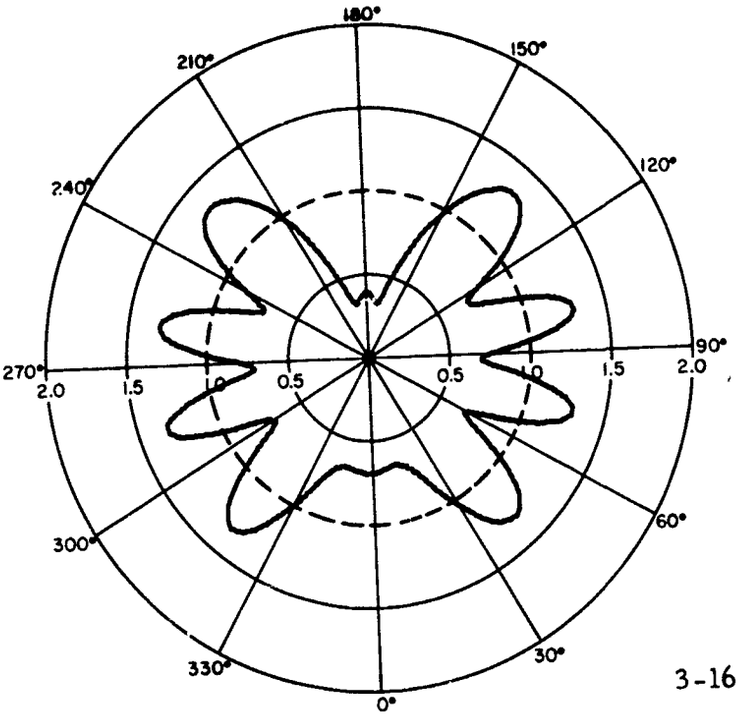

4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

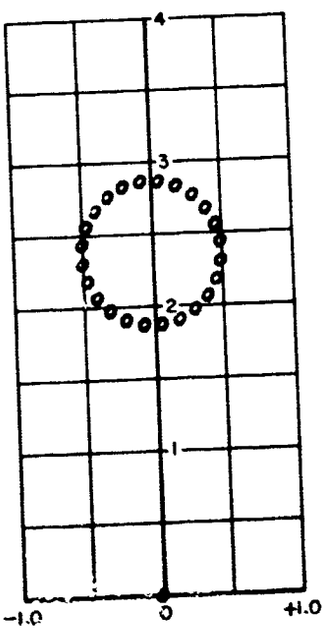
3-13



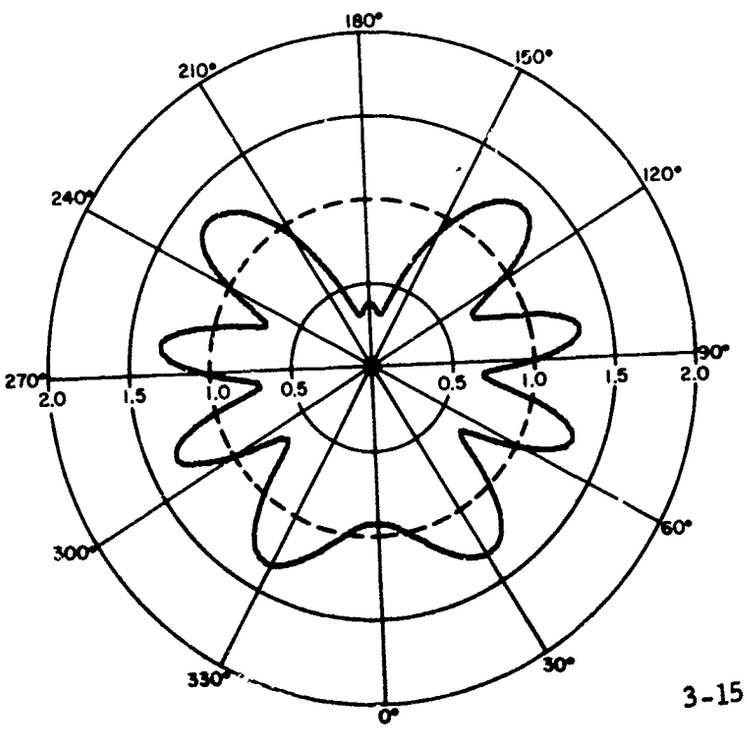
DISTANCE ~ WAVELENGTHS



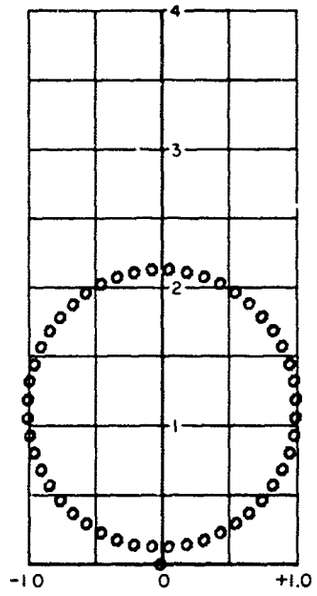
3-16



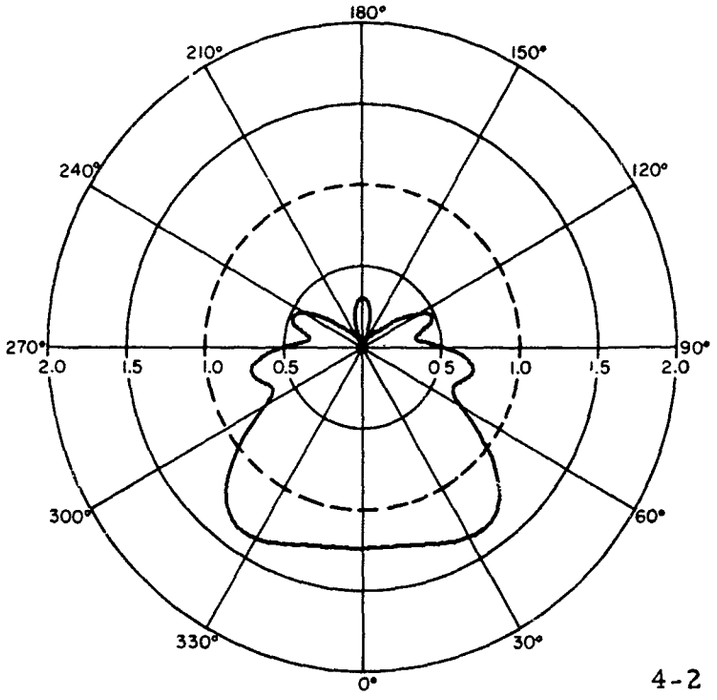
STANCE ~ WAVELENGTHS



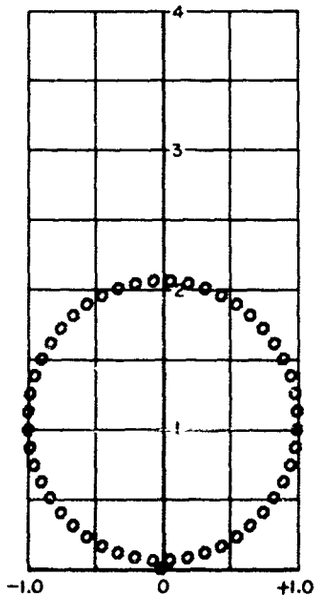
3-15



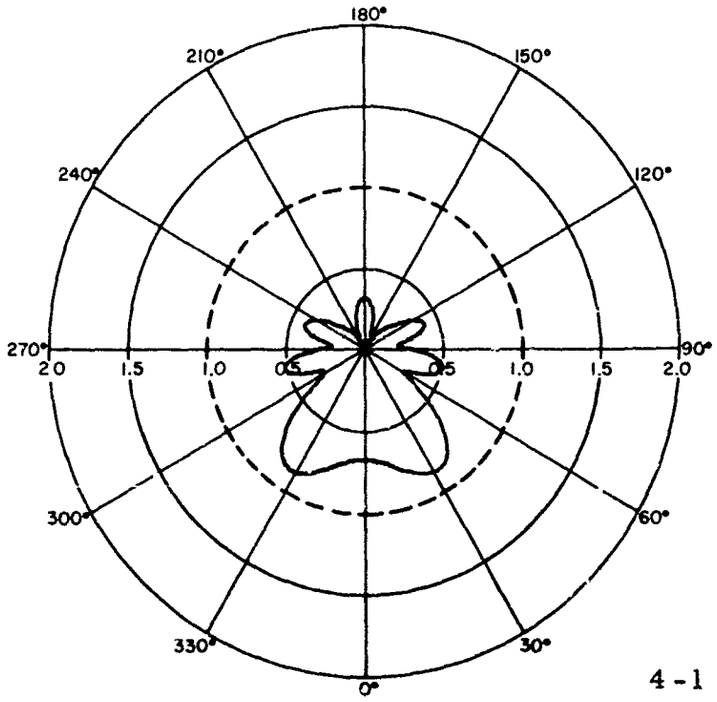
DISTANCE ~ WAVELENGTHS



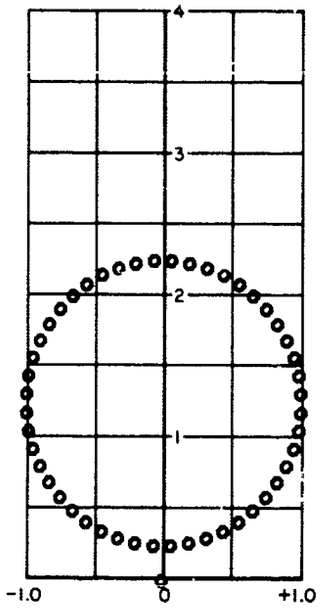
4-2



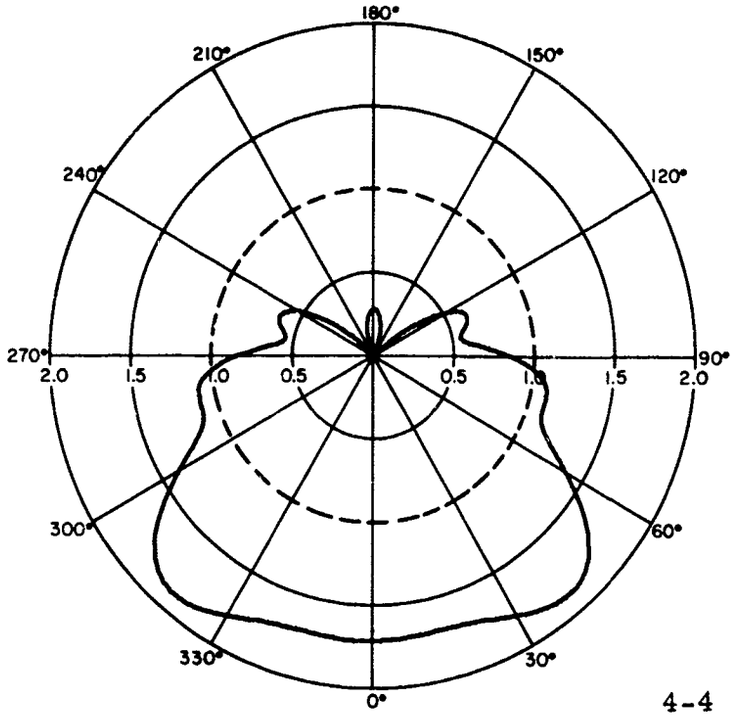
DISTANCE ~ WAVELENGTHS



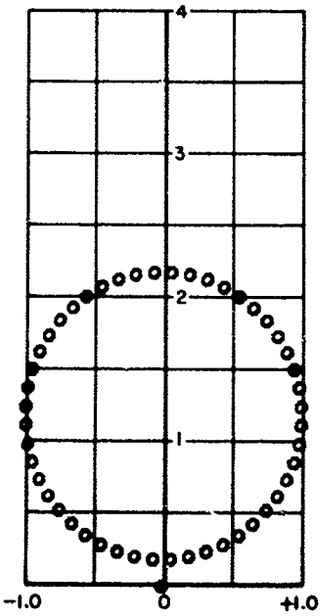
4-1



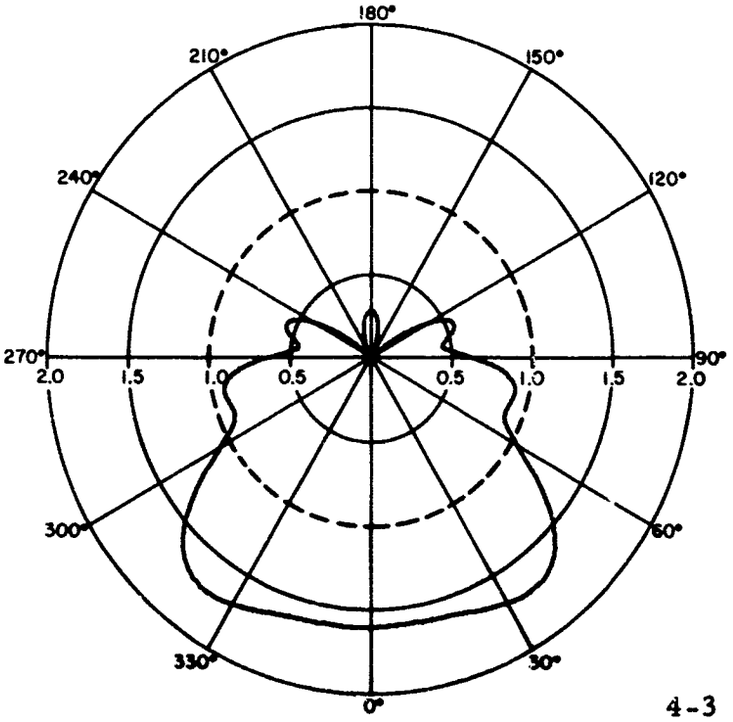
DISTANCE ~ WAVELENGTHS



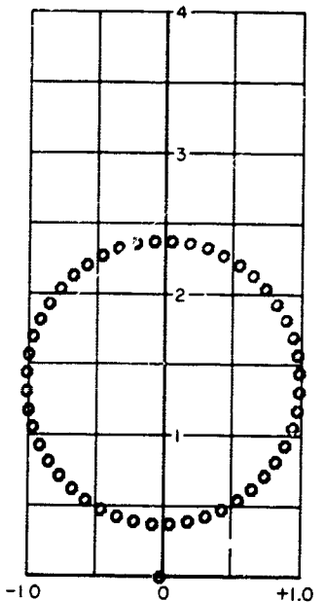
4-4



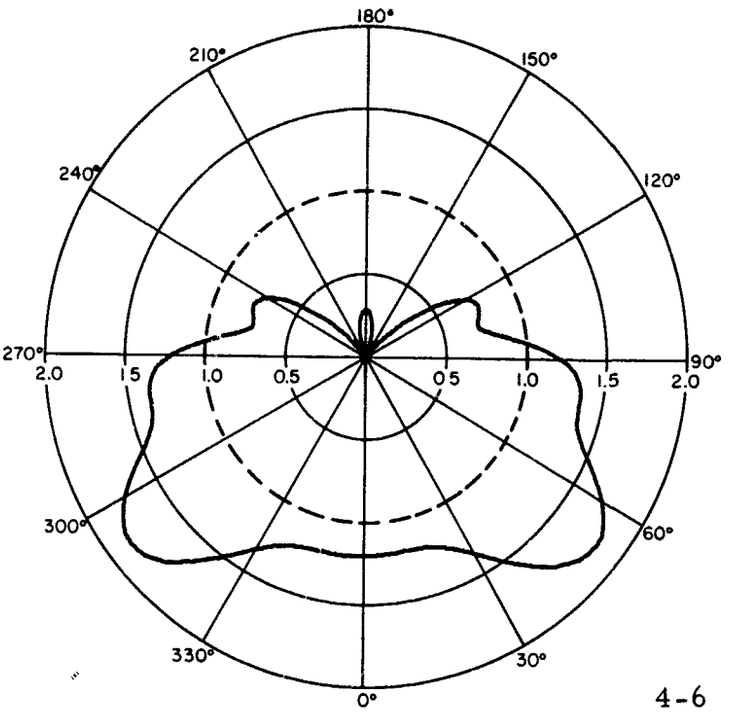
DISTANCE ~ WAVELENGTHS



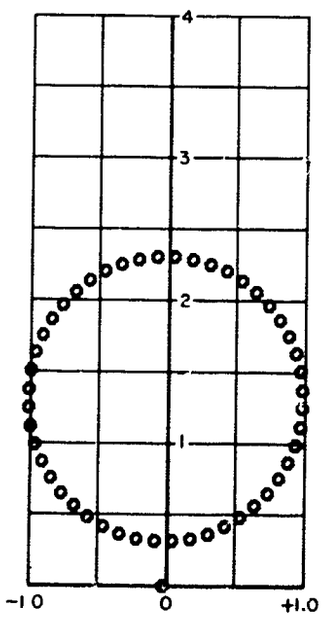
4-3



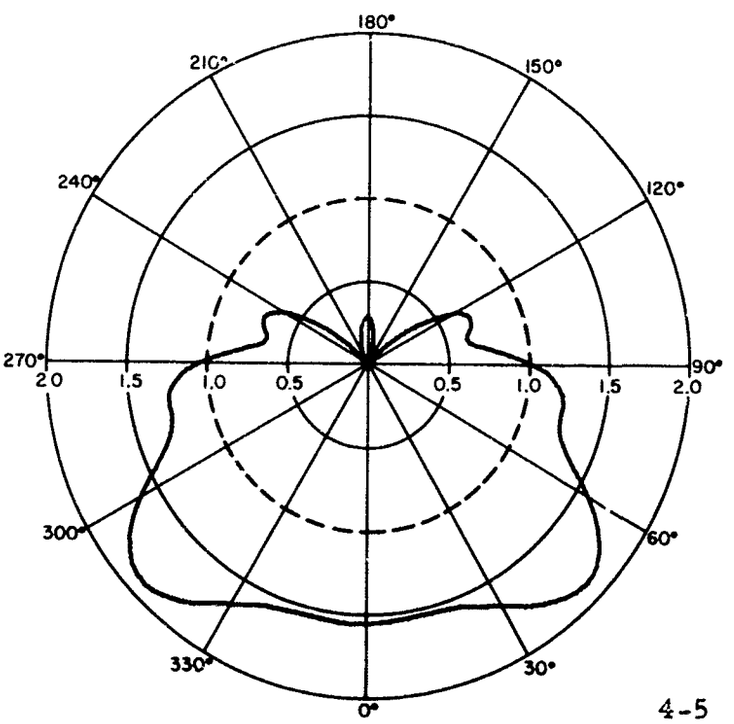
DISTANCE ~ WAVELENGTHS



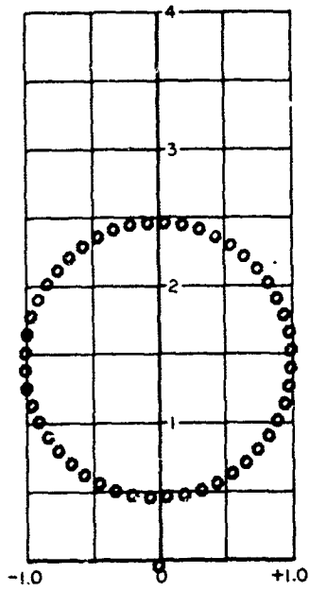
4-6

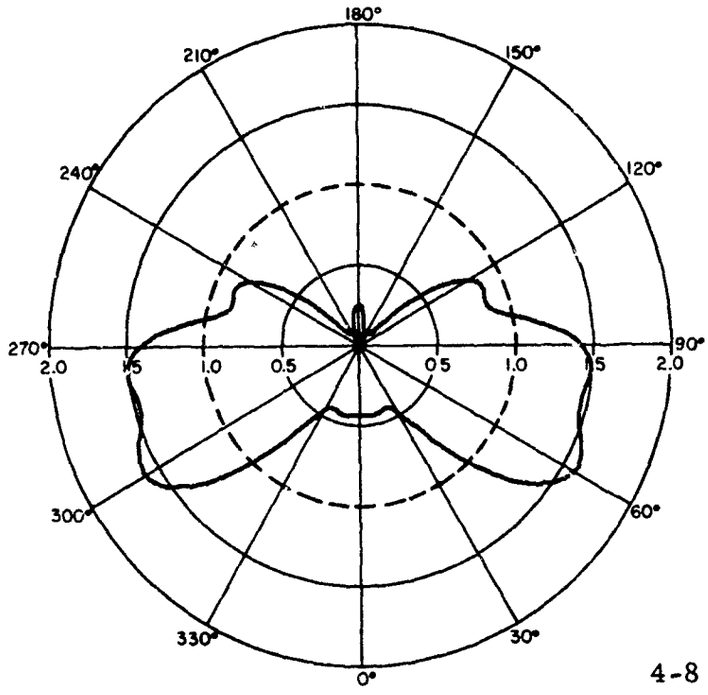


DISTANCE ~ WAVELENGTHS

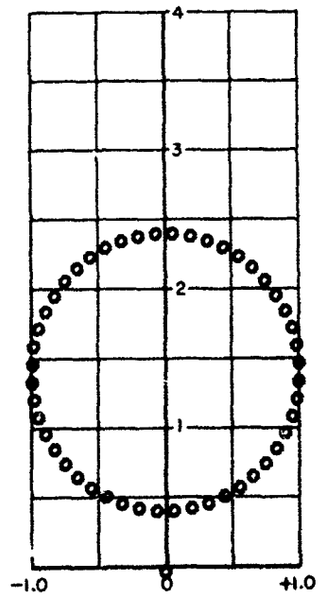


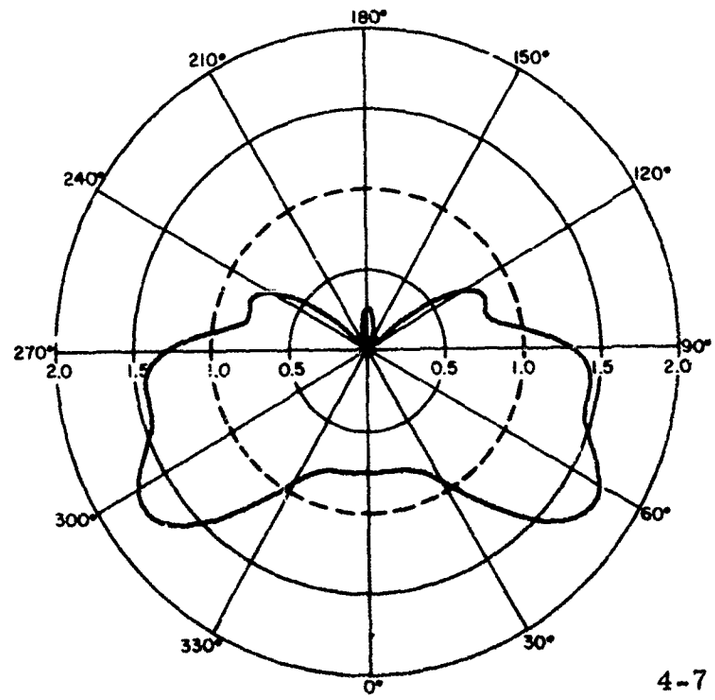
4-5


4
3
2
1
0
-1.0
+1.0
DISTANCE ~ WAVELENGTHS

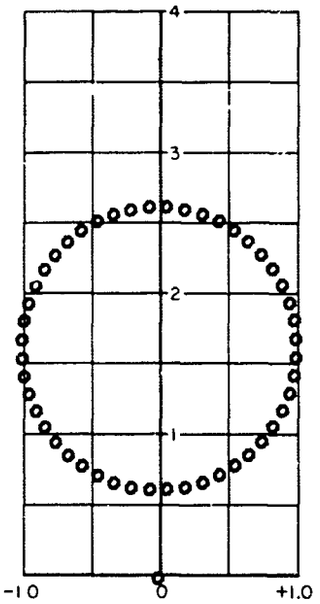

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

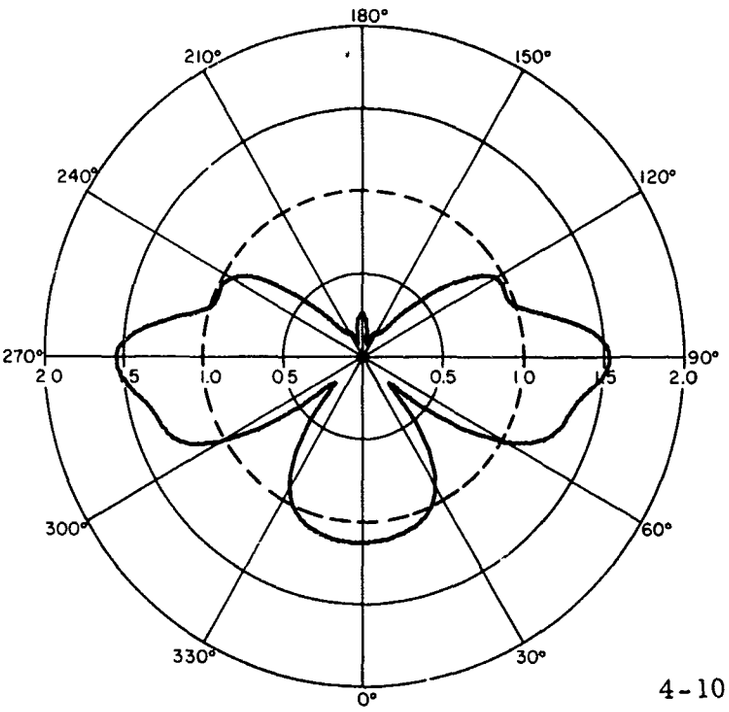
4-8


4
3
2
1
0
-1.0
+1.0
DISTANCE ~ WAVELENGTHS

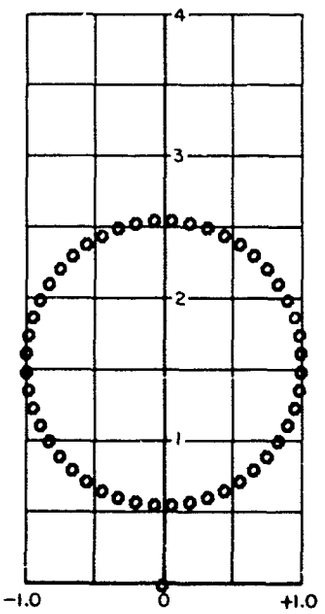

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

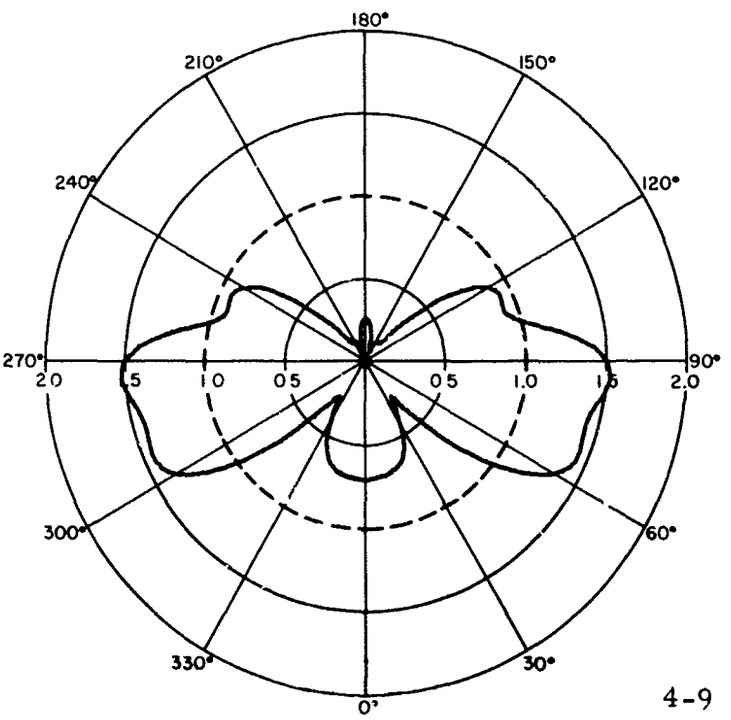
4-7


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

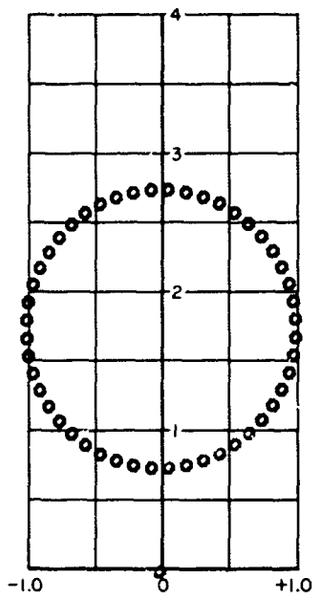

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

4-10

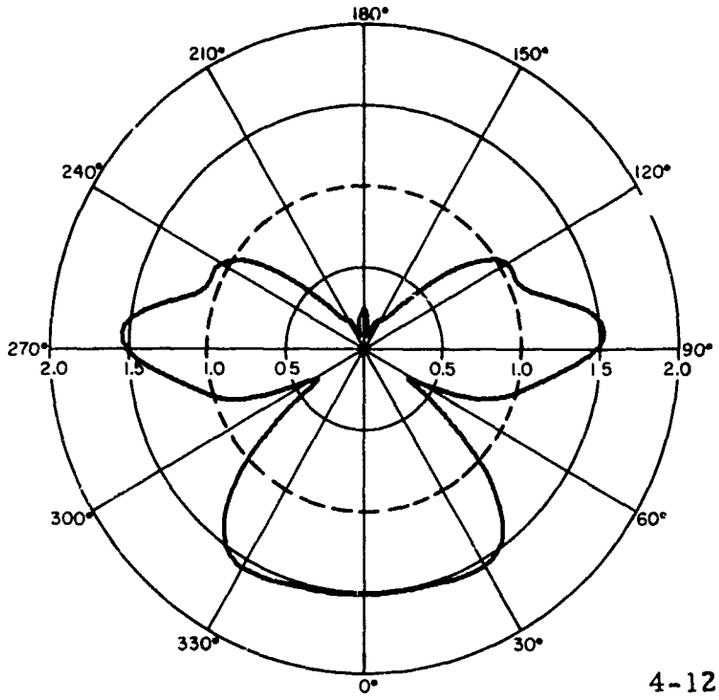

4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

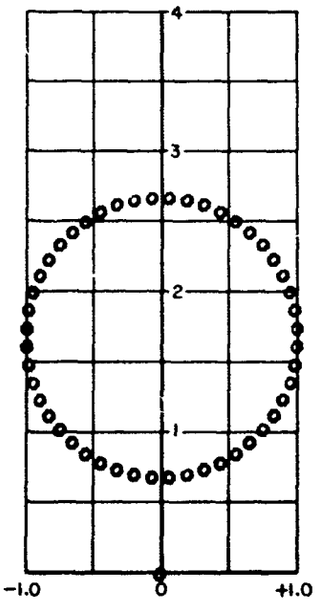
4-9



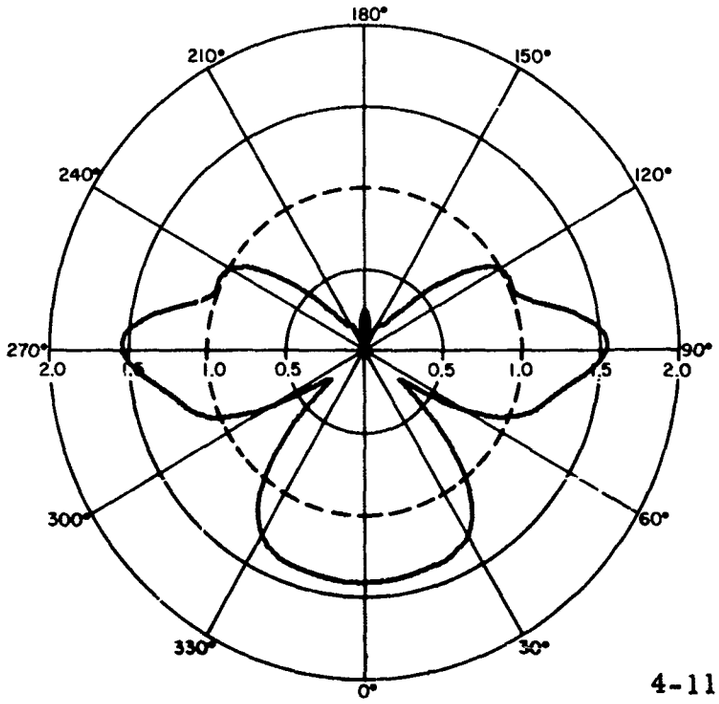
DISTANCE ~ WAVELENGTHS



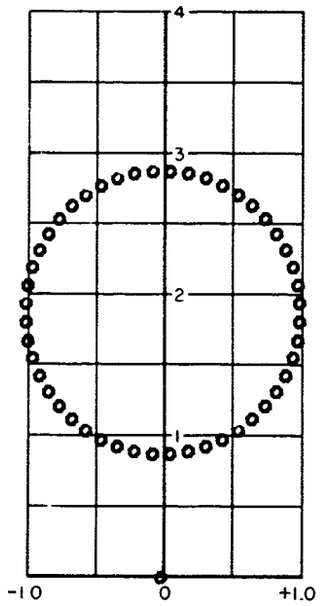
4-12



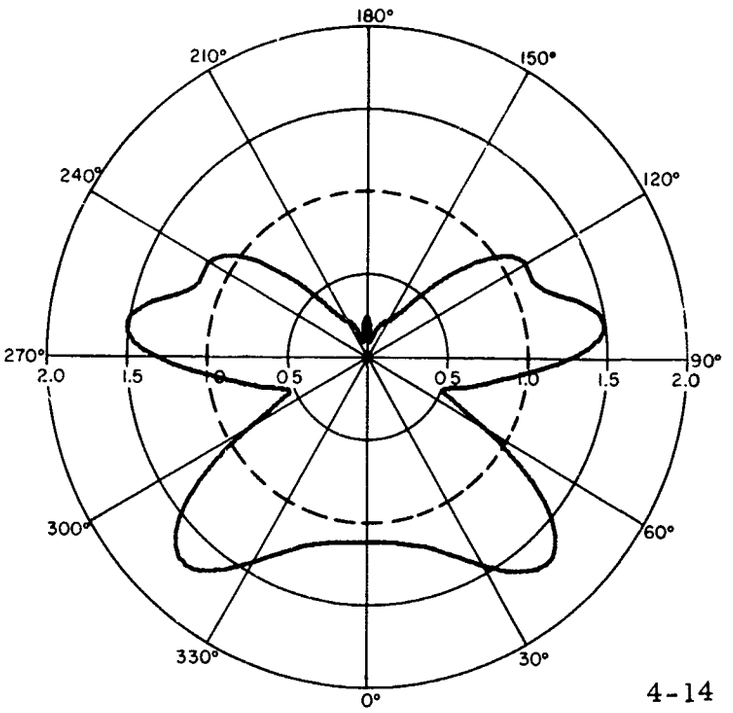
DISTANCE ~ WAVELENGTHS



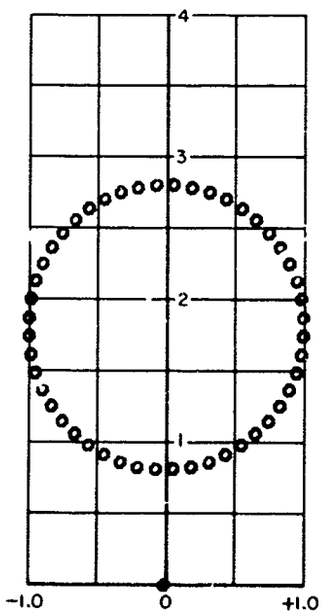
4-11



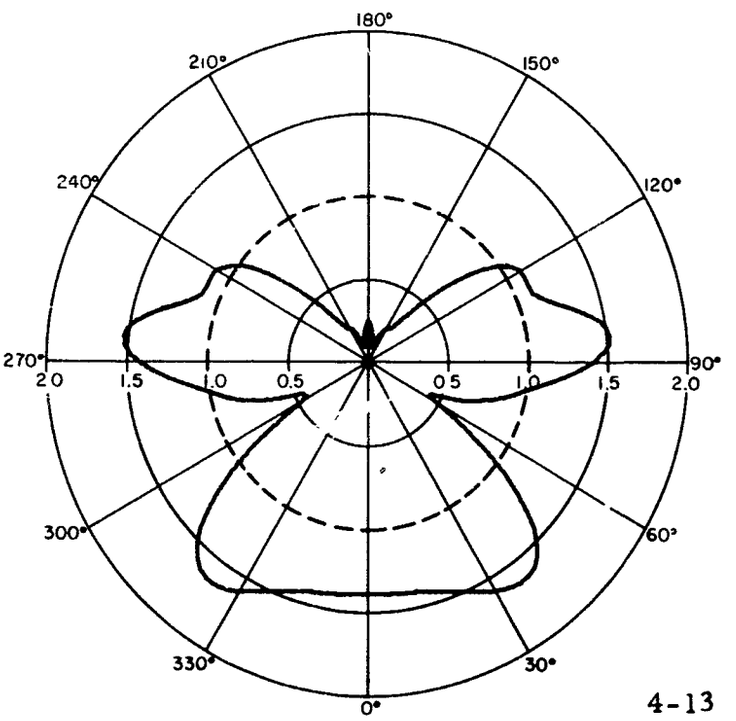
DISTANCE ~ WAVELENGTHS



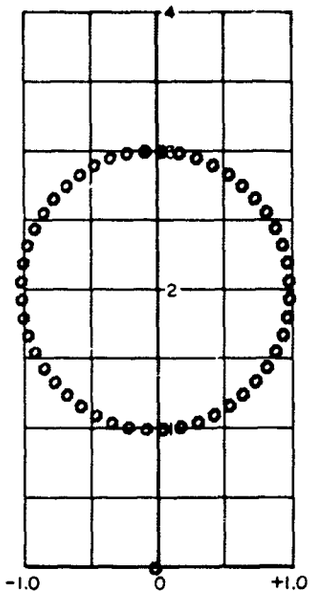
4-14



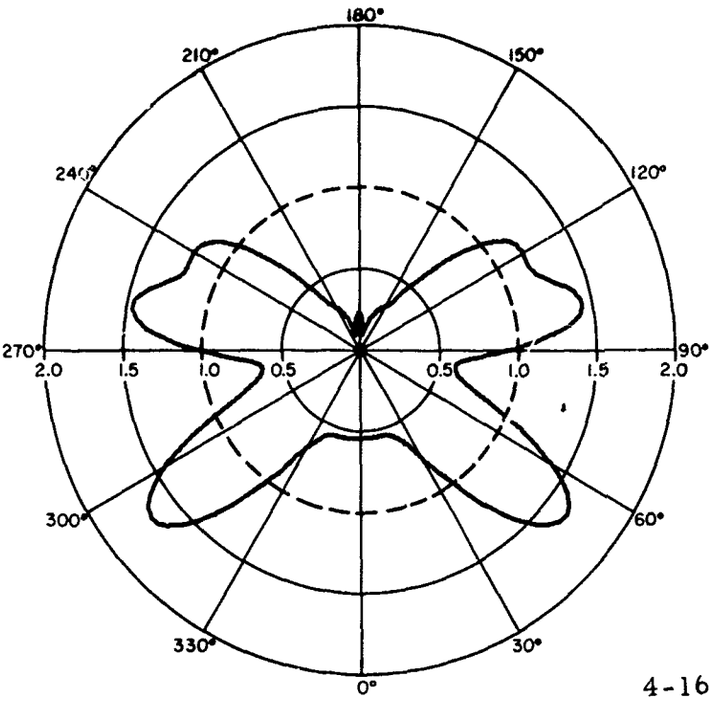
DISTANCE ~ WAVELENGTHS



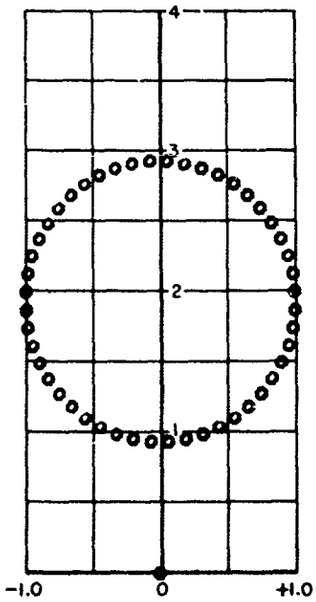
4-13



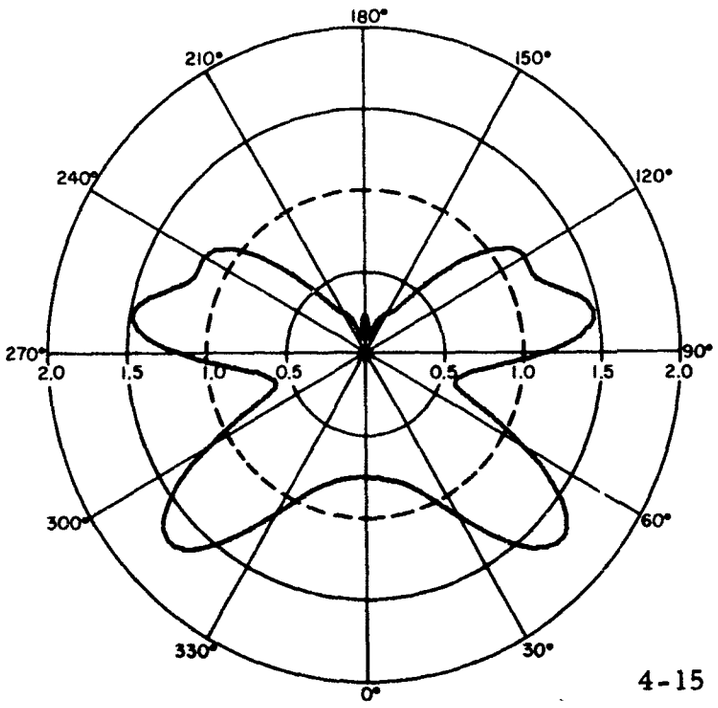
DISTANCE ~ WAVELENGTHS



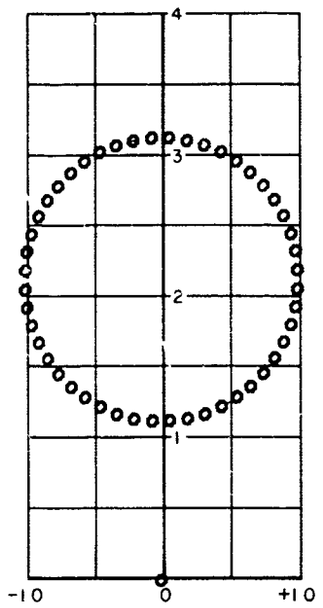
4-16

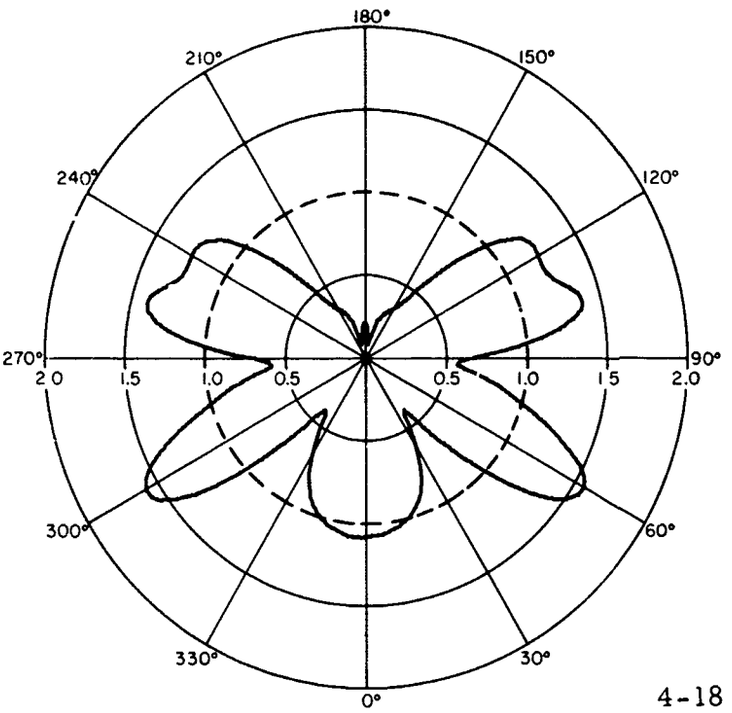


DISTANCE ~ WAVELENGTHS

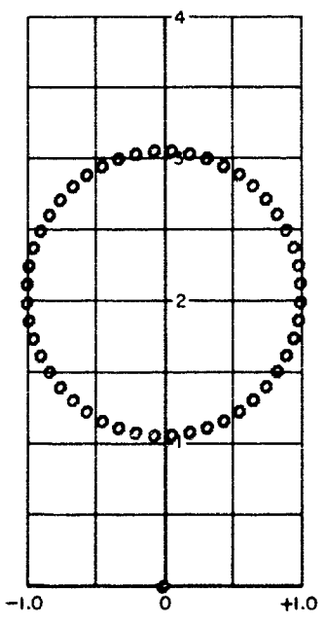


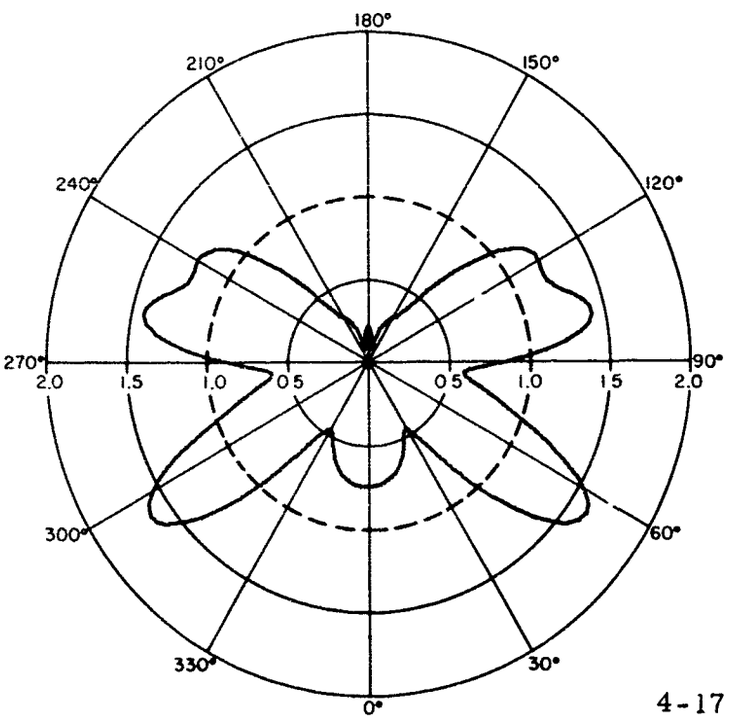
4-15


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

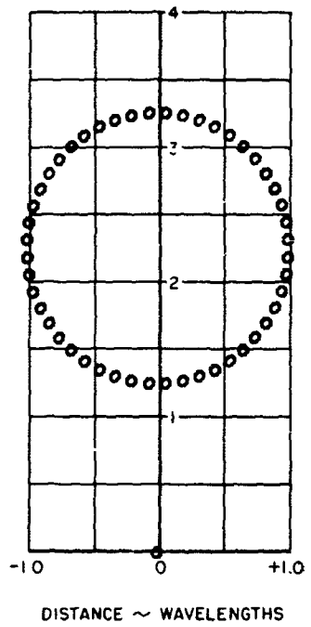

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

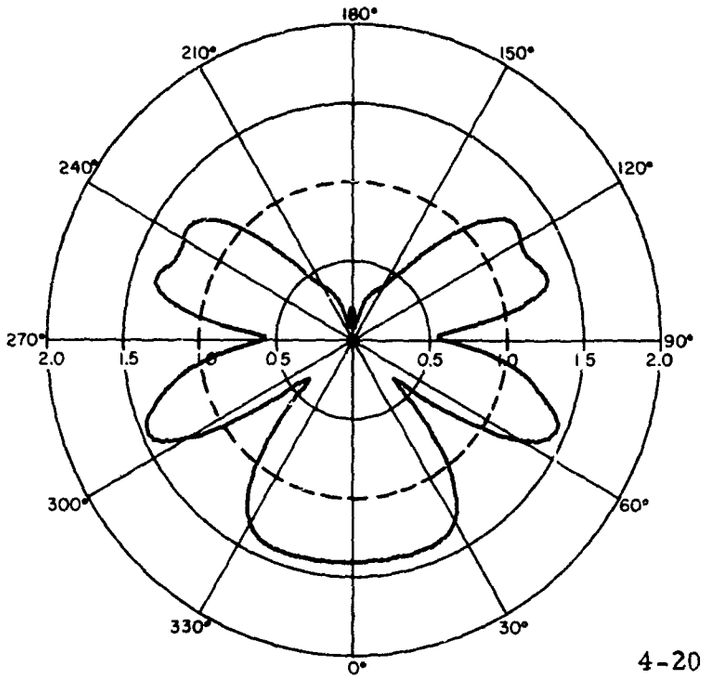
4-18


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

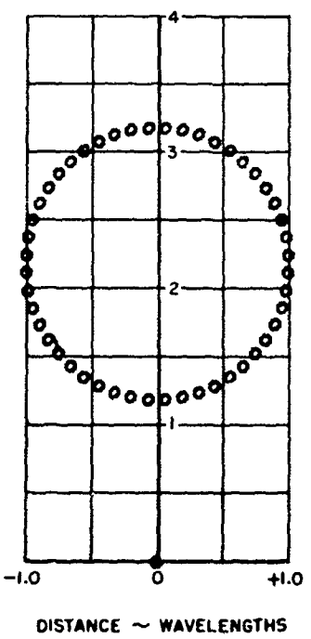

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

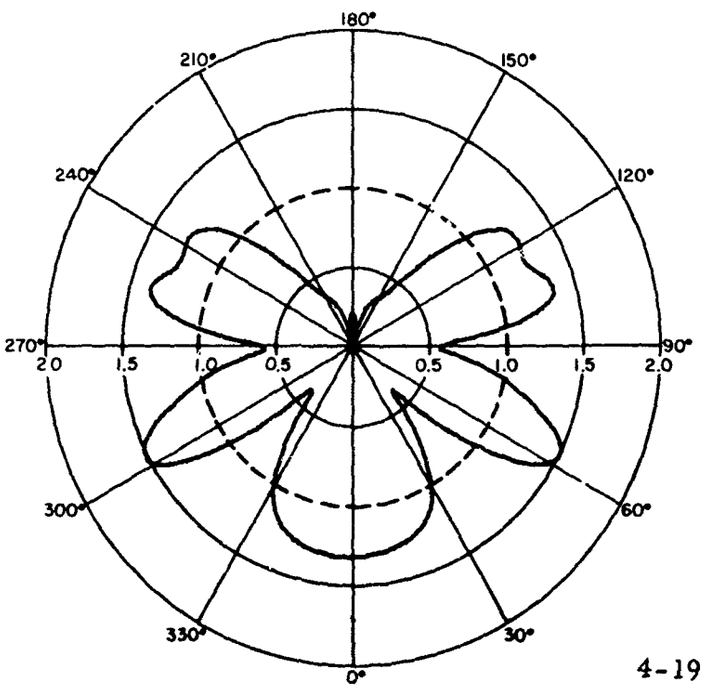
4-17


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

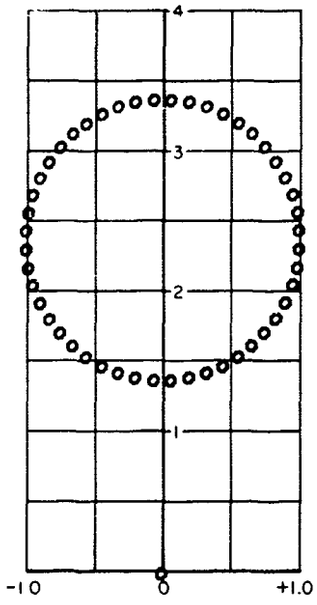

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

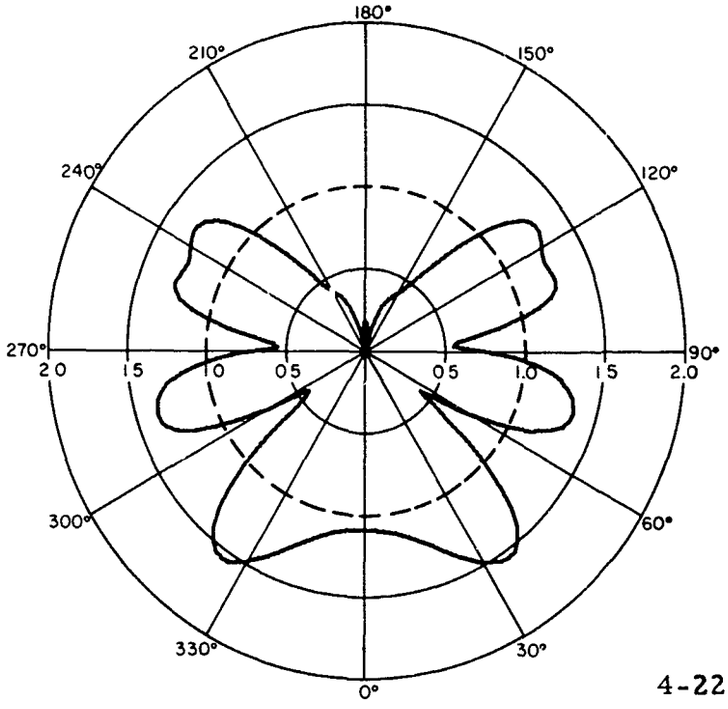
4-20


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

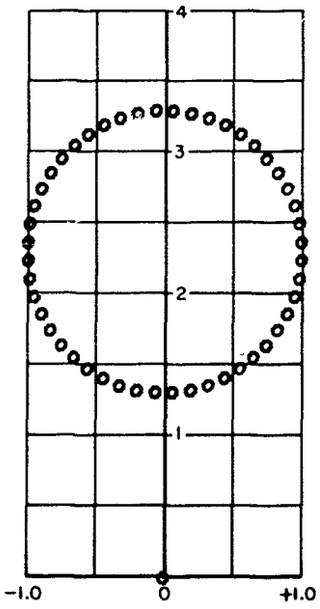

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

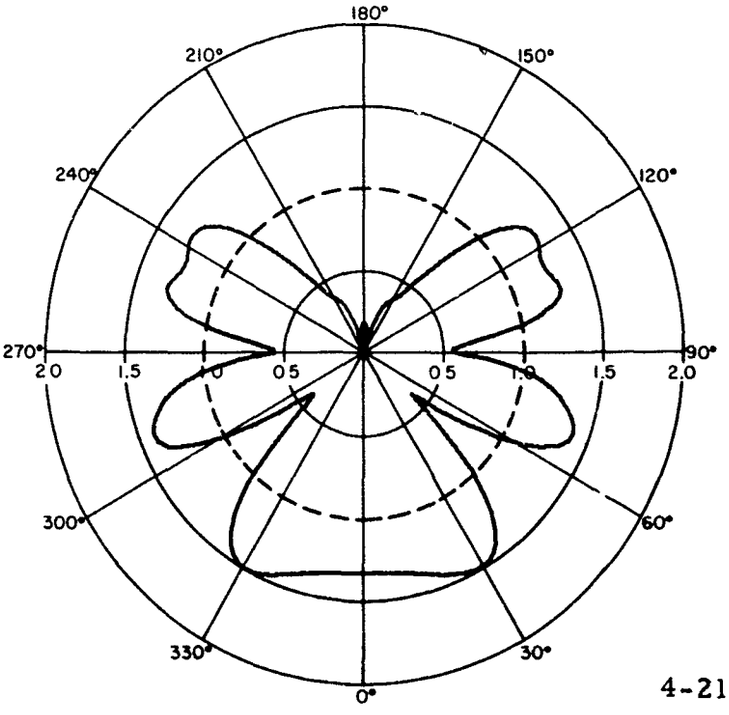
4-19


4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS

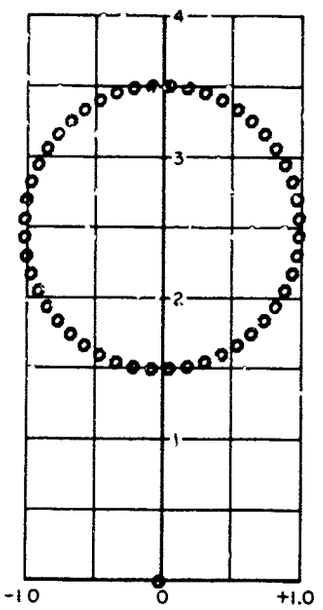

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

4-22

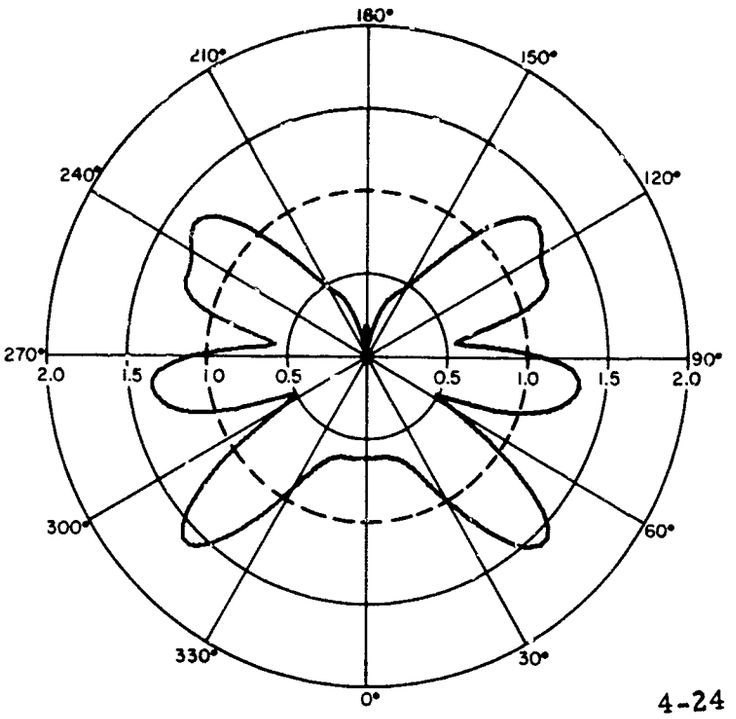

4
3
2
1
-1.0
0
+1.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

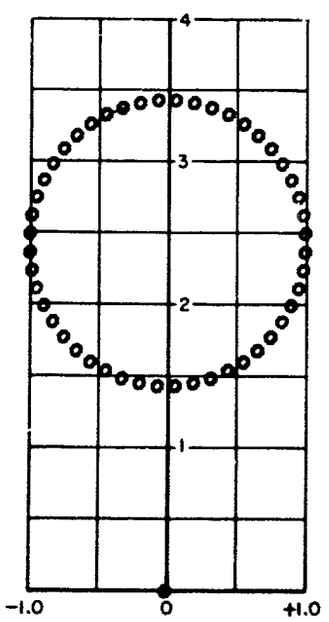
4-21



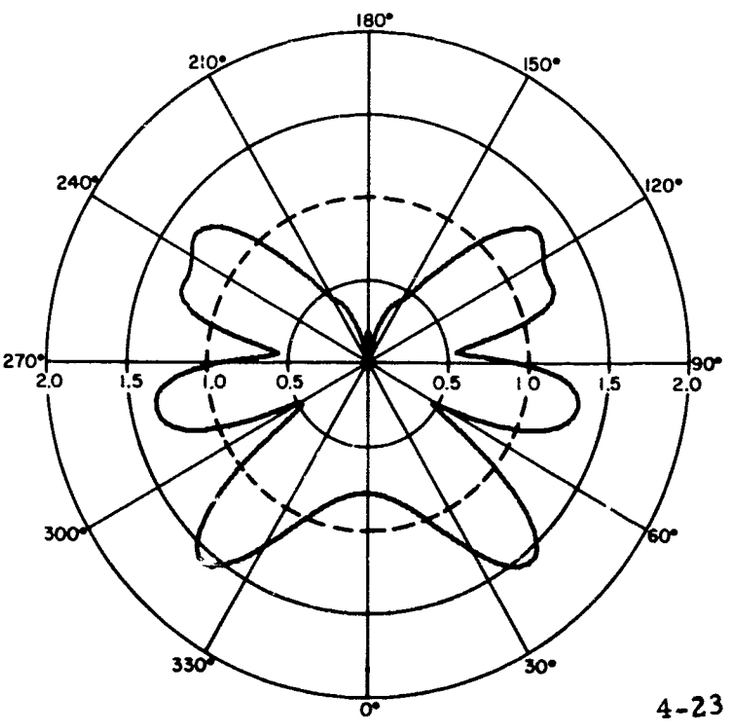
DISTANCE ~ WAVELENGTHS



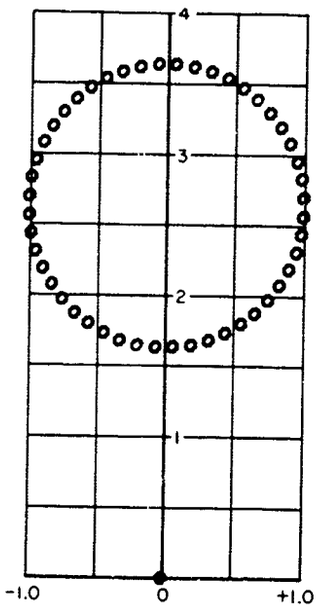
4-24



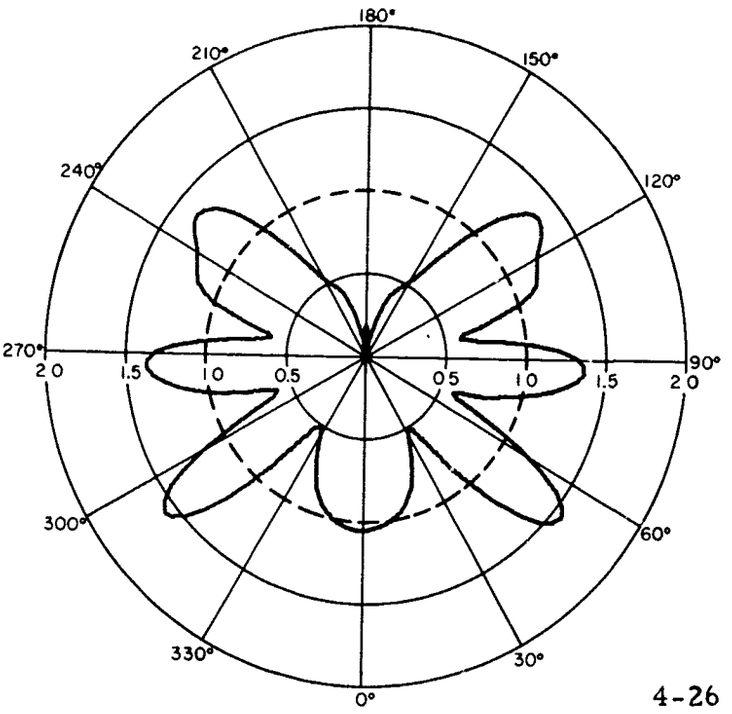
DISTANCE ~ WAVELENGTHS



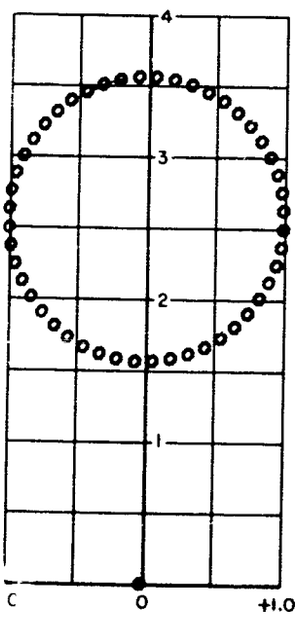
4-23



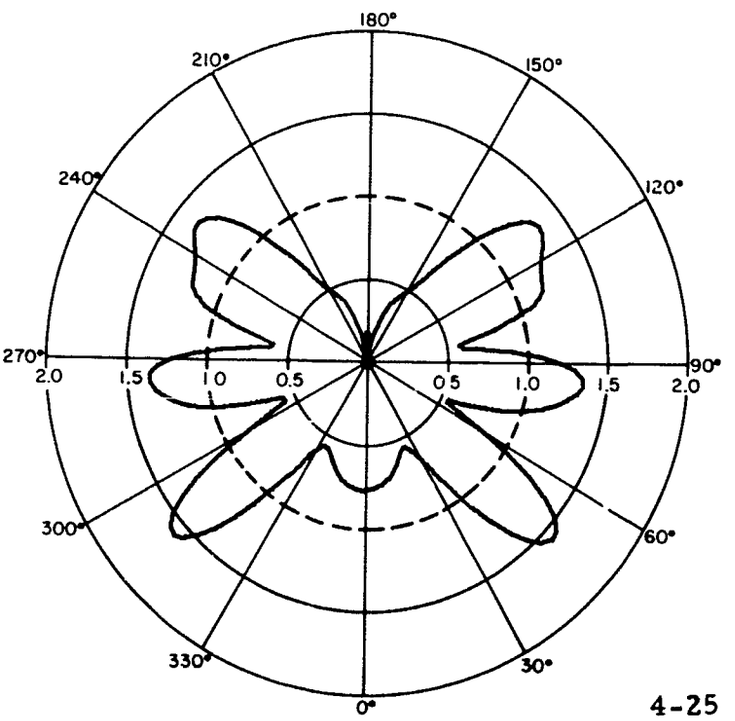
DISTANCE ~ WAVELENGTHS



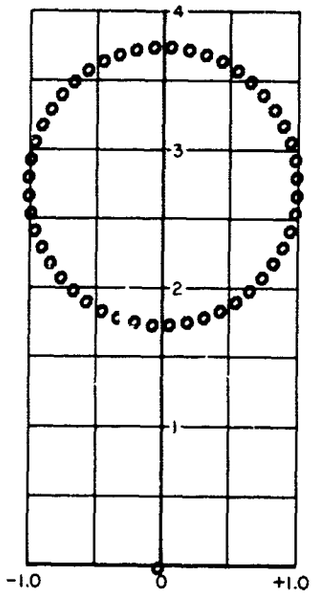
4-26



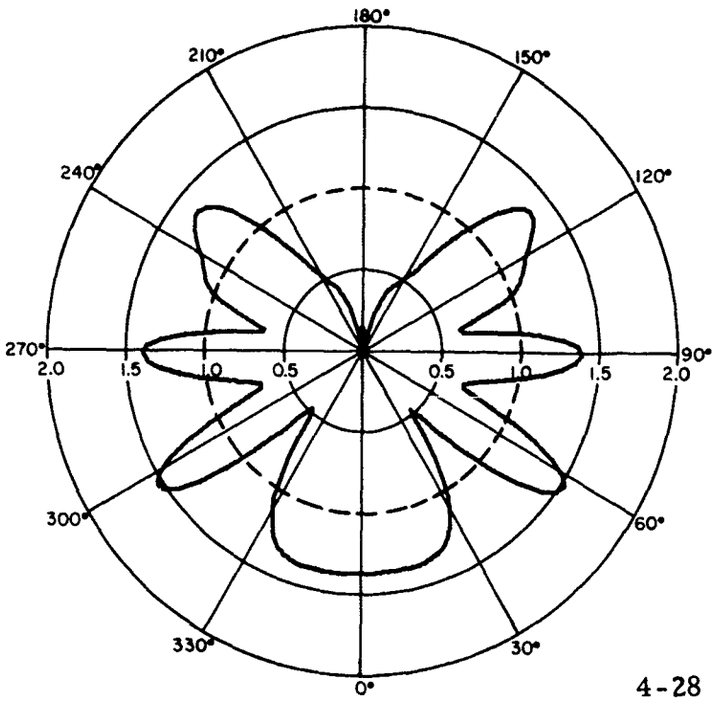
DISTANCE ~ WAVELENGTHS



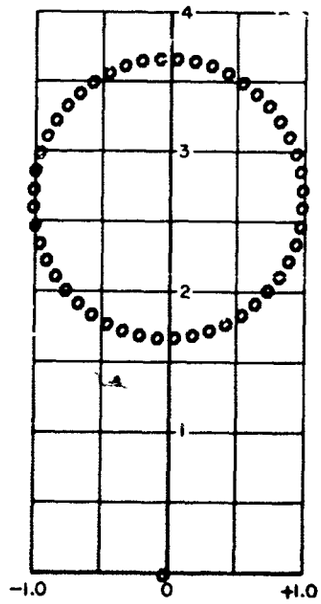
4-25



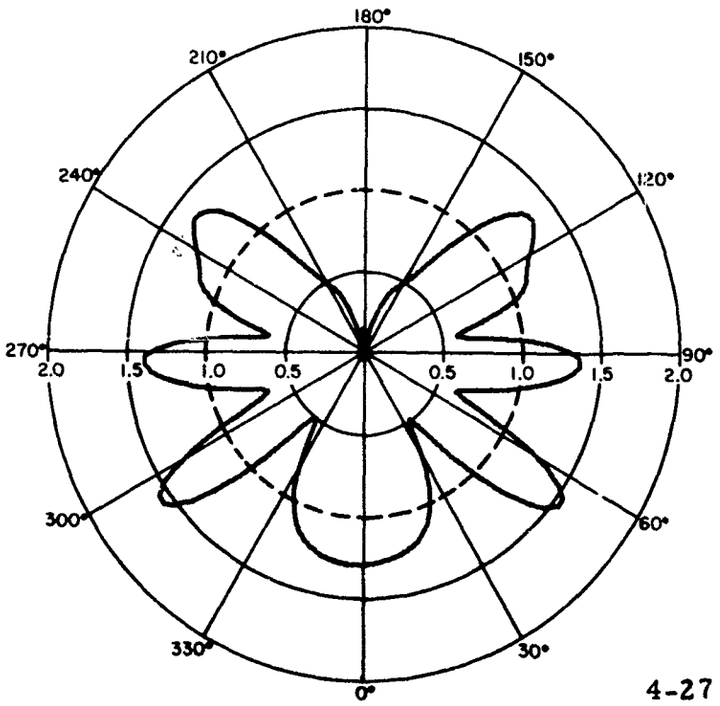
DISTANCE ~ WAVELENGTHS



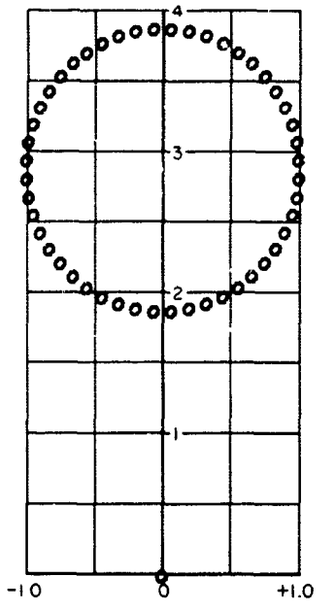
4-28



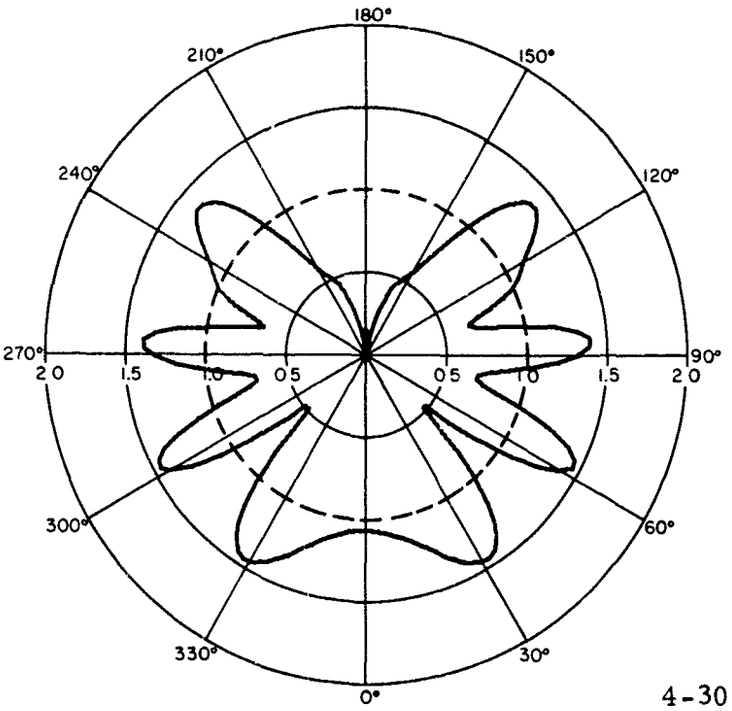
DISTANCE ~ WAVELENGTHS



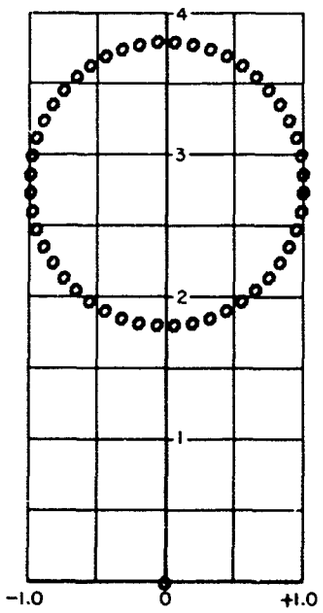
4-27



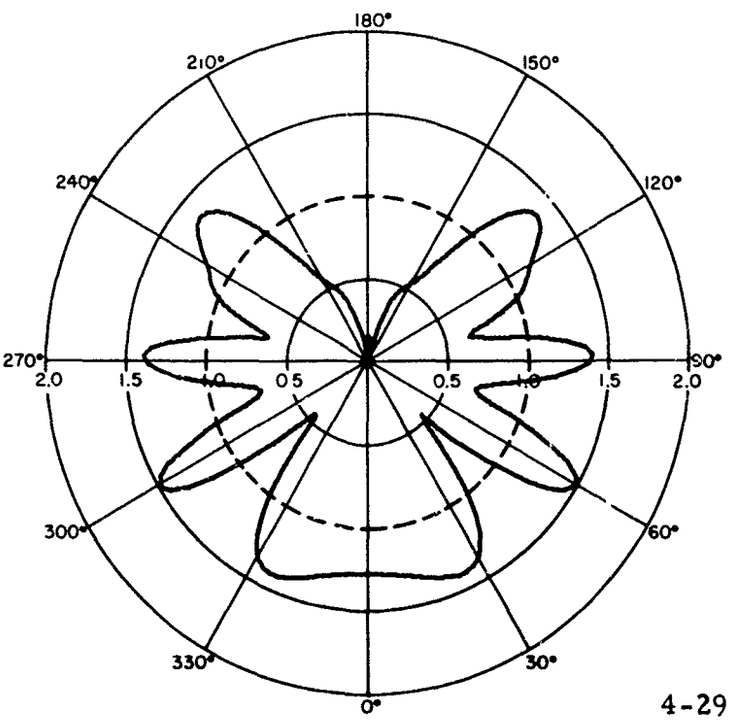
DISTANCE ~ WAVELENGTHS



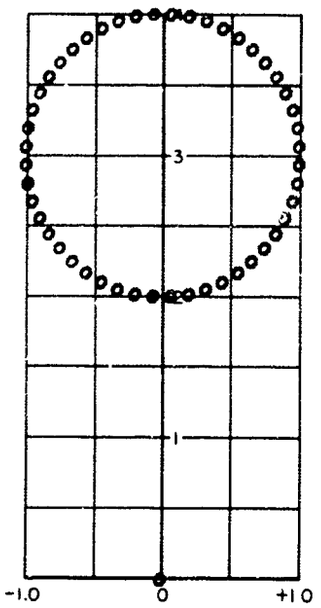
4-30



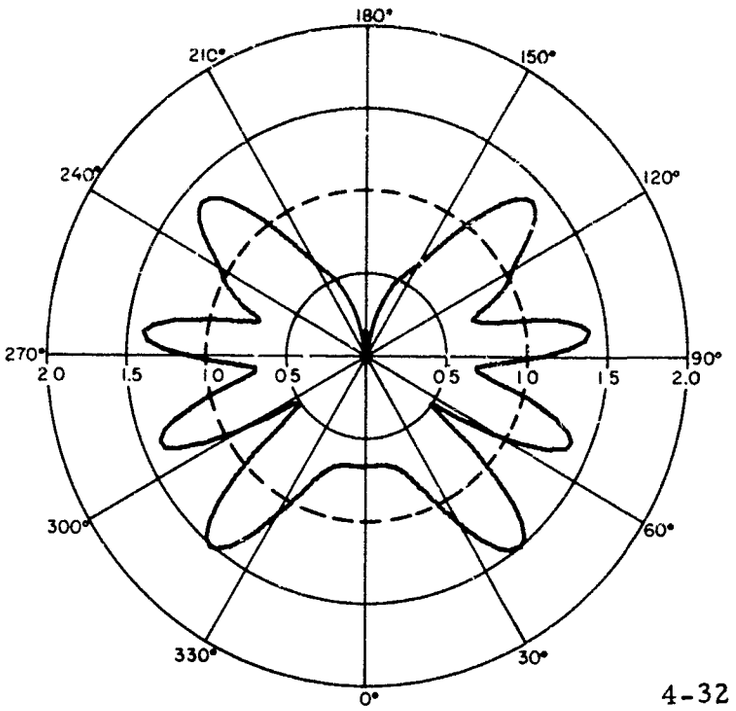
DISTANCE ~ WAVELENGTHS



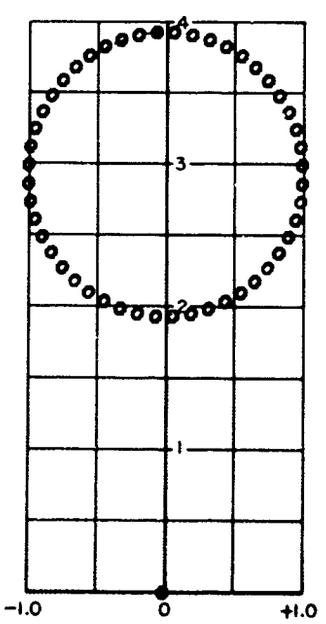
4-29



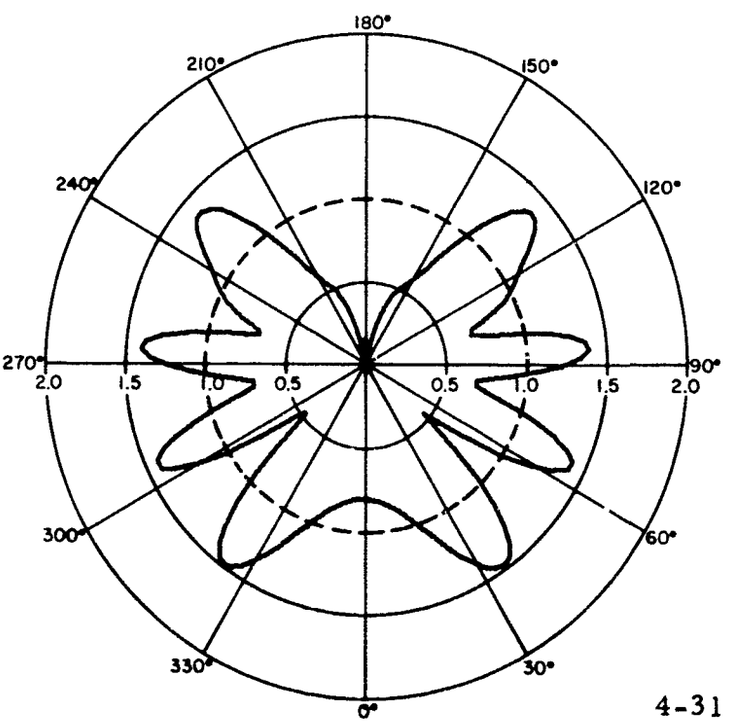
DISTANCE ~ WAVELENGTHS



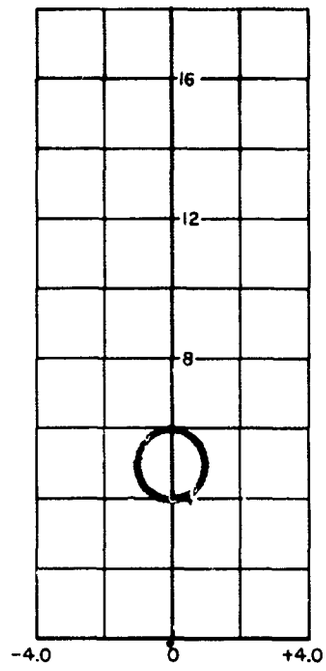
4-32

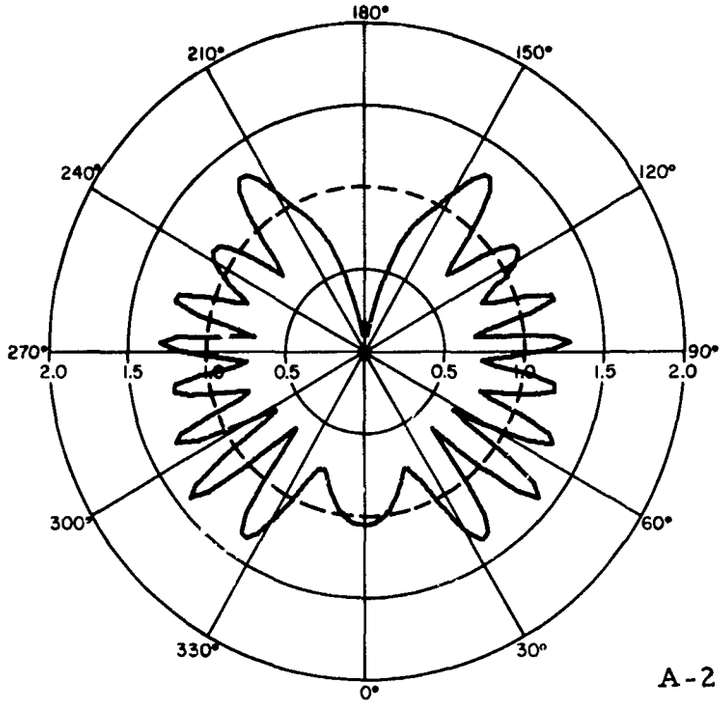


DISTANCE ~ WAVELENGTHS

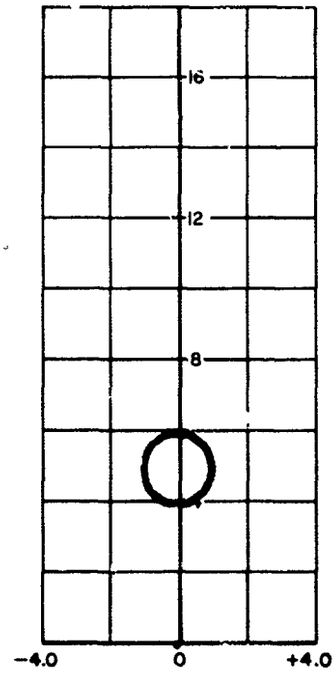


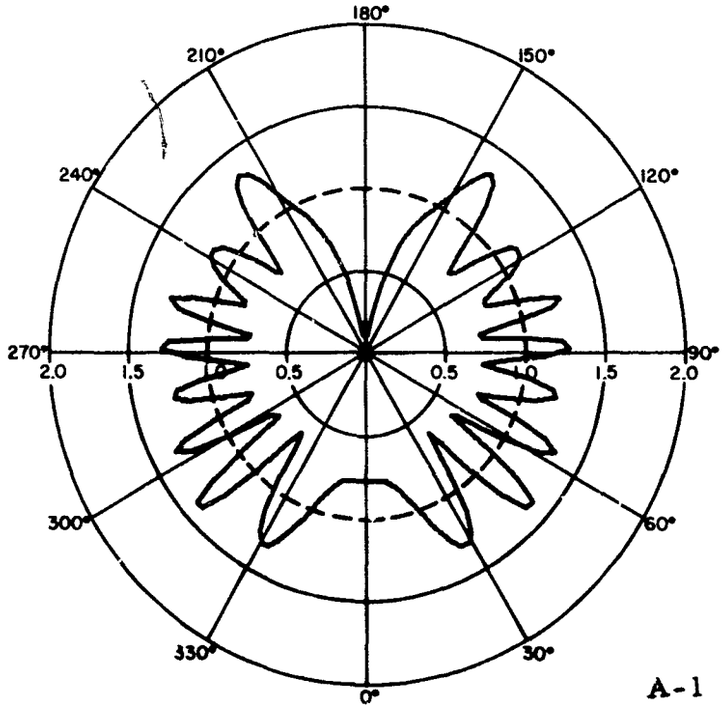
4-31


16
12
8
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

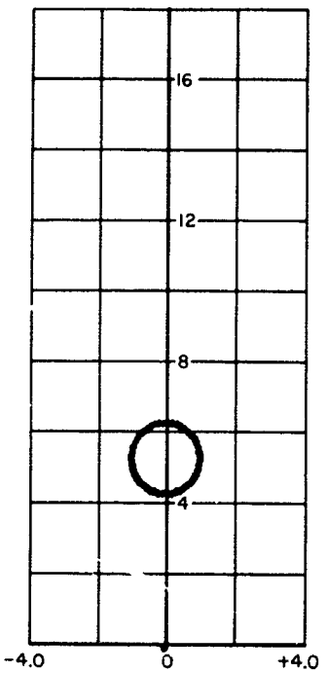

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

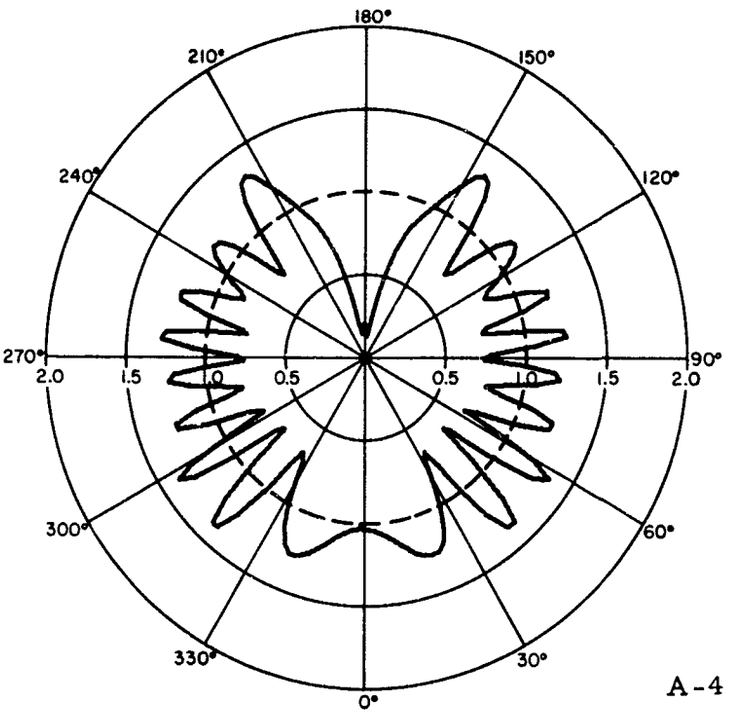
A-2


16
12
8
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

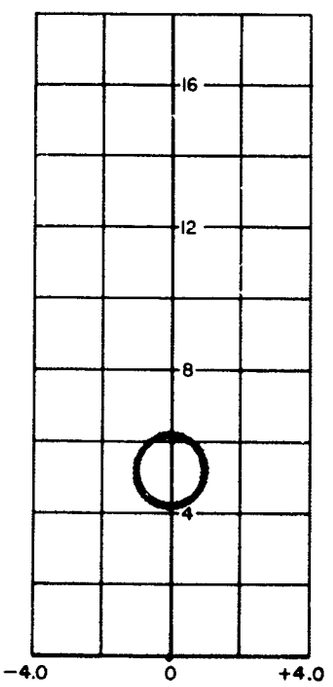

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0
300°
60°
330°
30°
0°

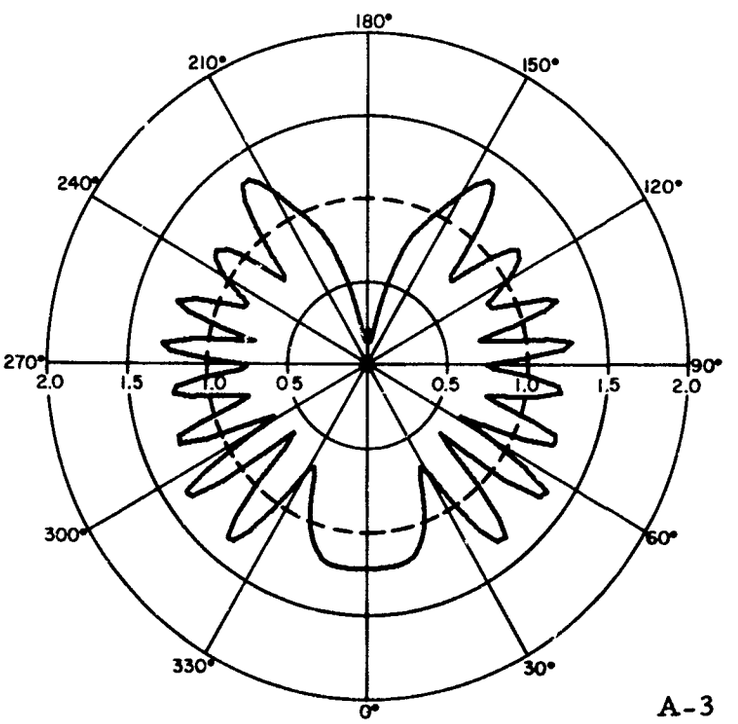
A-1


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

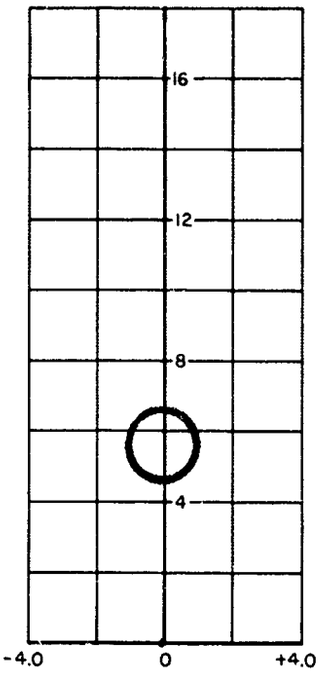

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

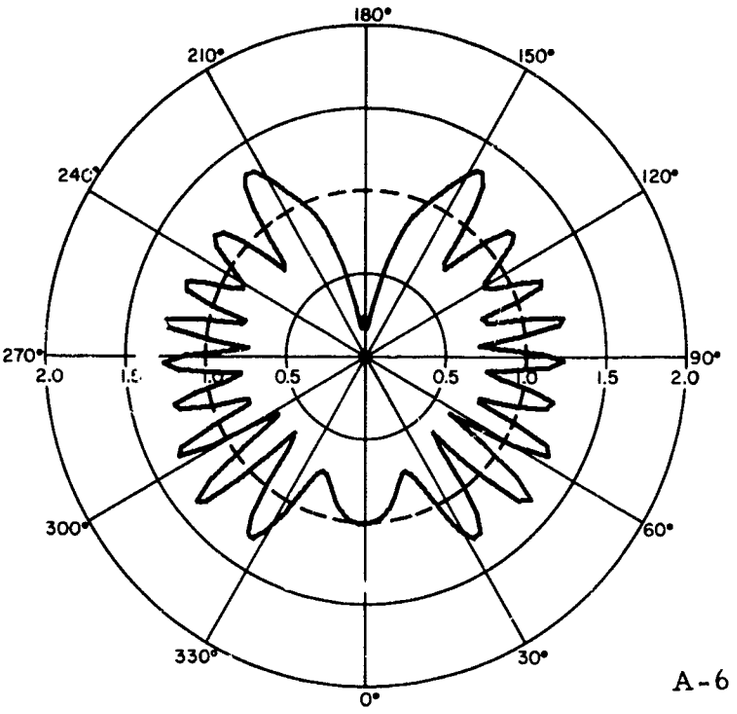
A-4


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

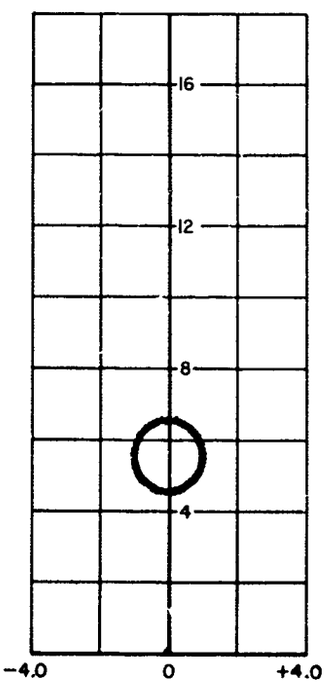

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

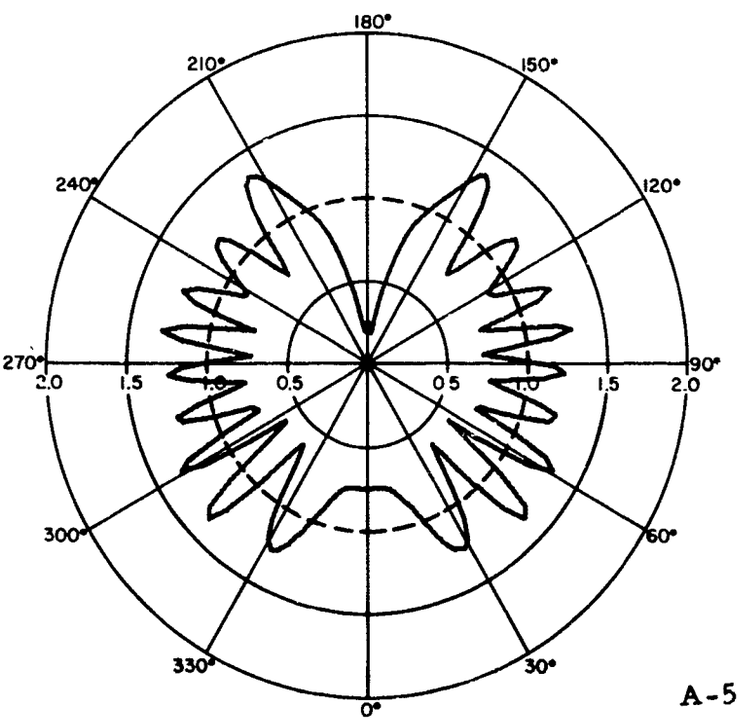
A-3


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

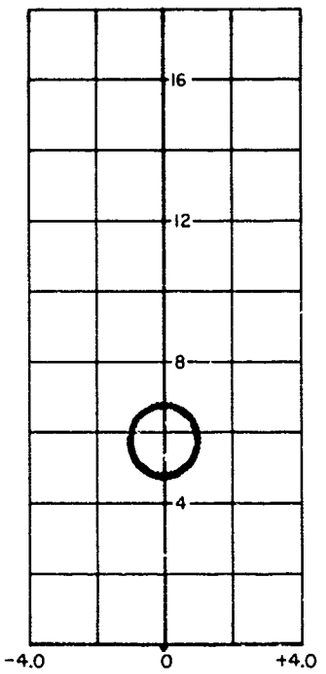

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

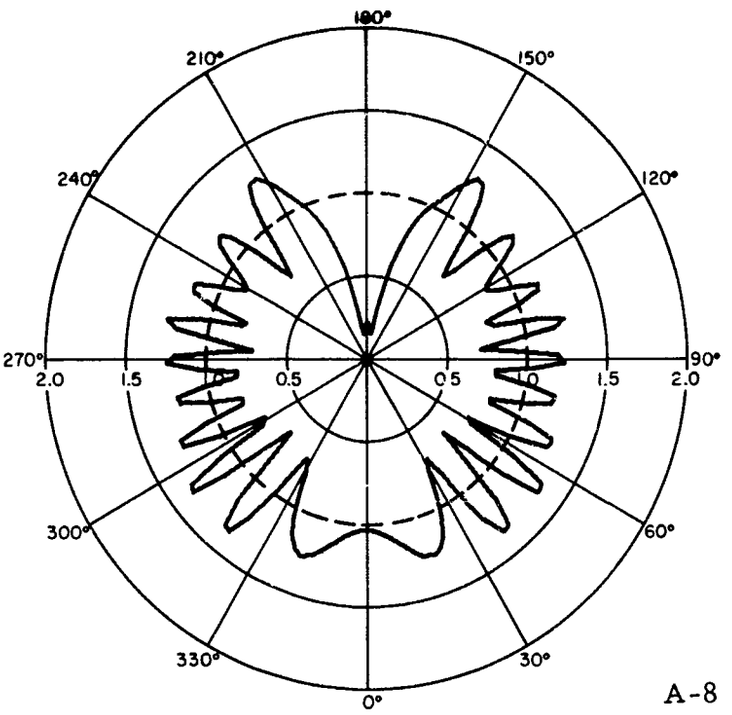
A-6


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

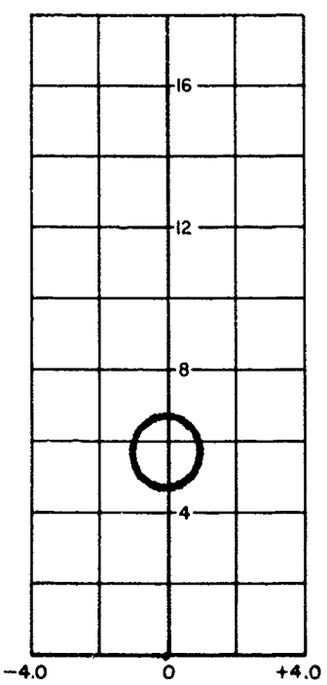

180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
2.0
1.5
1.0
0.5
0.5
1.0
1.5
2.0

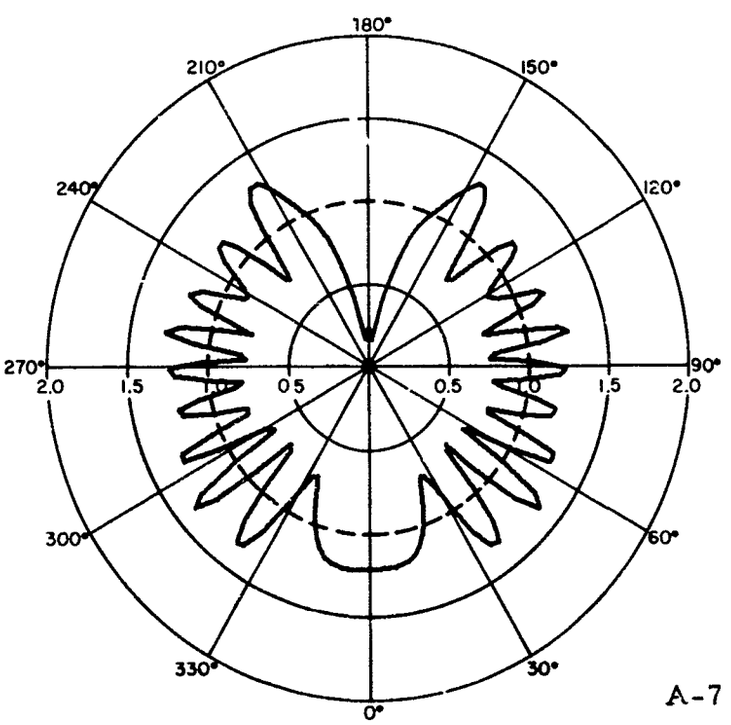
A-5


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

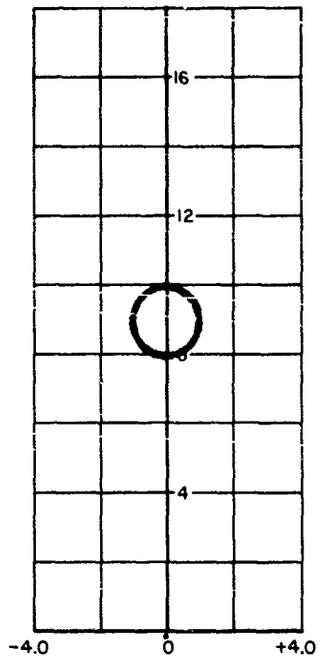

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

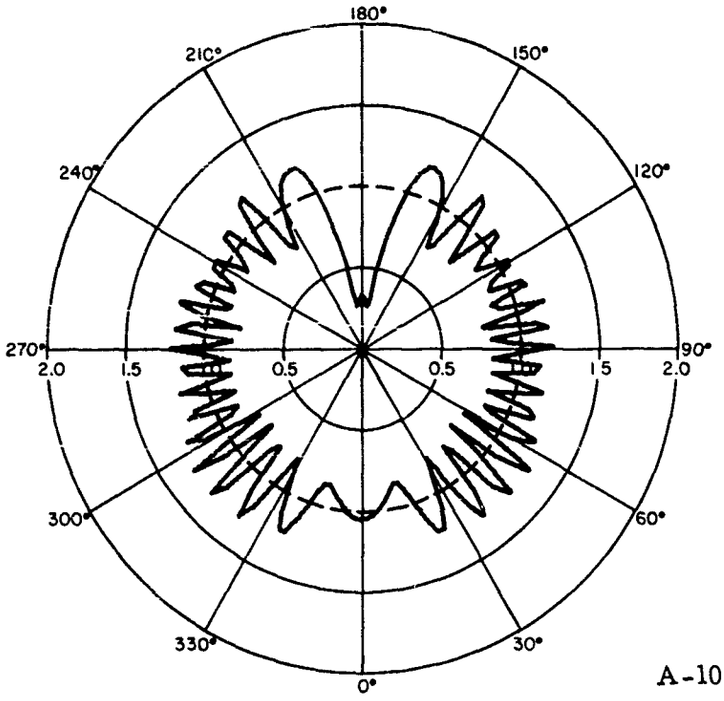
A-8


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

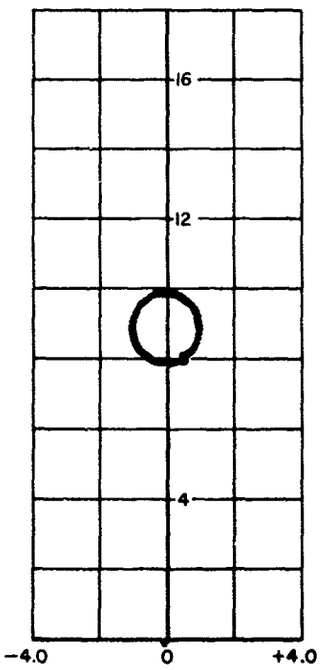

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

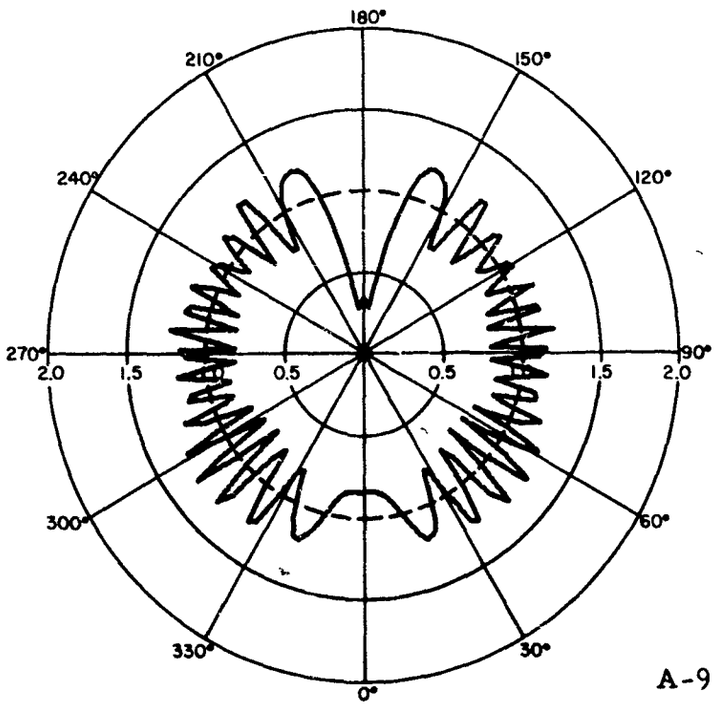
A-7


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

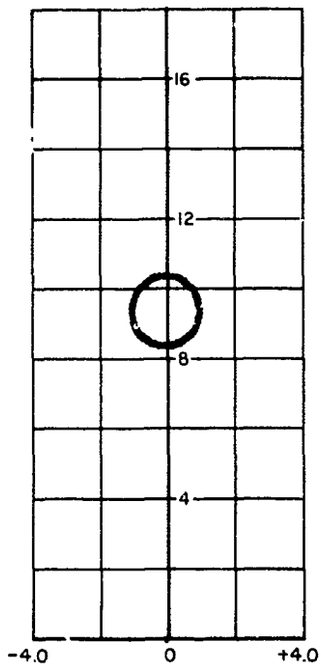

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

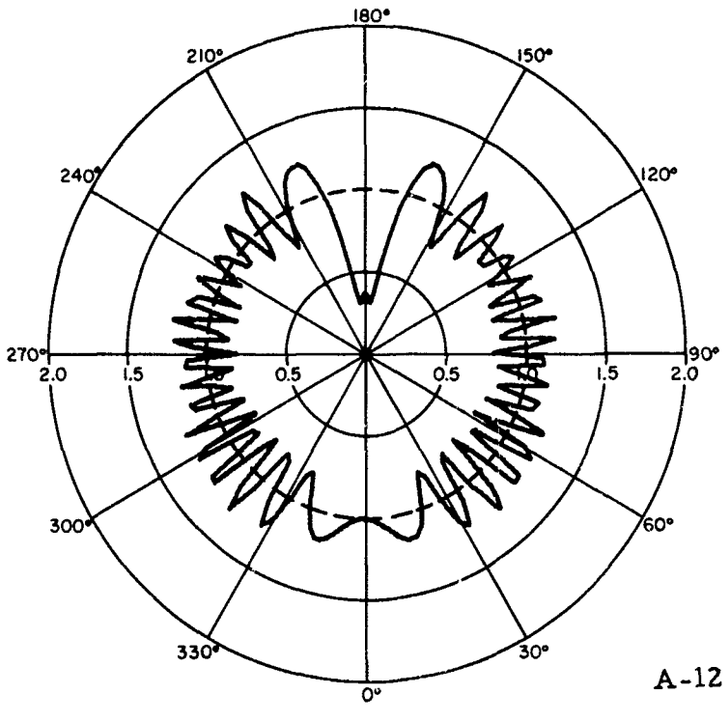
A-10


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

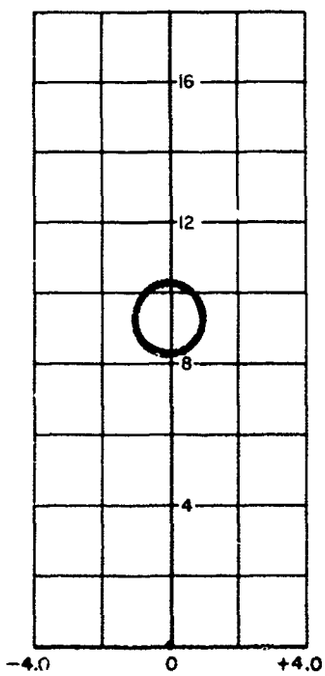

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

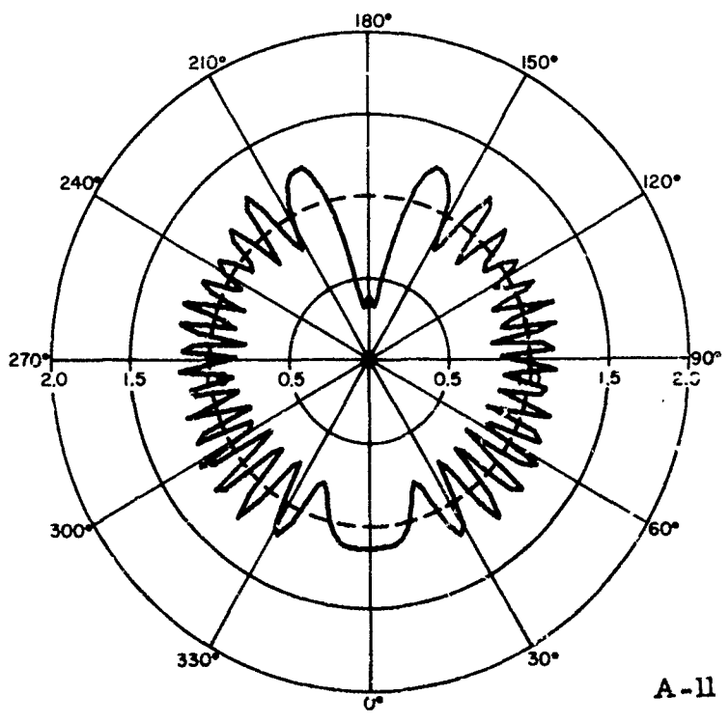
A-9


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

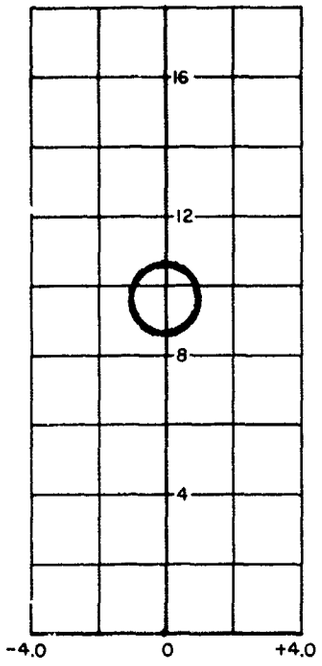

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

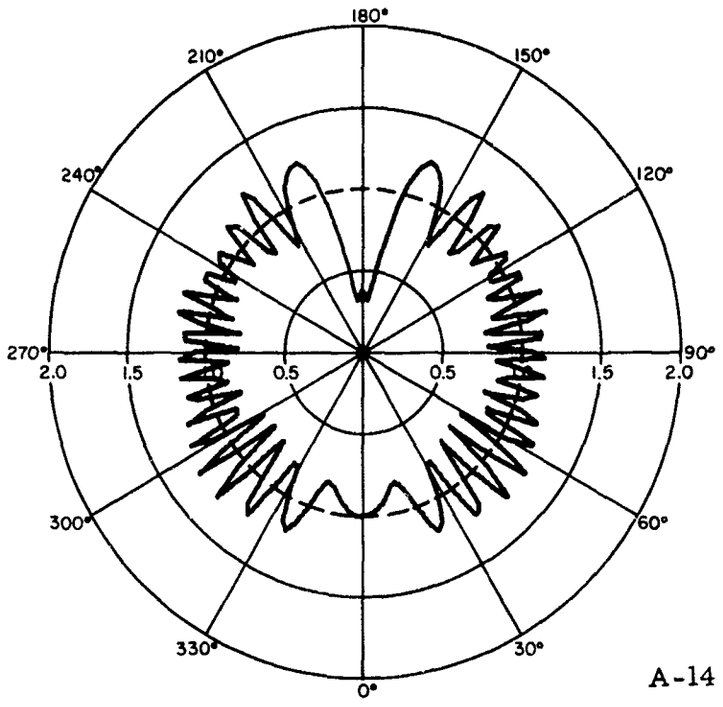
A-12


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

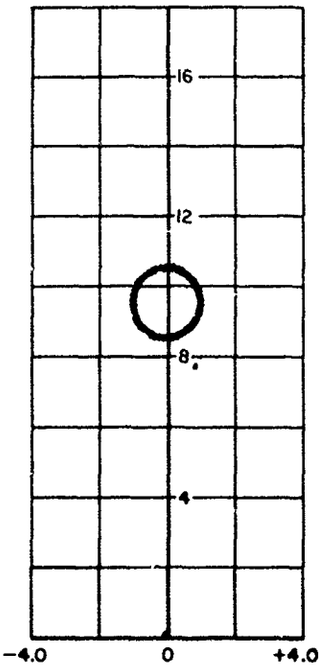

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

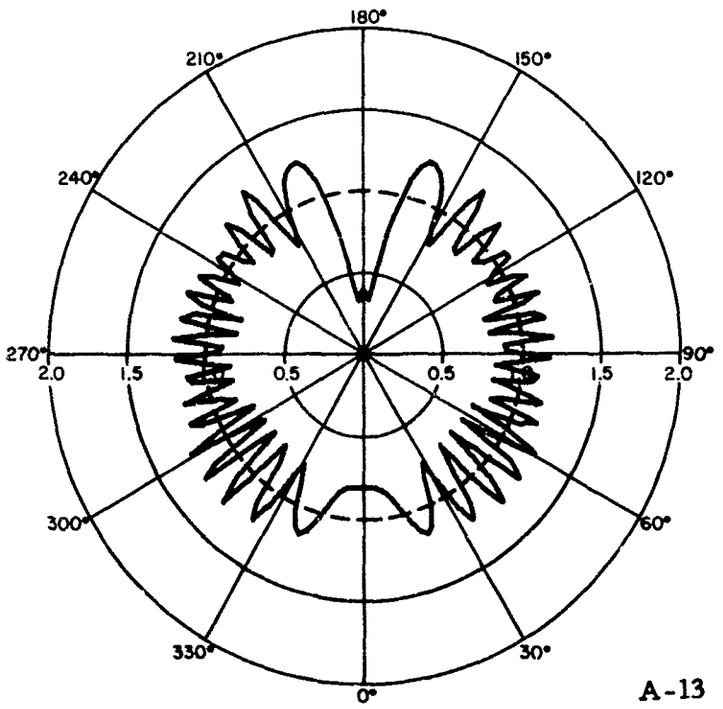
A-11


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

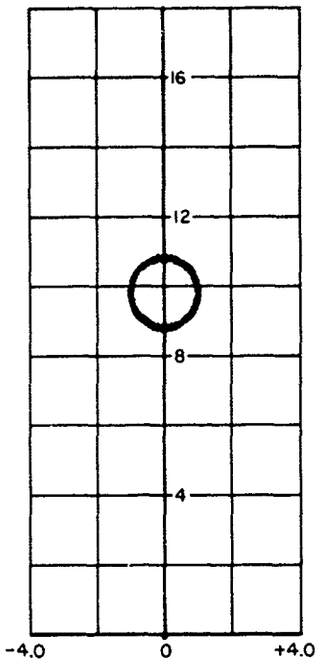

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

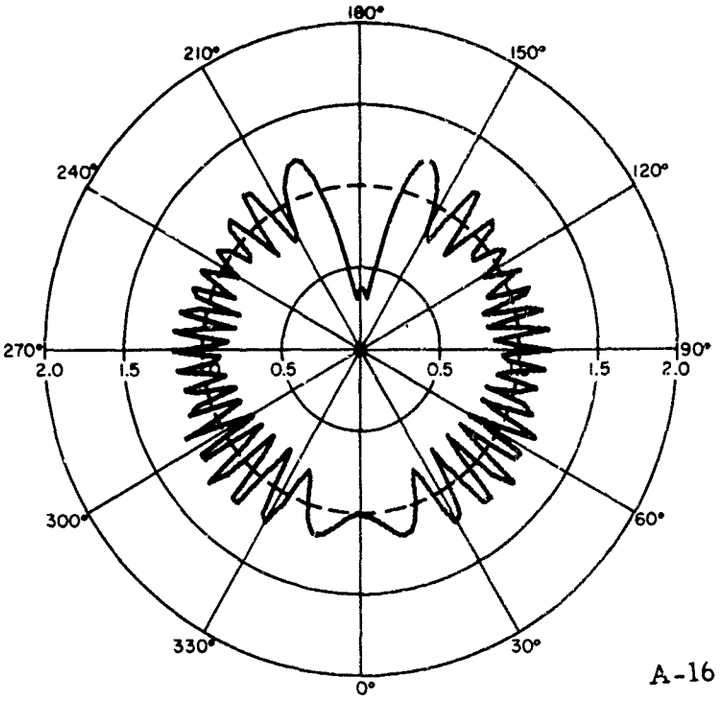
A-14


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

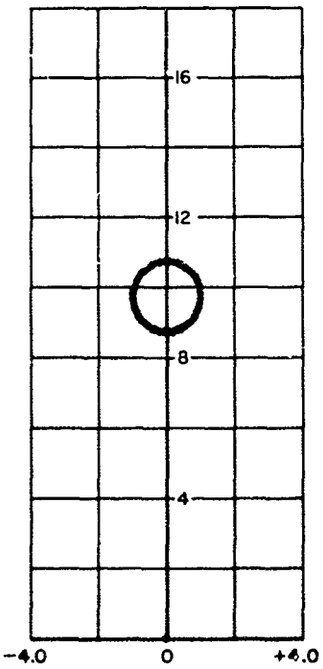

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

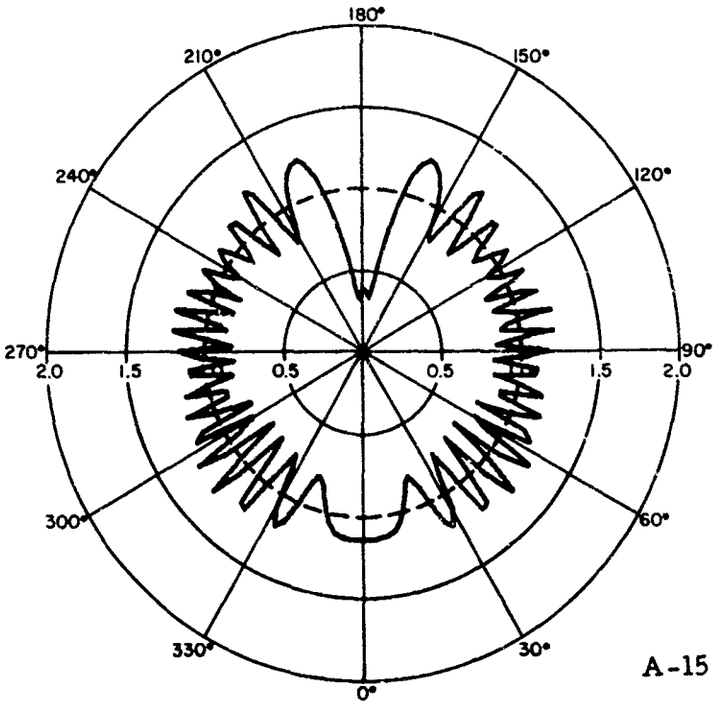
A-13


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

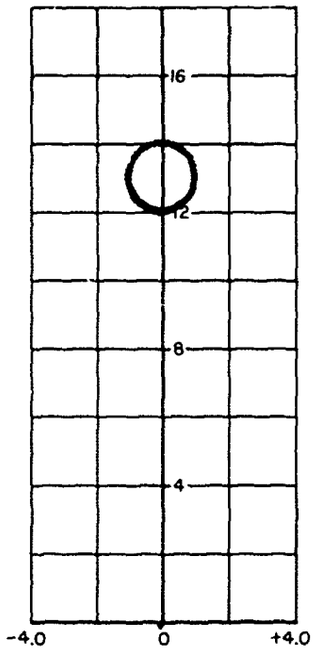

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

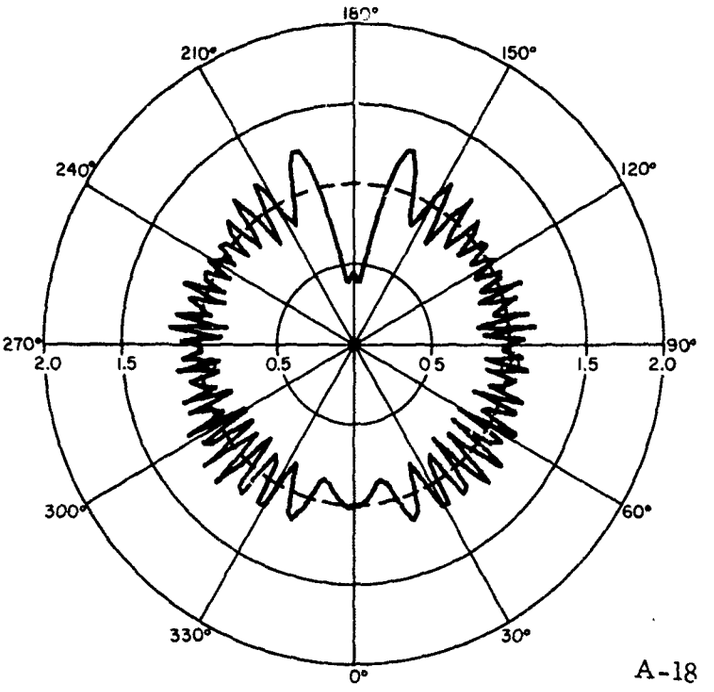
A-16


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

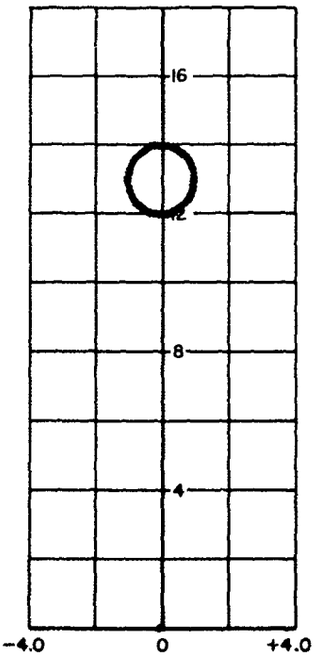

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

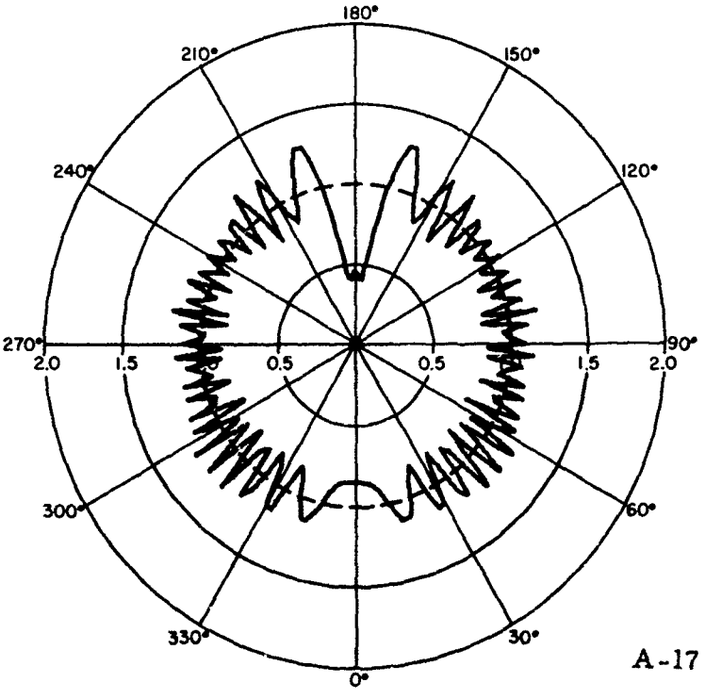
A-15


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

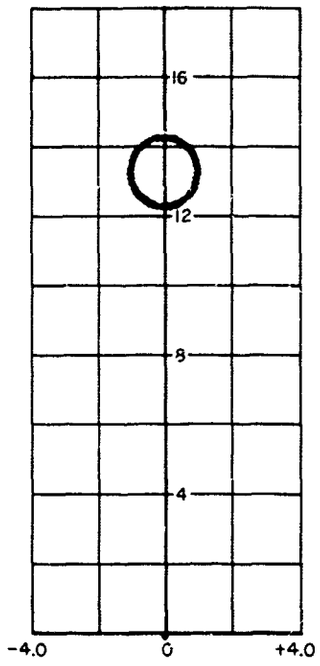

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

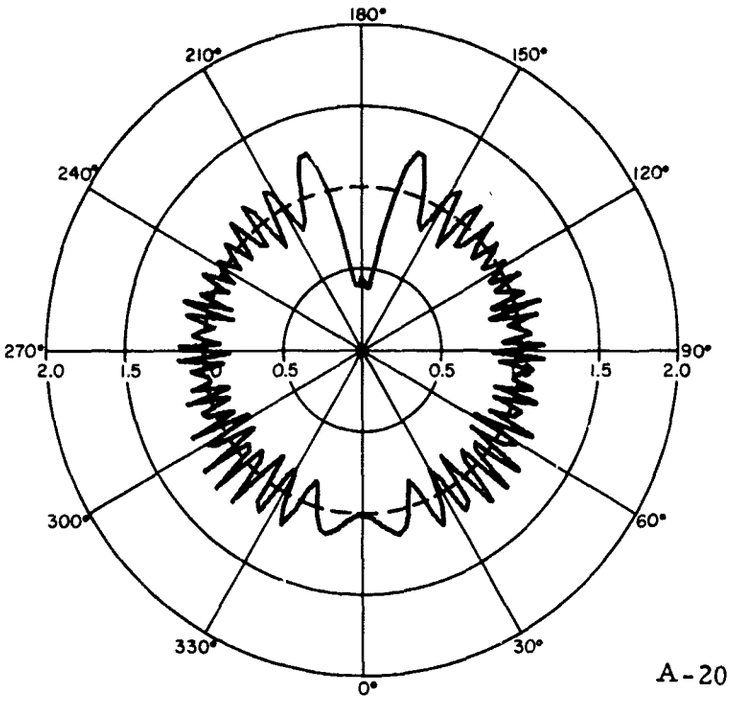
A-18


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

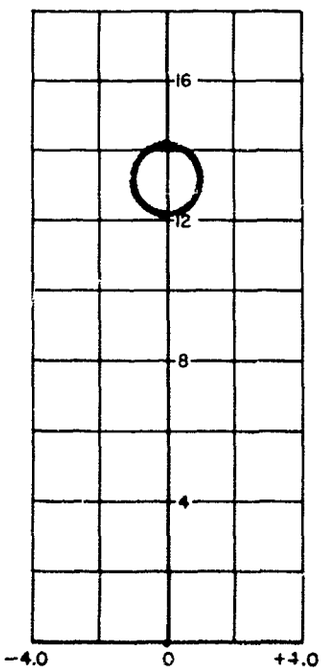

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

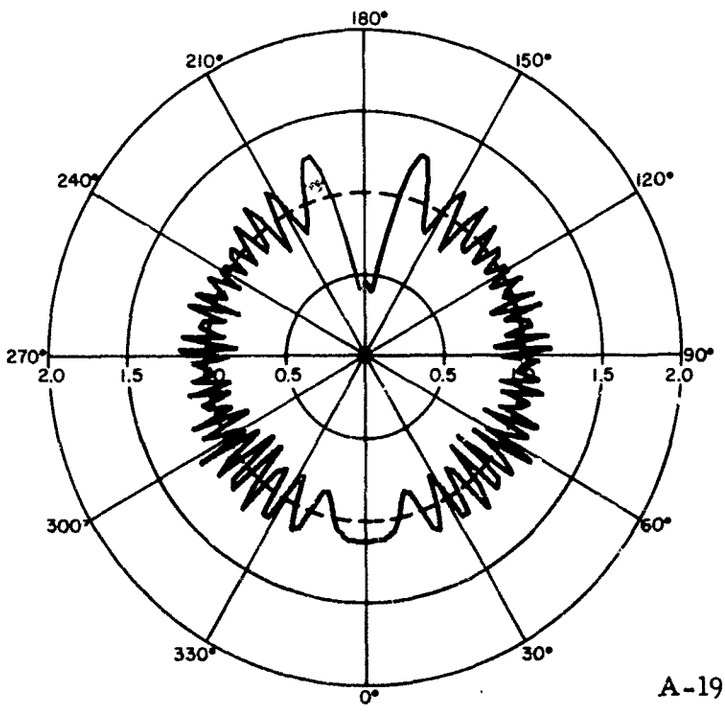
A-17


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

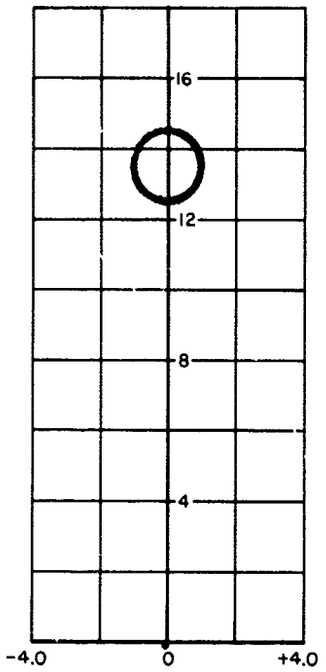

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

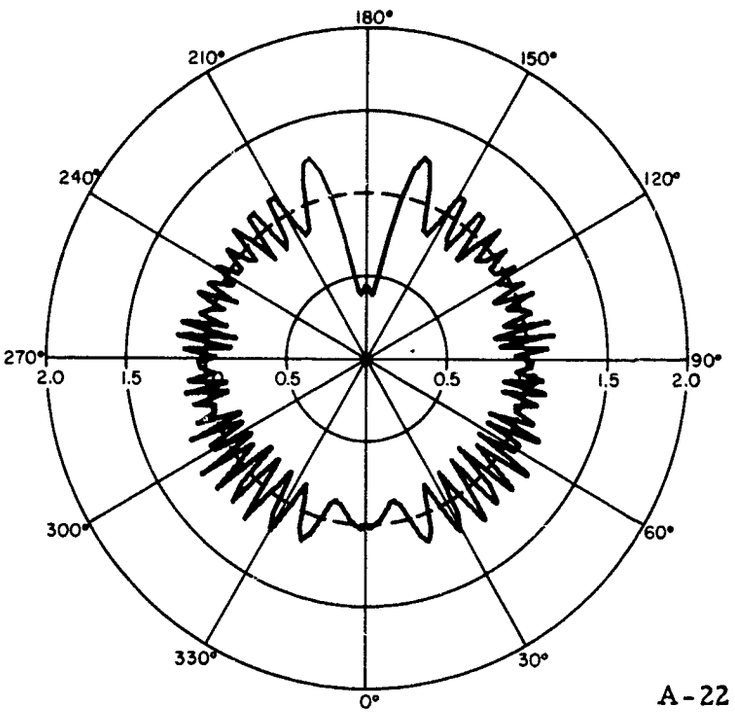
A-20


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

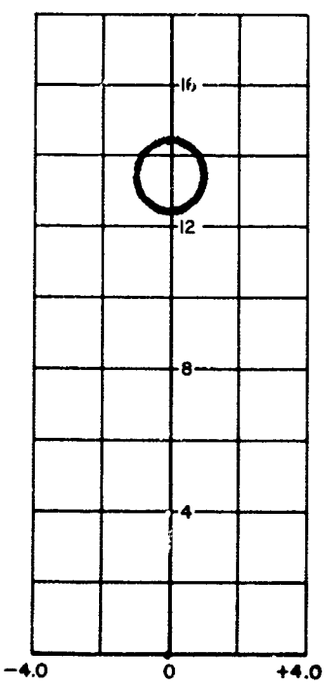

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

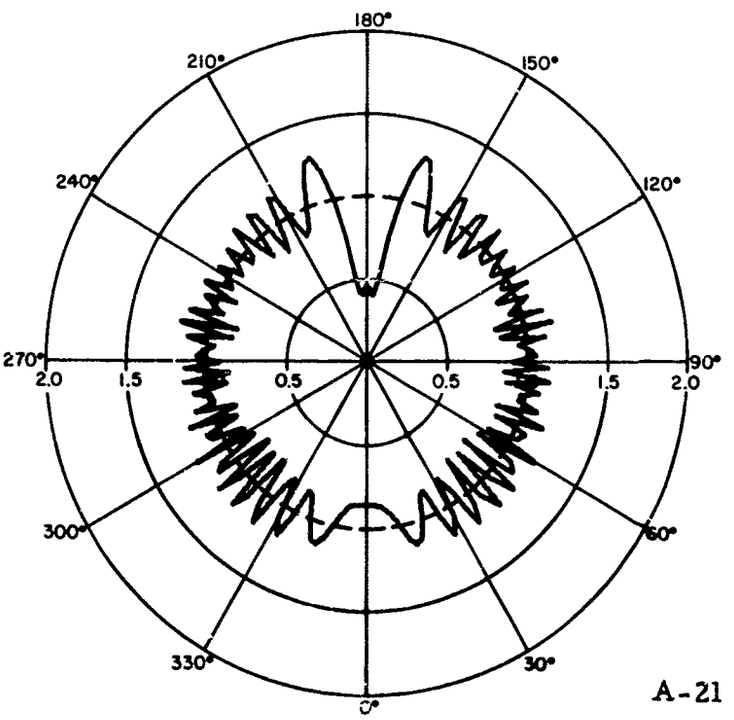
A-19


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

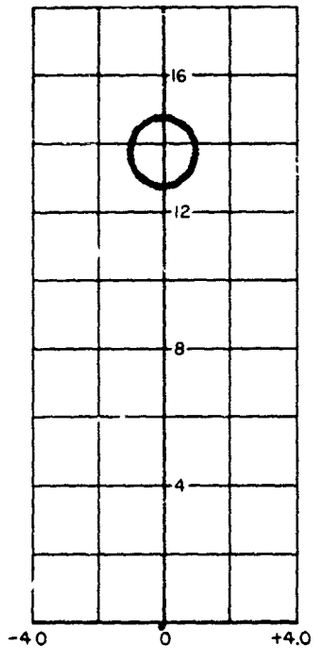

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

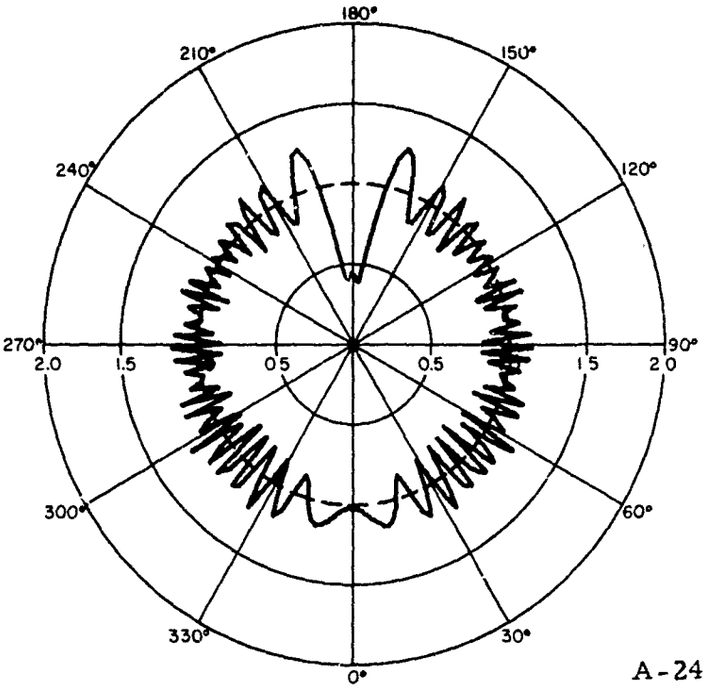
A-22


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

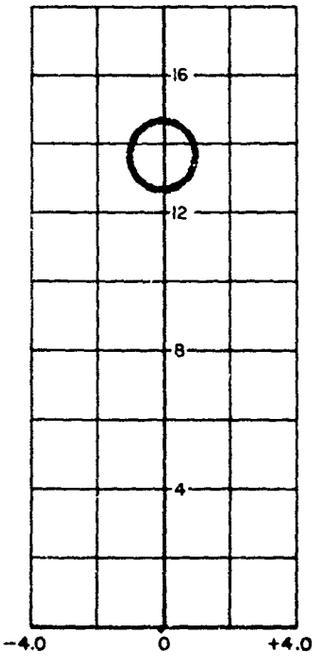

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

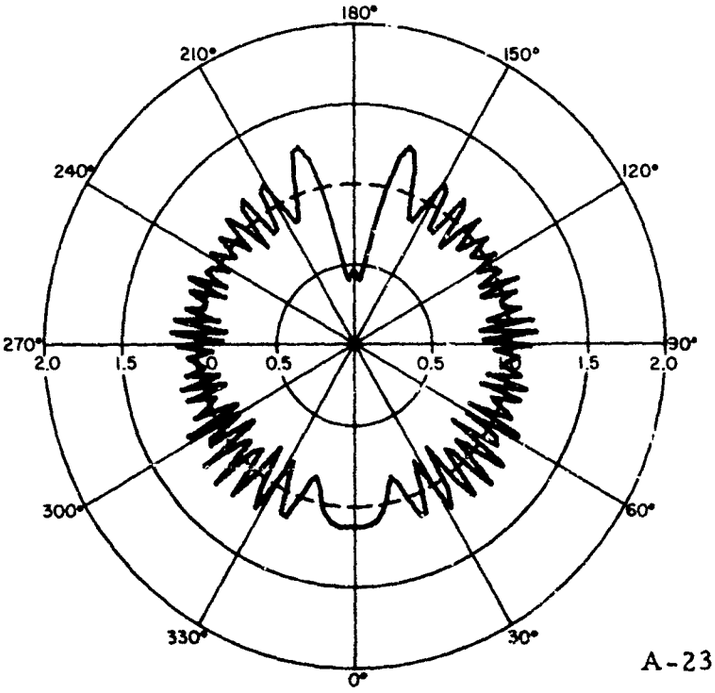
A-21


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

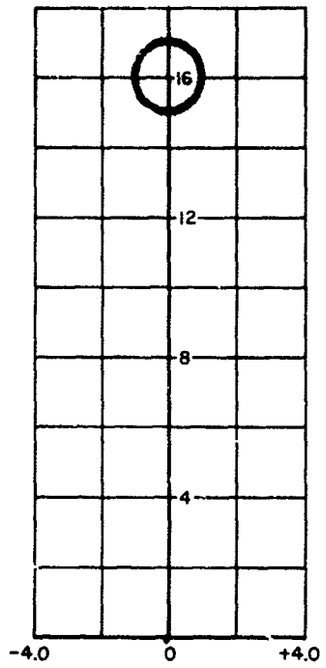

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

A-24

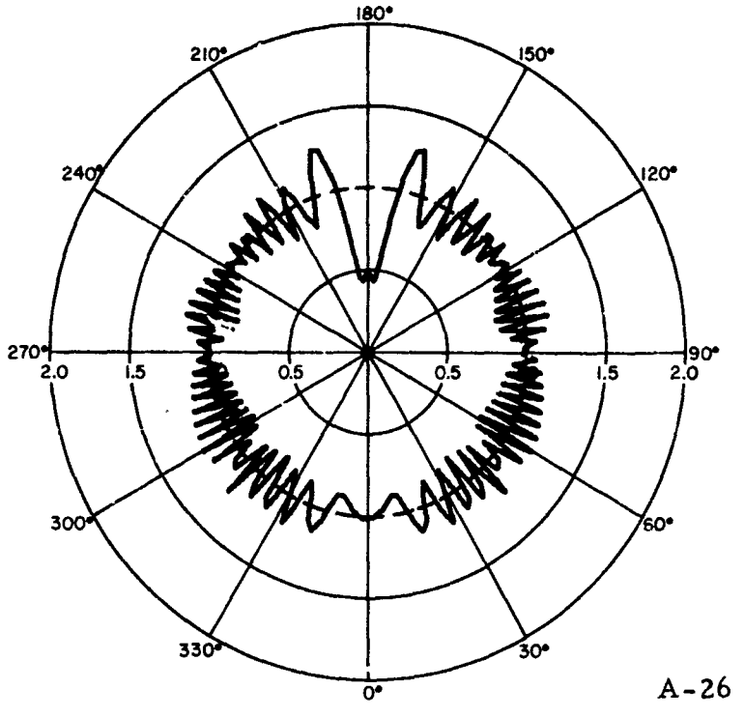

16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

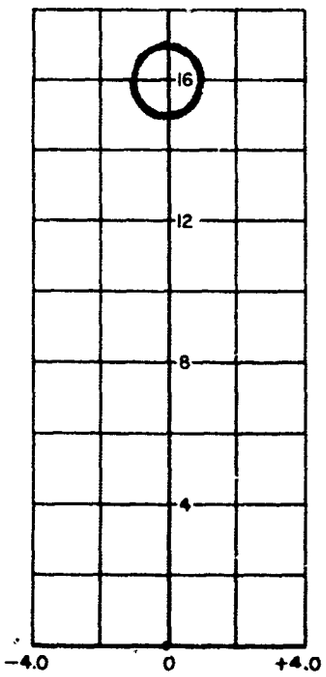
A-23



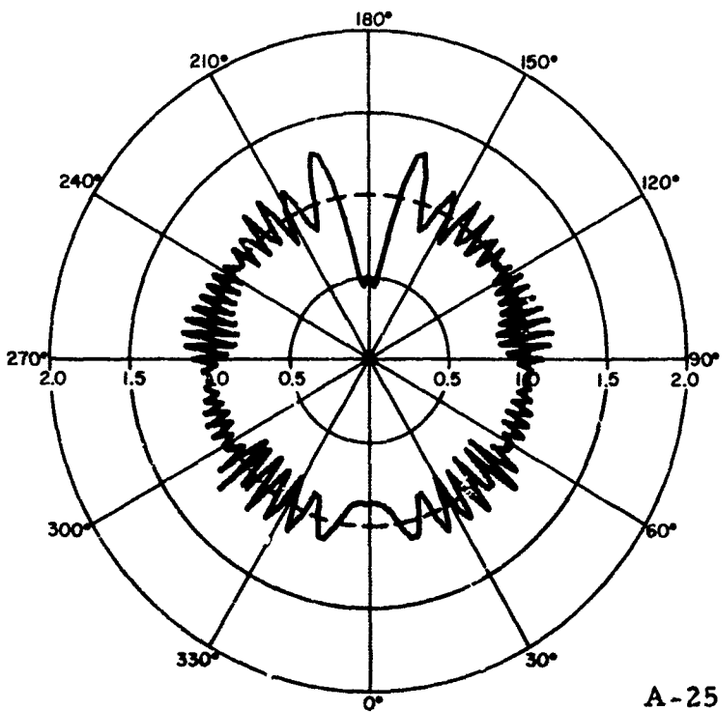
DISTANCE ~ WAVELENGTHS



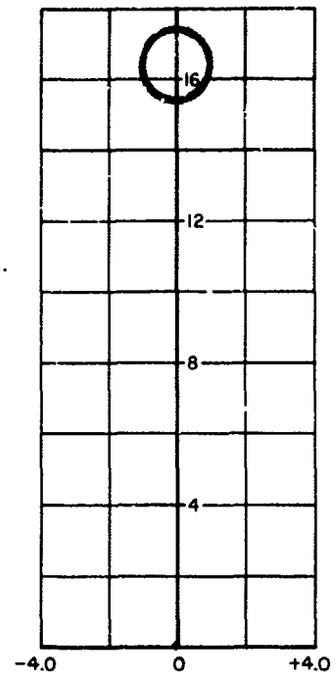
A-26

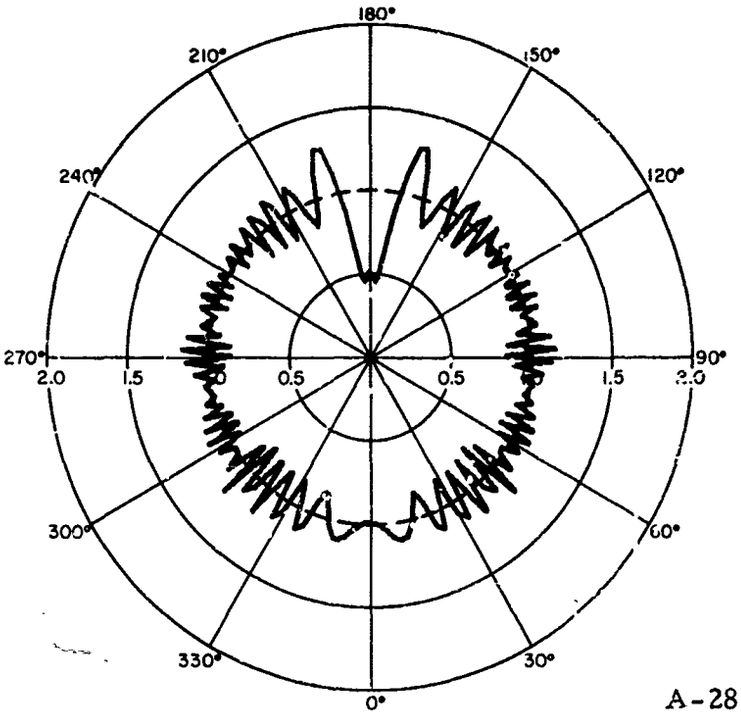


DISTANCE ~ WAVELENGTHS

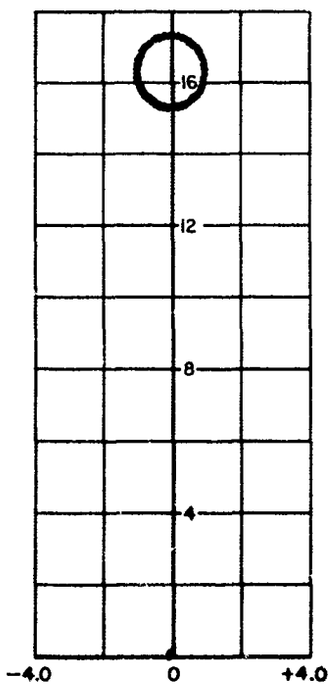


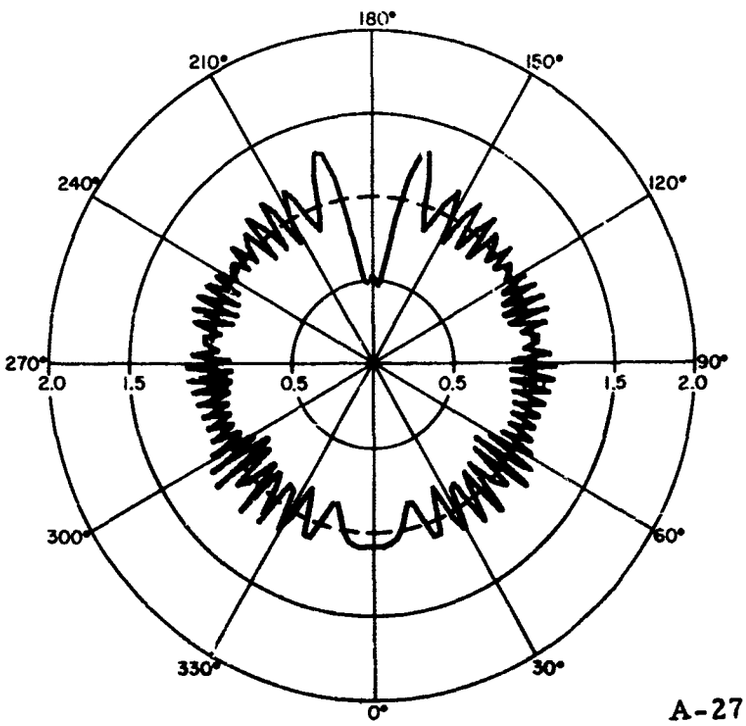
A-25


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

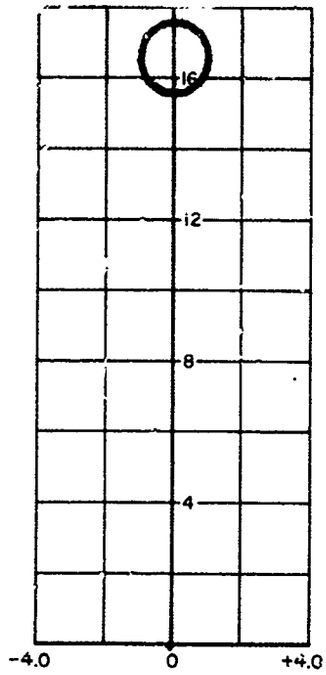

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

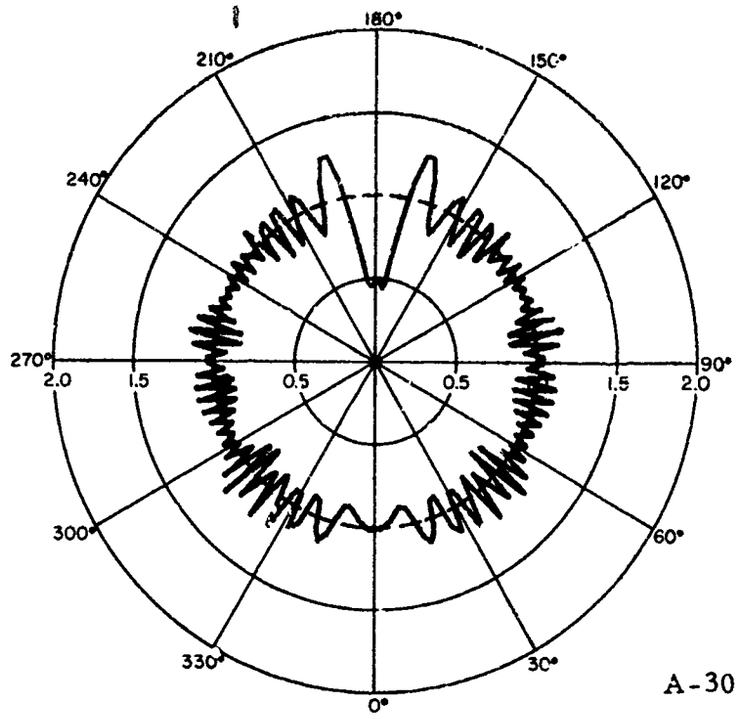
A-28


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

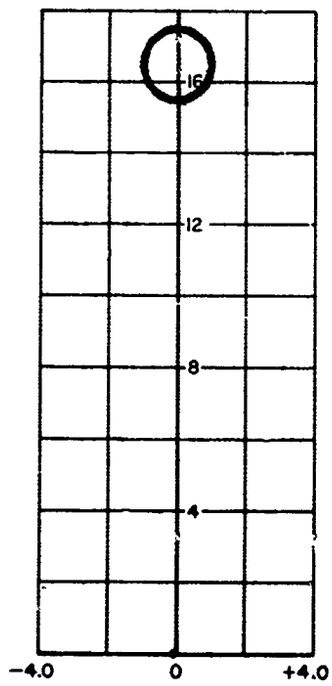

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

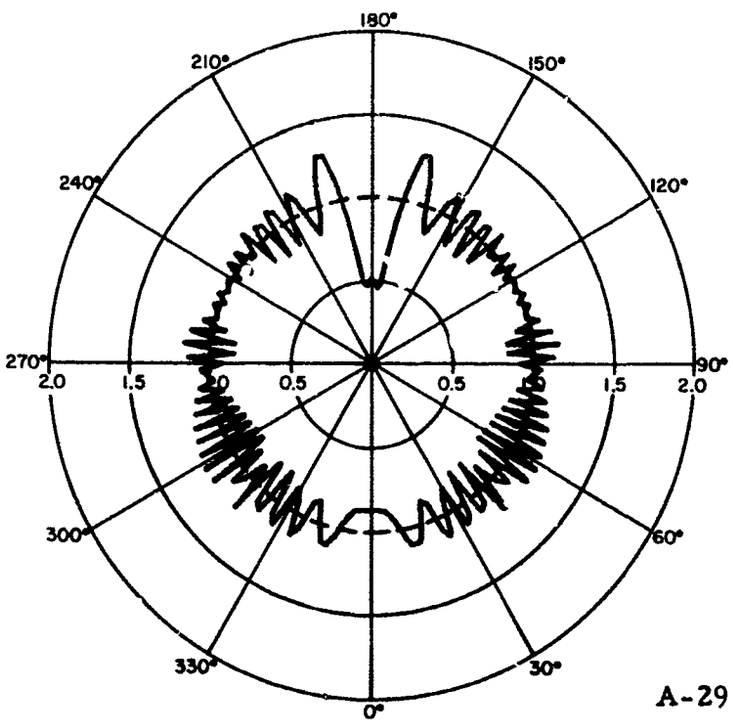
A-27


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

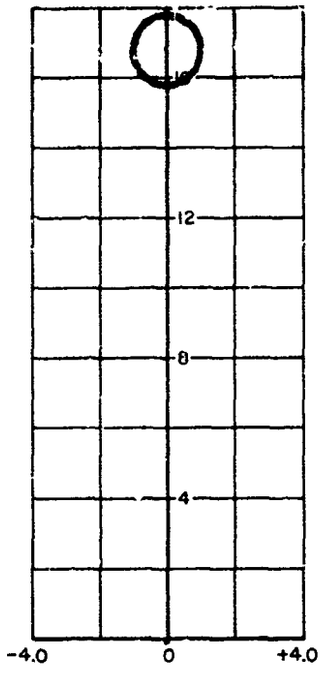

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

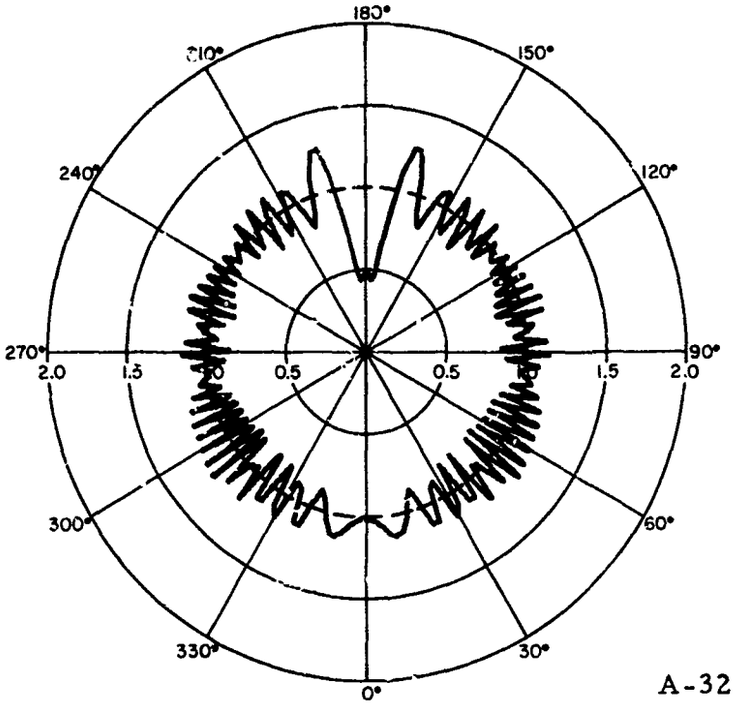
A-30


16
12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS

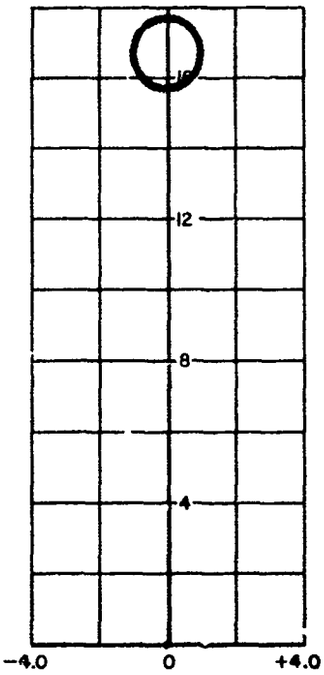

180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

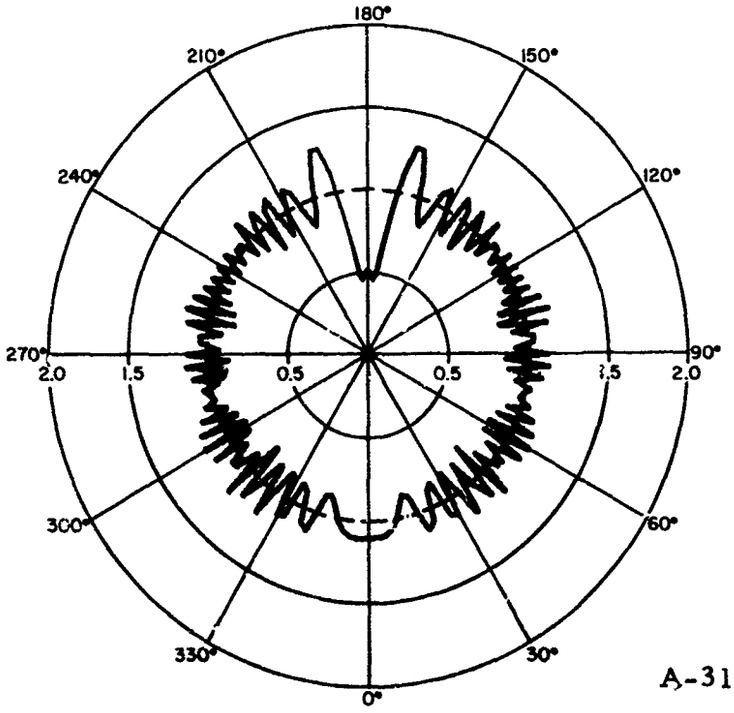
A-29


12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
1.0
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

A-32


12
8
4
-4.0
0
+4.0
DISTANCE ~ WAVELENGTHS


180°
210°
150°
240°
120°
270°
90°
2.0
1.5
0.5
0.5
1.5
2.0
300°
60°
330°
30°
0°

A-31

REFERENCES

1. Richmond, Jack H., "Scattering by an Arbitrary Array of Parallel Wires," Report 1522-7, 30 April 1964, Antenna Laboratory, The Ohio State University Research Foundation; prepared under Contract Number N123(953)-31663A, United States Navy Electronics Laboratory, San Diego, California. (AD 443 833).

2. Thiele, Gary A., "Far-Field Pattern Prediction for Shipboard Antennas," Report 1522-11, 31 March 1965, Antenna Laboratory, The Ohio State University Research Foundation; prepared under Contract Number N123(953)-31663A, United States Navy Electronics Laboratory, San Diego, California. (Vol. I of this handbook.)

3. Thiele, Gary A., "Memorandum on Shipboard Antenna Far-Field Pattern Prediction," Report 1522-12, 1 July 1965, Antenna Laboratory, The Ohio State University Research Foundation; prepared under Contract Number N123(953)-31663A, United States Navy Electronics Laboratory, San Diego, California. (Vol. II of this handbook).