

THE ANTENNA LABORATORY

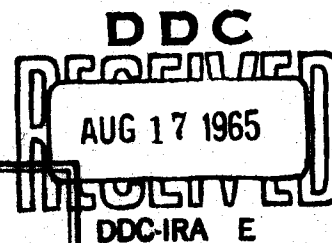
RESEARCH ACTIVITIES in ---

*Automatic Controls
Microwave Circuits
Laser Investigations
Wave Propagation*

*Antennas
Astronautics
Radomes*

*Echo Area Studies
E M Field Theory
Systems Analysis
Submillimeter Applications*

AD-467893



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

C. H. Brenner

Contract No. N123(953)-31663A

1522-13

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

REPORT 1522-13

REPORT
by
THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION
COLUMBUS, OHIO 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 III: Far-Field Patterns of a Linear Antenna
Radiating in the Presence of Square Cylinders

Submitted by C.M. 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 wavelengths 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.

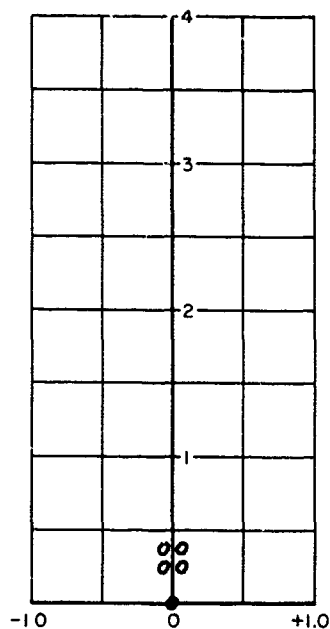
TABLE OF CONTENTS

	Page
I. $1/8\lambda \times 1/8\lambda$ SQUARE CYLINDERS LOCATED AT $1/8\lambda$ INTERVALS FROM $1/8\lambda$ to 2λ (Figs. 1-X)	1
A. $\phi = 0.0^\circ$	1
B. $\phi = 22.5^\circ$	9
C. $\phi = 45.0^\circ$	17
II. $1/4\lambda \times 1/4\lambda$ SQUARE CYLINDERS LOCATED AT $1/8\lambda$ INTERVALS FROM $1/8\lambda$ to 2λ (Figs. 2-X)	25
A. $\phi = 0.0^\circ$	25
B. $\phi = 22.5^\circ$	33
C. $\phi = 45.0^\circ$	41
III. $1/2\lambda \times 1/2\lambda$ SQUARE CYLINDERS LOCATED AT $1/8\lambda$ INTERVALS FROM $1/8\lambda$ to 2λ (Figs. 3-X)	49
A. $\phi = 0.0^\circ$	49
B. $\phi = 22.5^\circ$	57
C. $\phi = 45.0^\circ$	65
IV. $1\lambda \times 1\lambda$ SQUARE CYLINDERS LOCATED AT $1/8\lambda$ INTERVALS FROM $1/8\lambda$ to 2λ (Figs. 4-X)	73
A. $\phi = 0.0^\circ$	73
B. $\phi = 22.5^\circ$	81
C. $\phi = 45.0^\circ$	89

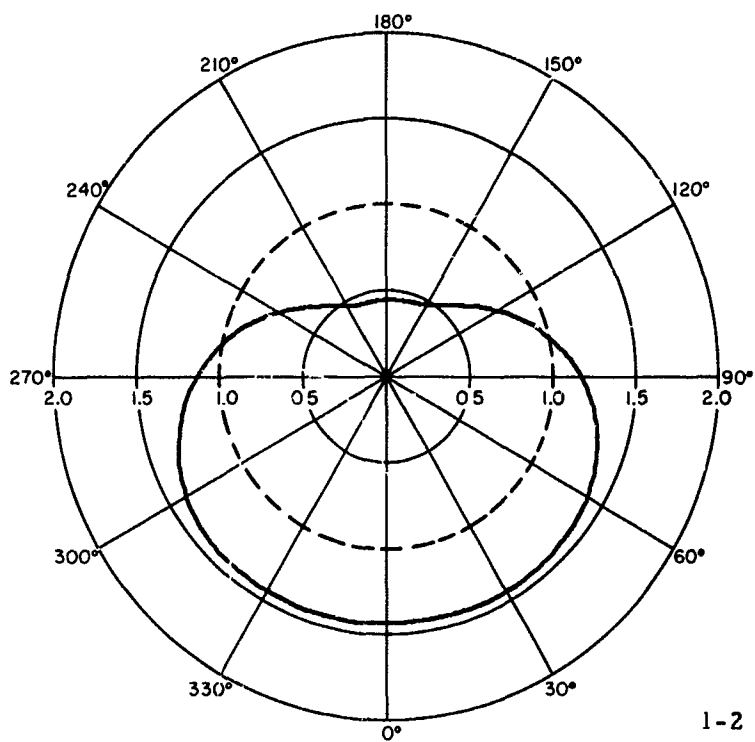
TABLE OF CONTENTS (cont)

	Page
V. $2\lambda \times 2\lambda$ SQUARE CYLINDERS LOCATED AT $1/8\lambda$ INTERVALS FROM $1/8\lambda$ to 2λ (Figs. 5-X)	97
A. $\phi = 0.0^\circ$	97
B. $\phi = 22.5^\circ$	105
C. $\phi = 45.0^\circ$	113
VI. SQUARE CYLINDERS LOCATED AT DISTANCES OF 4λ , 8λ , 12λ , 16λ (Figs. A-X)	121
A. $1/2\lambda \times 1/2\lambda$	121
1. $\phi = 0^\circ$	121
2. $\phi = 22.5^\circ$	123
3. $\phi = 45.^\circ$	125
B. $1\lambda \times 1\lambda$	127
1. $\phi = 0^\circ$	127
2. $\phi = 22.5^\circ$	129
3. $\phi = 45.^\circ$	131
C. $2\lambda \times 2\lambda$	133
1. $\phi = 0^\circ$	133
2. $\phi = 22.5^\circ$	135
3. $\phi = 45.^\circ$	137
VII. SQUARE CYLINDERS LOCATED AT INTERVALS OF $1/8\lambda$ FROM $8 1/8\lambda$ TO 9λ WITH $\phi = 0^\circ$ (Figs. B-X)	139
A. $1/2\lambda \times 1/2\lambda$	139
B. $1\lambda \times 1\lambda$	143
C. $2\lambda \times 2\lambda$	147

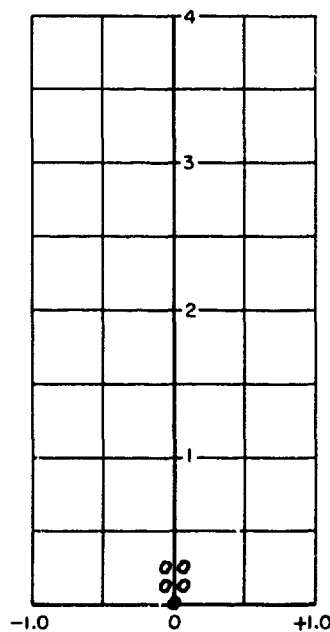
REFERENCES



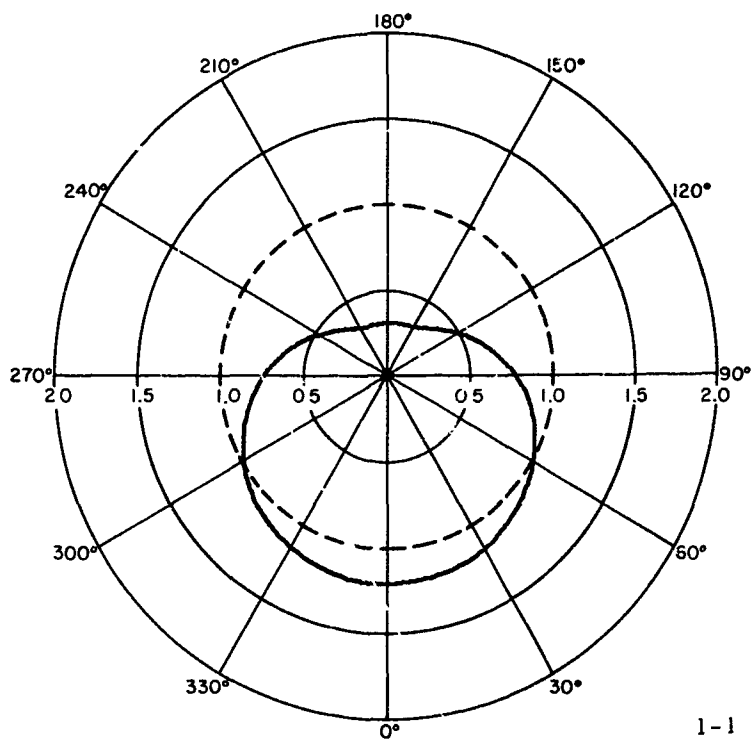
DISTANCE ~ WAVELENGTHS



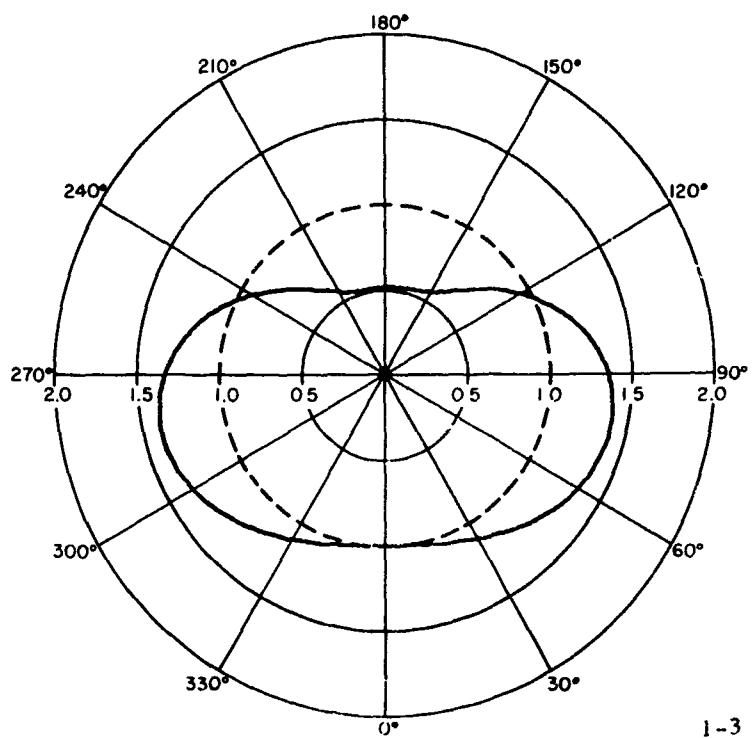
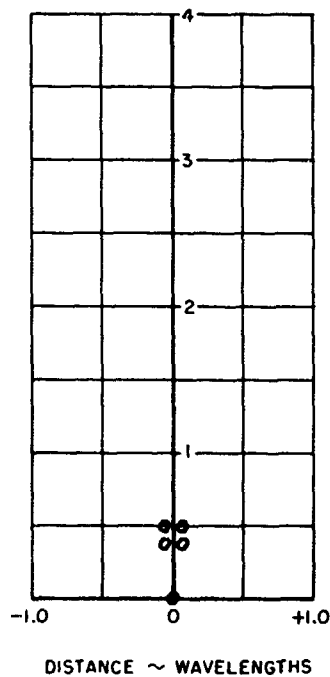
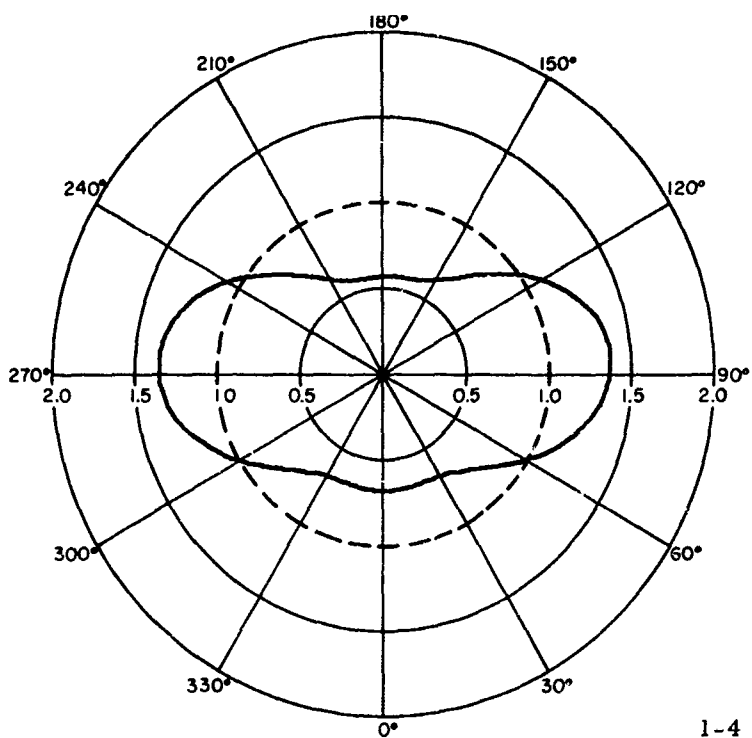
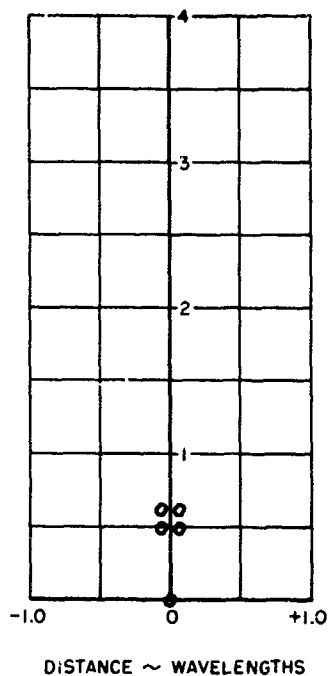
1-2

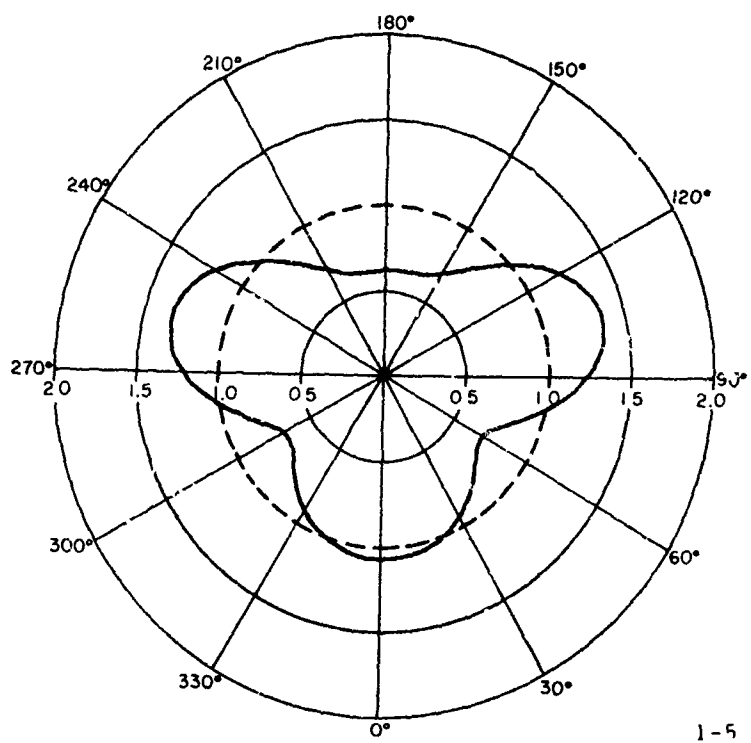
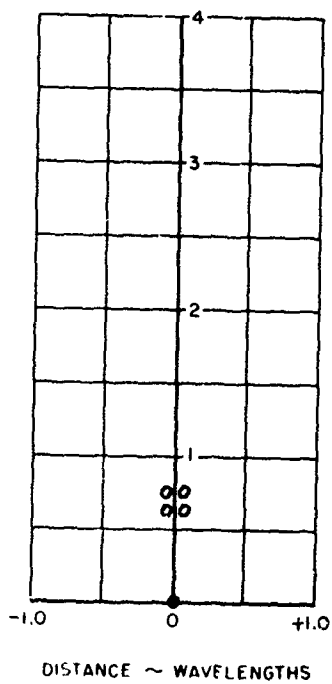
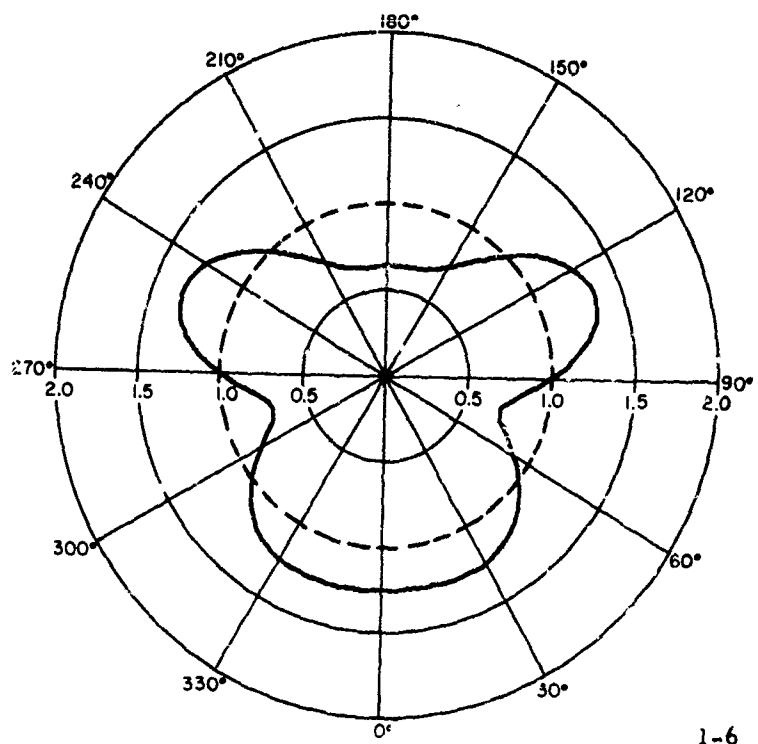
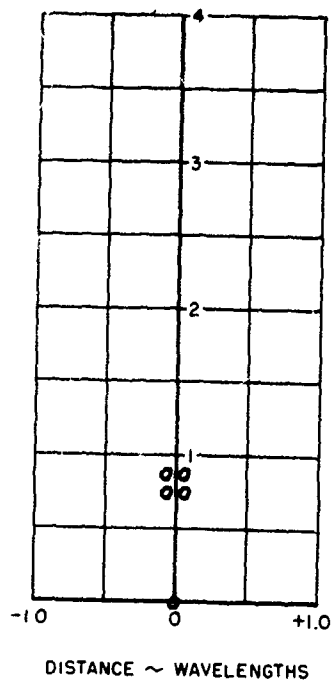


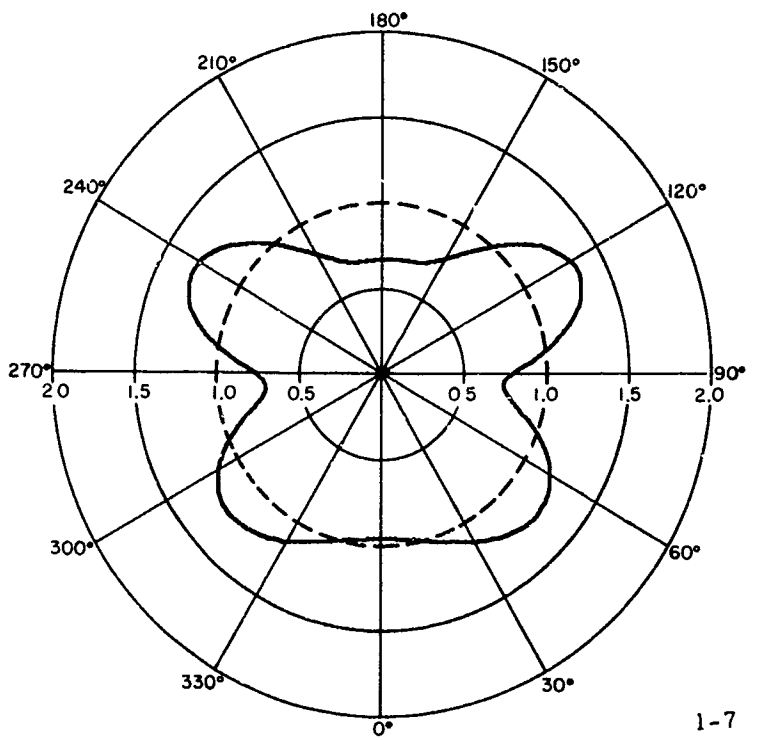
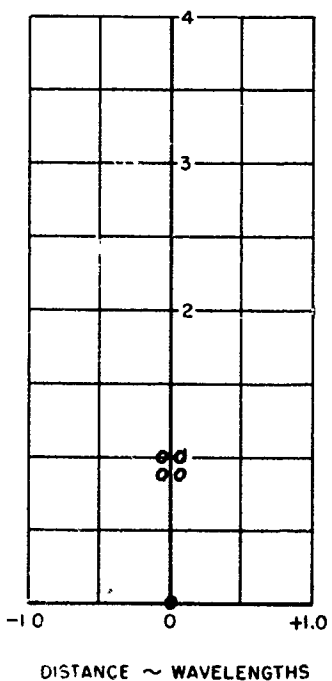
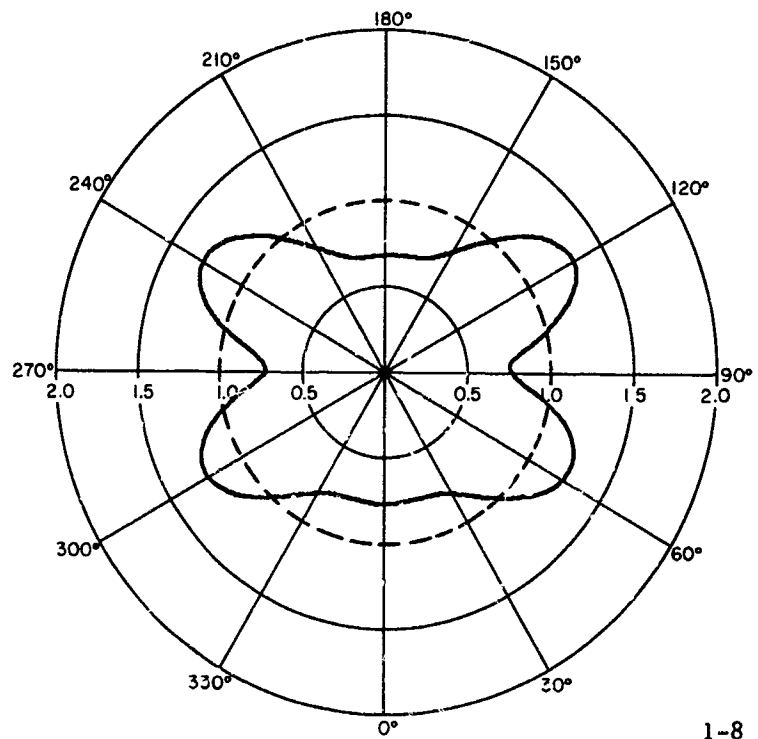
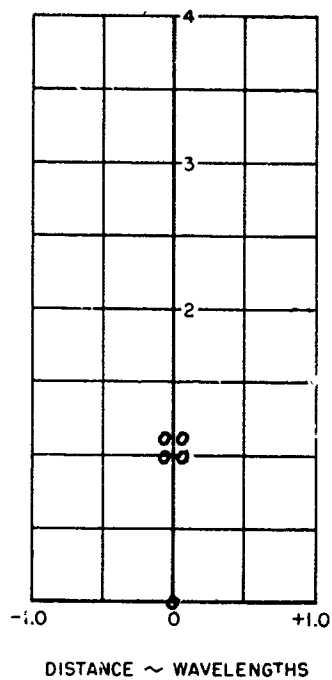
DISTANCE ~ WAVELENGTHS

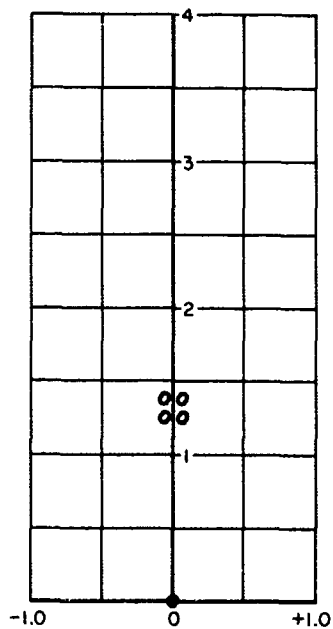


1-1

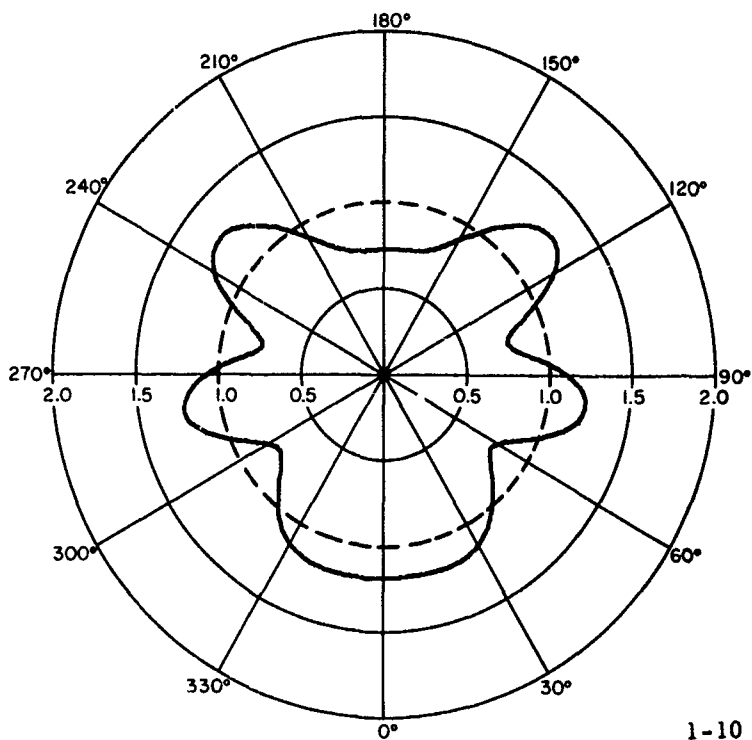




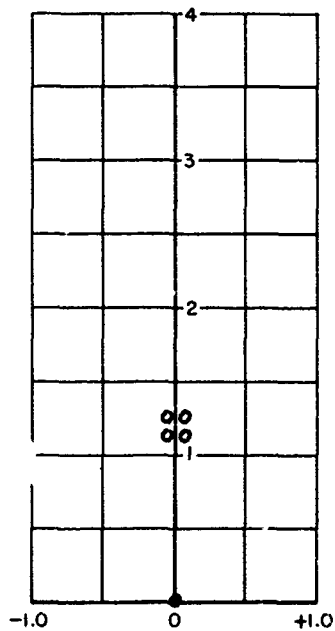




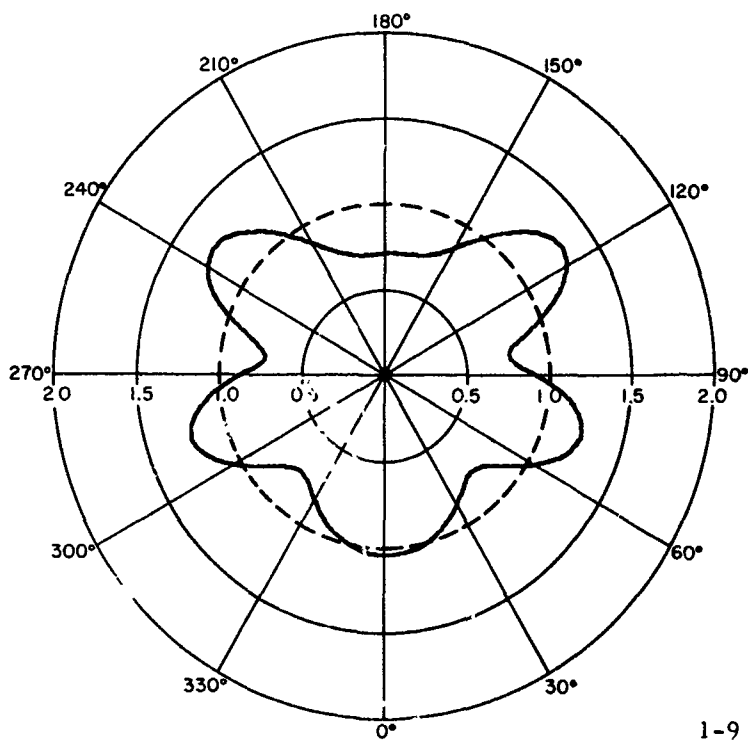
DISTANCE ~ WAVELENGTHS



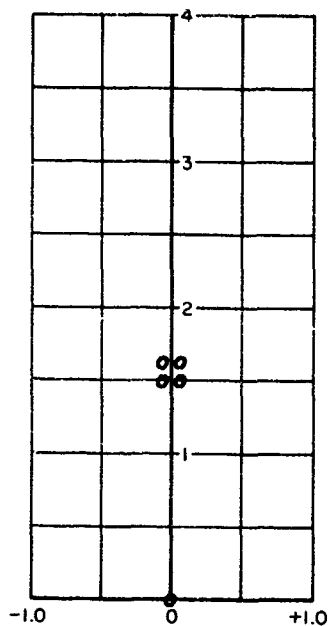
1-10



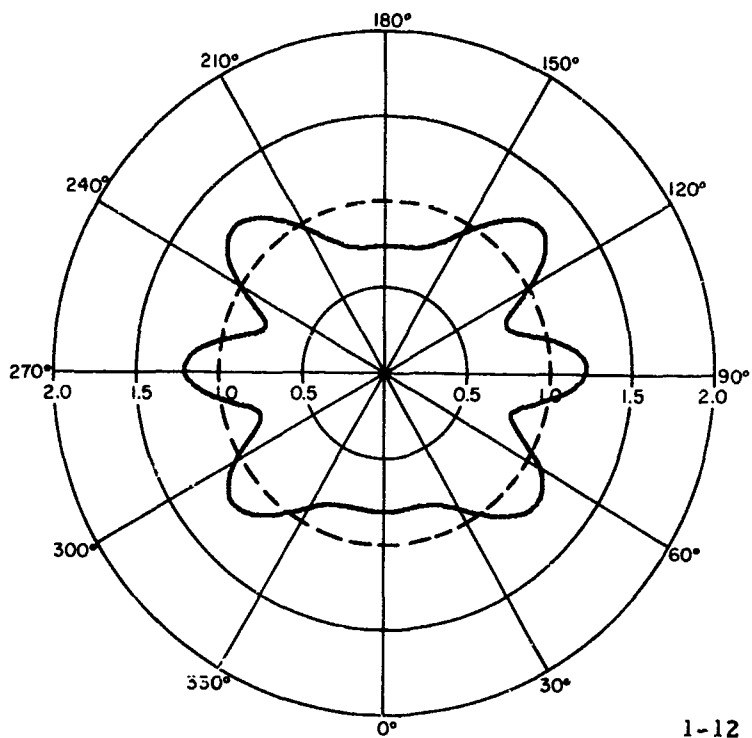
DISTANCE ~ WAVELENGTHS



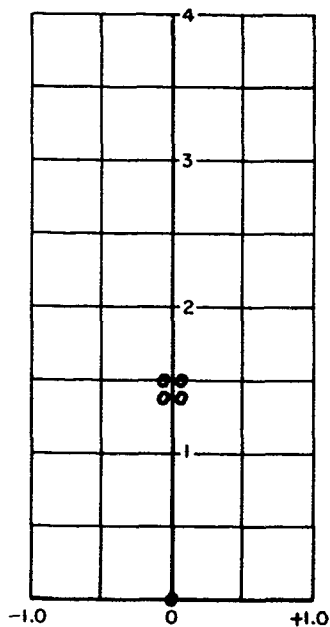
1-9



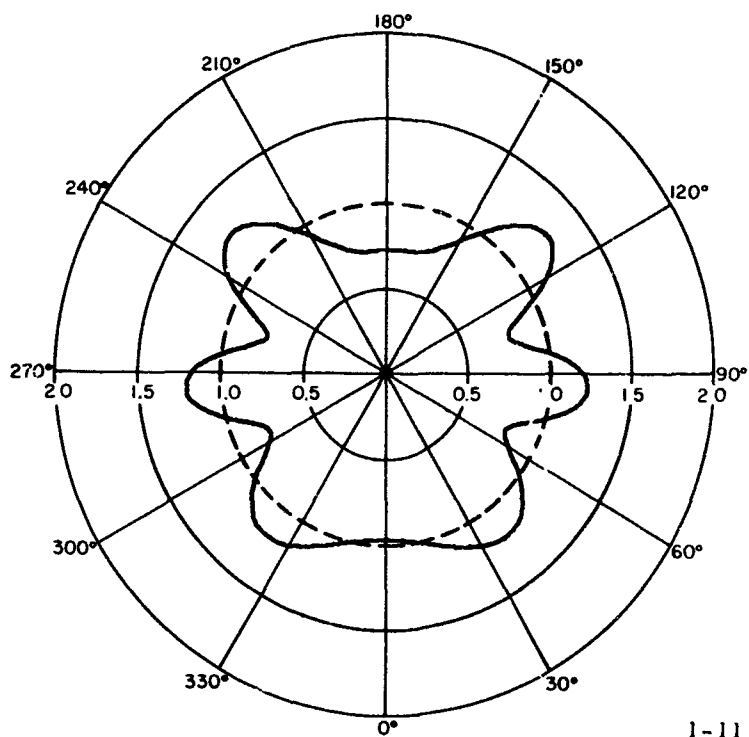
DISTANCE ~ WAVELENGTHS



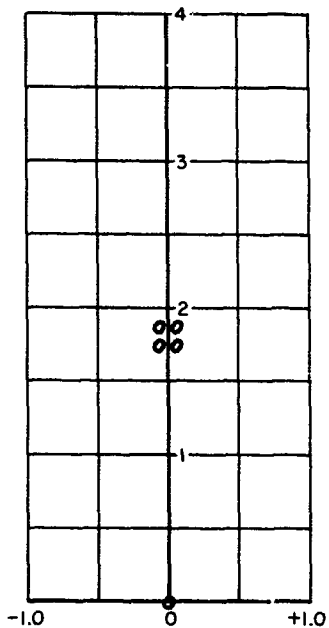
1-12



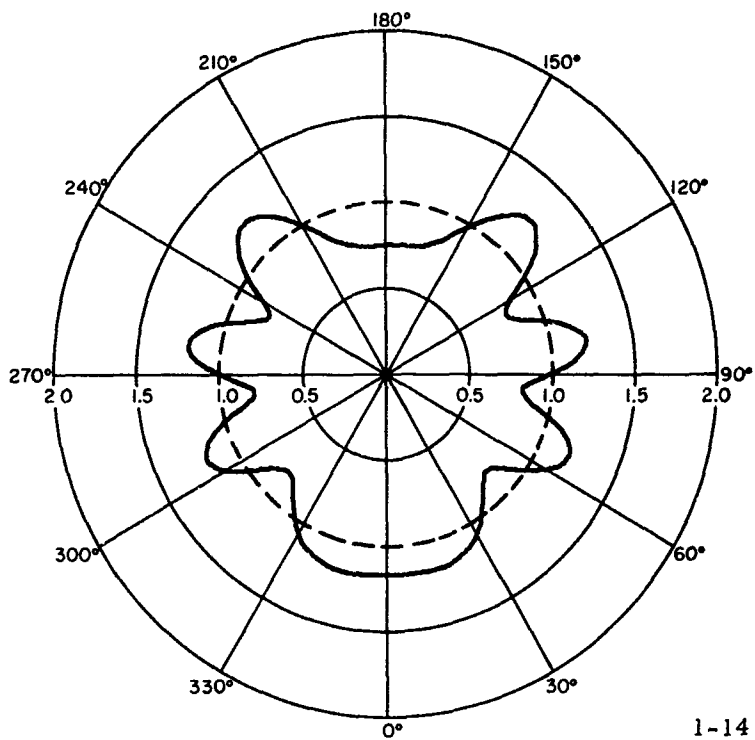
DISTANCE ~ WAVELENGTHS



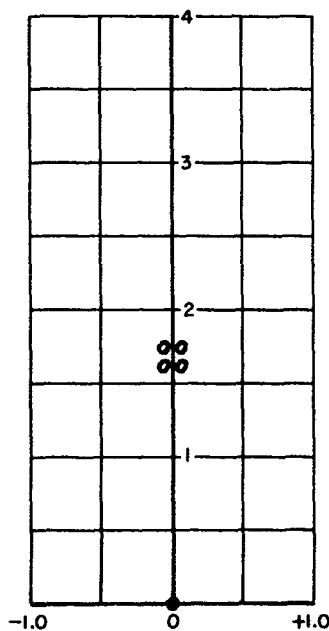
1-11



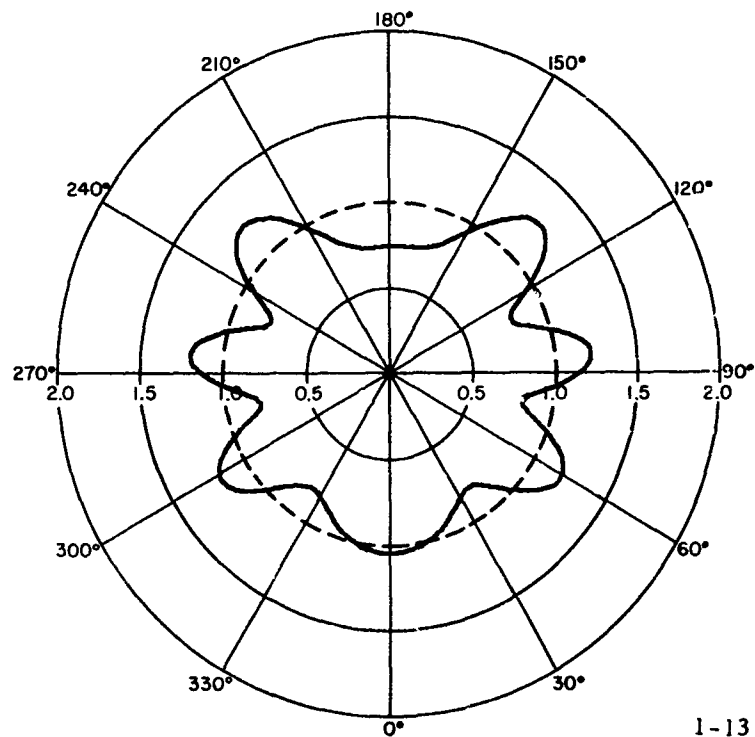
DISTANCE ~ WAVELENGTHS



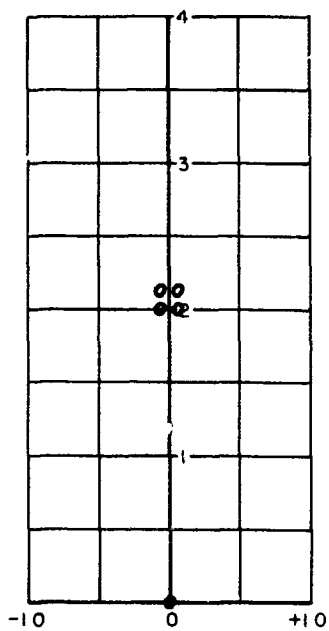
1-14



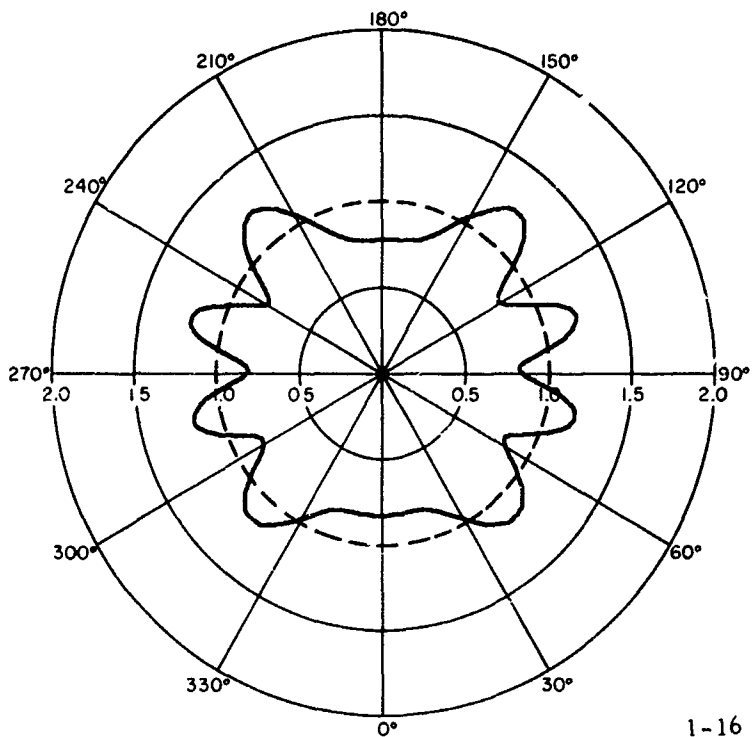
DISTANCE ~ WAVELENGTHS



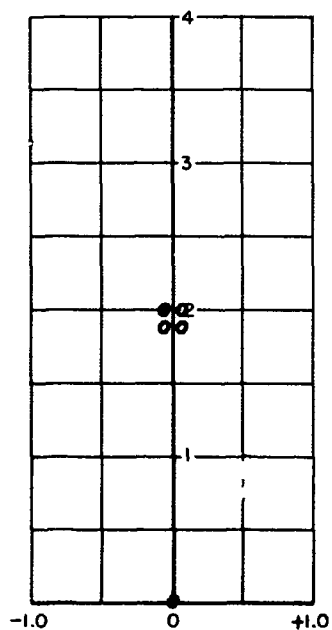
1-13



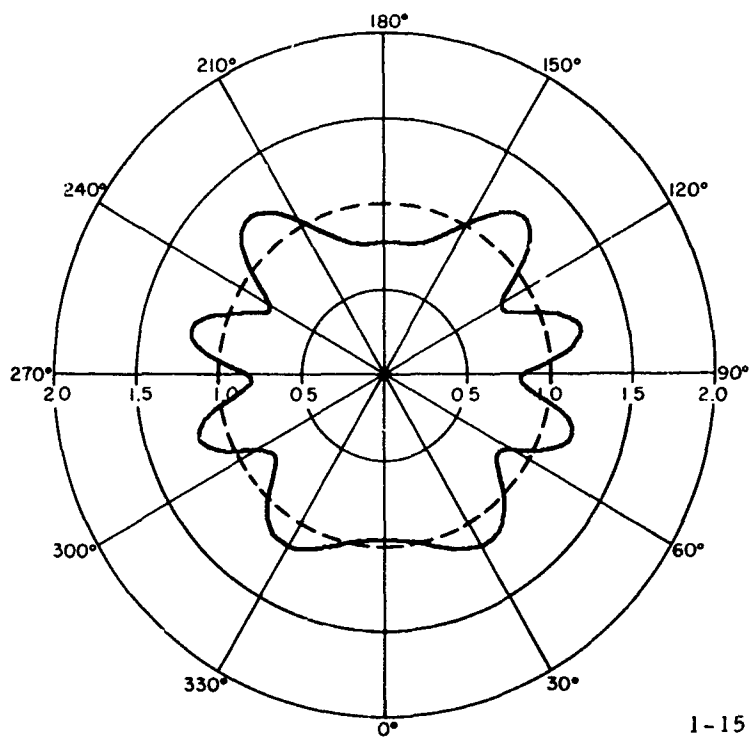
DISTANCE ~ WAVELENGTHS



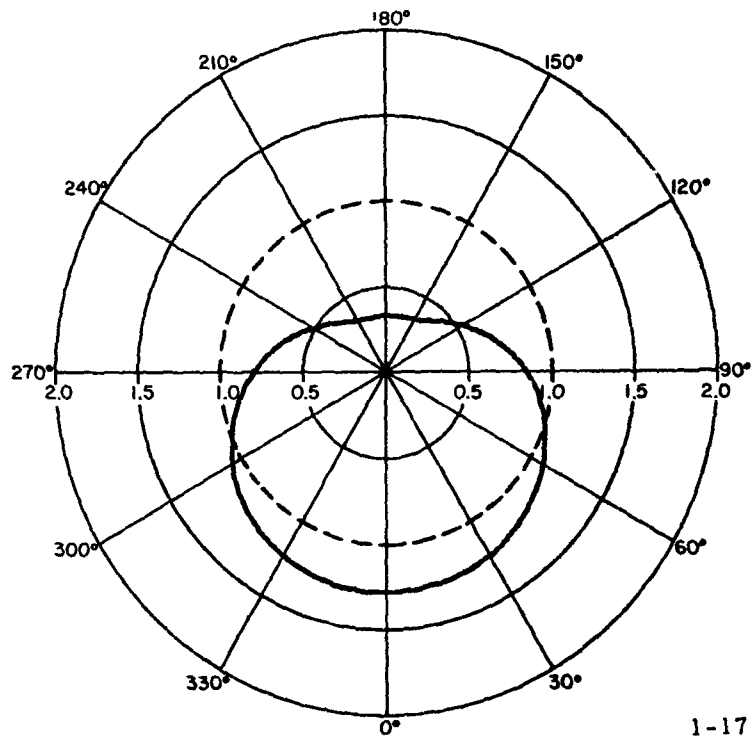
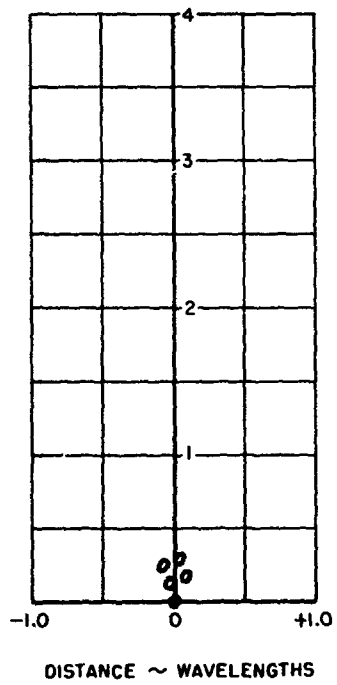
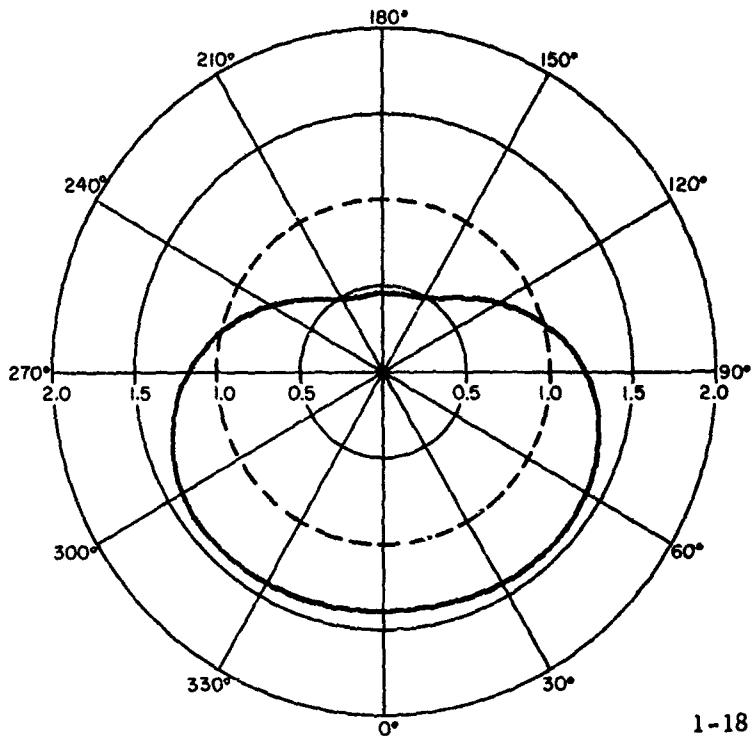
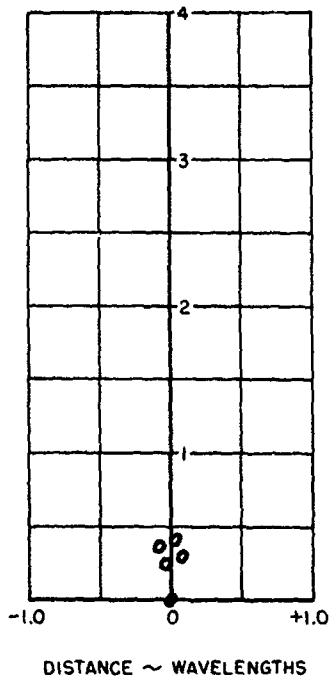
1-16

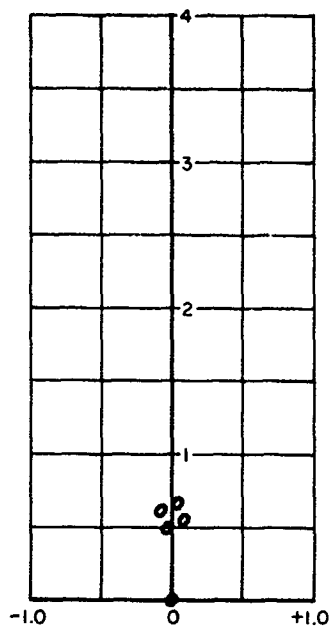


DISTANCE ~ WAVELENGTHS

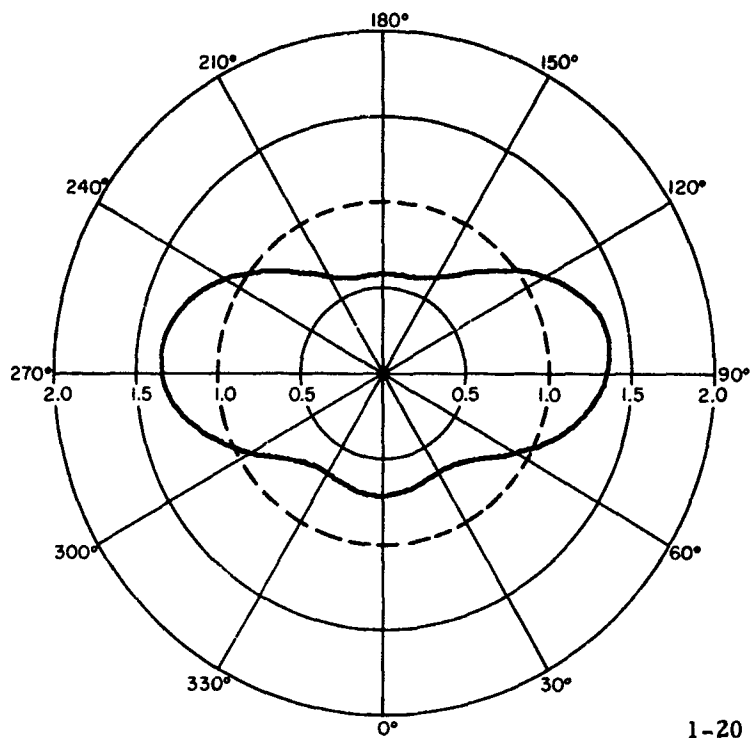


1-15

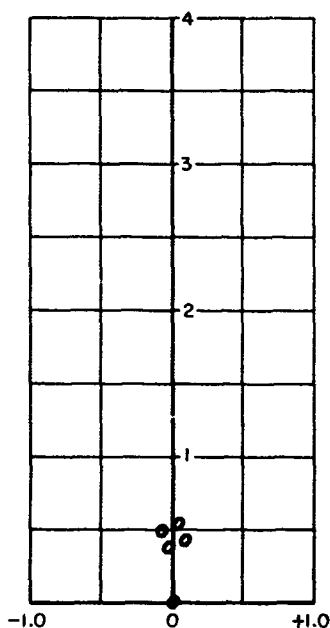




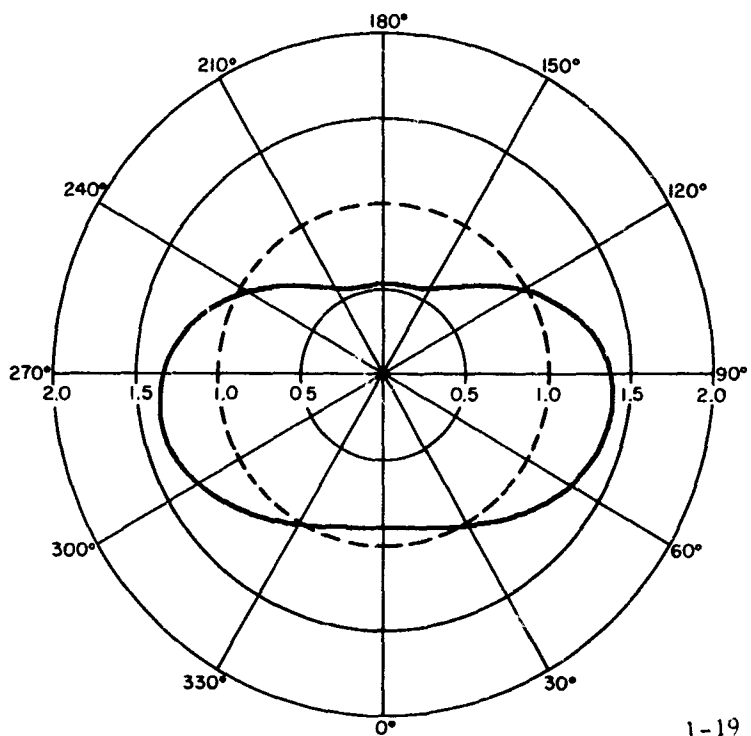
DISTANCE ~ WAVELENGTHS



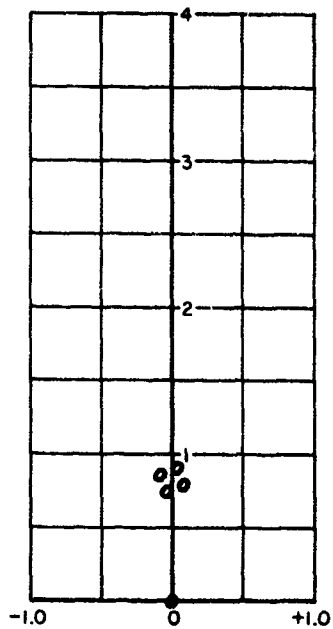
1-20



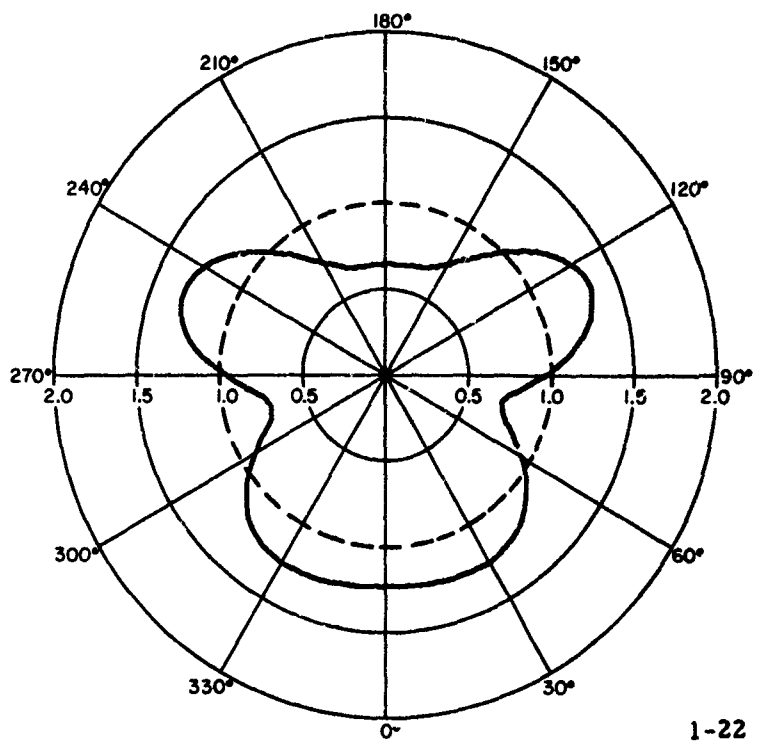
DISTANCE ~ WAVELENGTHS



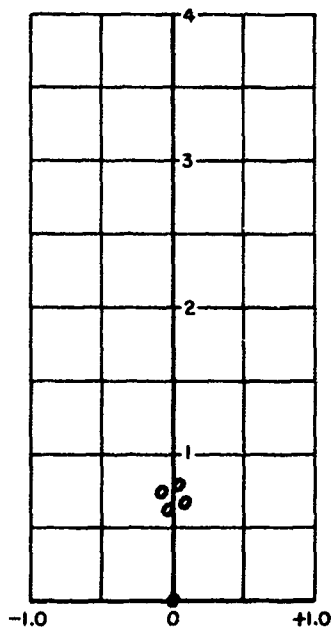
1-19



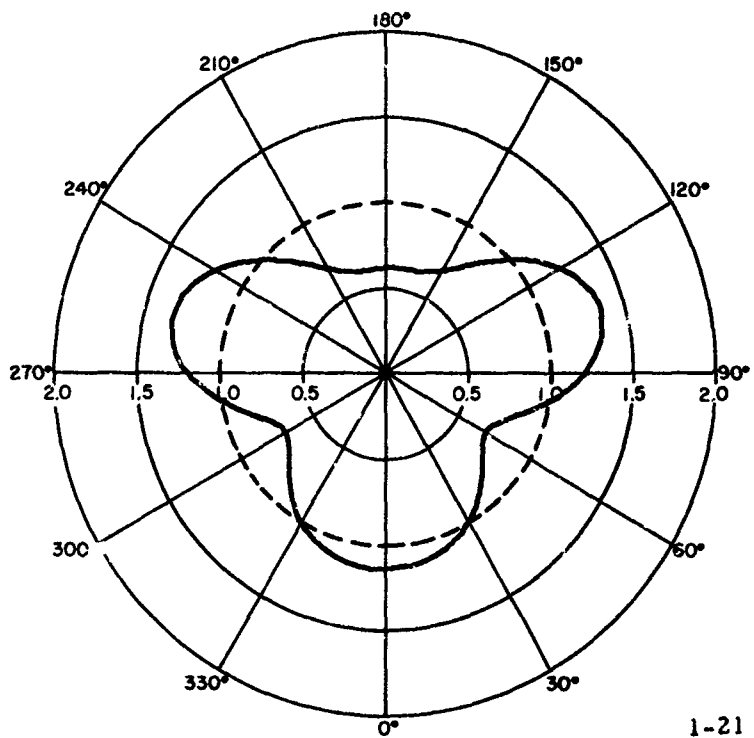
DISTANCE ~ WAVELENGTHS



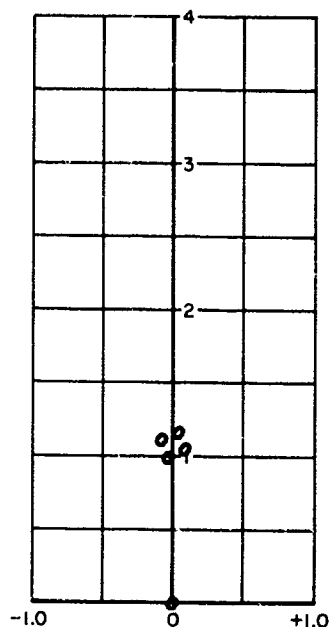
1-22



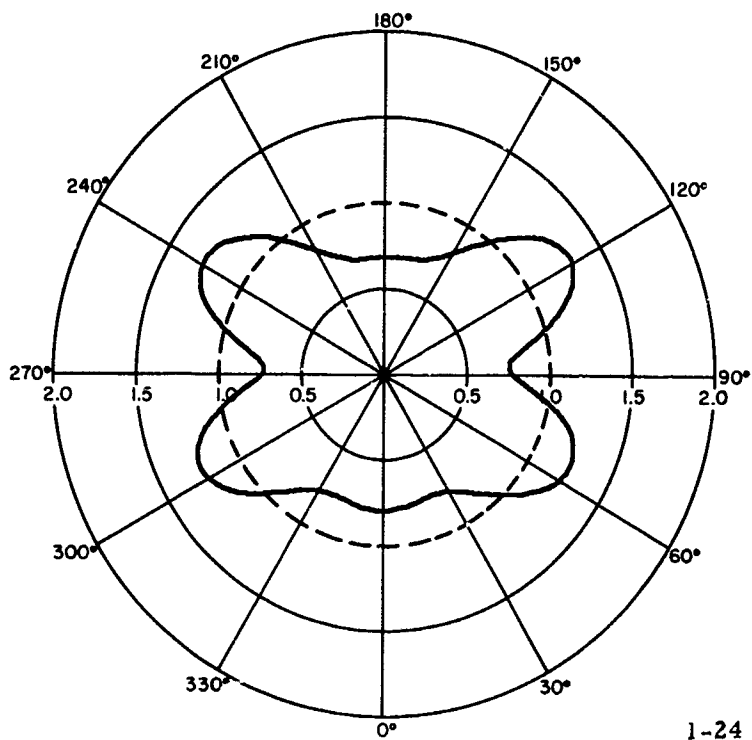
DISTANCE ~ WAVELENGTHS



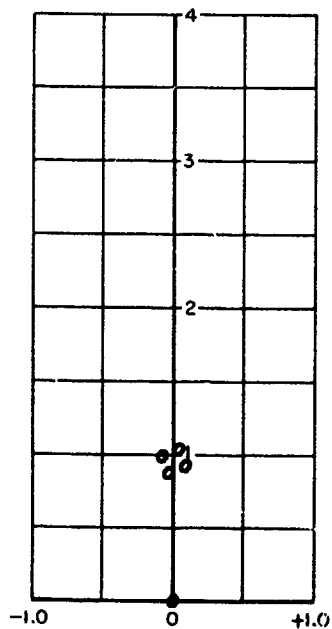
1-21



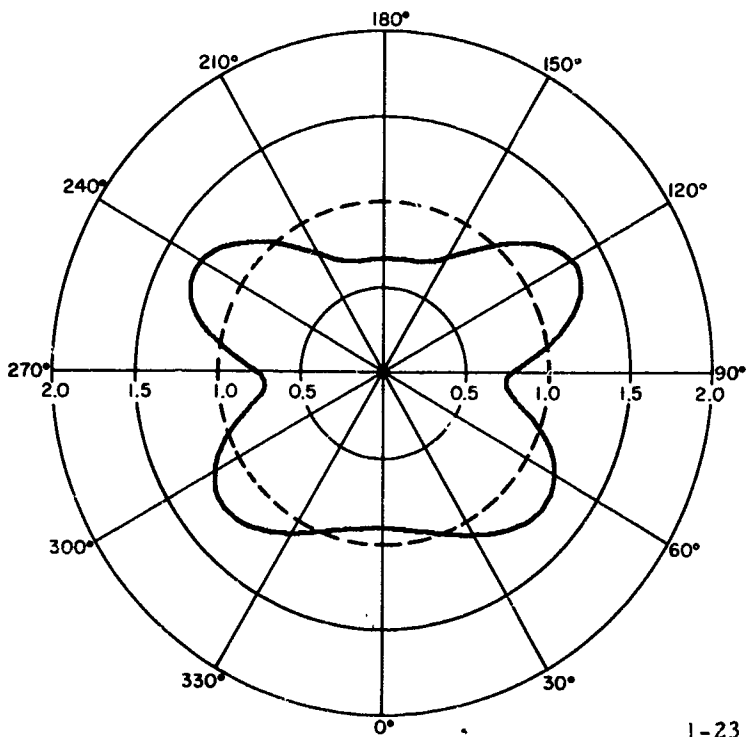
DISTANCE ~ WAVELENGTHS



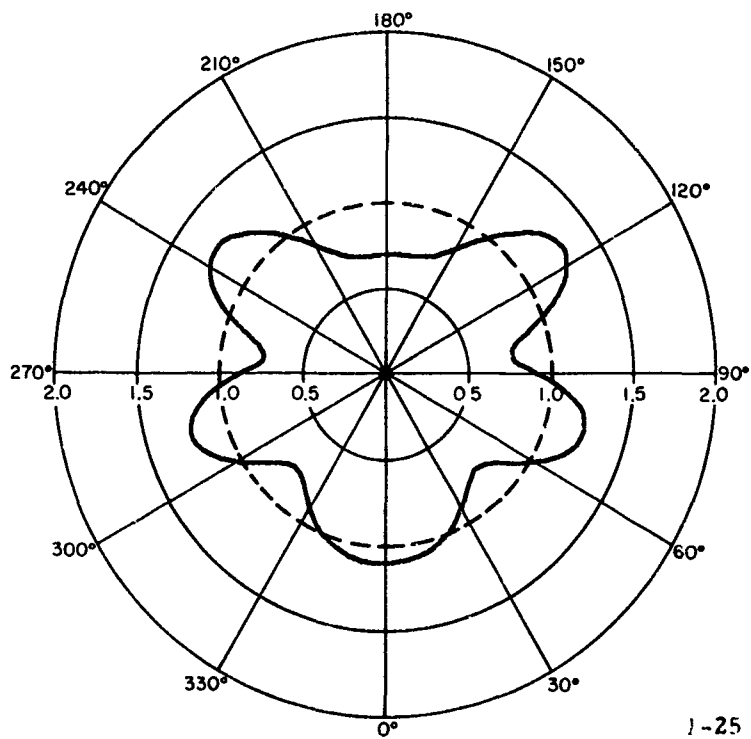
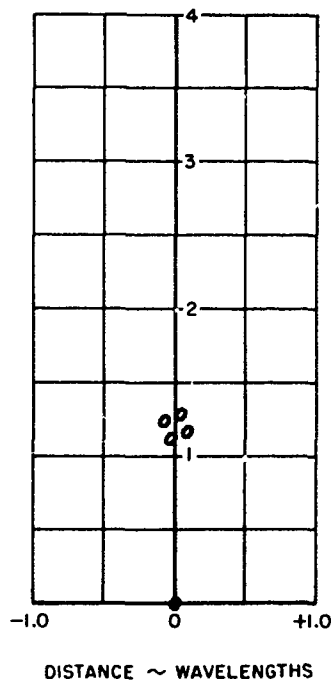
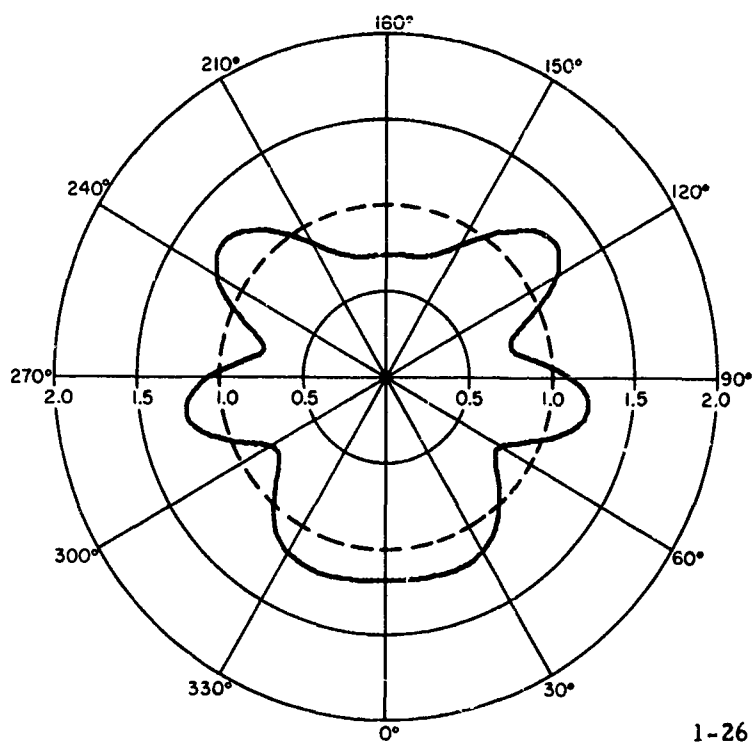
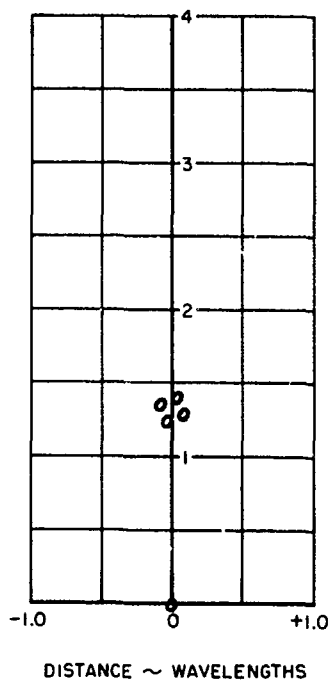
1-24

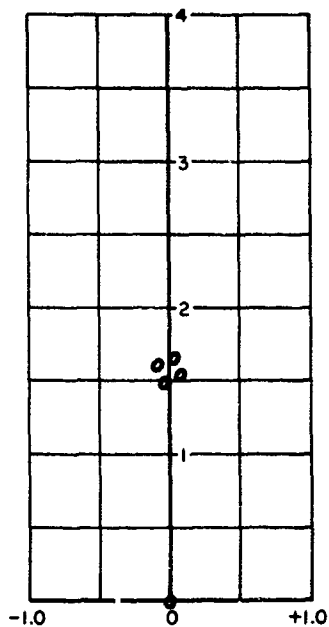


DISTANCE ~ WAVELENGTHS

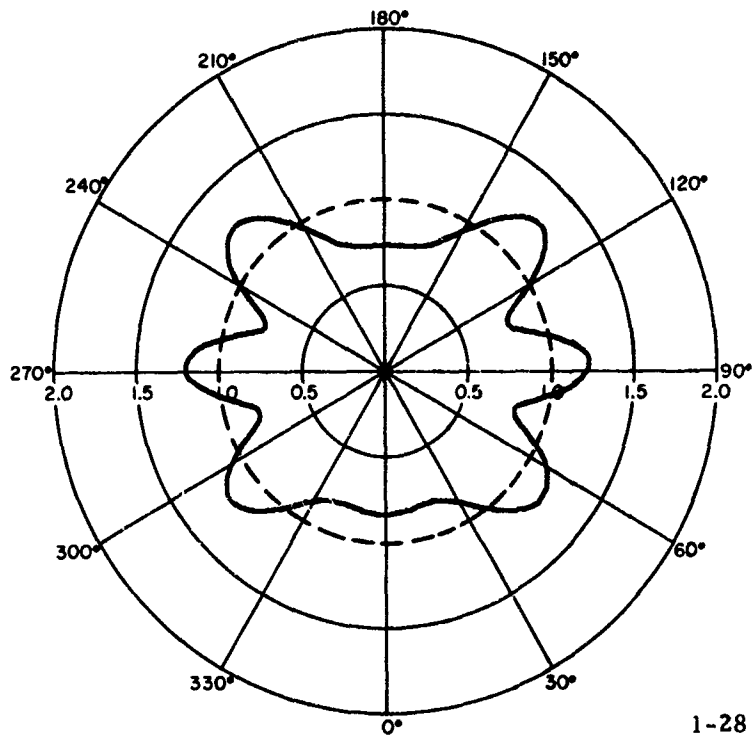


1-23

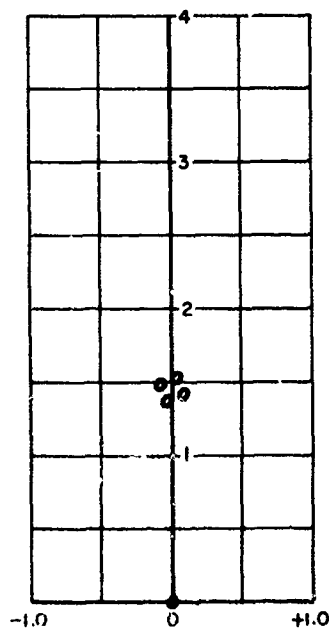




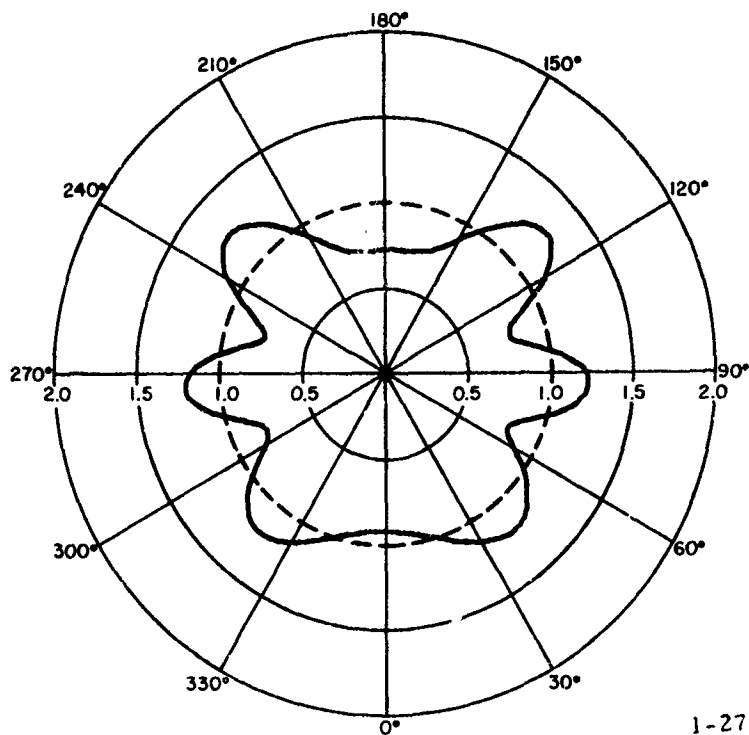
DISTANCE ~ WAVELENGTHS



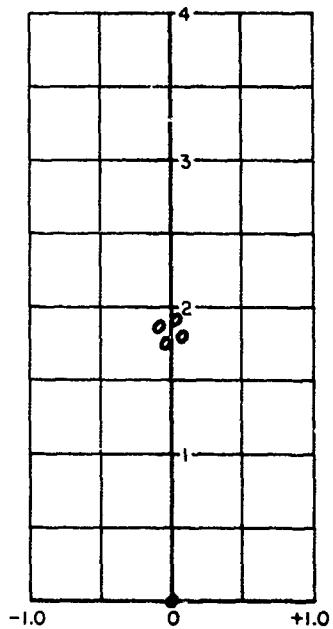
1-28



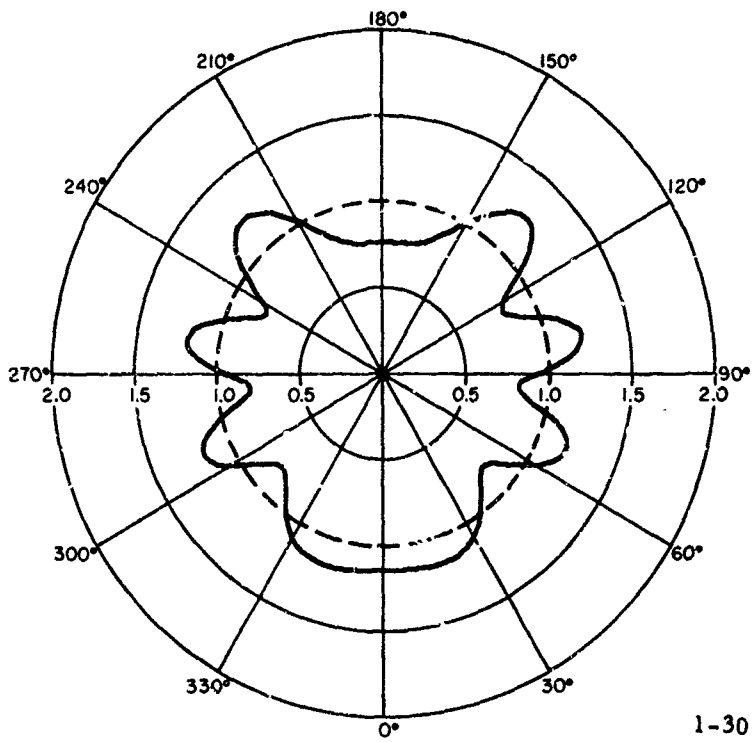
DISTANCE ~ WAVELENGTHS



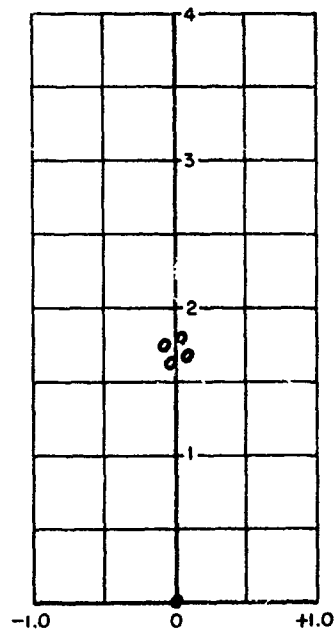
1-27



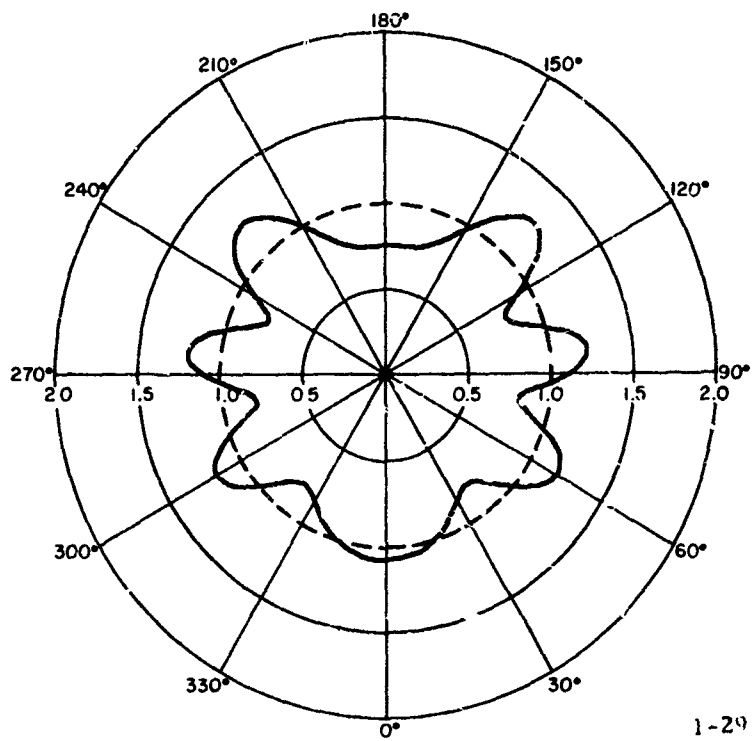
DISTANCE ~ WAVELENGTHS



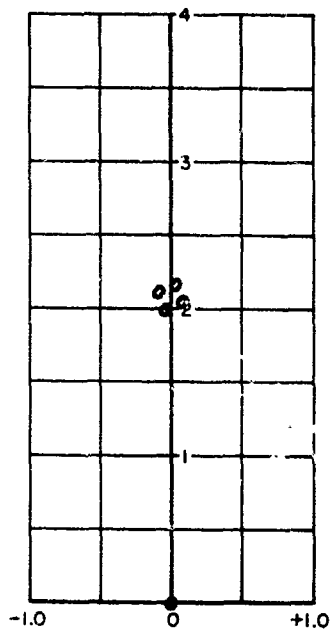
1-30



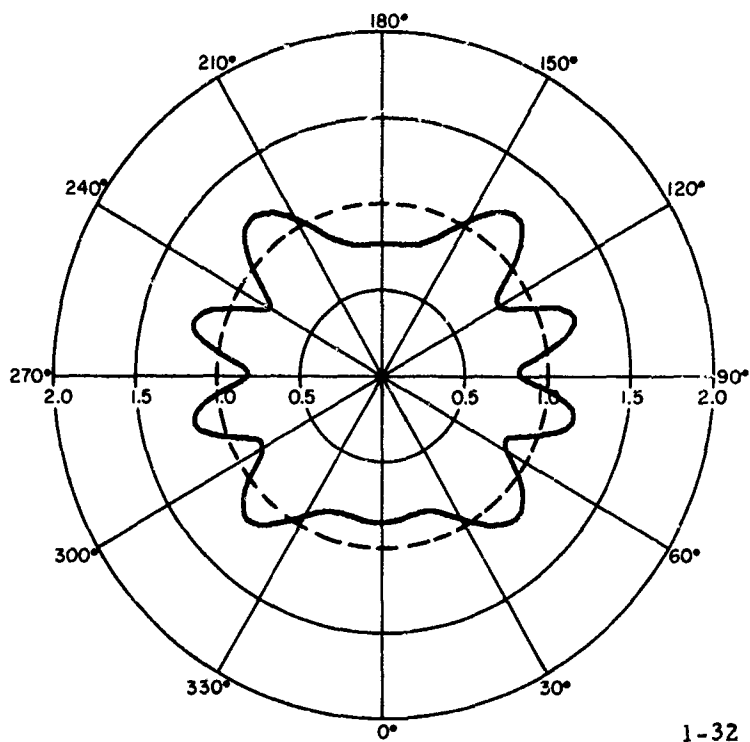
DISTANCE ~ WAVELENGTHS



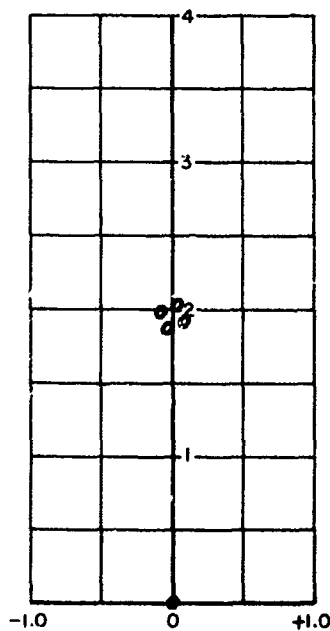
1-20



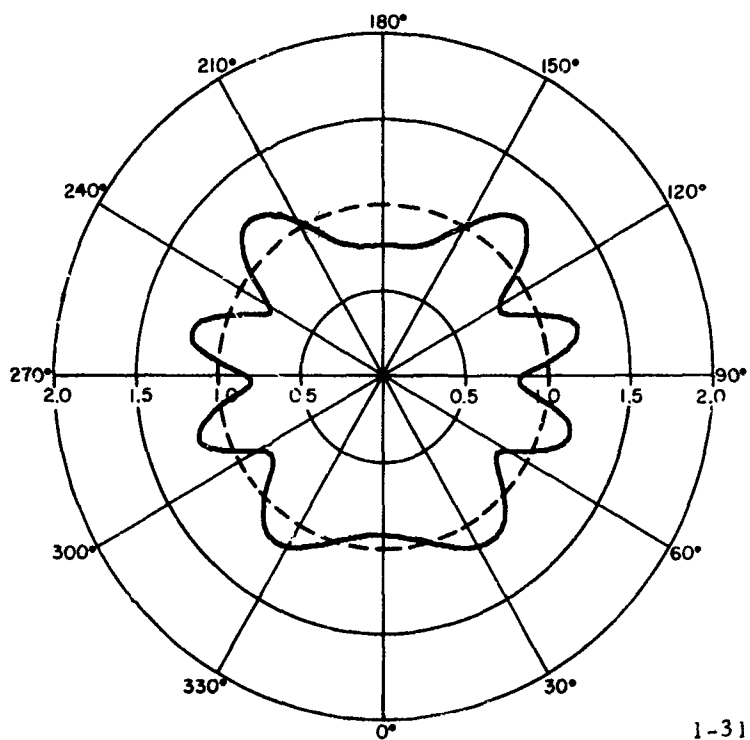
DISTANCE ~ WAVELENGTHS



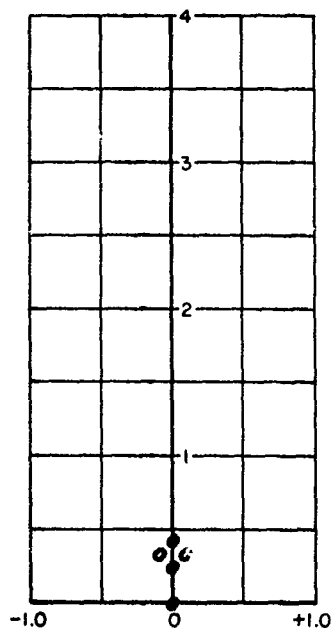
1-32



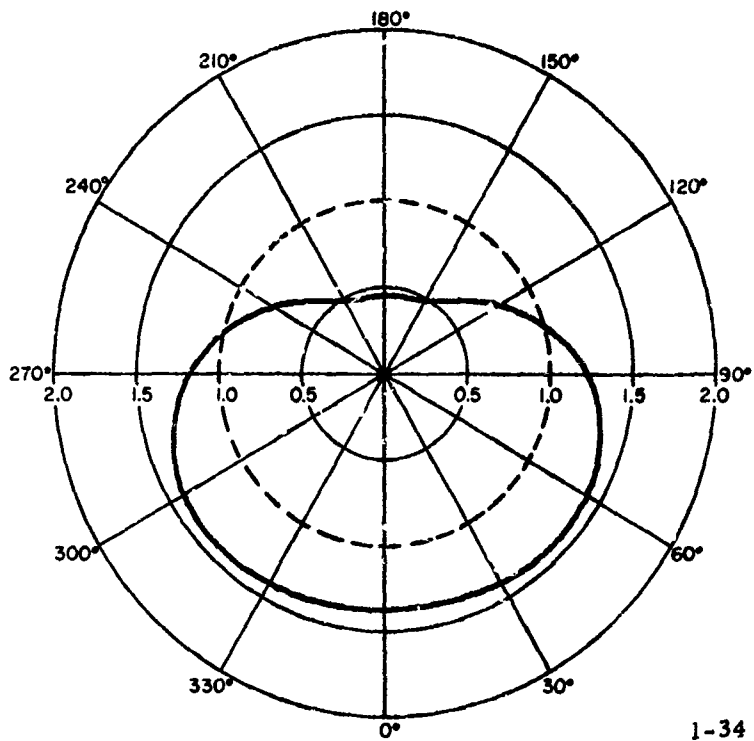
DISTANCE ~ WAVELENGTHS



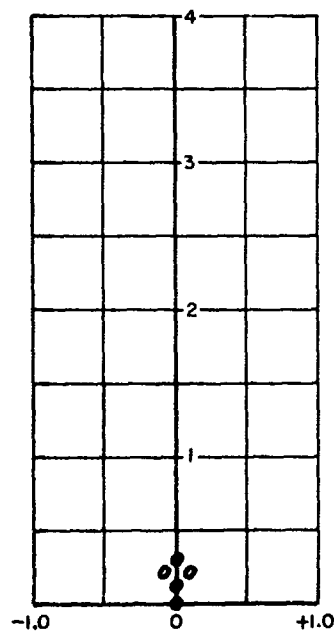
1-31



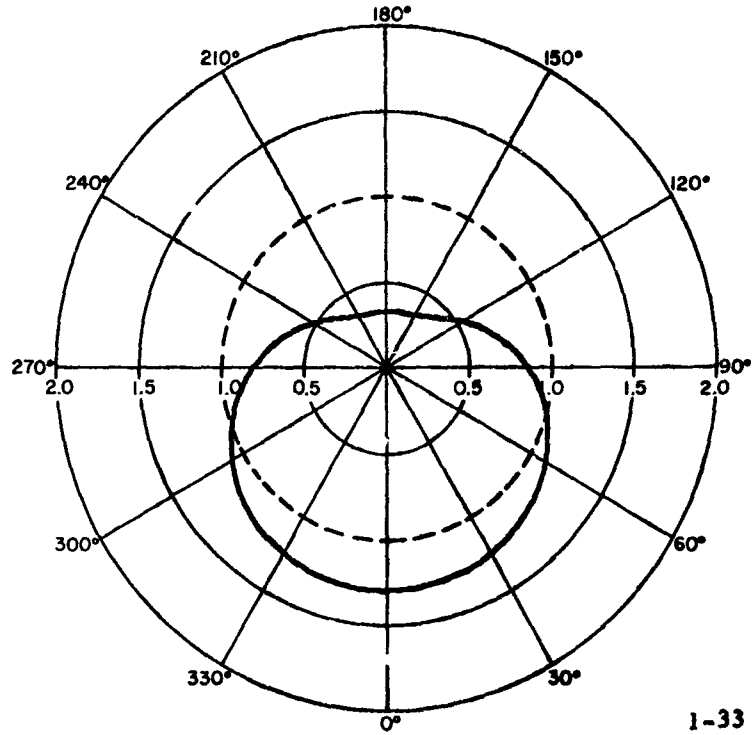
DISTANCE ~ WAVELENGTHS



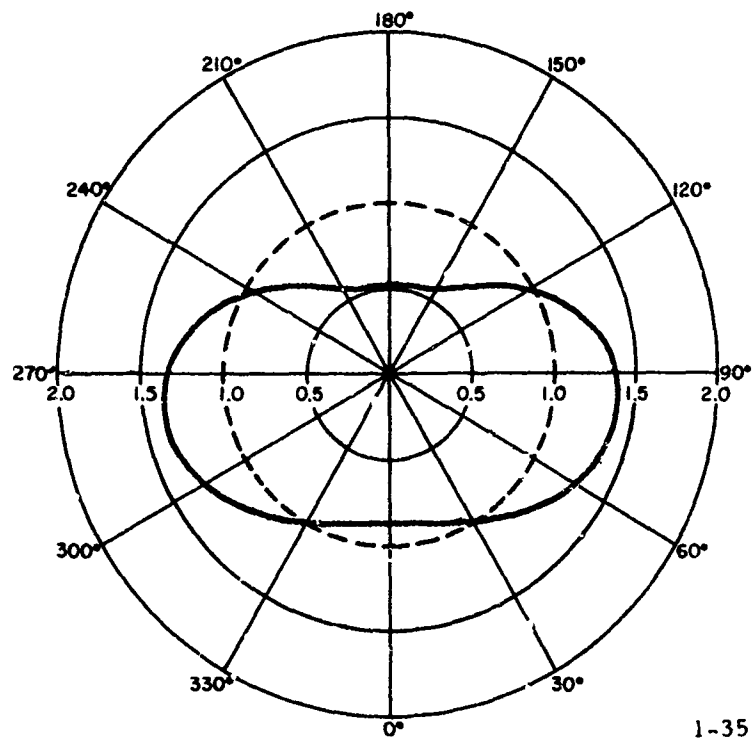
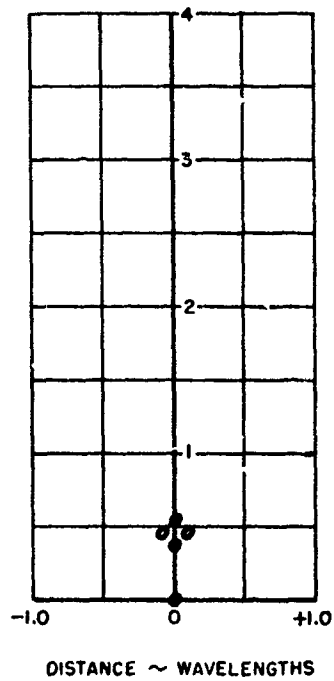
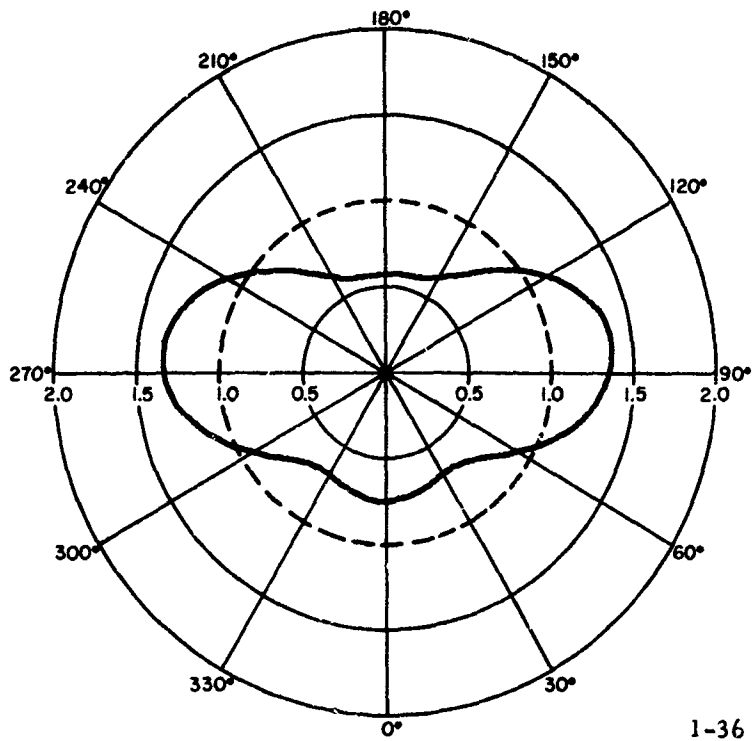
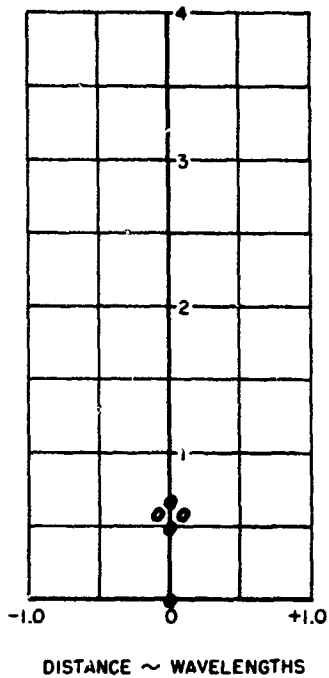
1-34

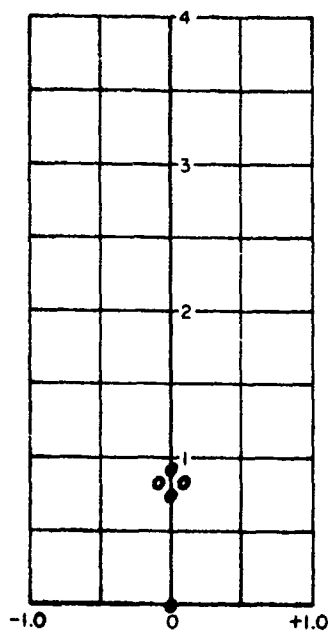


DISTANCE ~ WAVELENGTHS

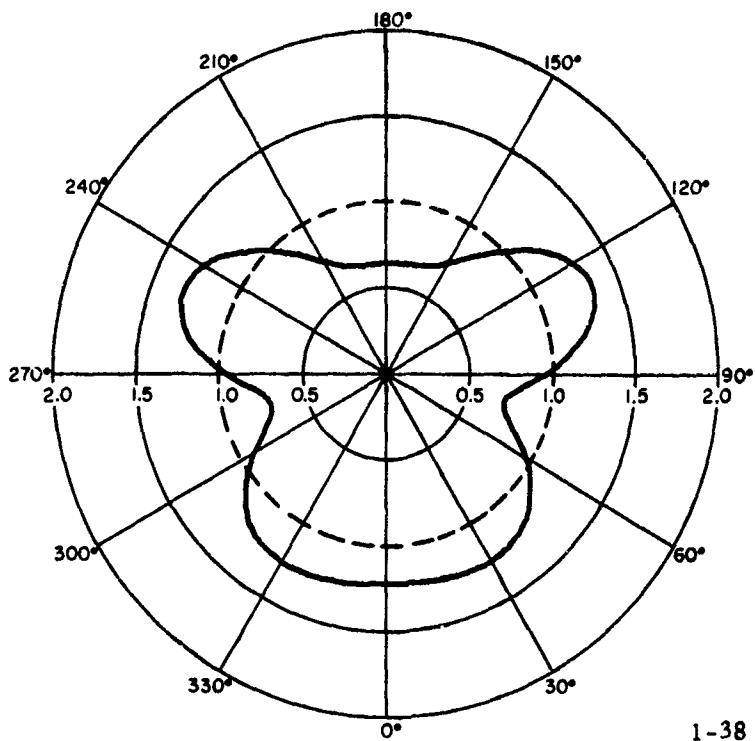


1-33

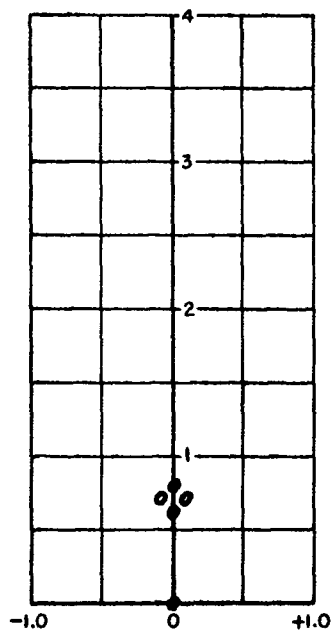




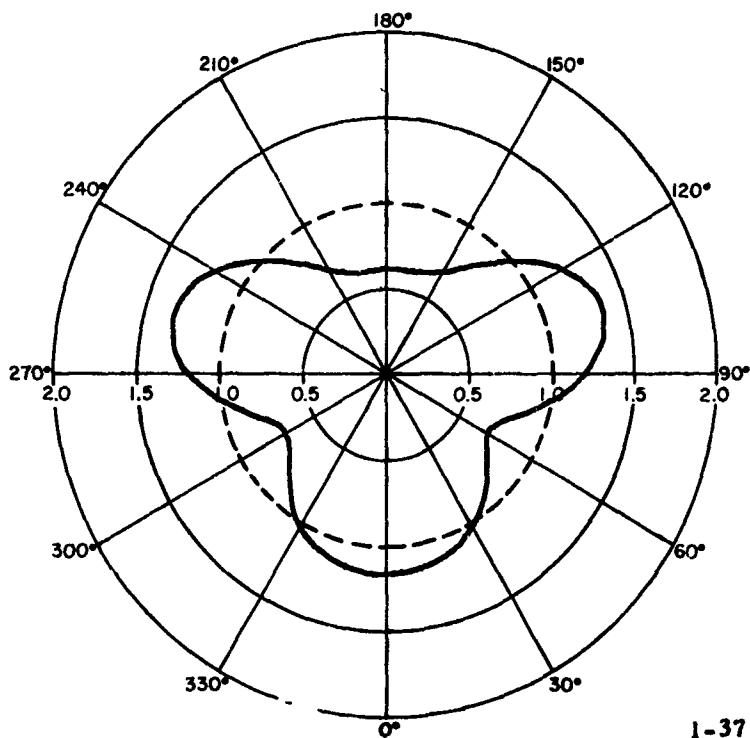
DISTANCE ~ WAVELENGTHS



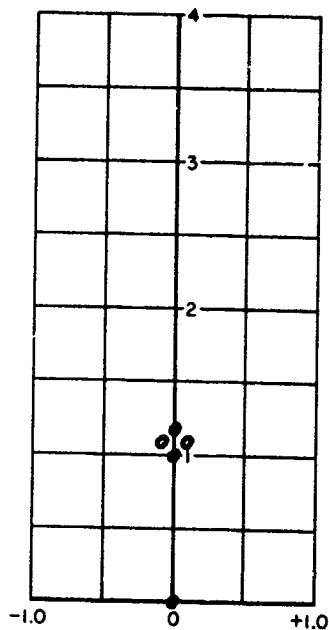
1-38



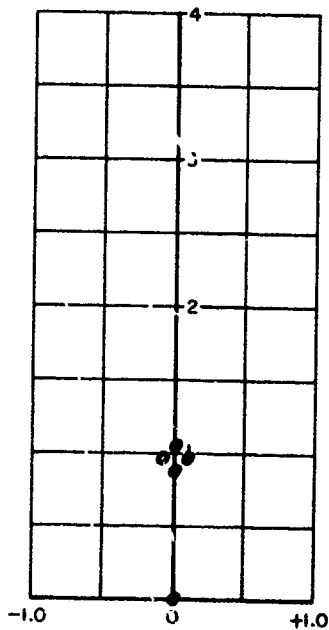
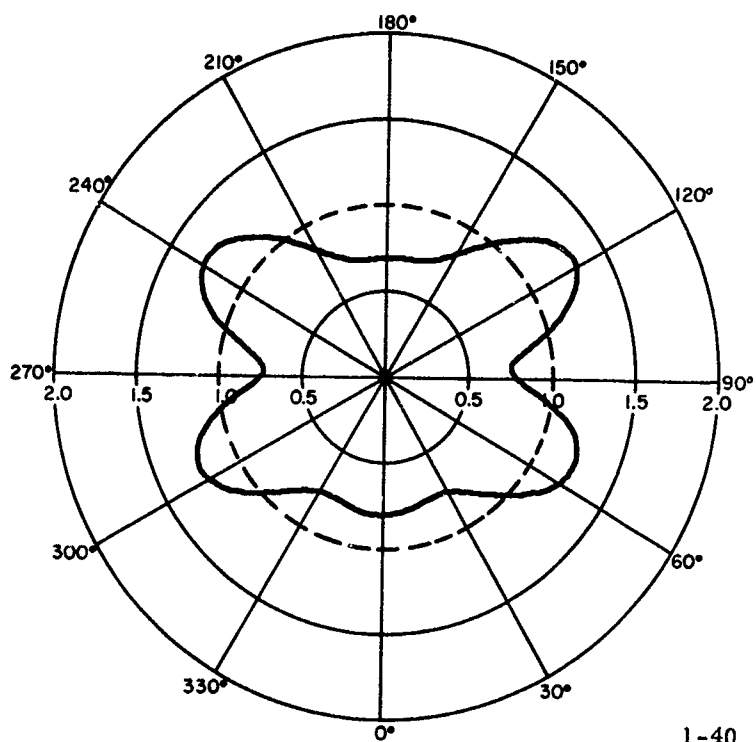
DISTANCE ~ WAVELENGTHS



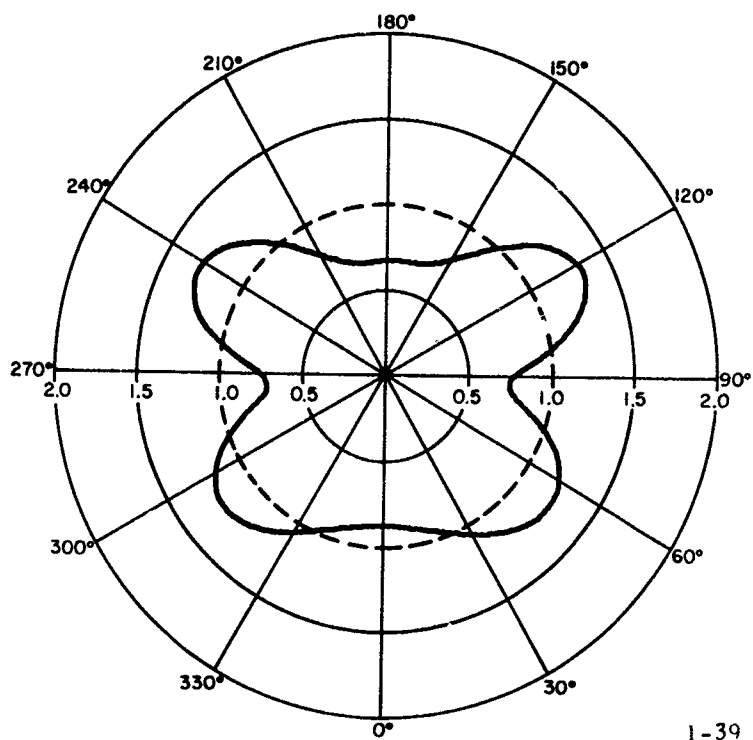
1-37

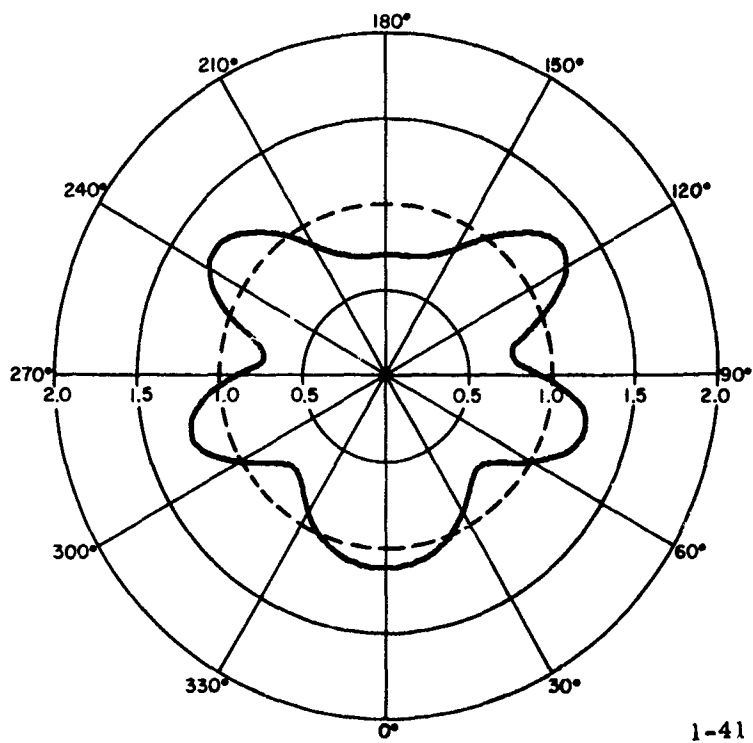
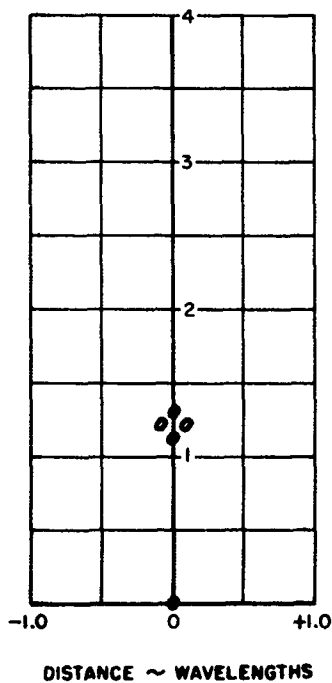
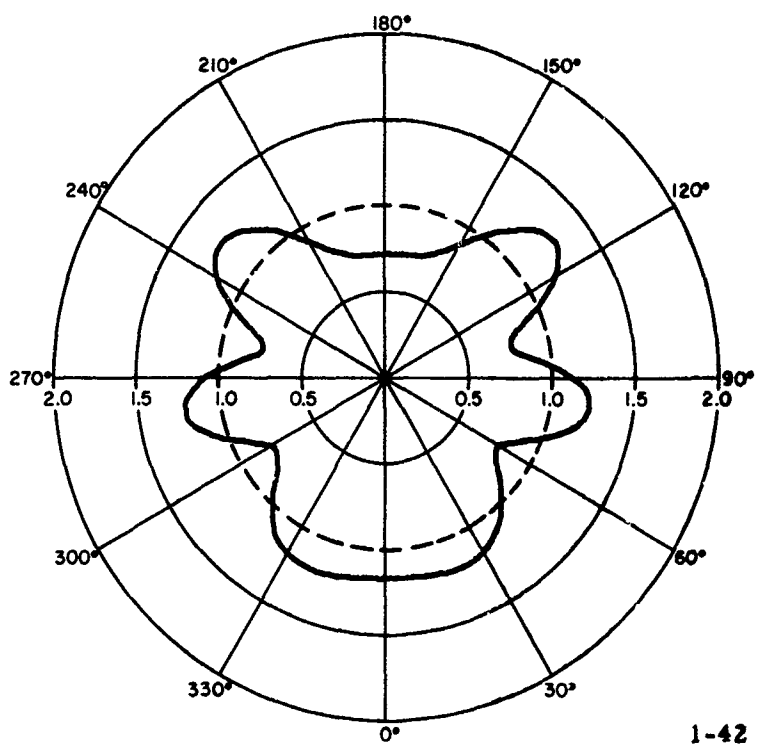
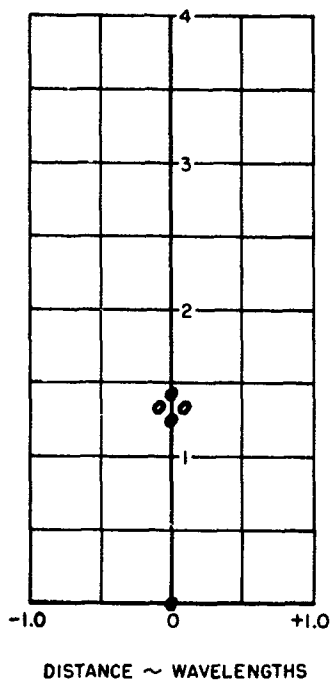


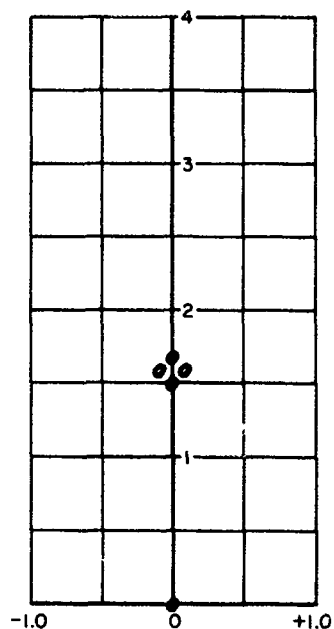
DISTANCE ~ WAVELENGTHS



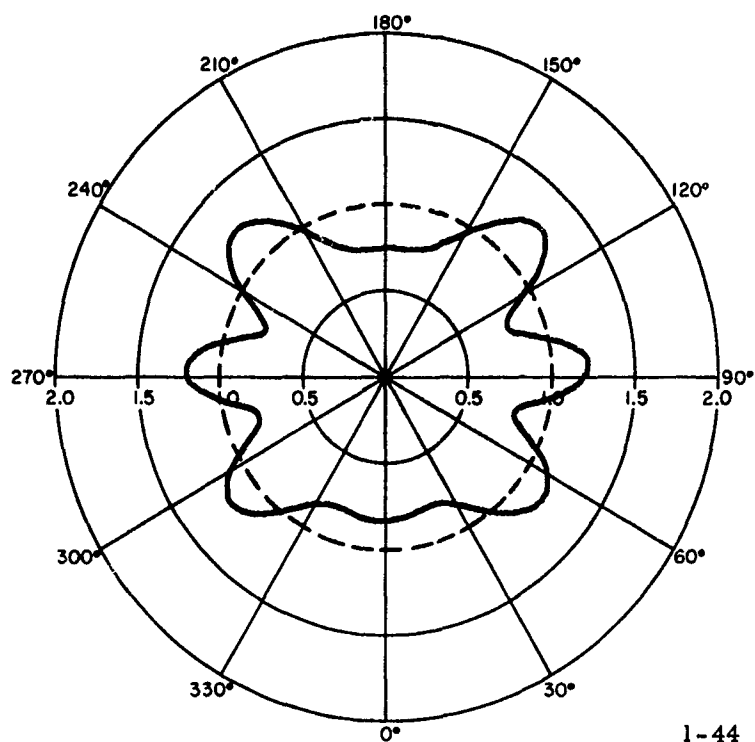
DISTANCE ~ WAVELENGTHS



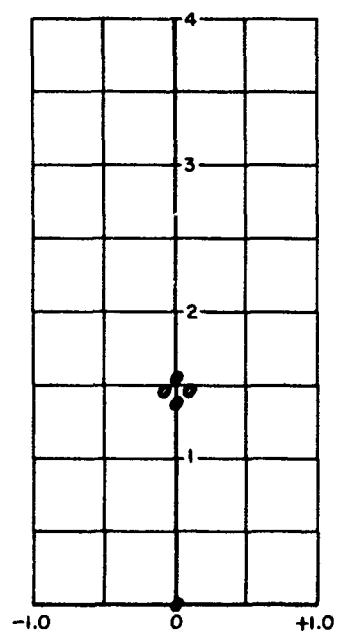




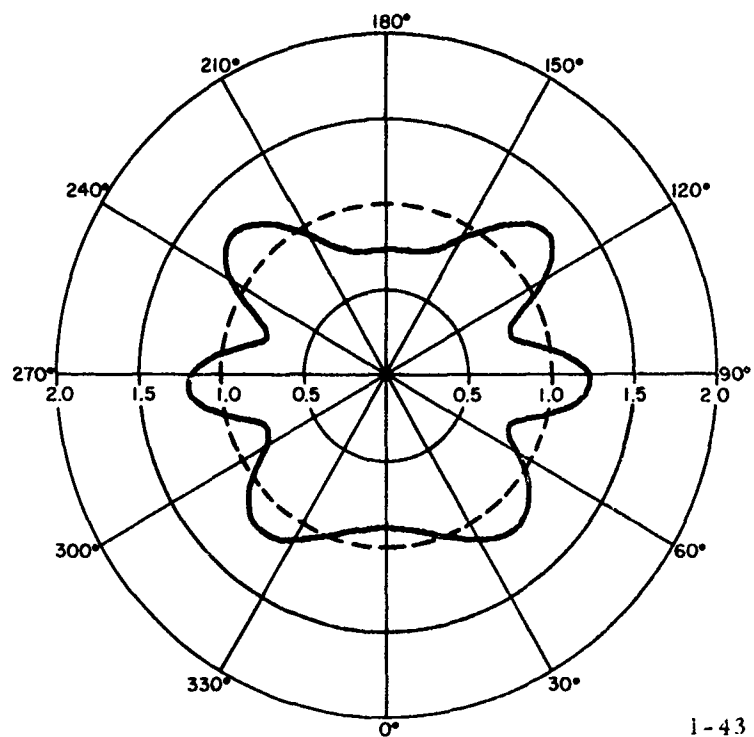
DISTANCE ~ WAVELENGTHS



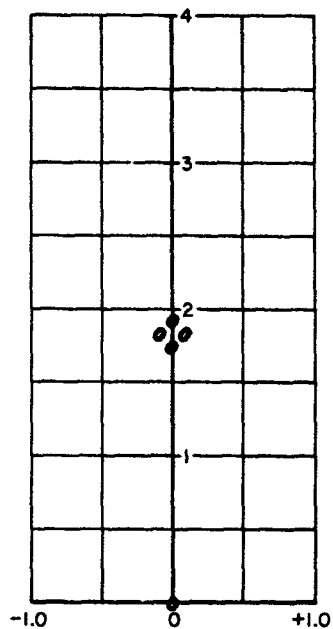
1-44



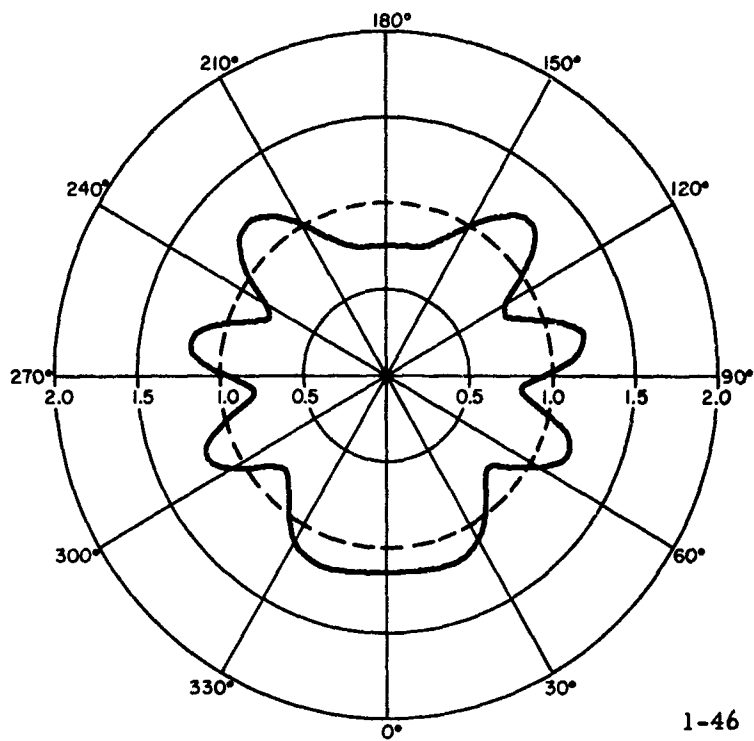
DISTANCE ~ WAVELENGTHS



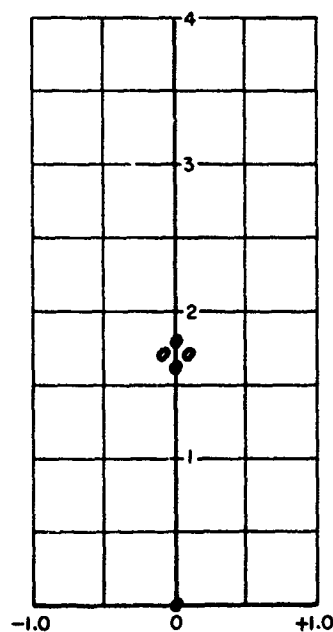
1-43



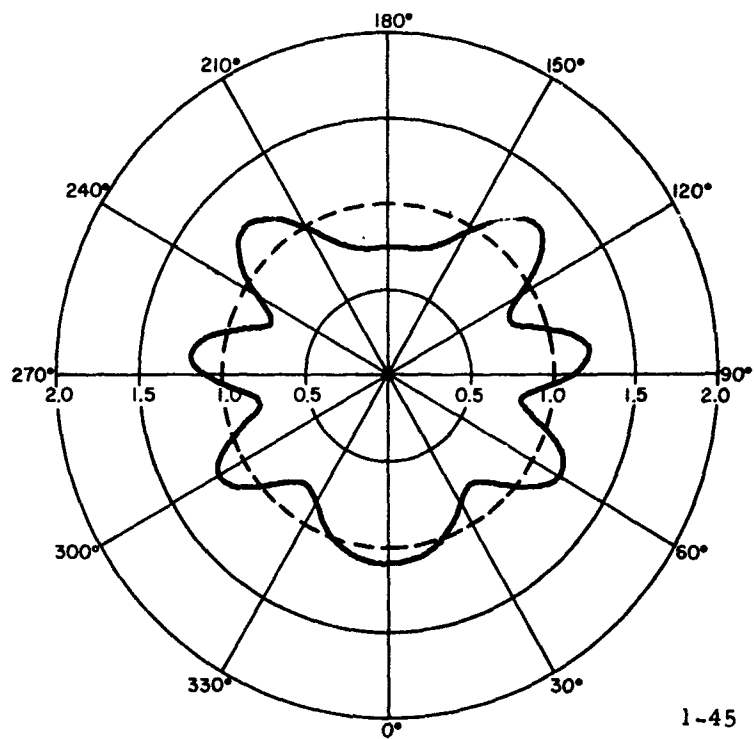
DISTANCE ~ WAVELENGTHS



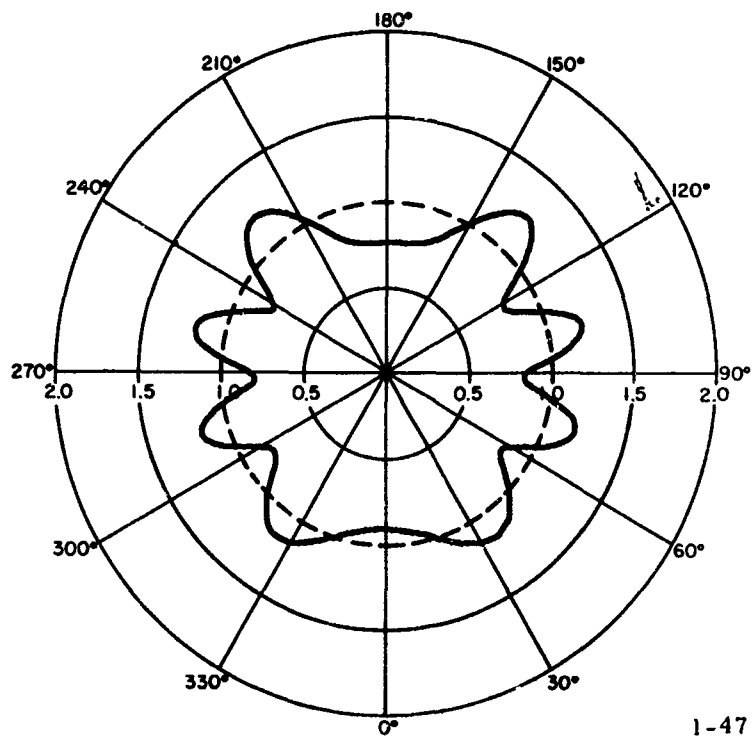
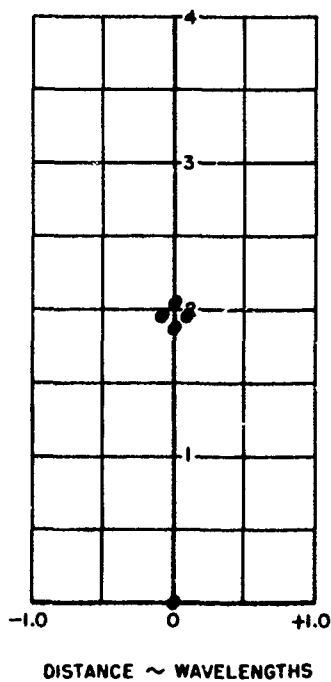
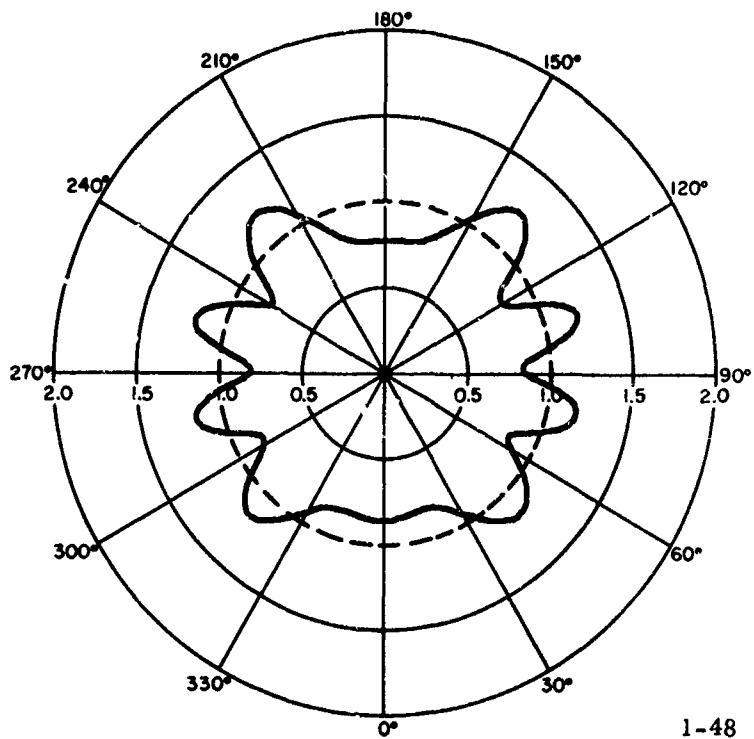
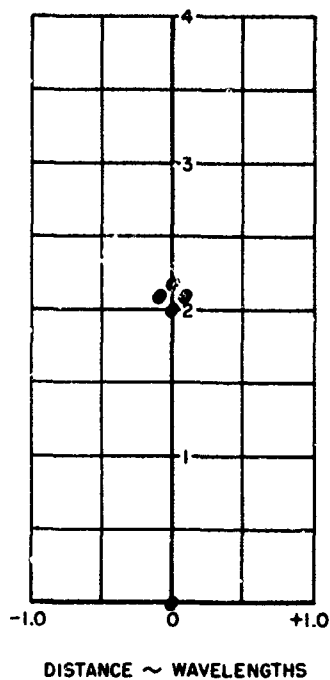
1-46

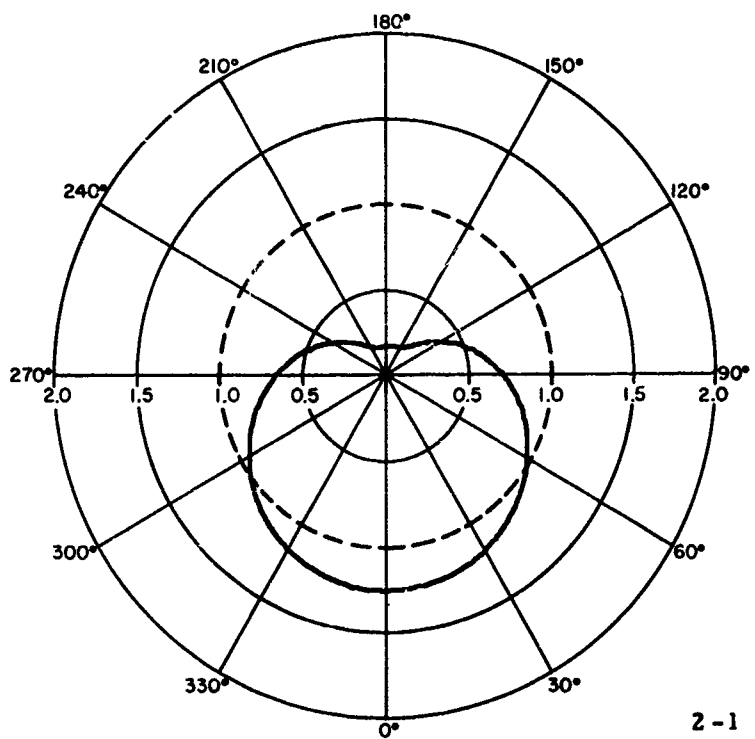
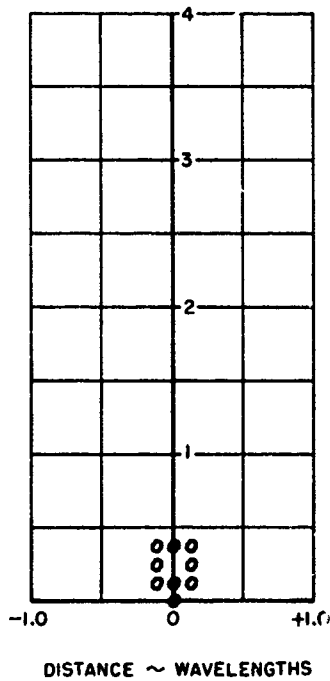
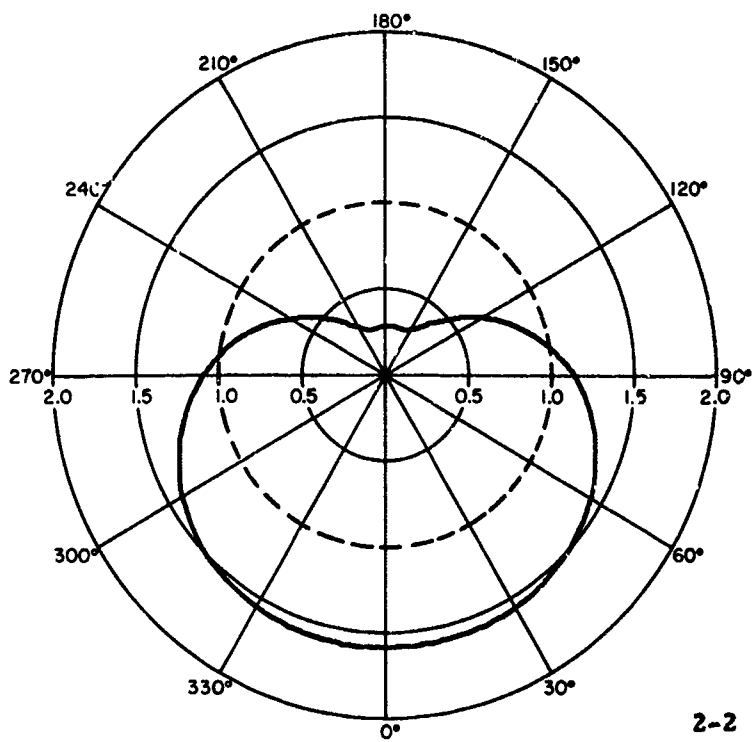
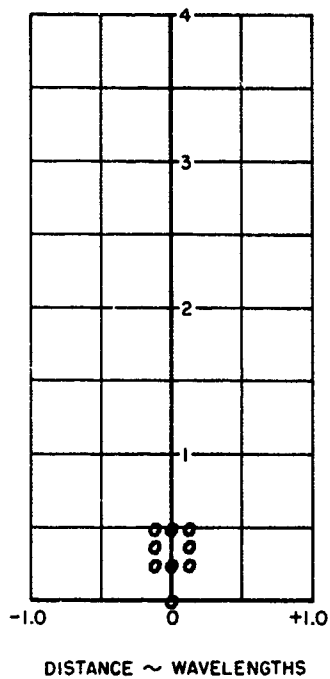


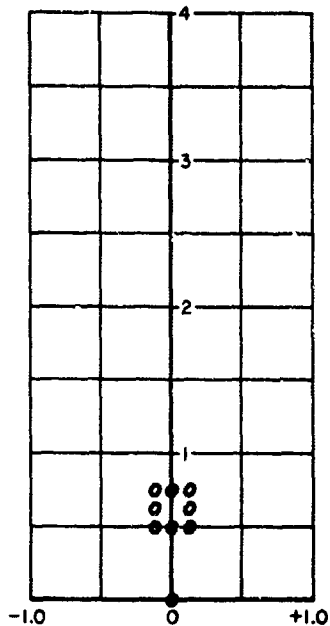
DISTANCE ~ WAVELENGTHS



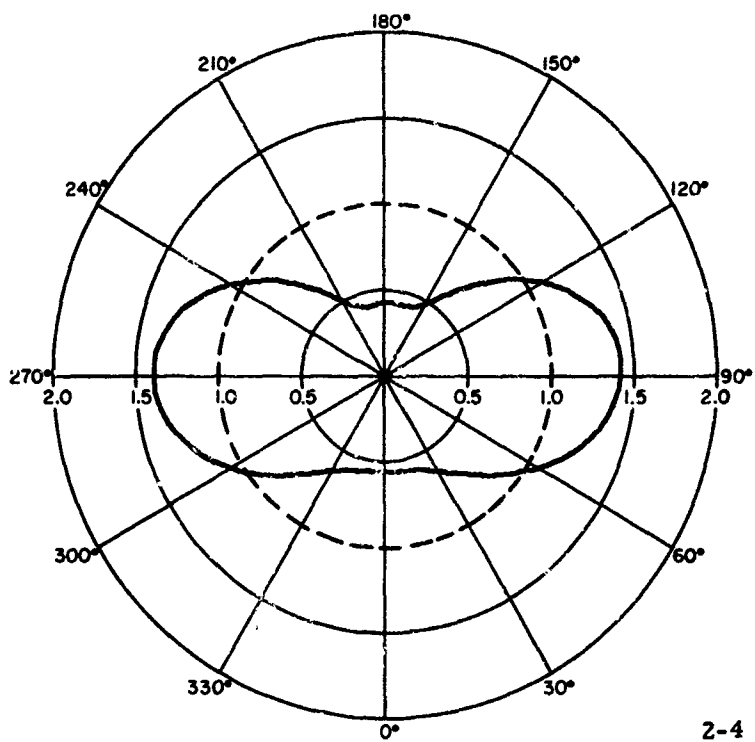
1-45



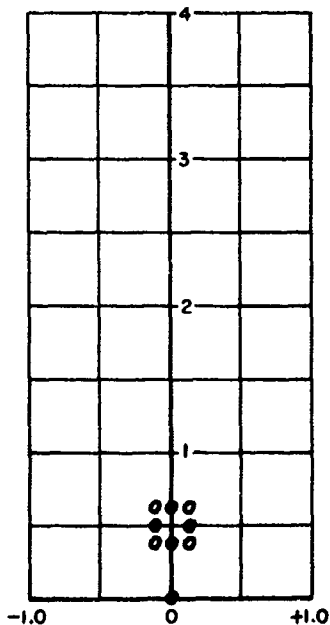




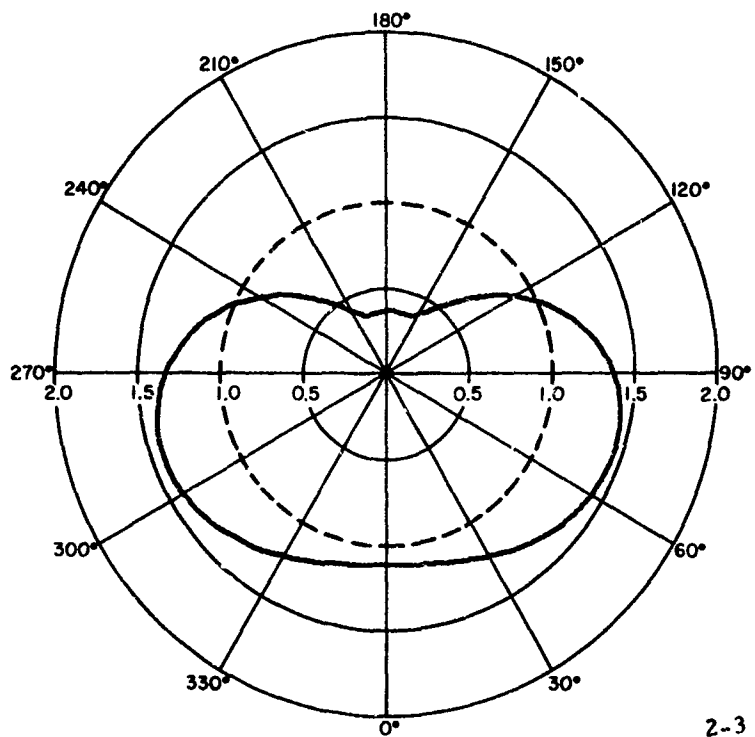
DISTANCE ~ WAVELENGTHS



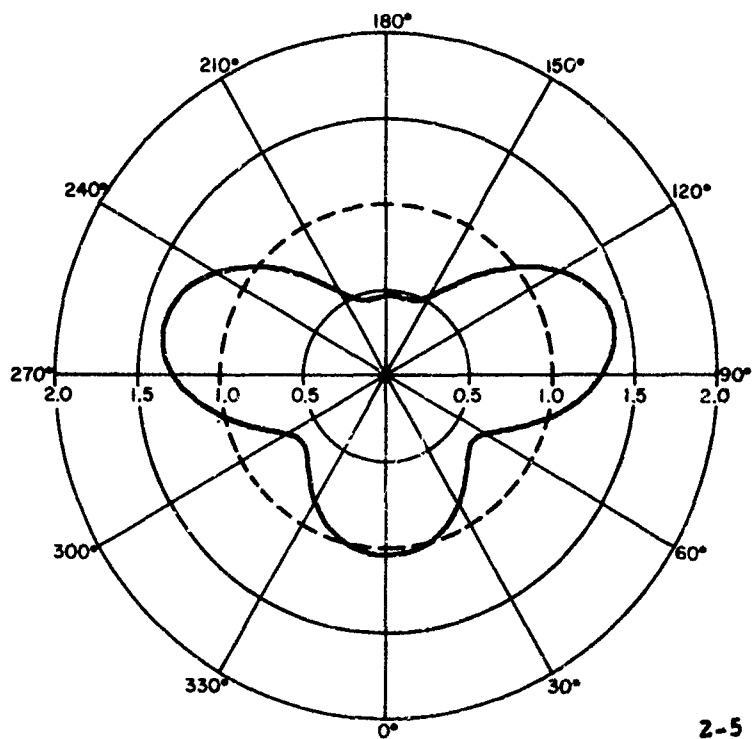
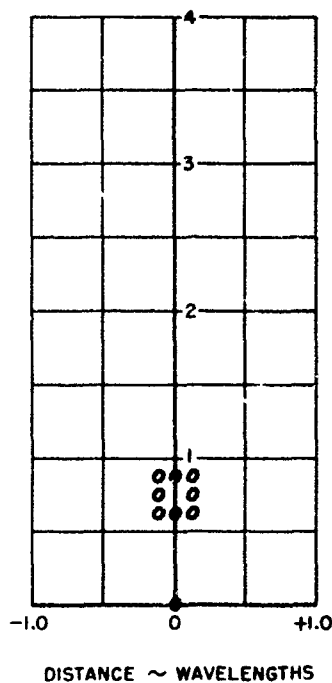
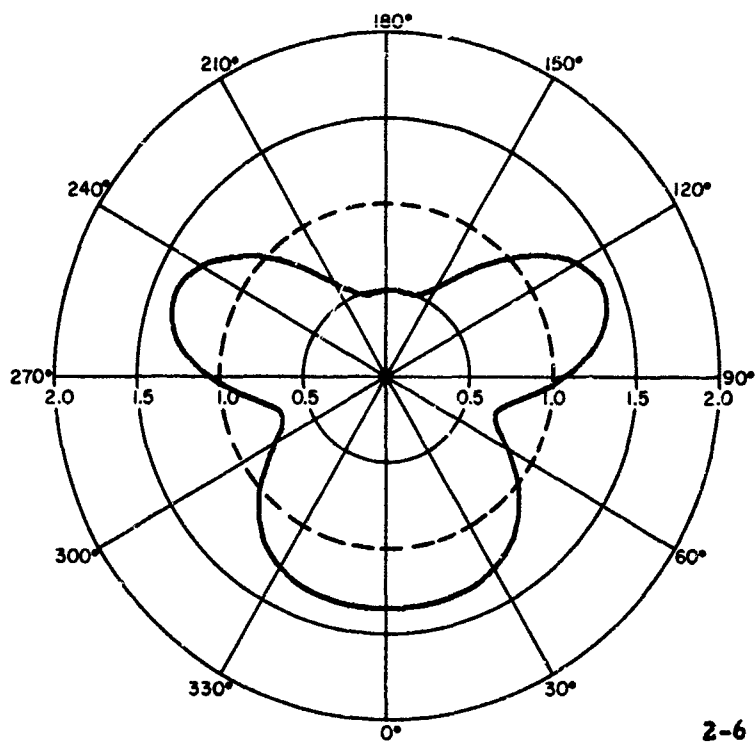
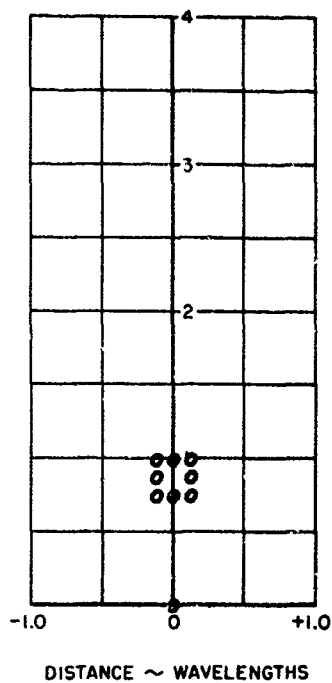
2-4

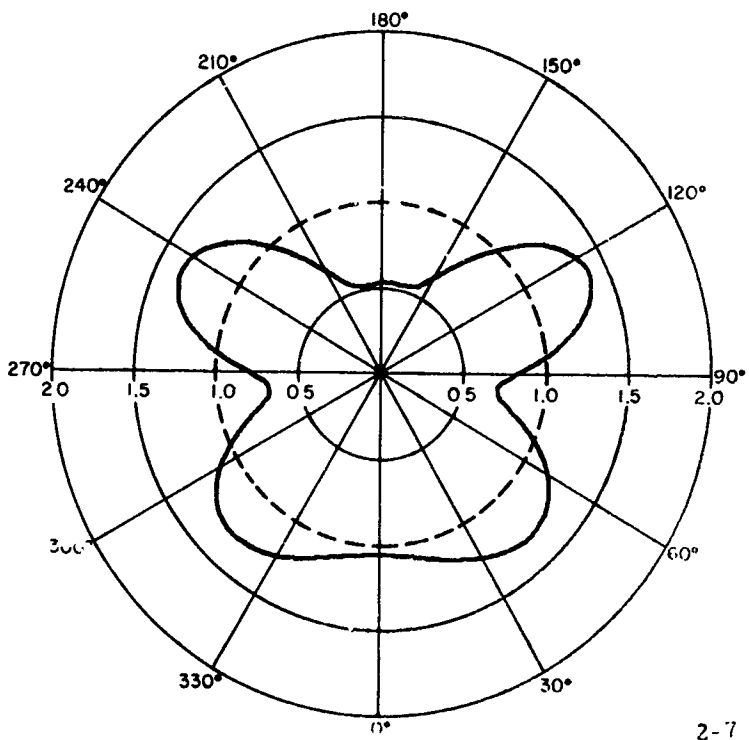
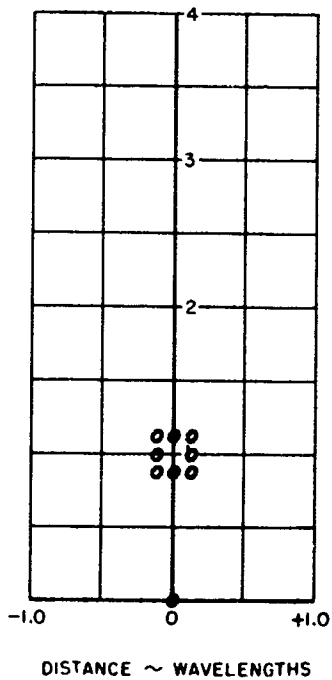
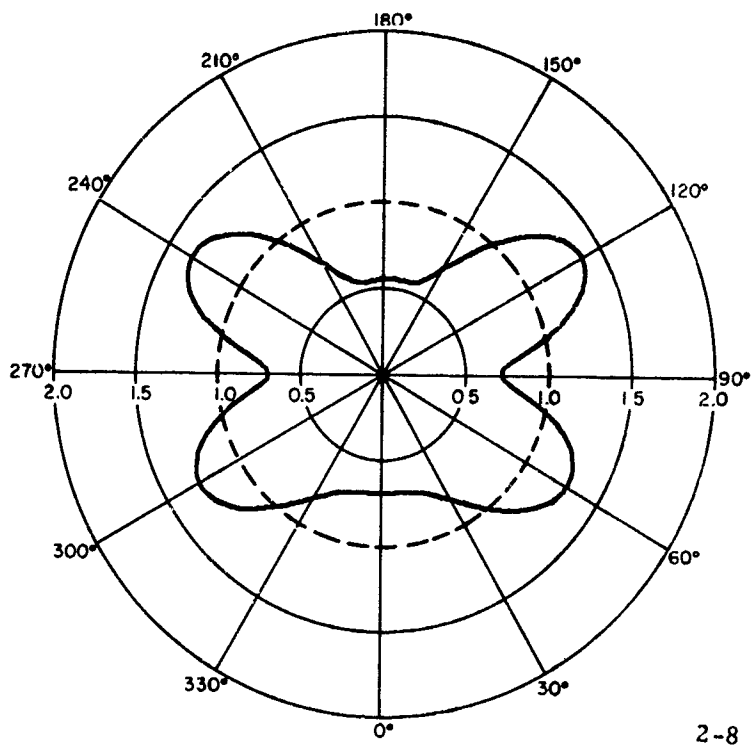
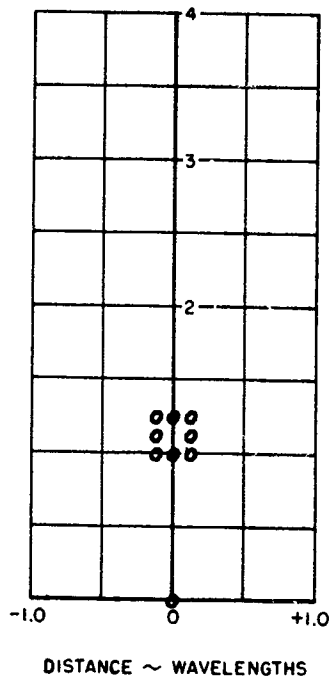


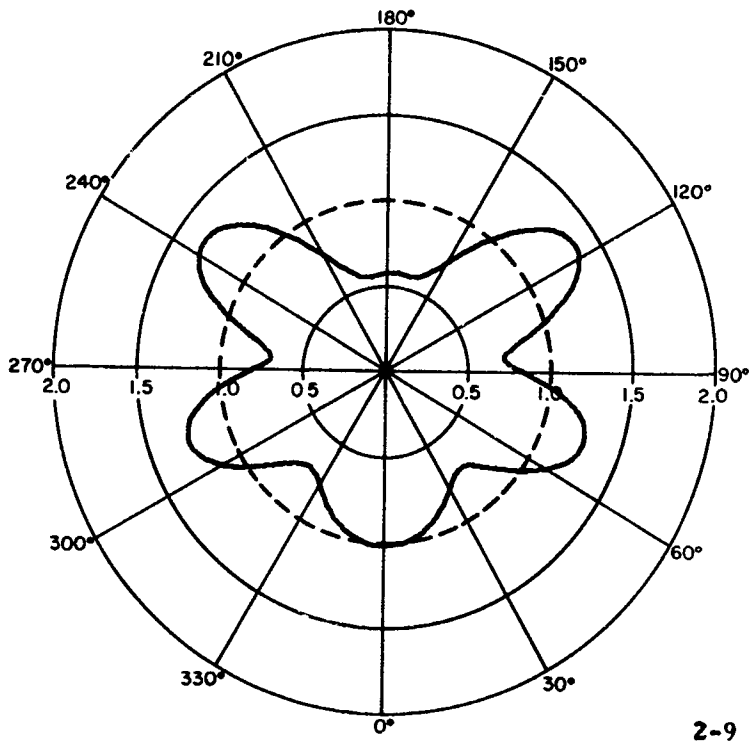
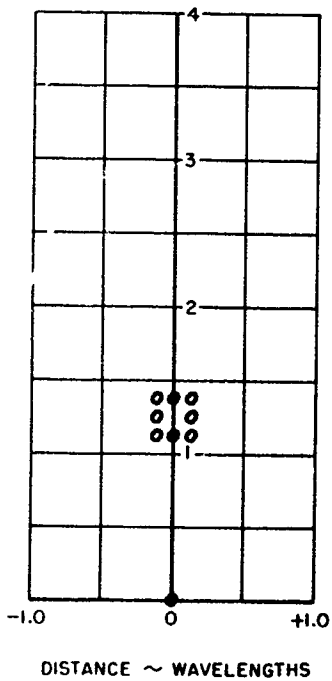
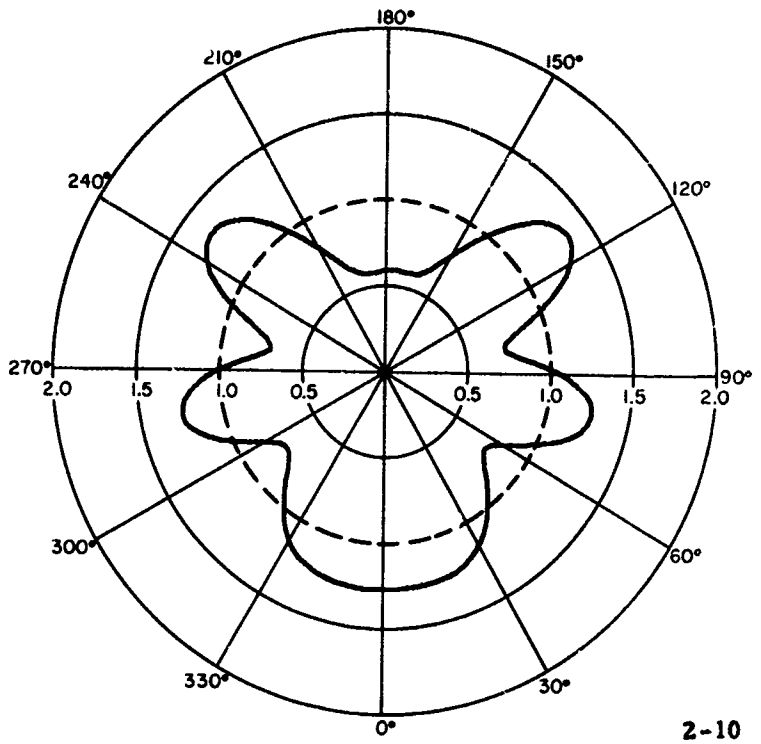
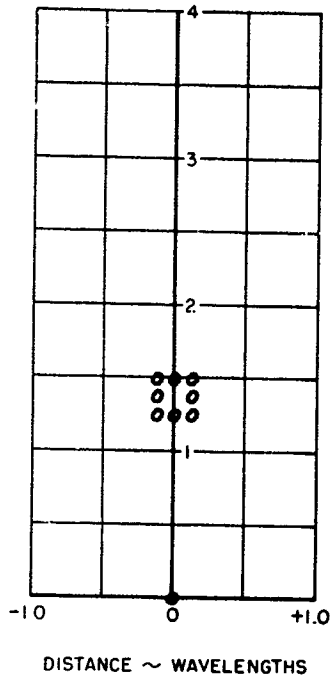
DISTANCE ~ WAVELENGTHS

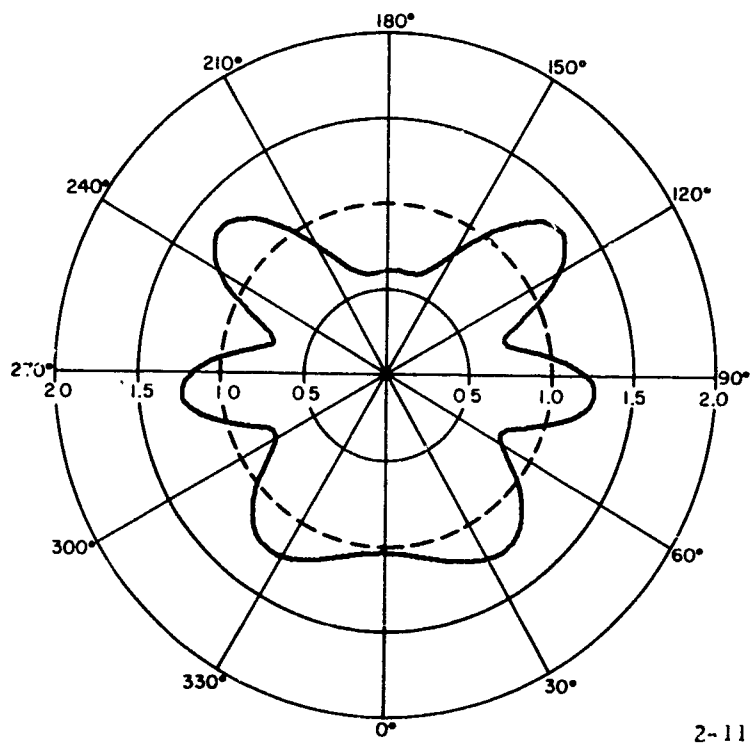
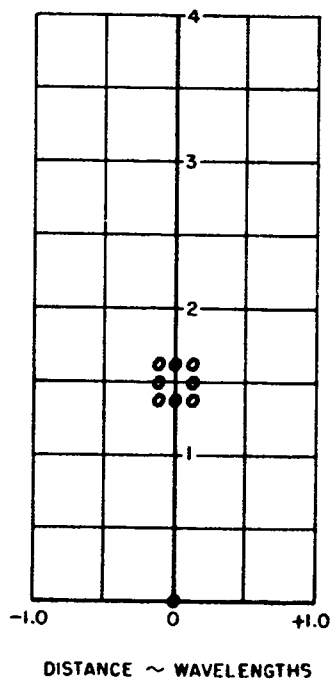
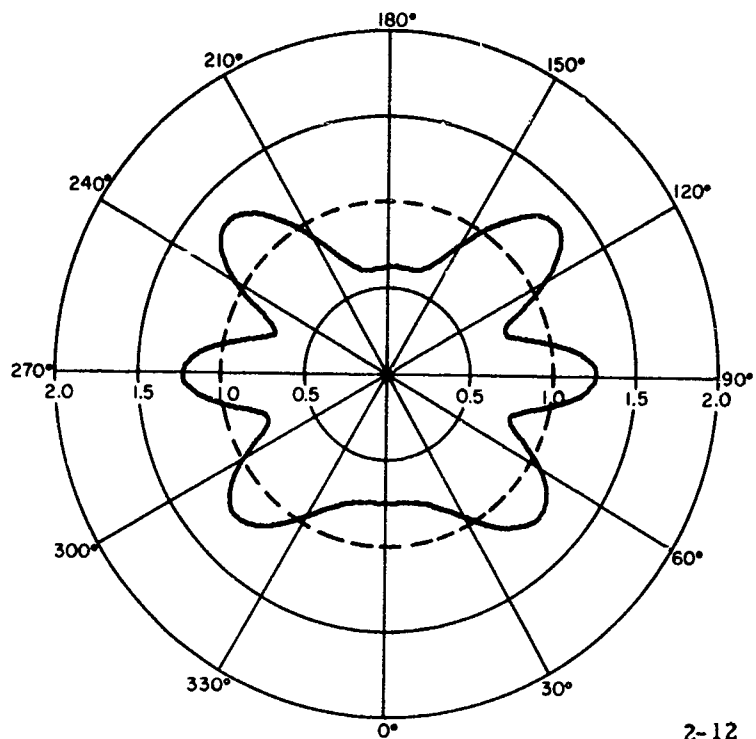
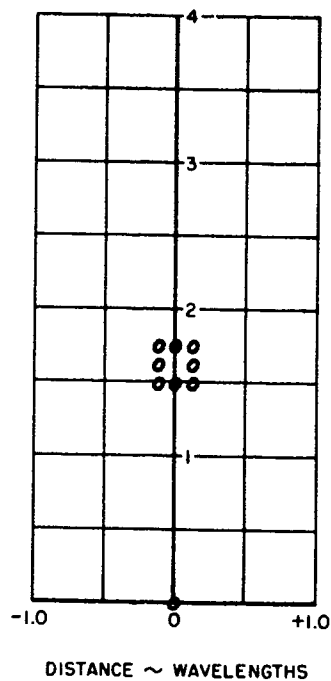


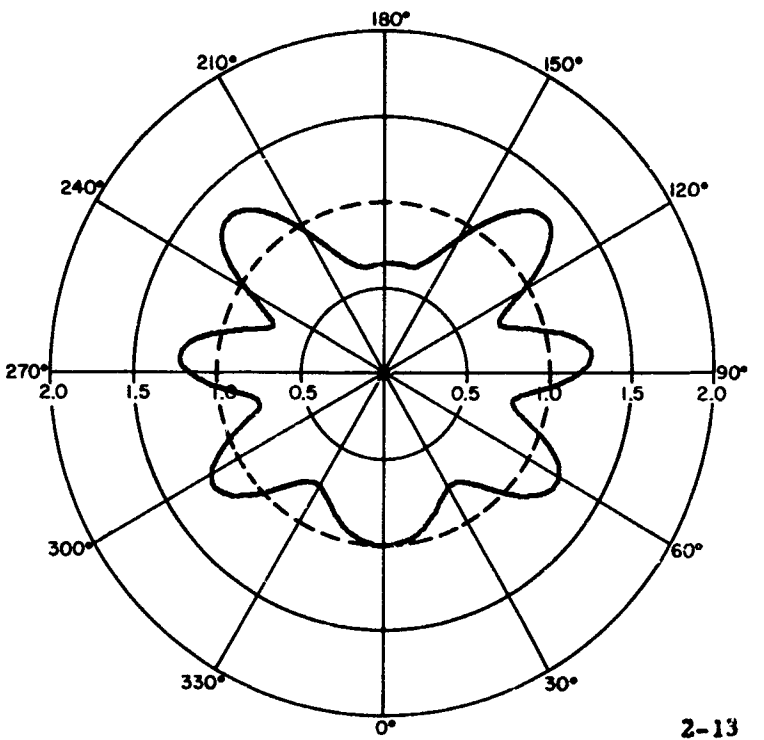
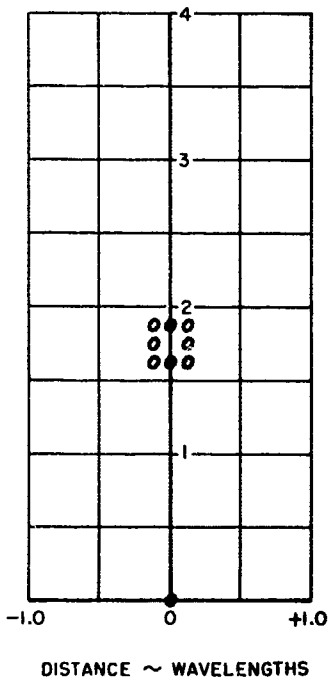
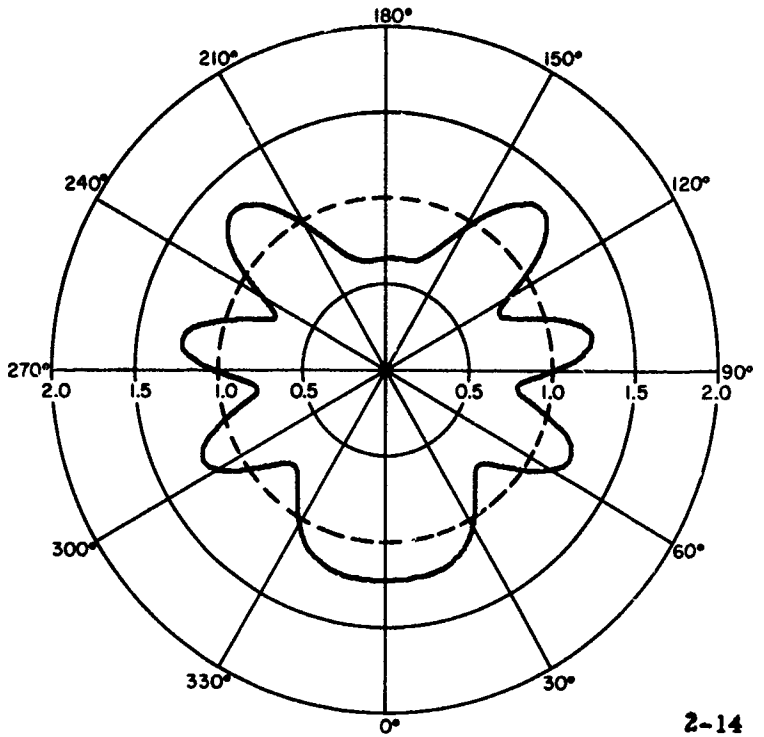
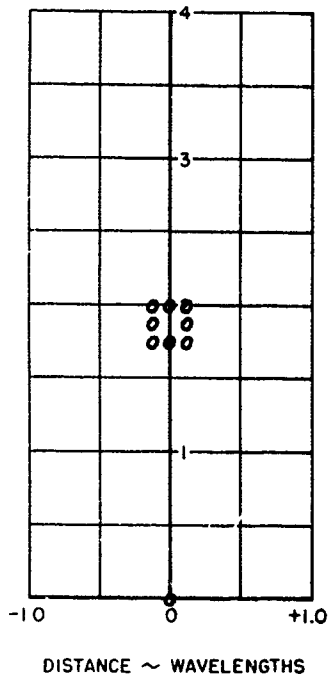
2-3

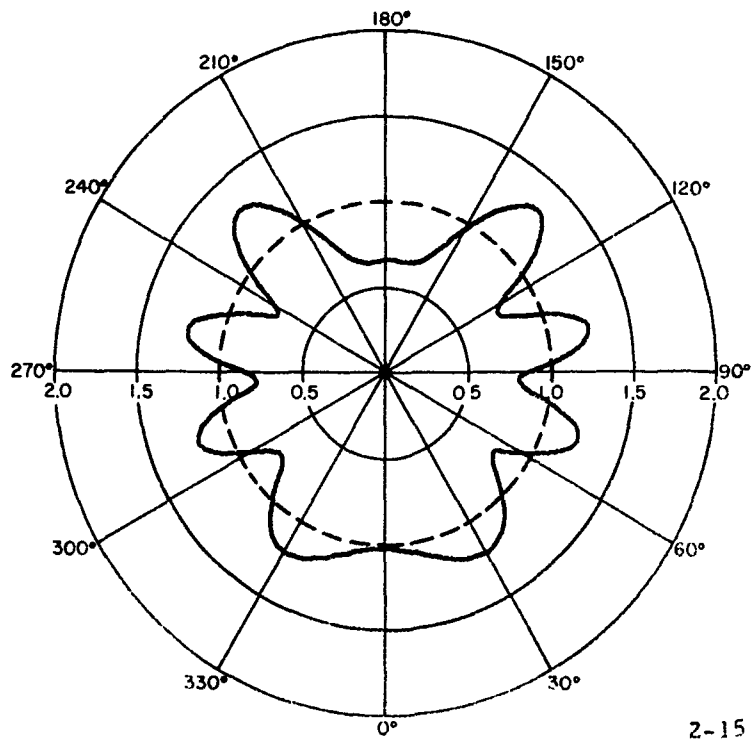
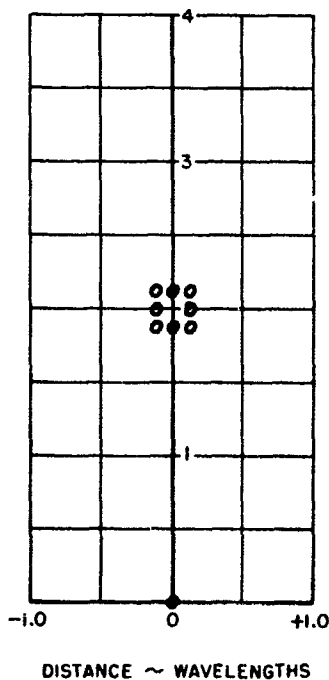
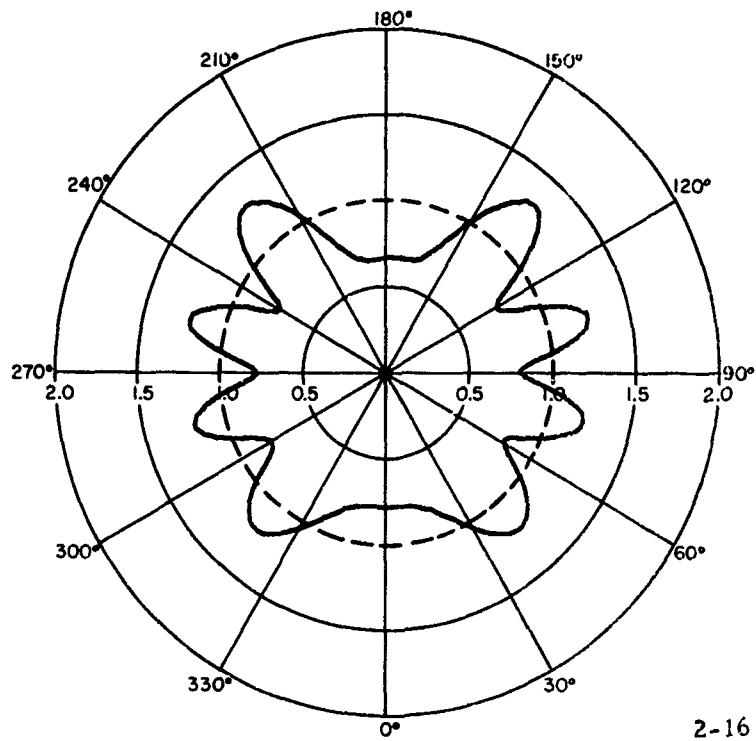
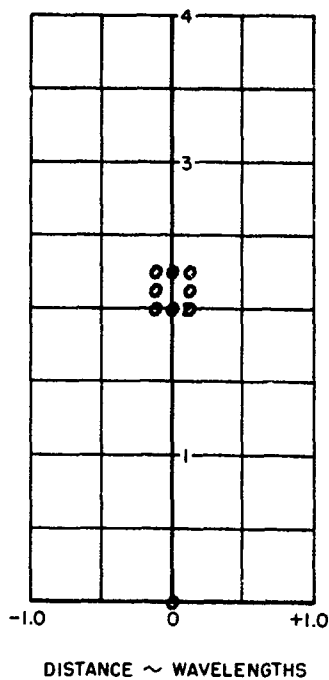


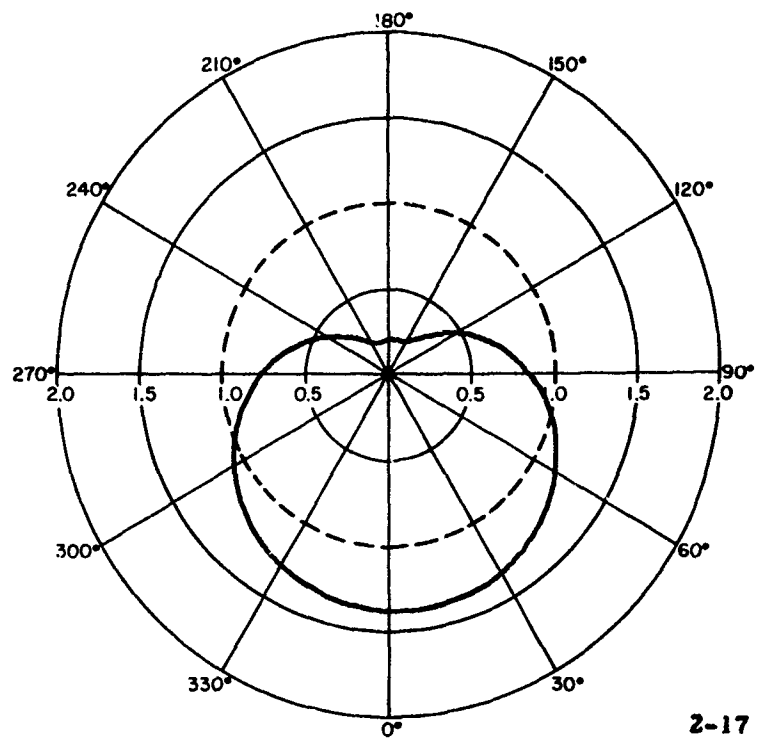
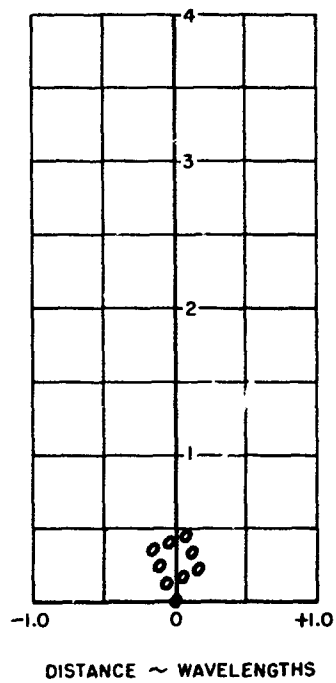
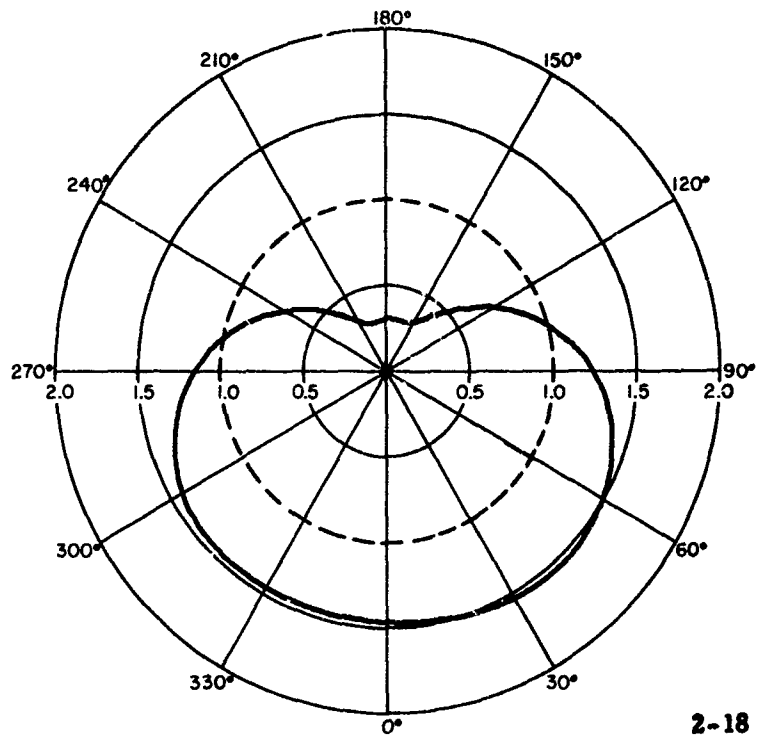
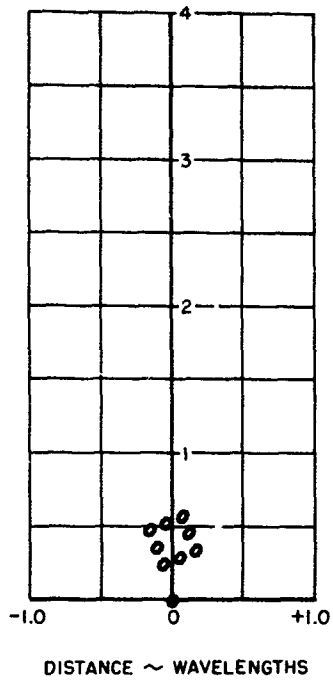


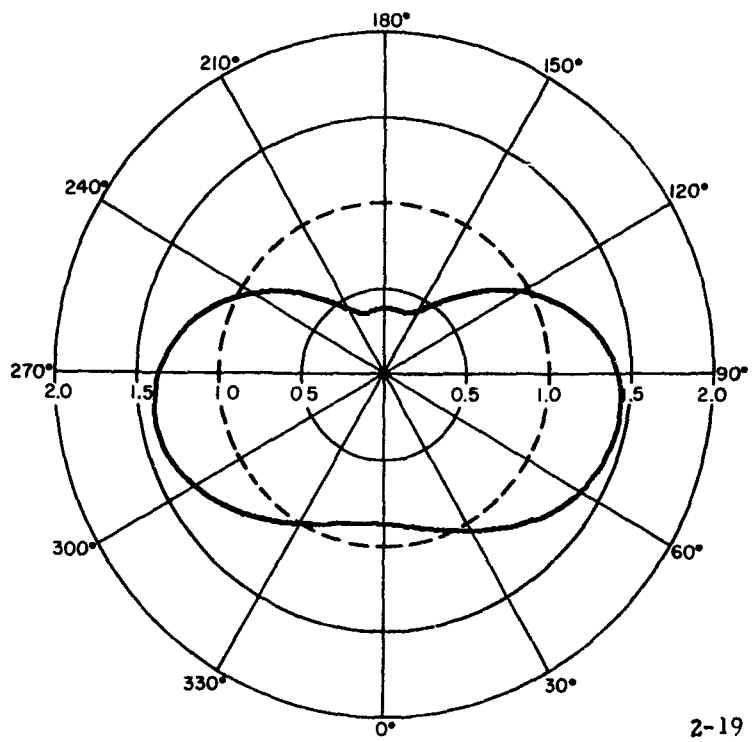
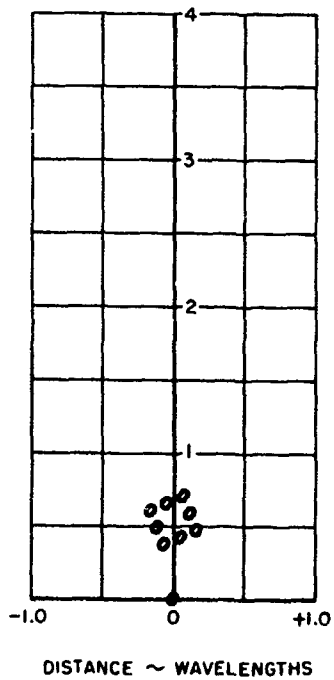
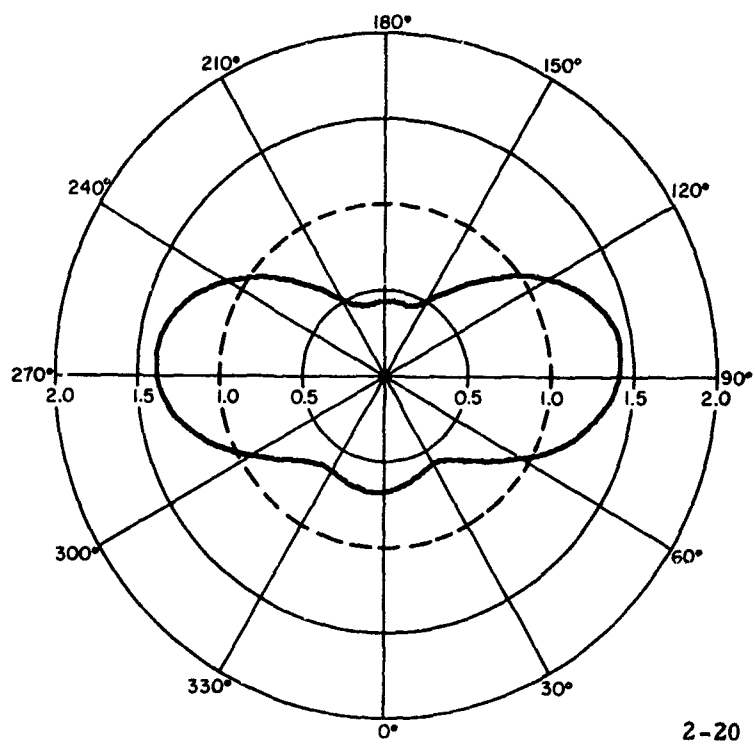
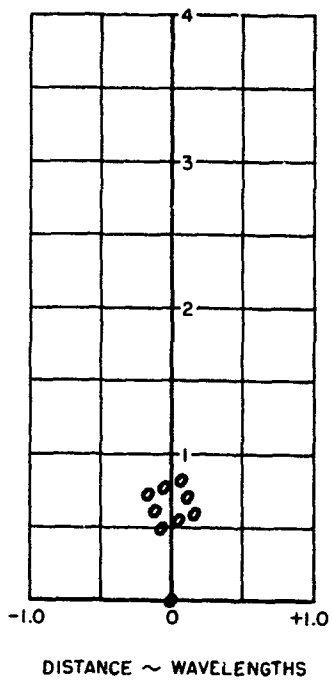


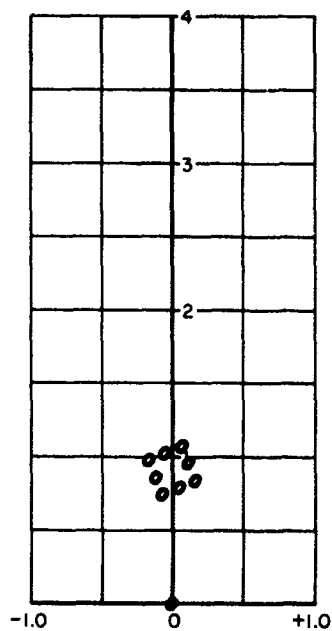




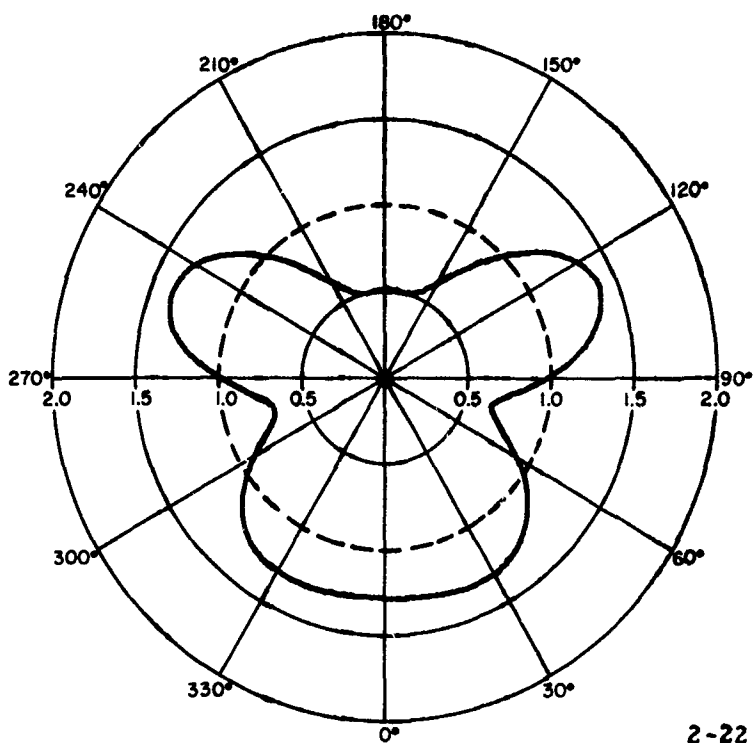




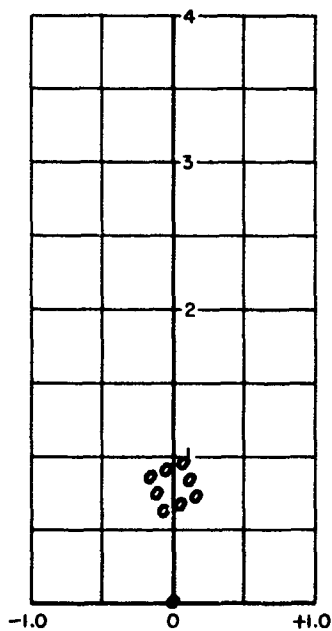




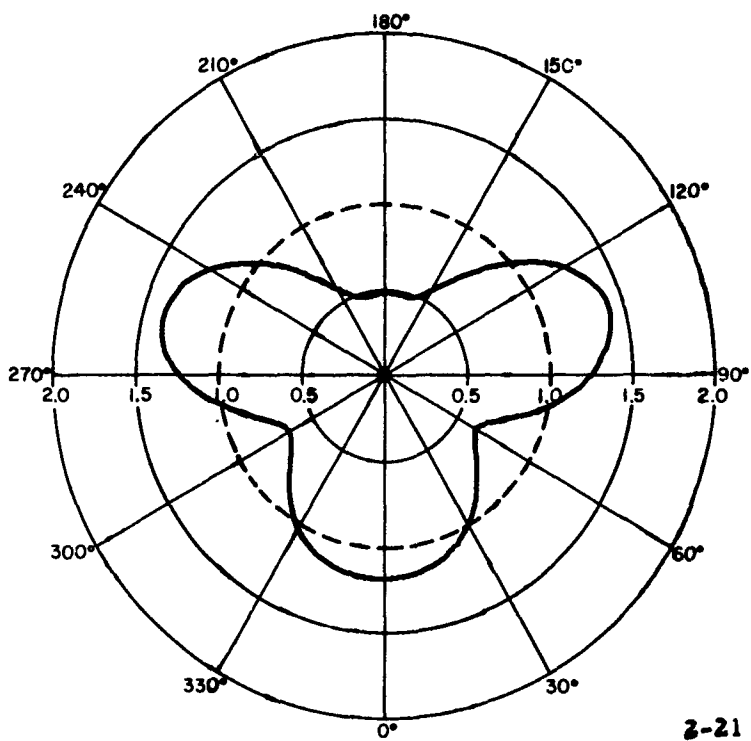
DISTANCE ~ WAVELENGTHS



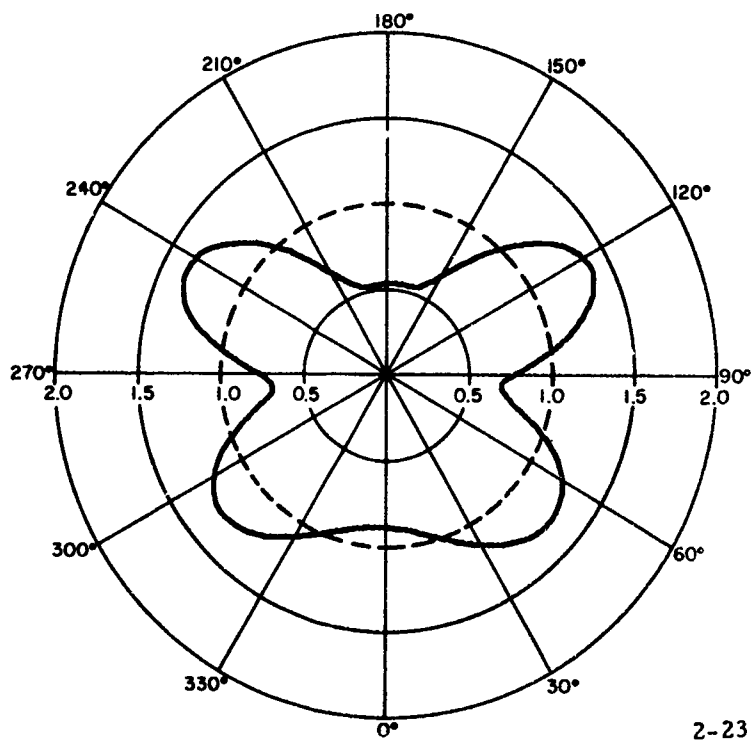
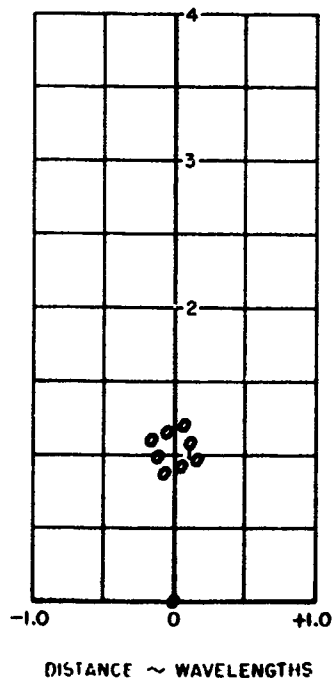
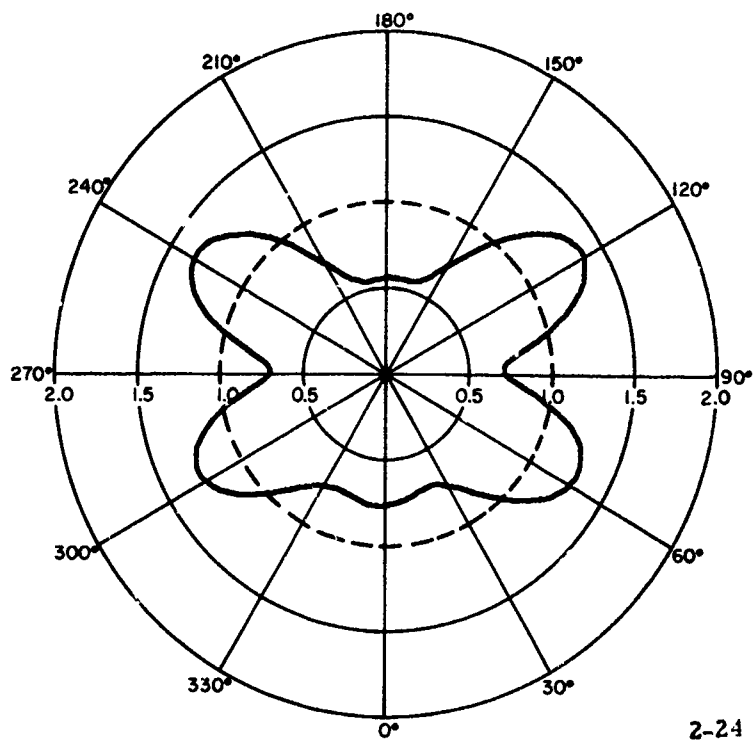
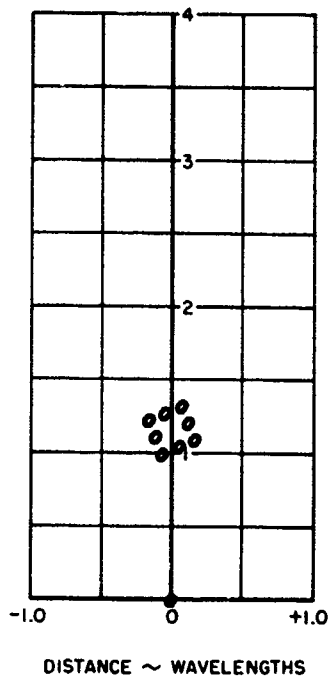
2-22

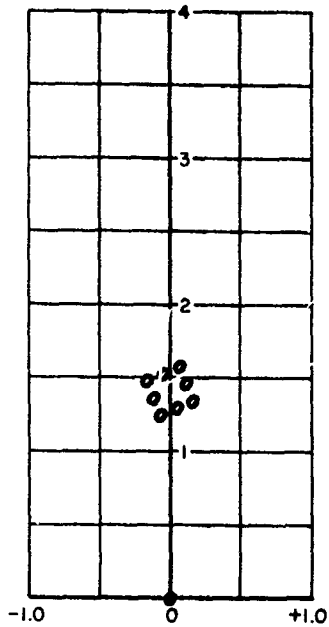


DISTANCE ~ WAVELENGTHS

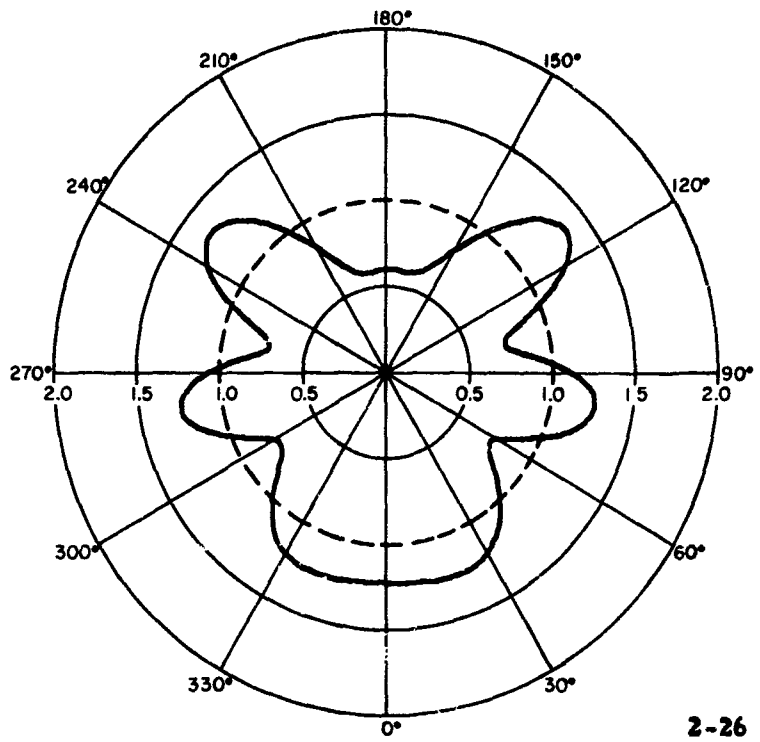


2-21

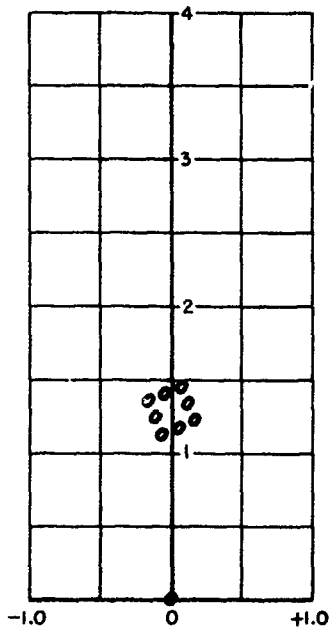




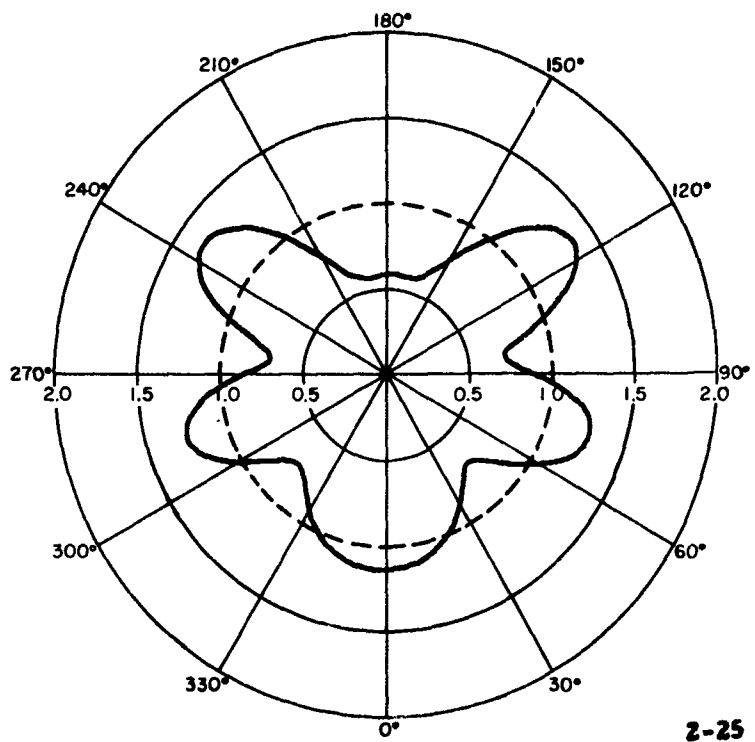
DISTANCE ~ WAVELENGTHS



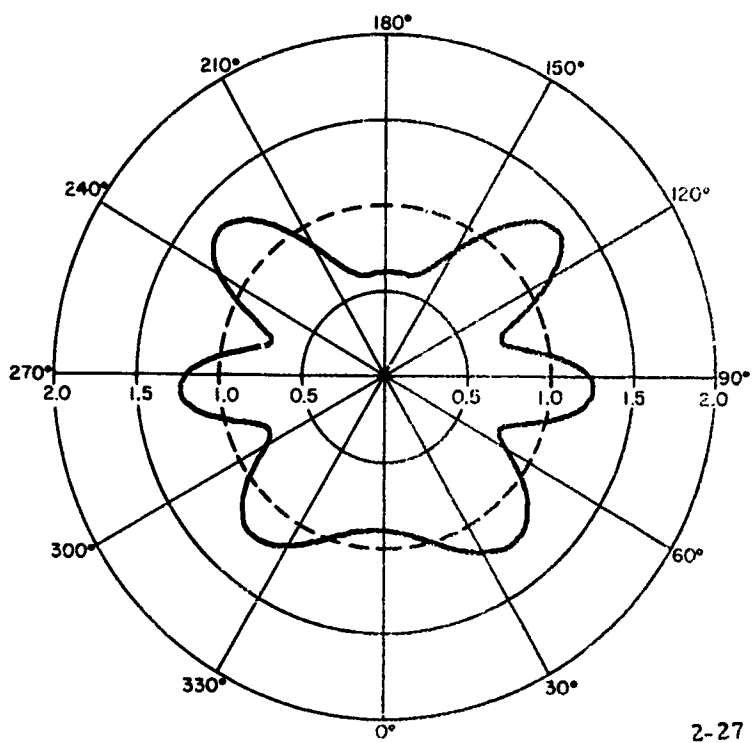
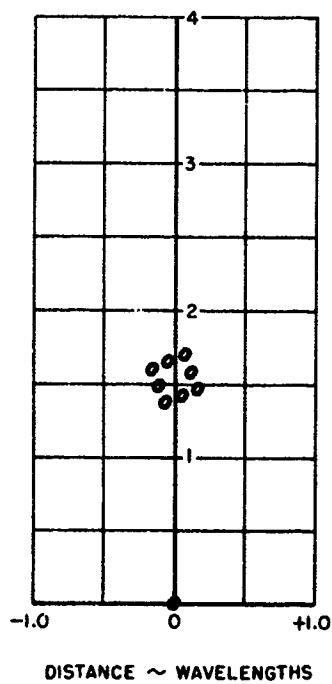
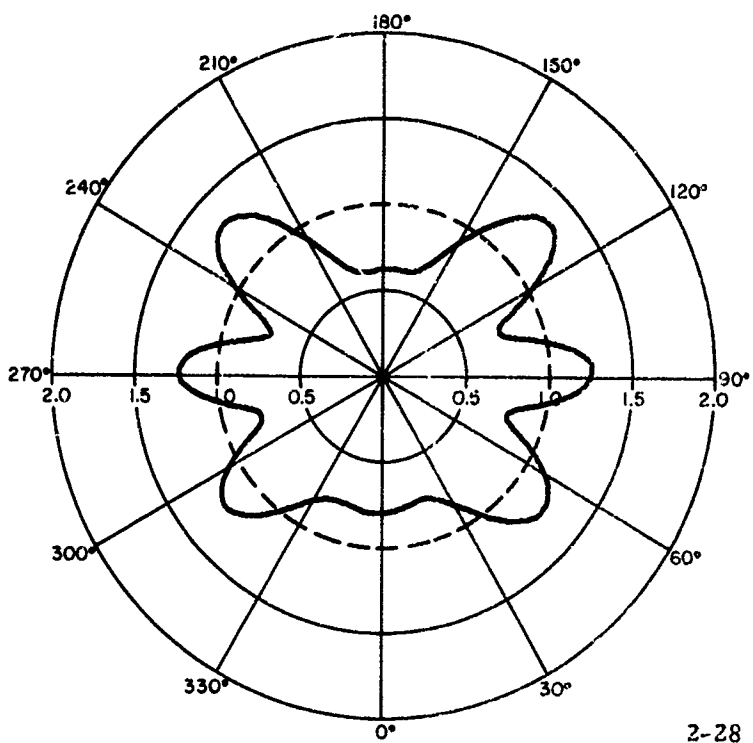
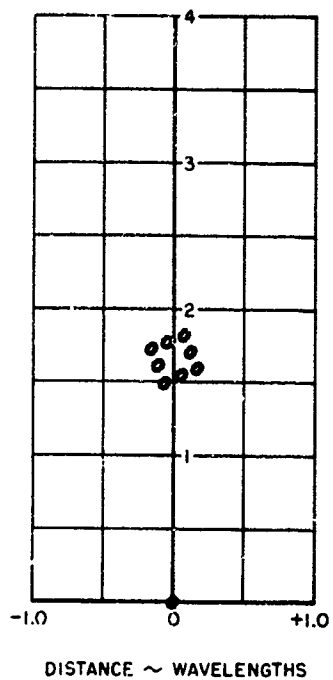
2-26

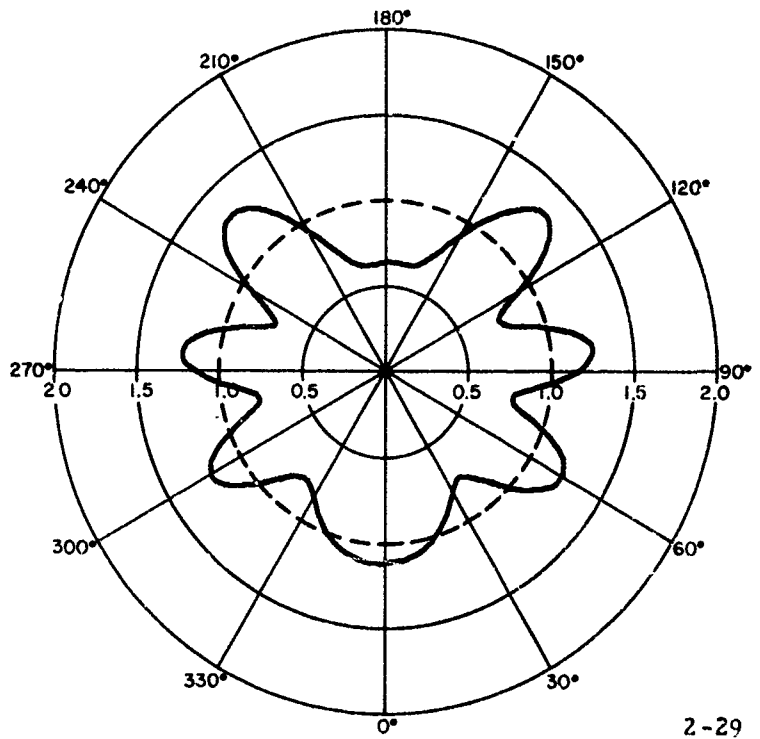
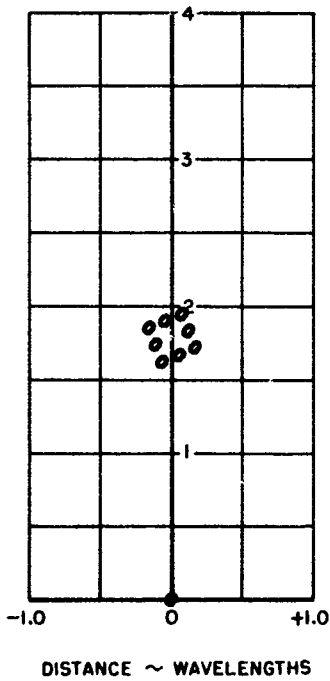
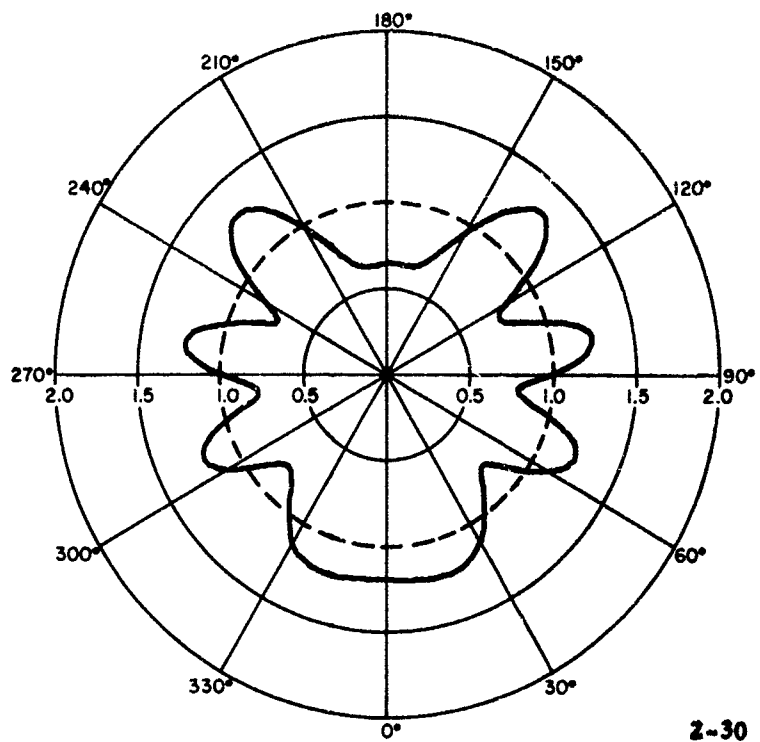
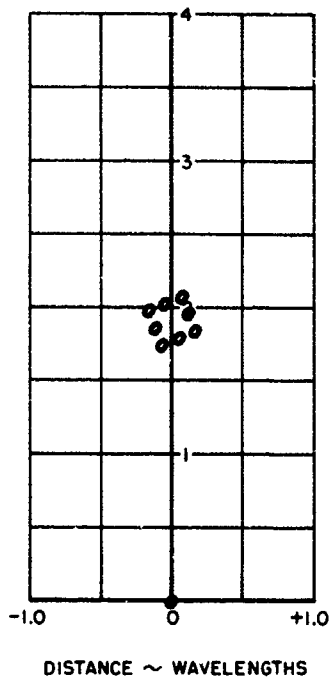


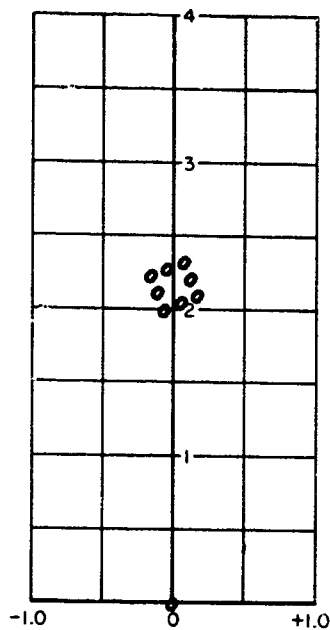
DISTANCE ~ WAVELENGTHS



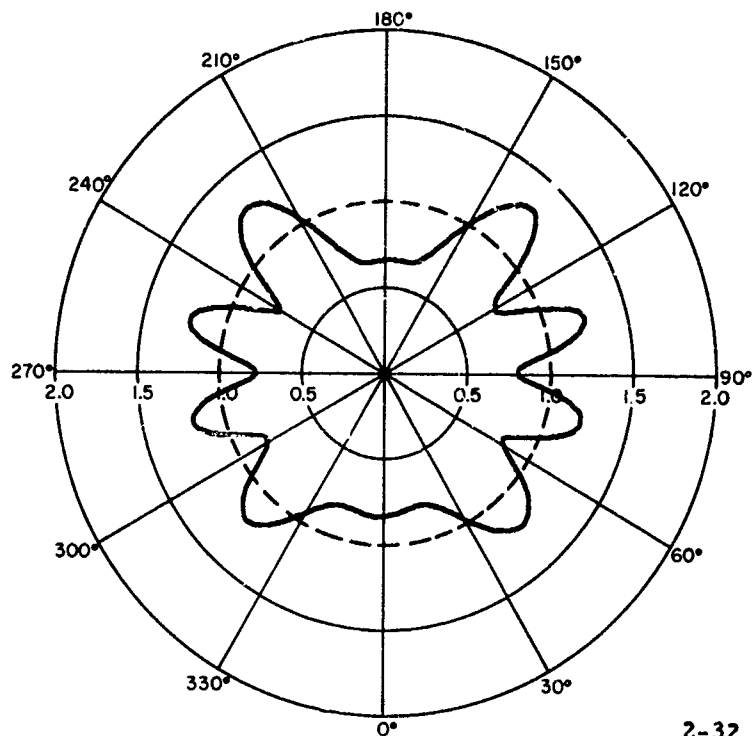
2-25



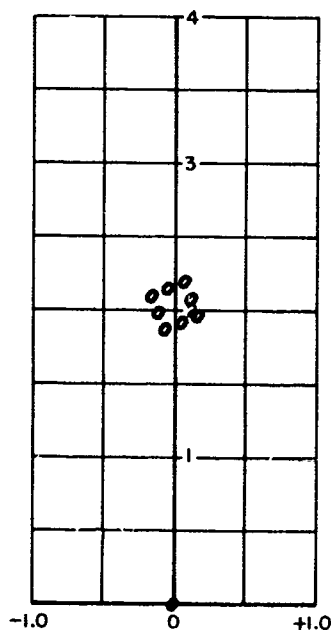




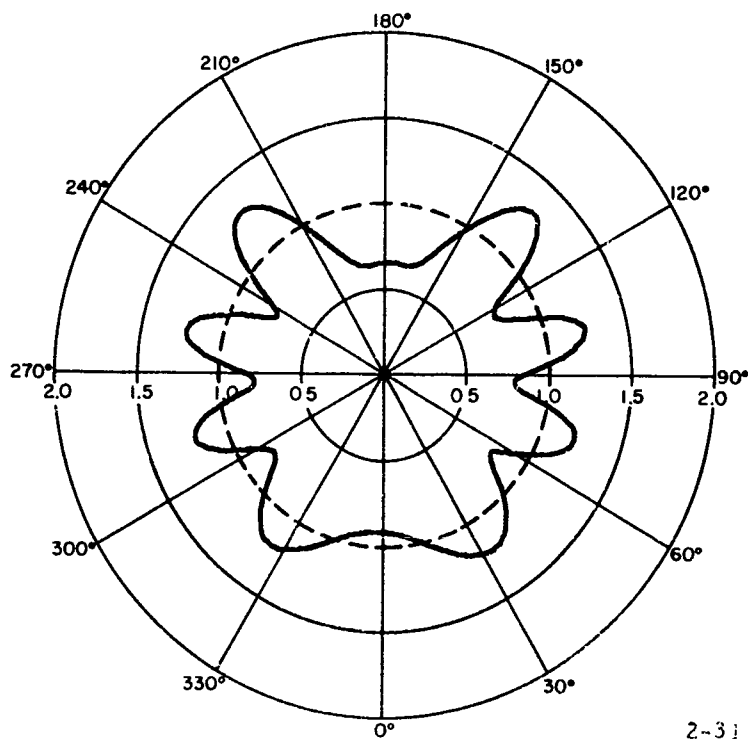
DISTANCE ~ WAVELENGTHS



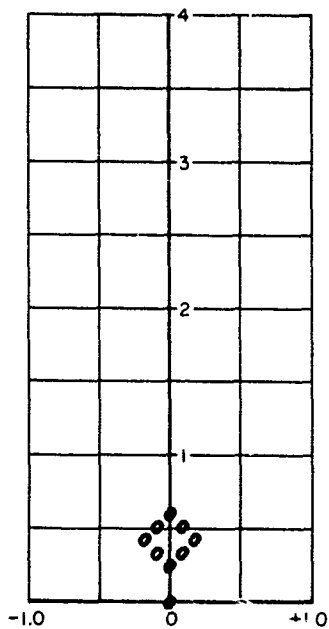
2-32



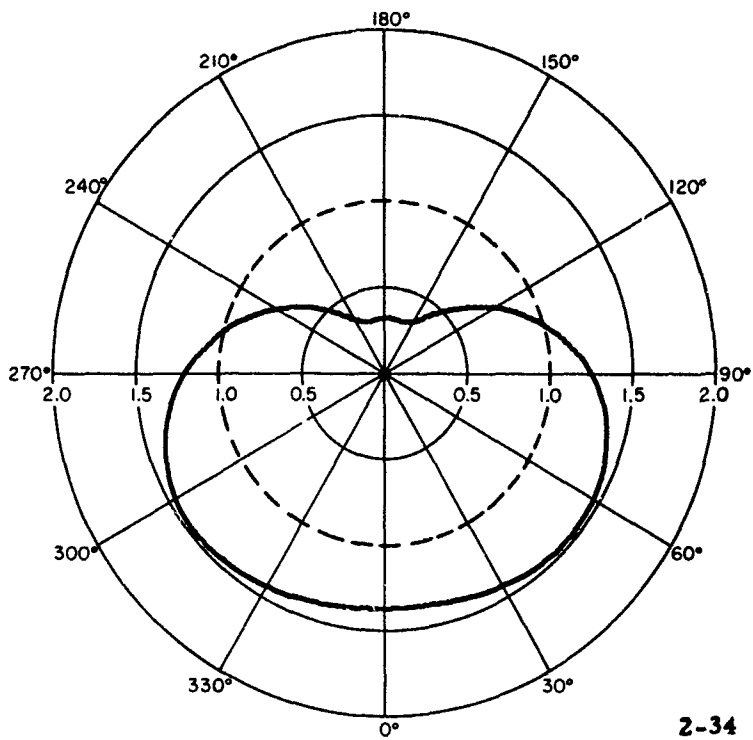
DISTANCE ~ WAVELENGTHS



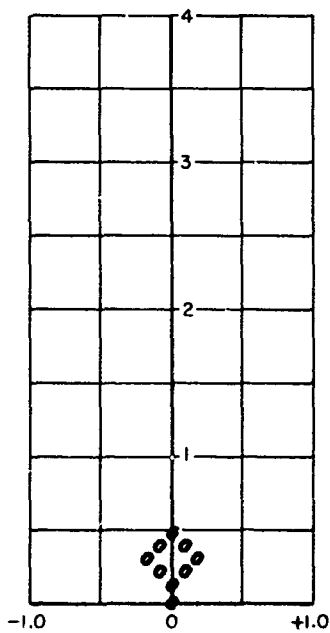
2-31



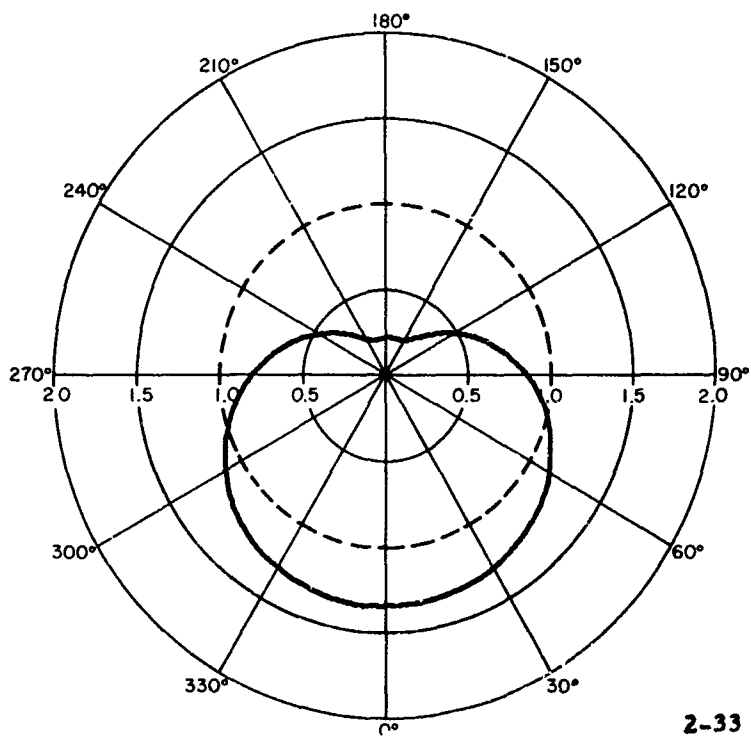
DISTANCE ~ WAVELENGTHS



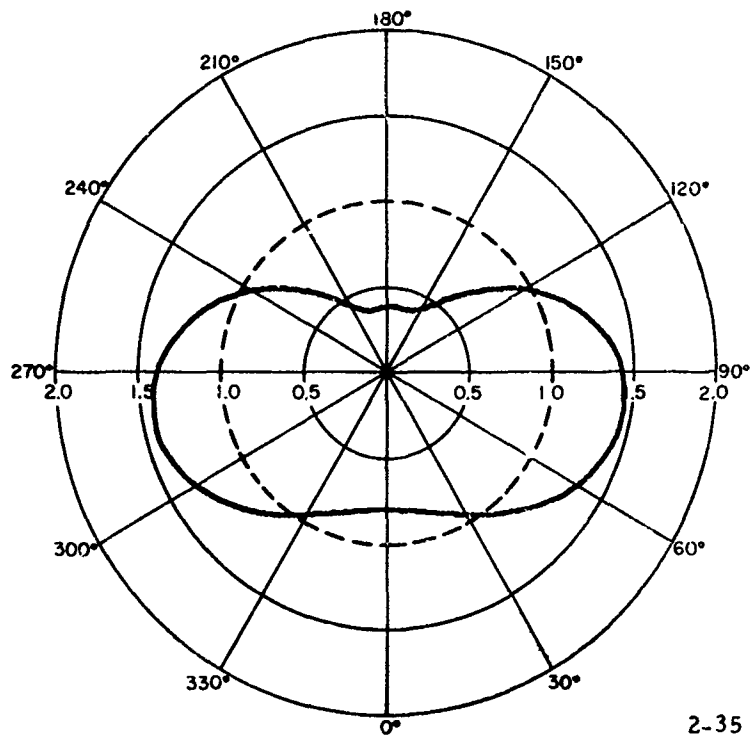
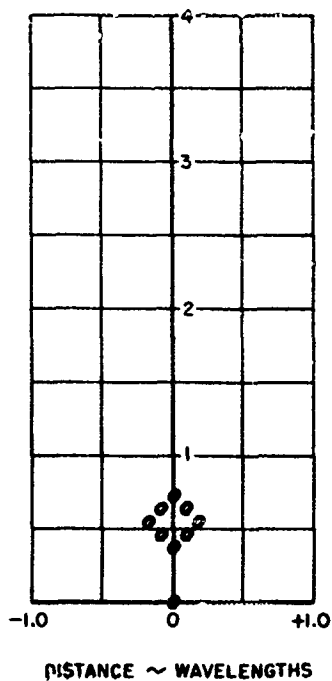
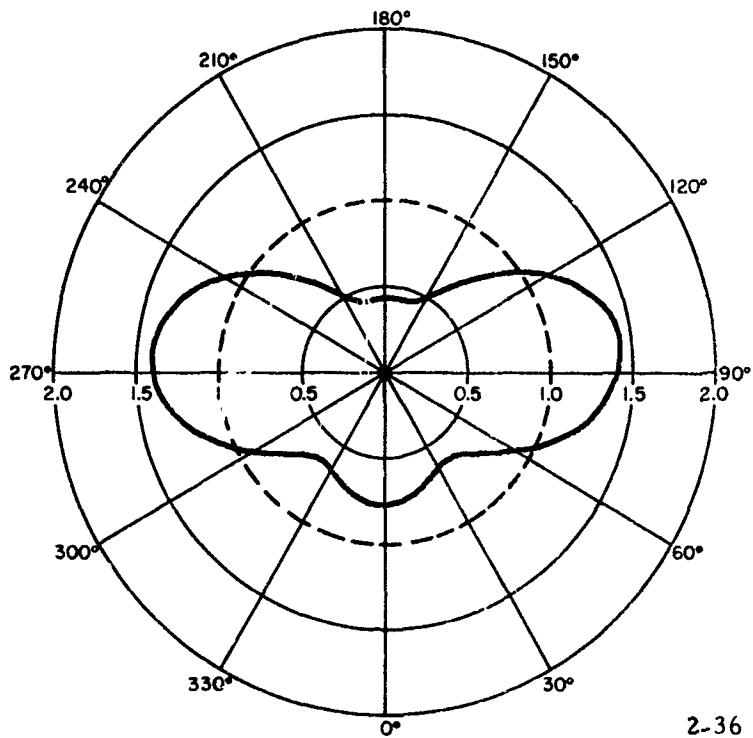
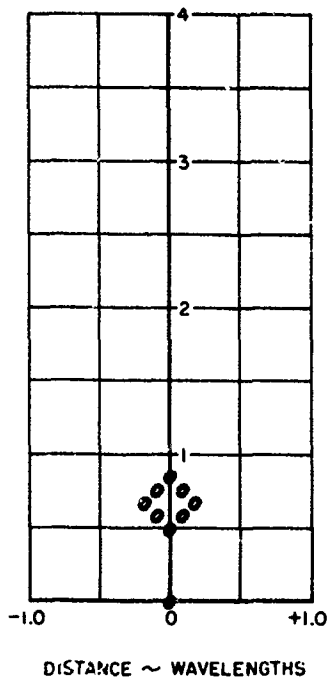
2-34

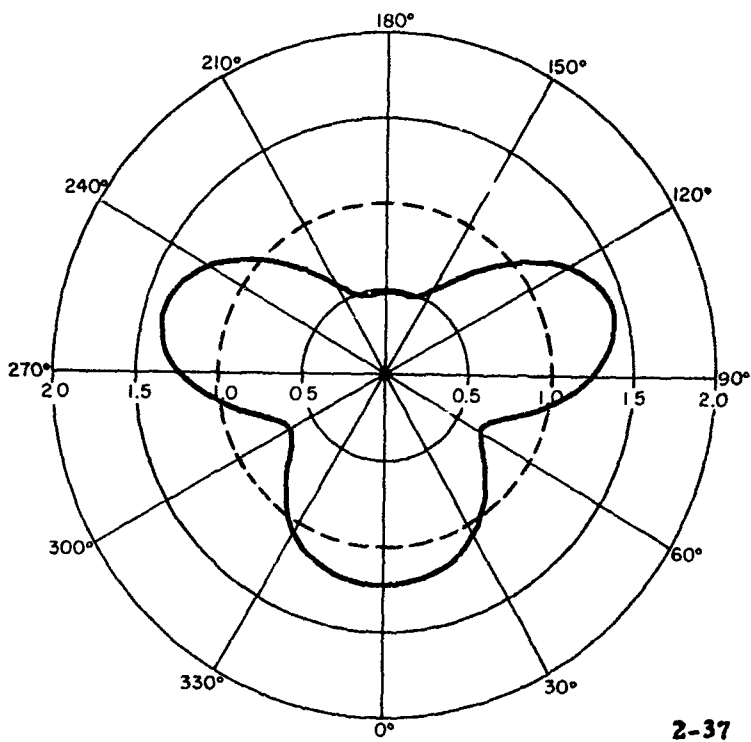
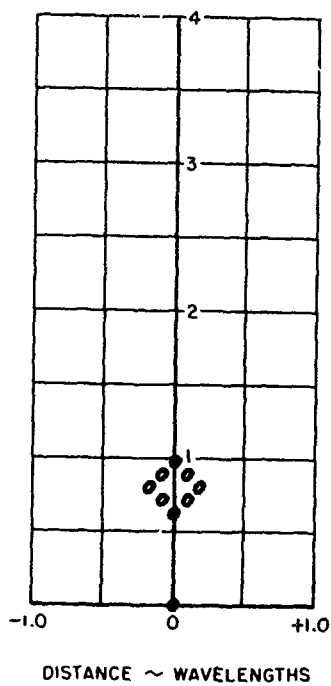
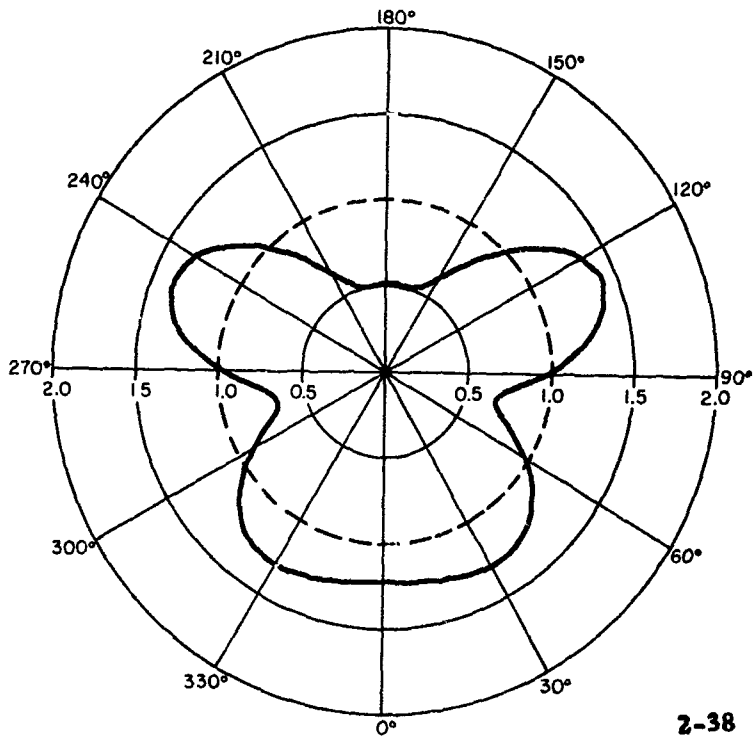
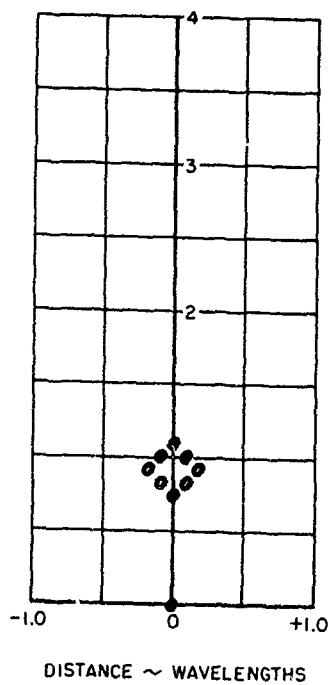


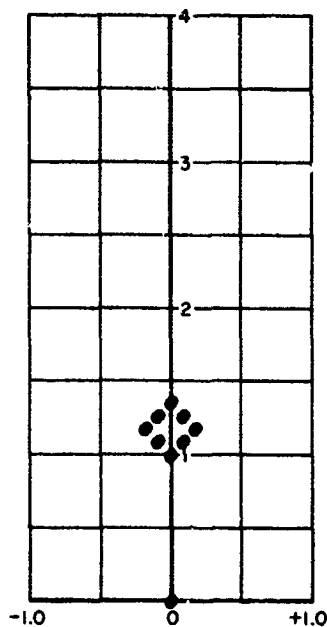
DISTANCE ~ WAVELENGTHS



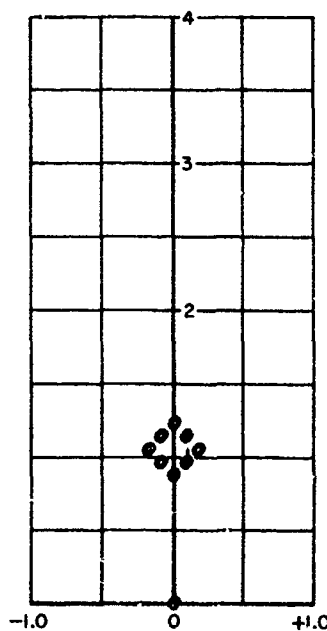
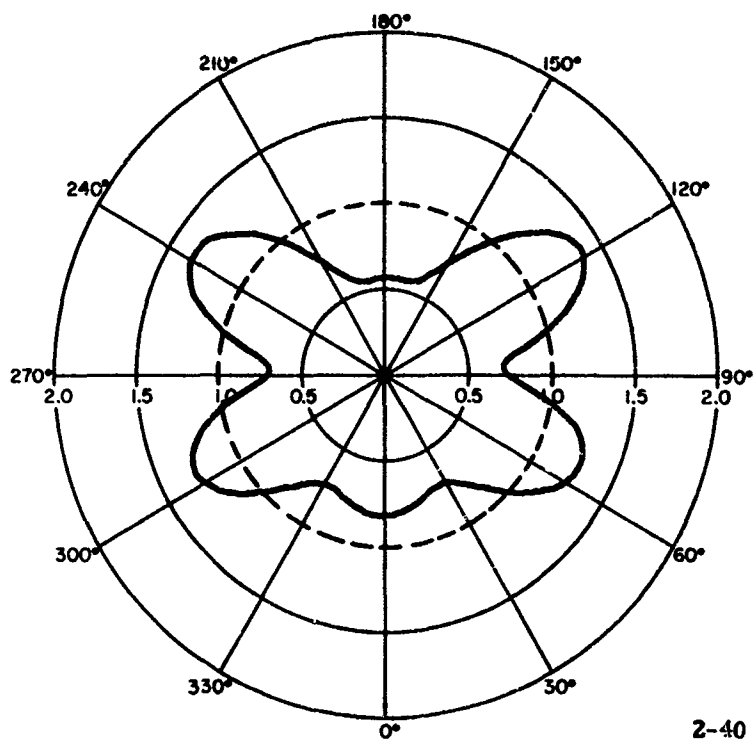
2-33



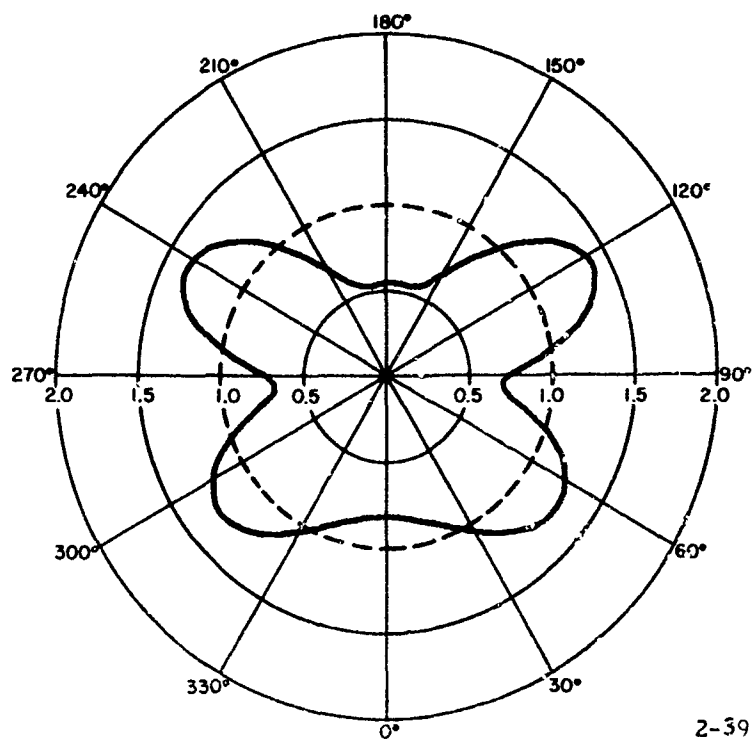


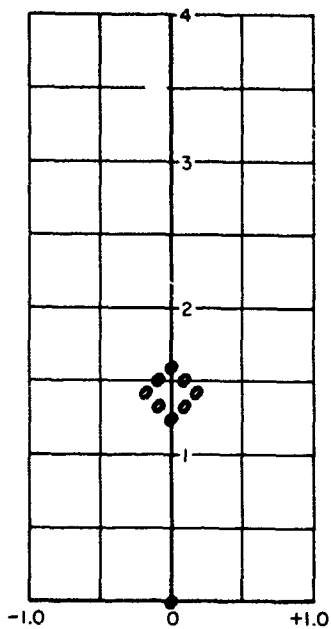


DISTANCE ~ WAVELENGTHS

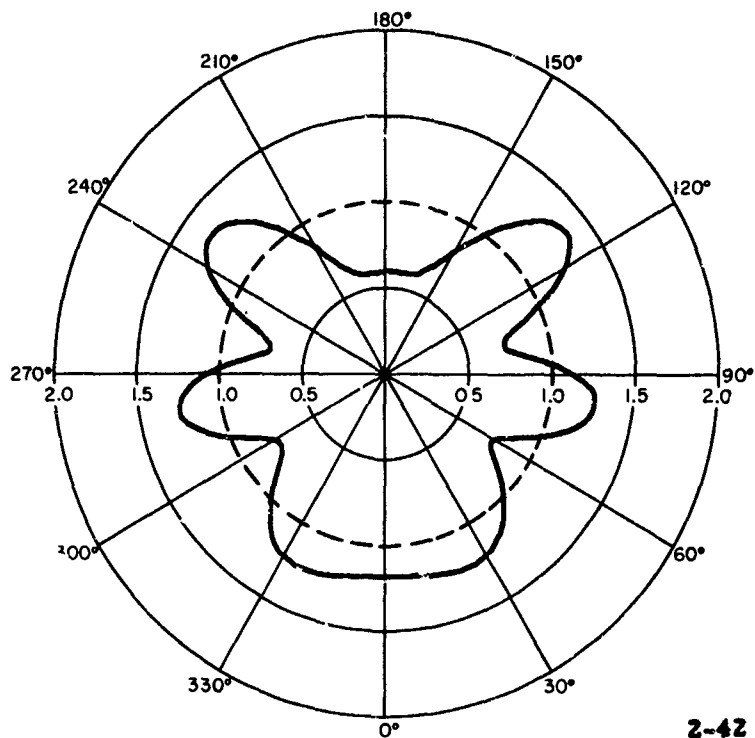


DISTANCE ~ WAVELENGTHS

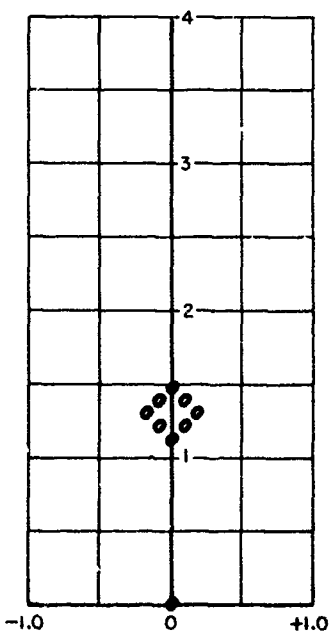




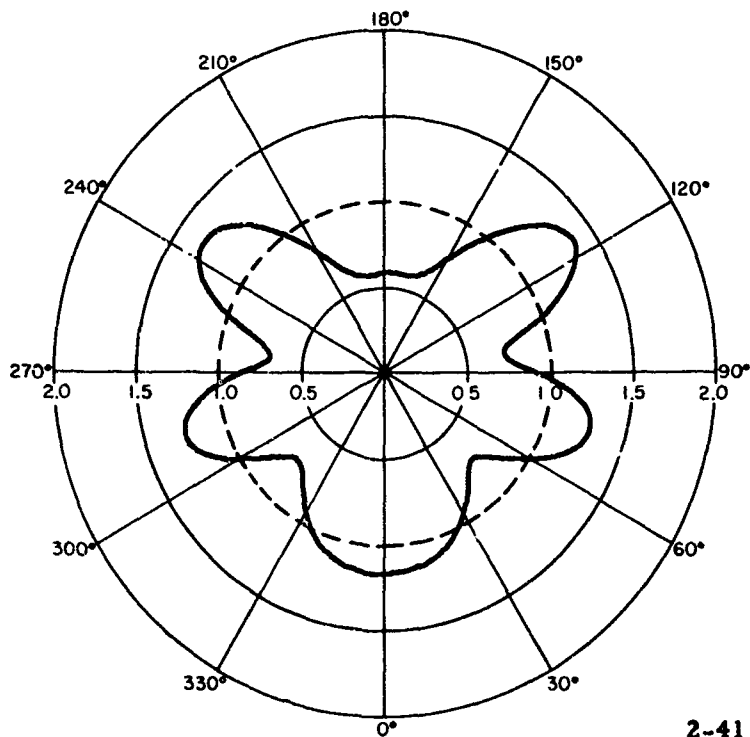
DISTANCE ~ WAVELENGTHS



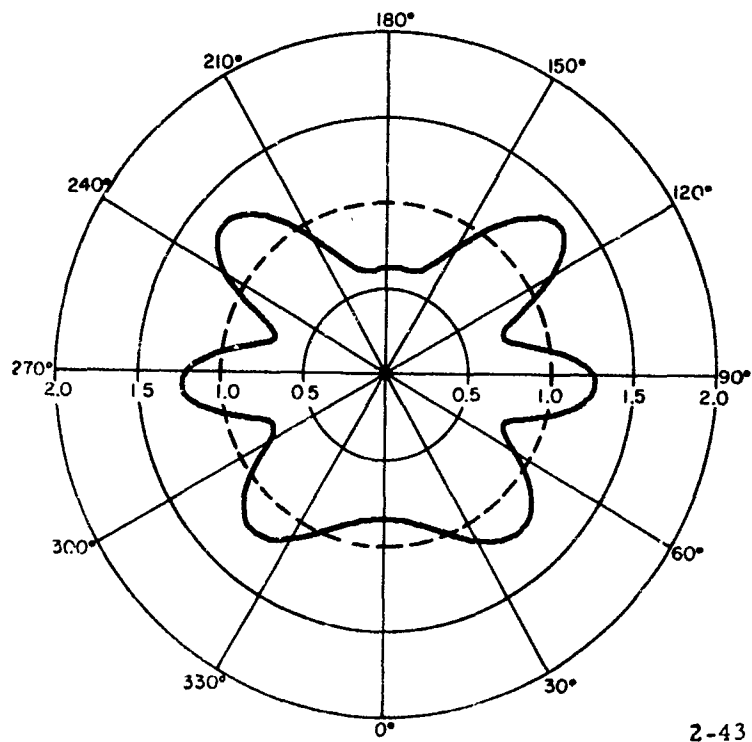
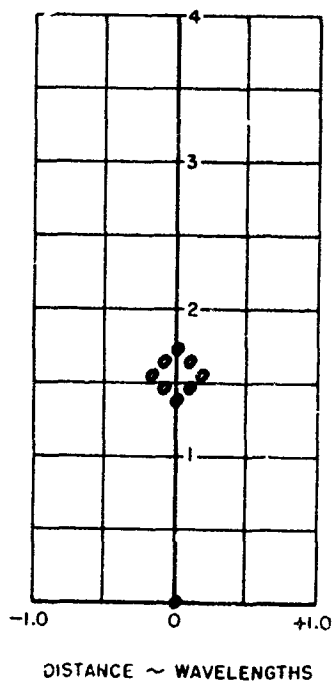
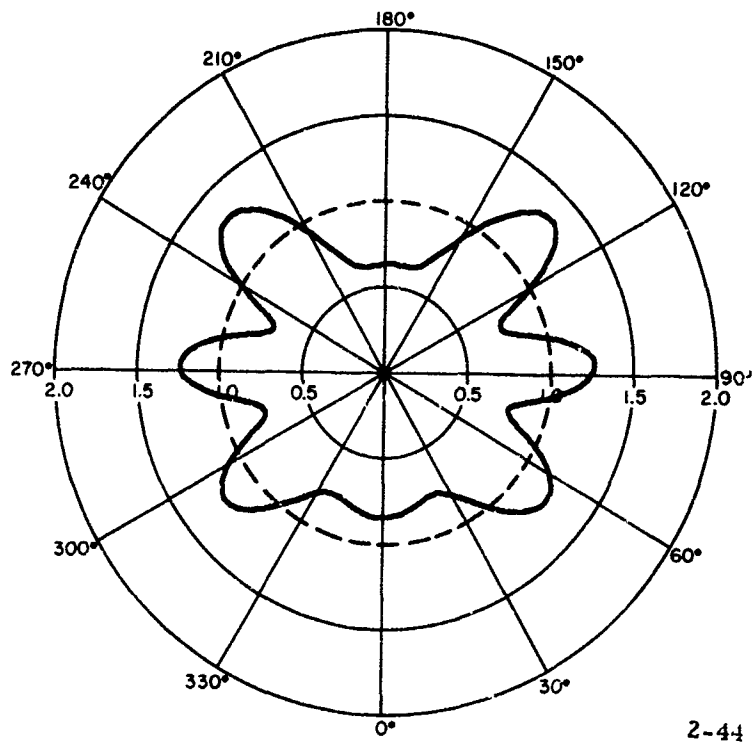
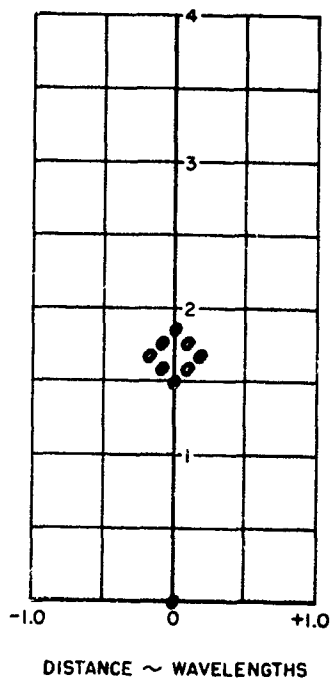
2-42

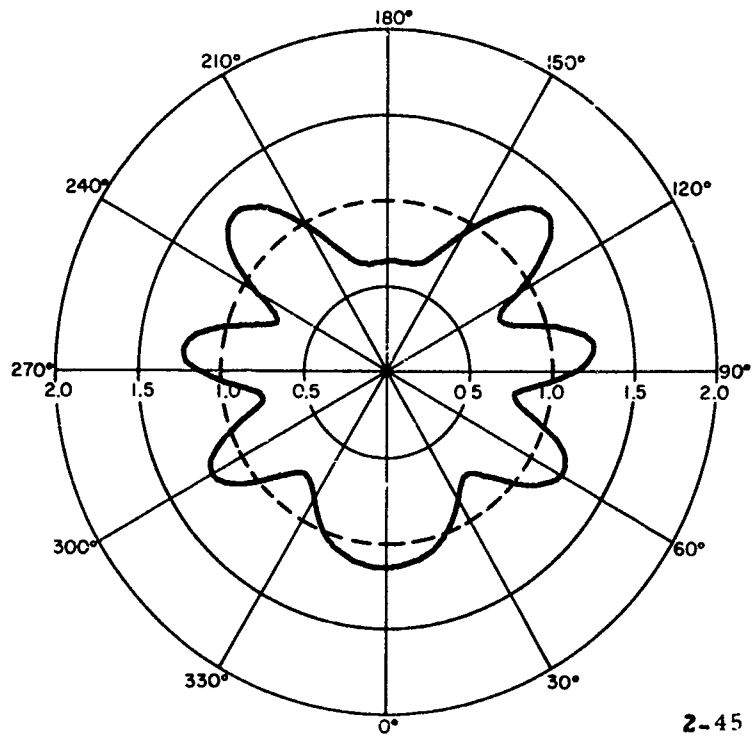
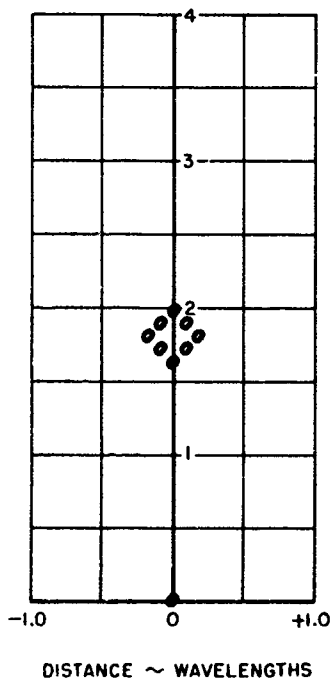
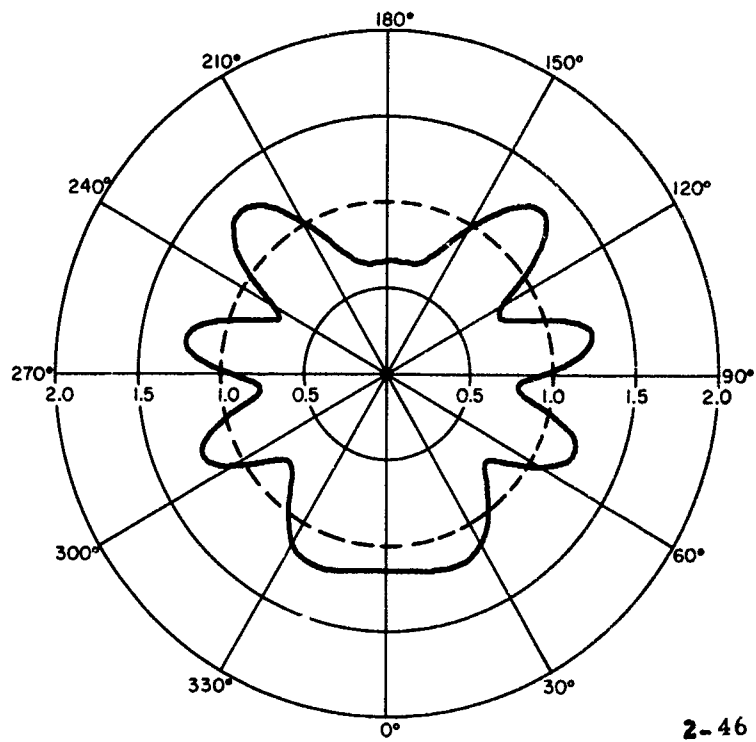
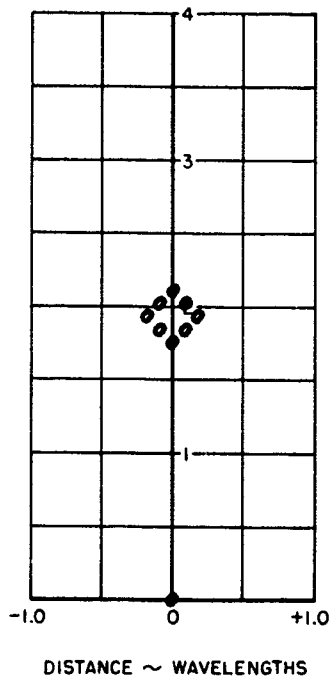


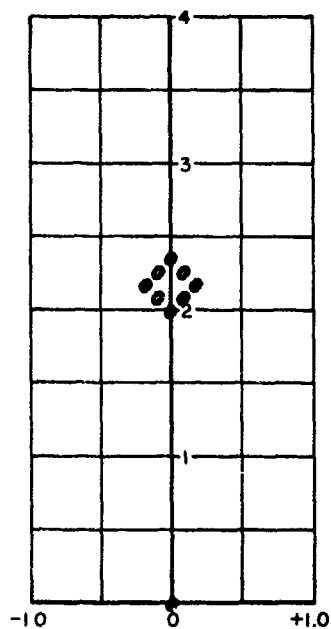
DISTANCE ~ WAVELENGTHS



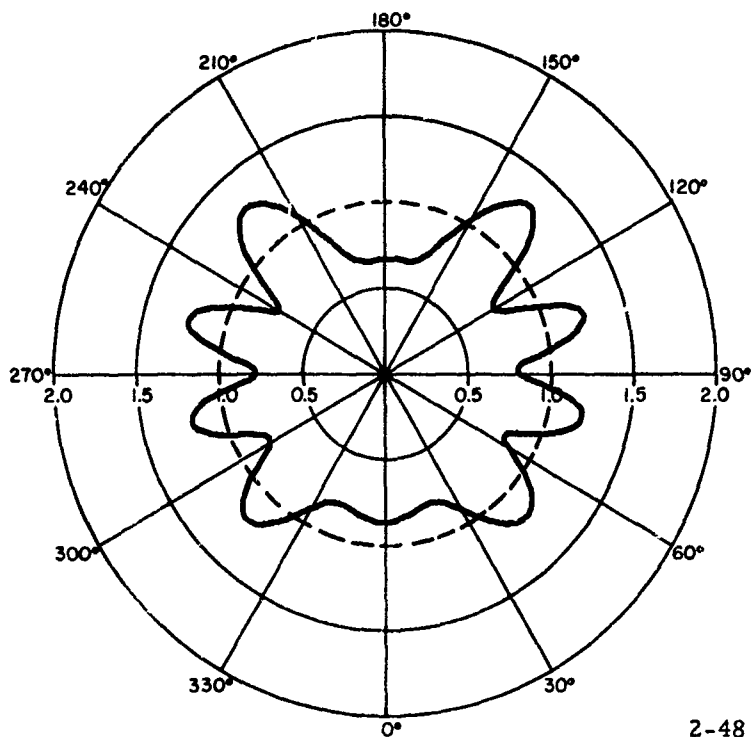
2-41



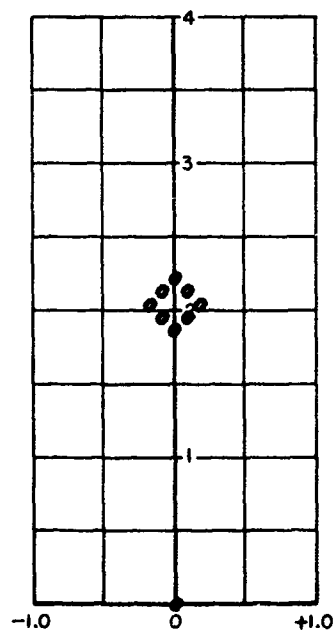




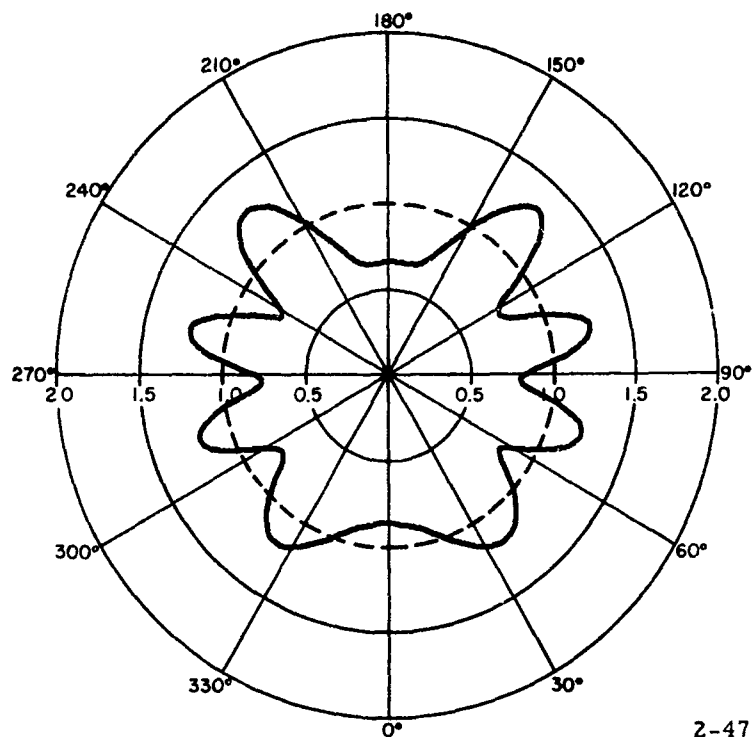
DISTANCE ~ WAVELENGTHS



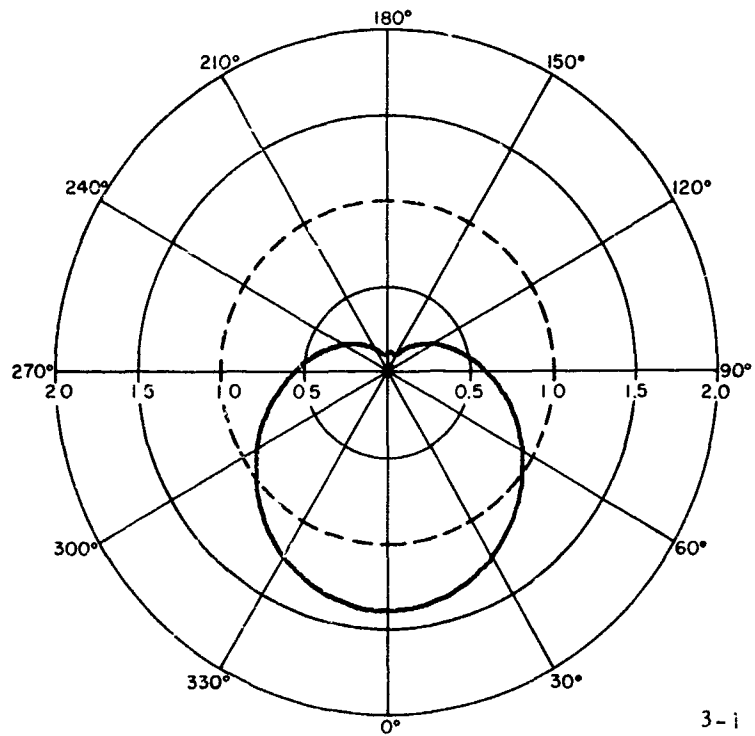
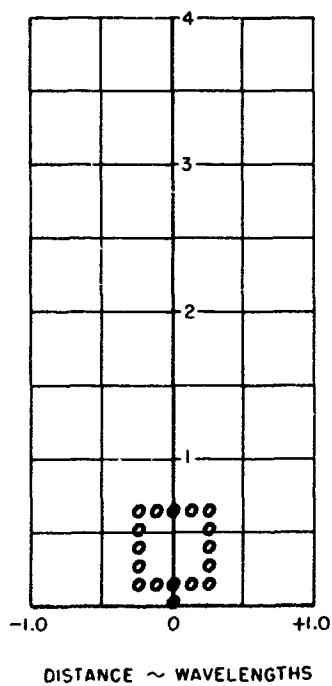
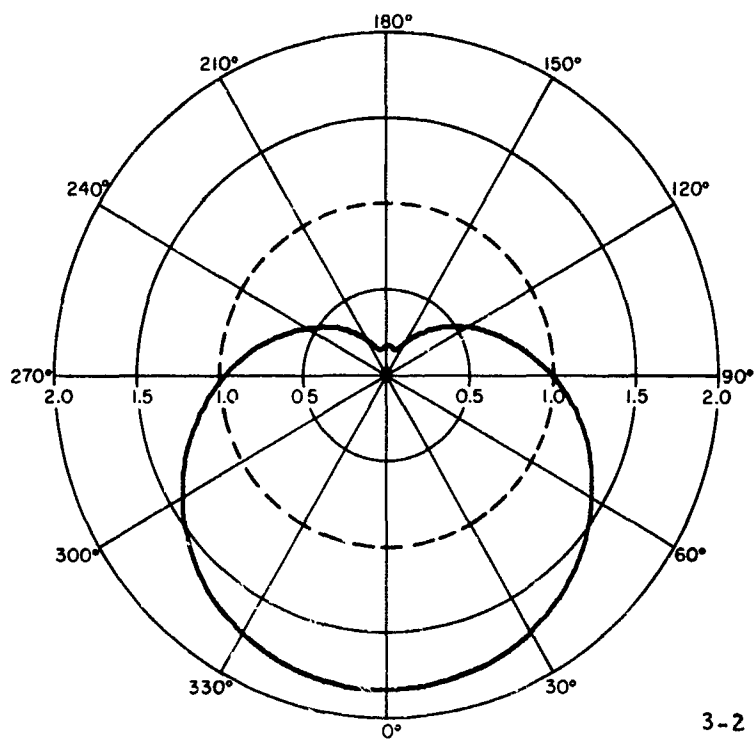
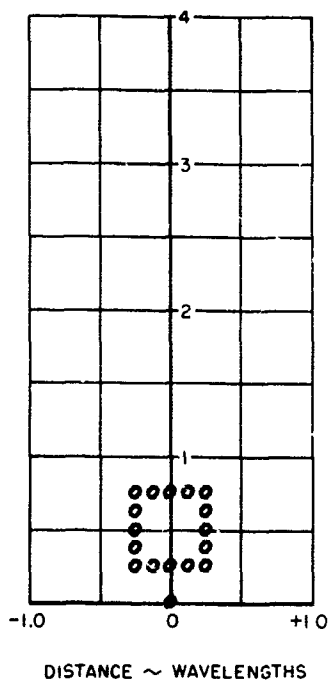
2-48

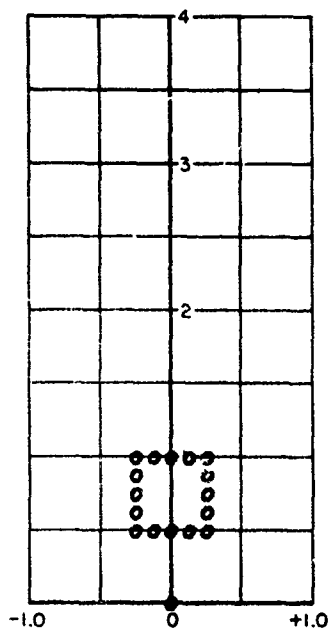


DISTANCE ~ WAVELENGTHS

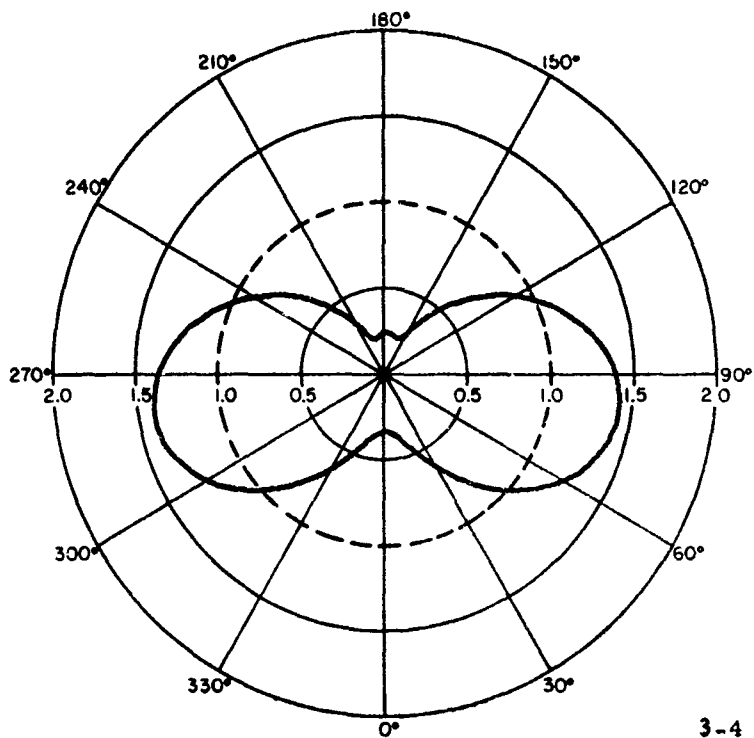


2-47

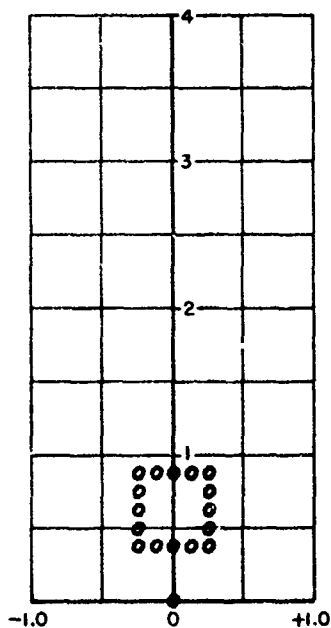




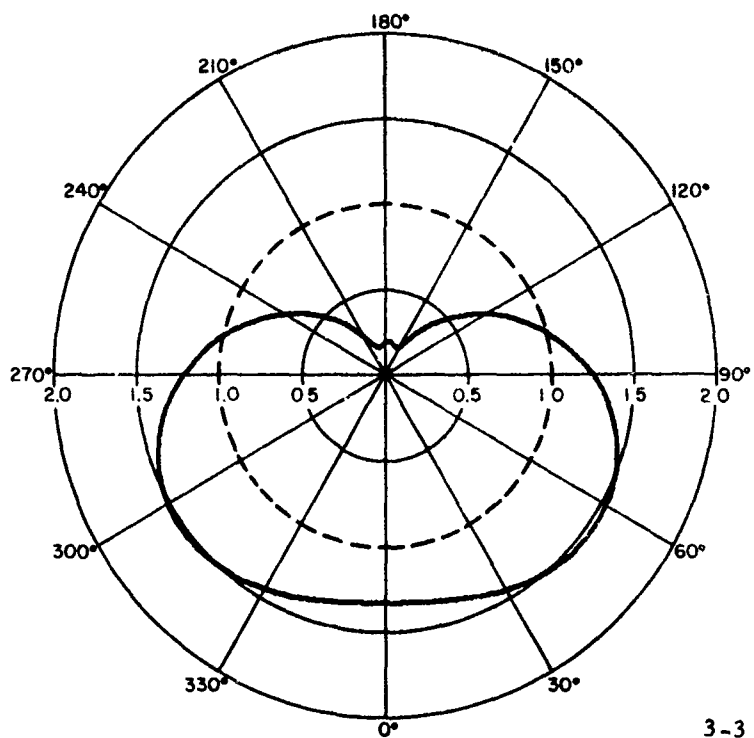
DISTANCE ~ WAVELENGTHS



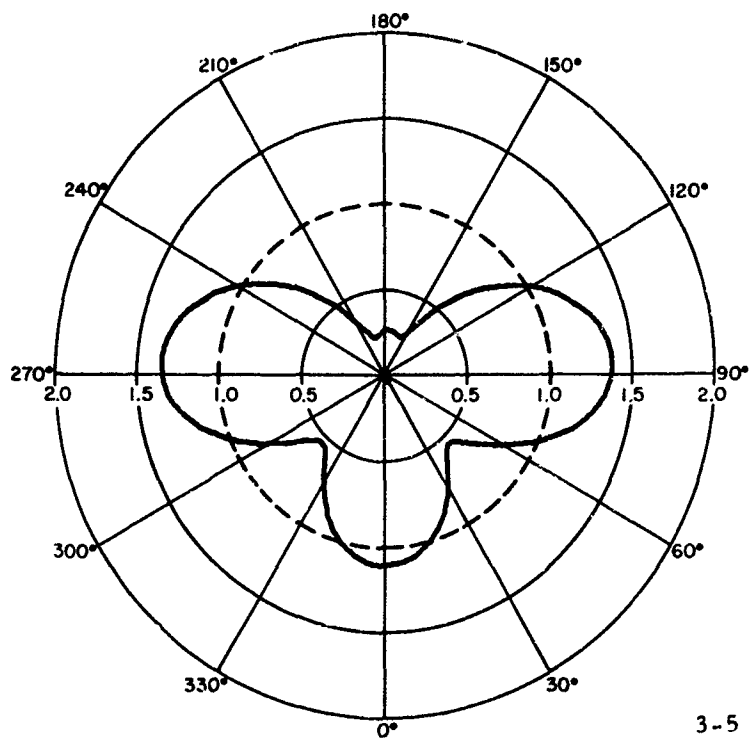
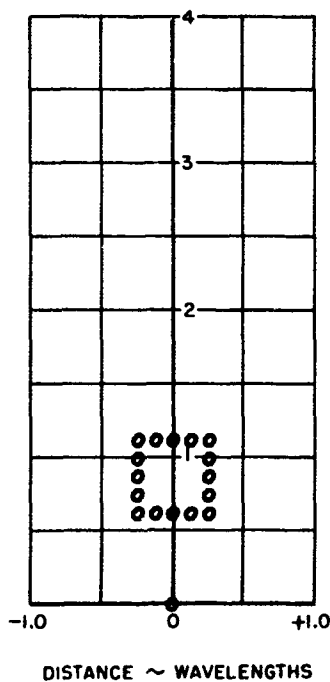
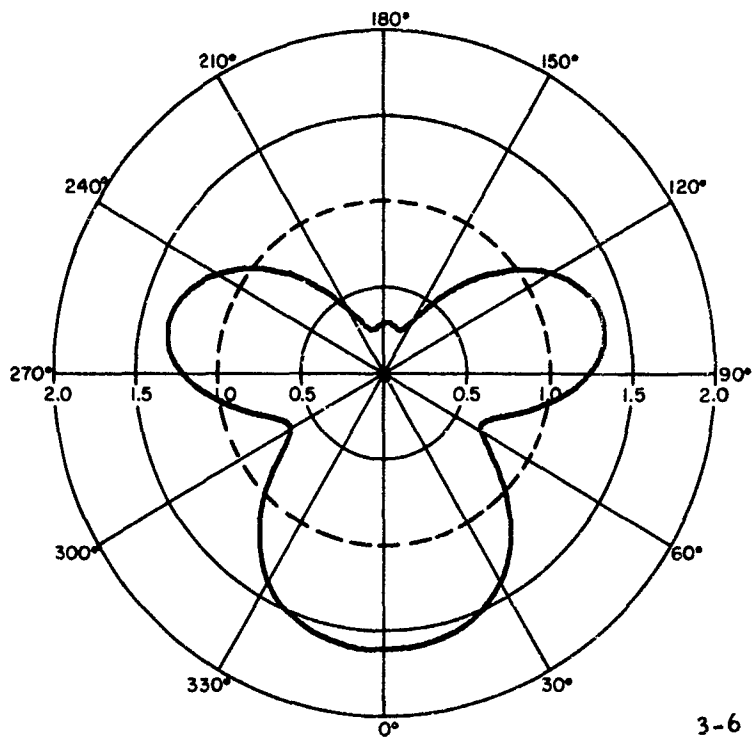
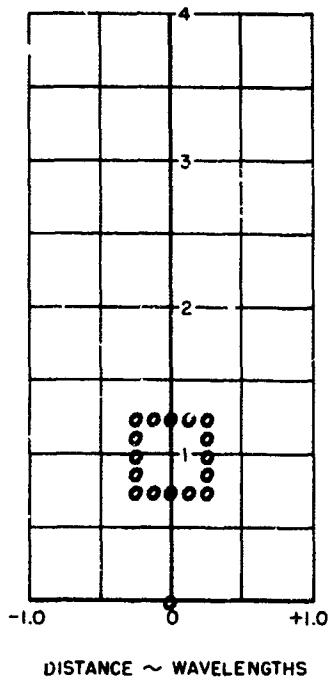
3-4

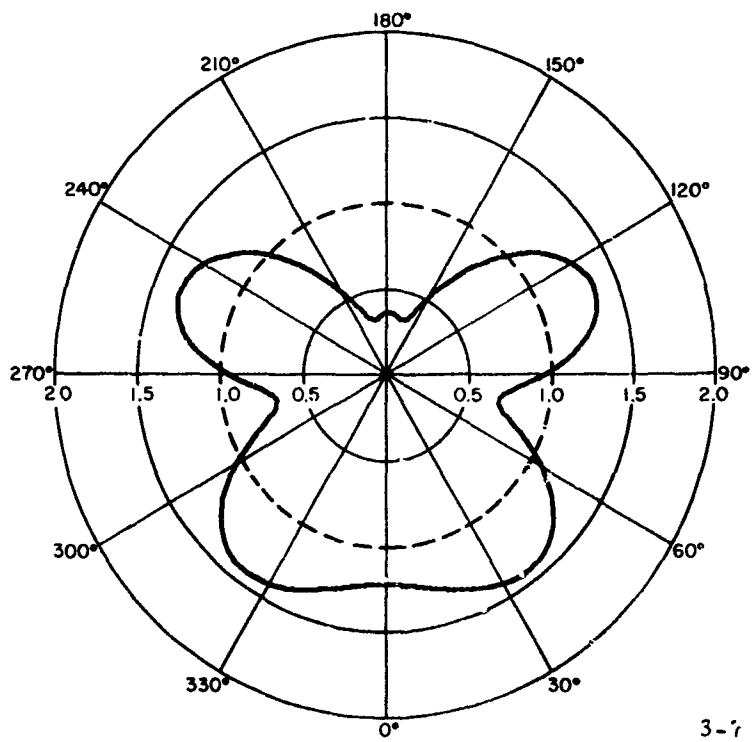
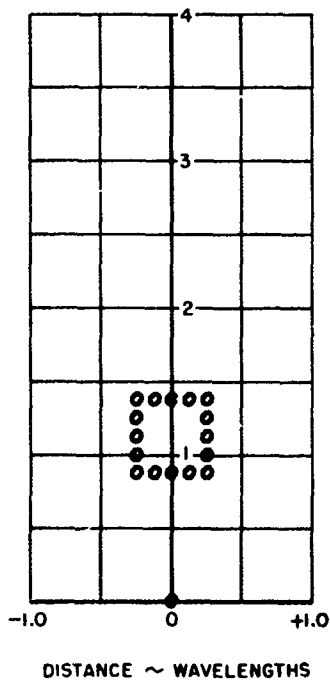
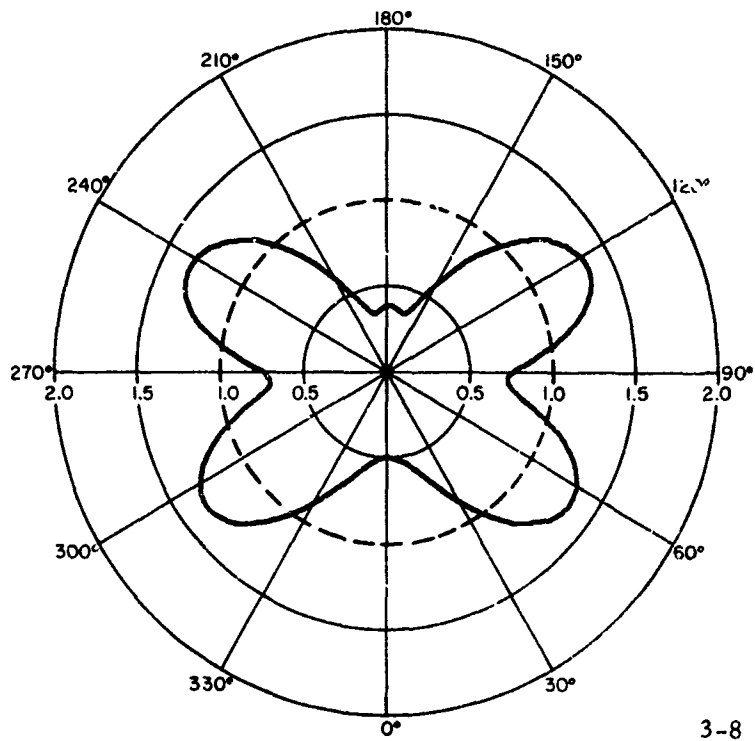
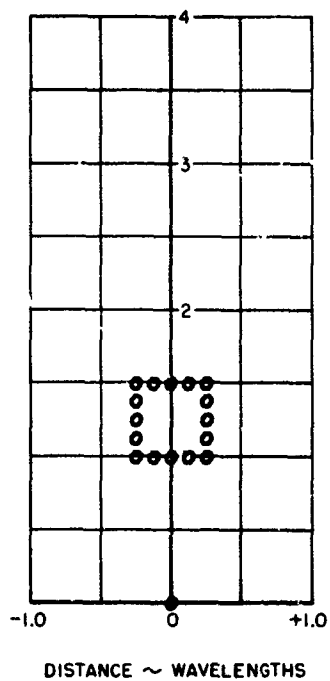


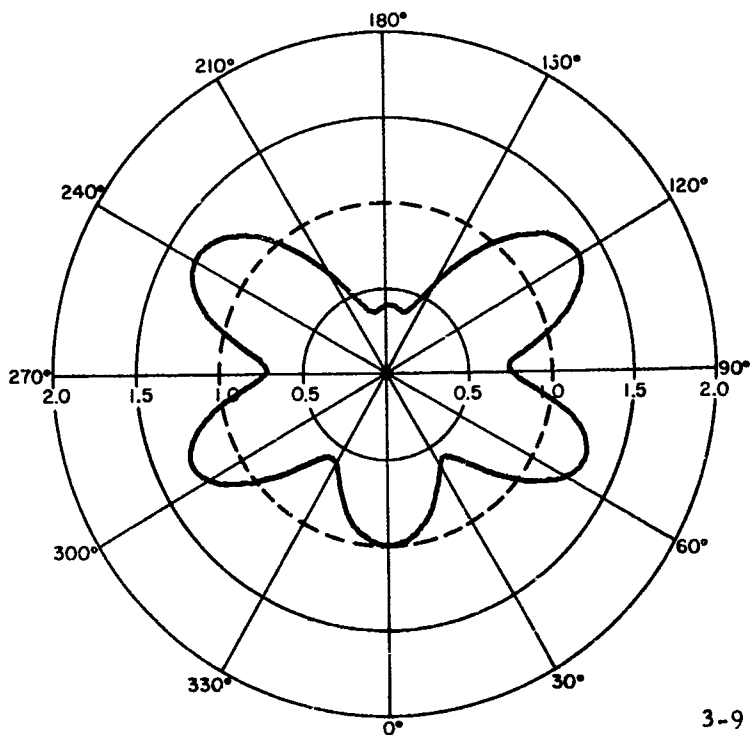
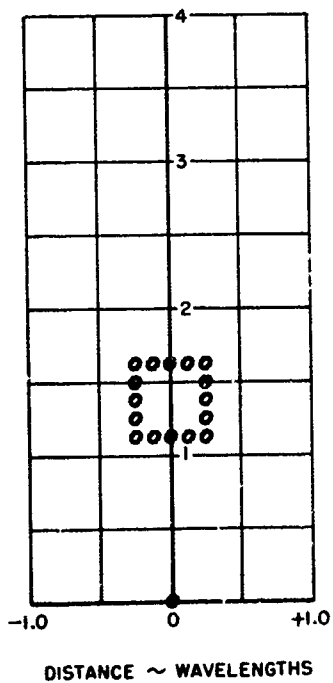
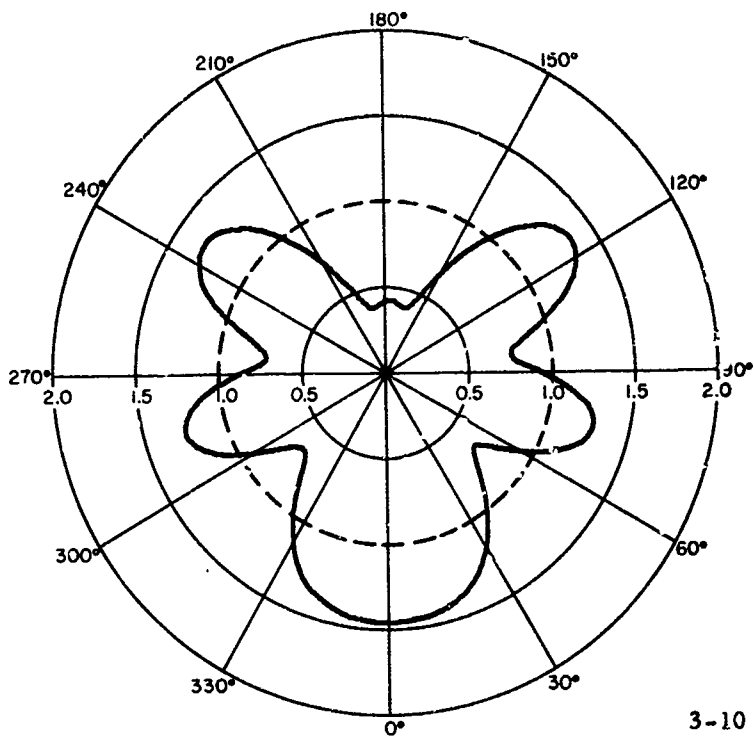
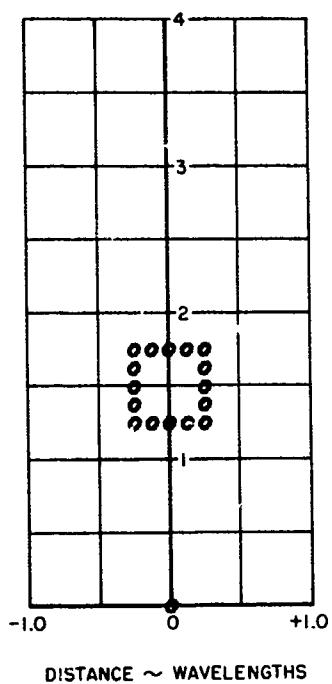
DISTANCE ~ WAVELENGTHS

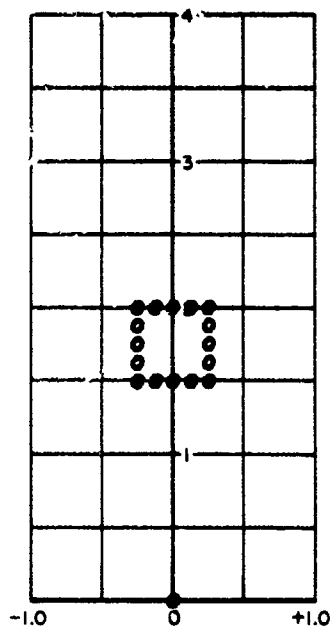


3-3

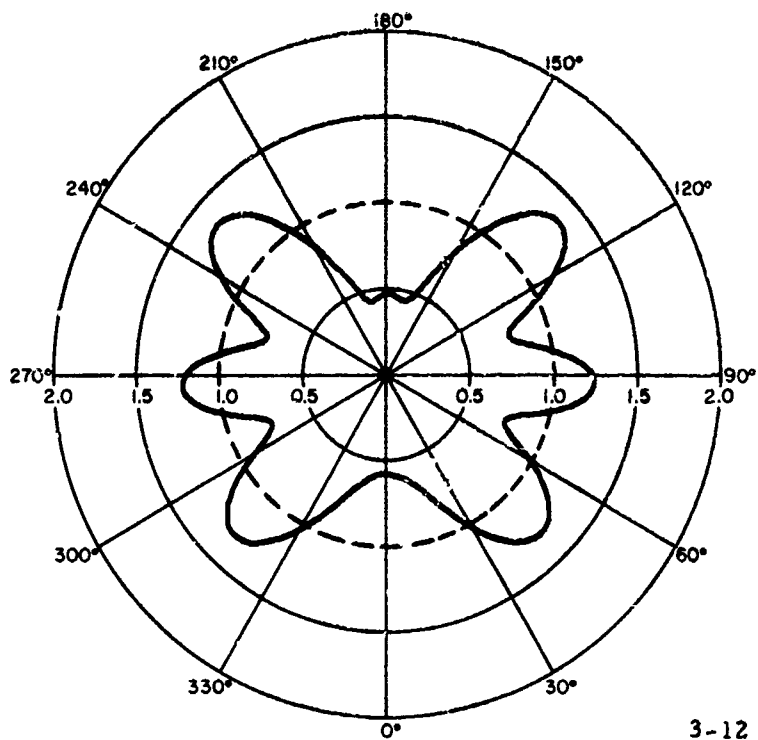




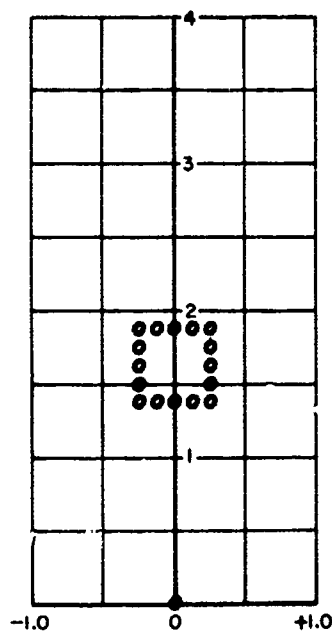




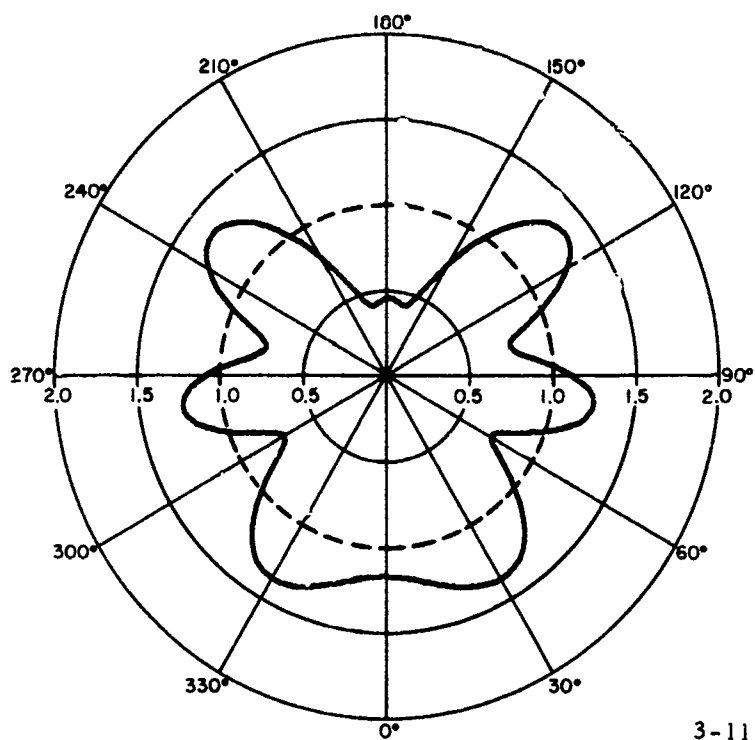
DISTANCE ~ WAVELENGTHS



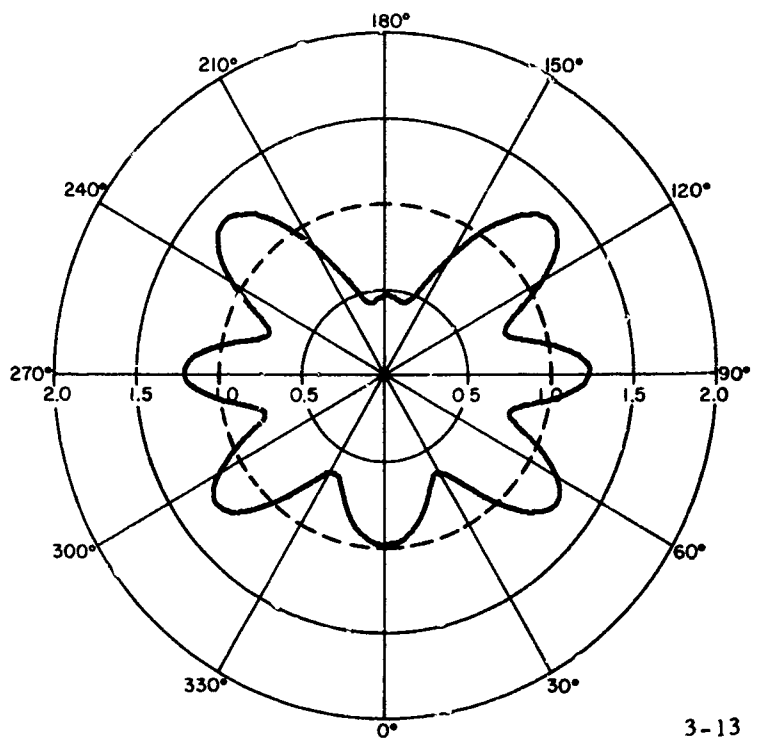
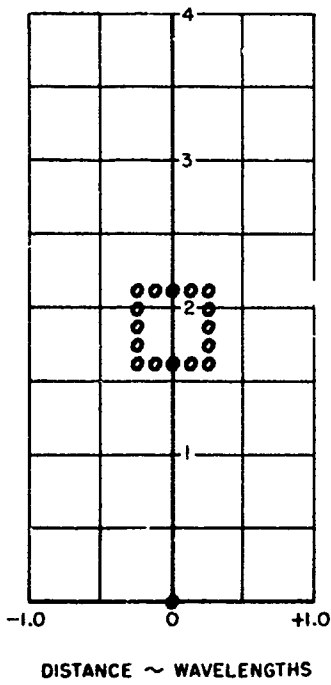
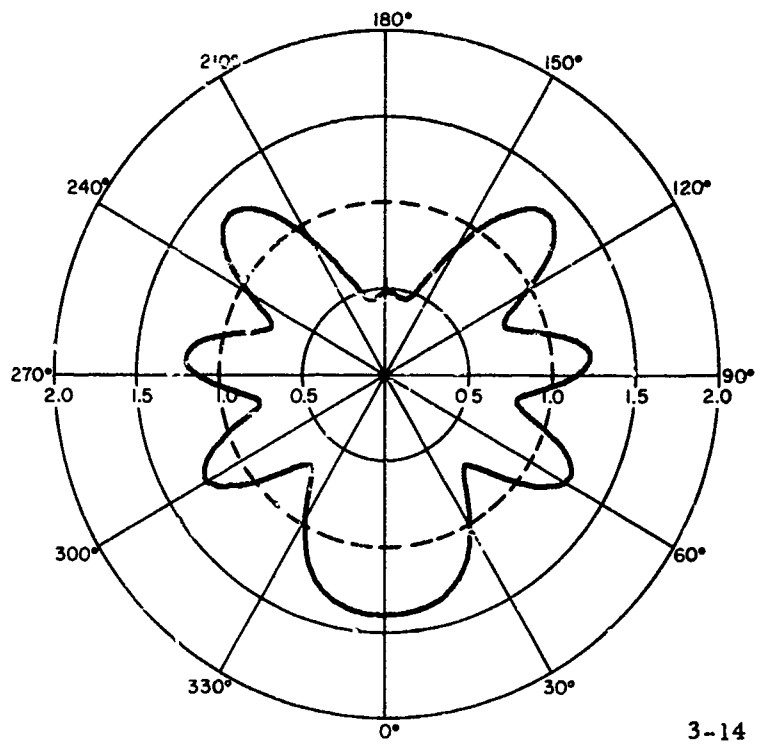
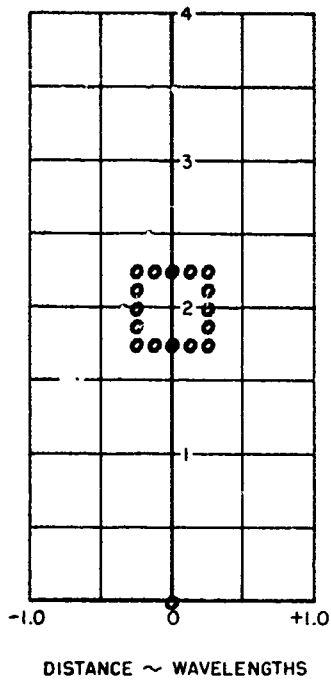
3-12

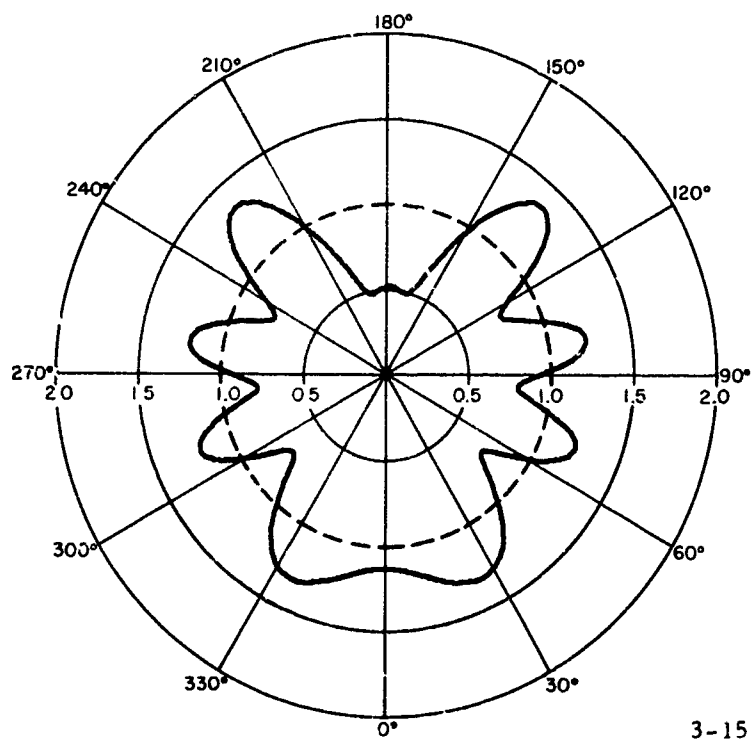
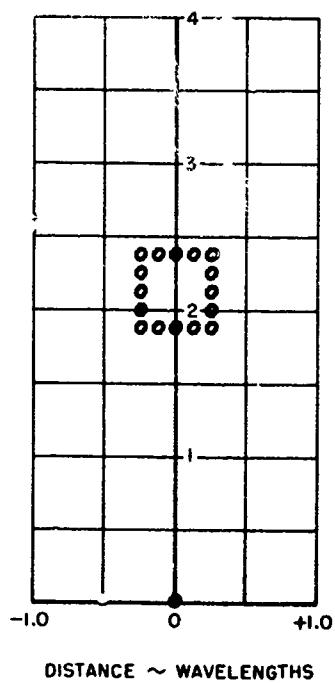
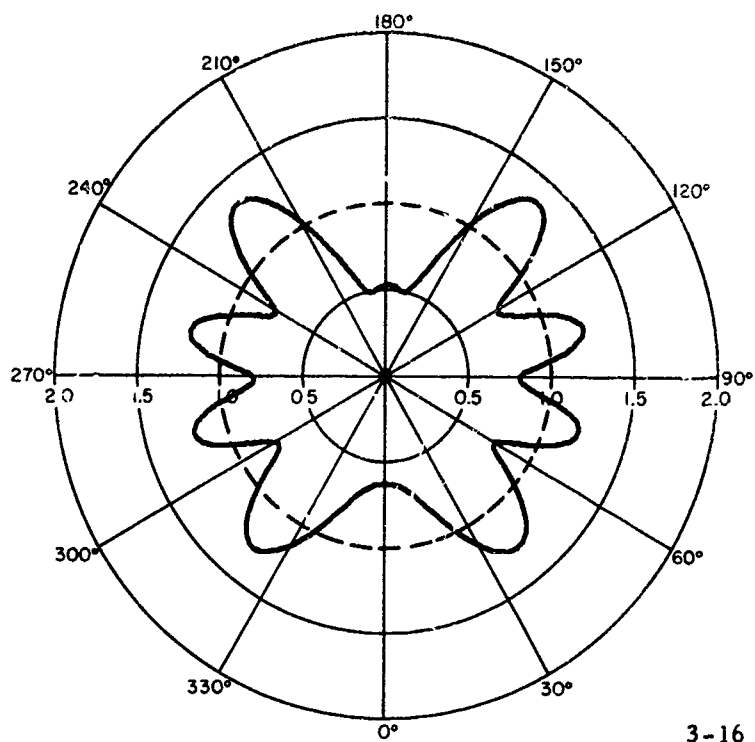
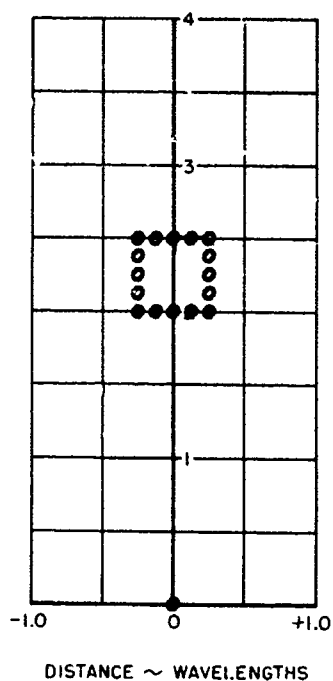


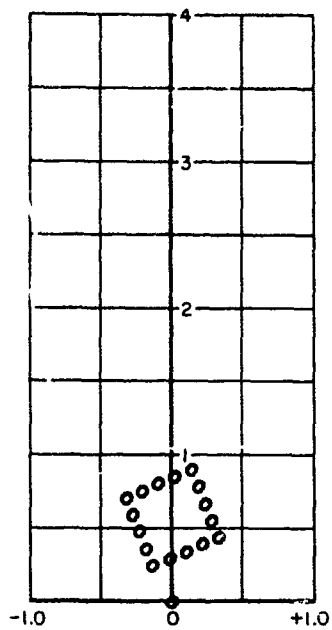
DISTANCE ~ WAVELENGTHS



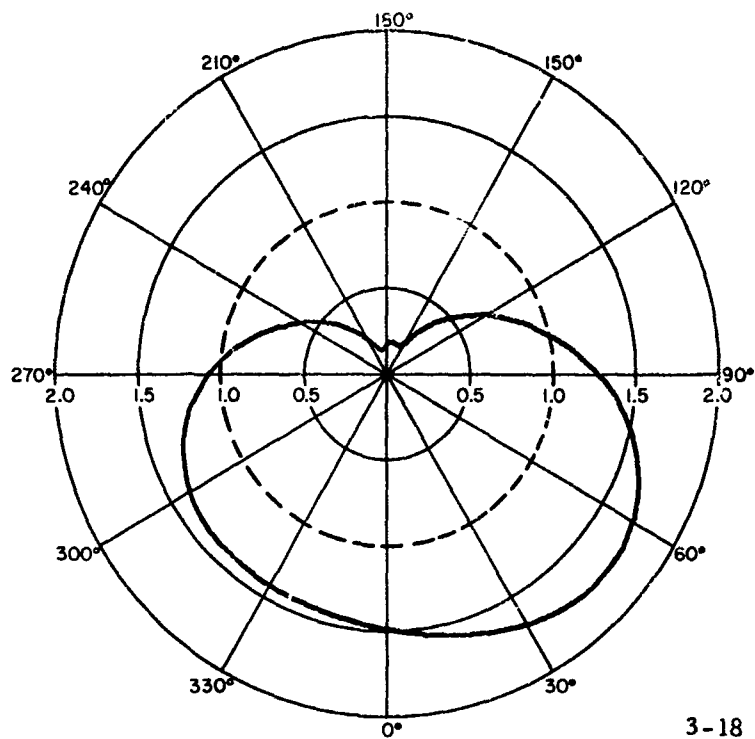
3-11



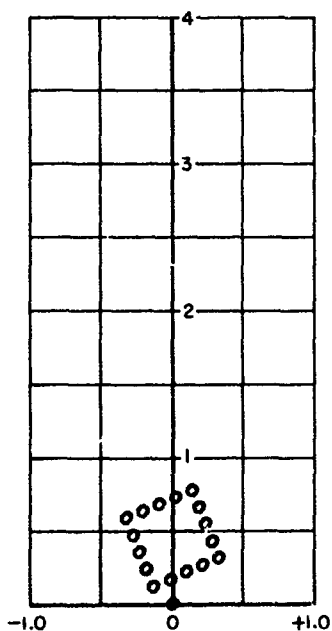




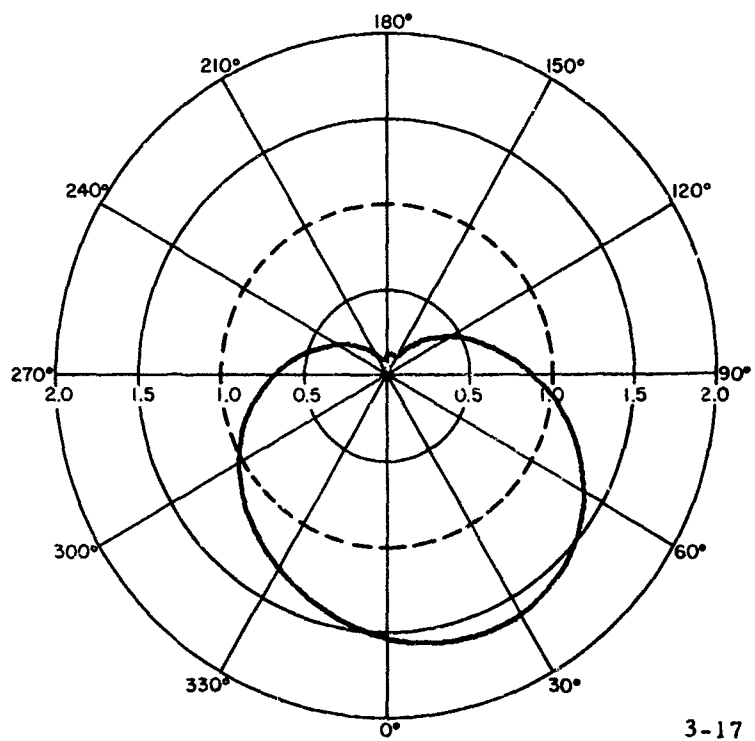
DISTANCE ~ WAVELENGTHS



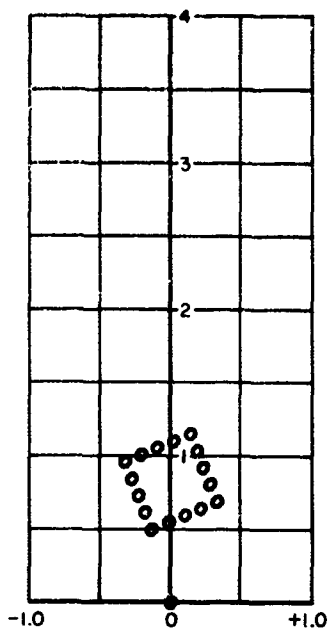
3-18



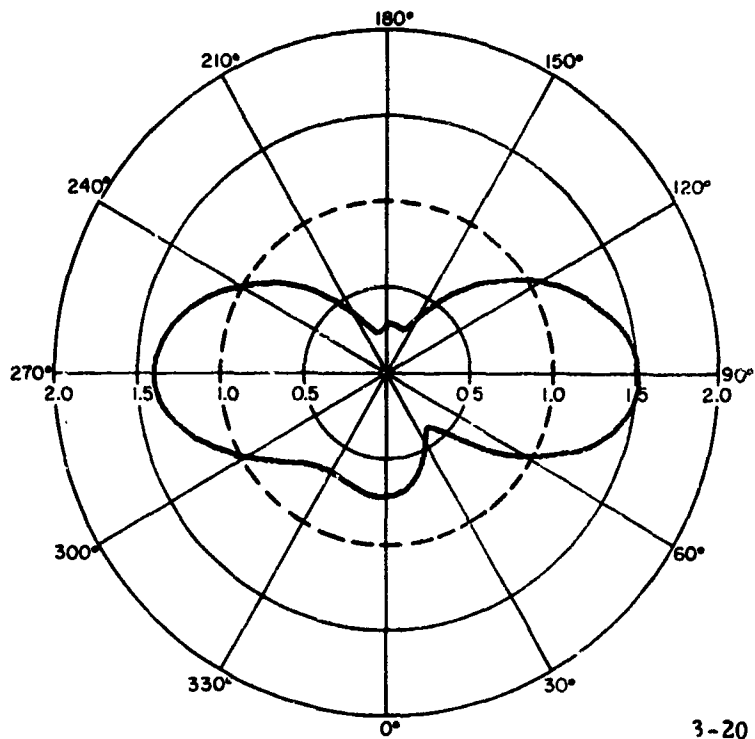
DISTANCE ~ WAVELENGTHS



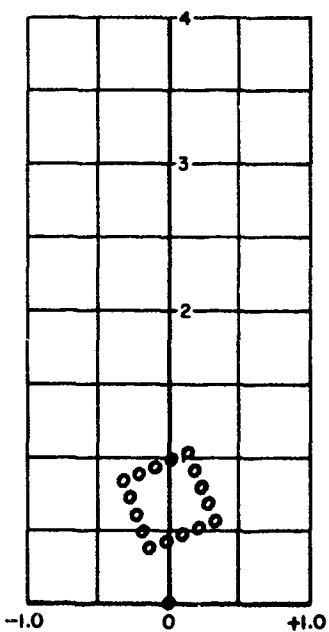
3-17



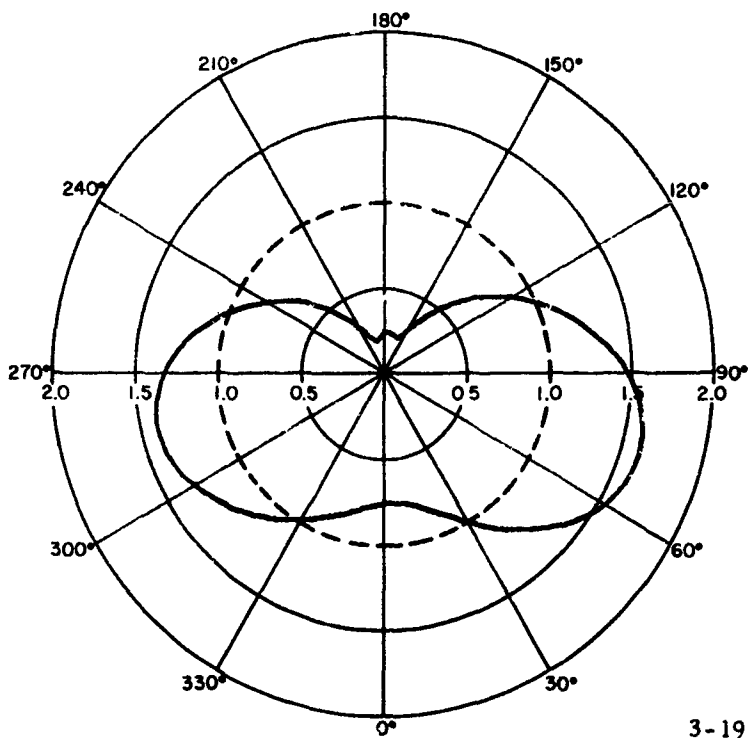
DISTANCE ~ WAVELENGTHS



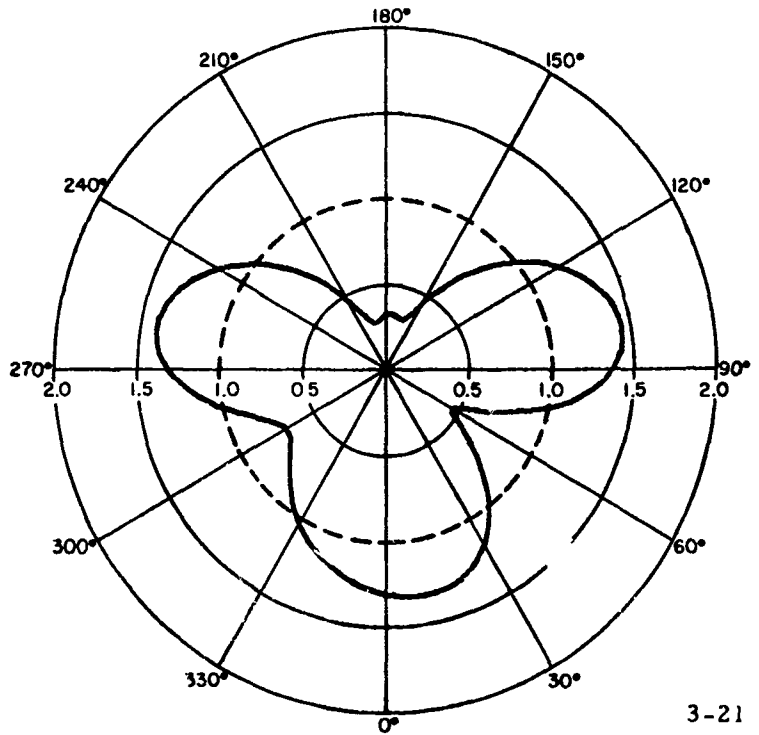
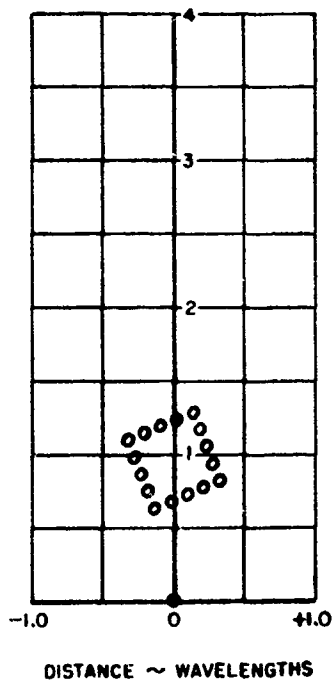
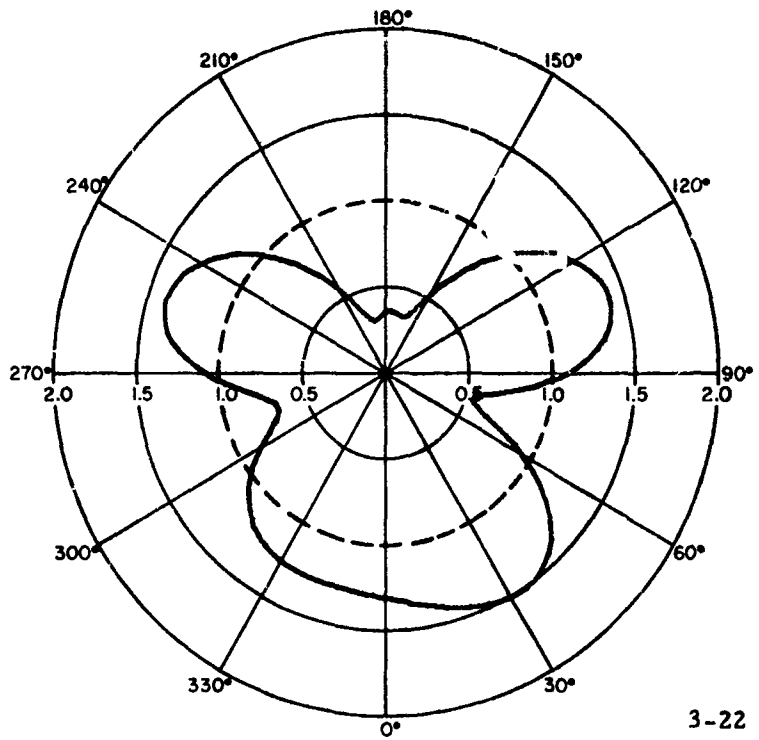
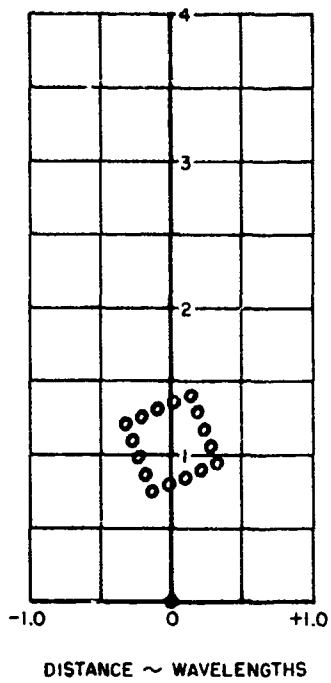
3-20

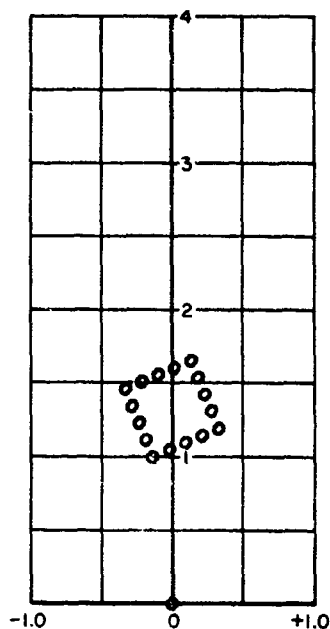


DISTANCE ~ WAVELENGTHS

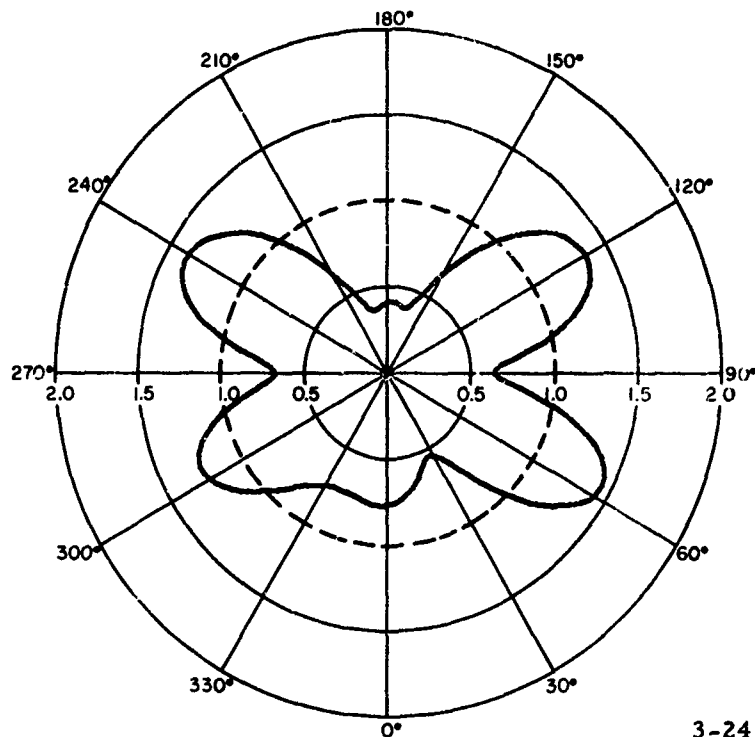


3-19

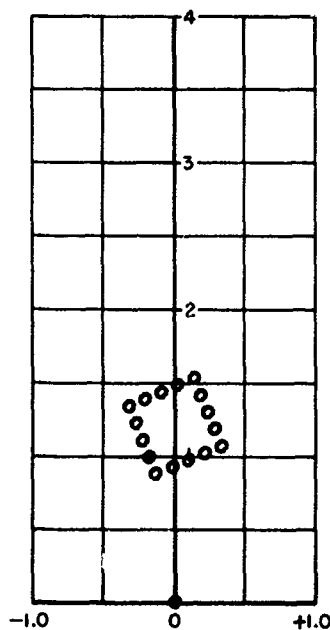




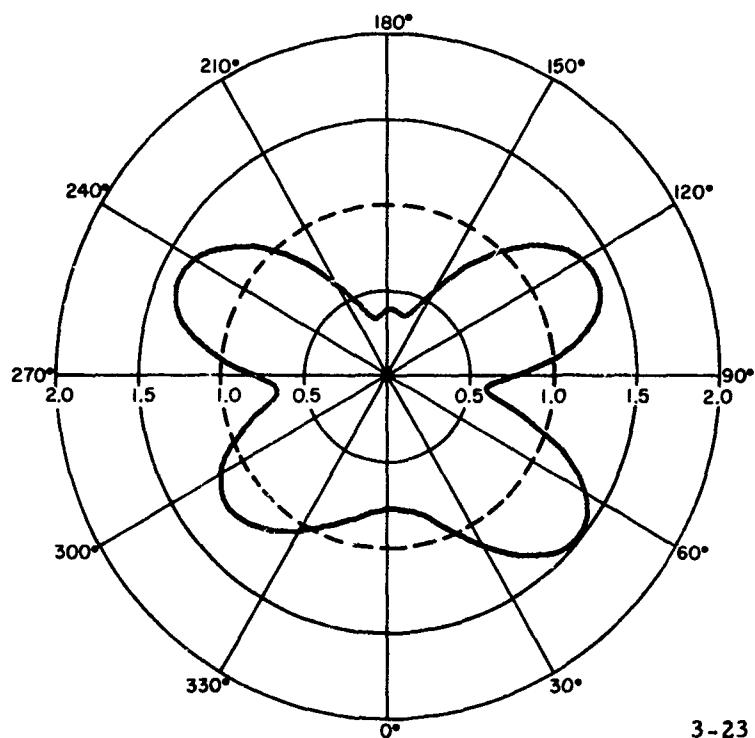
DISTANCE ~ WAVELENGTHS



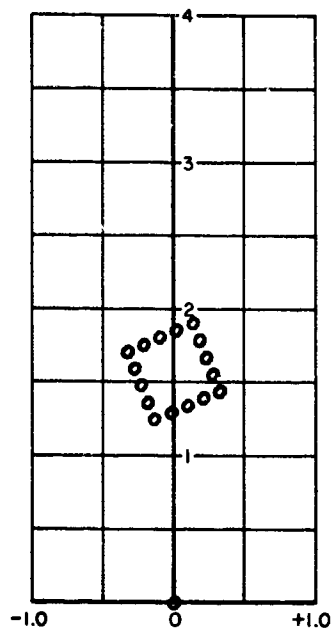
3-24



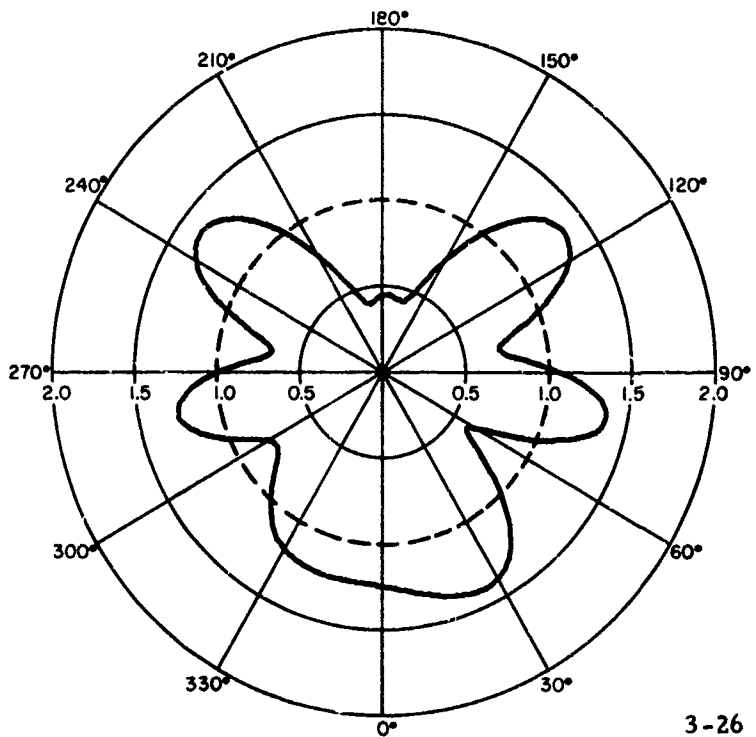
DISTANCE ~ WAVELENGTHS



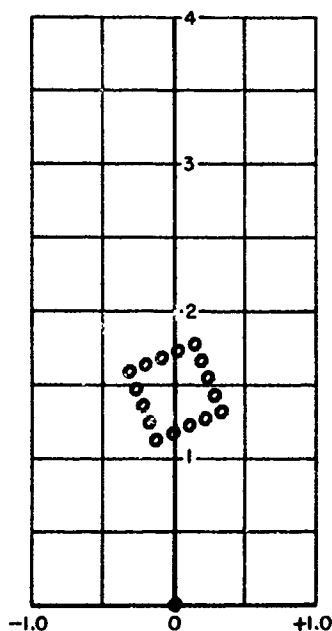
3-23



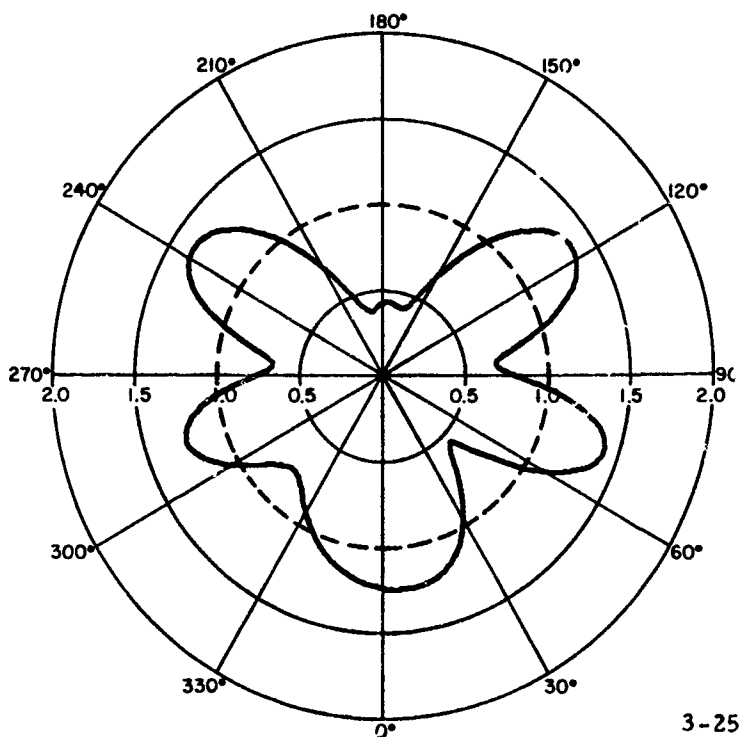
DISTANCE ~ WAVELENGTHS



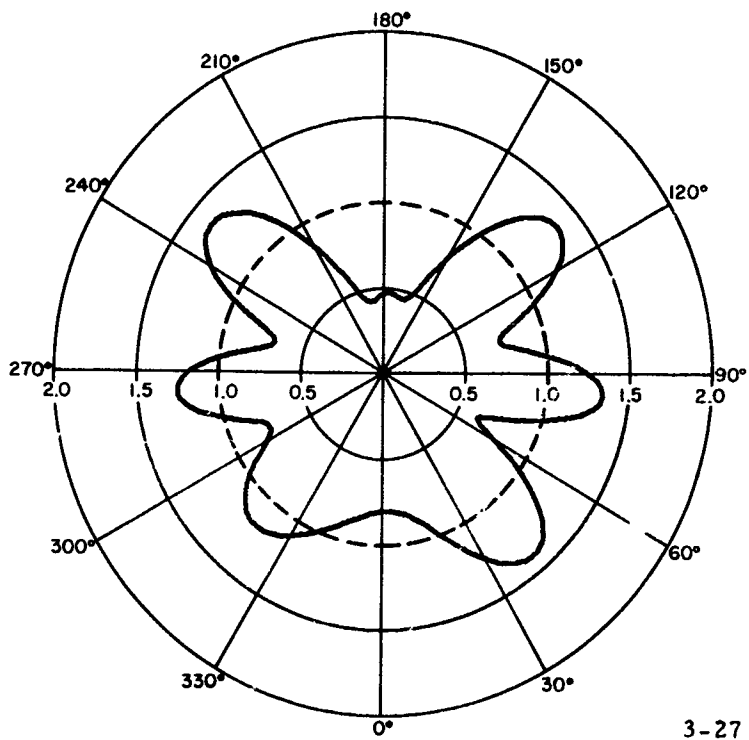
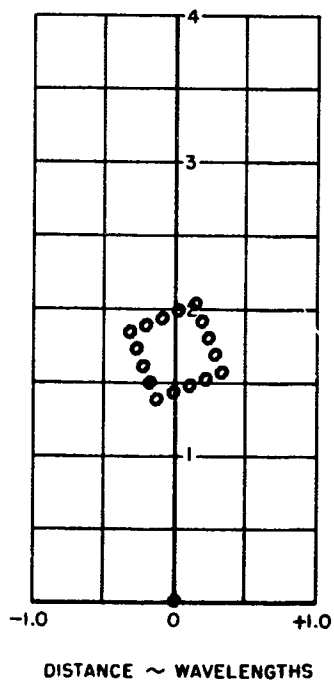
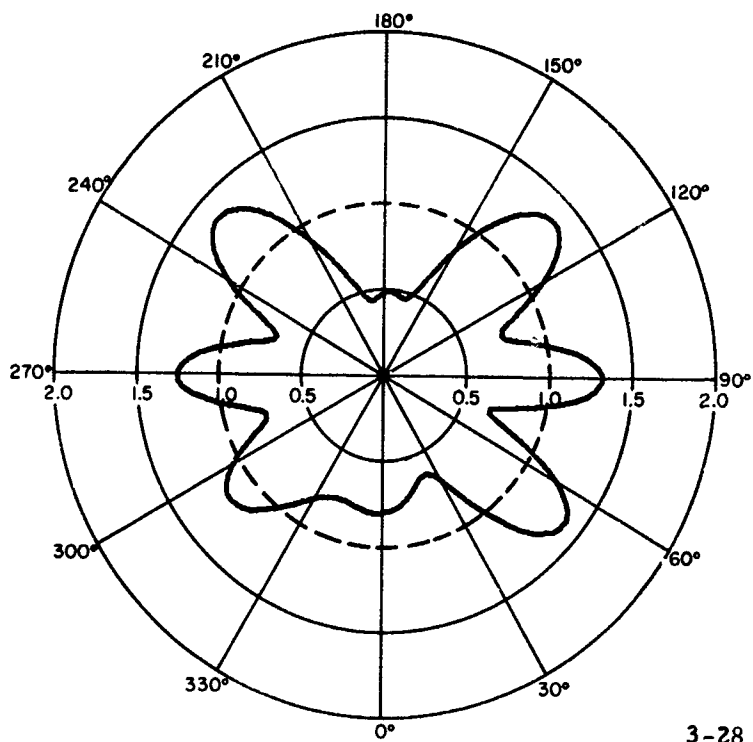
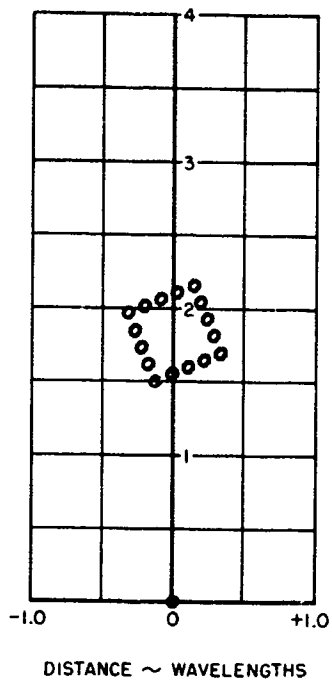
3-26

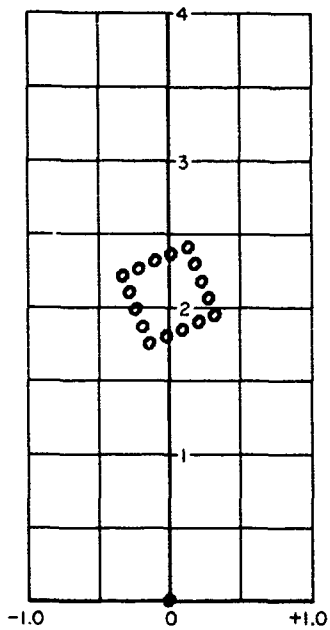


DISTANCE ~ WAVELENGTHS

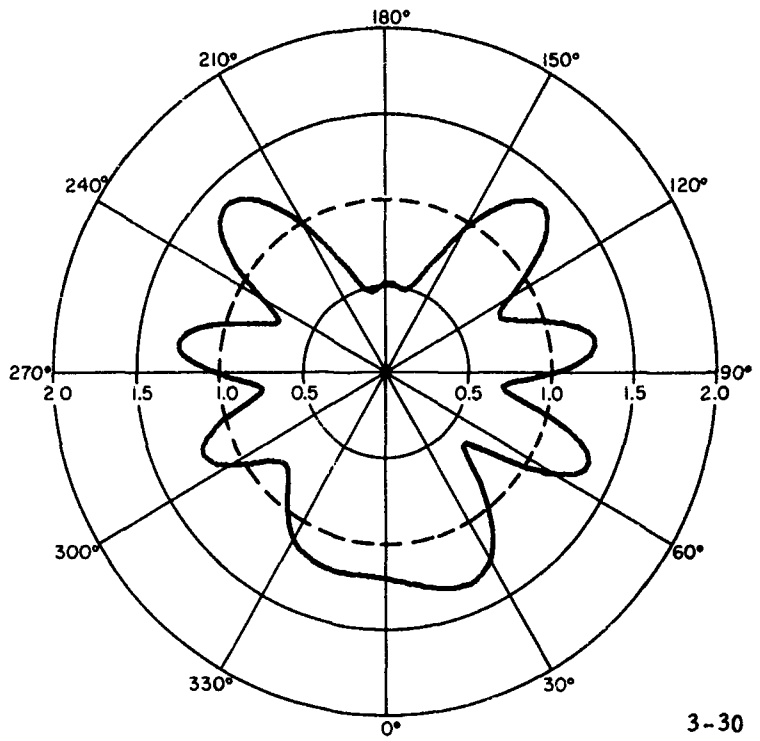


3-25

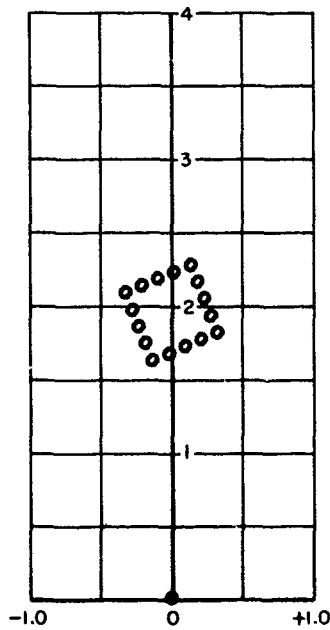




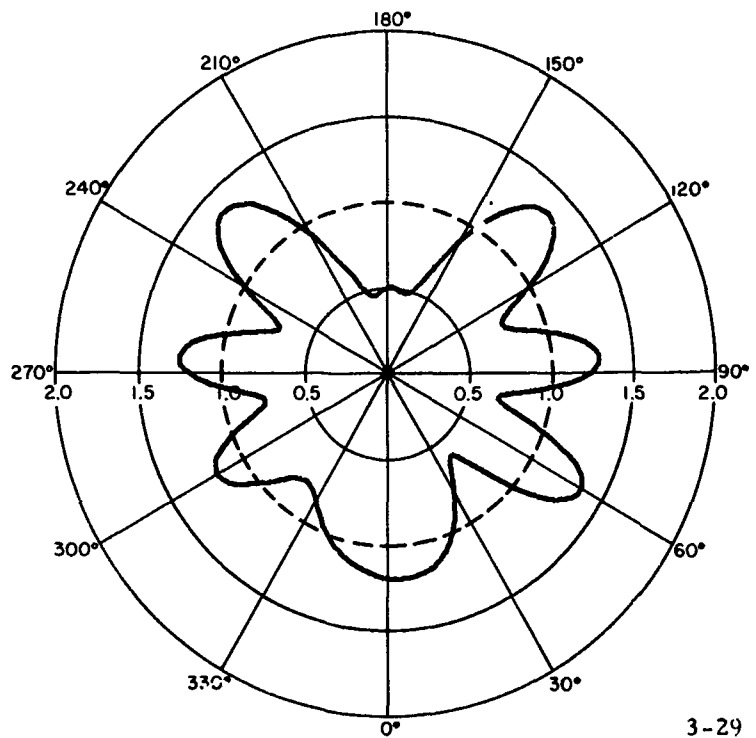
DISTANCE ~ WAVELENGTHS



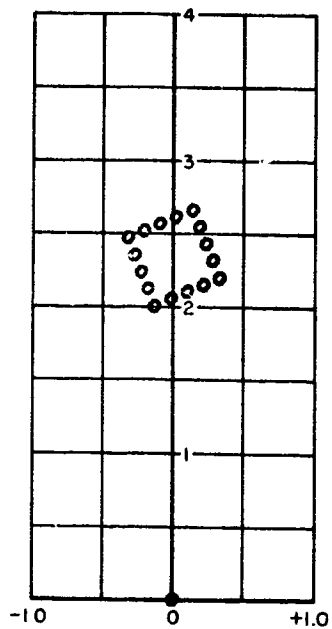
3-30



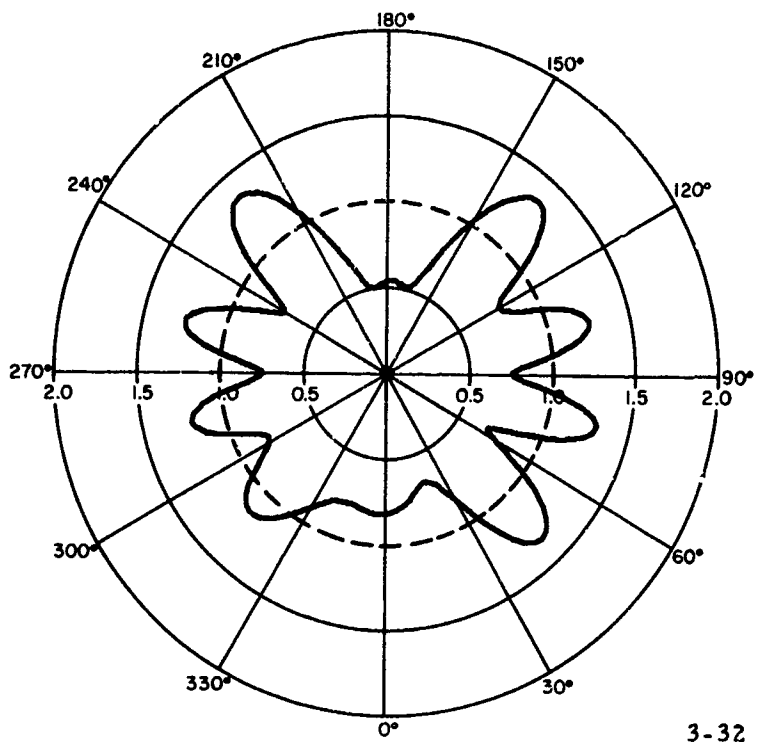
DISTANCE ~ WAVELENGTHS



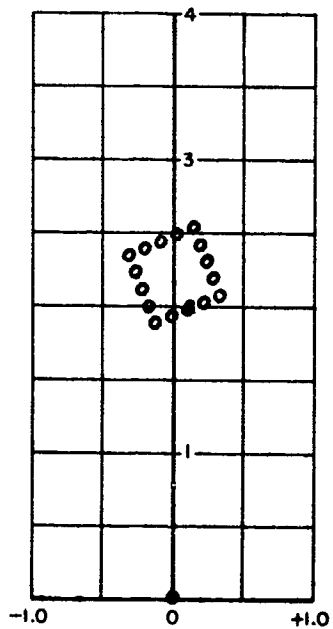
3-29



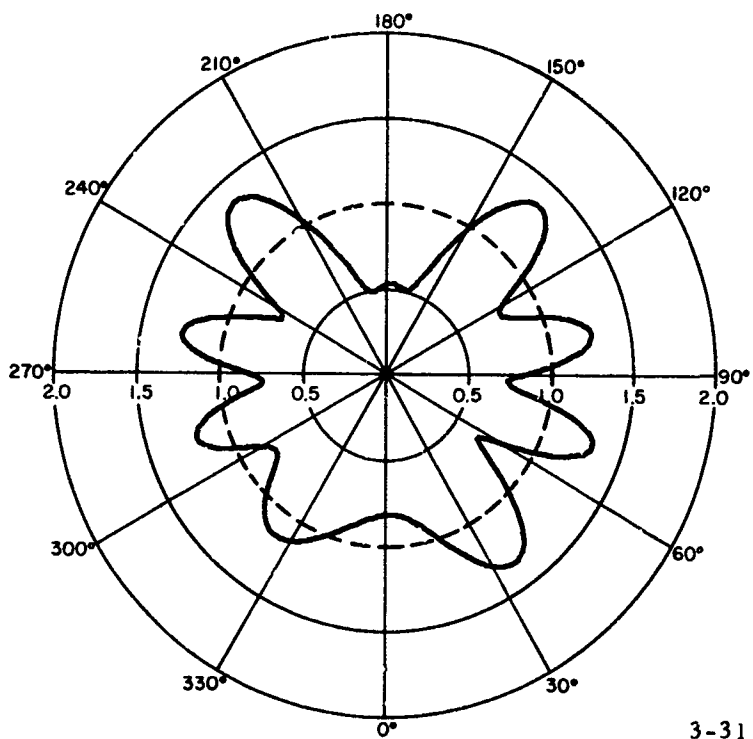
DISTANCE ~ WAVELENGTHS



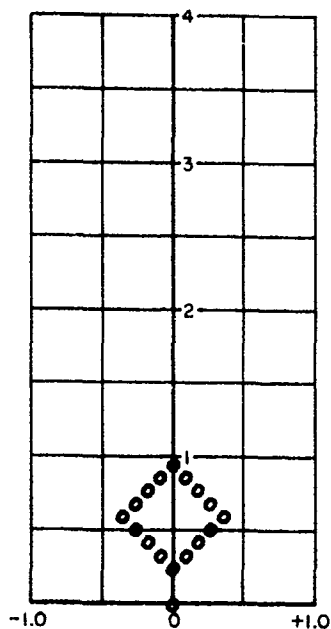
3-32



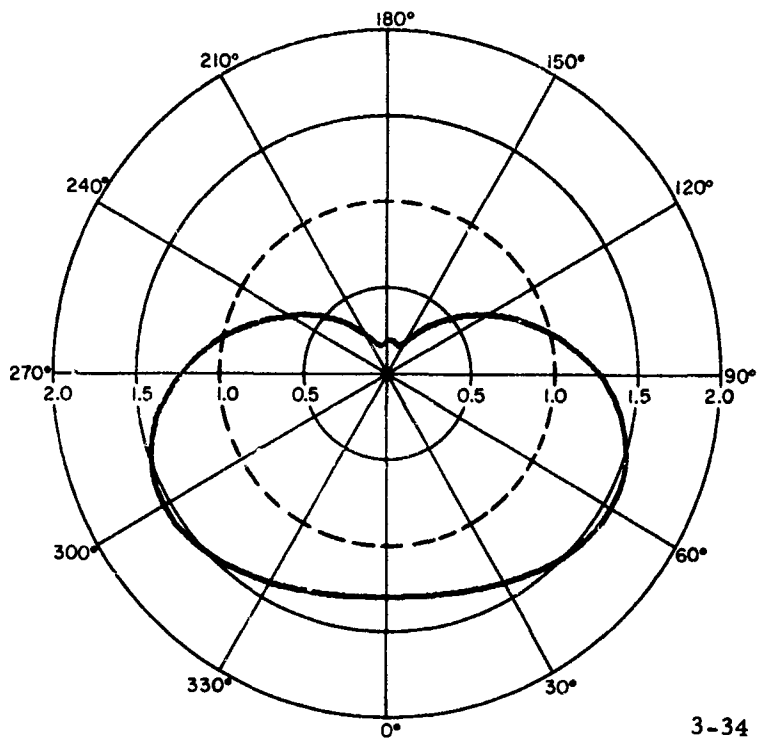
DISTANCE ~ WAVELENGTHS



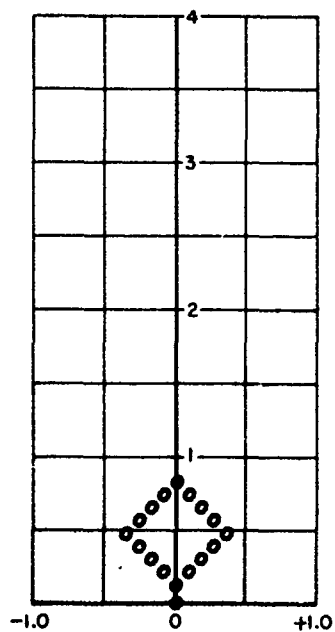
3-31



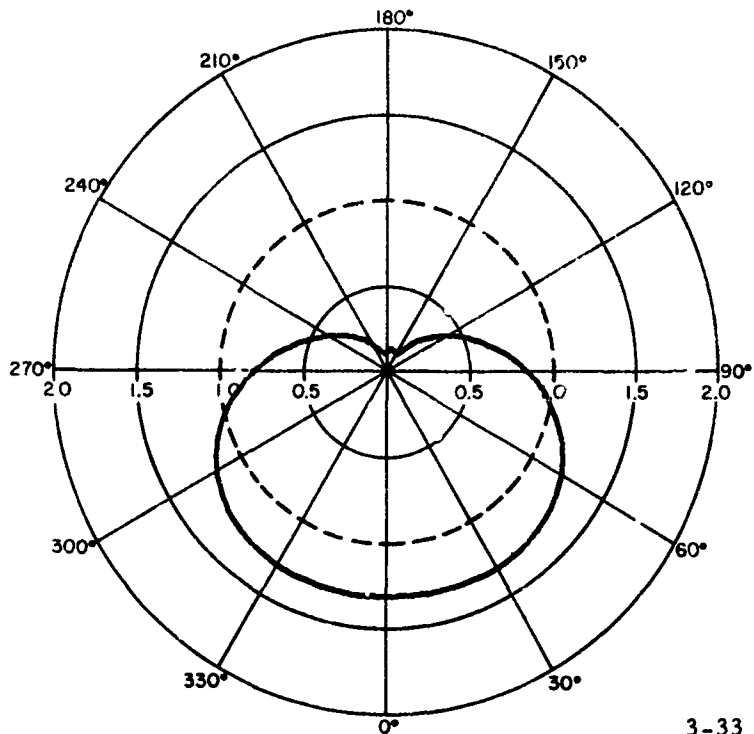
DISTANCE ~ WAVELENGTHS



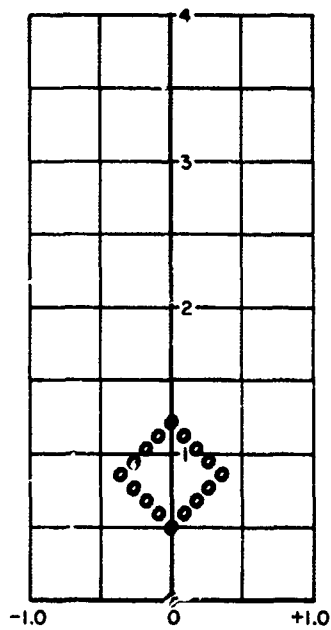
3-34



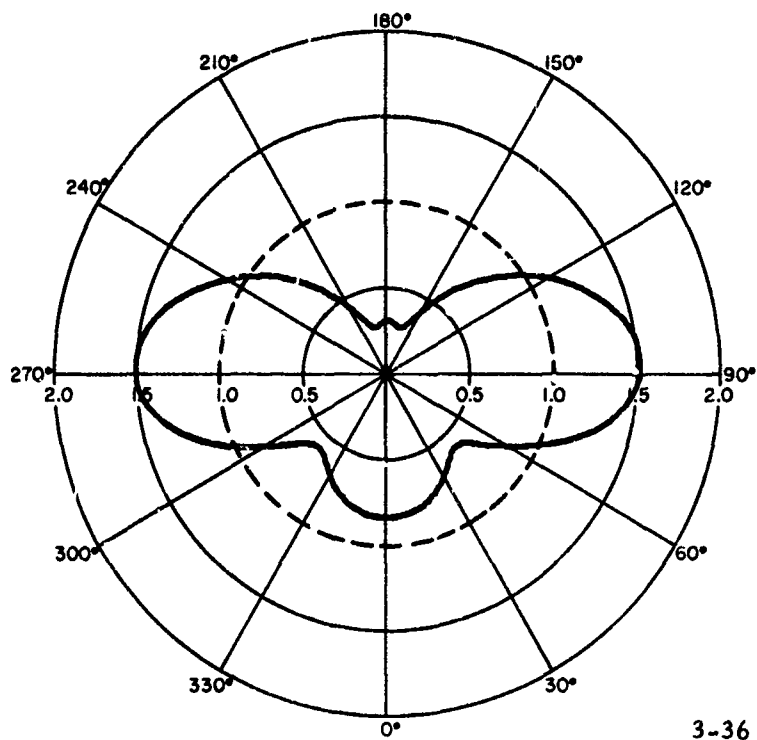
DISTANCE ~ WAVELENGTHS



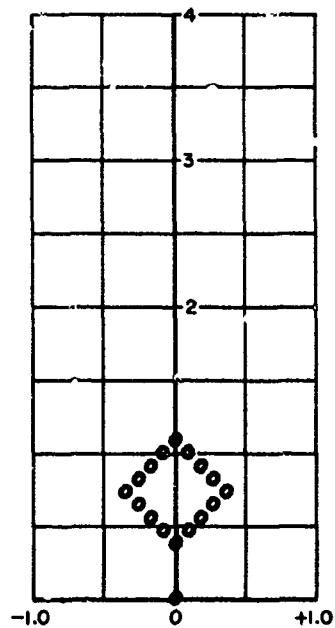
3-33



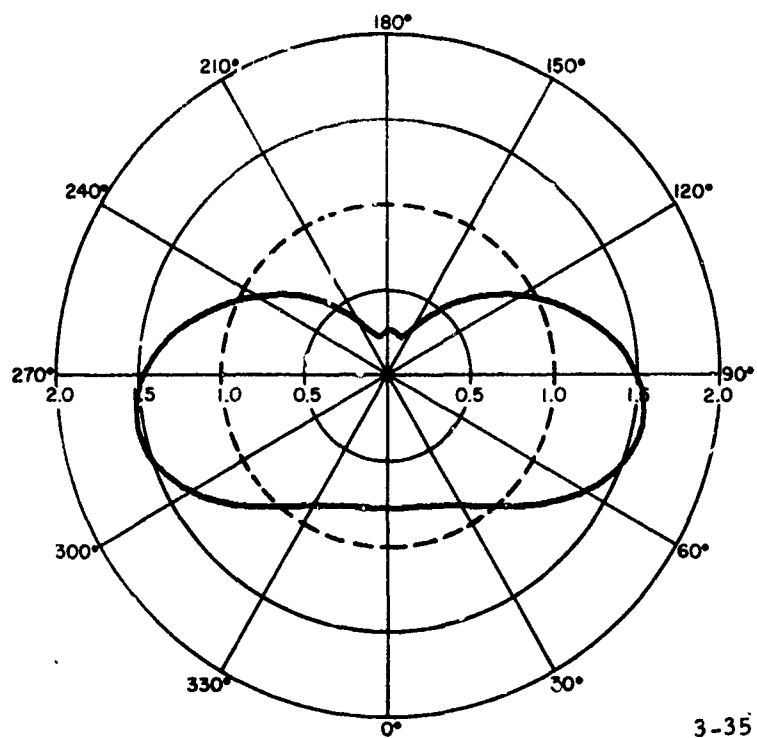
DISTANCE ~ WAVELENGTHS



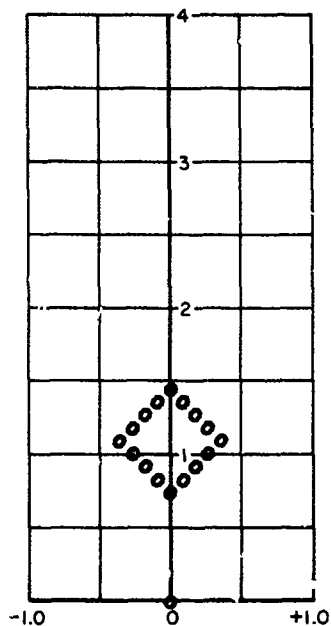
3-36



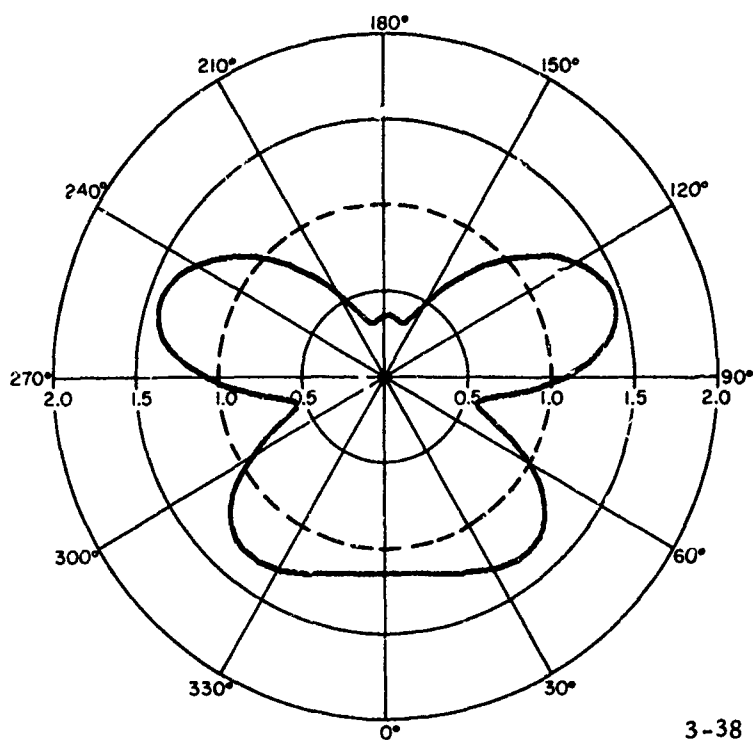
DISTANCE ~ WAVELENGTHS



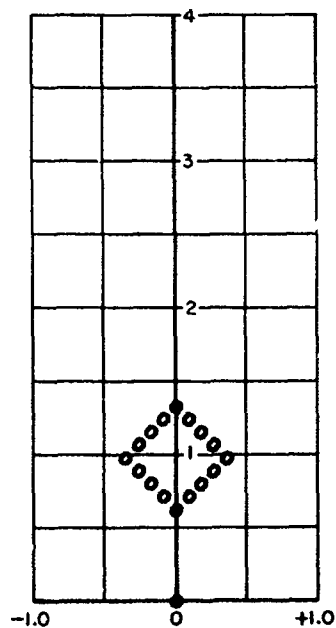
3-35



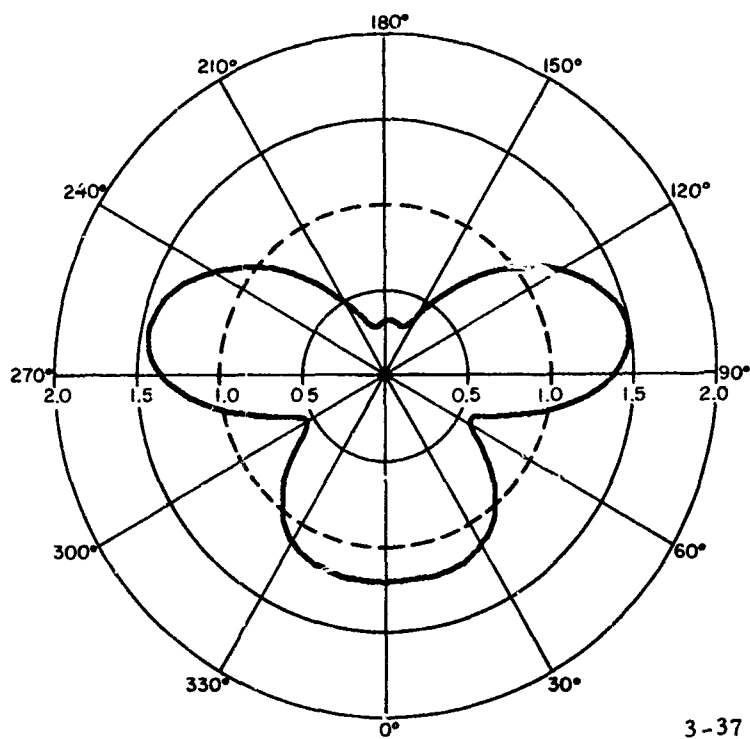
DISTANCE ~ WAVELENGTHS



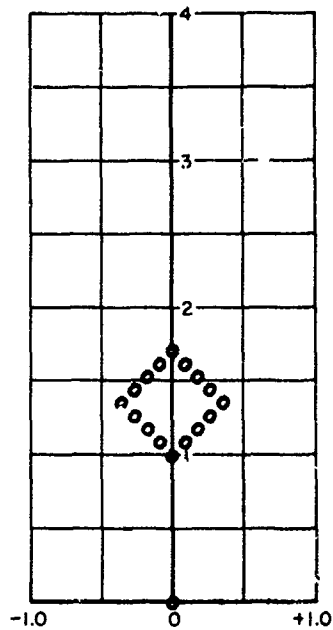
3-38



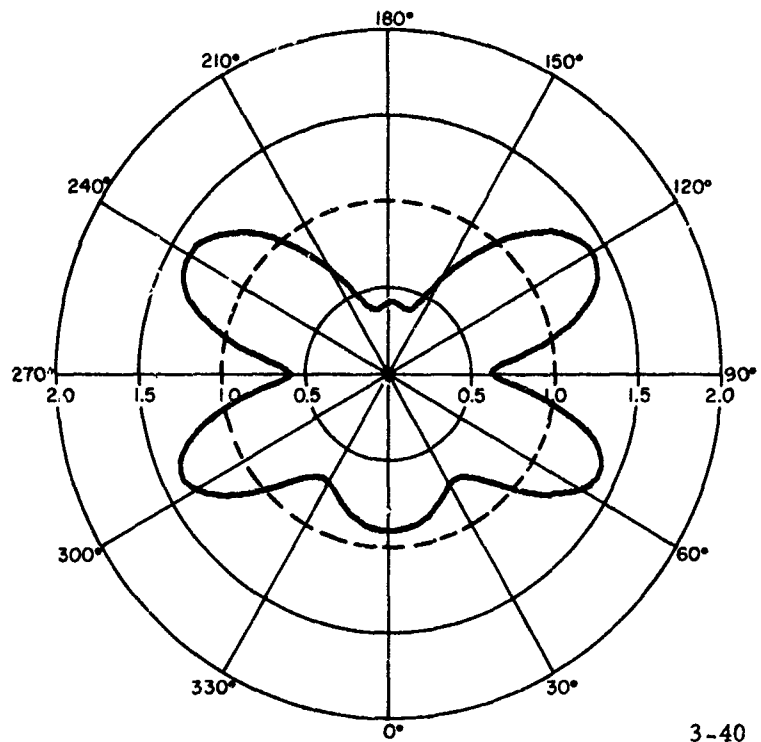
DISTANCE ~ WAVELENGTHS



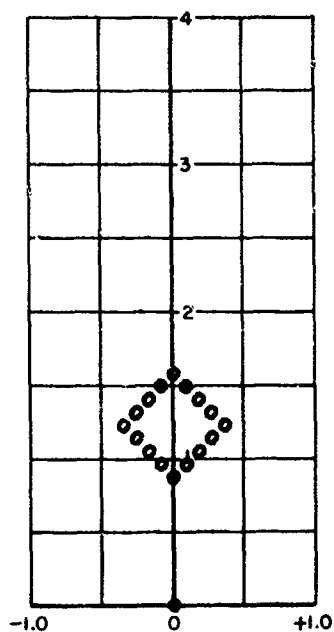
3-37



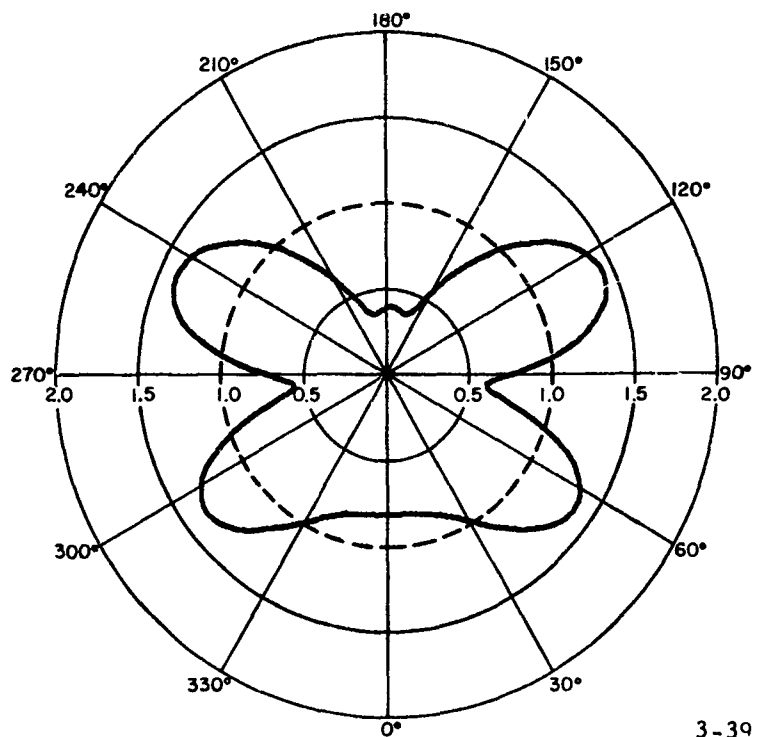
DISTANCE ~ WAVELENGTHS



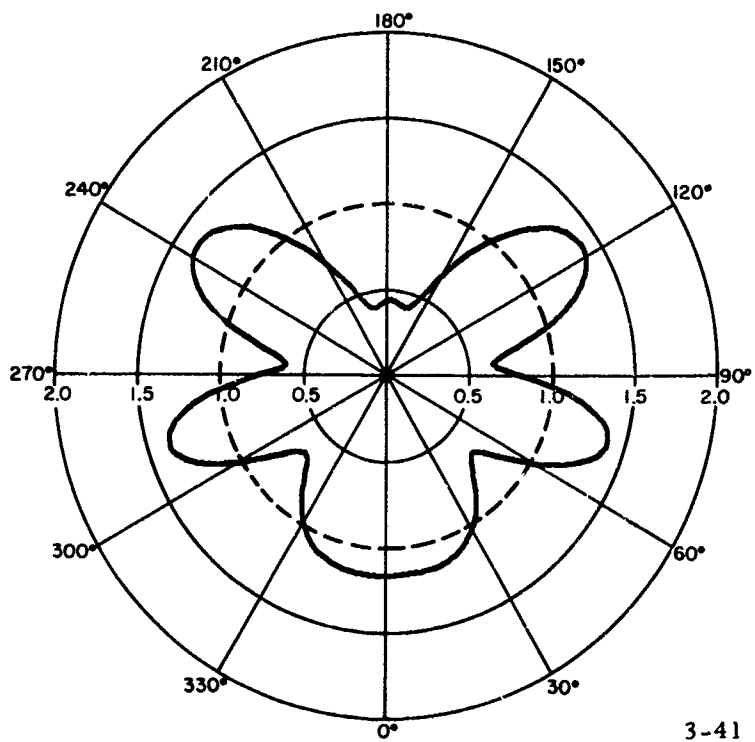
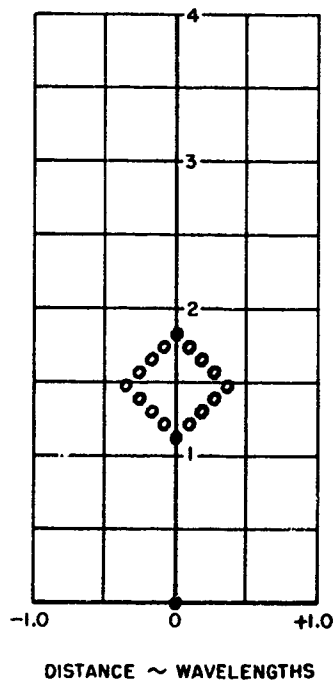
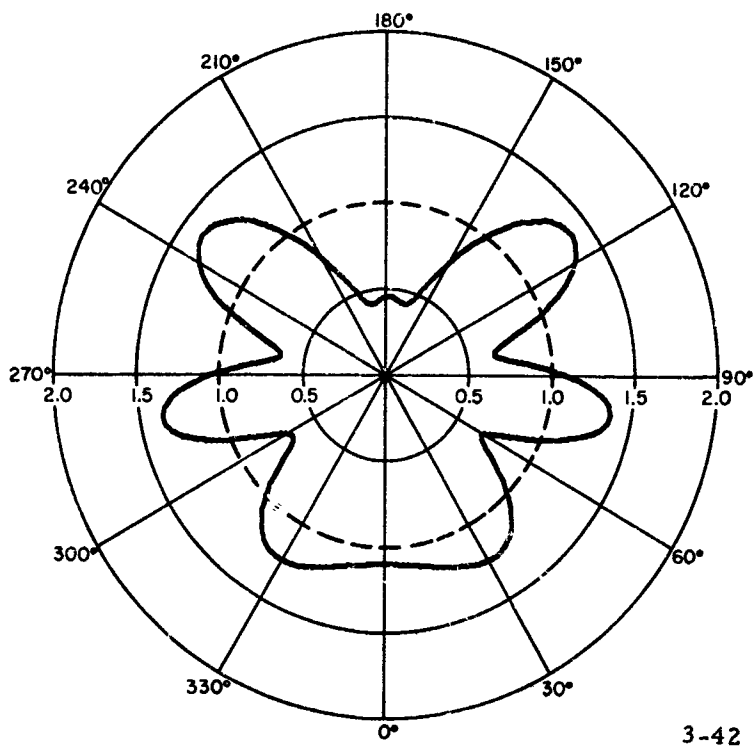
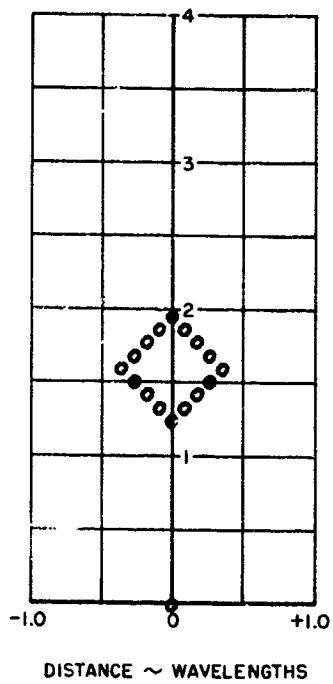
3-40

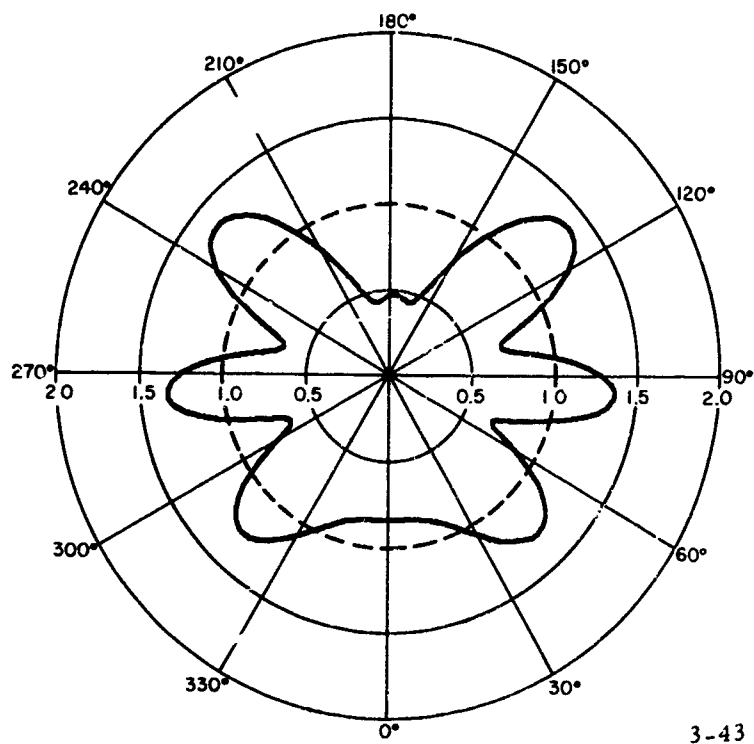
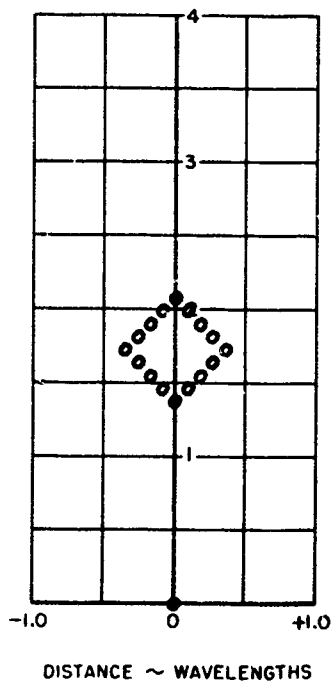
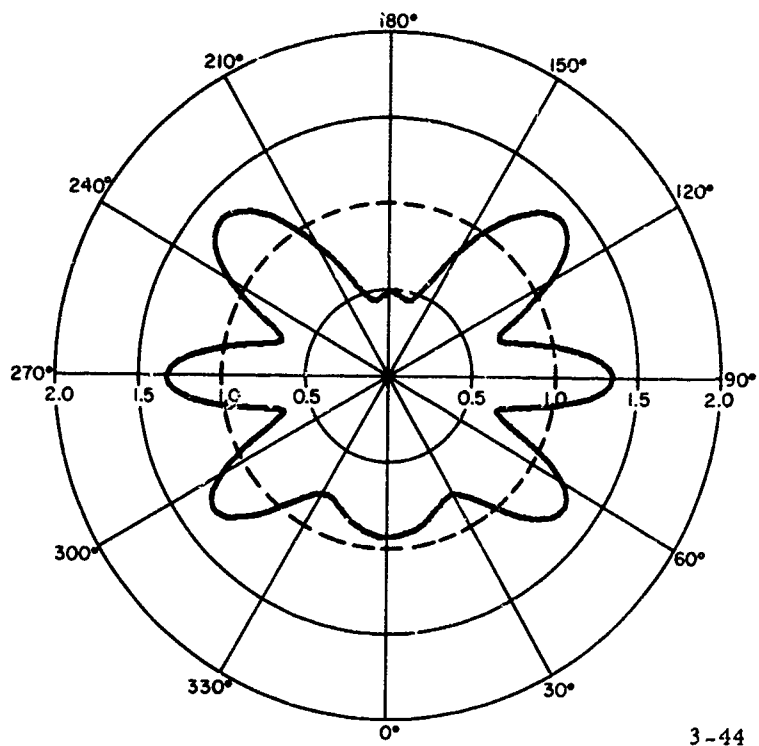
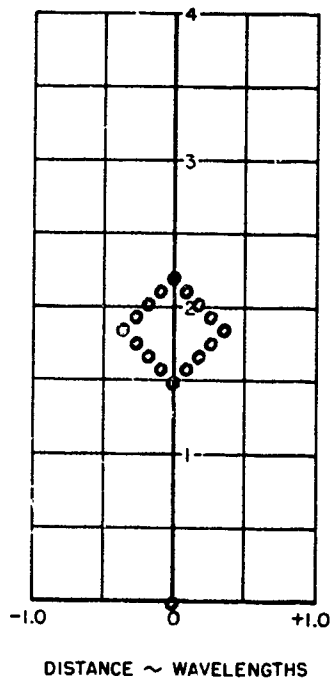


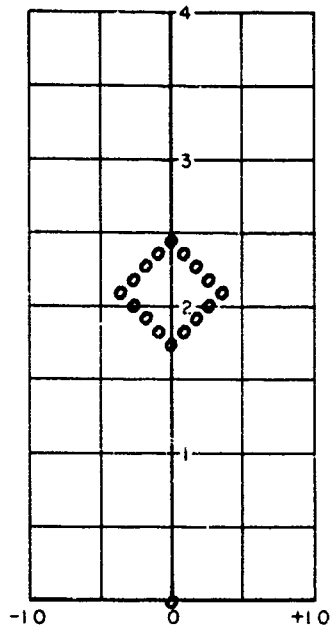
DISTANCE ~ WAVELENGTHS



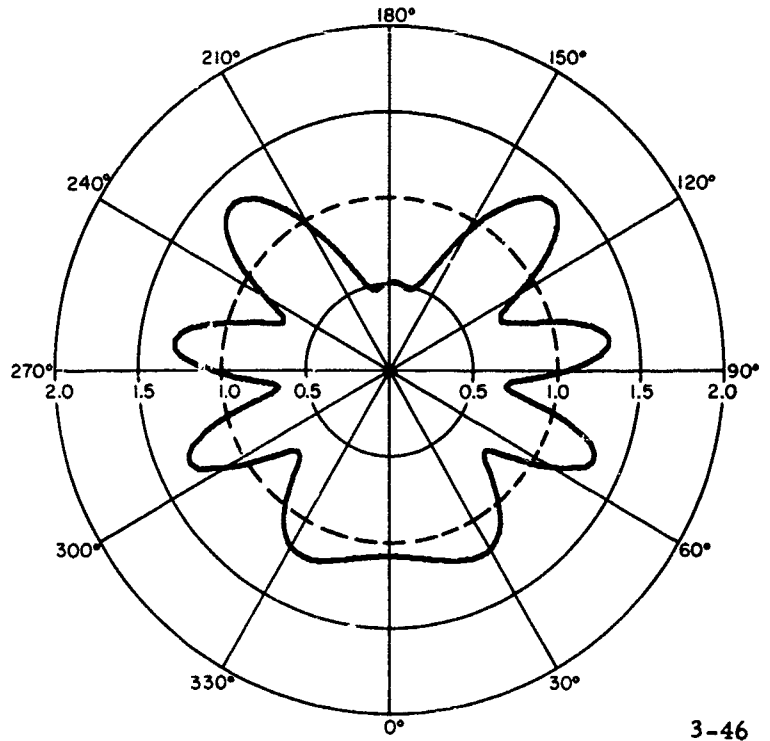
3-39



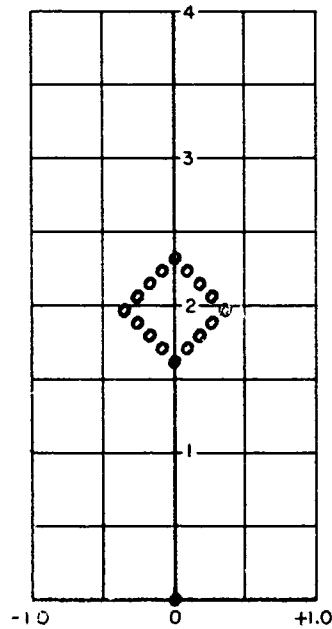




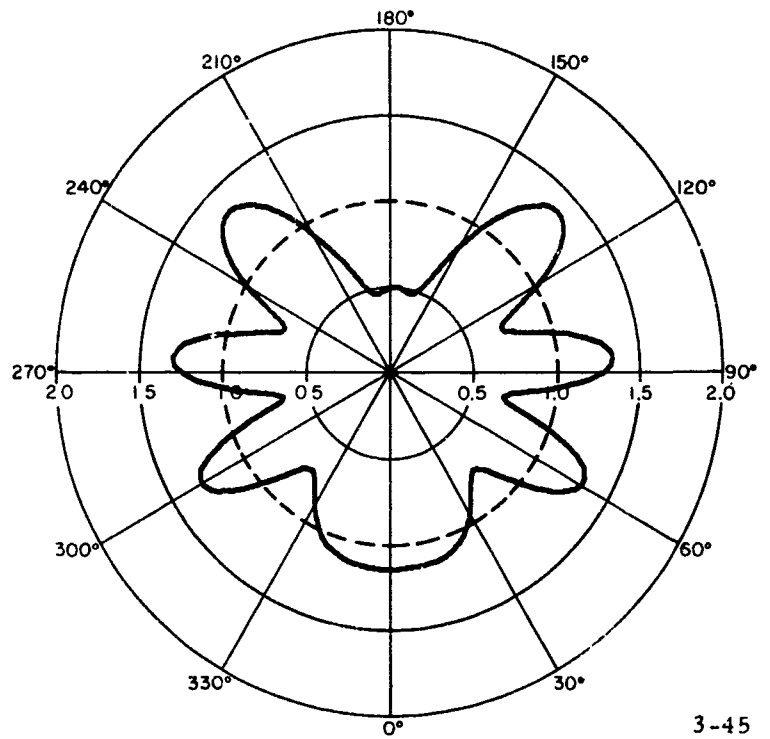
DISTANCE ~ WAVELENGTHS



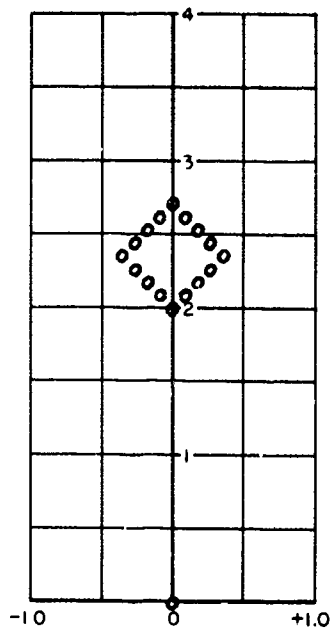
3-46



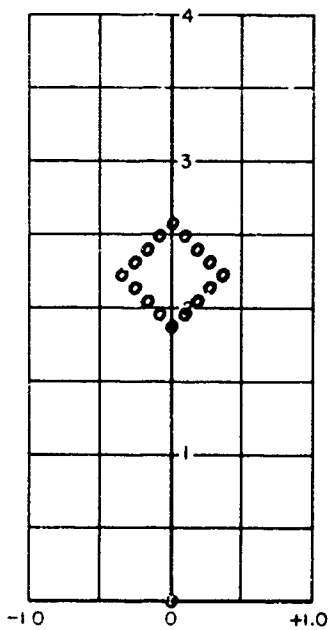
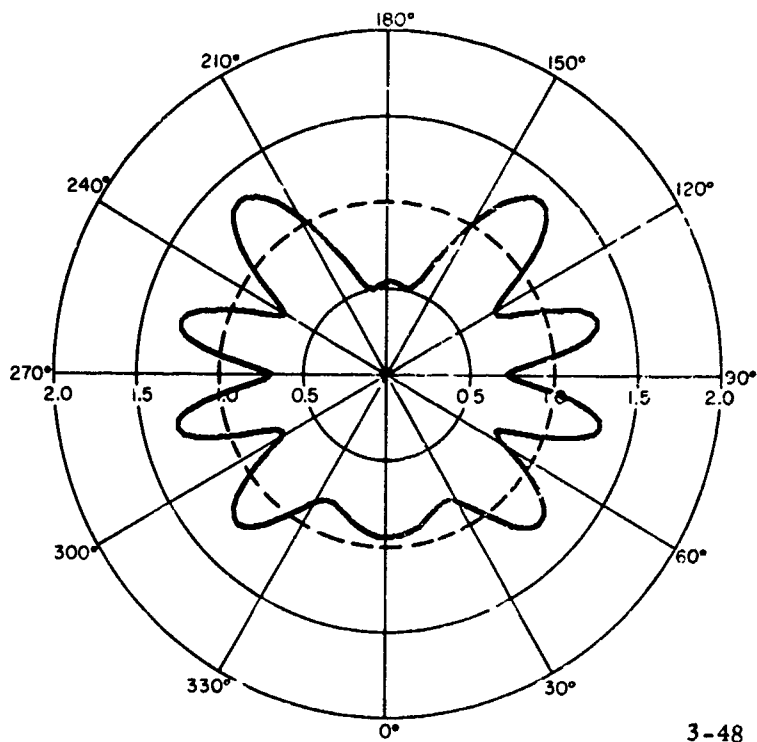
DISTANCE ~ WAVELENGTHS



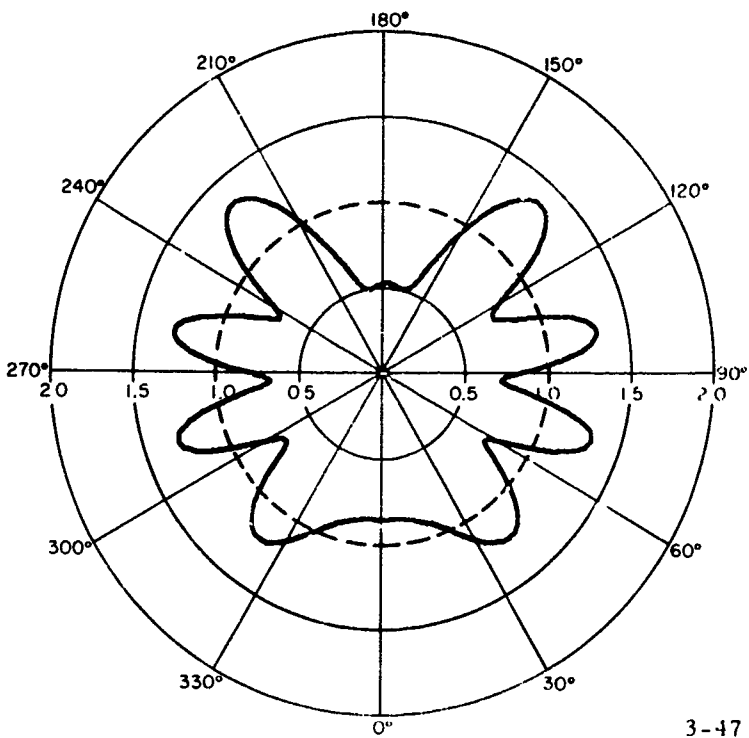
3-45

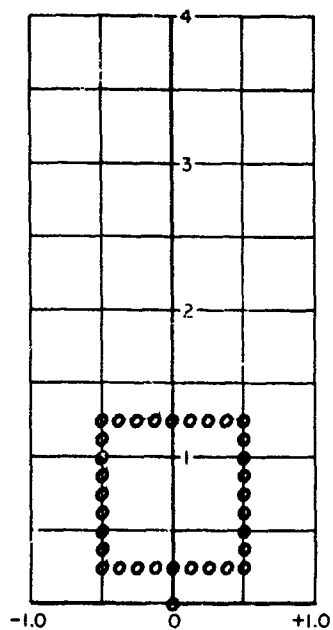


DISTANCE ~ WAVELENGTHS

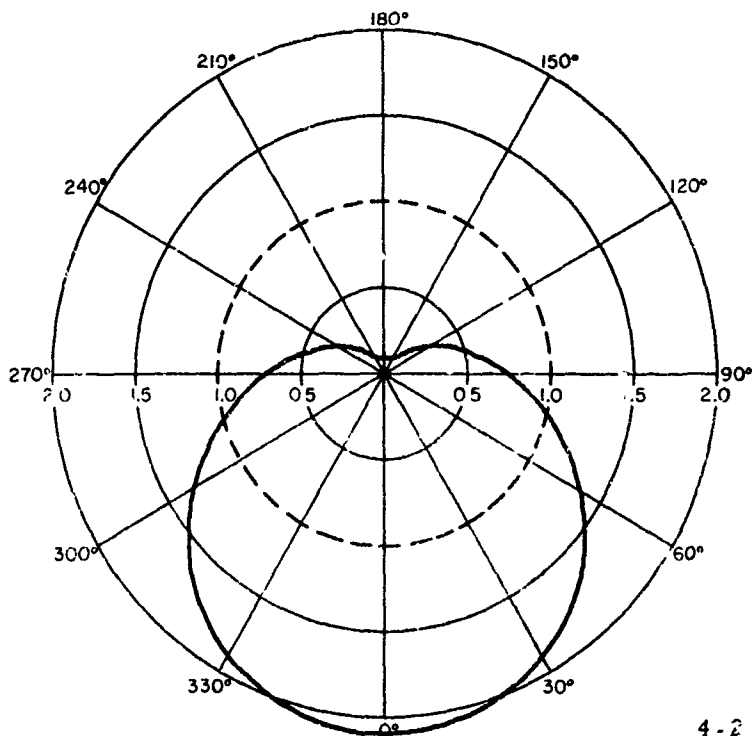


DISTANCE ~ WAVELENGTHS

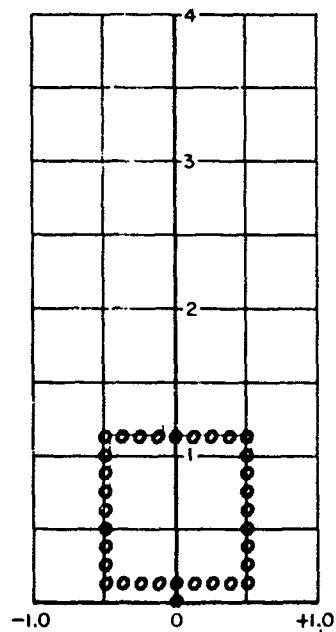




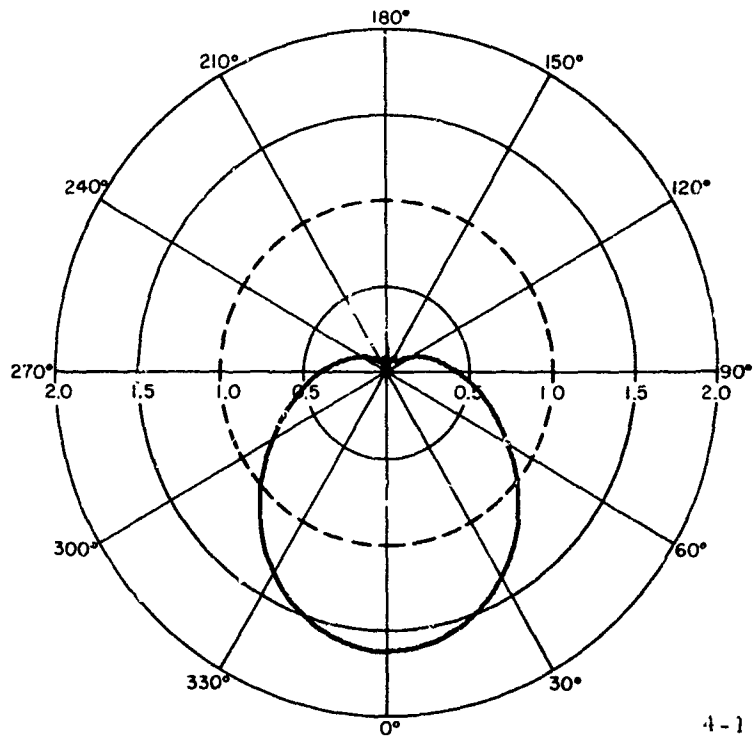
DISTANCE ~ WAVELENGTHS



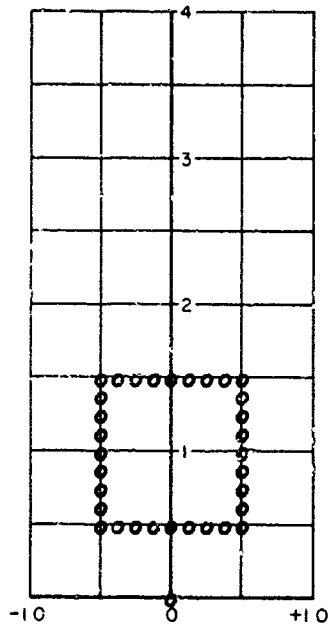
4 - 2



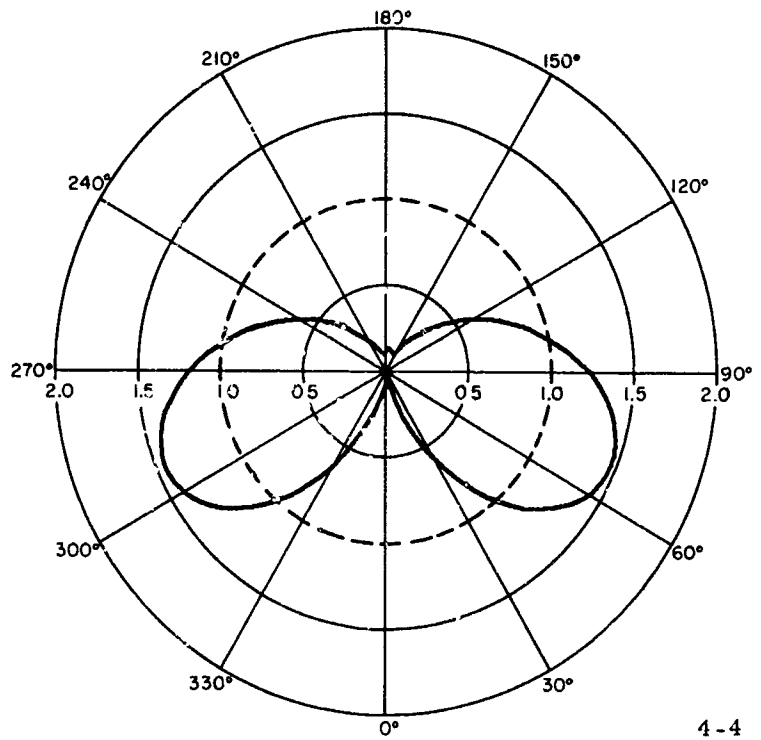
DISTANCE ~ WAVELENGTHS



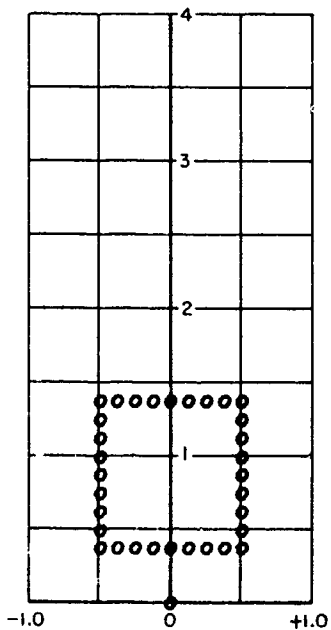
4 - 1



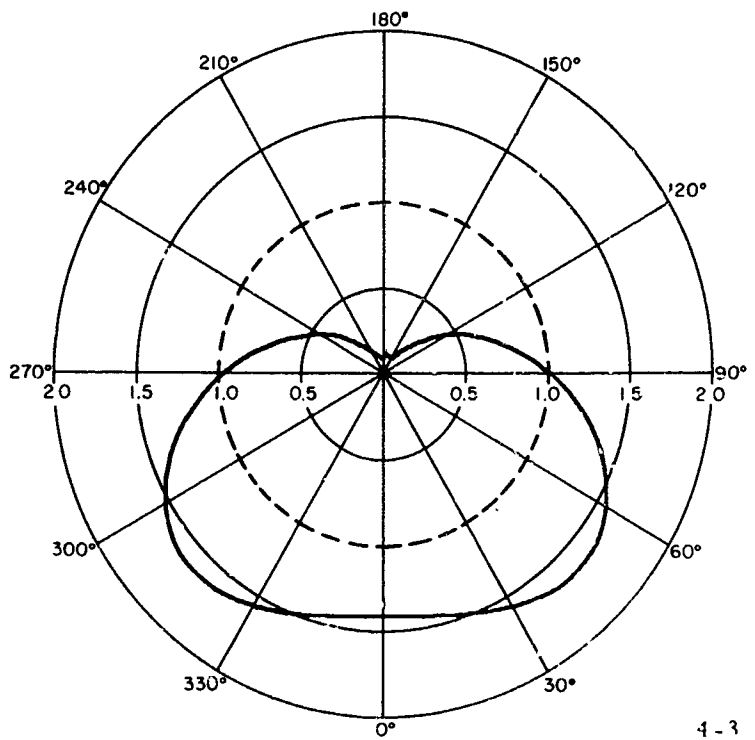
DISTANCE ~ WAVELENGTHS



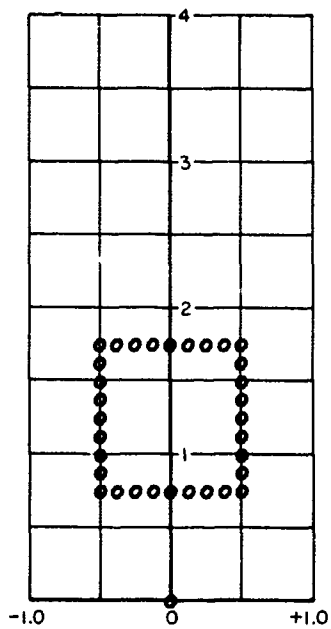
4-4



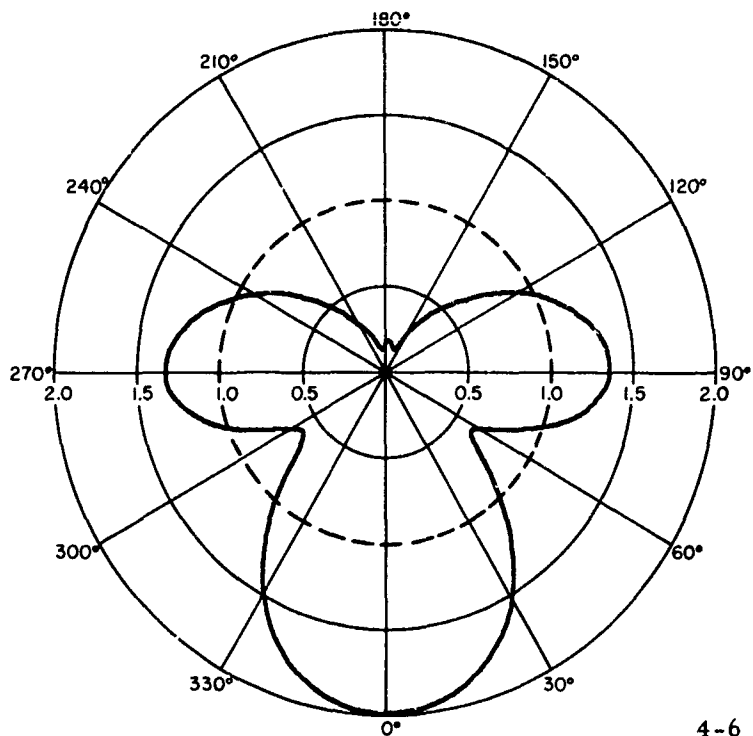
DISTANCE ~ WAVELENGTHS



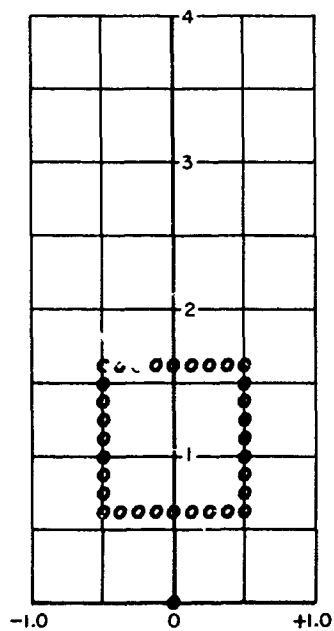
4-3



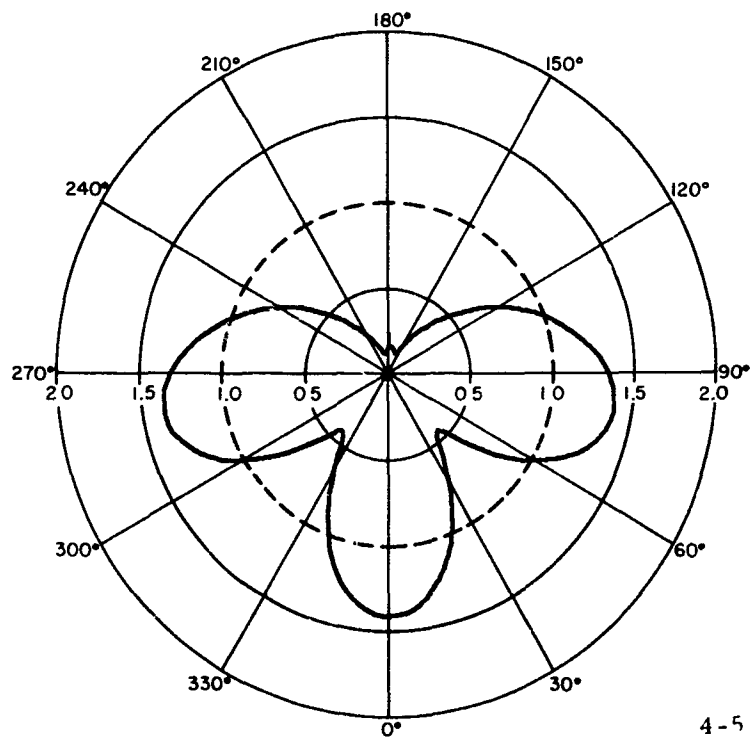
DISTANCE ~ WAVELENGTHS



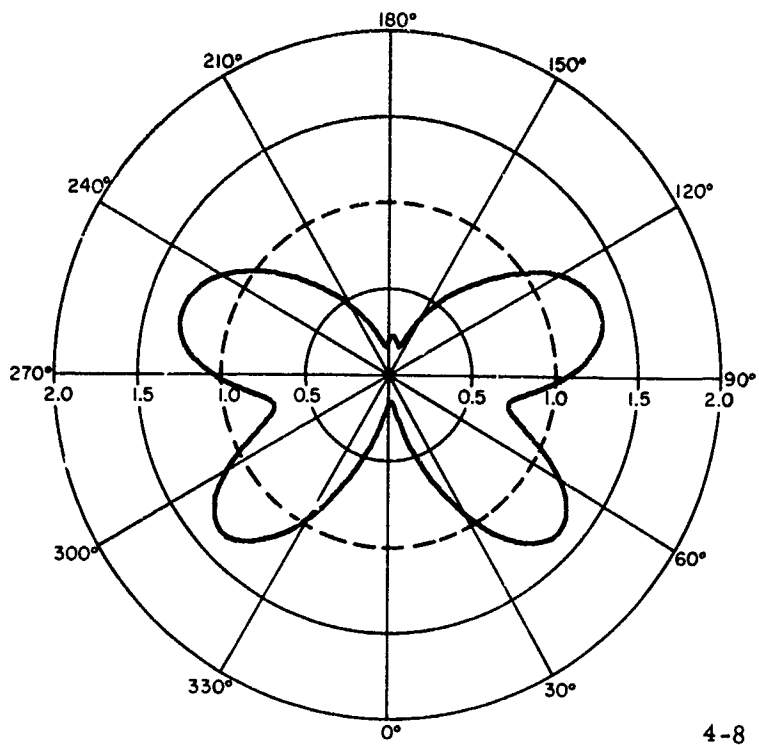
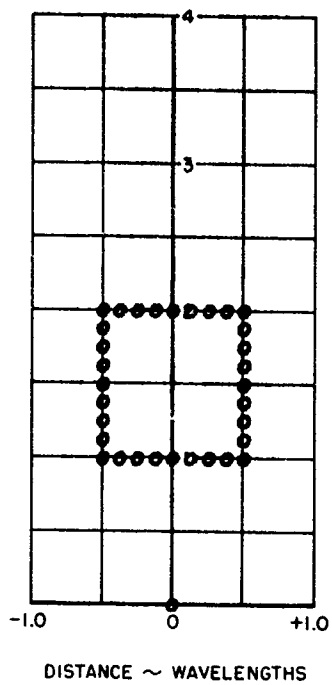
4-6



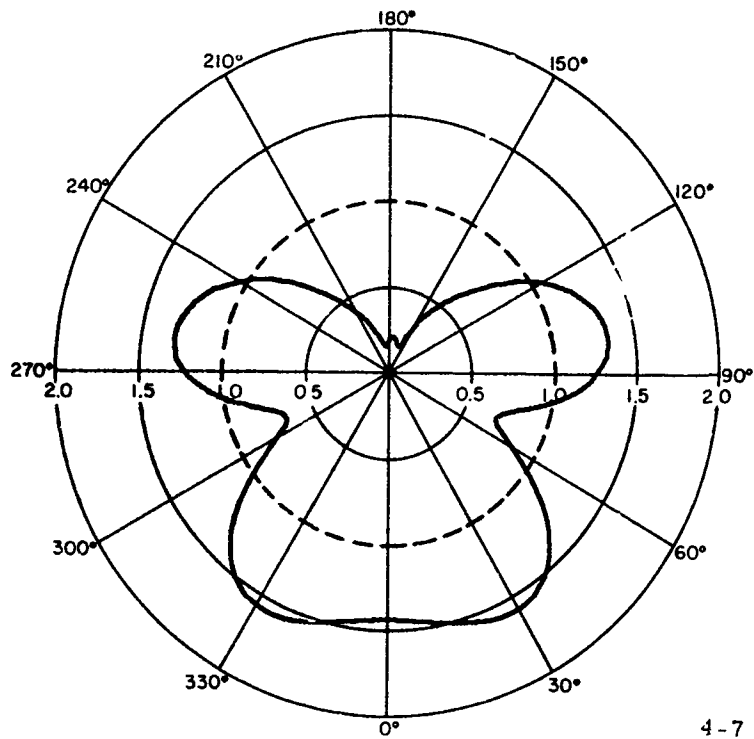
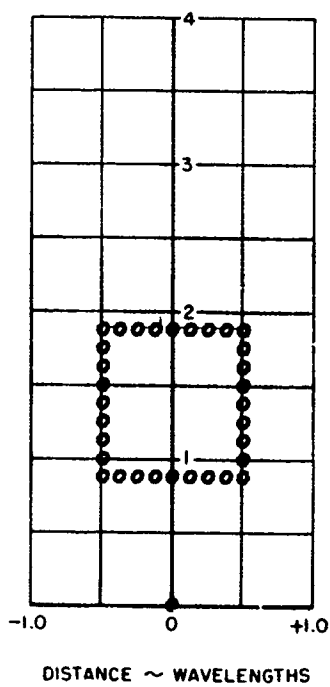
DISTANCE ~ WAVELENGTHS



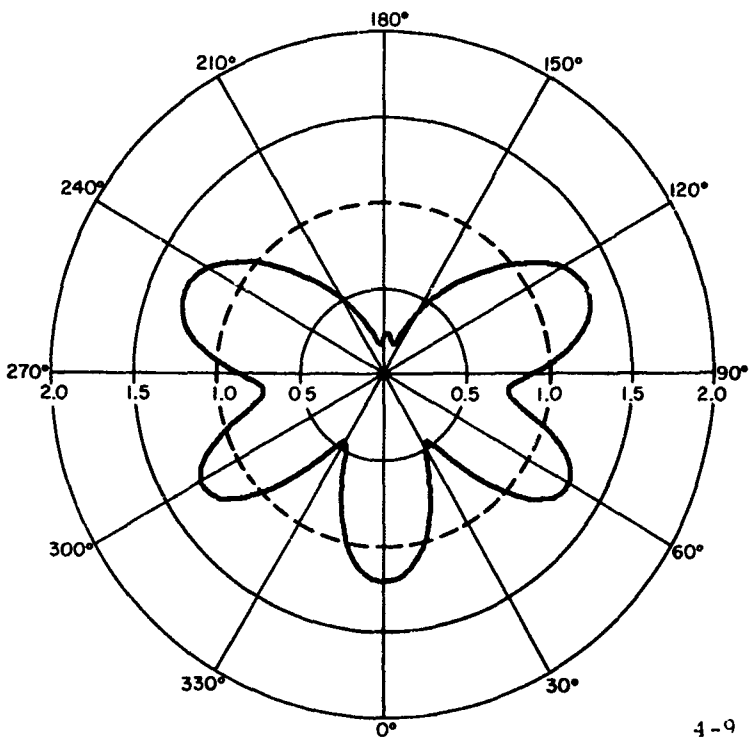
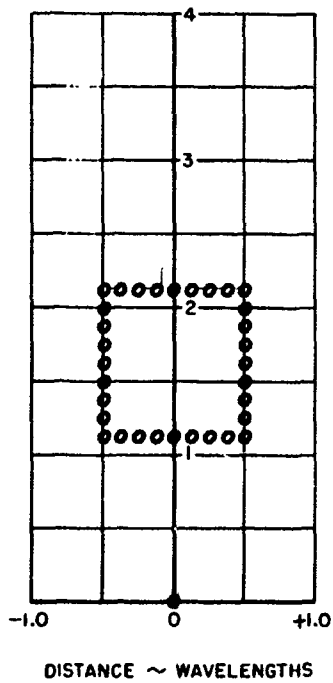
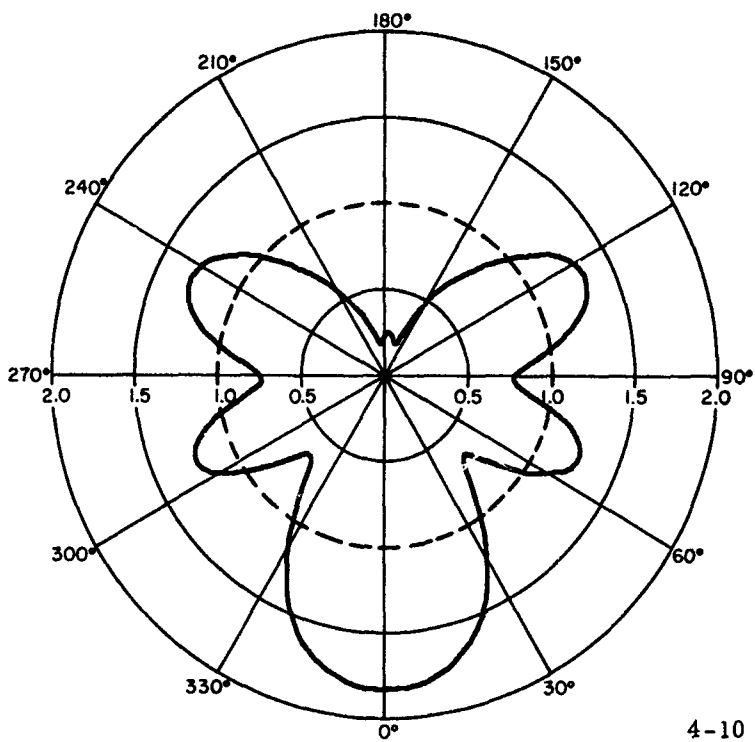
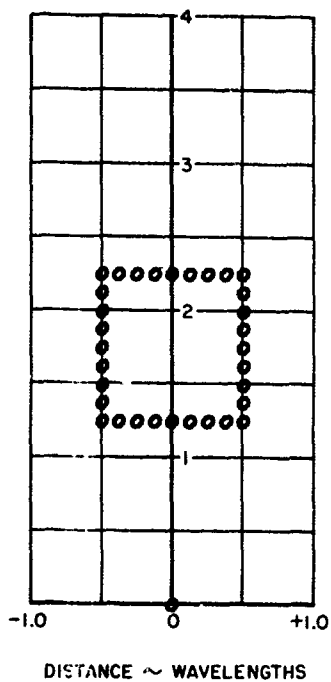
4-5

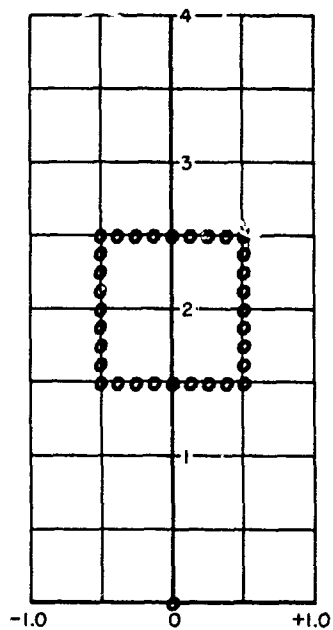


4-8

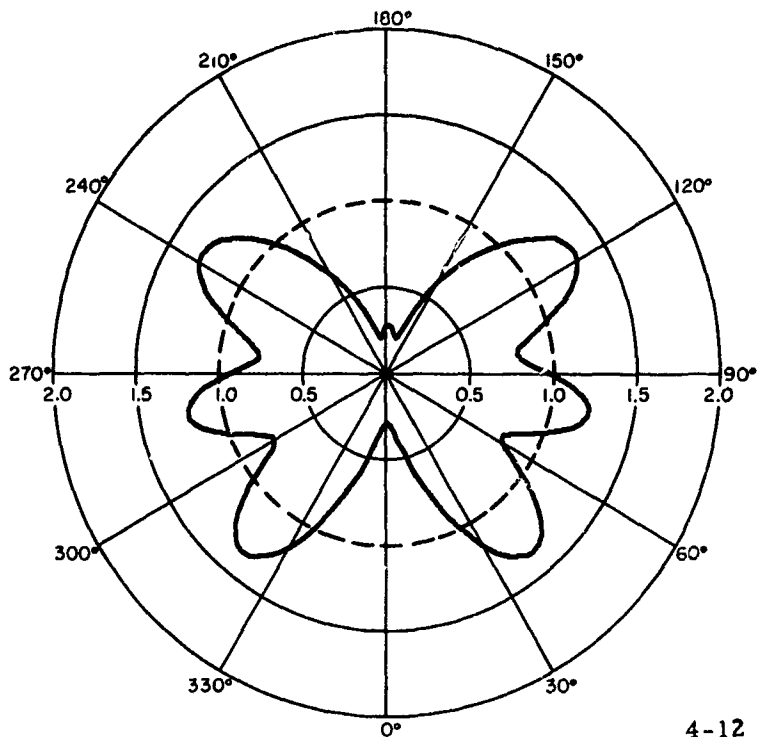


4-7

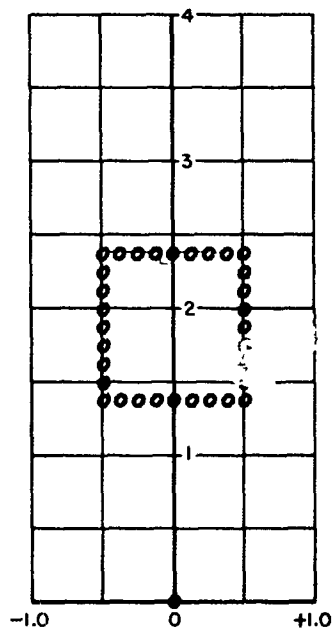




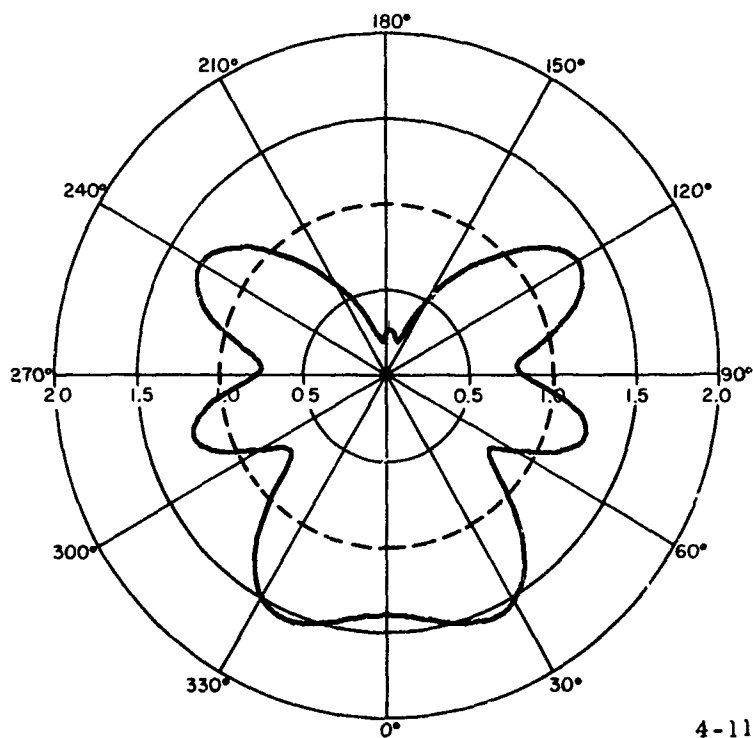
DISTANCE ~ WAVELENGTHS



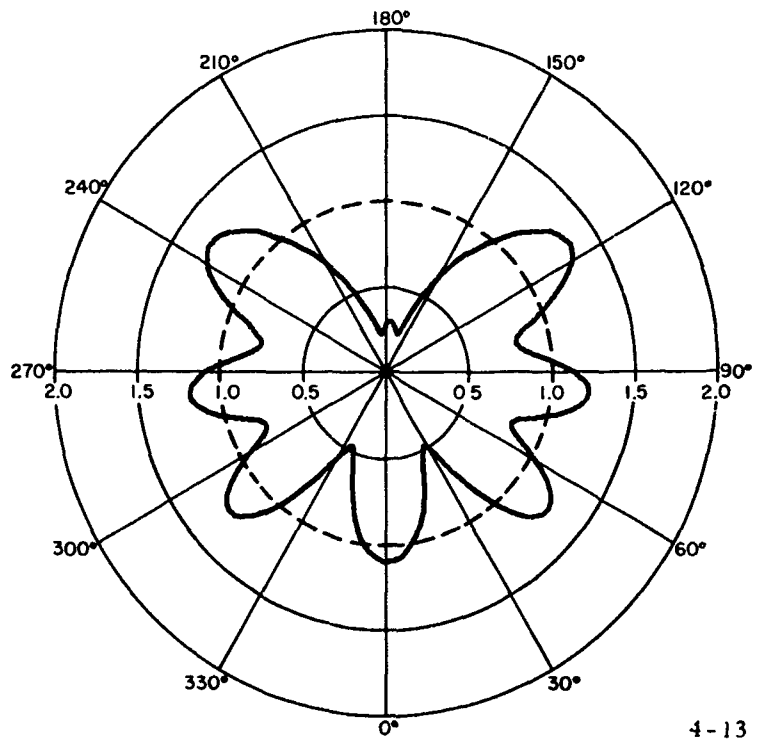
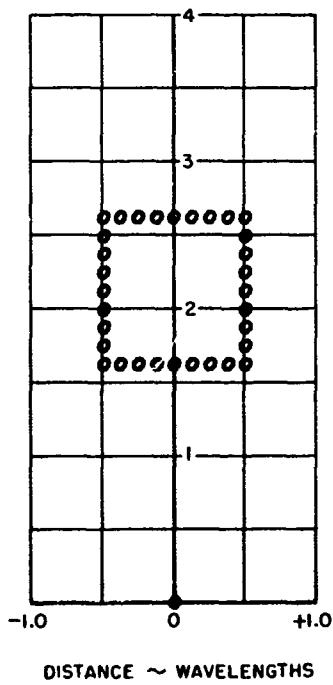
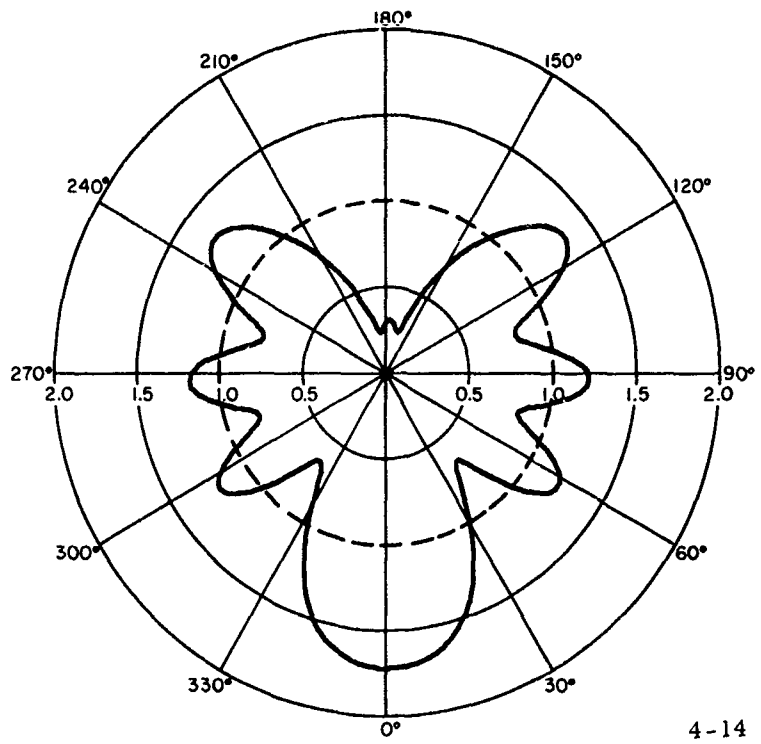
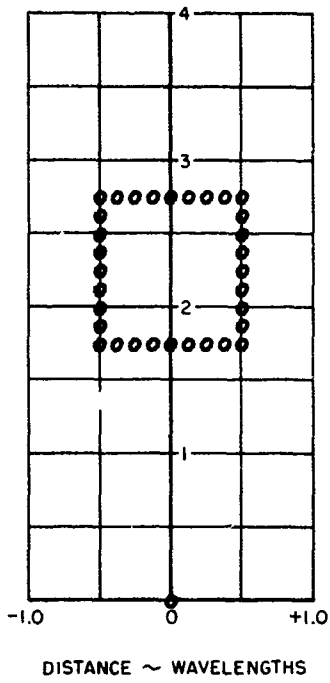
4-12

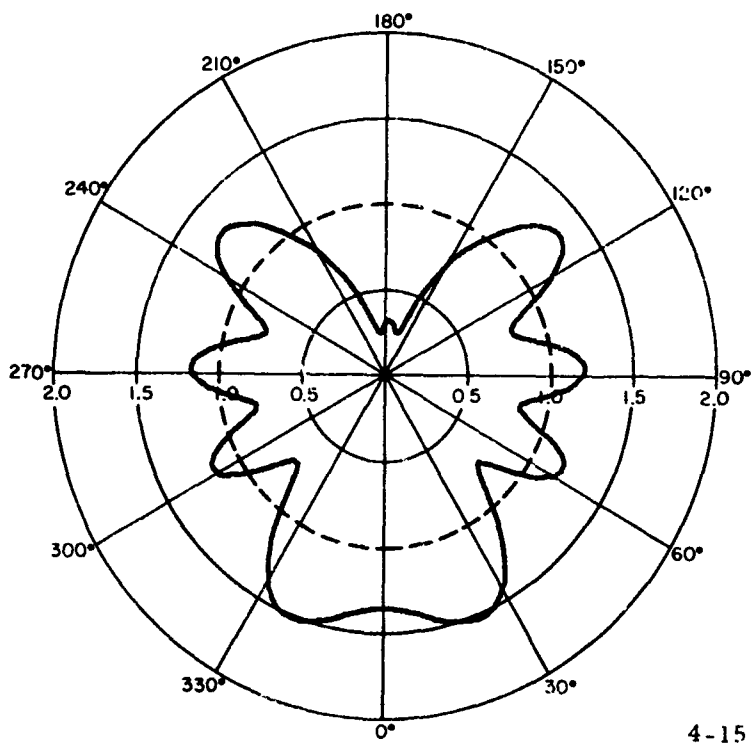
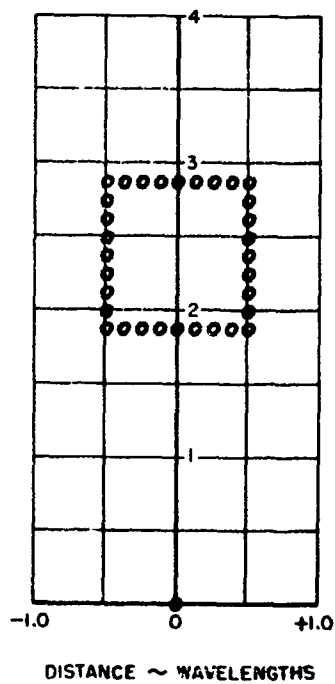
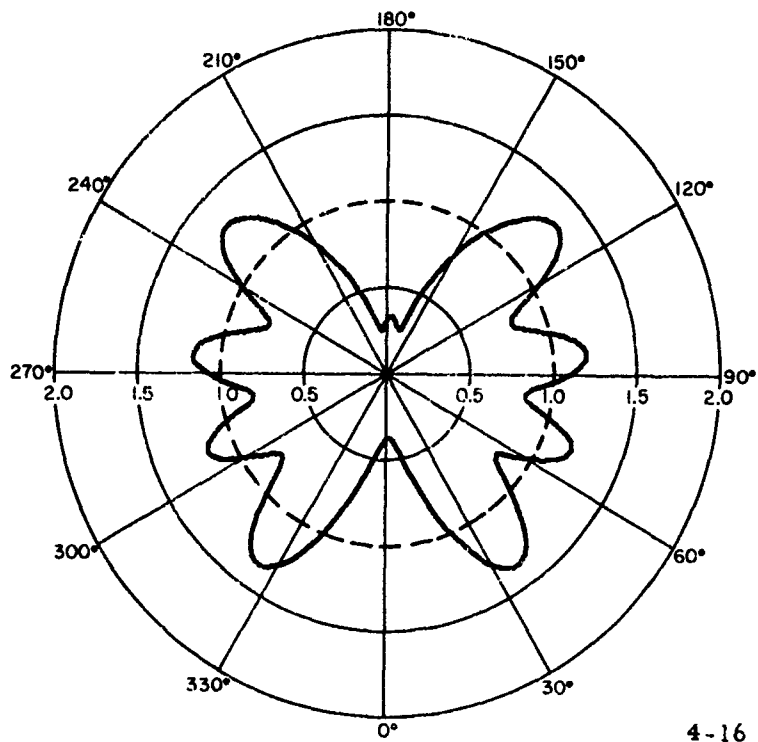
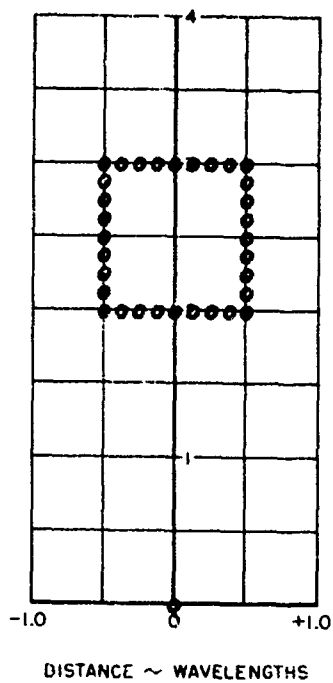


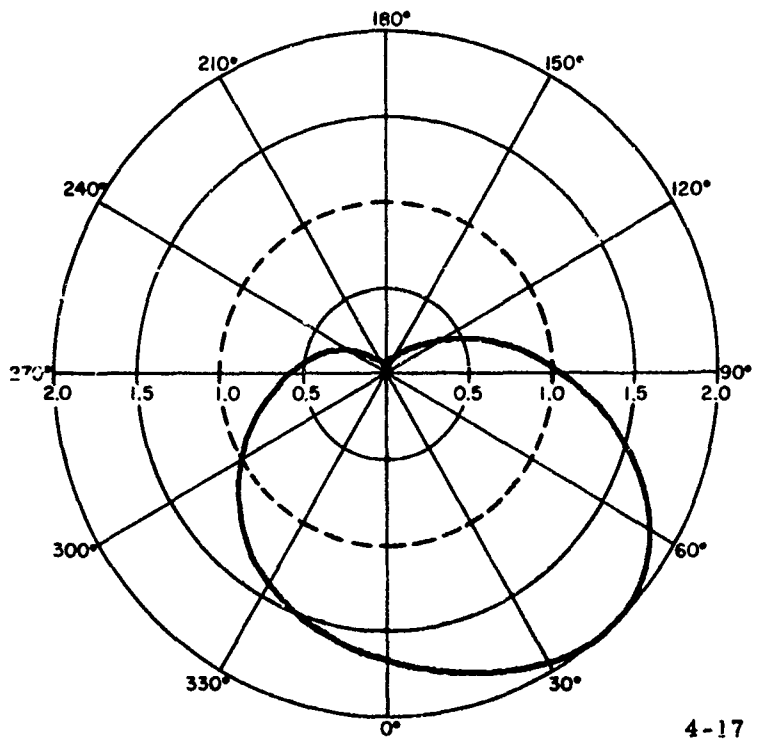
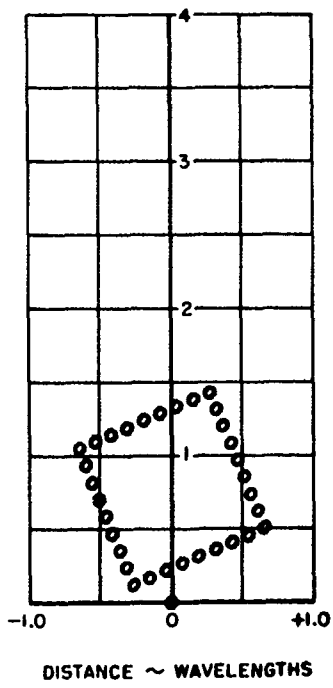
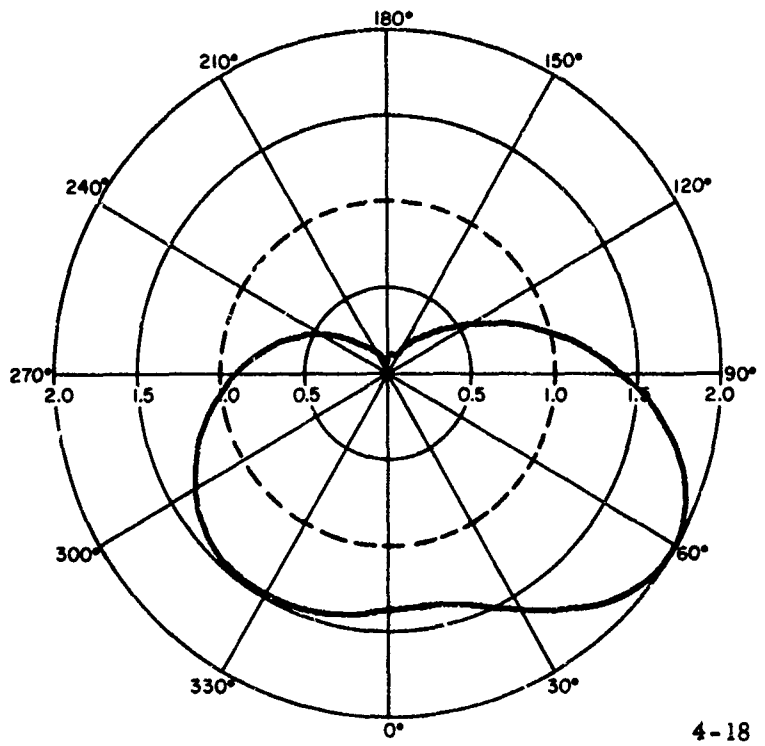
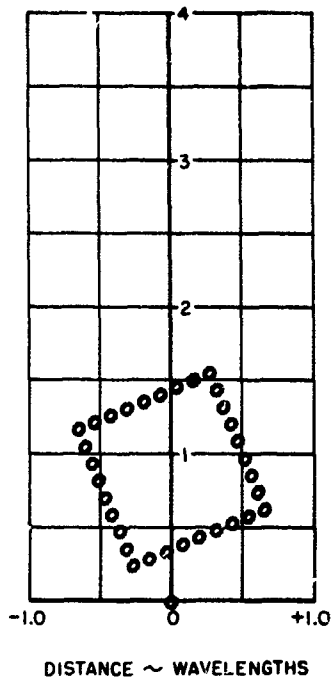
DISTANCE ~ WAVELENGTHS

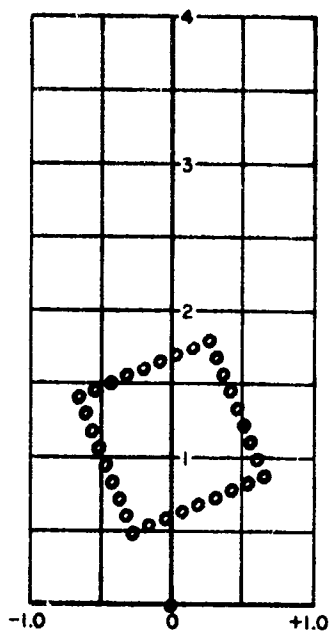


4-11

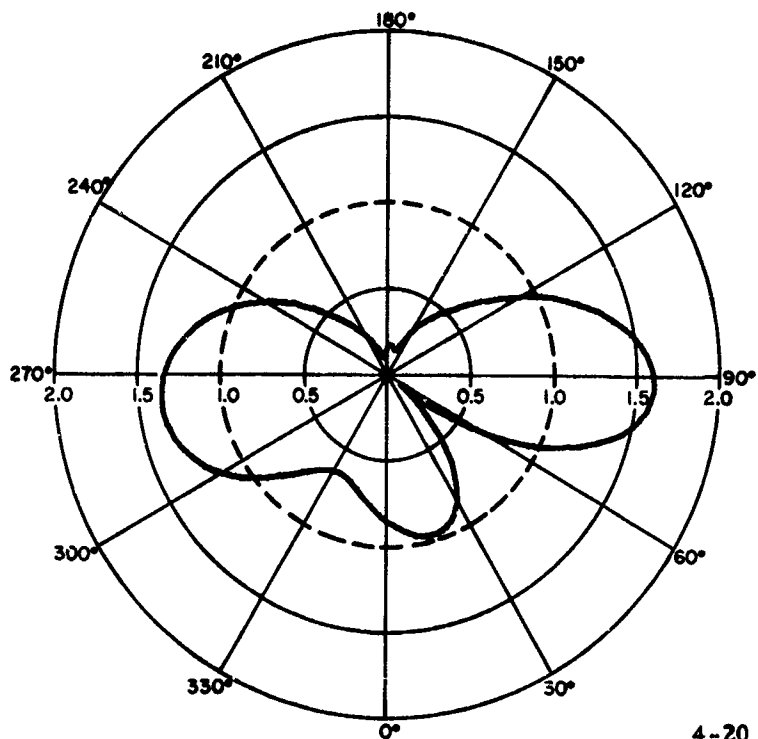




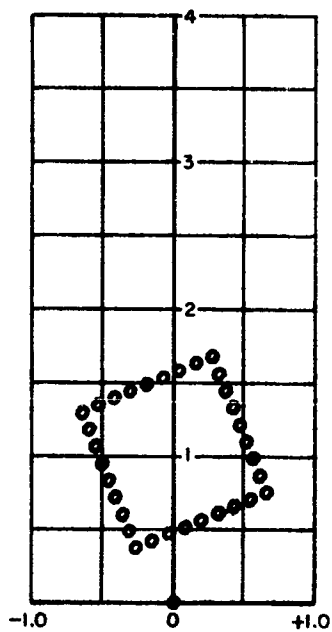




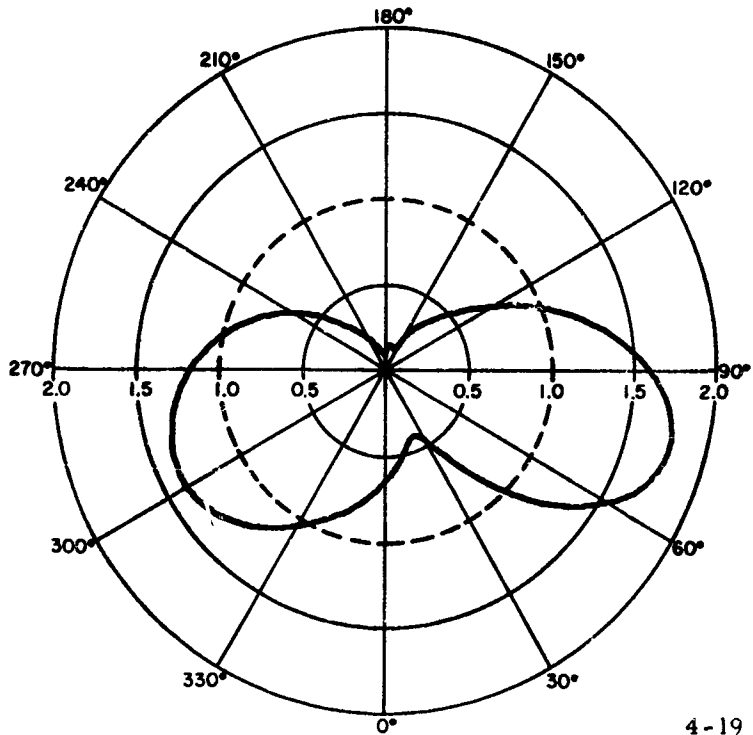
DISTANCE ~ WAVELENGTHS



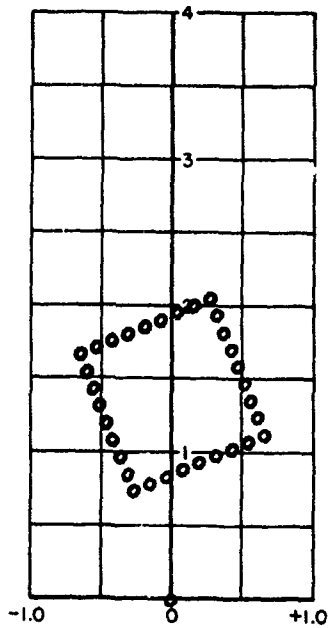
4-20



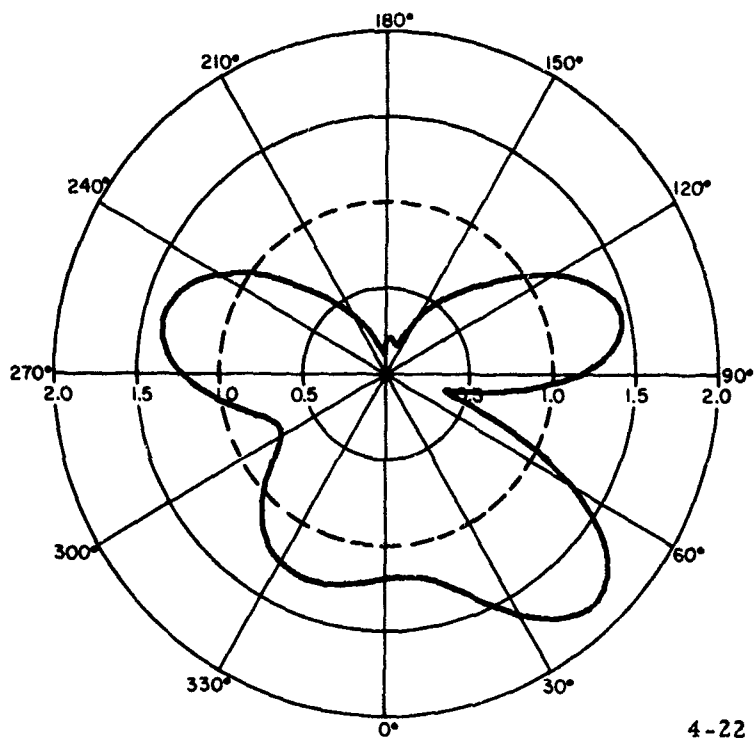
DISTANCE ~ WAVELENGTHS



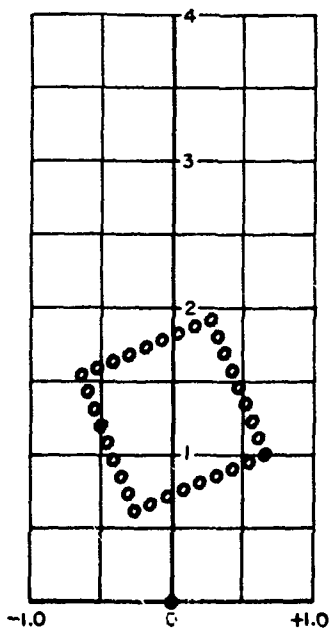
4-19



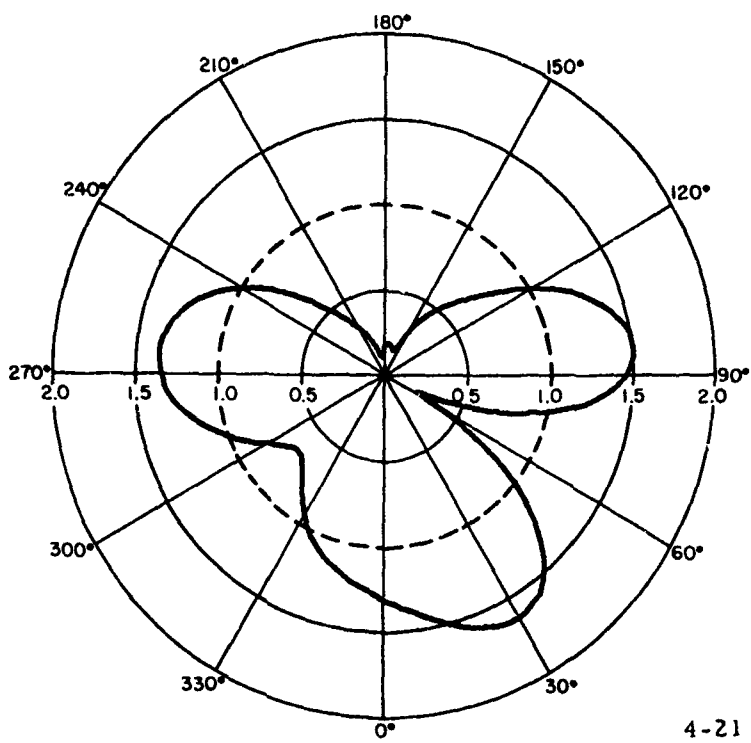
DISTANCE ~ WAVELENGTHS



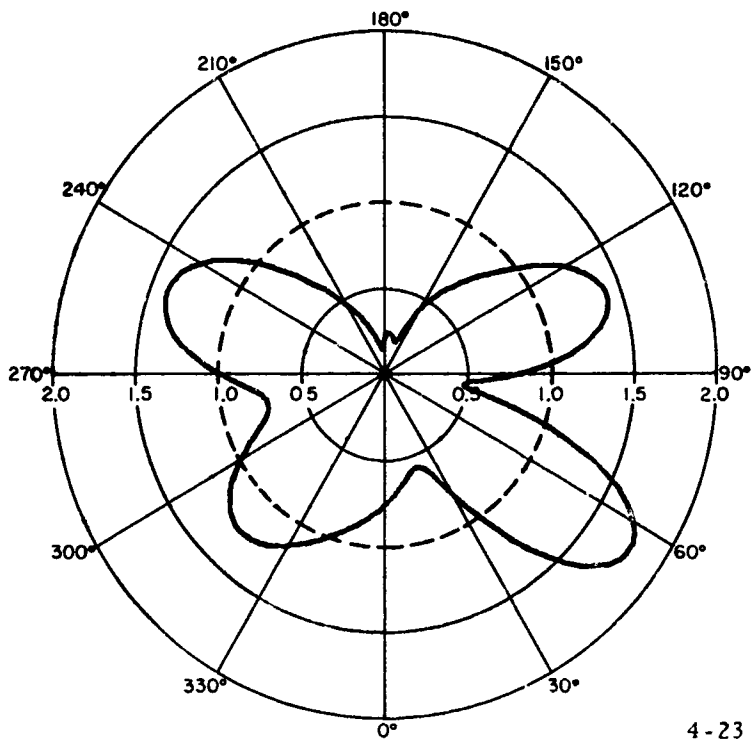
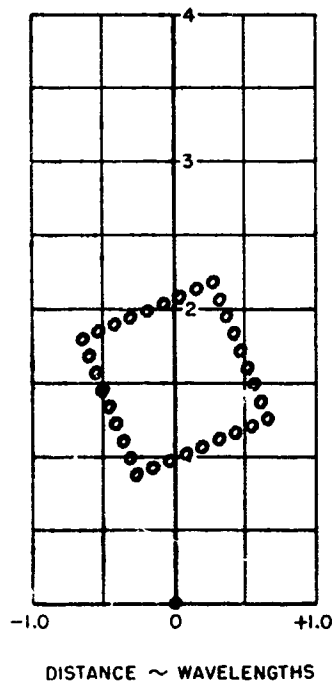
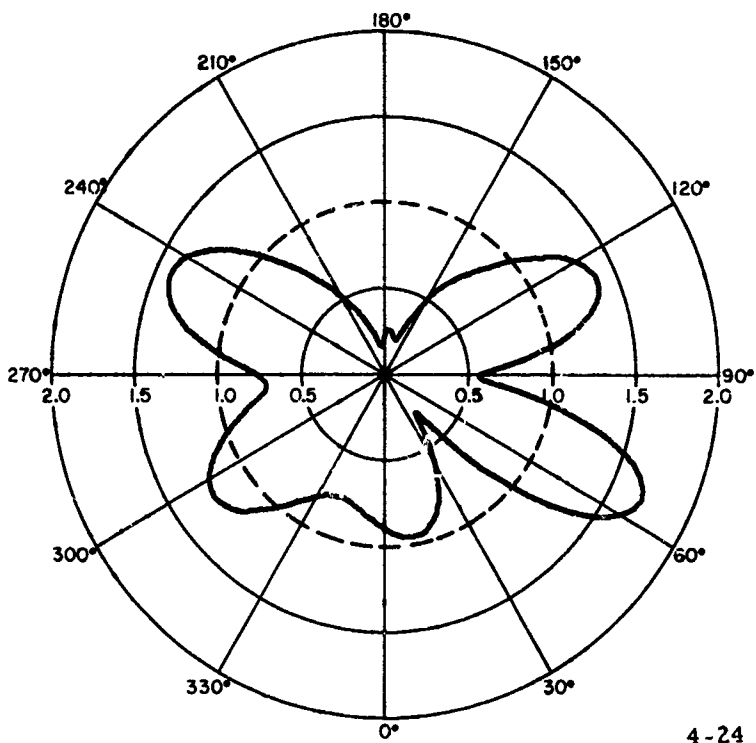
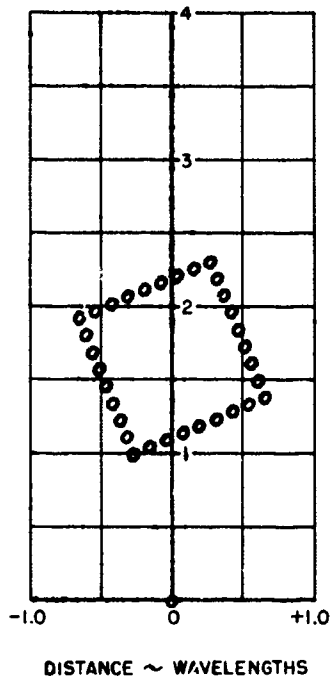
4-22

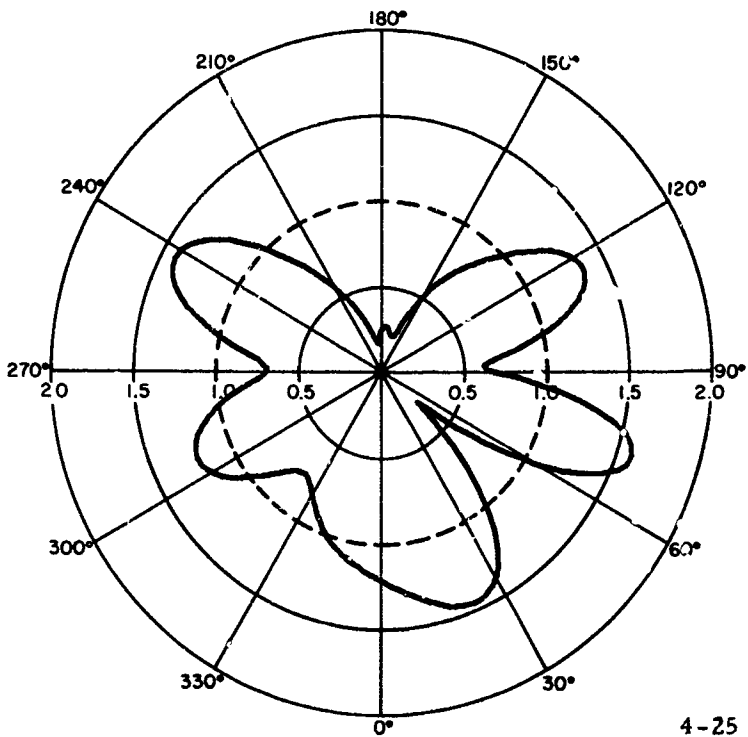
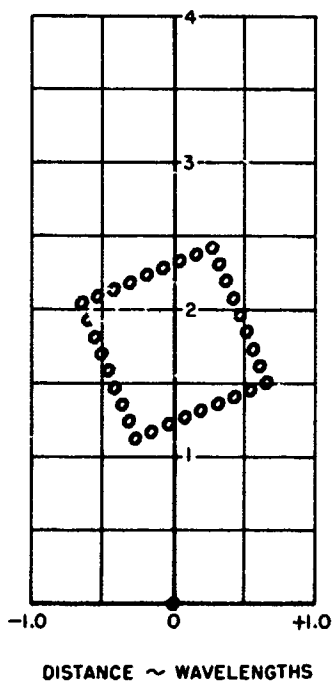
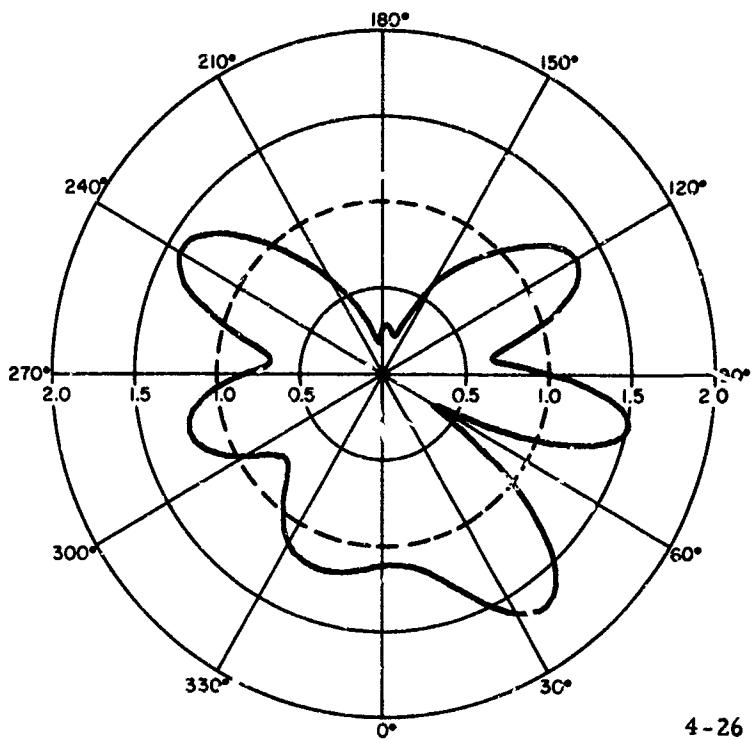
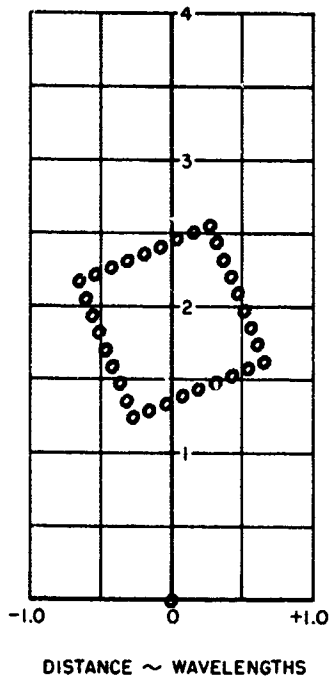


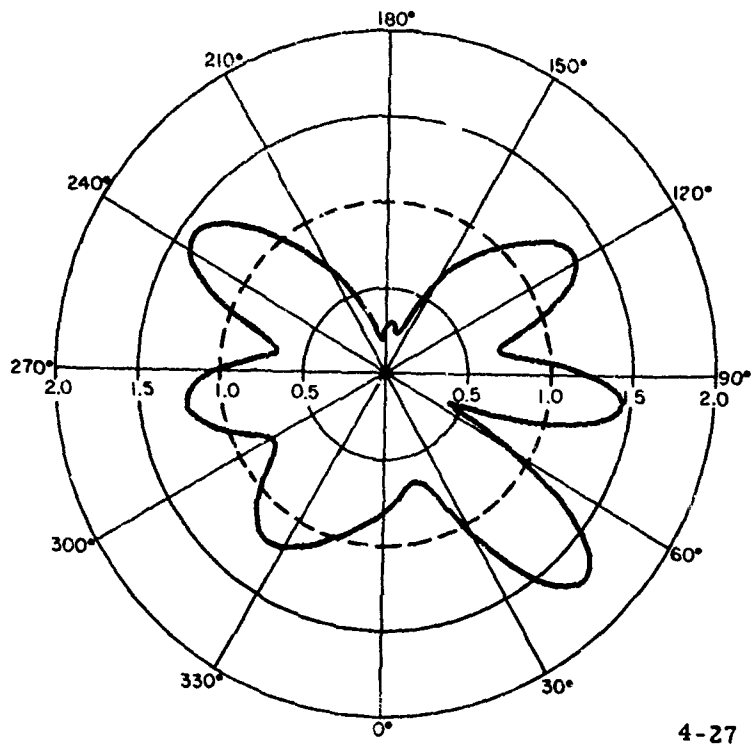
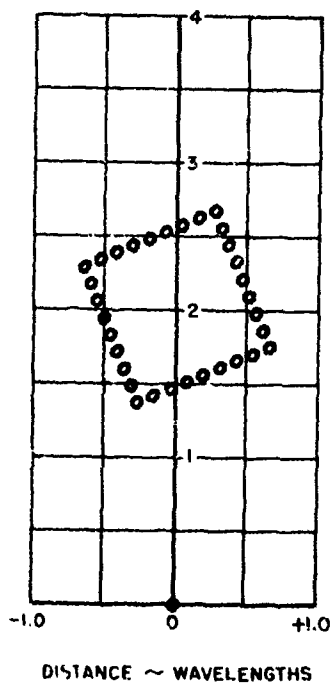
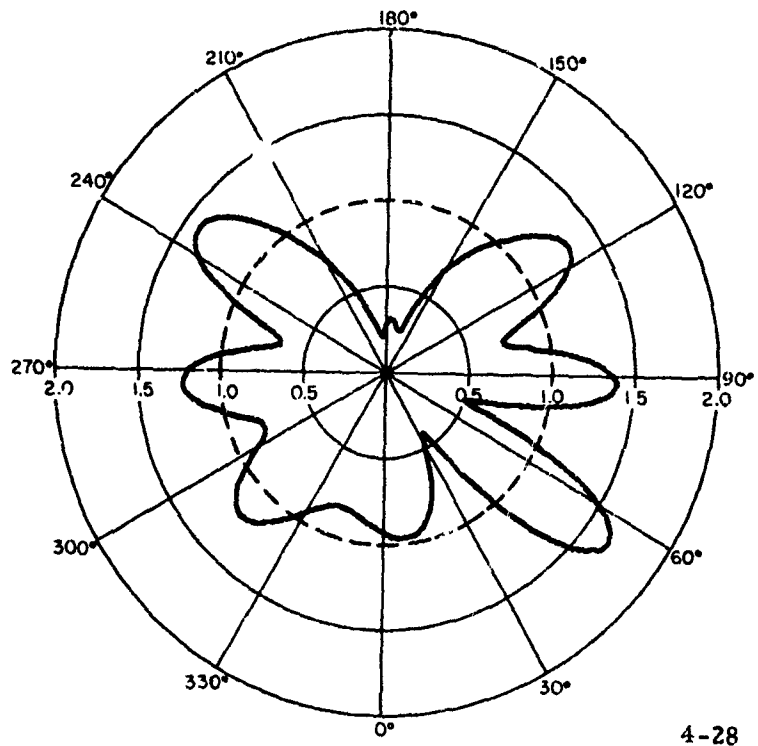
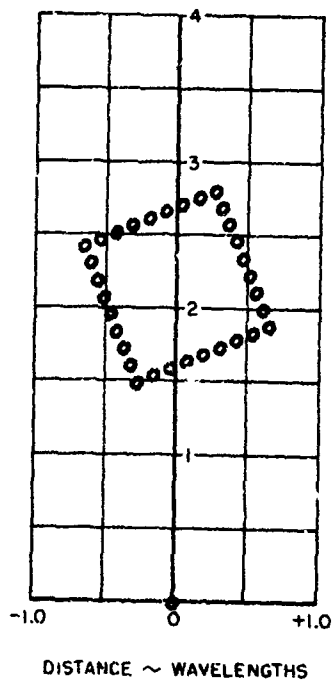
DISTANCE ~ WAVELENGTHS

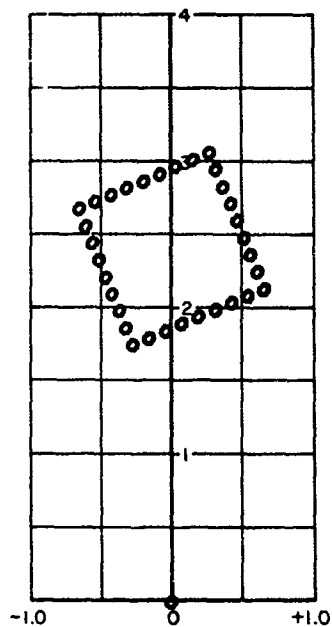


4-21

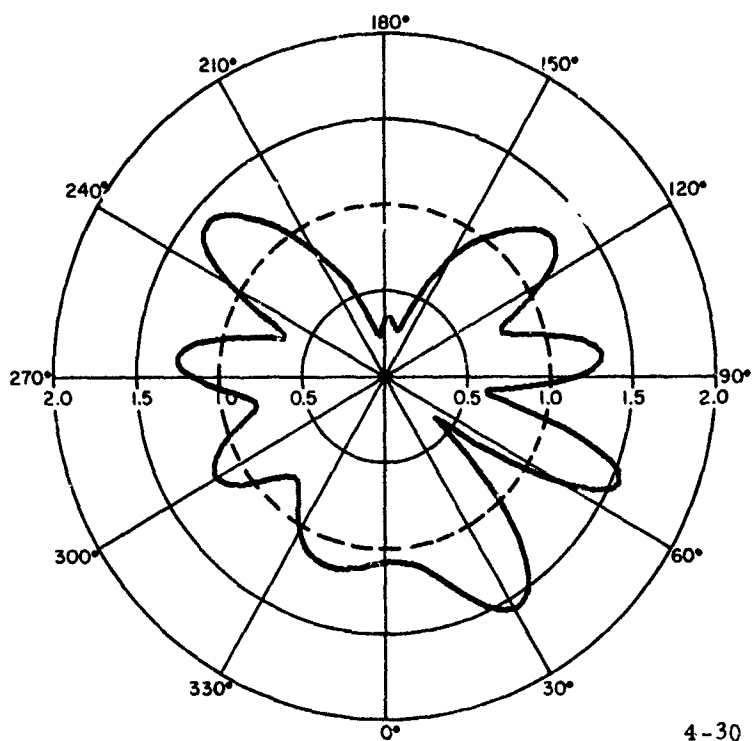




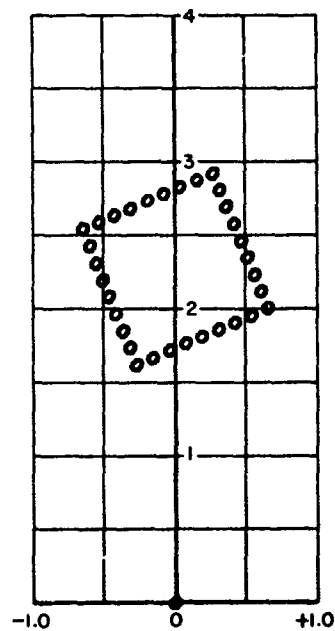




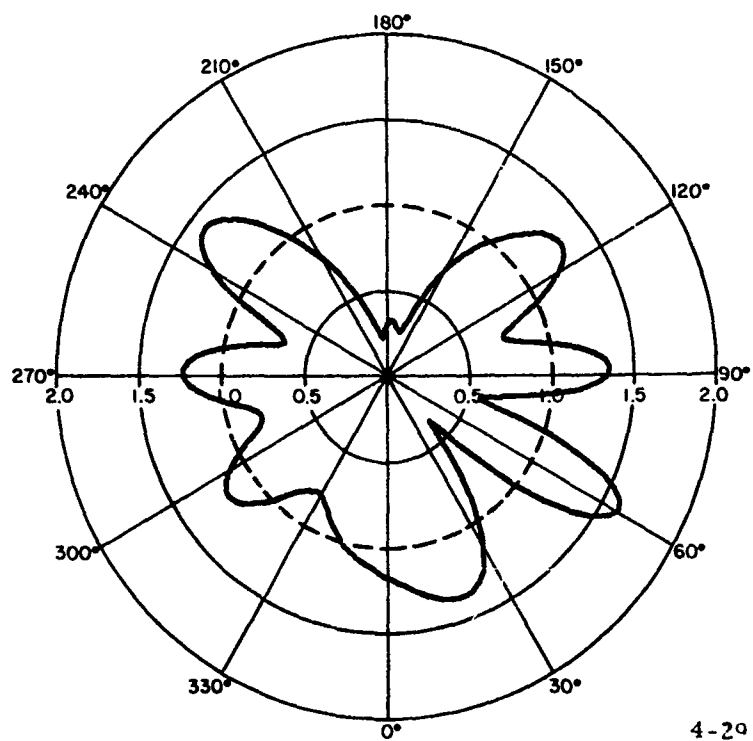
DISTANCE ~ WAVELENGTHS



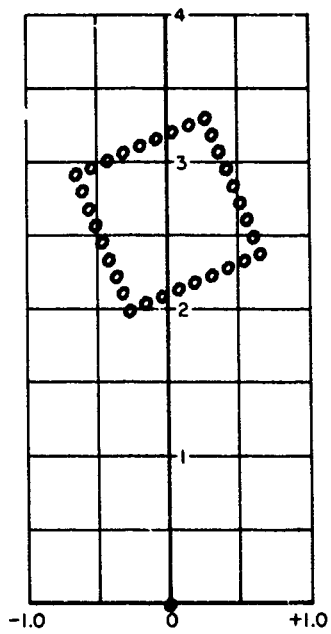
4-30



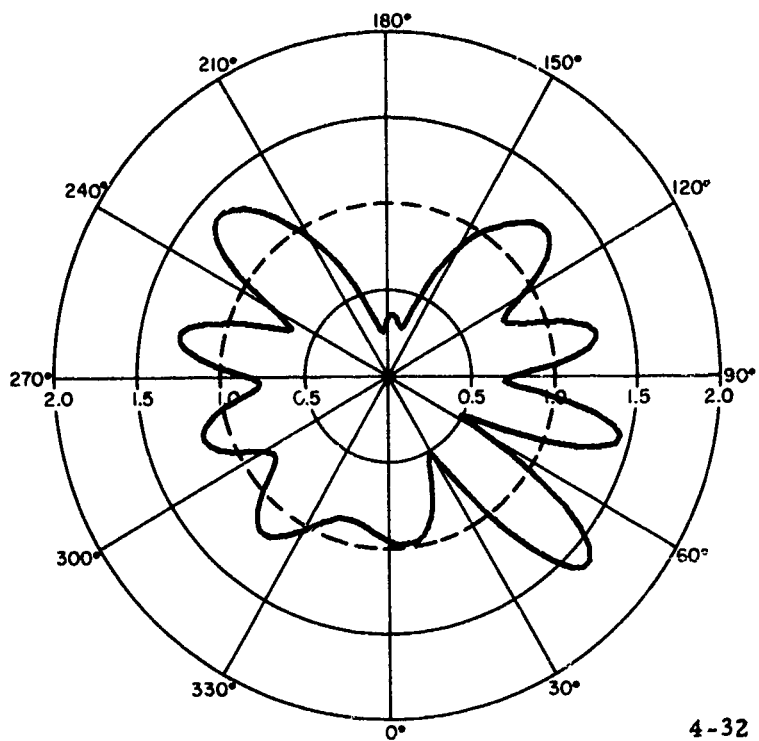
DISTANCE ~ WAVELENGTHS



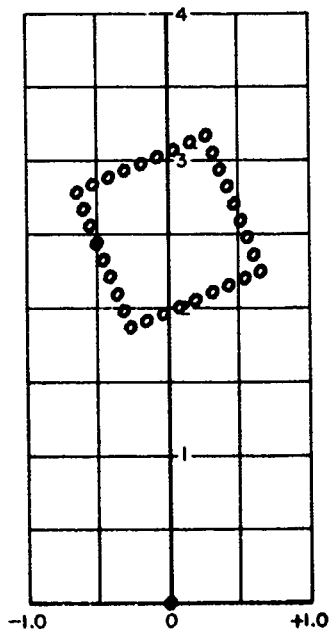
4-20



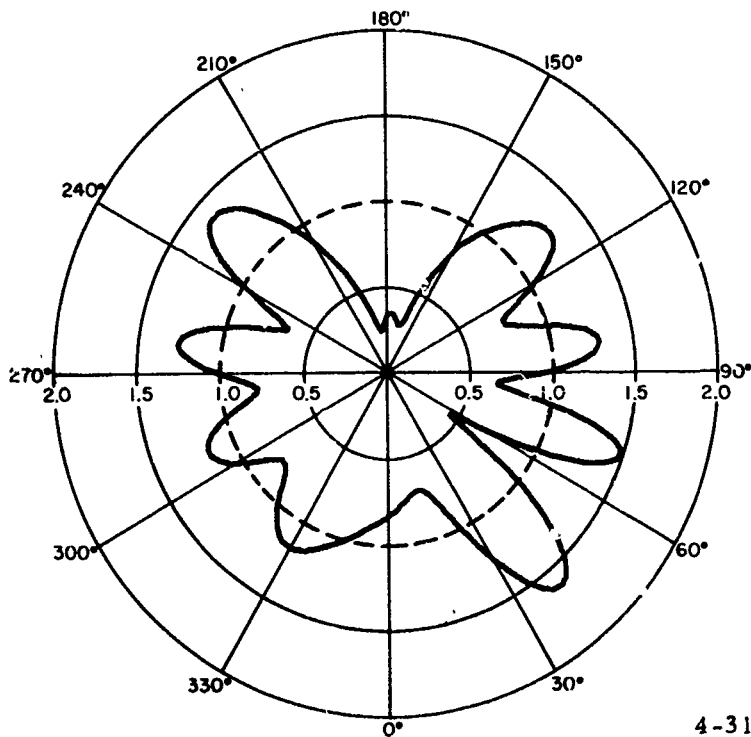
DISTANCE ~ WAVELENGTHS



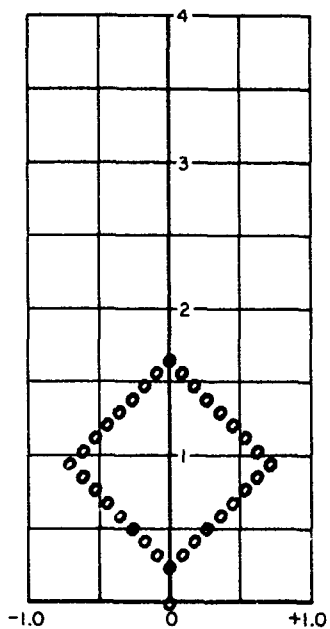
4-32



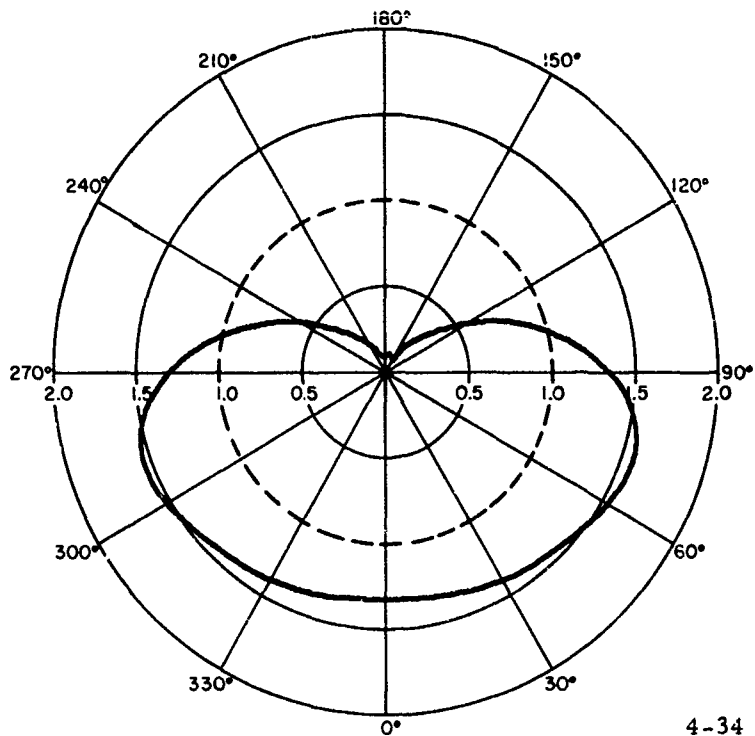
DISTANCE ~ WAVELENGTHS



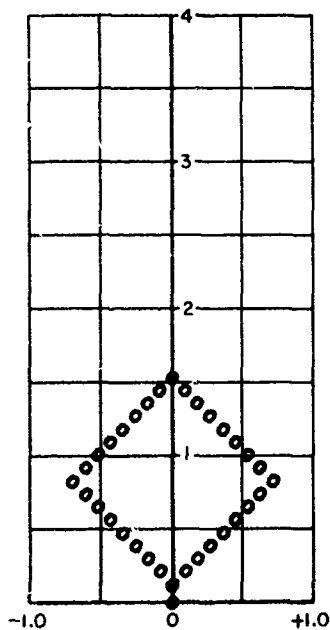
4-31



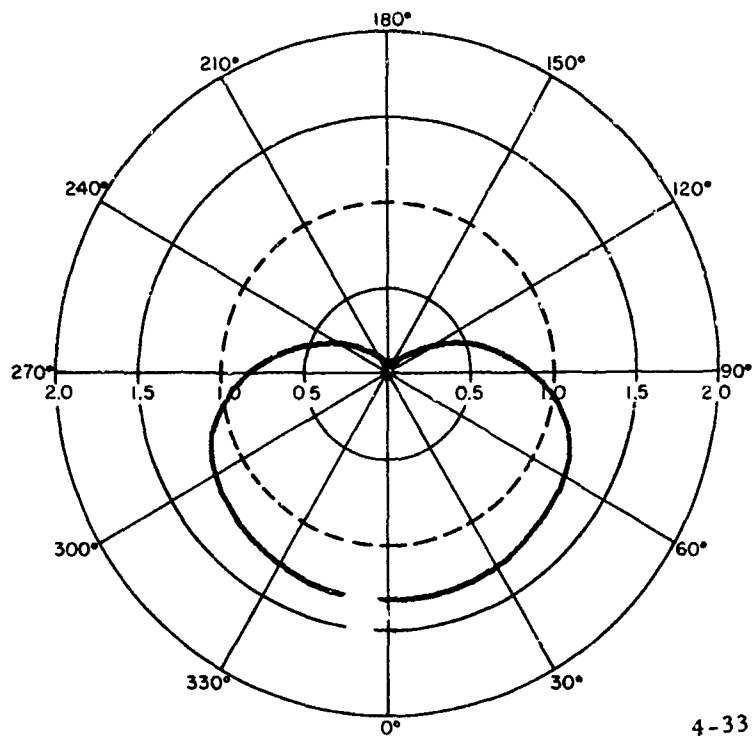
DISTANCE ~ WAVELENGTHS



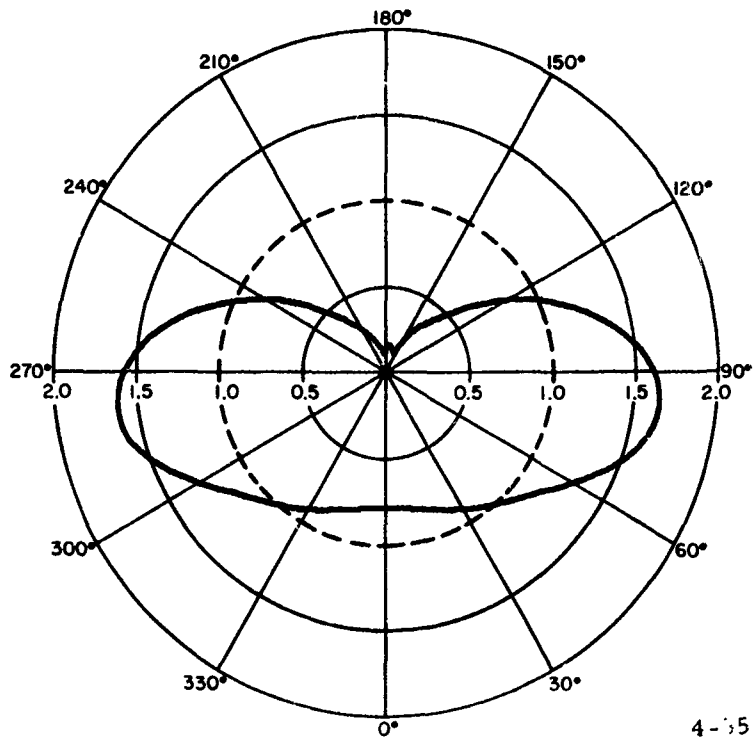
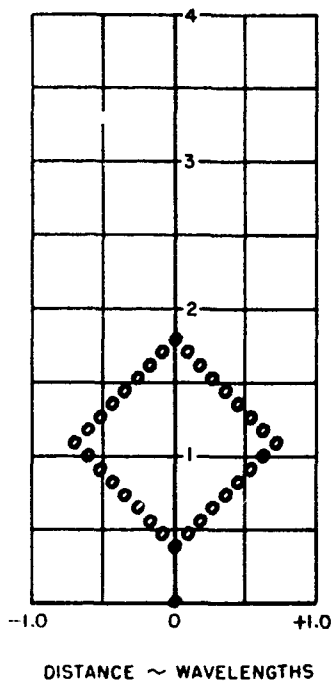
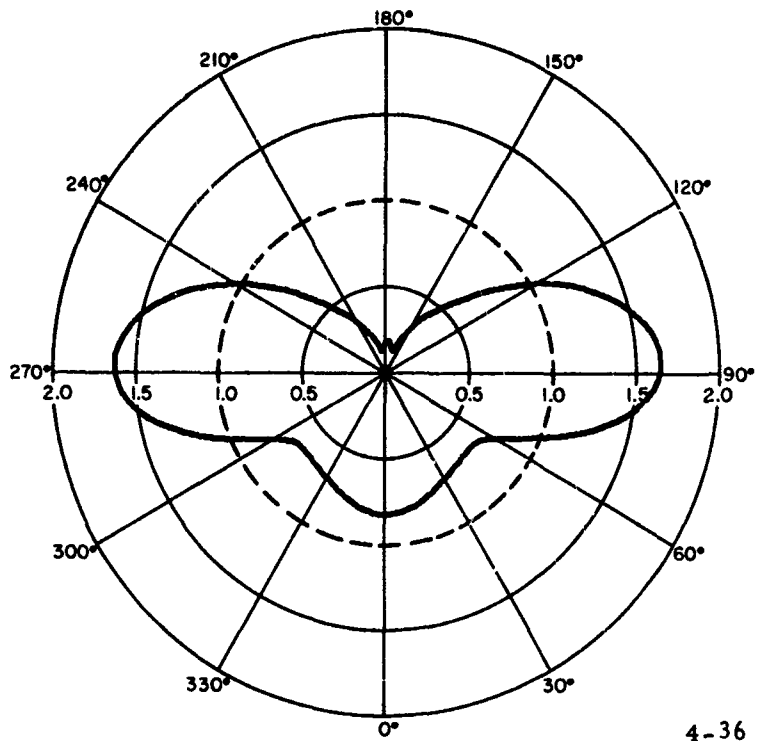
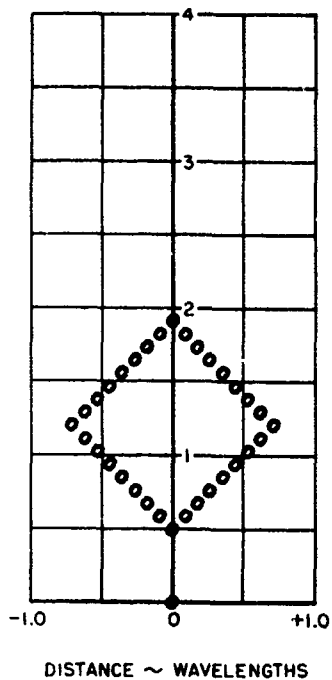
4-34

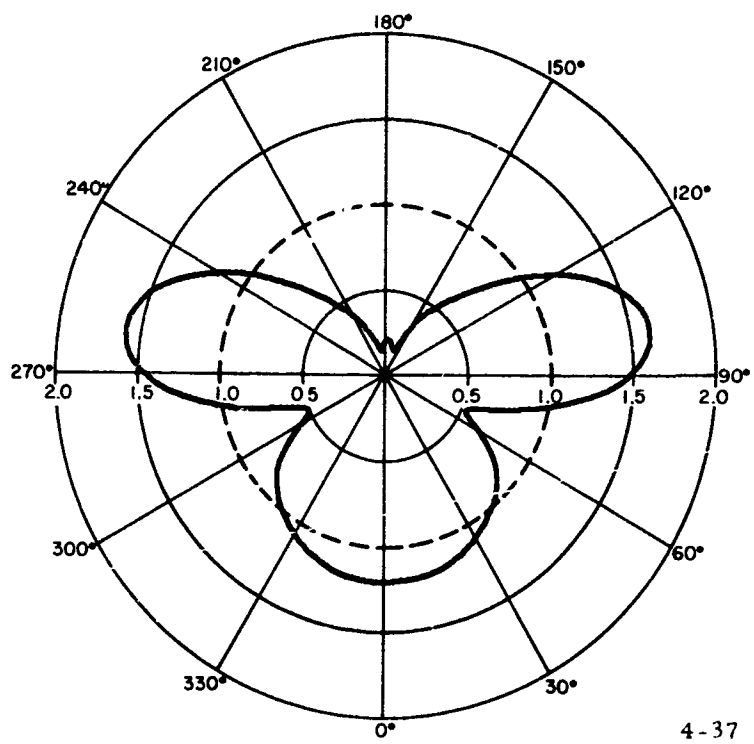
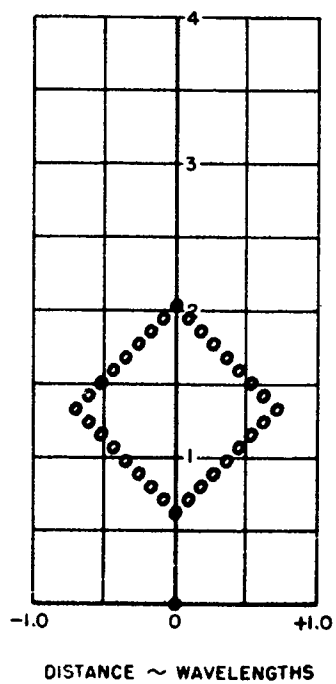
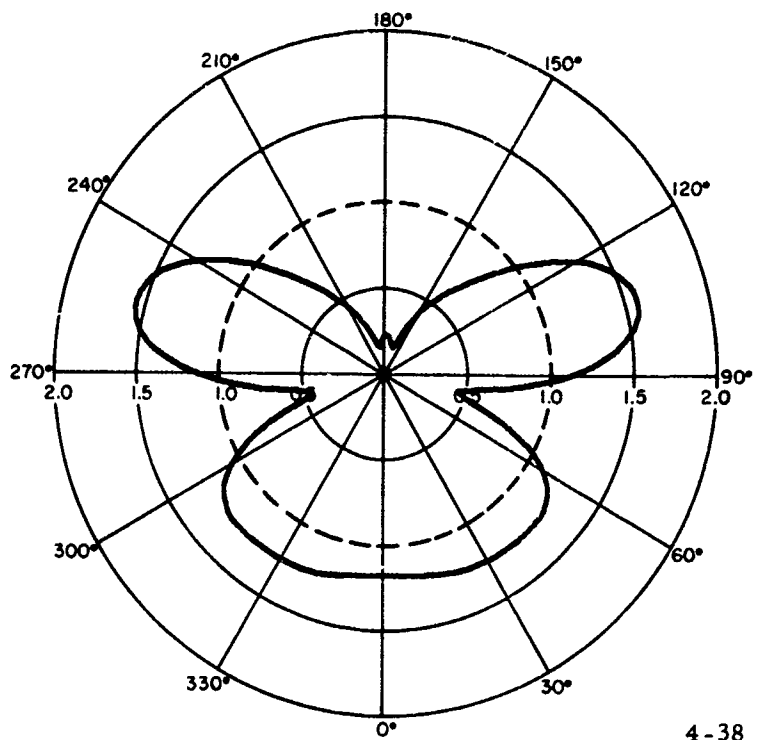
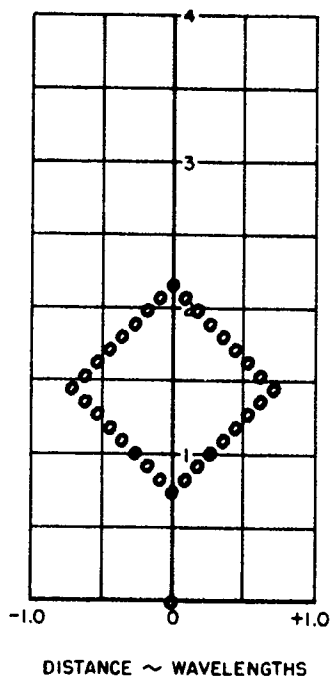


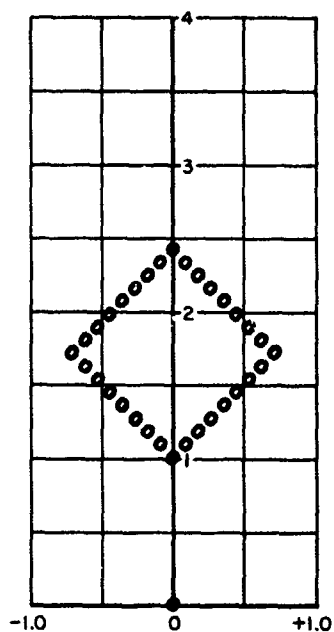
DISTANCE ~ WAVELENGTHS



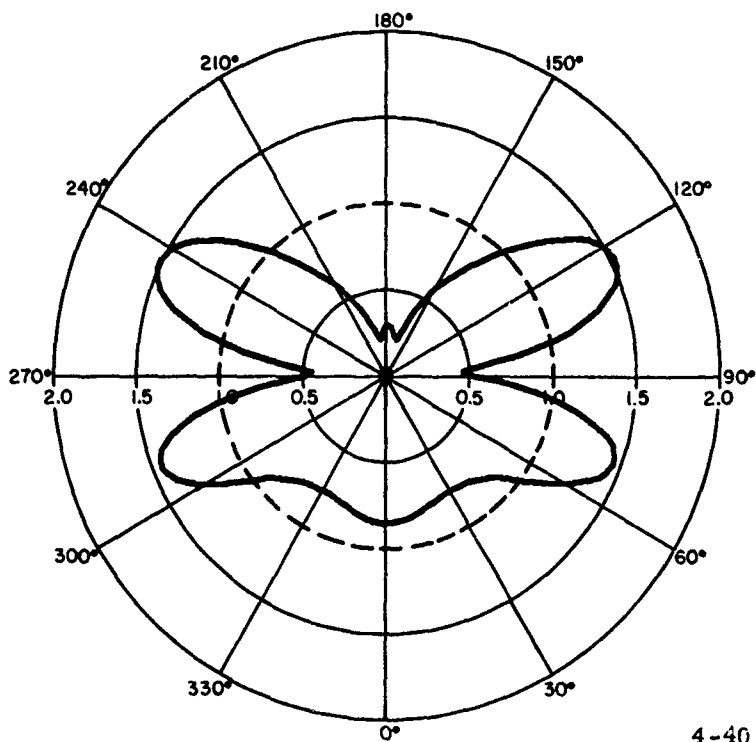
4-33



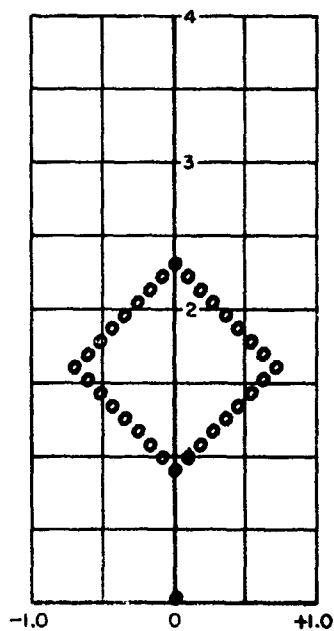




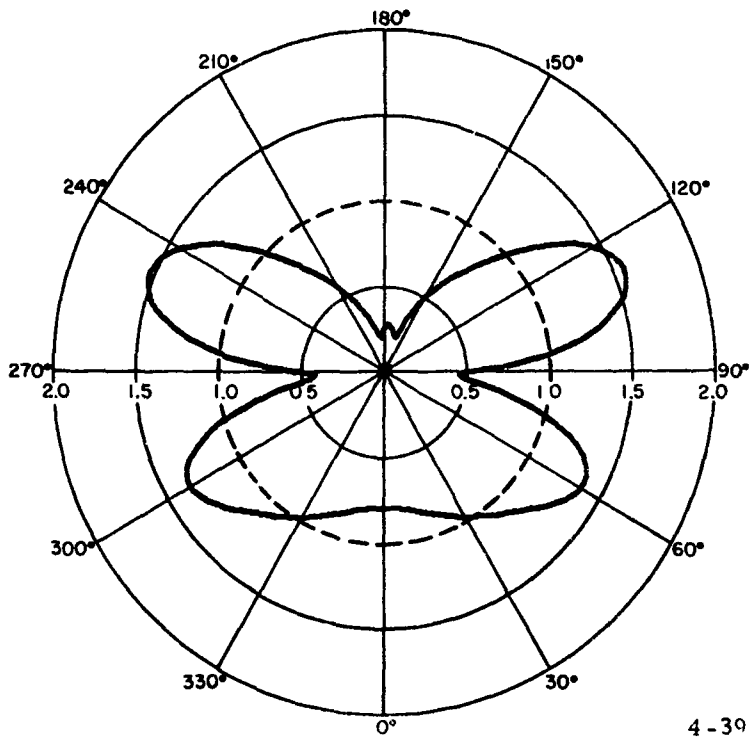
DISTANCE ~ WAVELENGTHS



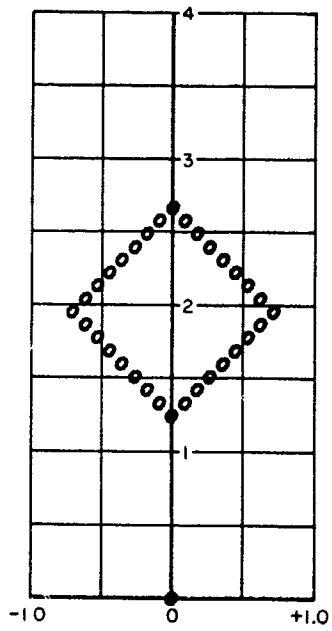
4-40



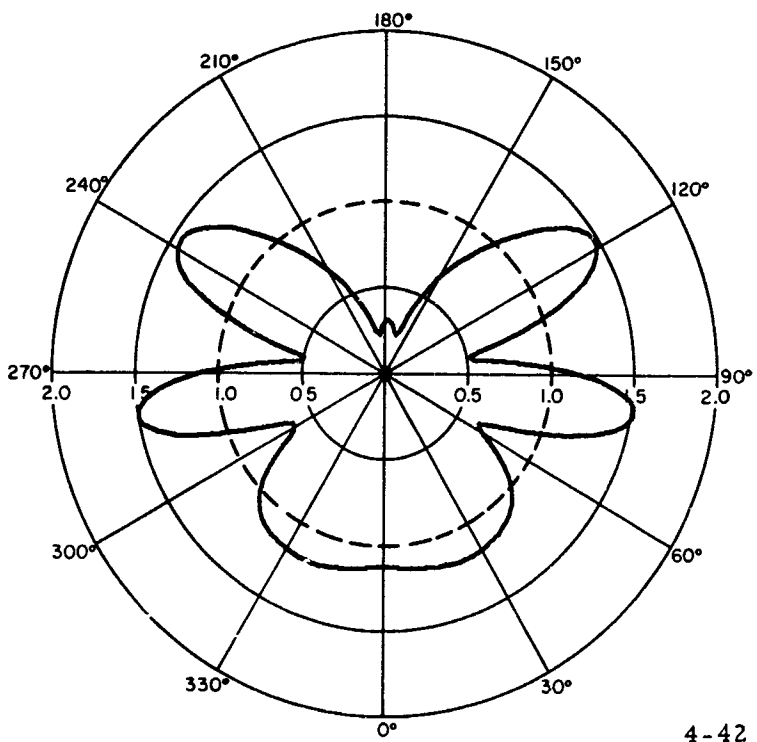
DISTANCE ~ WAVELENGTHS



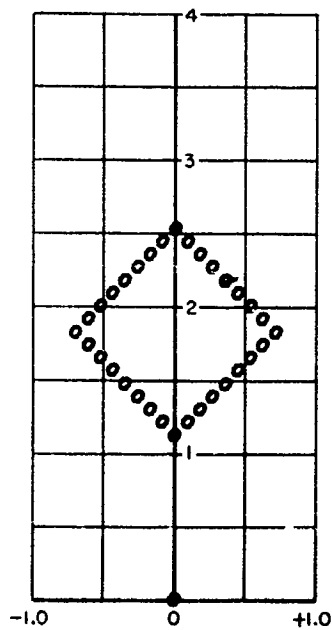
4-39



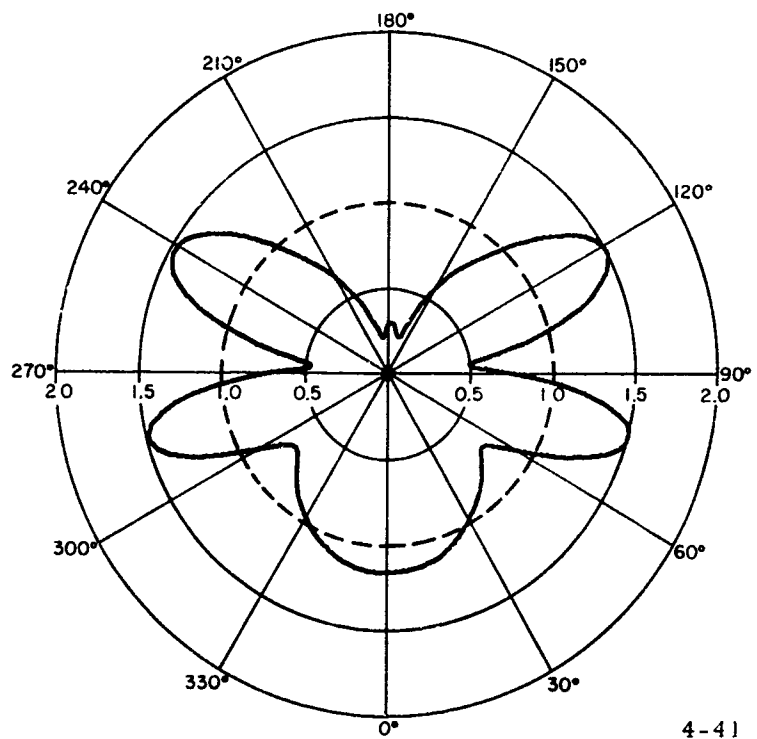
DISTANCE ~ WAVELENGTHS



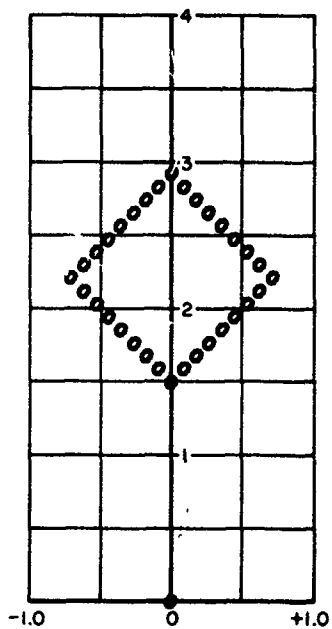
4-42



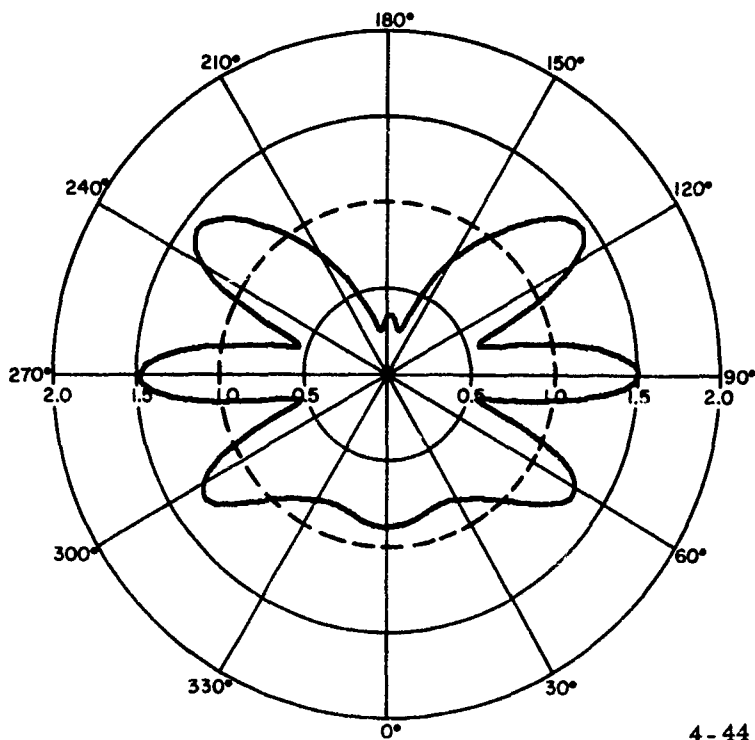
DISTANCE ~ WAVELENGTHS



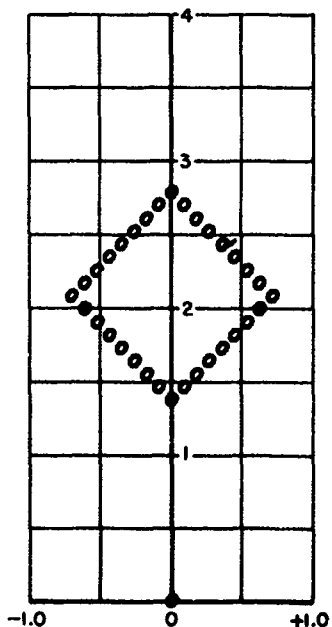
4-41



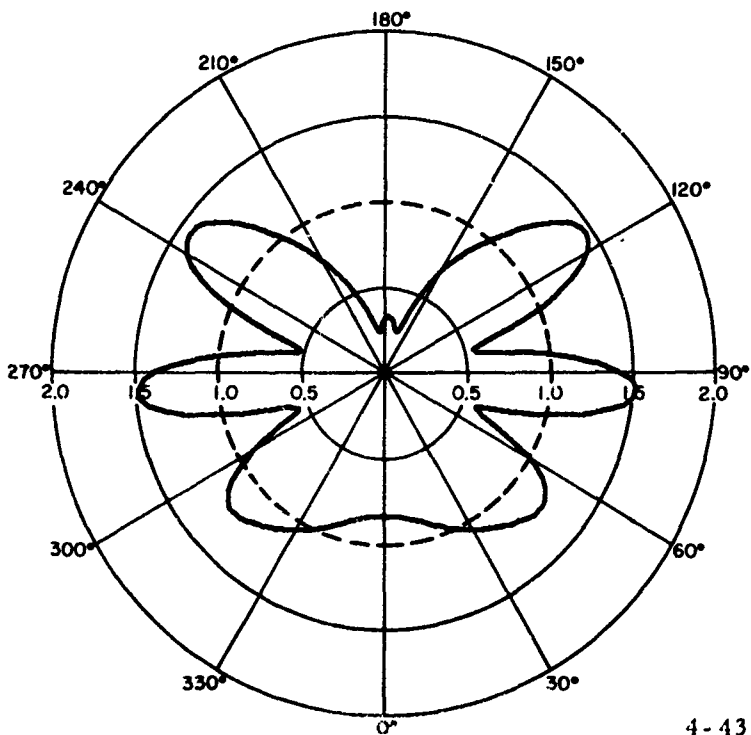
DISTANCE ~ WAVELENGTHS



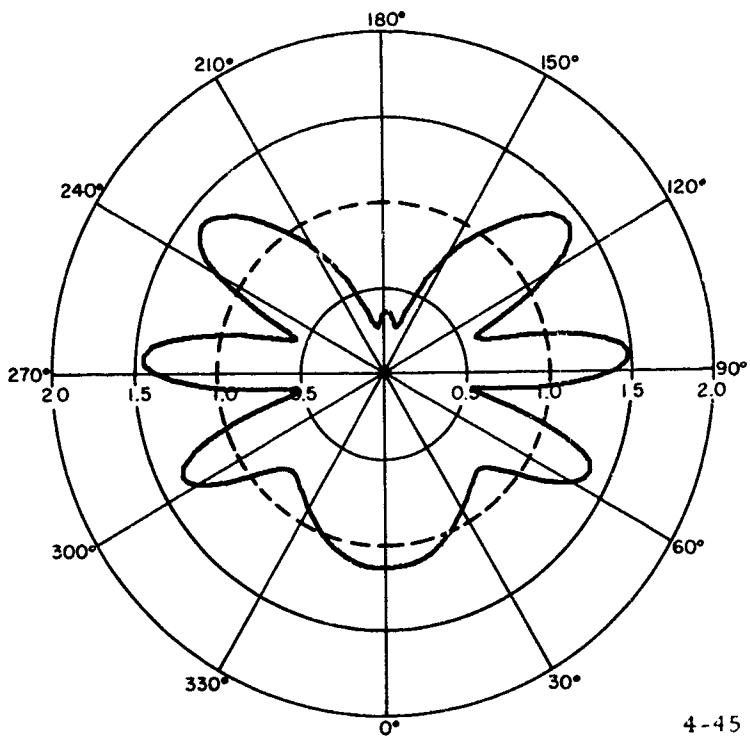
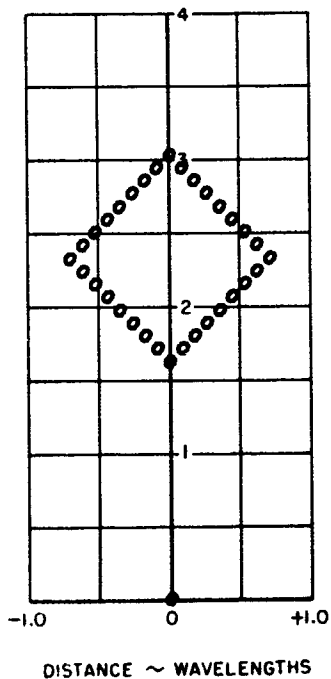
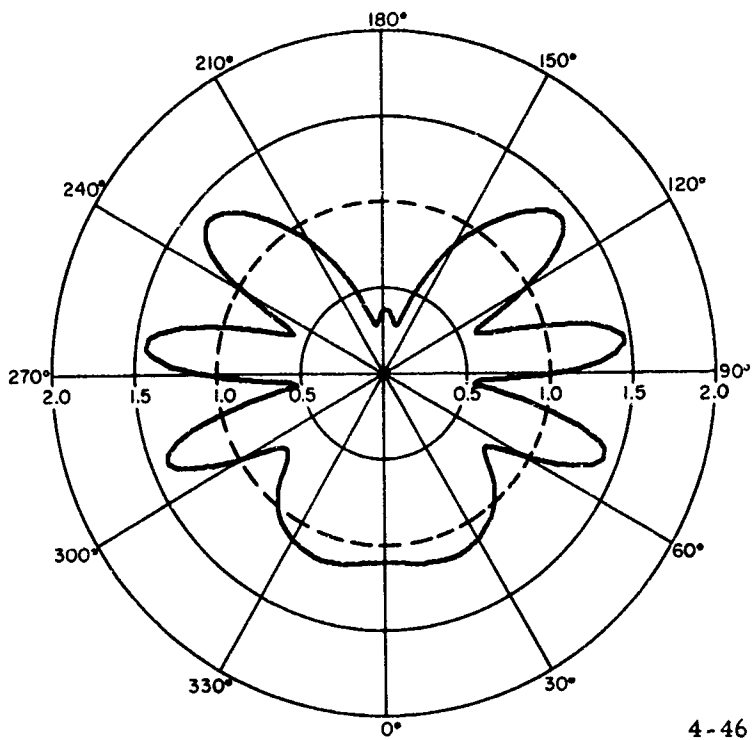
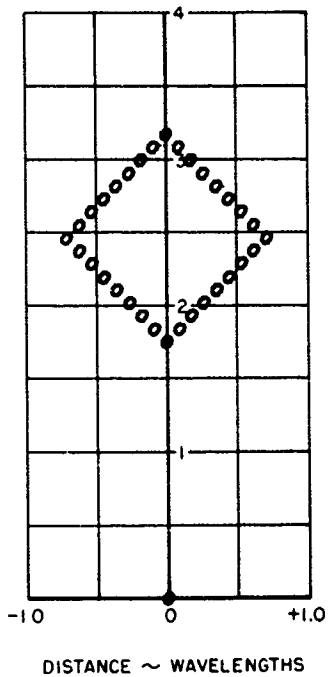
4-44

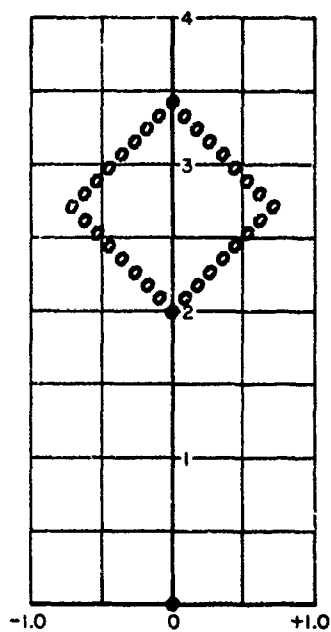


DISTANCE ~ WAVELENGTHS

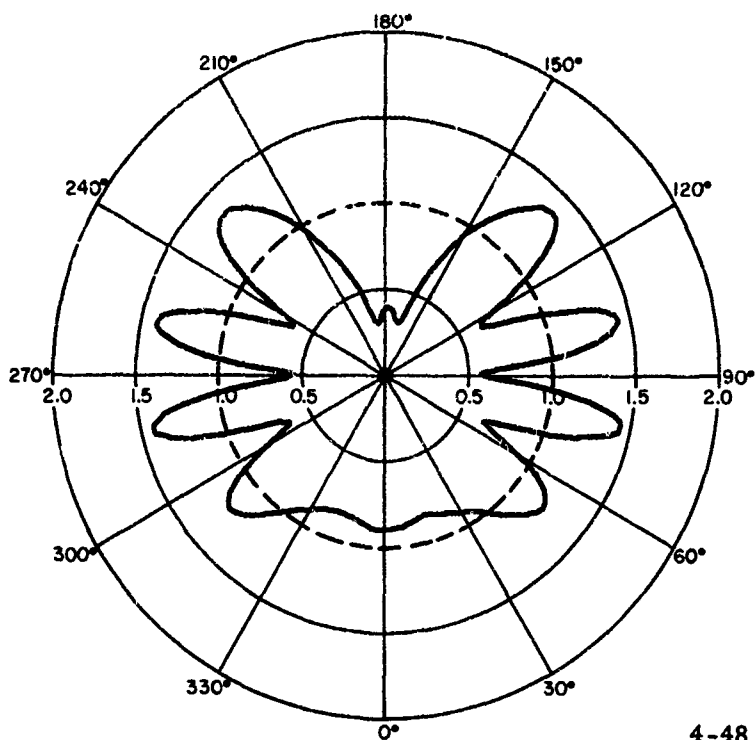


4-43

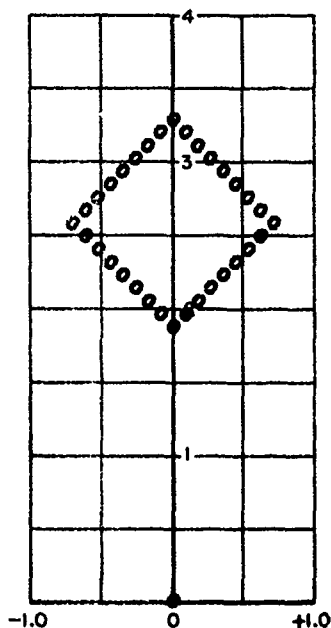




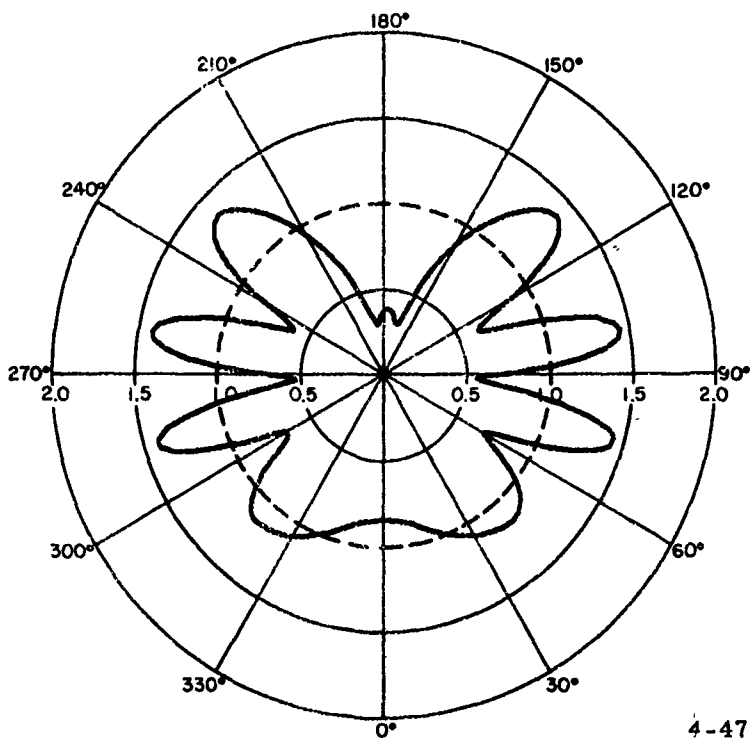
DISTANCE ~ WAVELENGTHS



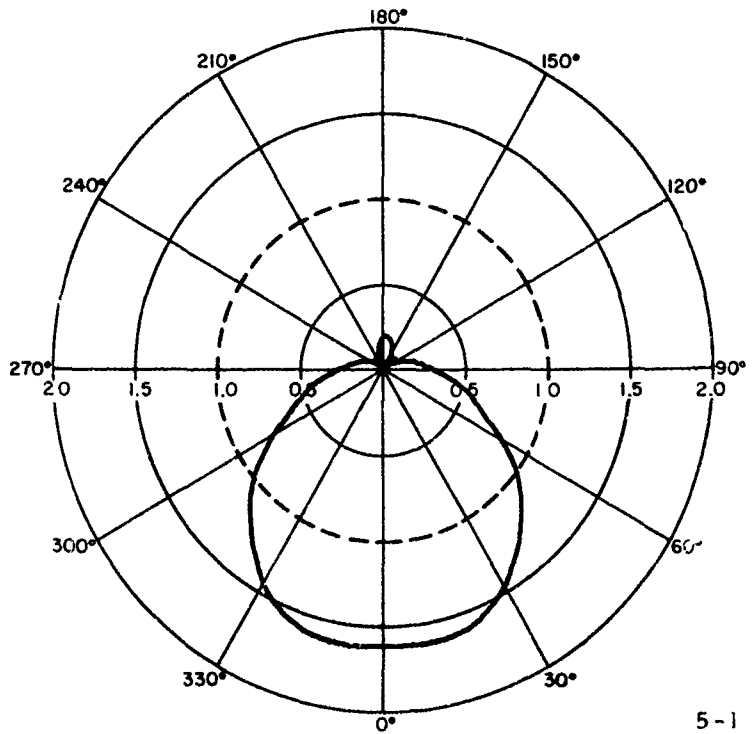
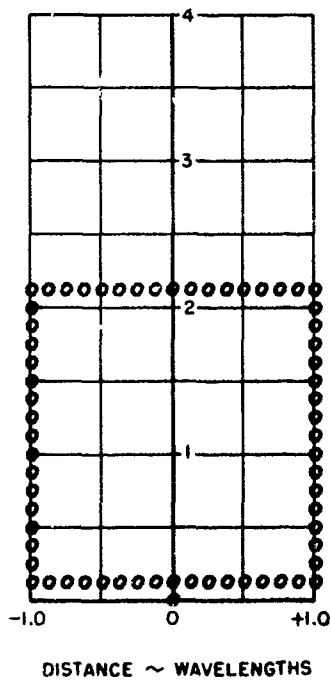
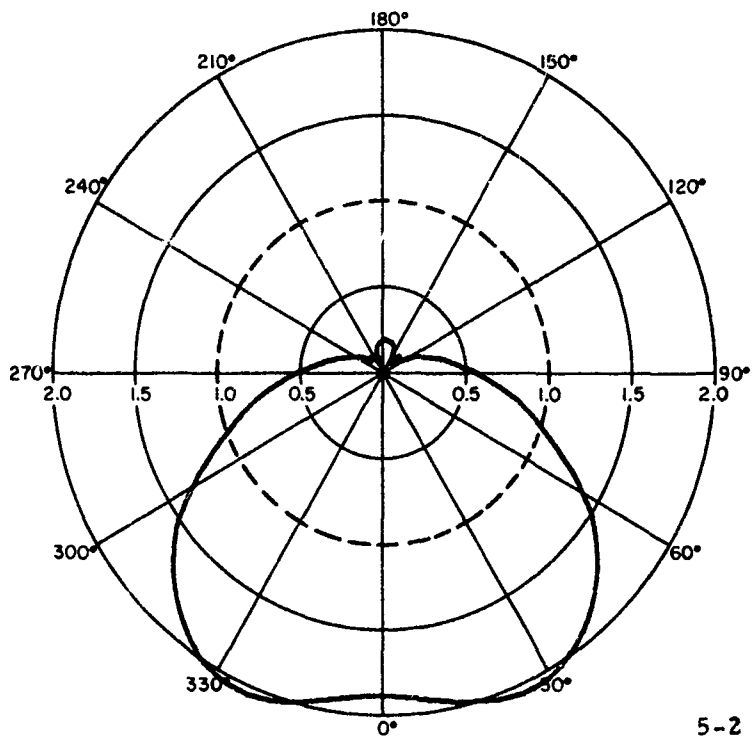
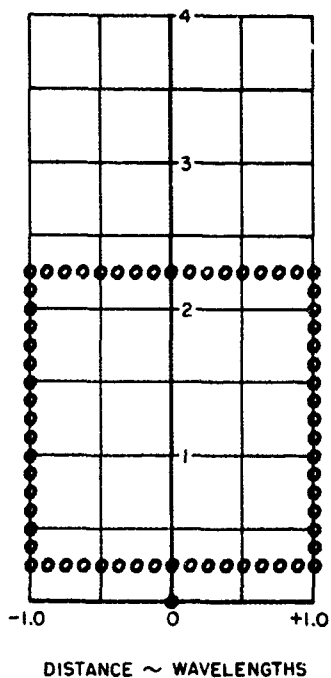
4-48

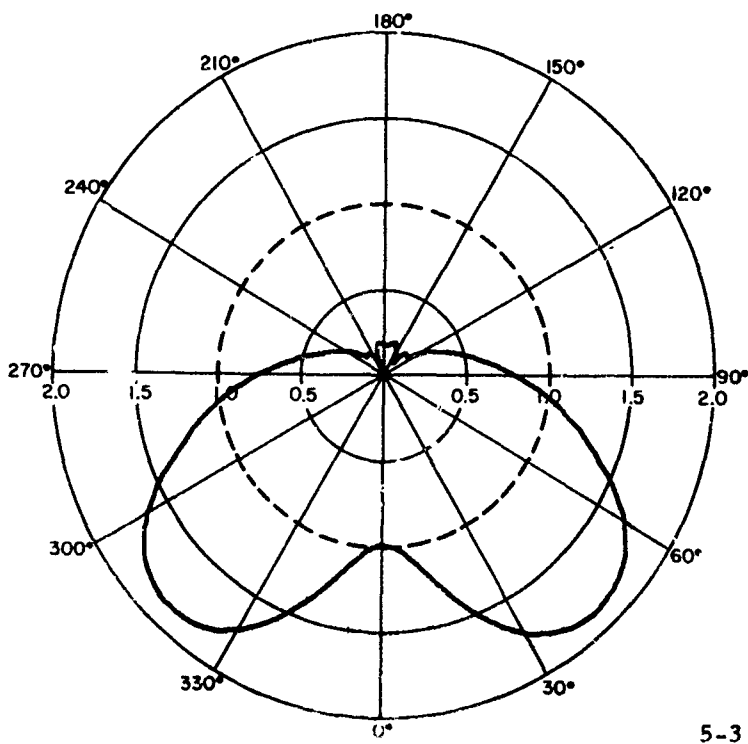
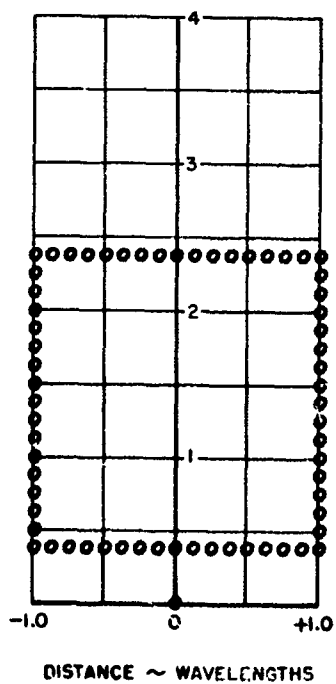
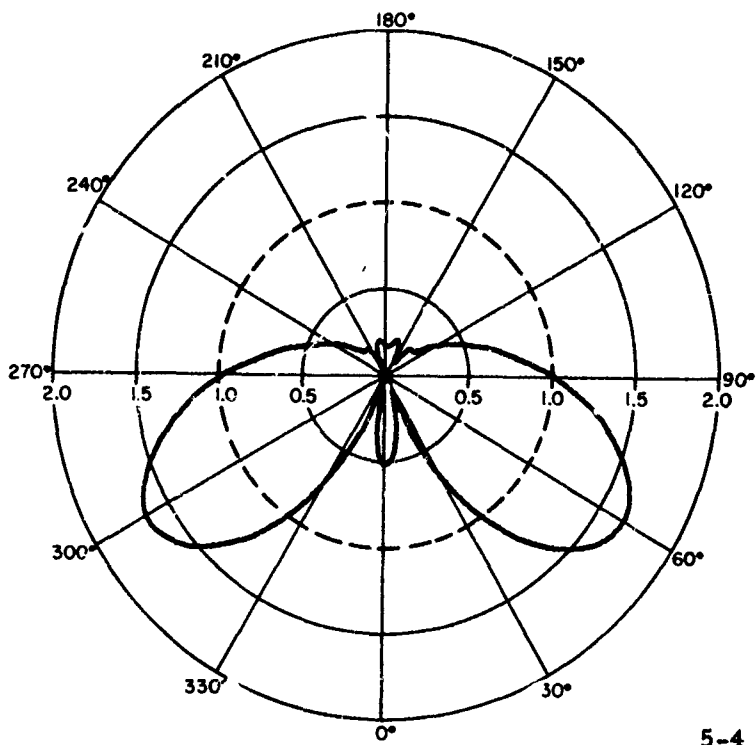
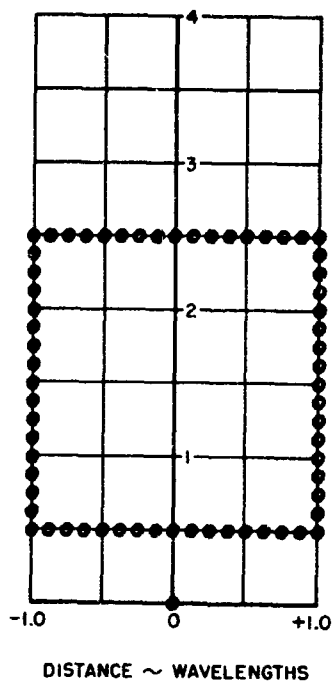


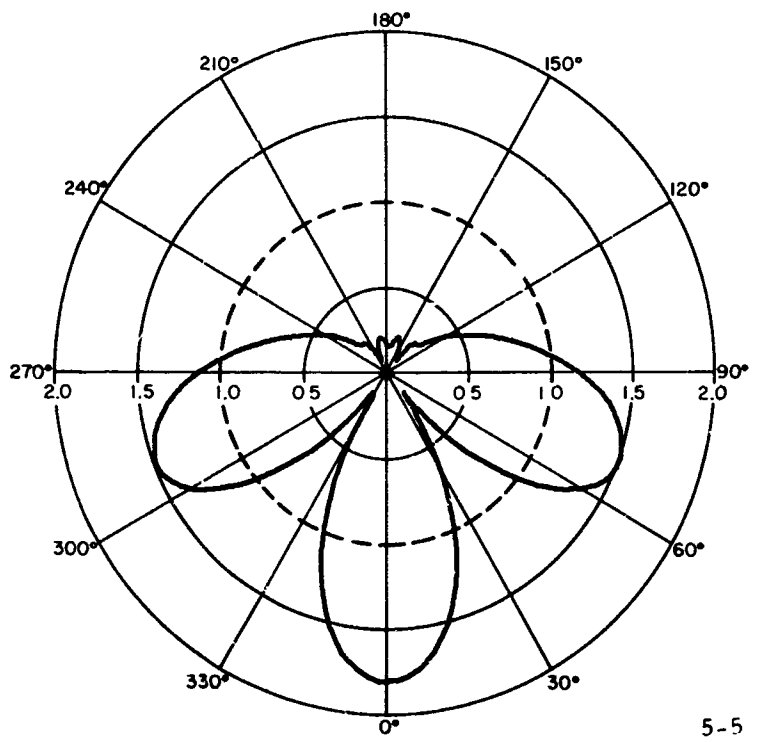
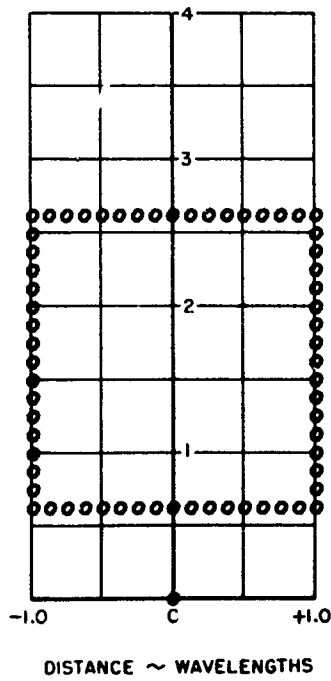
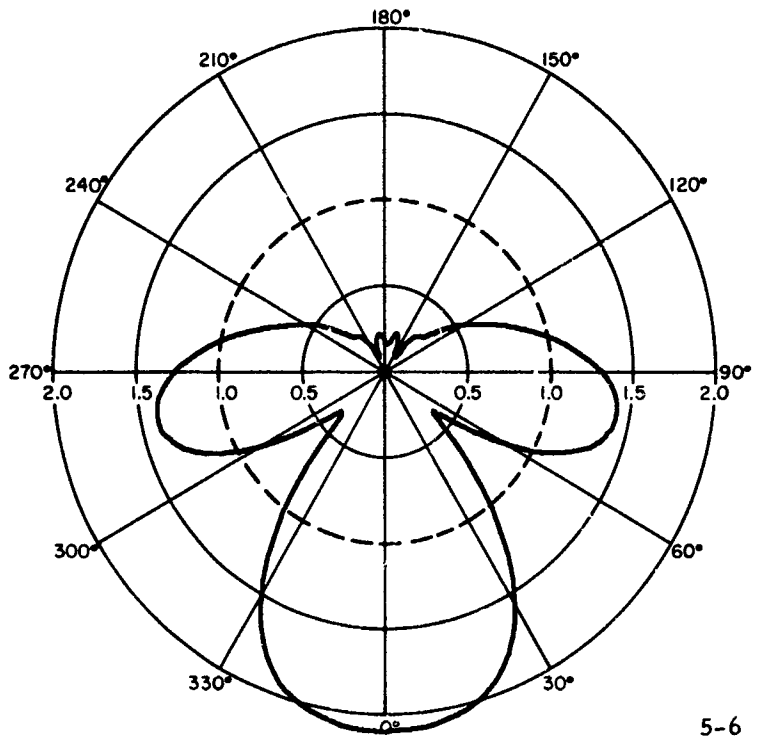
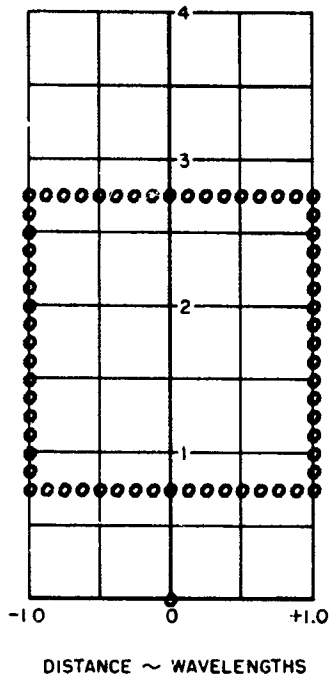
DISTANCE ~ WAVELENGTHS

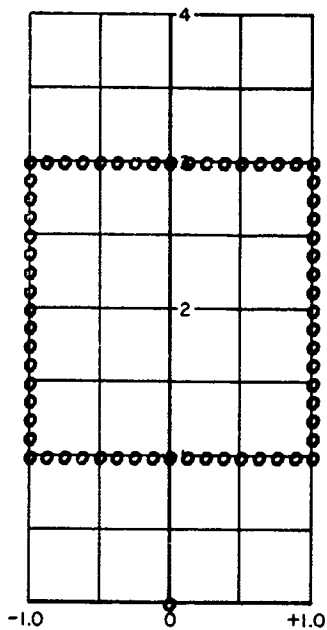


4-47

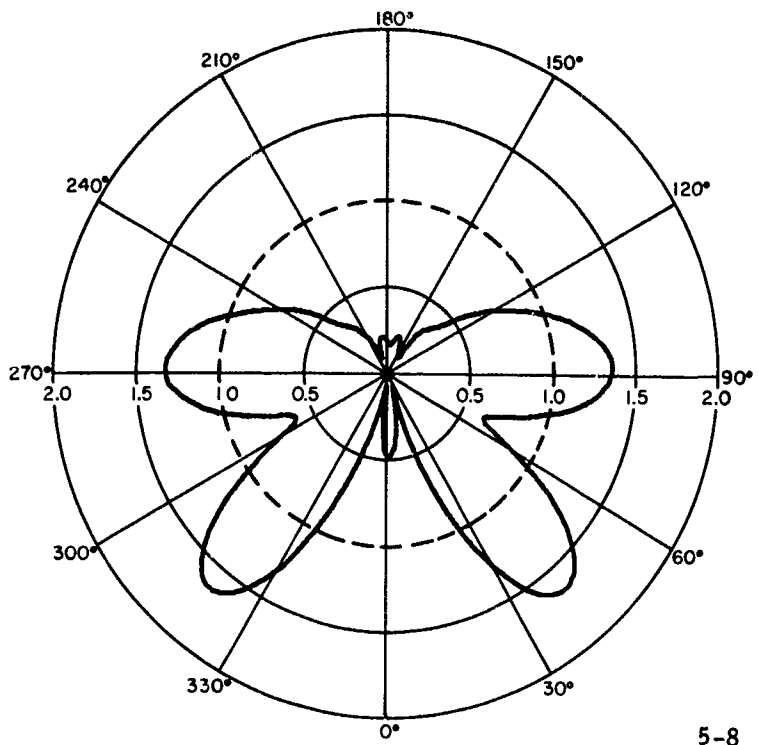




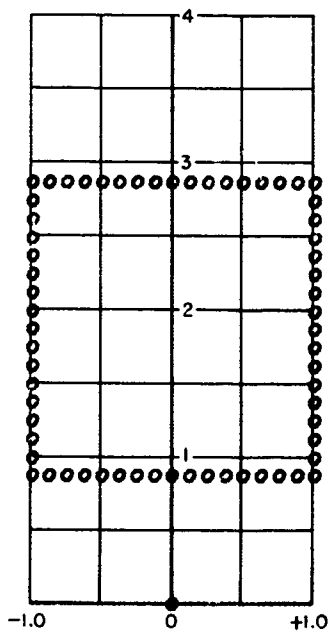




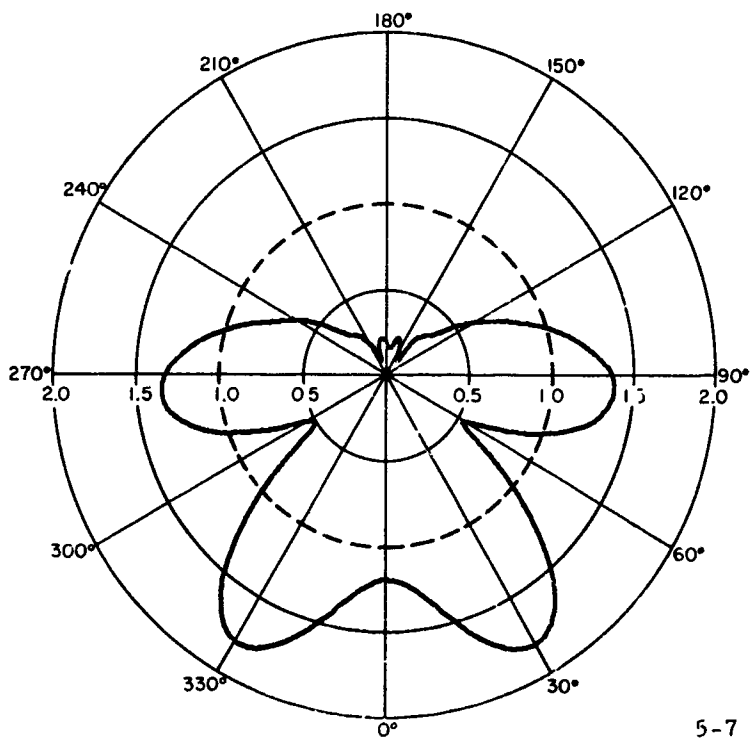
DISTANCE ~ WAVELENGTHS



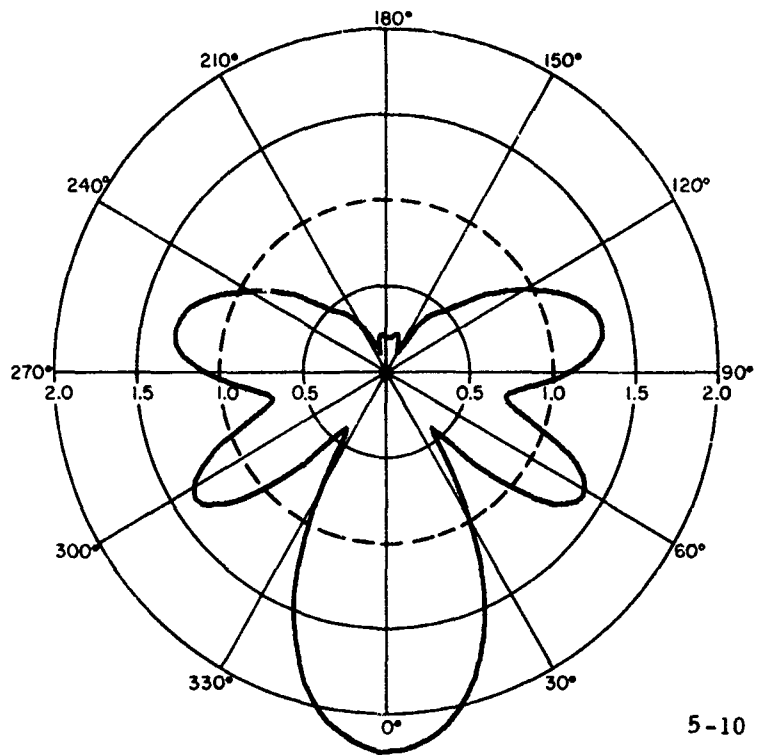
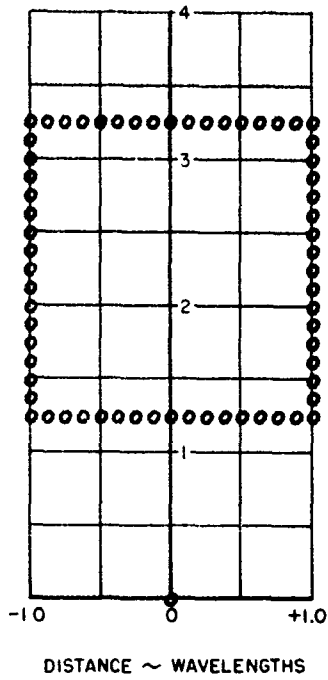
5-8



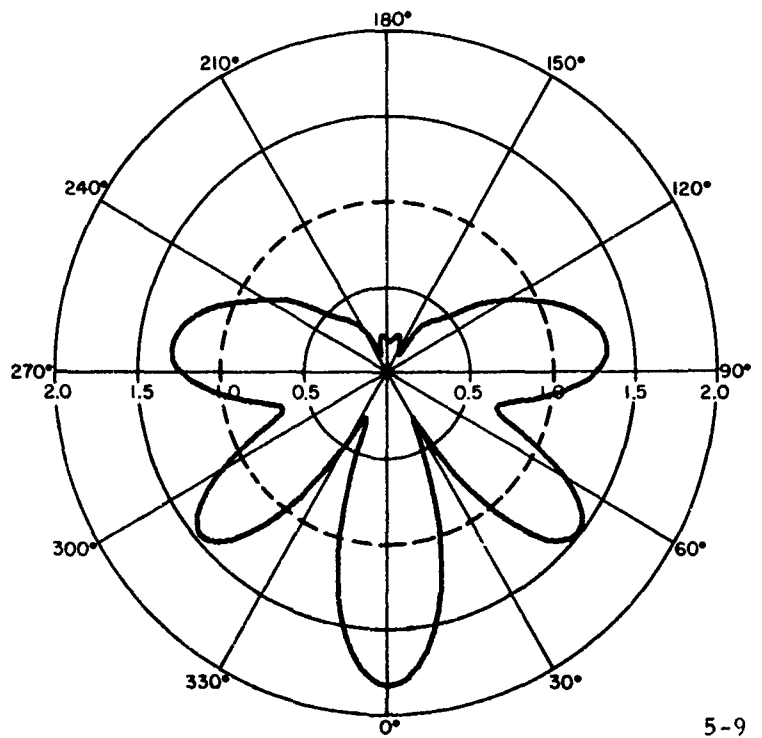
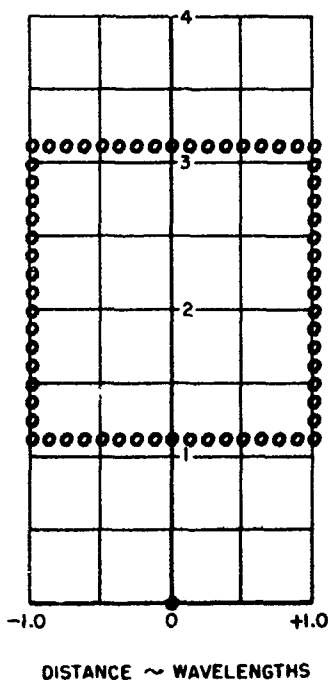
DISTANCE ~ WAVELENGTHS



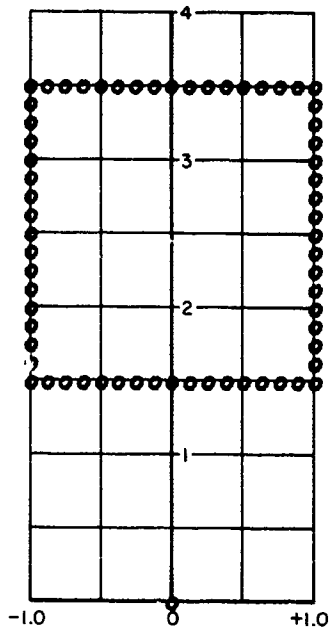
5-7



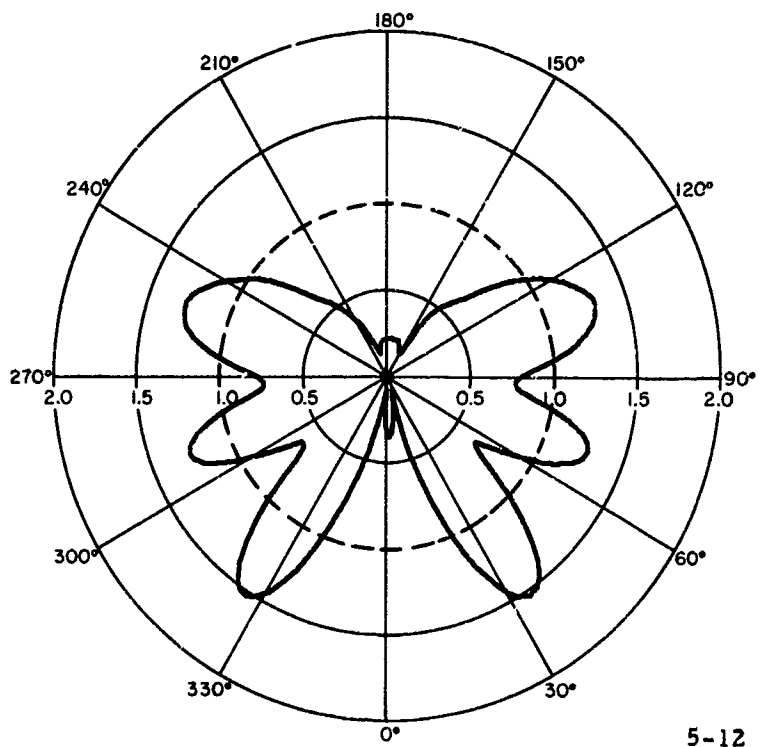
5-10



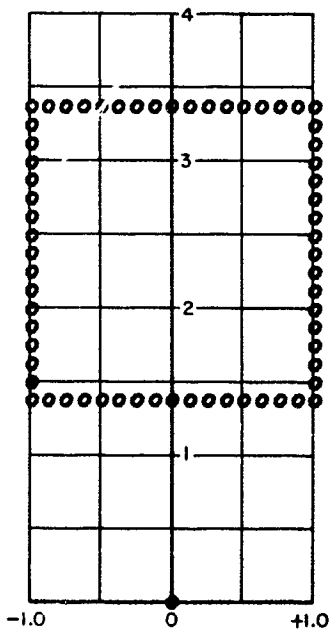
5-9



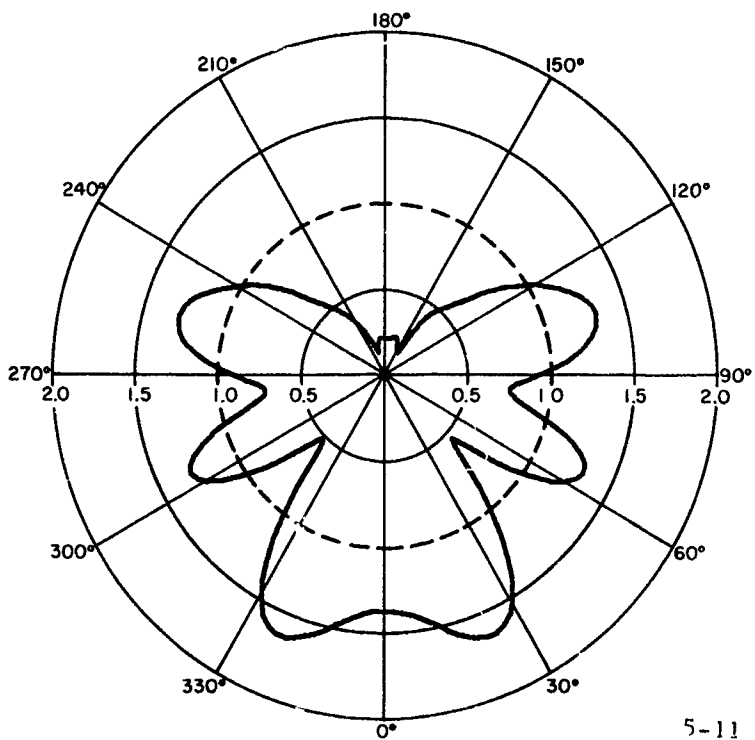
DISTANCE ~ WAVELENGTHS



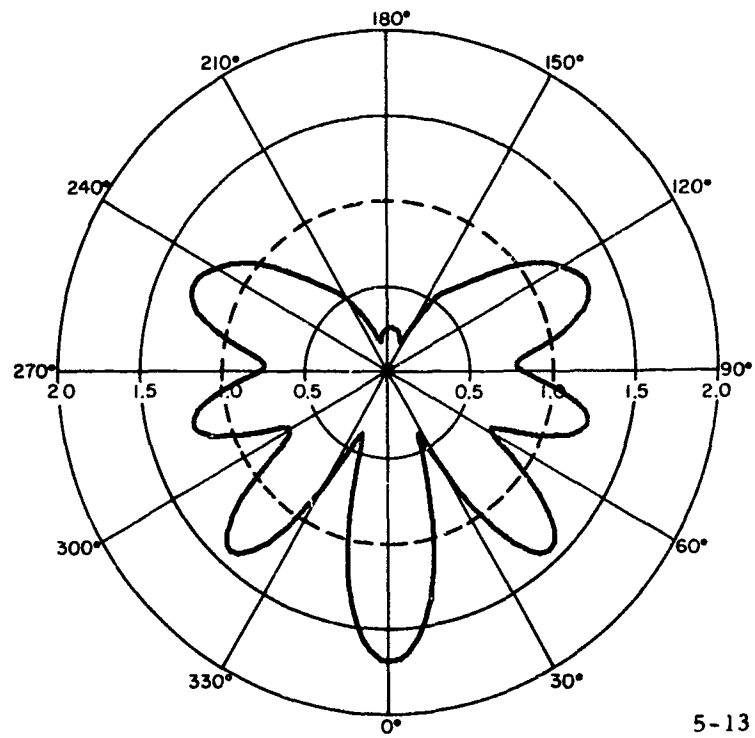
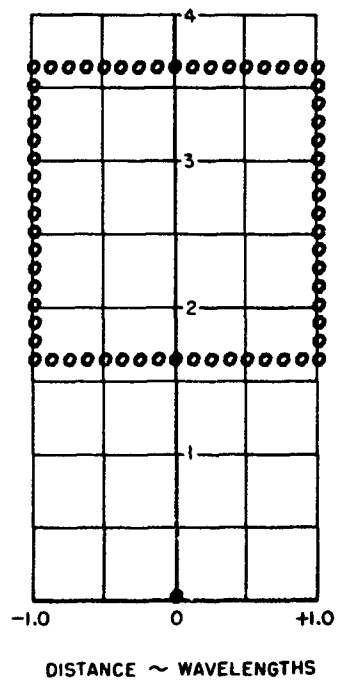
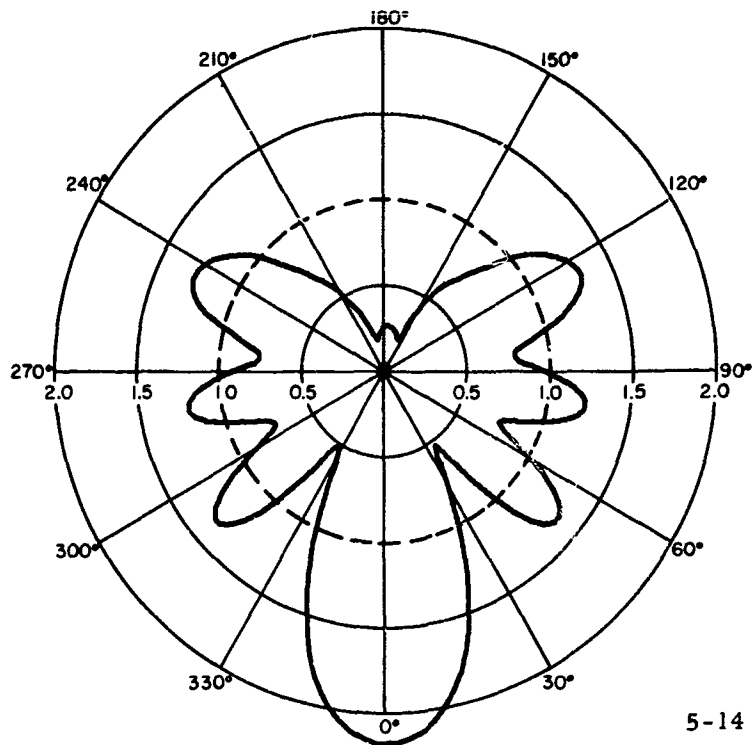
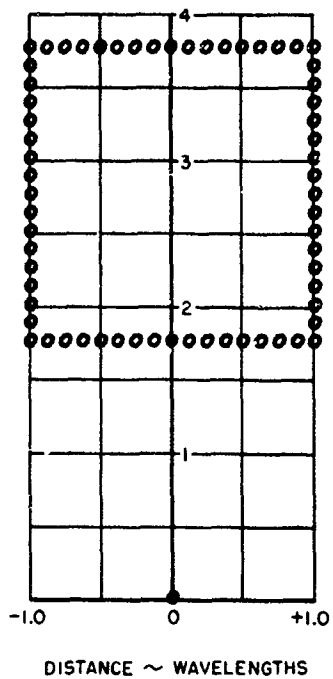
5-12

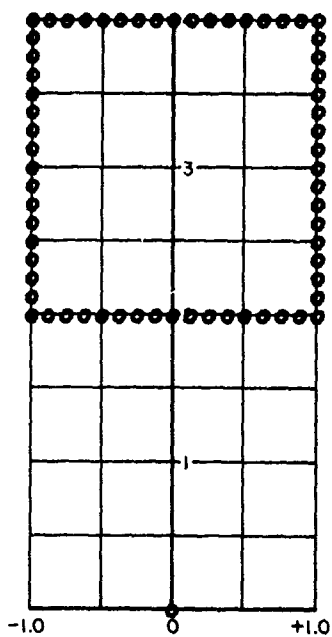


DISTANCE ~ WAVELENGTHS

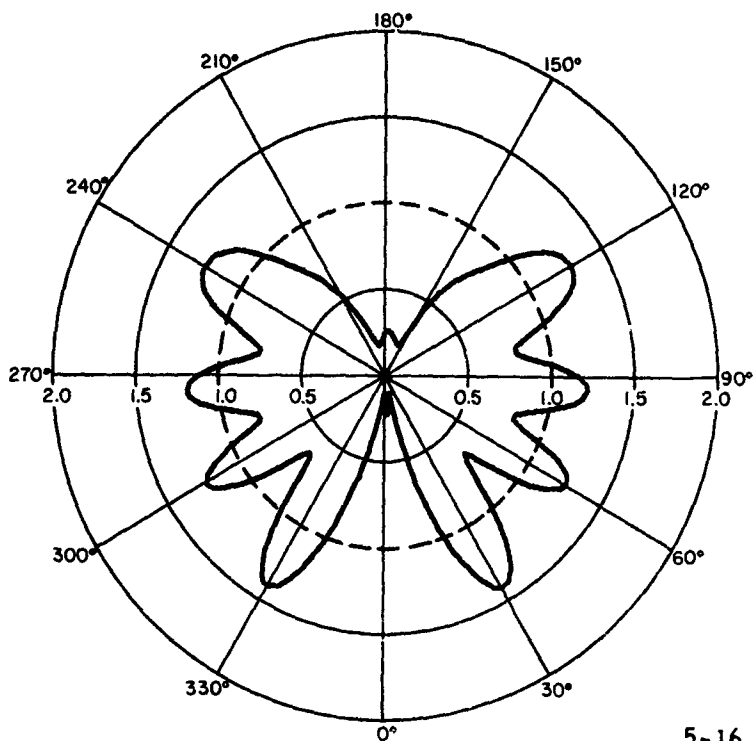


5-11

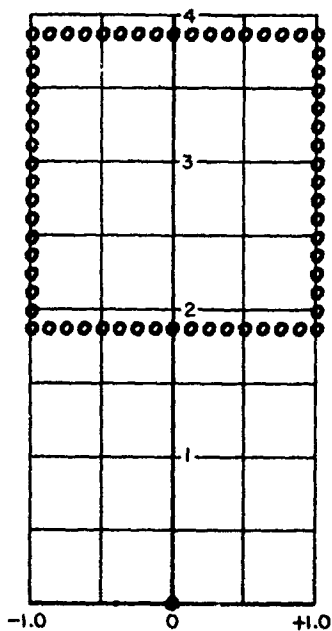




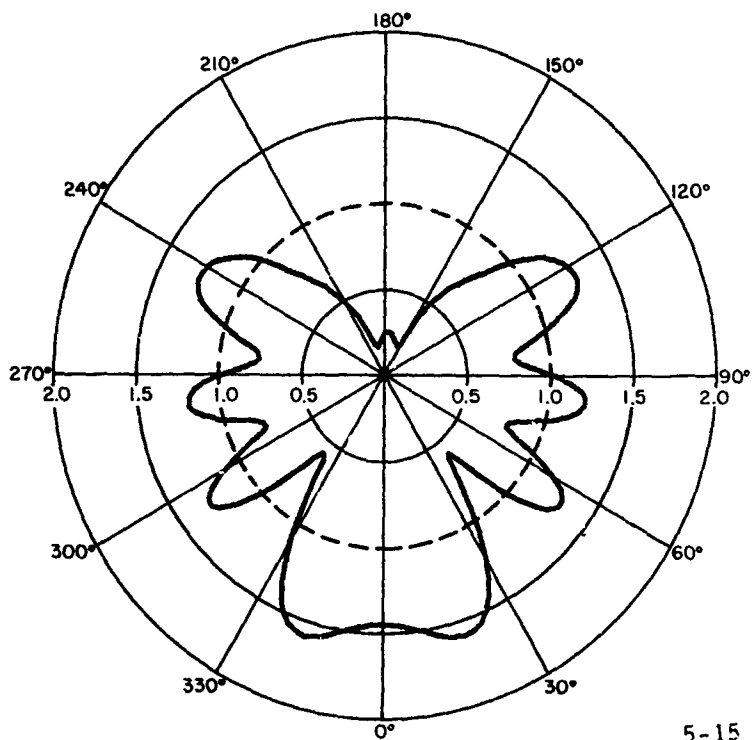
DISTANCE ~ WAVELENGTHS



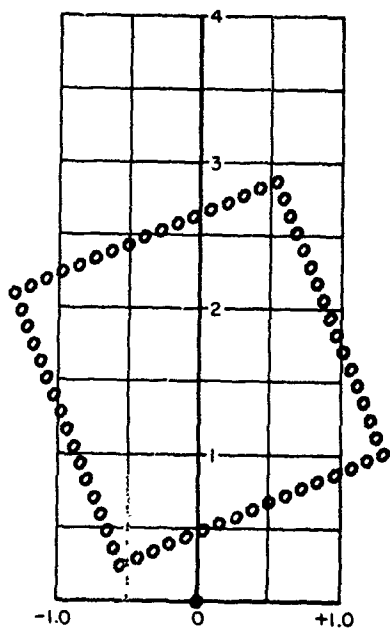
5-16



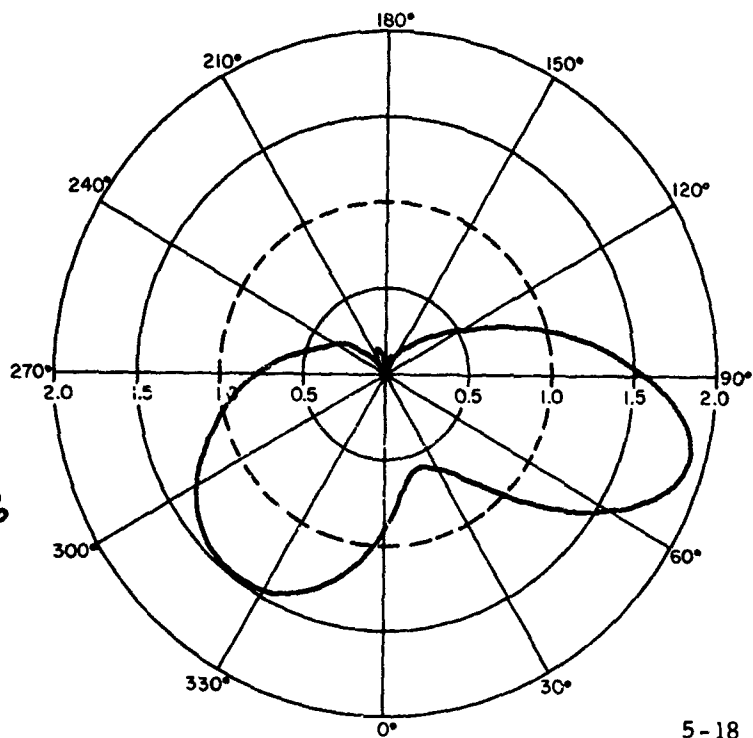
DISTANCE ~ WAVELENGTHS



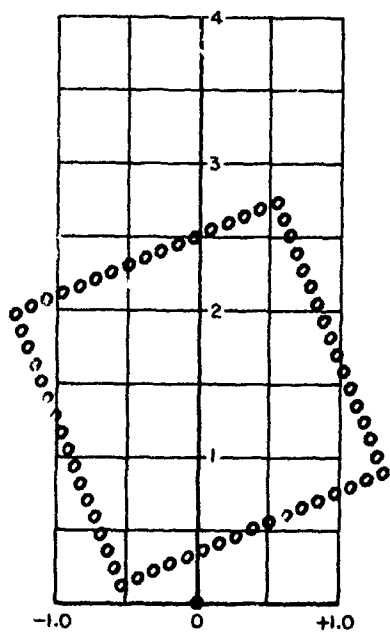
5-15



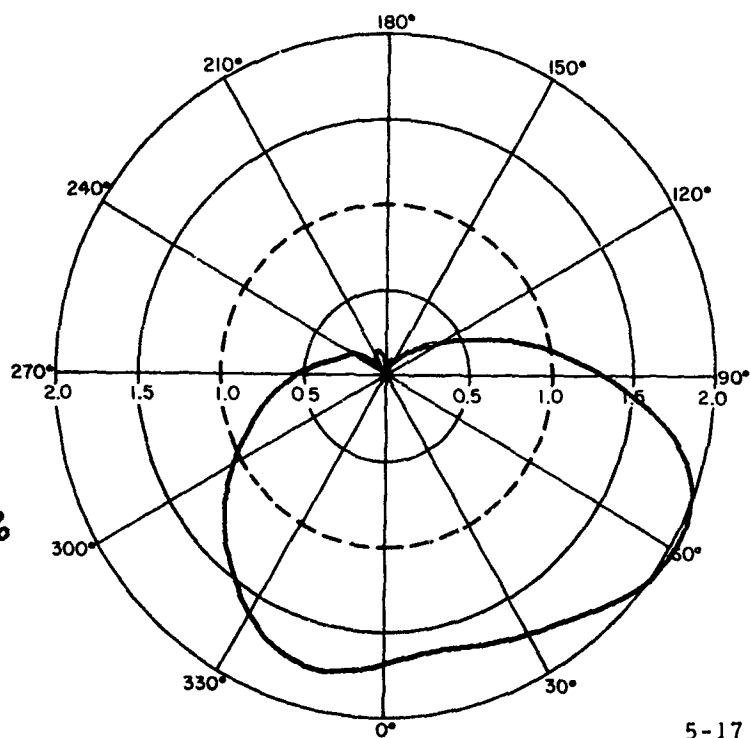
DISTANCE ~ WAVELENGTHS



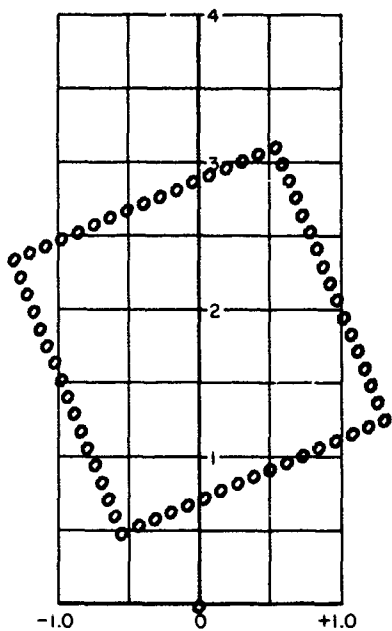
5-18



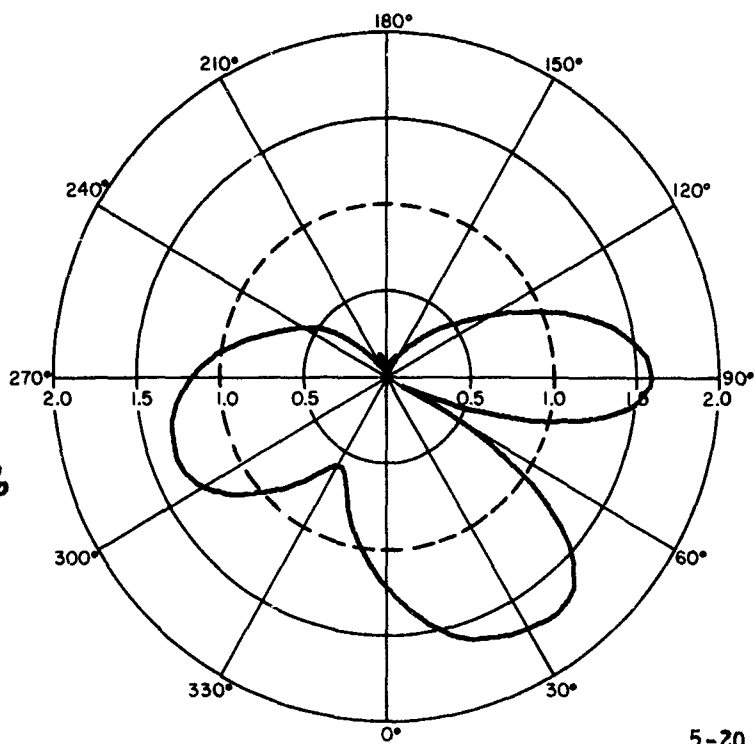
DISTANCE ~ WAVELENGTHS



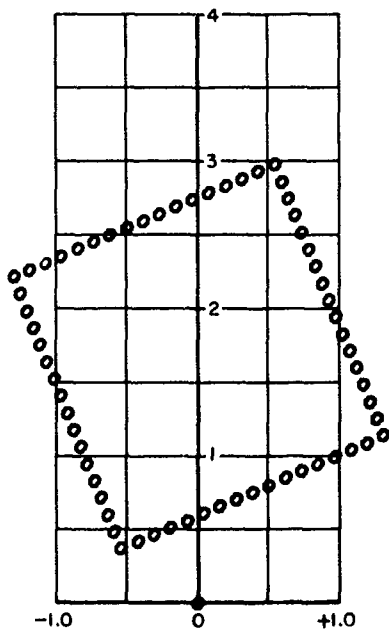
5-17



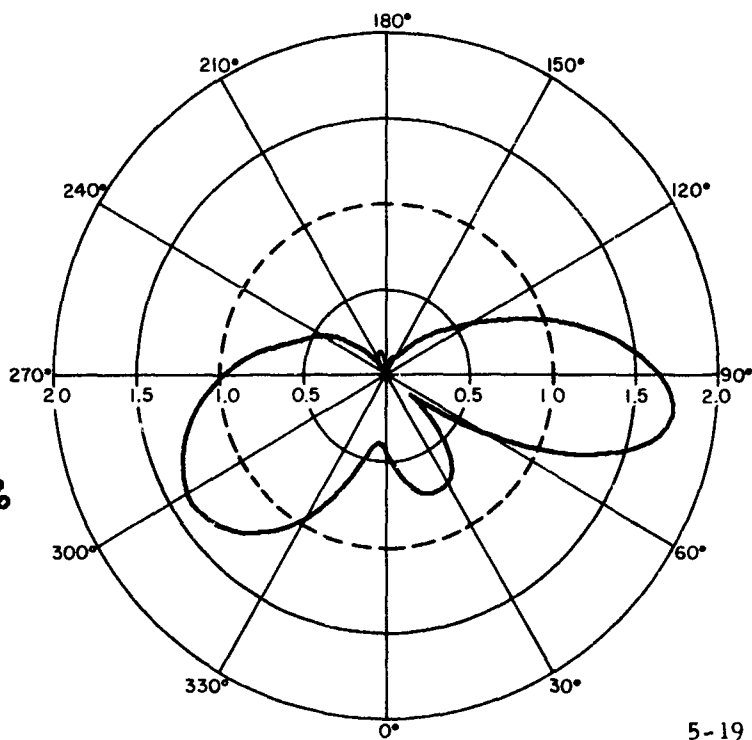
DISTANCE ~ WAVELENGTHS



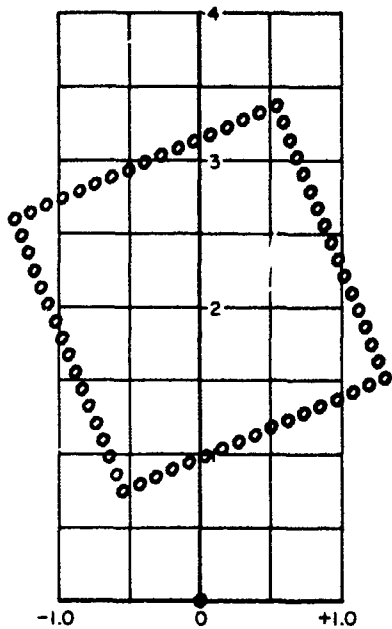
5-20



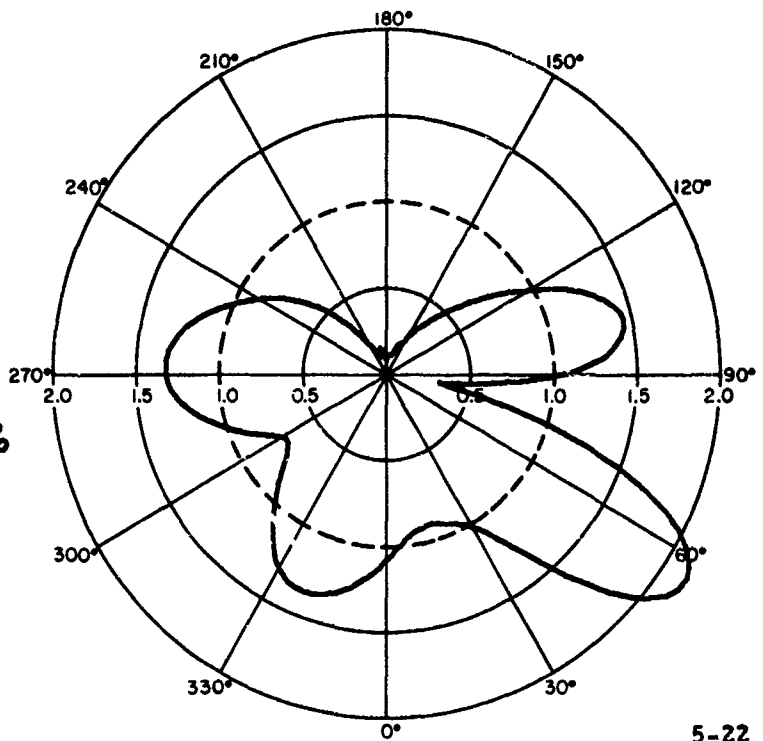
DISTANCE ~ WAVELENGTHS



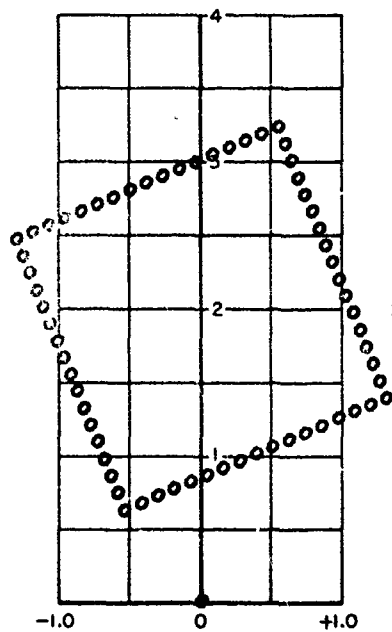
5-19



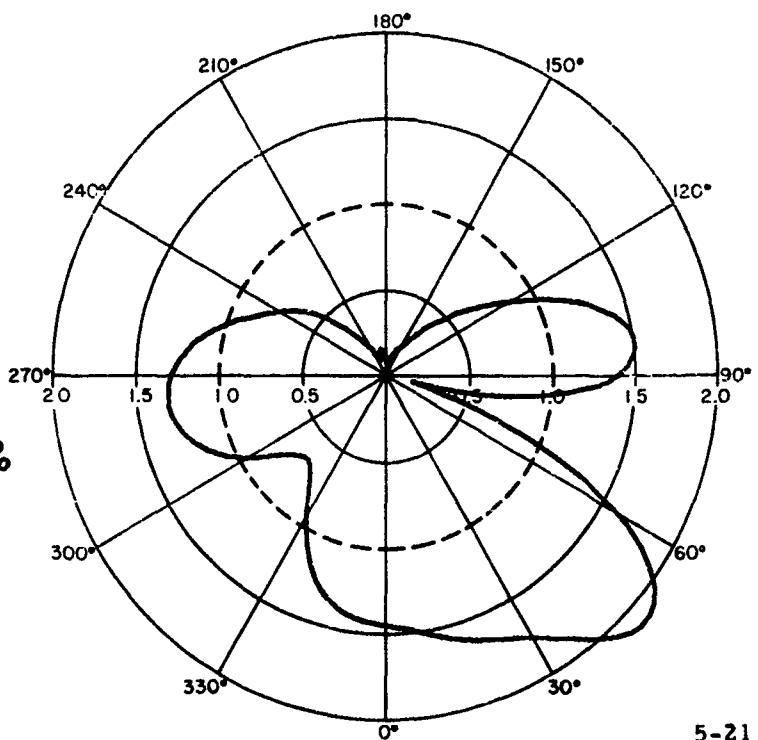
DISTANCE ~ WAVELENGTHS



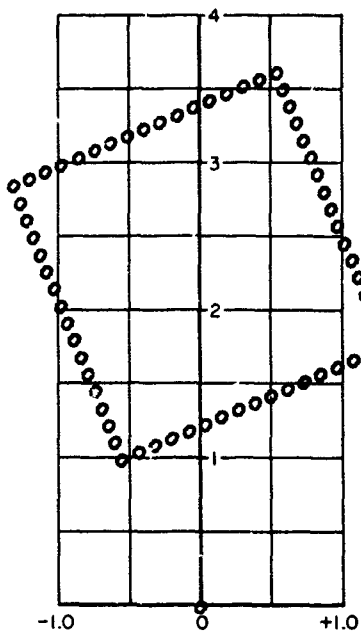
5-22



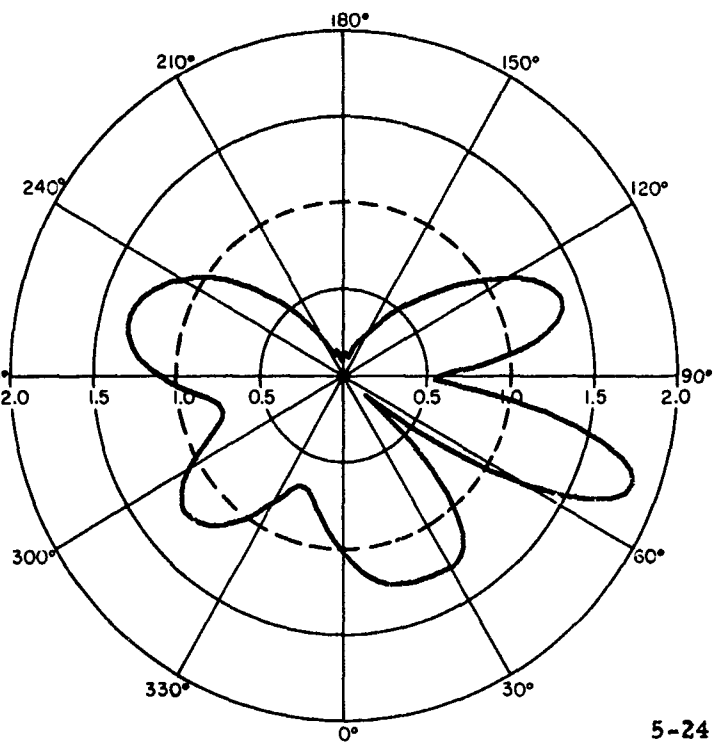
DISTANCE ~ WAVELENGTHS



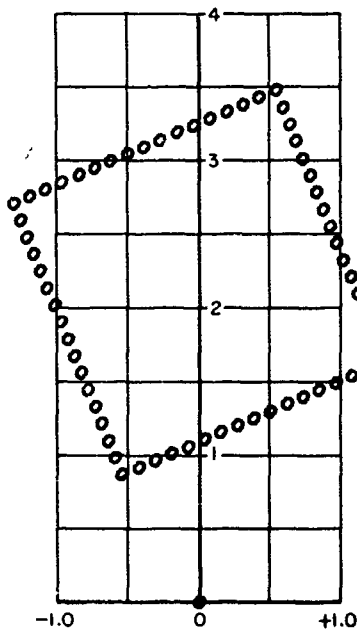
5-21



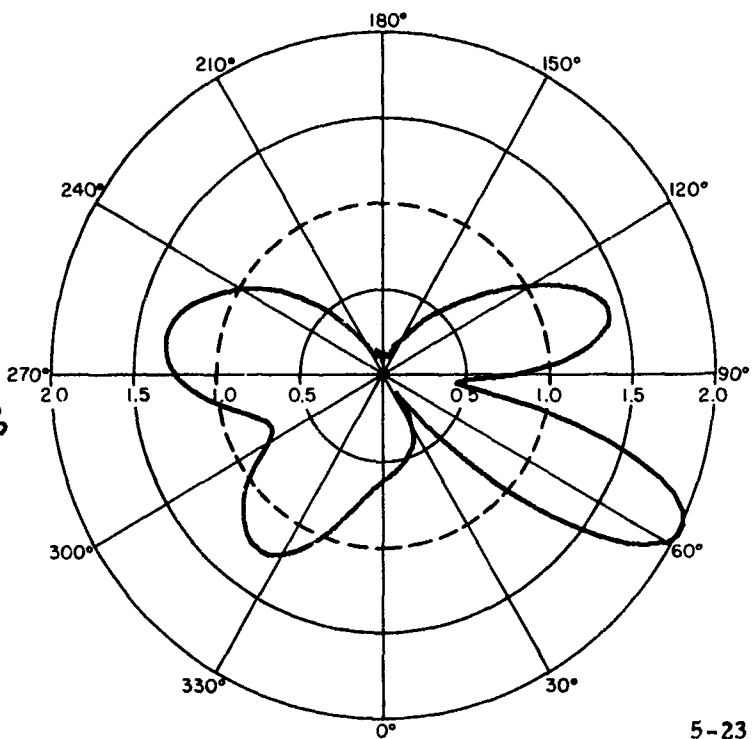
DISTANCE ~ WAVELENGTHS



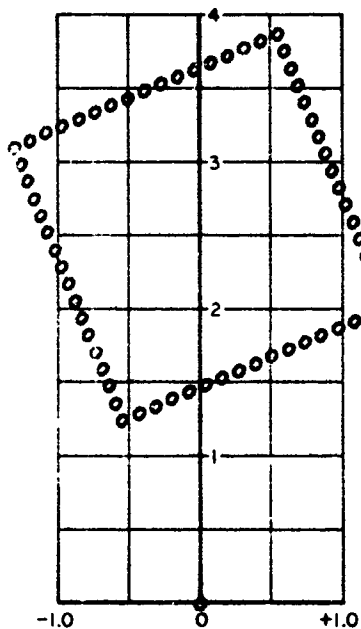
5-24



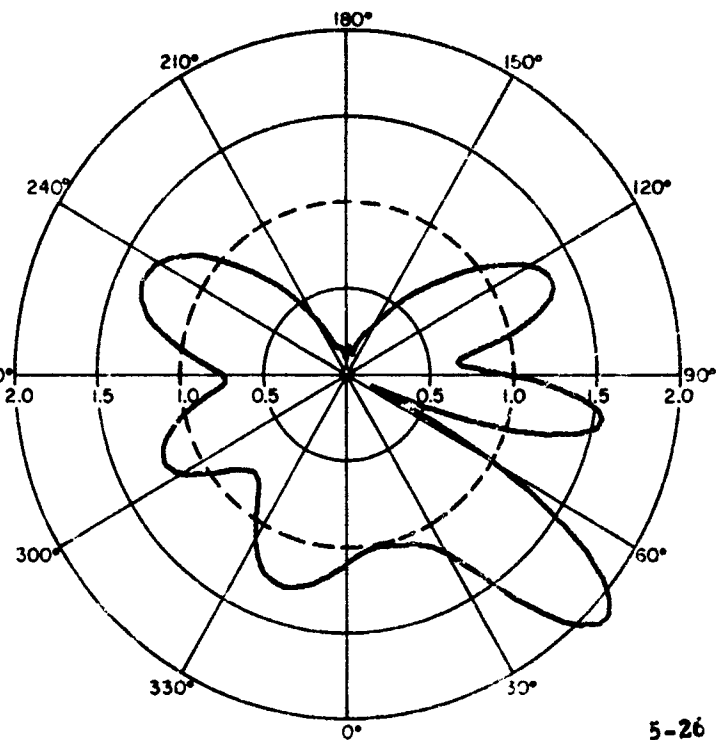
DISTANCE ~ WAVELENGTHS



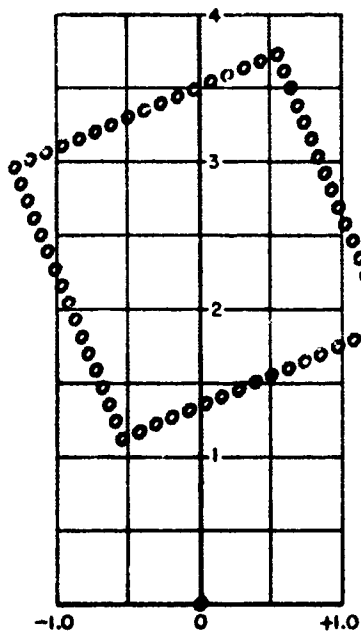
5-23



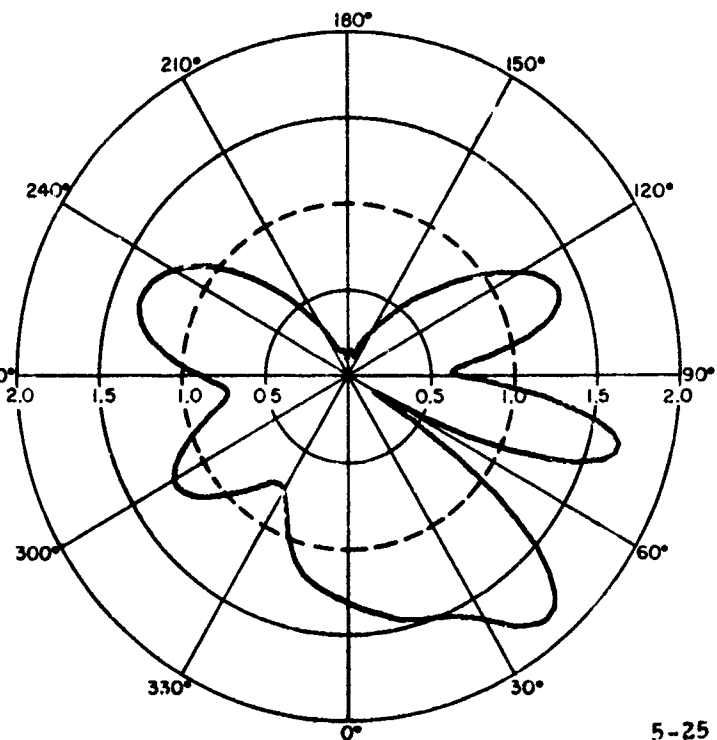
DISTANCE ~ WAVELENGTHS



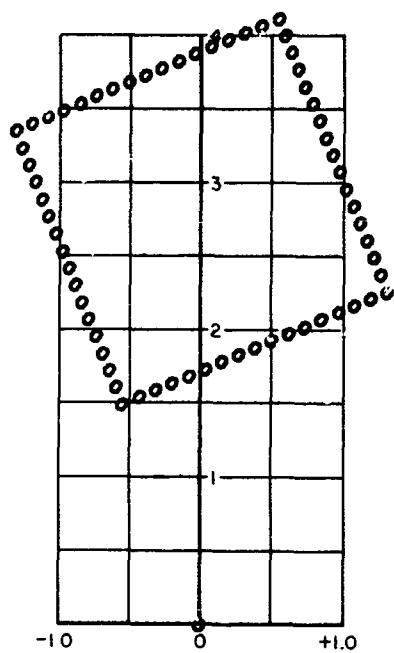
5-26



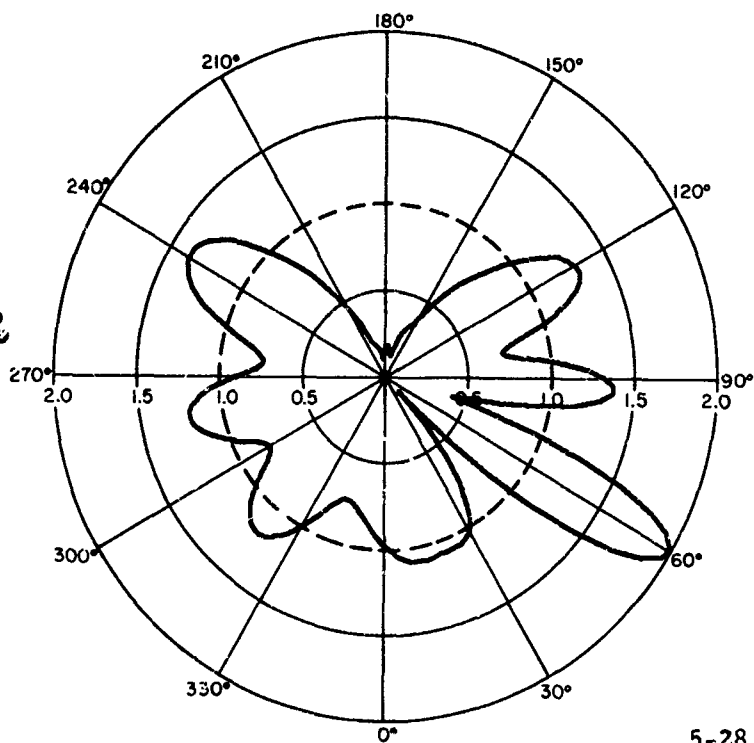
DISTANCE ~ WAVELENGTHS



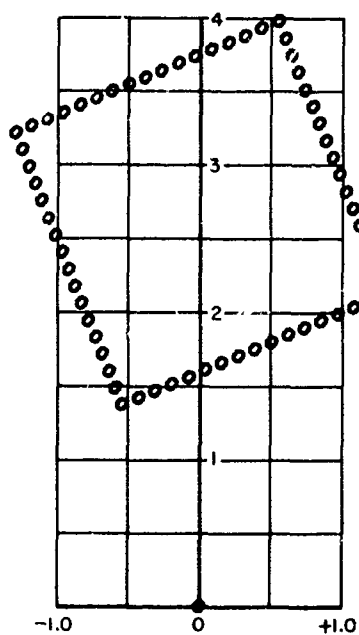
5-25



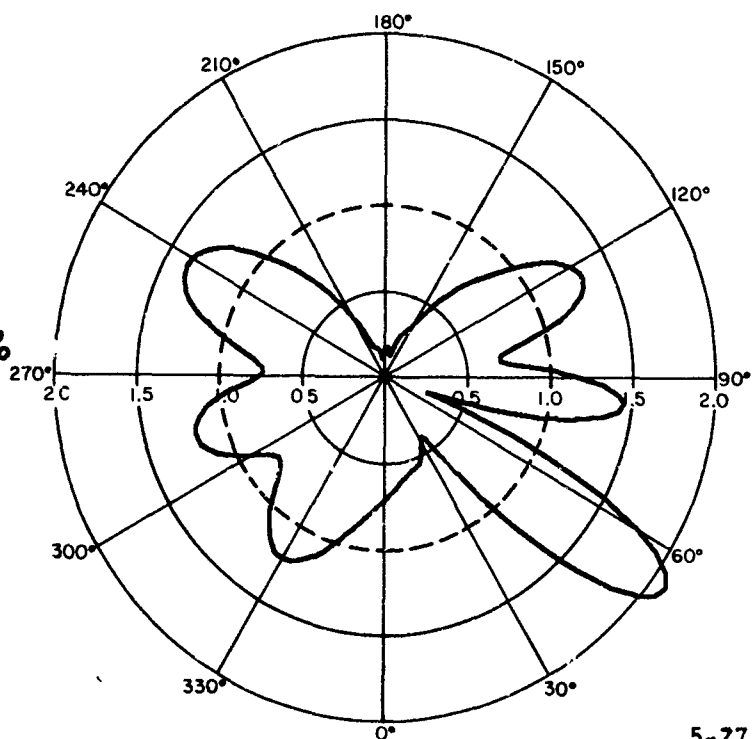
DISTANCE ~ WAVELENGTHS



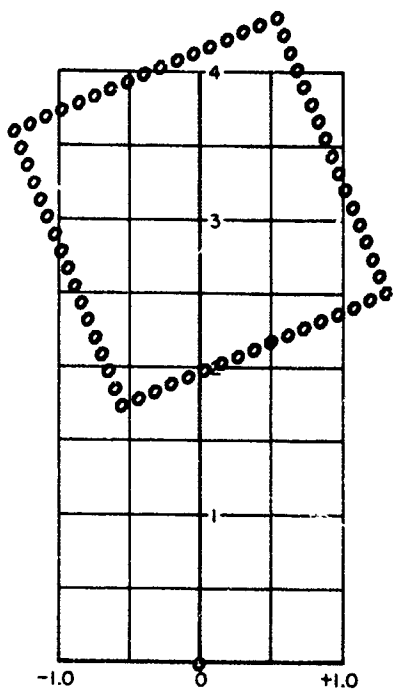
5-28



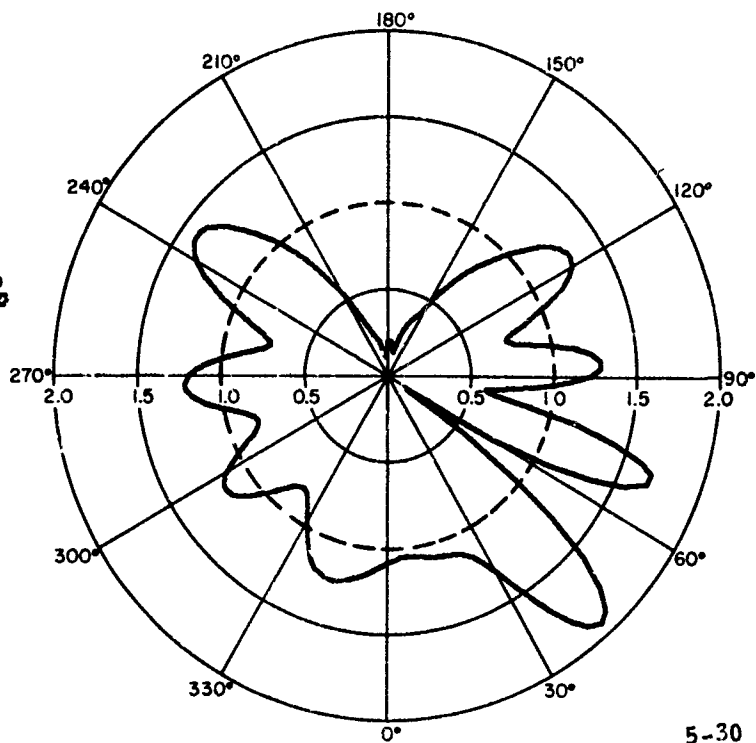
DISTANCE ~ WAVELENGTHS



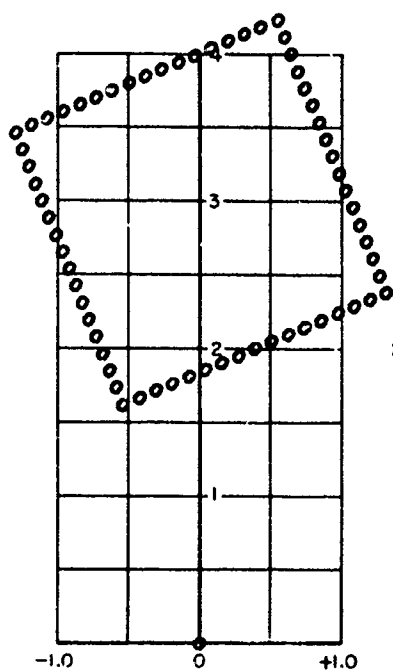
5-27



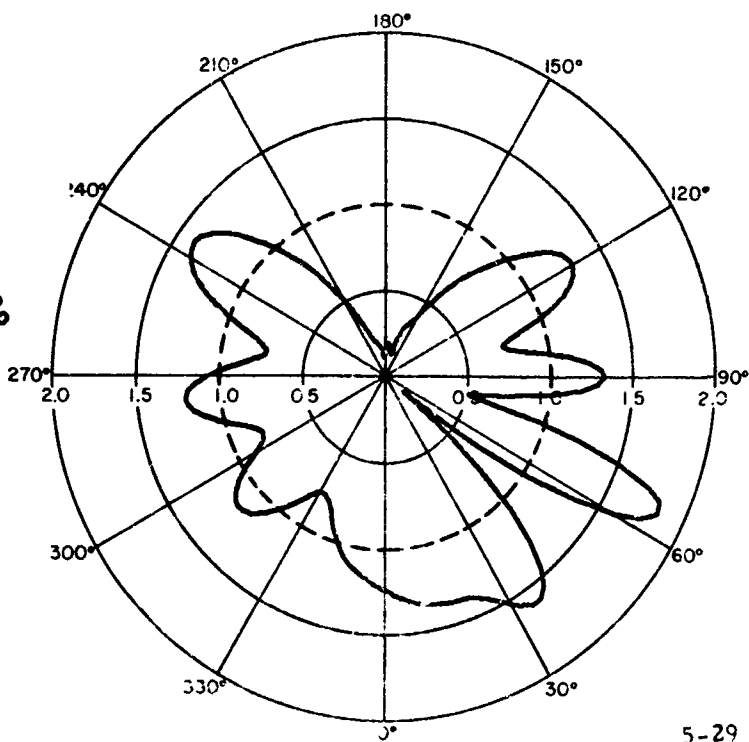
DISTANCE ~ WAVELENGTHS



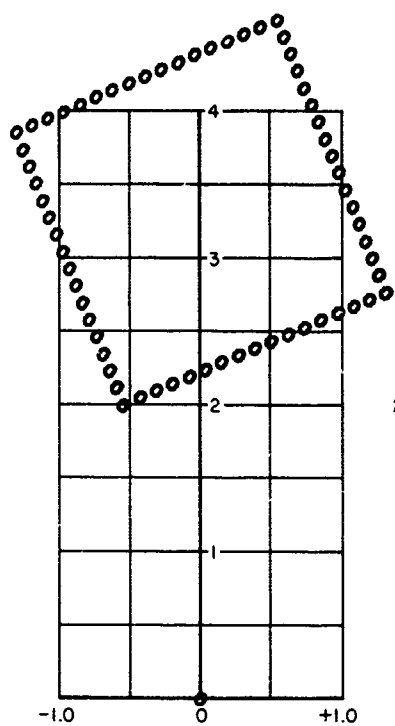
5-30



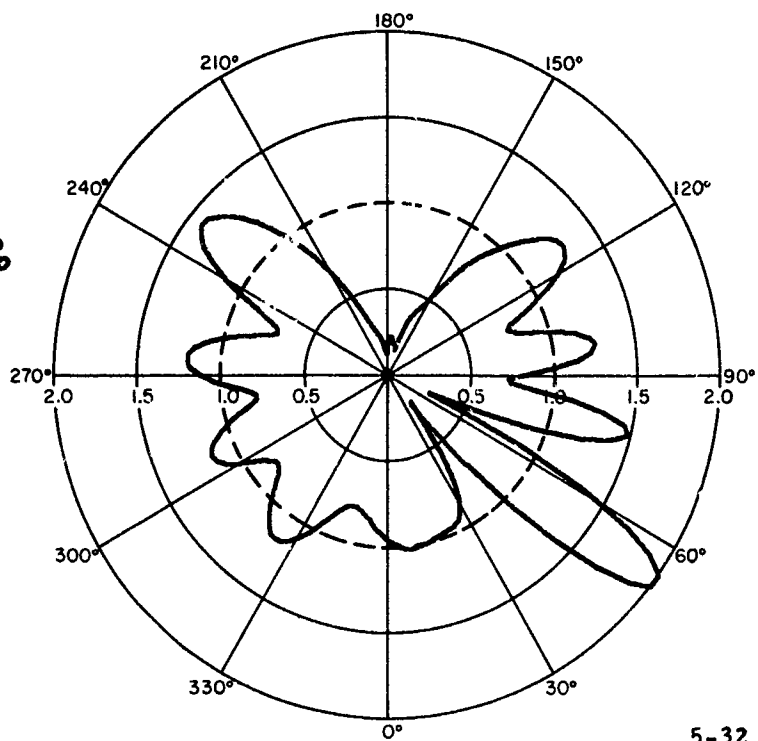
DISTANCE ~ WAVELENGTHS



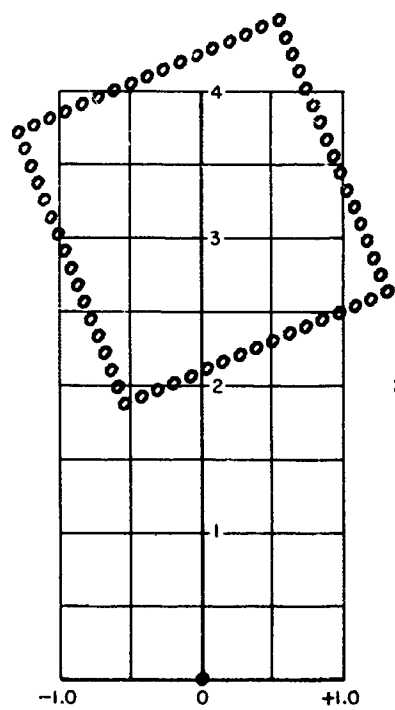
5-29



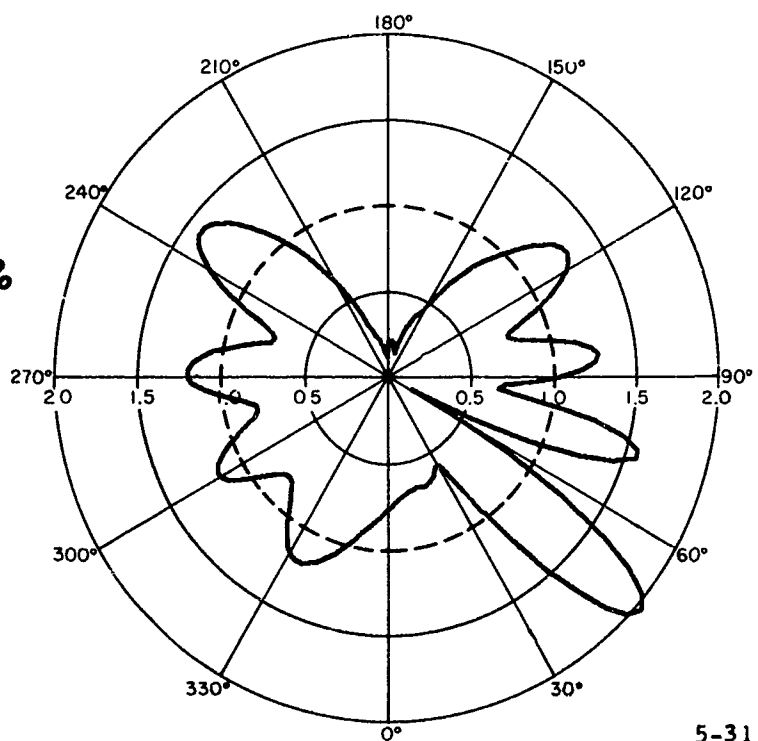
DISTANCE ~ WAVELENGTHS



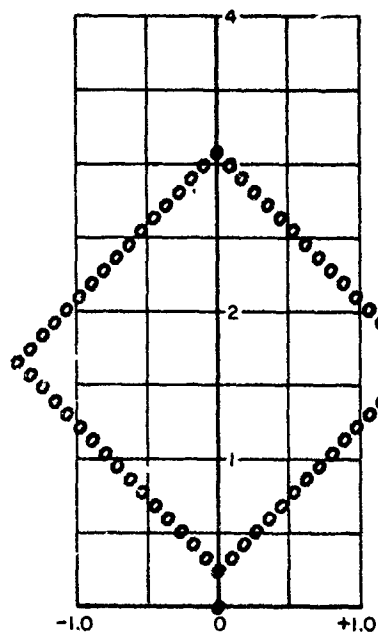
5-32



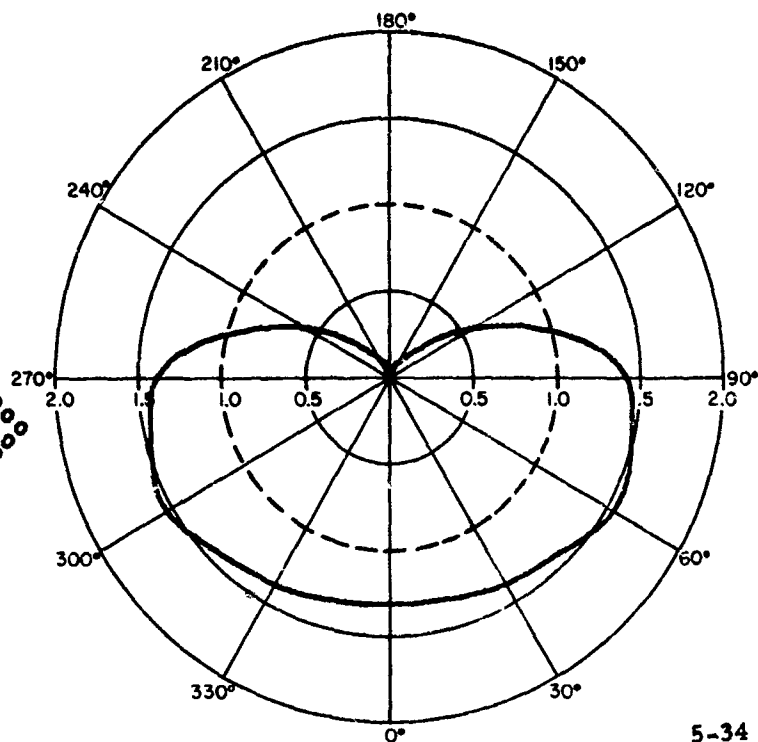
DISTANCE ~ WAVELENGTHS



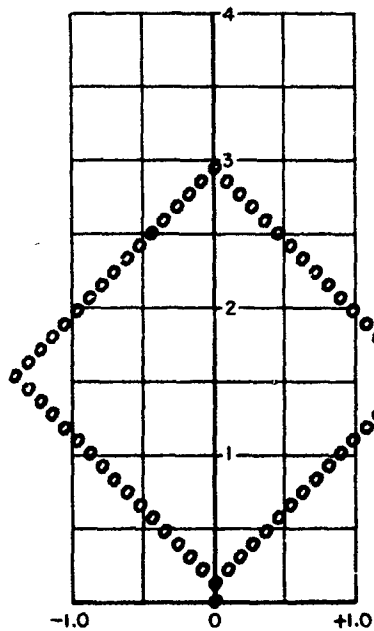
5-31



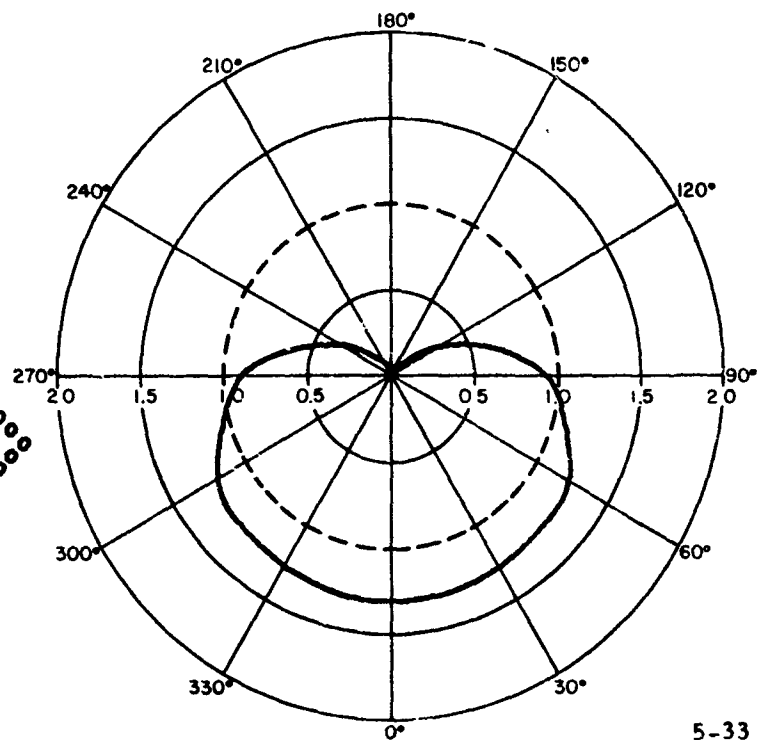
DISTANCE ~ WAVELENGTHS



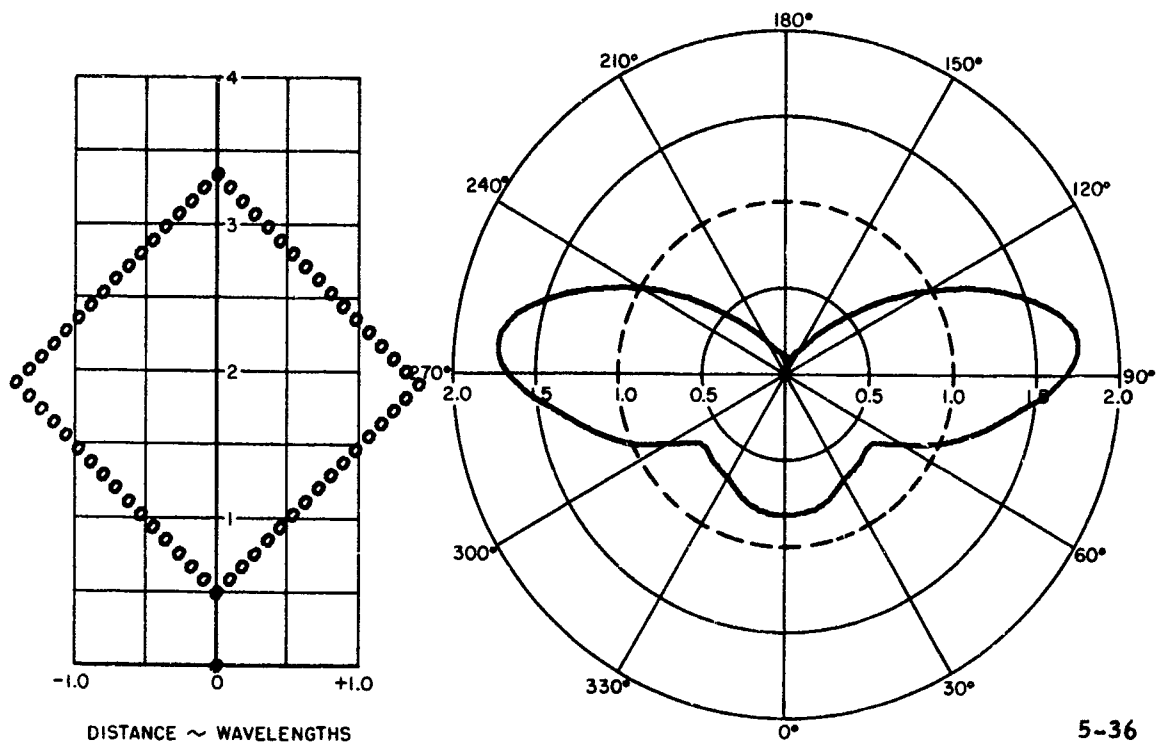
5-34



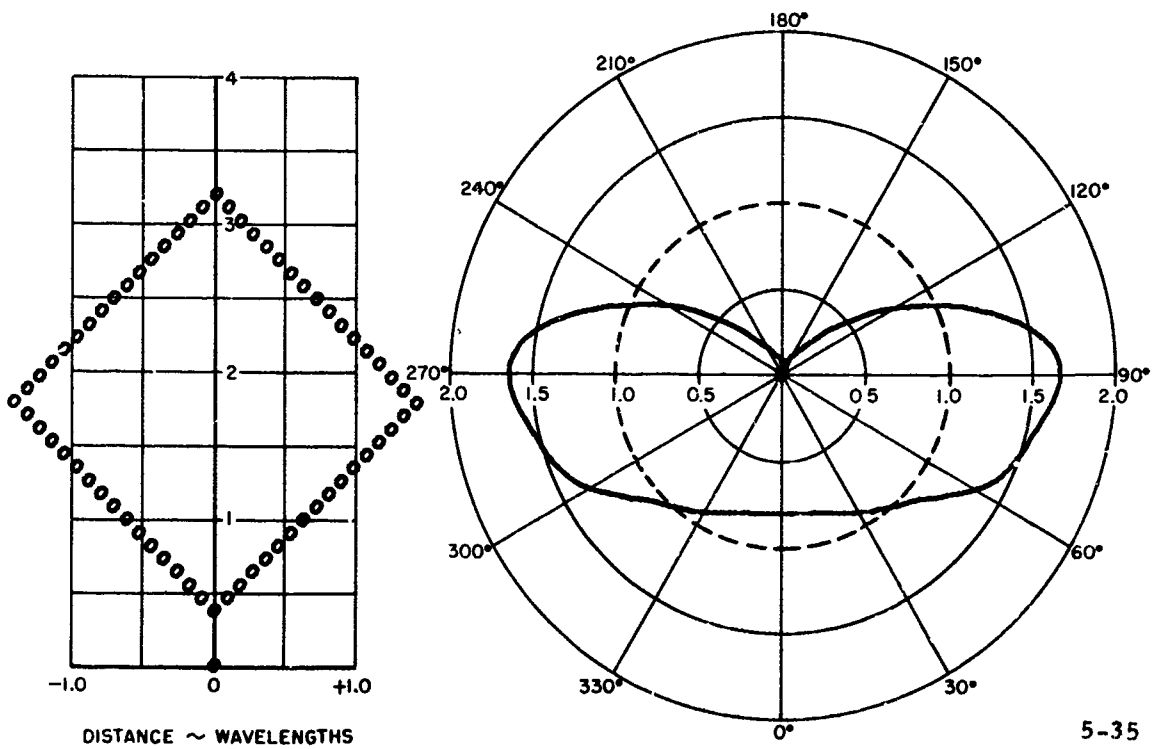
DISTANCE ~ WAVELENGTHS



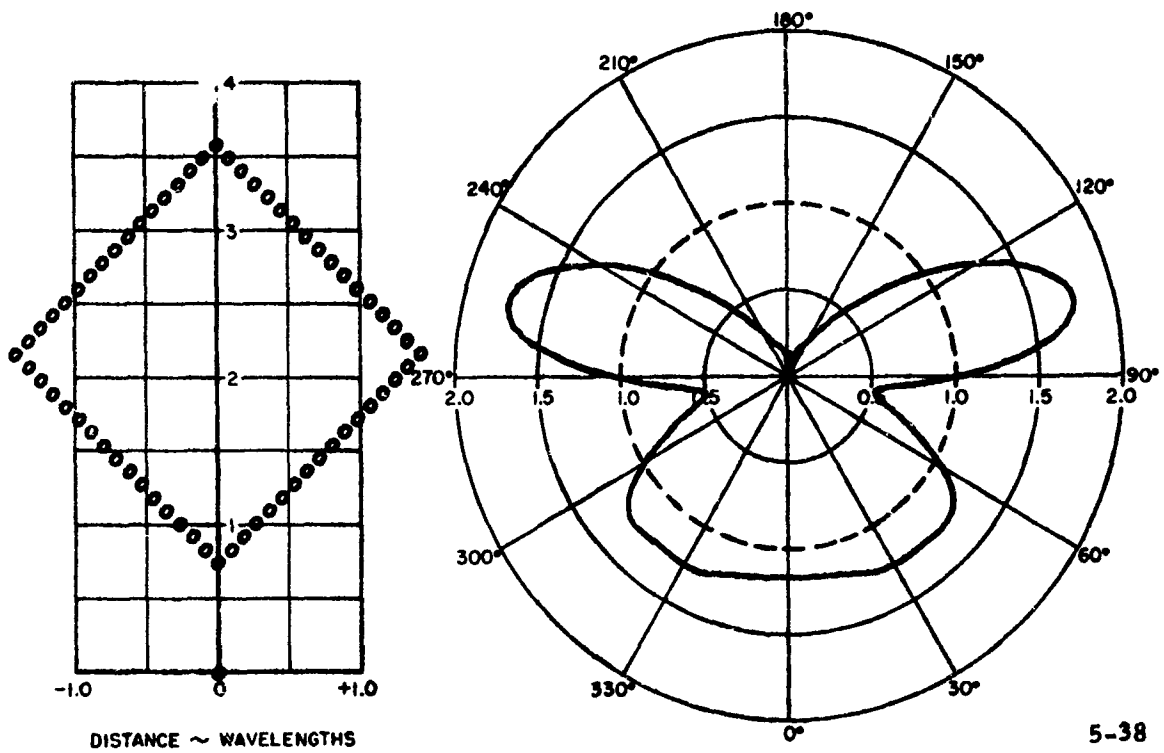
5-33



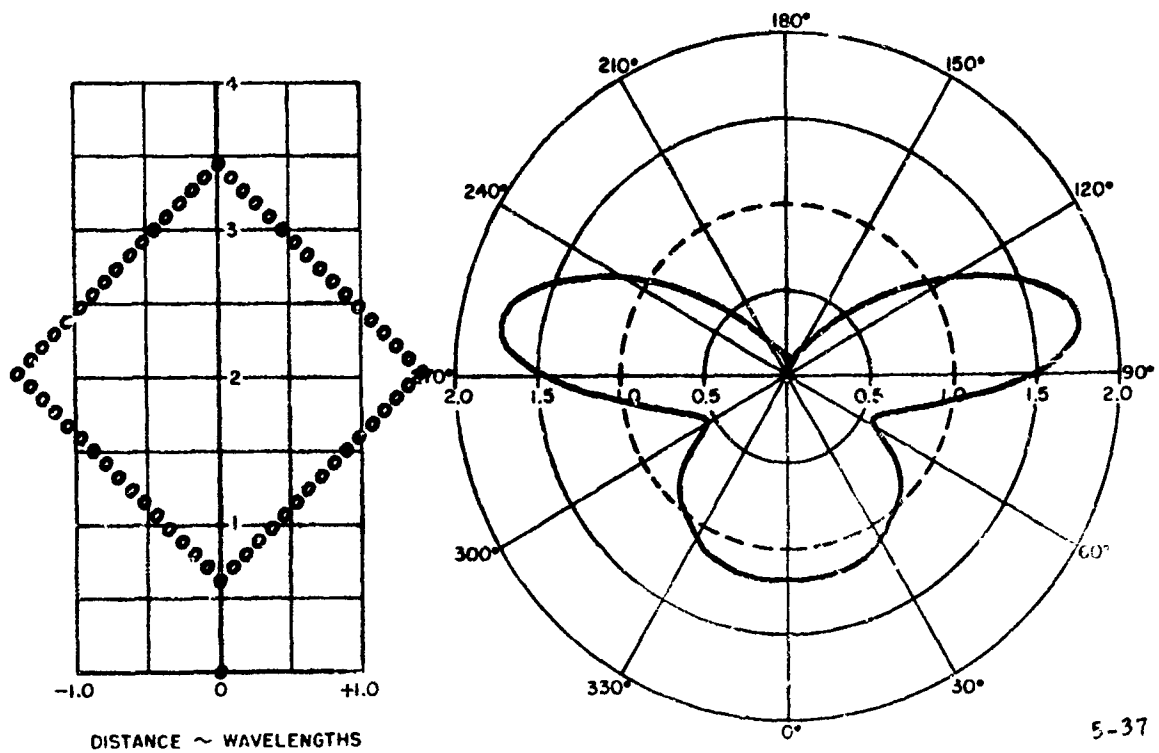
5-36



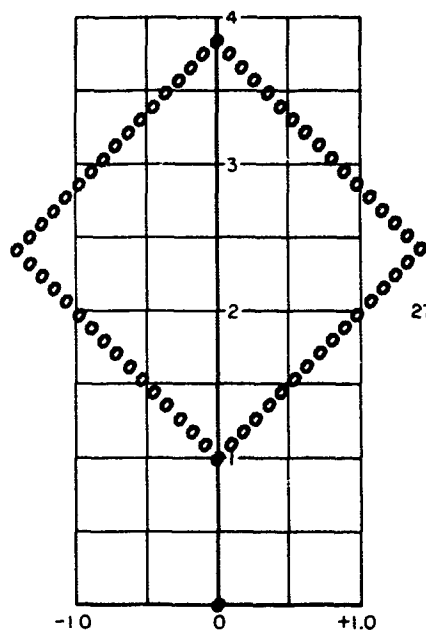
5-35



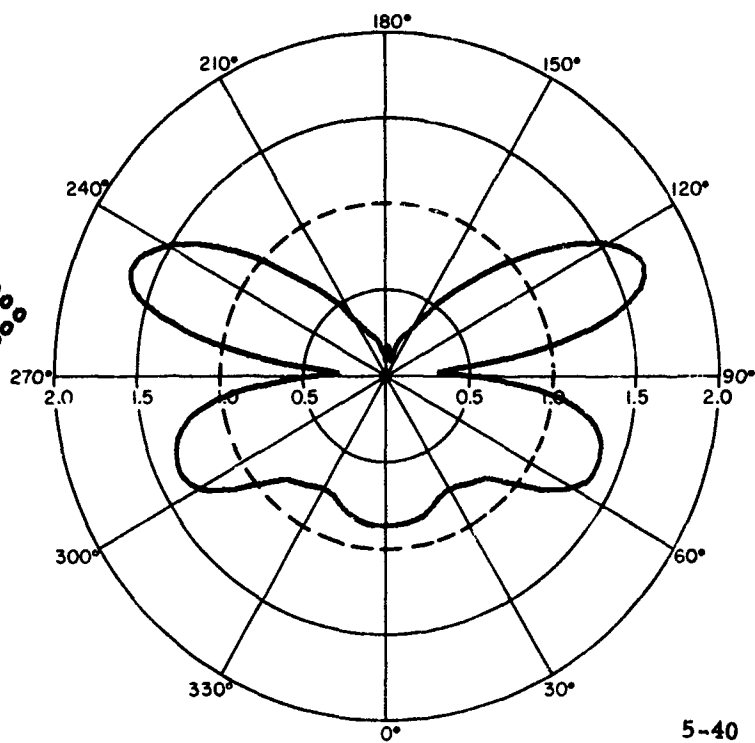
5-38



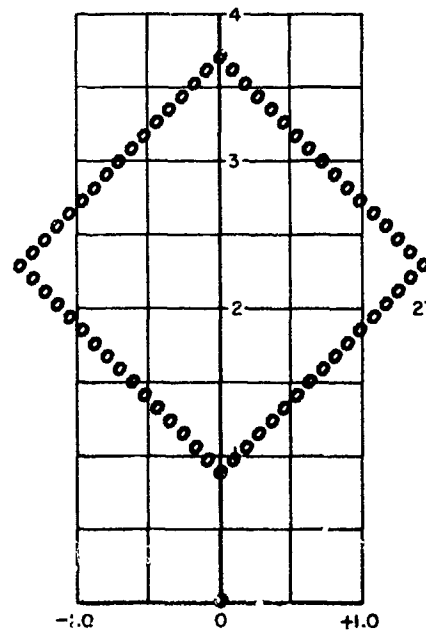
5-37



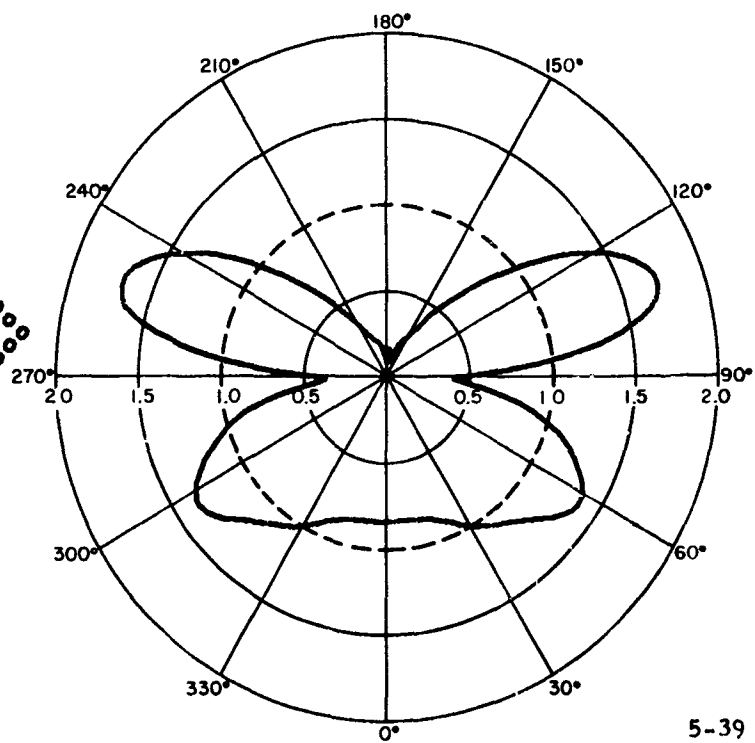
DISTANCE ~ WAVELENGTHS



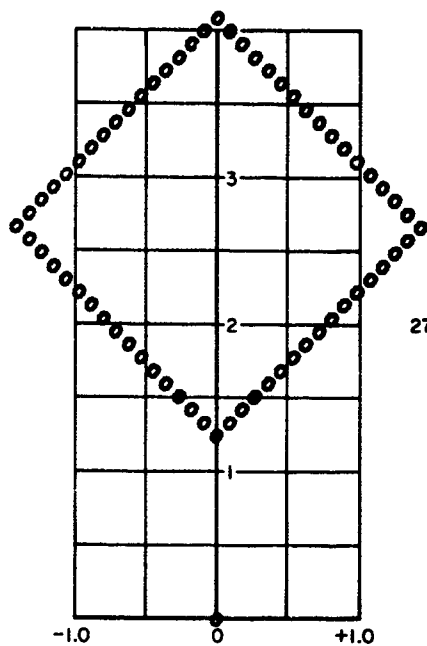
5-40



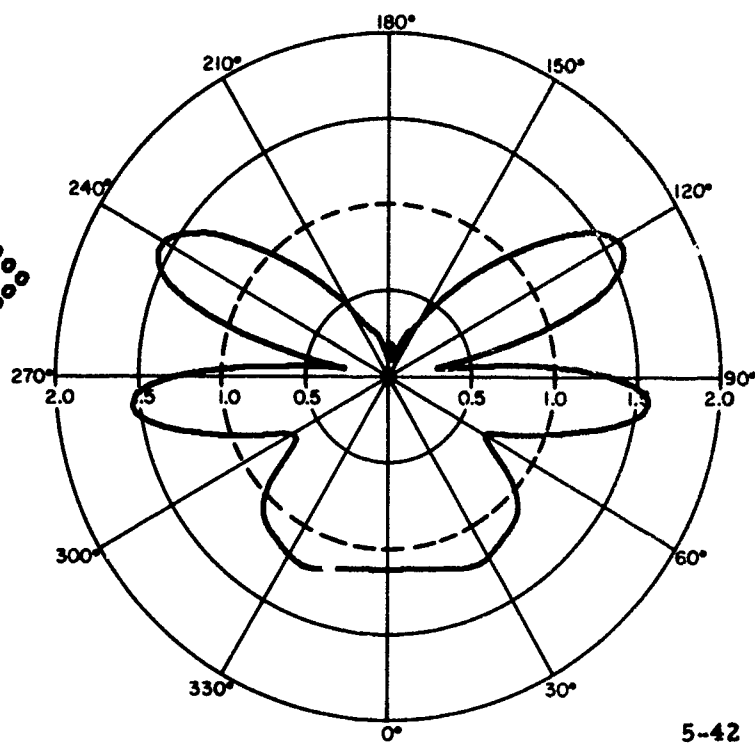
DISTANCE ~ WAVELENGTHS



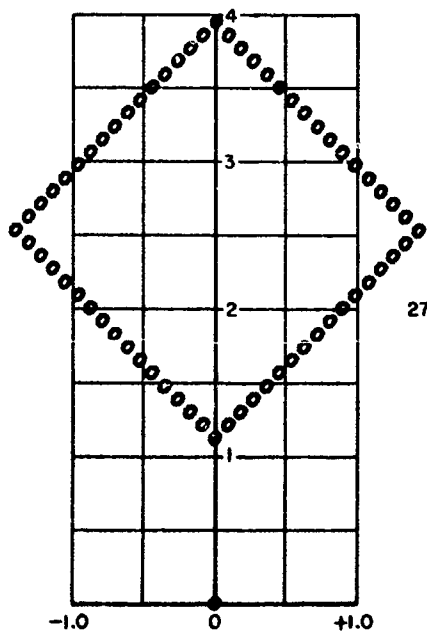
5-39



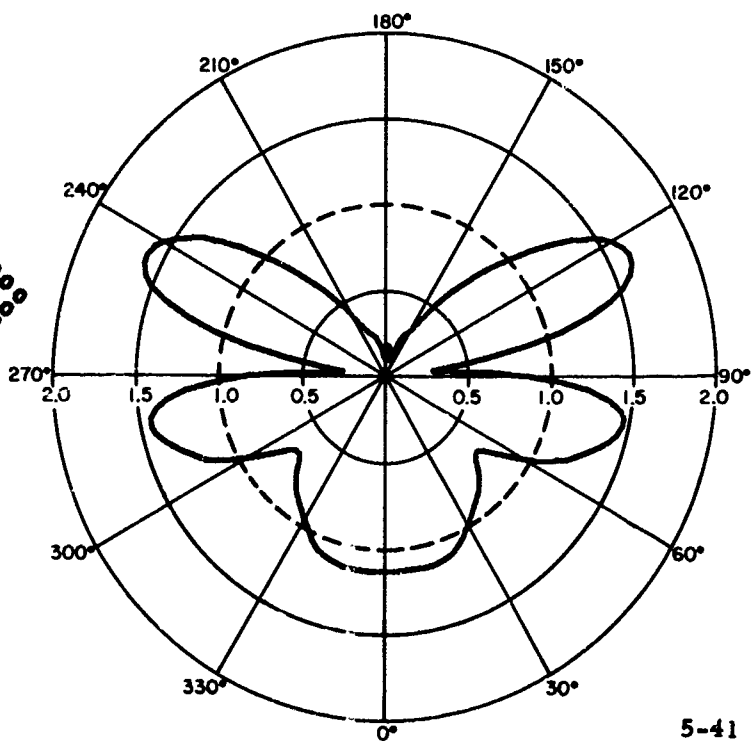
DISTANCE ~ WAVELENGTHS



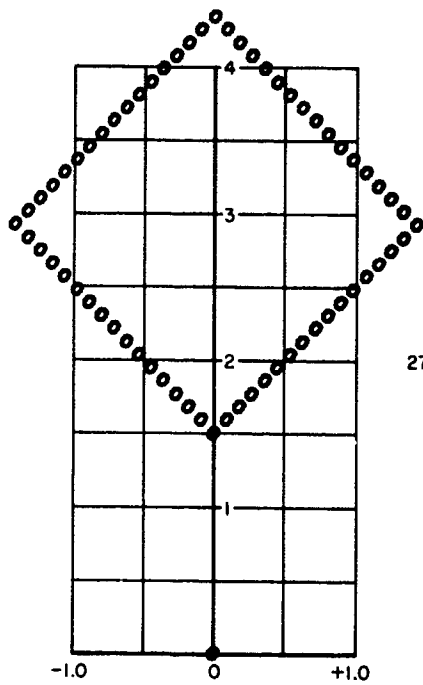
5-42



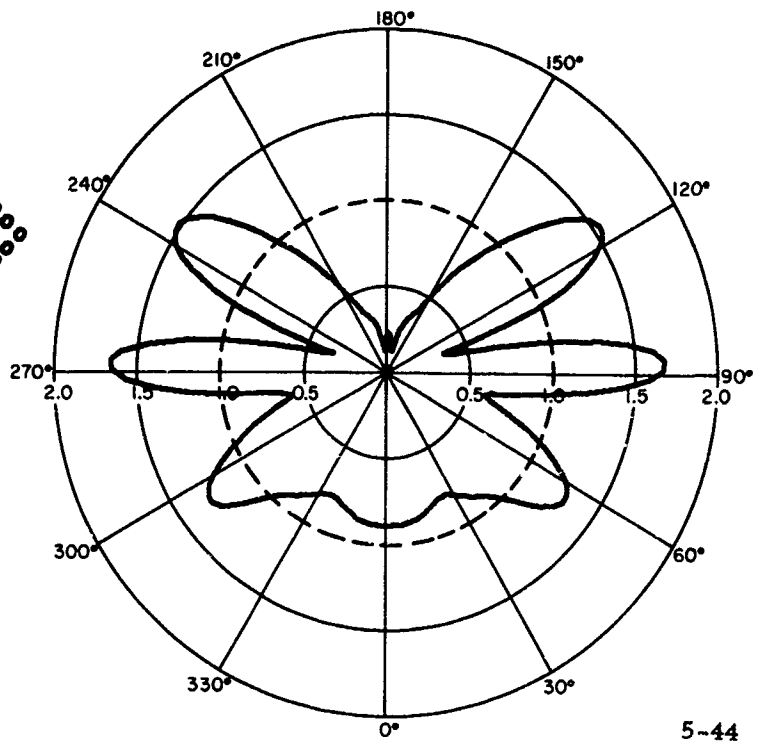
DISTANCE ~ WAVELENGTHS



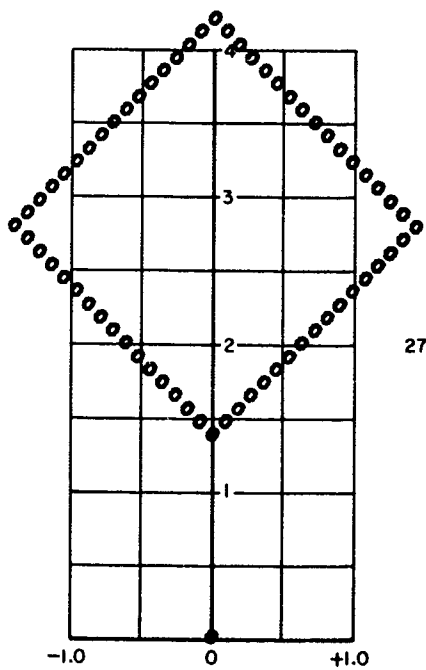
5-41



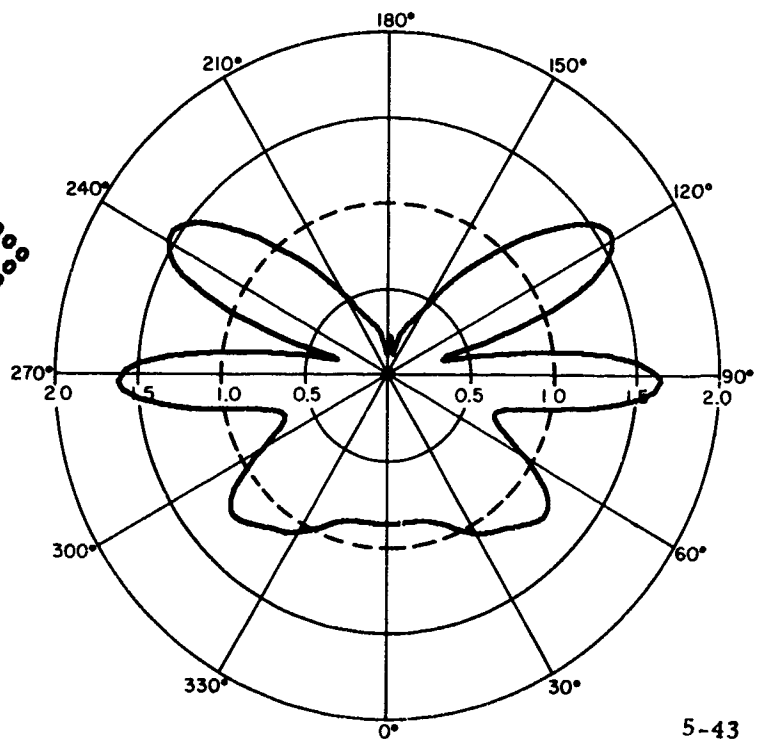
DISTANCE ~ WAVELENGTHS



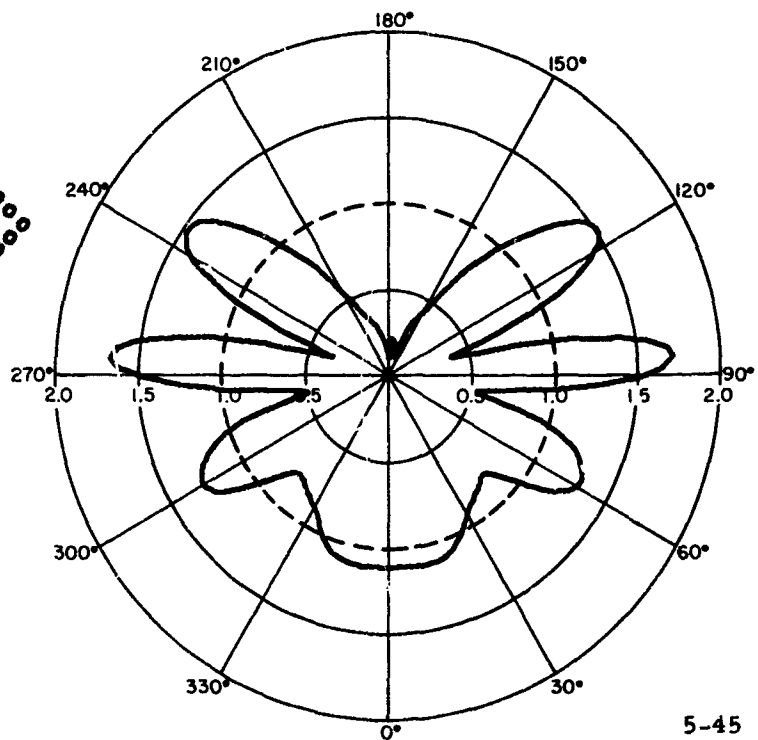
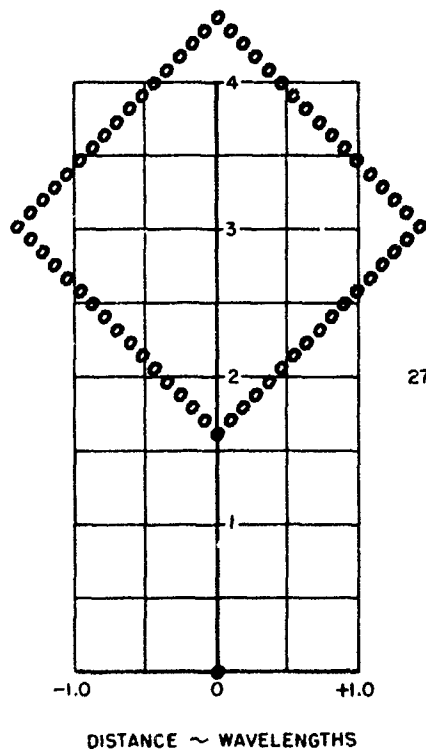
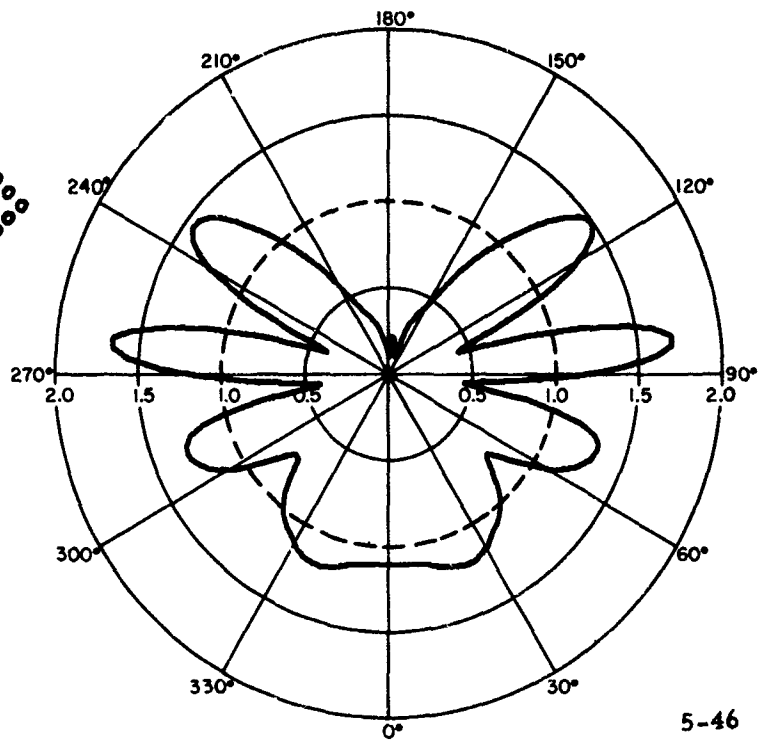
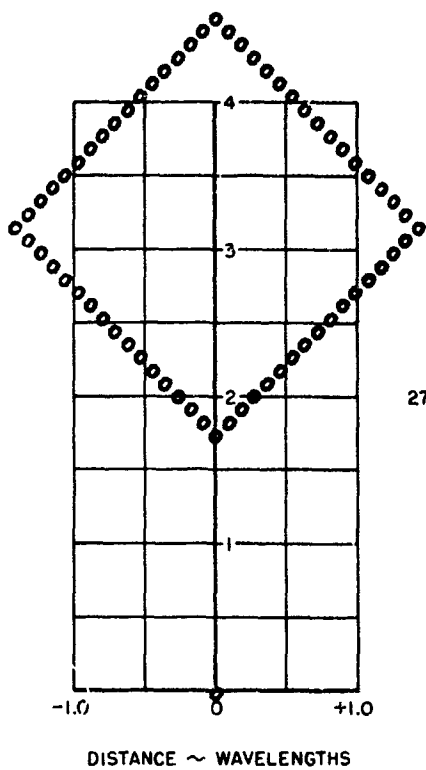
5-44

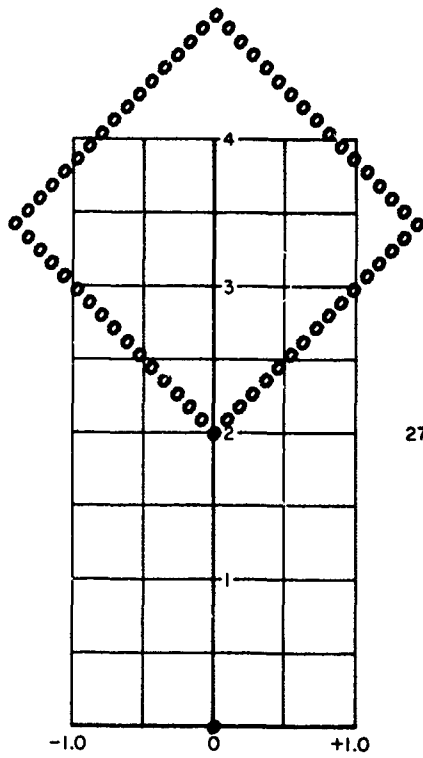


DISTANCE ~ WAVELENGTHS

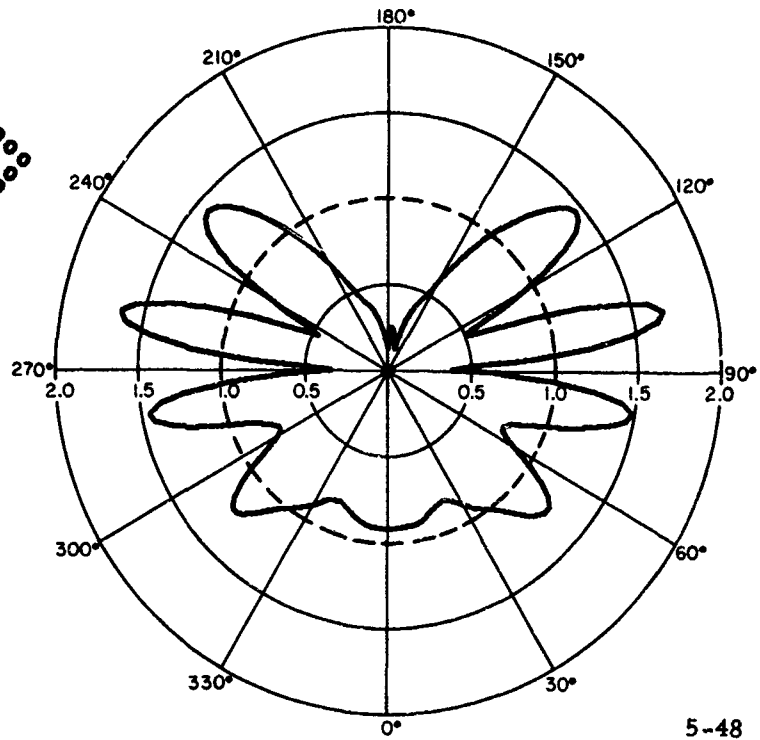


5-43

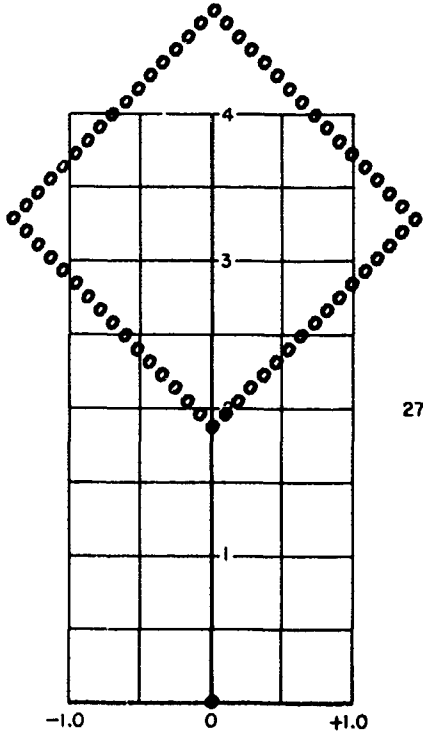




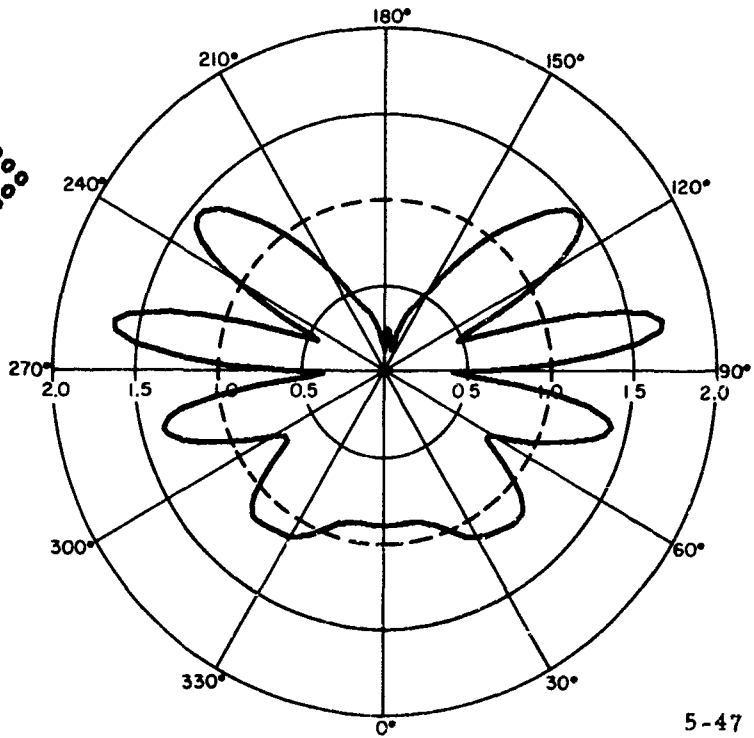
DISTANCE ~ WAVELENGTHS



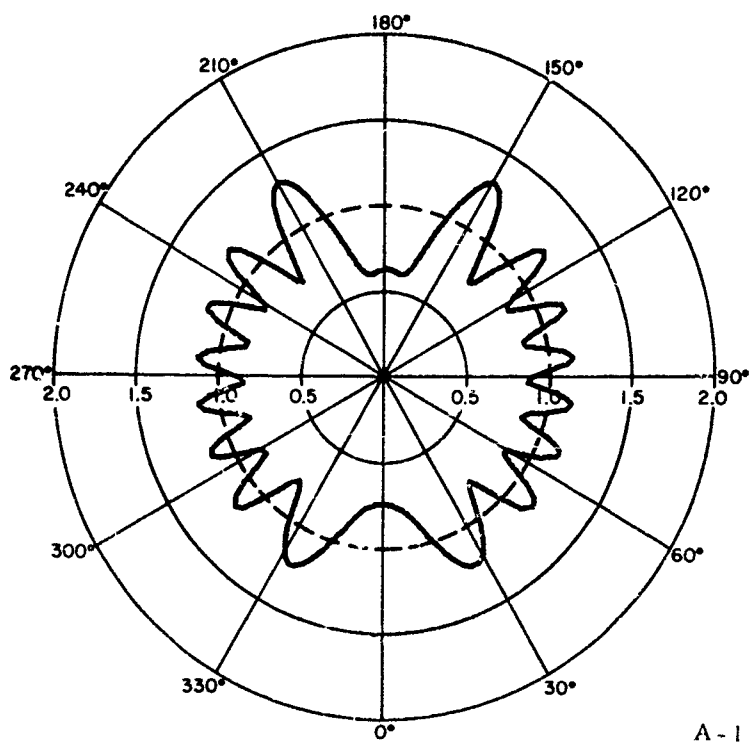
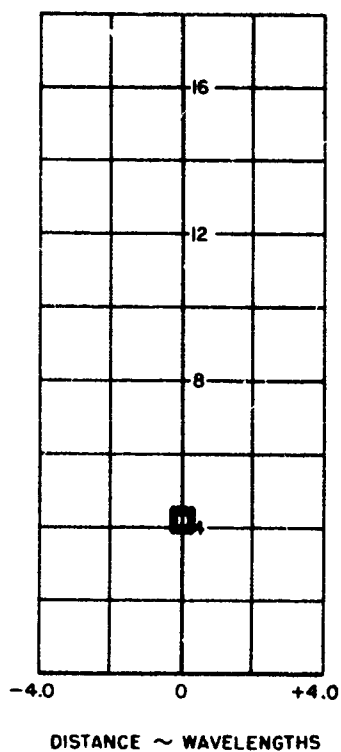
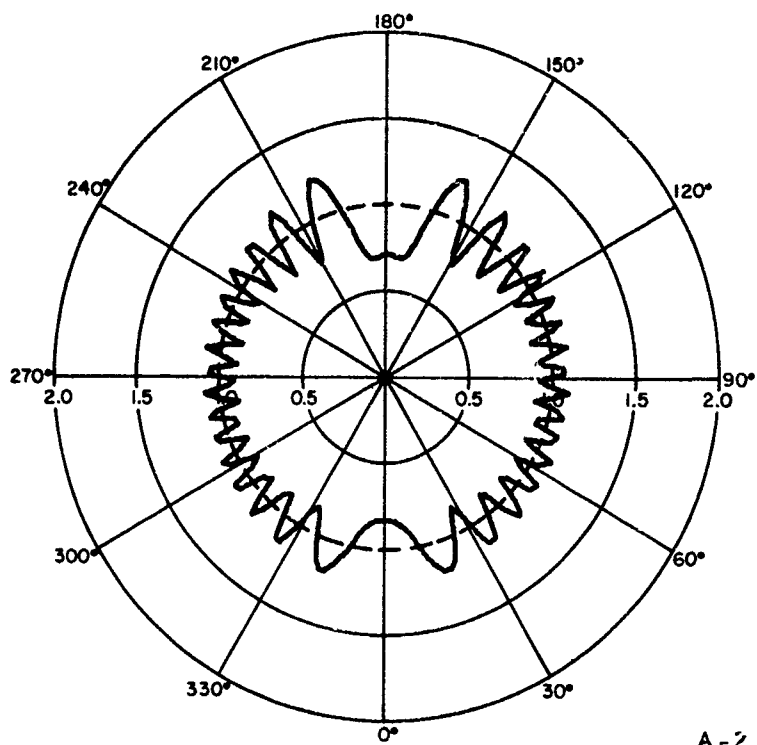
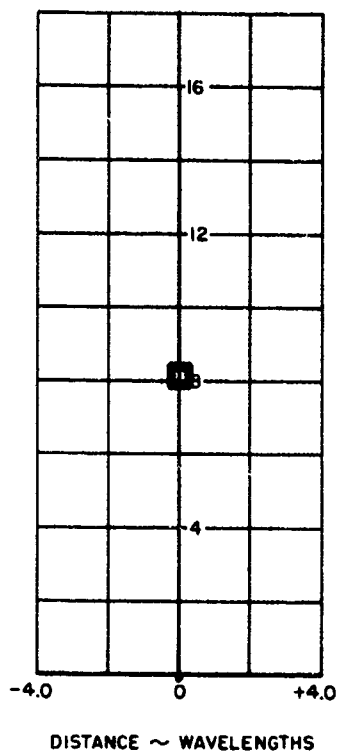
5-48

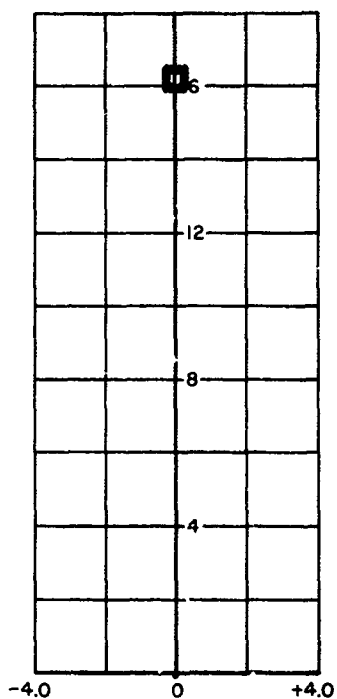


DISTANCE ~ WAVELENGTHS

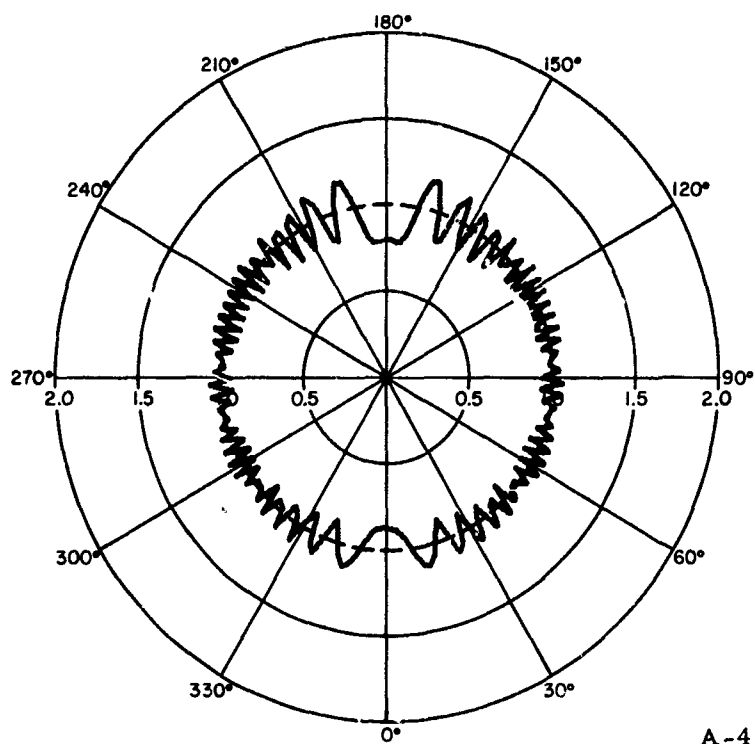


5-47

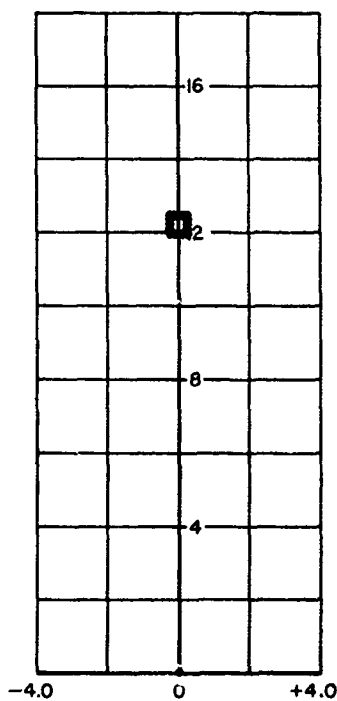




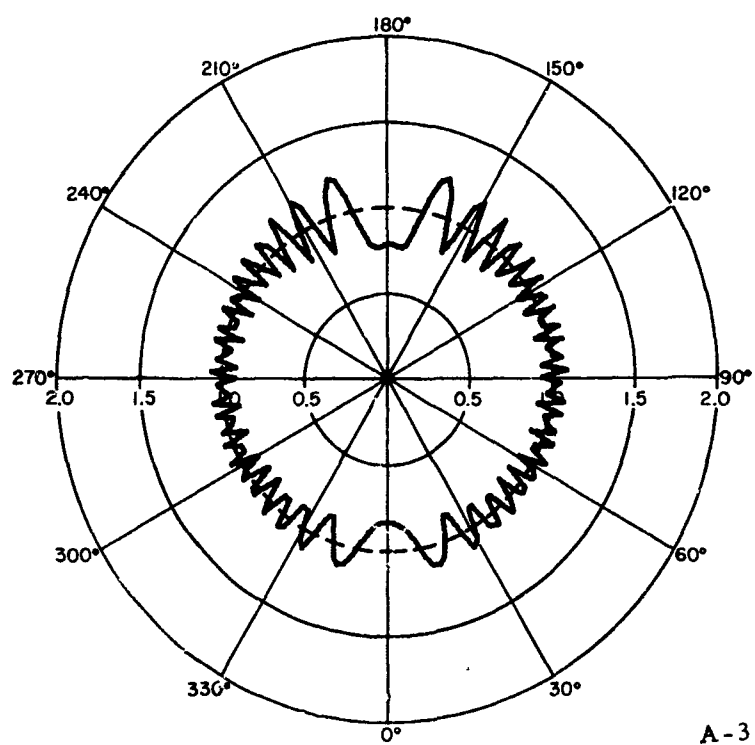
DISTANCE ~ WAVELENGTHS



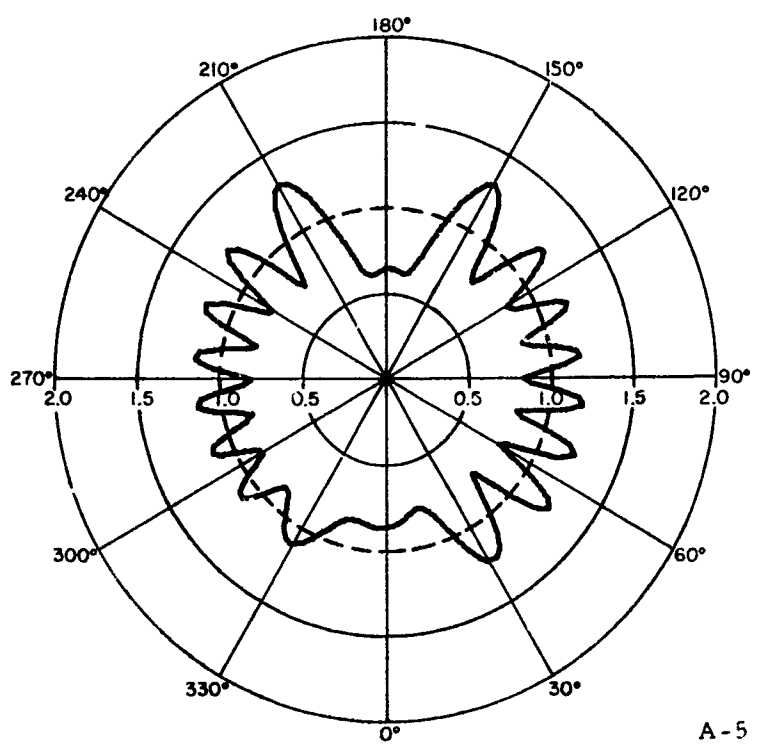
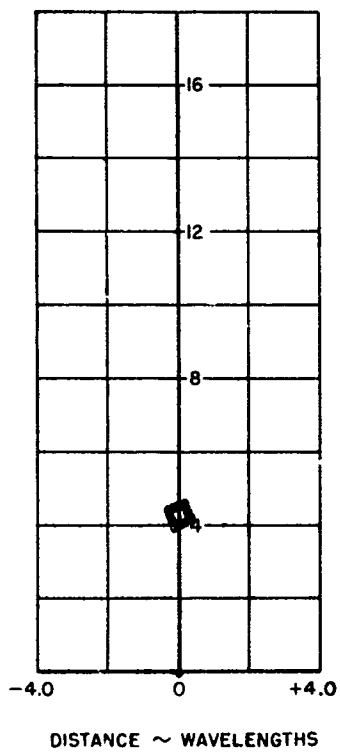
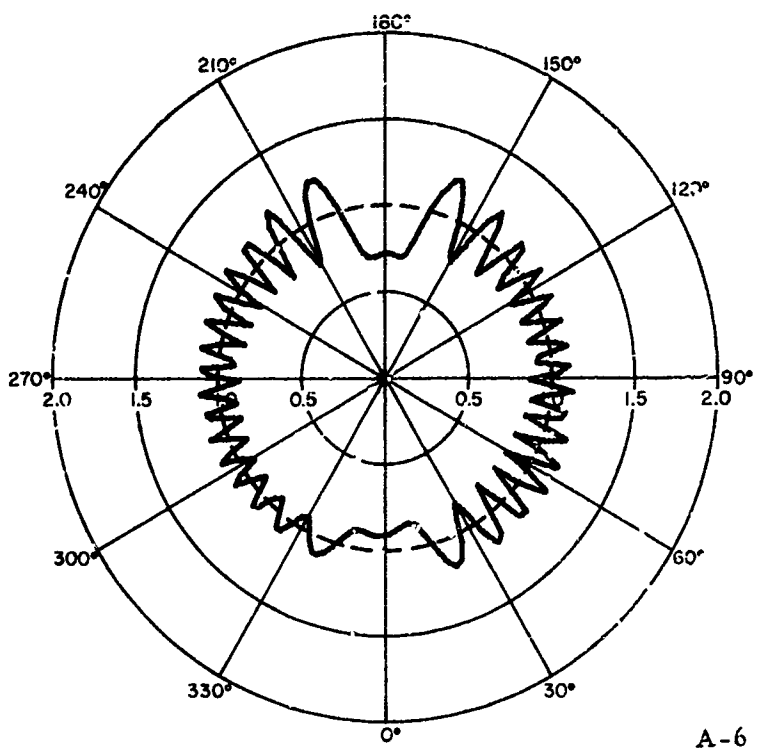
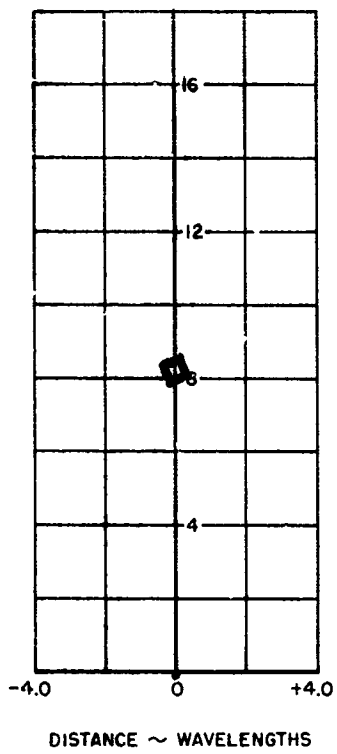
A-4

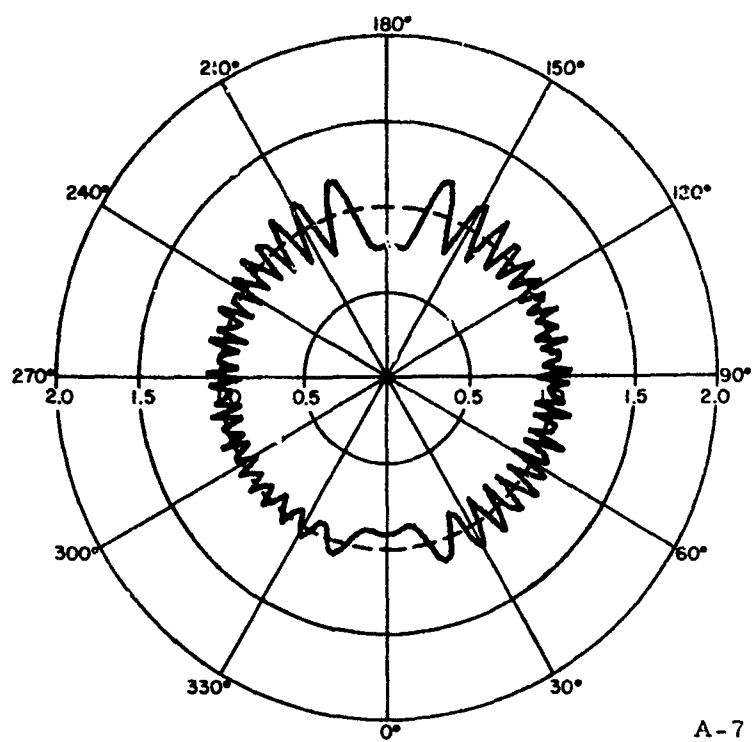
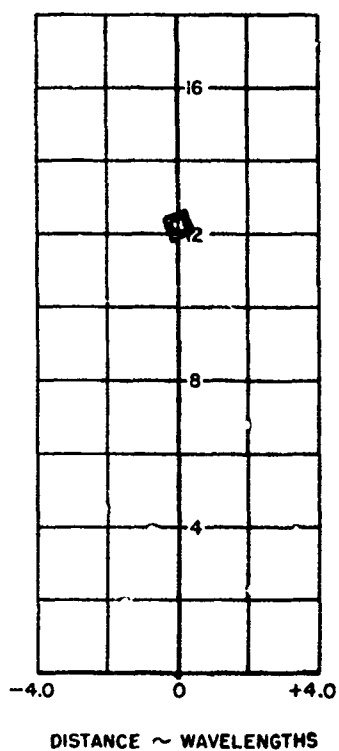
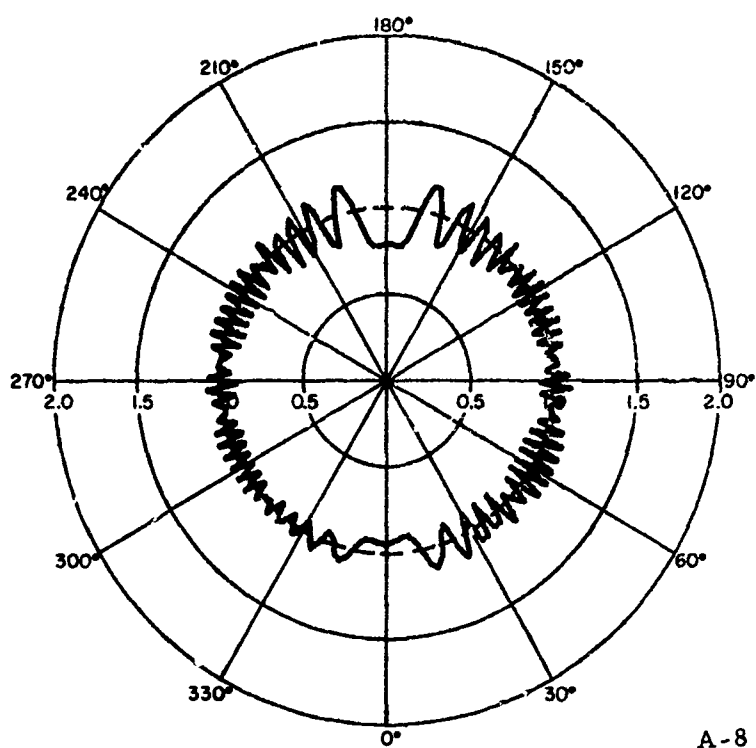
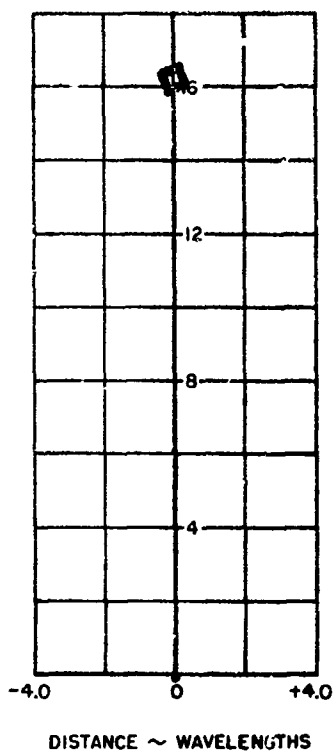


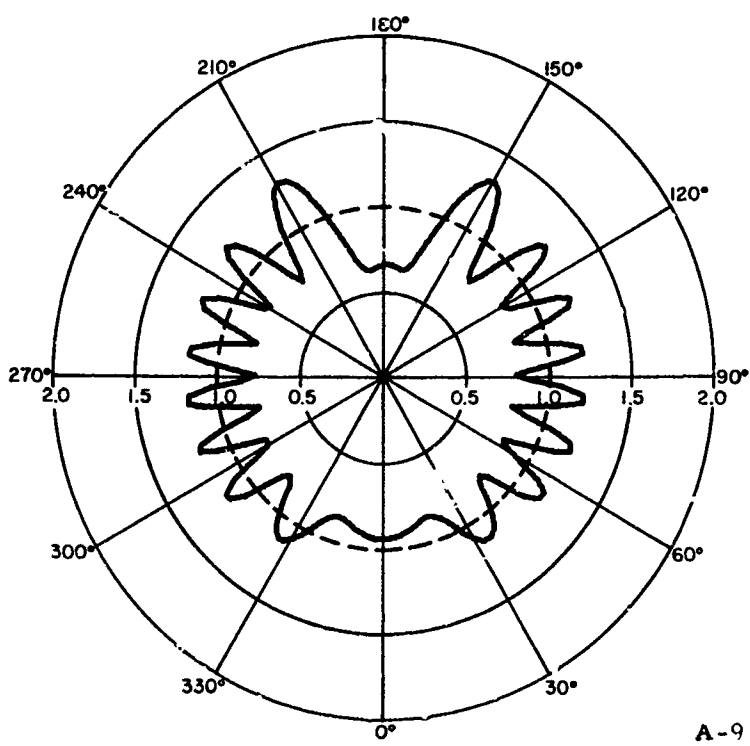
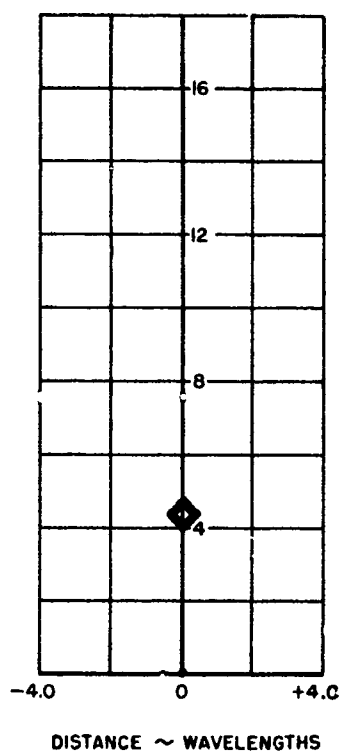
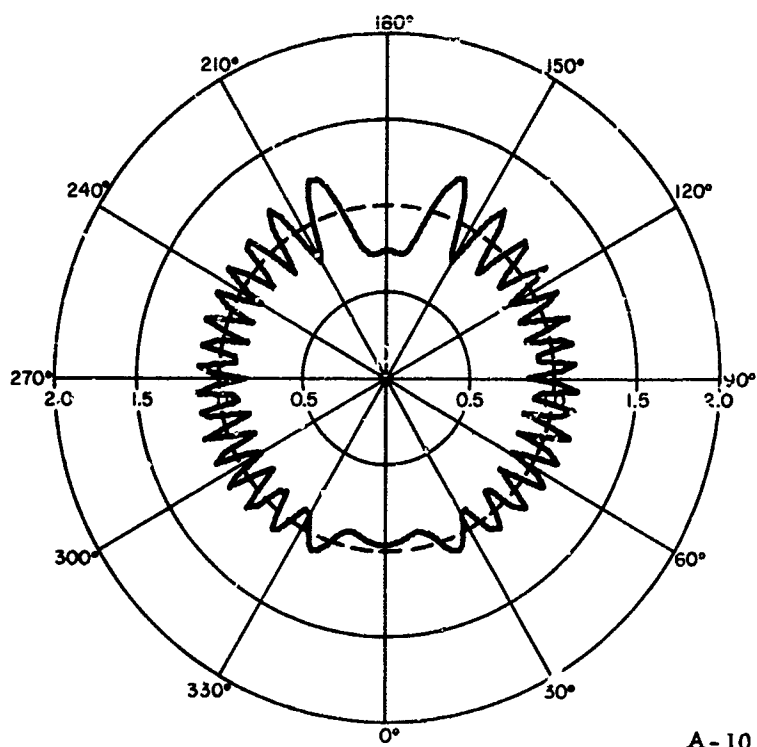
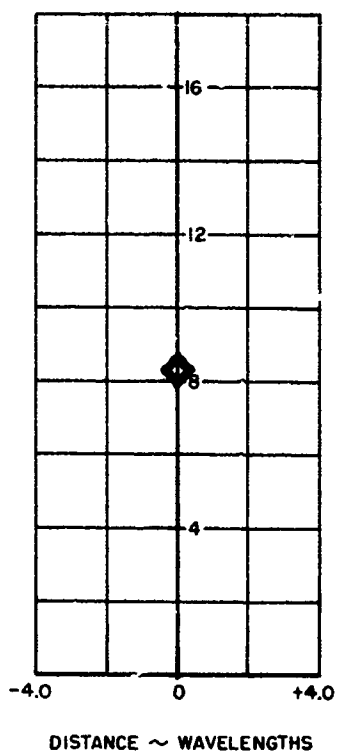
DISTANCE ~ WAVELENGTHS

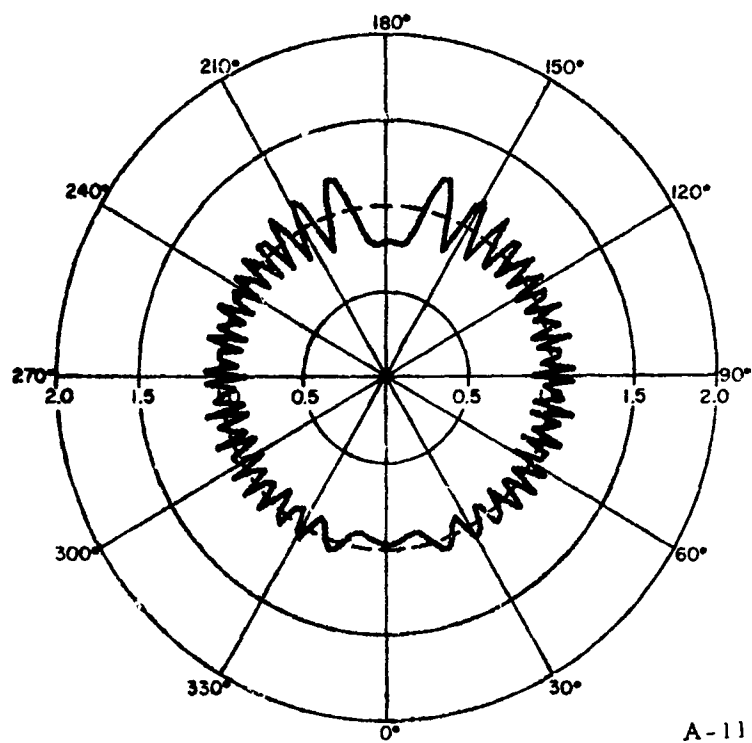
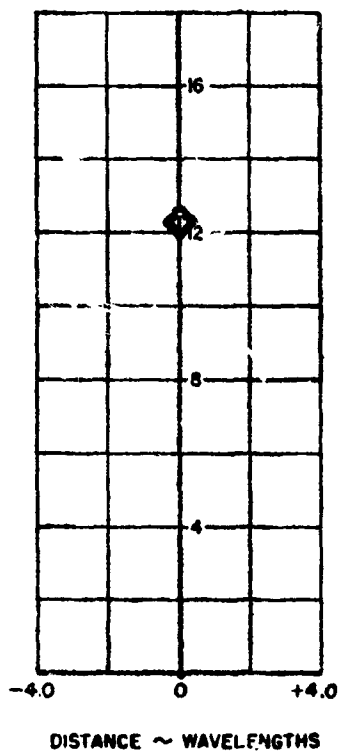
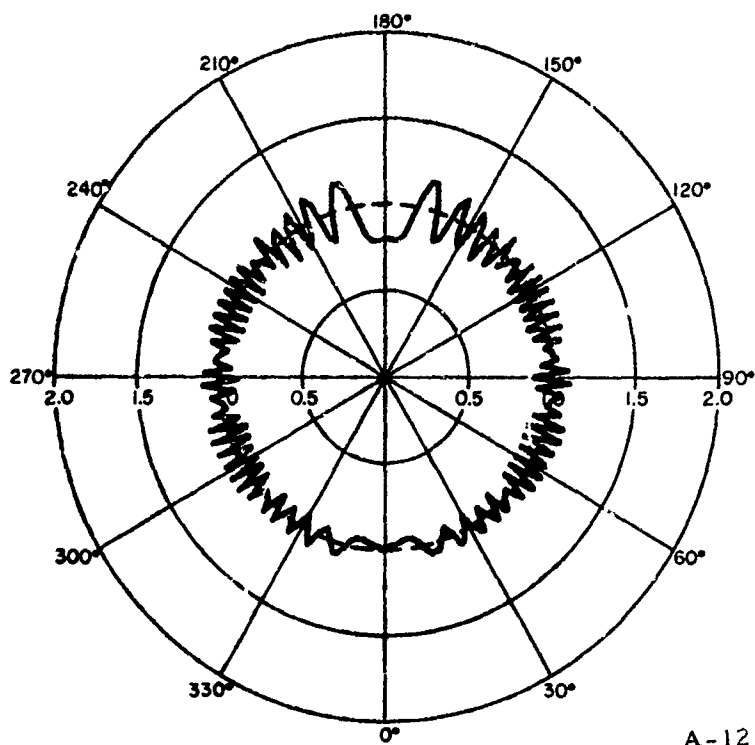
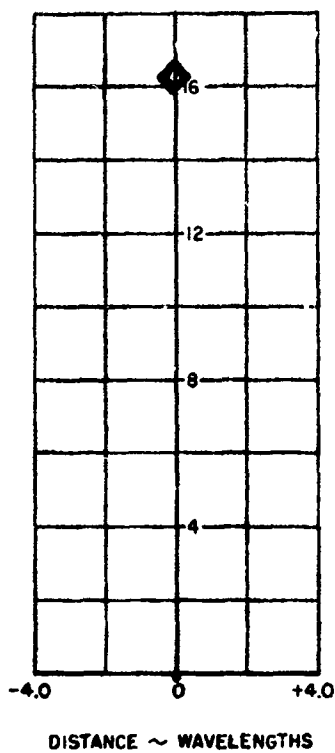


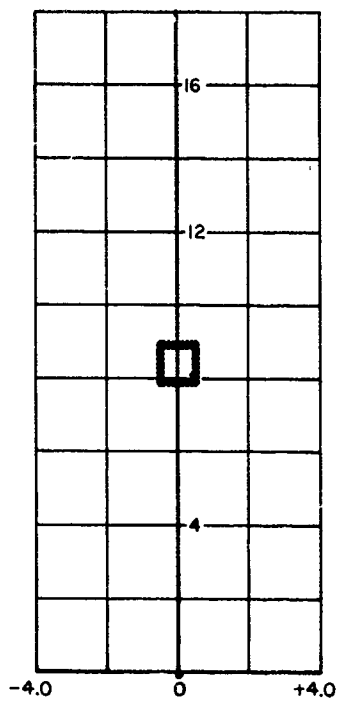
A-3



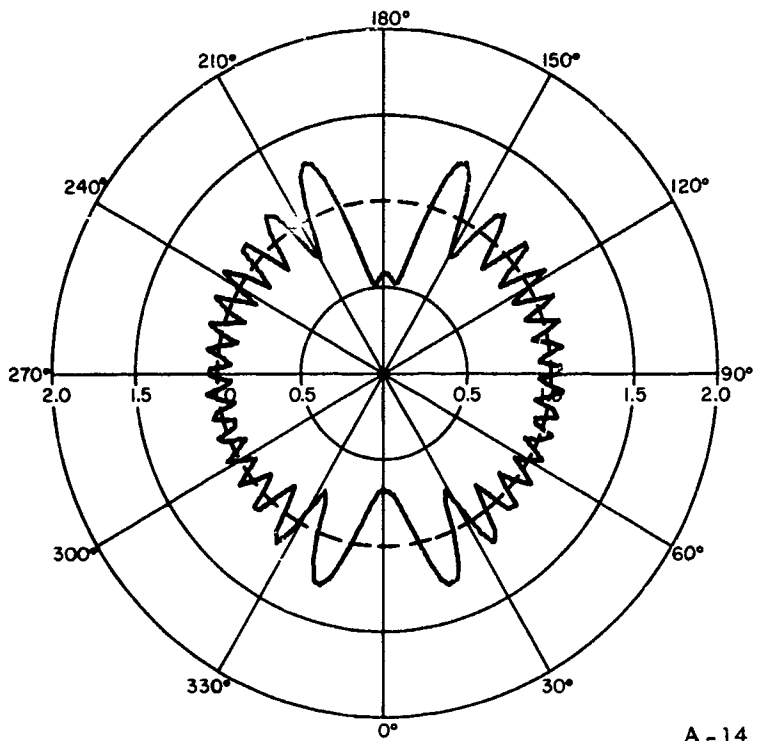




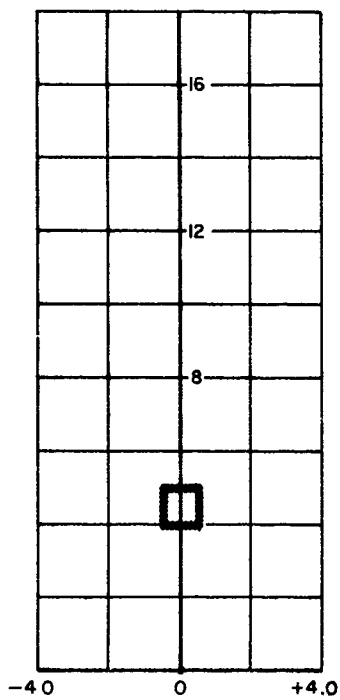




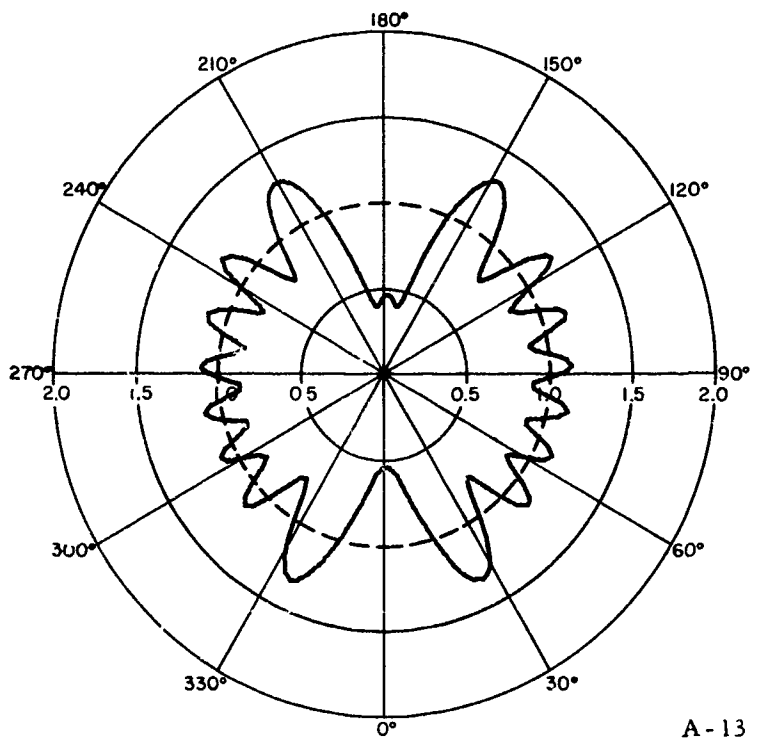
DISTANCE ~ WAVELENGTHS



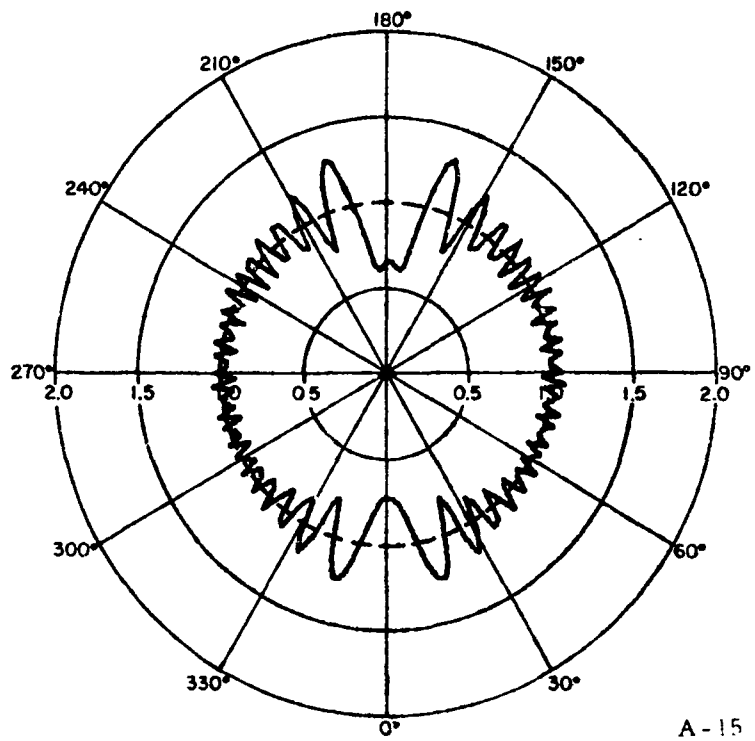
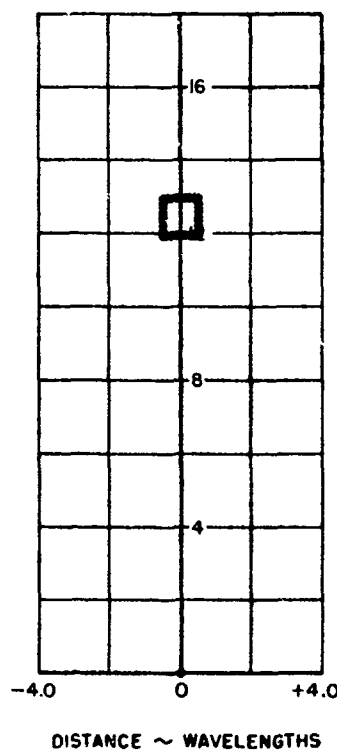
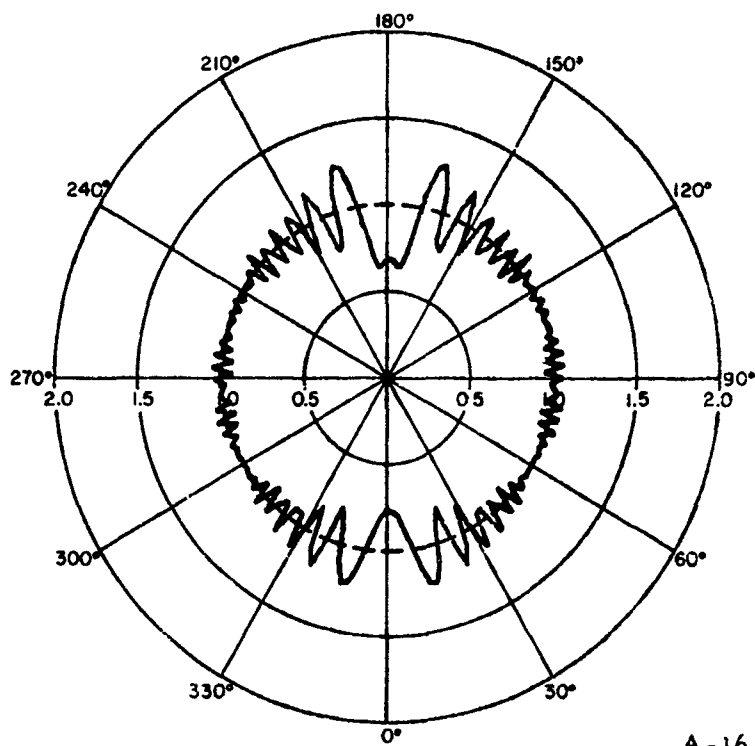
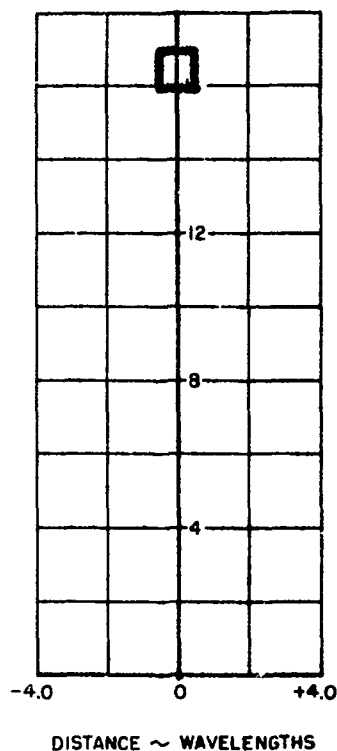
A-14

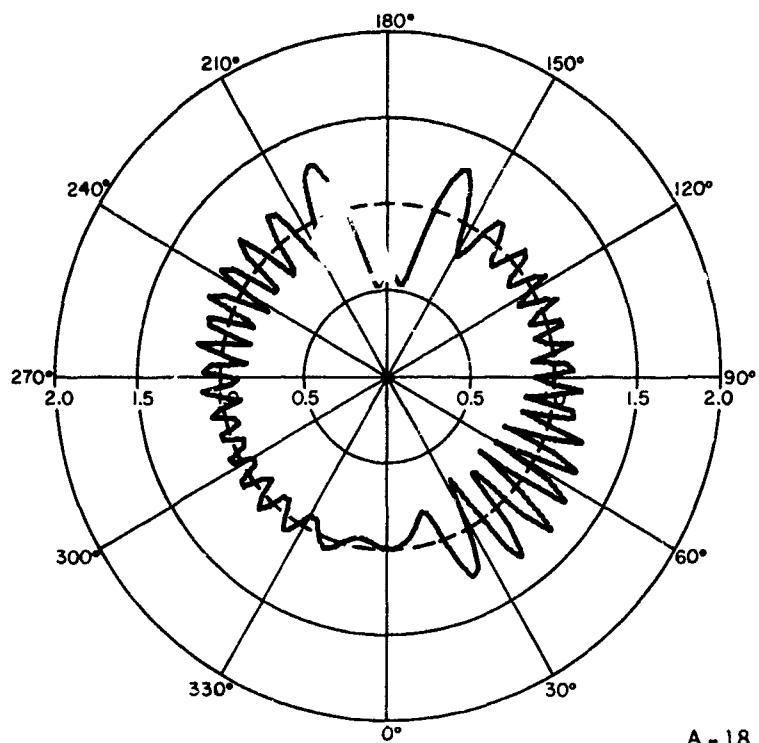
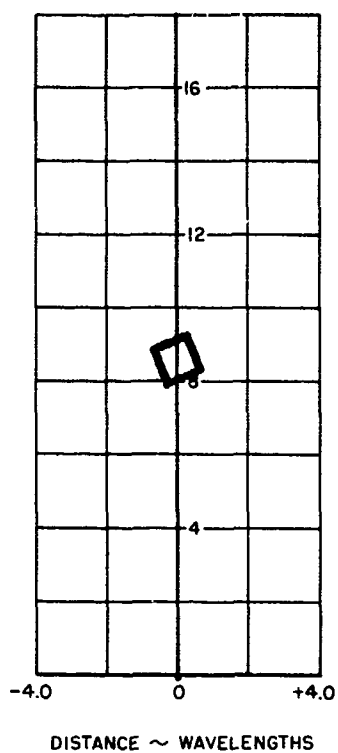


DISTANCE ~ WAVELENGTHS

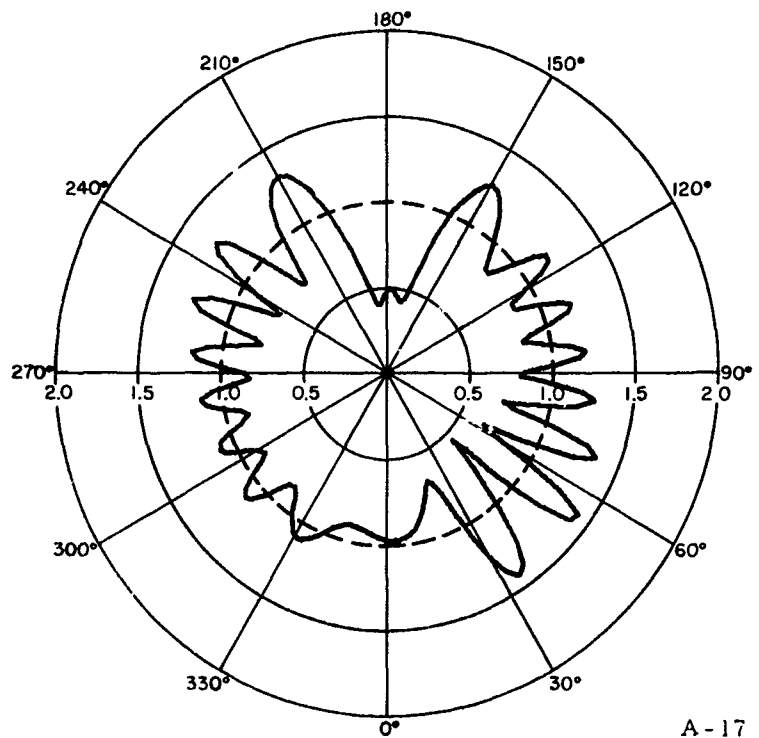
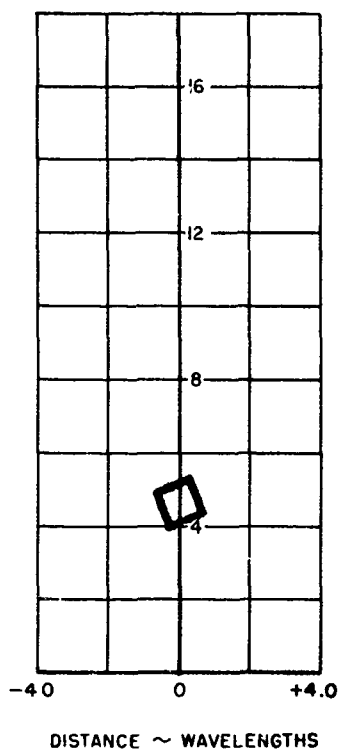


A-13

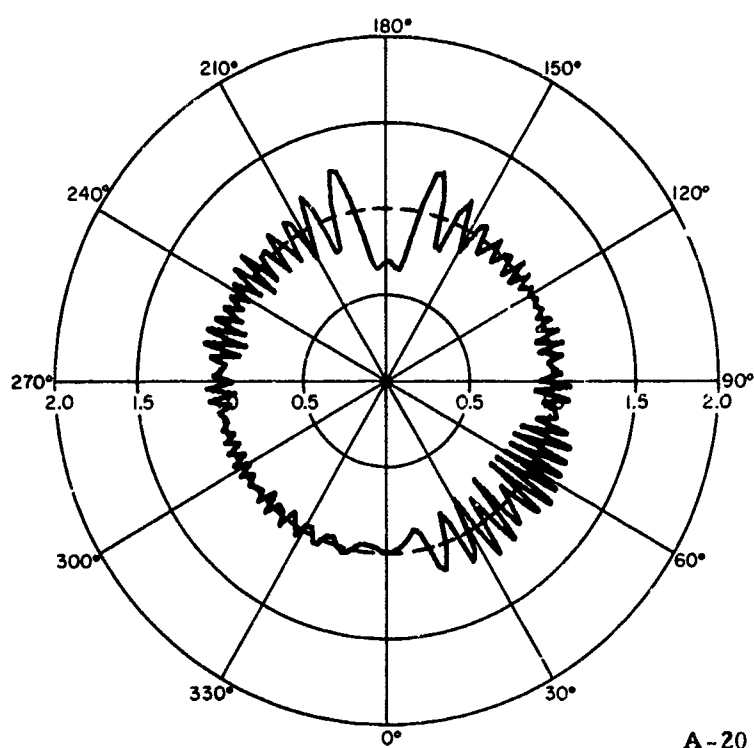
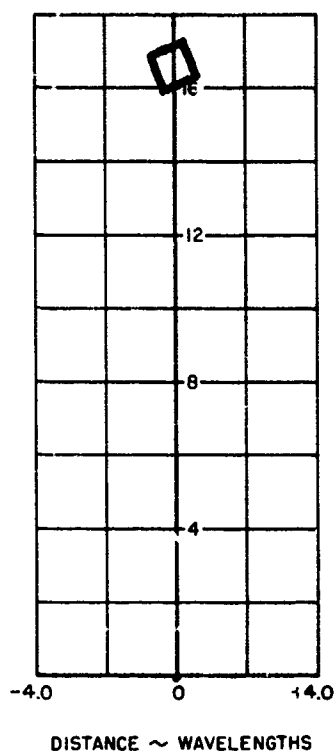




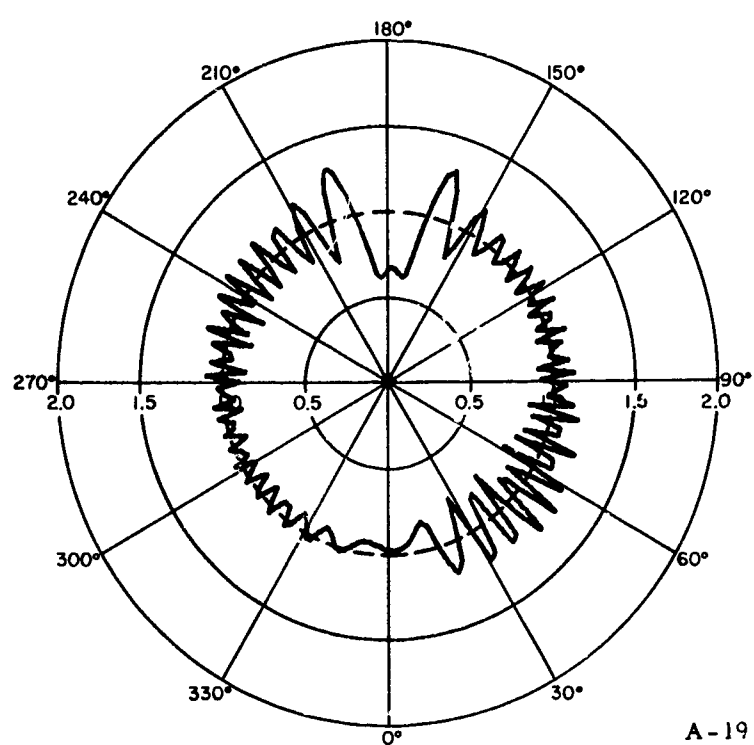
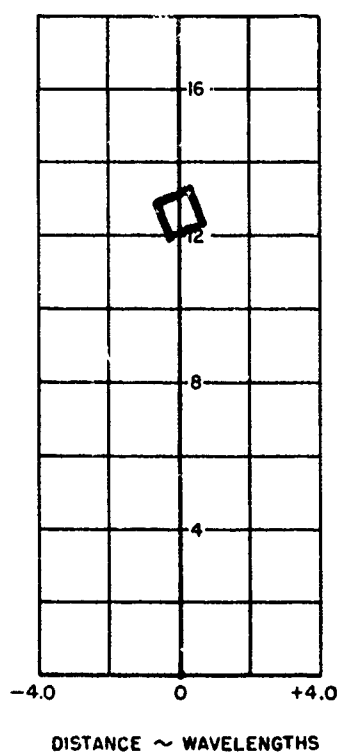
A-18



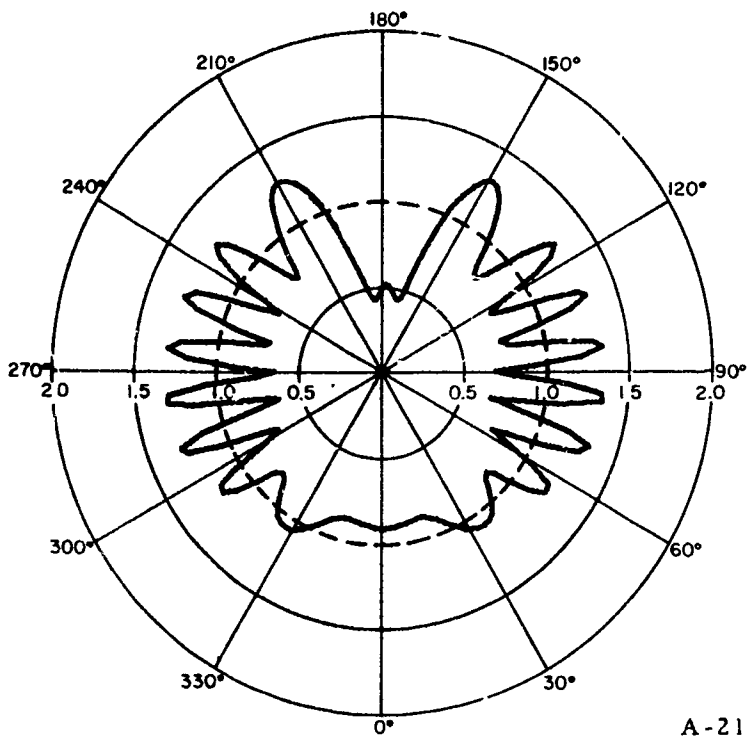
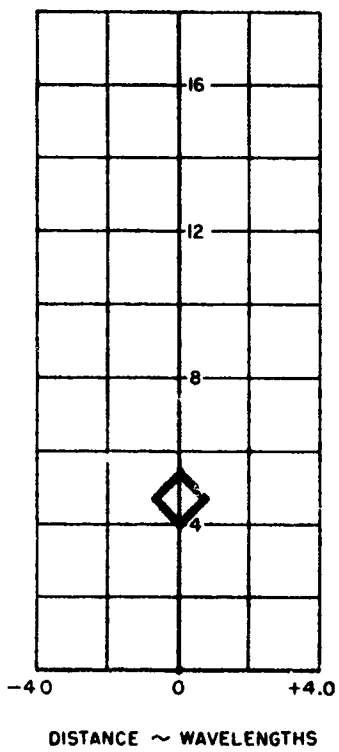
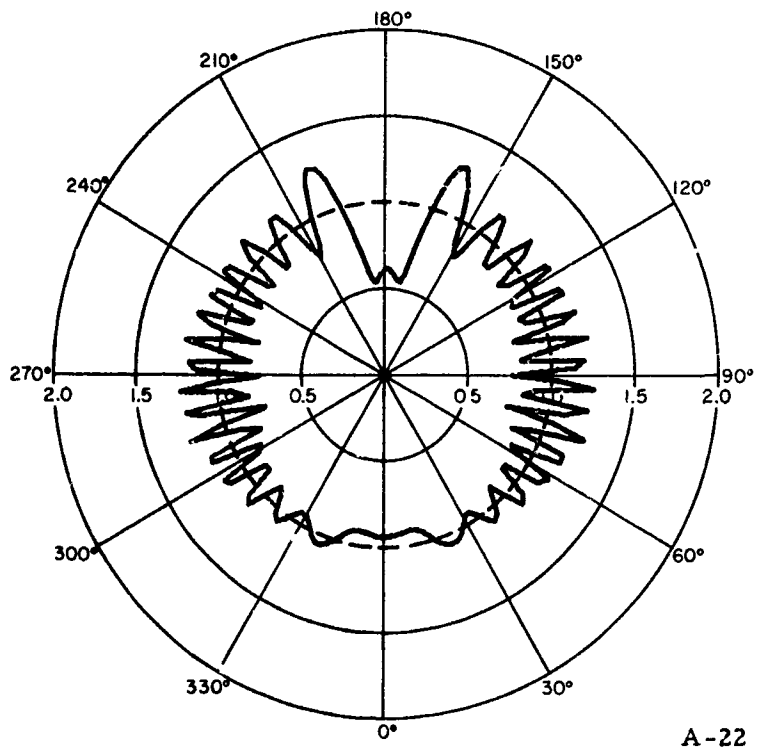
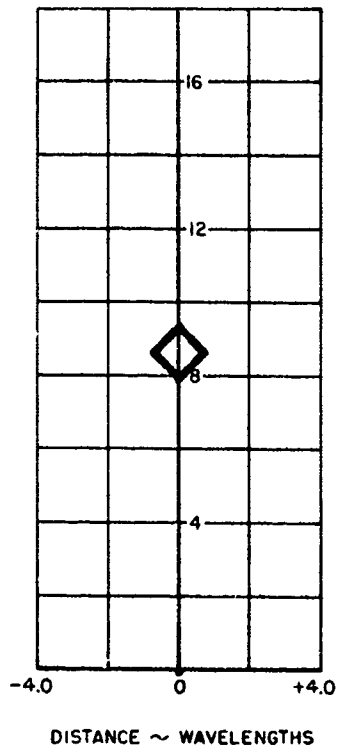
A-17

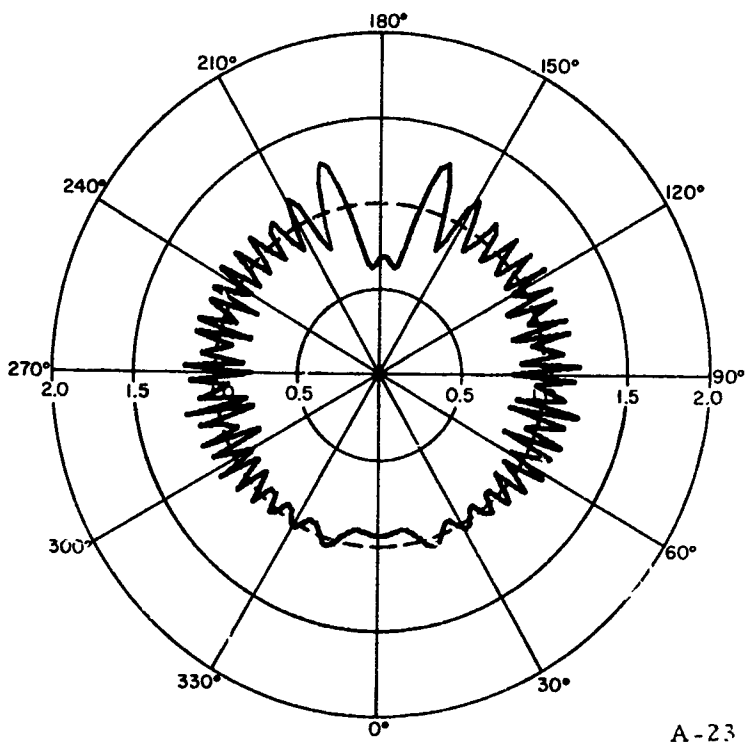
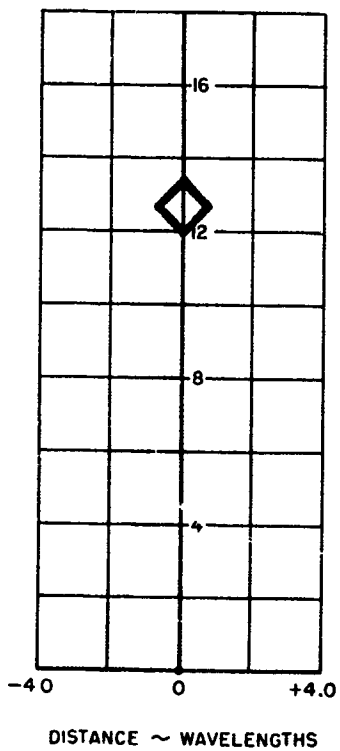
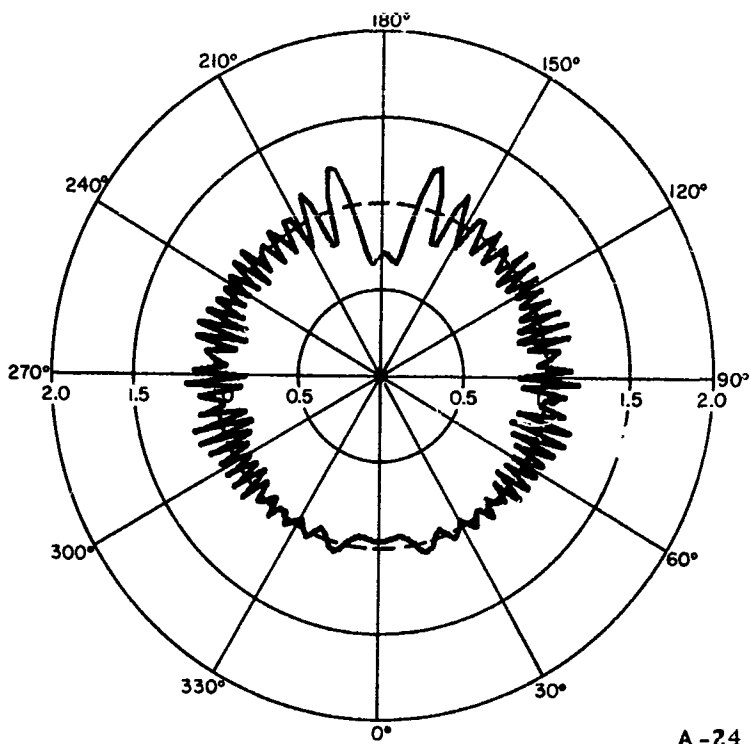
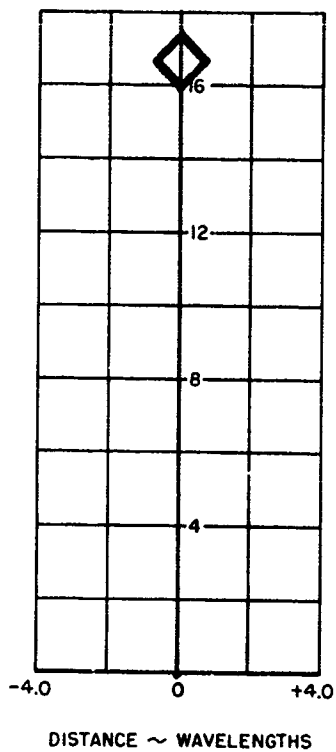


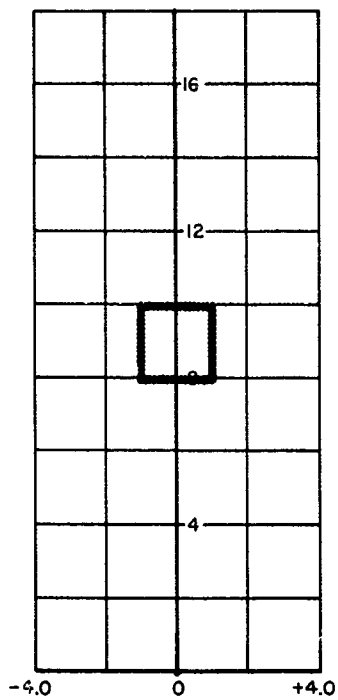
A-20



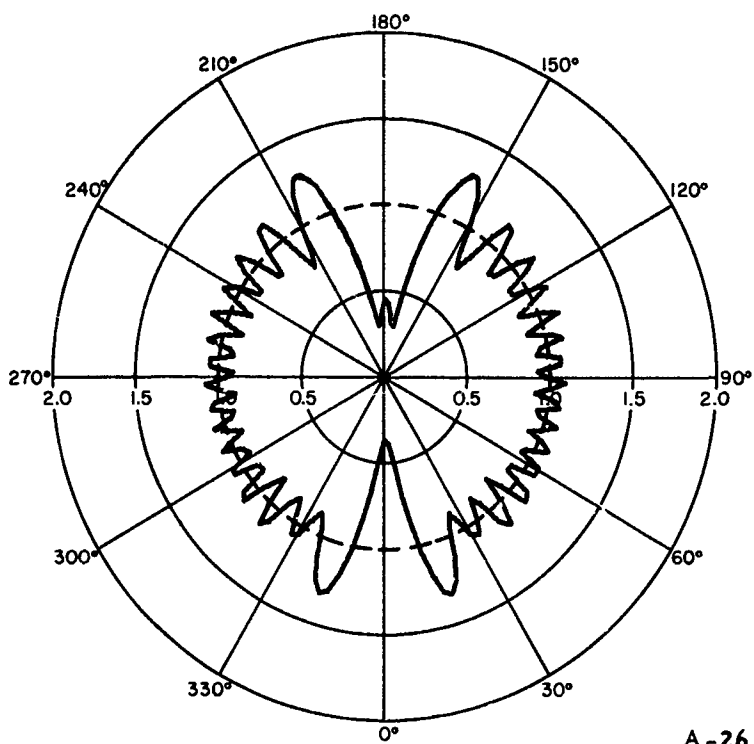
A-19



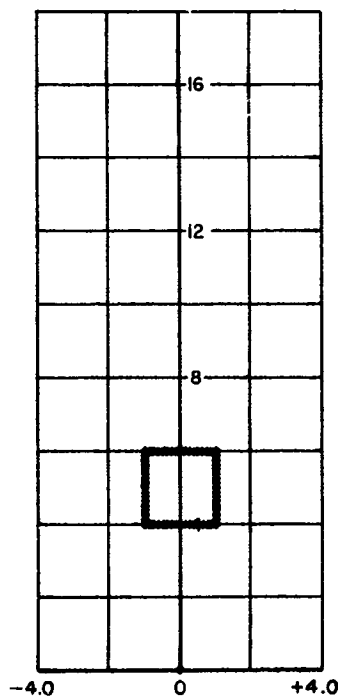




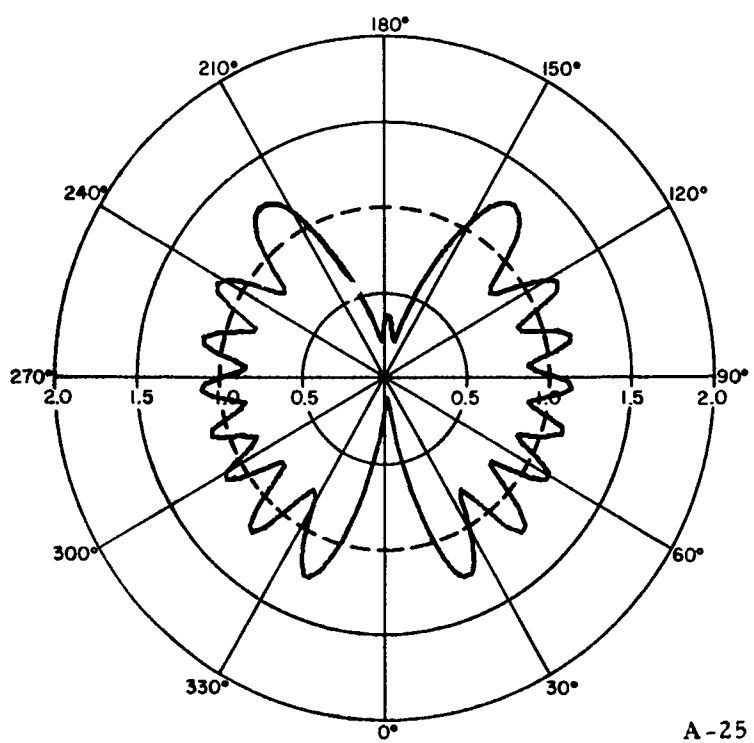
DISTANCE ~ WAVELENGTHS



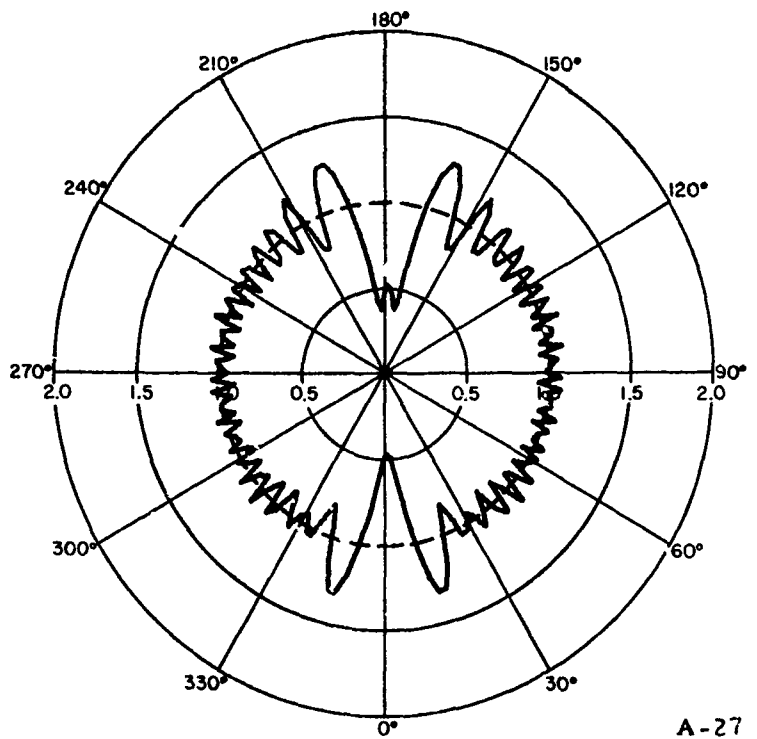
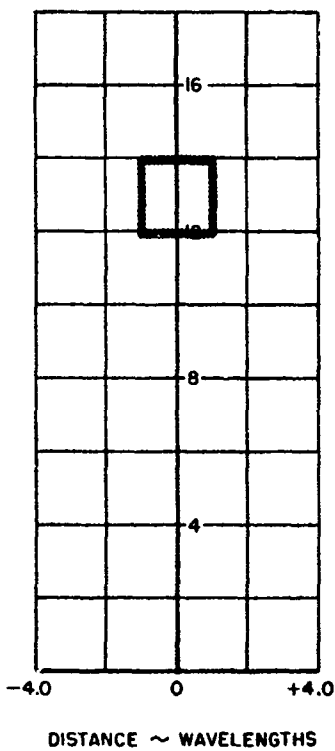
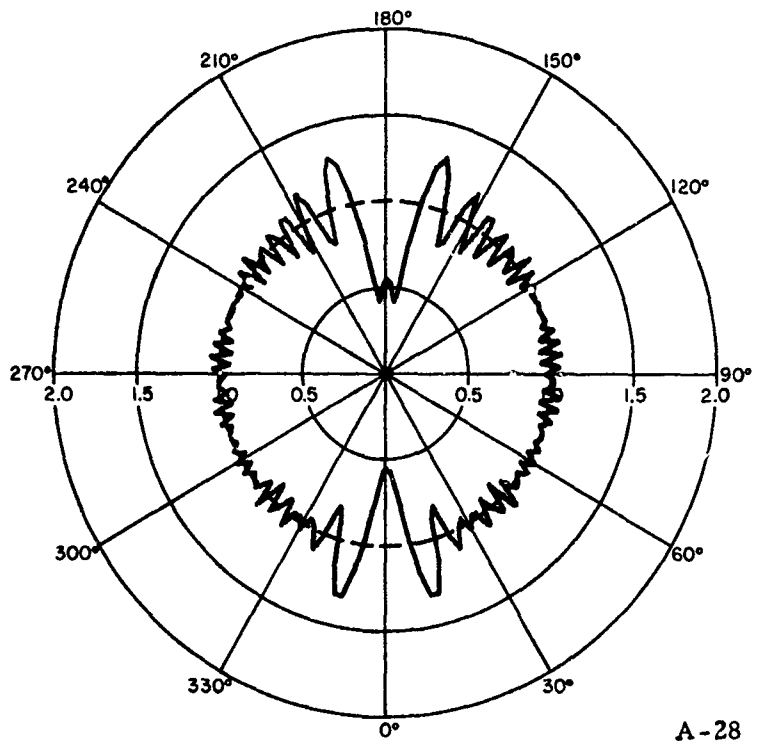
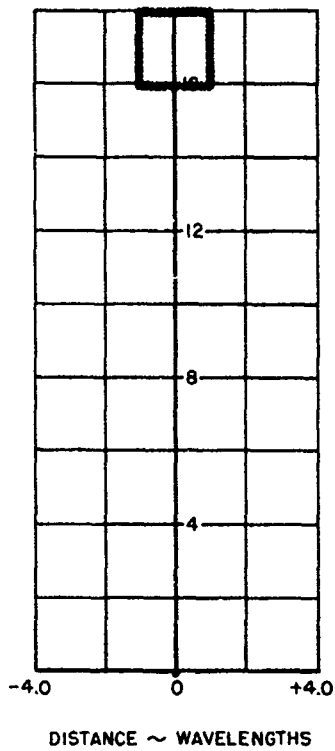
A-26

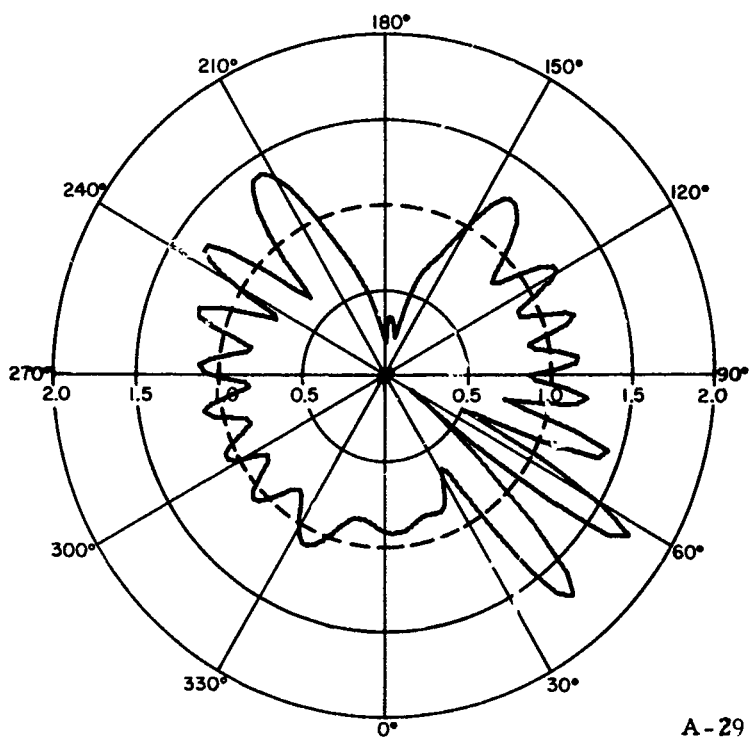
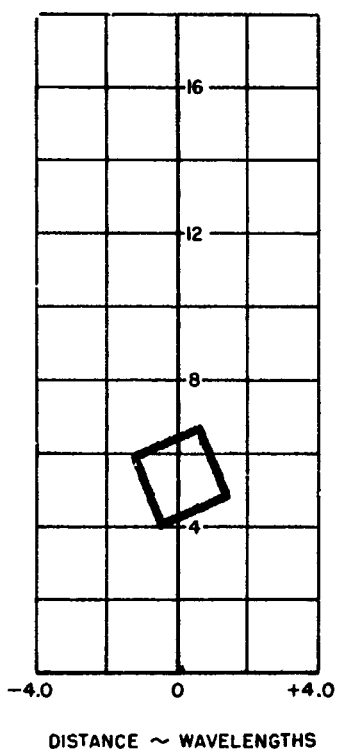
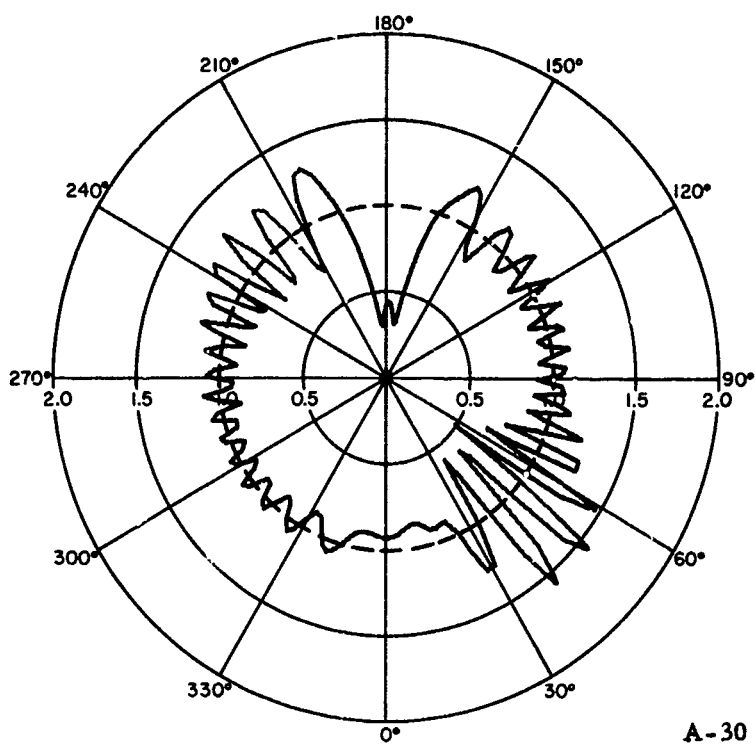
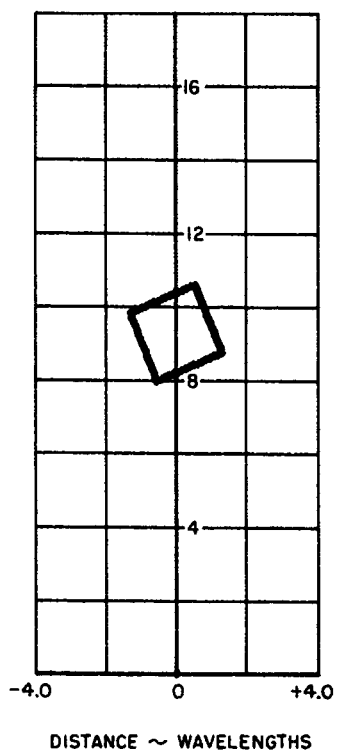


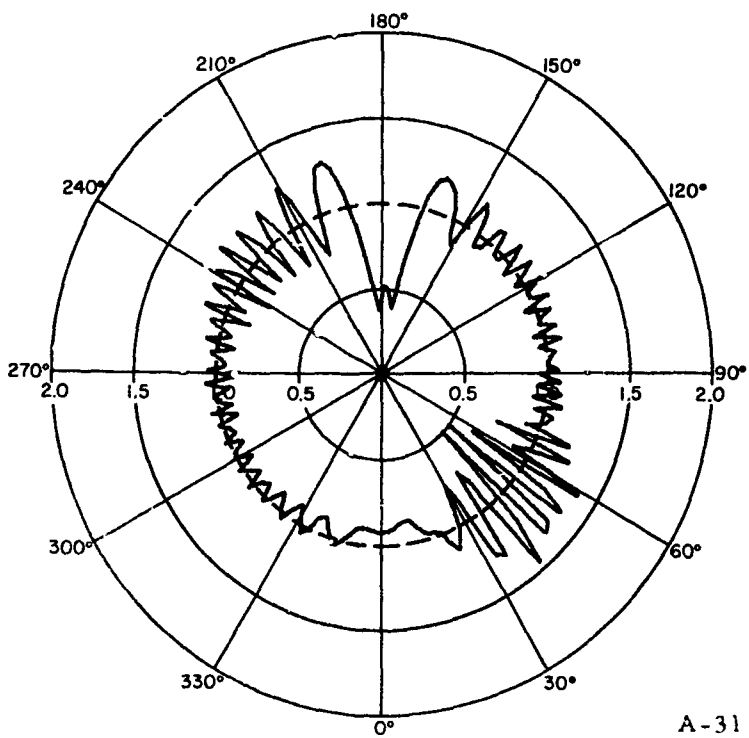
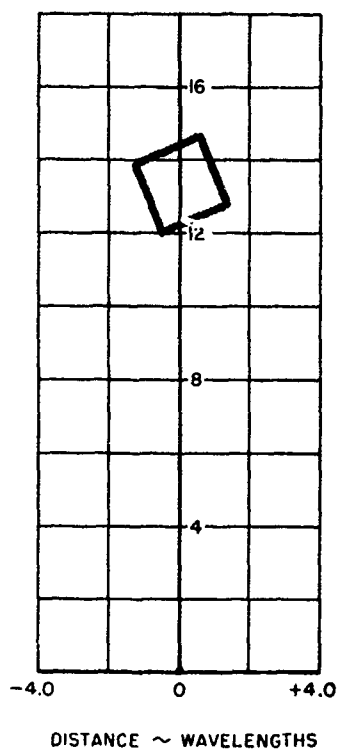
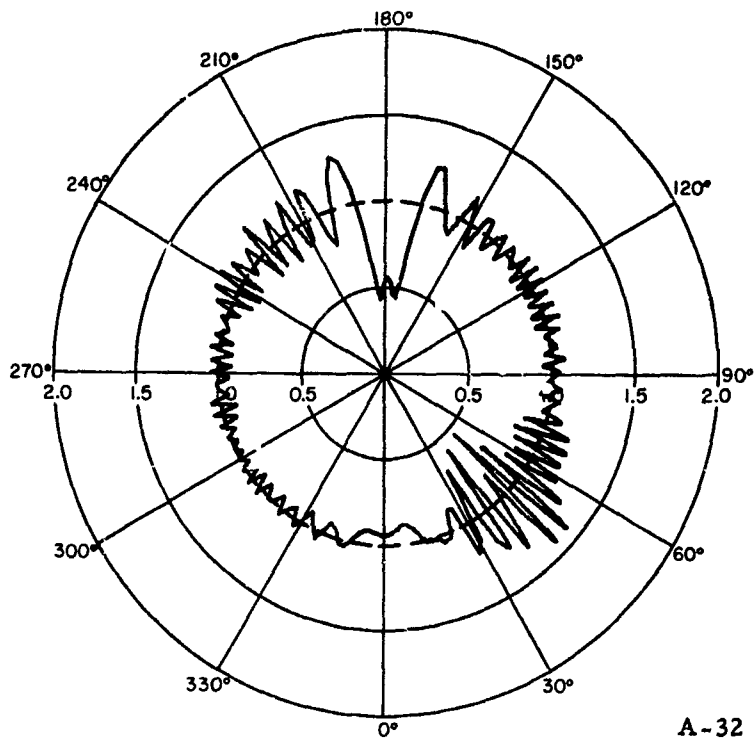
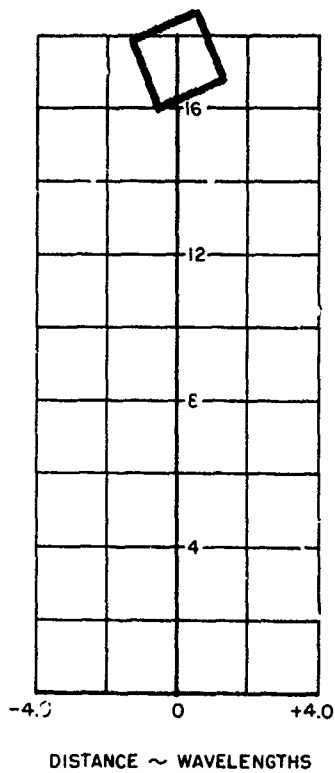
DISTANCE ~ WAVELENGTHS

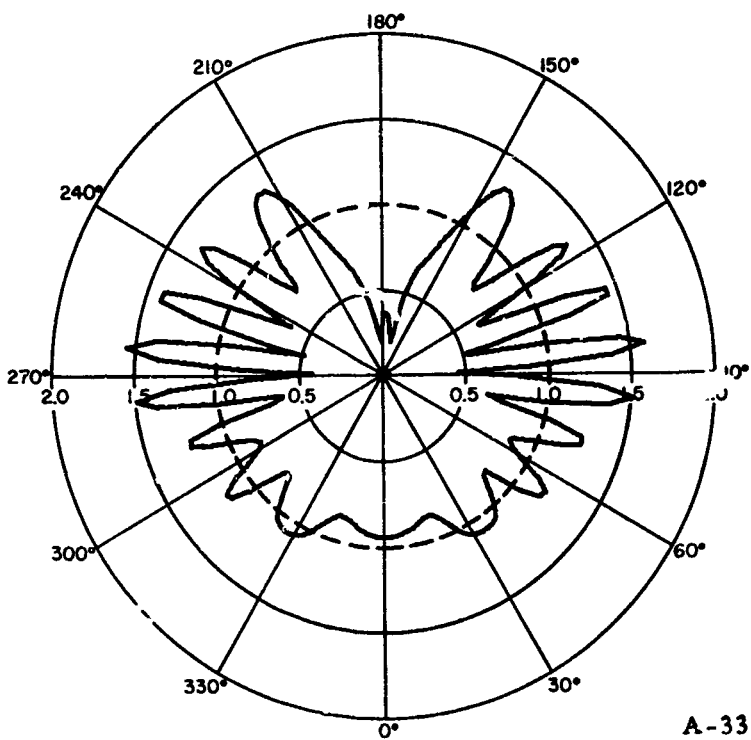
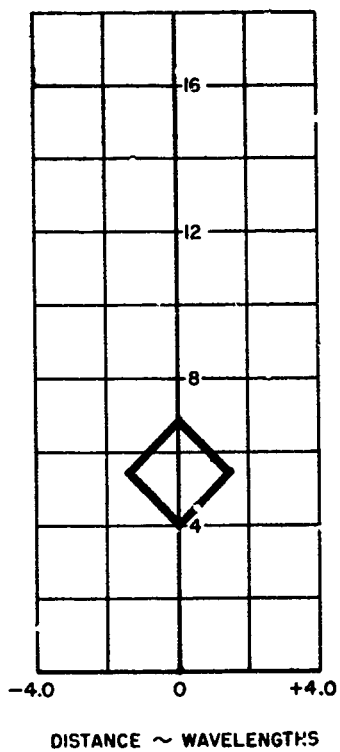
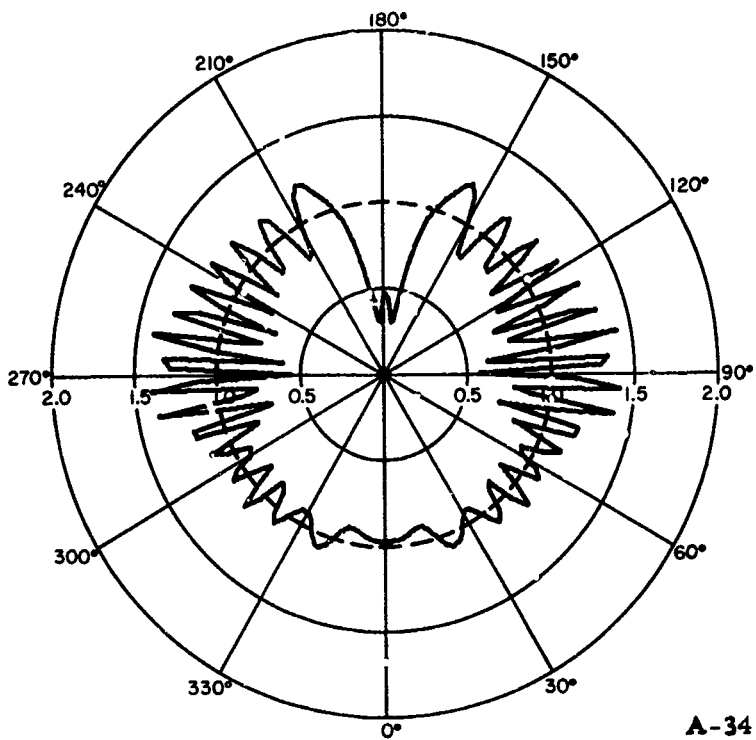
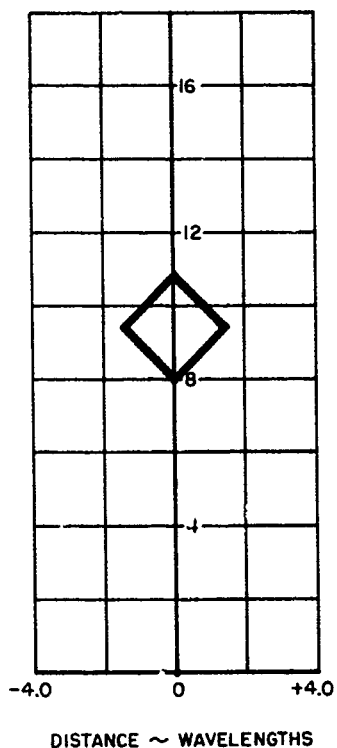


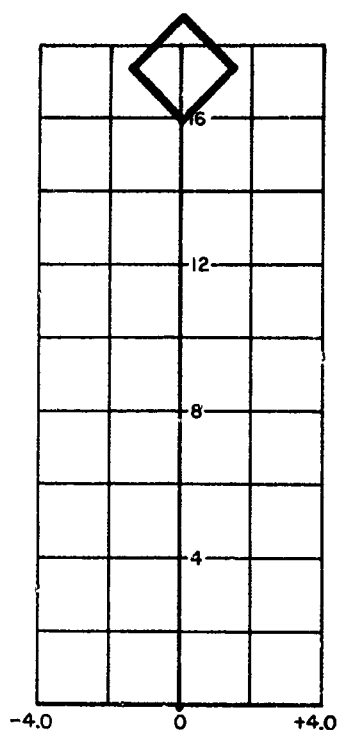
A-25



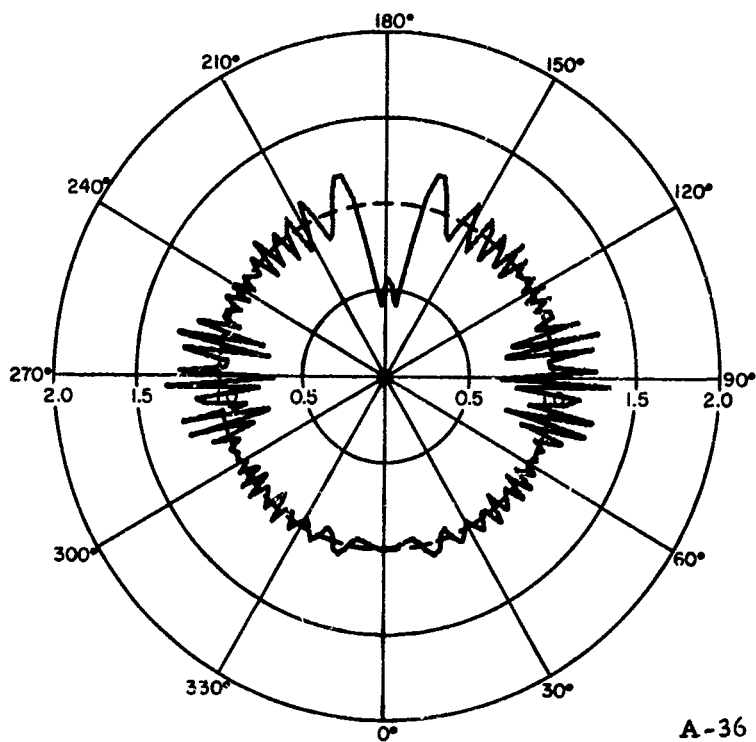




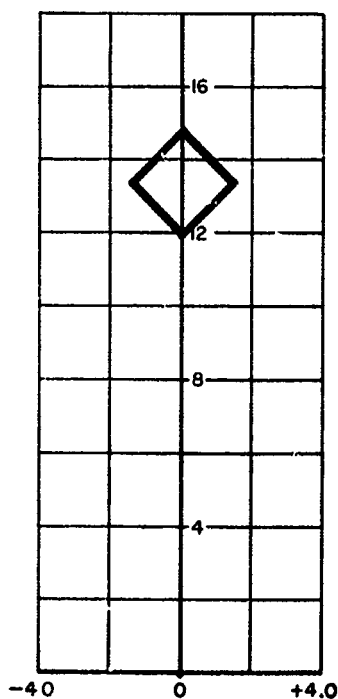




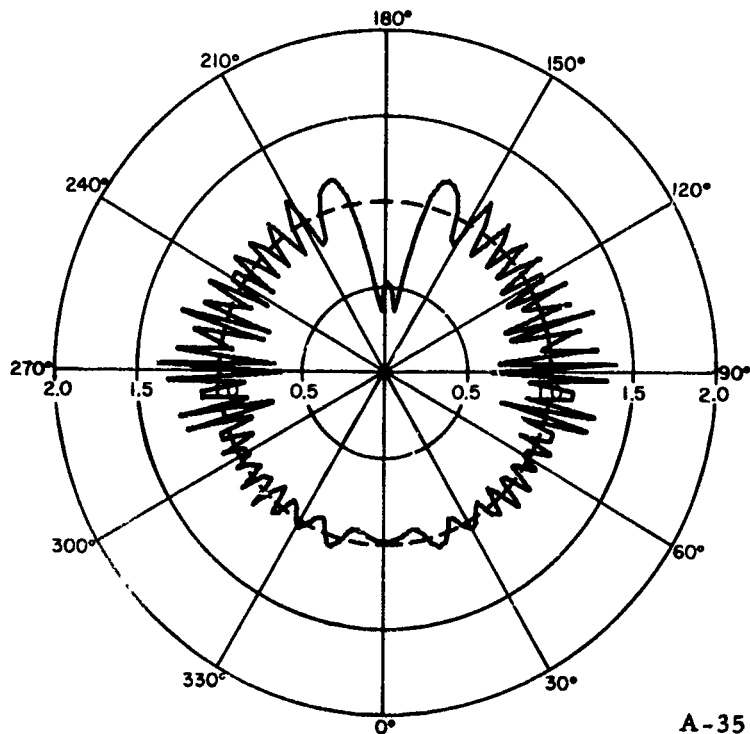
DISTANCE ~ WAVELENGTHS



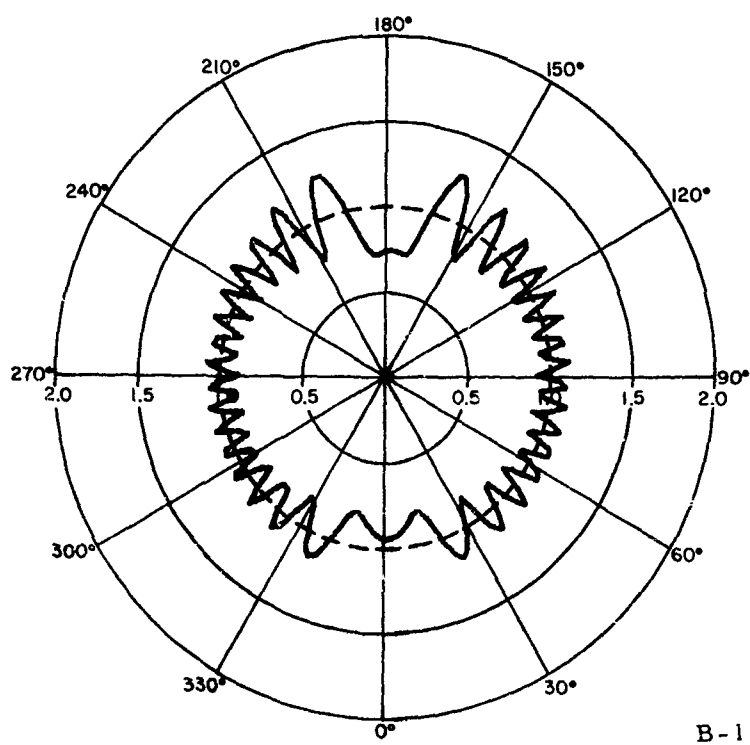
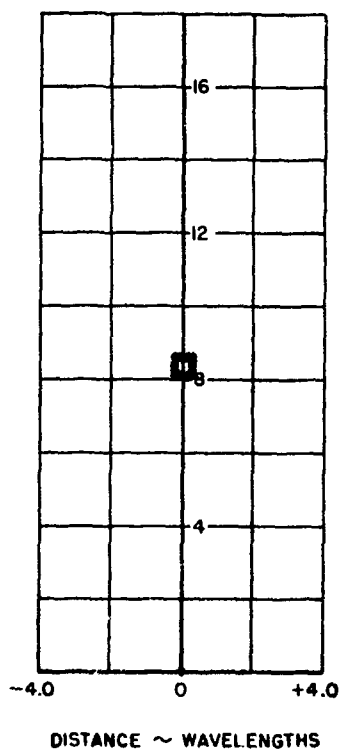
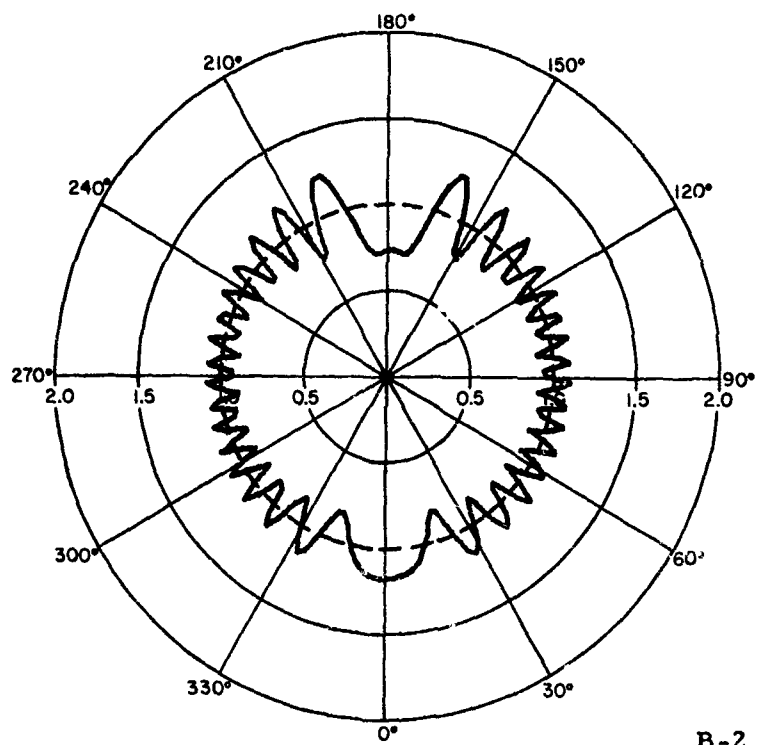
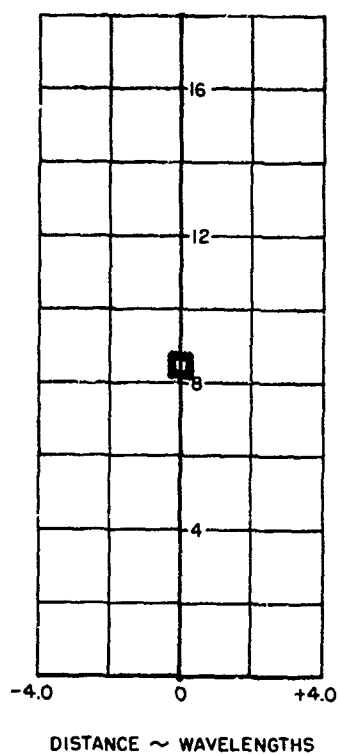
A-36

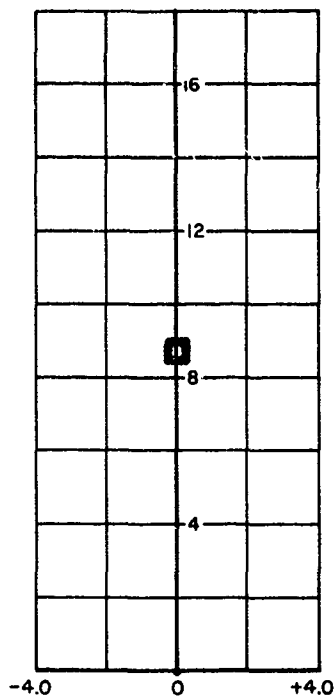


DISTANCE ~ WAVELENGTHS

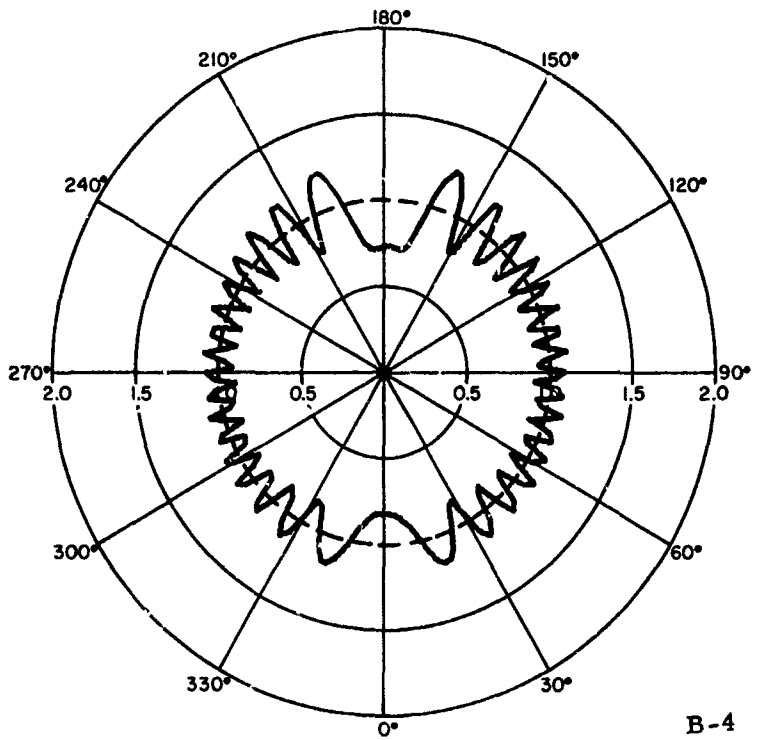


A-35

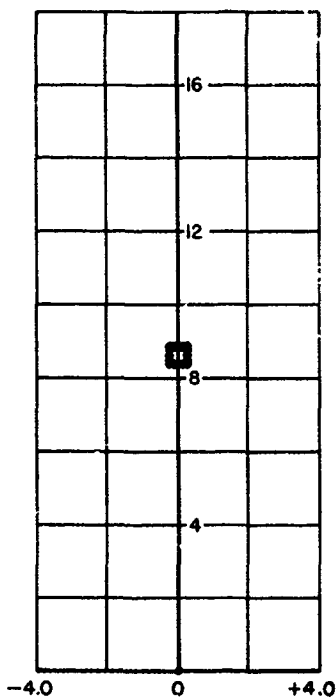




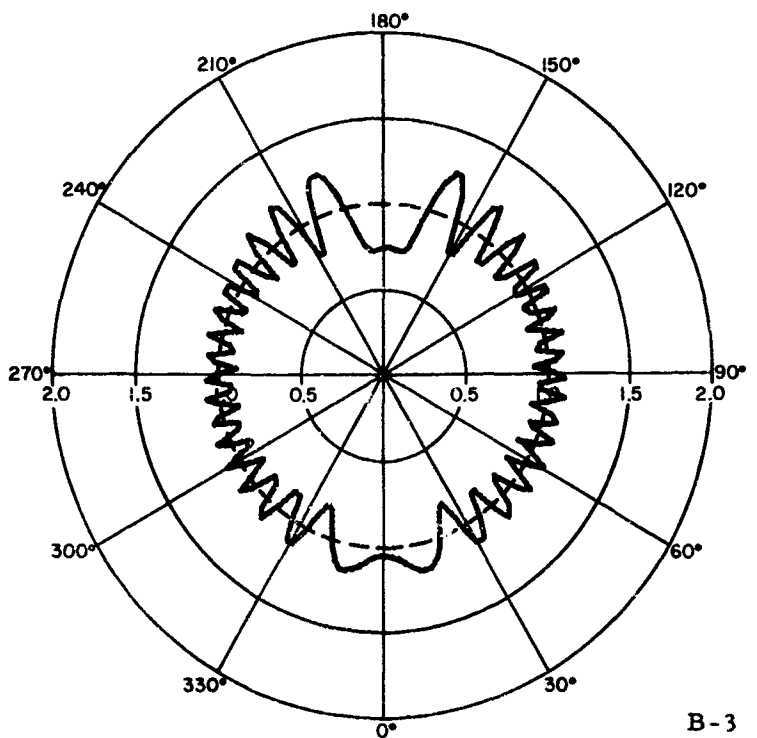
DISTANCE ~ WAVELENGTHS



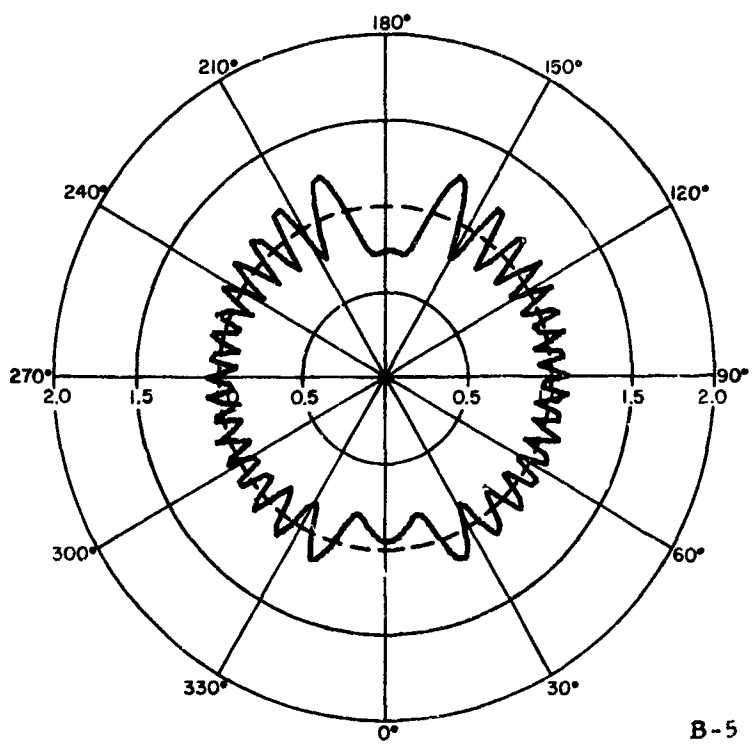
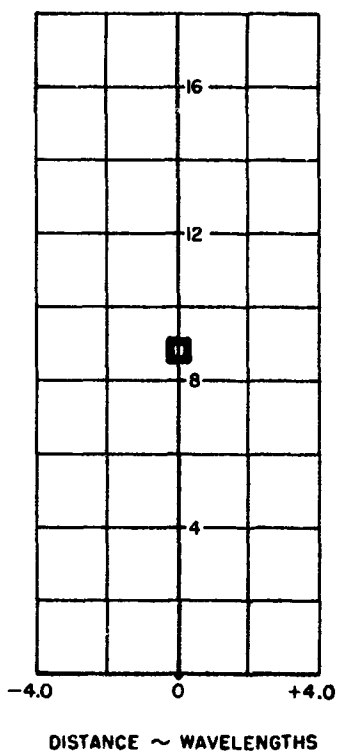
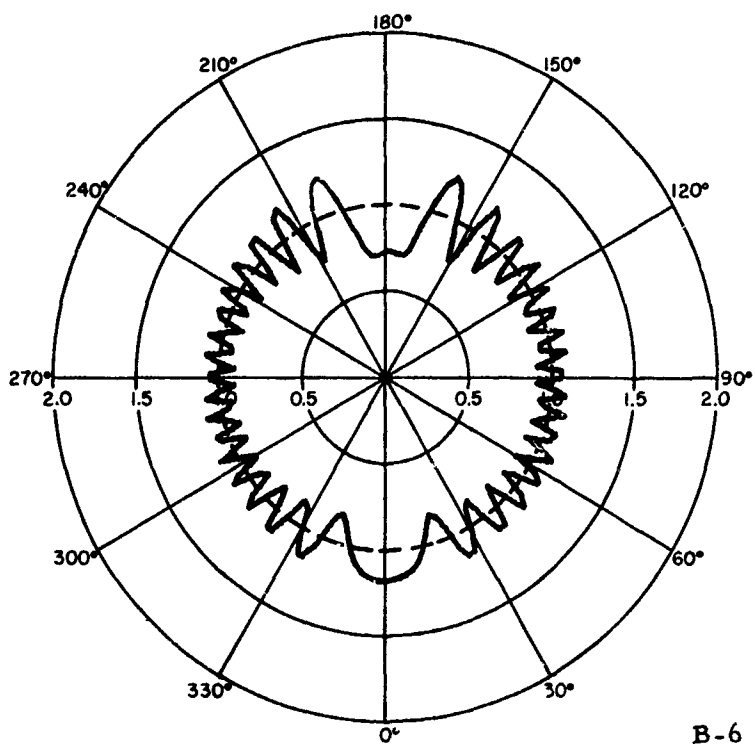
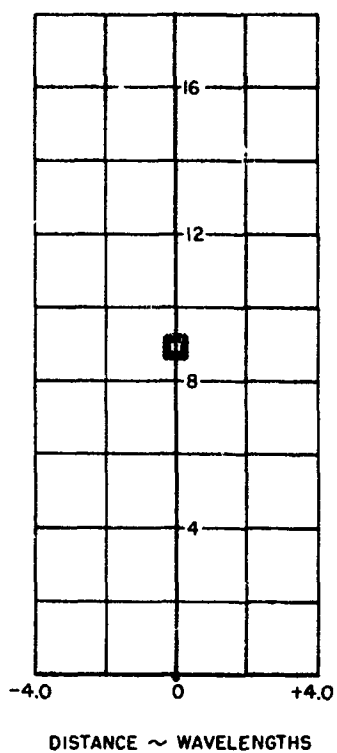
B-4

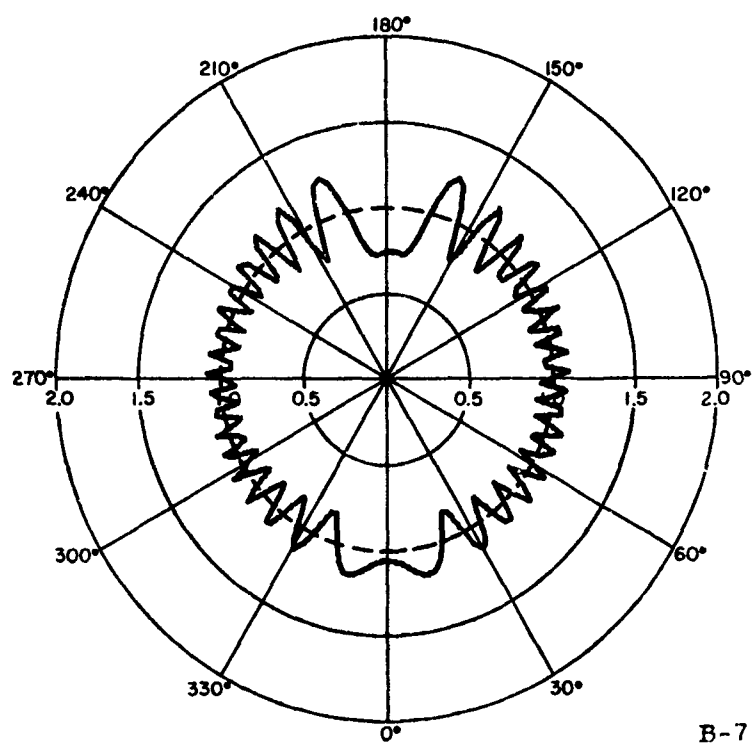
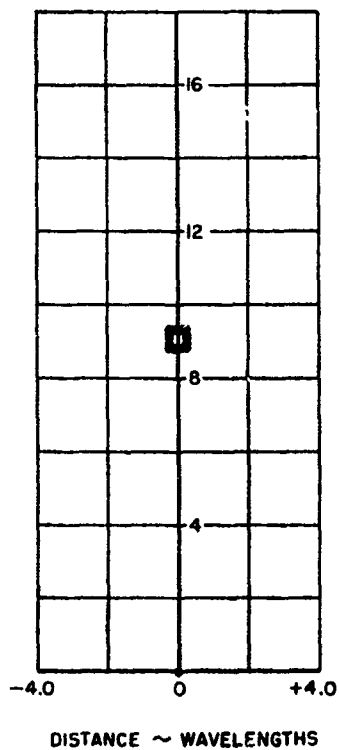
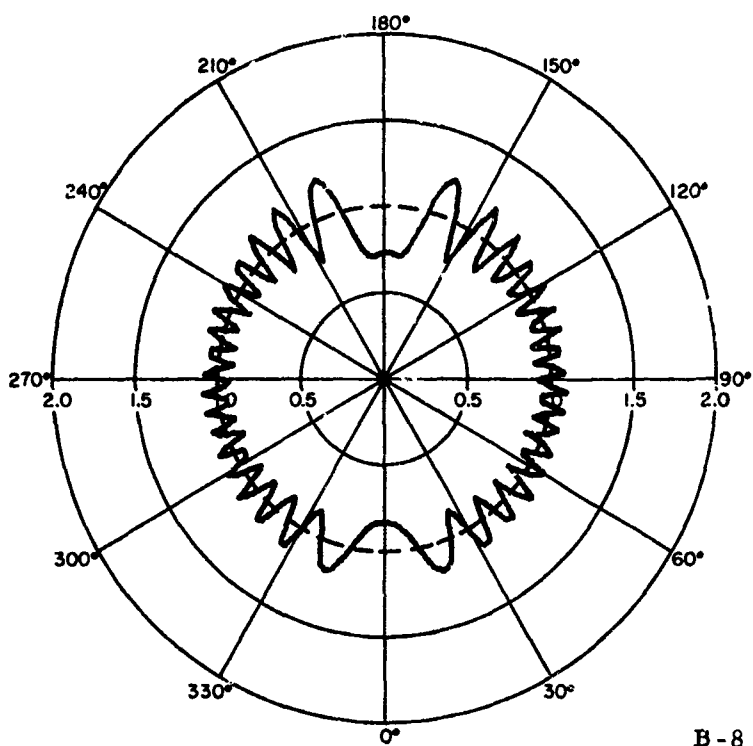
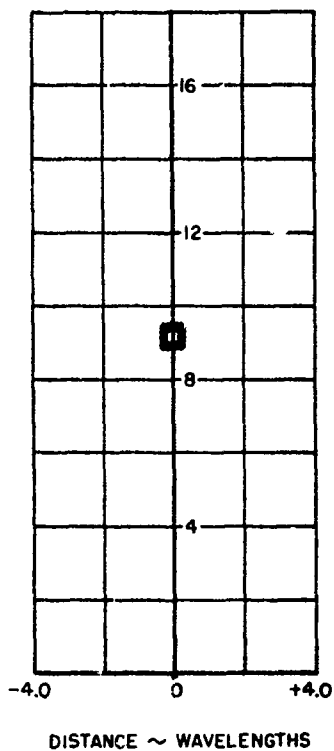


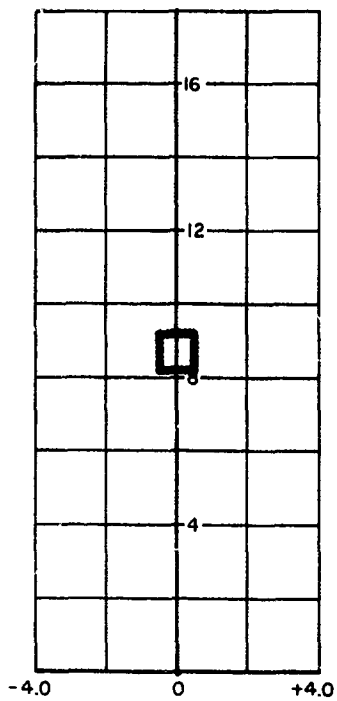
DISTANCE ~ WAVELENGTHS



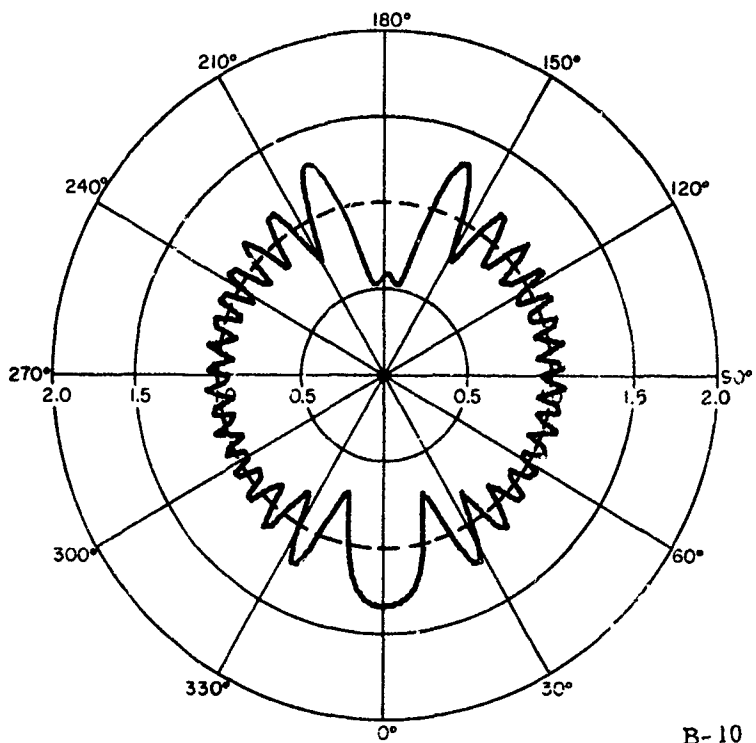
B-3



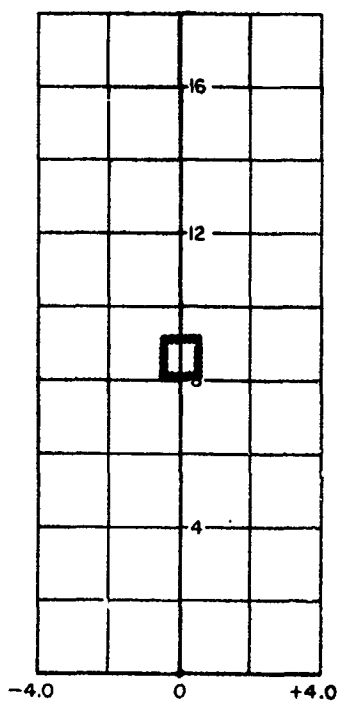




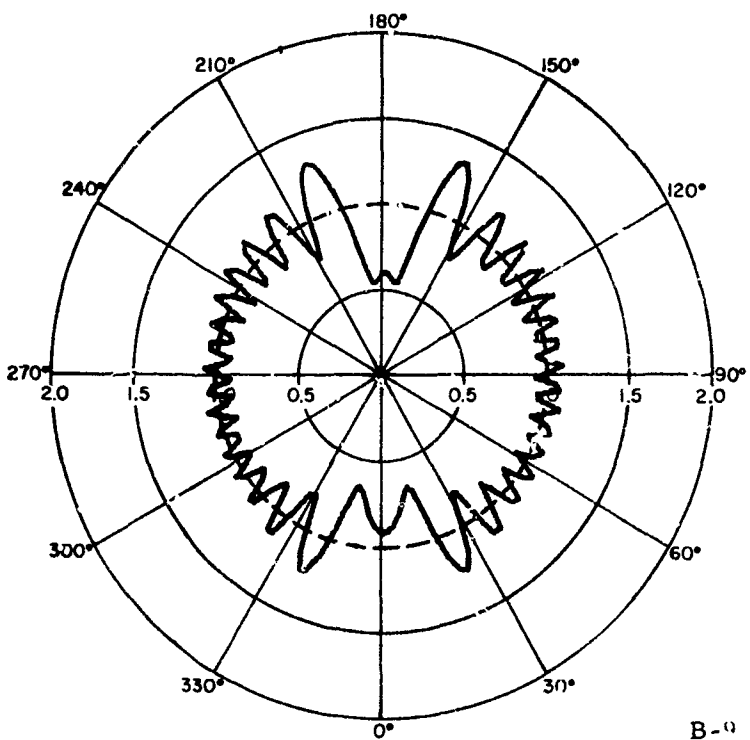
DISTANCE ~ WAVELENGTHS



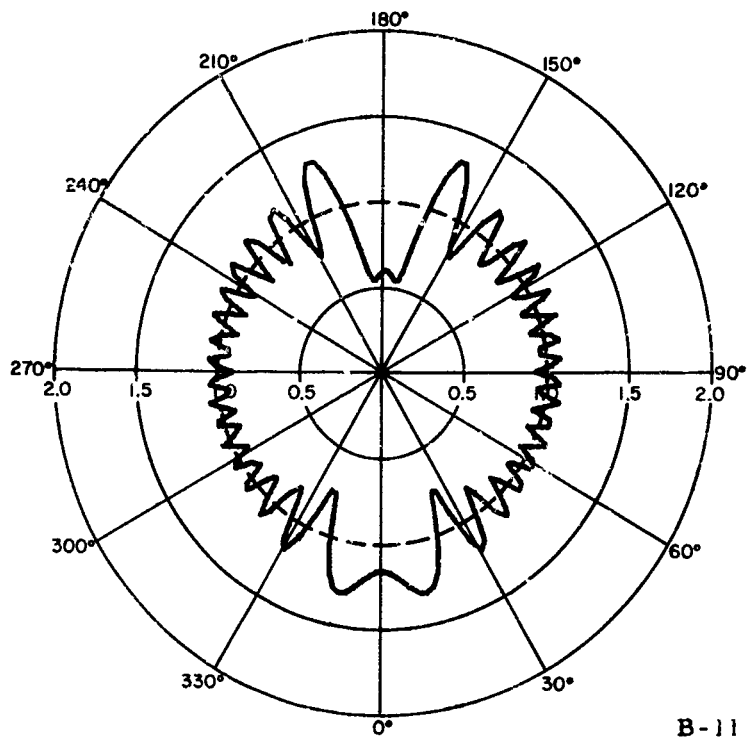
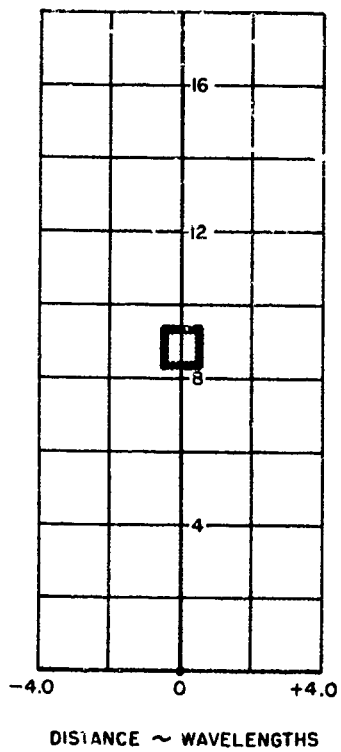
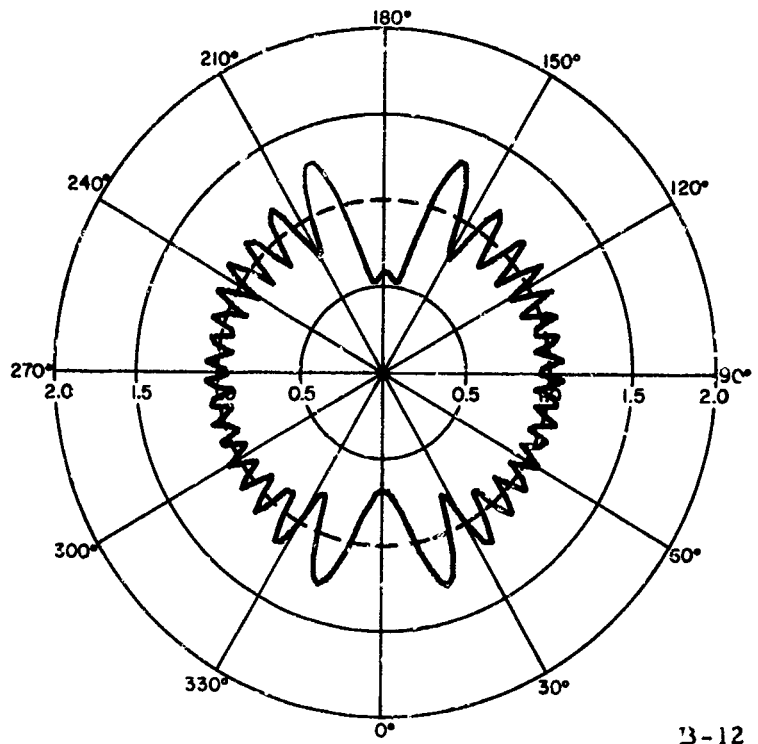
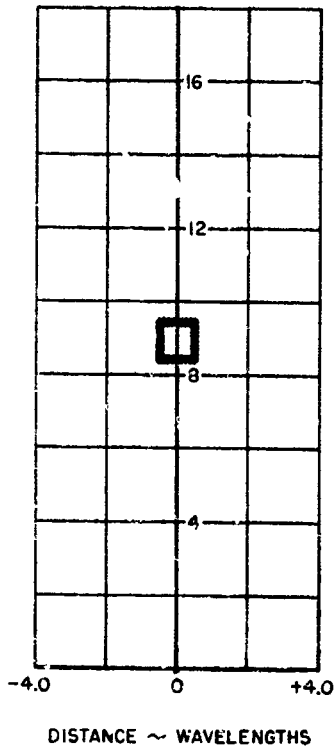
B-10

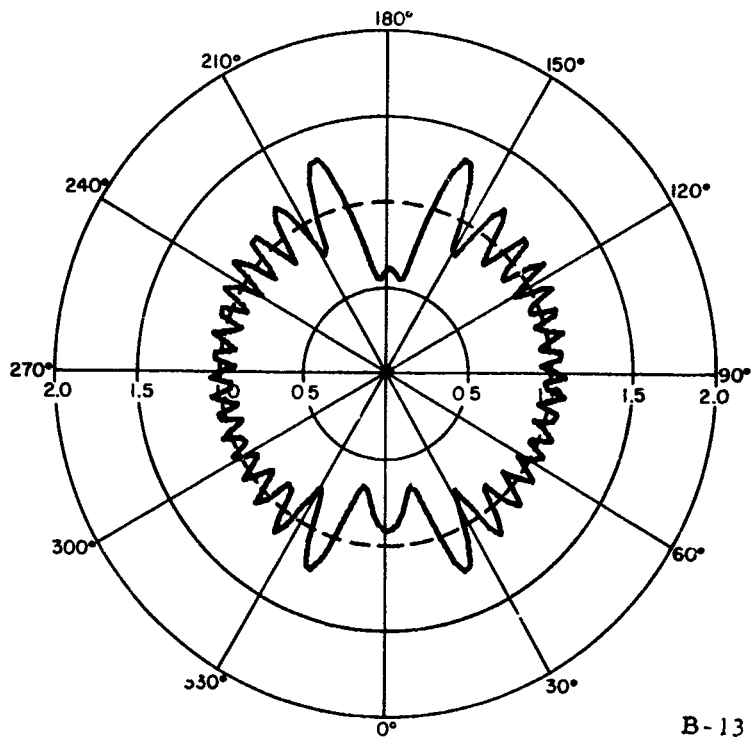
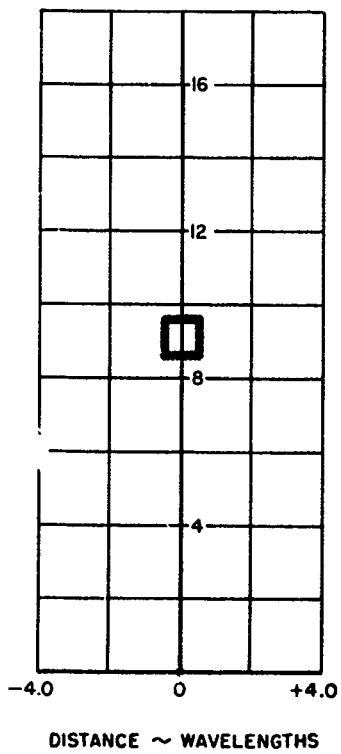
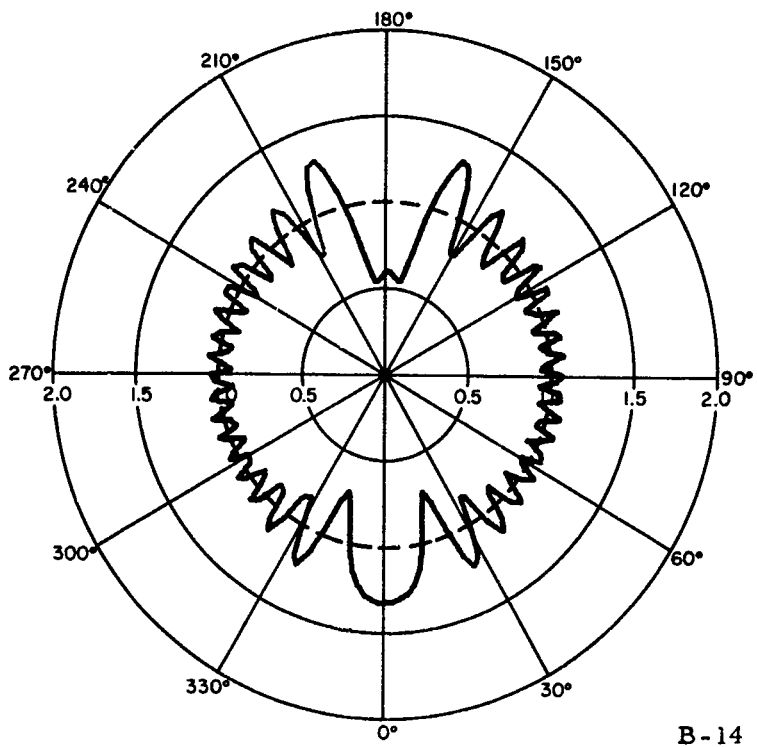
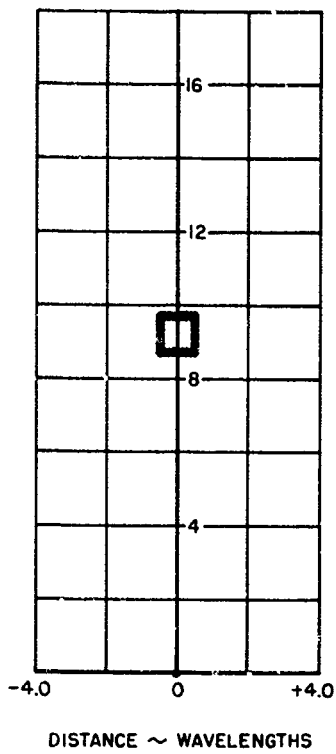


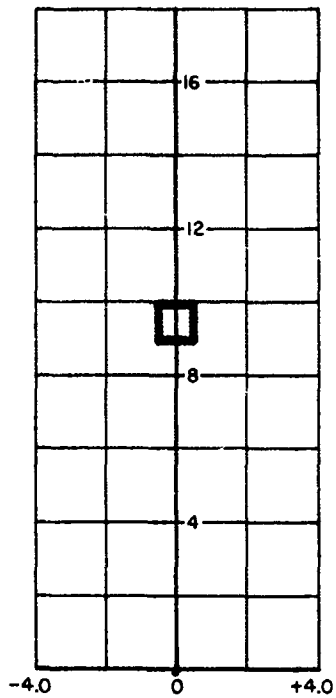
DISTANCE ~ WAVELENGTHS



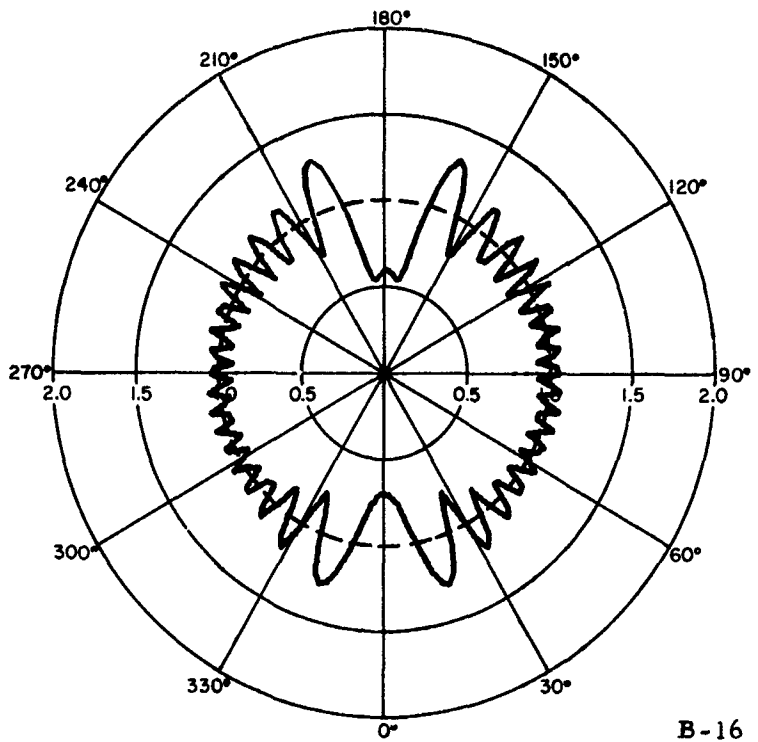
B-11



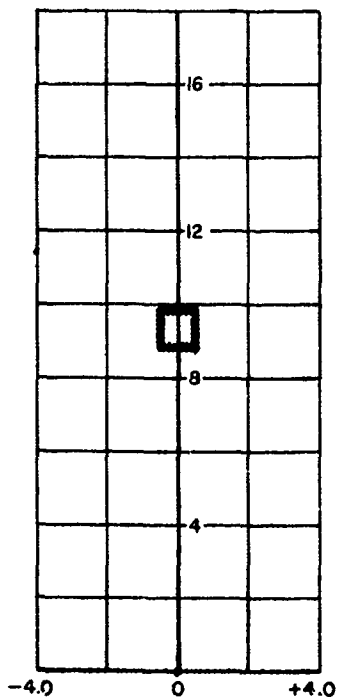




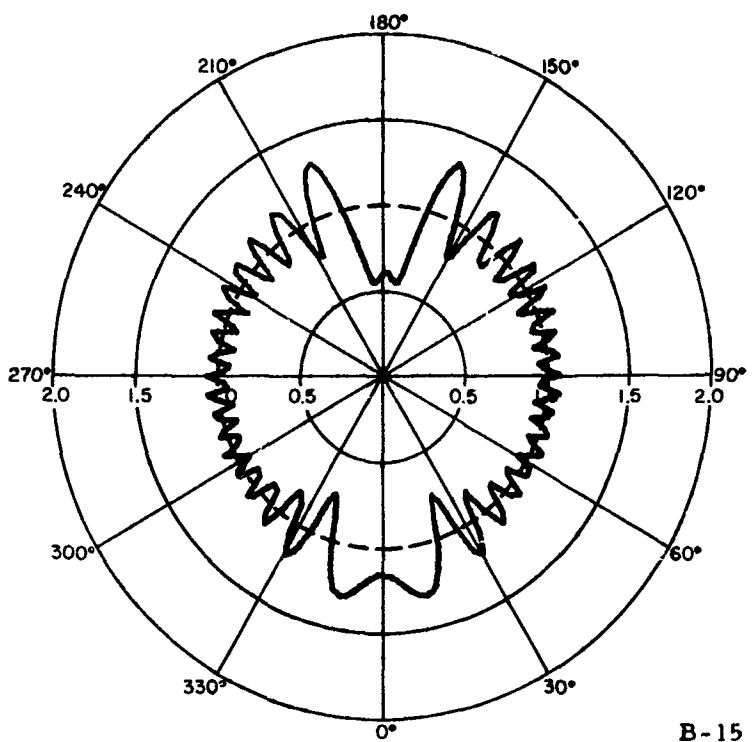
DISTANCE ~ WAVELENGTHS



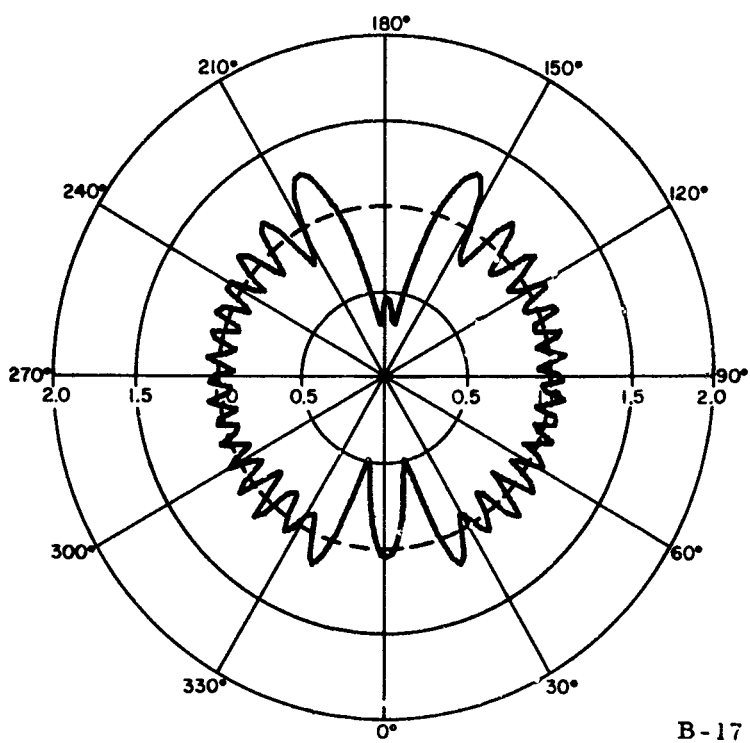
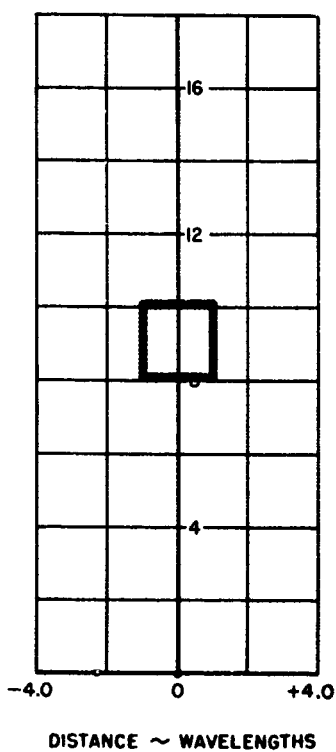
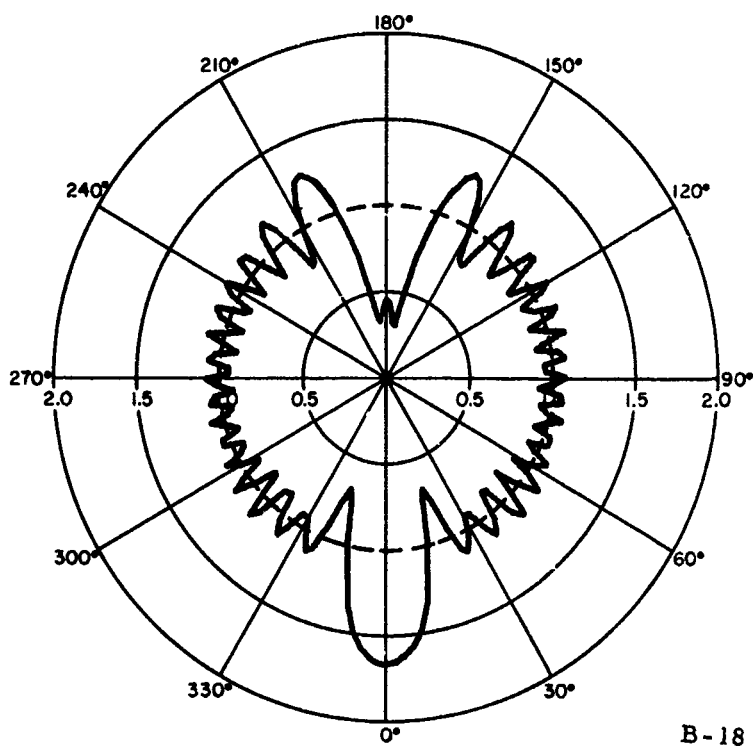
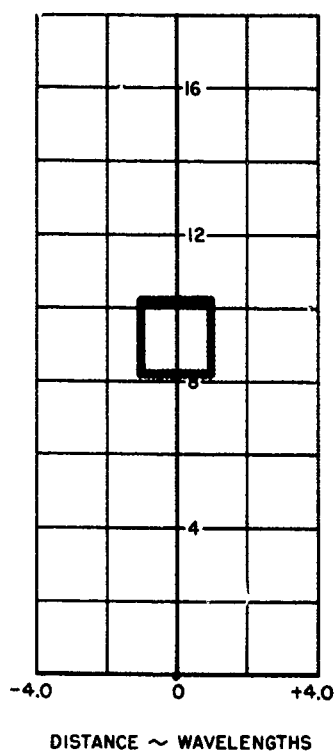
B-16

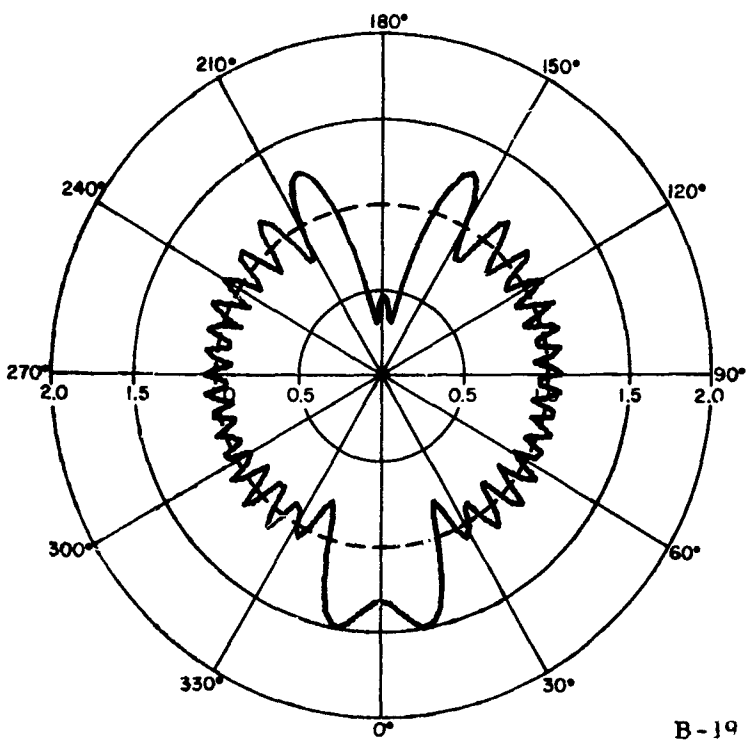
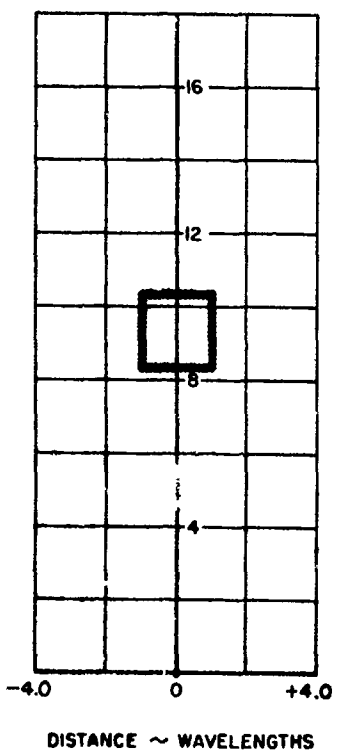
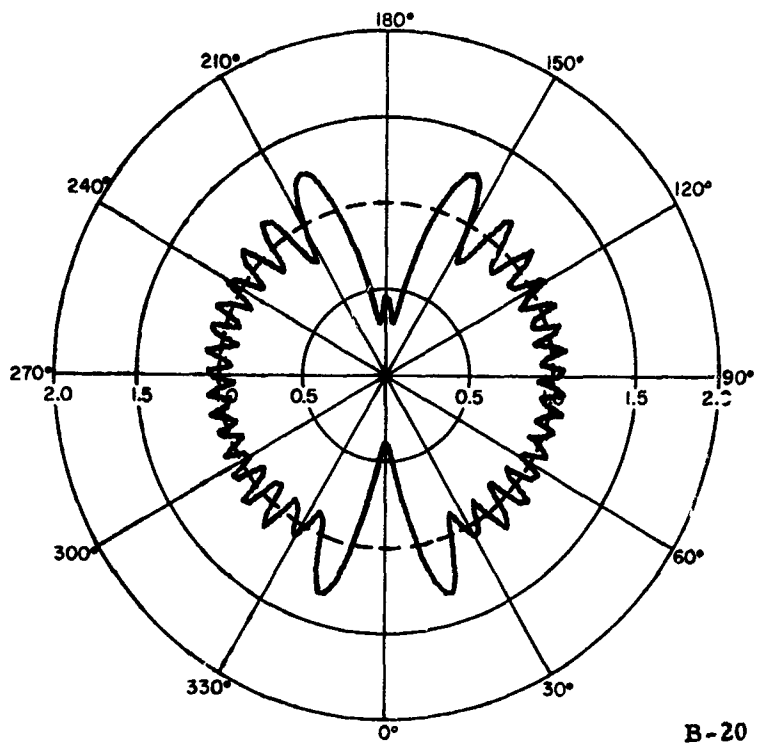
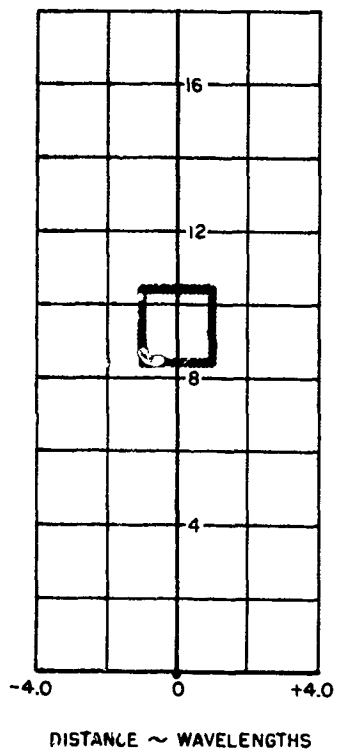


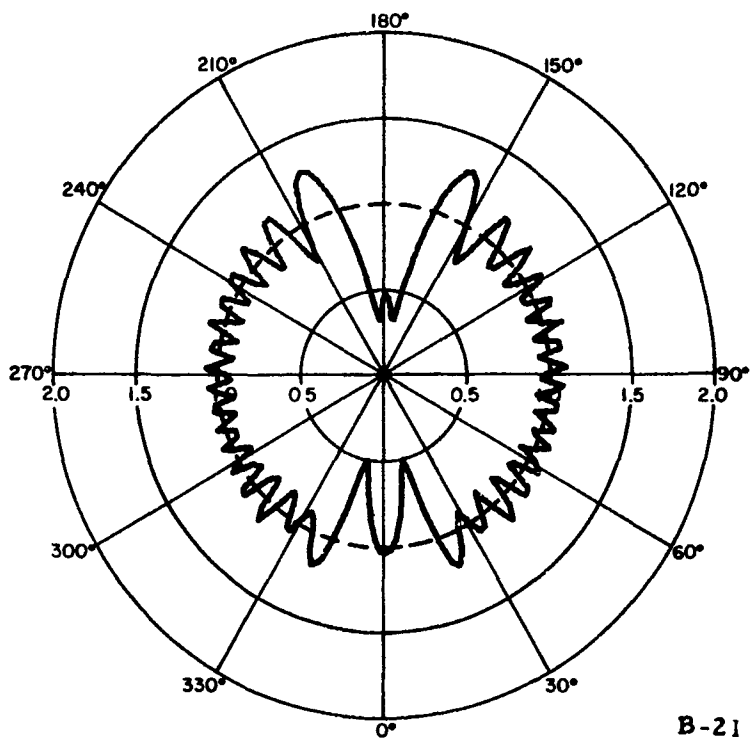
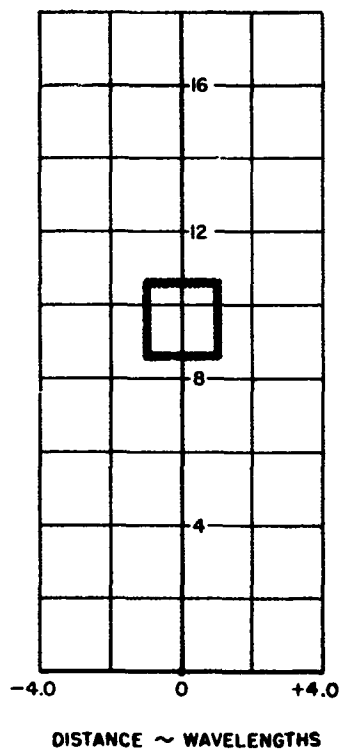
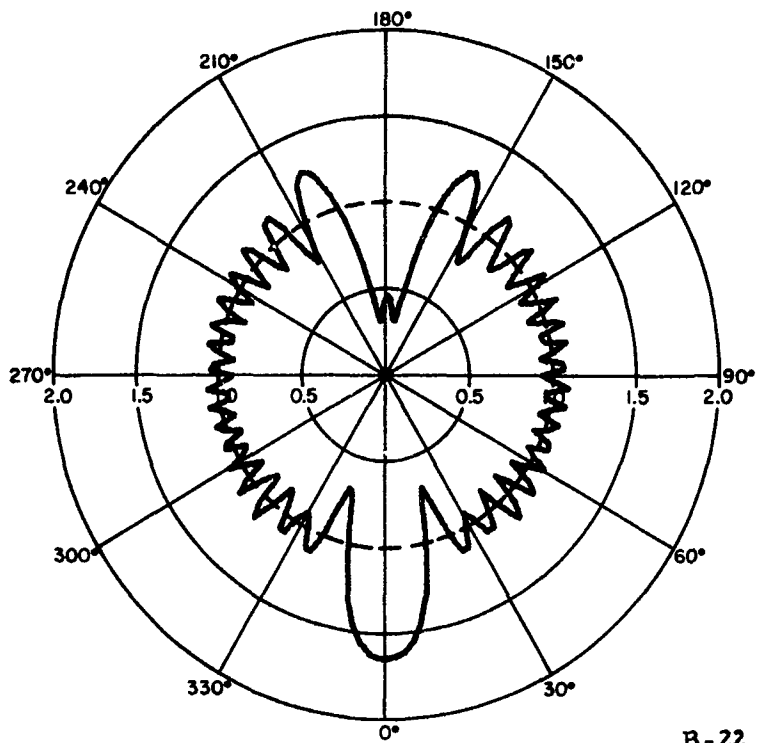
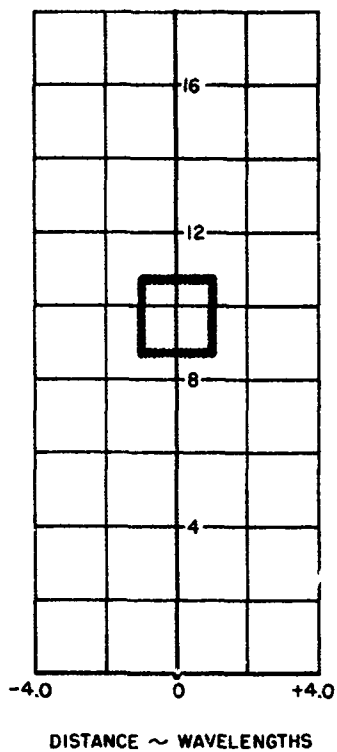
DISTANCE ~ WAVELENGTHS

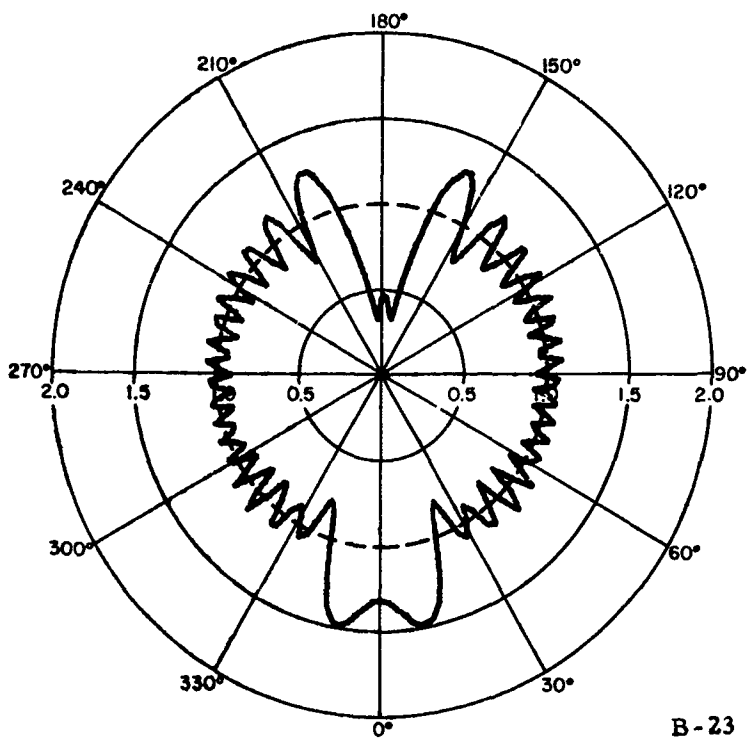
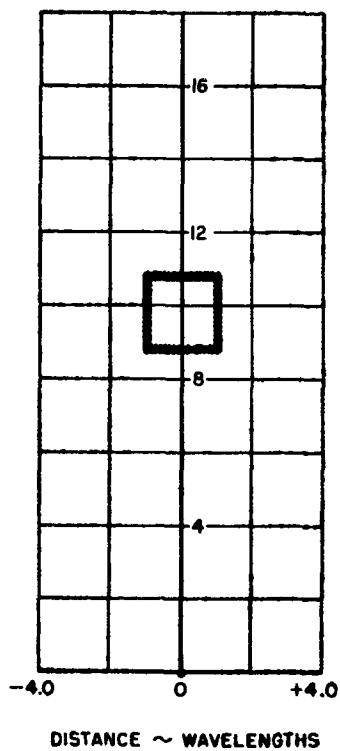
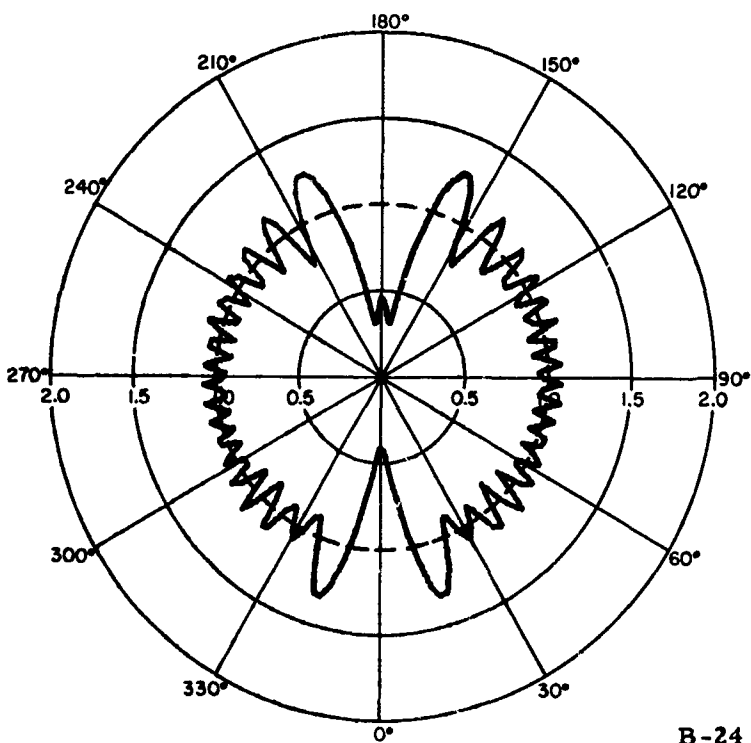
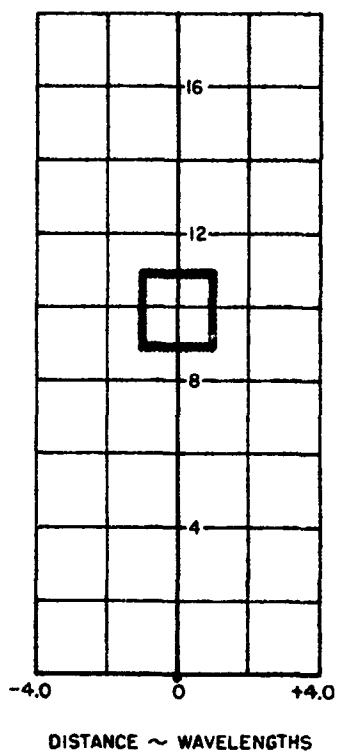


B-15









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).