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

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San Diego, California

Department of ELECTRICAL ENGINEERING



THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION
Columbus, Ohio

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REPORT
by
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COLUMBUS, OHIO 43212

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San Diego, California

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Investigation of Study Program Related to Shipboard
Antenna System Environment

Subject of Report Pattern Handbook
Volume IV: Far-Field Patterns of a Linear
Antenna Radiating in the Presence of Rectangular
Cylinders

Submitted by C.H. Brenner
Antenna Laboratory
Department of Electrical Engineering

Date 1 August 1965

PREFACE

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

Because long distance communication systems aboard ship usually operate at 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

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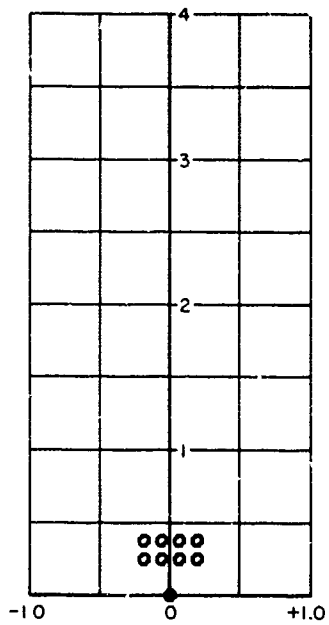
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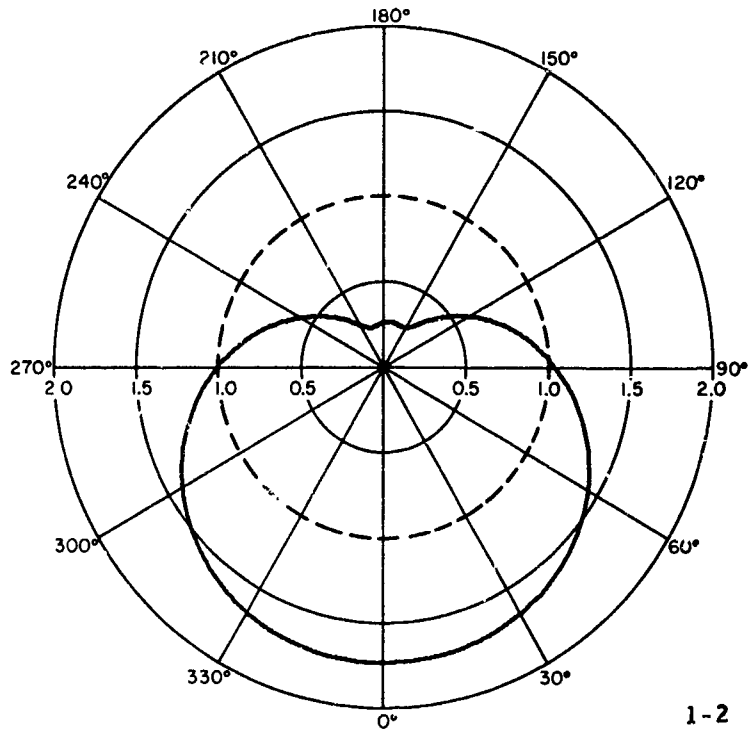
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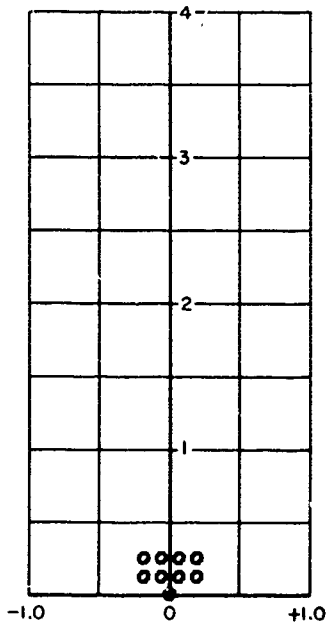
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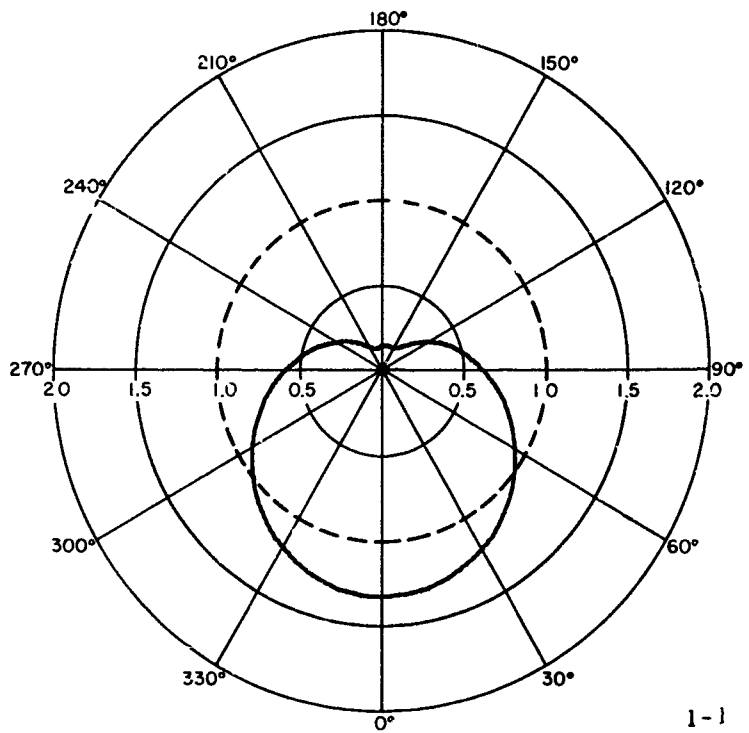
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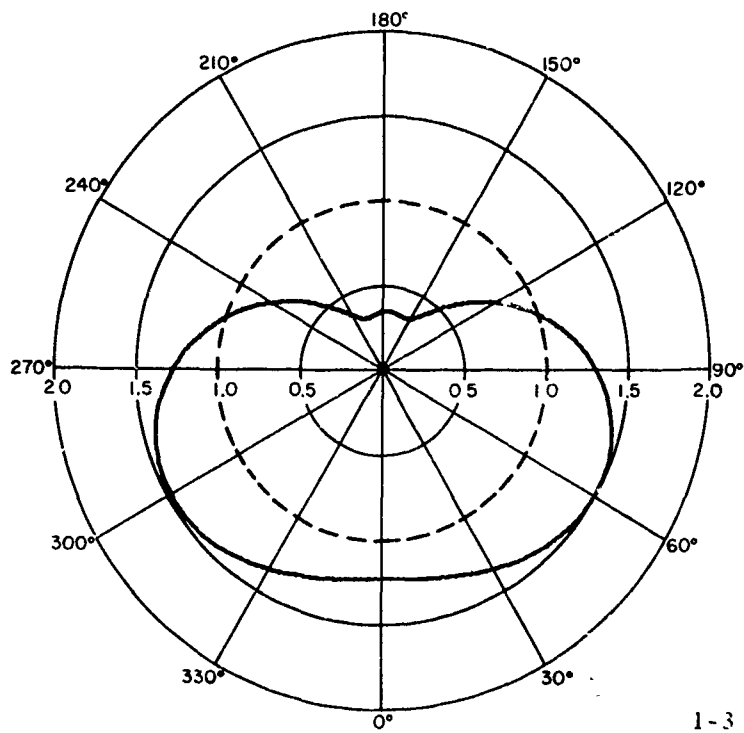
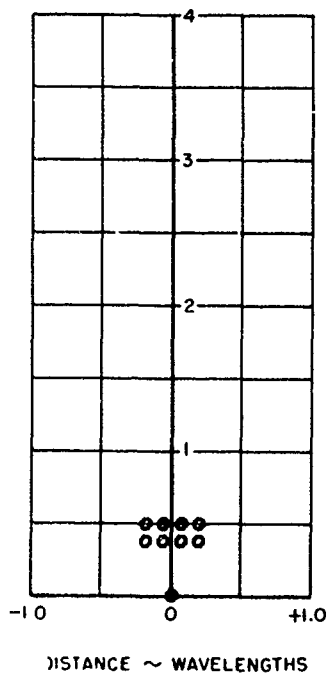
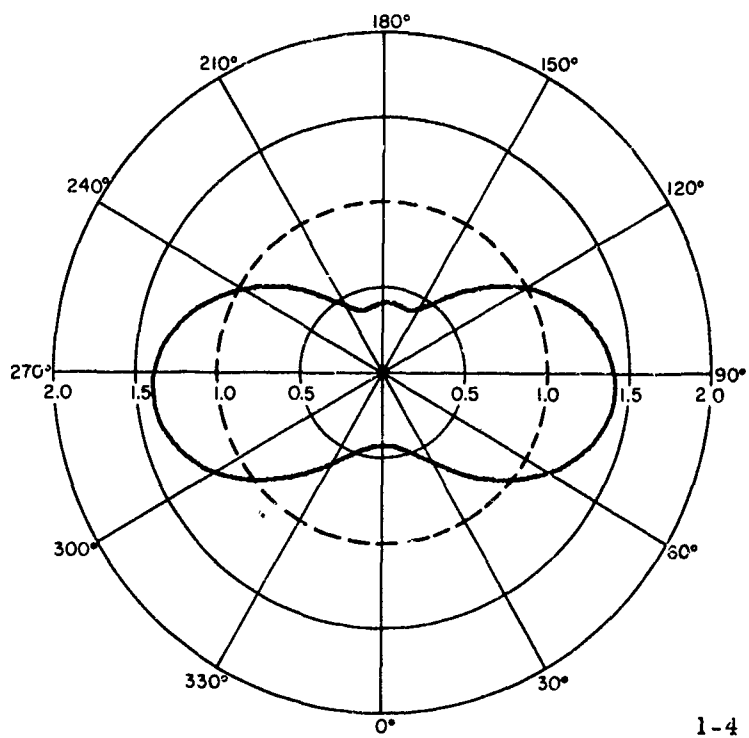
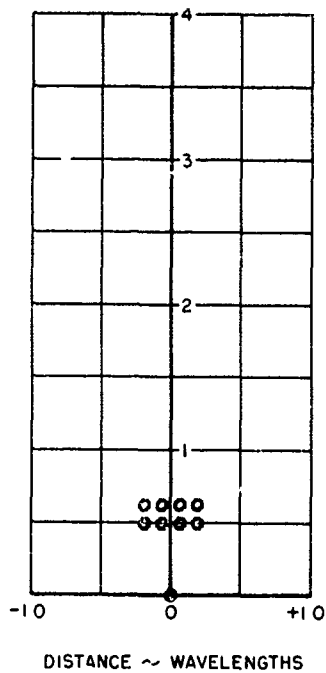
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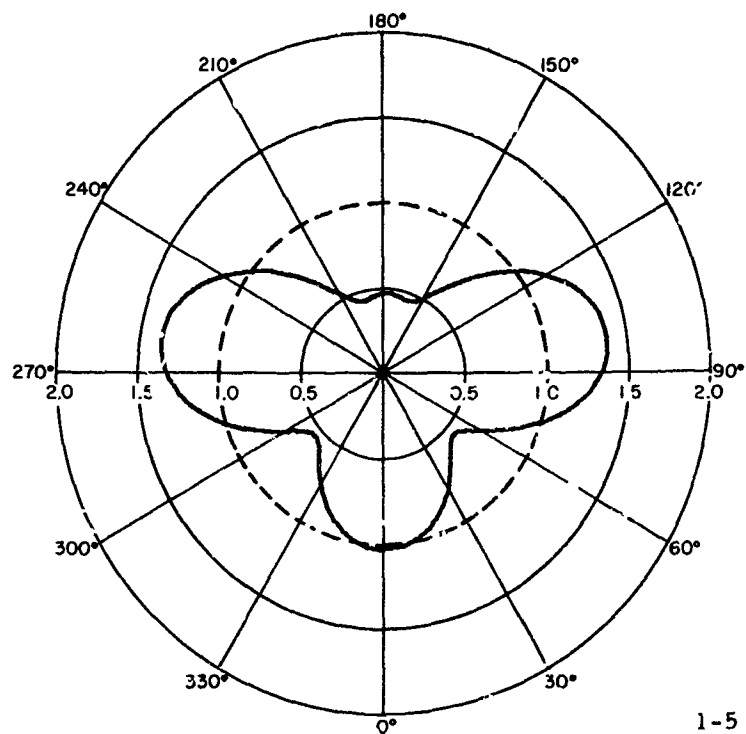
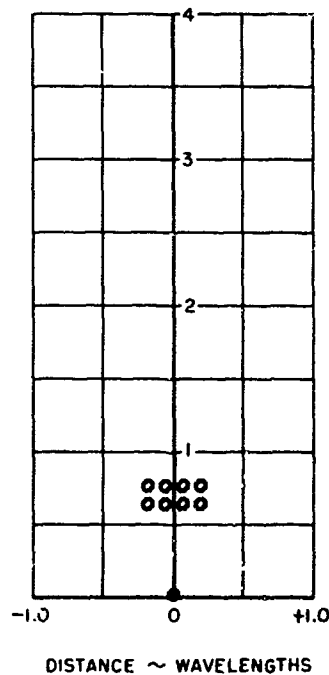
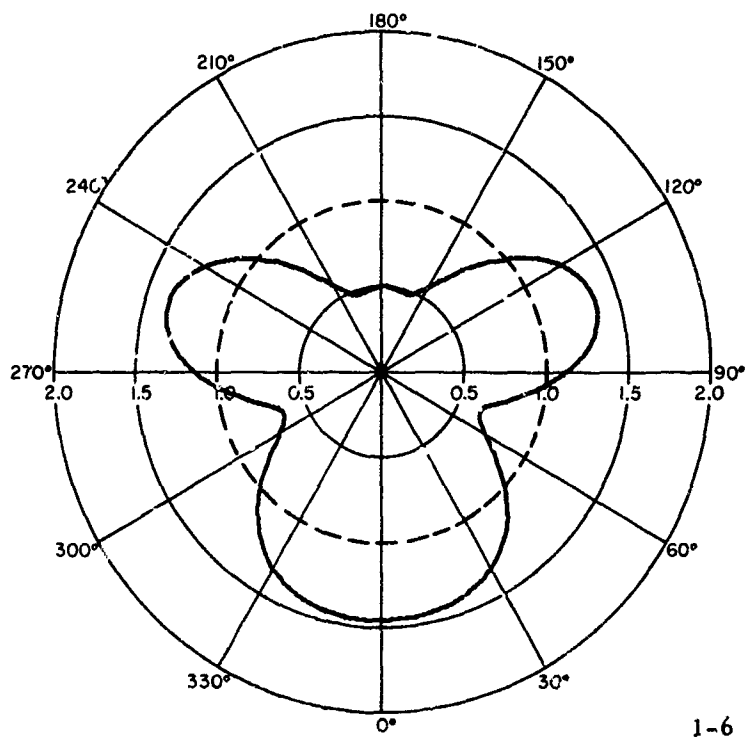
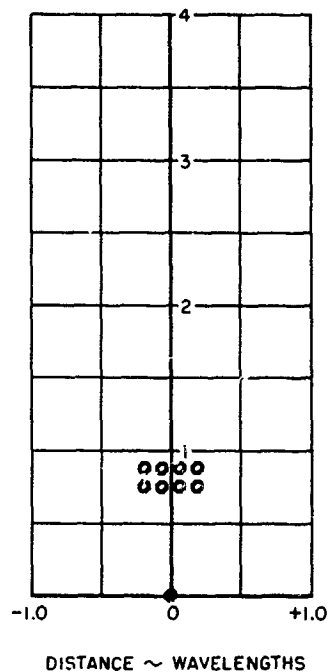


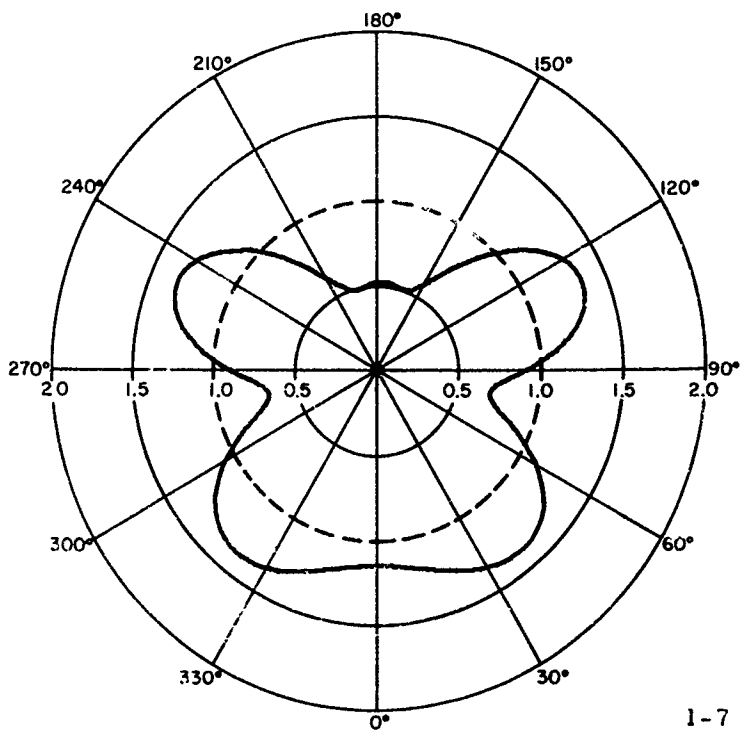
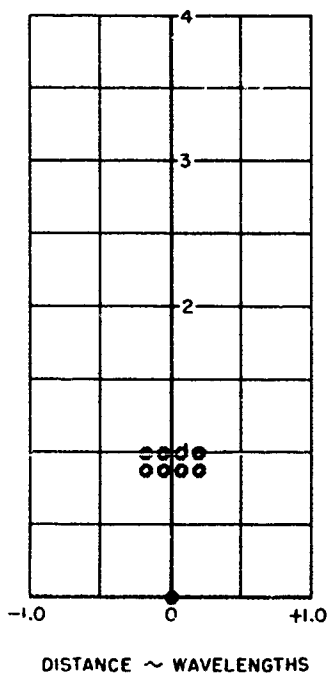
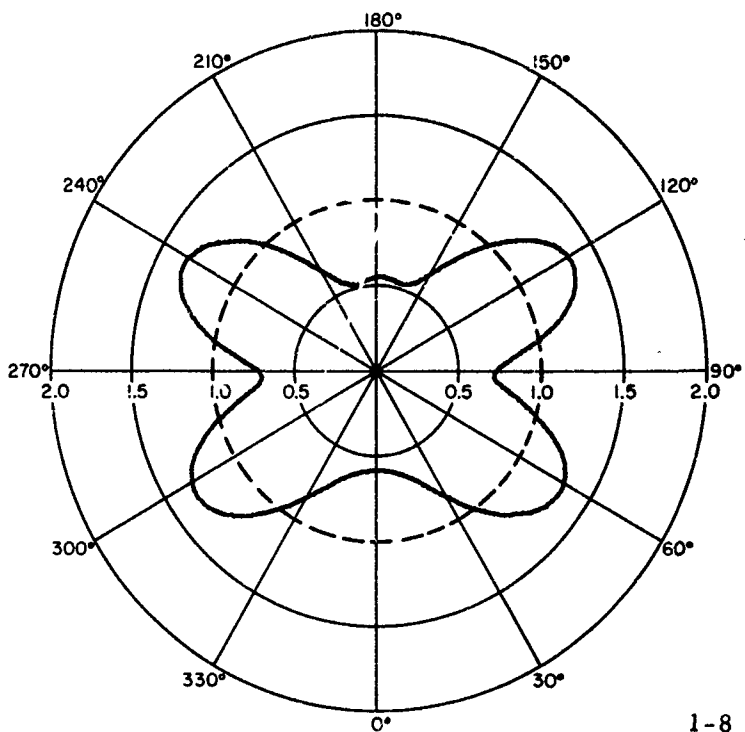
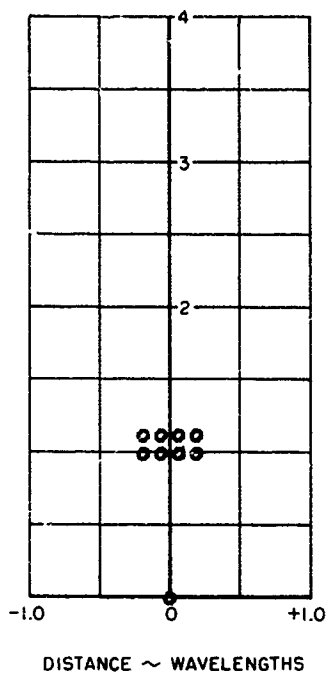
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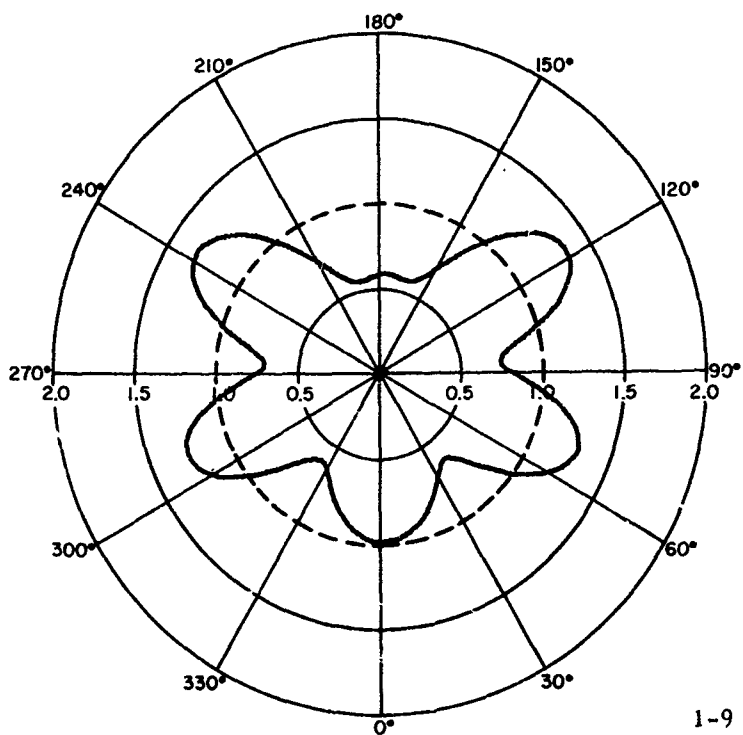
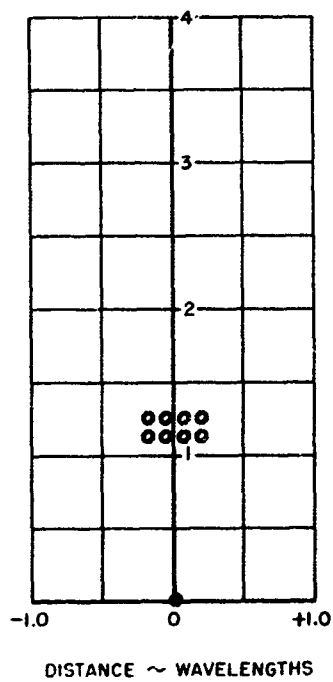
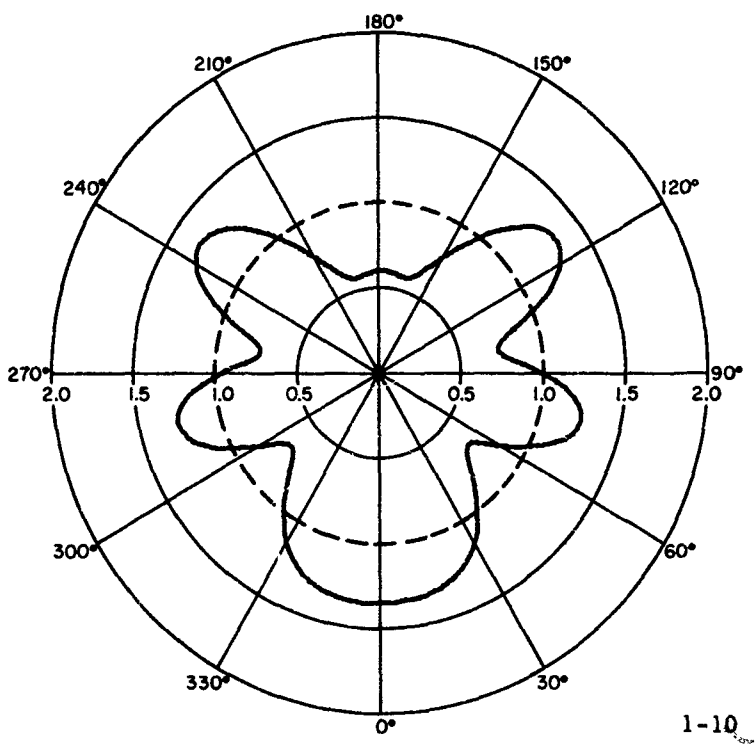
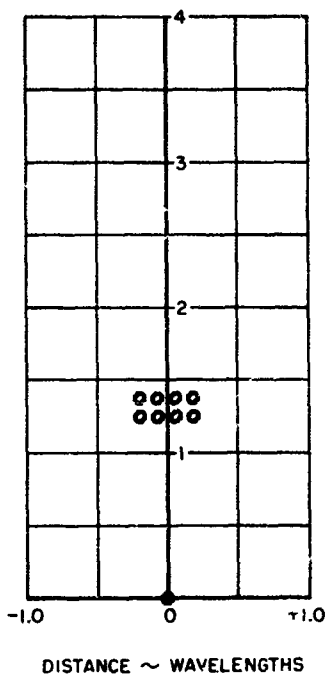


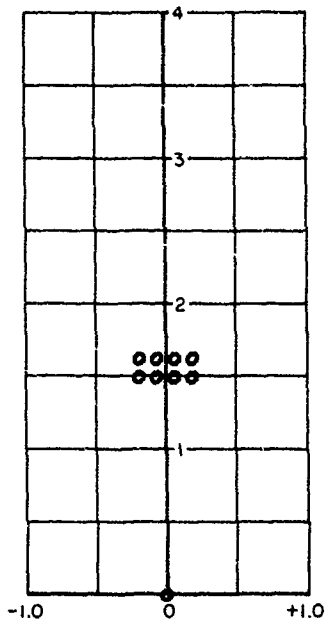
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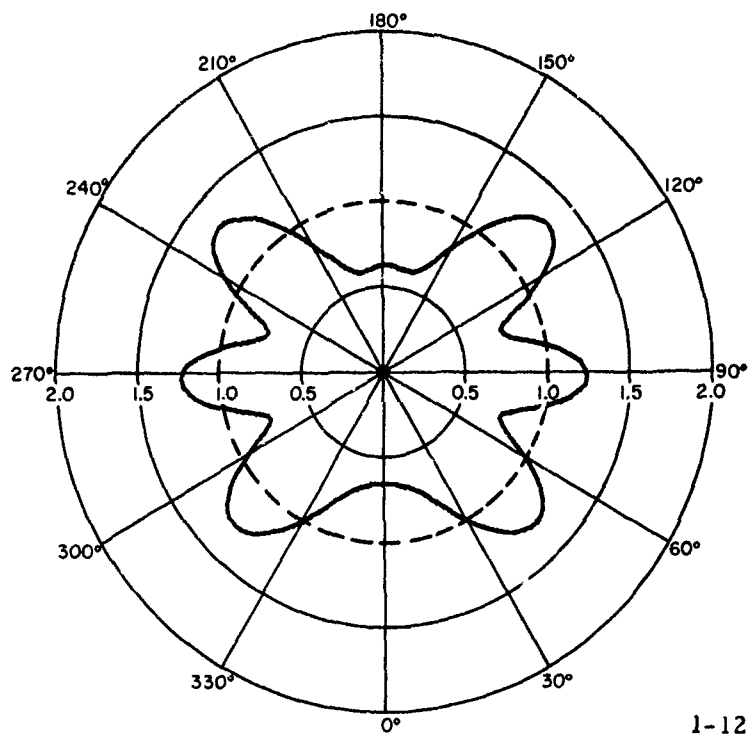




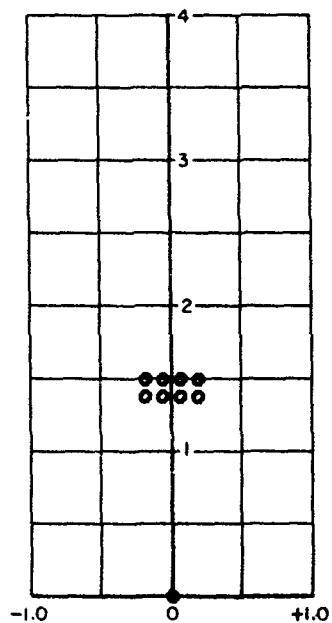




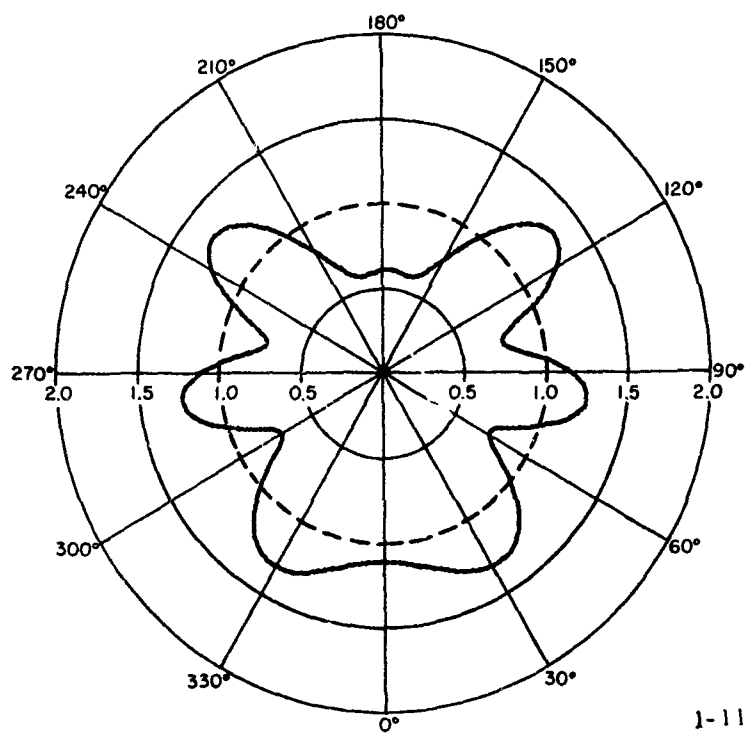
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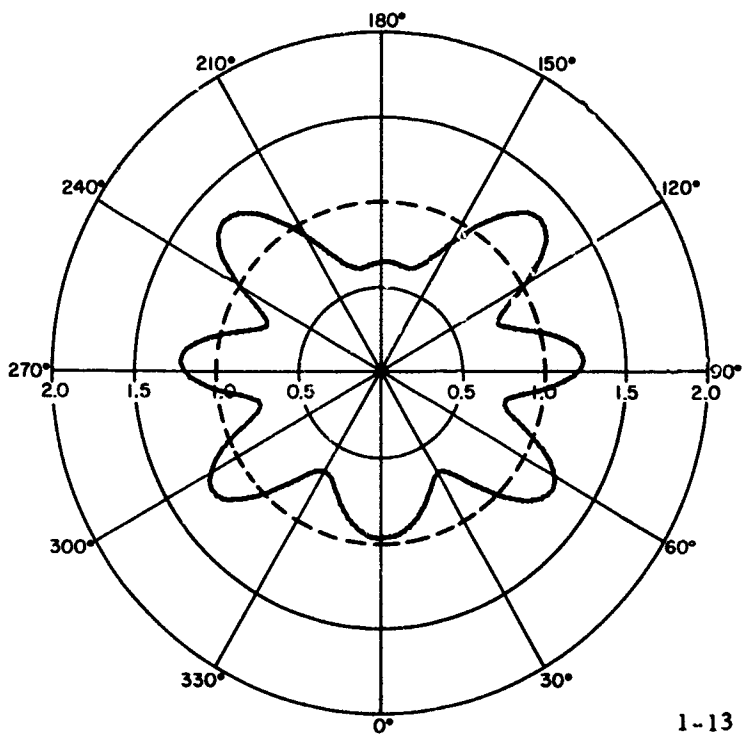
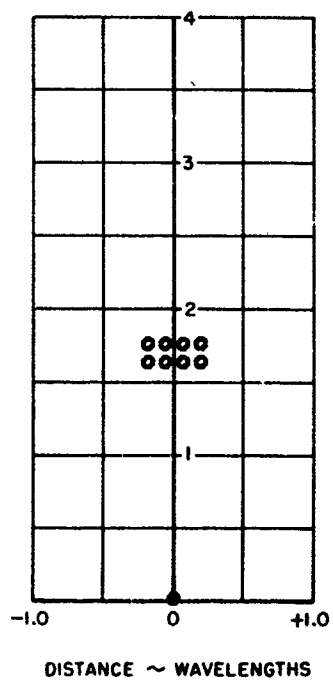
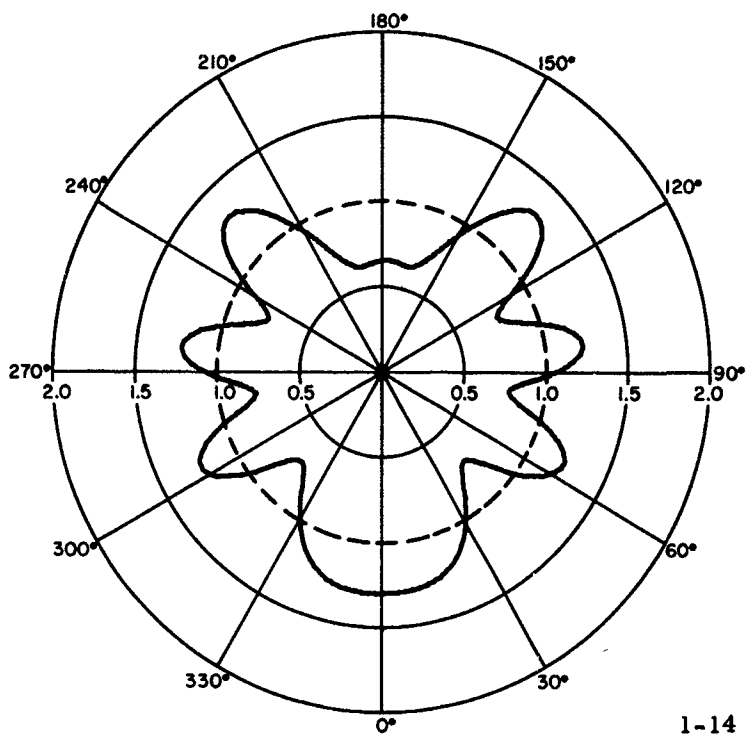
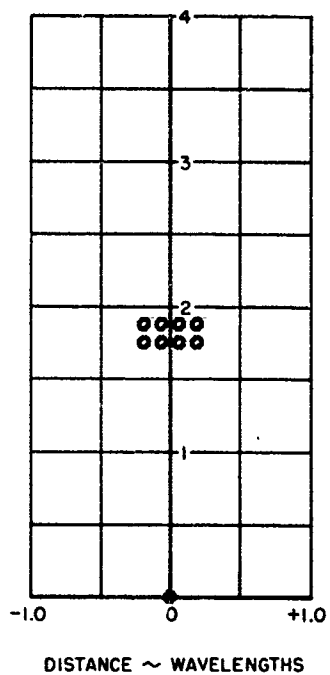
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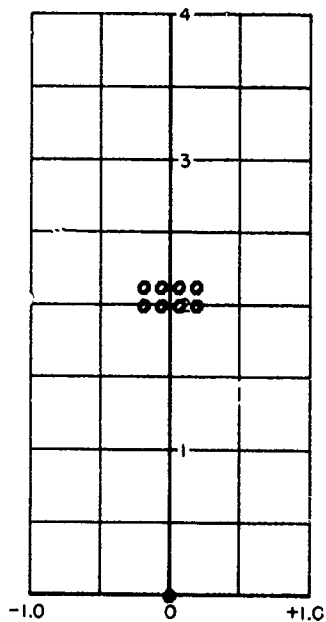


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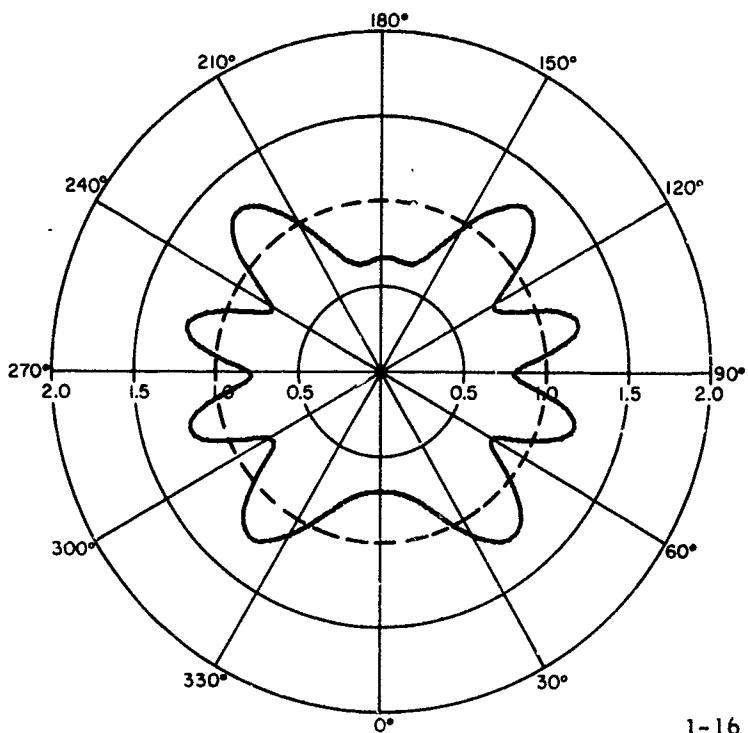


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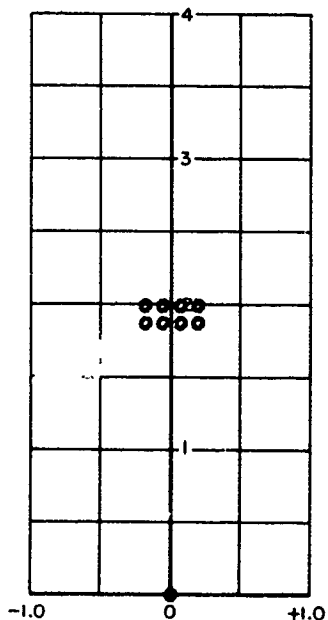




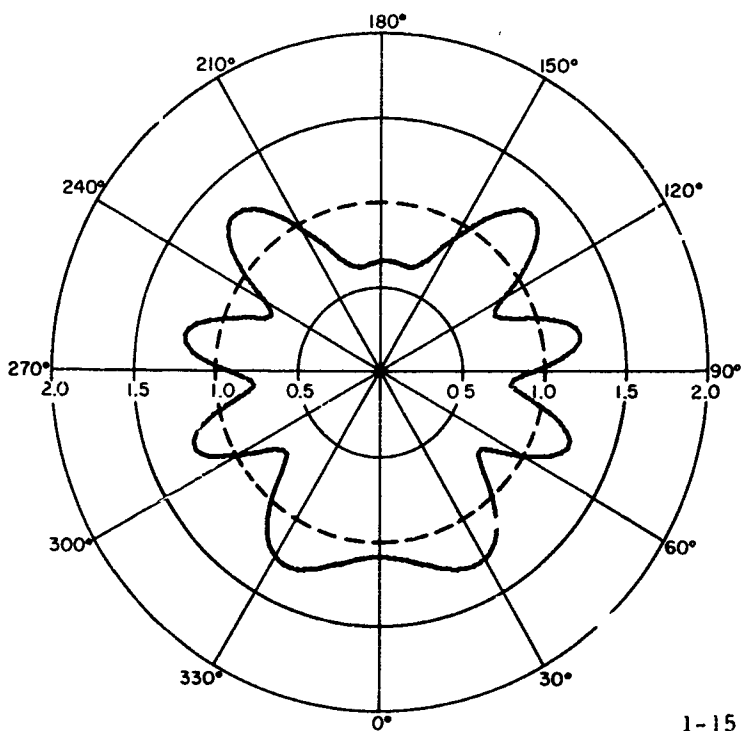
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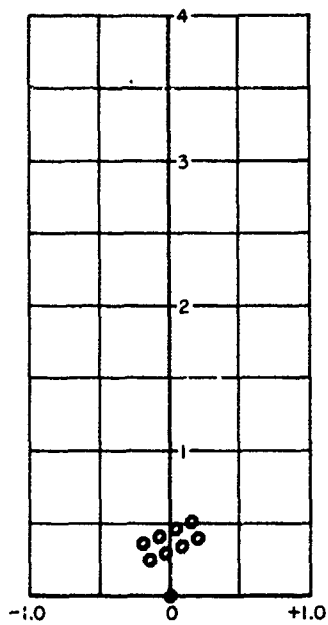
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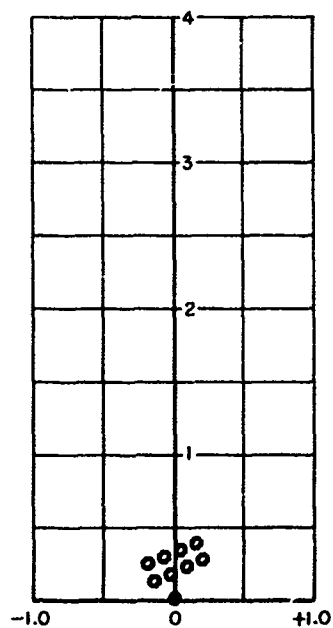
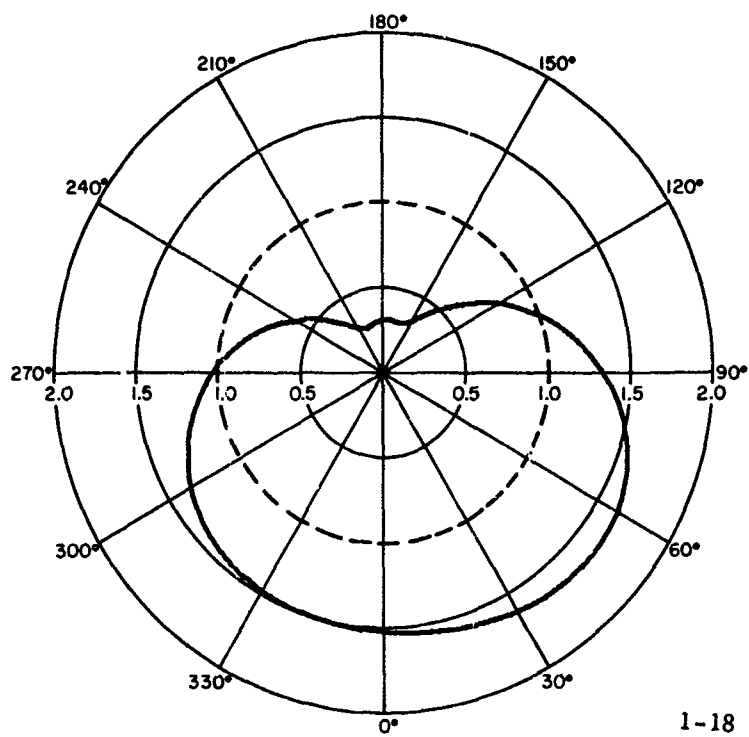
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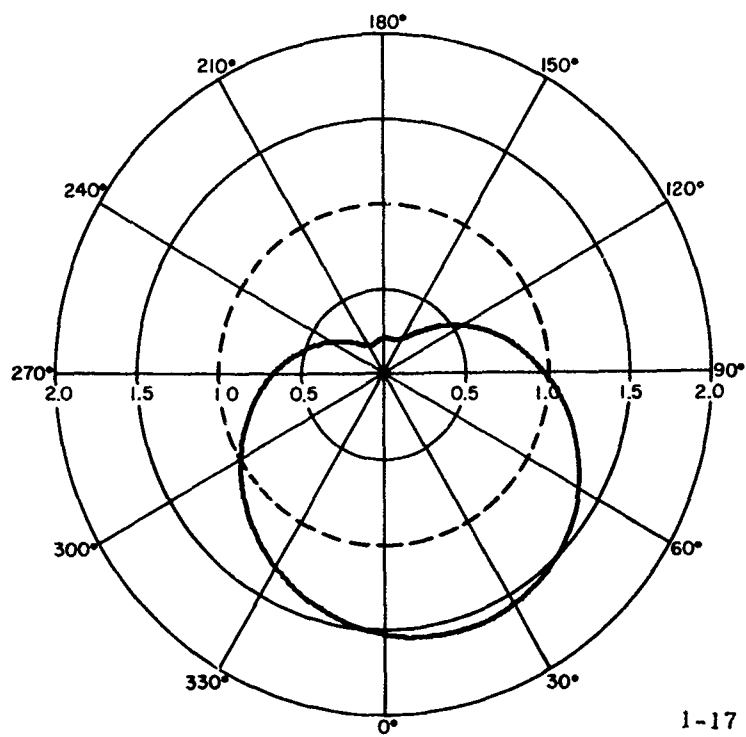
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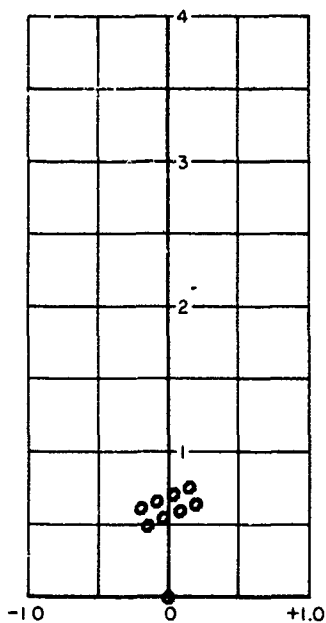


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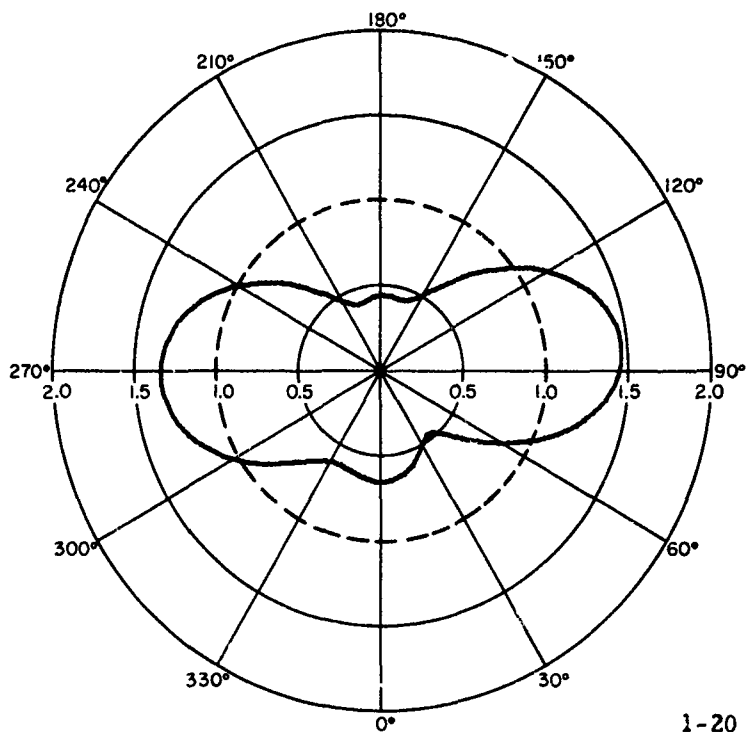


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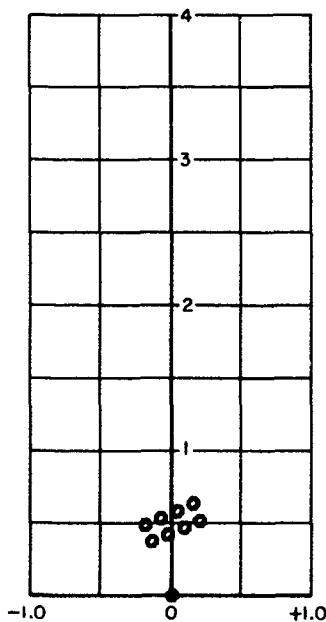




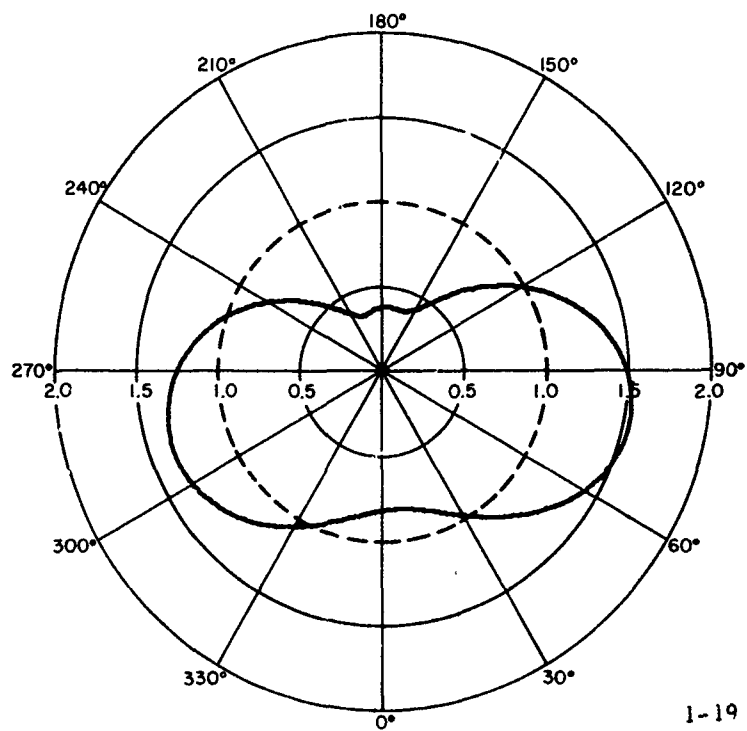
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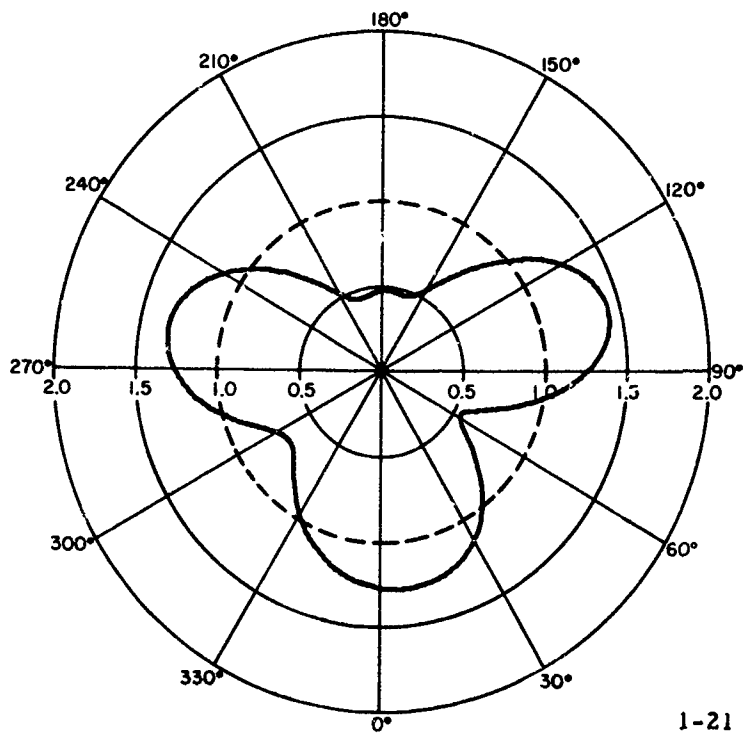
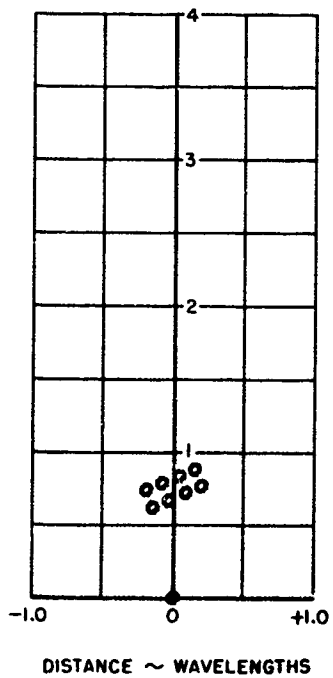
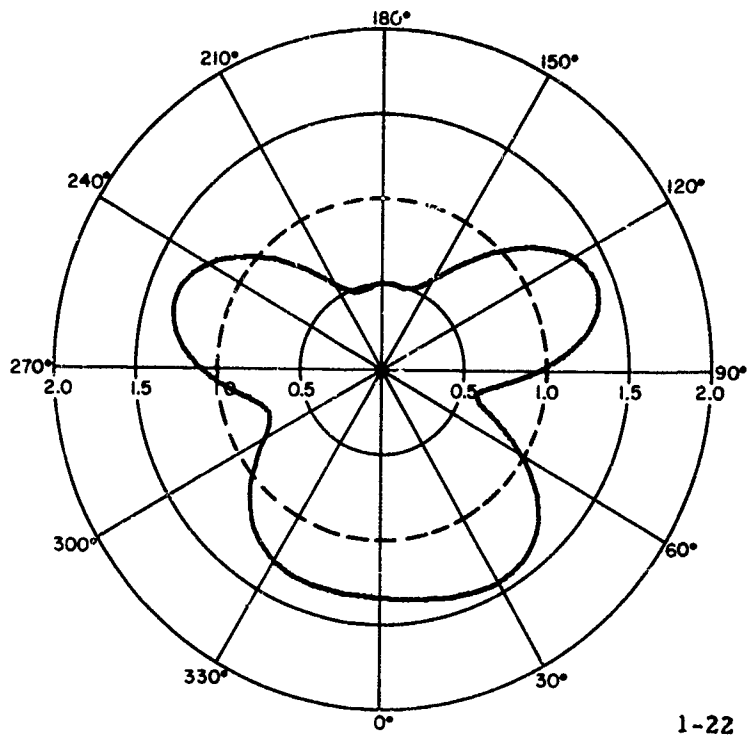
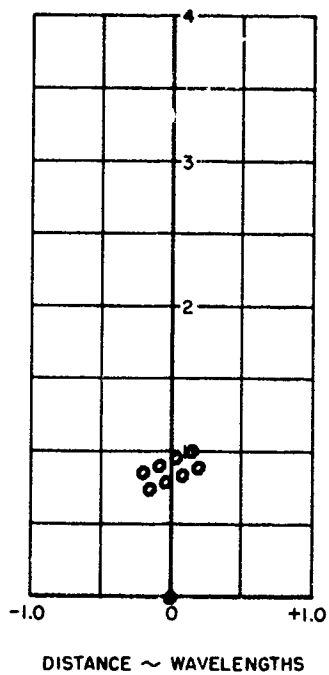
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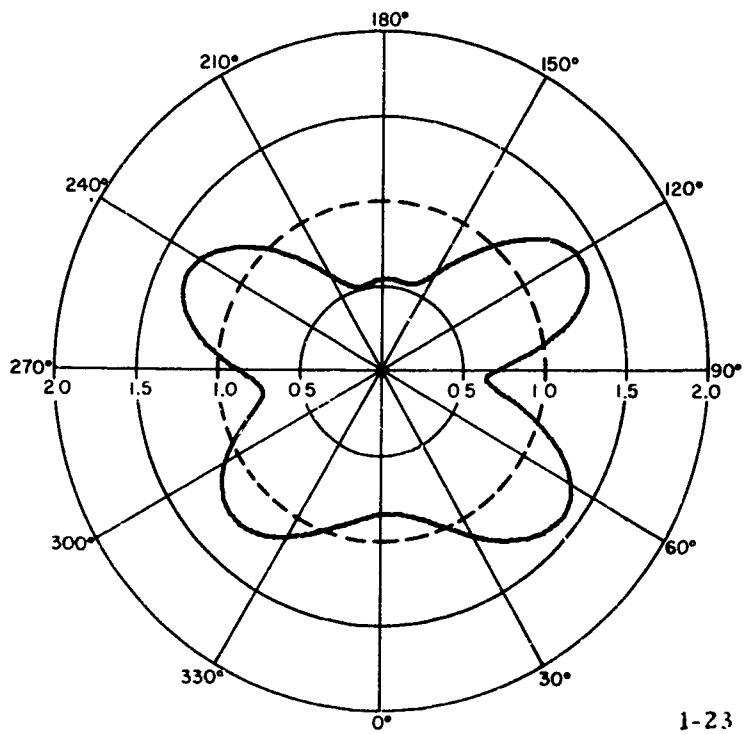
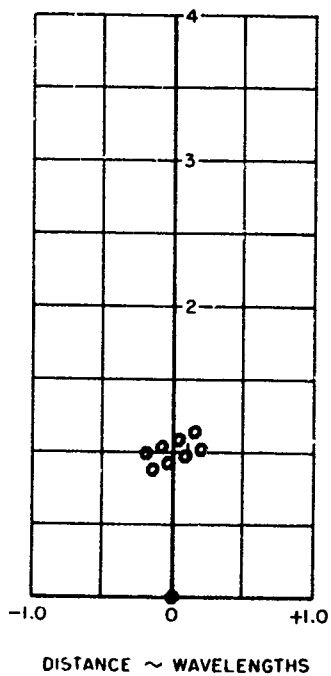
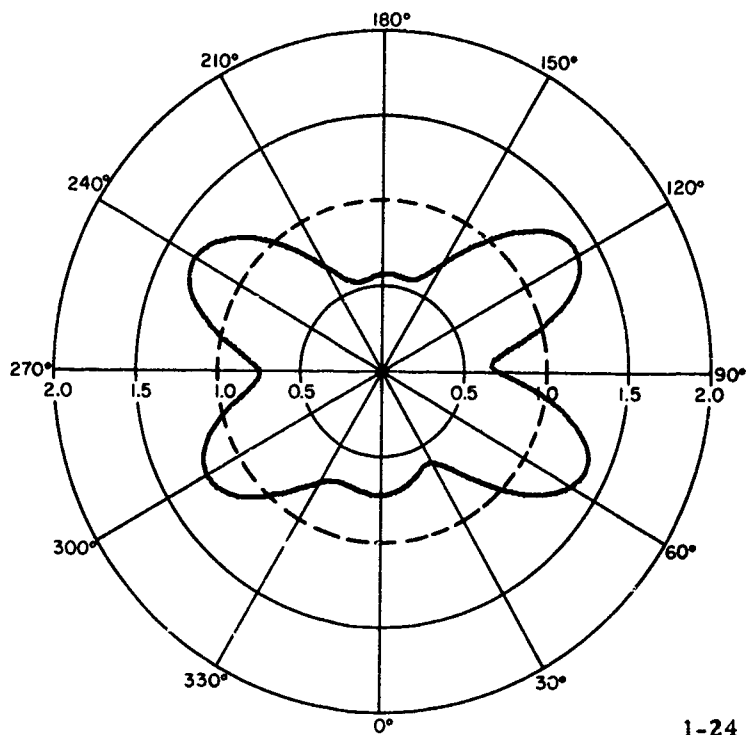
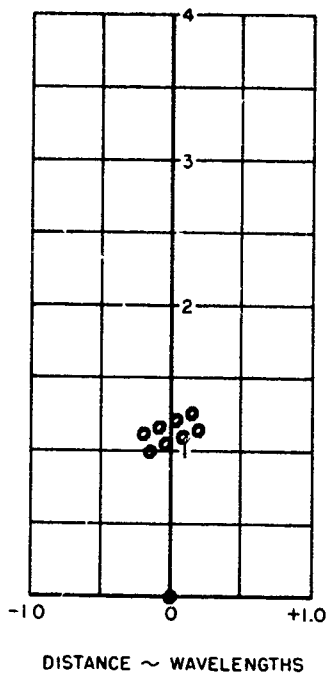


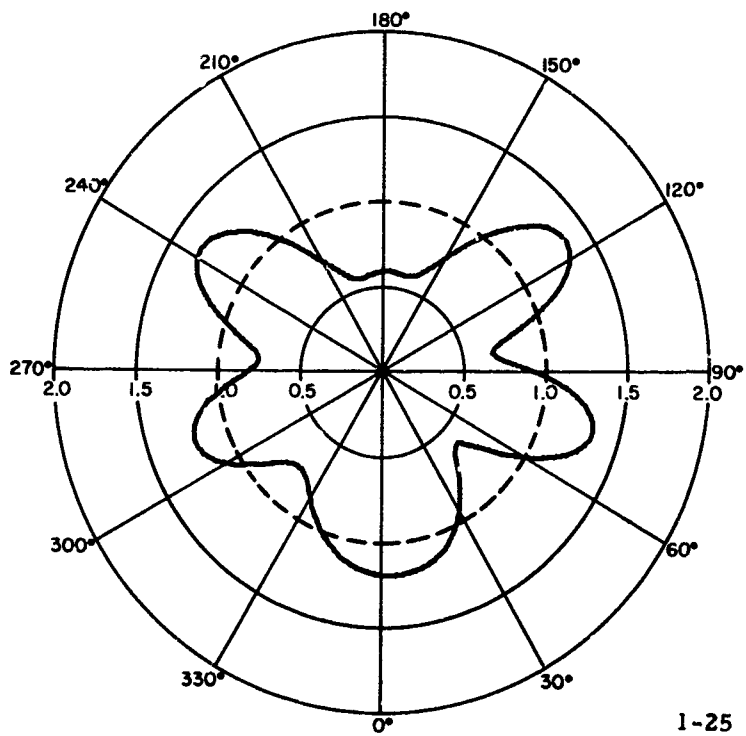
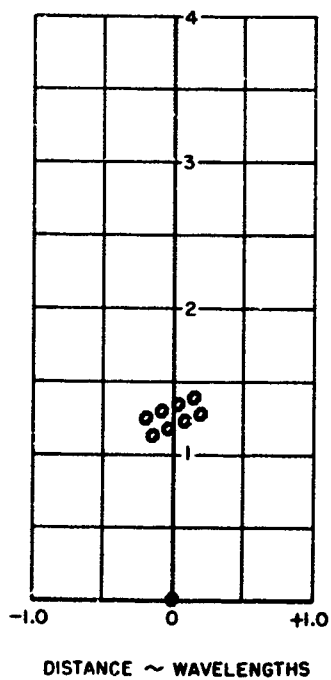
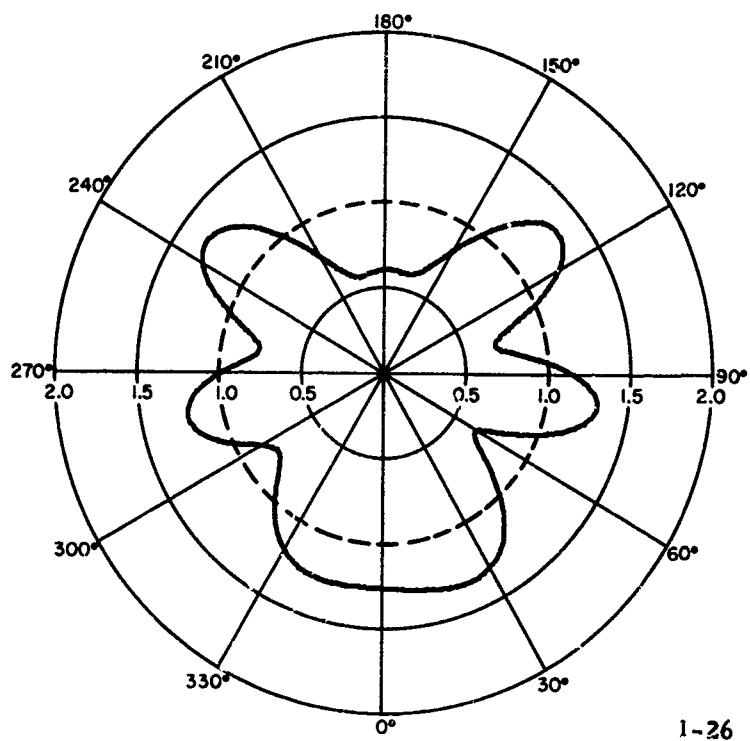
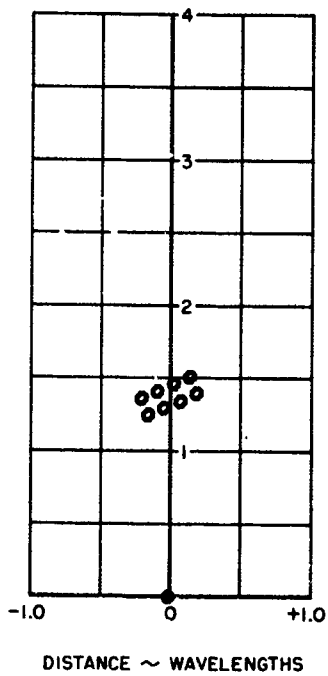
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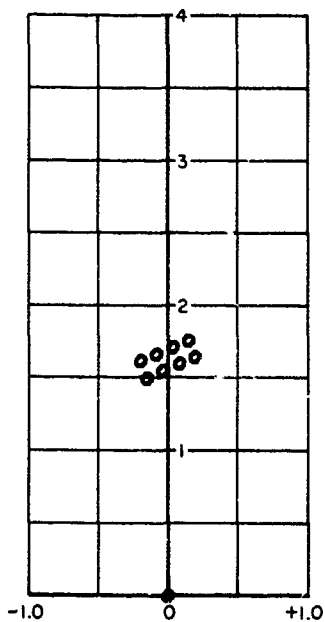


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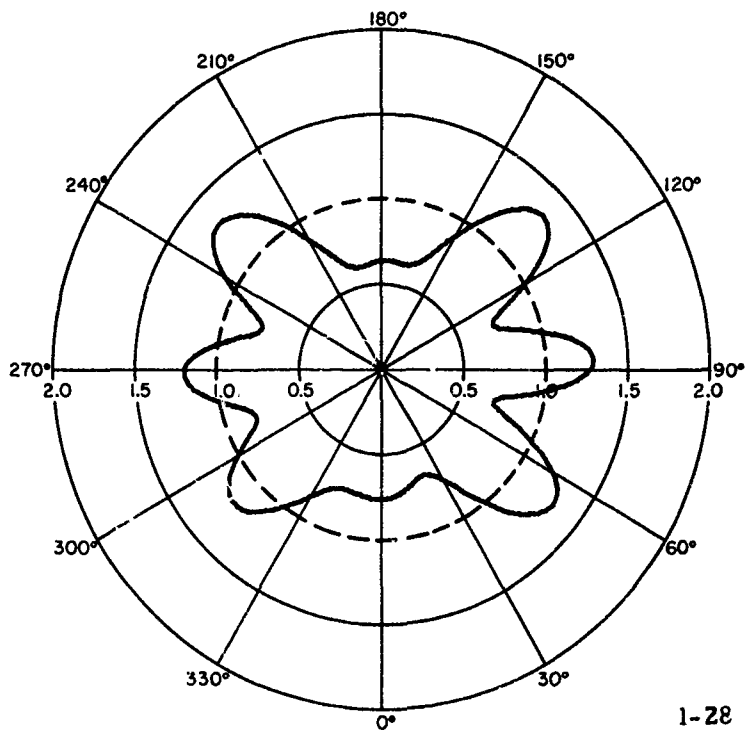




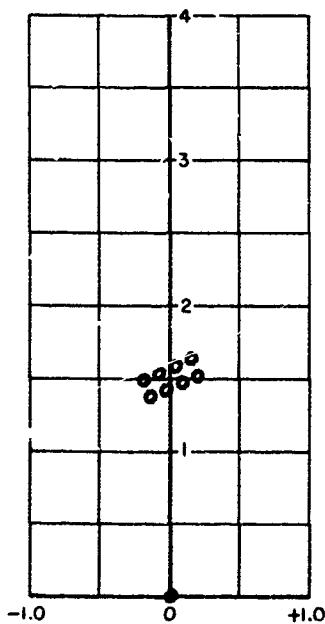




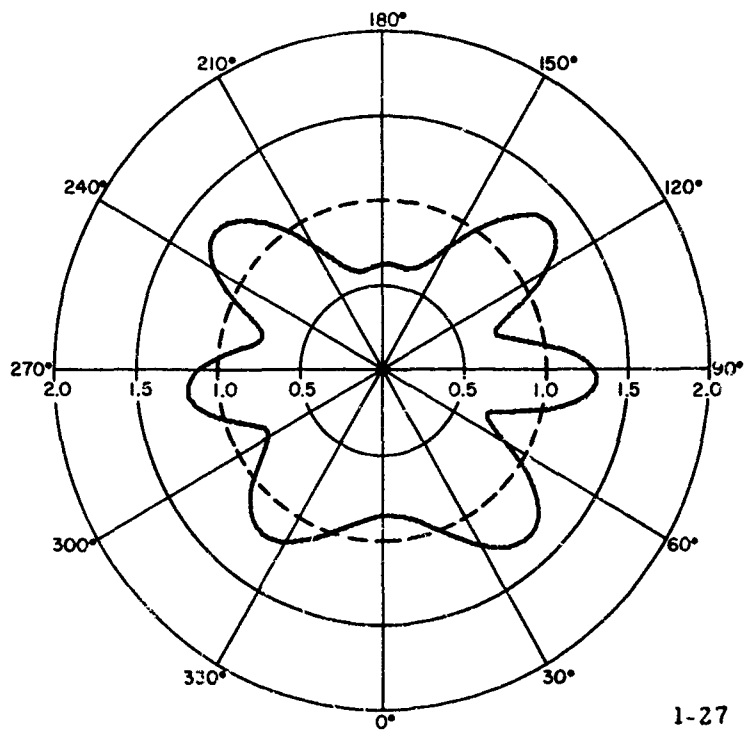
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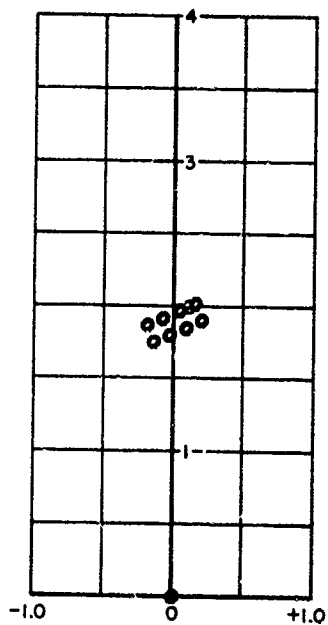
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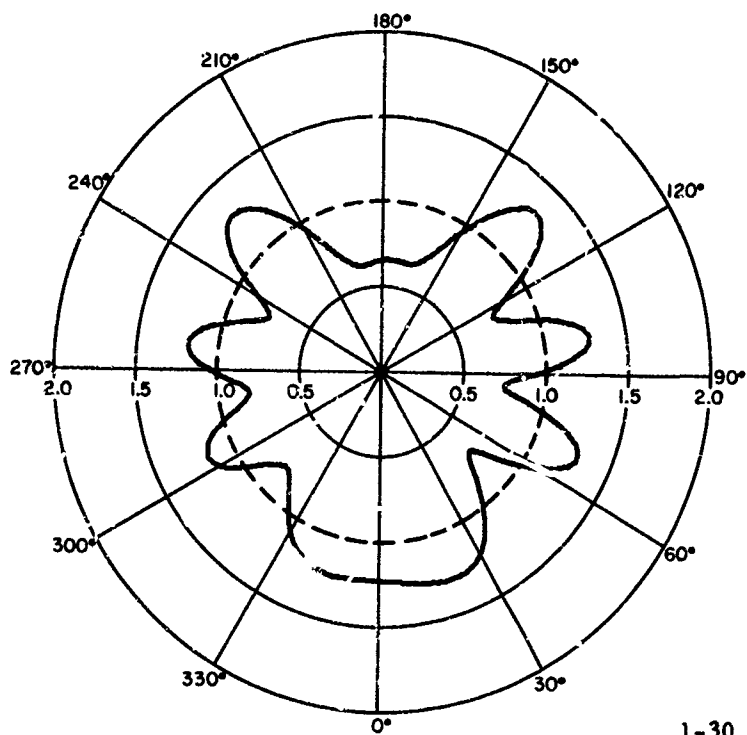
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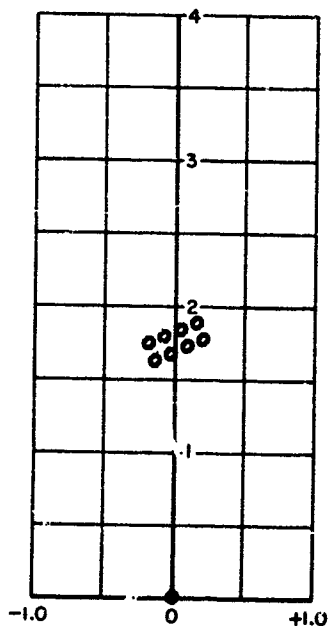
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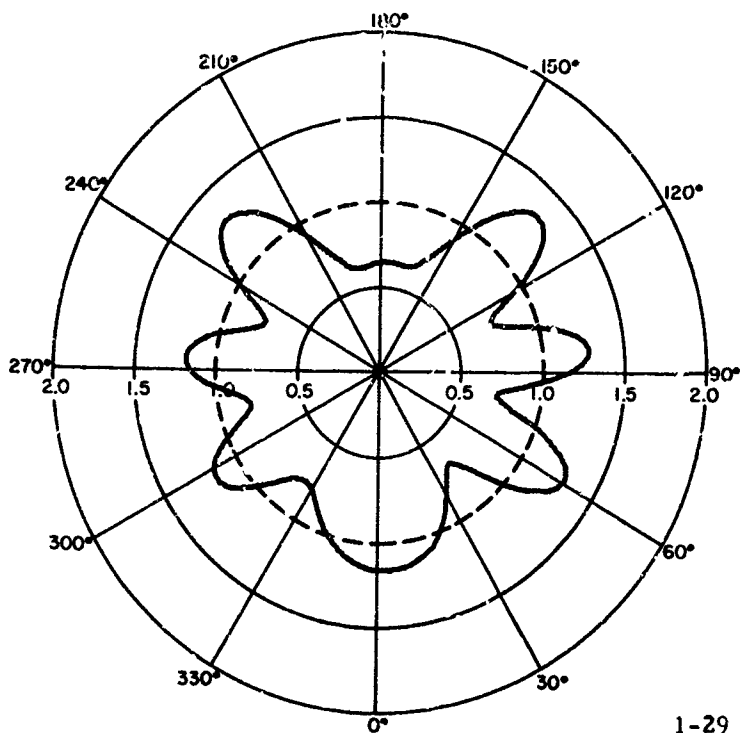
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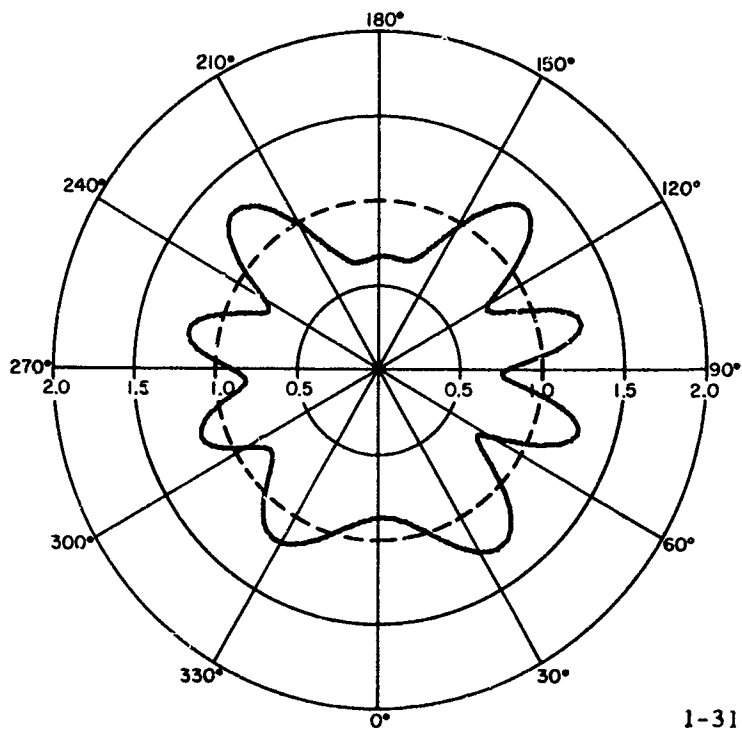
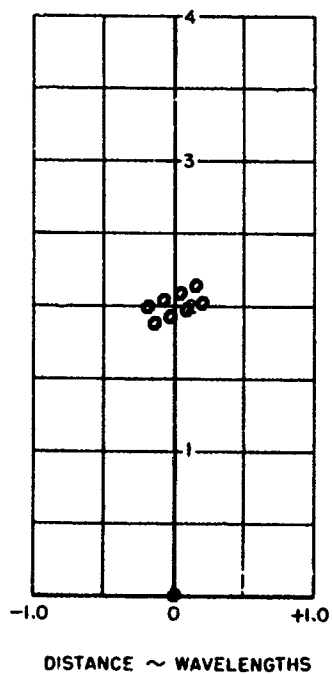
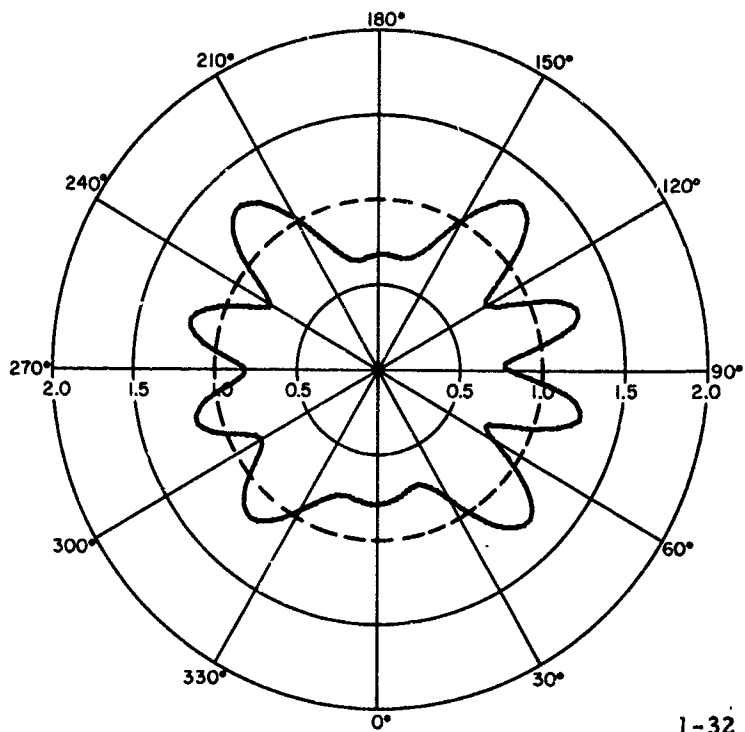
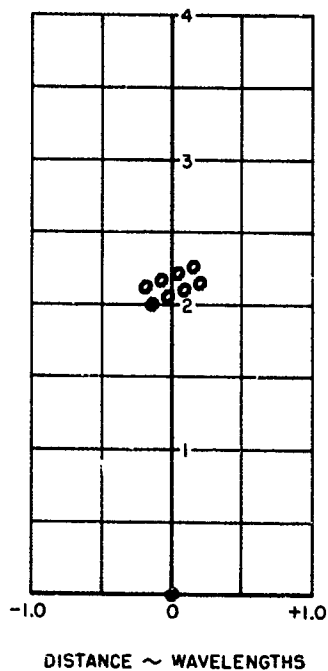
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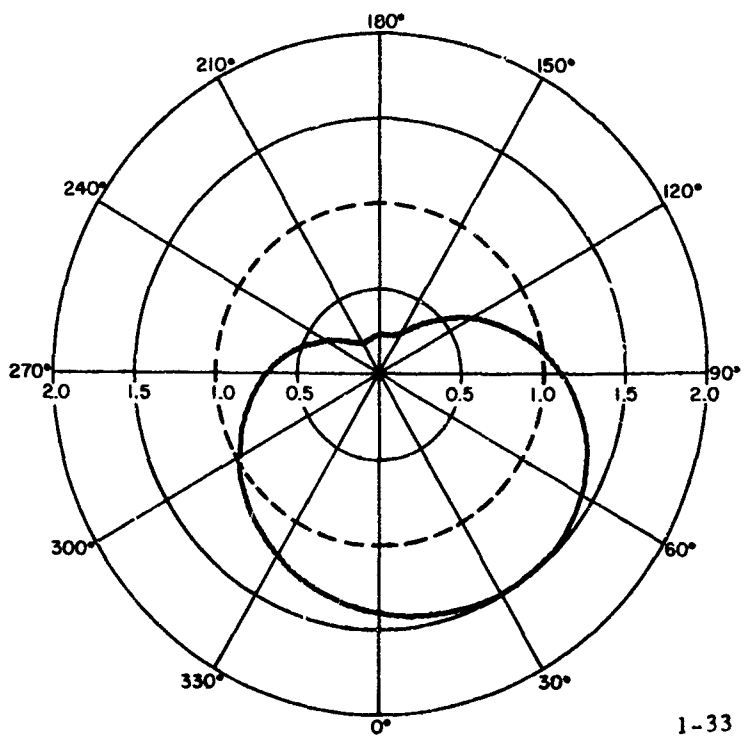
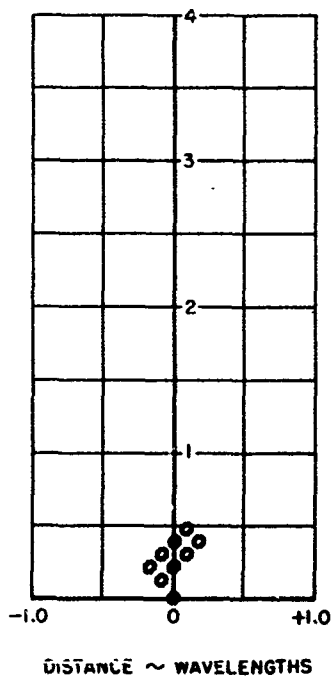
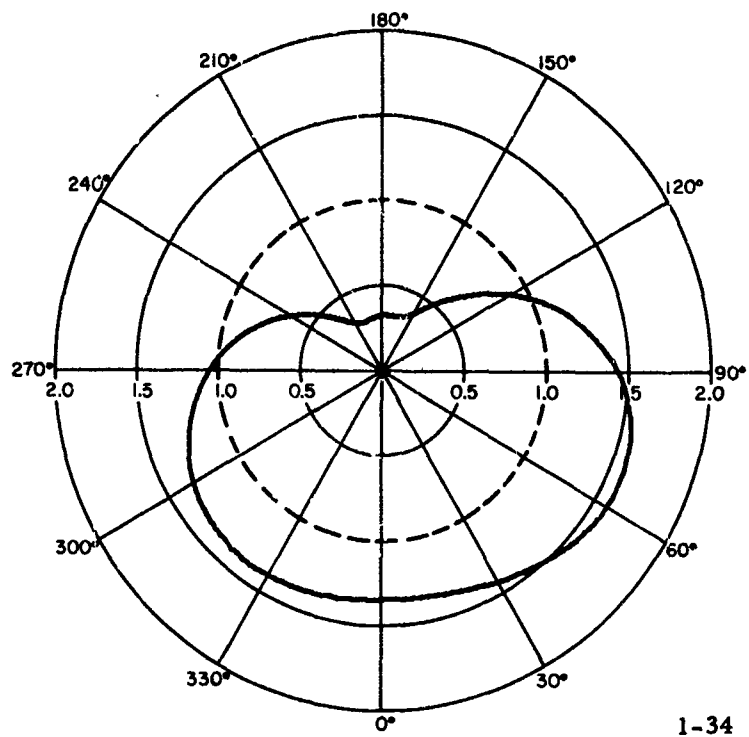
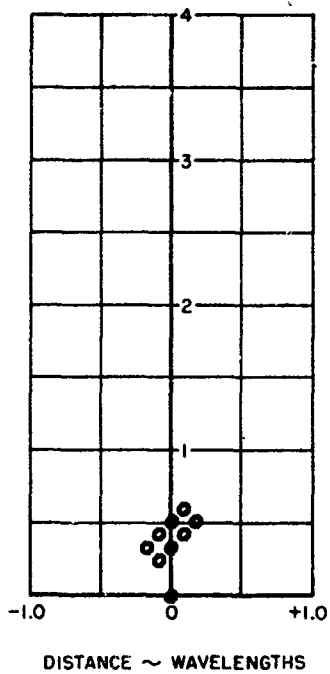


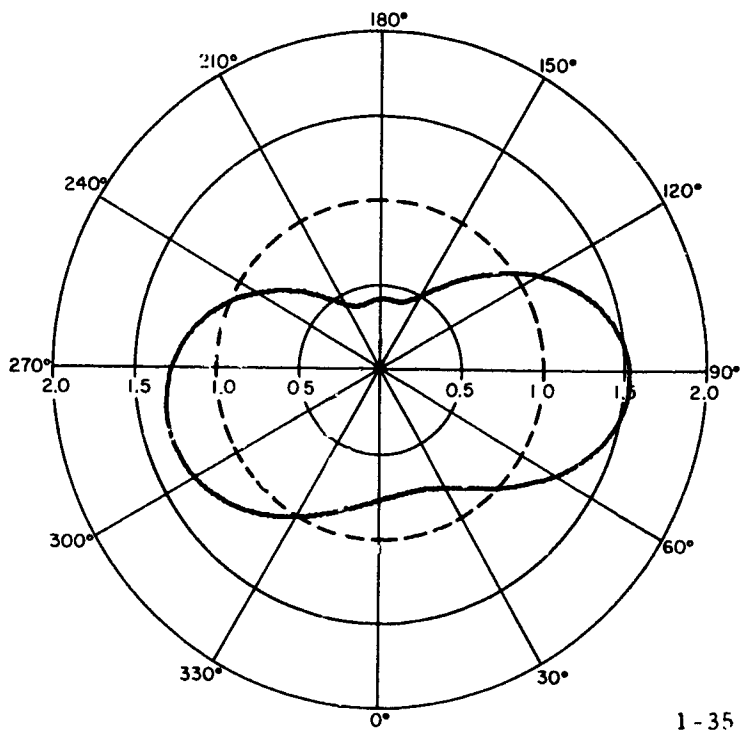
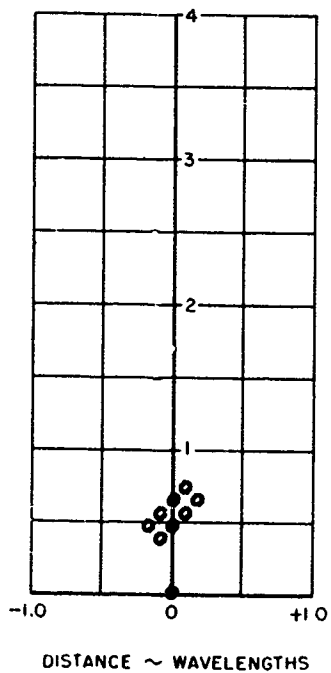
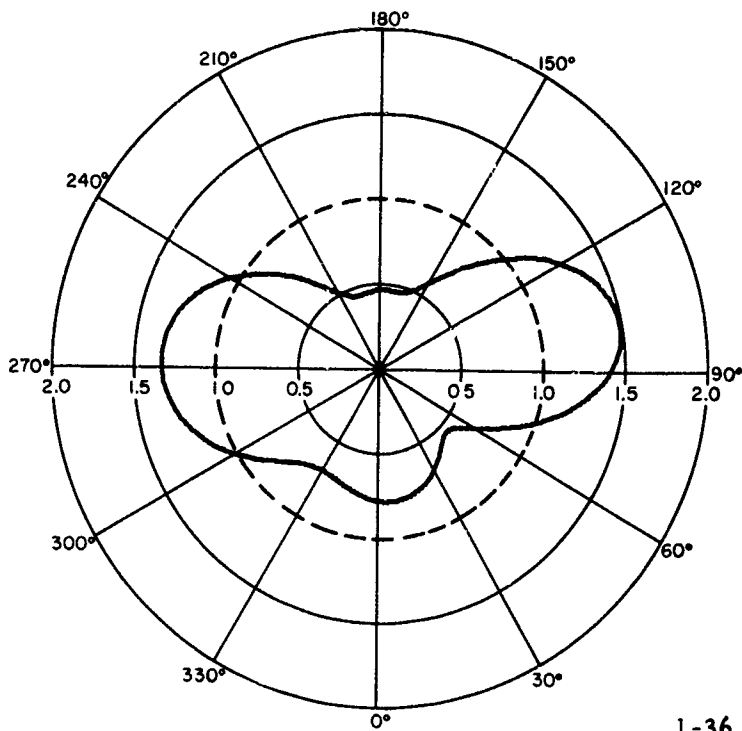
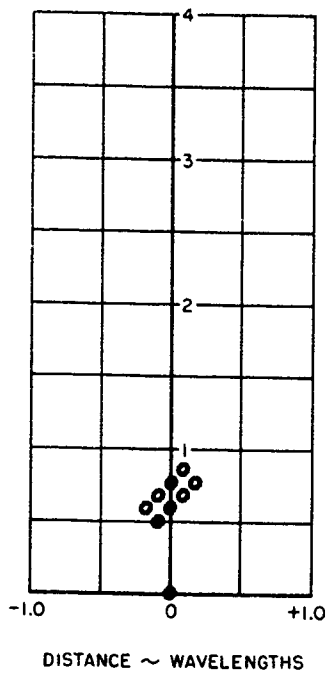
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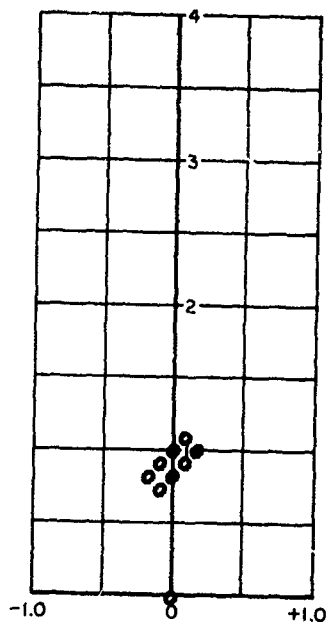


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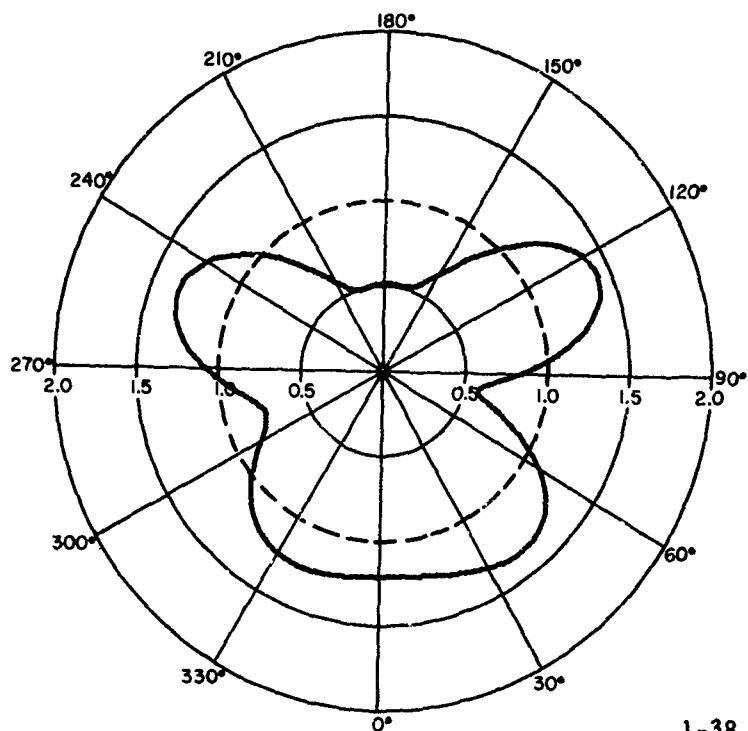




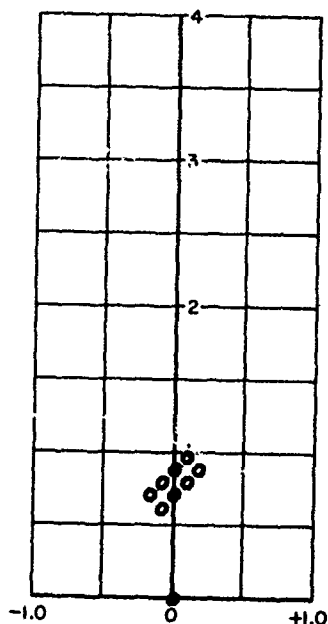




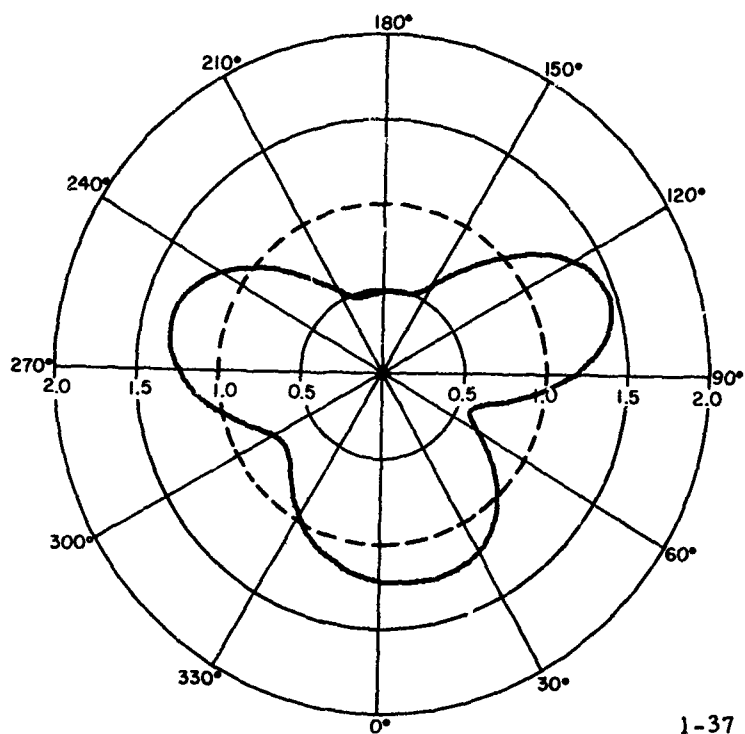
DISTANCE ~ WAVELENGTHS



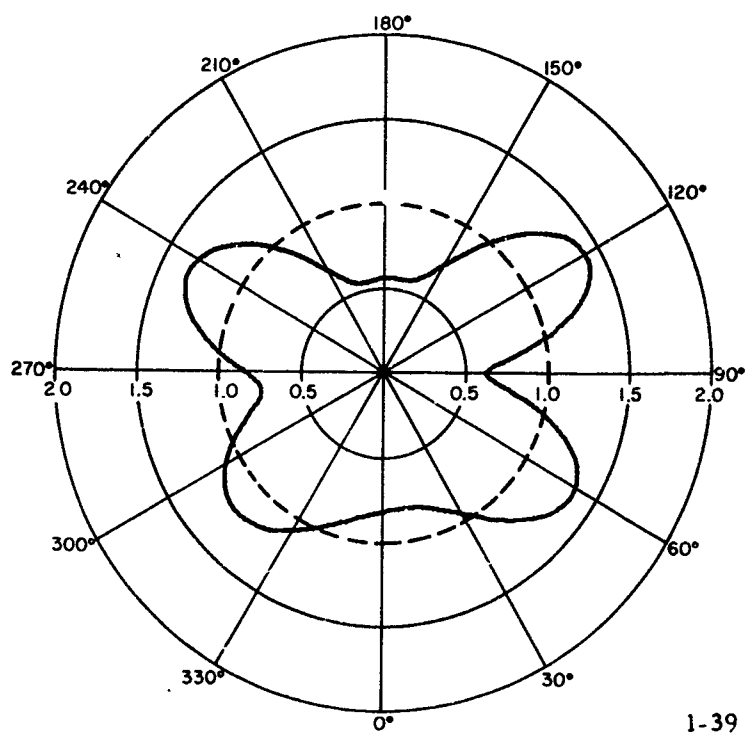
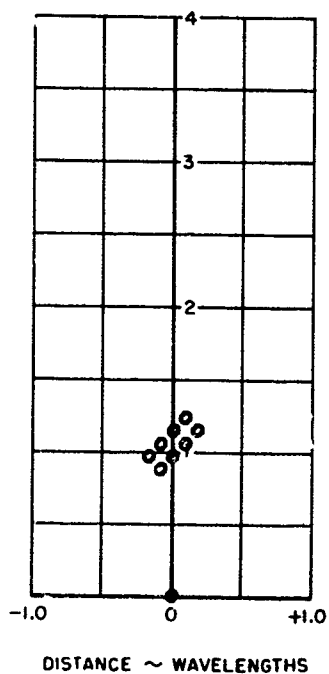
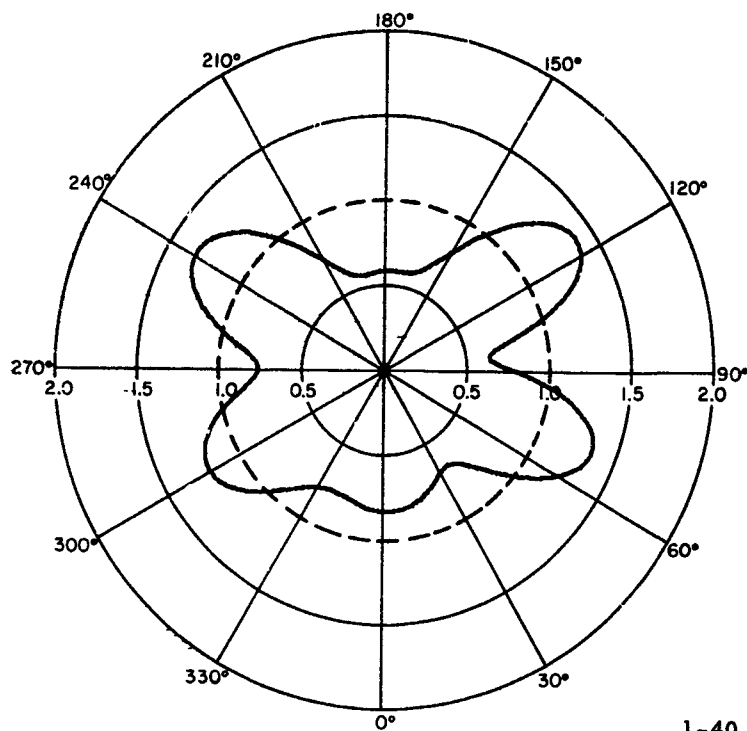
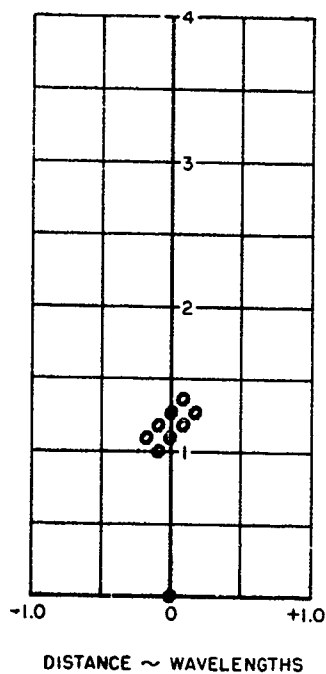
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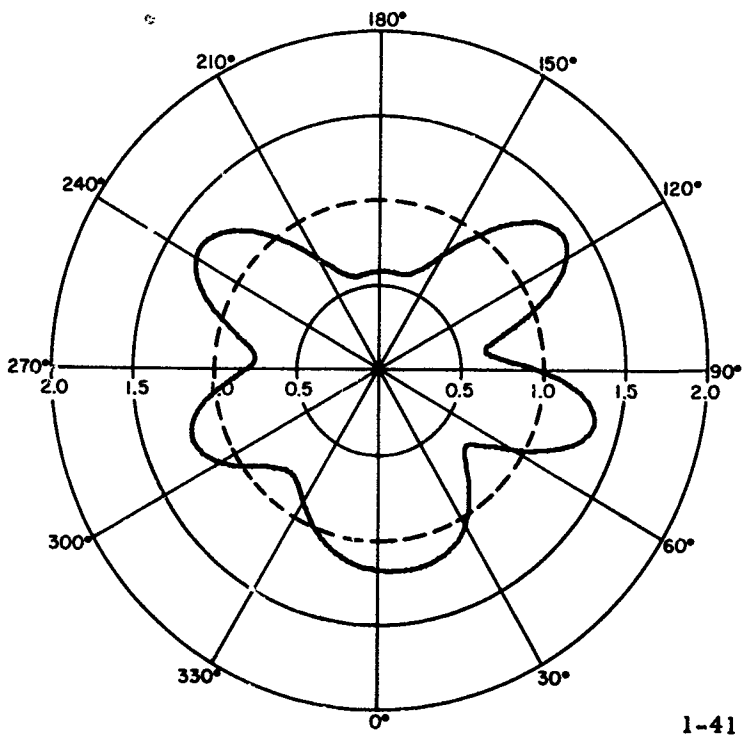
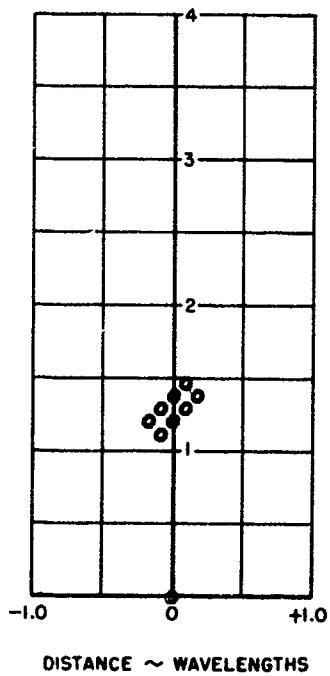
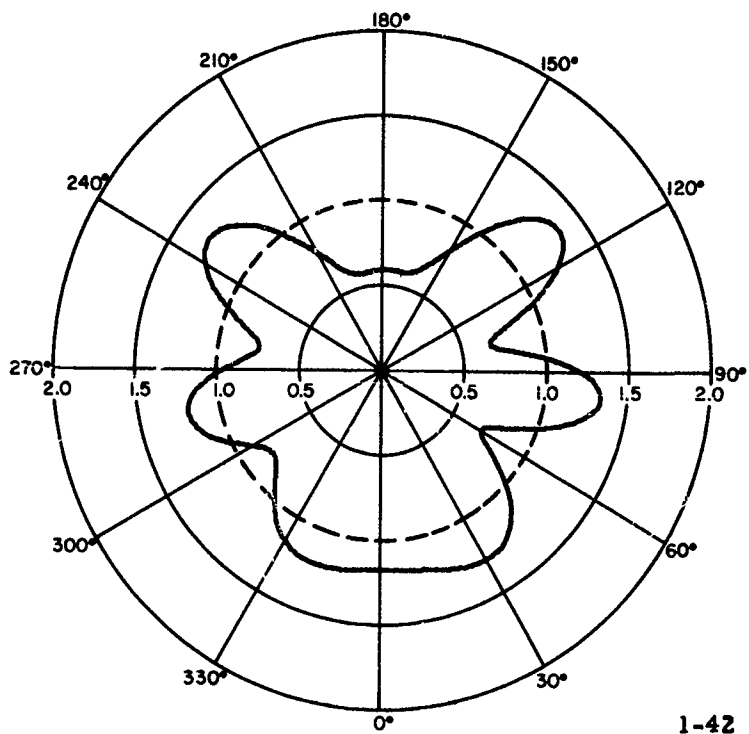
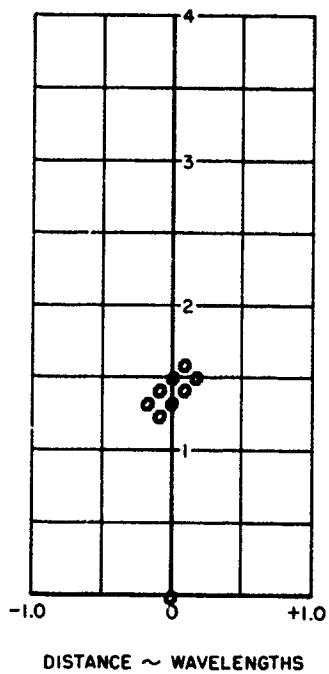


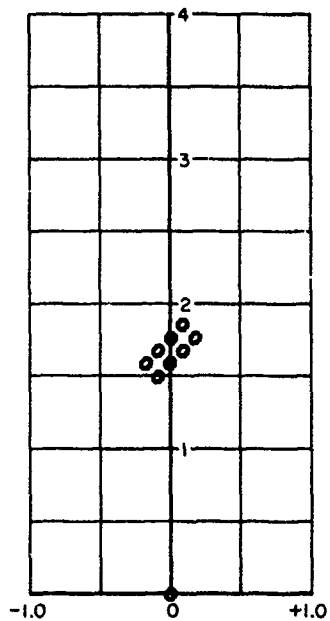
DISTANCE ~ WAVELENGTHS



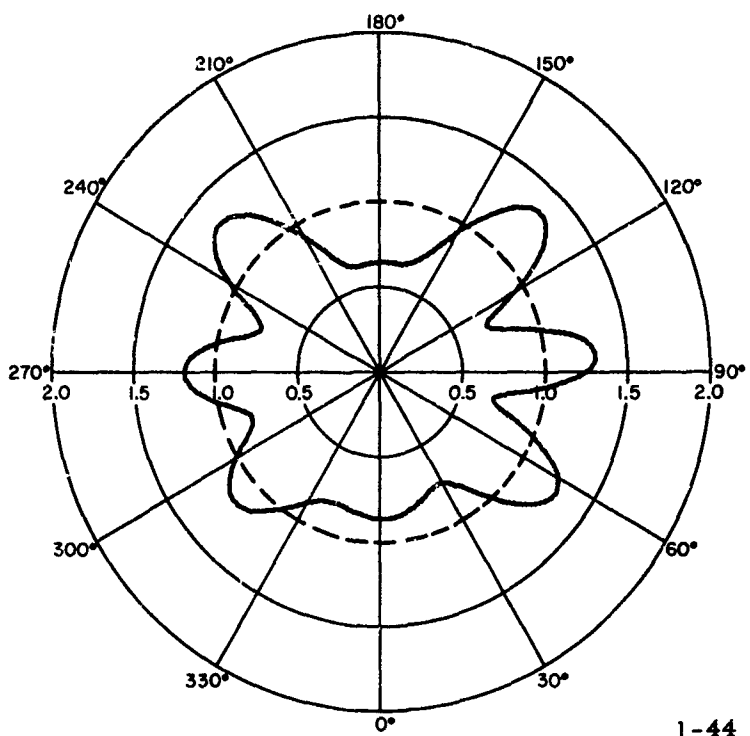
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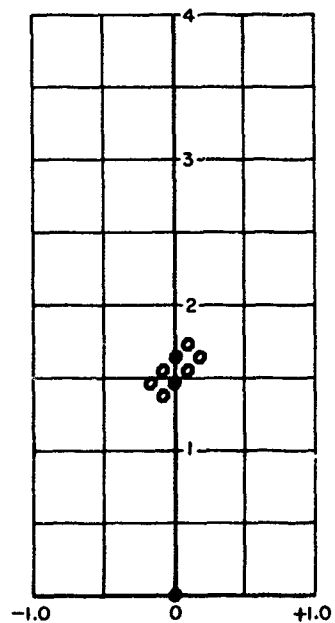




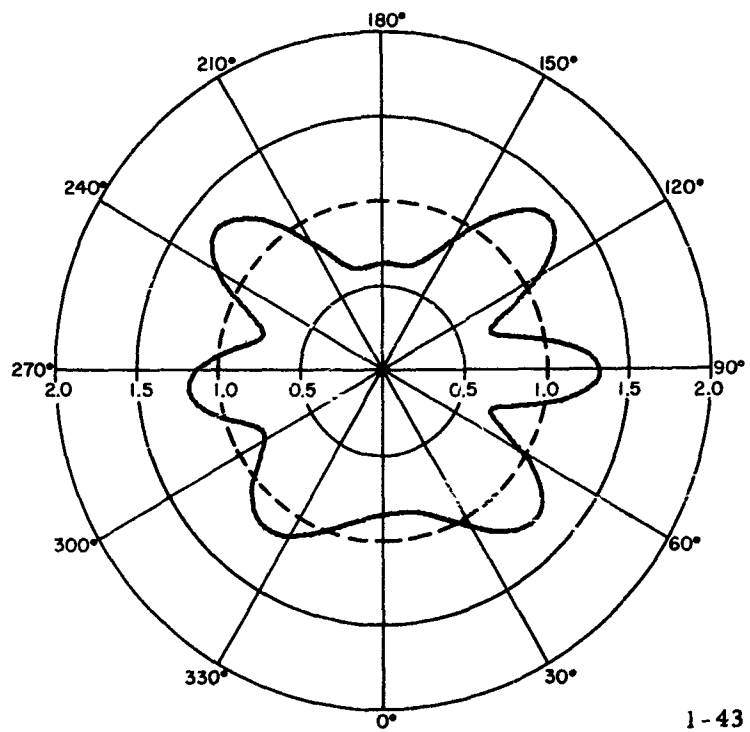
DISTANCE ~ WAVELENGTHS



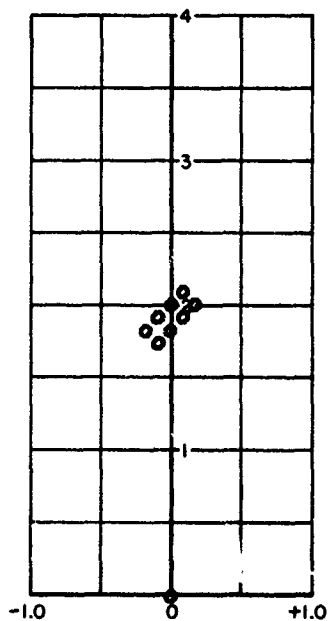
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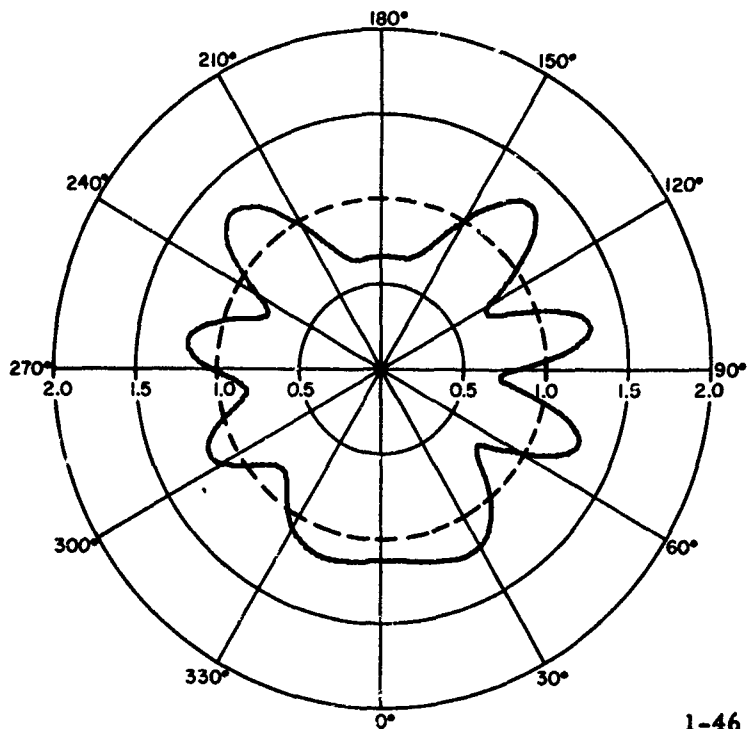
DISTANCE ~ WAVELENGTHS



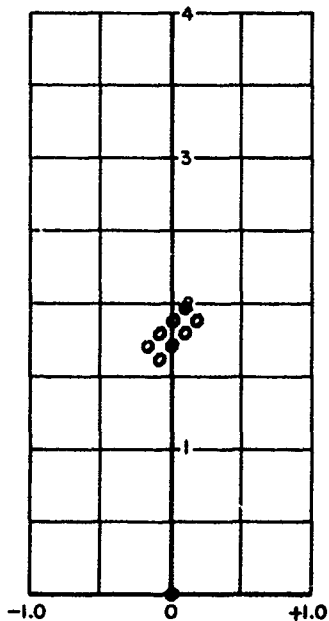
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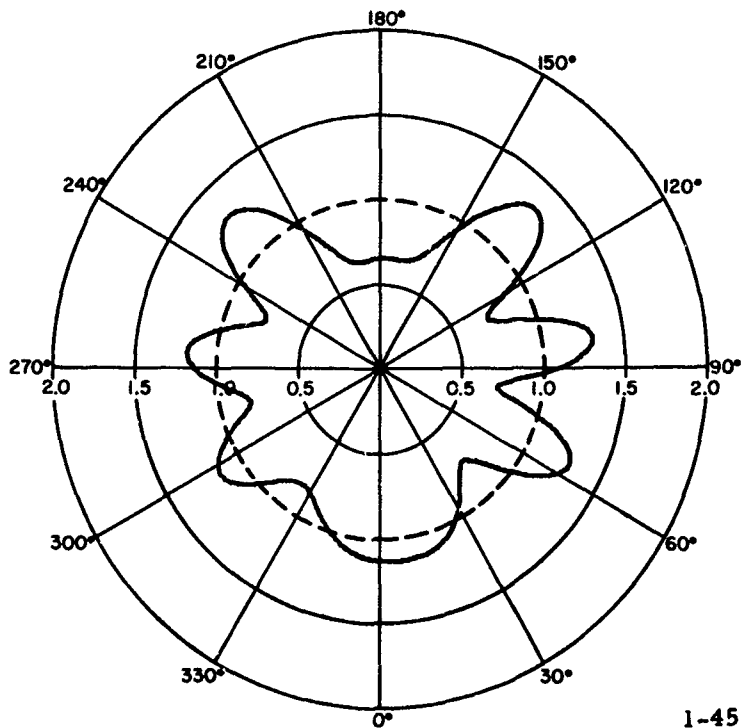
DISTANCE ~ WAVELENGTHS



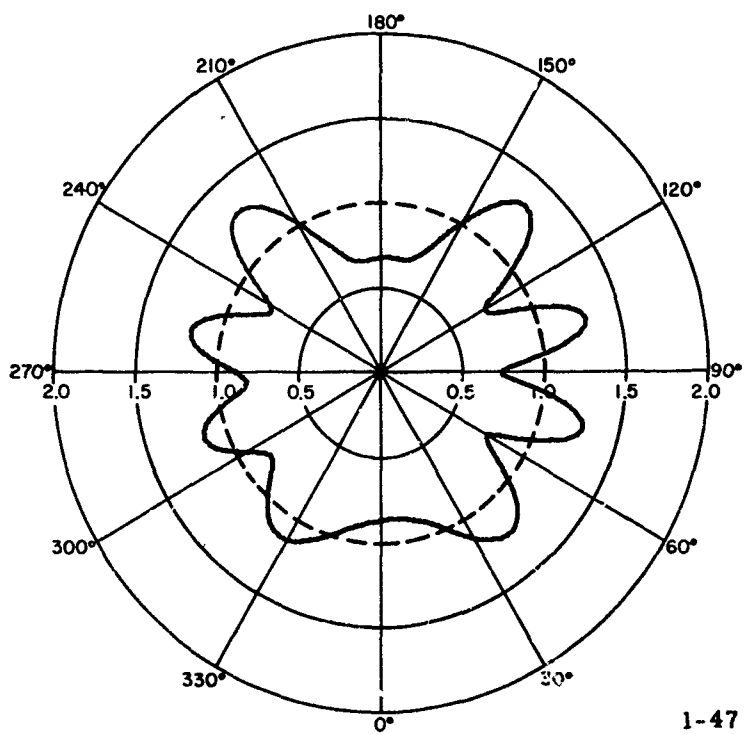
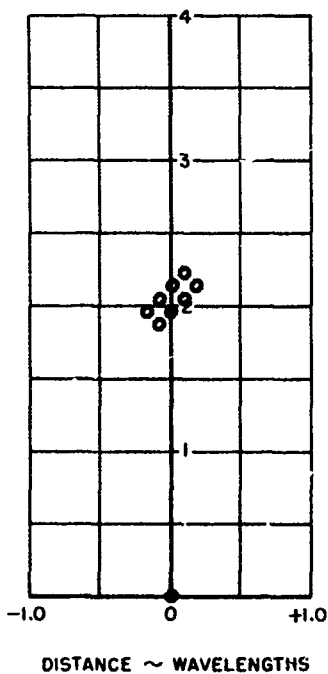
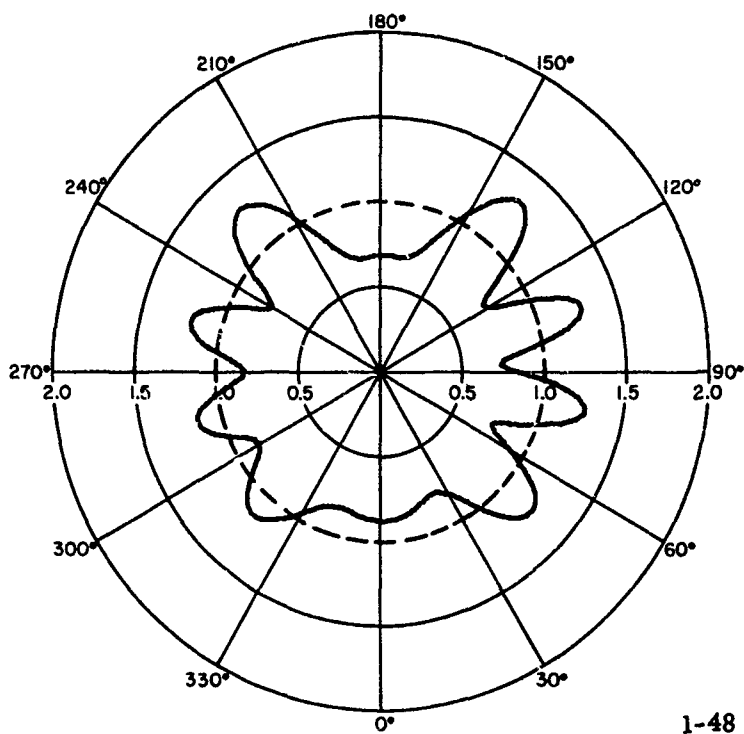
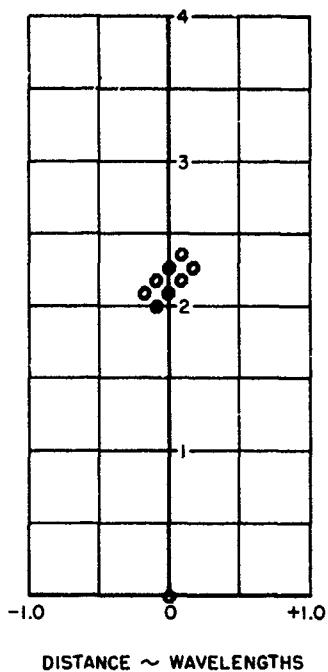
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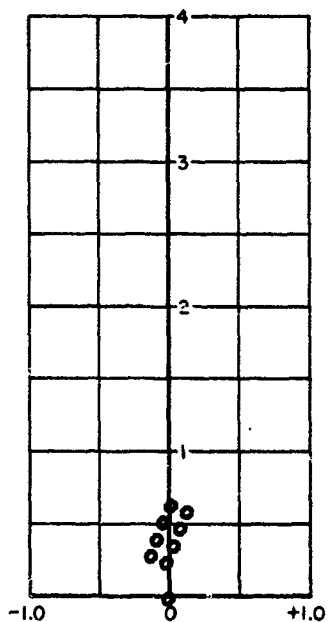


DISTANCE ~ WAVELENGTHS

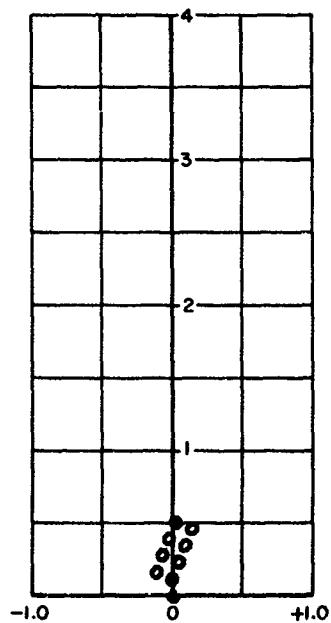
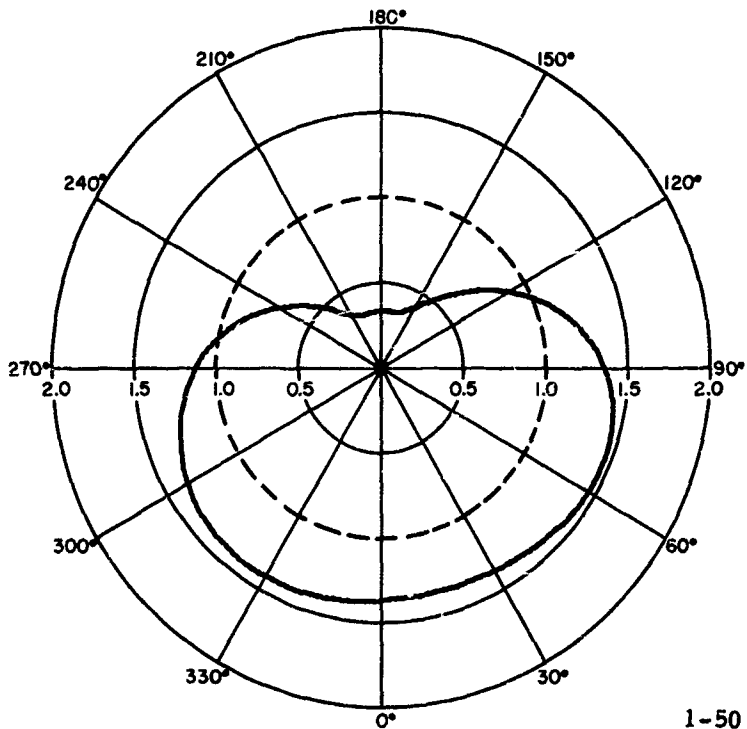


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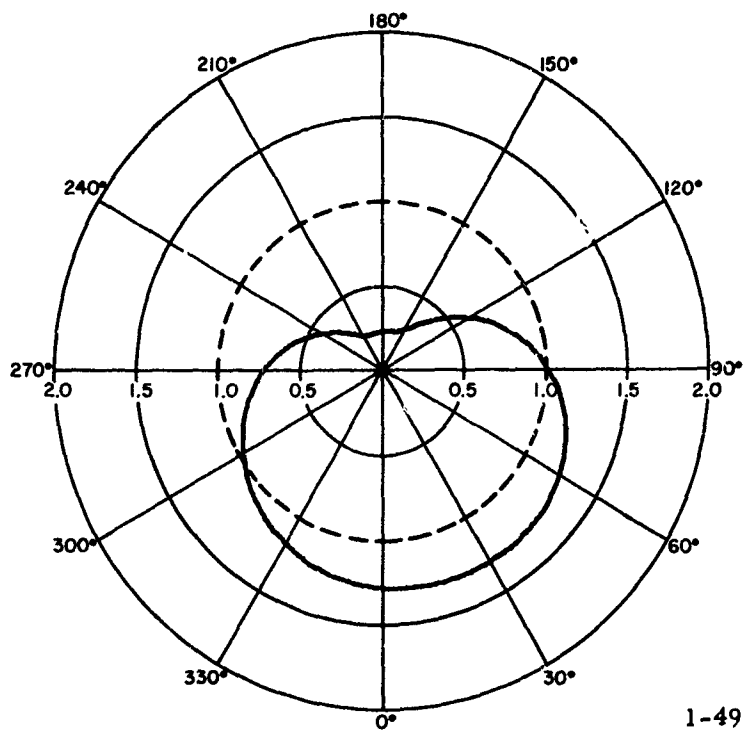


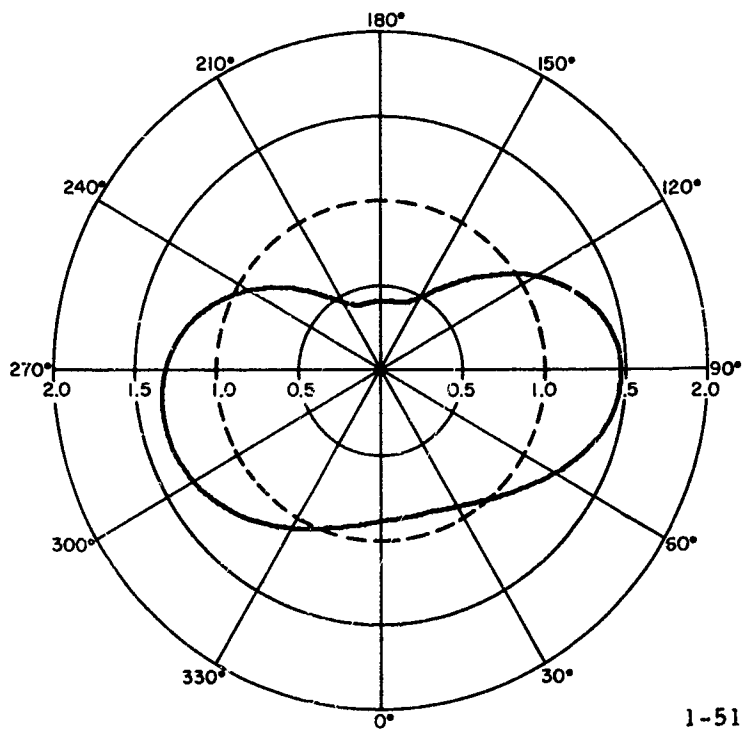
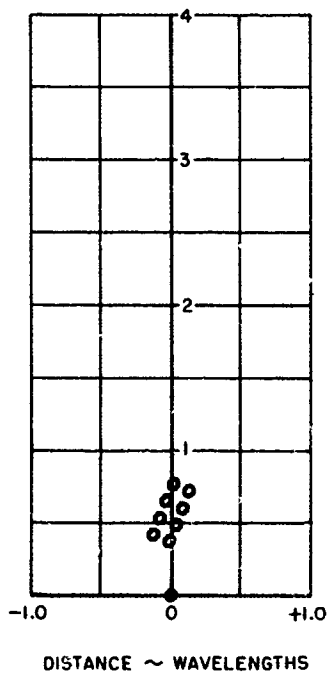
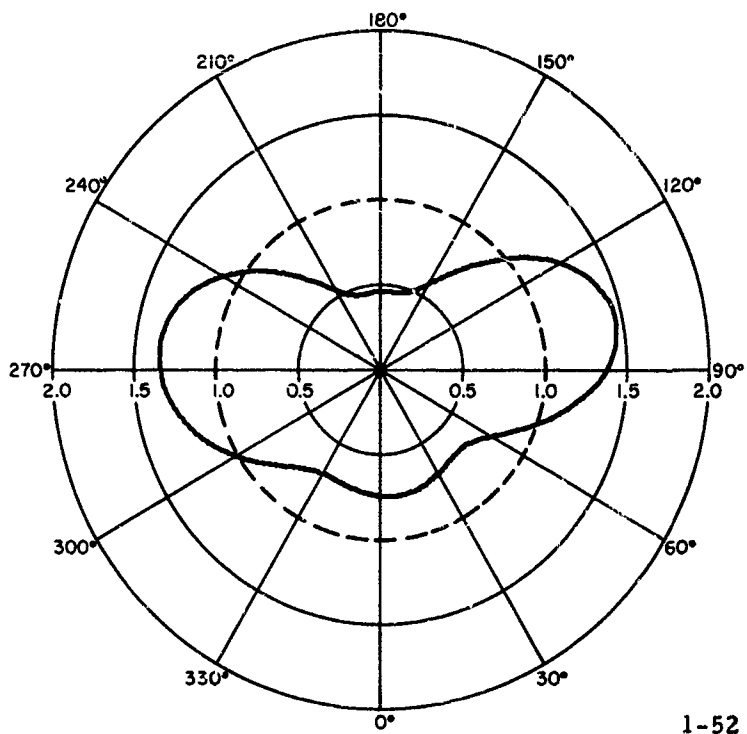
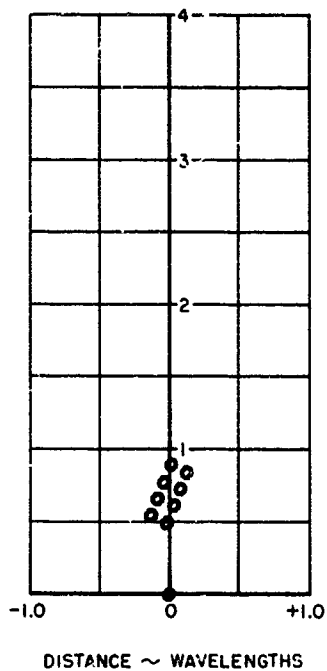


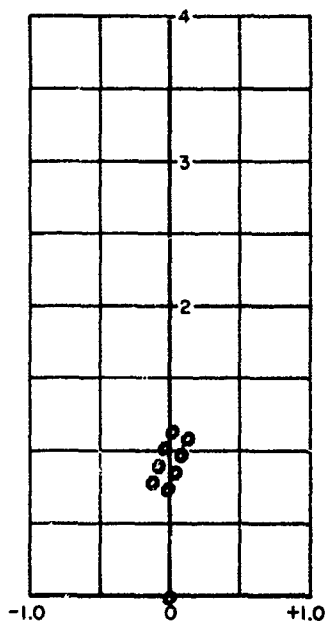
DISTANCE ~ WAVELENGTHS



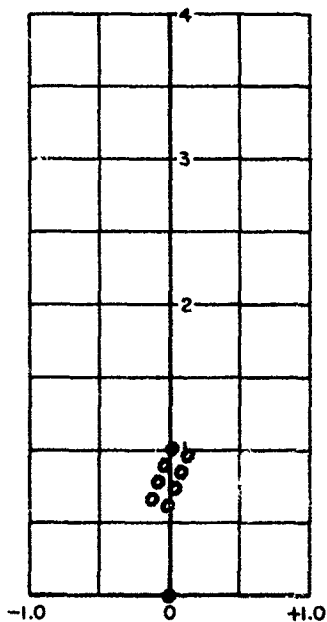
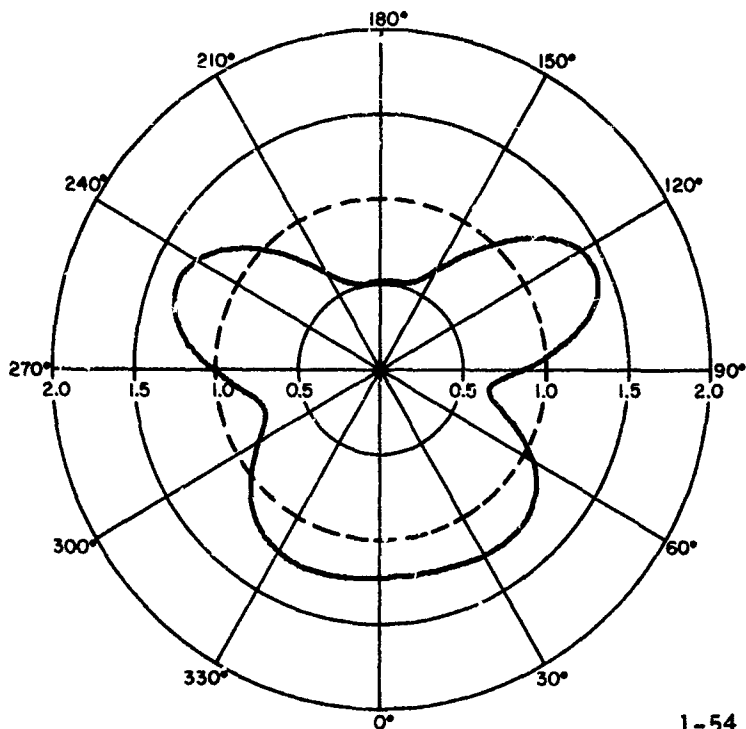
DISTANCE ~ WAVELENGTHS



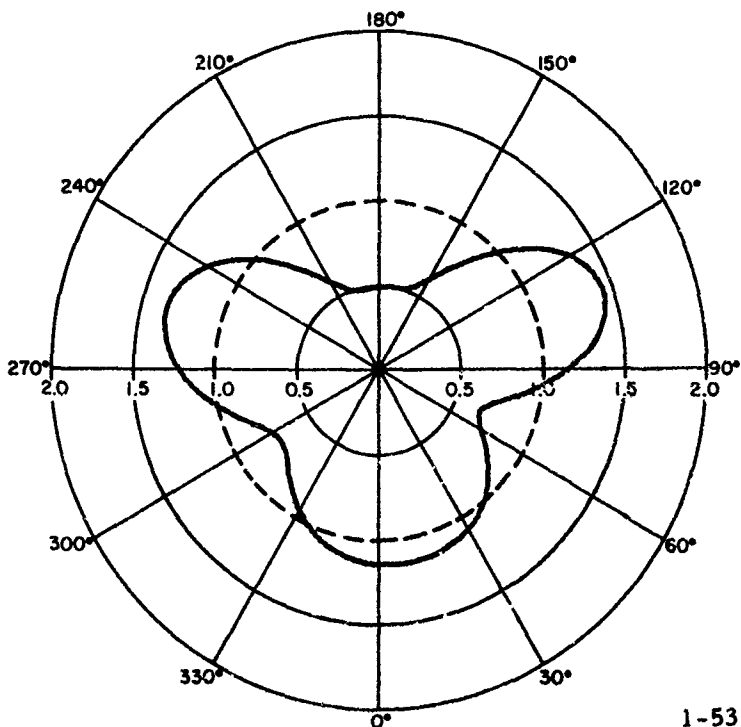


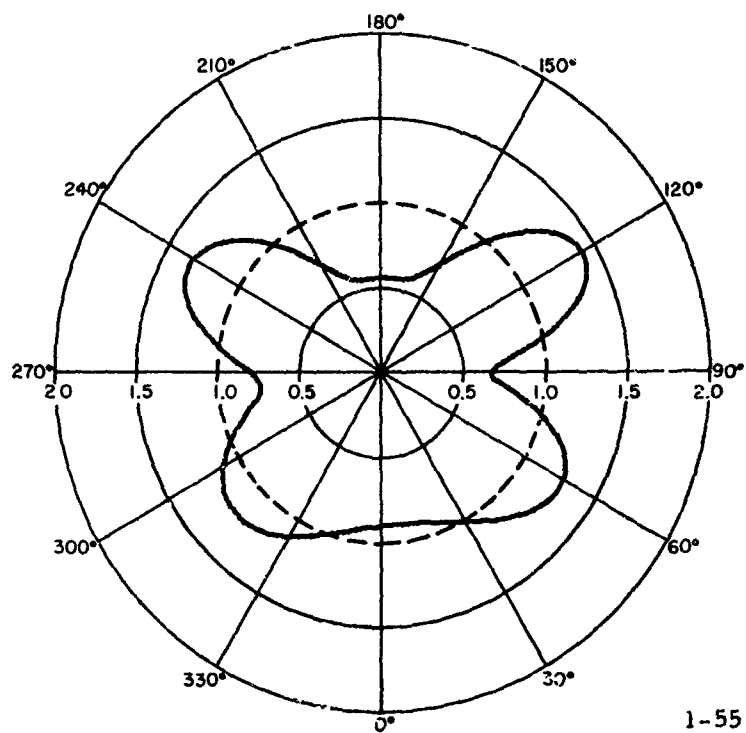
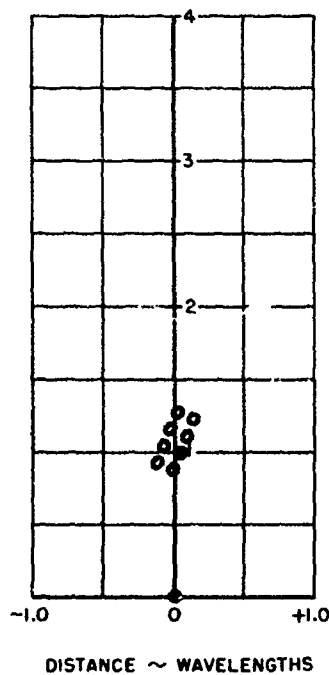
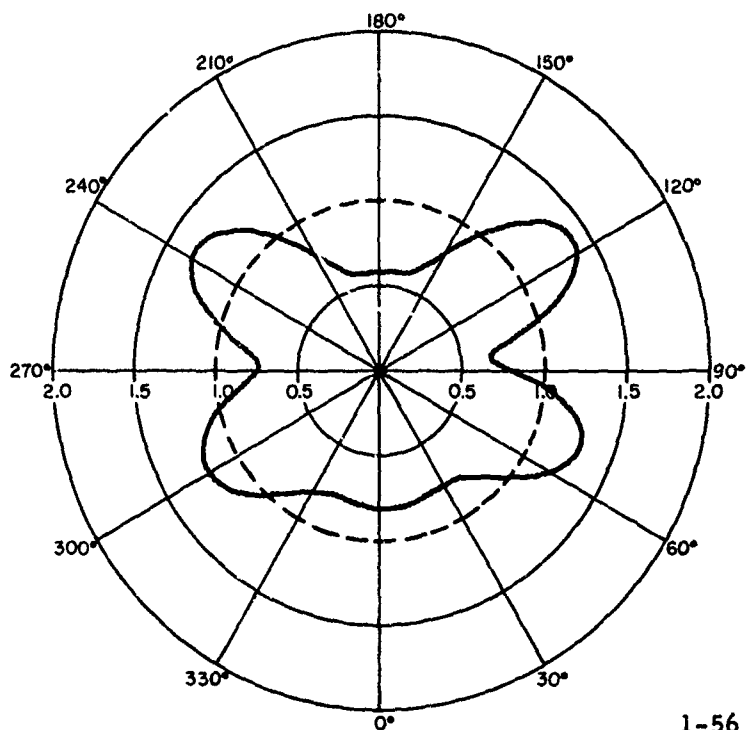
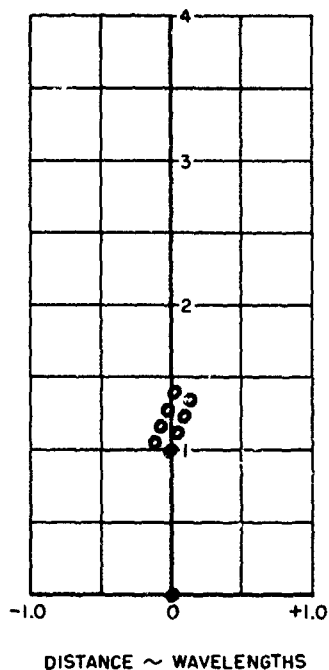


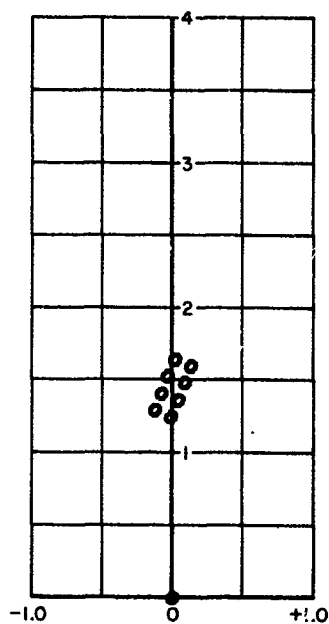
DISTANCE ~ WAVELENGTHS



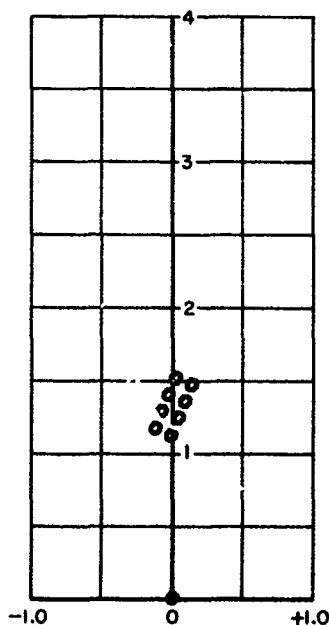
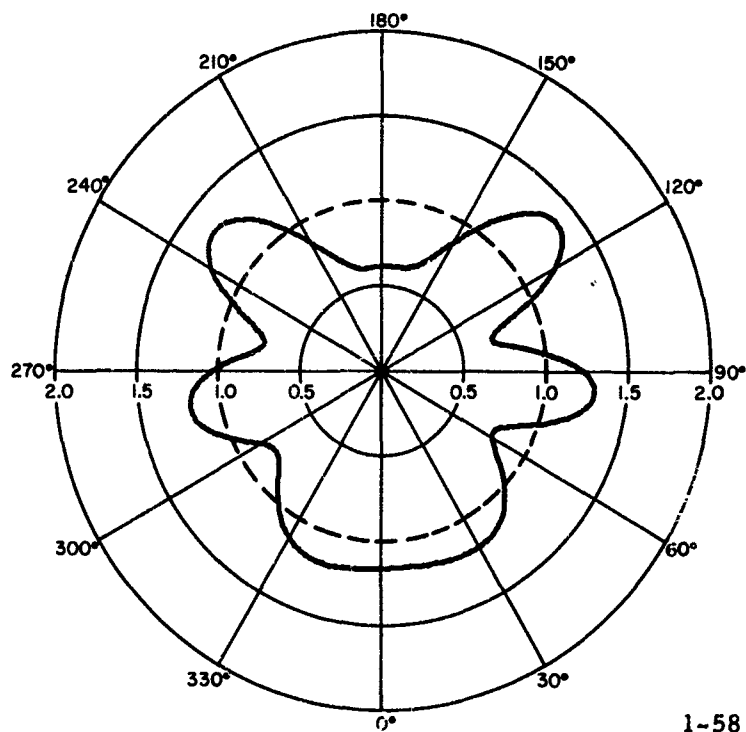
DISTANCE ~ WAVELENGTHS



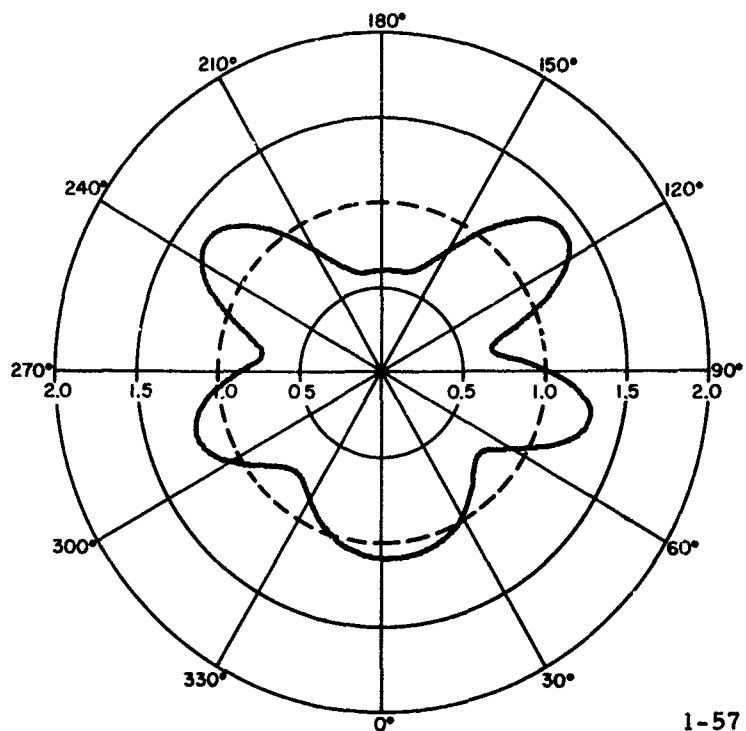


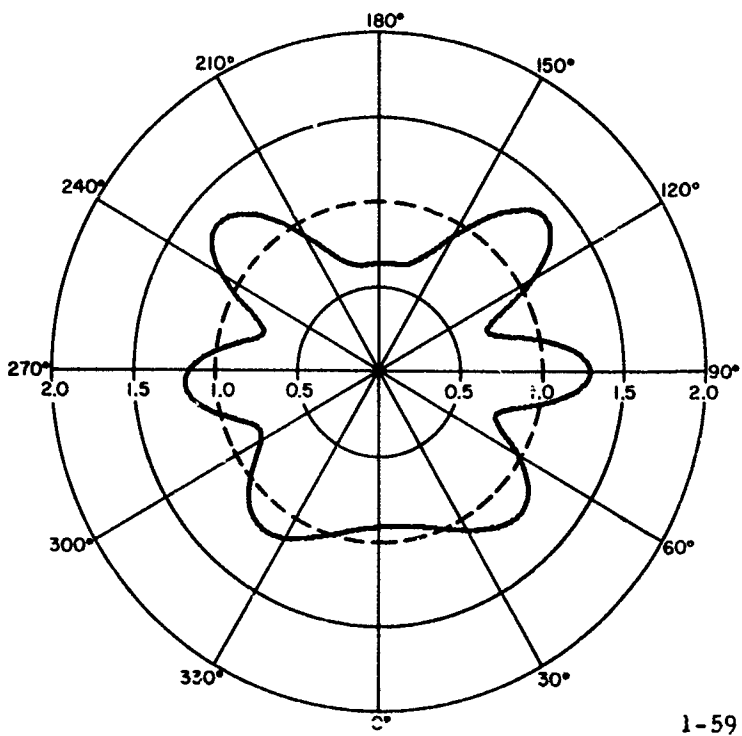
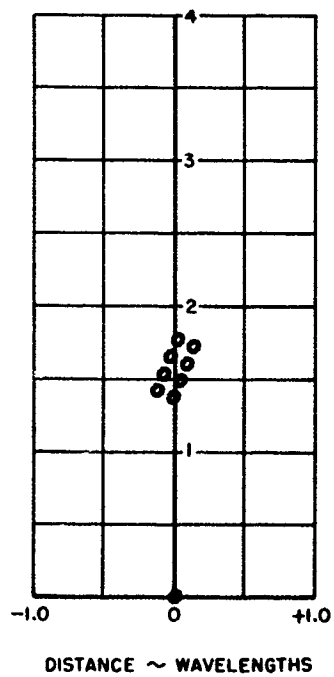
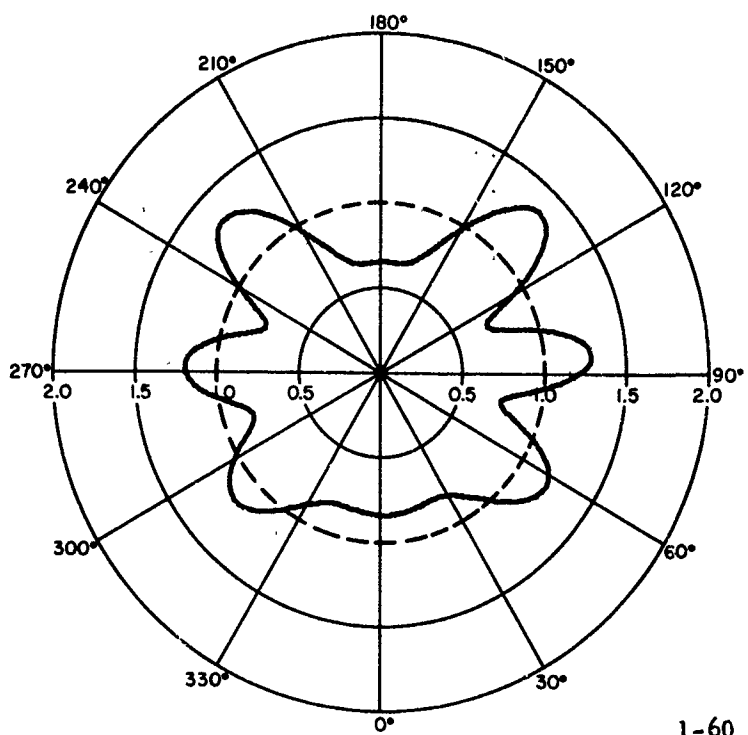
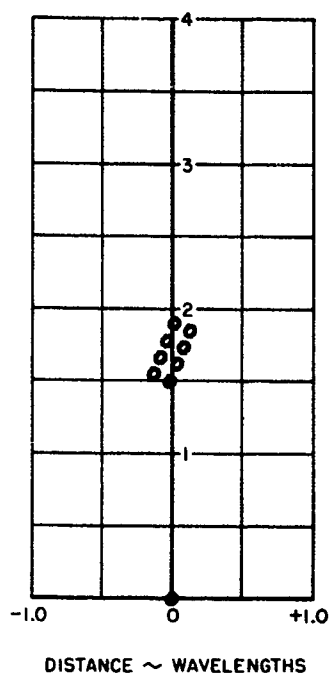


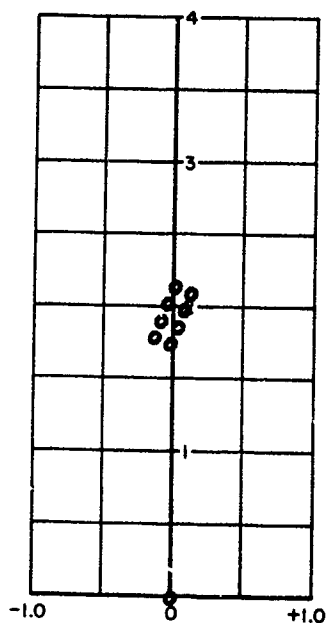
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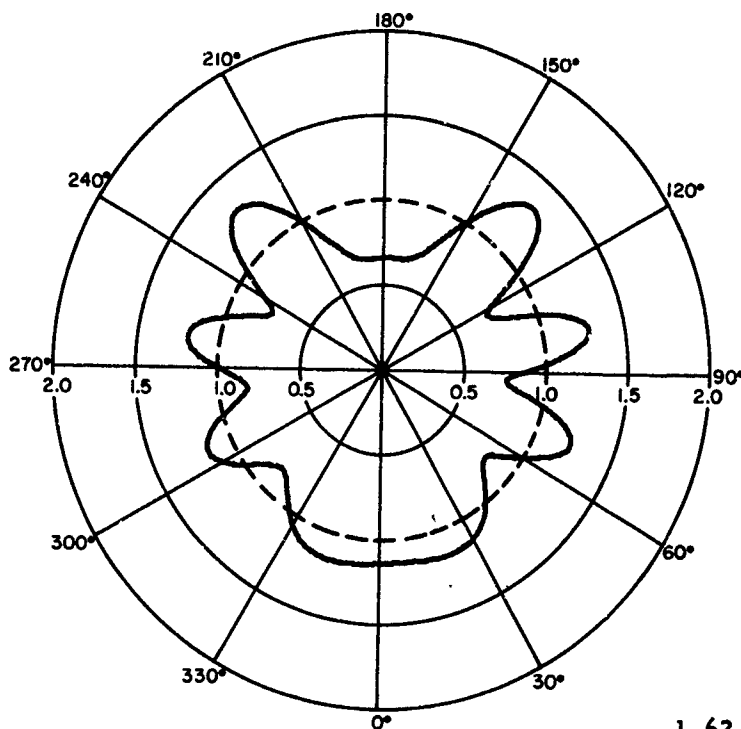
DISTANCE ~ WAVELENGTHS



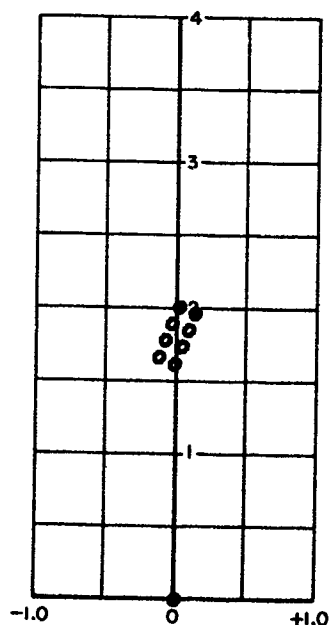




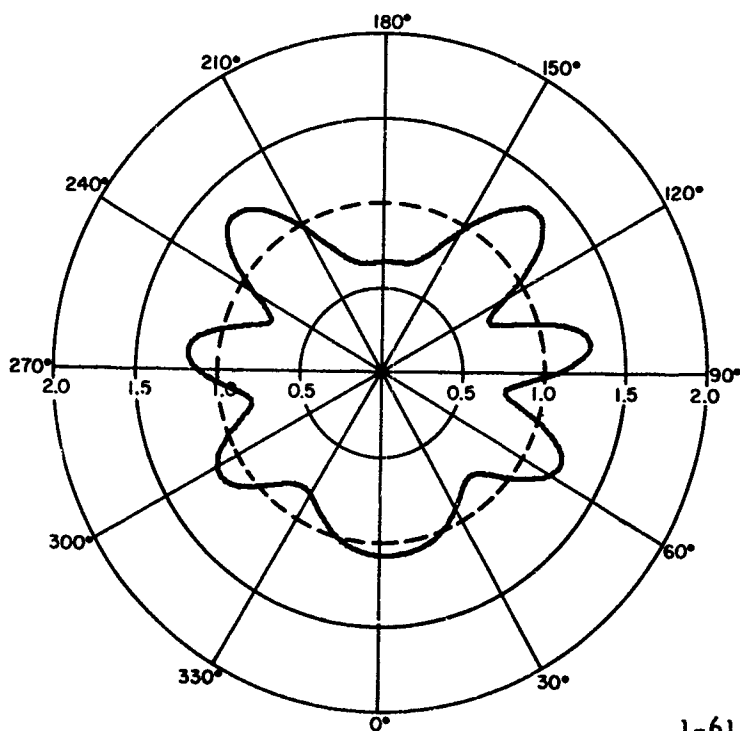
DISTANCE ~ WAVELENGTHS



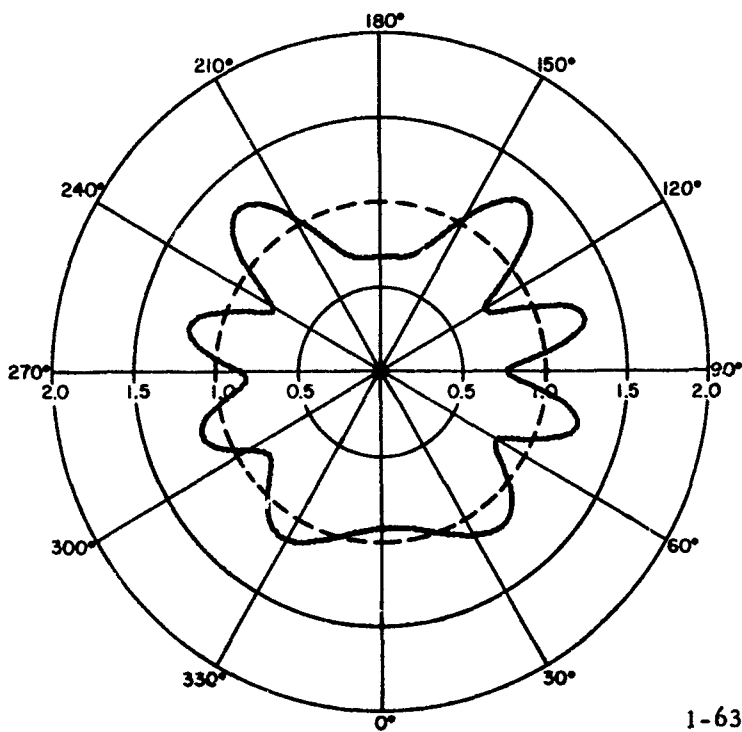
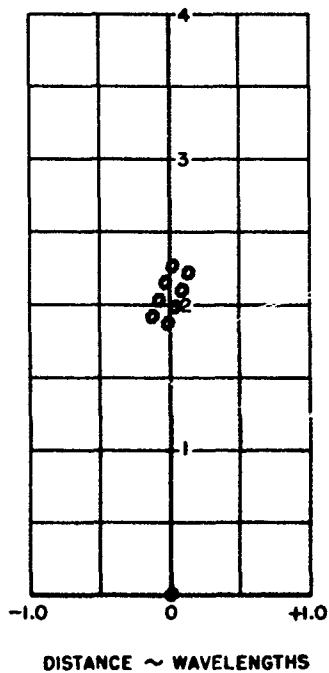
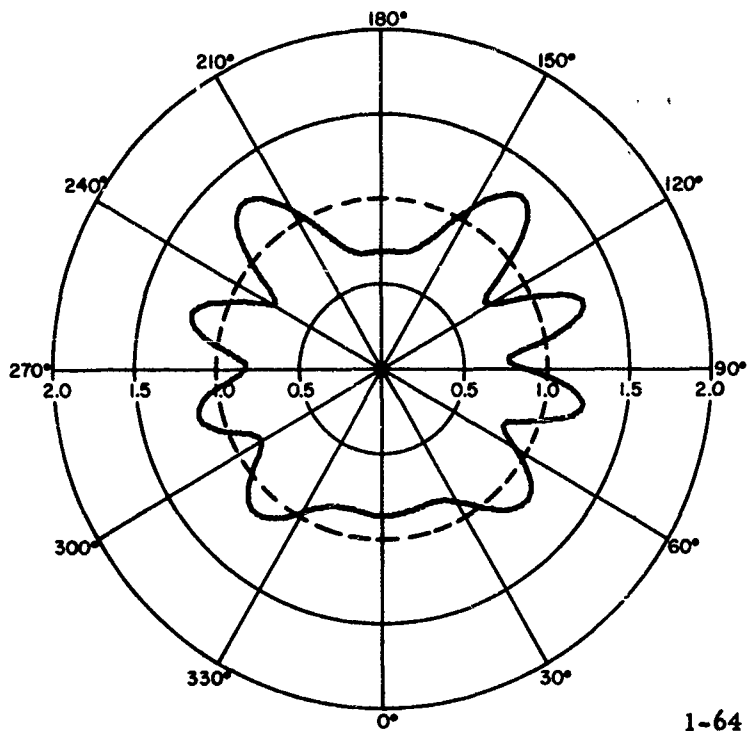
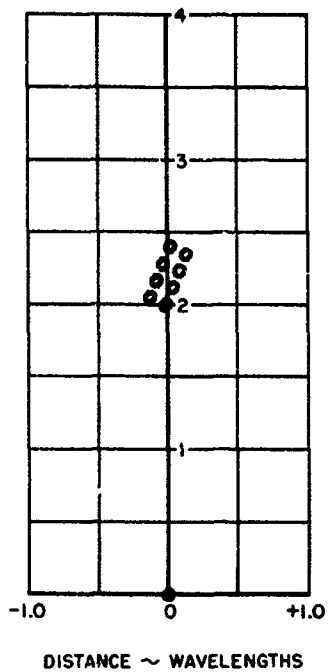
1-62

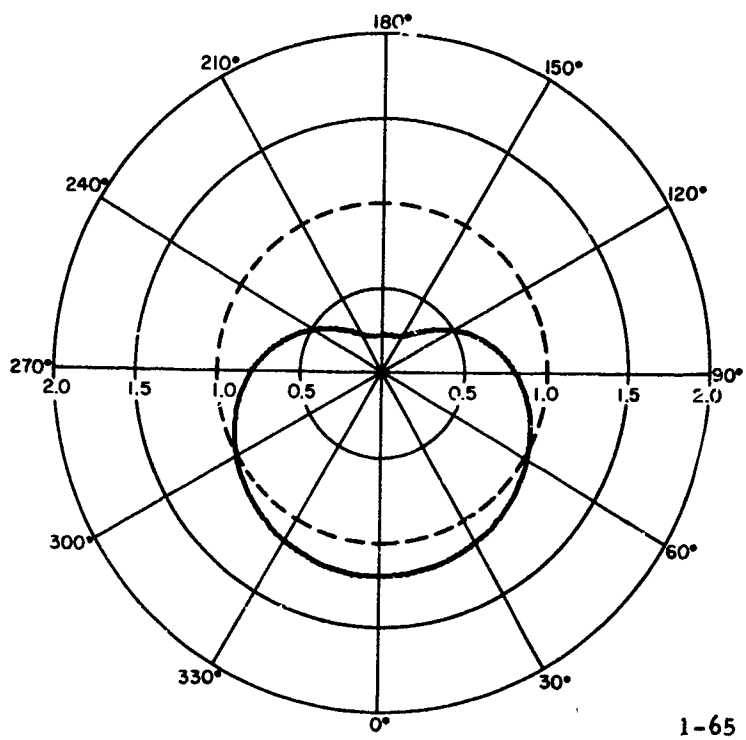
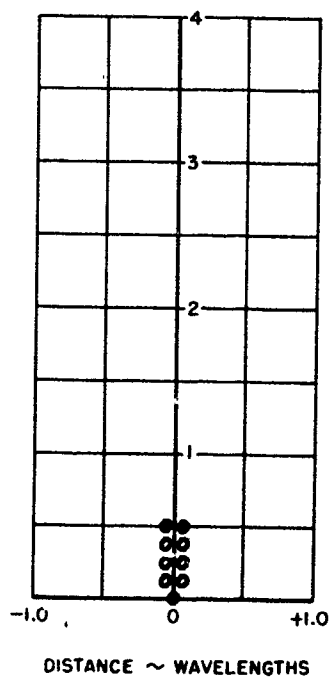
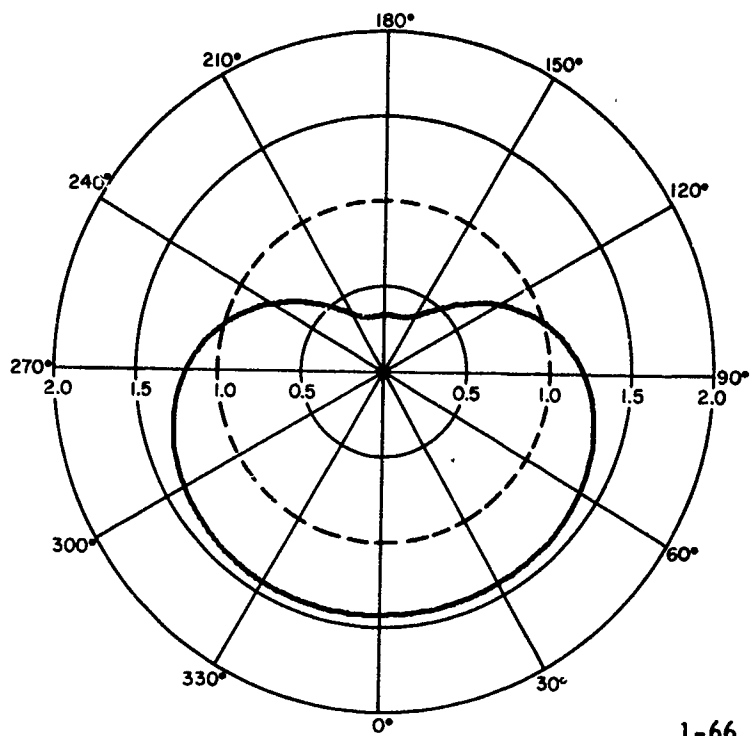
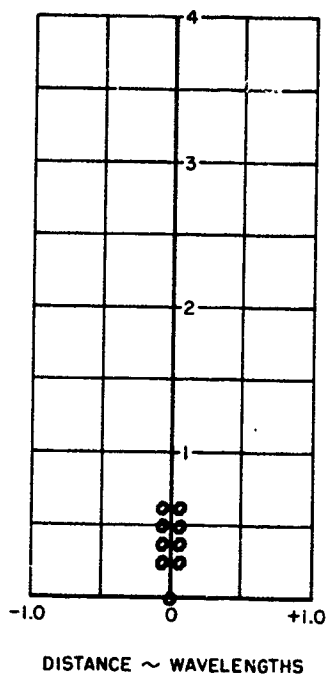


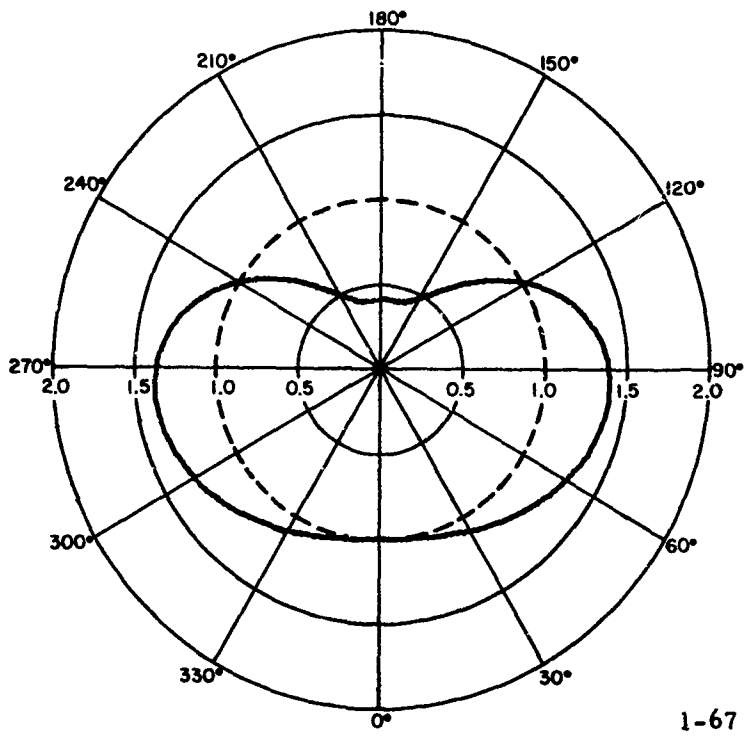
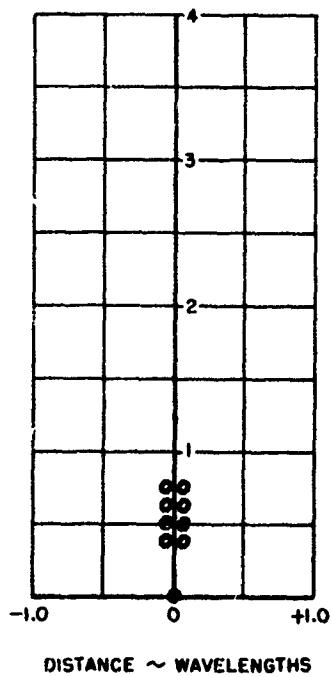
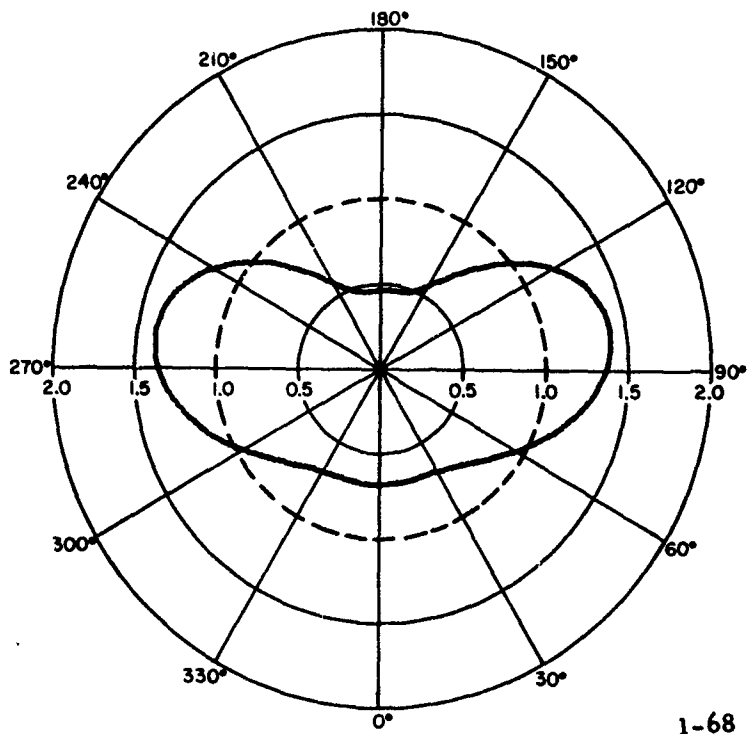
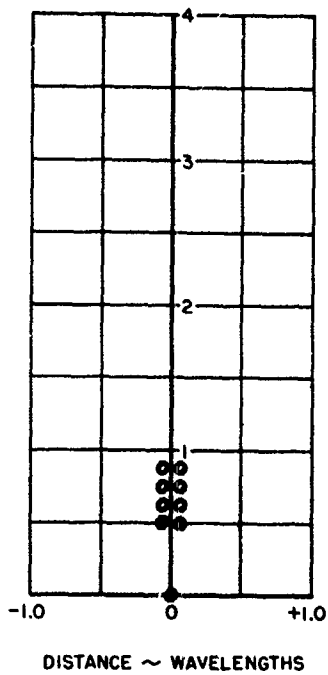
DISTANCE ~ WAVELENGTHS

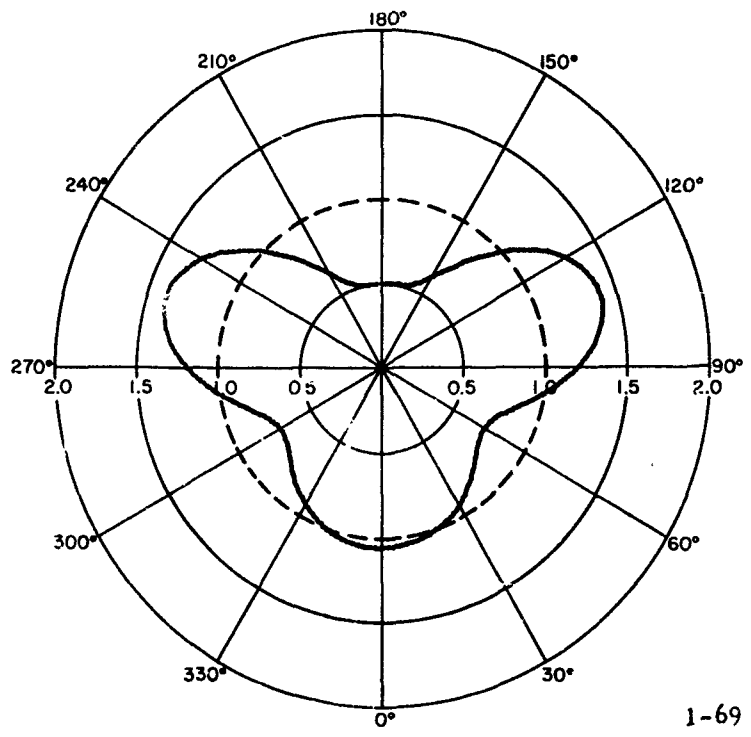
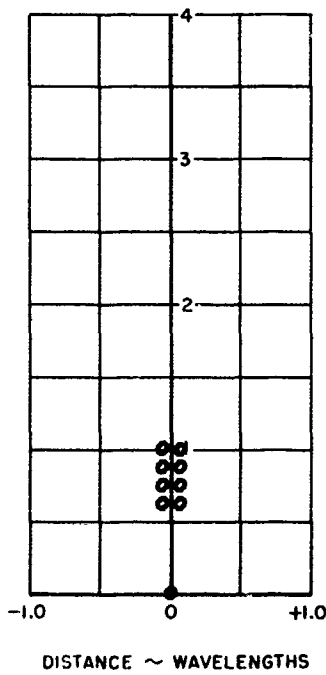
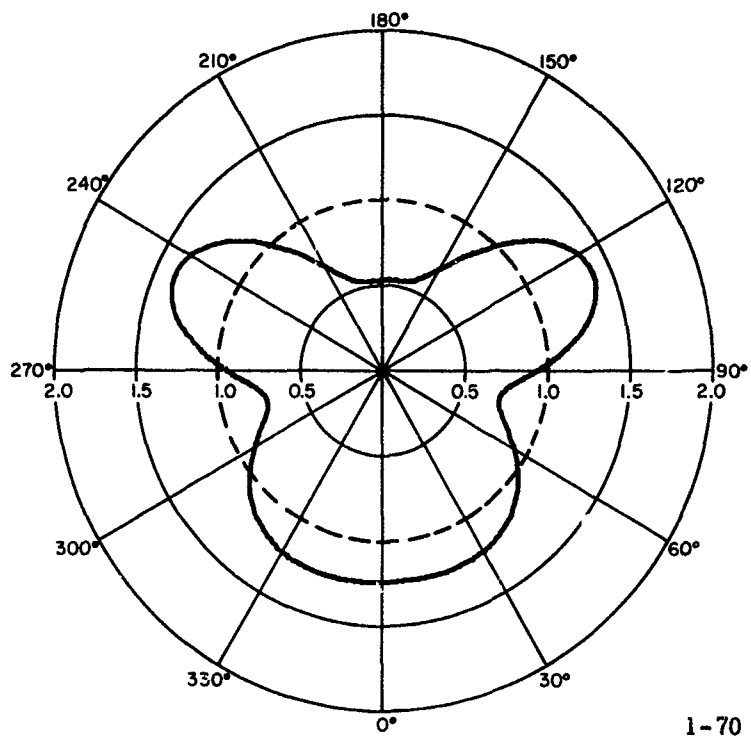
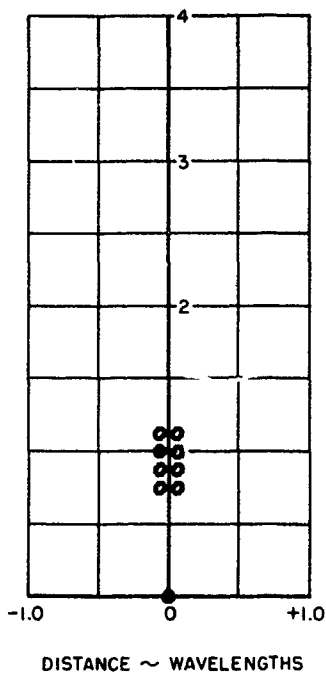


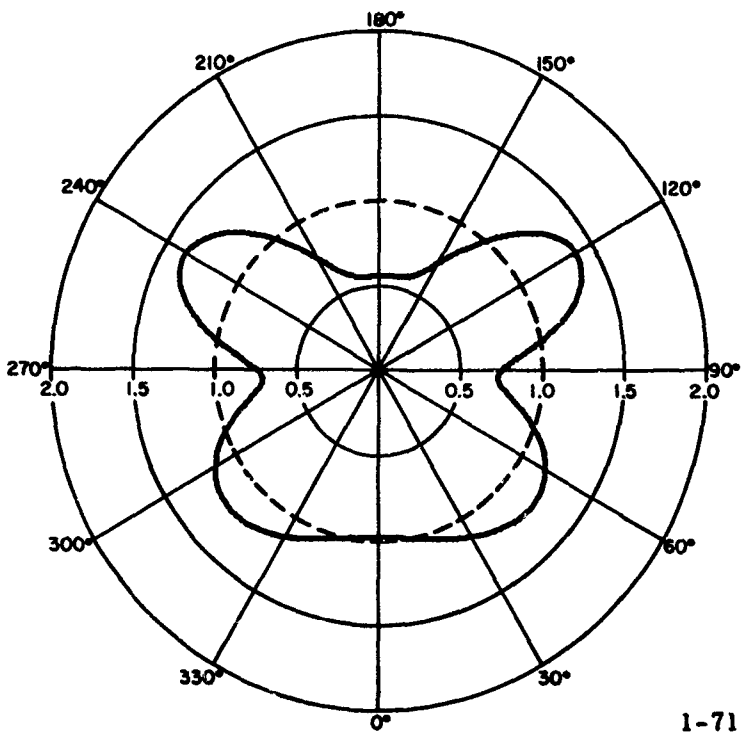
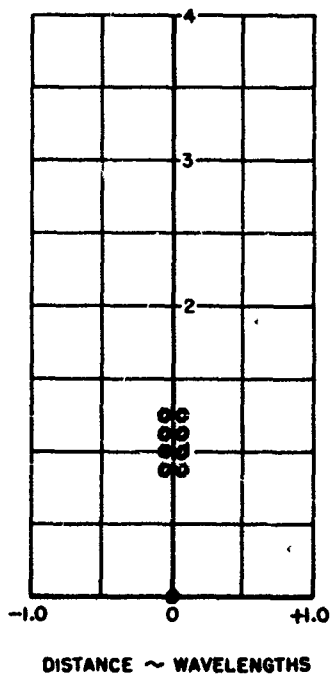
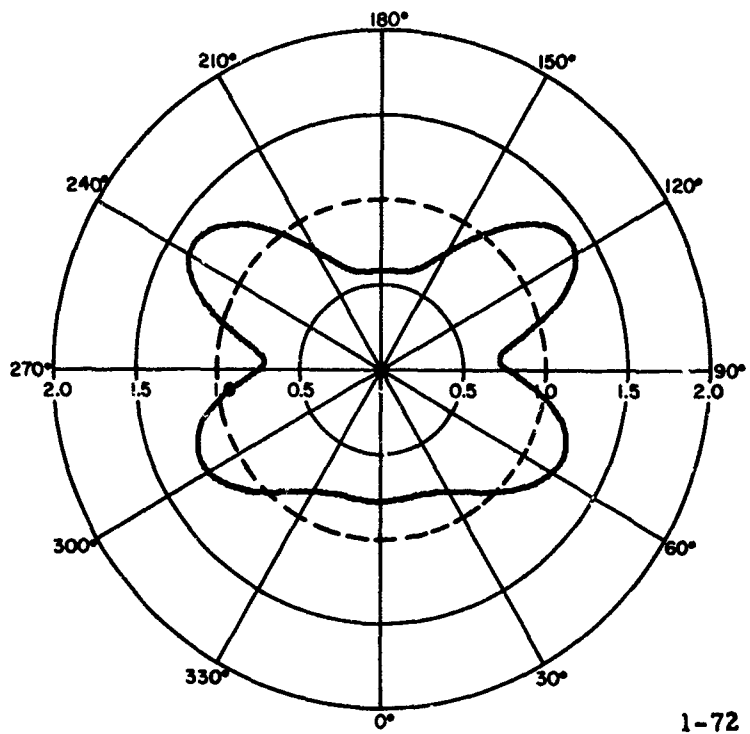
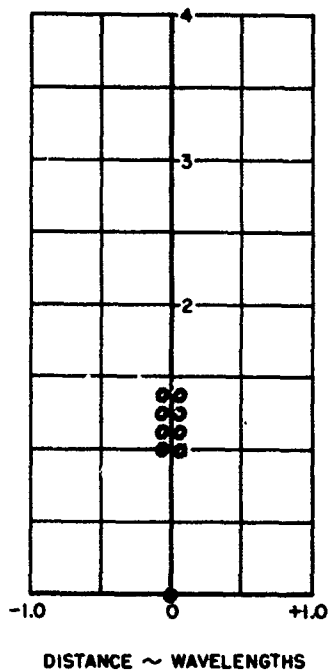
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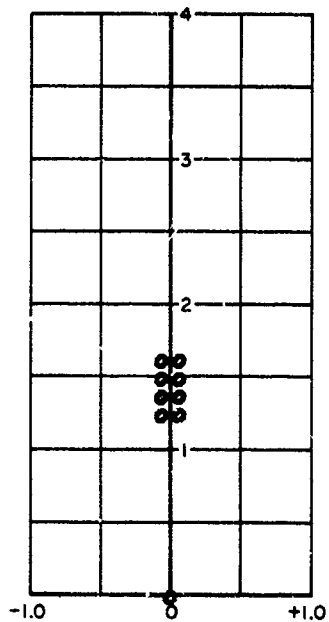




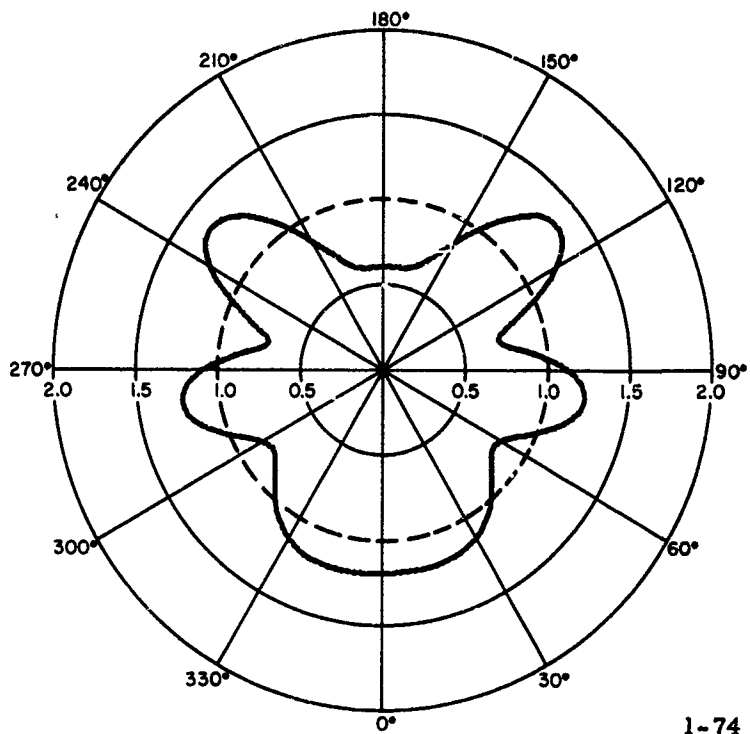




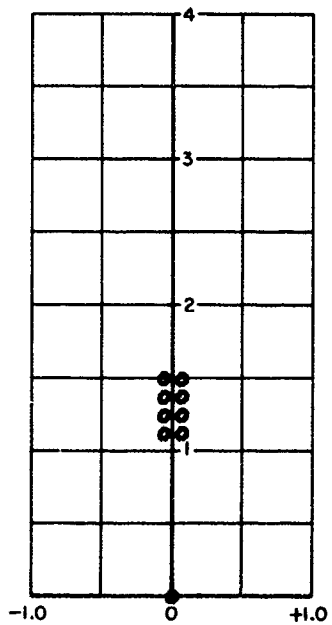




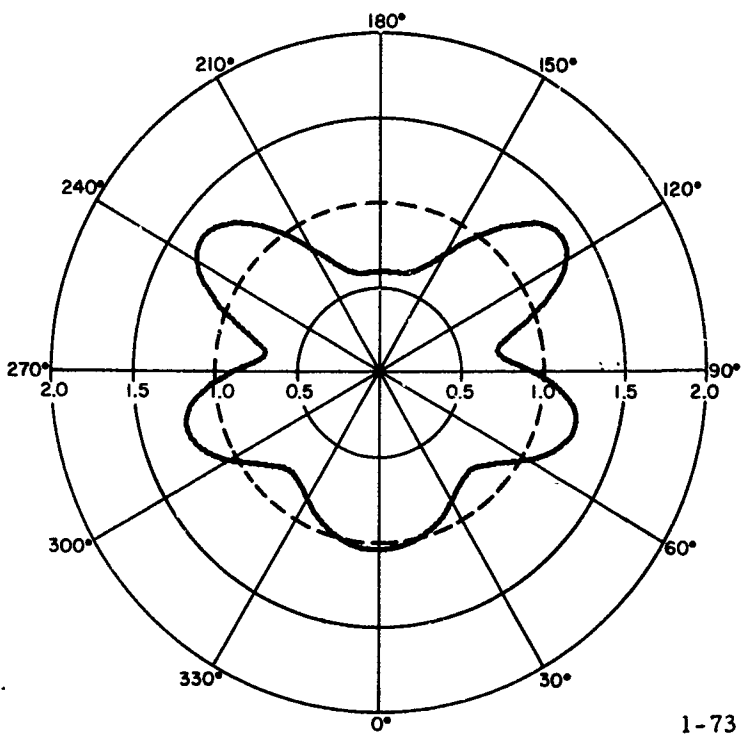
DISTANCE ~ WAVELENGTHS



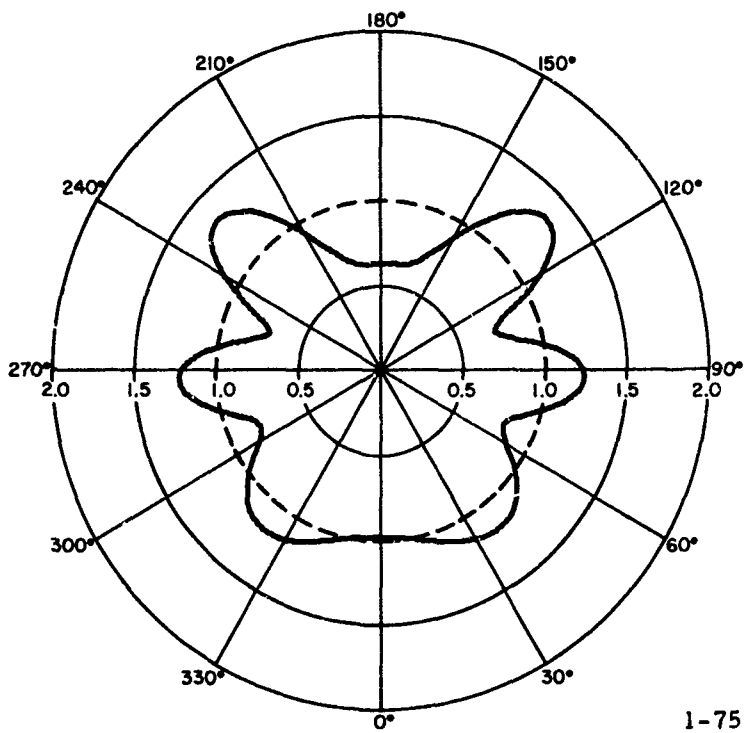
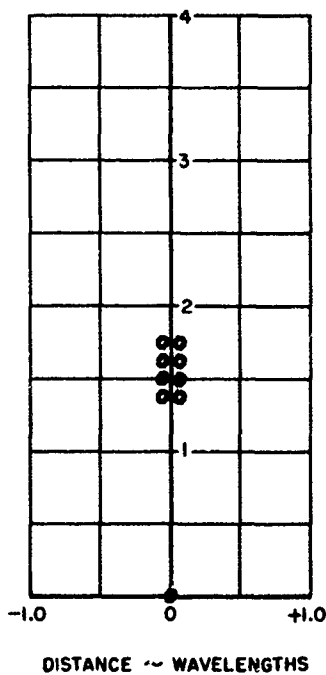
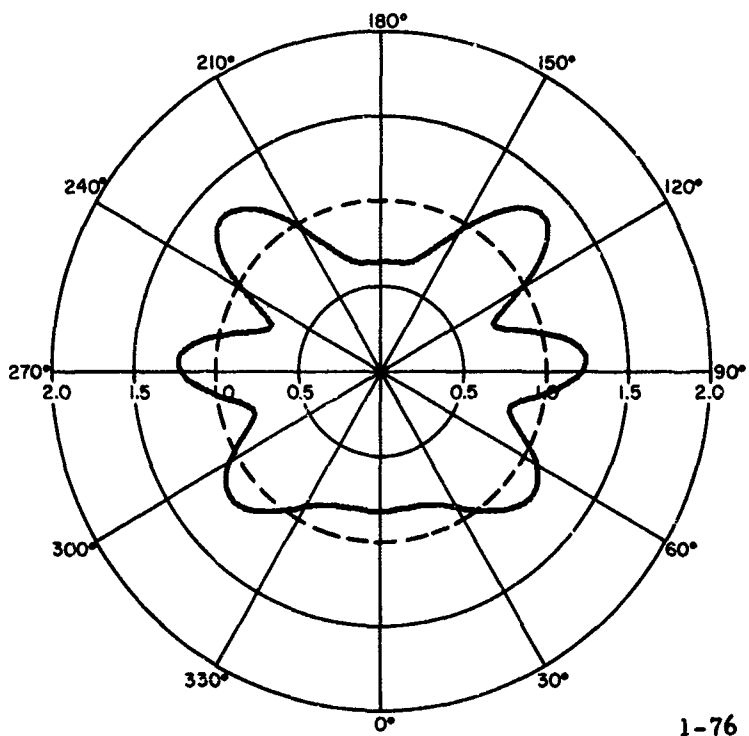
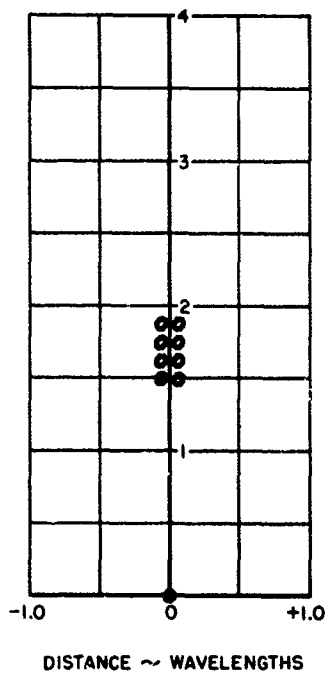
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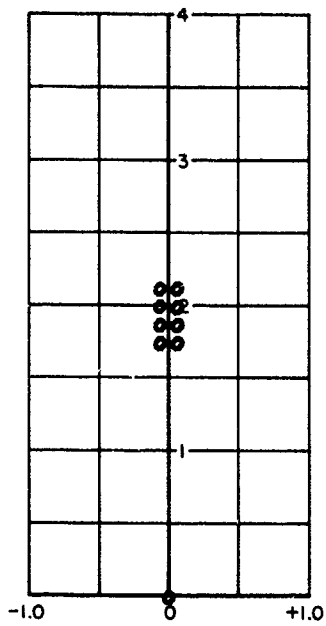


DISTANCE ~ WAVELENGTHS

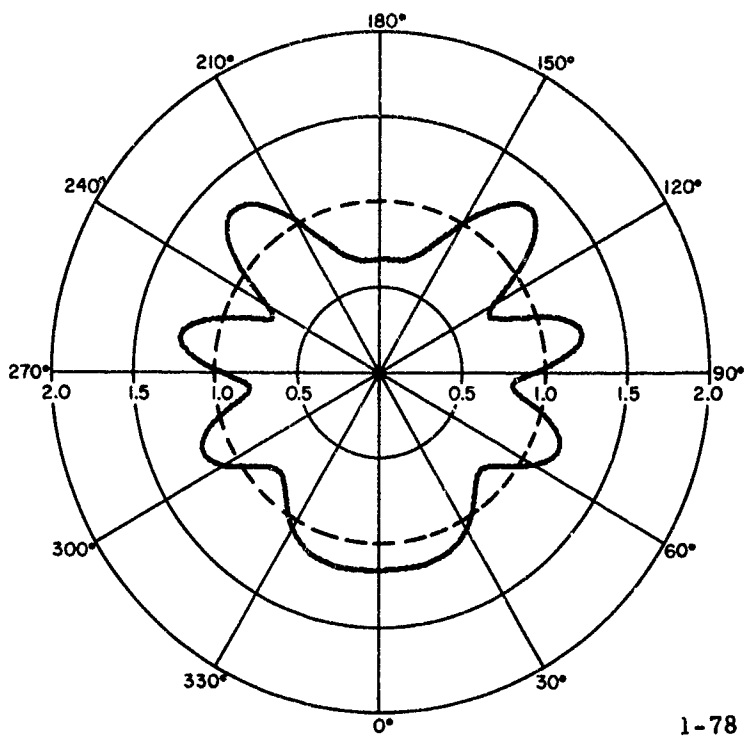


1-73

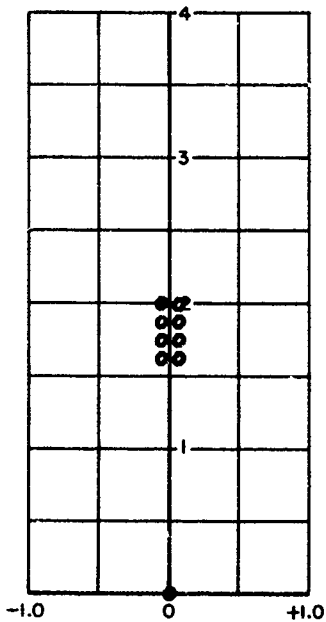




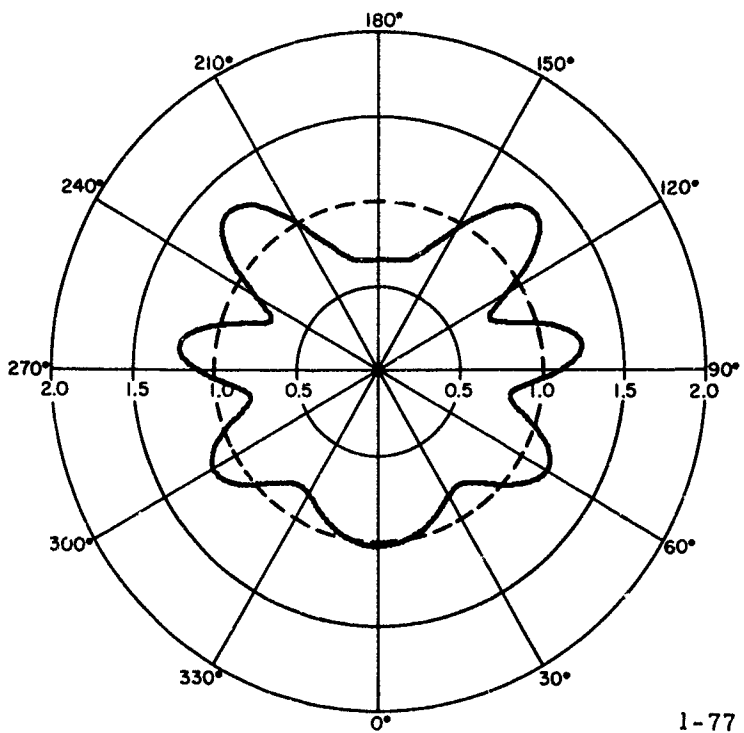
DISTANCE ~ WAVELENGTHS



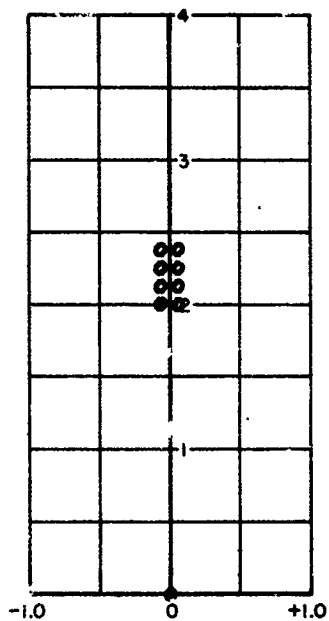
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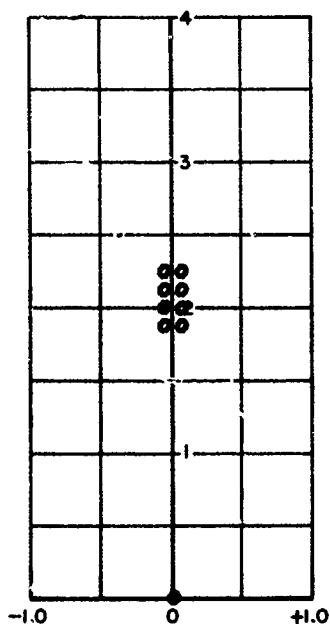
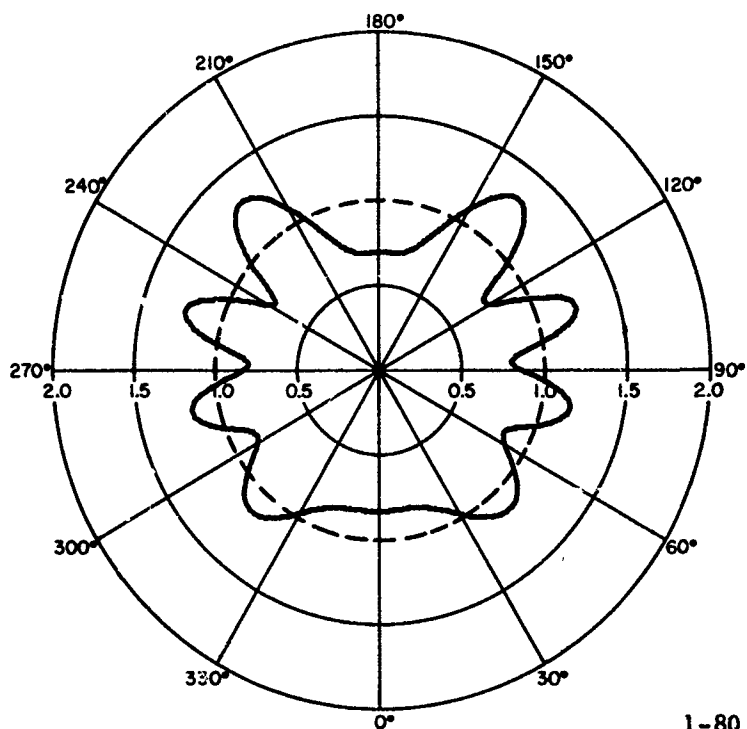
DISTANCE ~ WAVELENGTHS



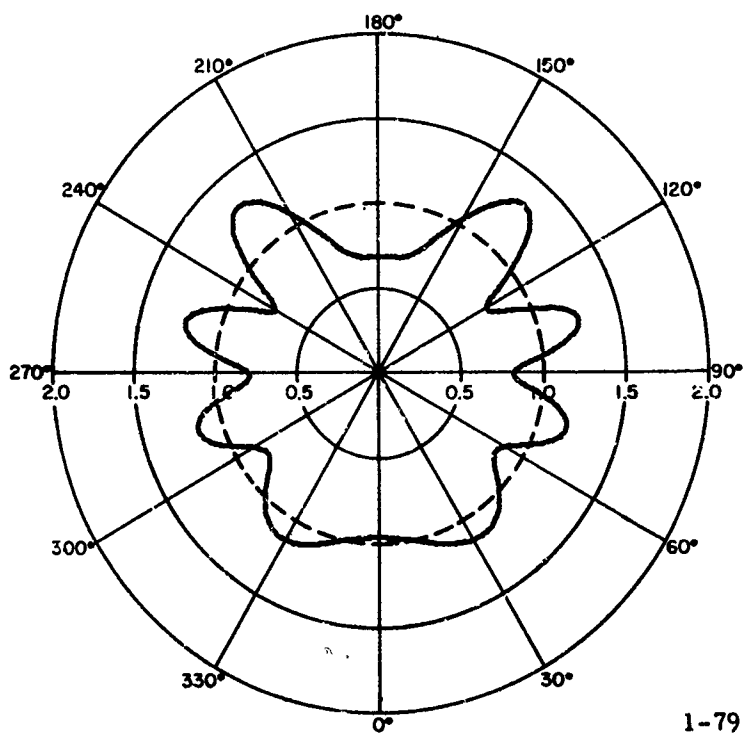
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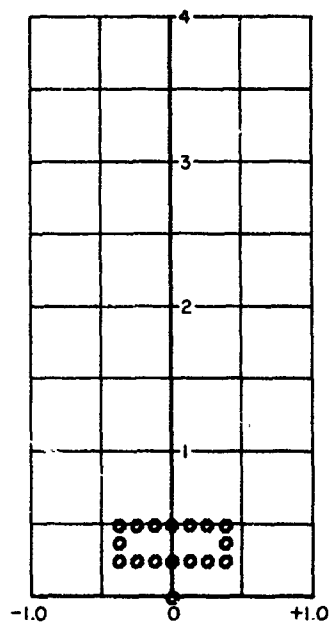


DISTANCE ~ WAVELENGTHS

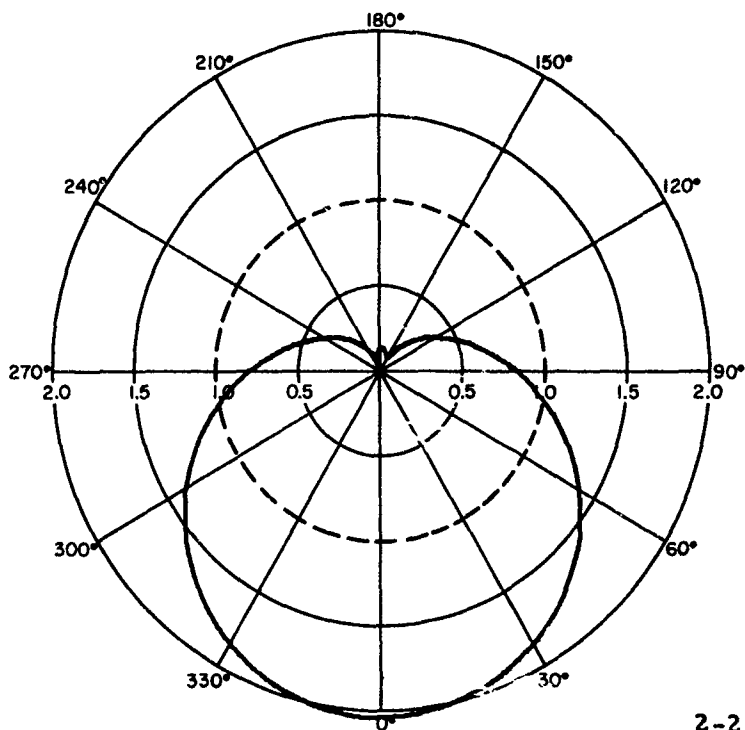


DISTANCE ~ WAVELENGTHS

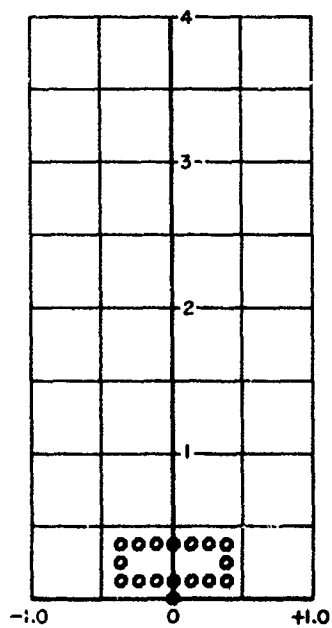




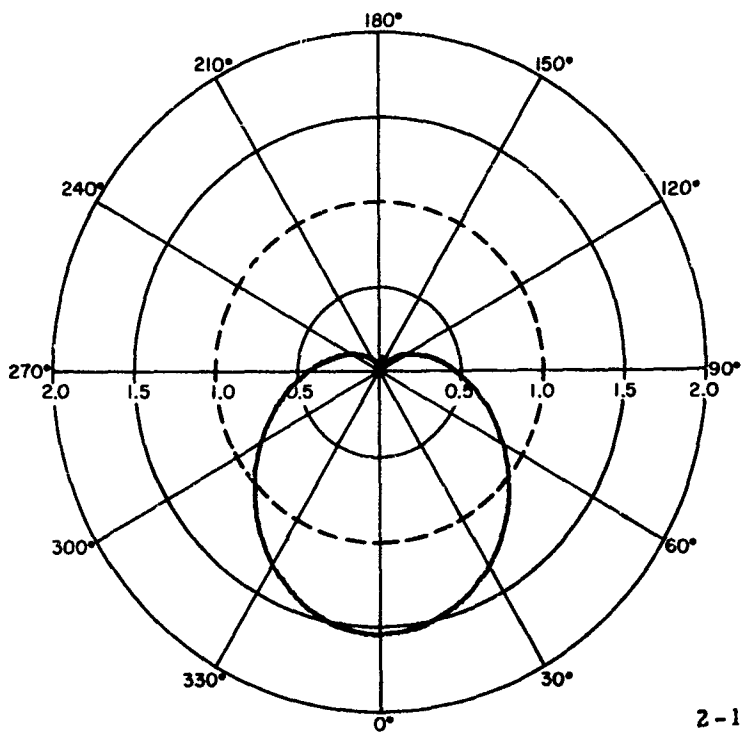
DISTANCE ~ WAVELENGTHS



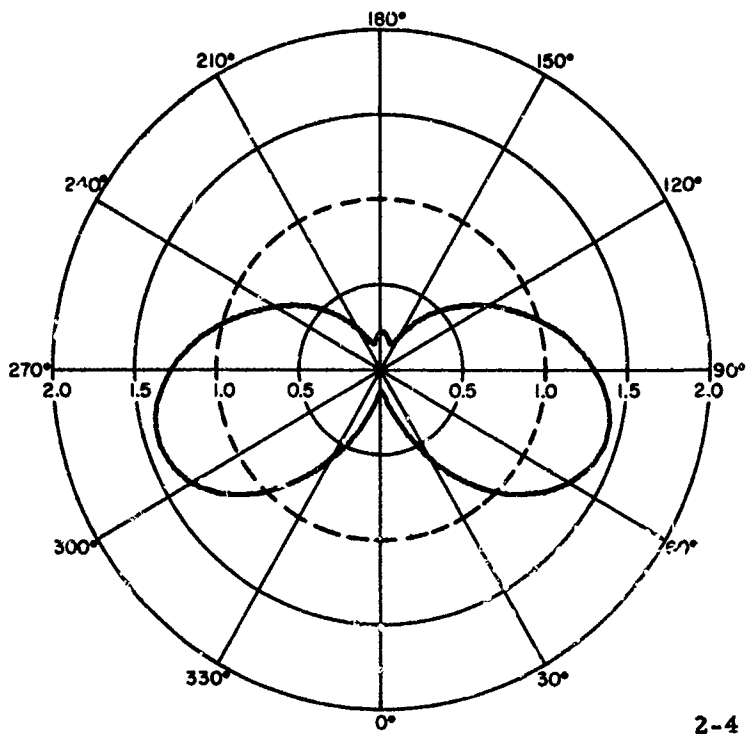
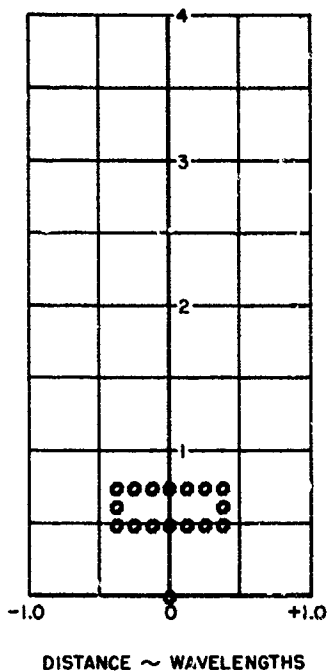
2-2



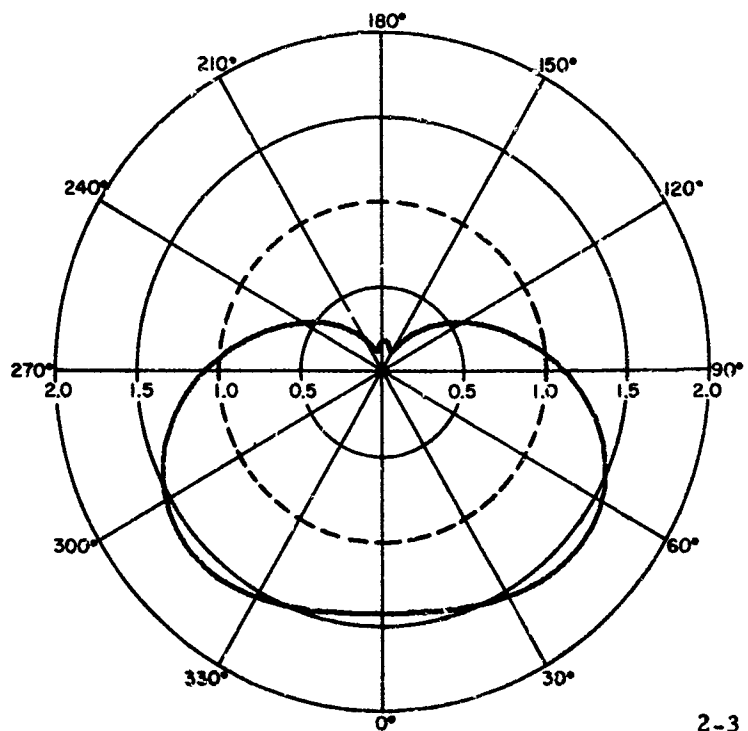
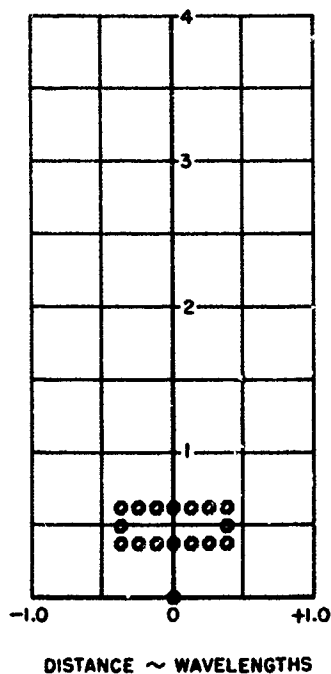
DISTANCE ~ WAVELENGTHS



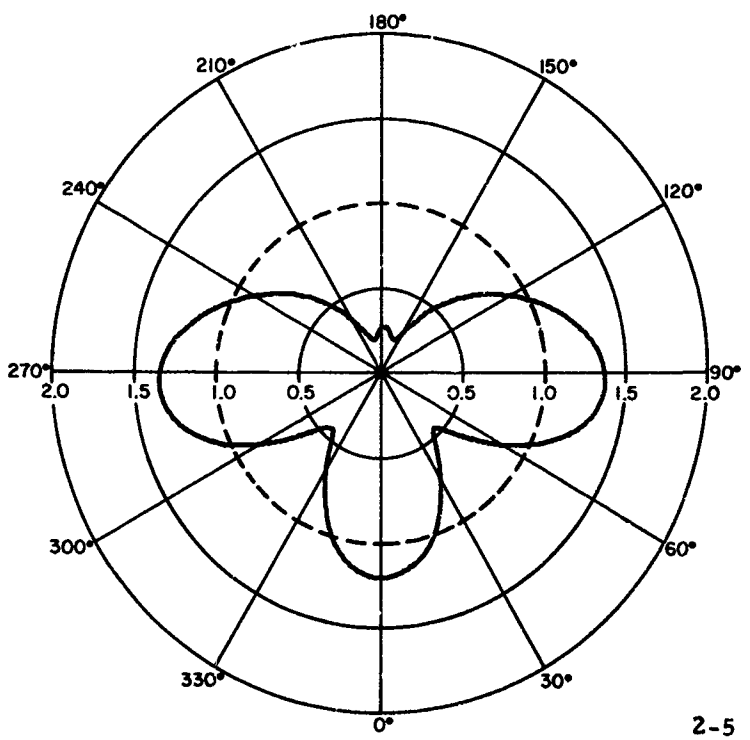
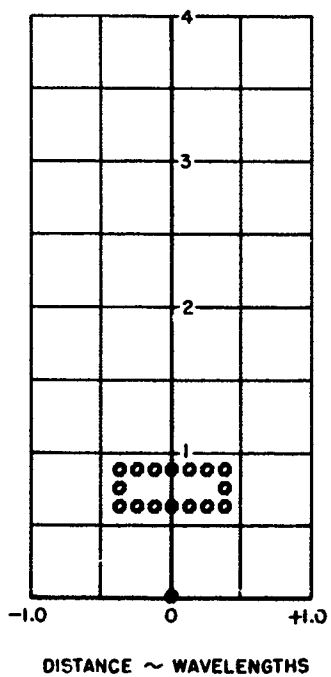
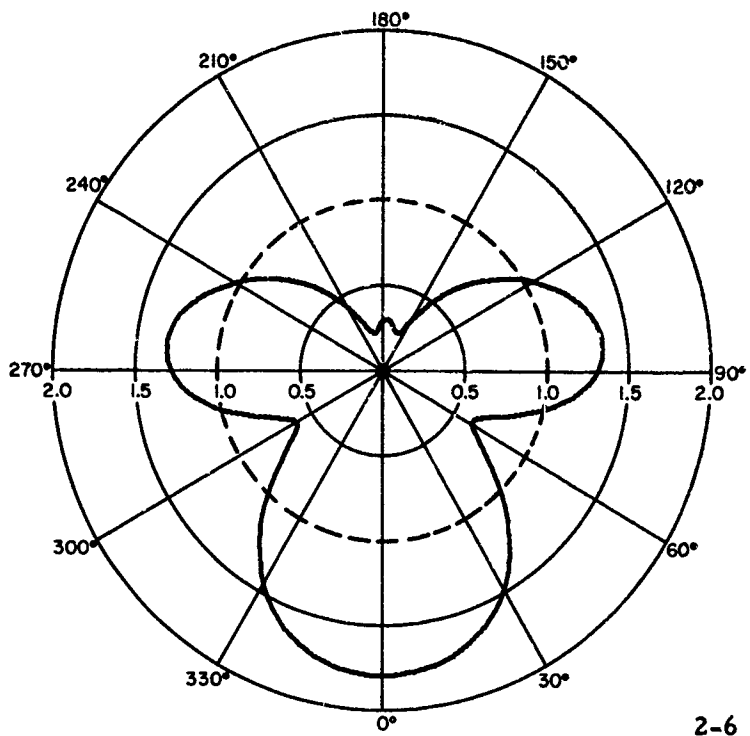
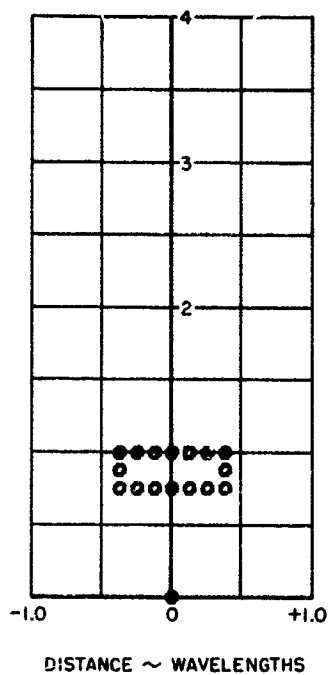
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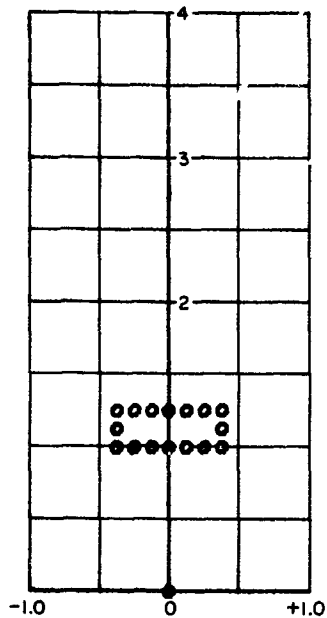


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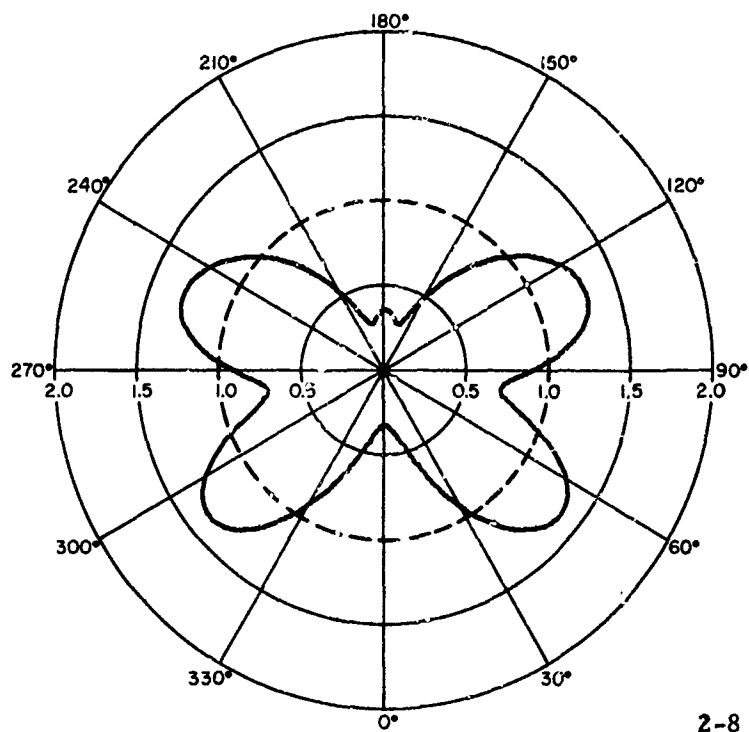


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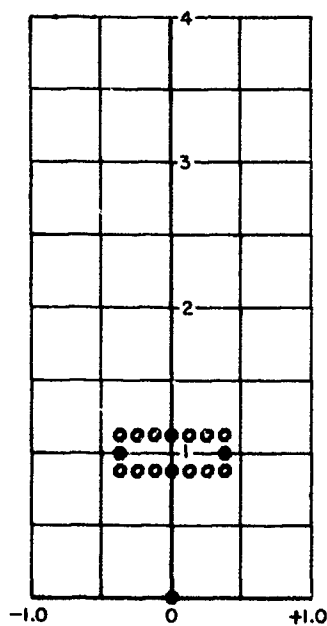




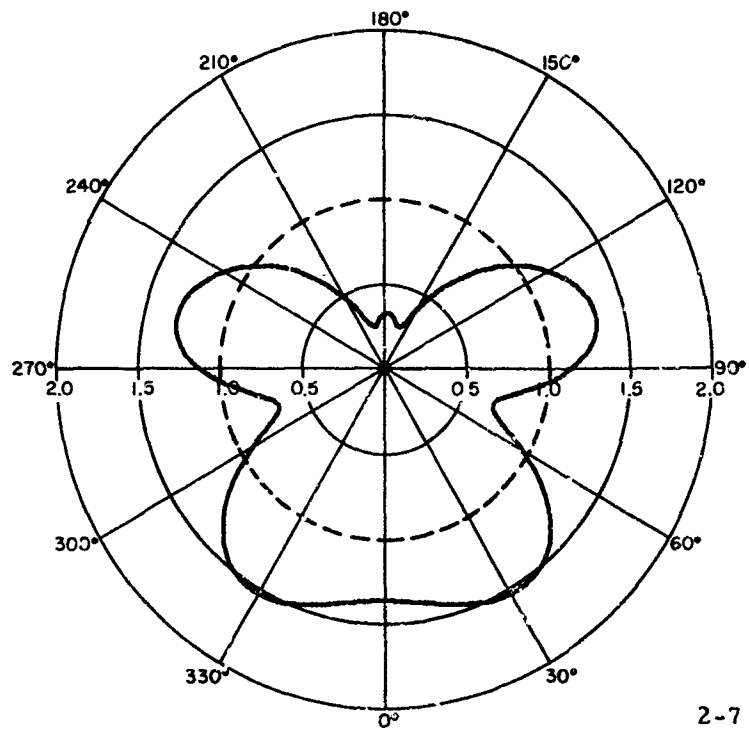
DISTANCE ~ WAVELENGTHS



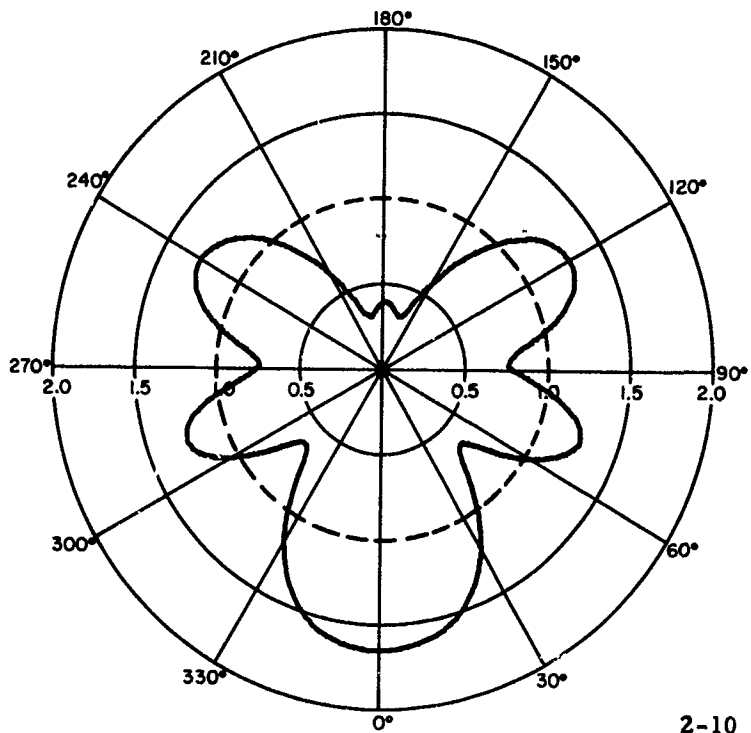
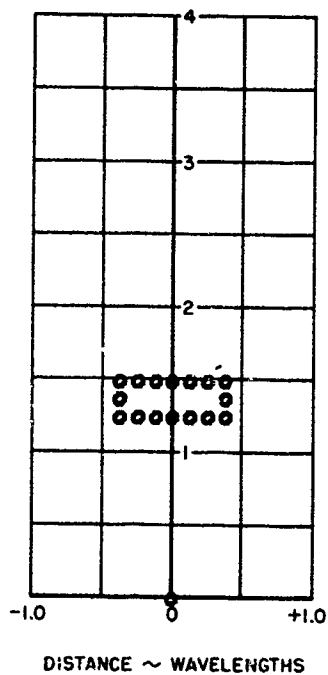
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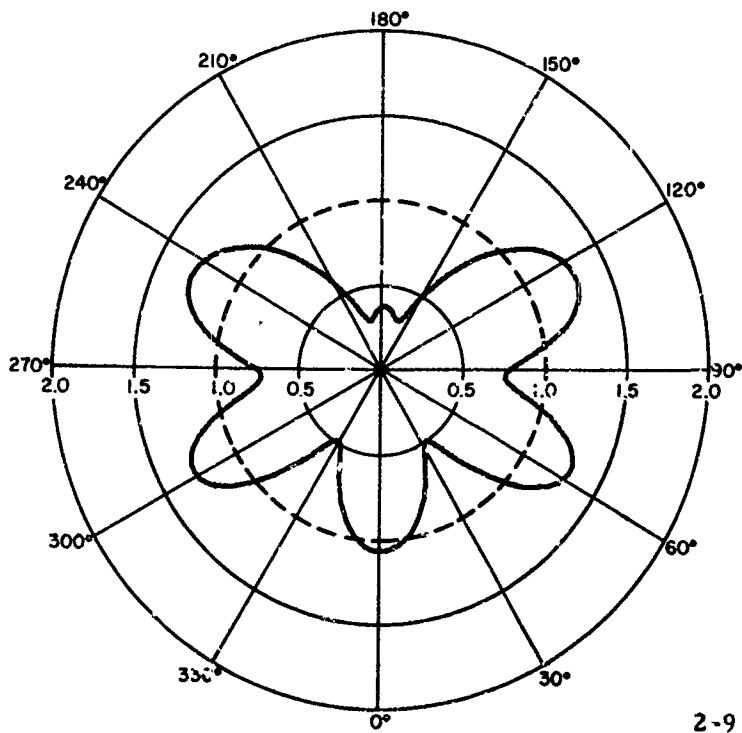
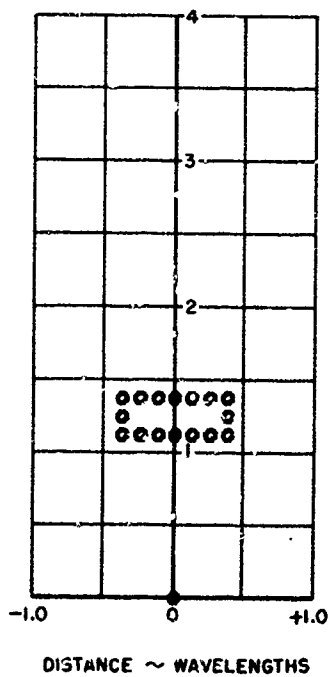
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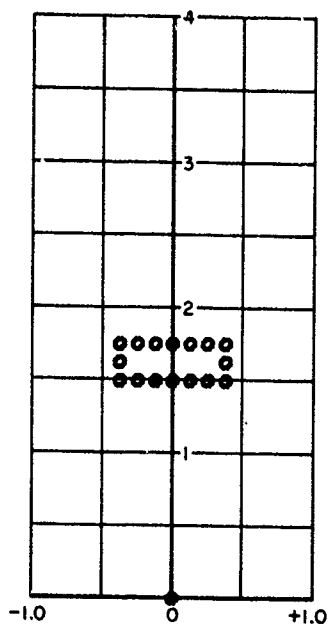
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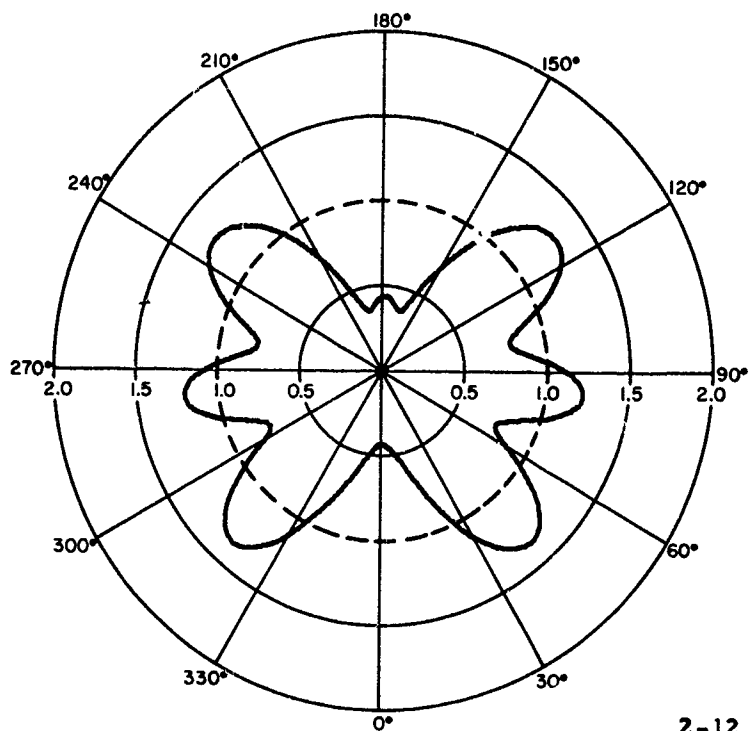
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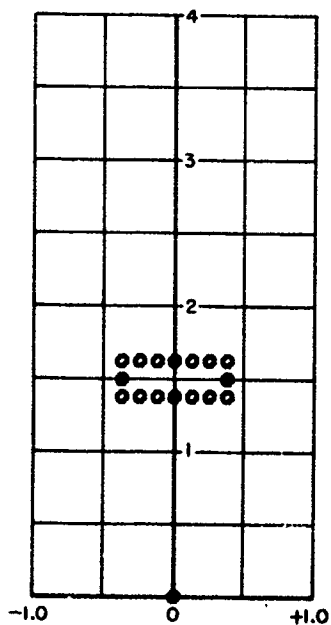
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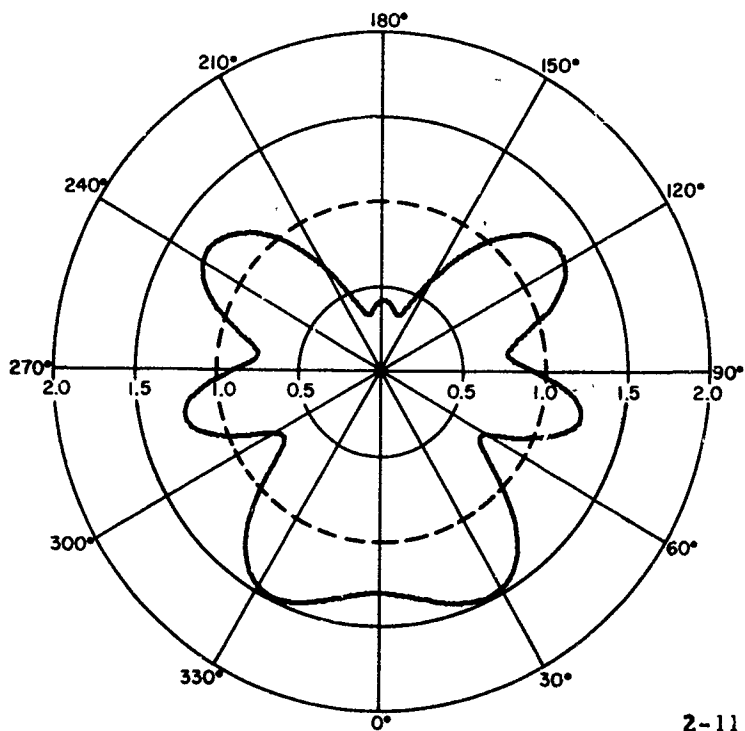
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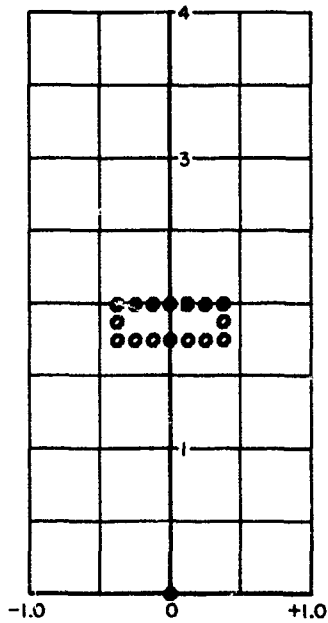
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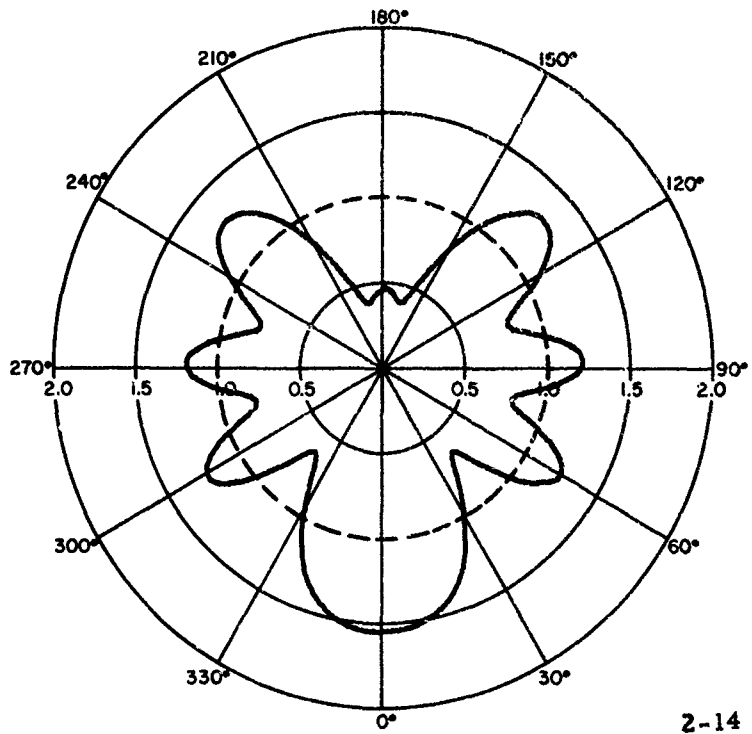
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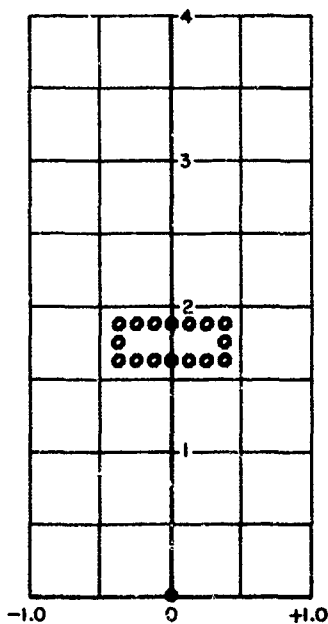
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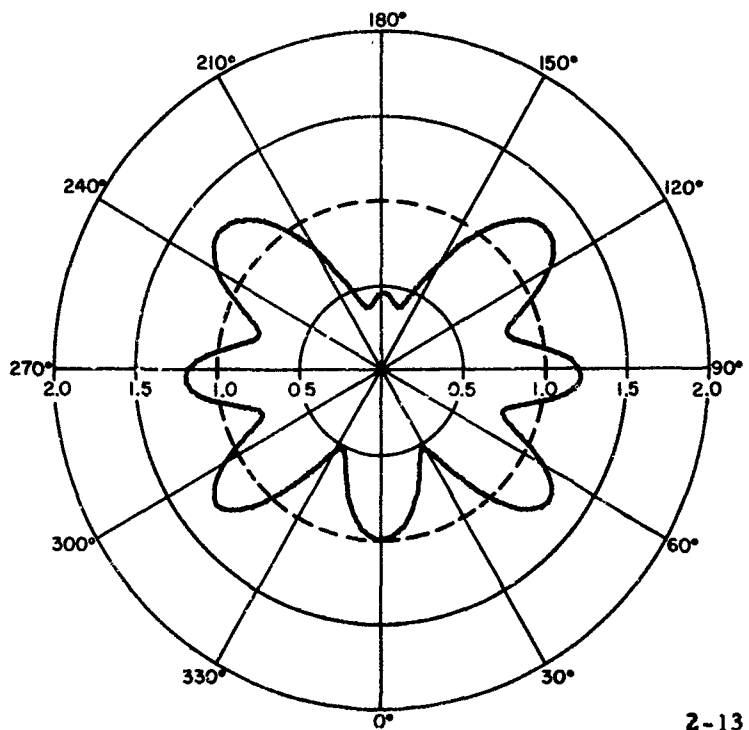
DISTANCE ~ WAVELENGTHS



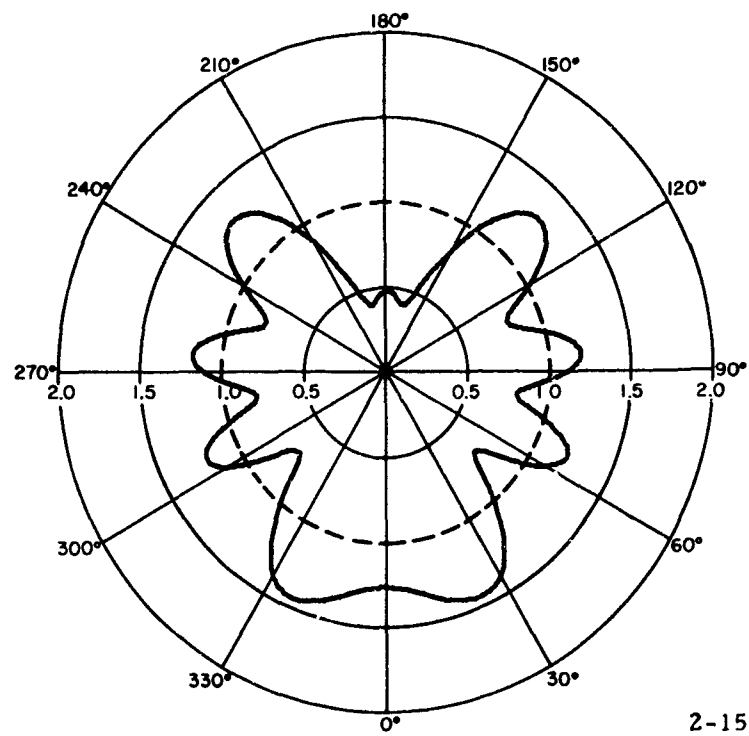
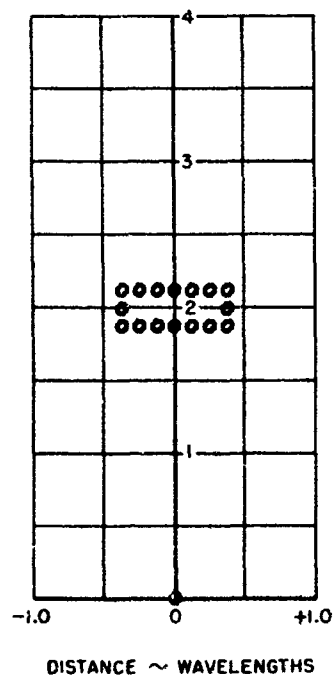
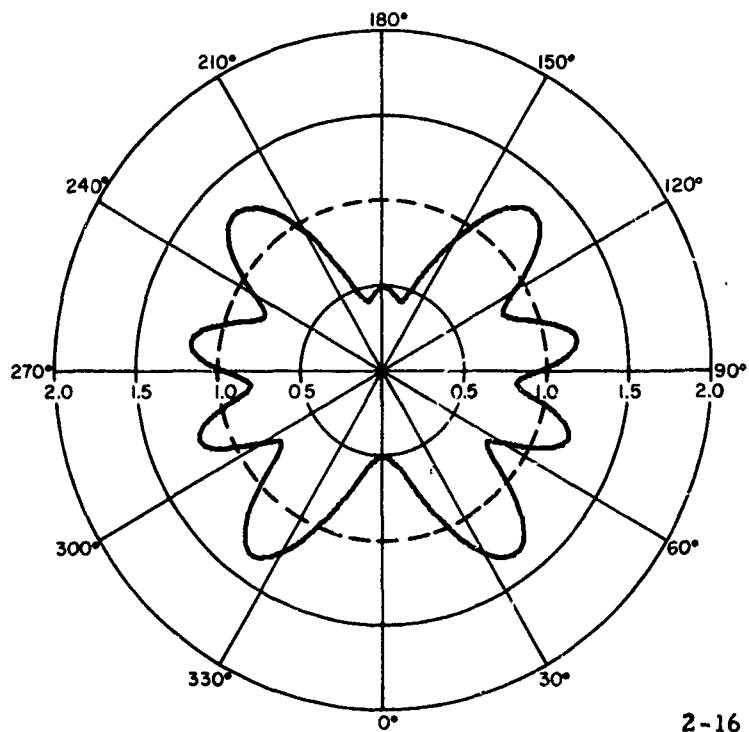
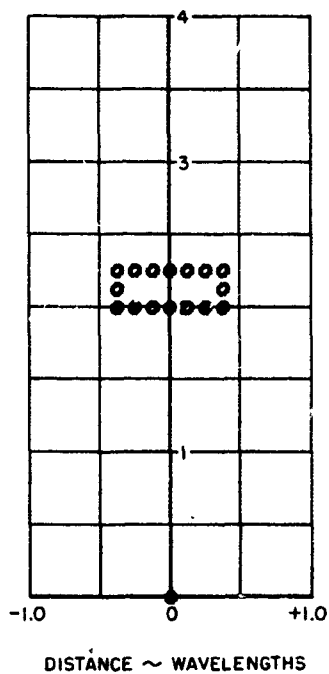
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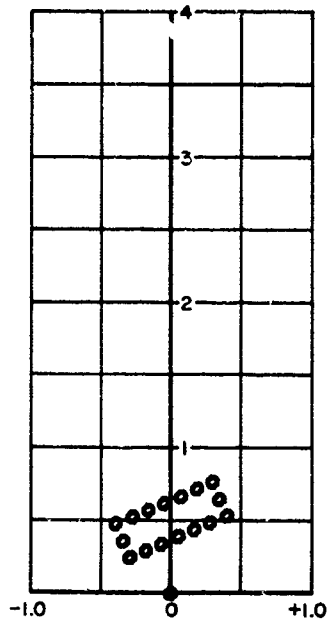


DISTANCE ~ WAVELENGTHS

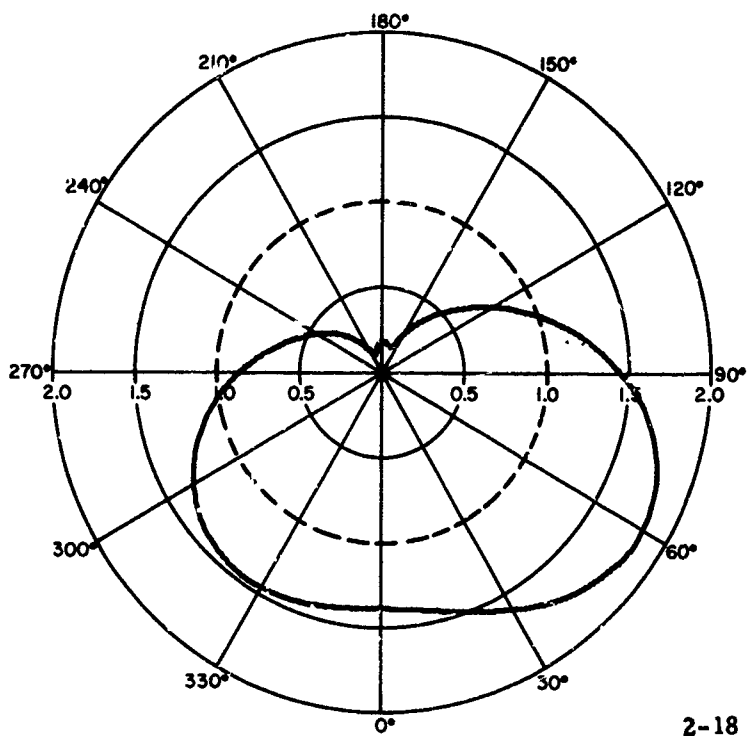


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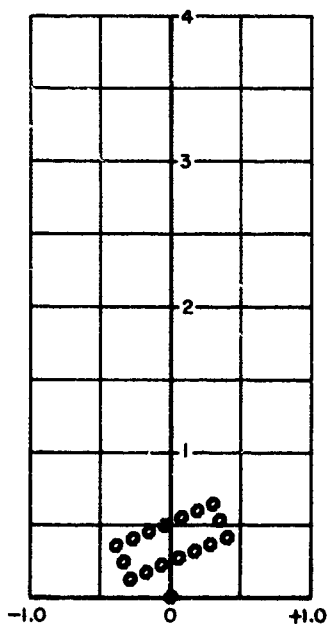




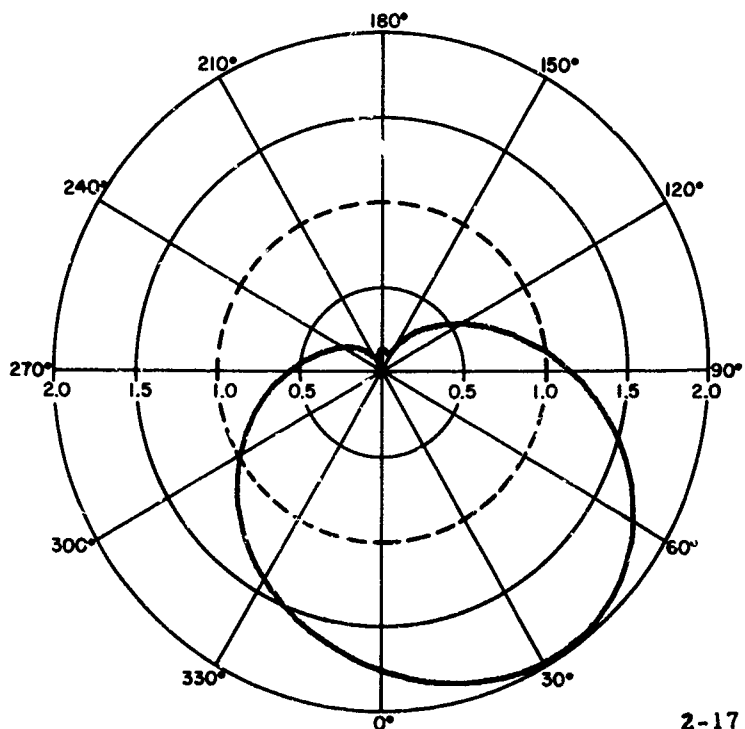
DISTANCE ~ WAVELENGTHS



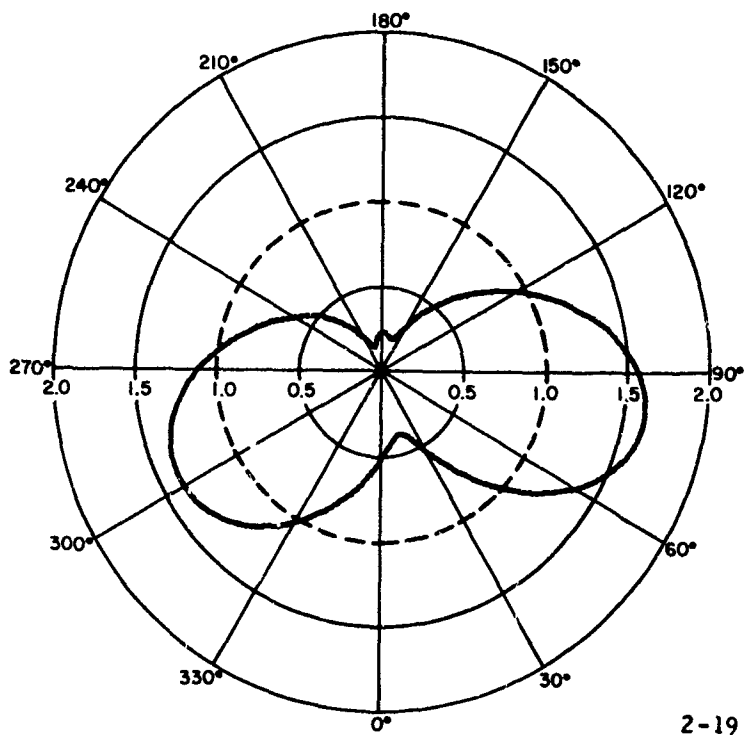
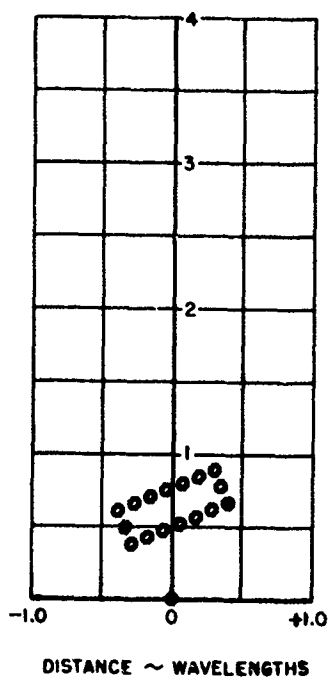
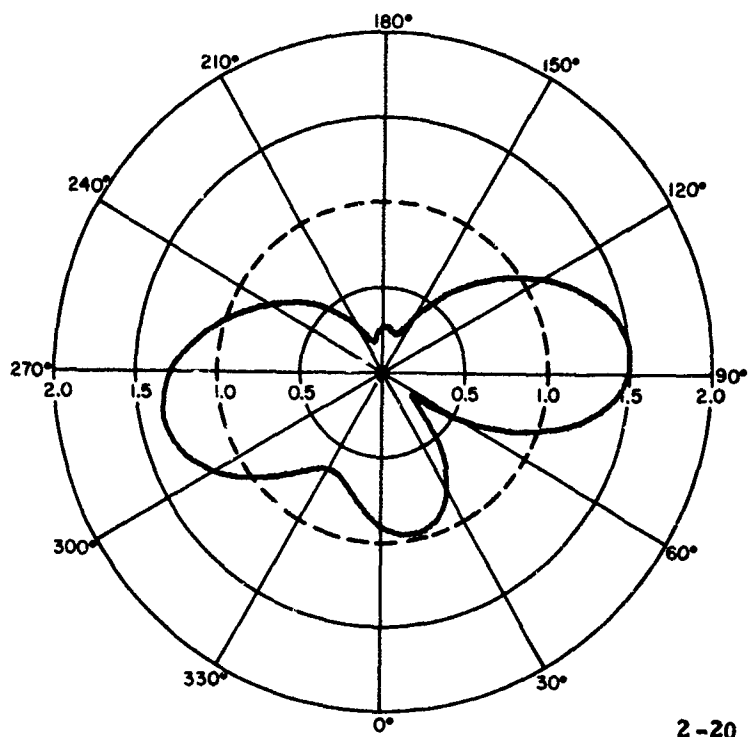
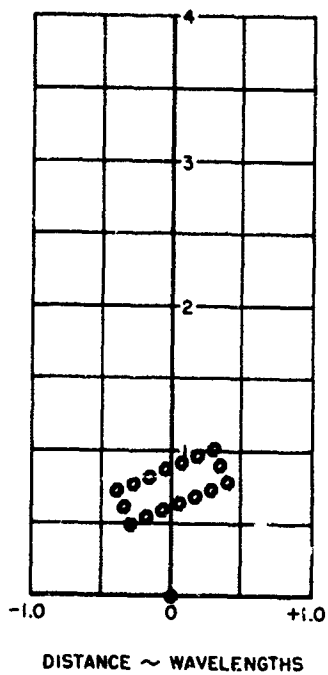
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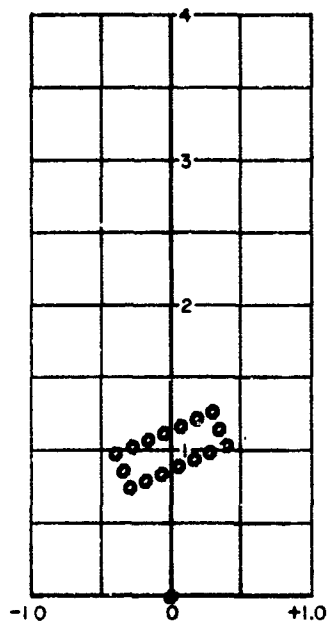


DISTANCE ~ WAVELENGTHS

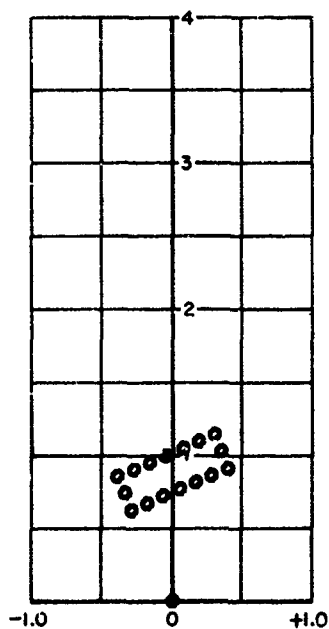
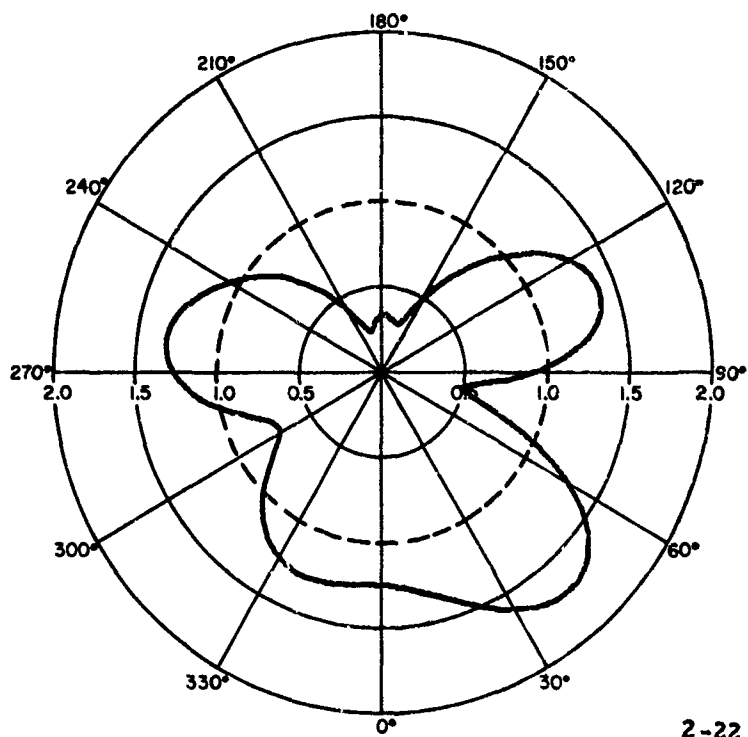


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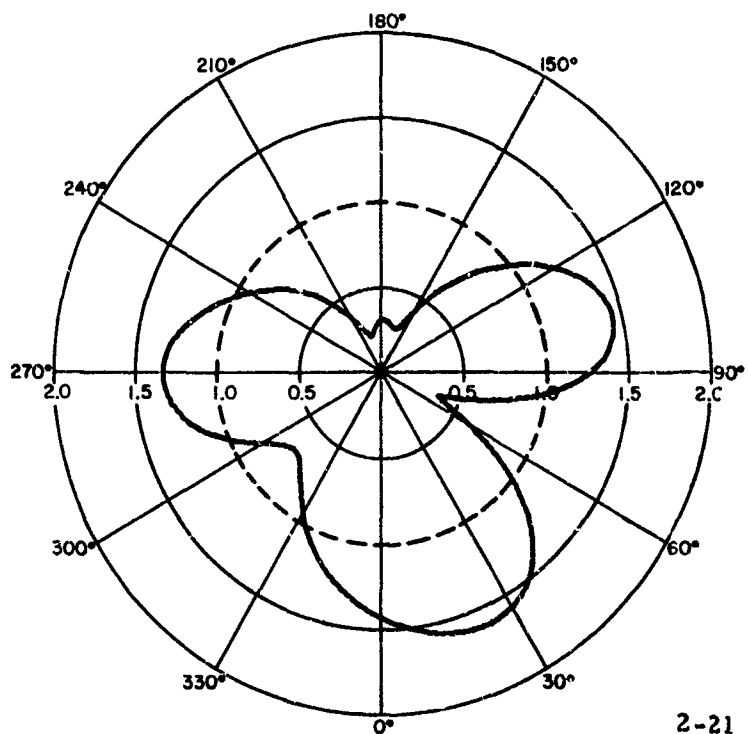


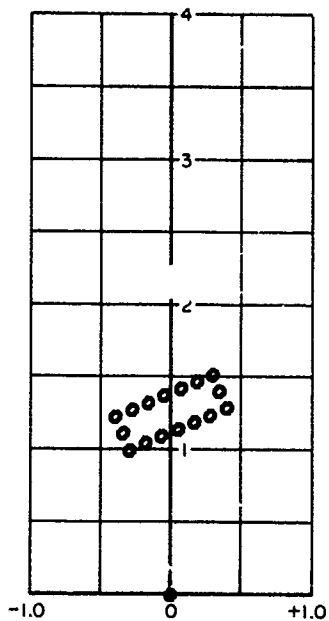


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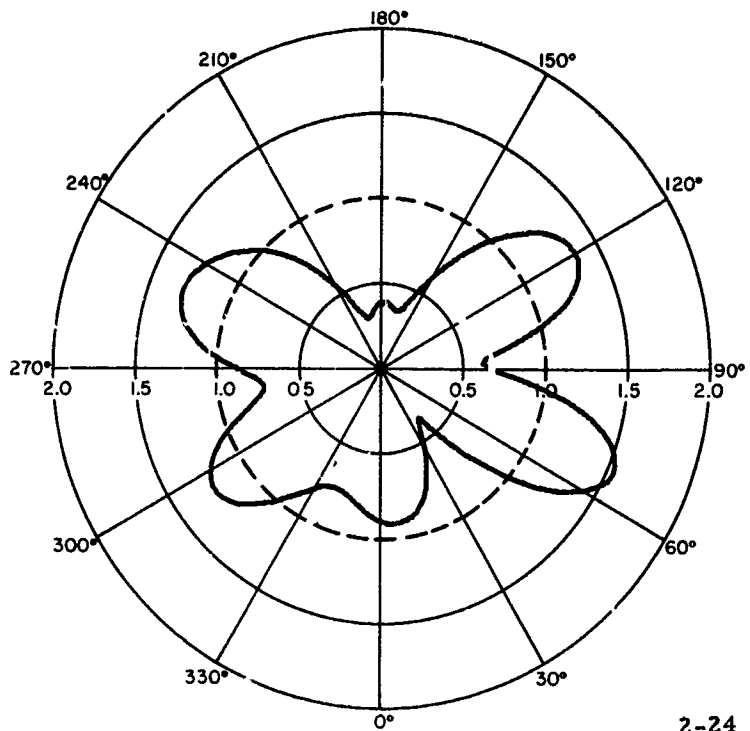


DISTANCE ~ WAVELENGTHS

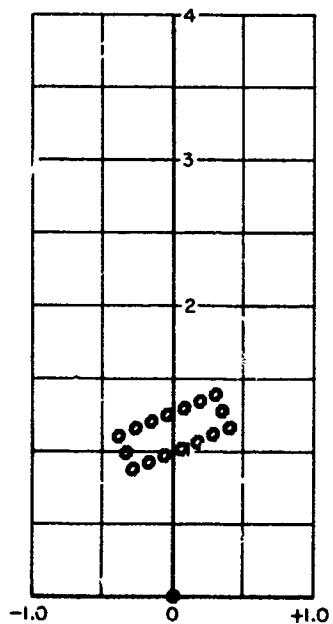




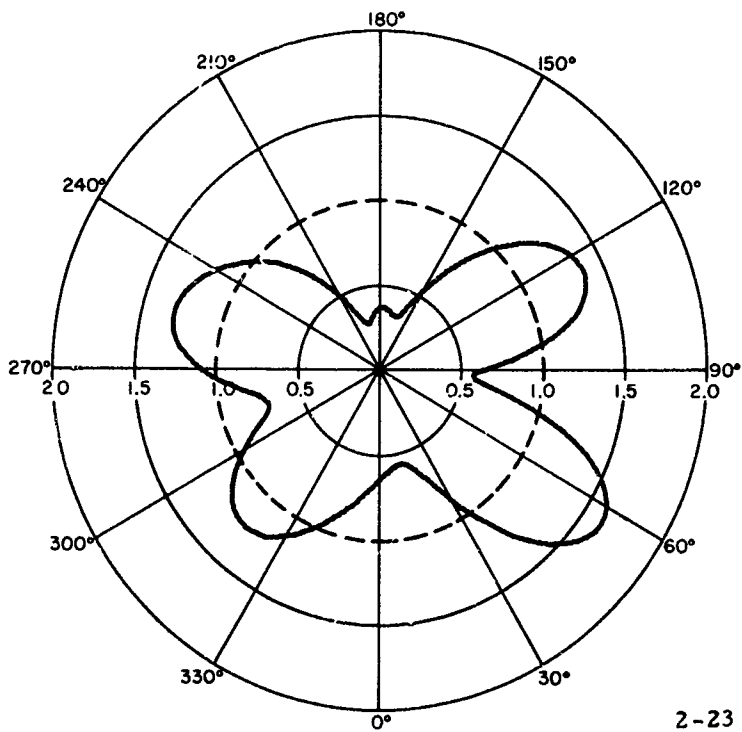
DISTANCE ~ WAVELENGTHS



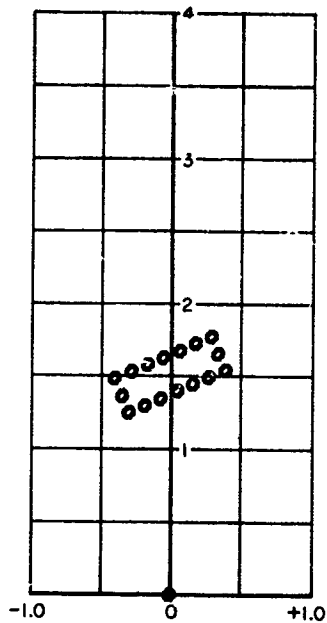
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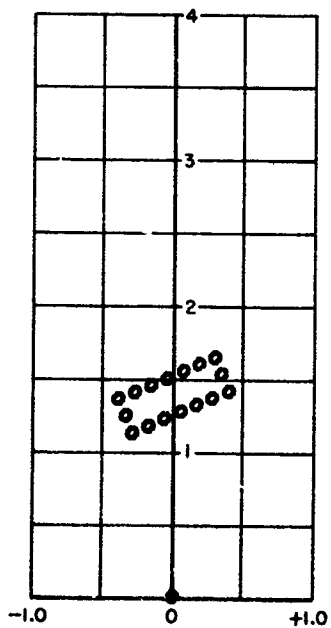
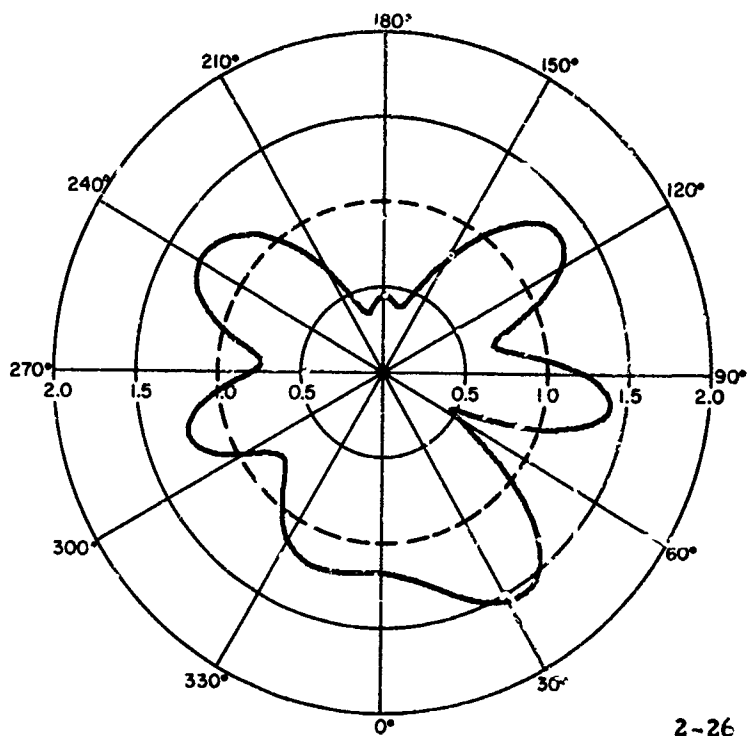
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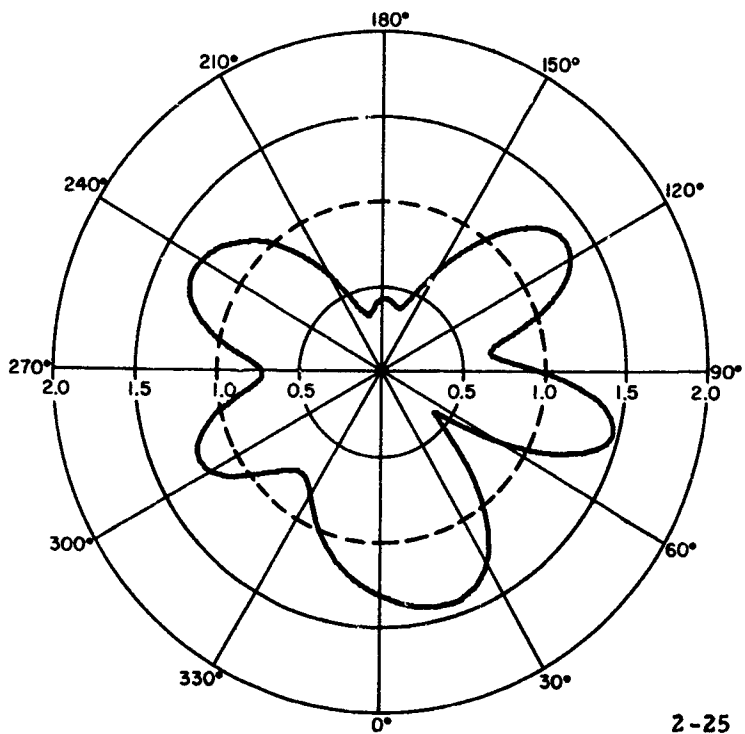
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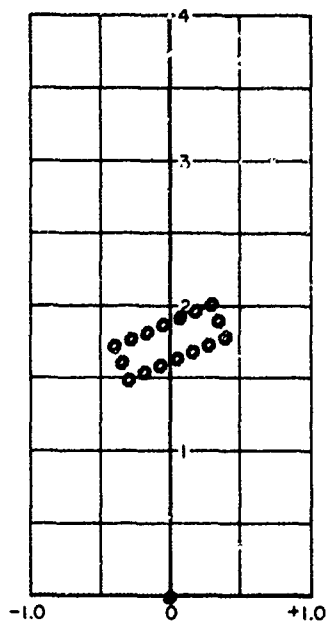


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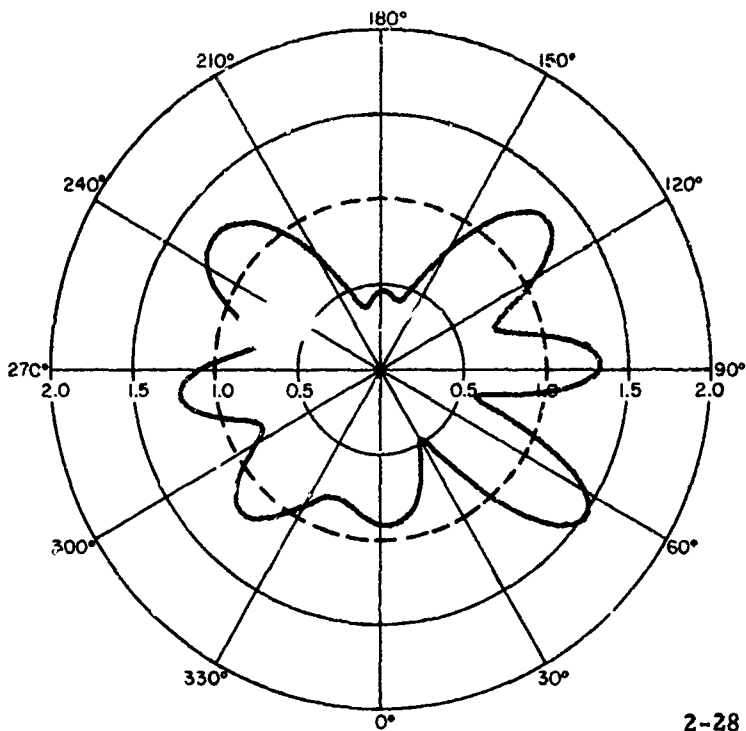


DISTANCE ~ WAVELENGTHS

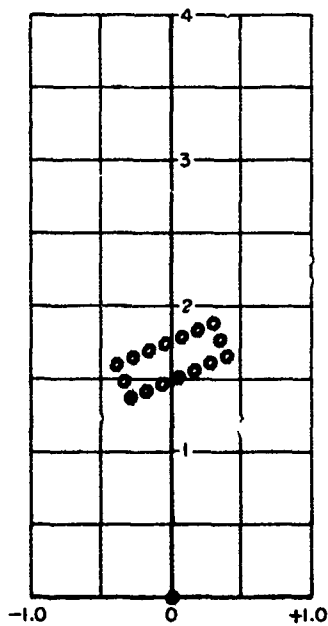




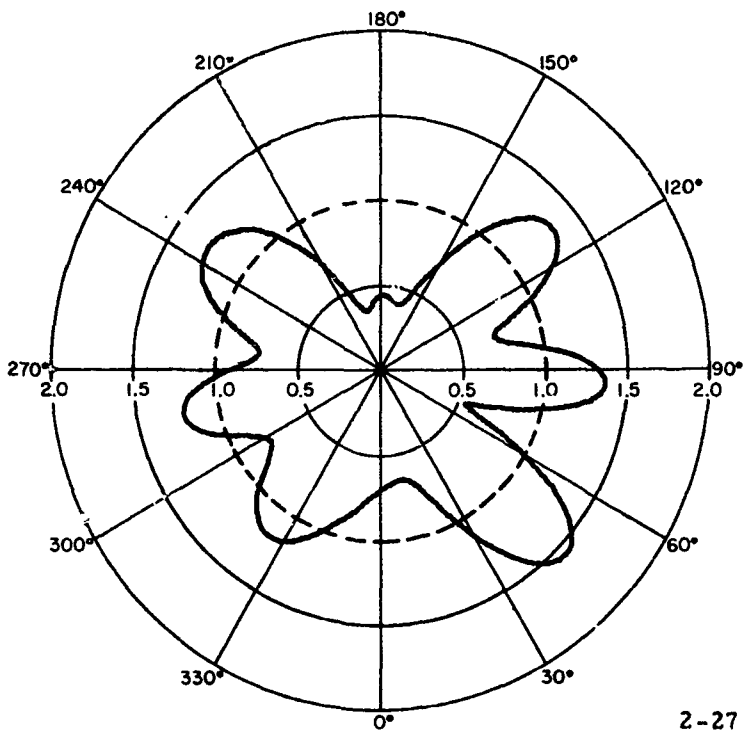
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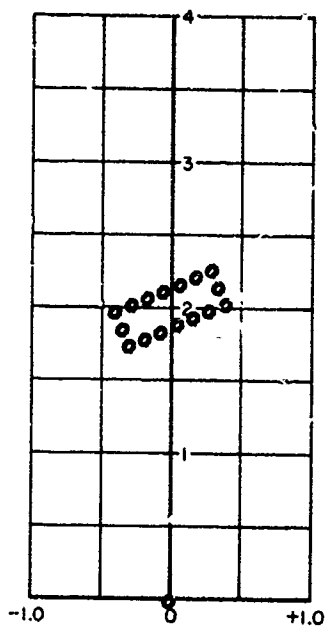
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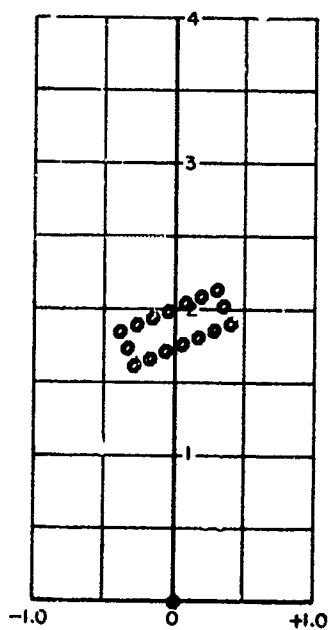
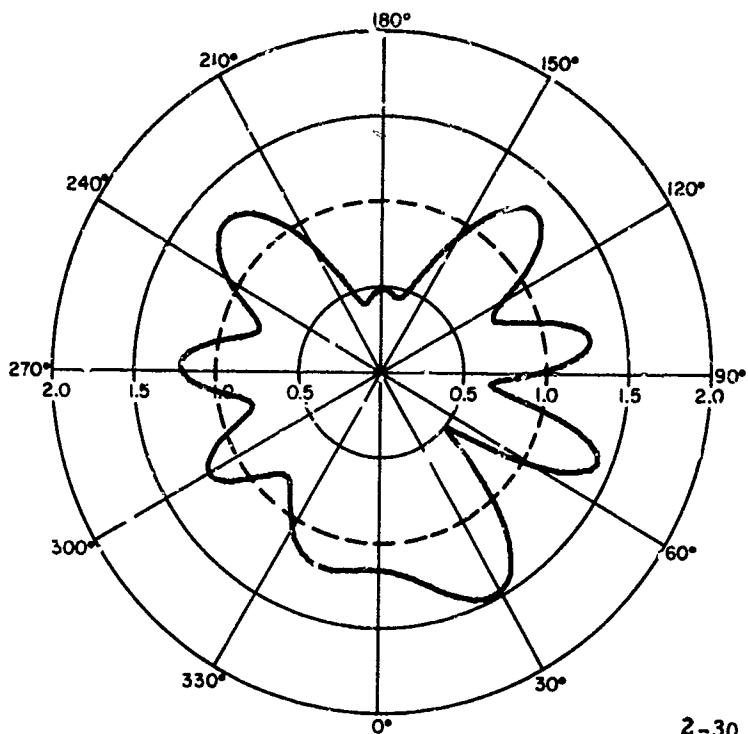
DISTANCE ~ WAVELENGTHS



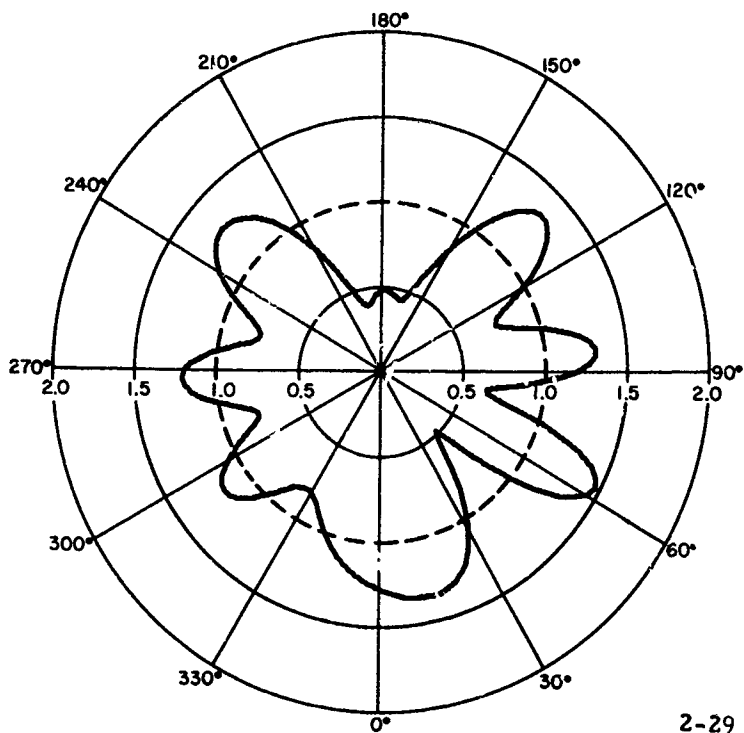
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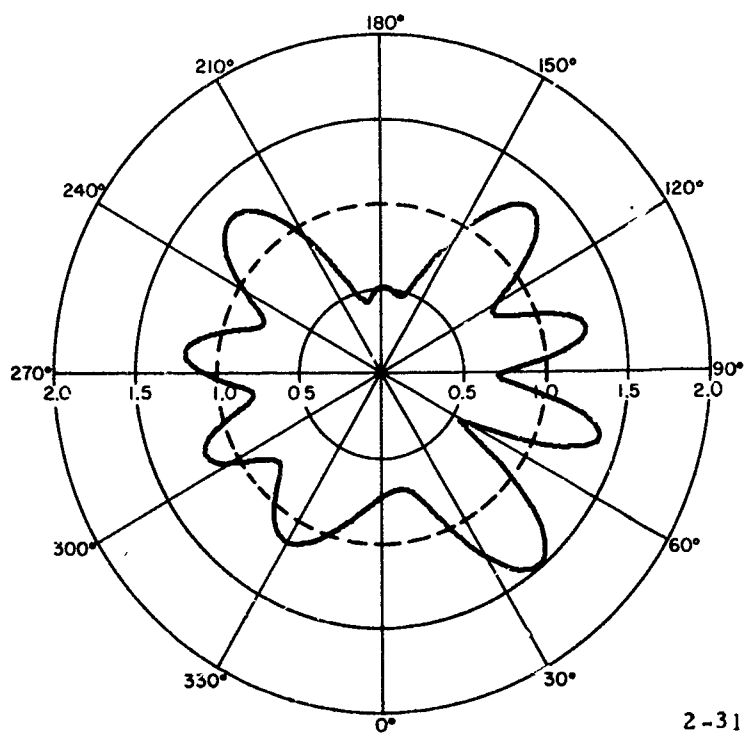
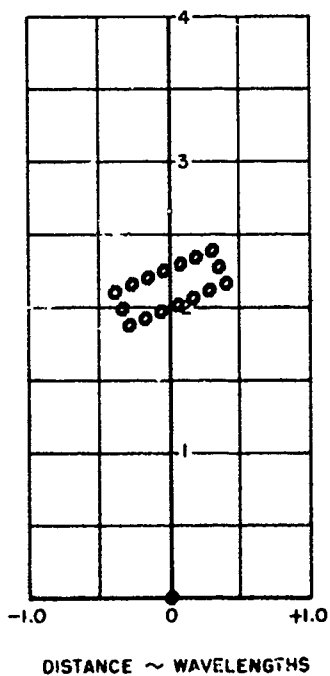
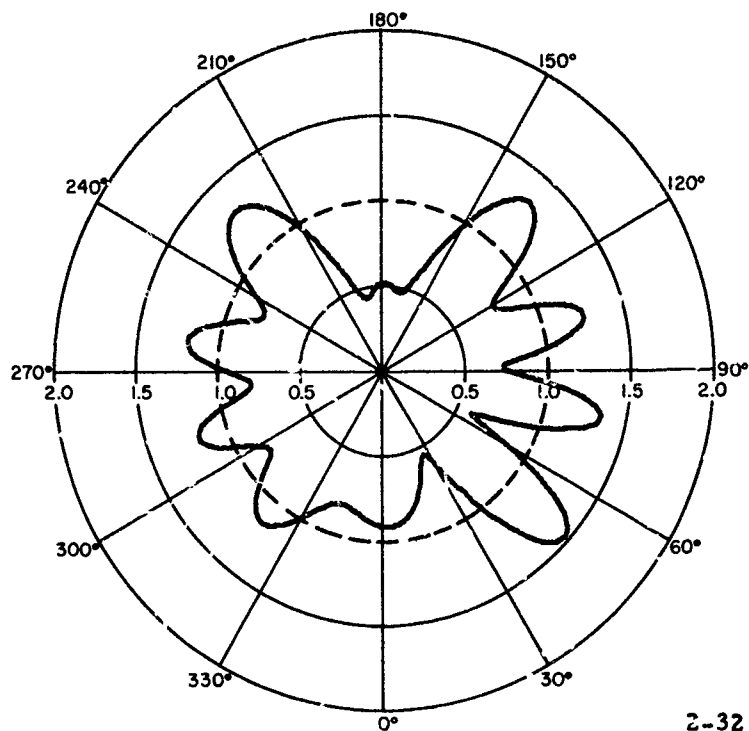
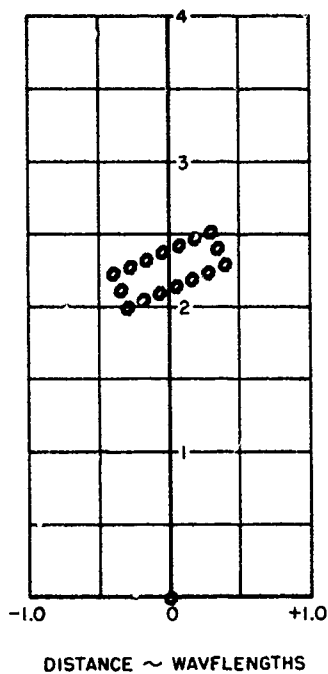


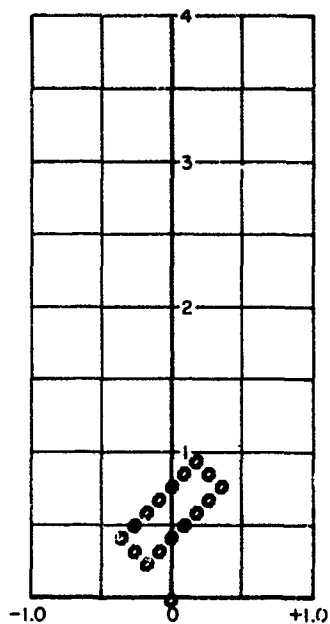
DISTANCE ~ WAVELENGTHS



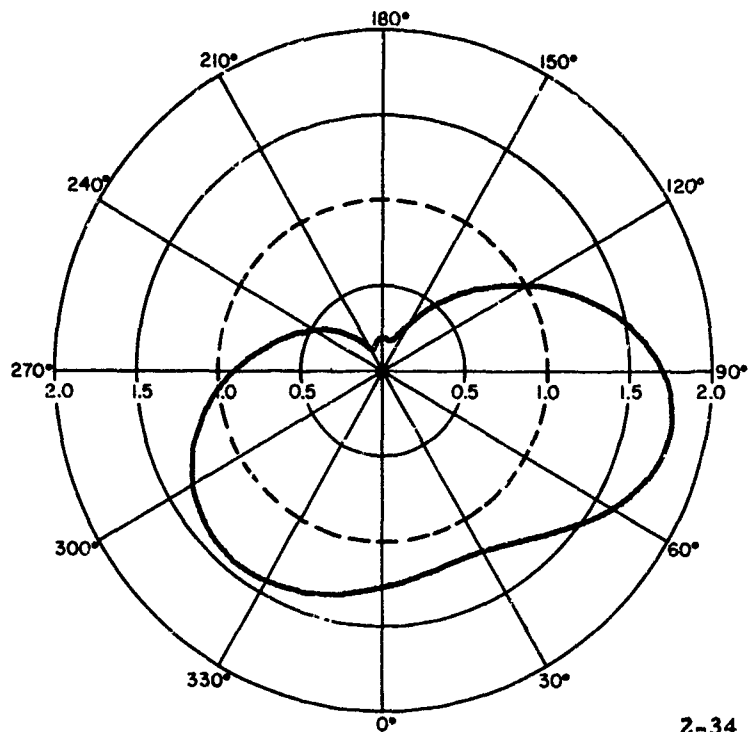
DISTANCE ~ WAVELENGTHS



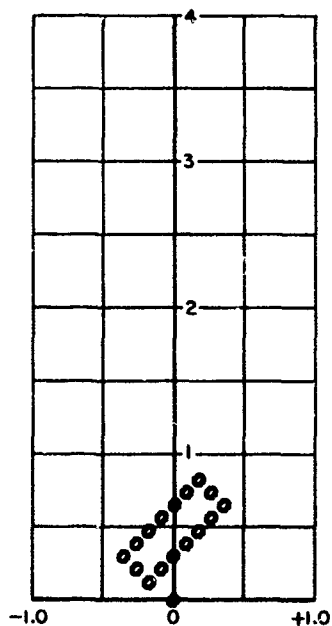




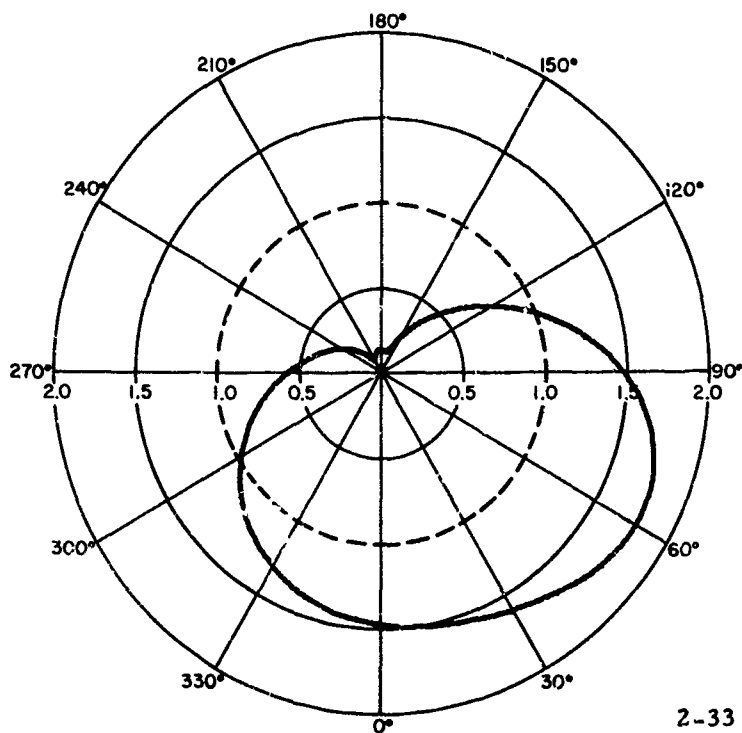
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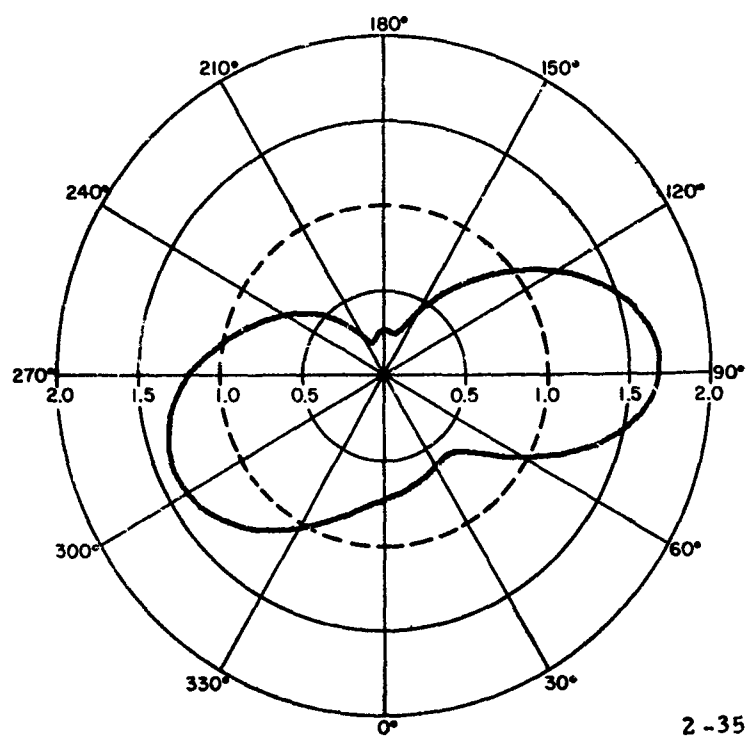
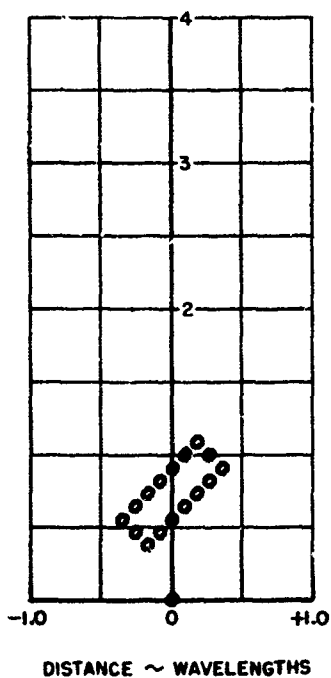
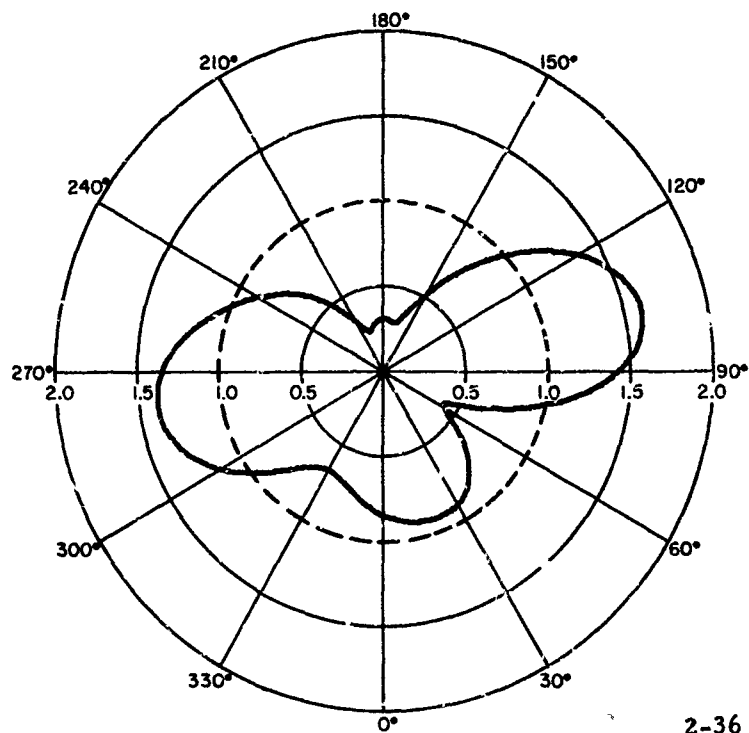
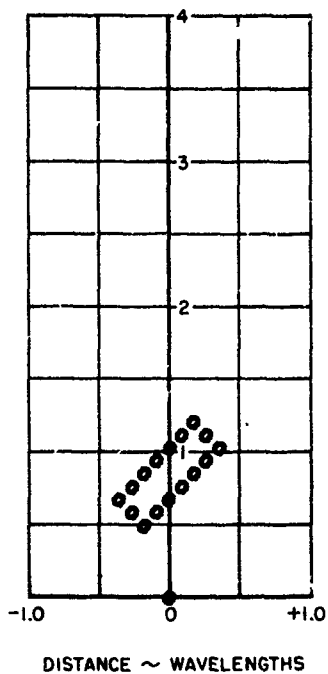
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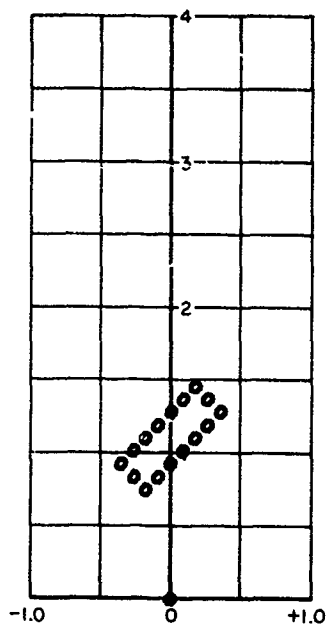


DISTANCE ~ WAVELENGTHS

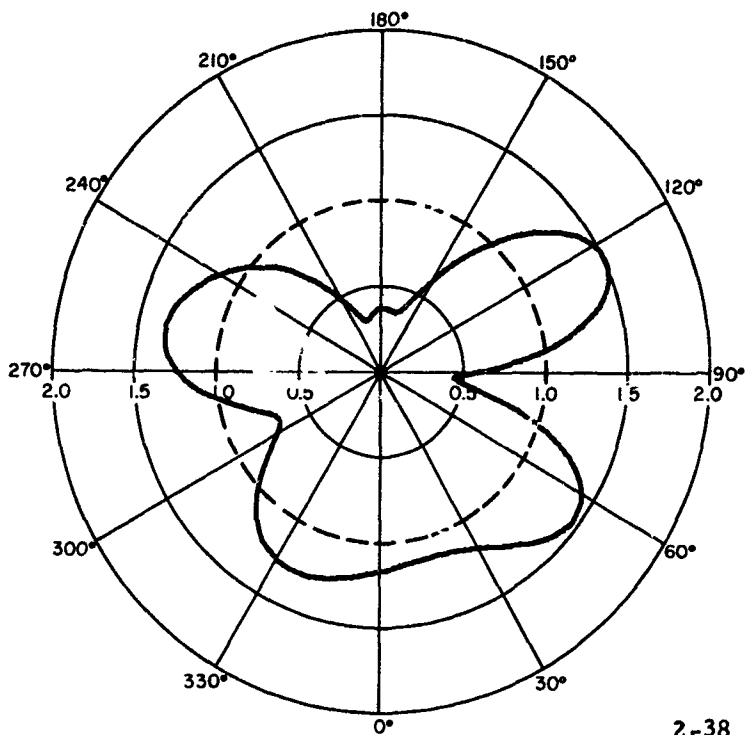


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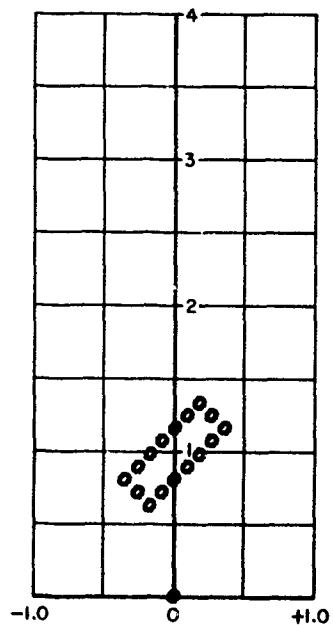




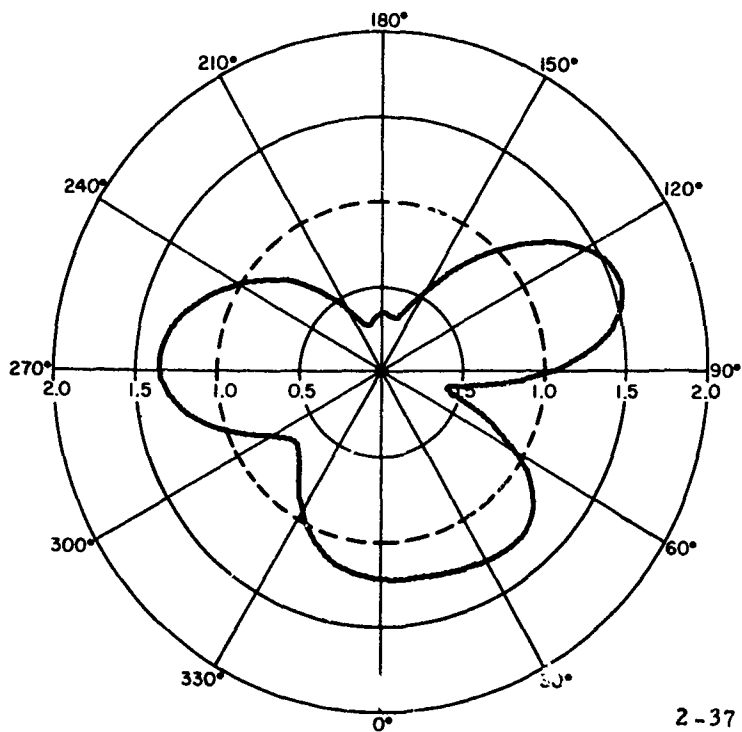
DISTANCE ~ WAVELENGTHS



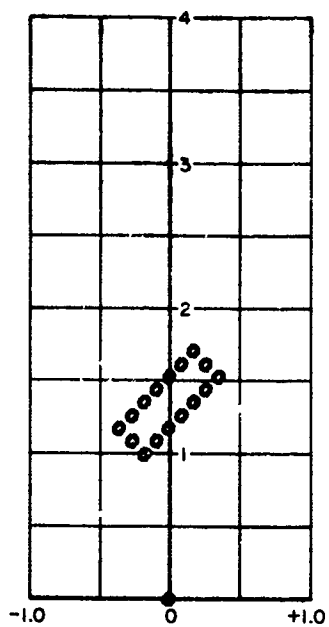
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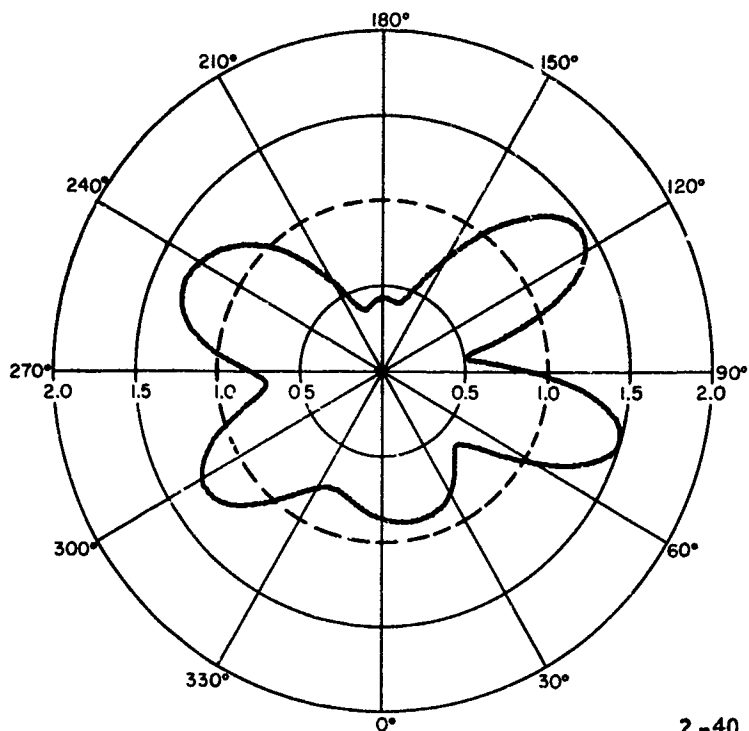
DISTANCE ~ WAVELENGTHS



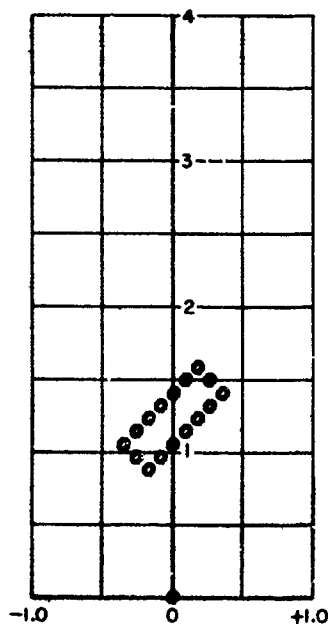
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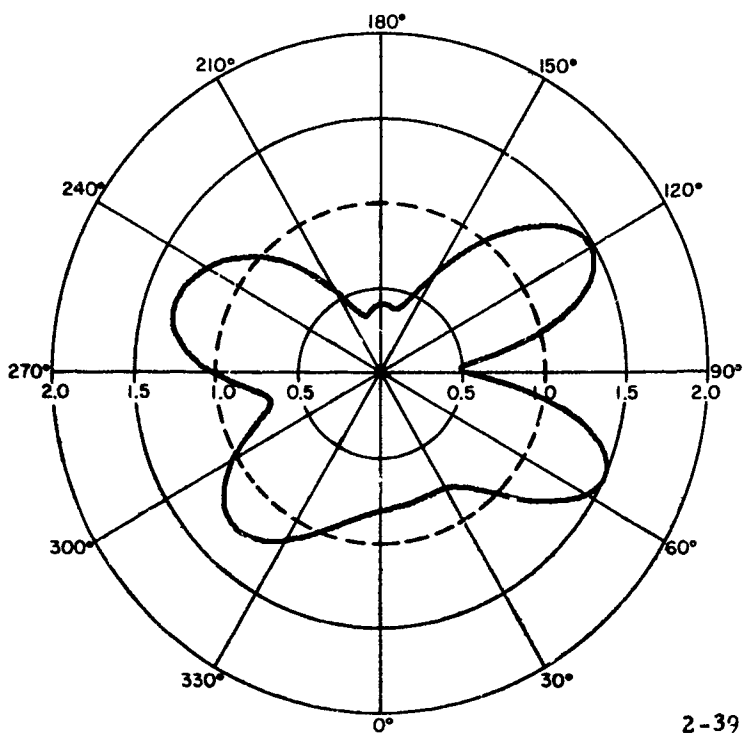
DISTANCE ~ WAVELENGTHS



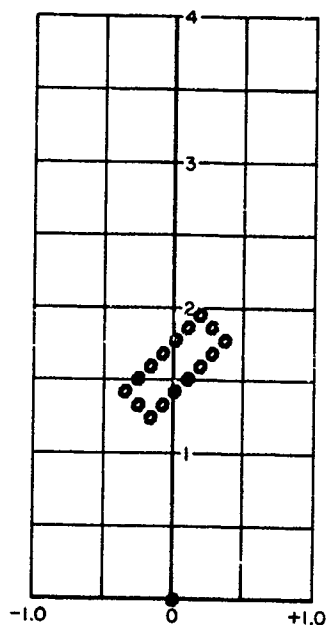
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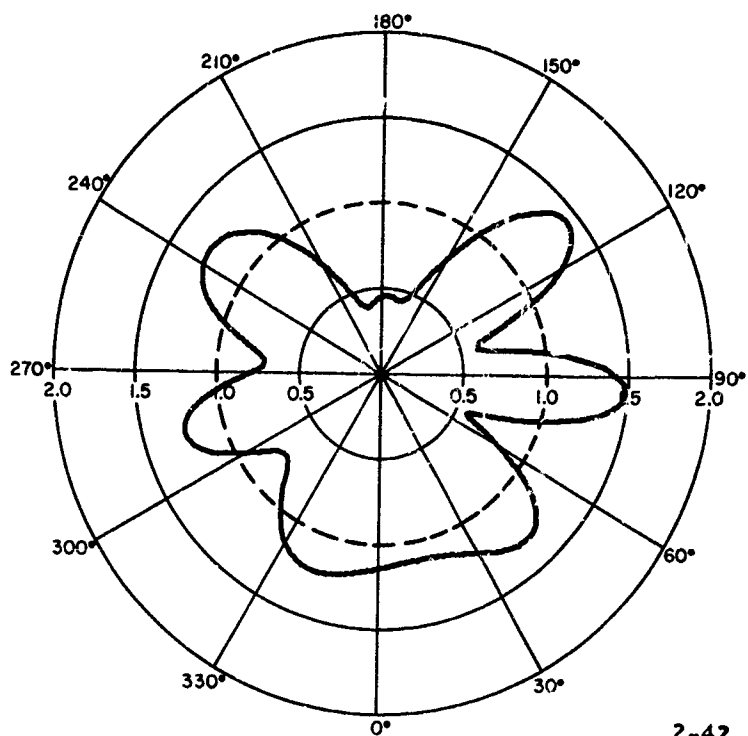
DISTANCE ~ WAVELENGTHS



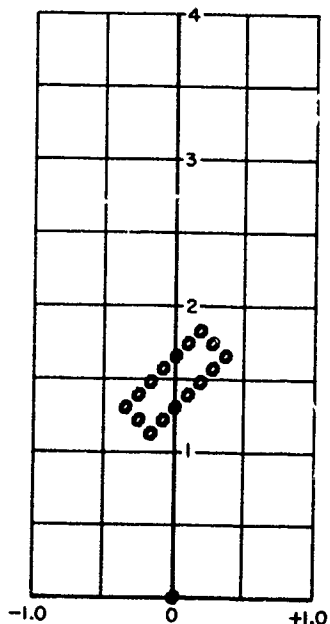
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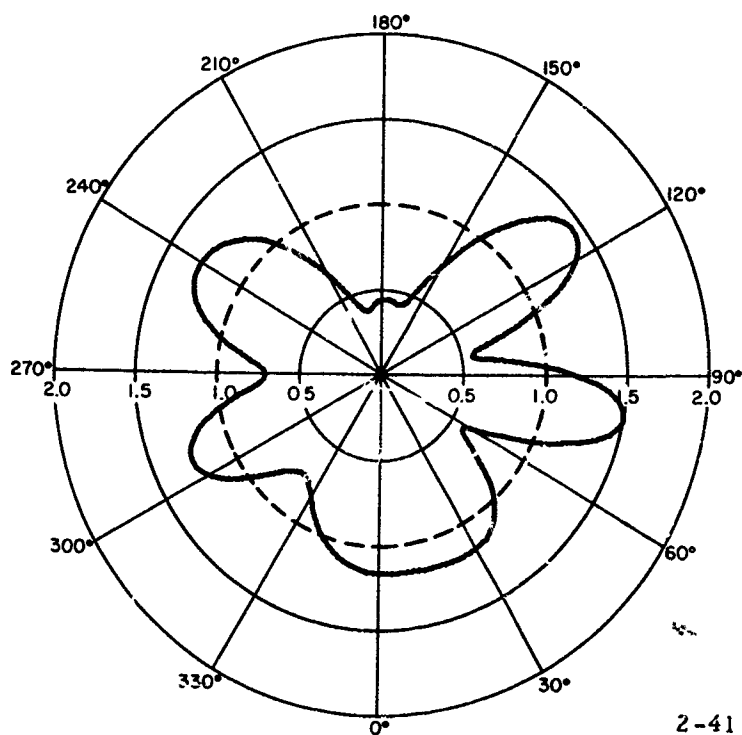
DISTANCE ~ WAVELENGTHS



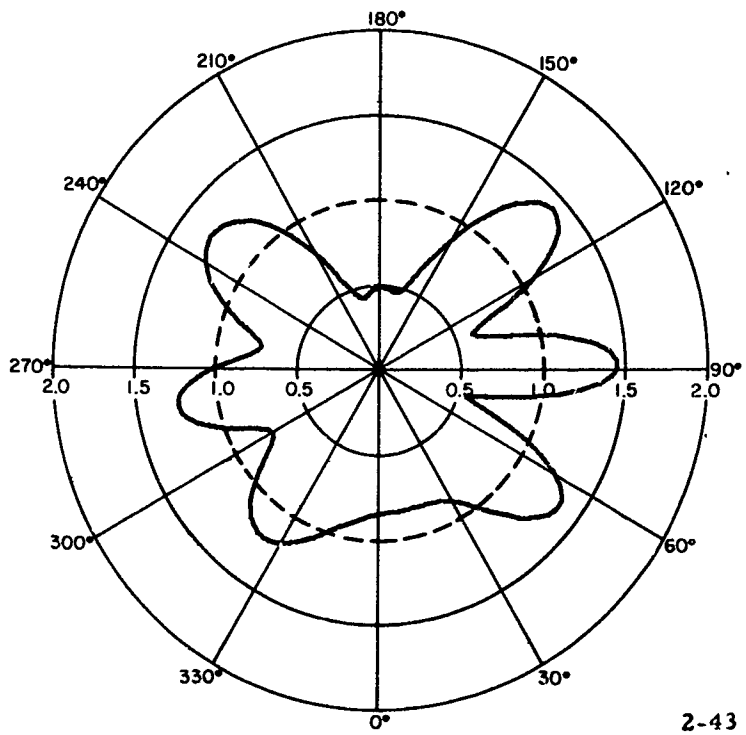
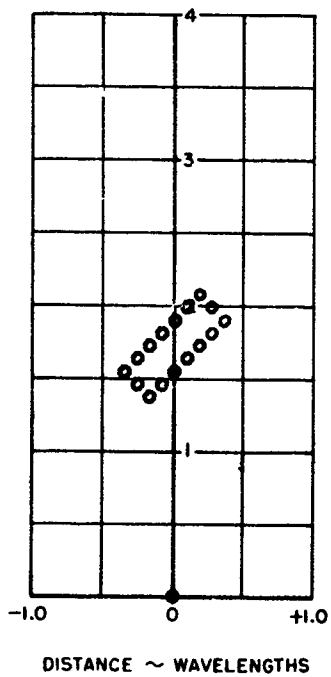
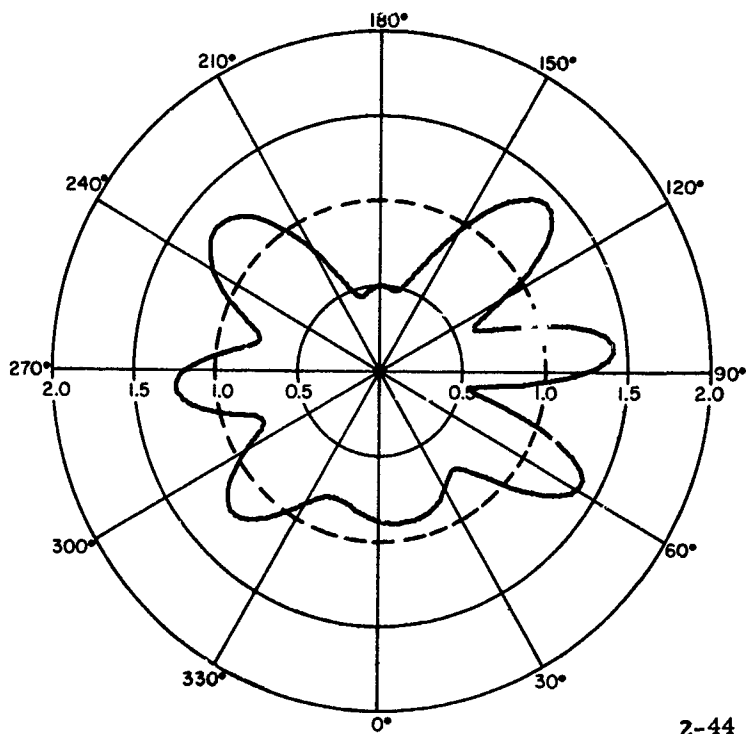
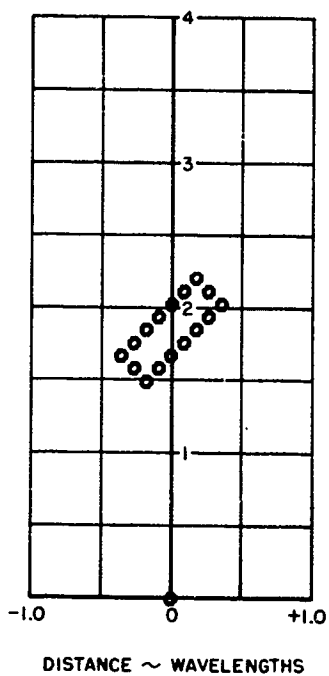
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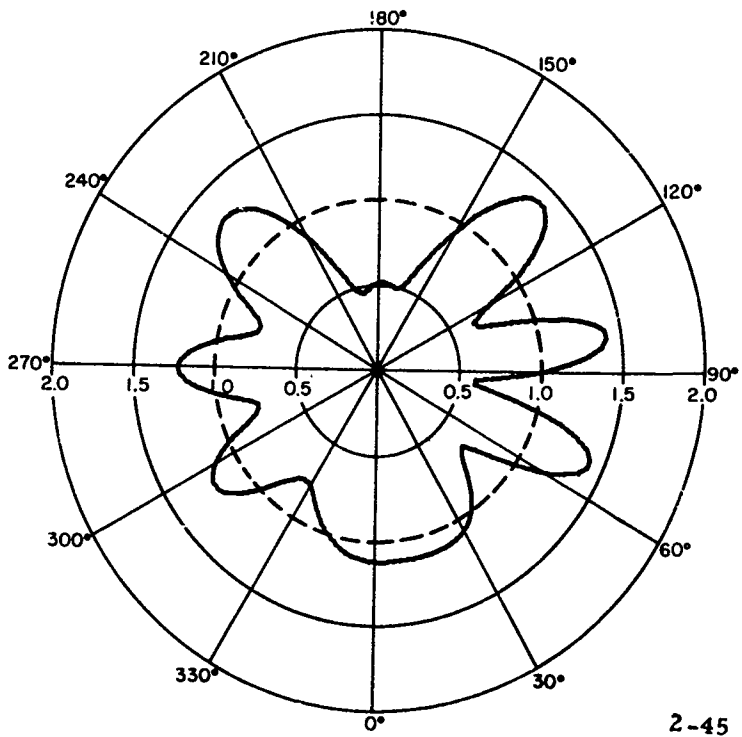
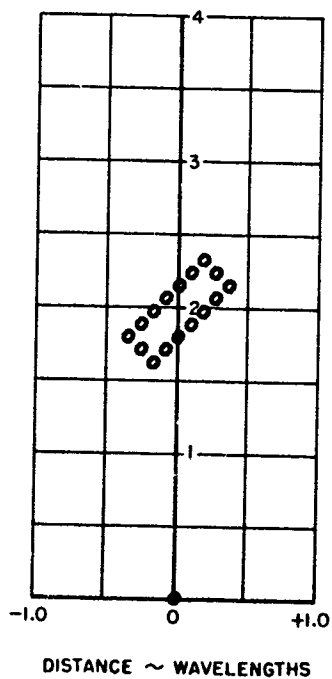
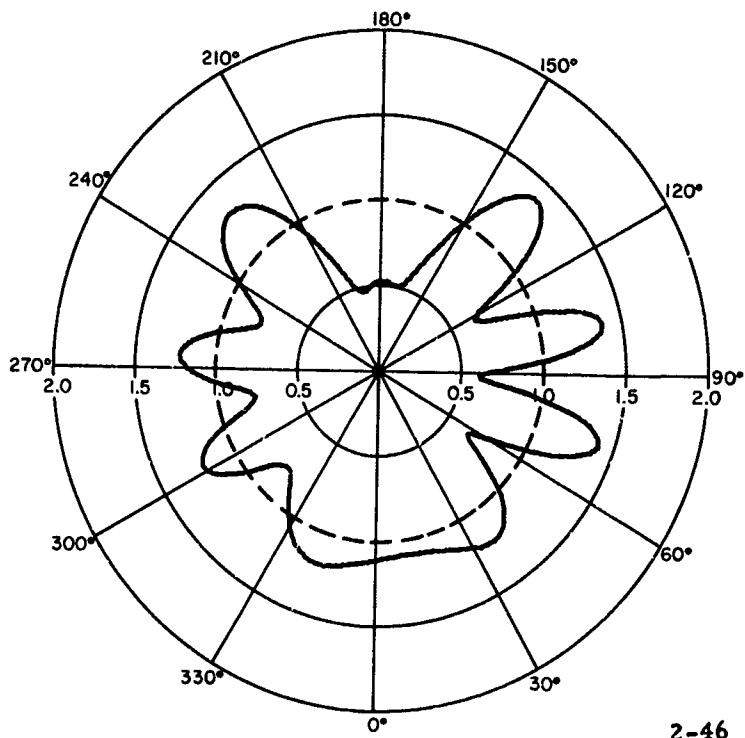
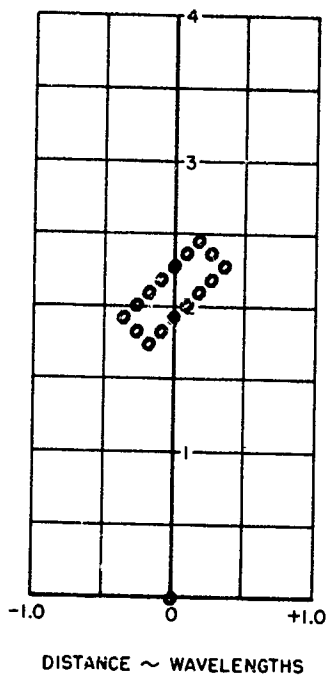


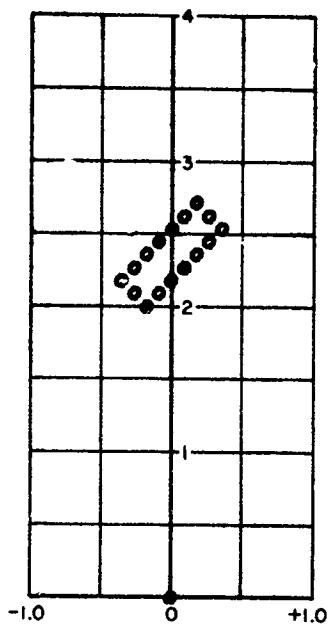
DISTANCE ~ WAVELENGTHS



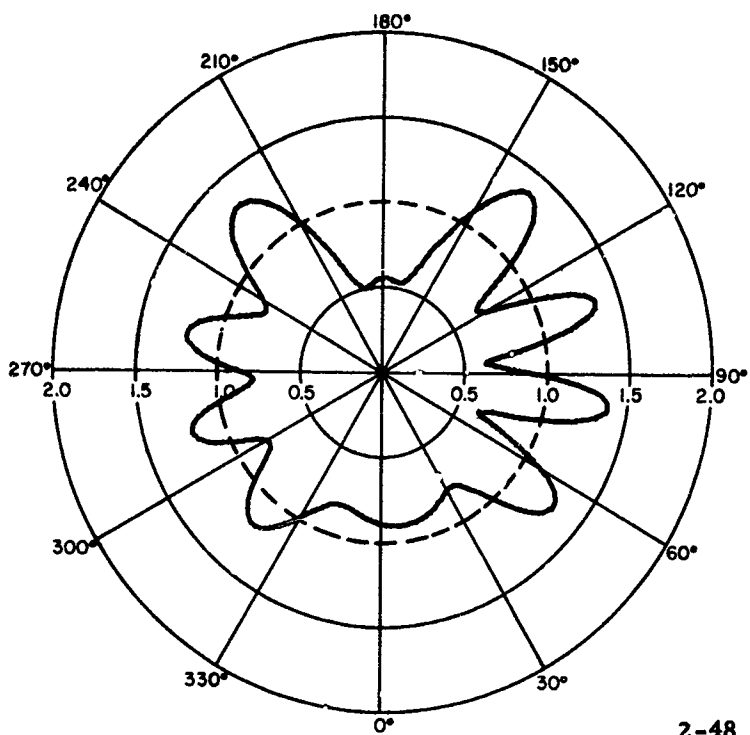
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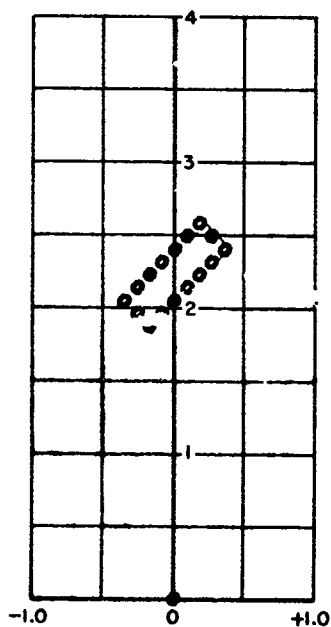




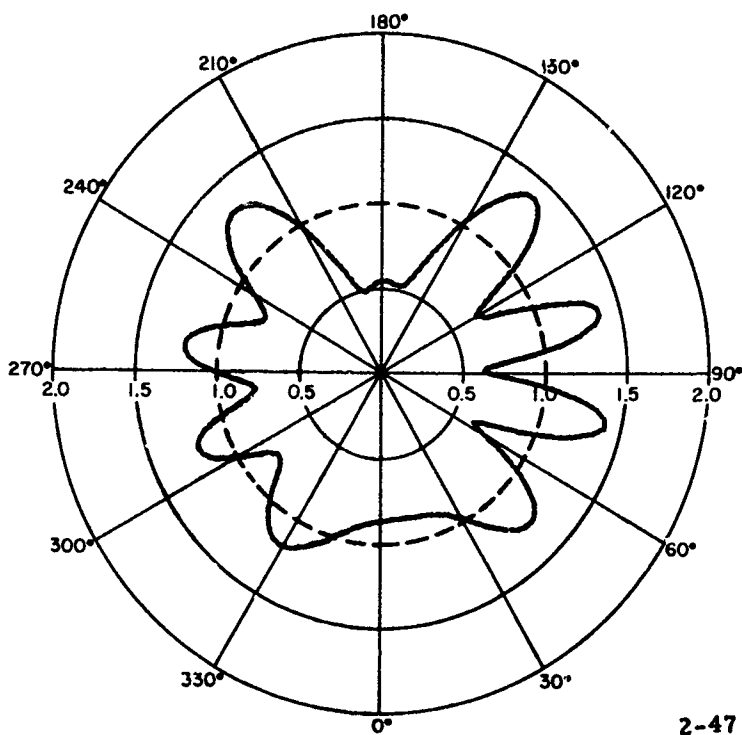
DISTANCE ~ WAVELENGTHS



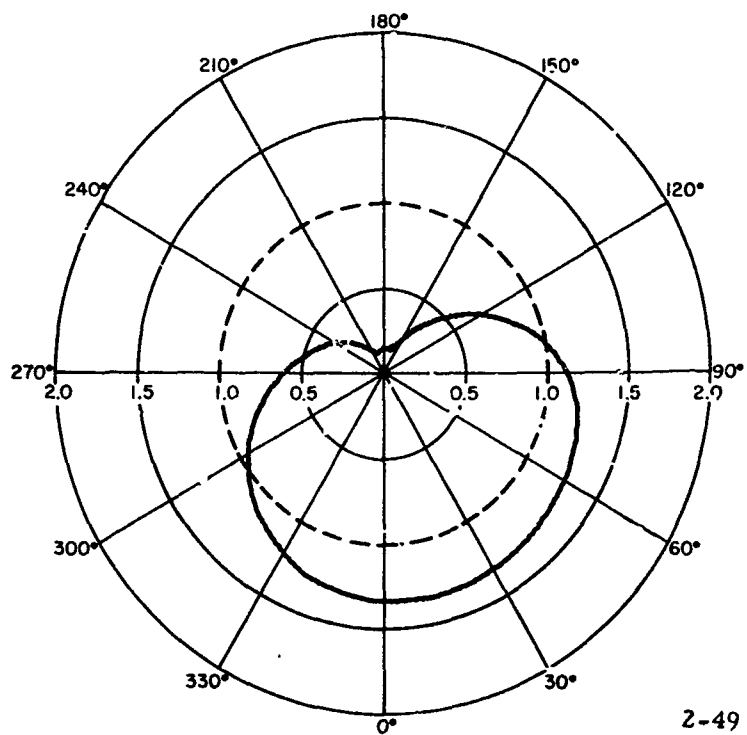
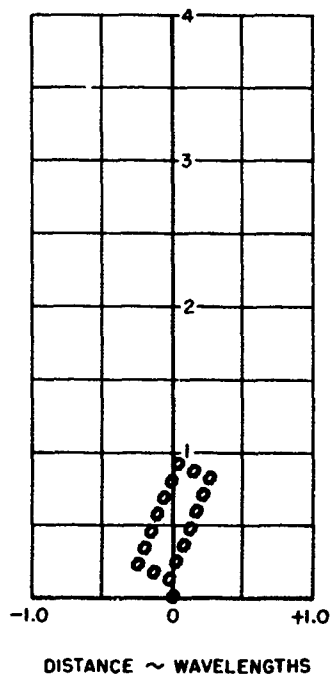
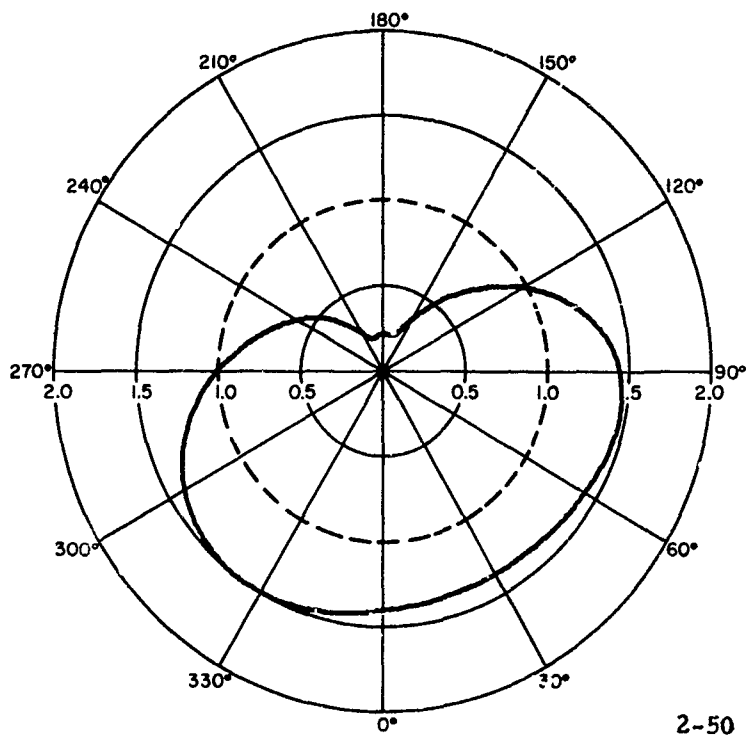
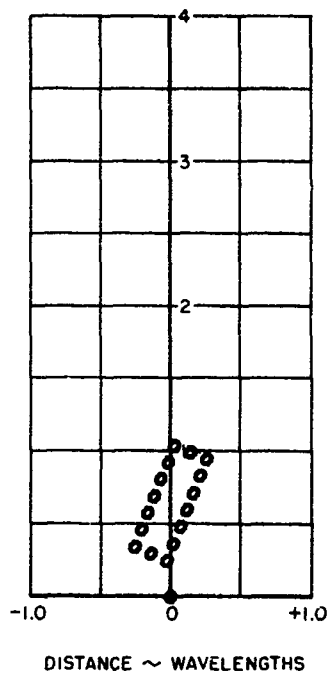
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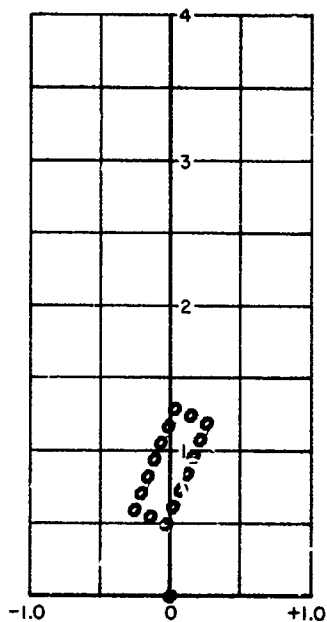


DISTANCE ~ WAVELENGTHS

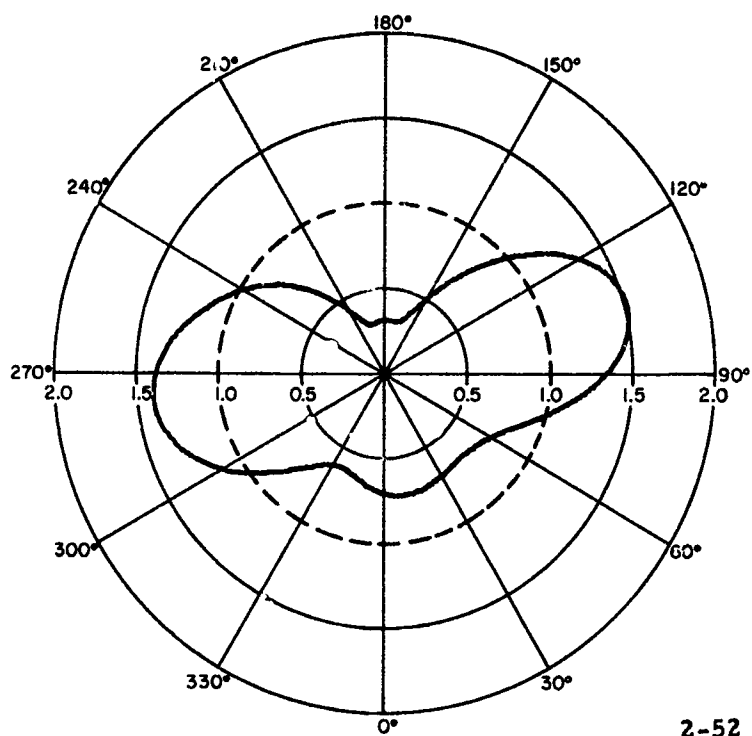


2-47

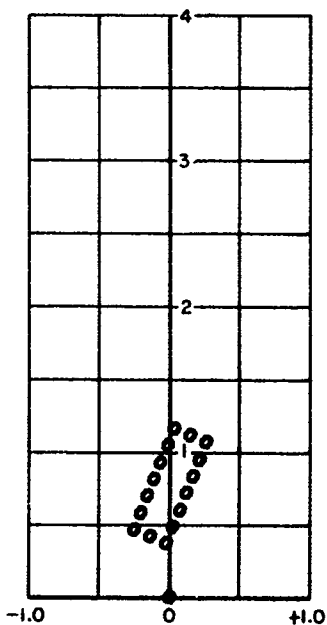




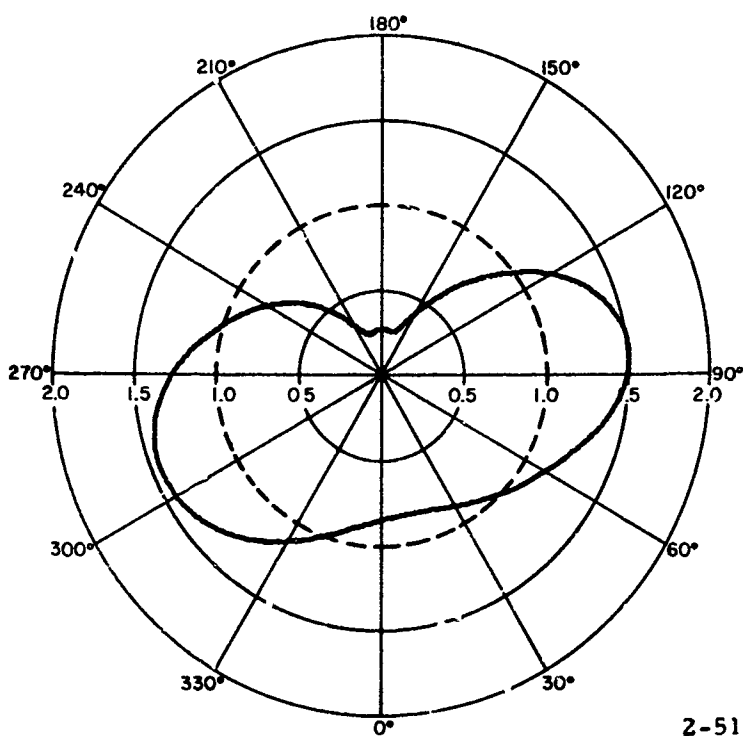
DISTANCE ~ WAVELENGTHS



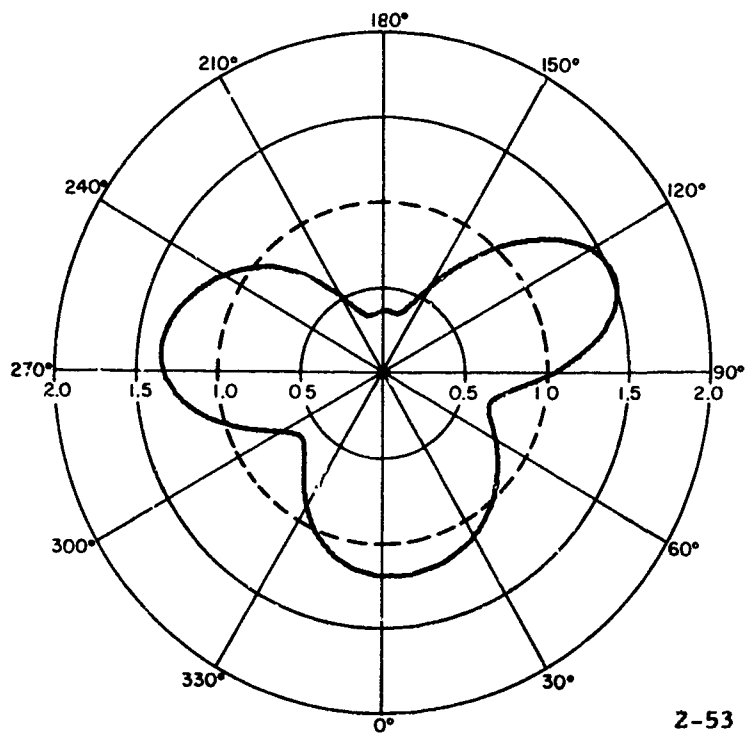
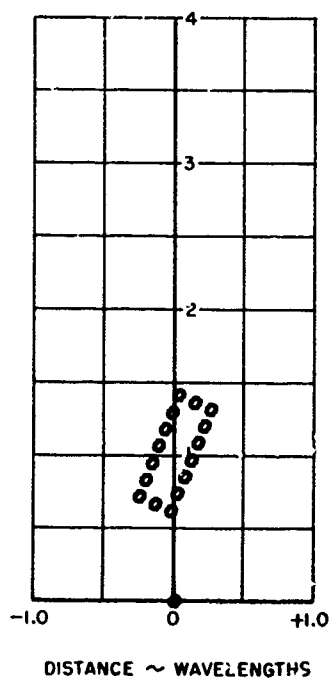
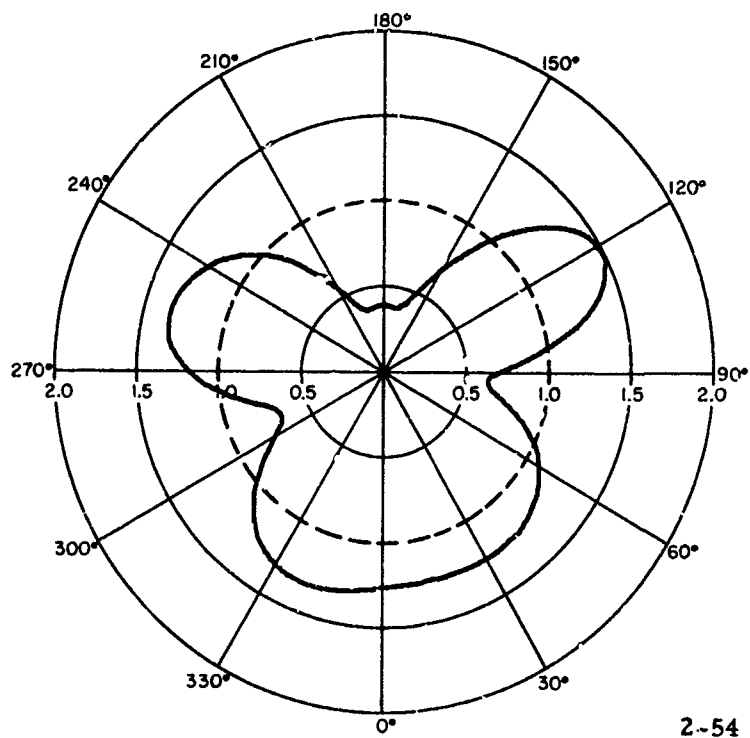
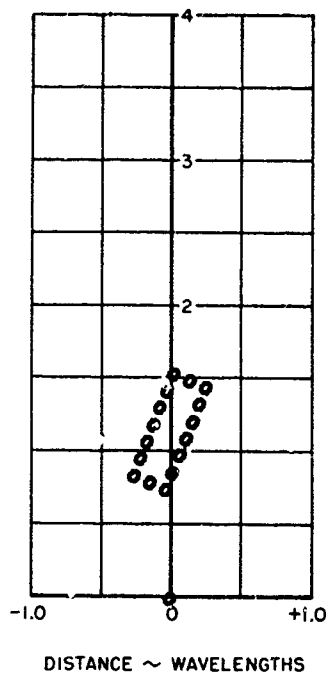
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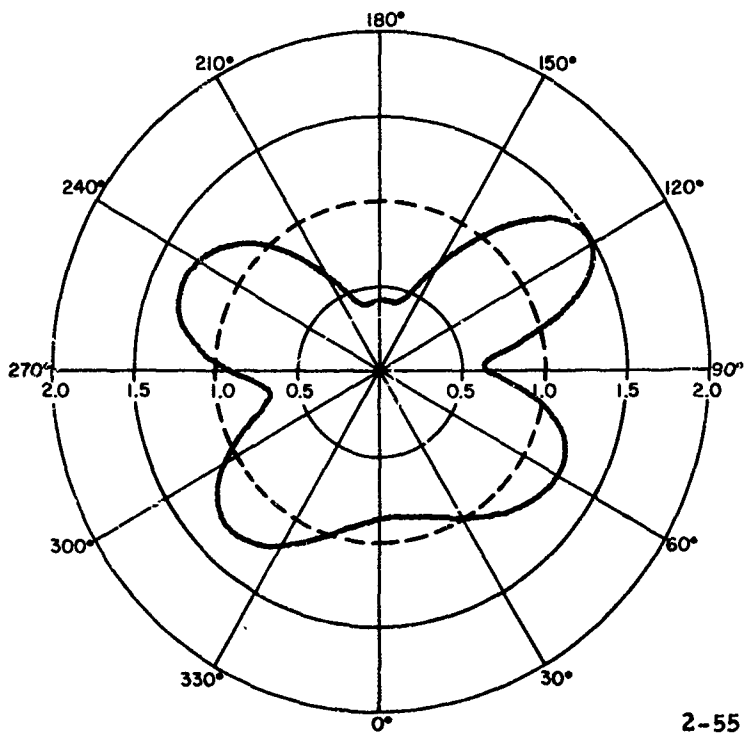
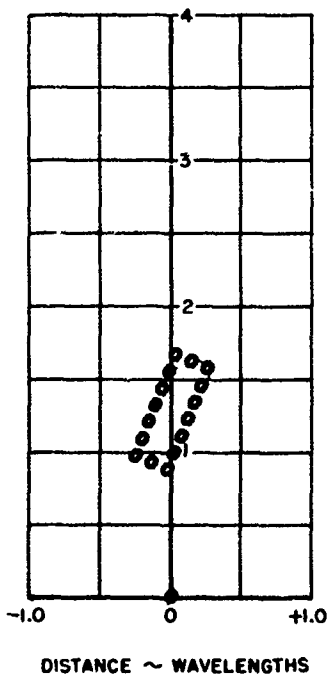
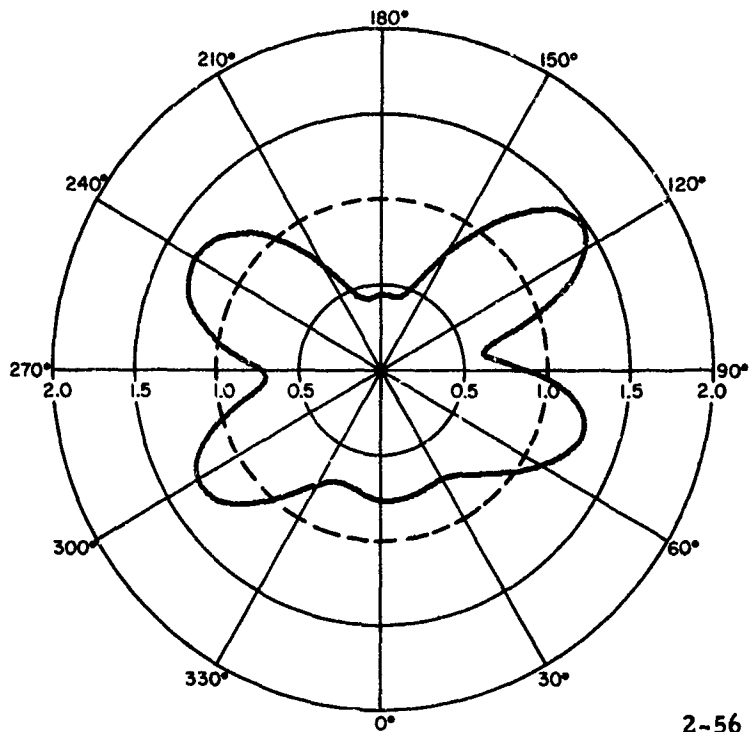
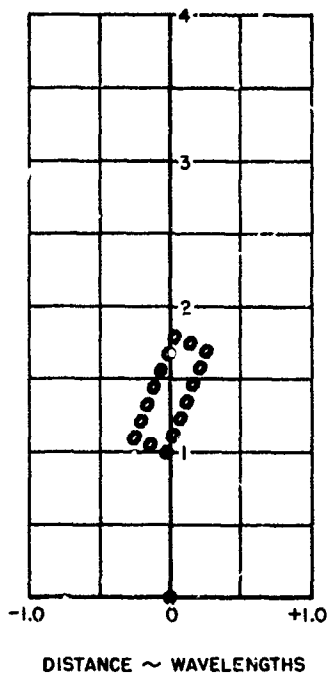


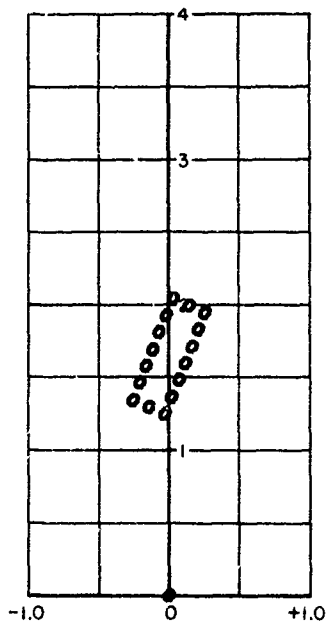
DISTANCE ~ WAVELENGTHS



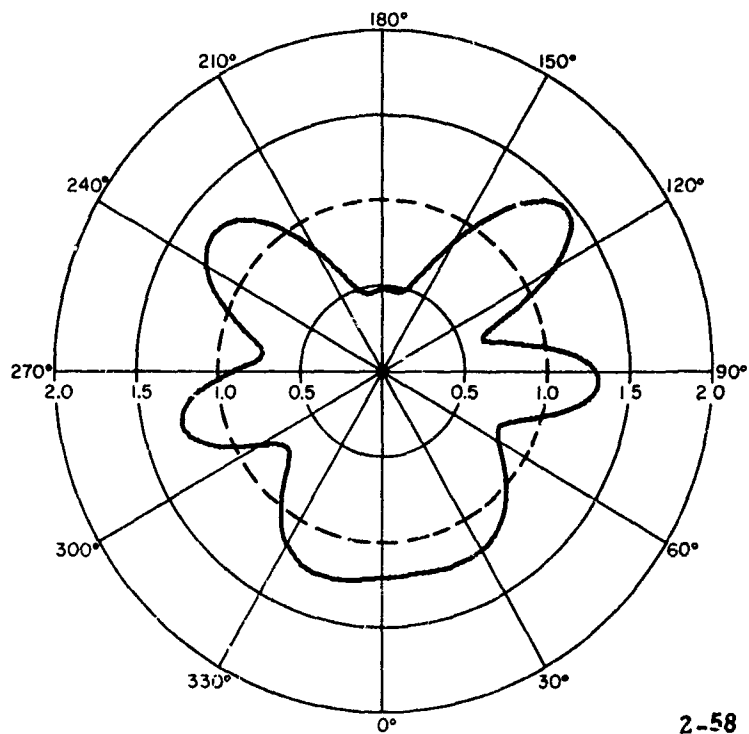
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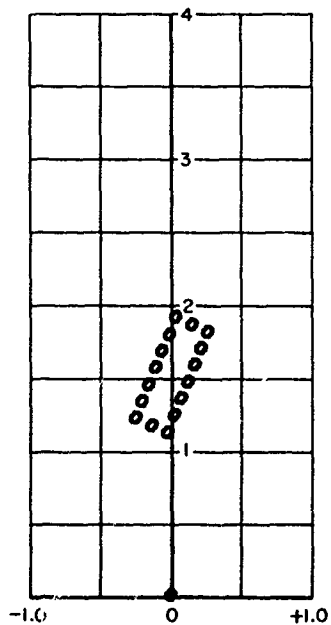




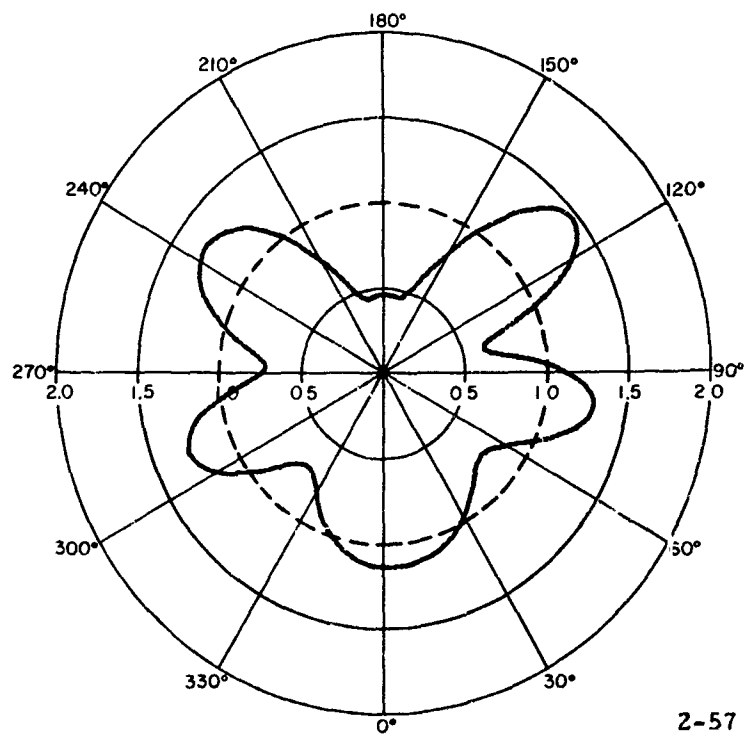
DISTANCE ~ WAVELENGTHS



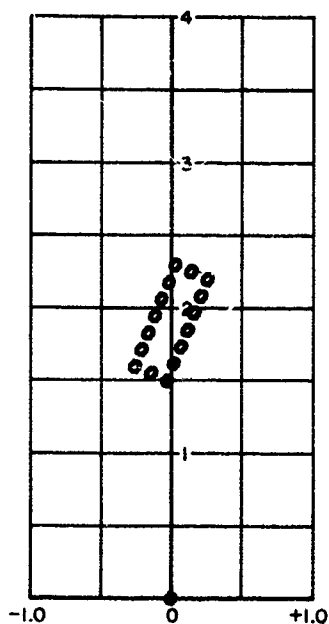
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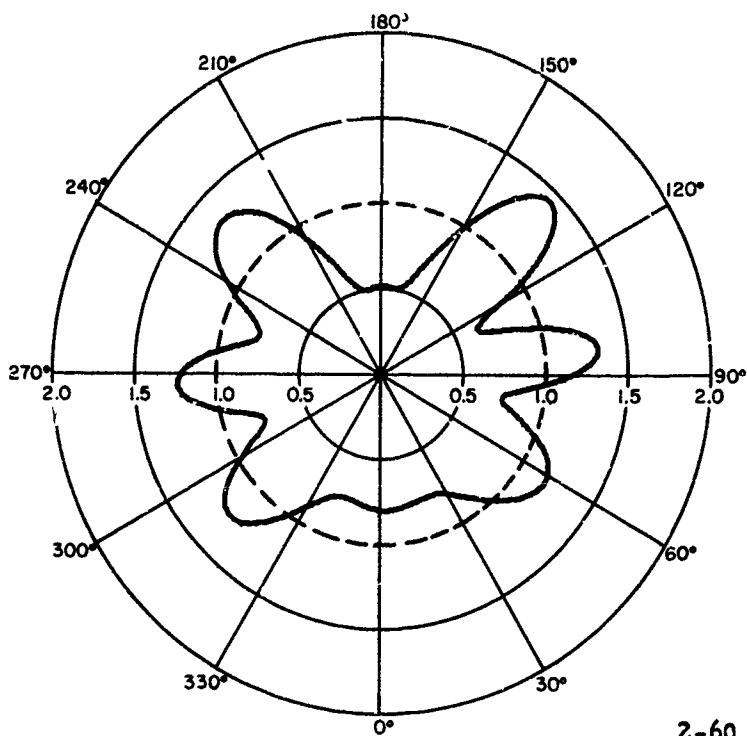
DISTANCE ~ WAVELENGTHS



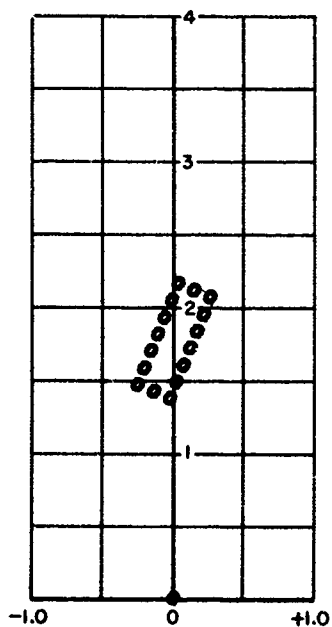
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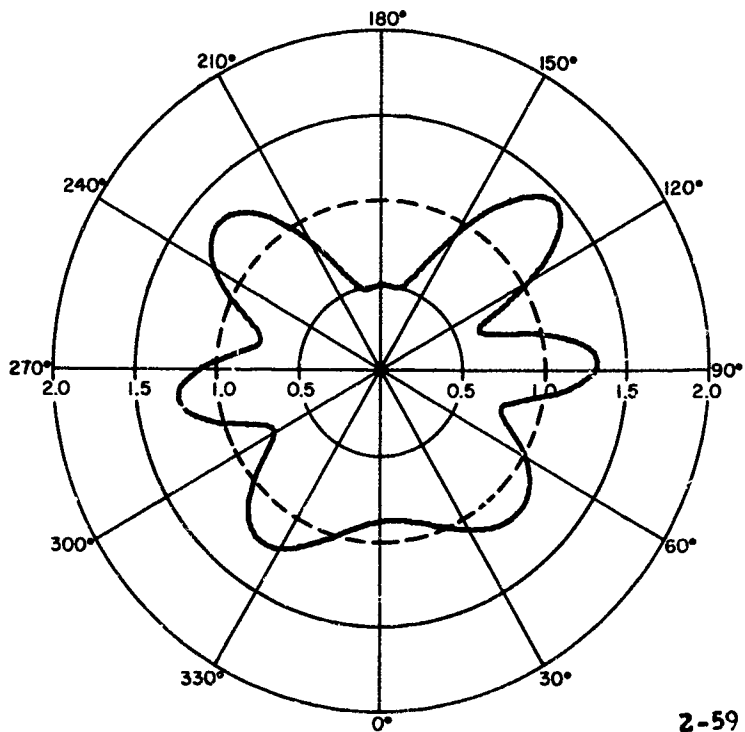
DISTANCE ~ WAVELENGTHS



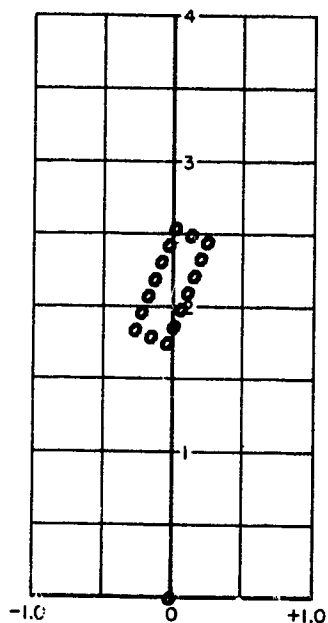
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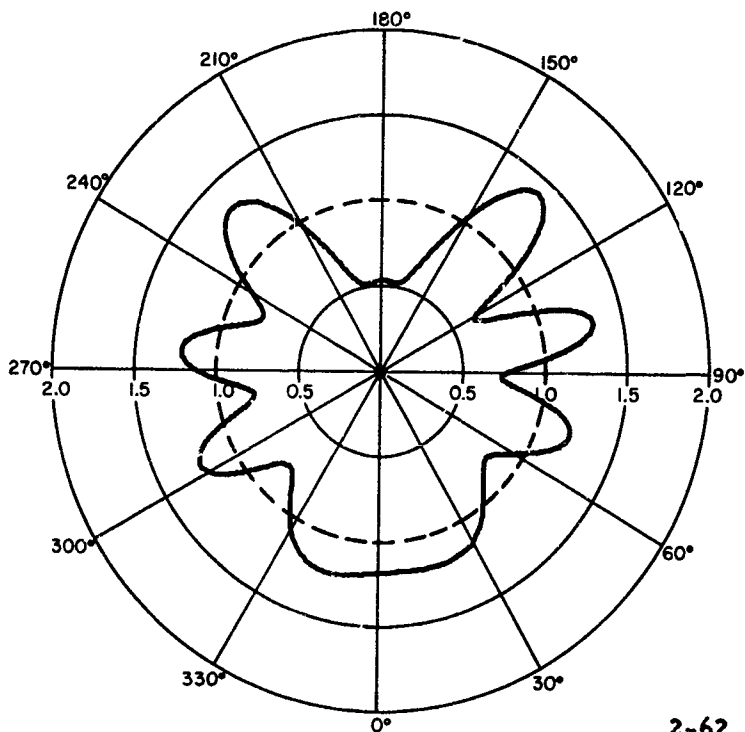
DISTANCE ~ WAVELENGTHS



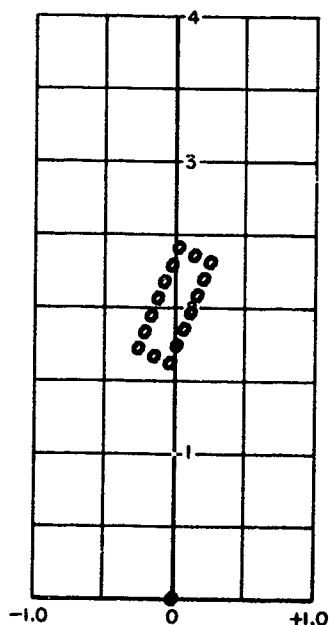
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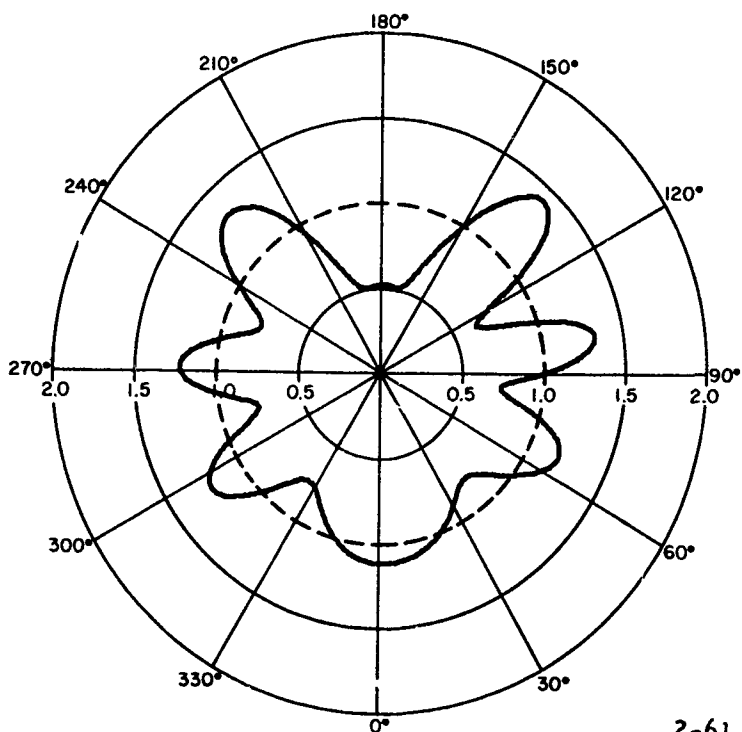
DISTANCE ~ WAVELENGTHS



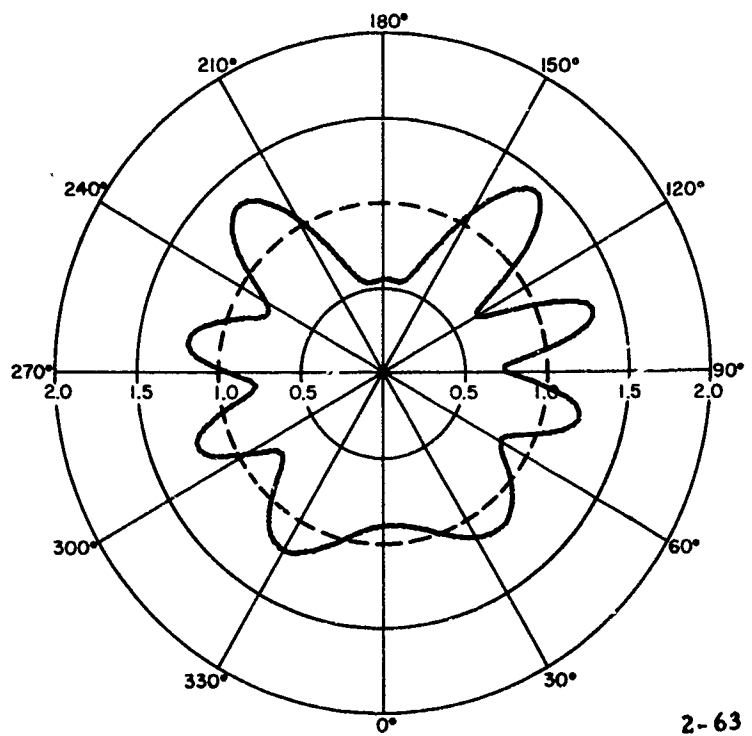
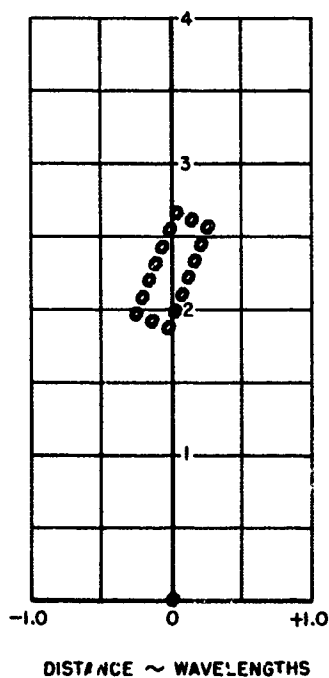
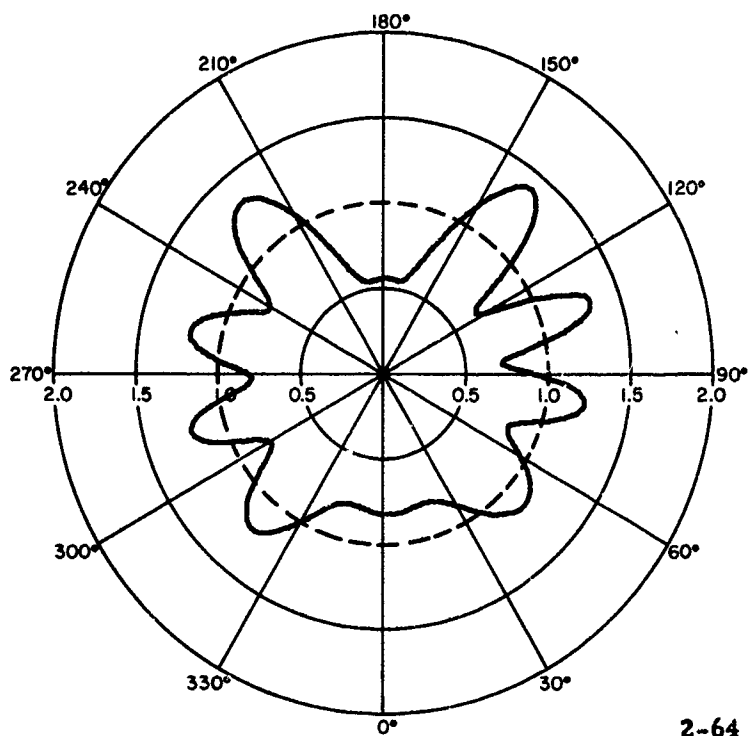
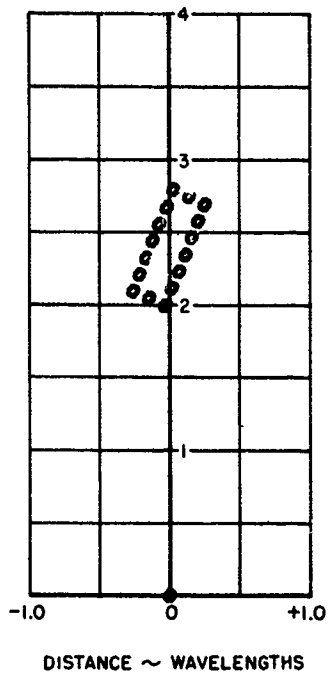
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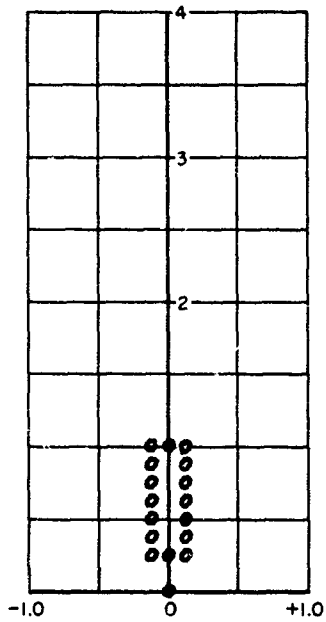


DISTANCE ~ WAVELENGTHS

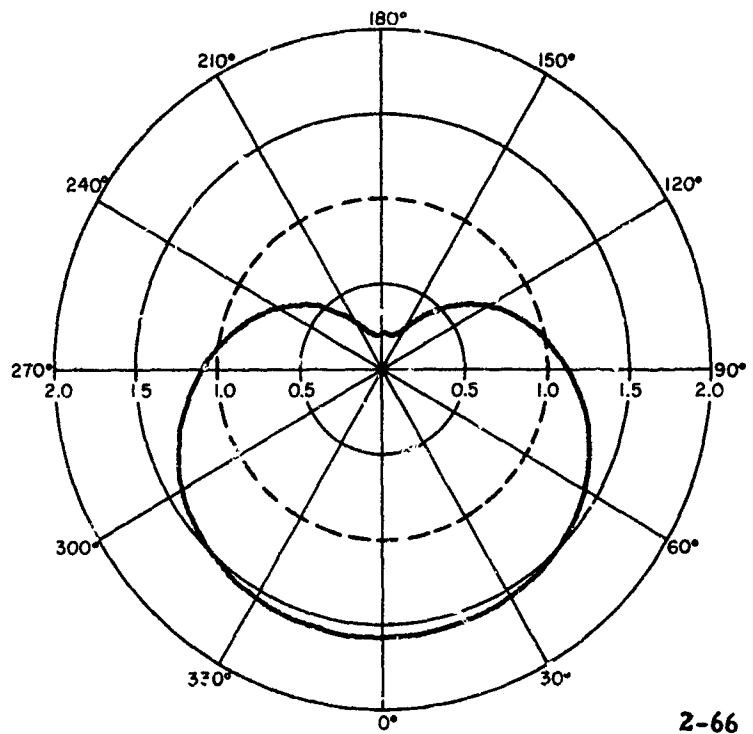


2-61

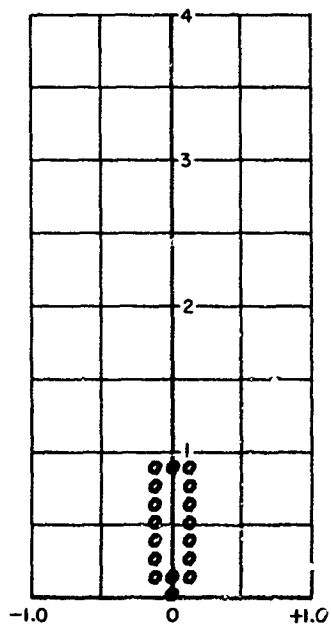




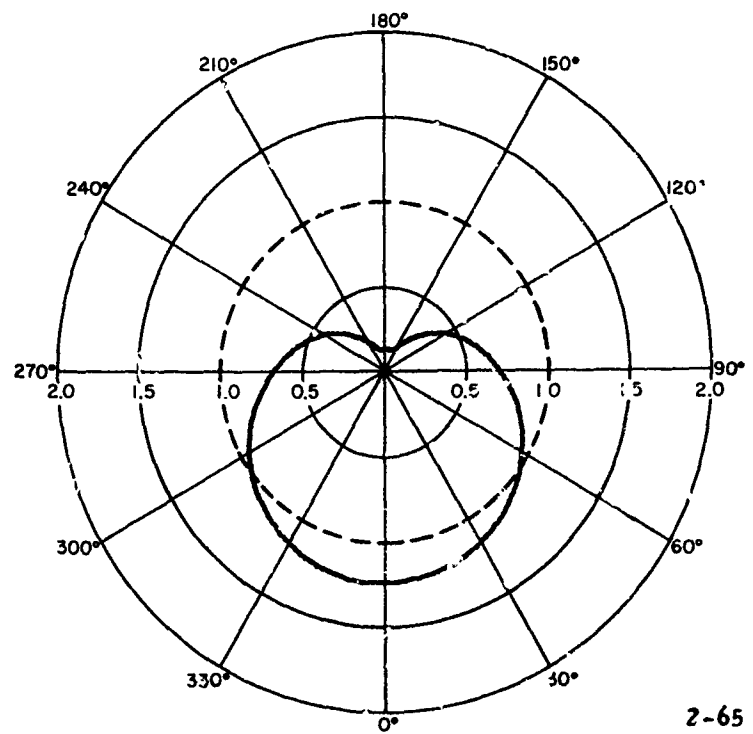
DISTANCE ~ WAVELENGTHS



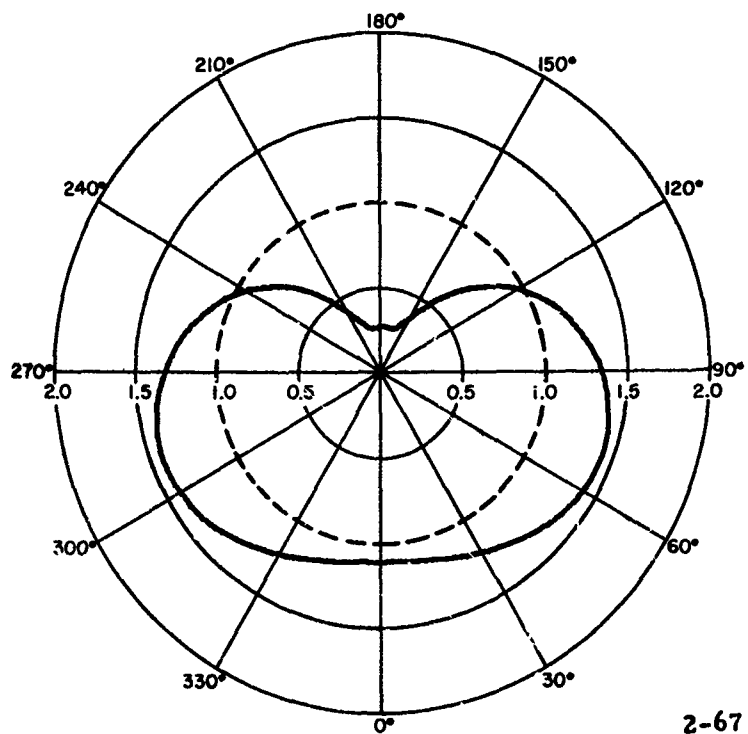
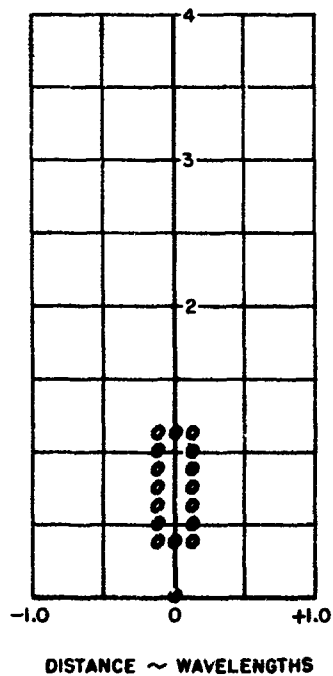
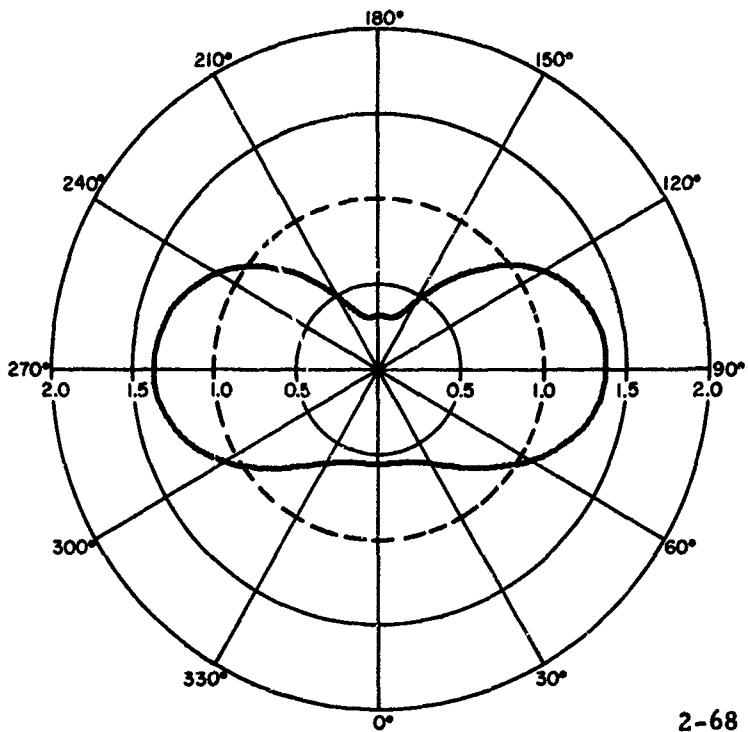
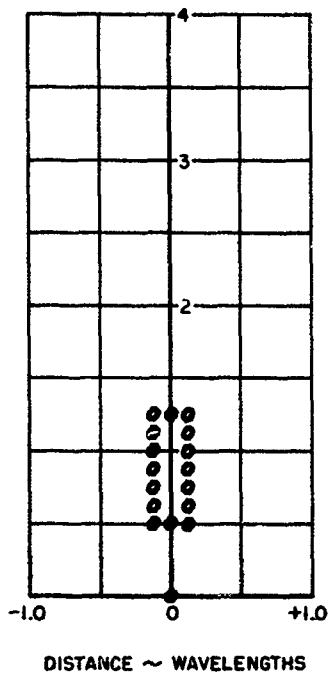
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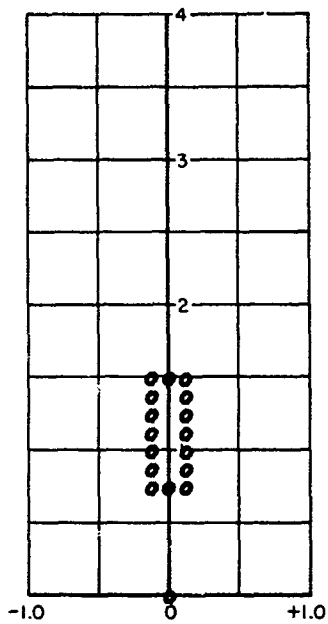


DISTANCE ~ WAVELENGTHS

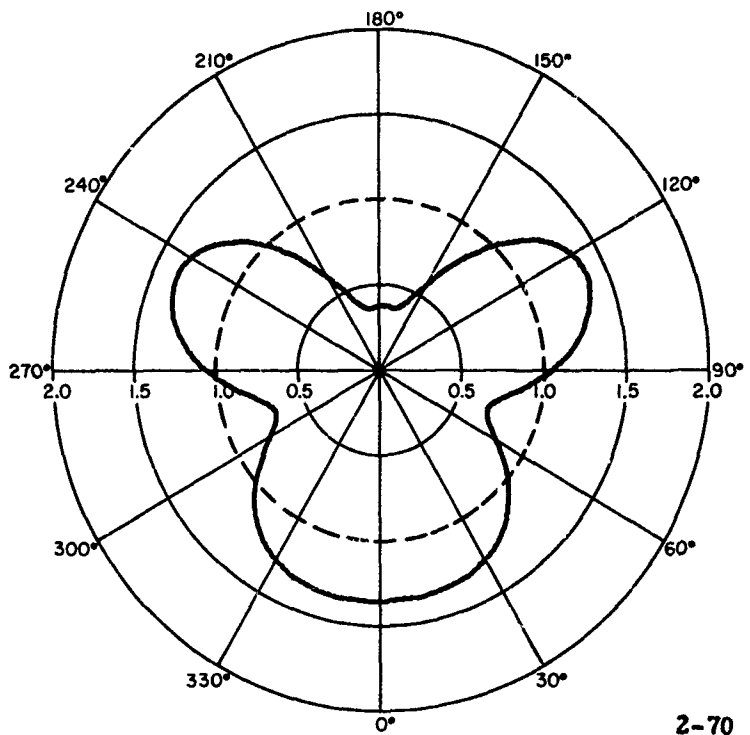


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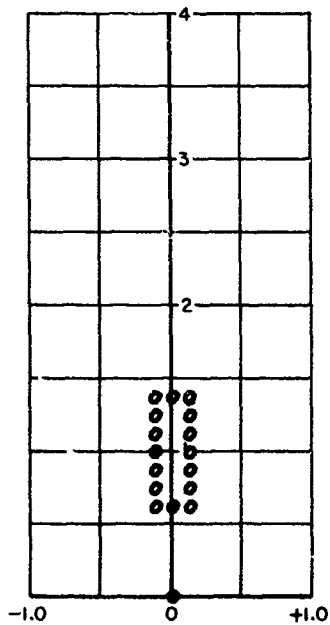




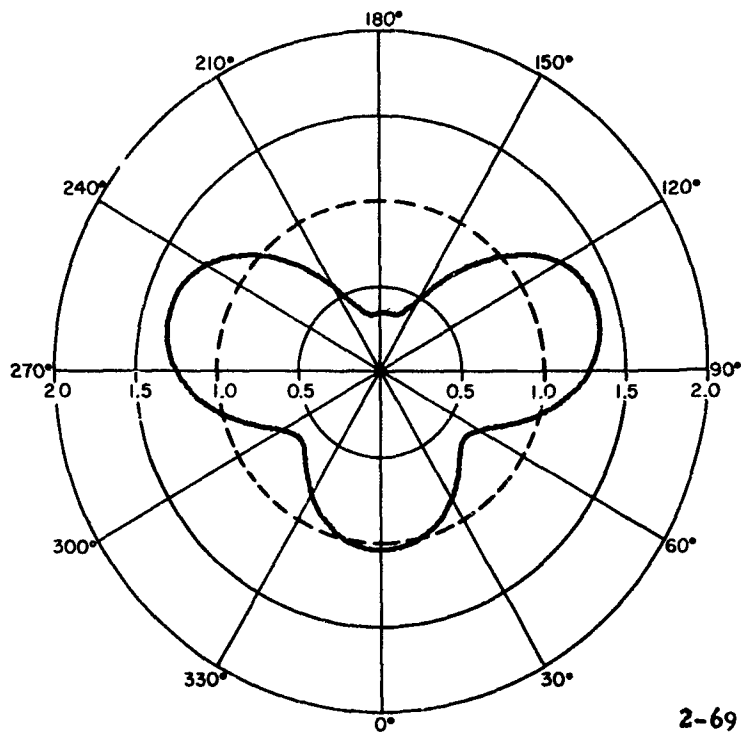
DISTANCE ~ WAVELENGTHS



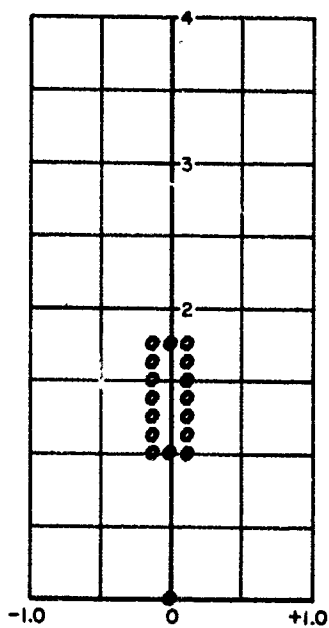
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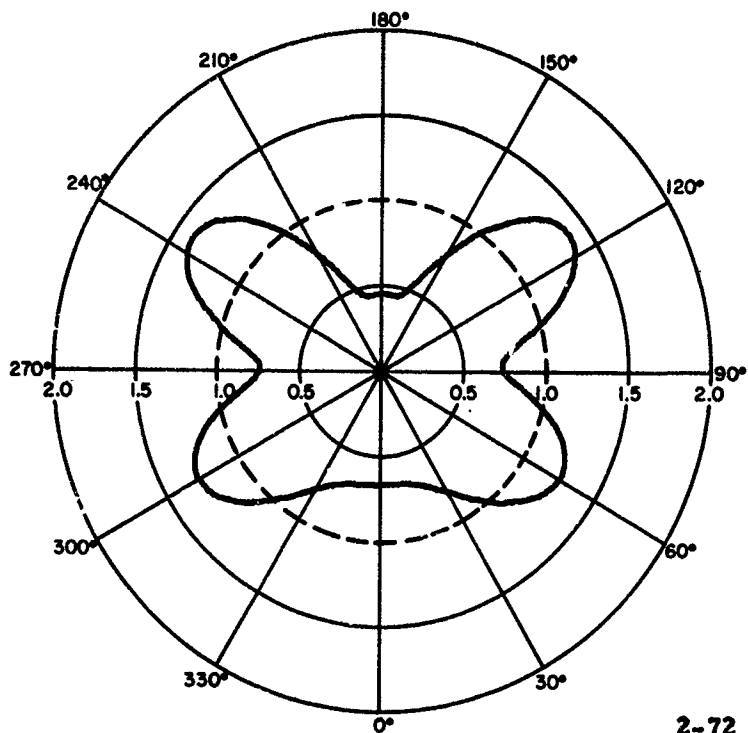
DISTANCE ~ WAVELENGTHS



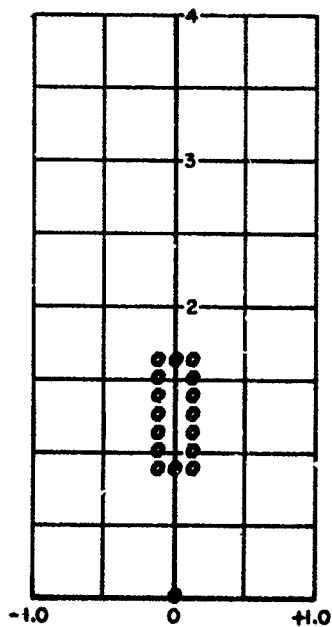
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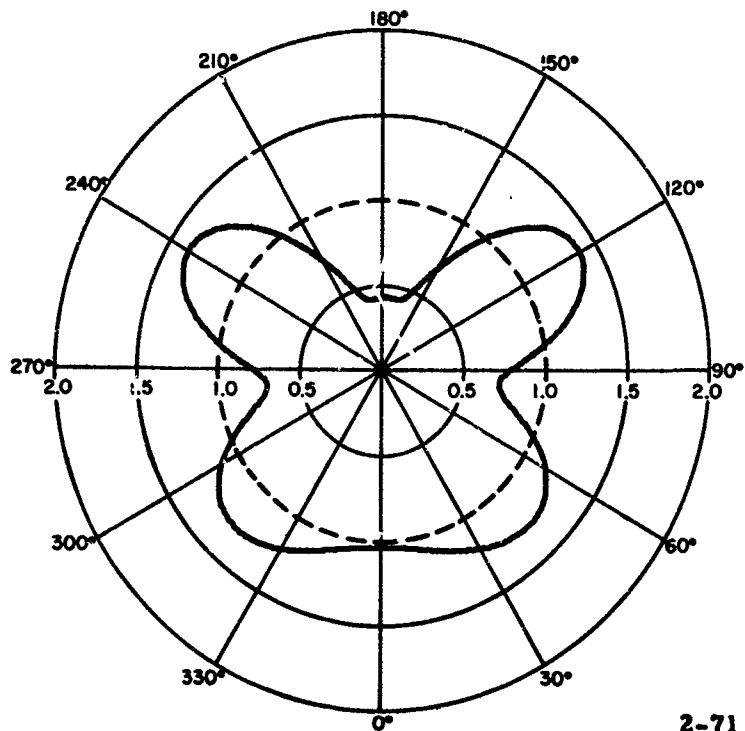
DISTANCE ~ WAVELENGTHS



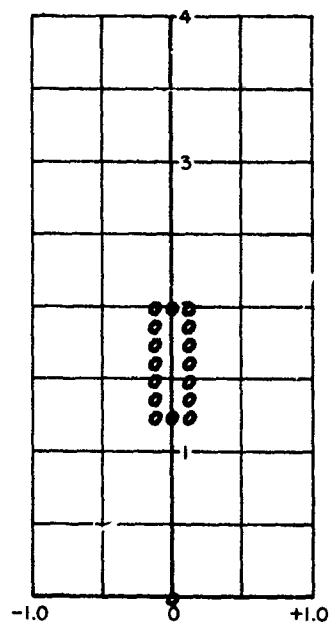
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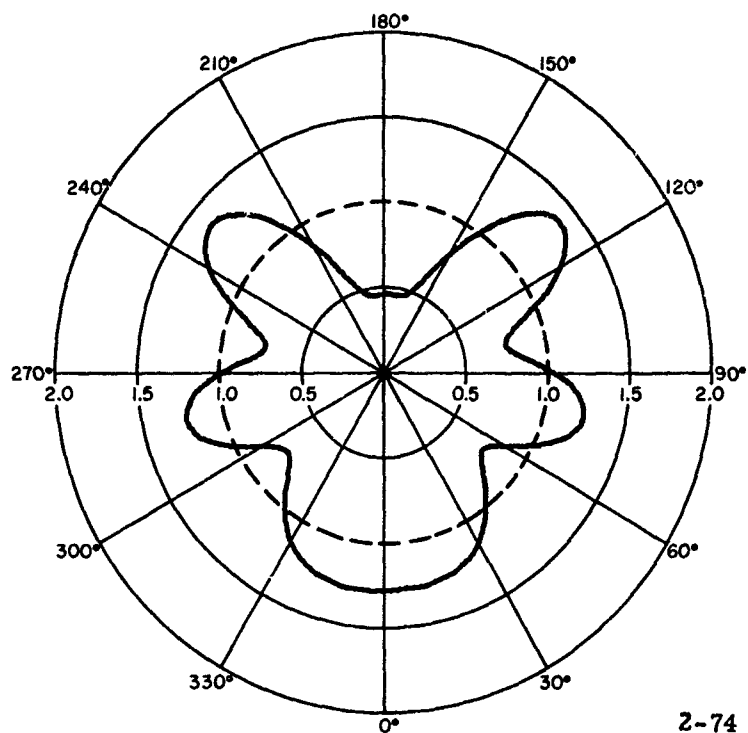
DISTANCE ~ WAVELENGTHS



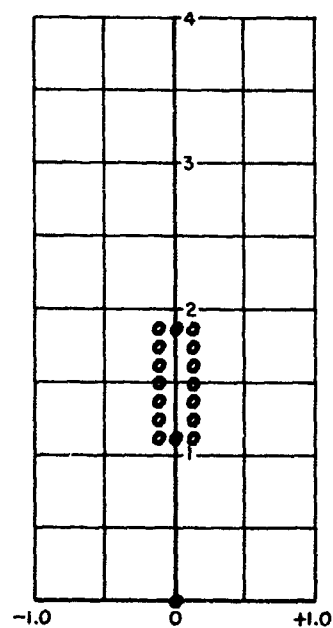
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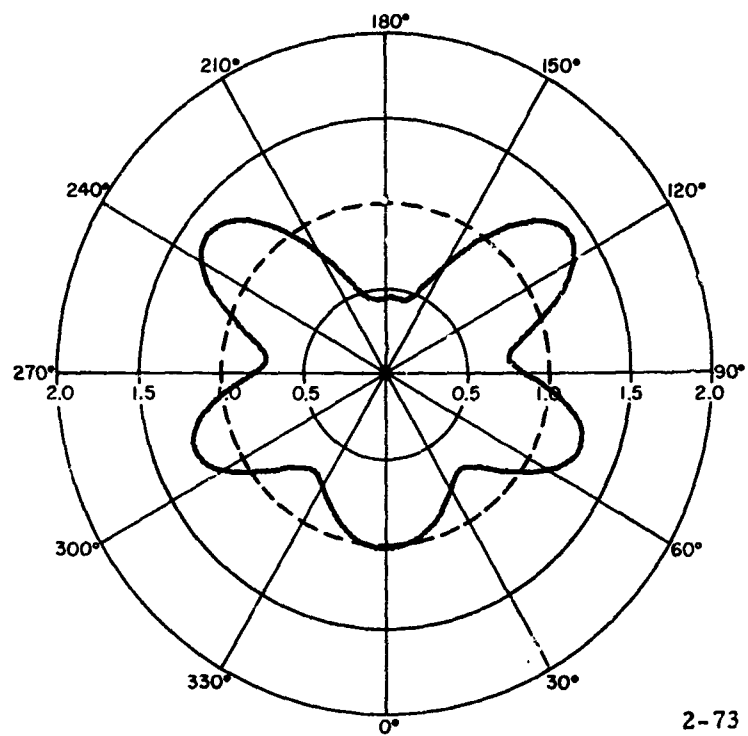
DISTANCE ~ WAVELENGTHS



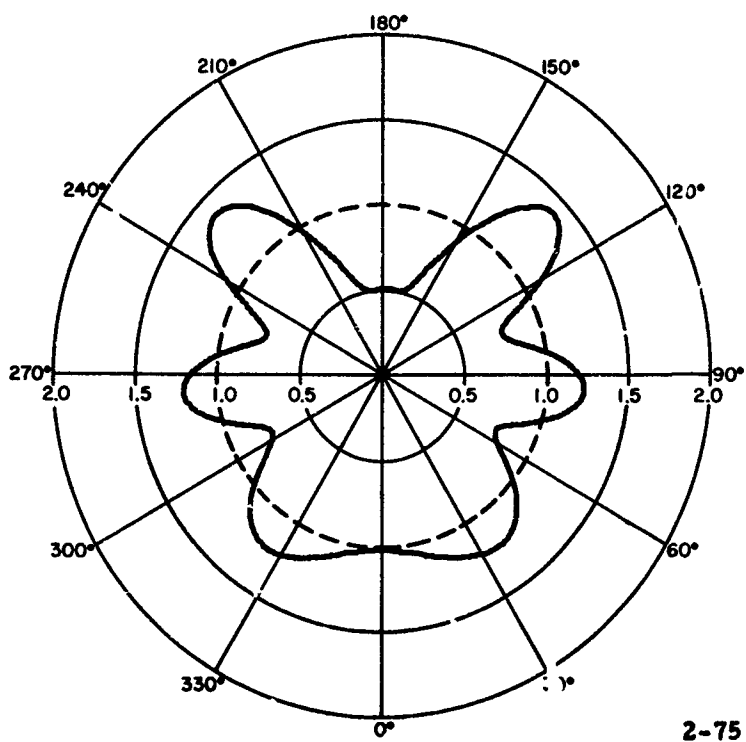
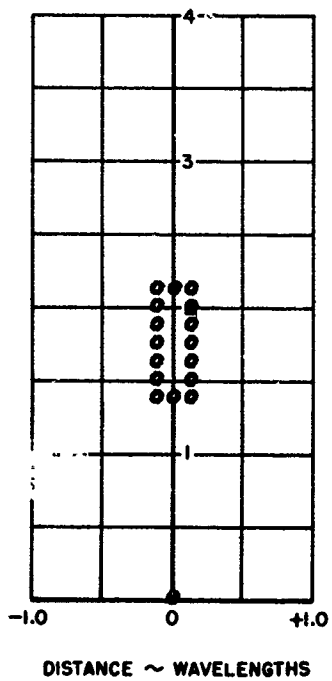
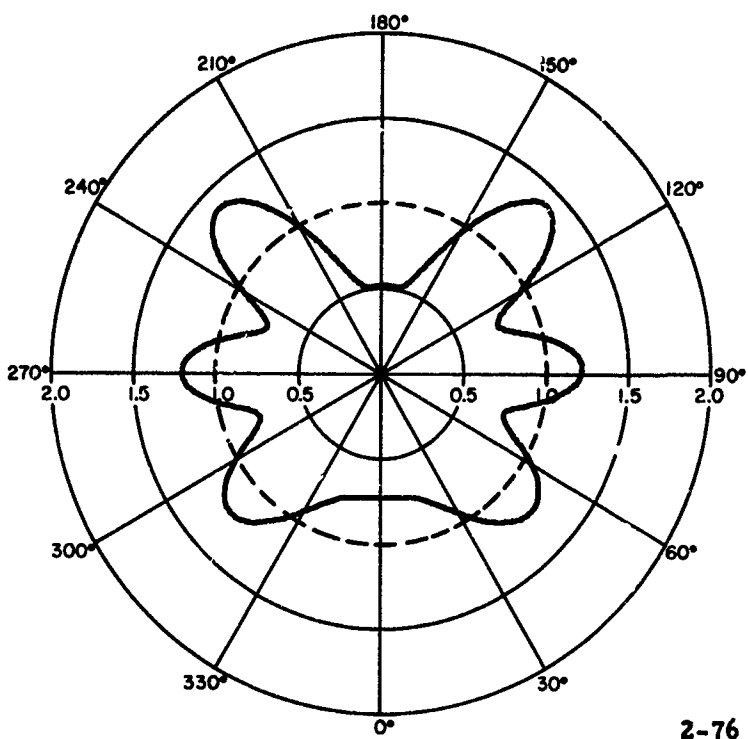
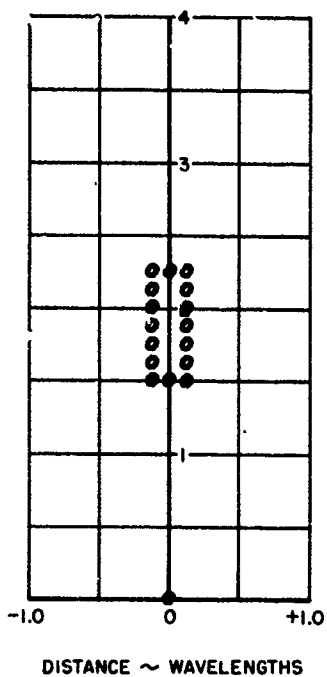
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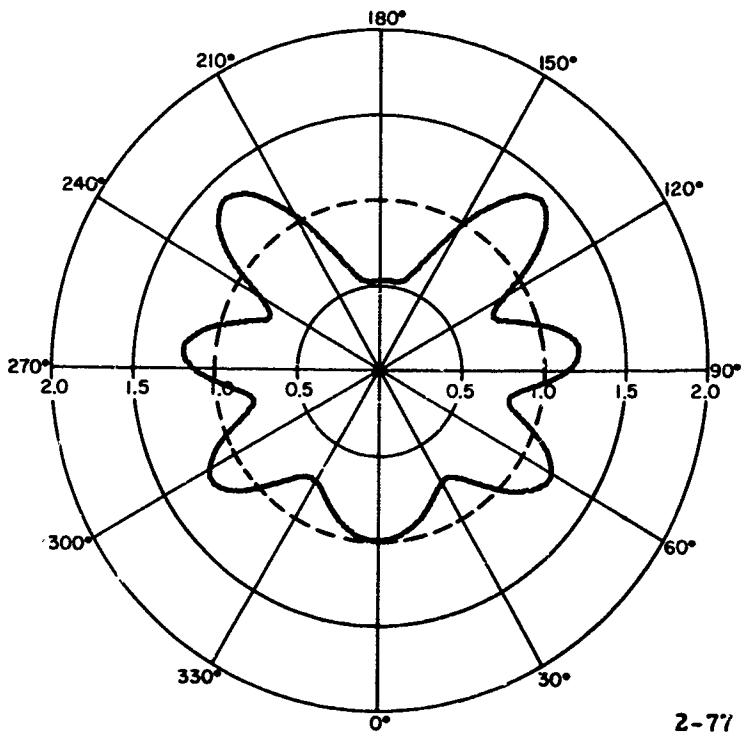
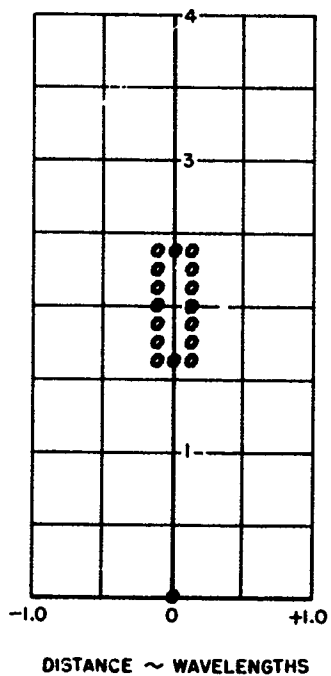
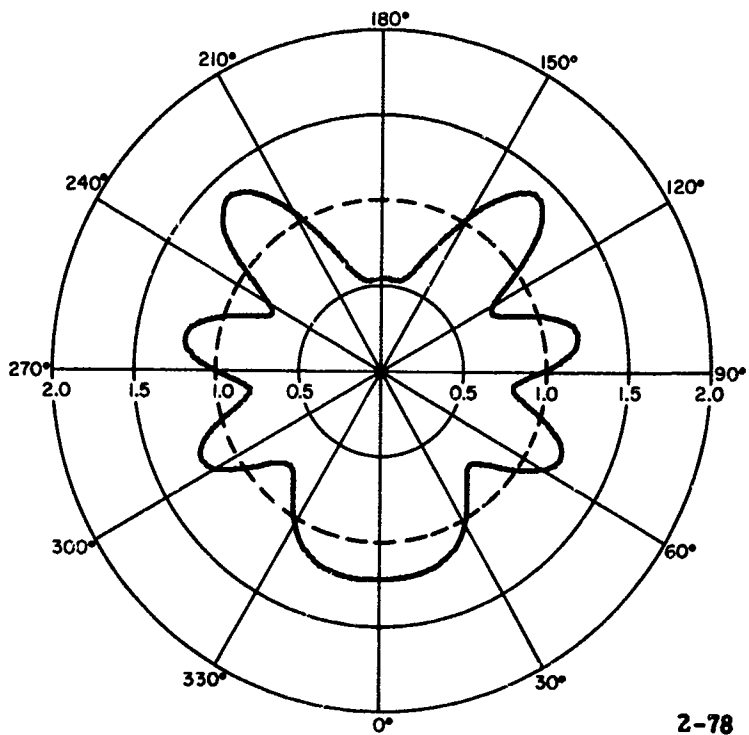
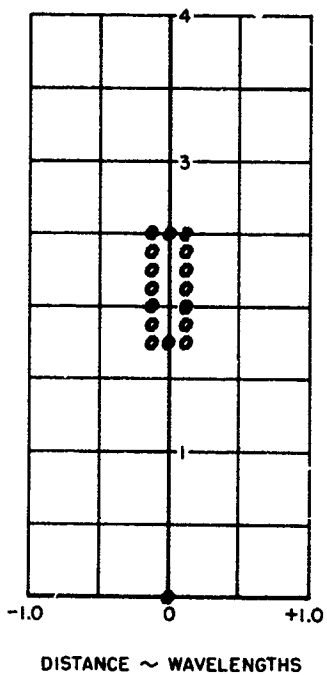


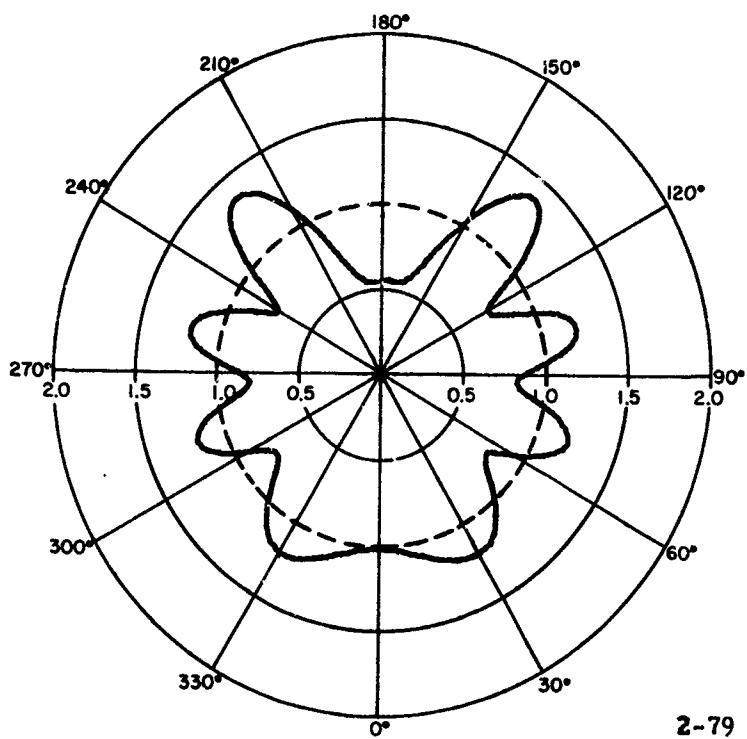
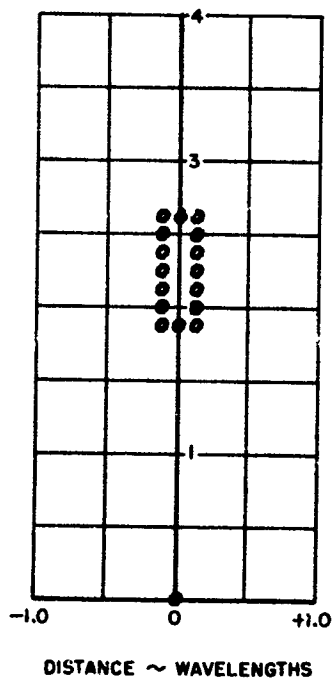
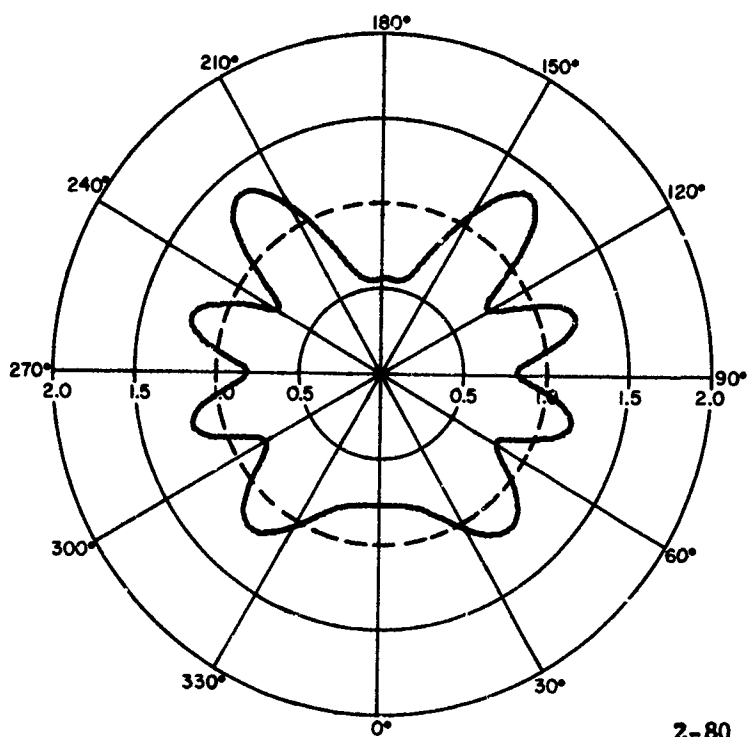
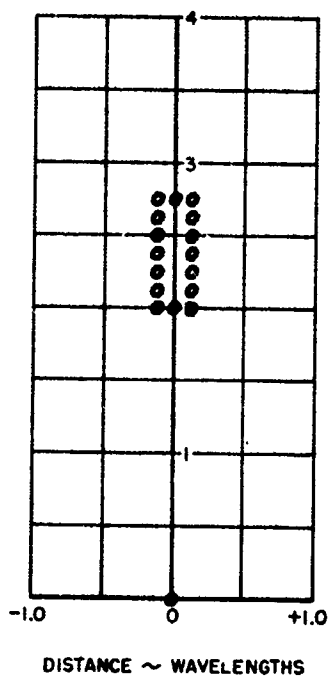
DISTANCE ~ WAVELENGTHS

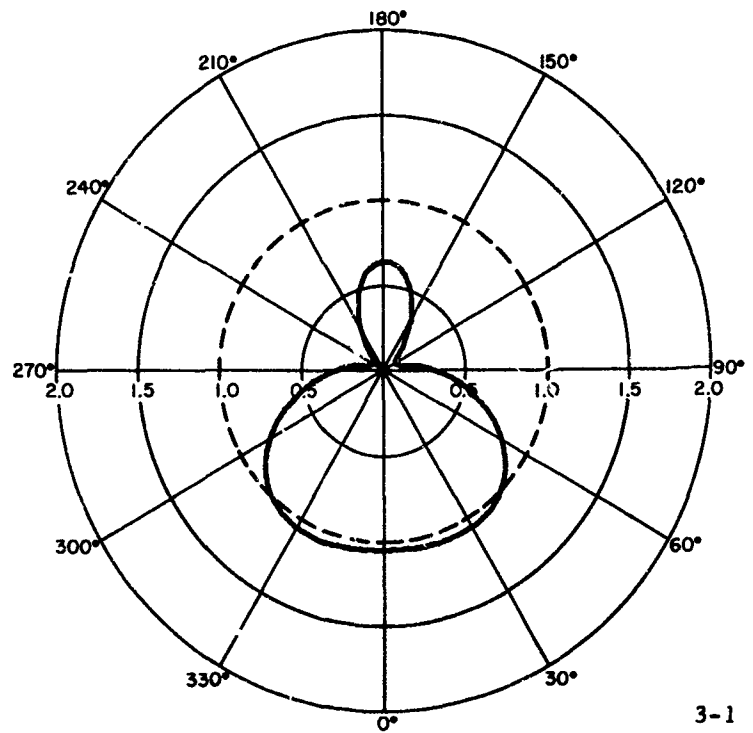
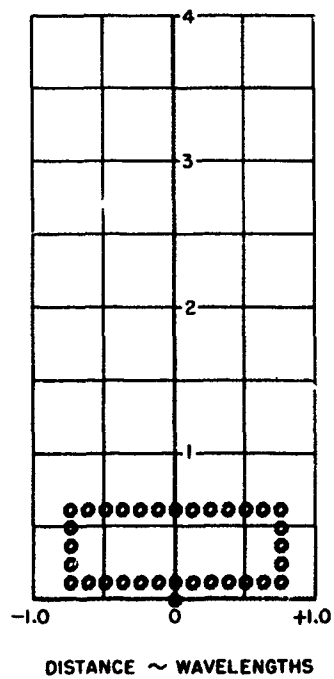
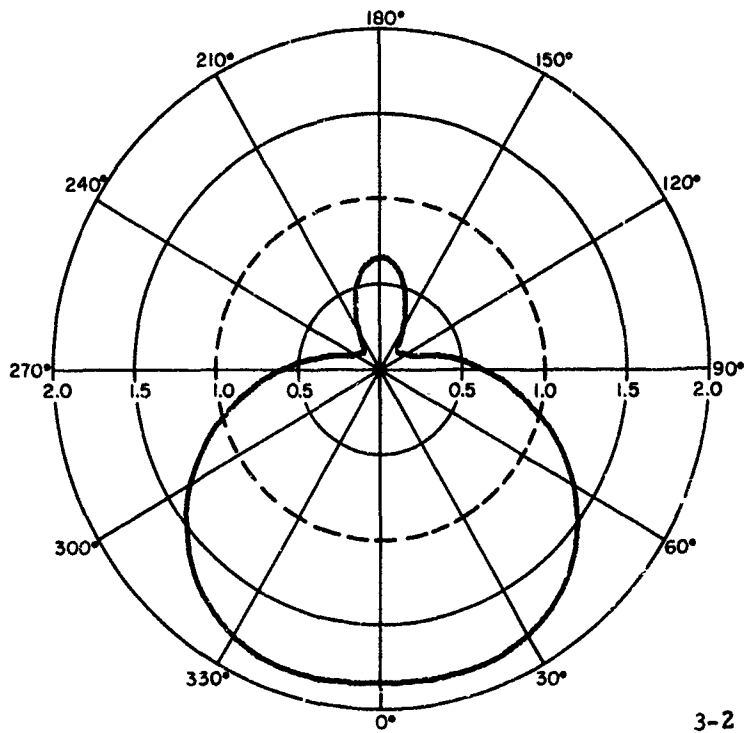
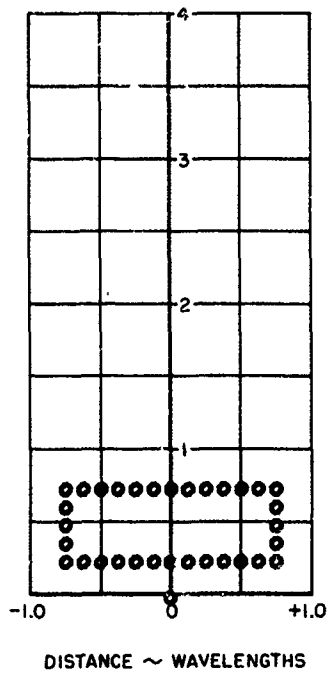


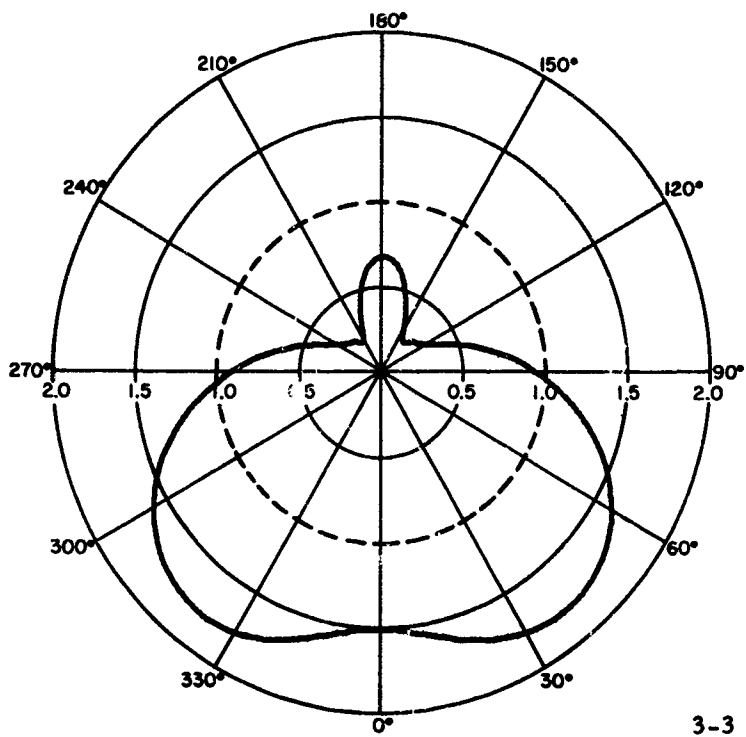
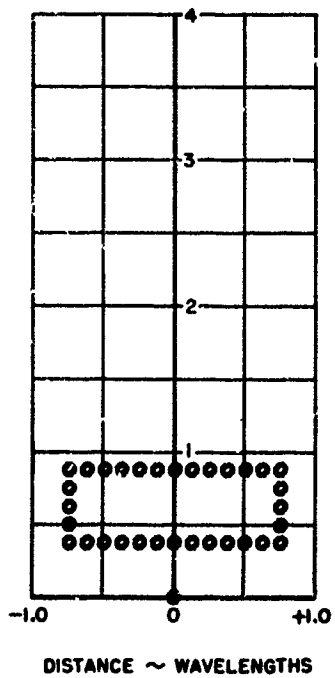
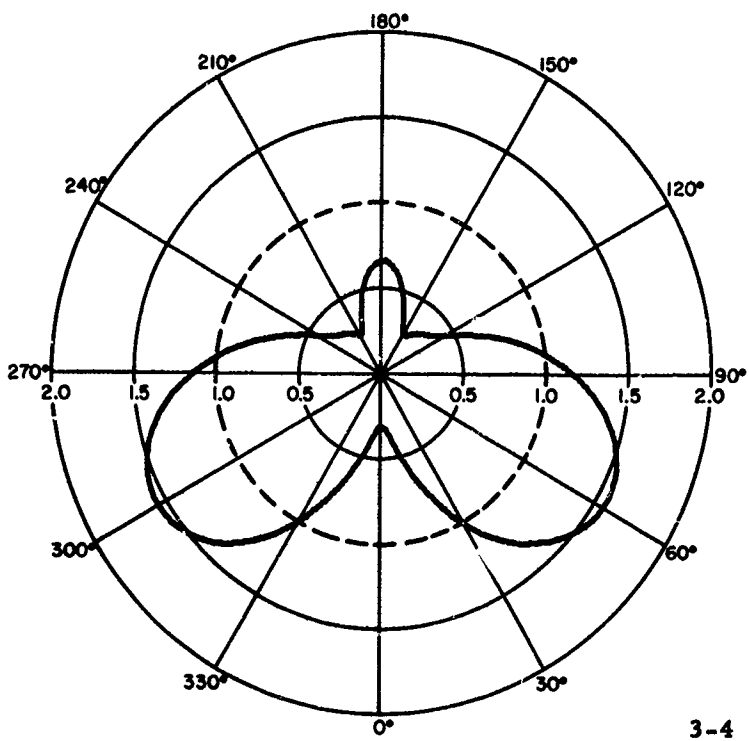
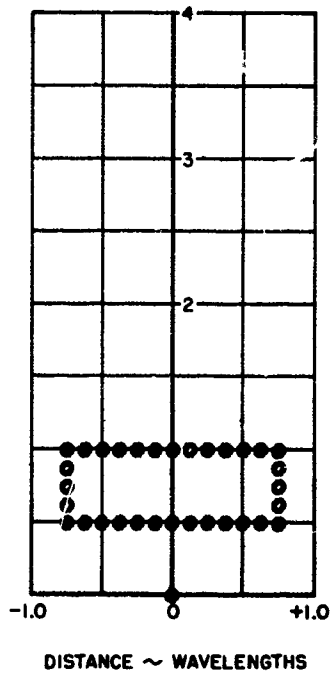
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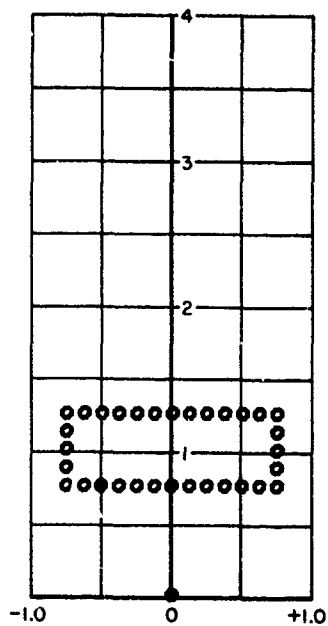




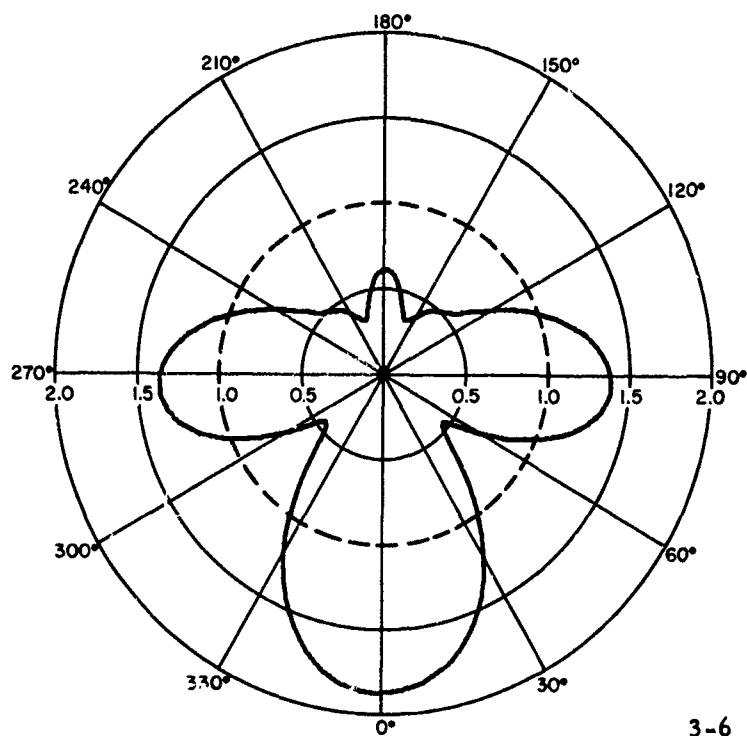




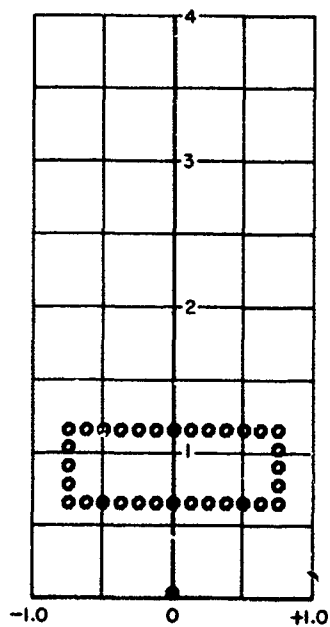




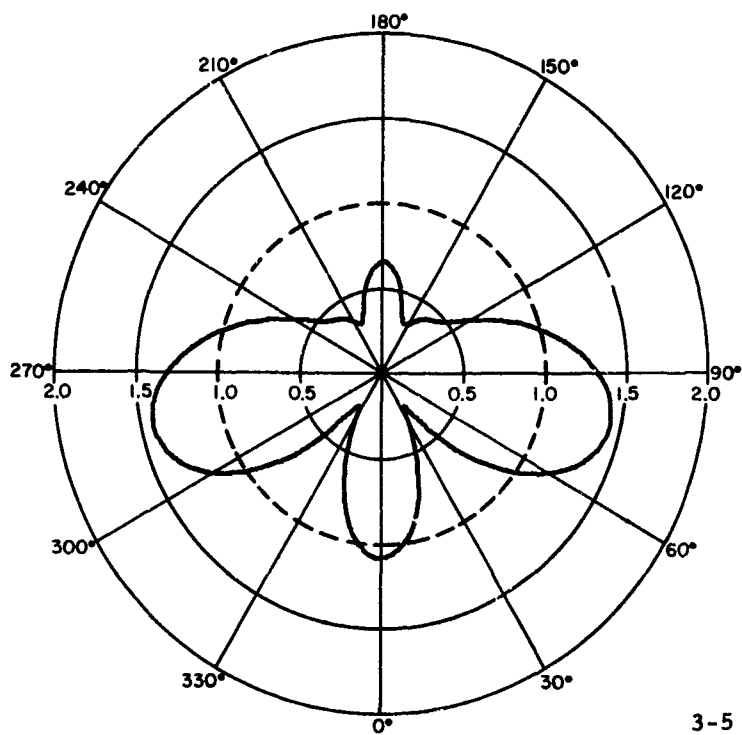
DISTANCE ~ WAVELENGTHS



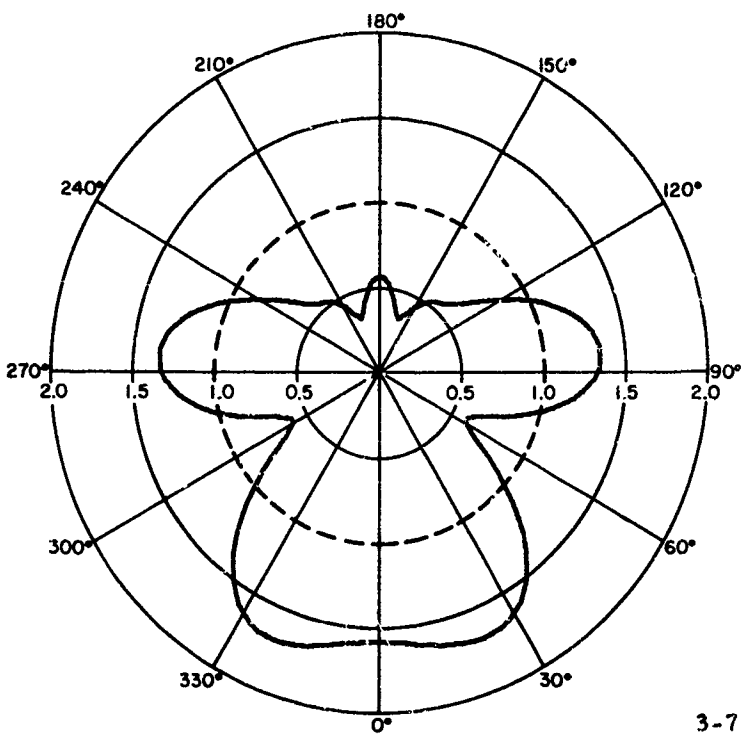
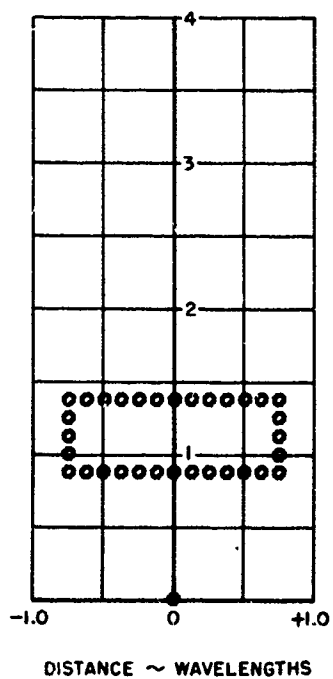
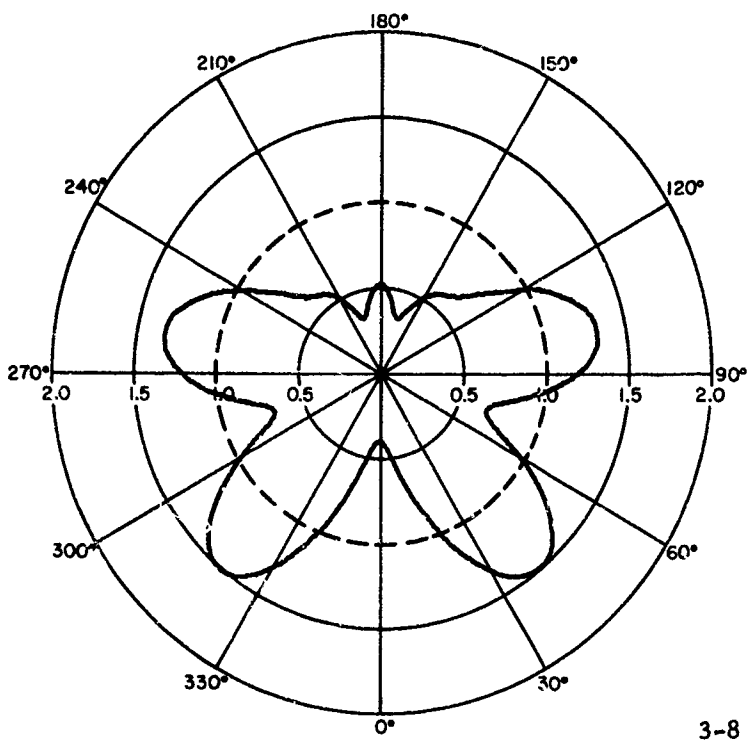
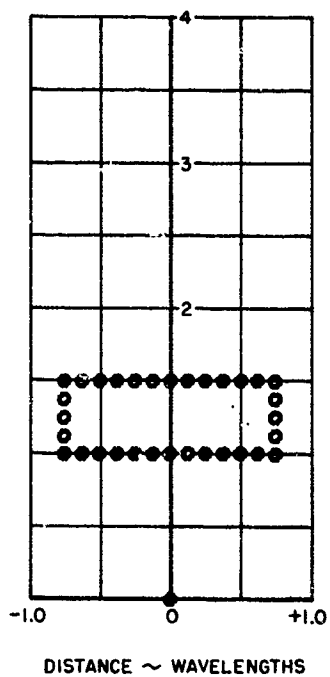
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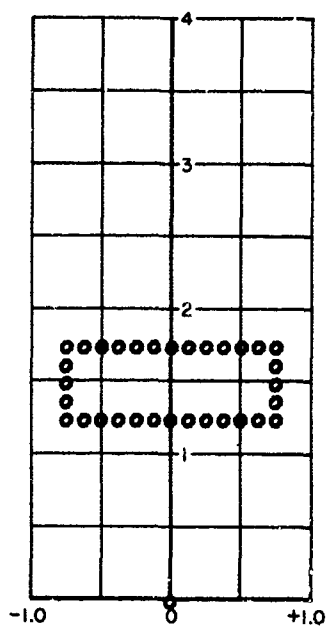


DISTANCE ~ WAVELENGTHS

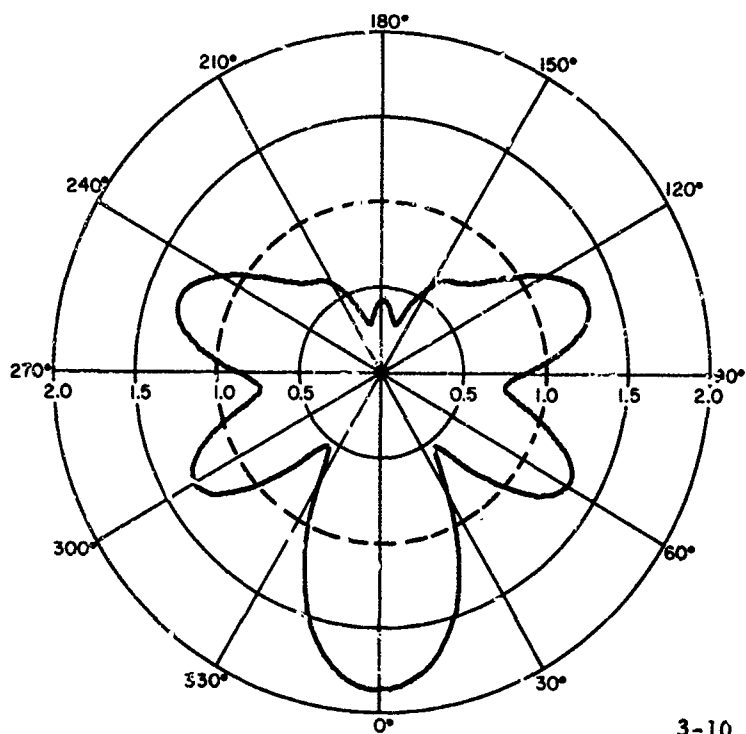


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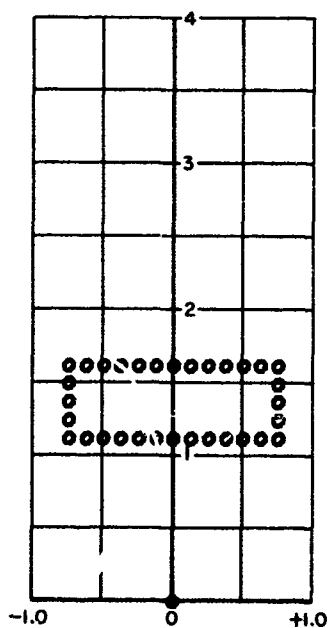




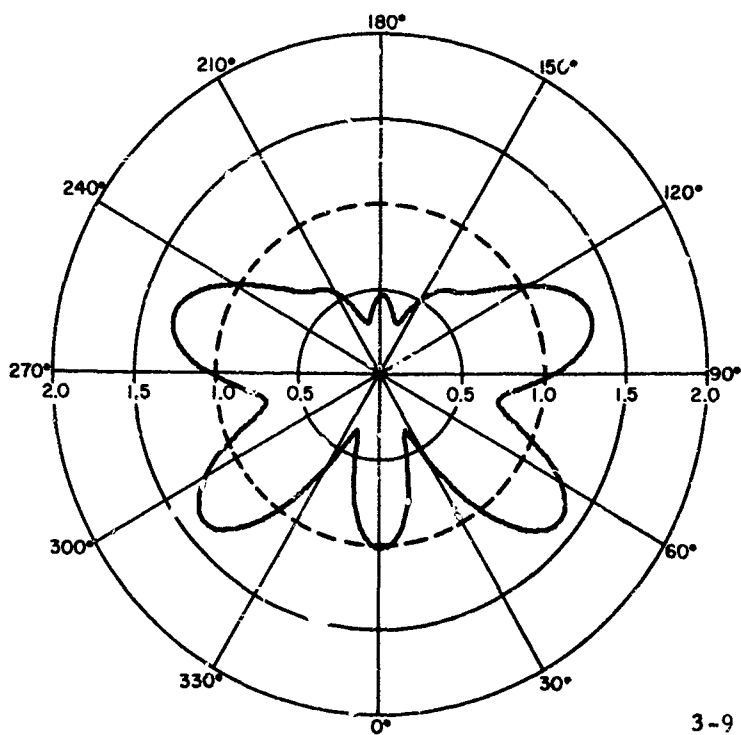
DISTANCE ~ WAVELENGTHS



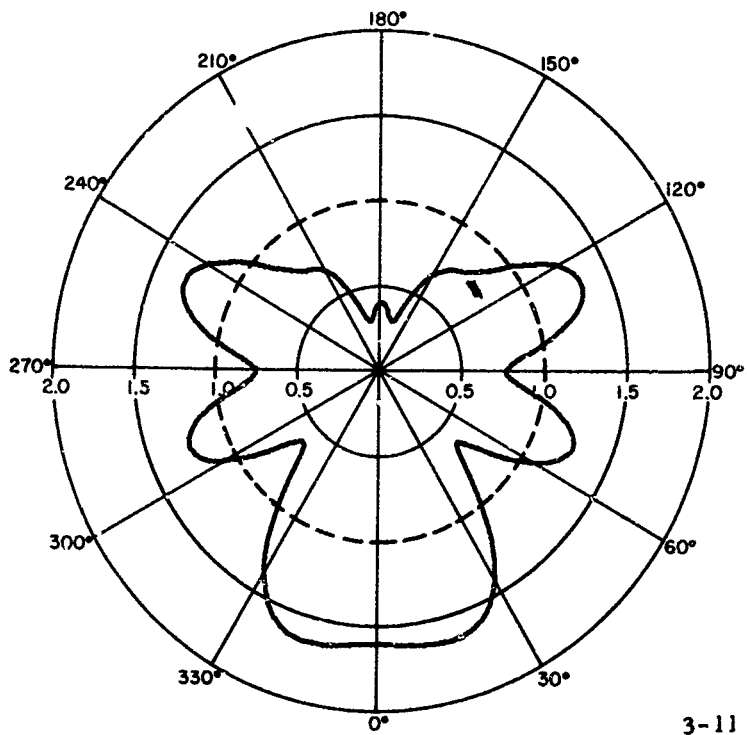
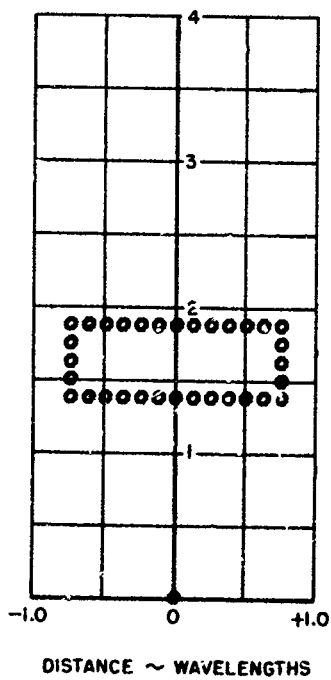
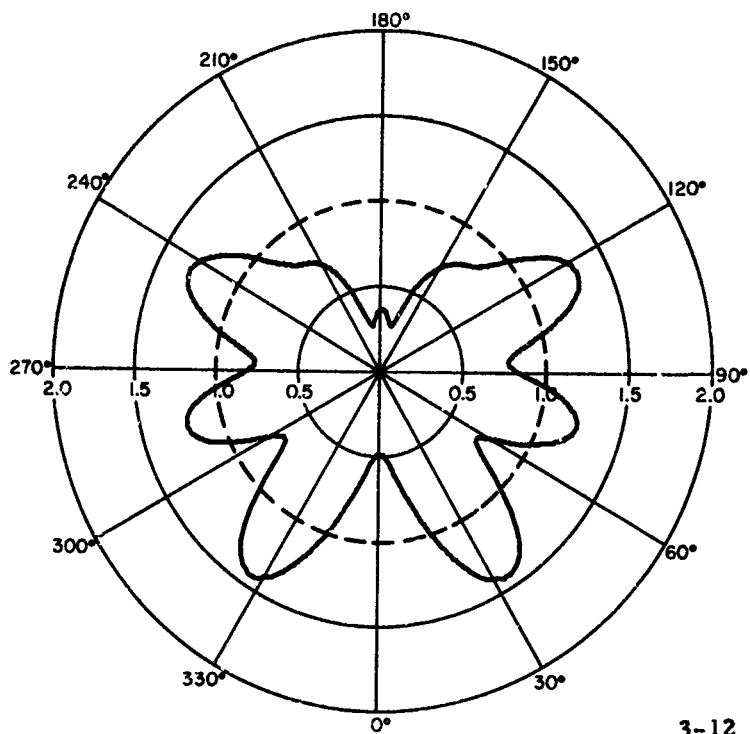
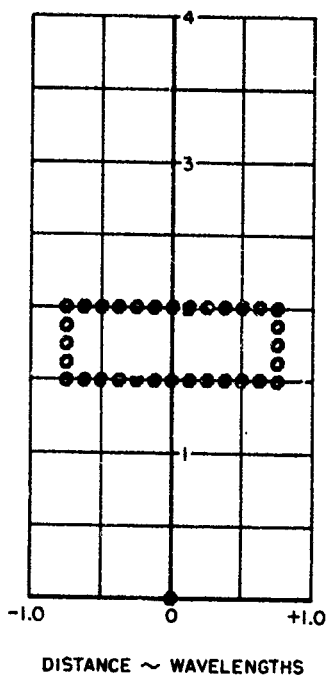
3-10

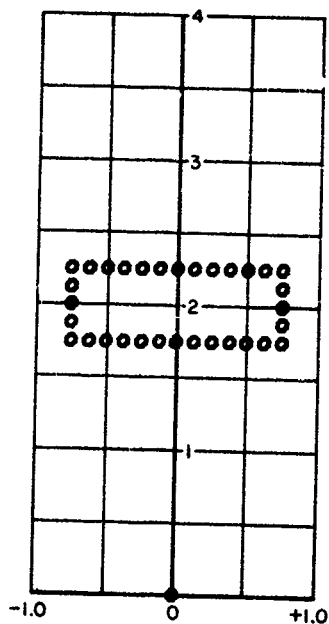


DISTANCE ~ WAVELENGTHS

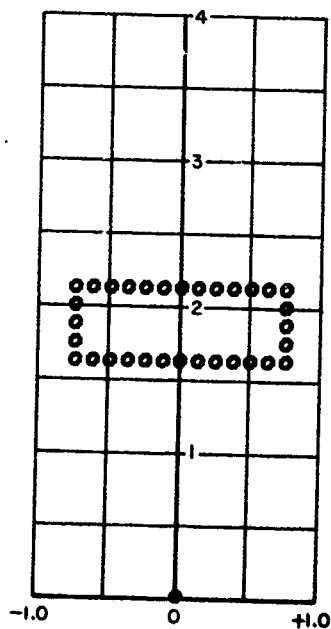
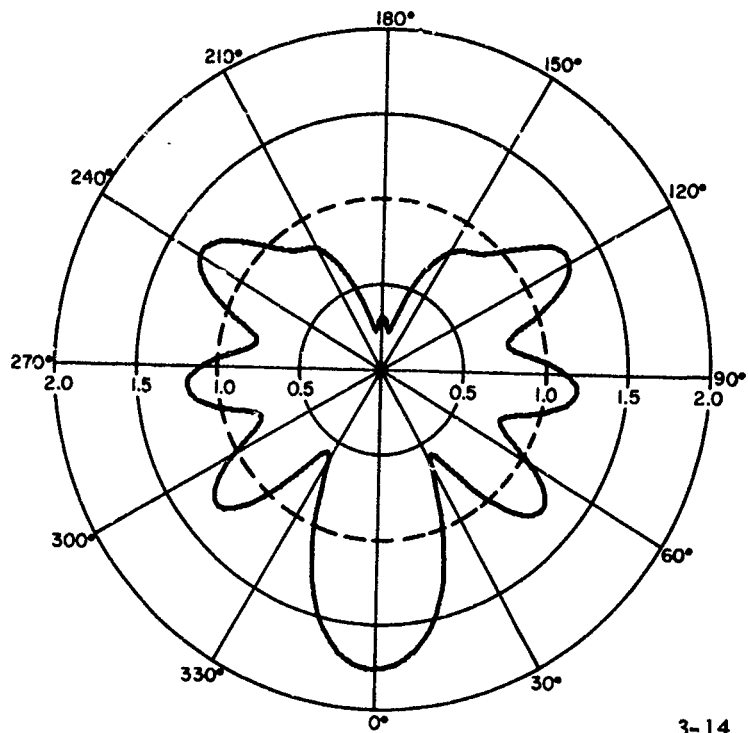


3-9

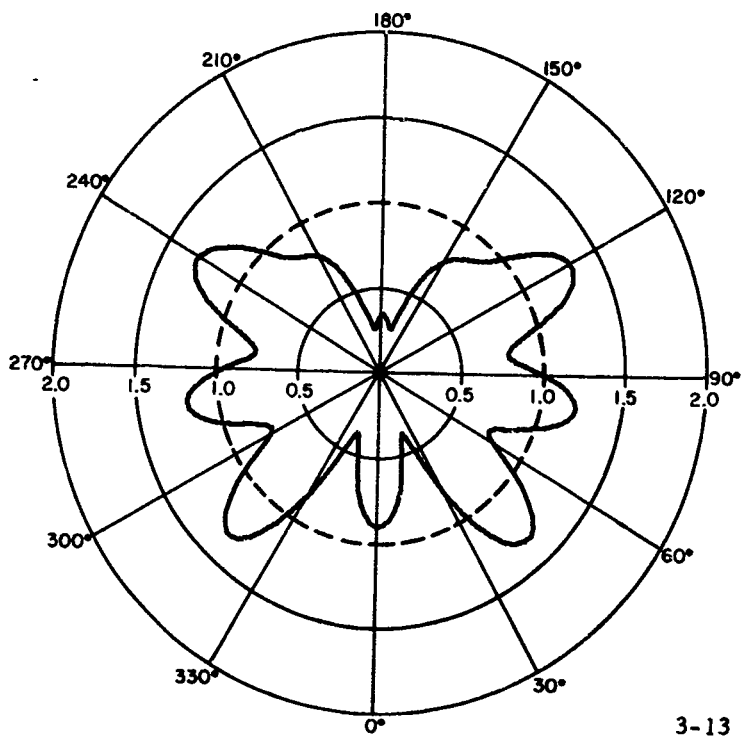


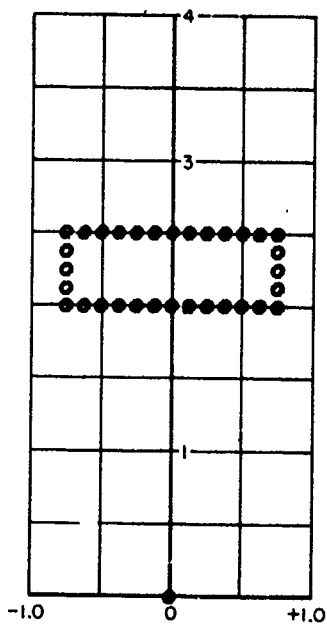


DISTANCE ~ WAVELENGTHS

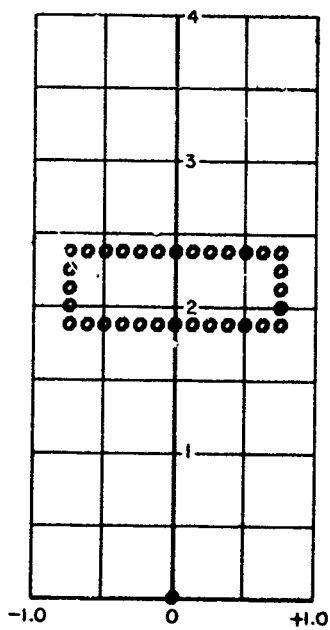
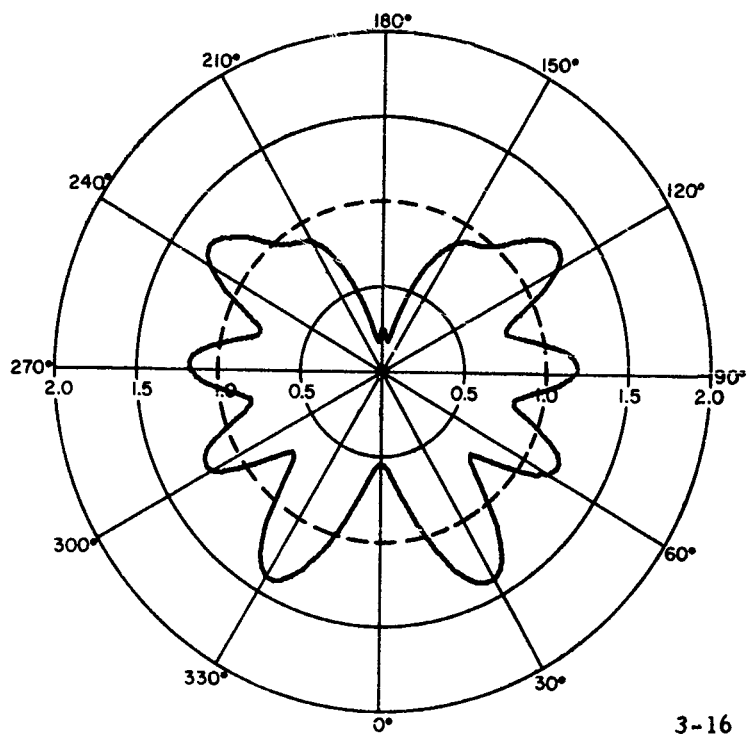


DISTANCE ~ WAVELENGTHS

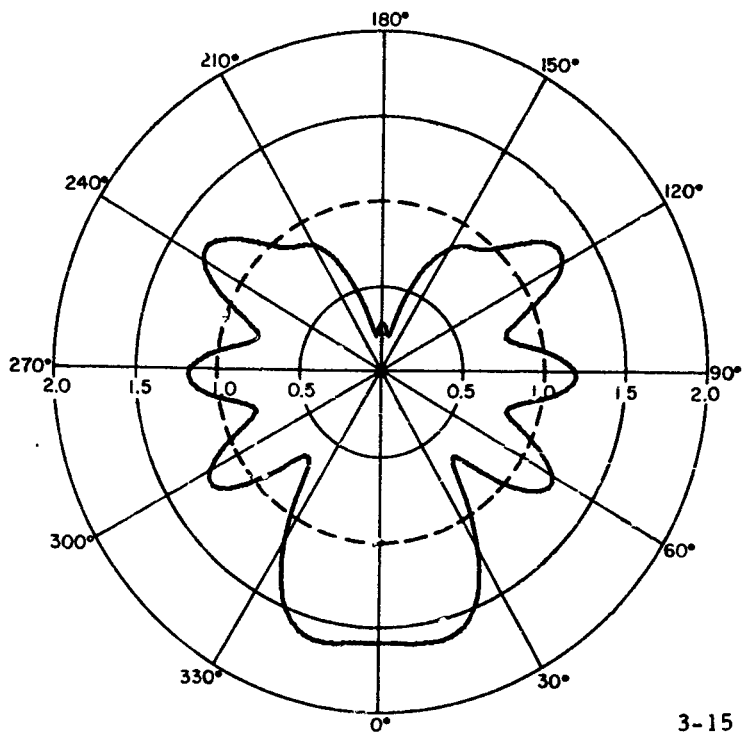


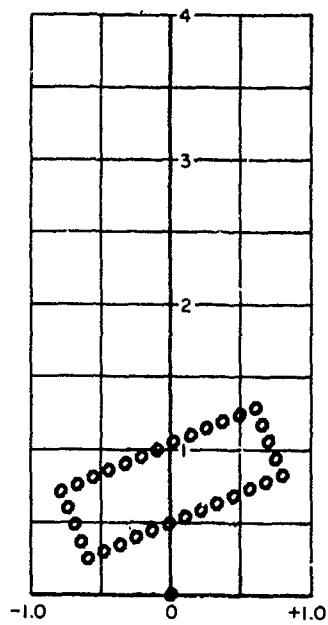


DISTANCE ~ WAVELENGTHS

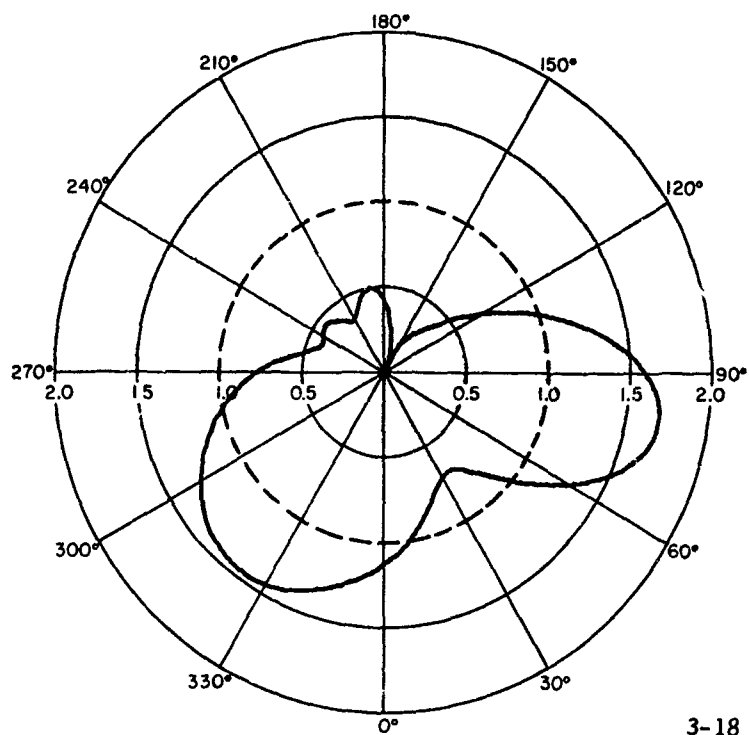


DISTANCE ~ WAVELENGTHS

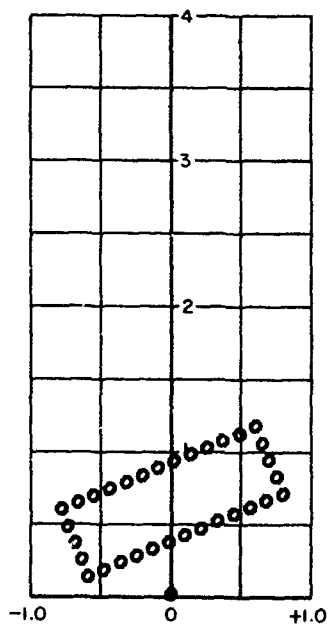




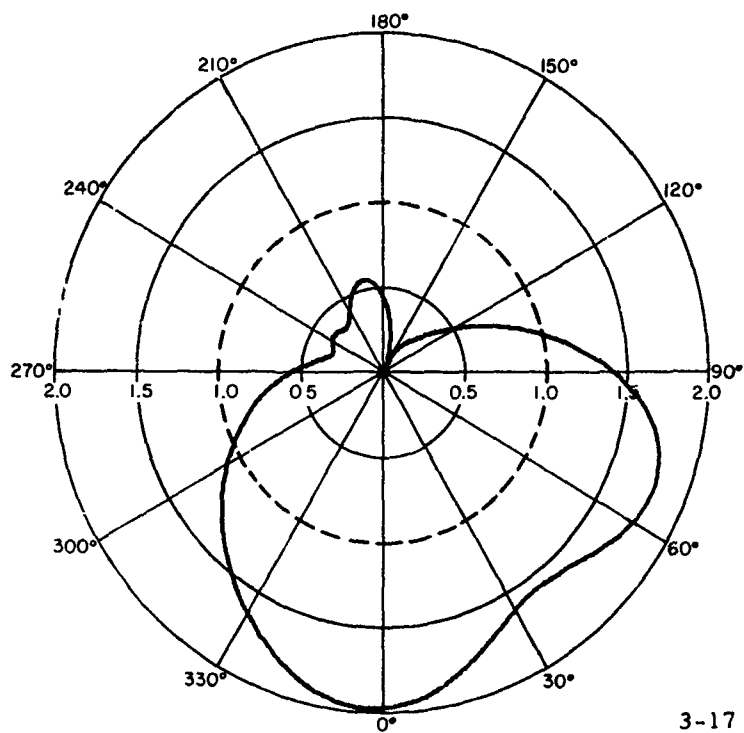
DISTANCE ~ WAVELENGTHS



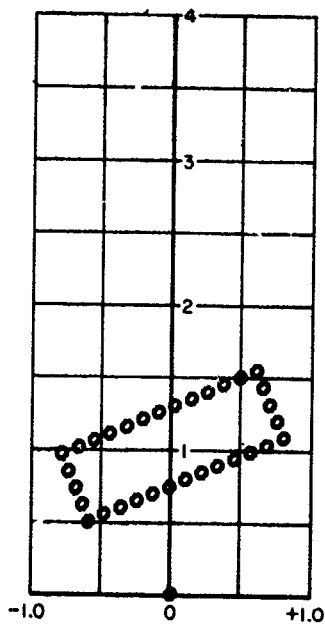
3-18



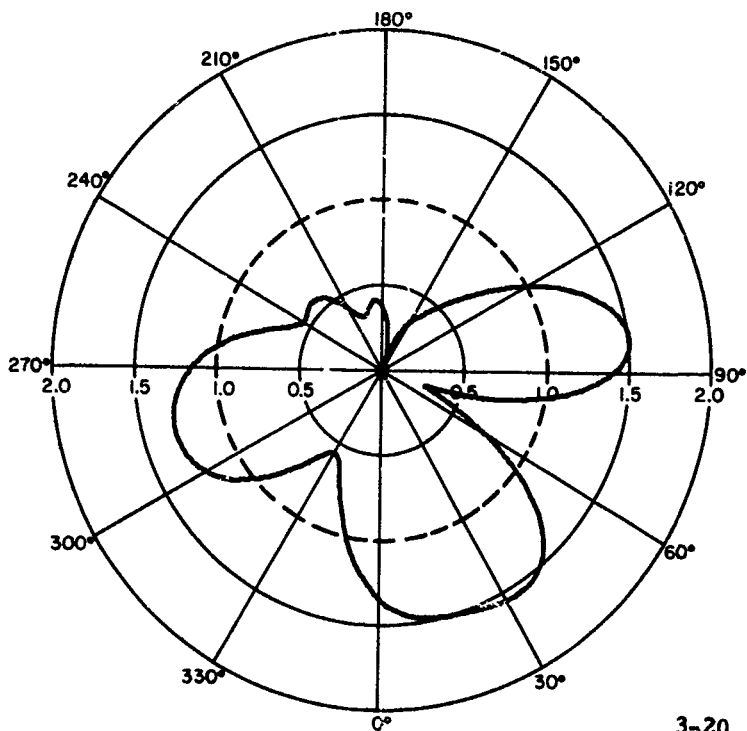
DISTANCE ~ WAVELENGTHS



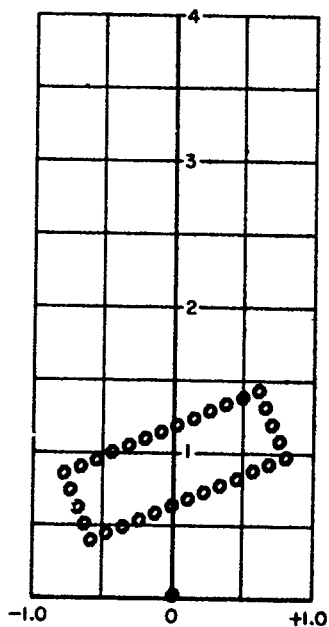
3-17



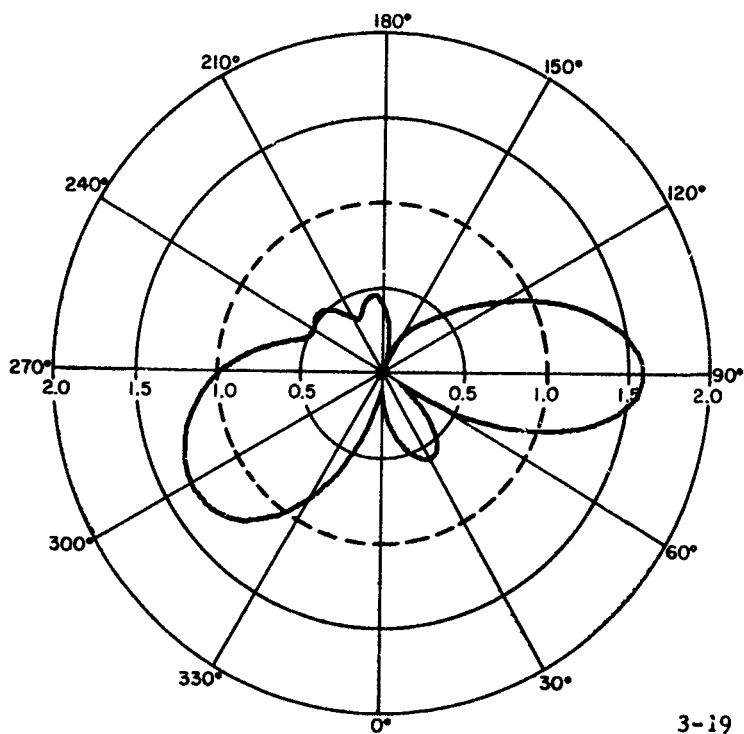
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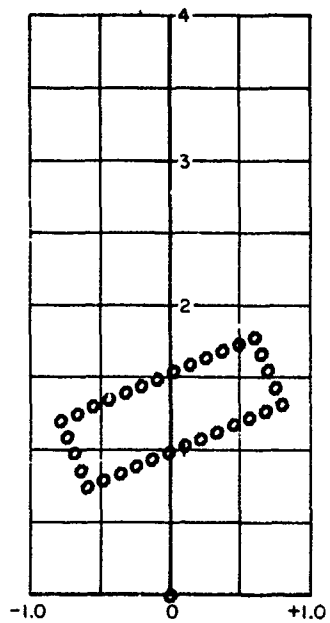
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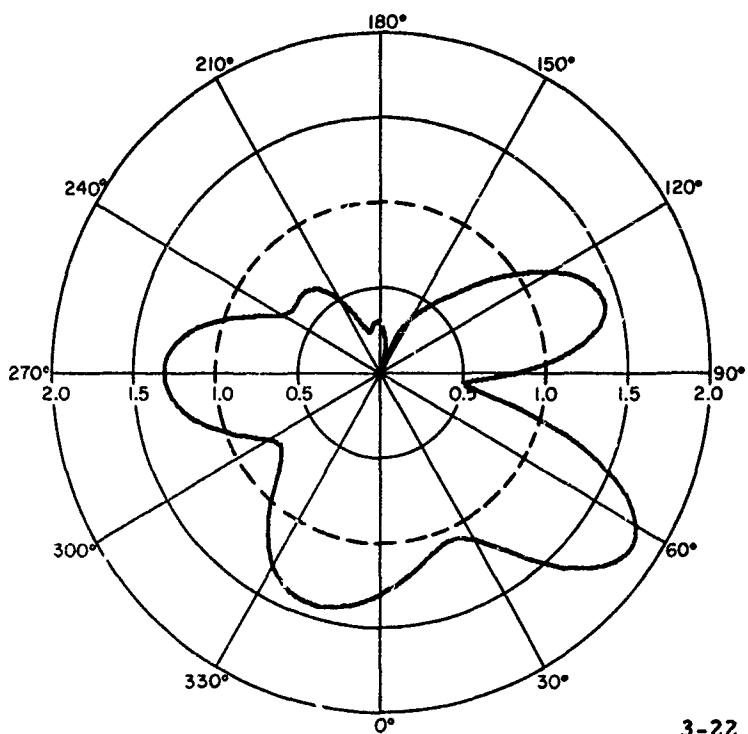
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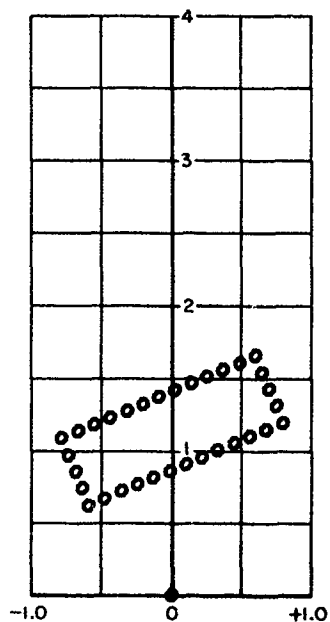
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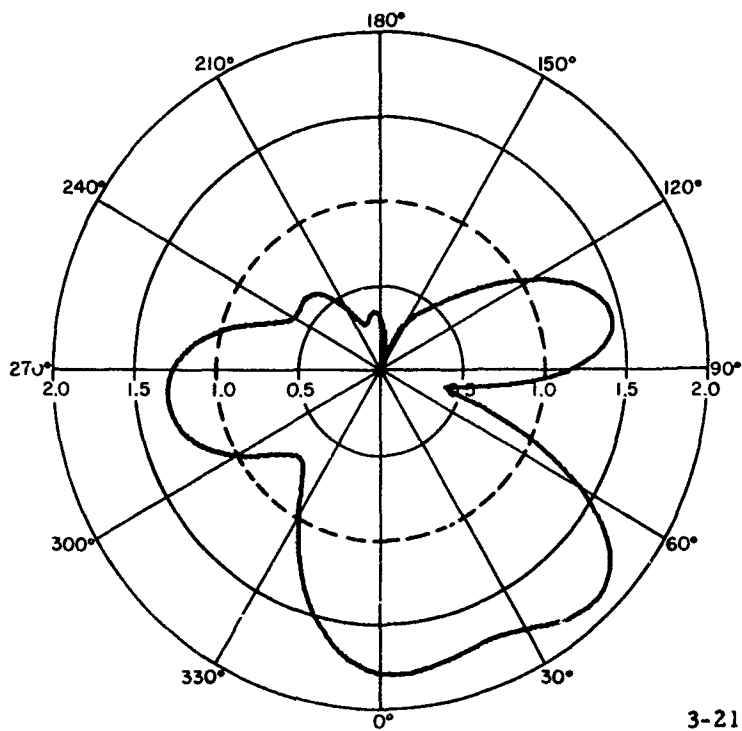
DISTANCE ~ WAVELENGTHS



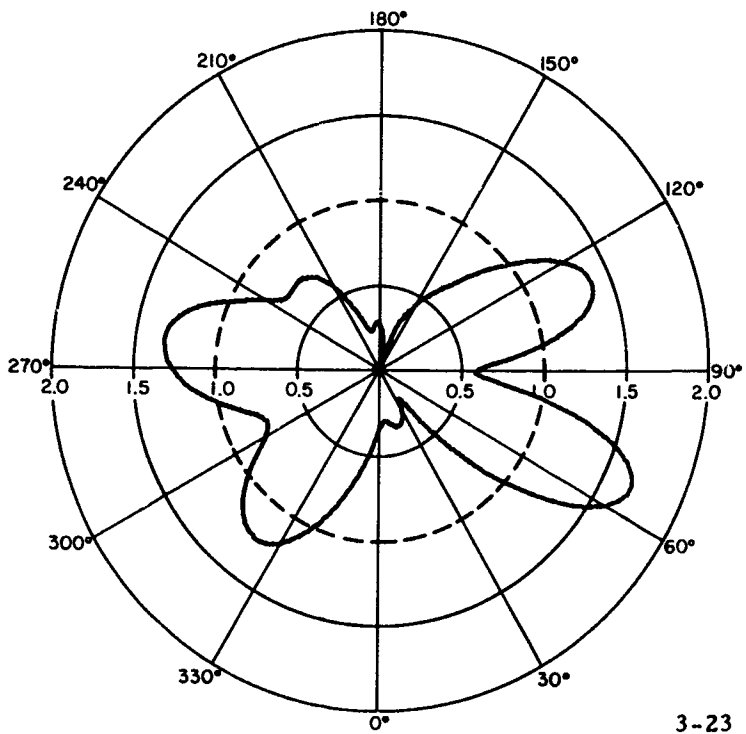
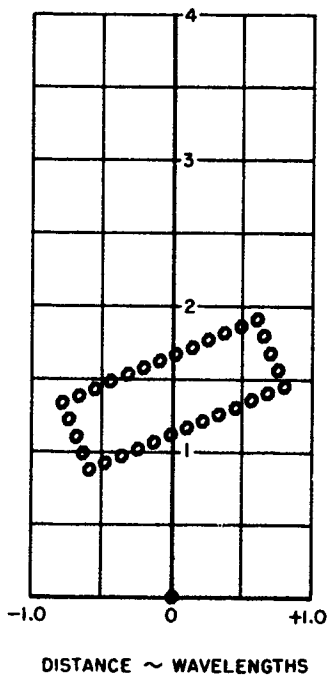
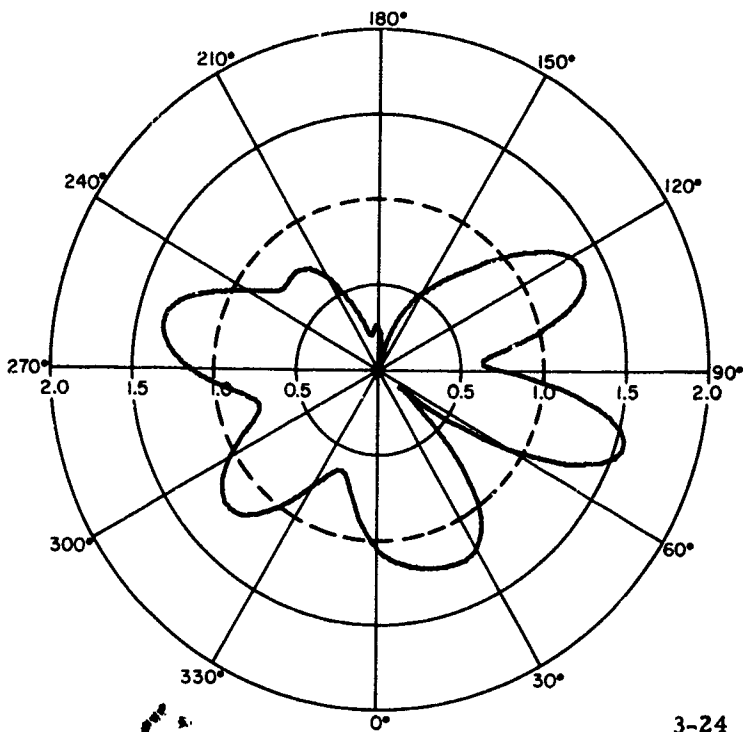
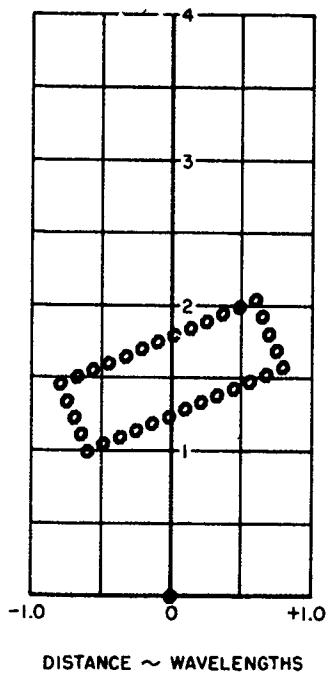
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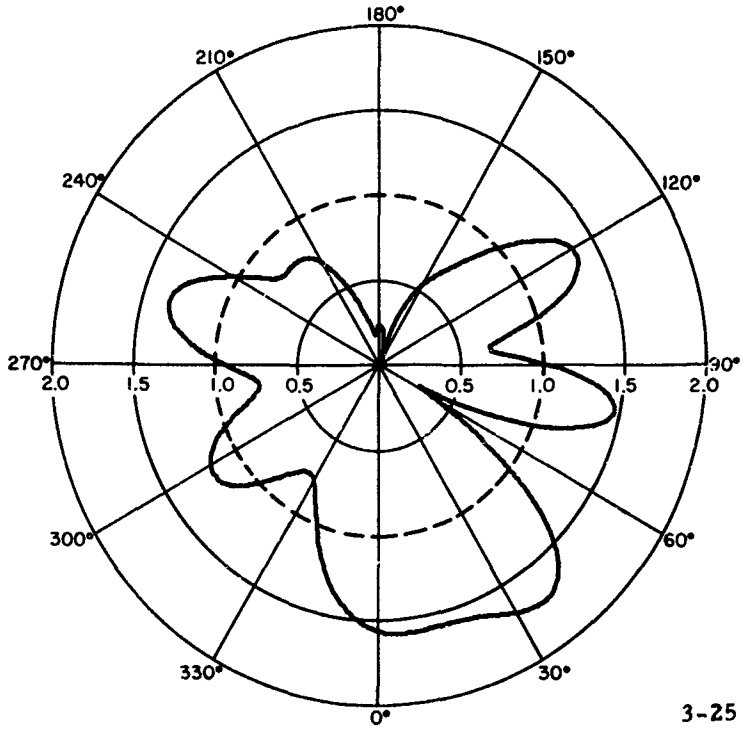
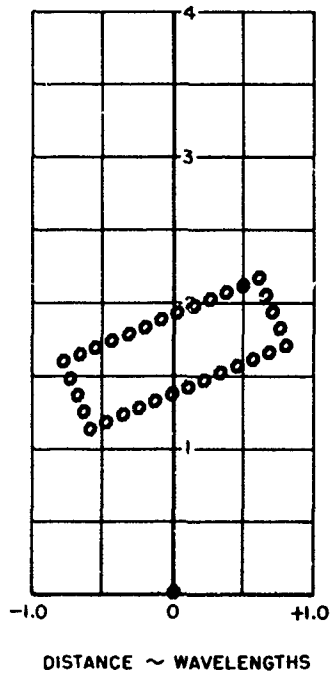
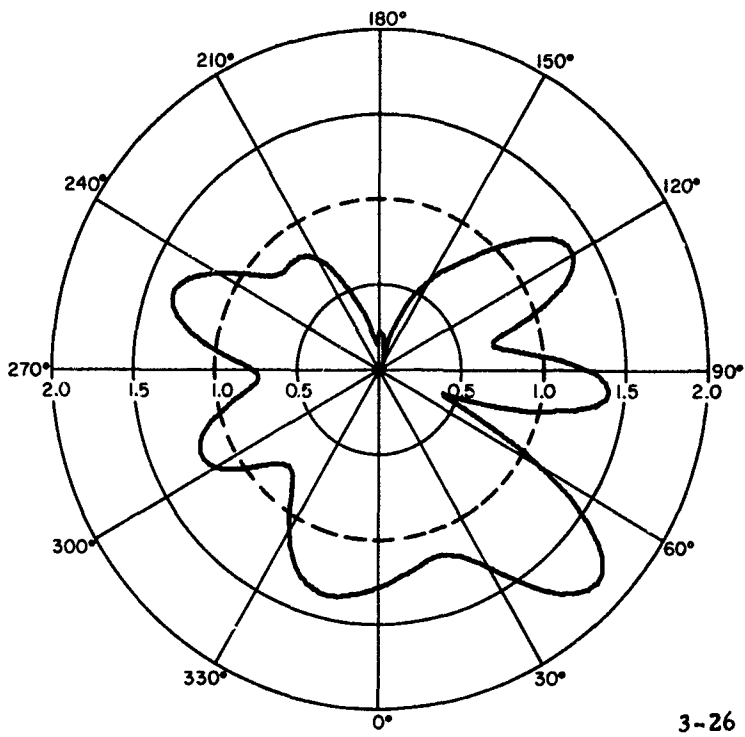
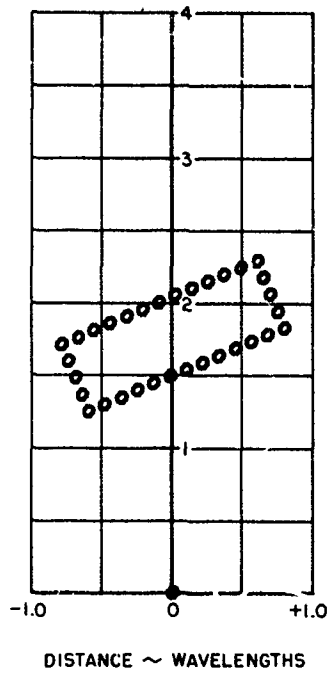


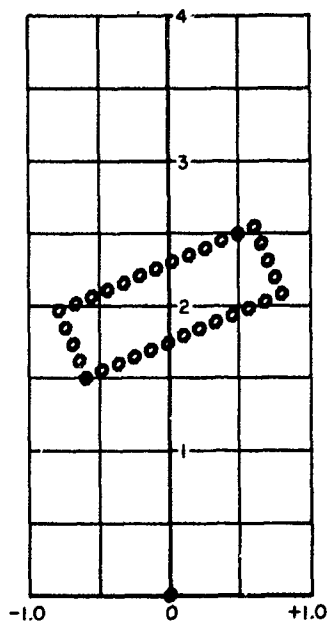
DISTANCE ~ WAVELENGTHS



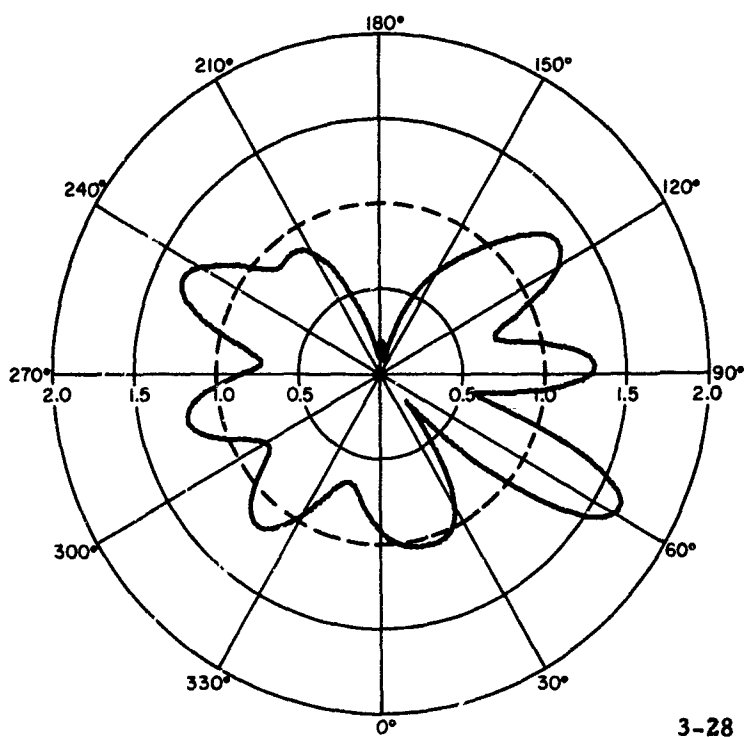
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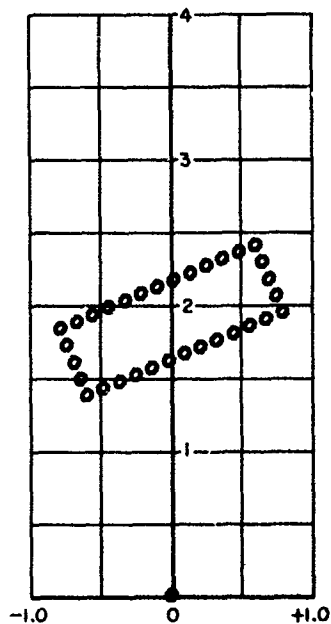




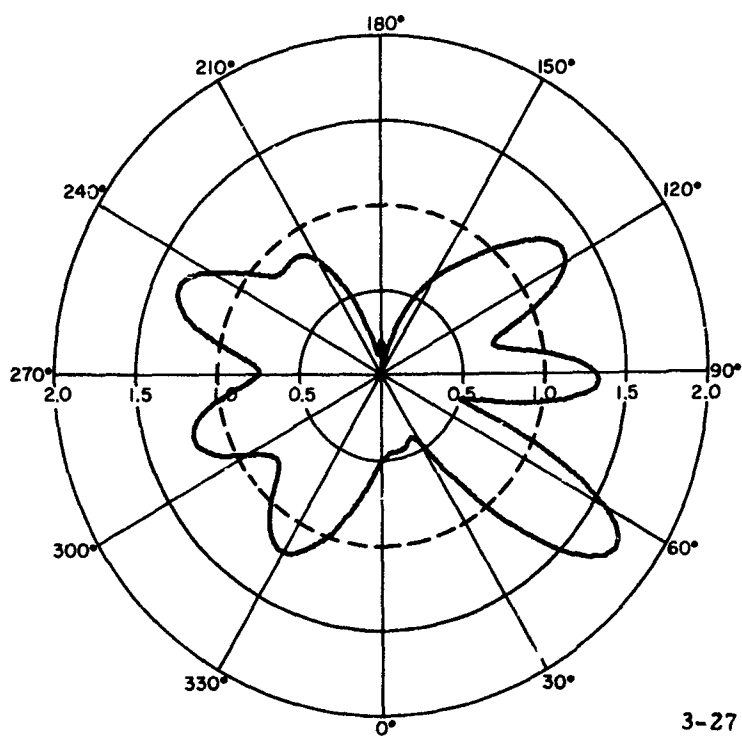
DISTANCE ~ WAVELENGTHS



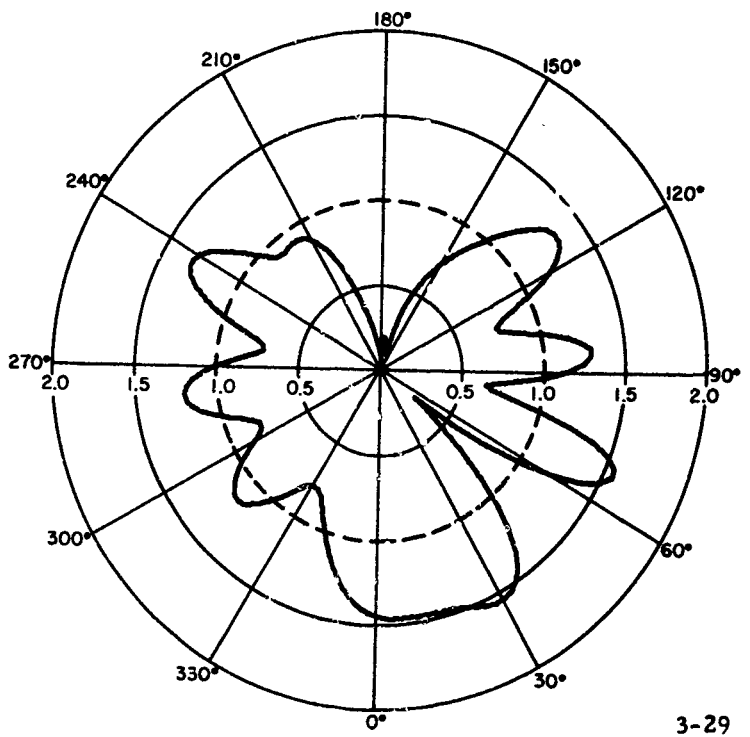
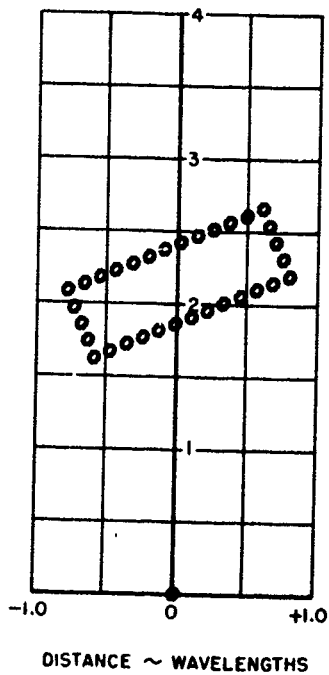
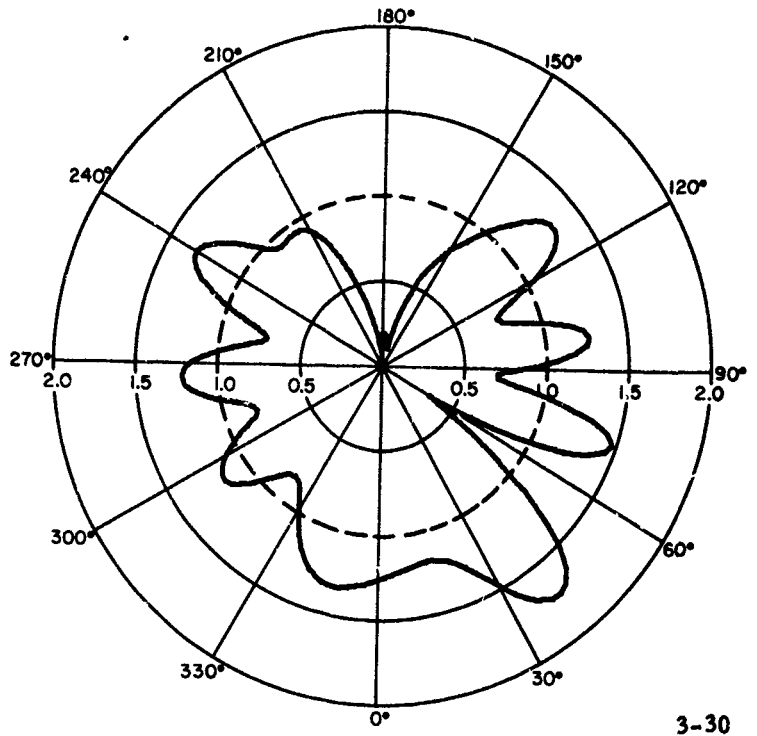
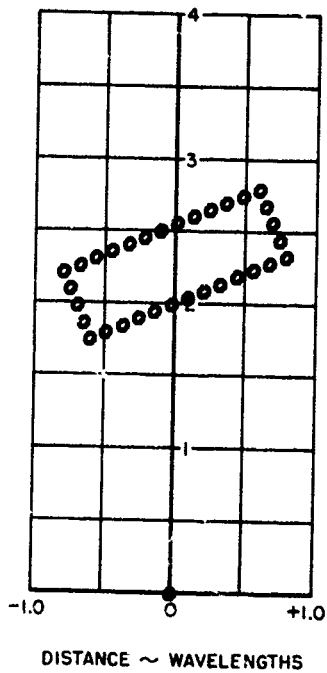
3-28

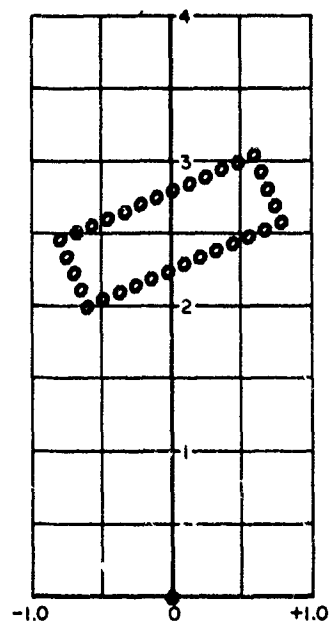


DISTANCE ~ WAVELENGTHS

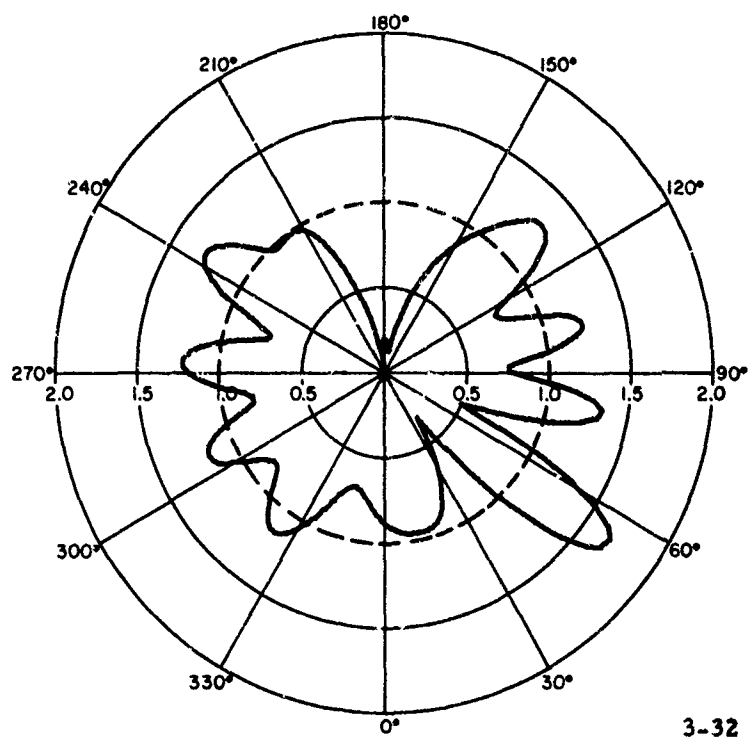


3-27

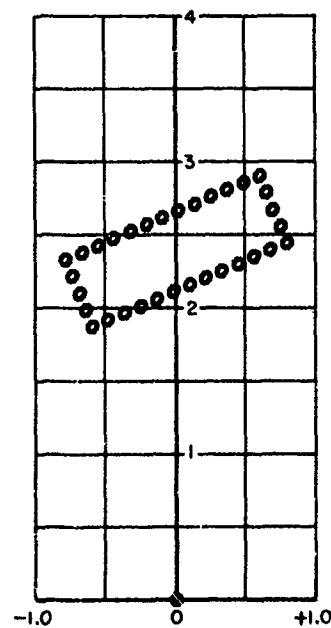




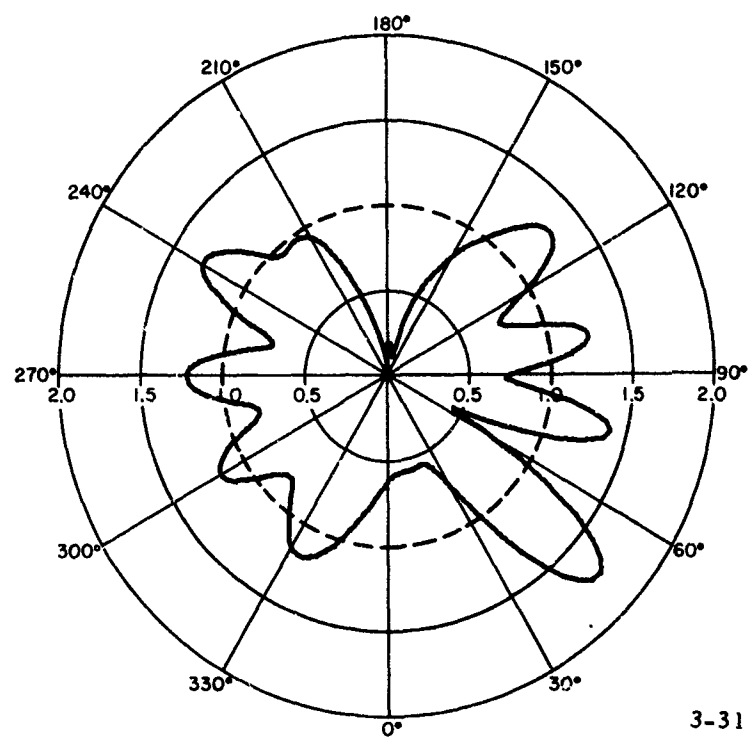
DISTANCE ~ WAVELENGTHS



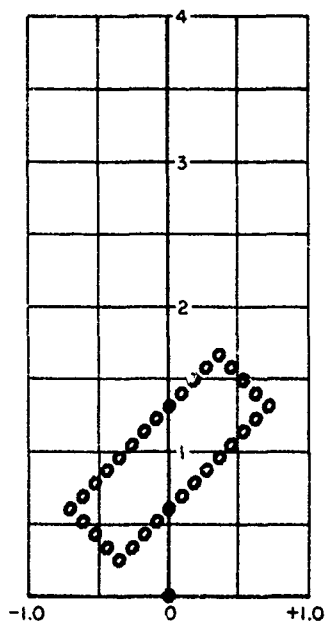
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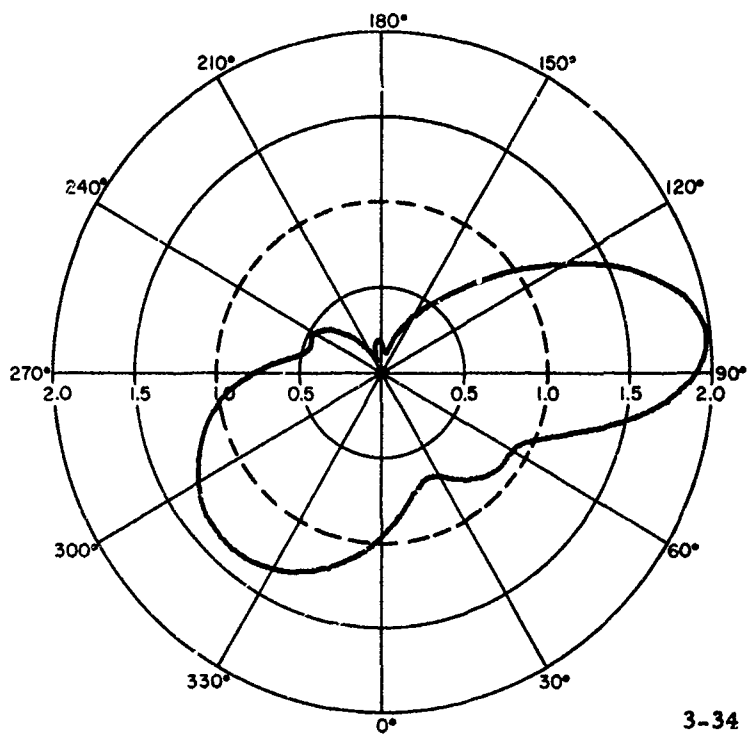
DISTANCE ~ WAVELENGTHS



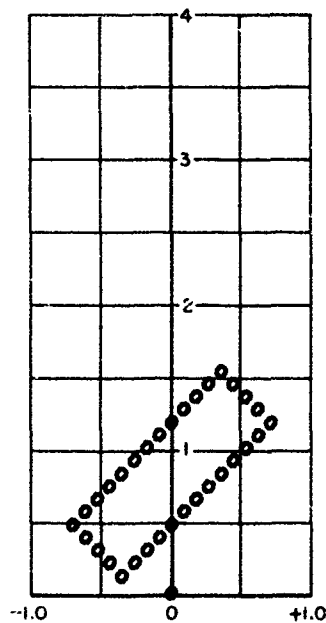
3-31



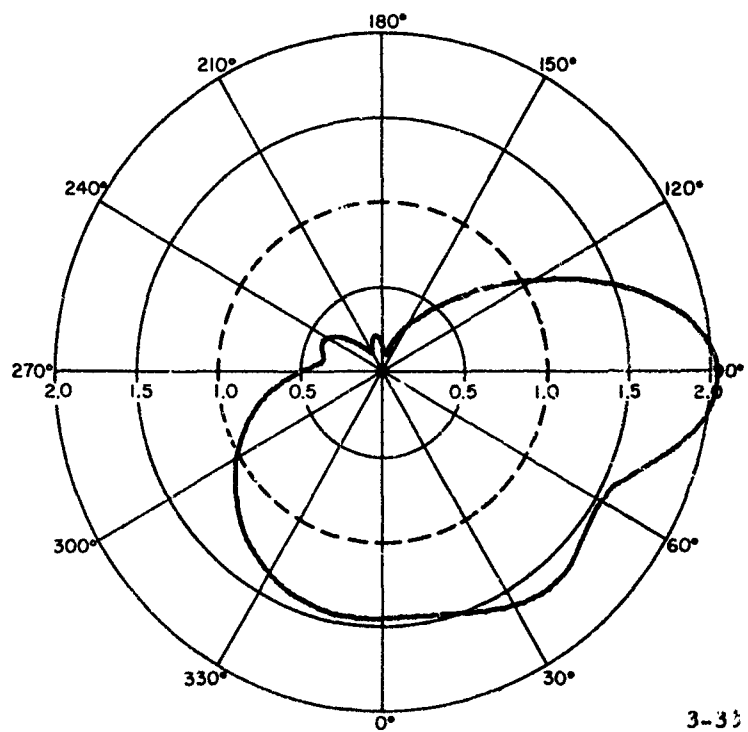
DISTANCE ~ WAVELENGTHS



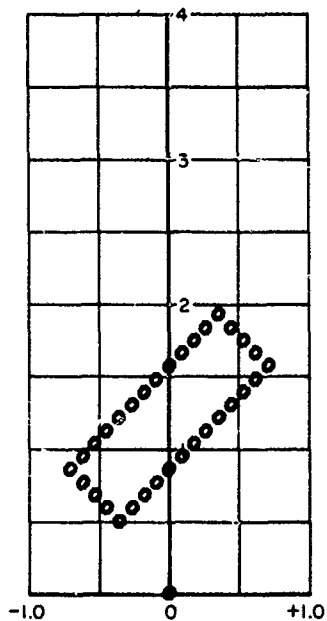
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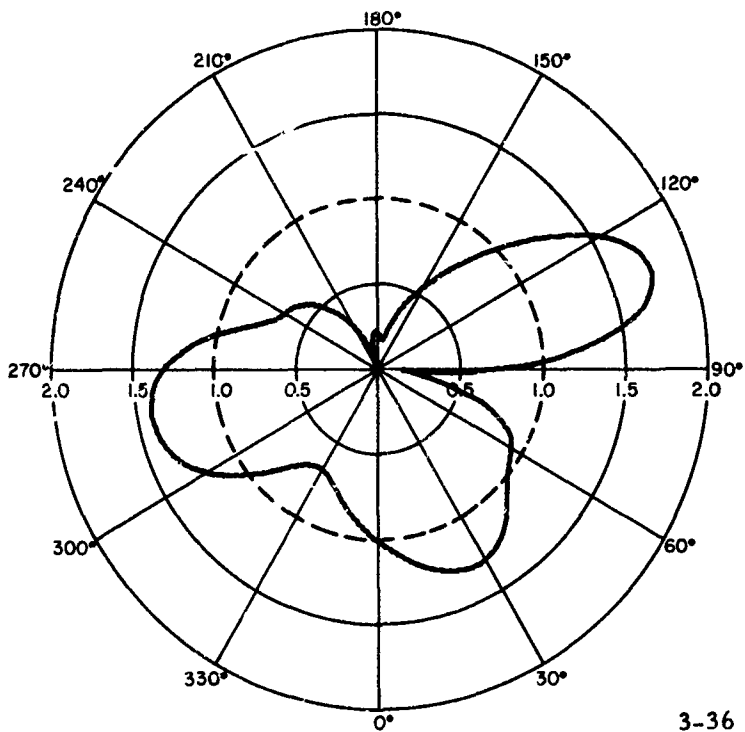
DISTANCE ~ WAVELENGTHS



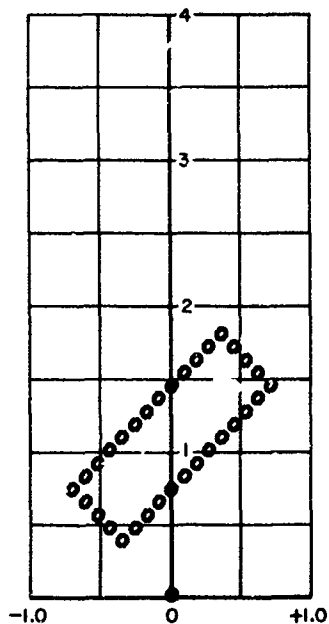
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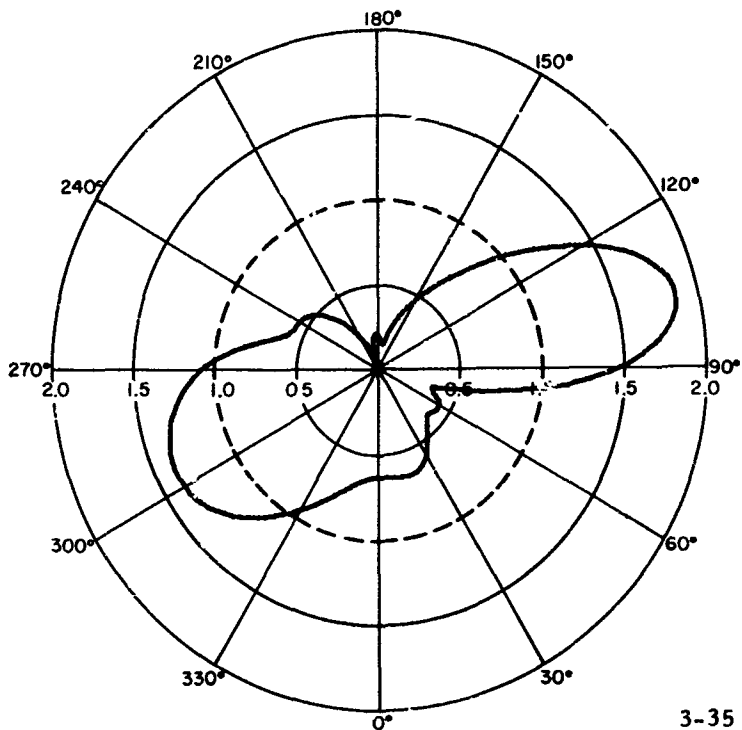
DISTANCE ~ WAVELENGTHS



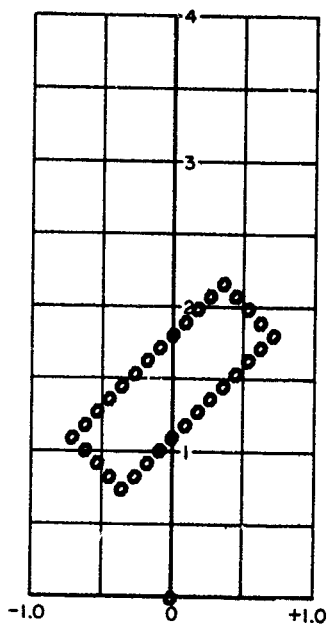
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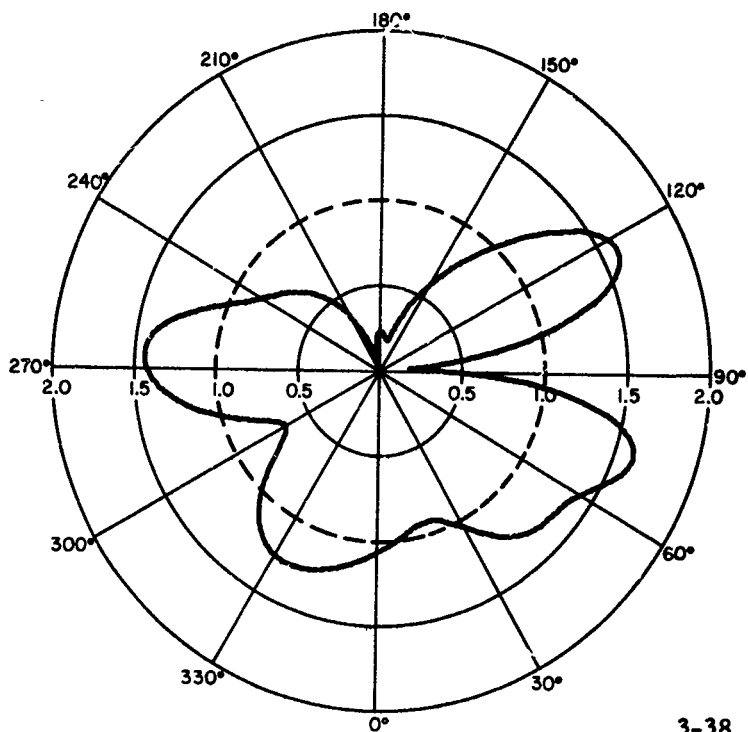
DISTANCE ~ WAVELENGTHS



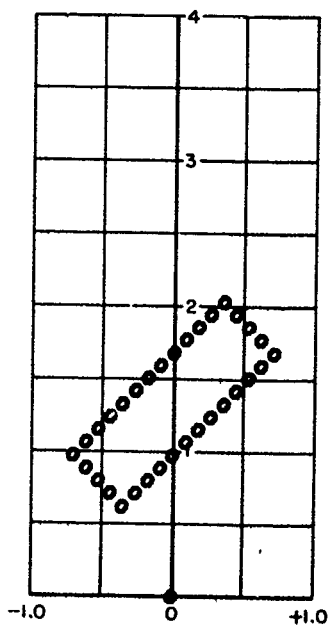
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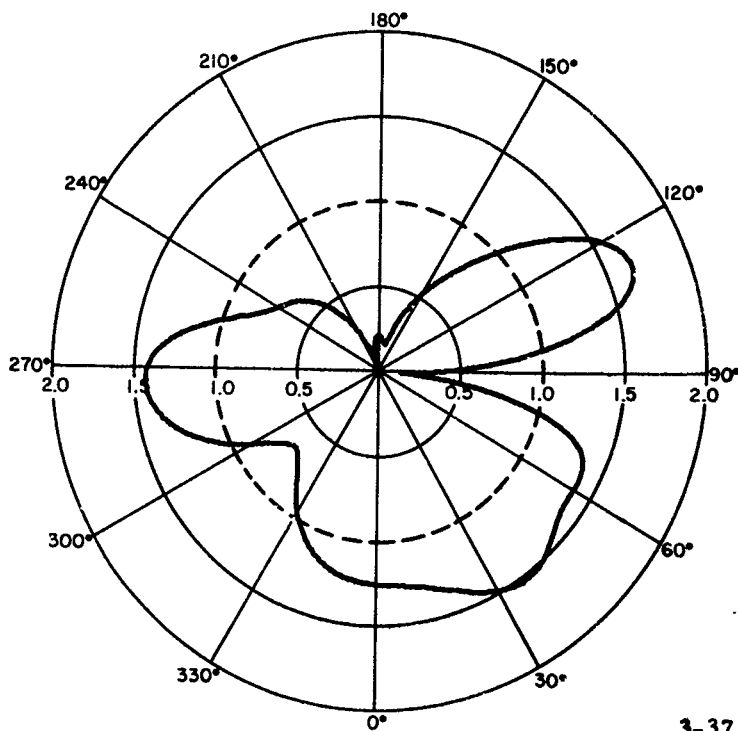
DISTANCE ~ WAVELENGTHS



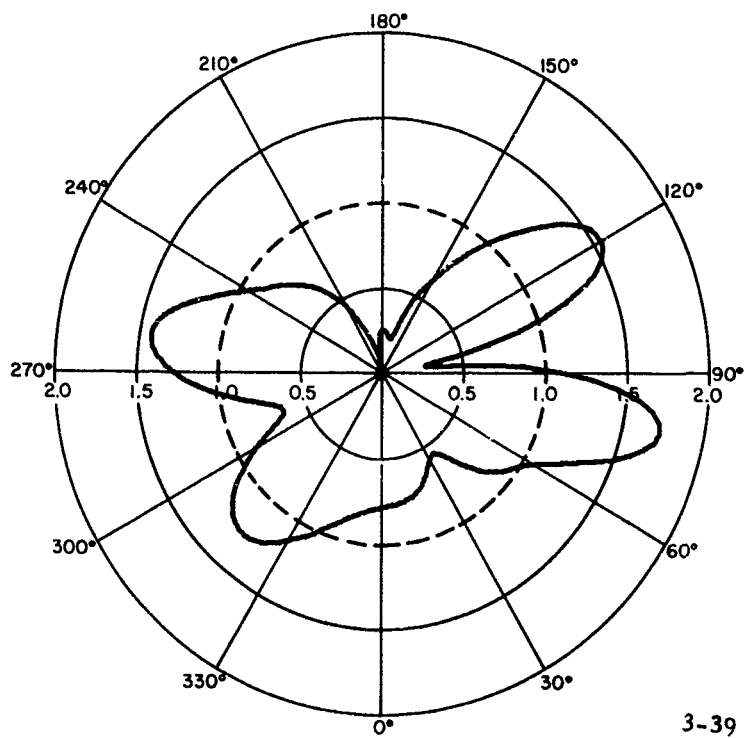
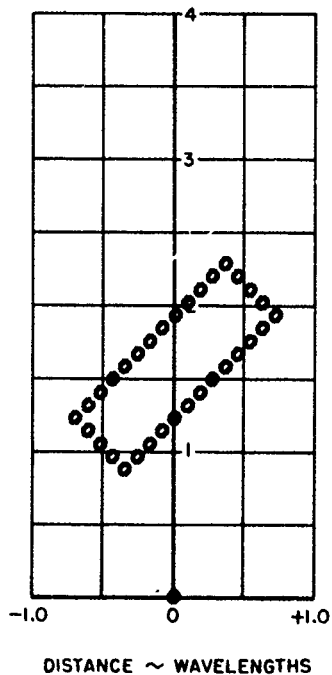
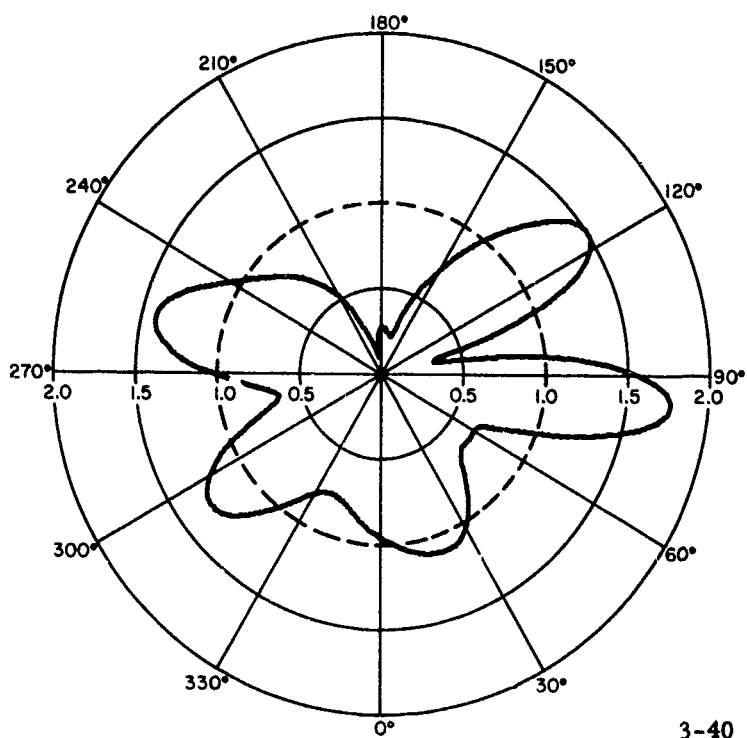
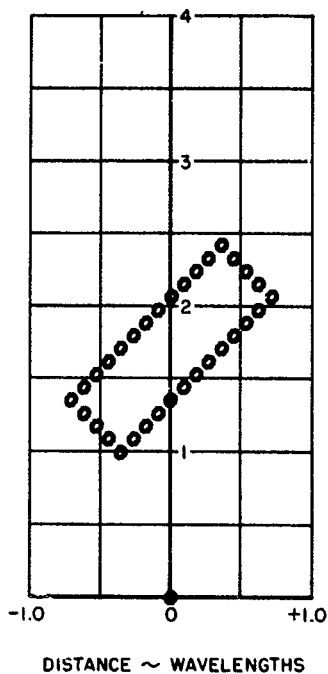
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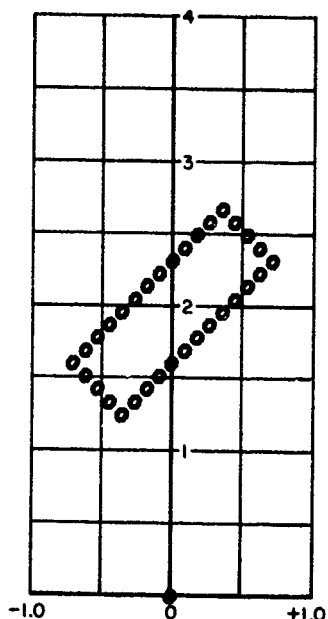


DISTANCE ~ WAVELENGTHS

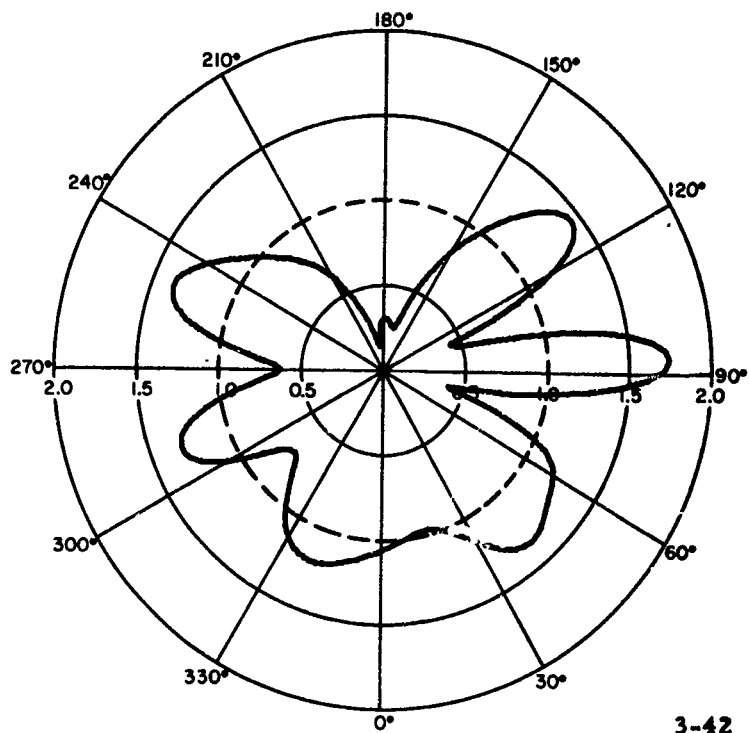


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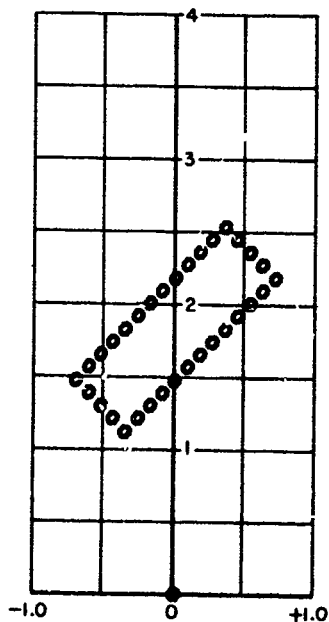




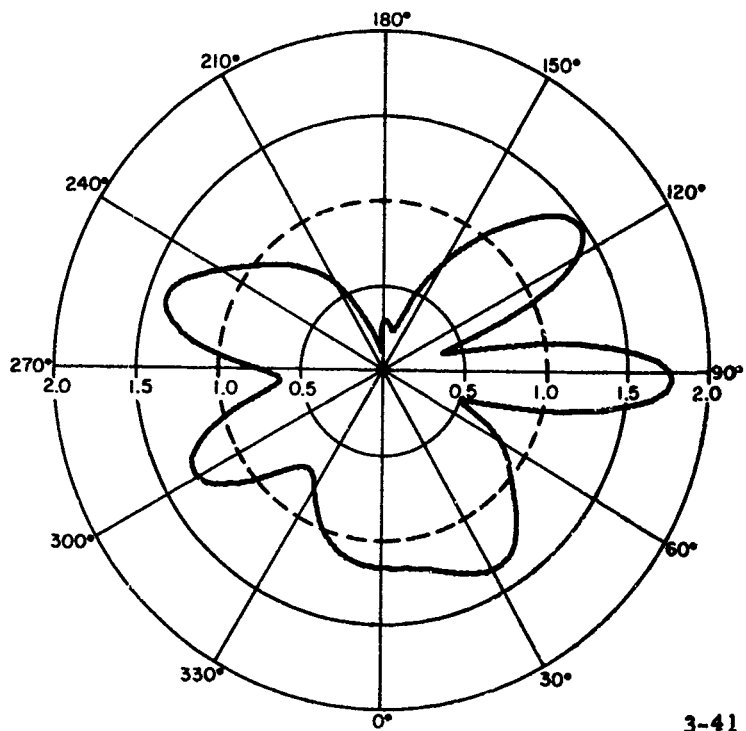
DISTANCE ~ WAVELENGTHS



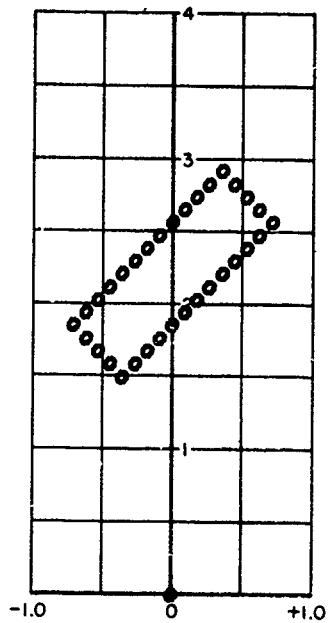
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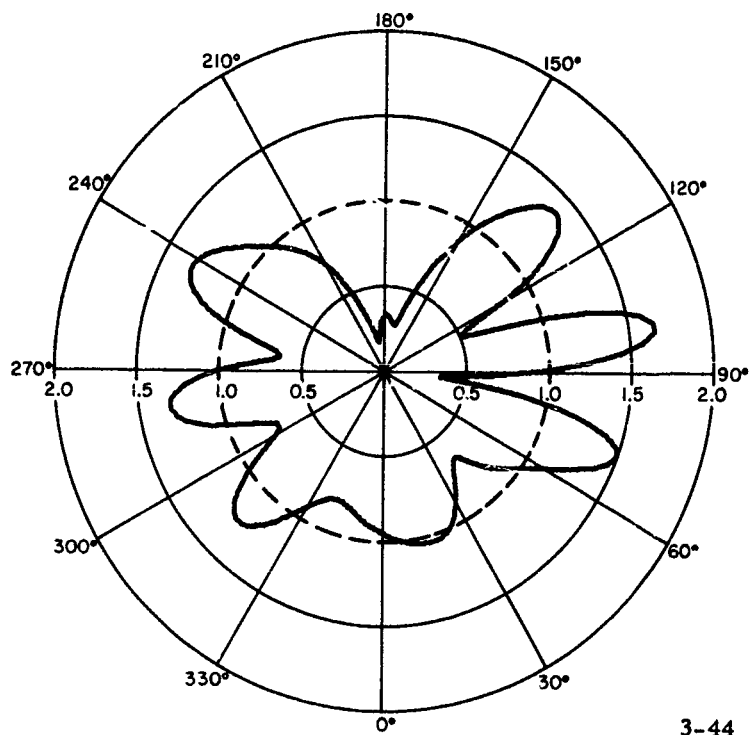
DISTANCE ~ WAVELENGTHS



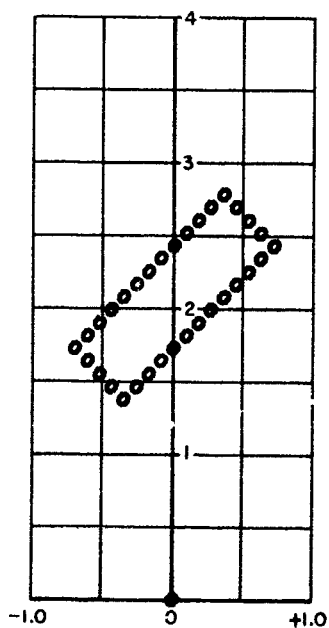
3-41



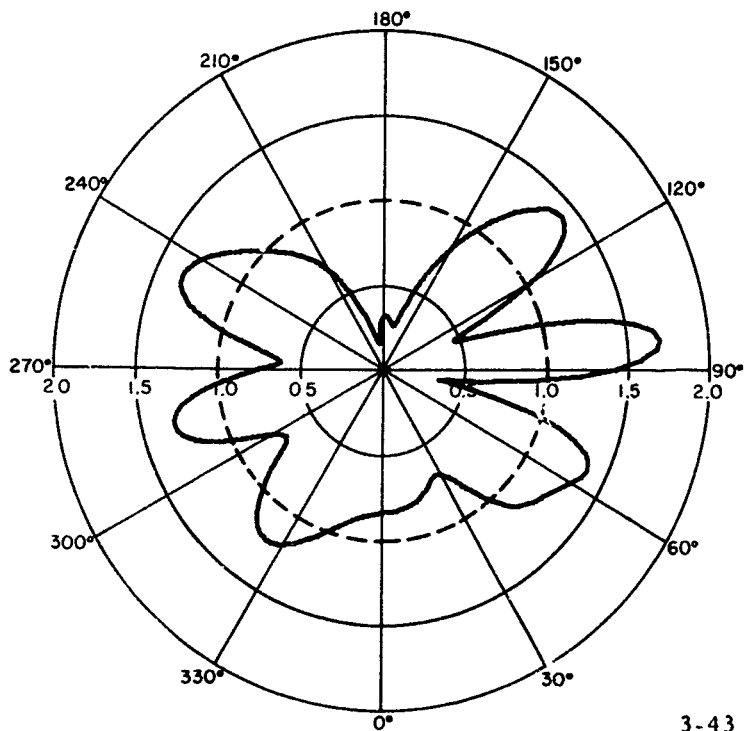
DISTANCE ~ WAVELENGTHS



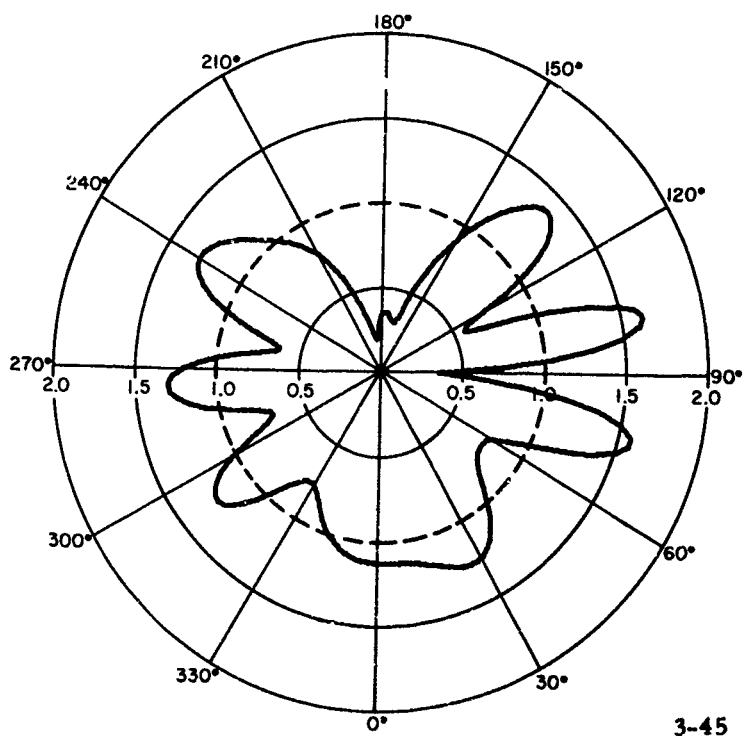
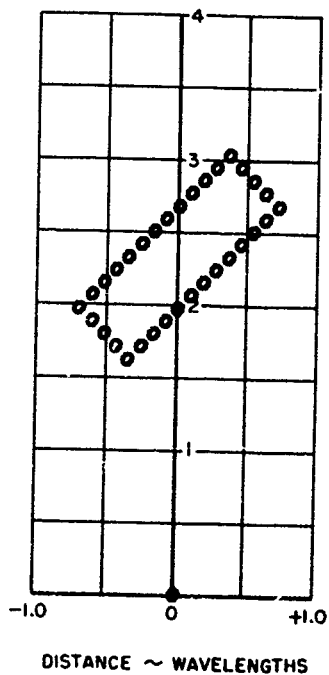
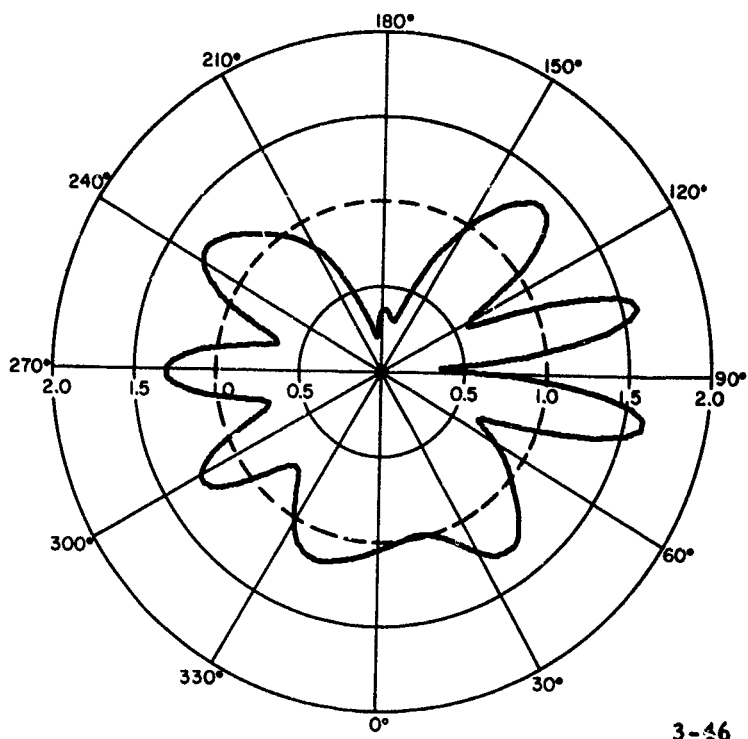
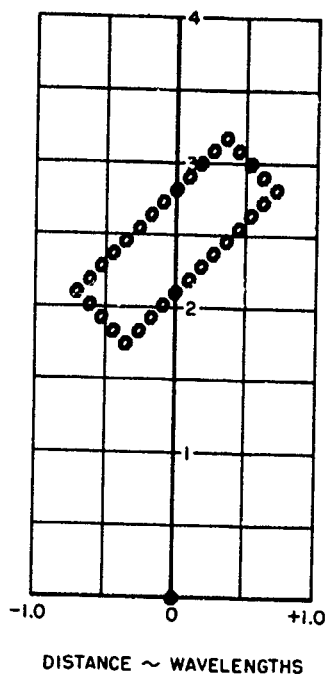
3-44

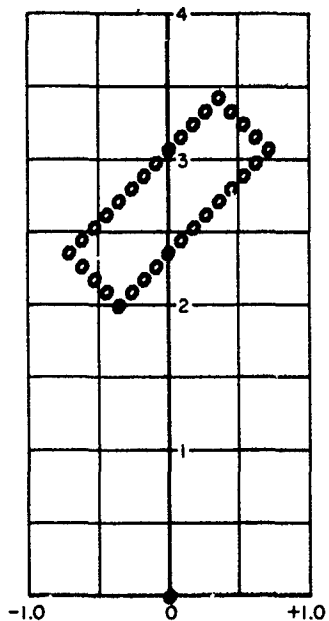


DISTANCE ~ WAVELENGTHS

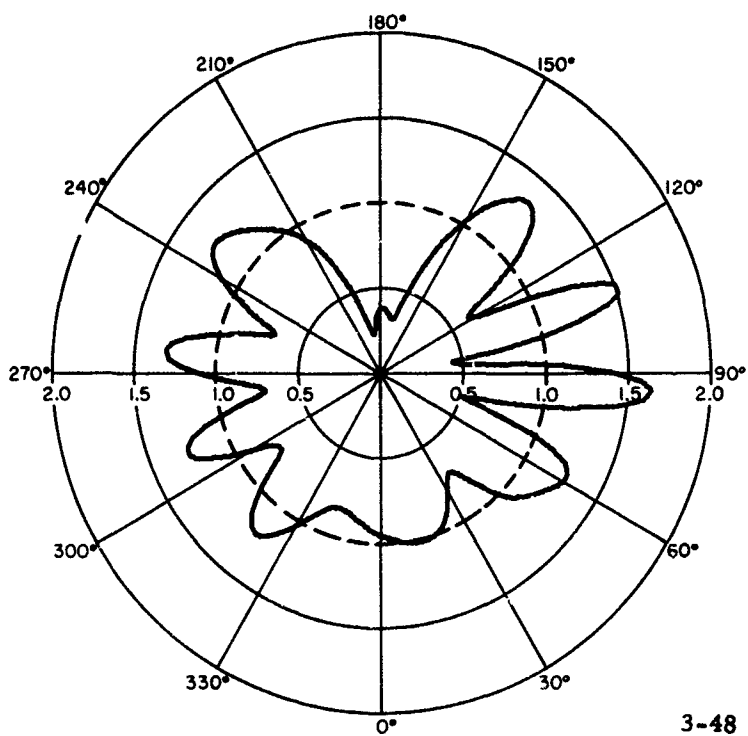


3-43

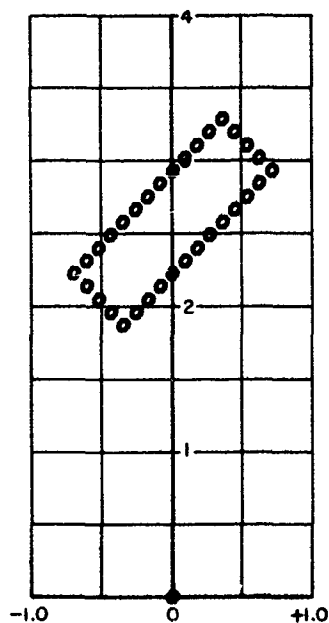




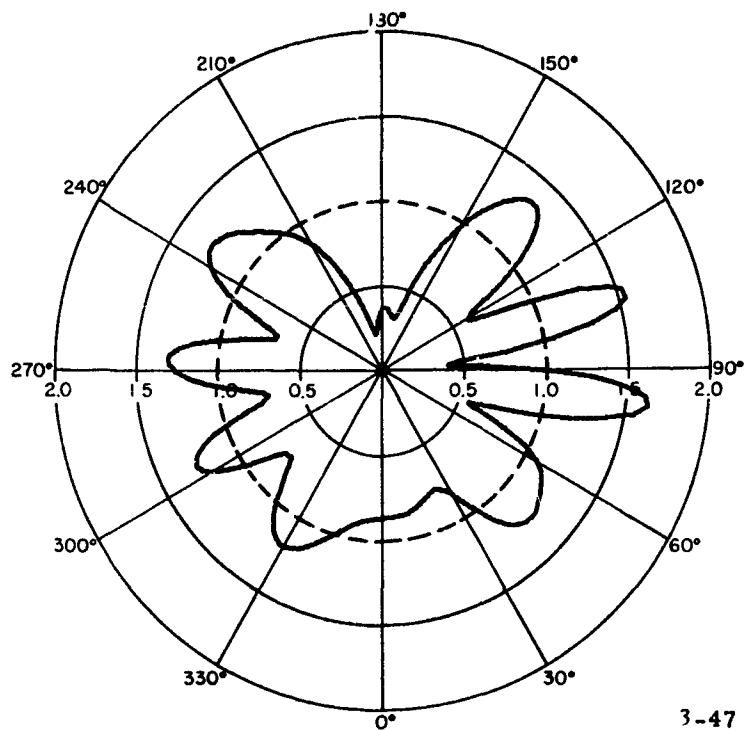
DISTANCE ~ WAVELENGTHS



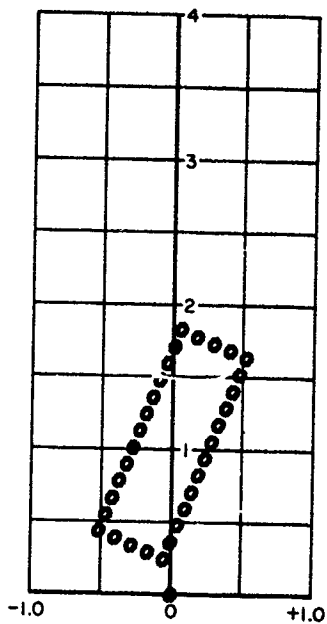
3-48



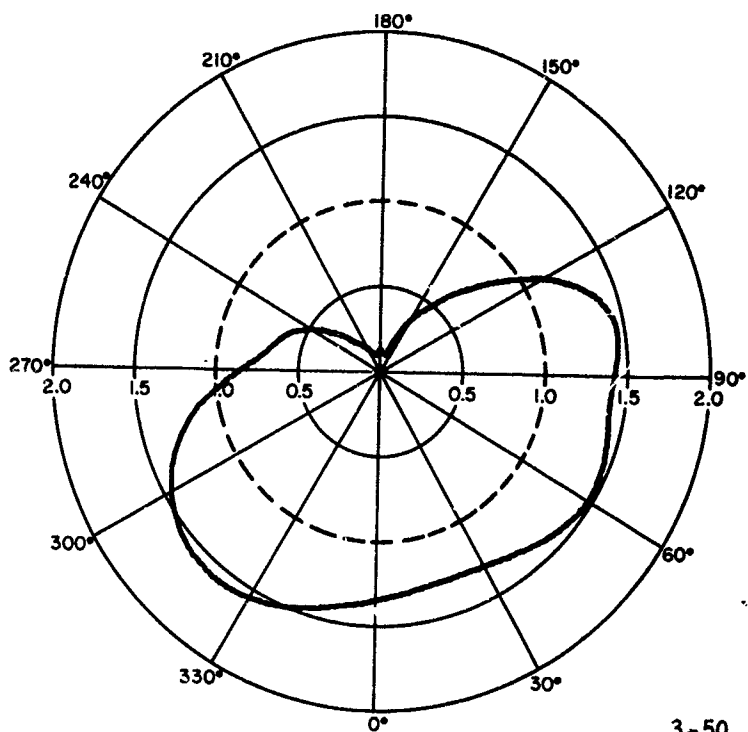
DISTANCE ~ WAVELENGTHS



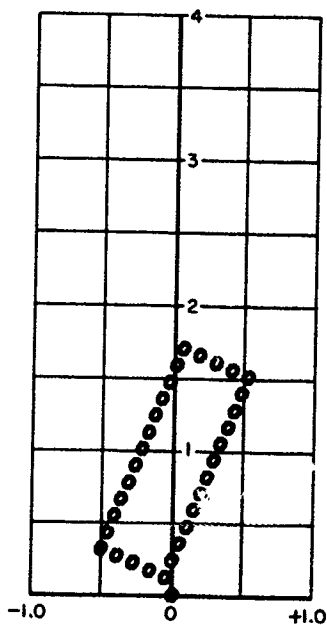
3-47



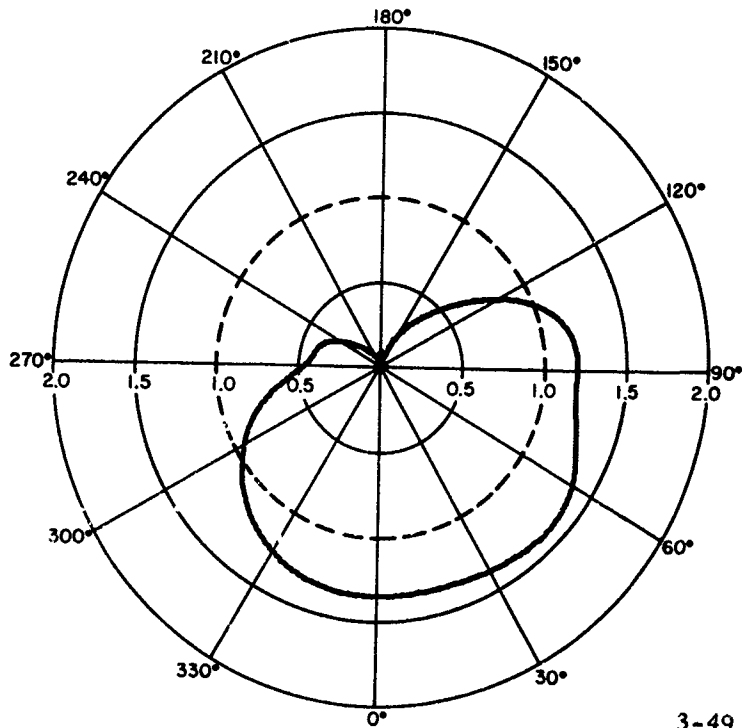
DISTANCE ~ WAVELENGTHS



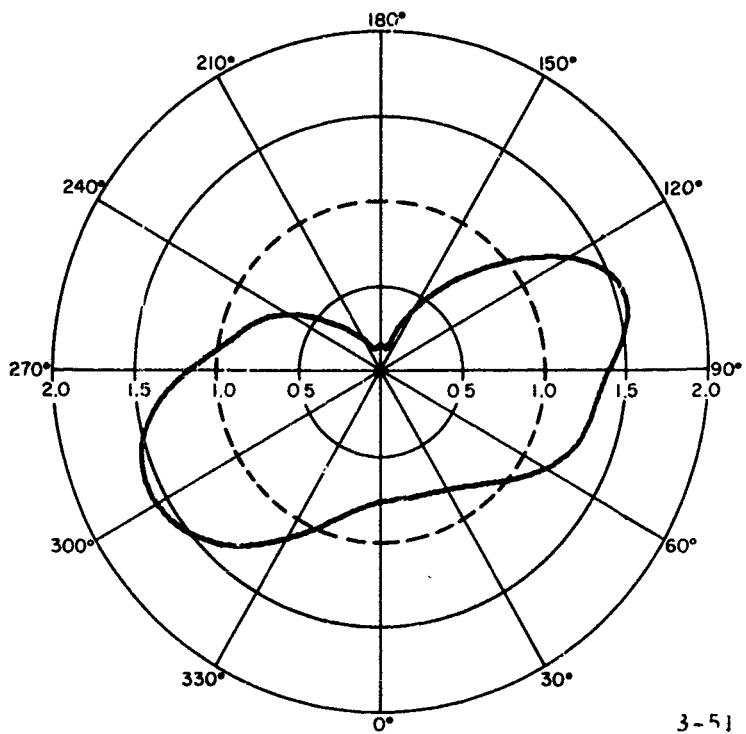
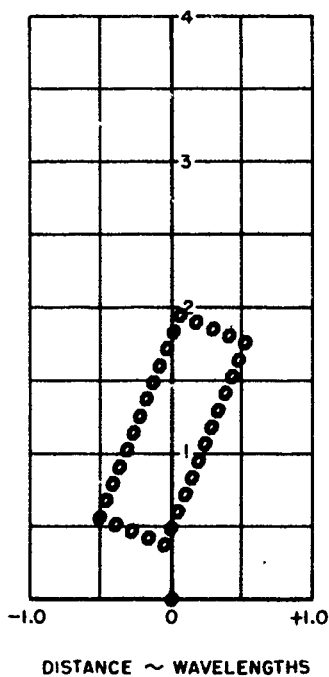
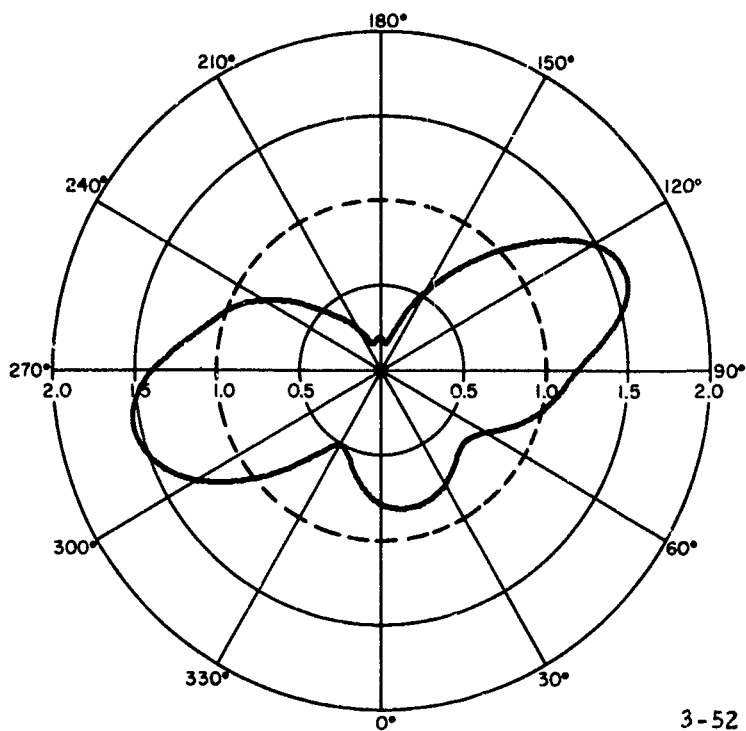
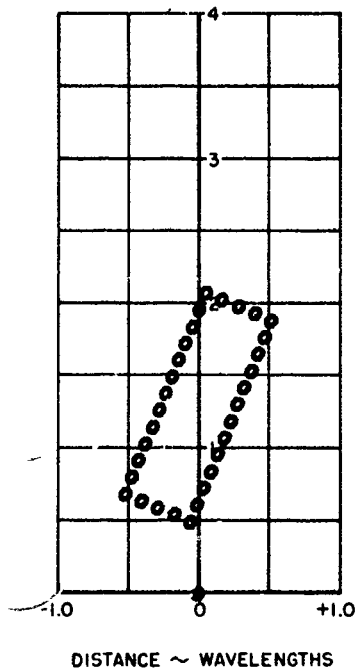
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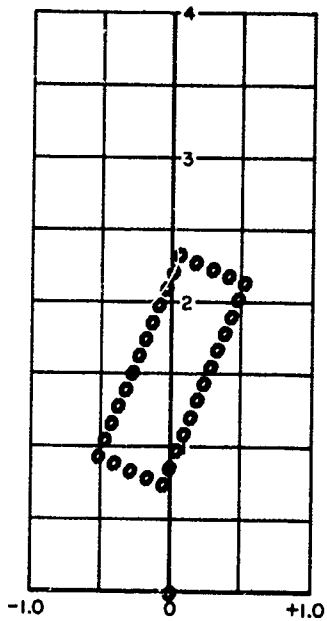


DISTANCE ~ WAVELENGTHS

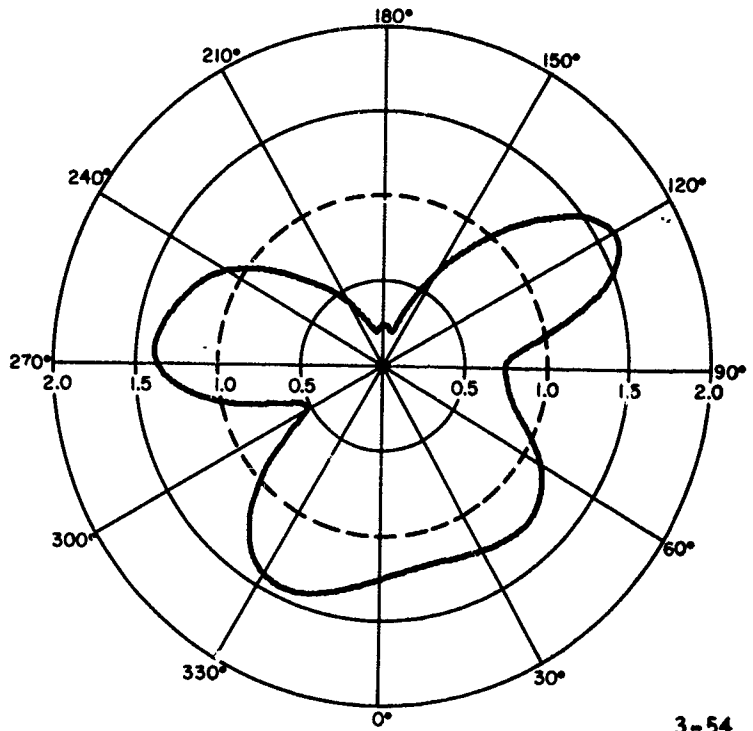


3-49

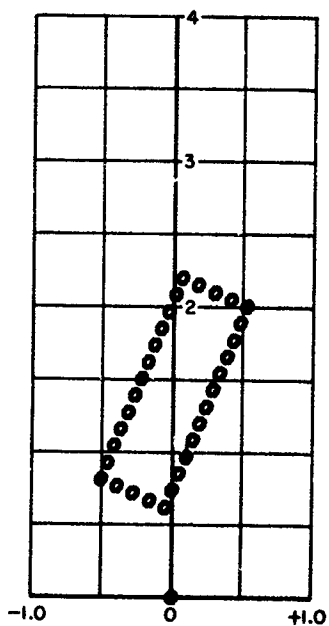




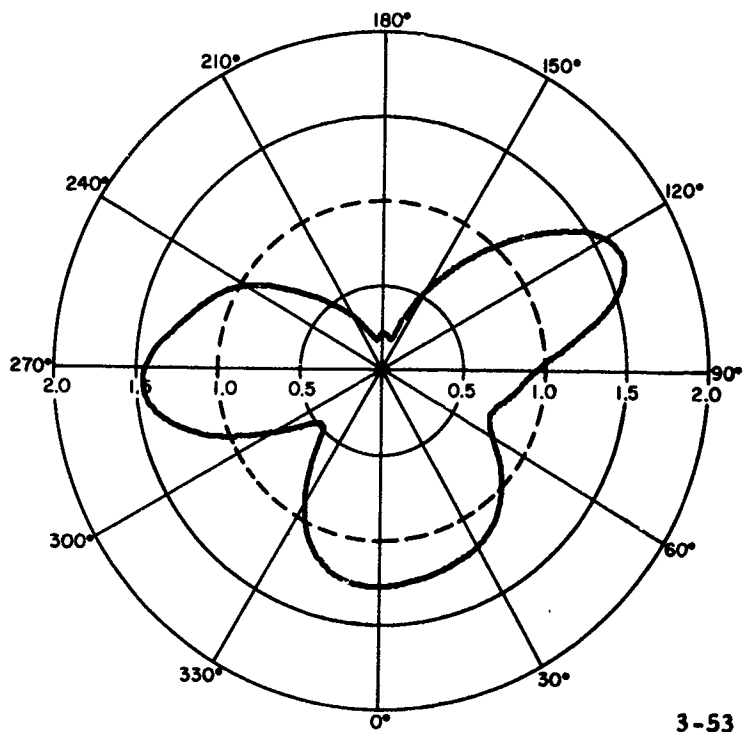
DISTANCE ~ WAVELENGTHS



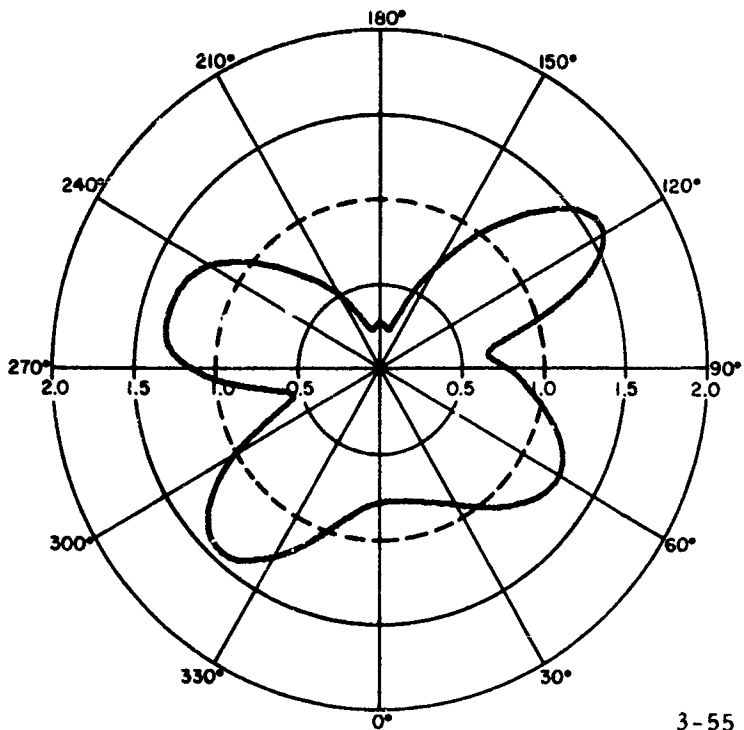
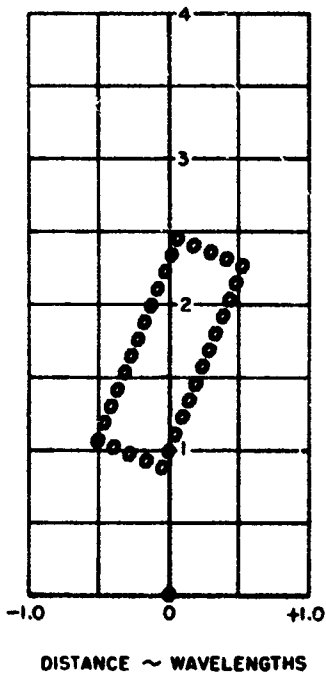
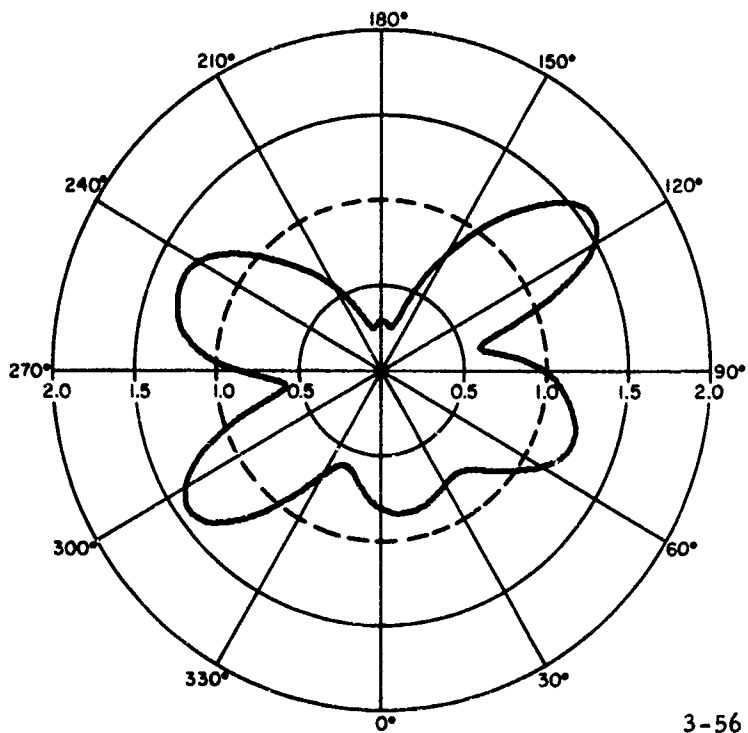
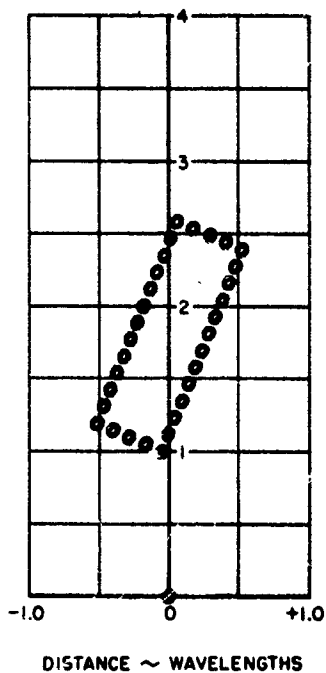
3-54

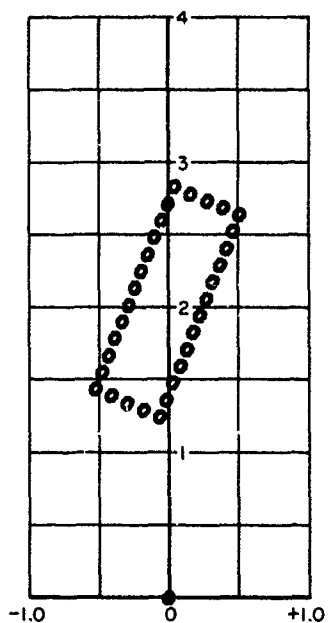


DISTANCE ~ WAVELENGTHS

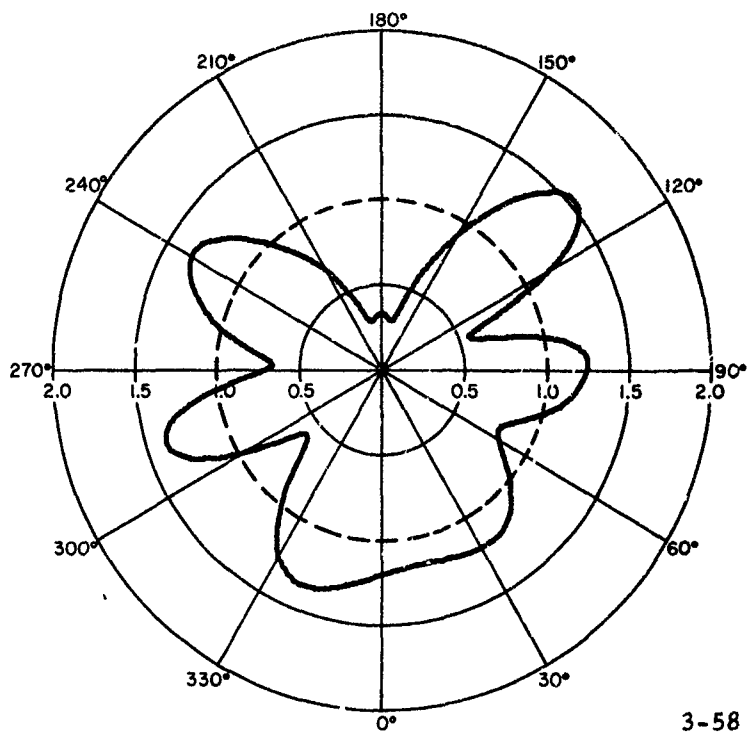


3-53

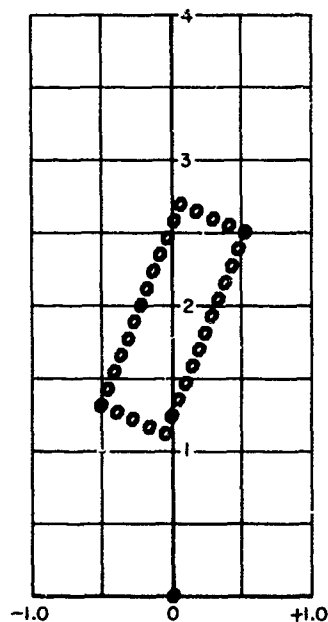




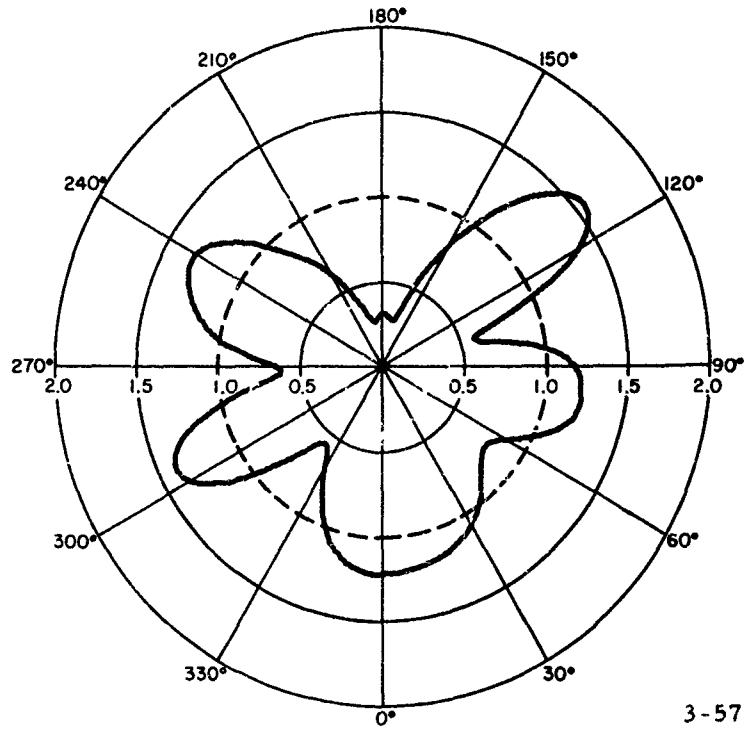
DISTANCE ~ WAVELENGTHS



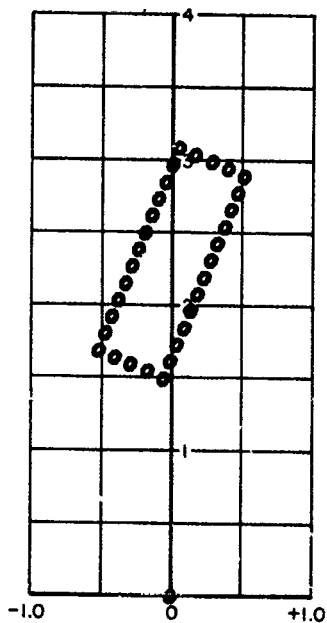
3-58



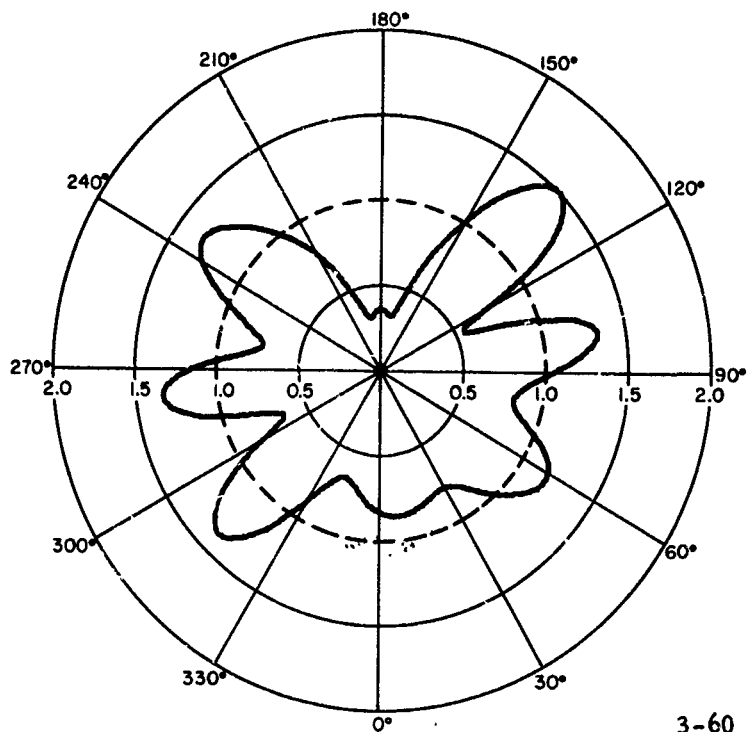
DISTANCE ~ WAVELENGTHS



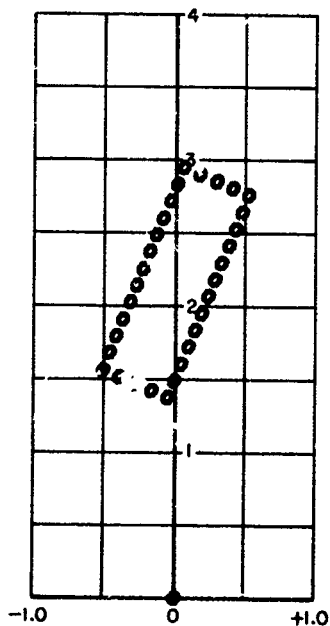
3-57



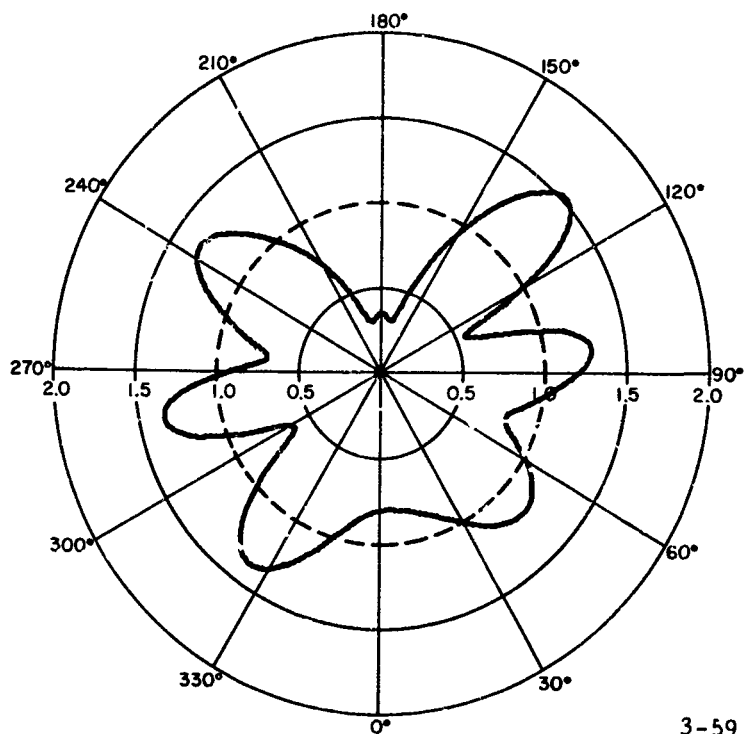
DISTANCE ~ WAVELENGTHS



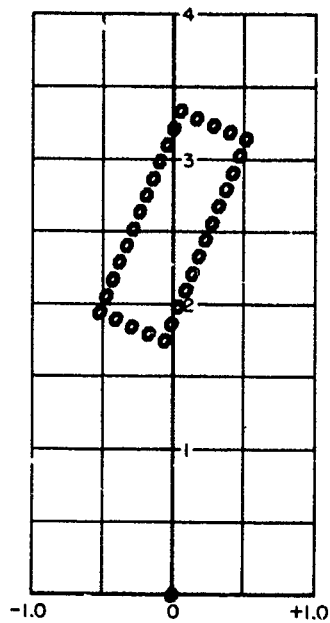
3-60



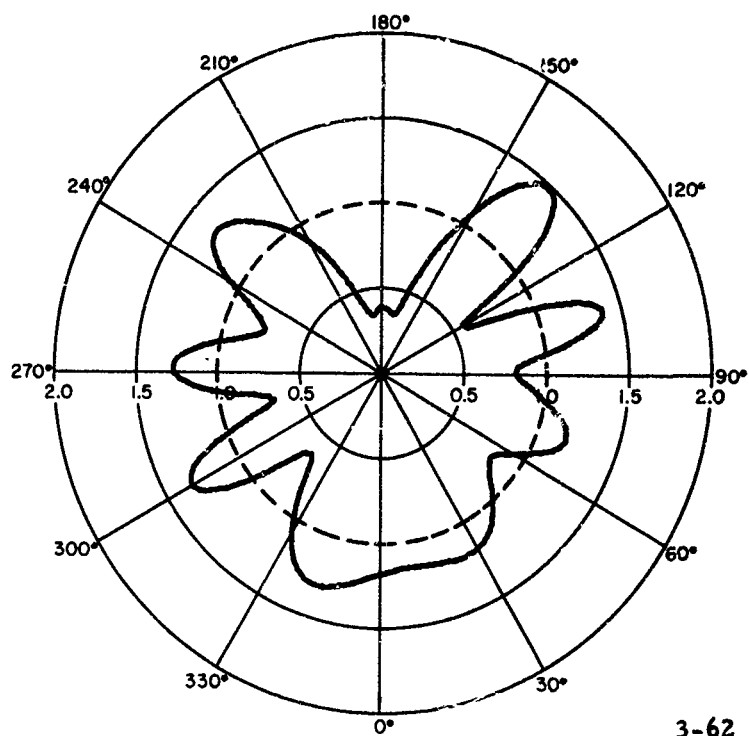
DISTANCE ~ WAVELENGTHS



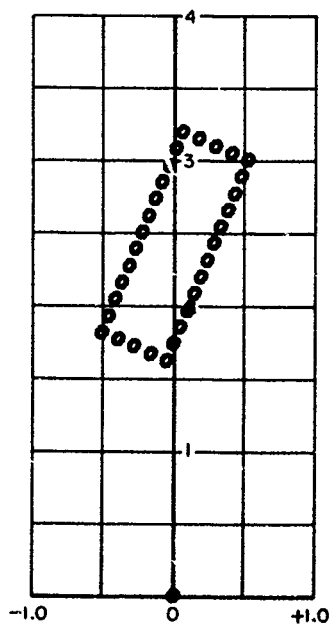
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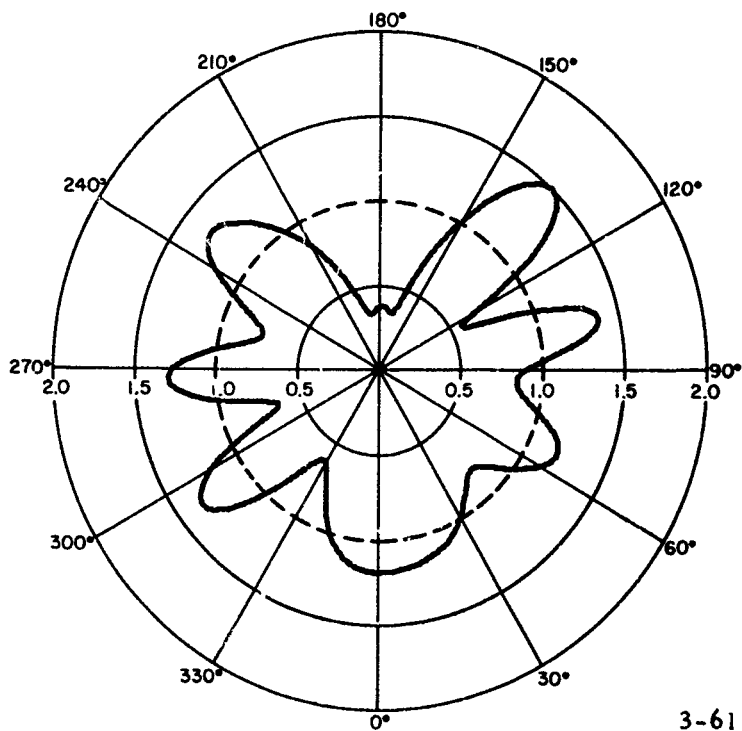
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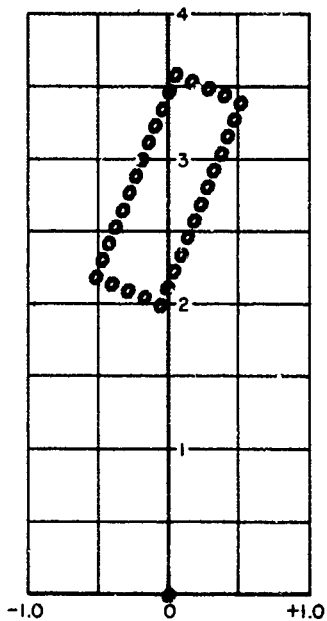
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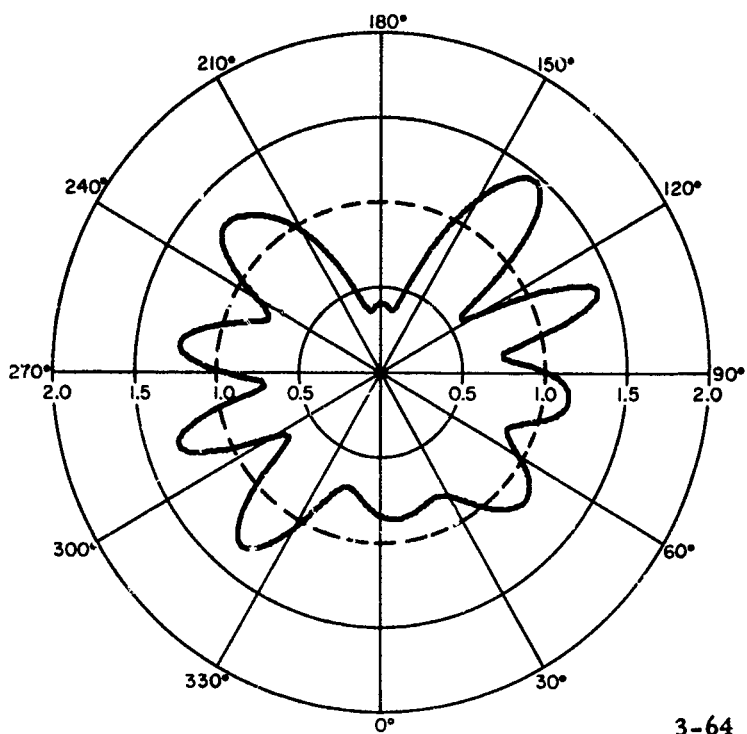
DISTANCE ~ WAVELENGTHS



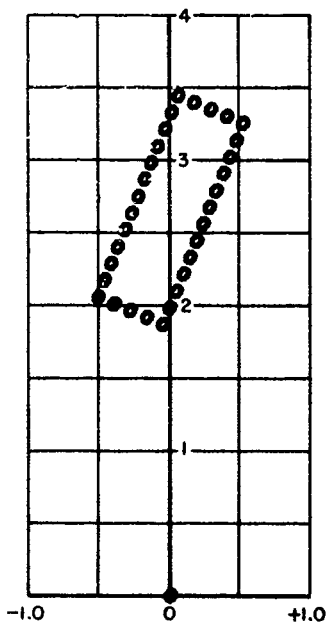
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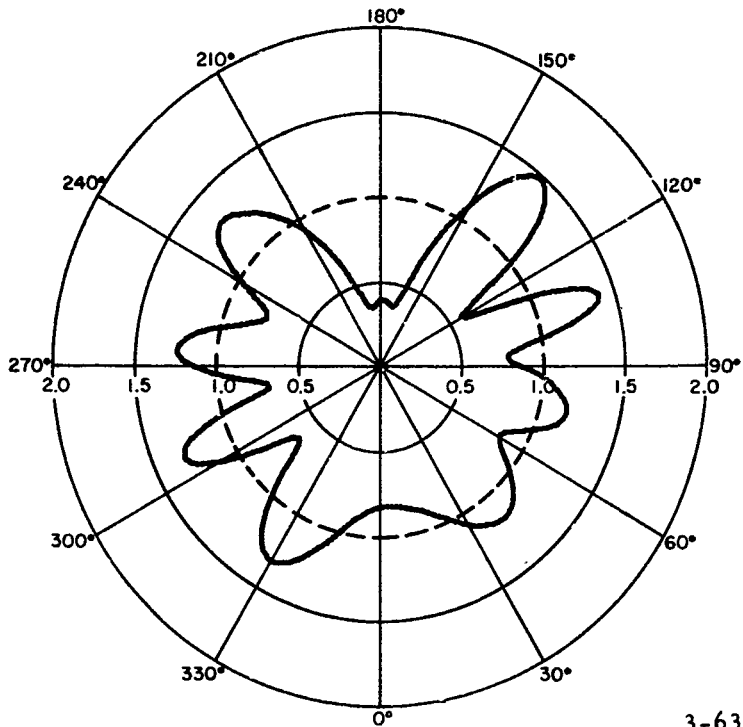
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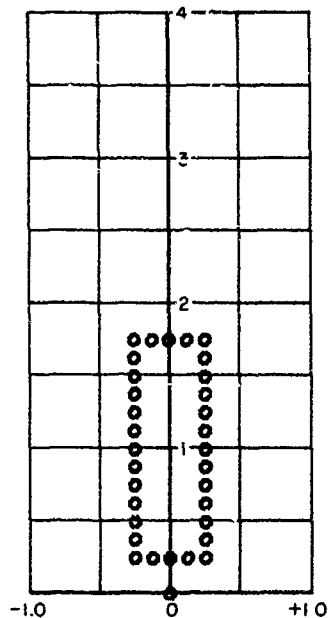
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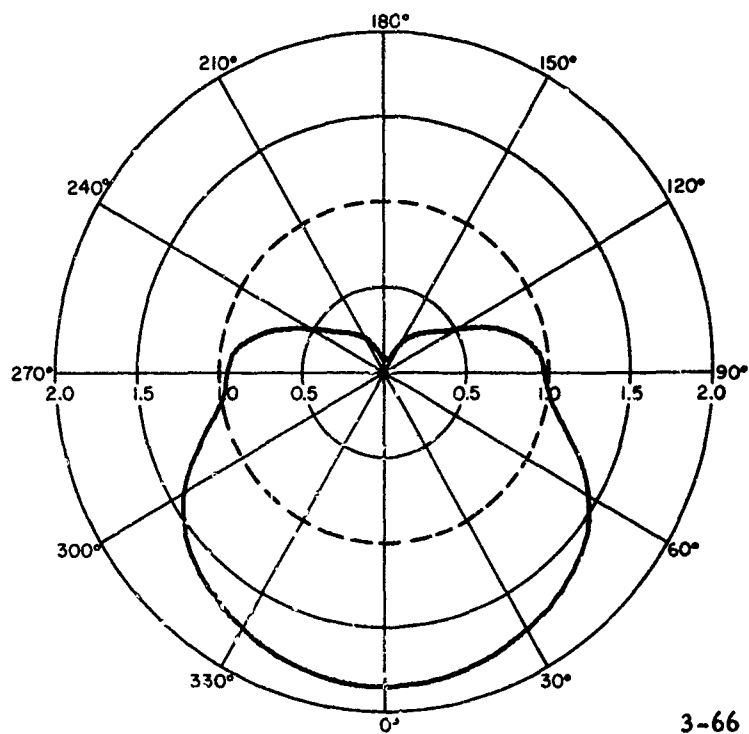
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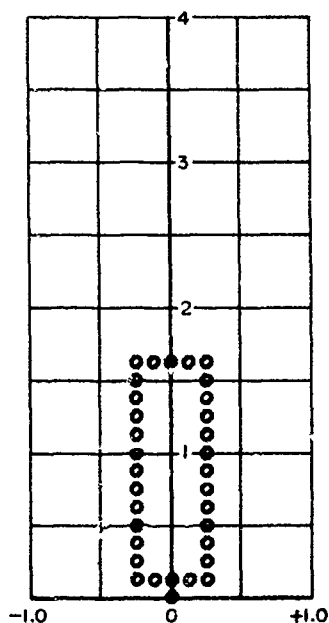
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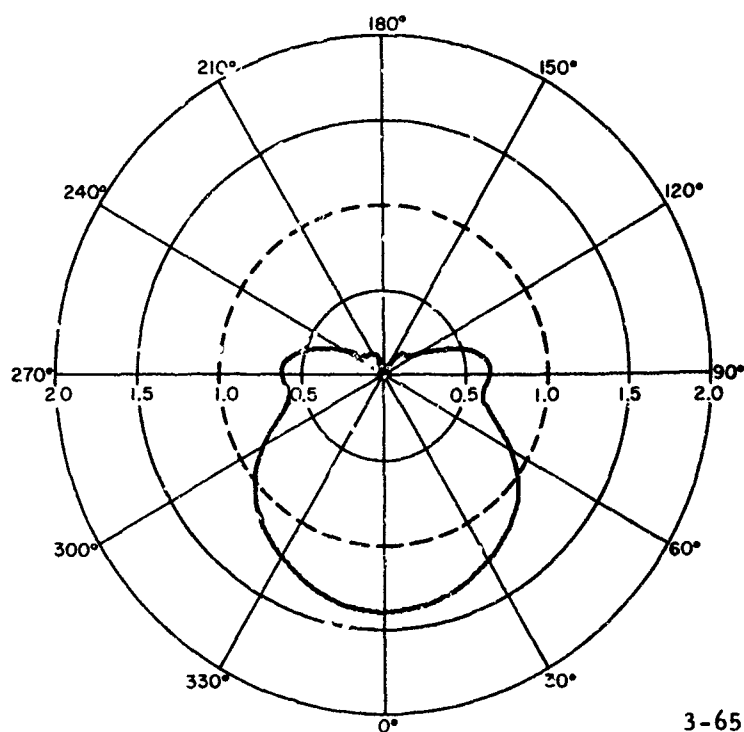
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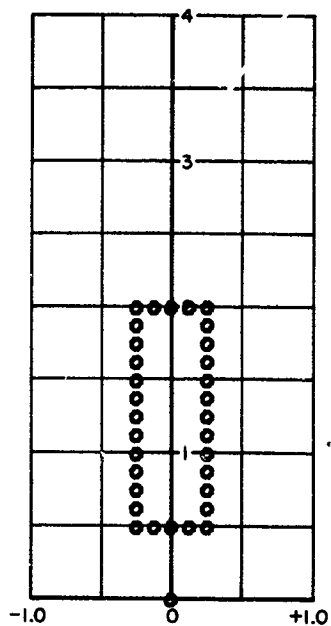
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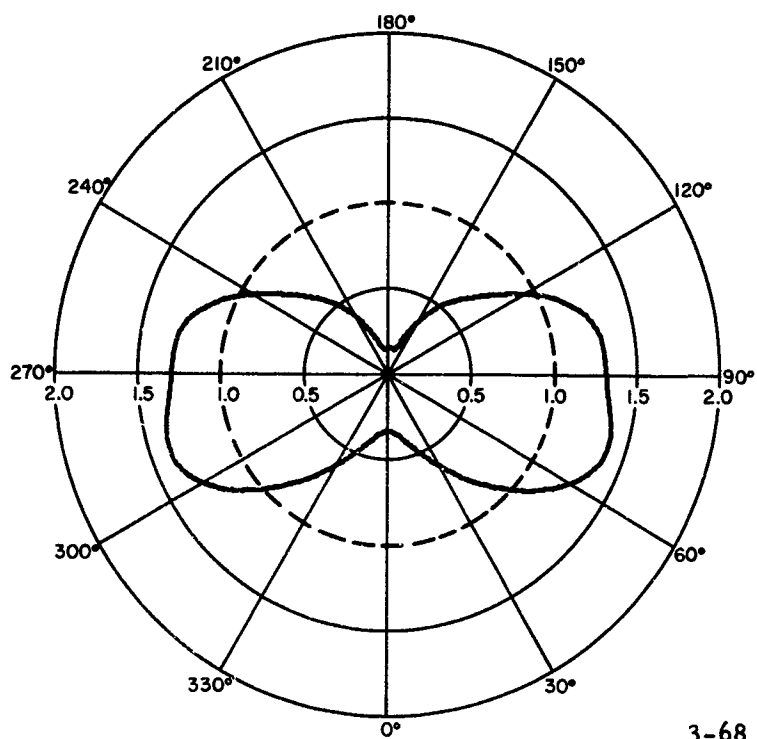
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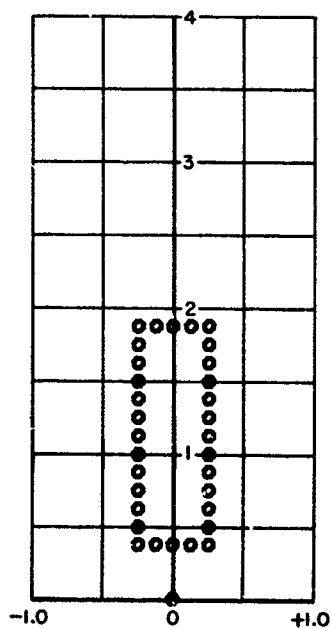
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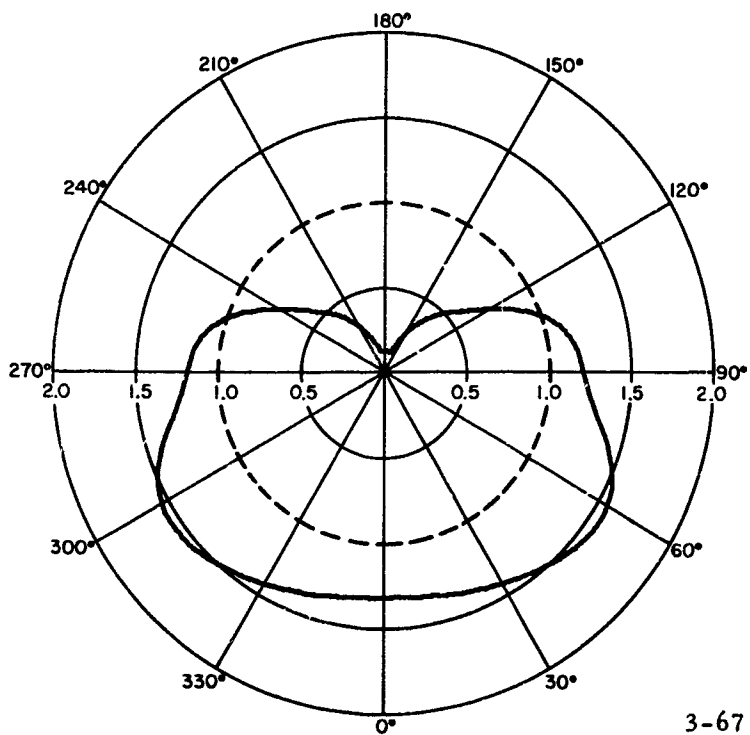
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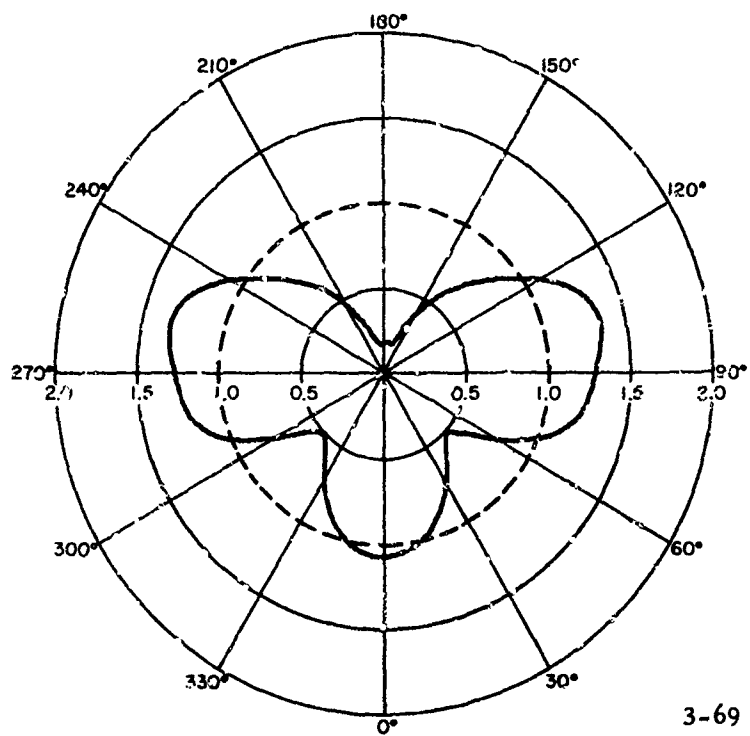
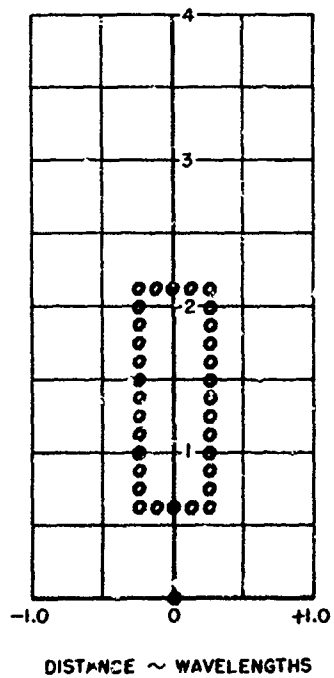
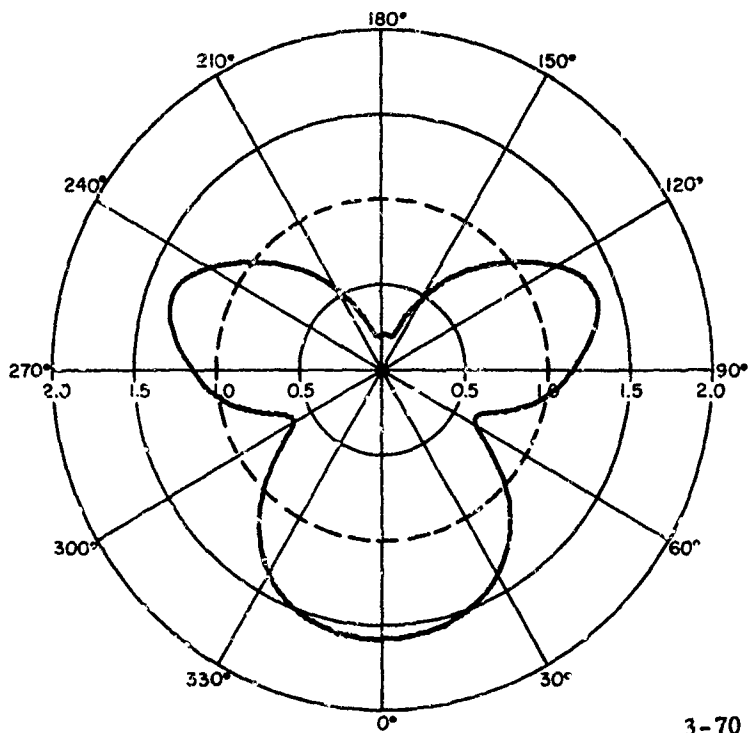
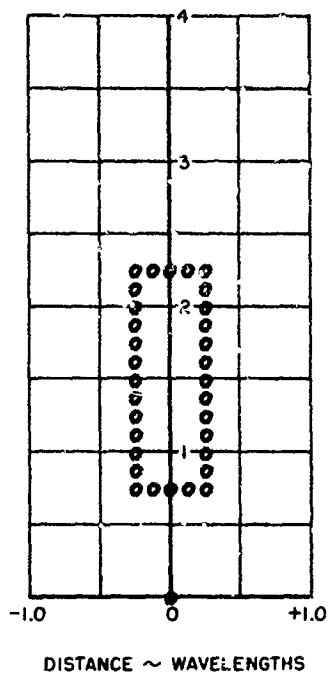
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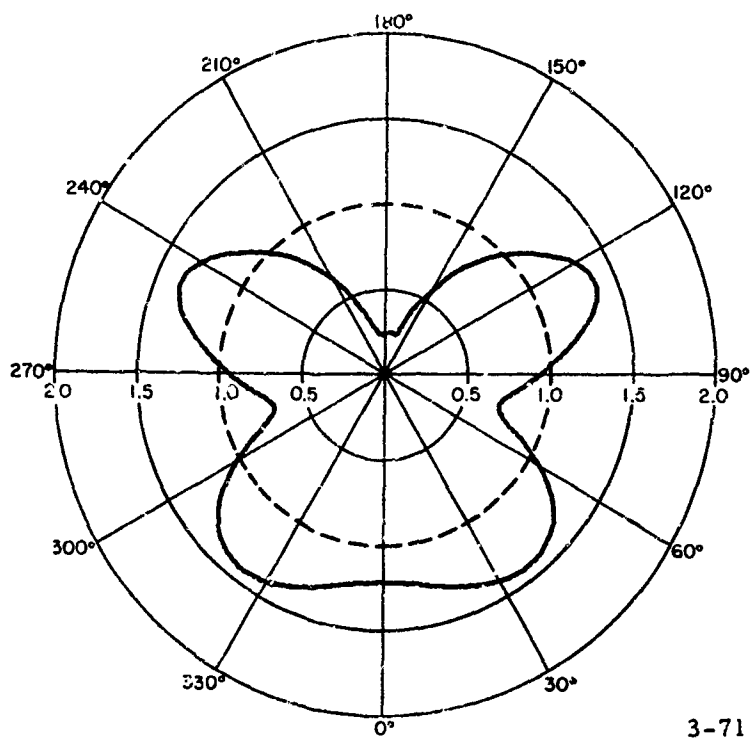
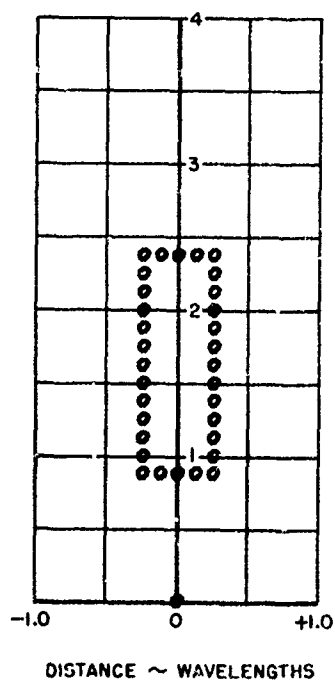
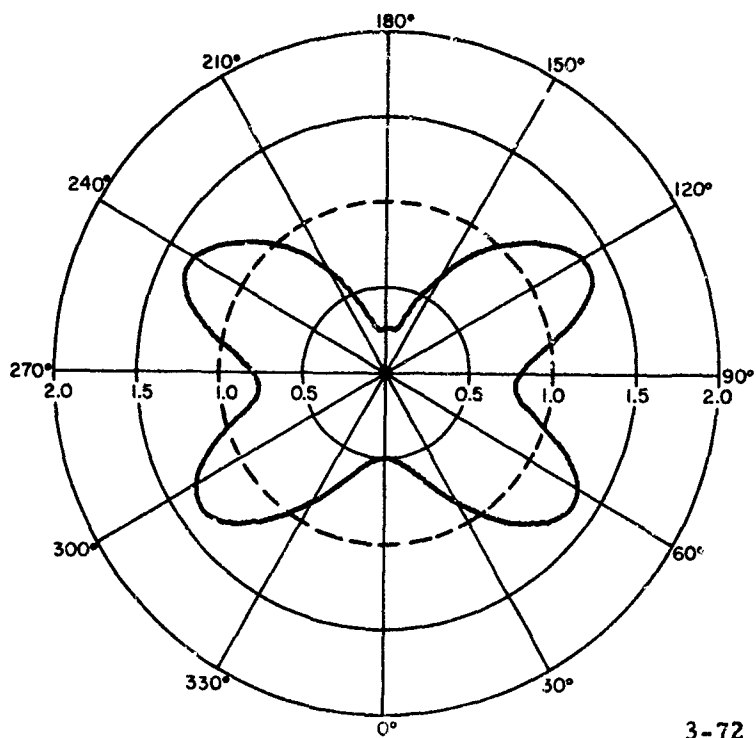
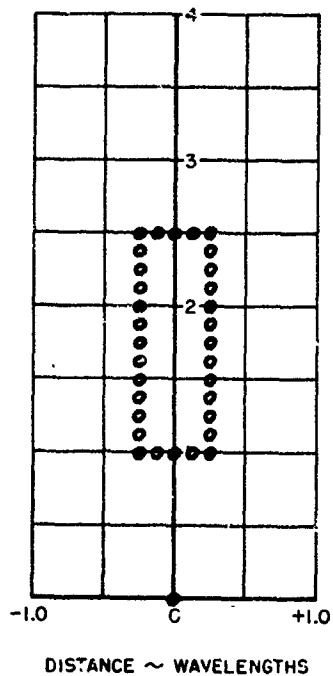


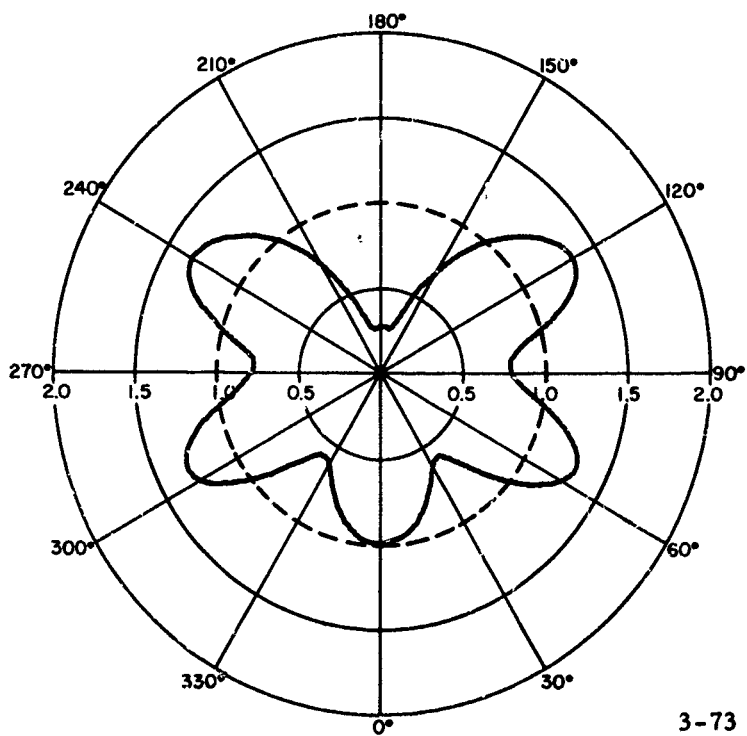
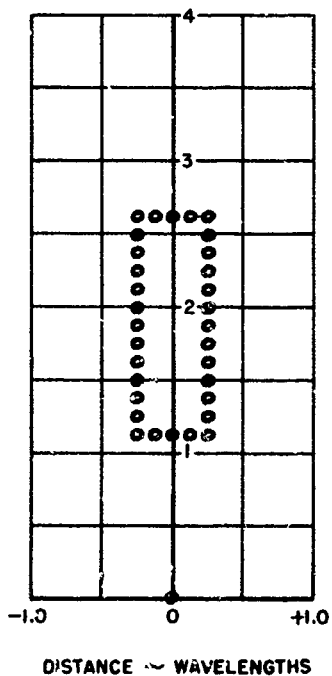
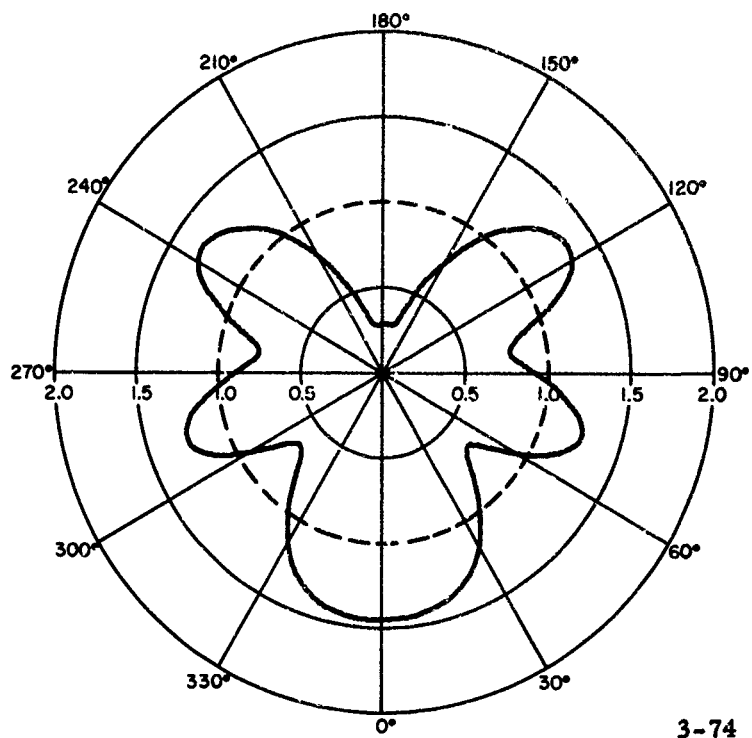
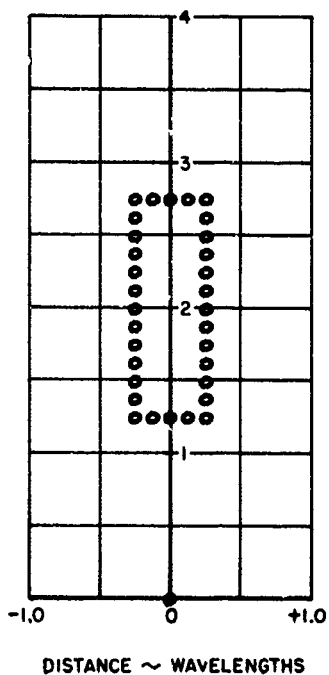
DISTANCE ~ WAVELENGTHS

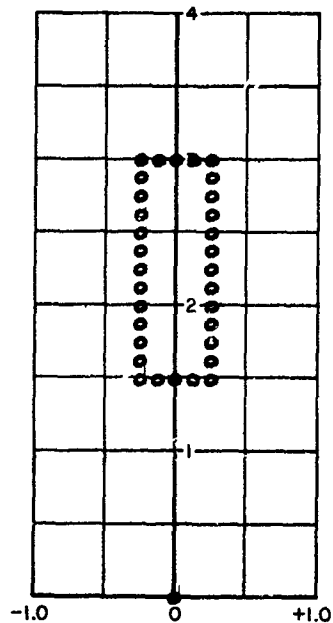


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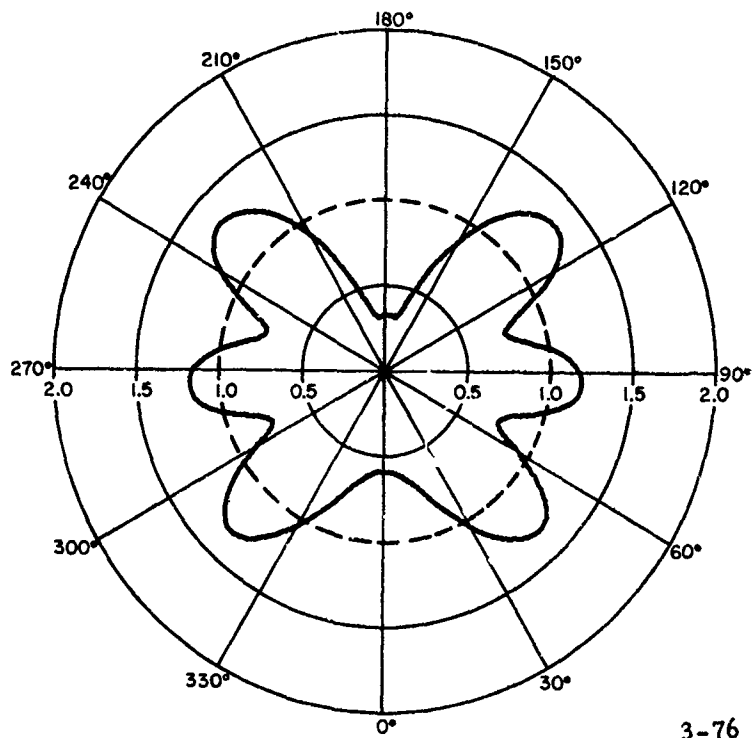




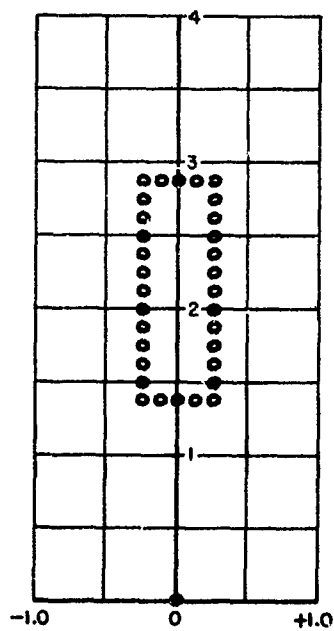




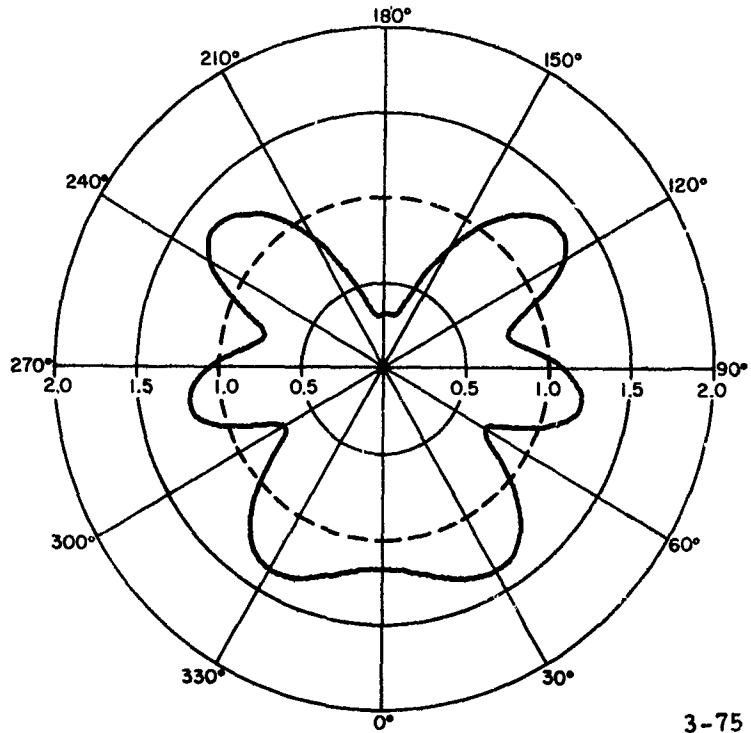
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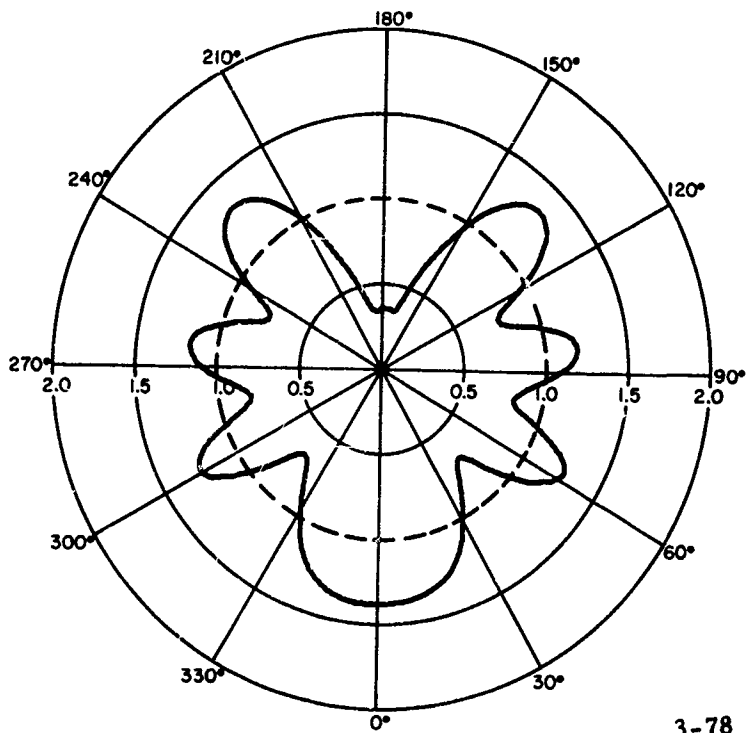
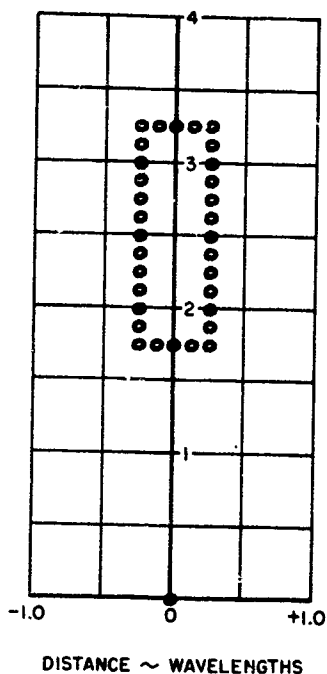
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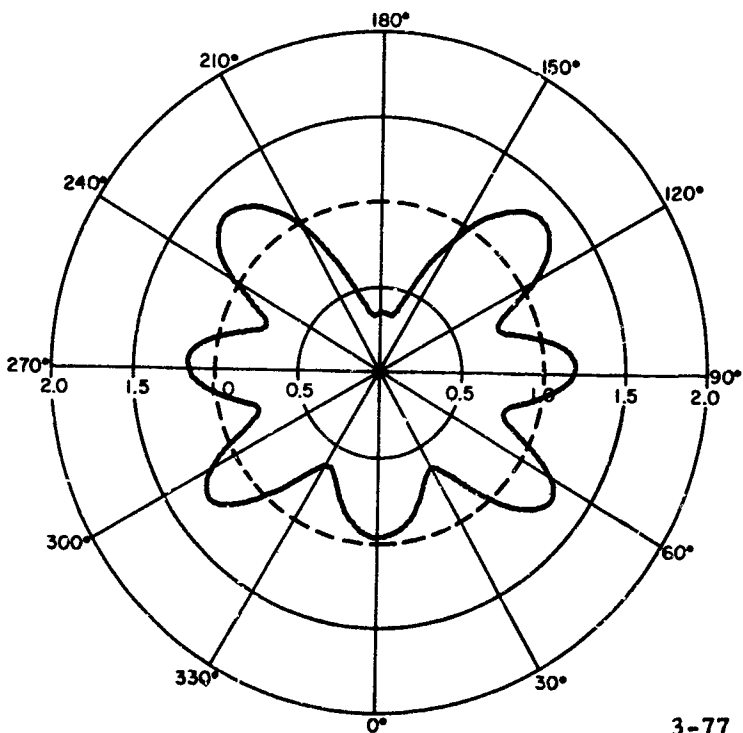
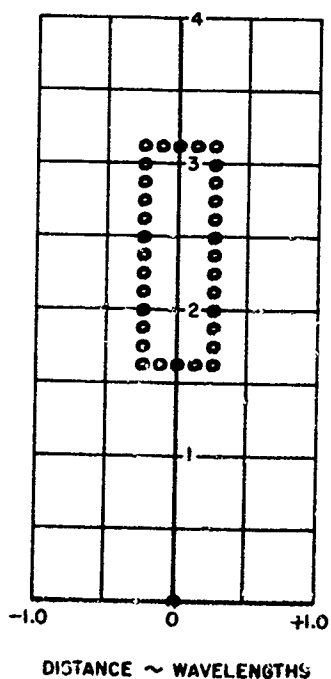
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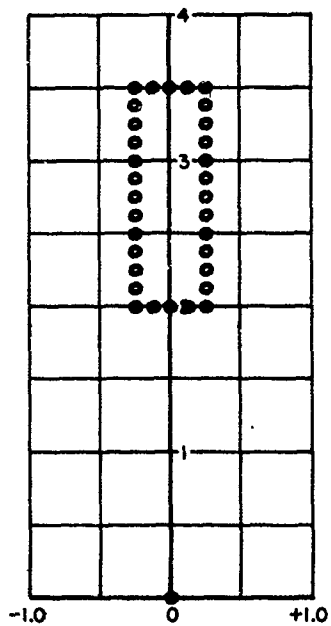
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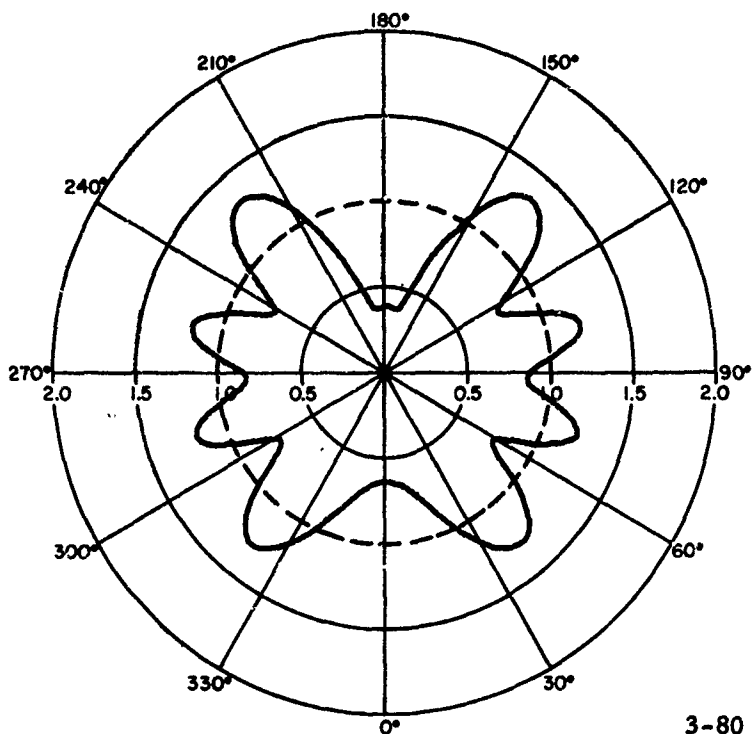
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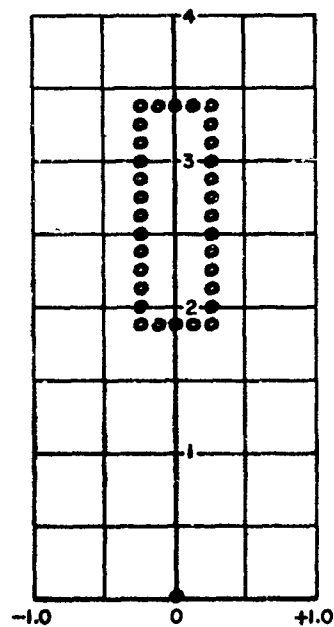
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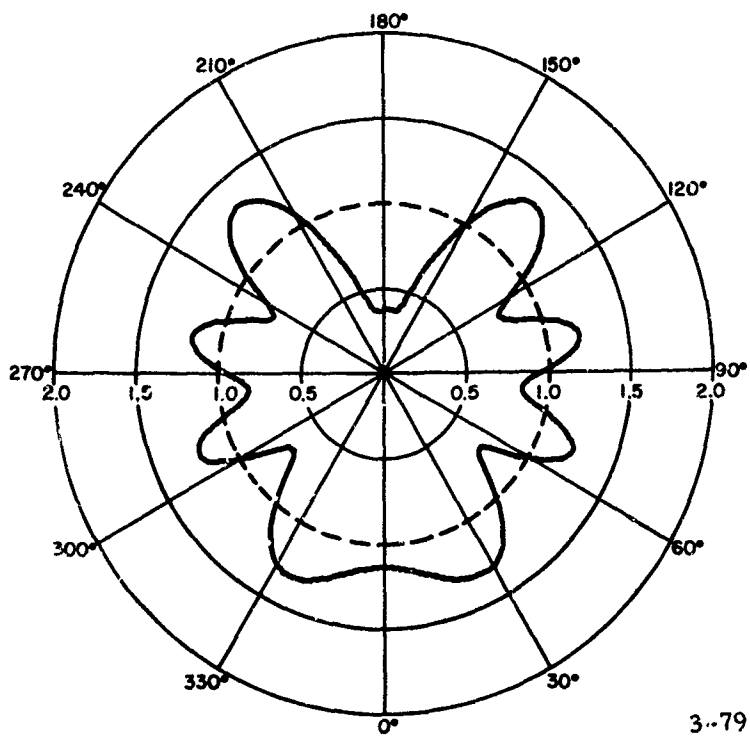
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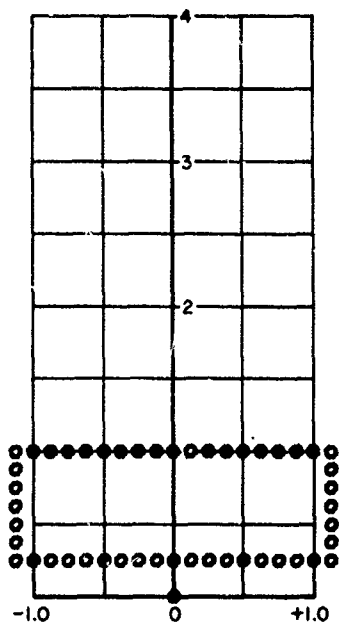
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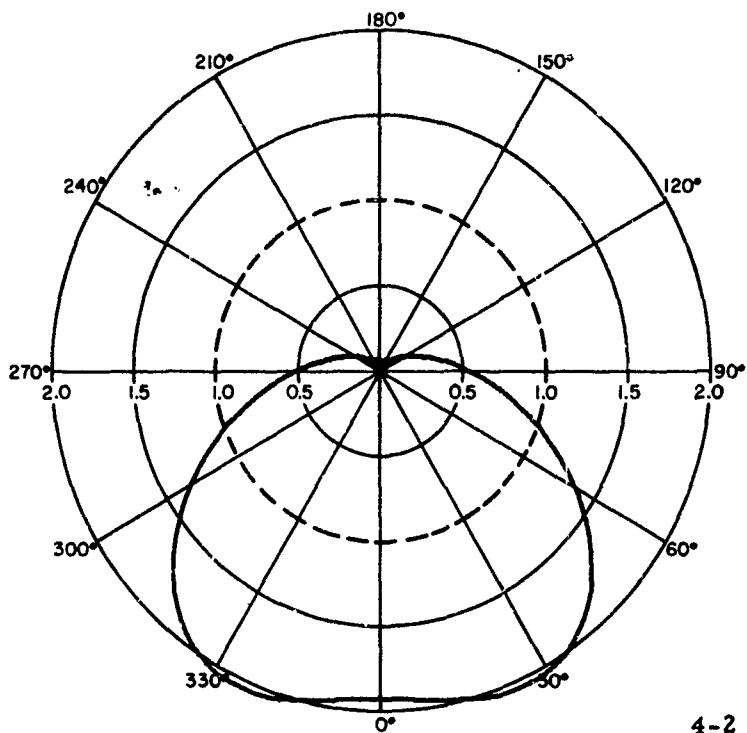
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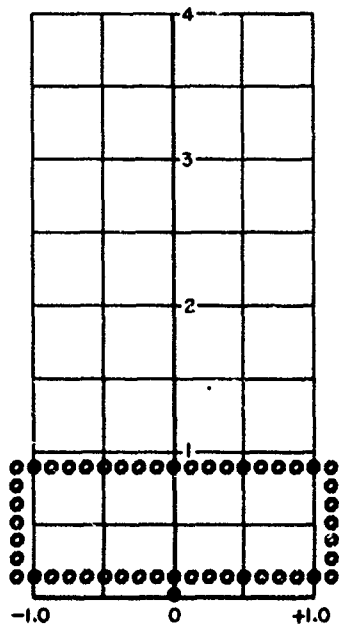
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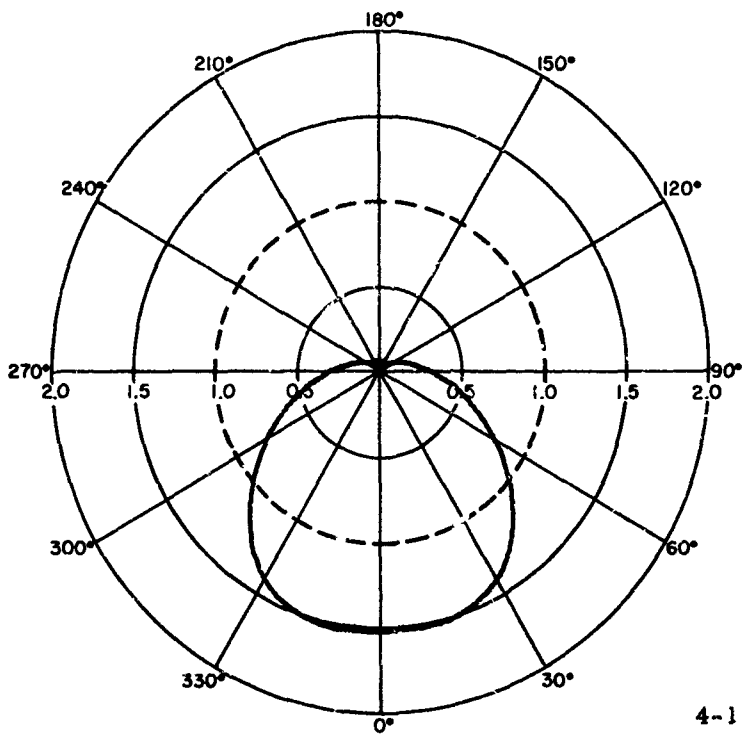
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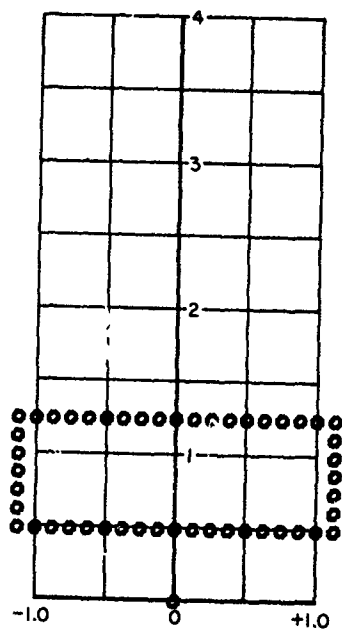
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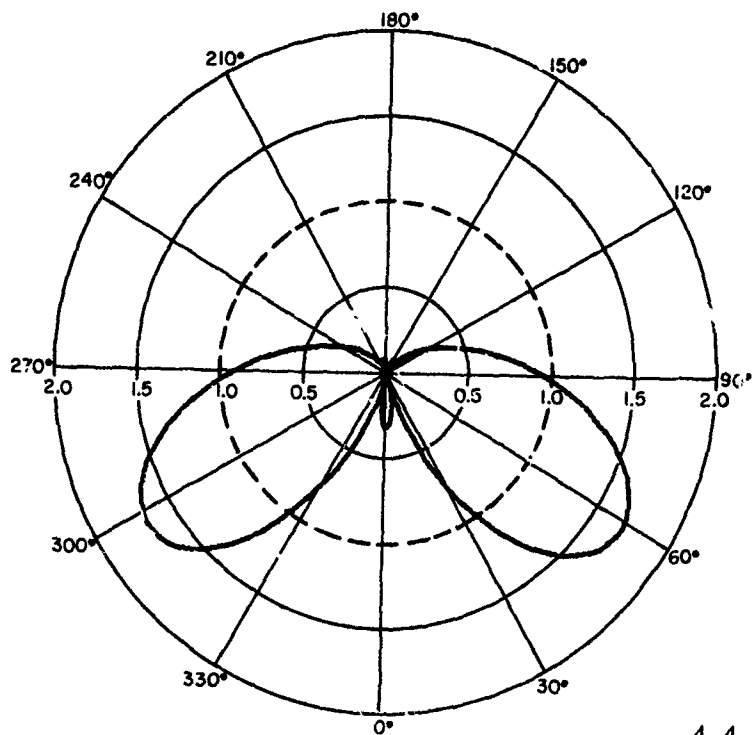
DISTANCE ~ WAVELENGTHS



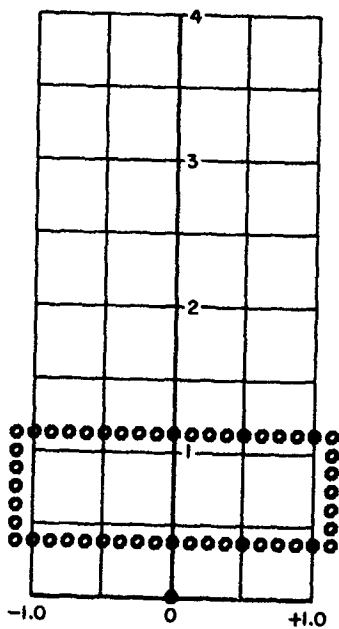
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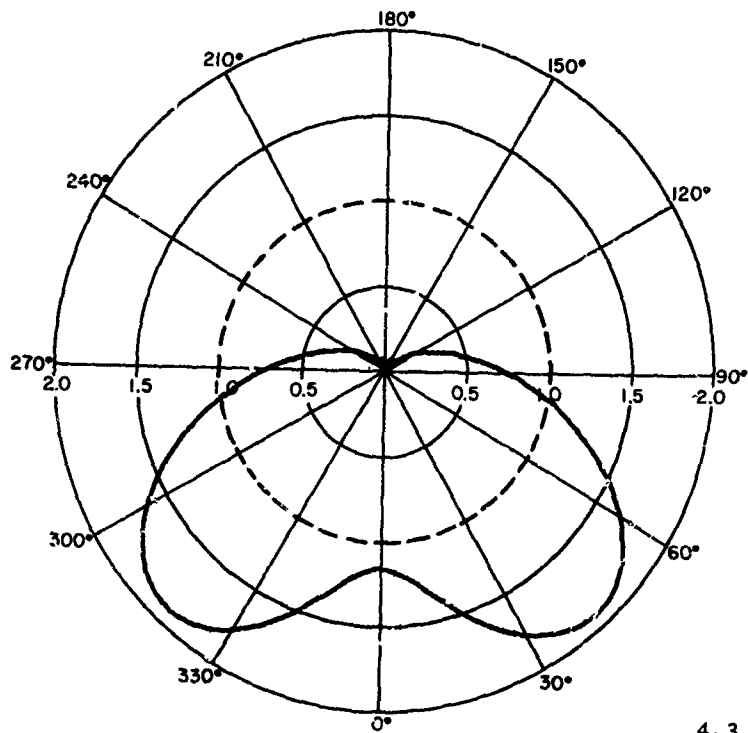
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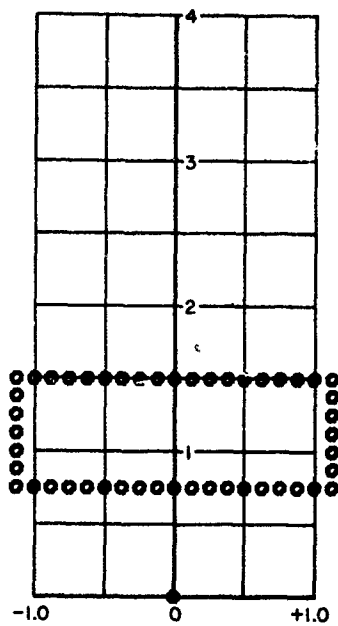
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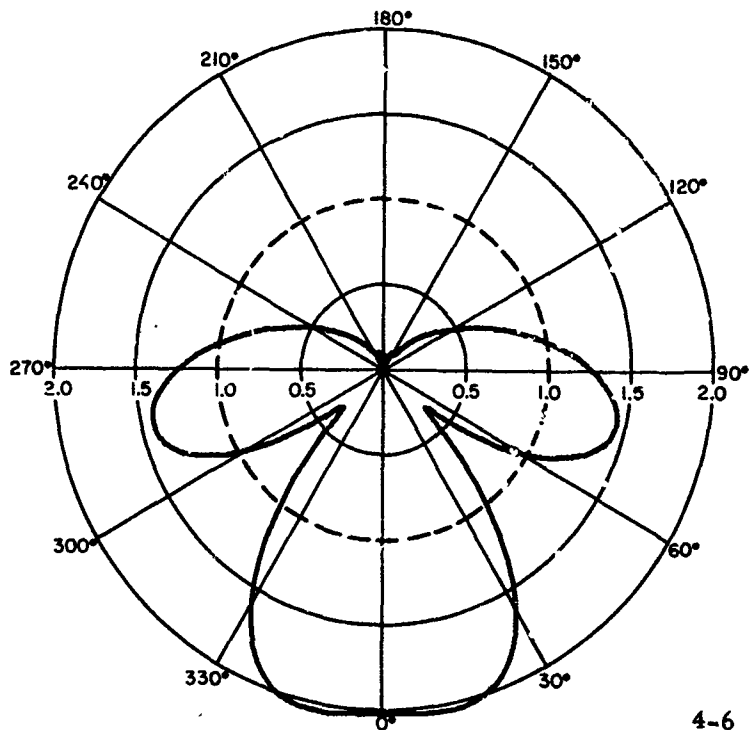
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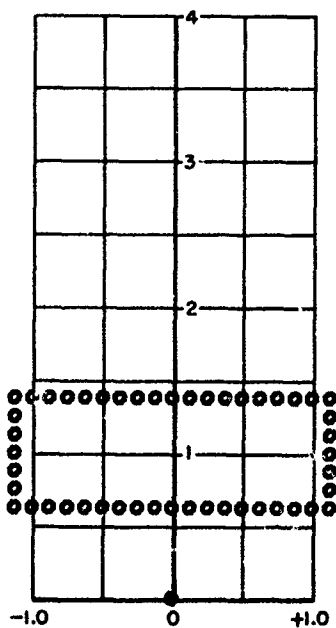
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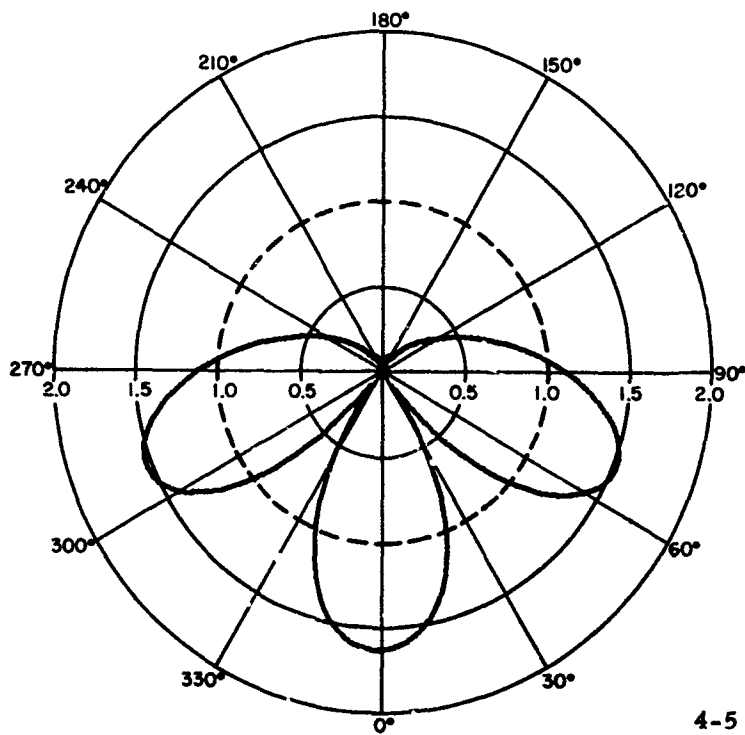
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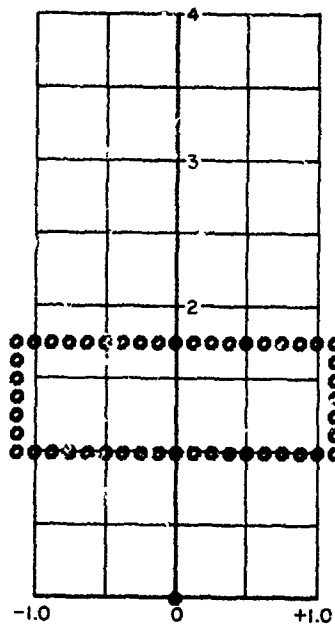
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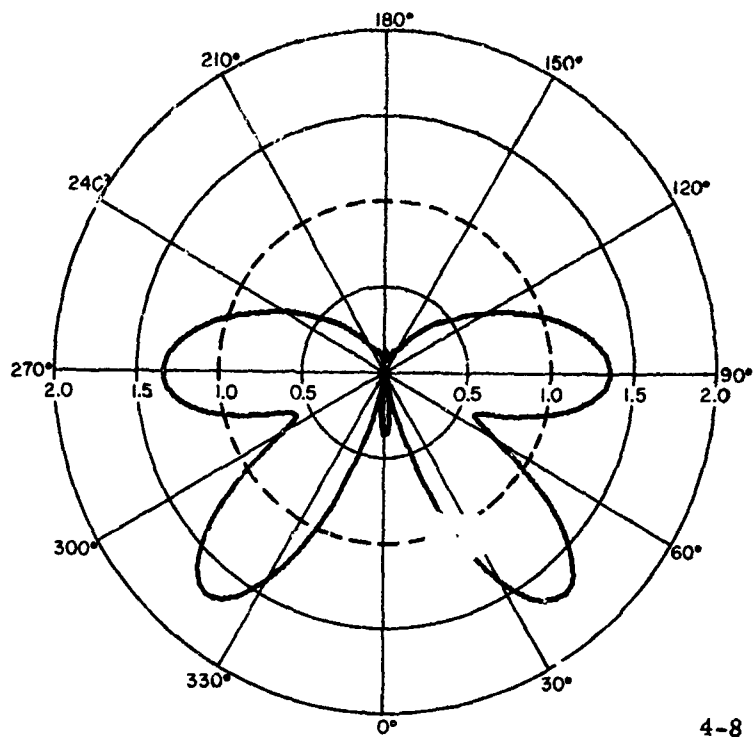
DISTANCE ~ WAVELENGTHS



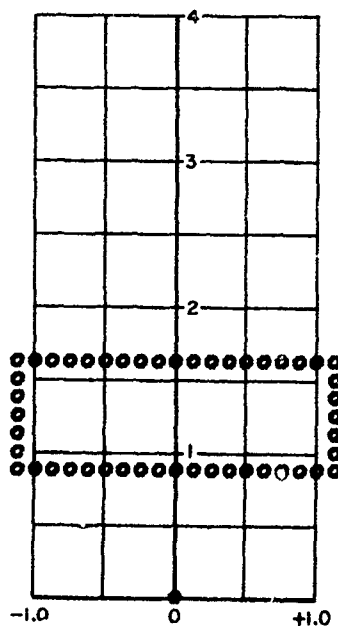
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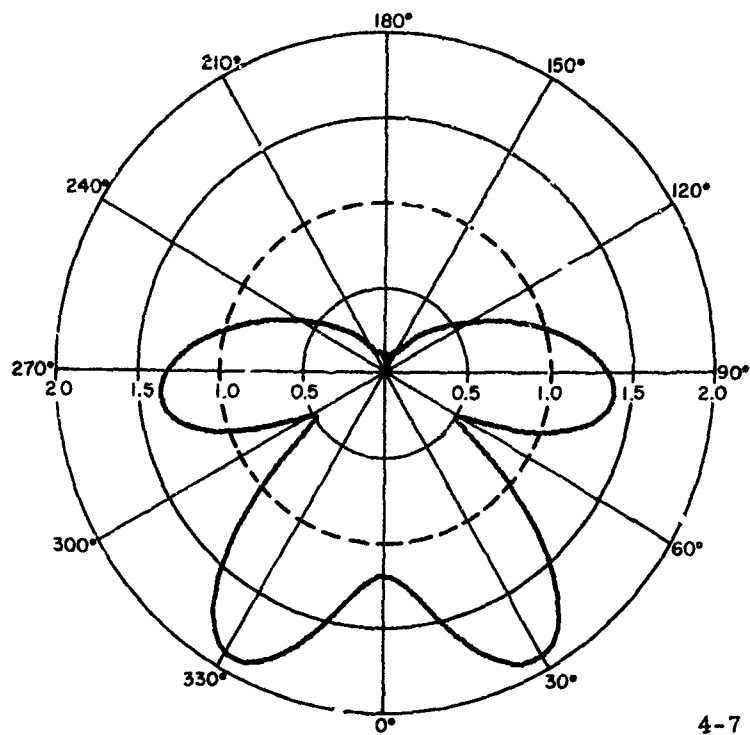
DISTANCE ~ WAVELENGTHS



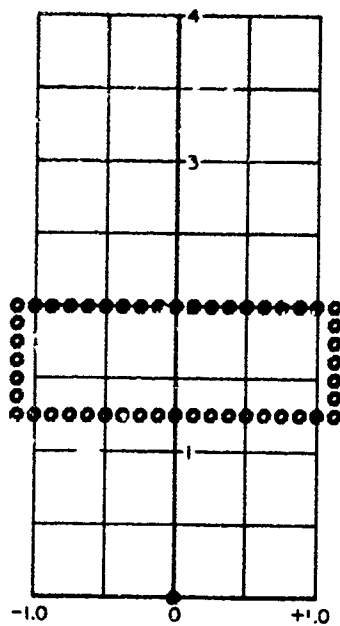
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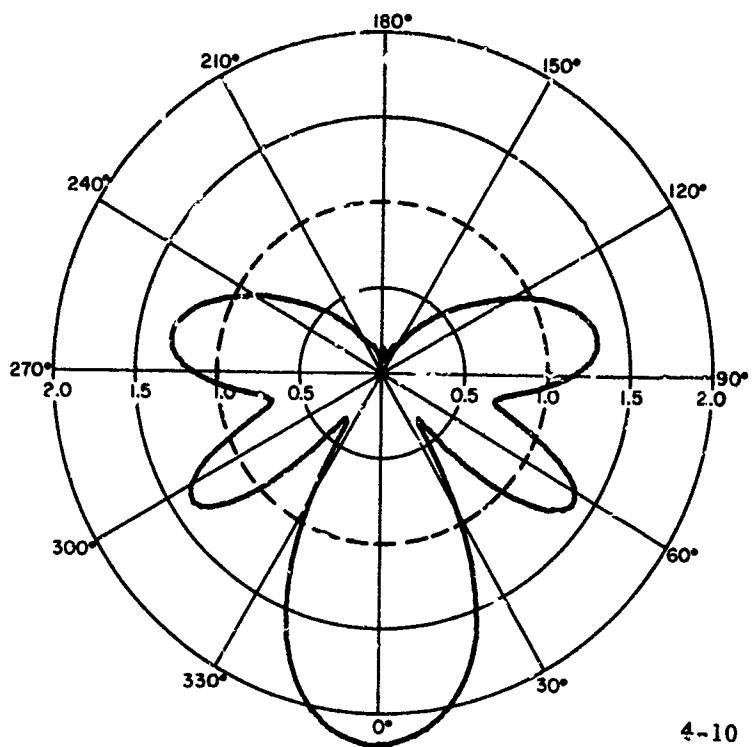
DISTANCE ~ WAVELENGTHS



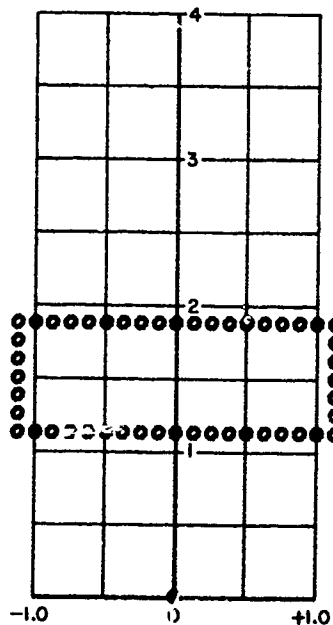
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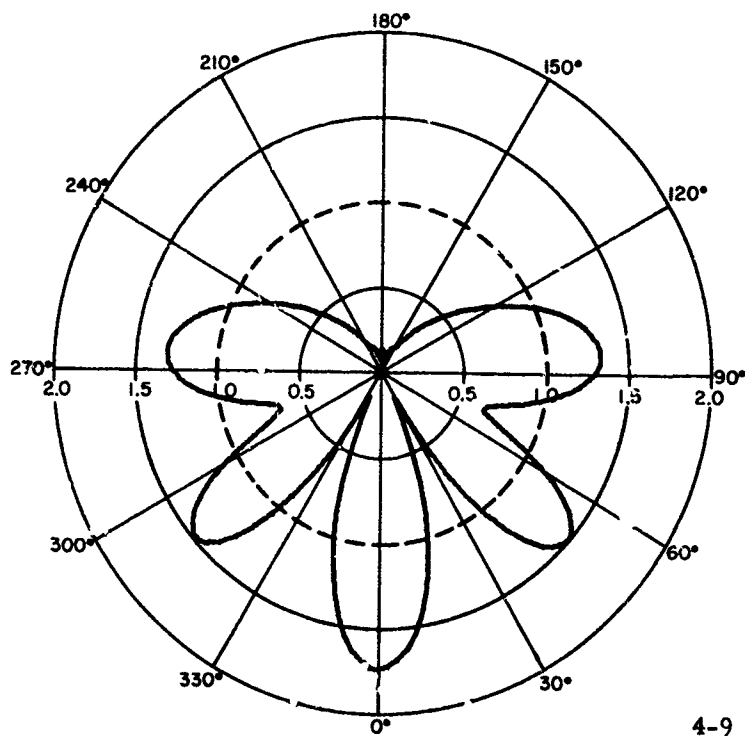
DISTANCE ~ WAVELENGTHS



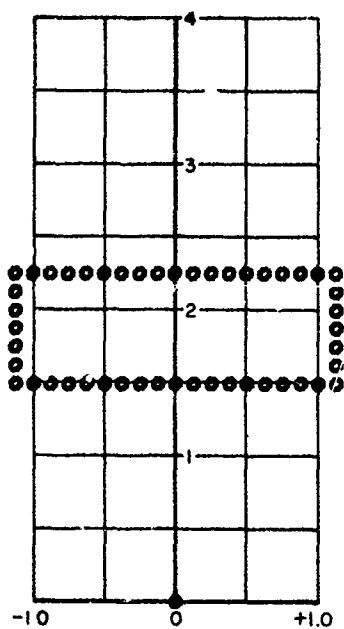
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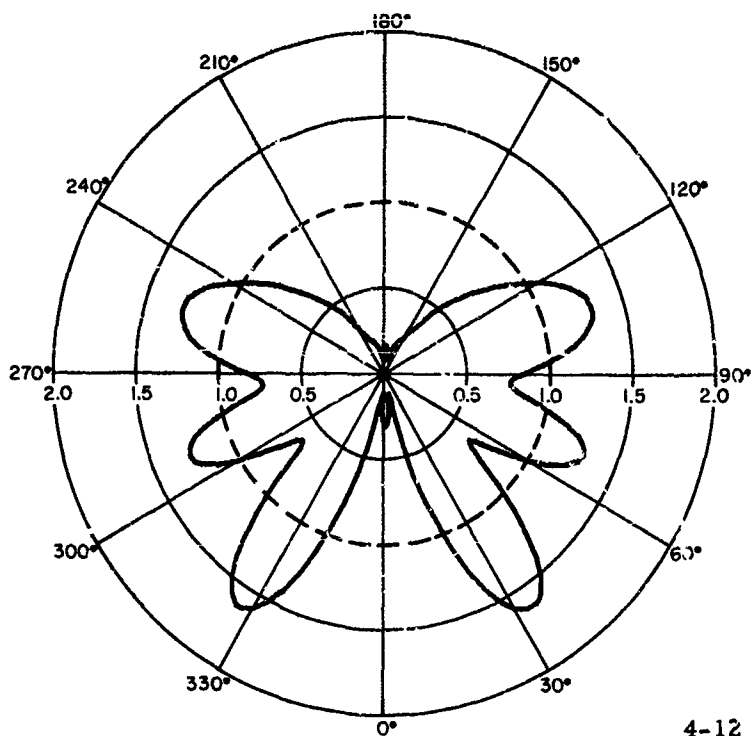
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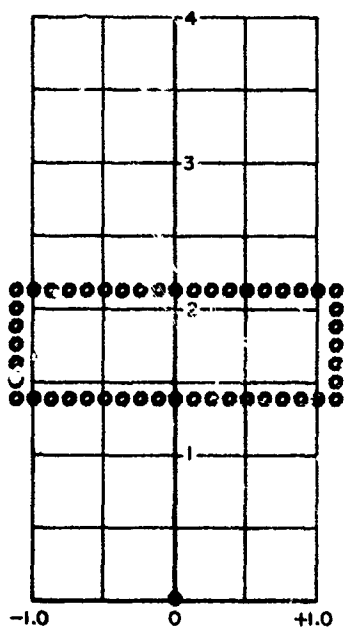
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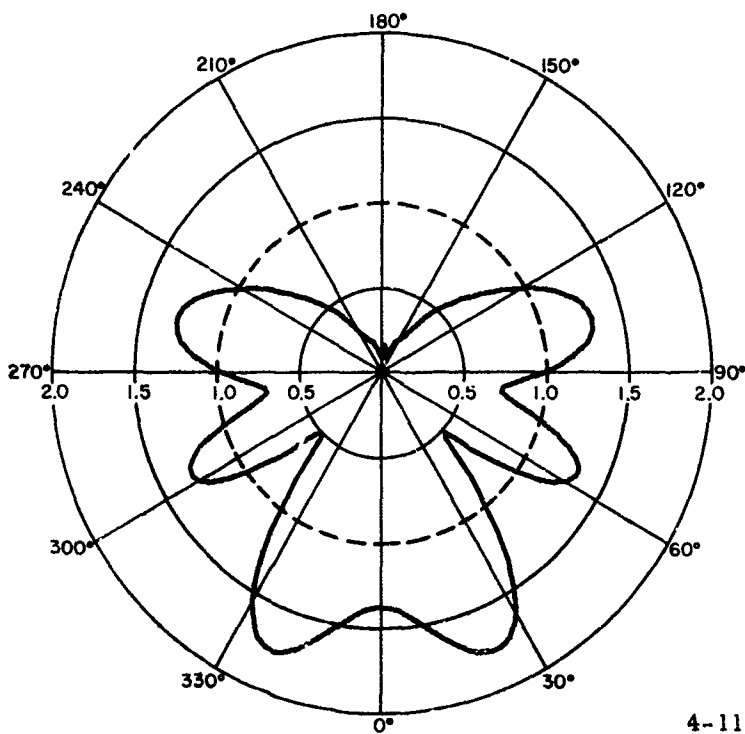
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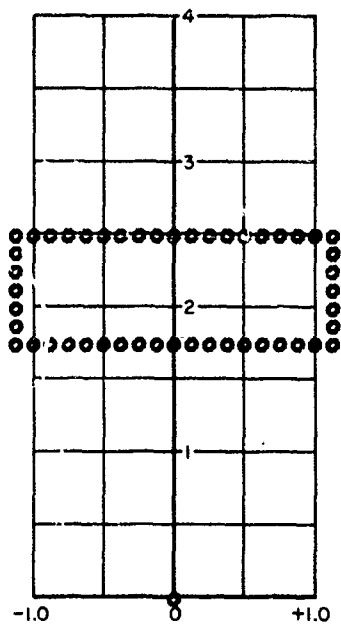
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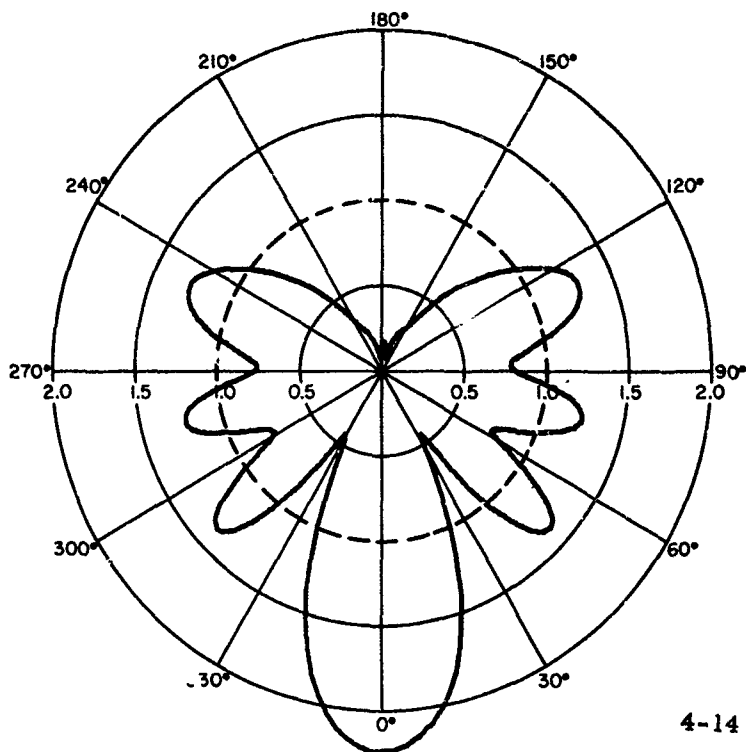
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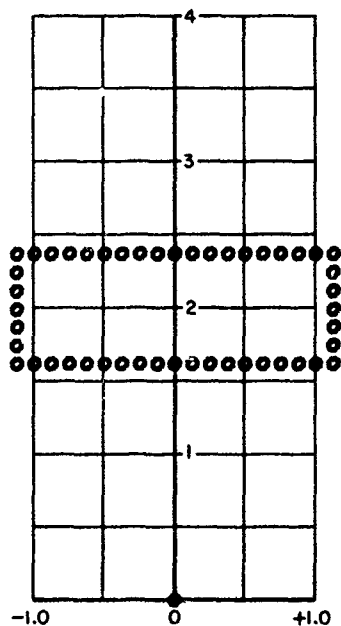
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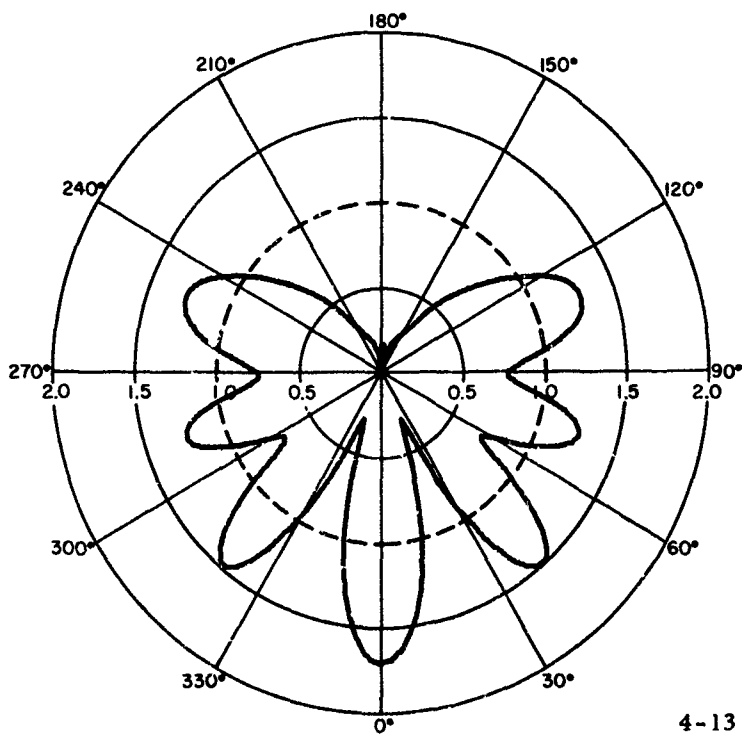
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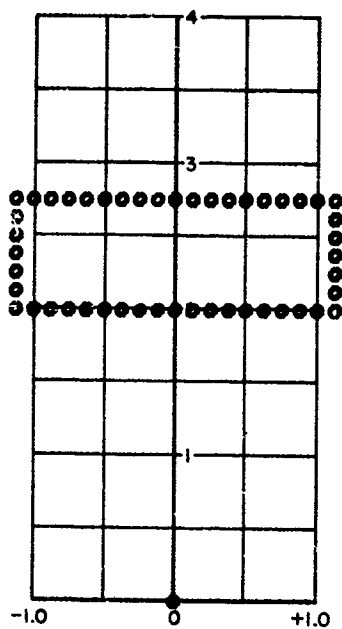
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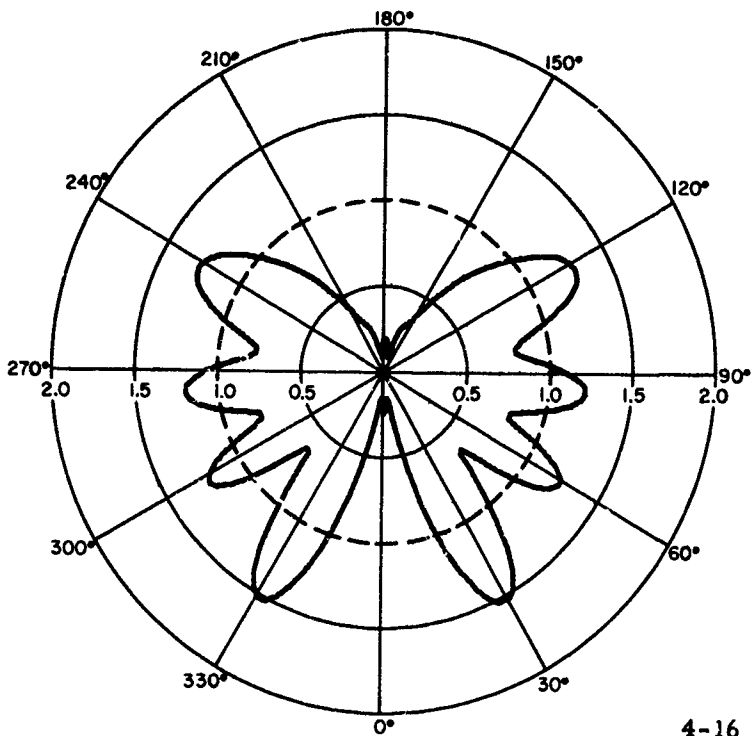
DISTANCE ~ WAVELENGTHS



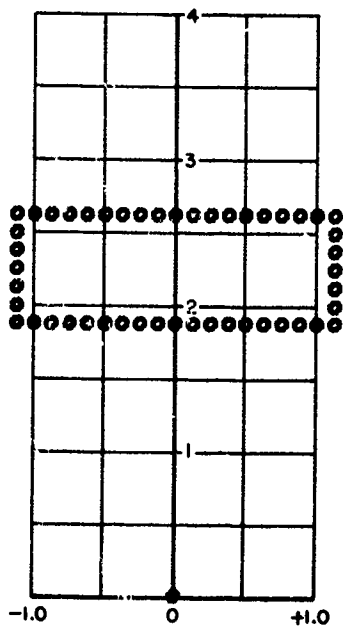
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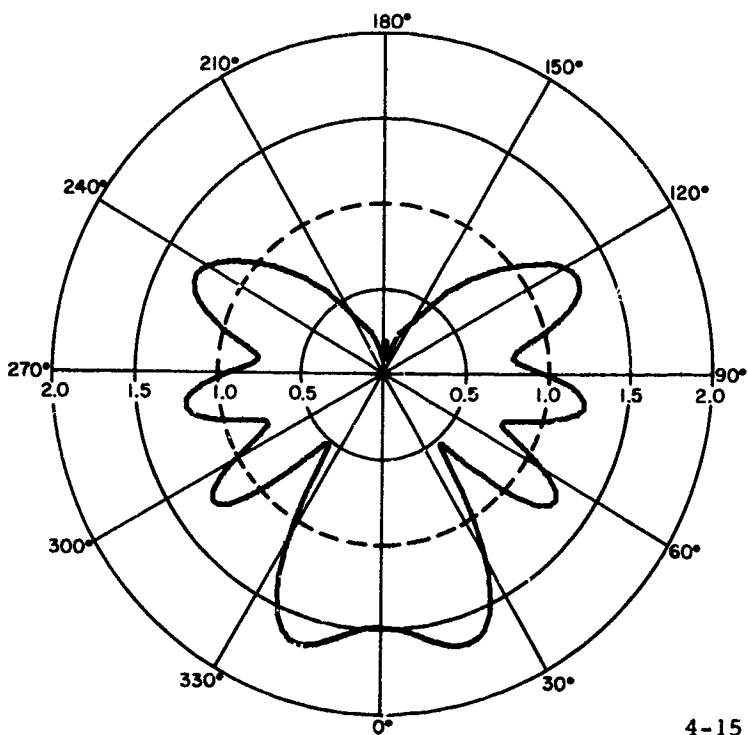
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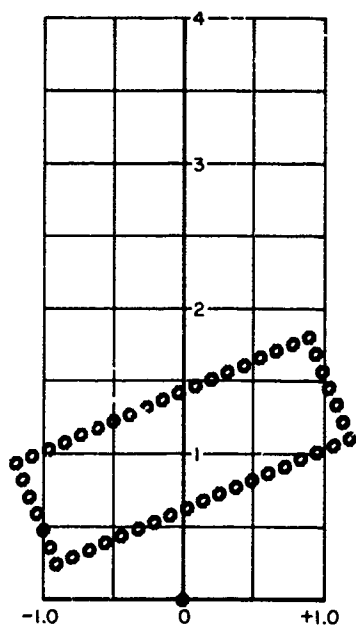
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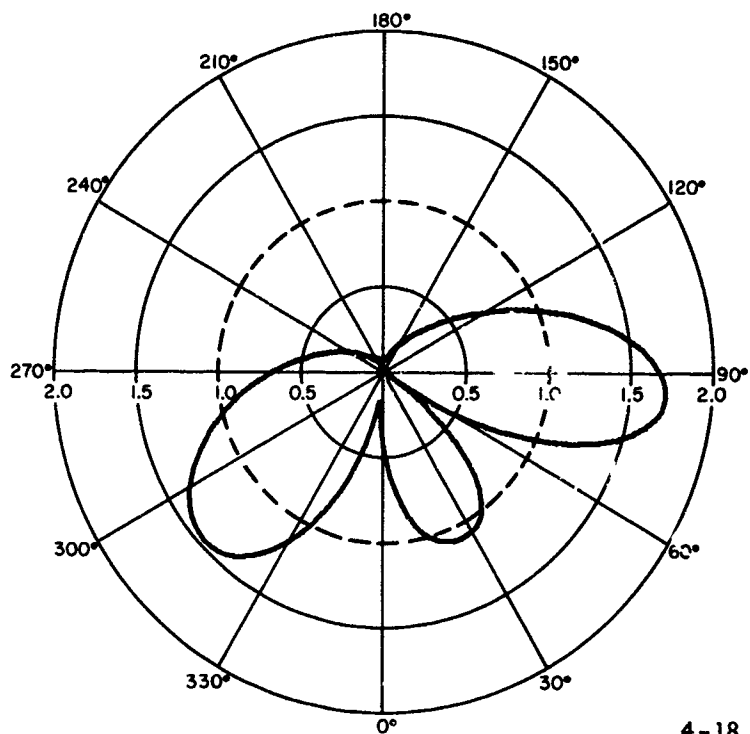
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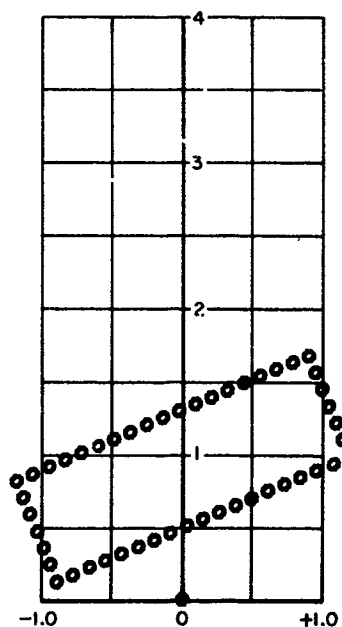
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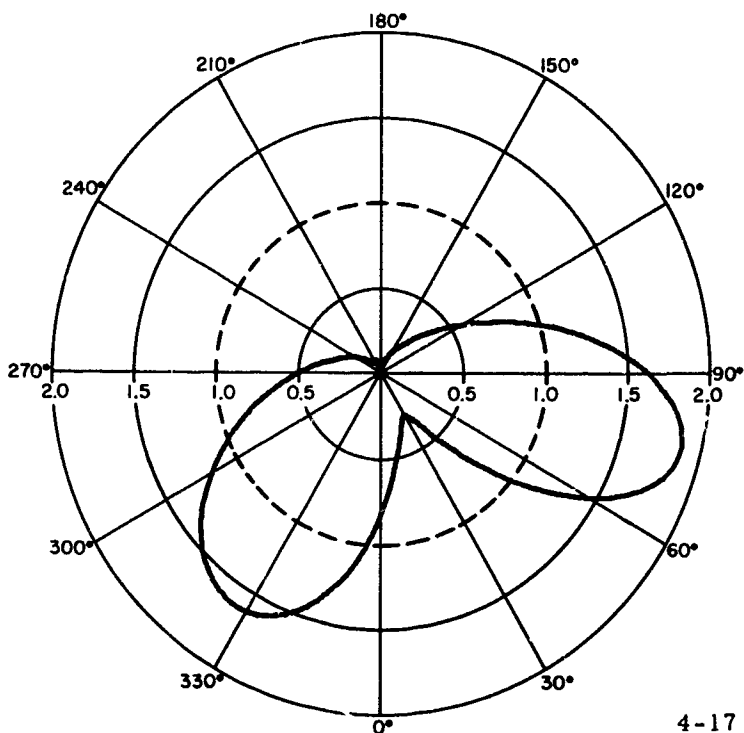
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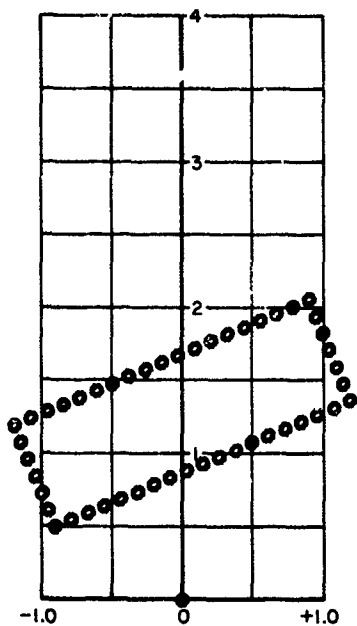
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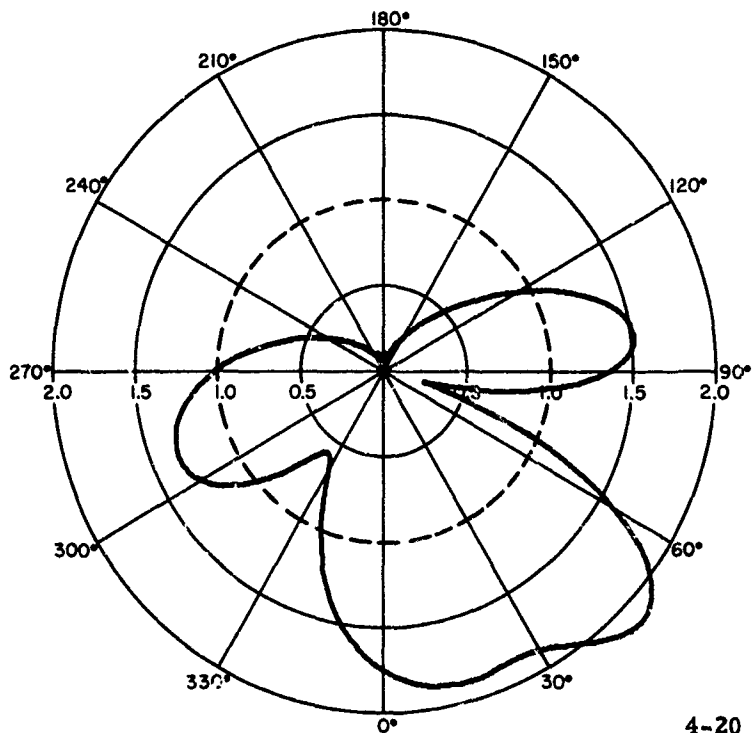
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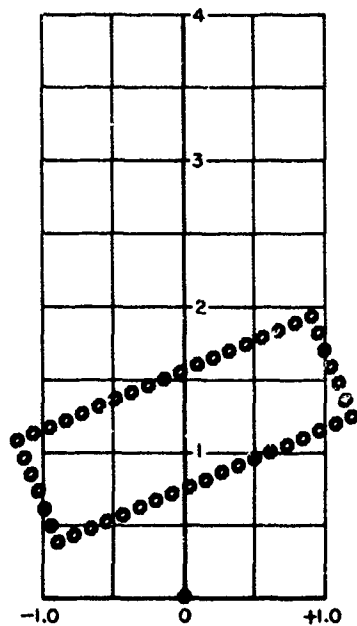
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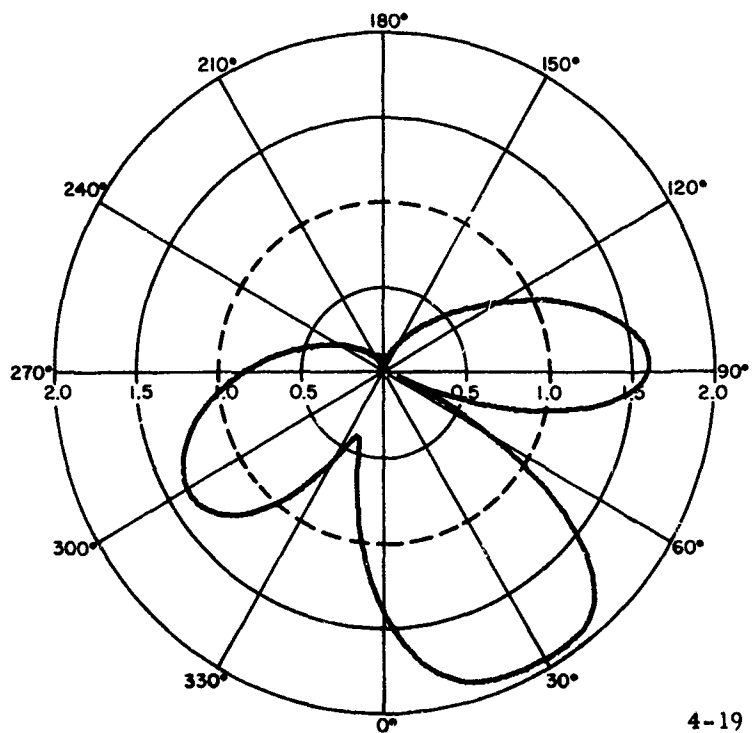
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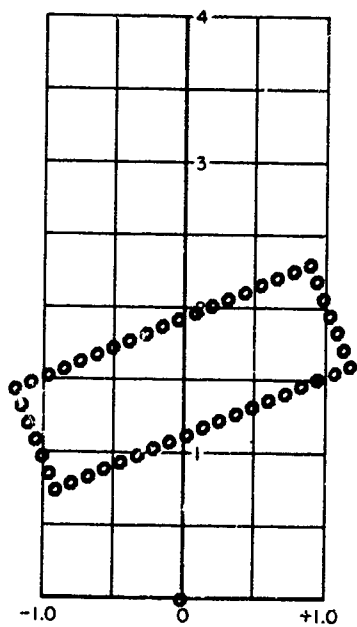
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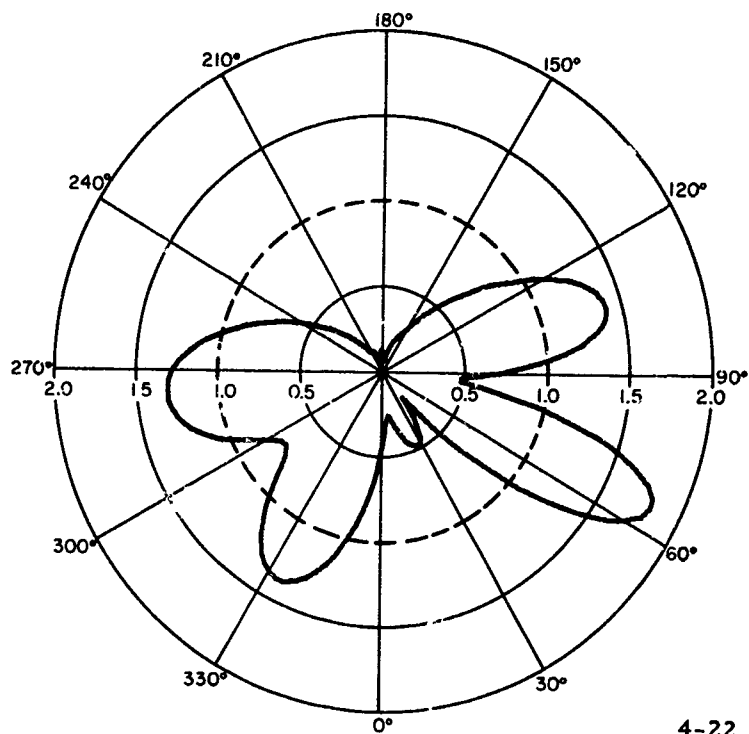
DISTANCE ~ WAVELENGTHS



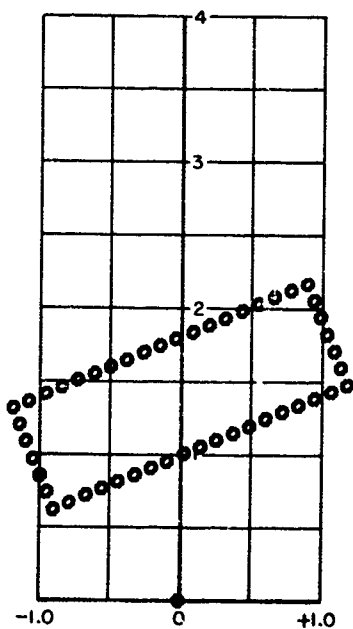
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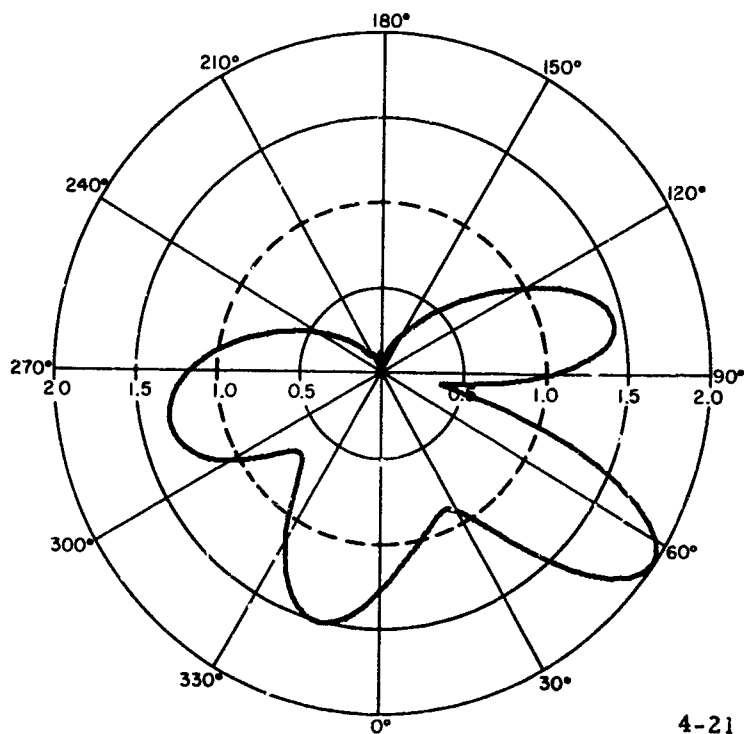
DISTANCE ~ WAVELENGTHS



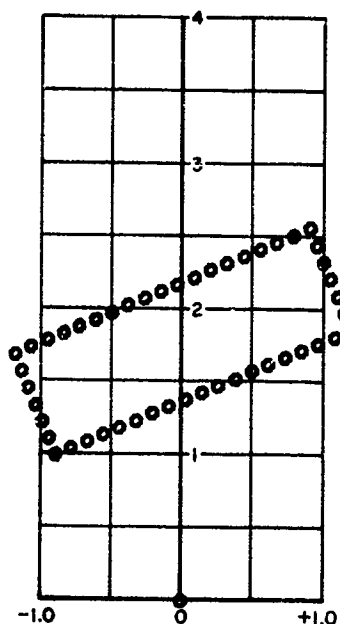
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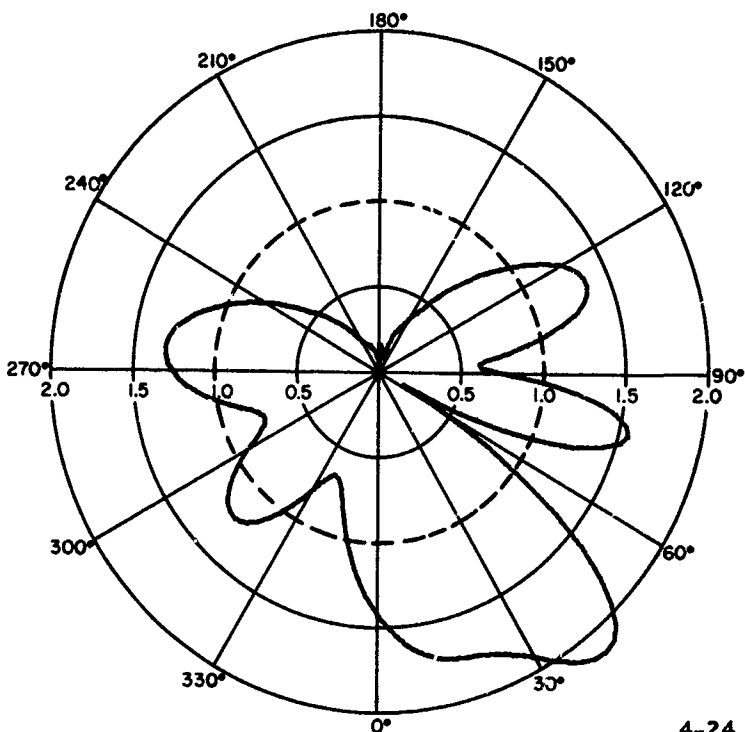
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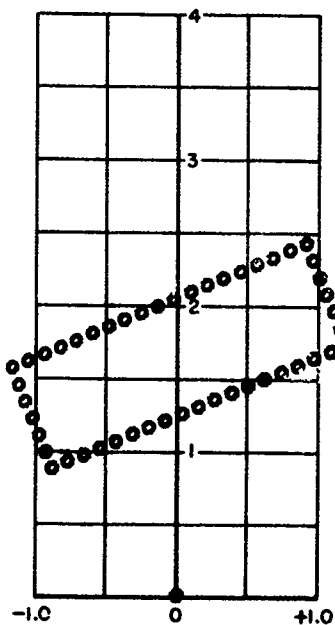
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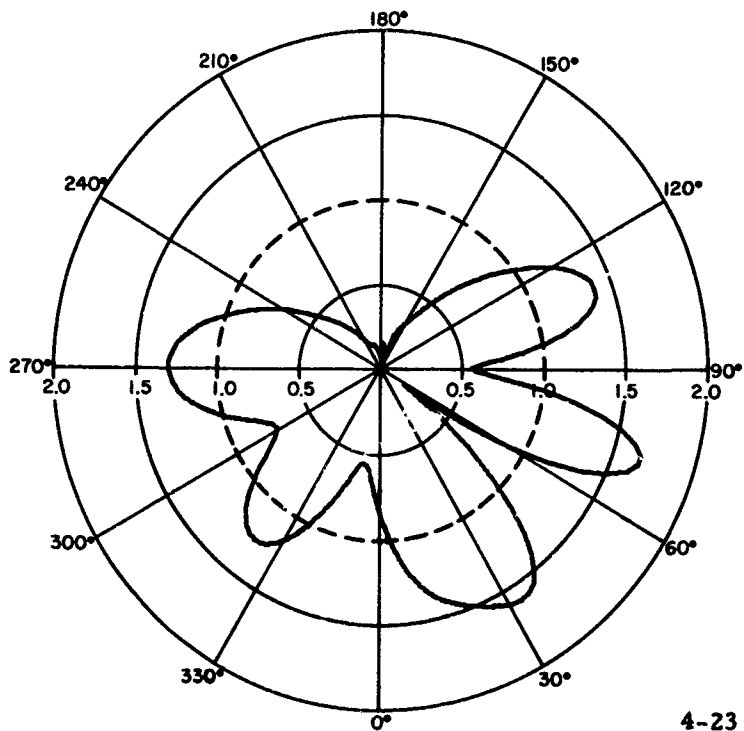
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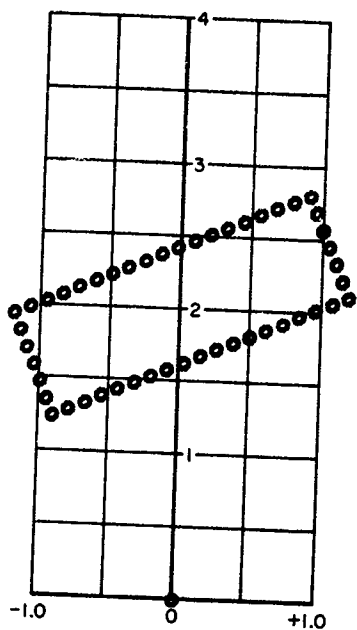
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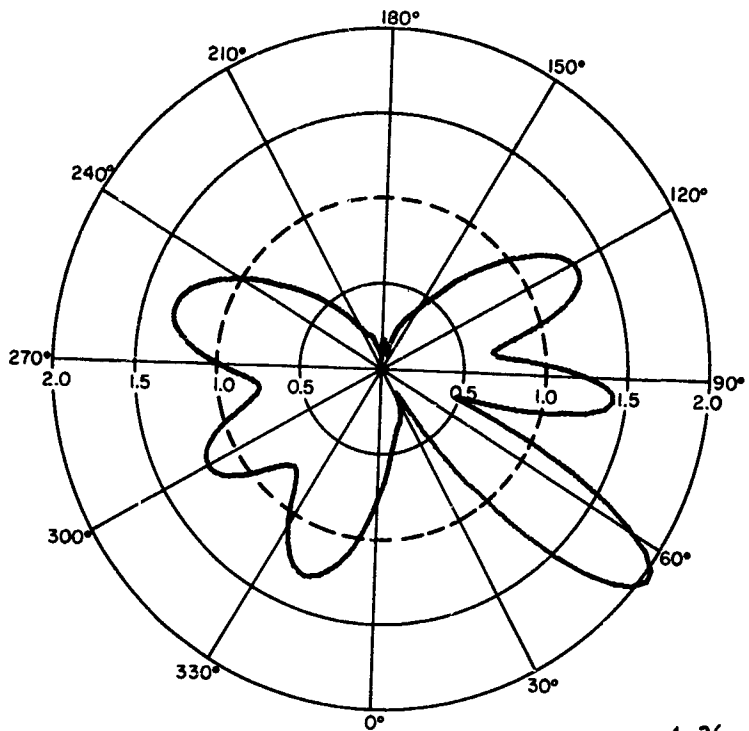
DISTANCE ~ WAVELENGTHS



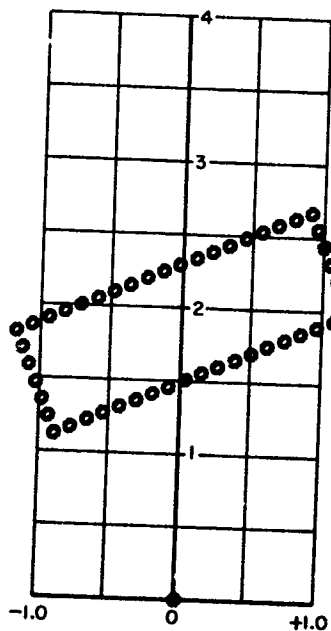
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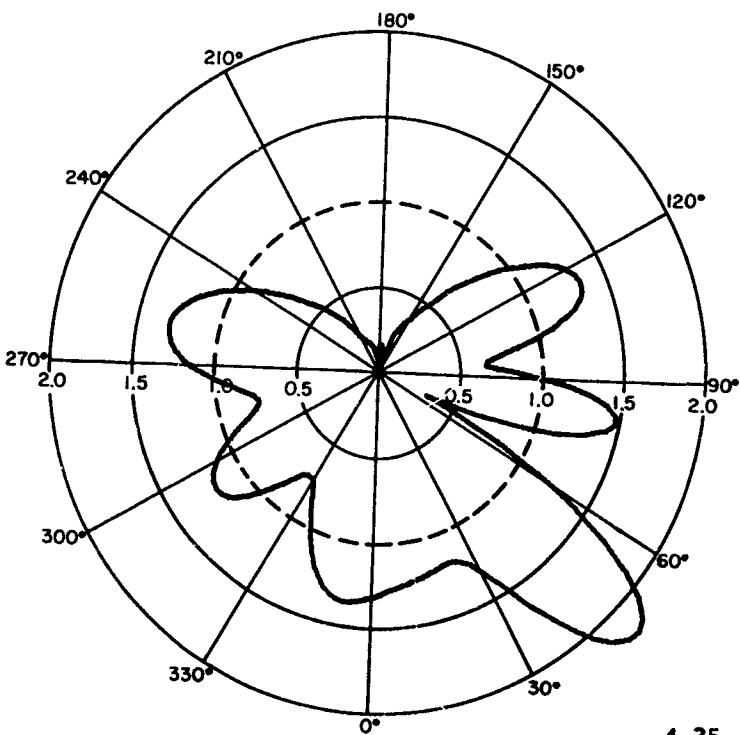
DISTANCE ~ WAVELENGTHS



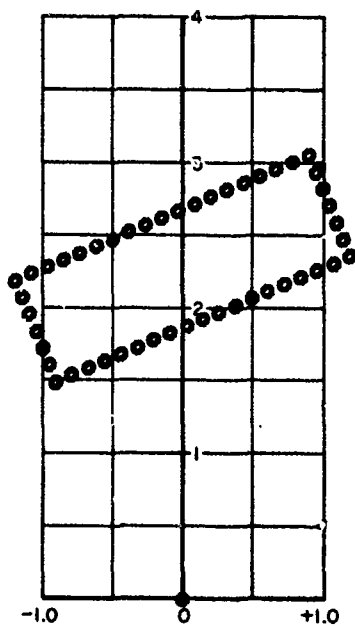
4-26



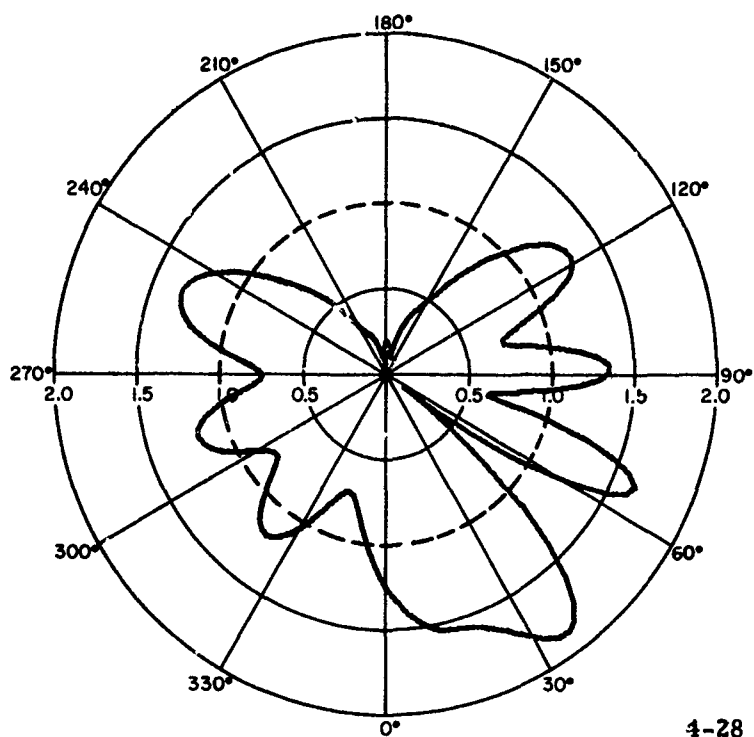
DISTANCE ~ WAVELENGTHS



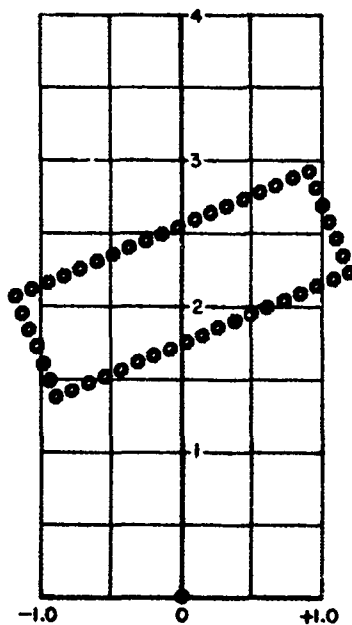
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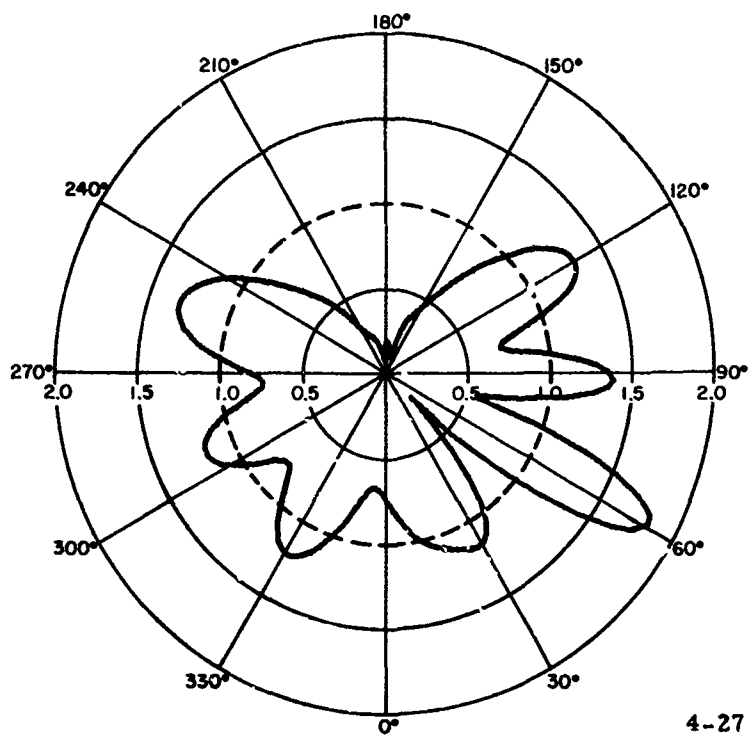
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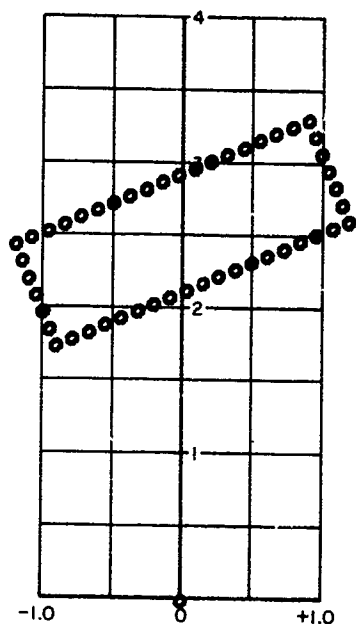
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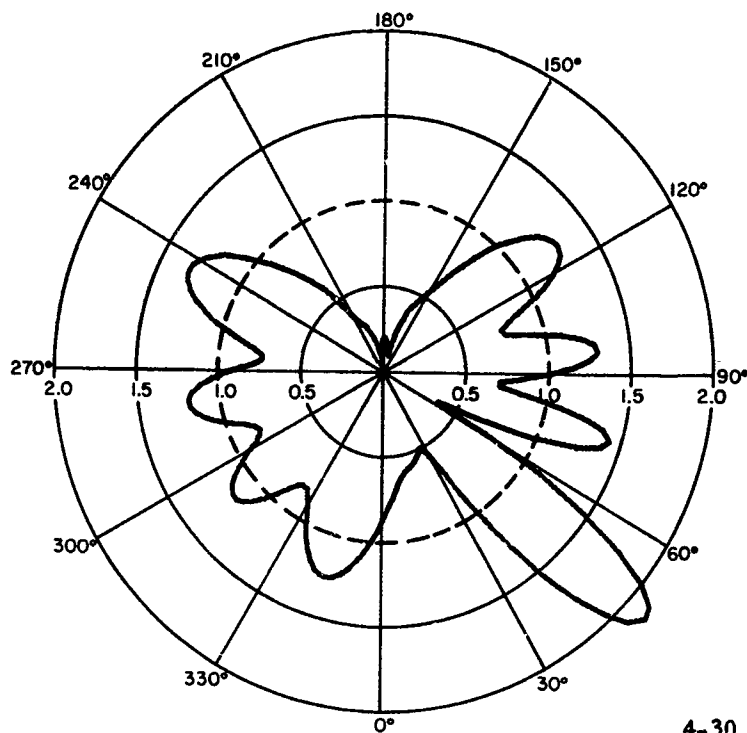
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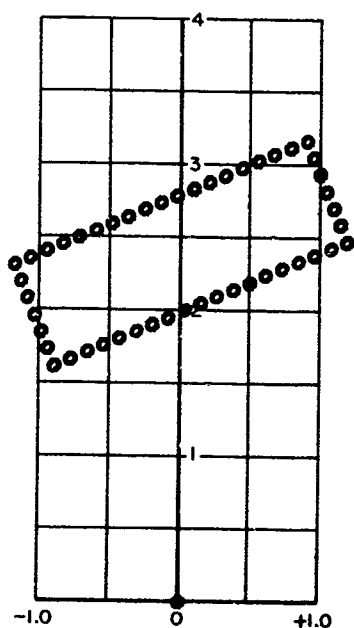
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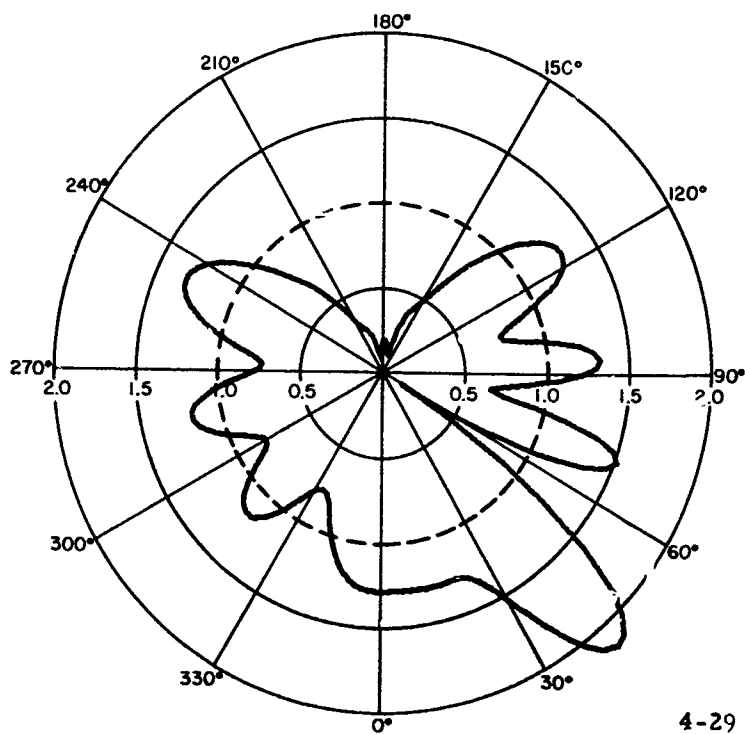
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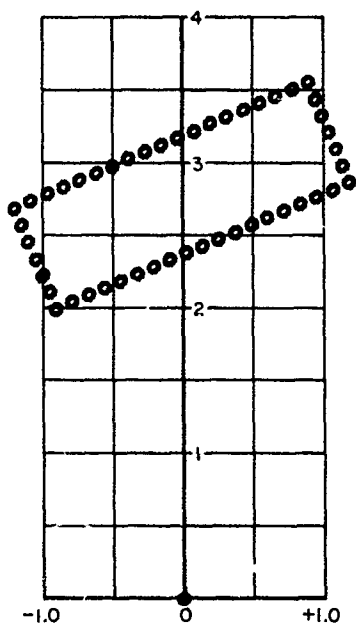
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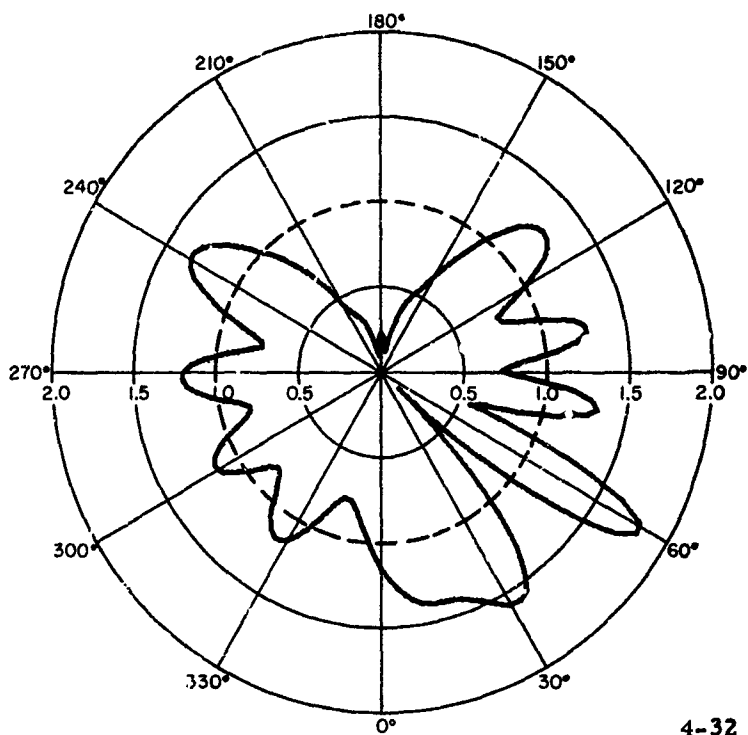
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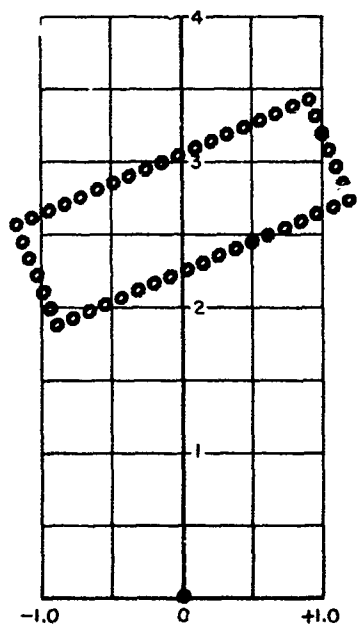
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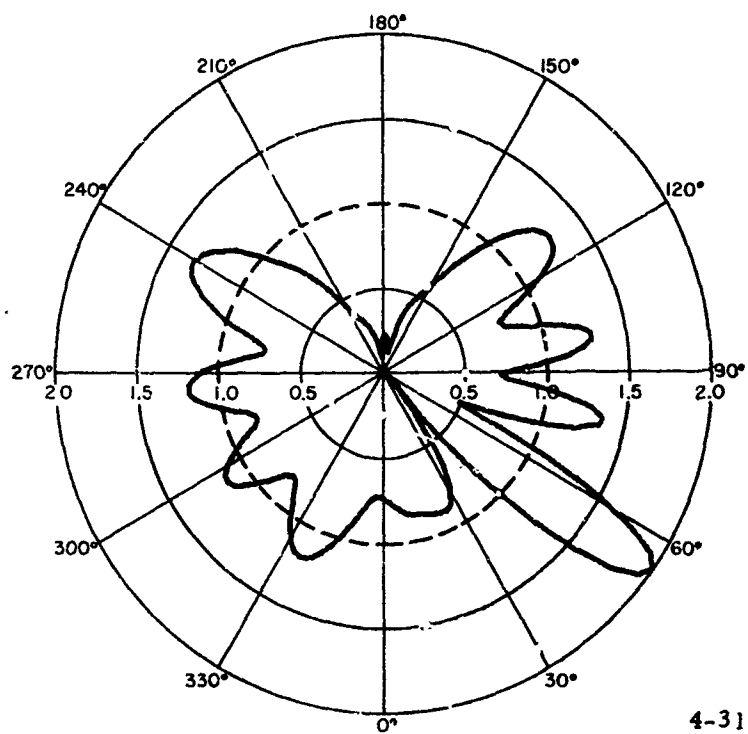
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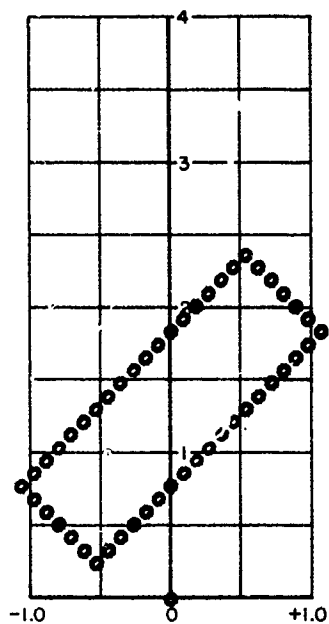
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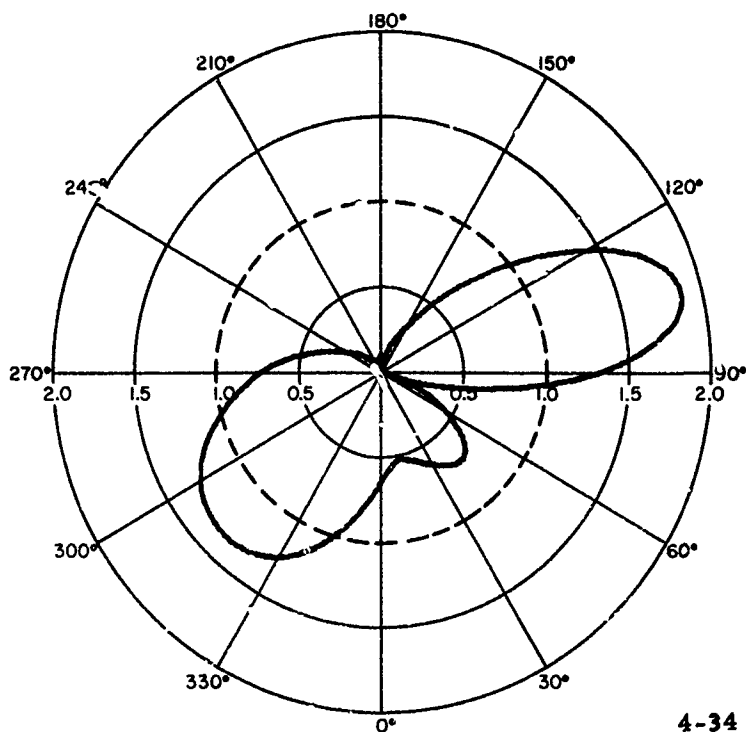
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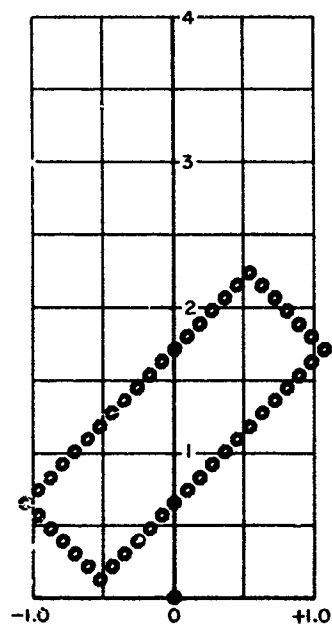
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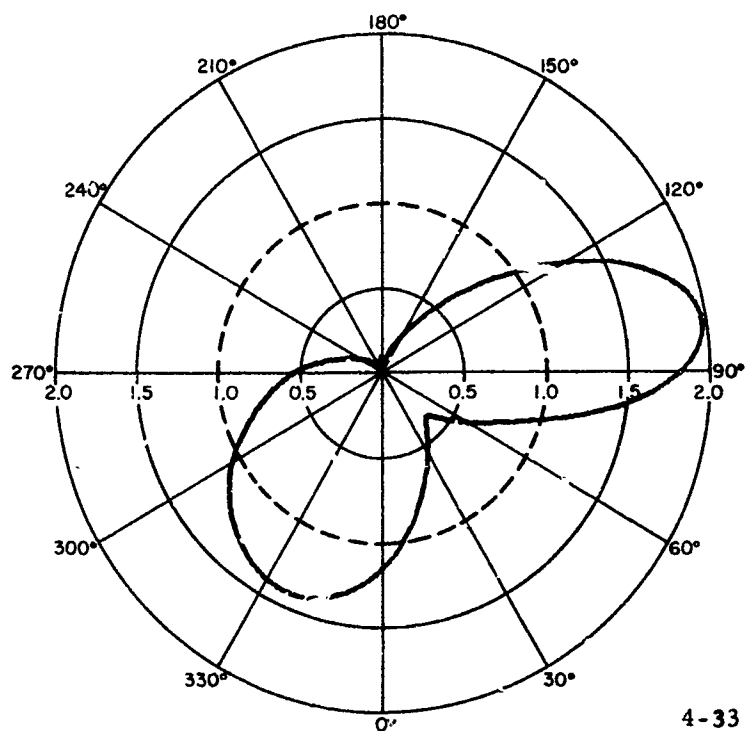
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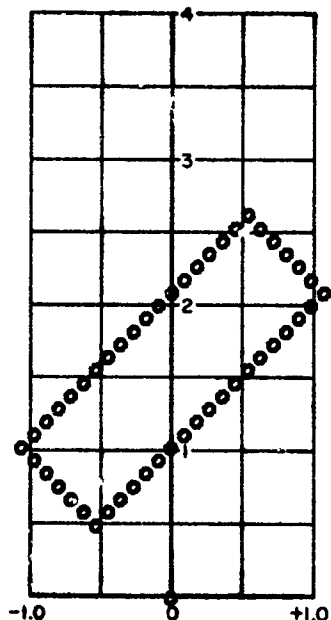
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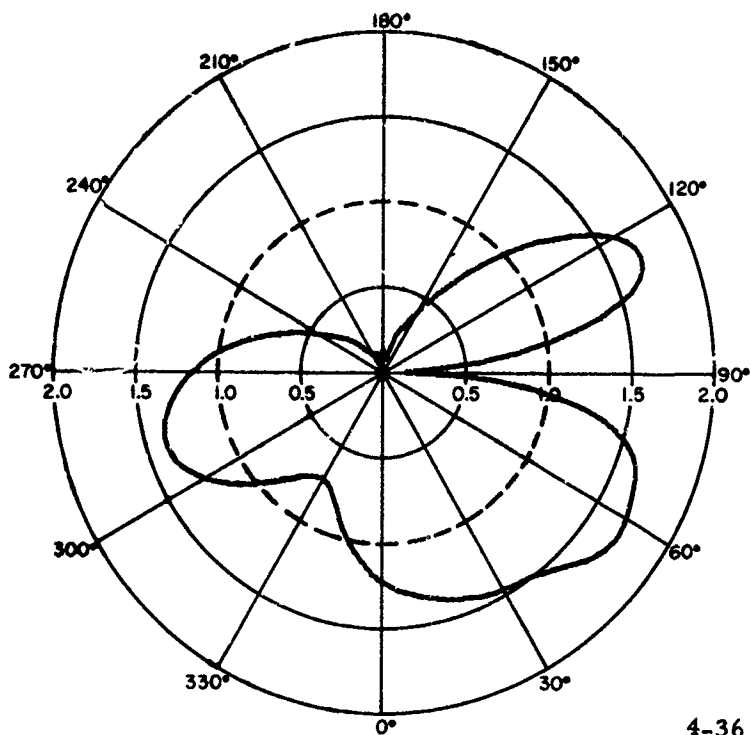
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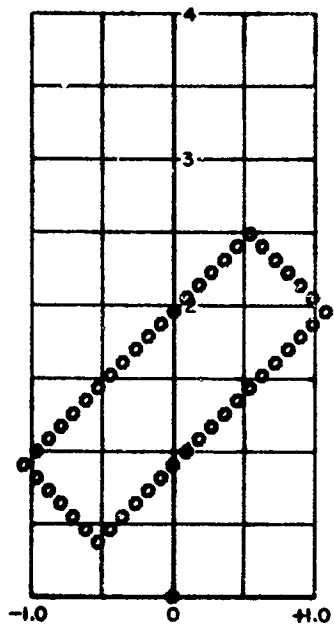
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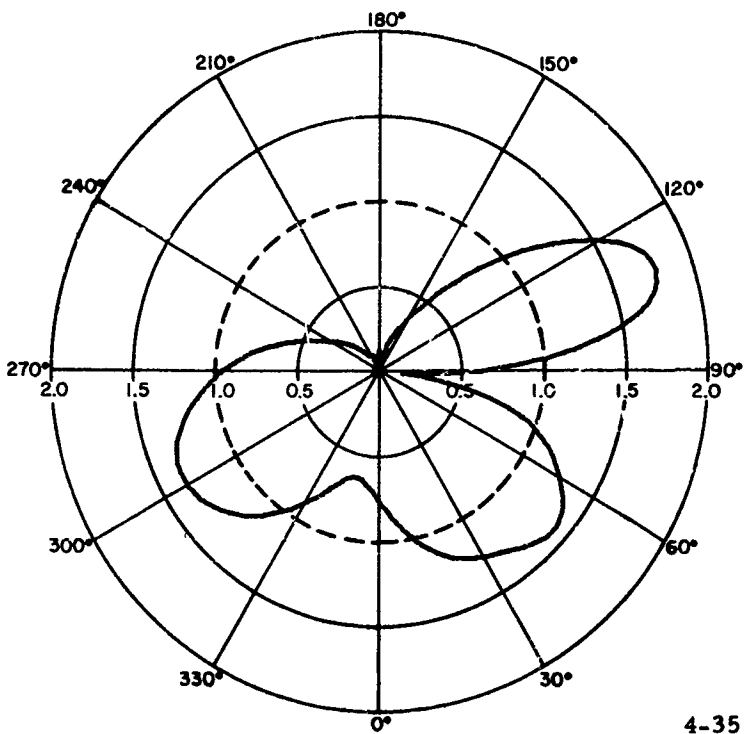
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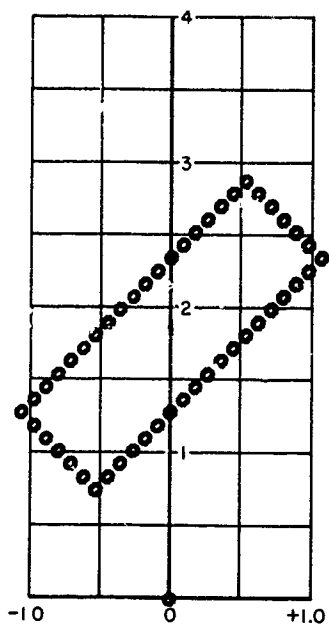
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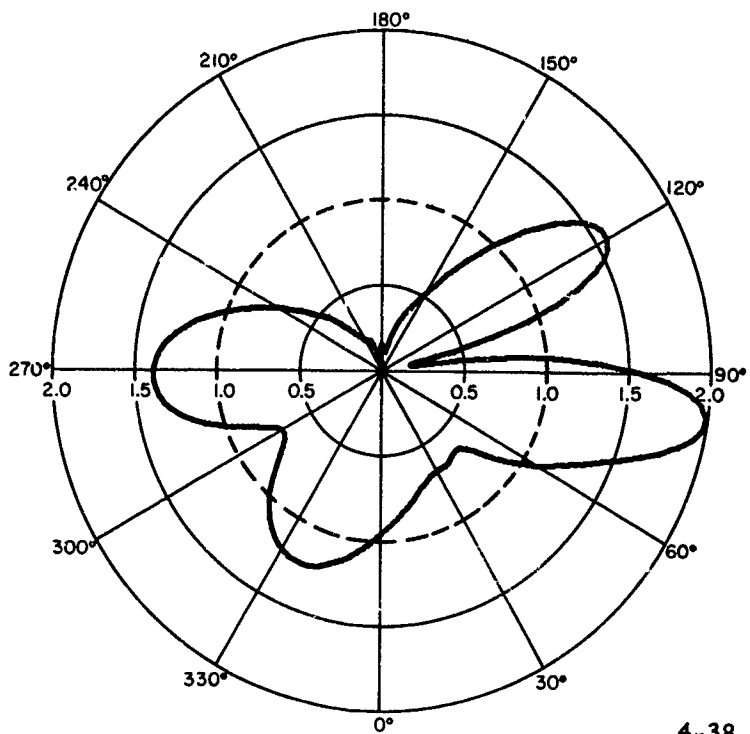
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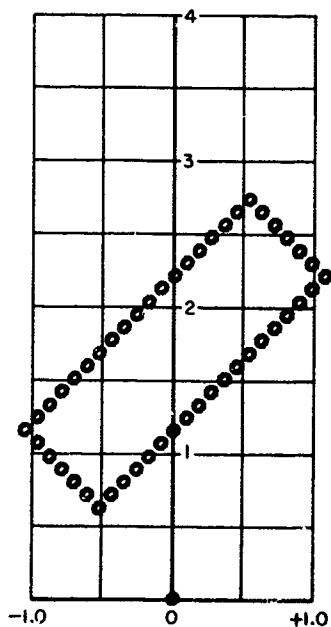
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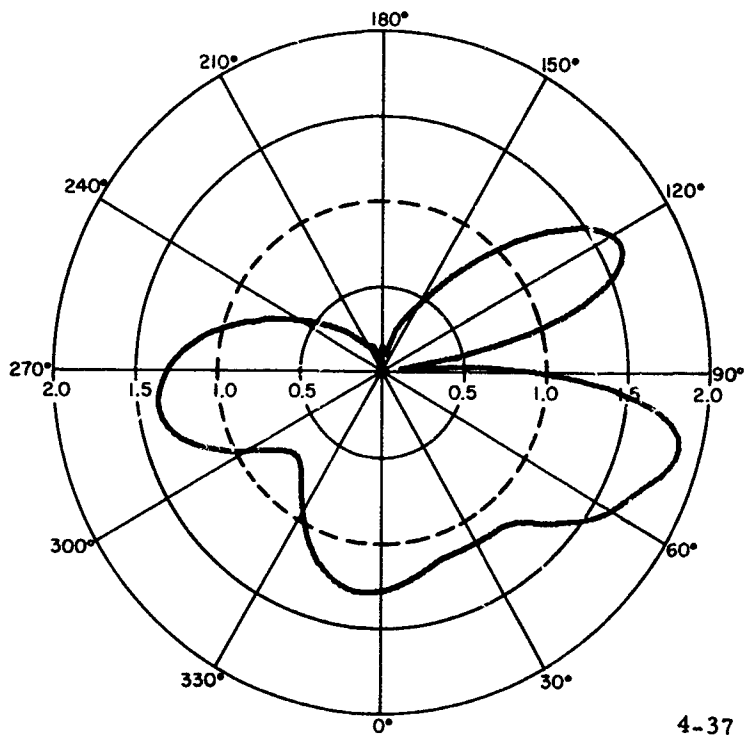
DISTANCE ~ WAVELENGTHS



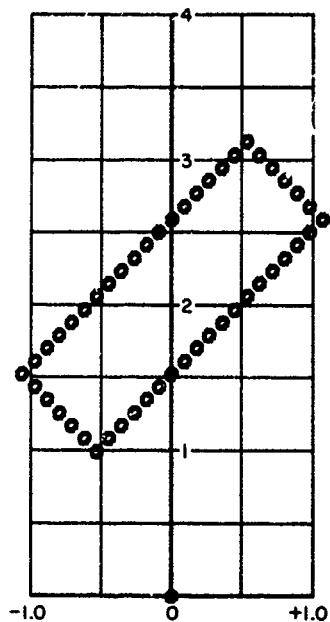
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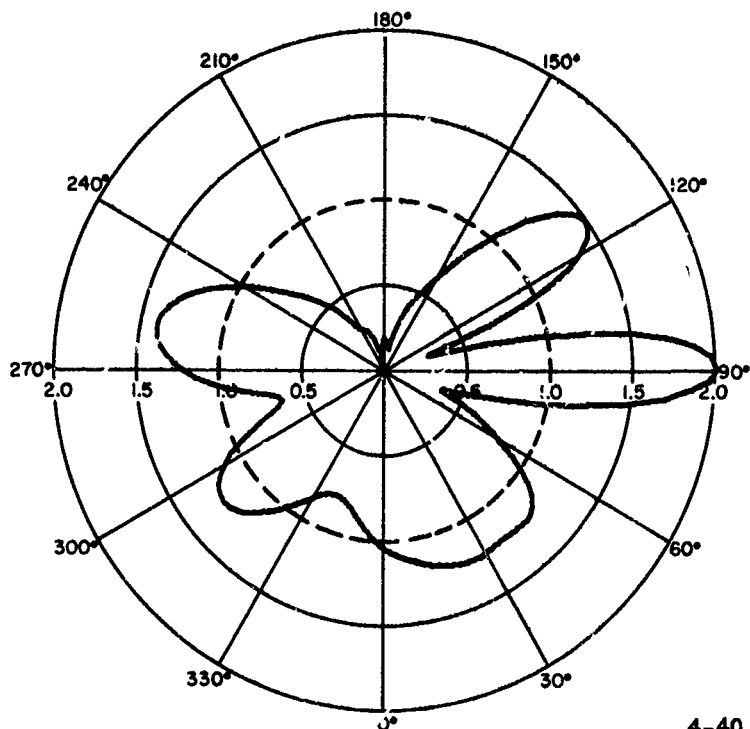
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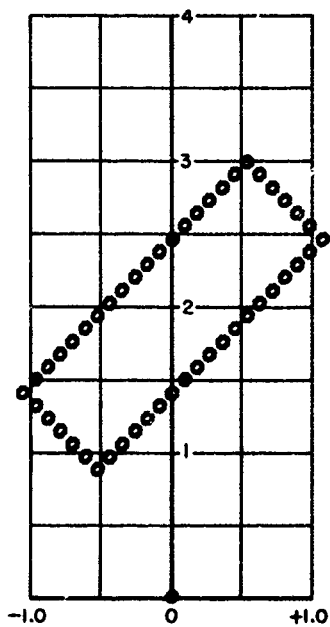
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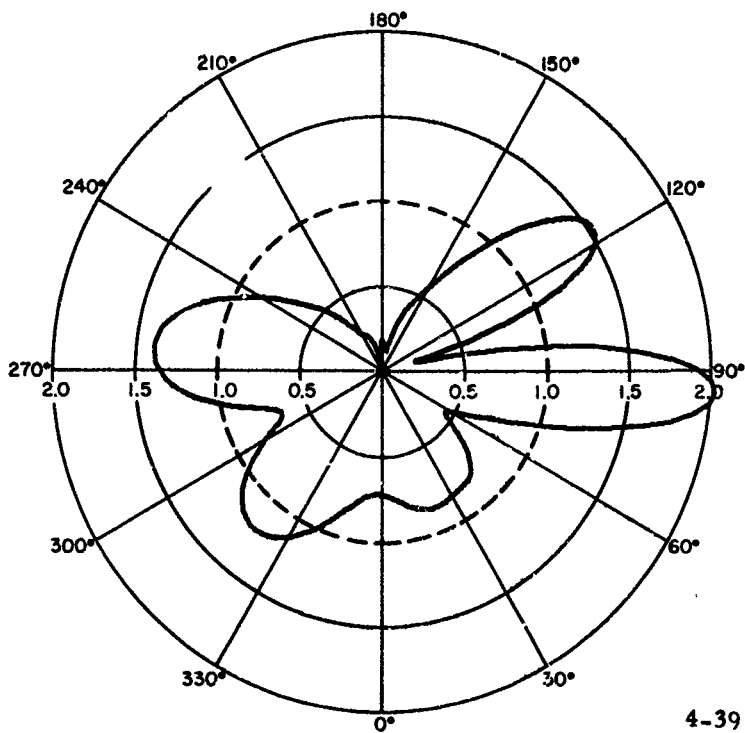
DISTANCE ~ WAVELENGTHS



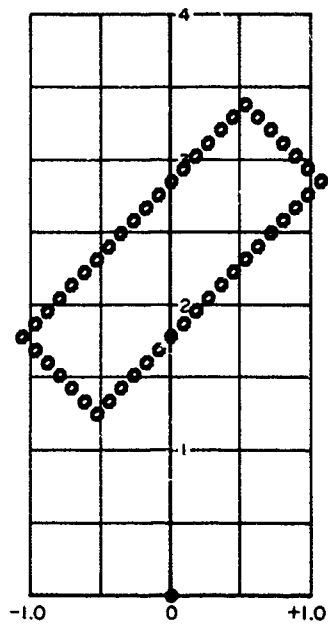
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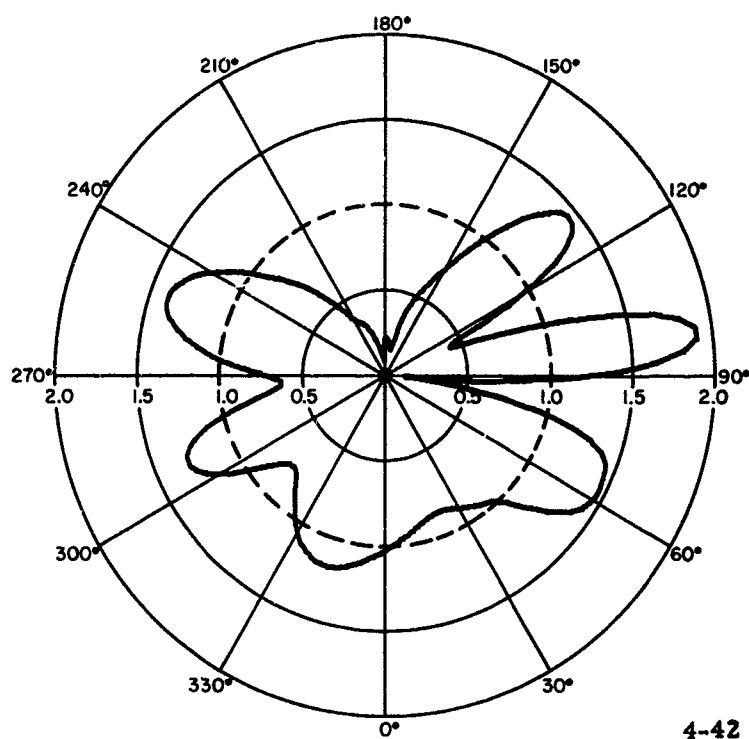
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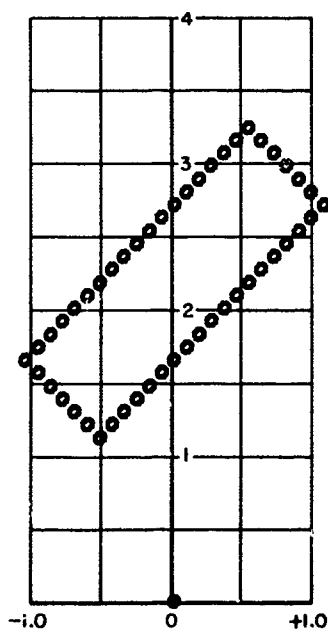
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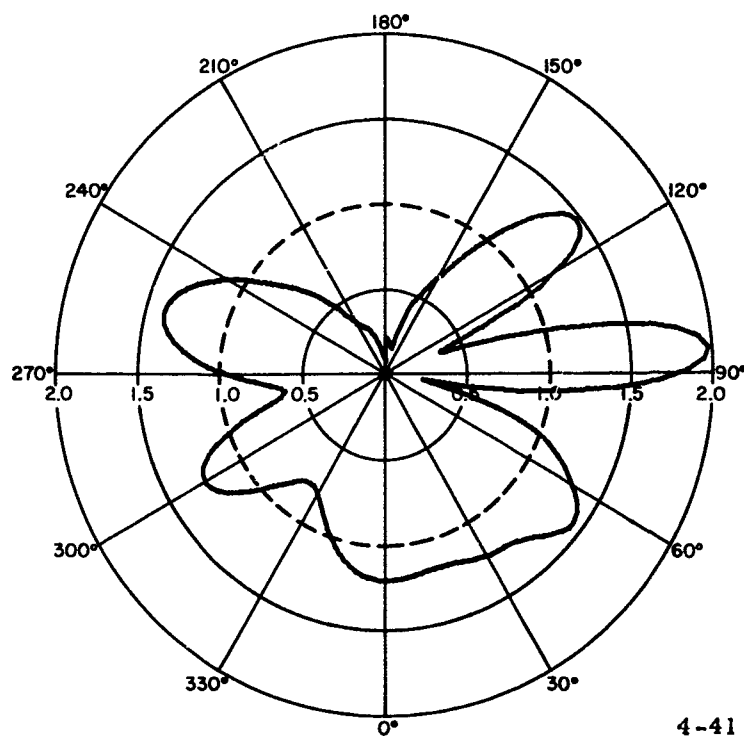
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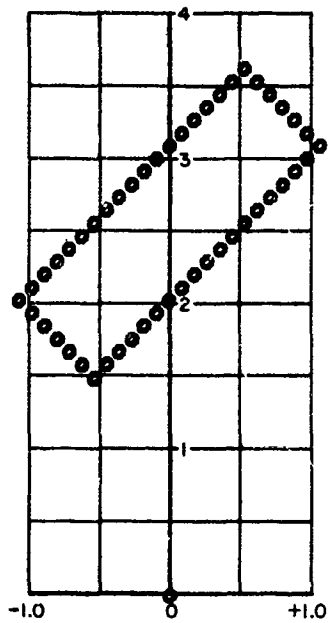
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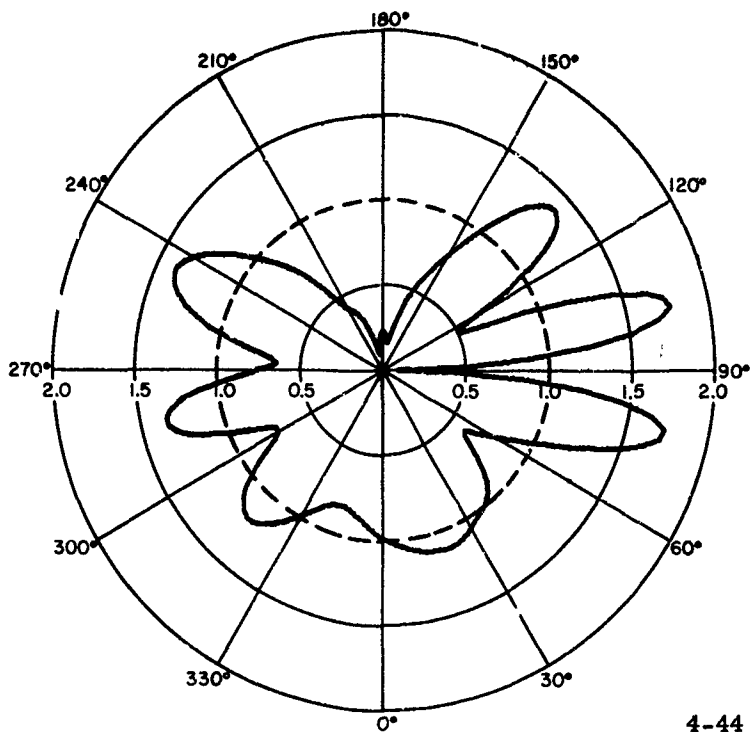
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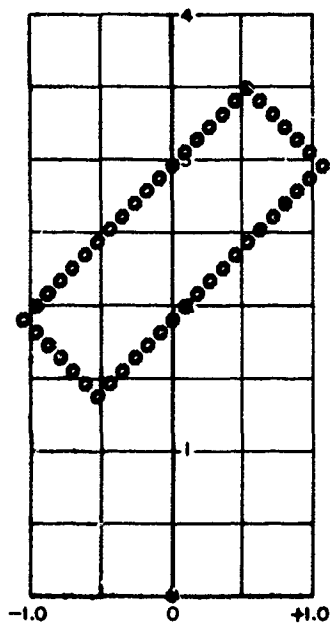
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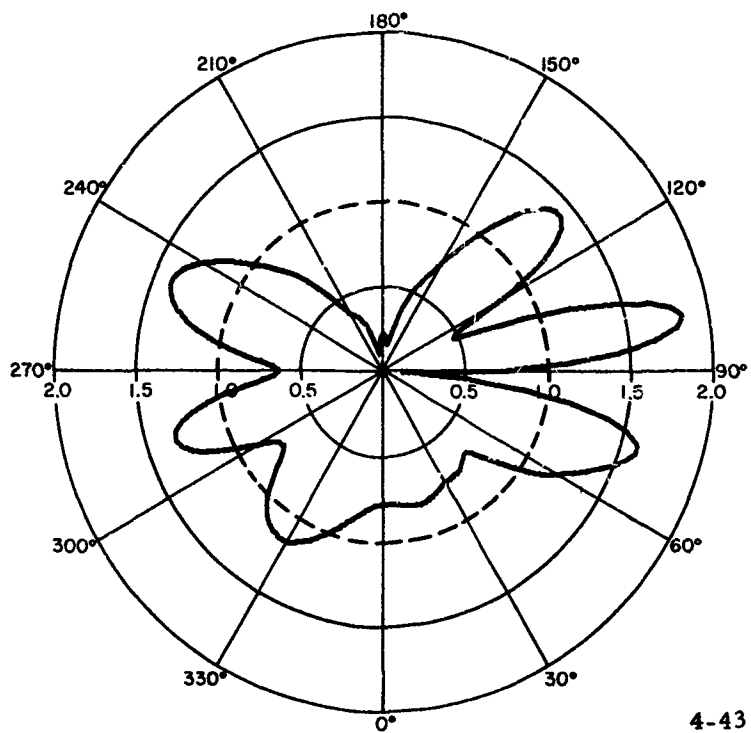
DISTANCE ~ WAVELENGTHS



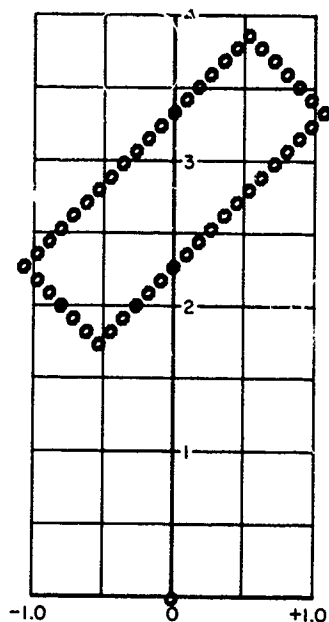
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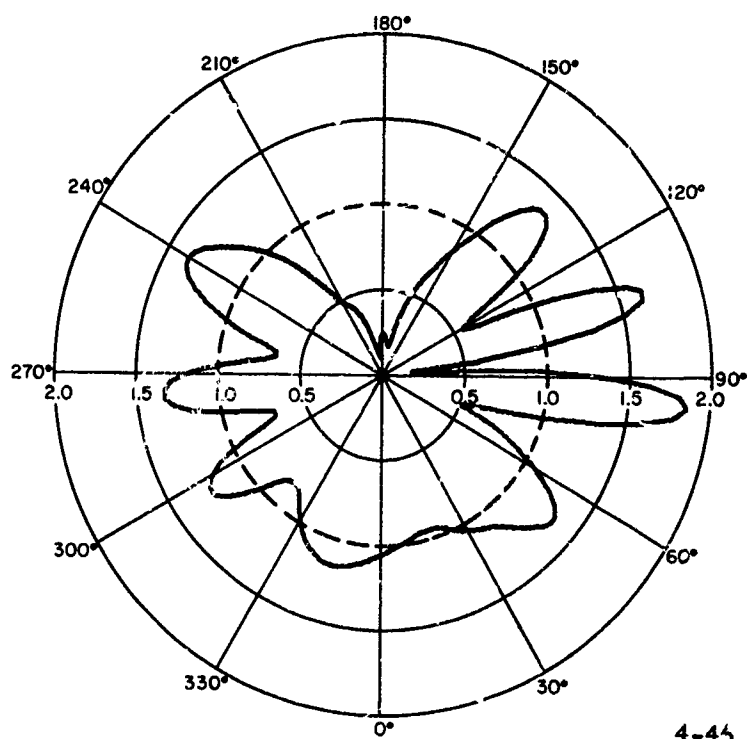
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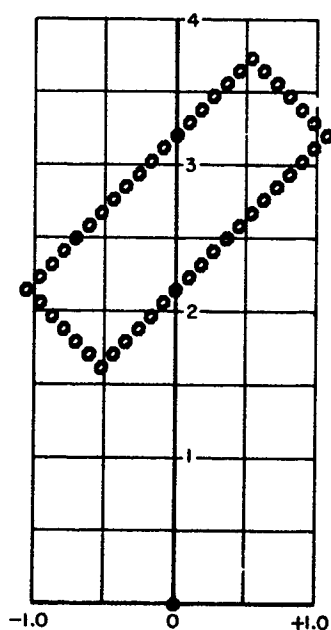
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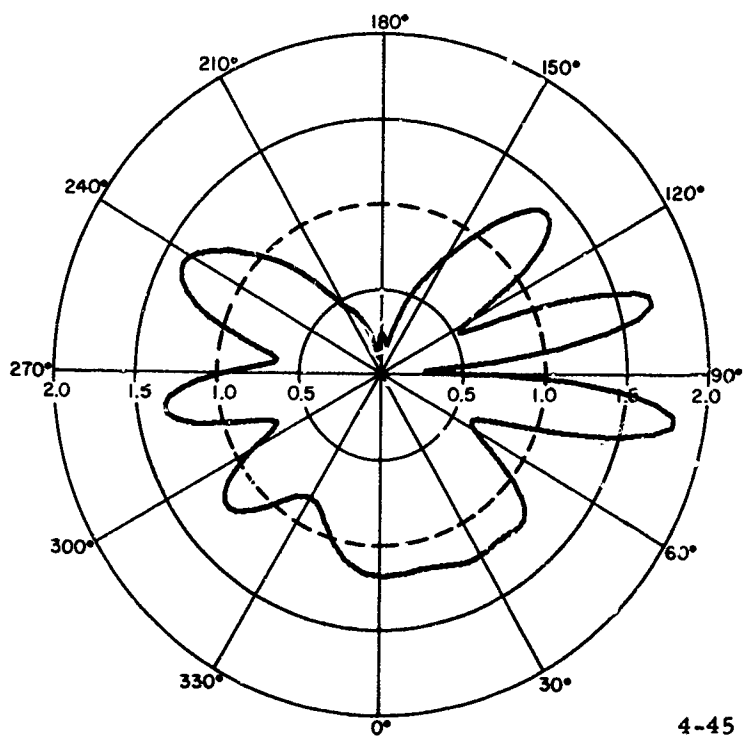
DISTANCE ~ WAVELENGTHS



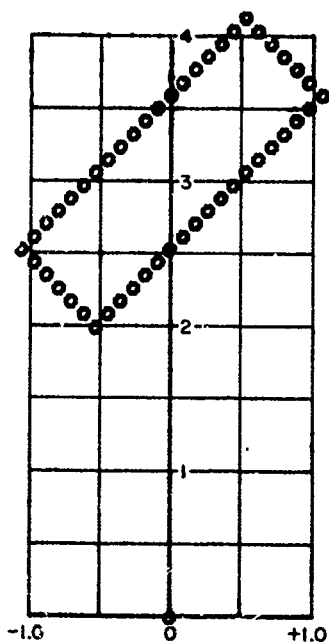
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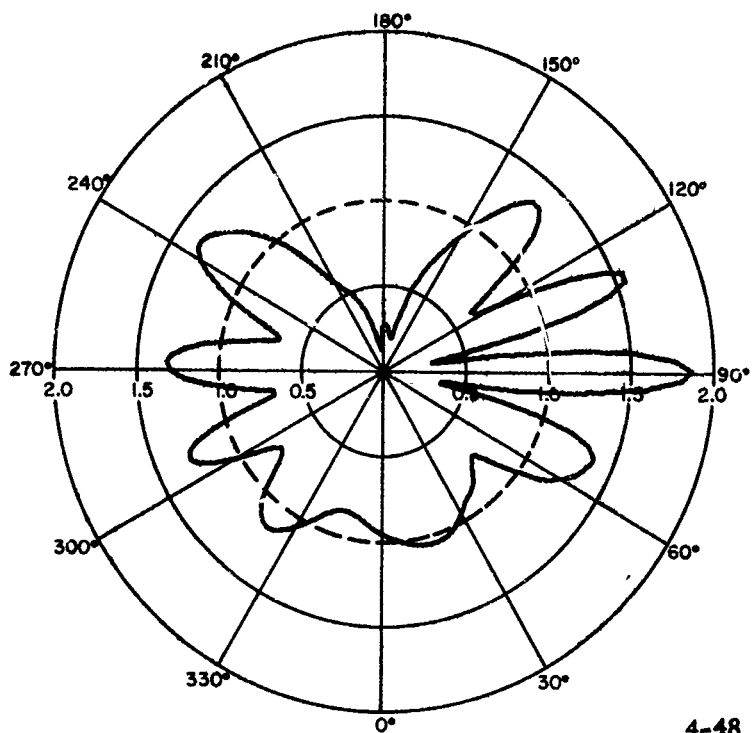
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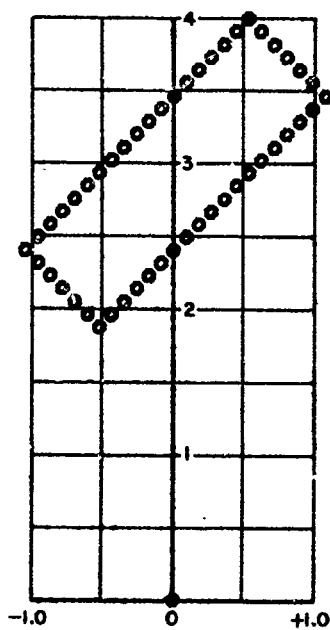
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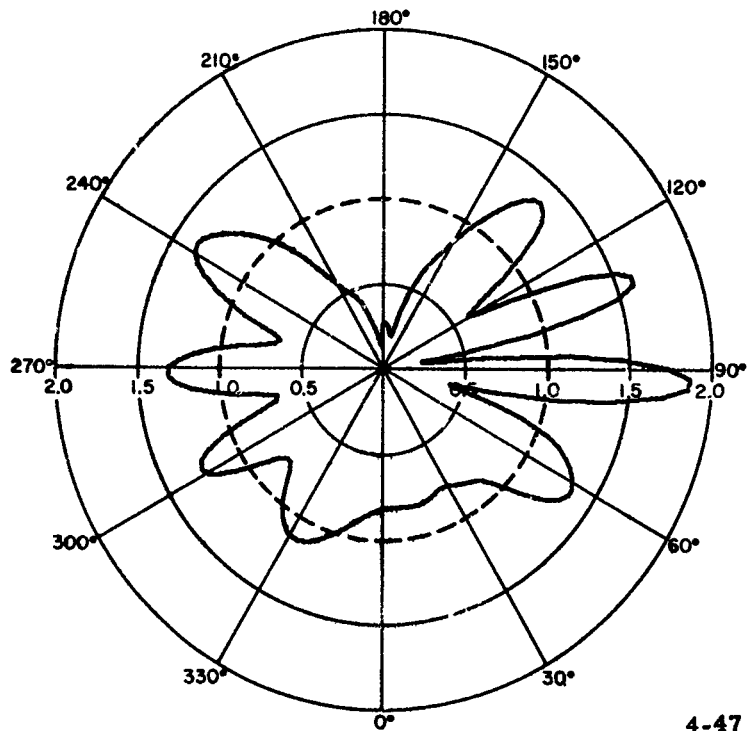
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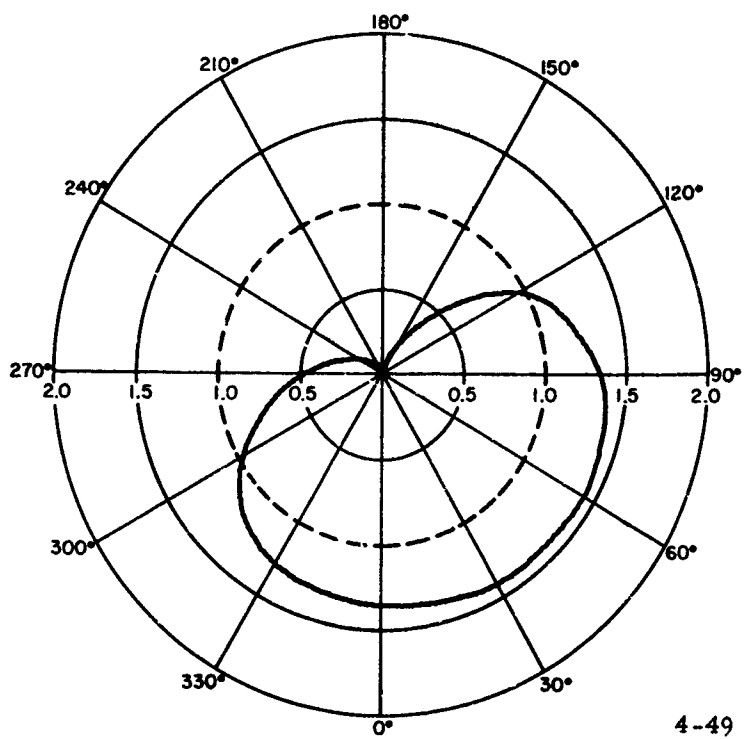
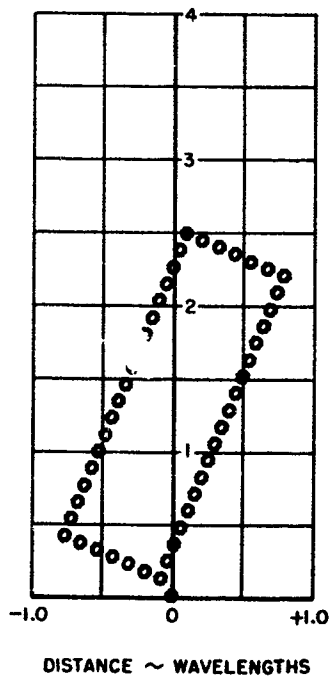
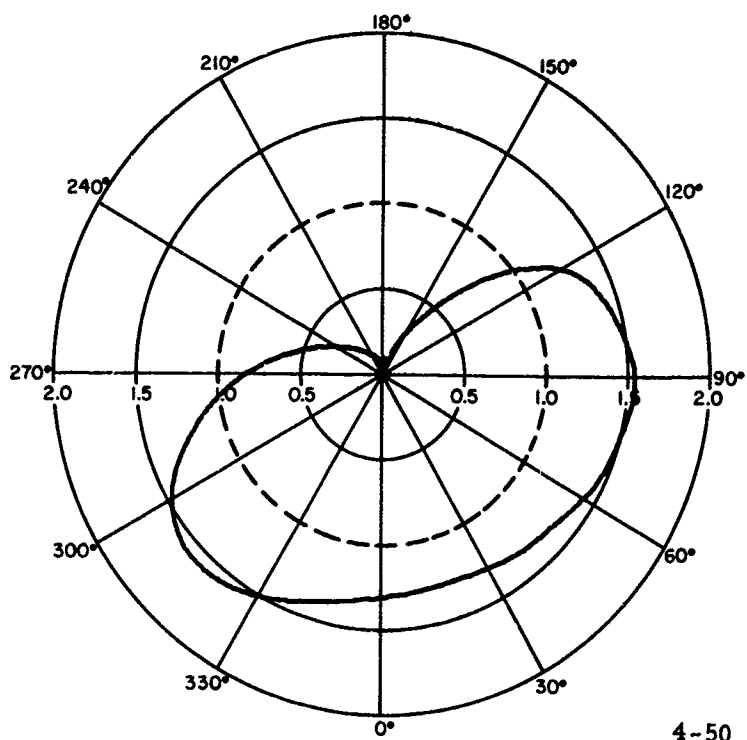
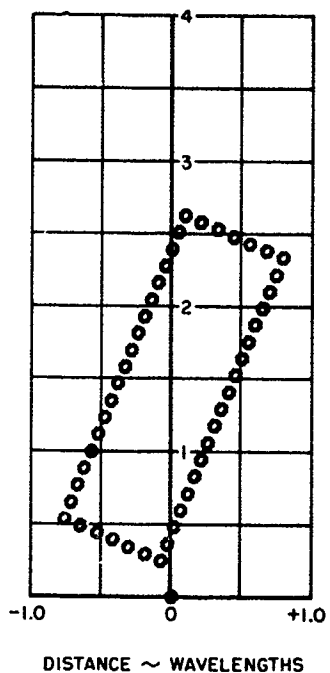
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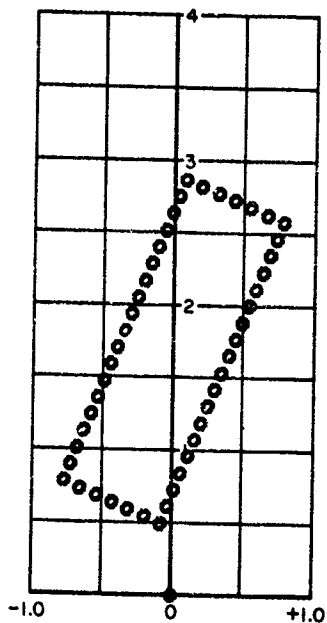


DISTANCE ~ WAVELENGTHS

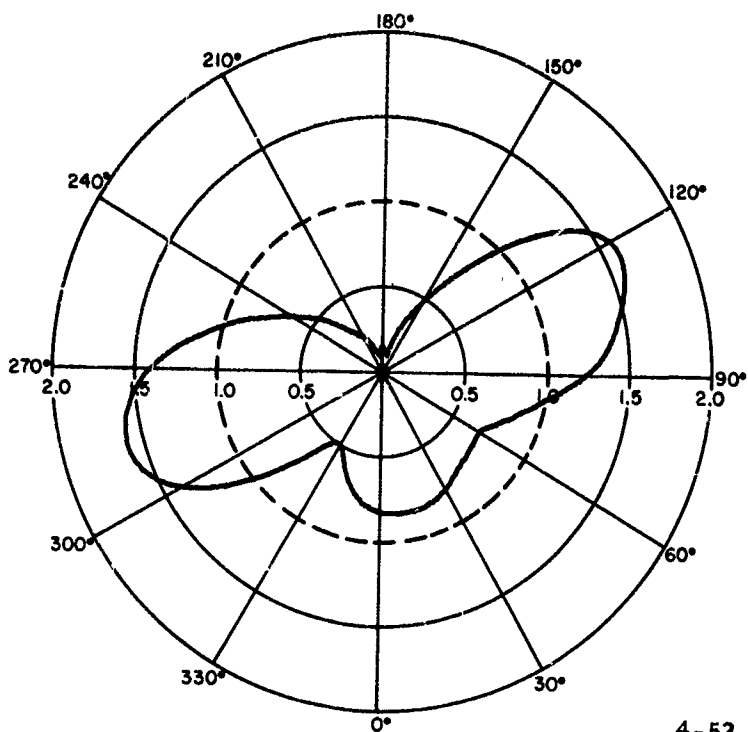


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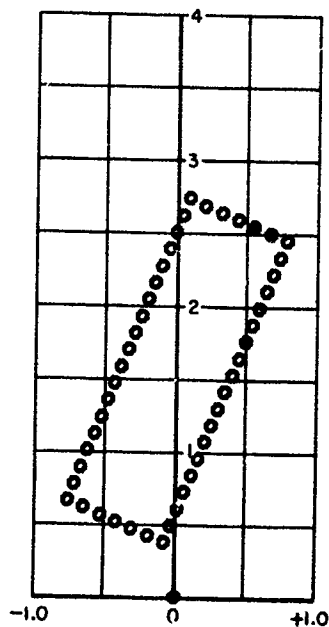




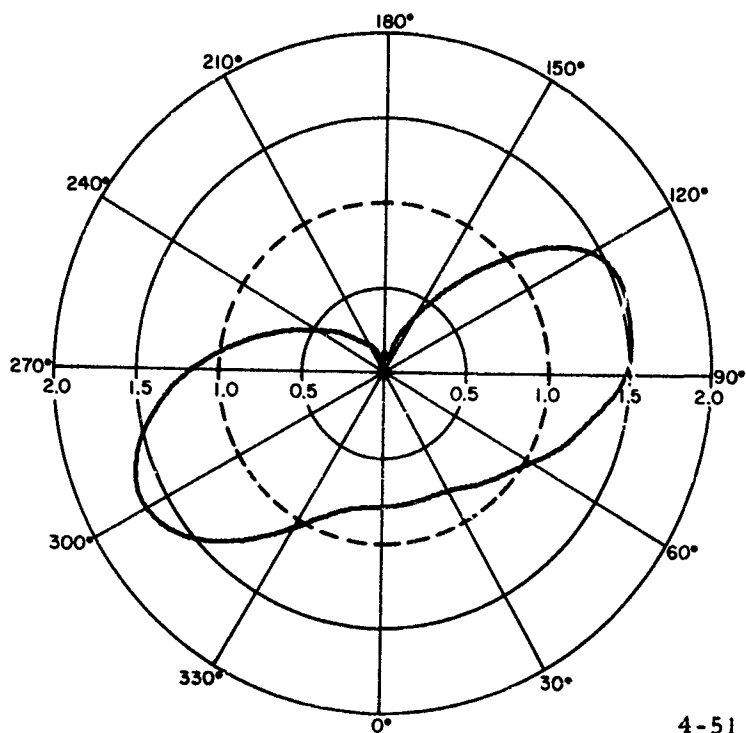
DISTANCE ~ WAVELENGTHS



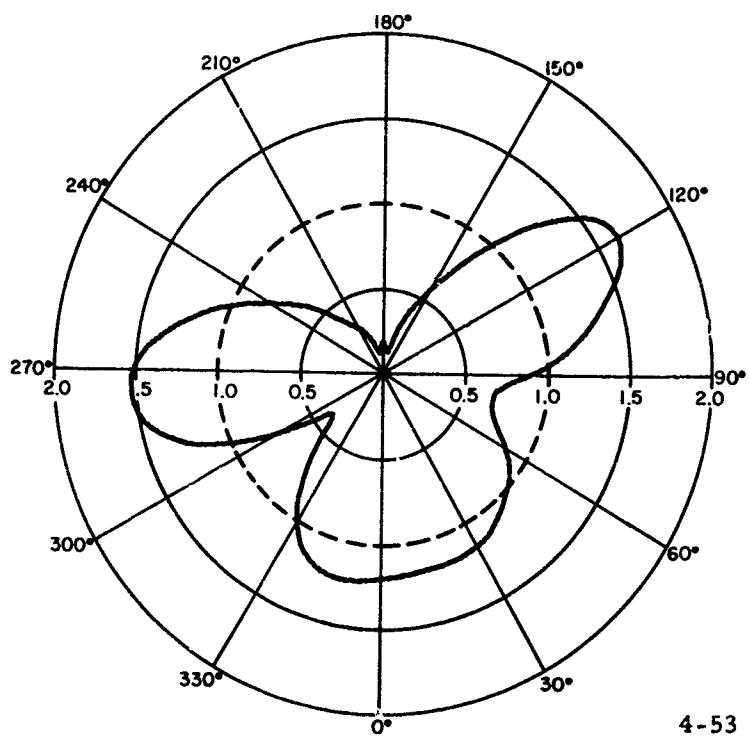
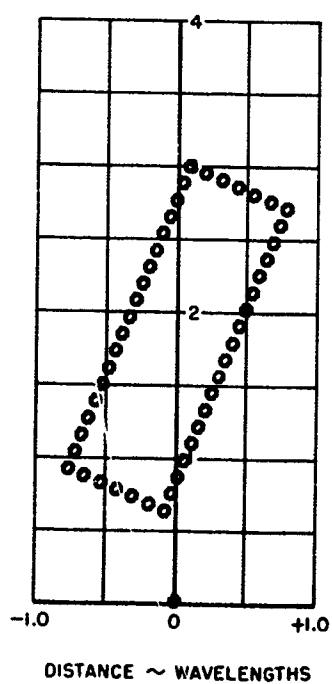
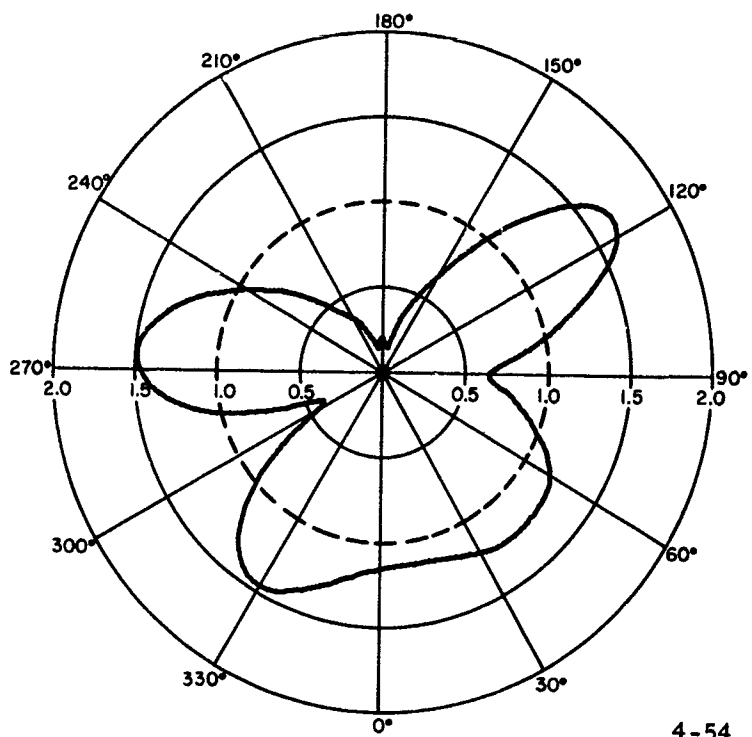
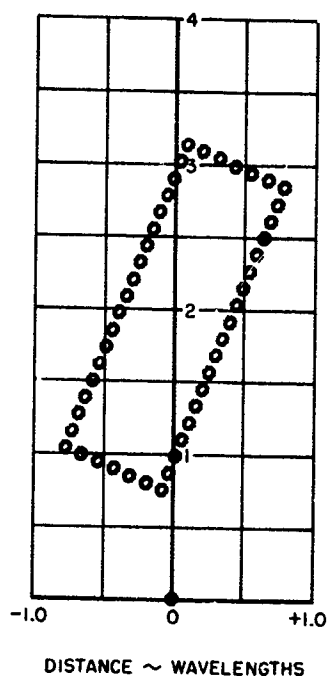
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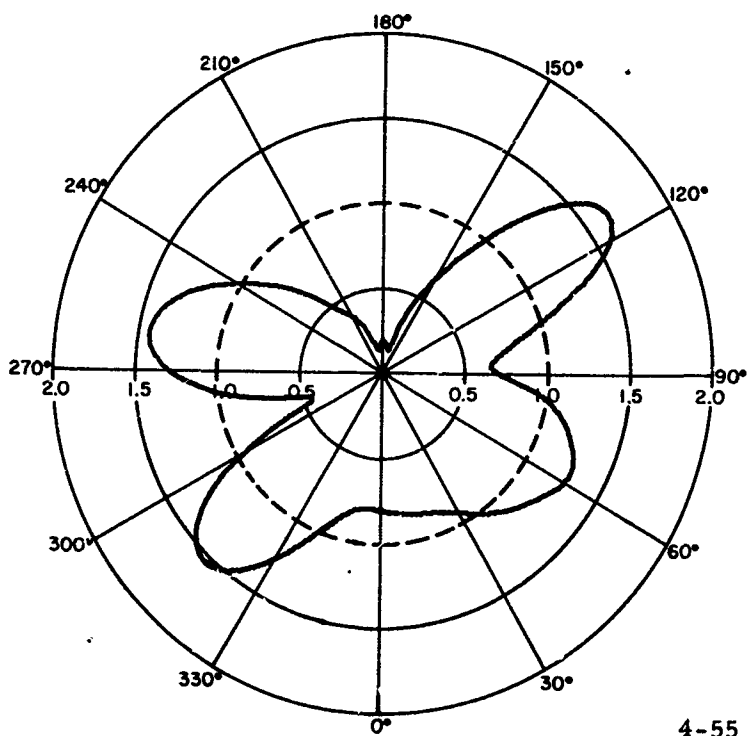
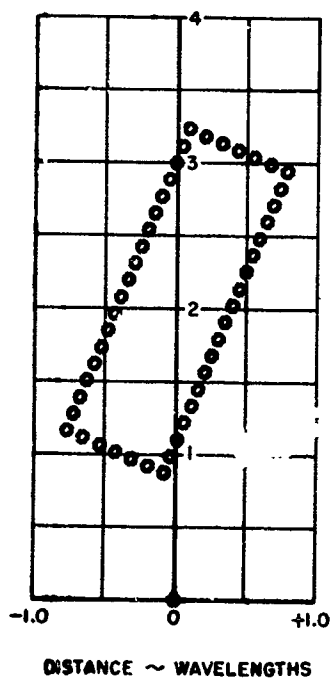
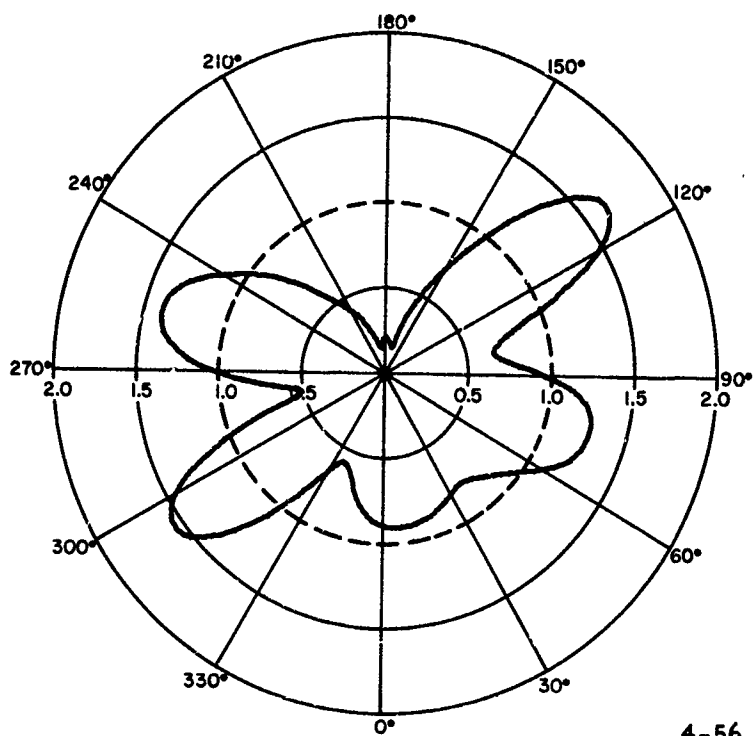
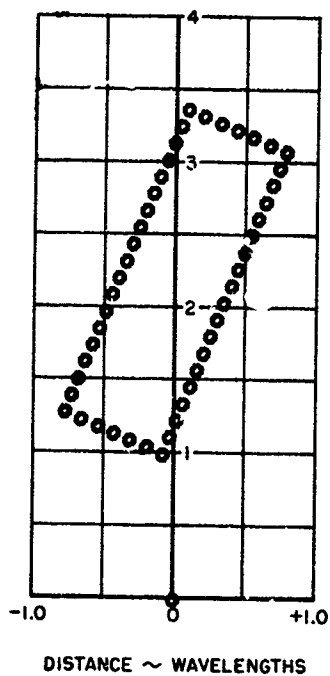


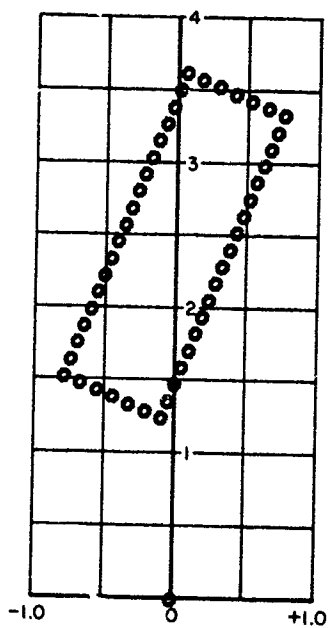
DISTANCE ~ WAVELENGTHS



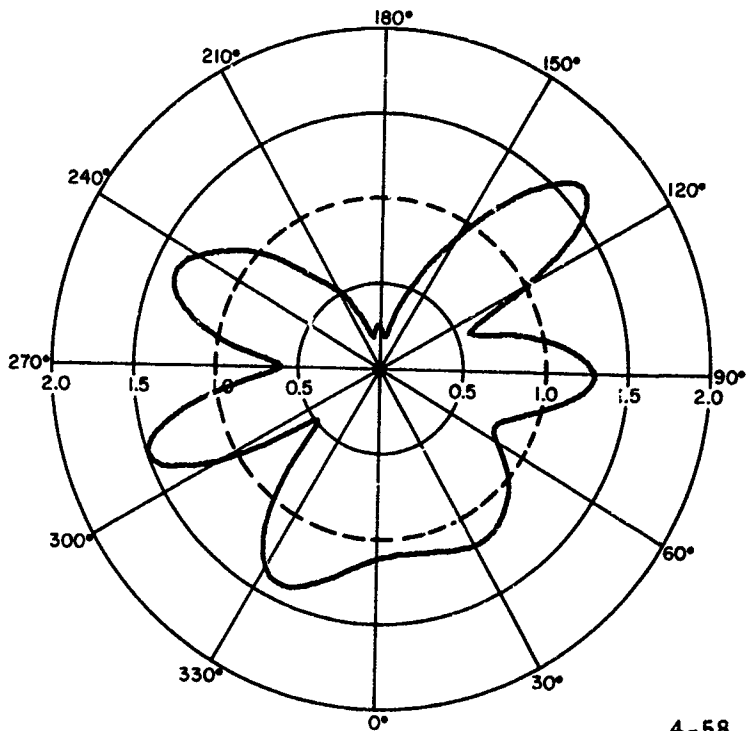
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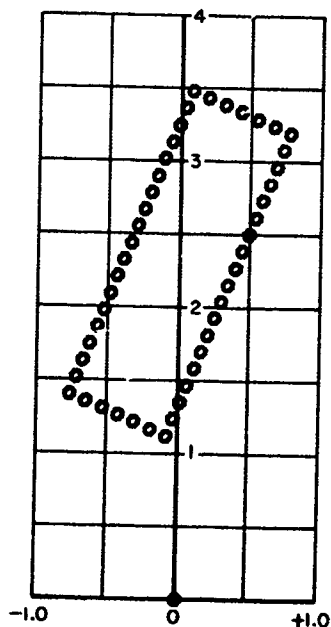




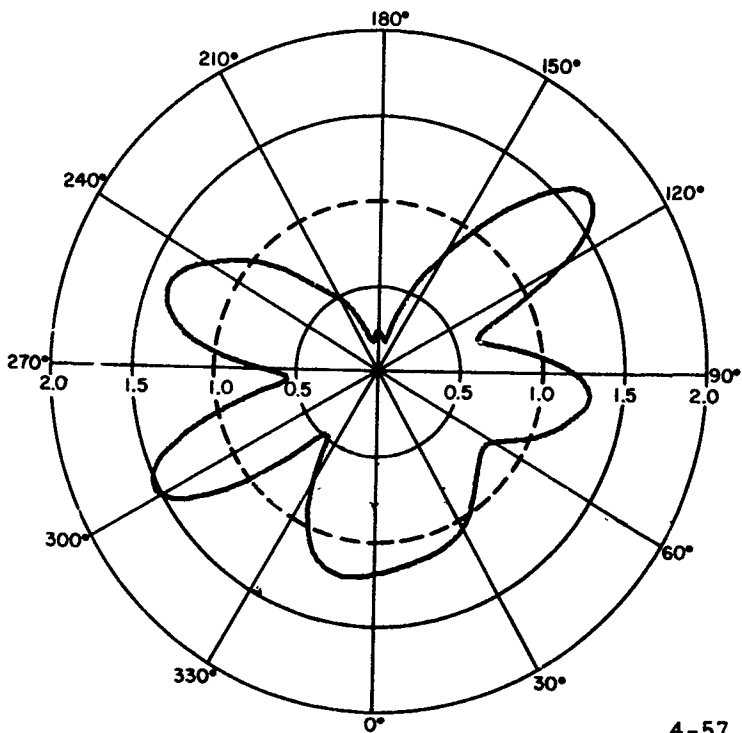
DISTANCE ~ WAVELENGTHS



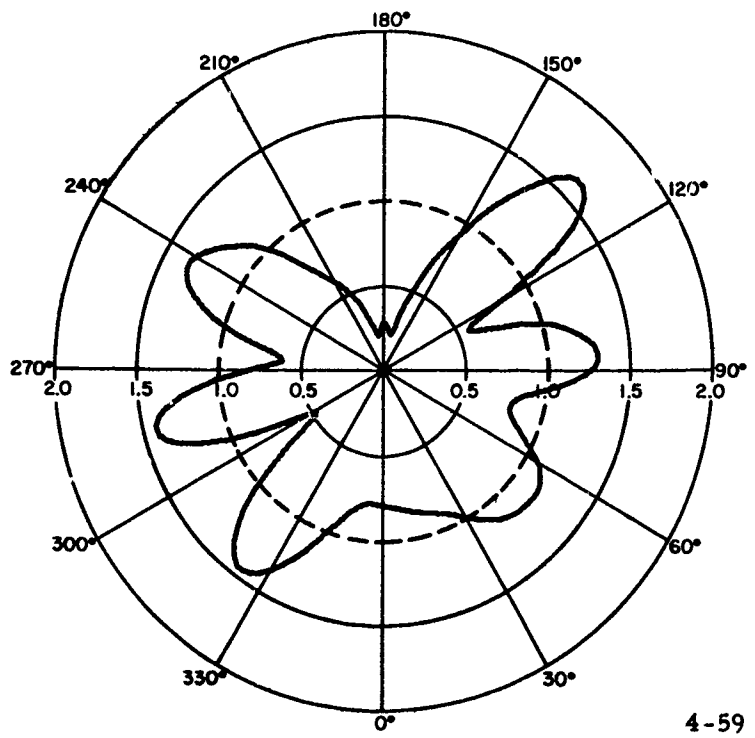
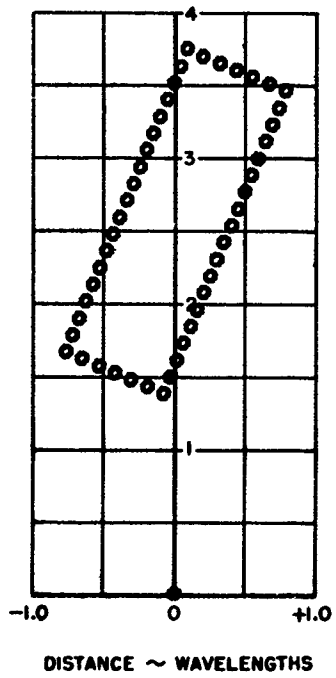
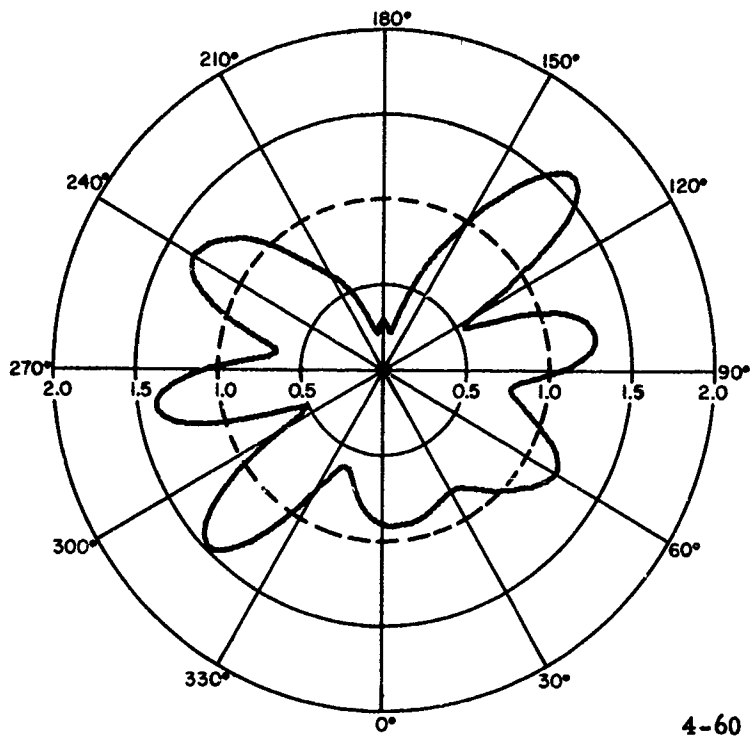
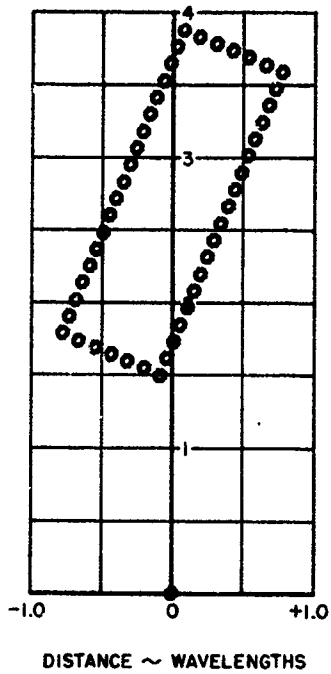
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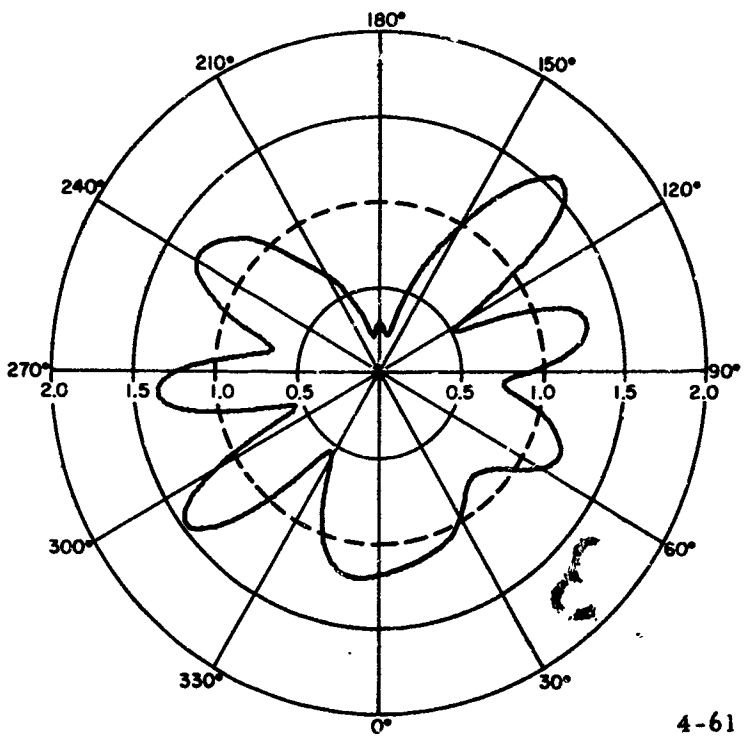
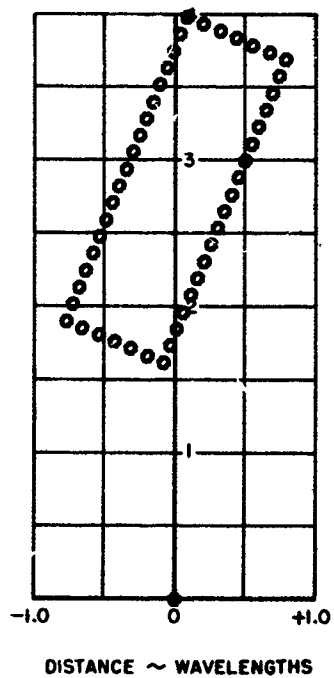
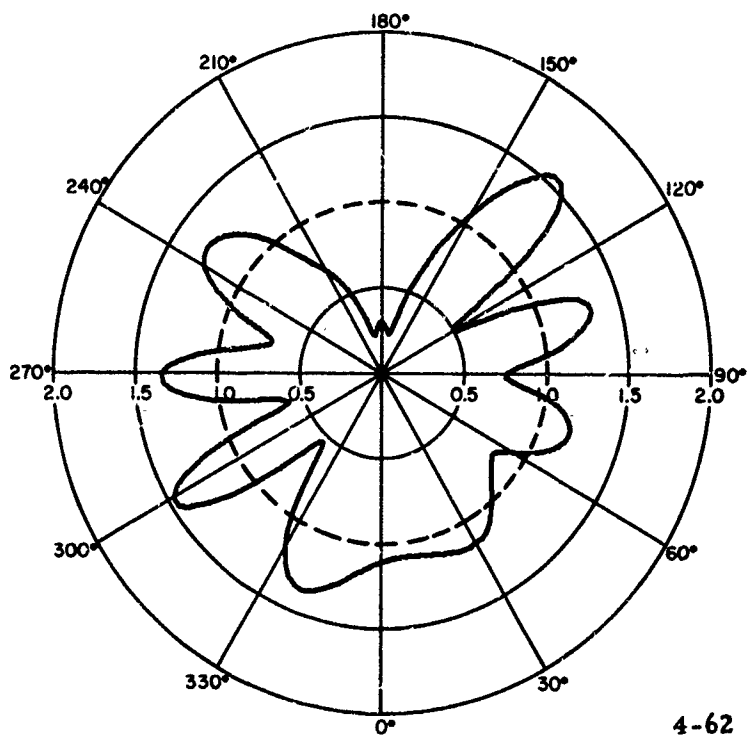
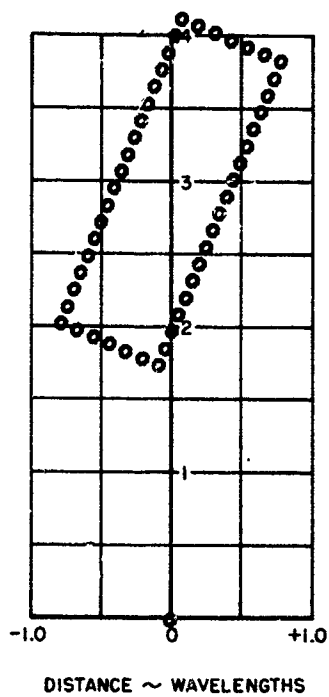


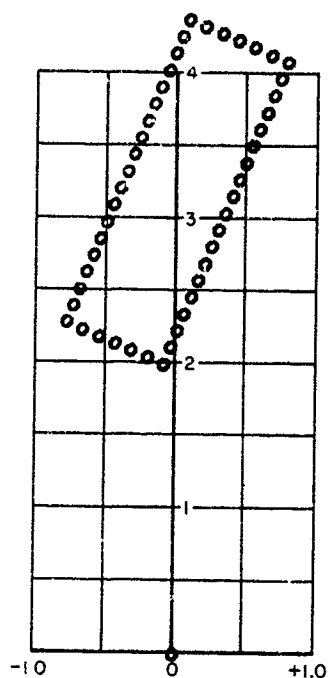
DISTANCE ~ WAVELENGTHS



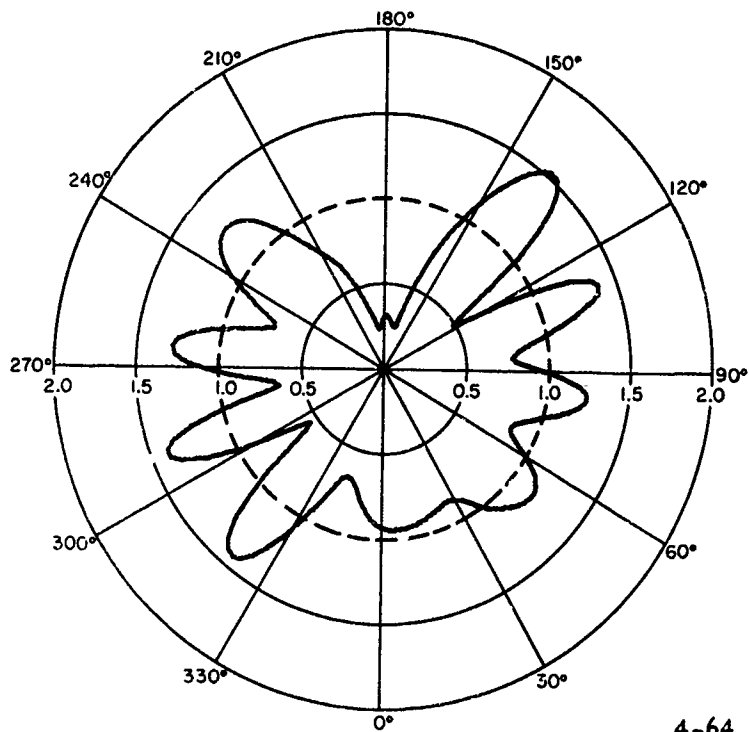
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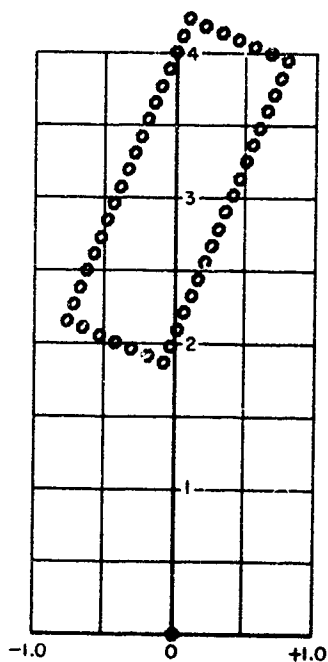




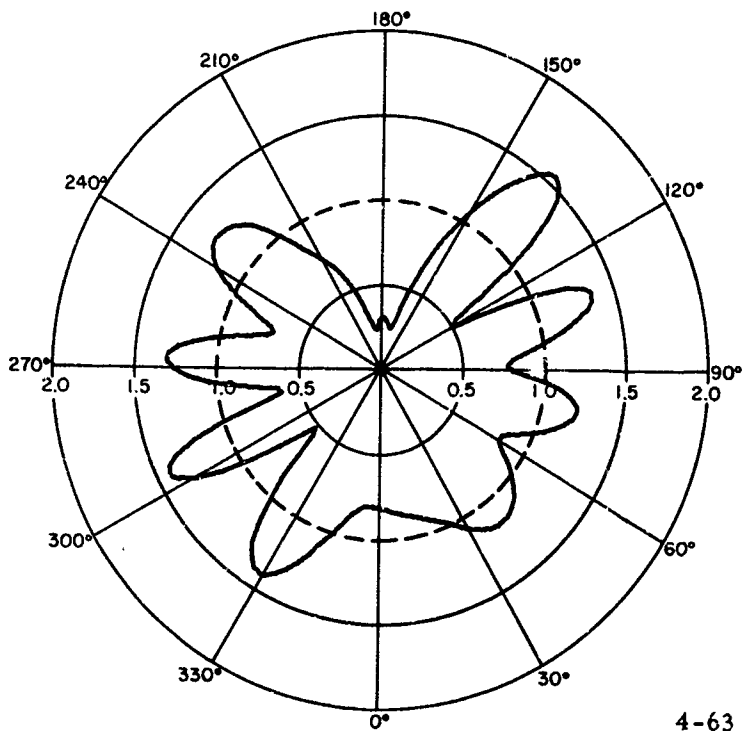
DISTANCE ~ WAVELENGTHS



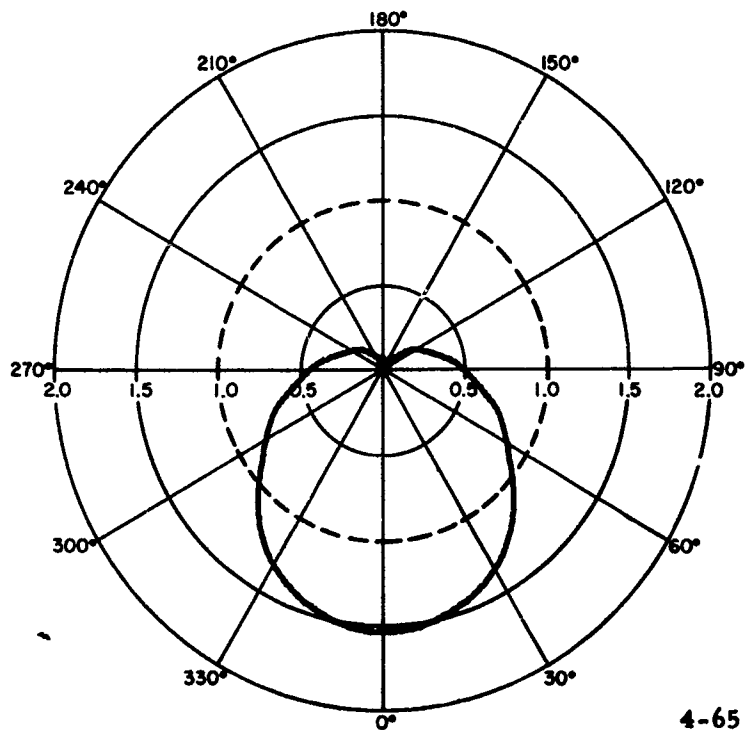
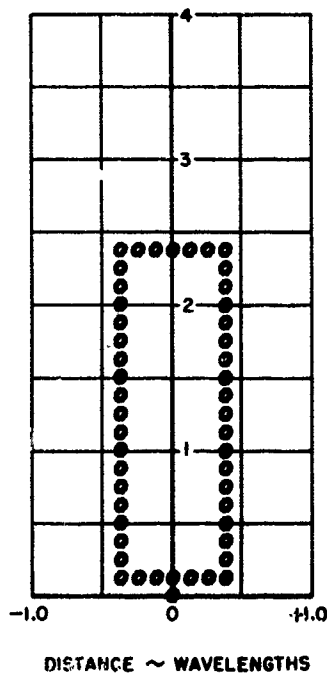
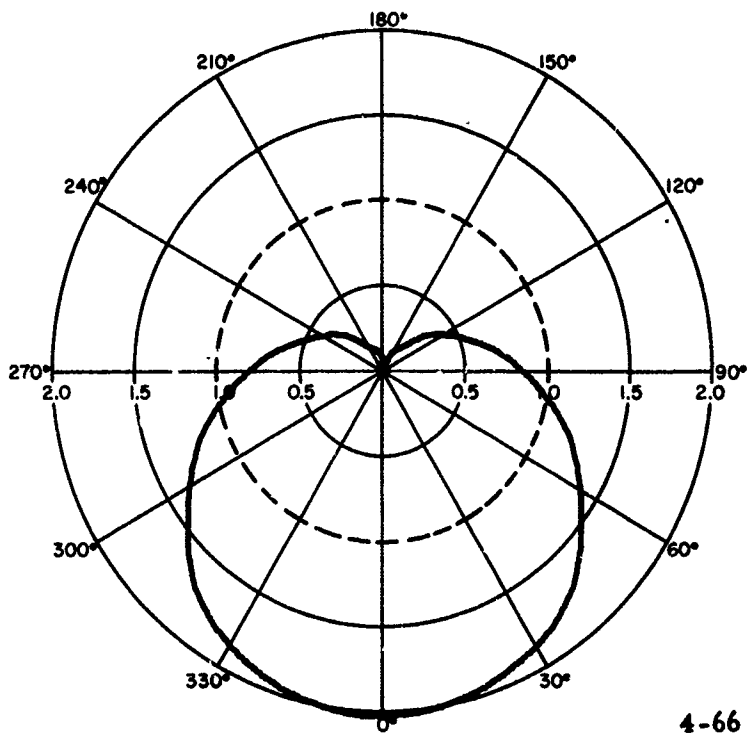
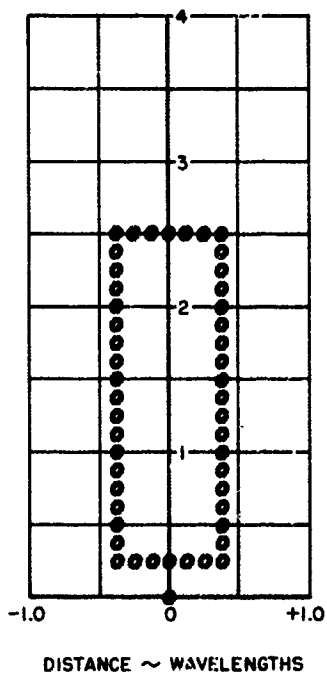
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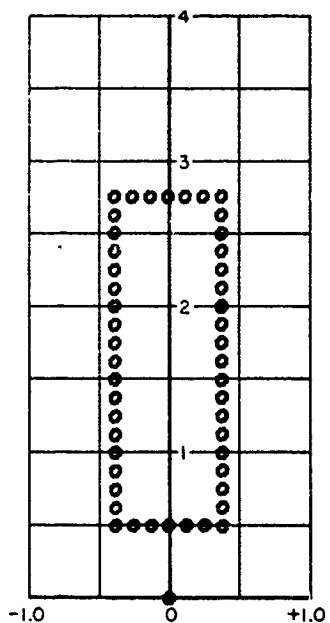


DISTANCE ~ WAVELENGTHS

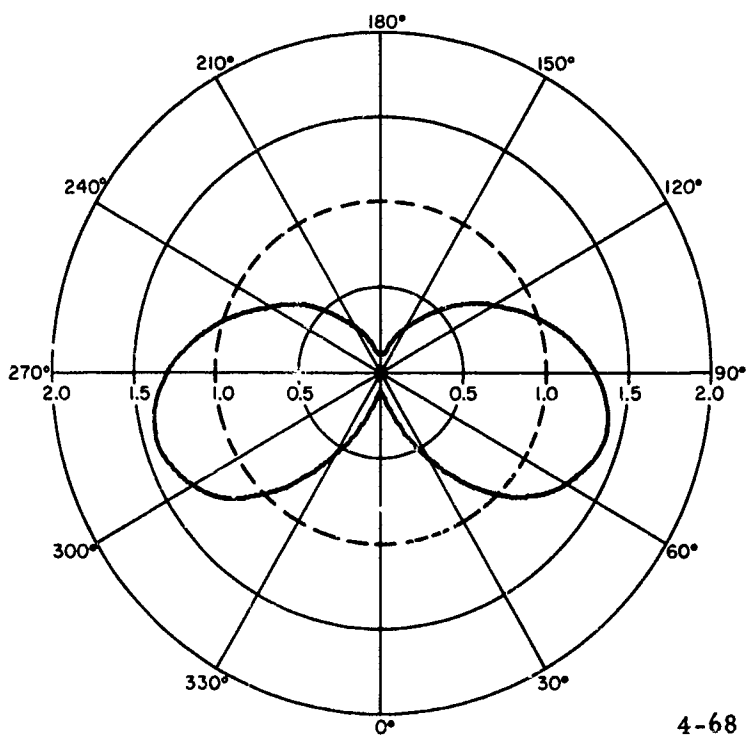


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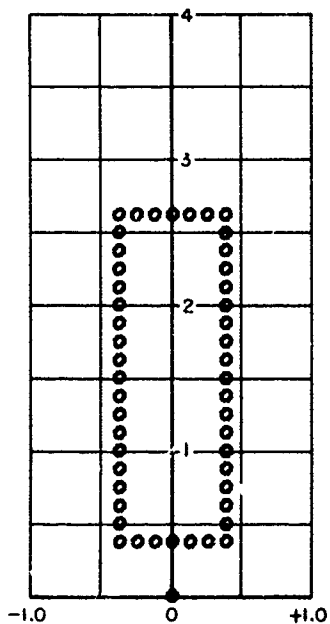




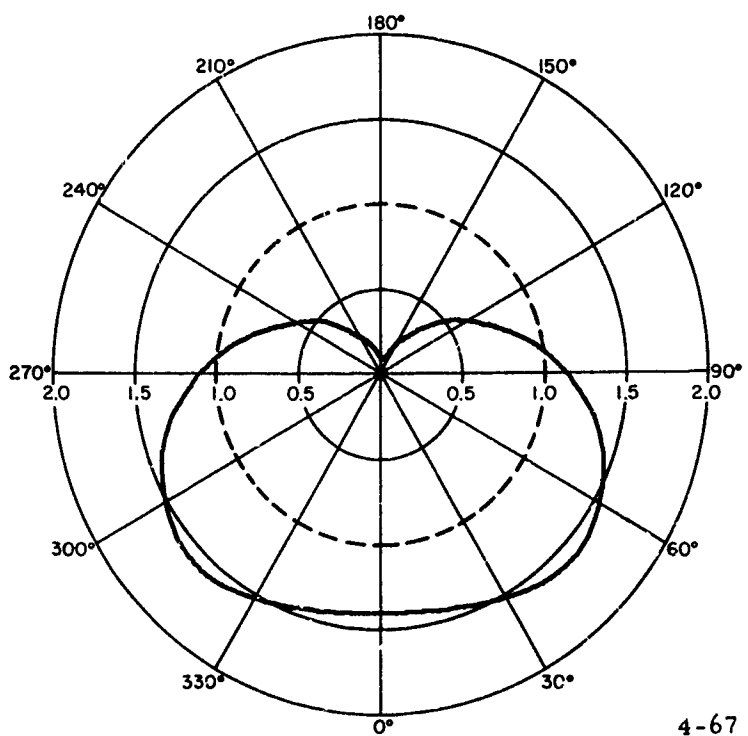
DISTANCE ~ WAVELENGTHS



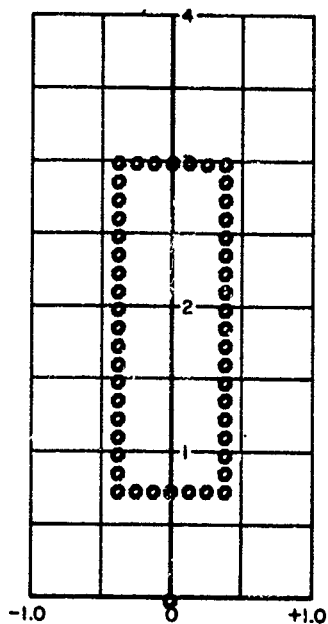
4-68



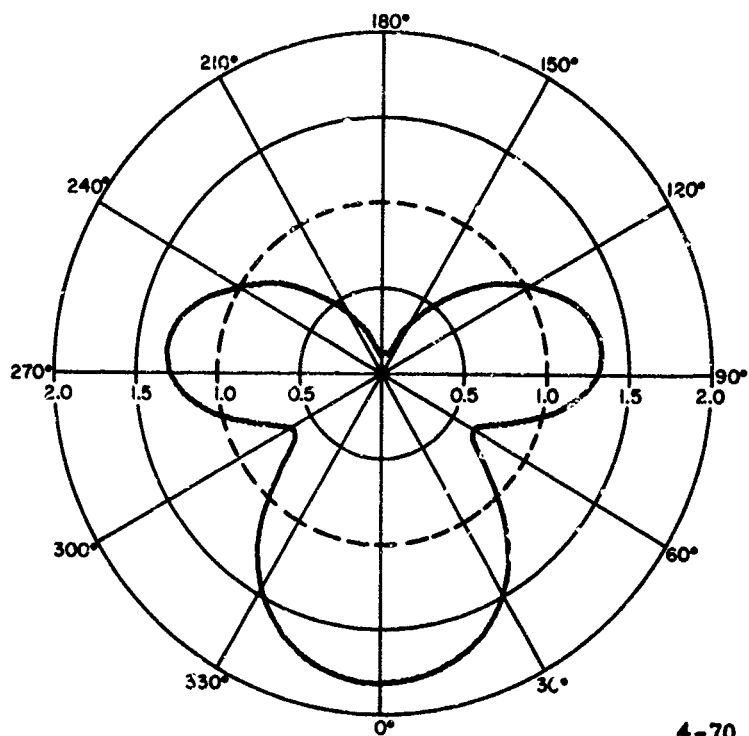
DISTANCE ~ WAVELENGTHS



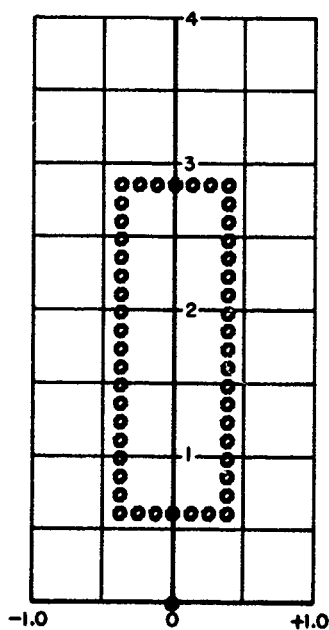
4-67



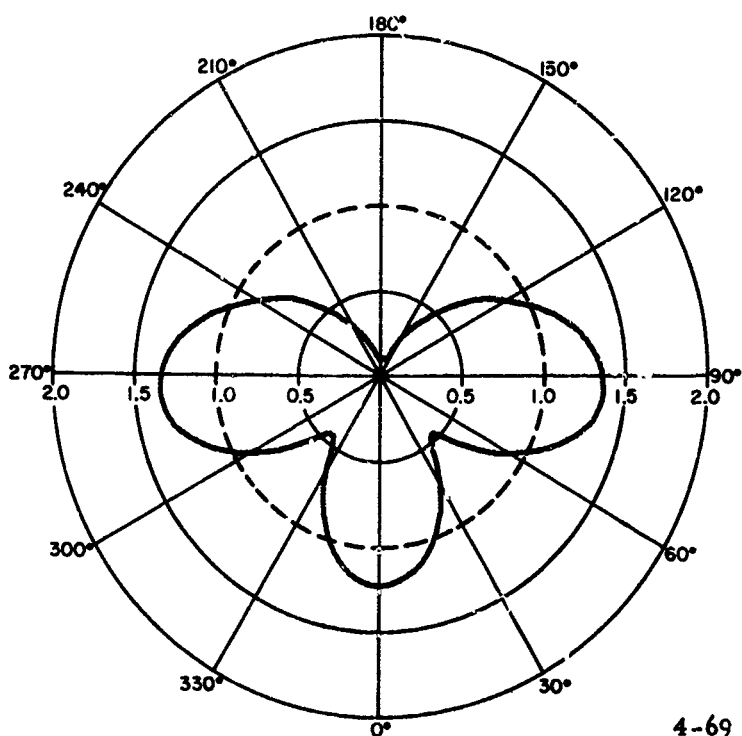
DISTANCE ~ WAVELENGTHS



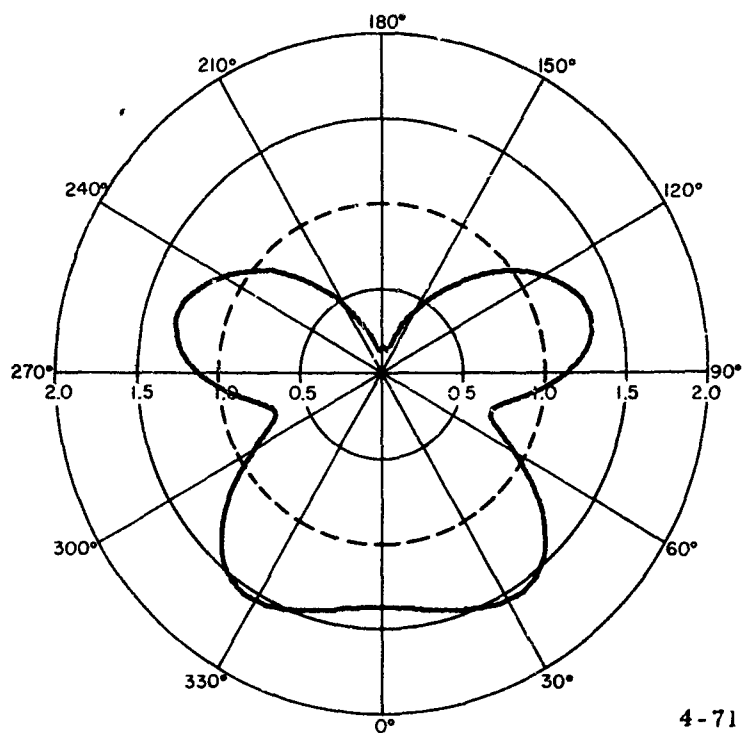
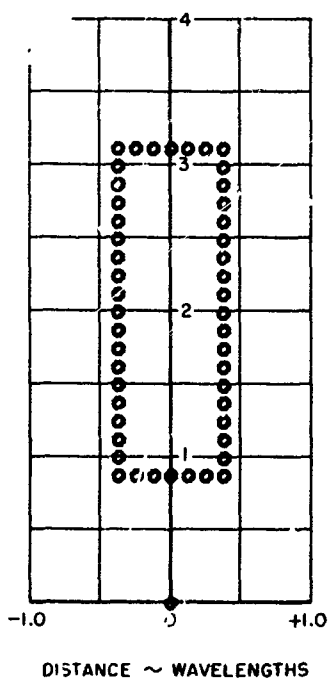
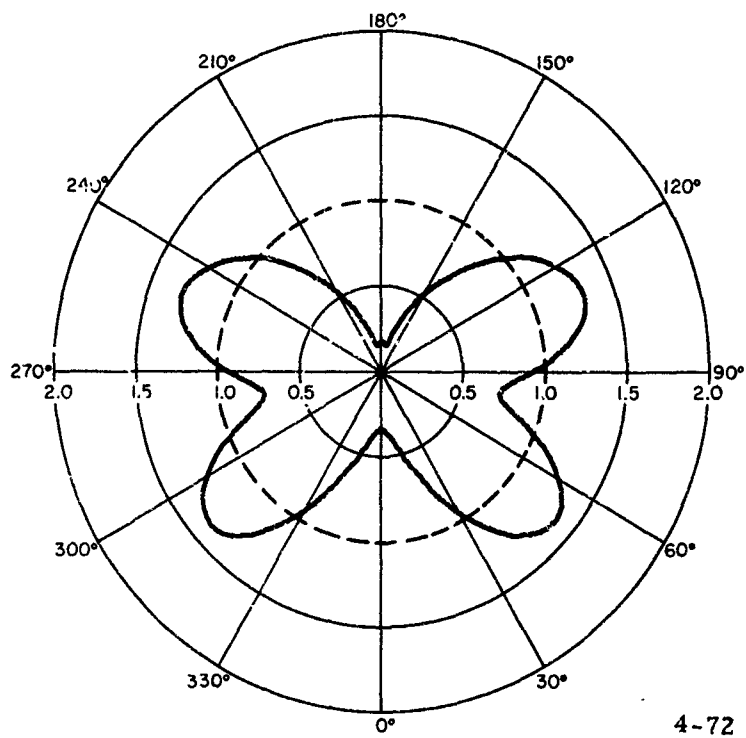
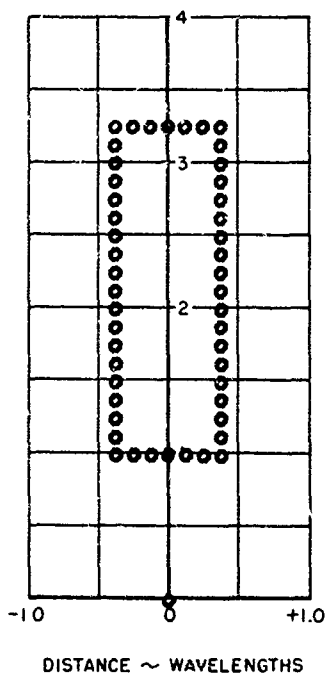
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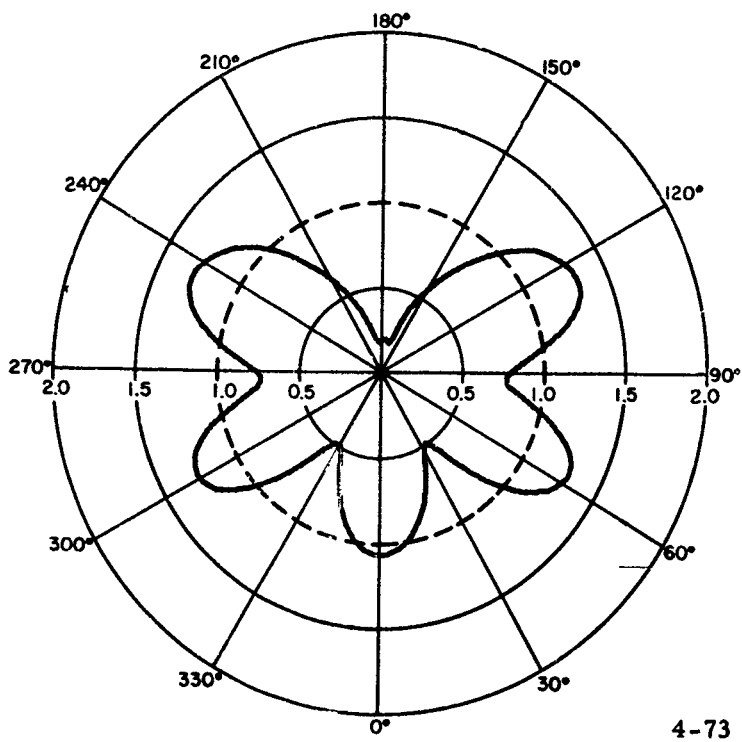
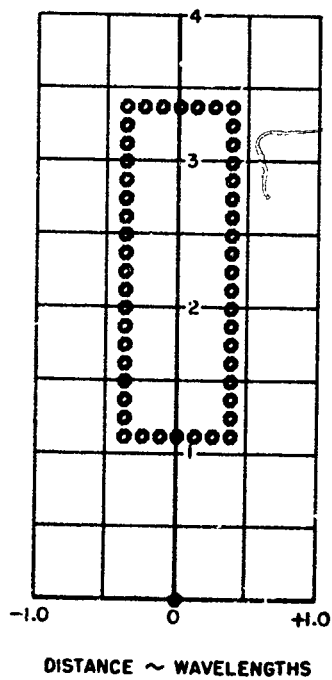
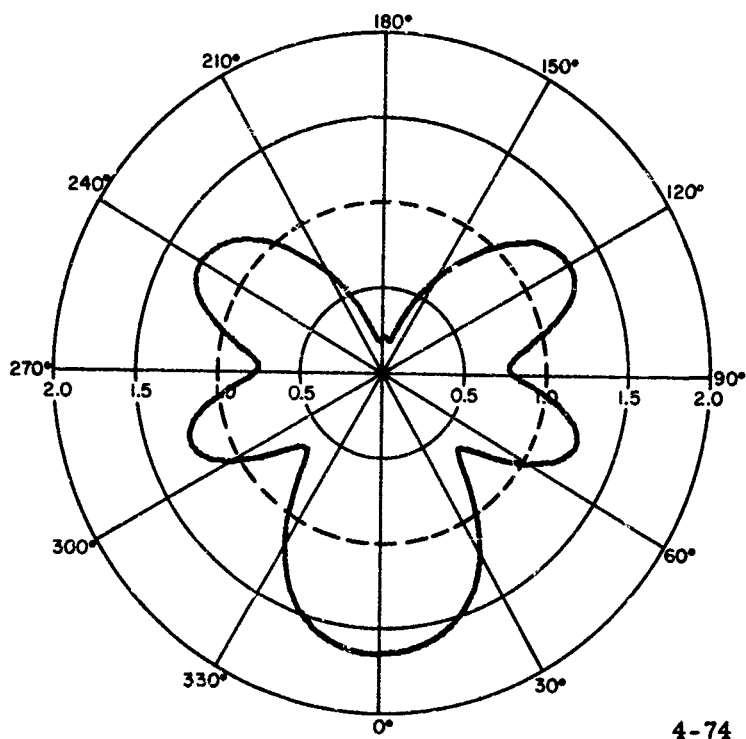
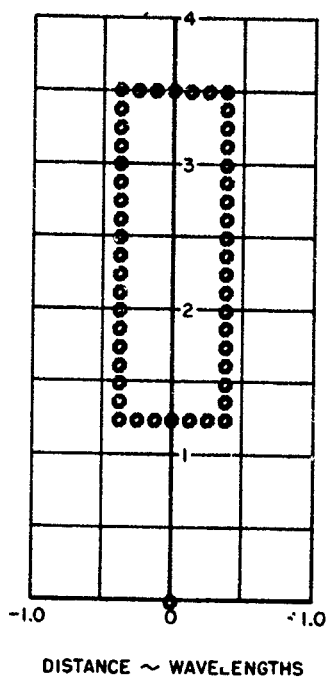


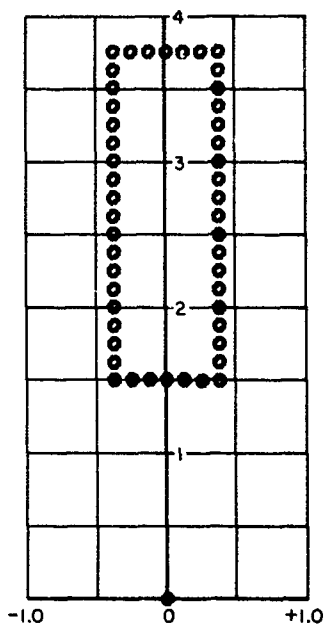
DISTANCE ~ WAVELENGTHS



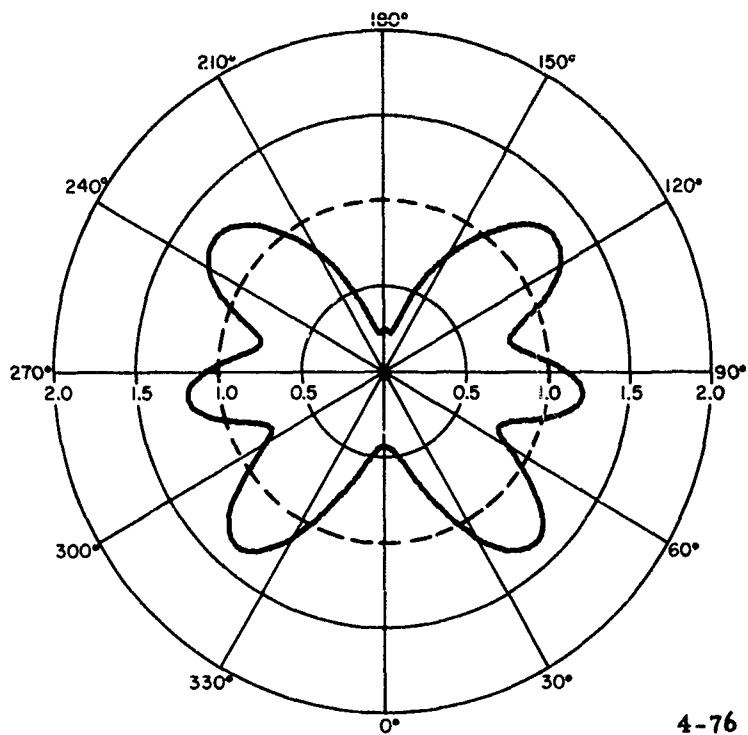
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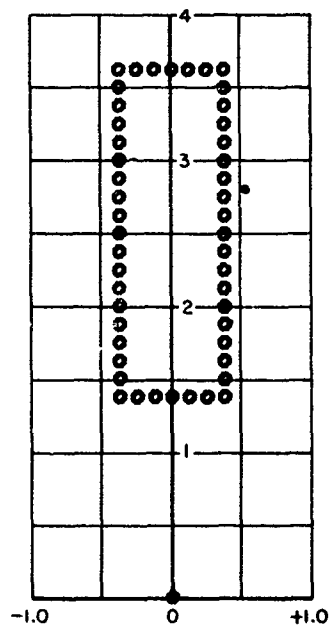




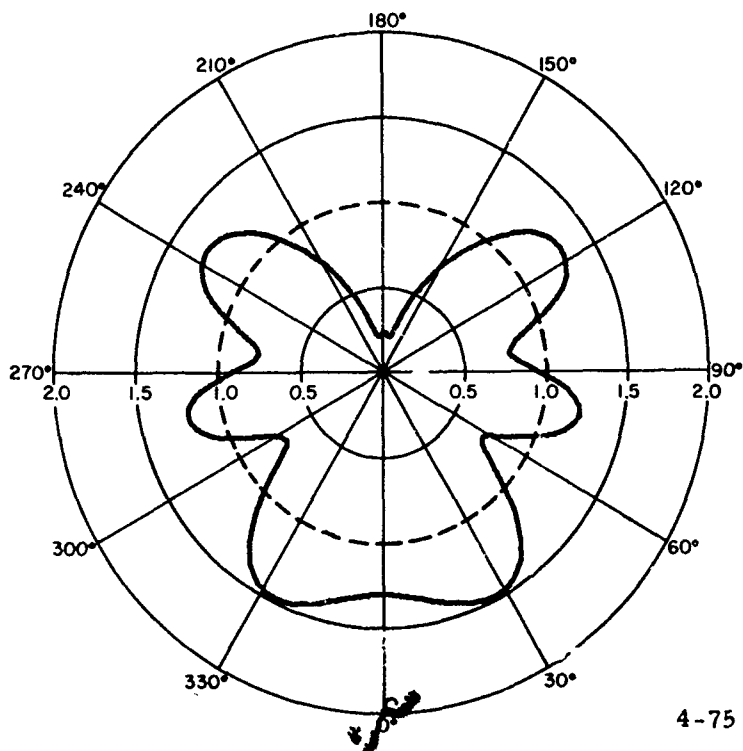
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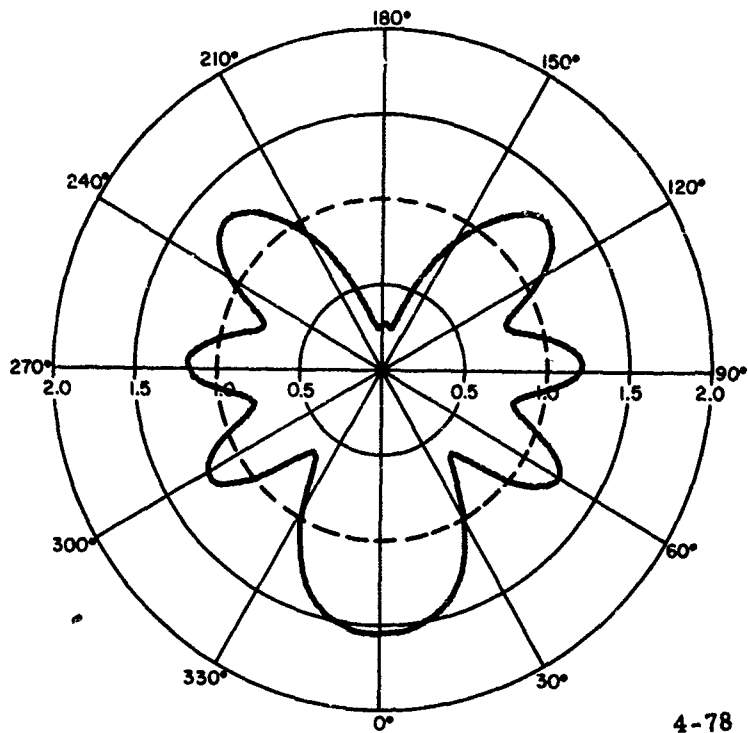
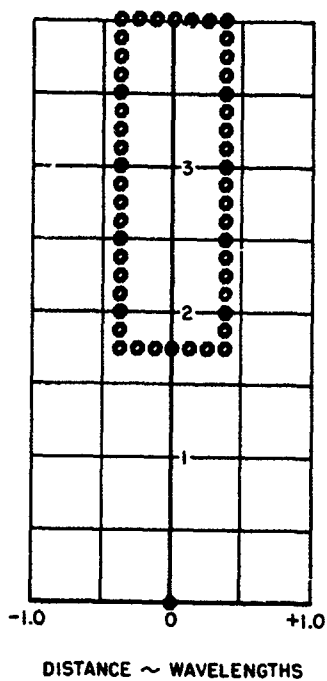
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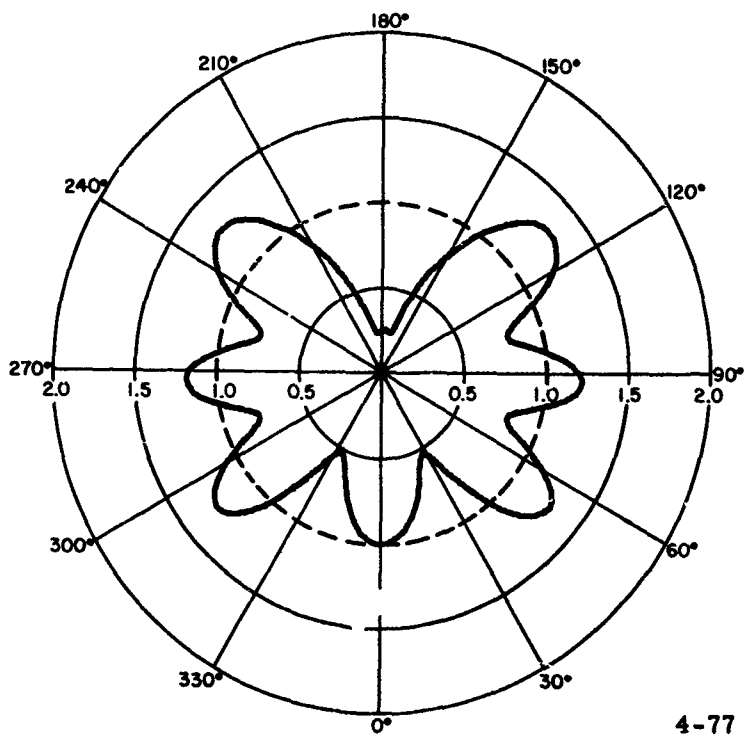
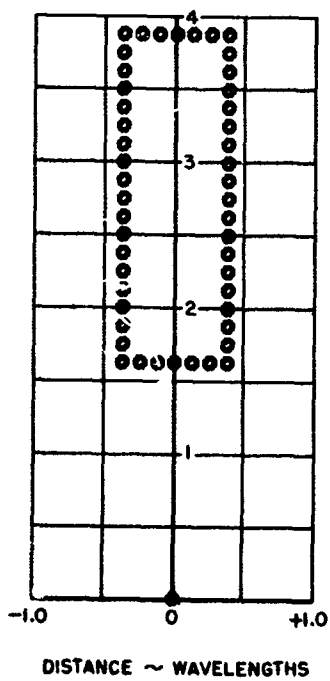
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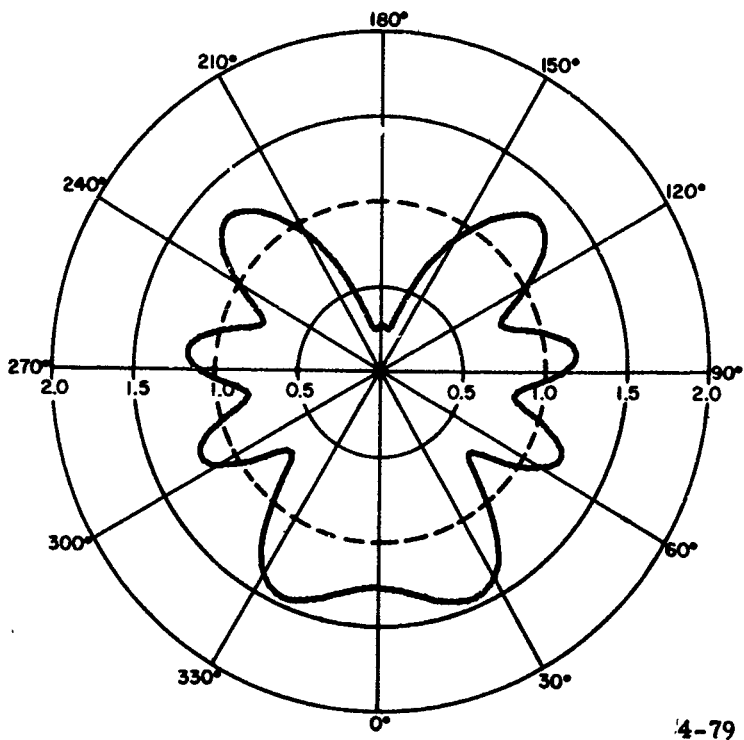
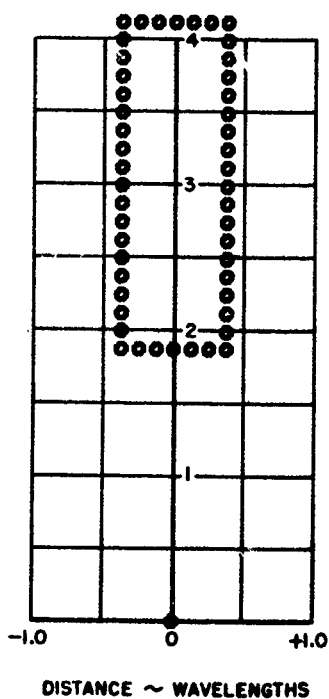
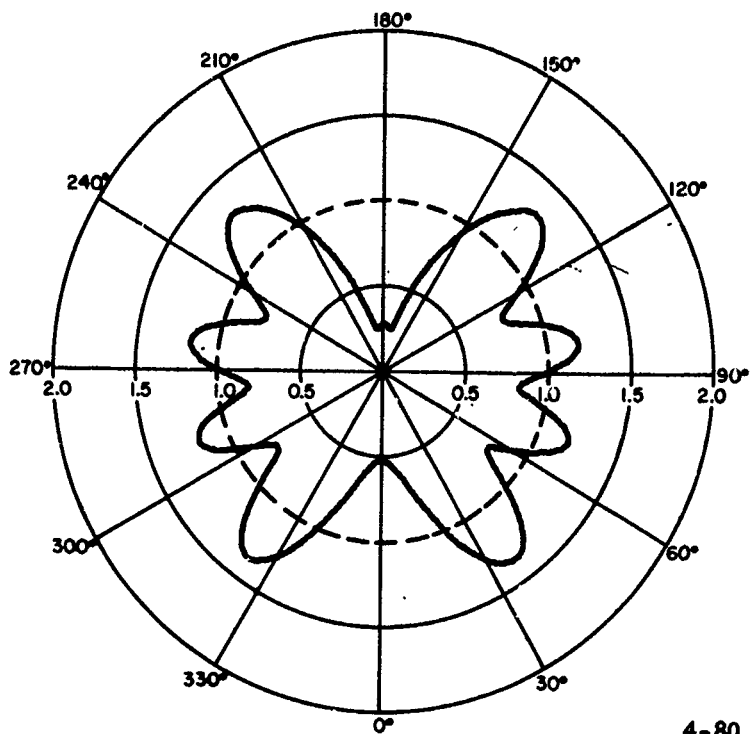
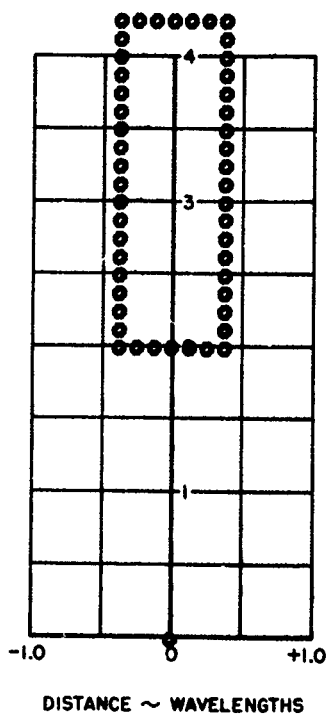
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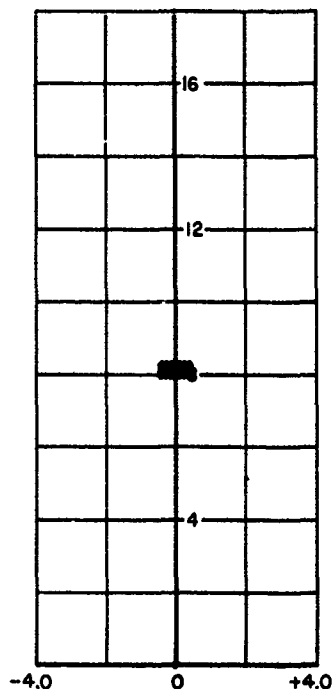


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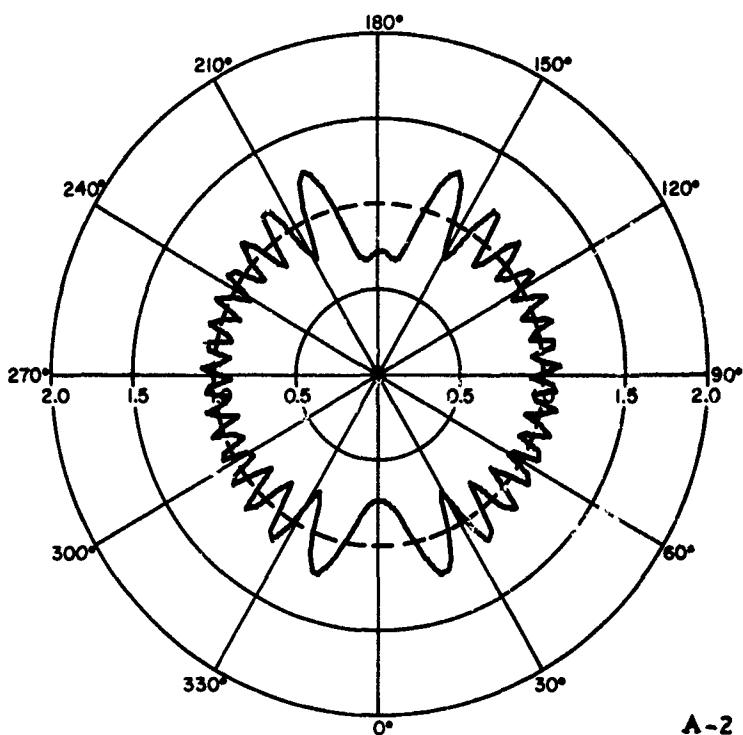


4-77

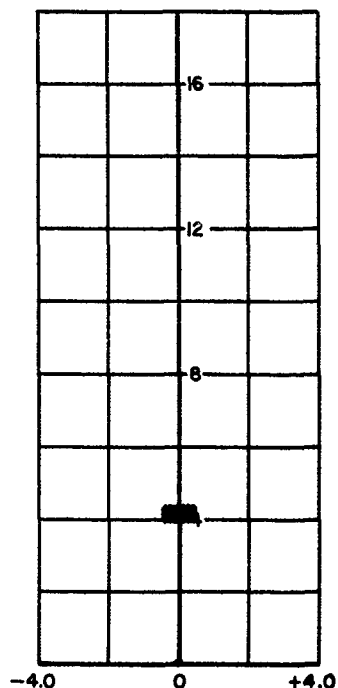




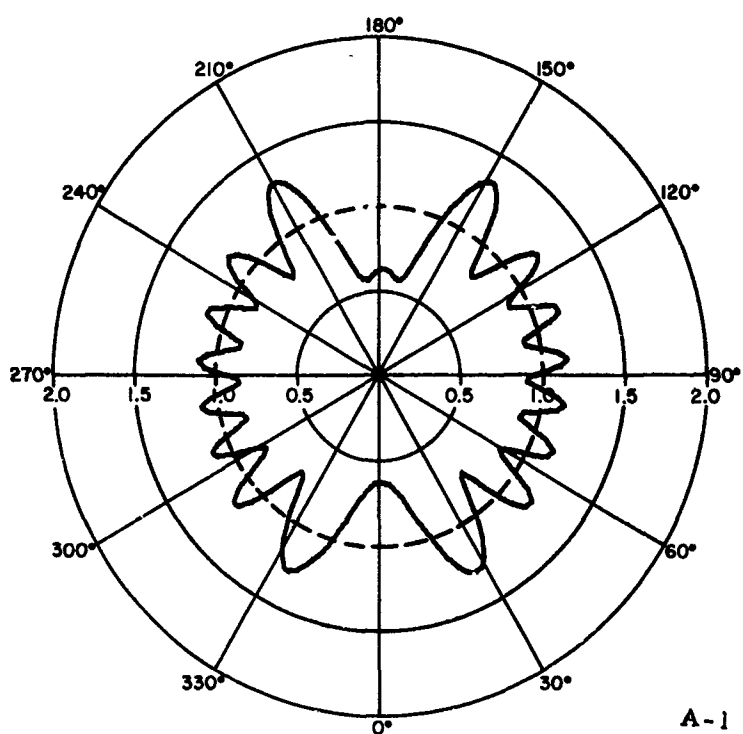
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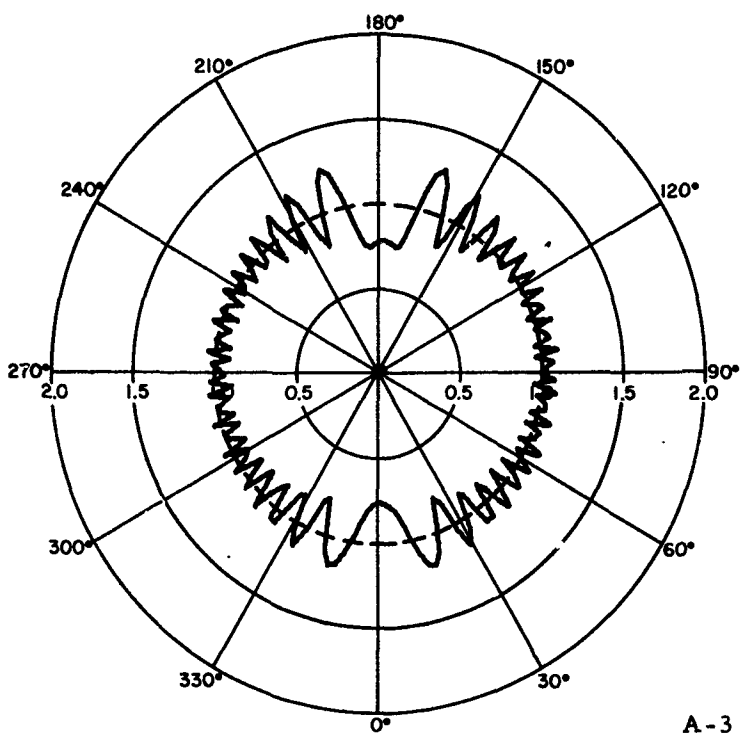
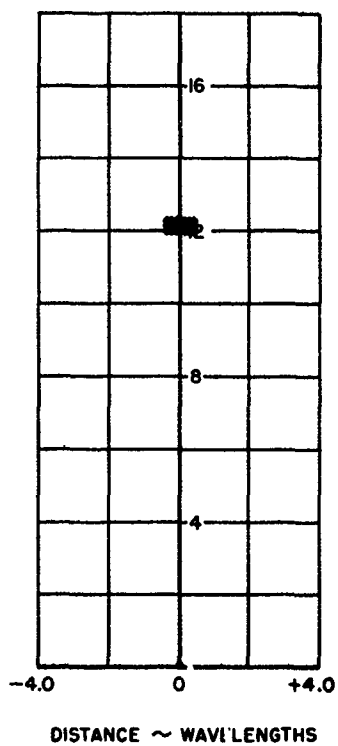
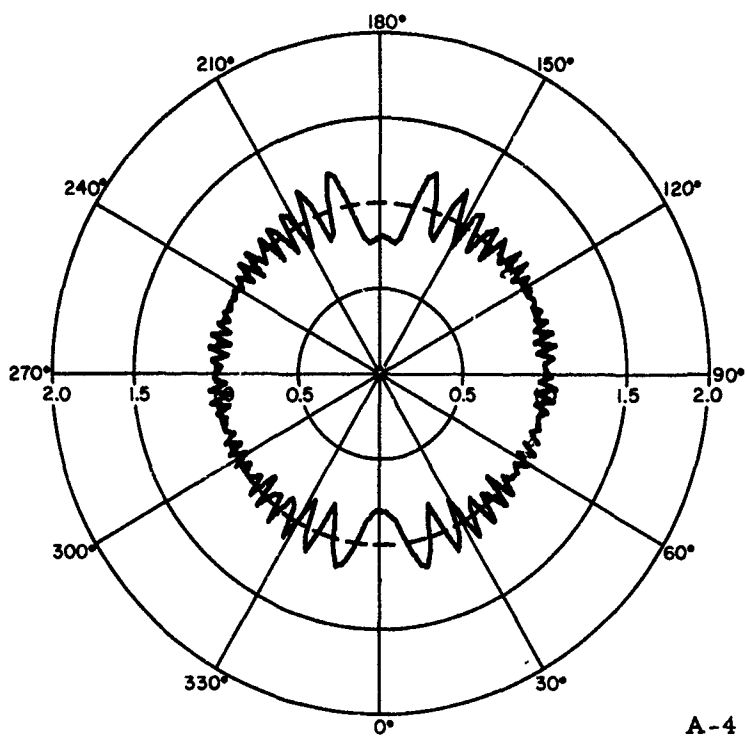
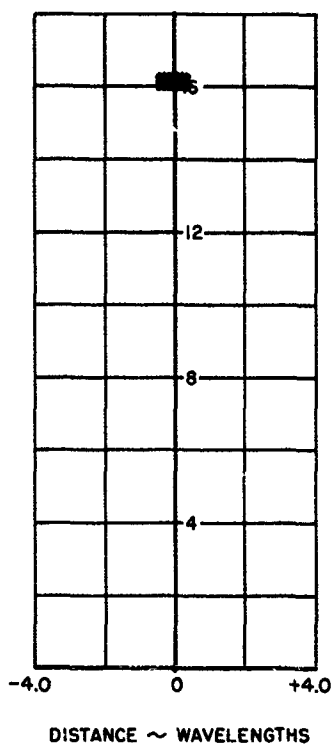
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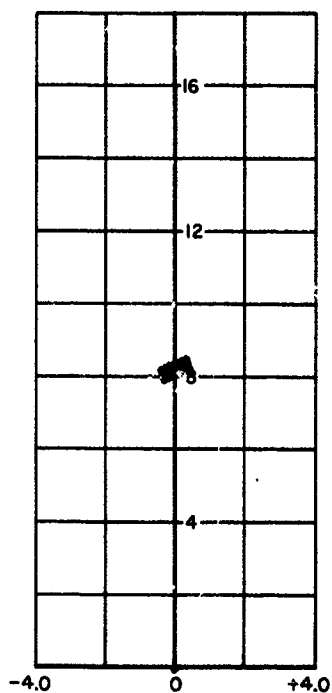


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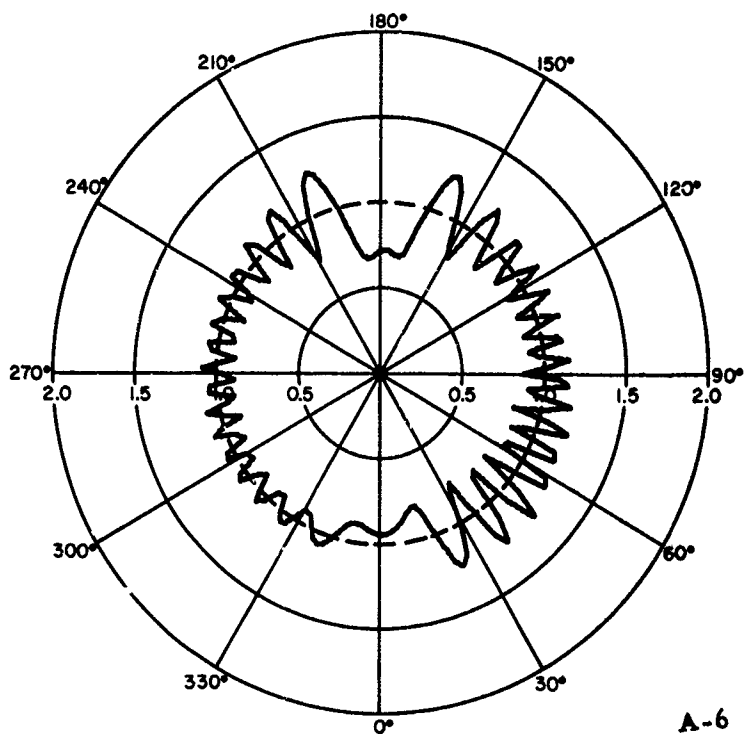


A-1

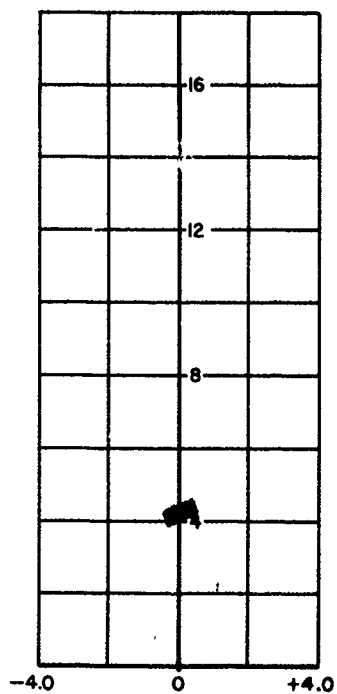




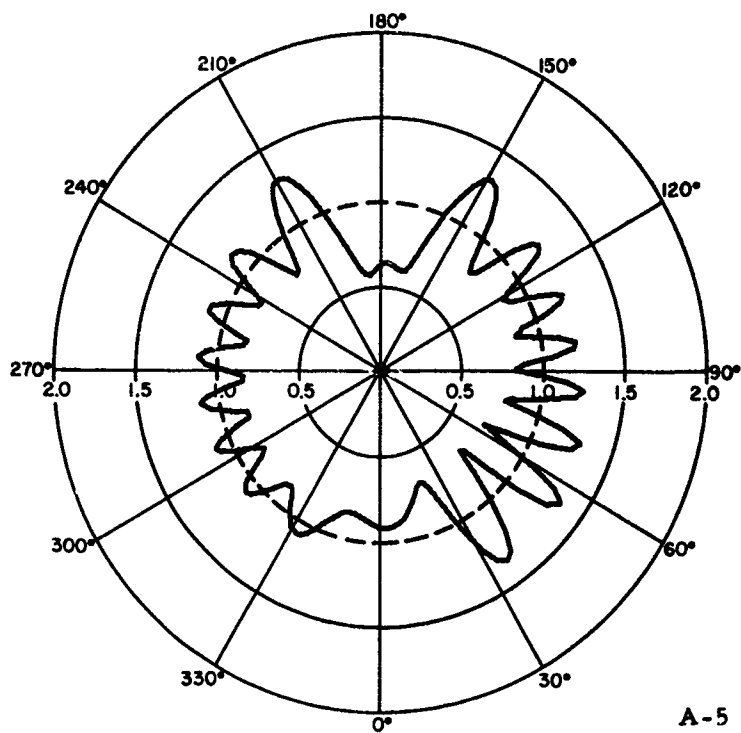
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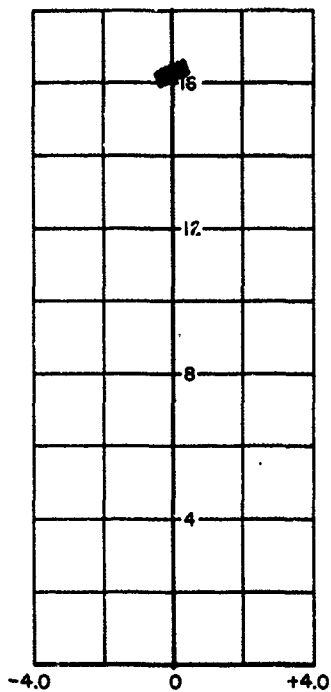
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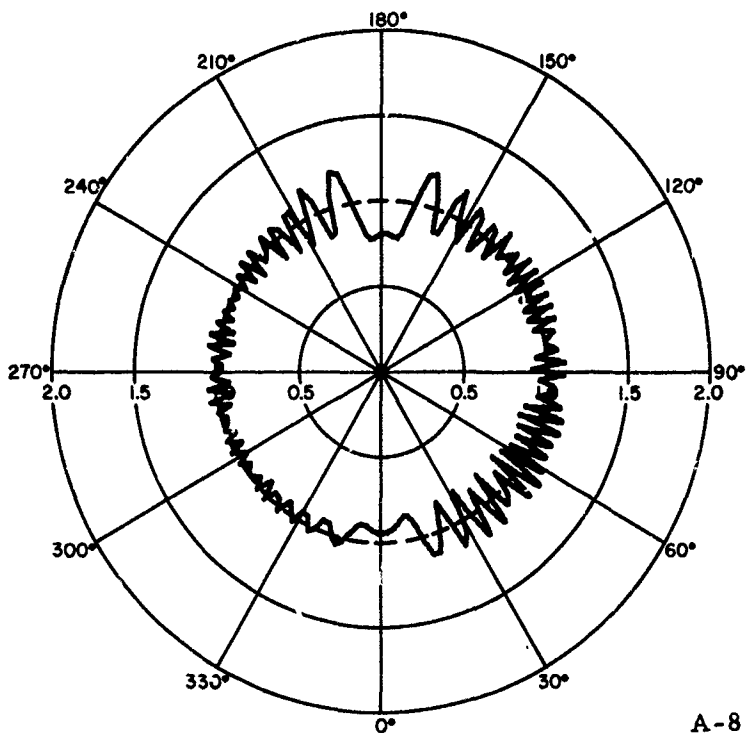
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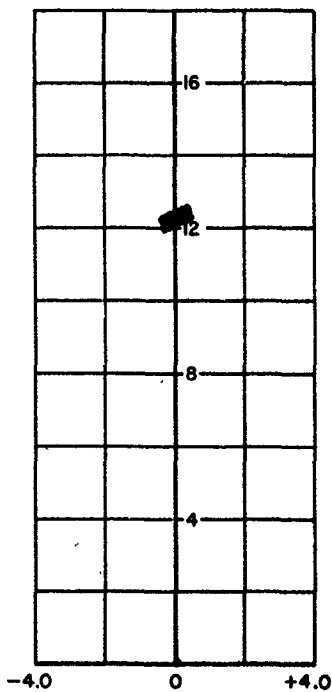
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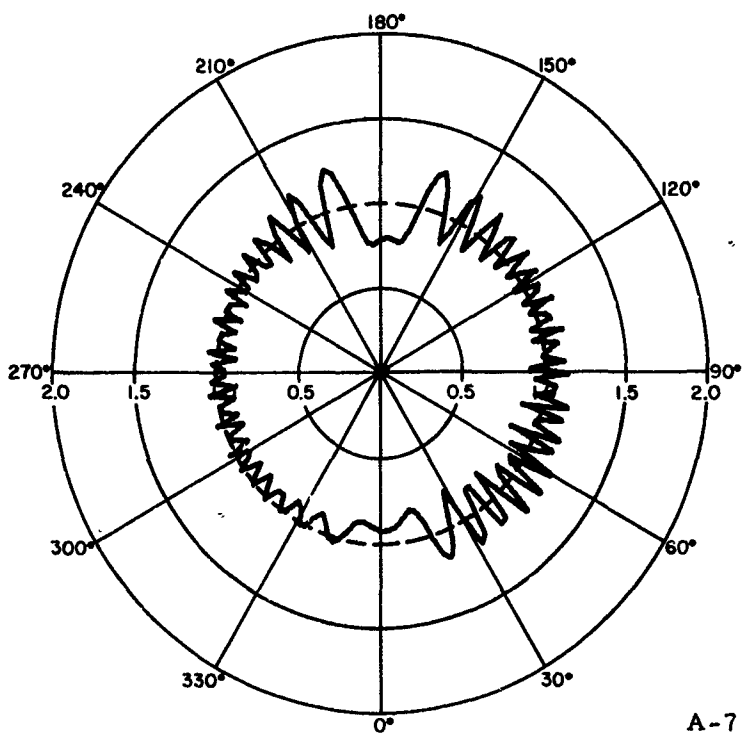
DISTANCE ~ WAVELENGTHS



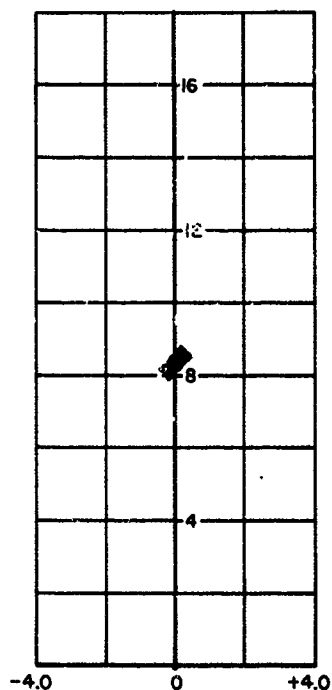
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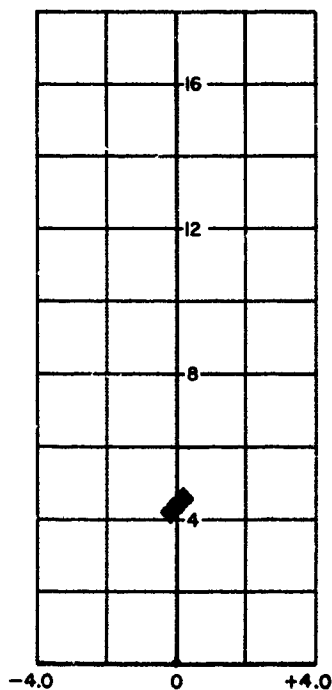
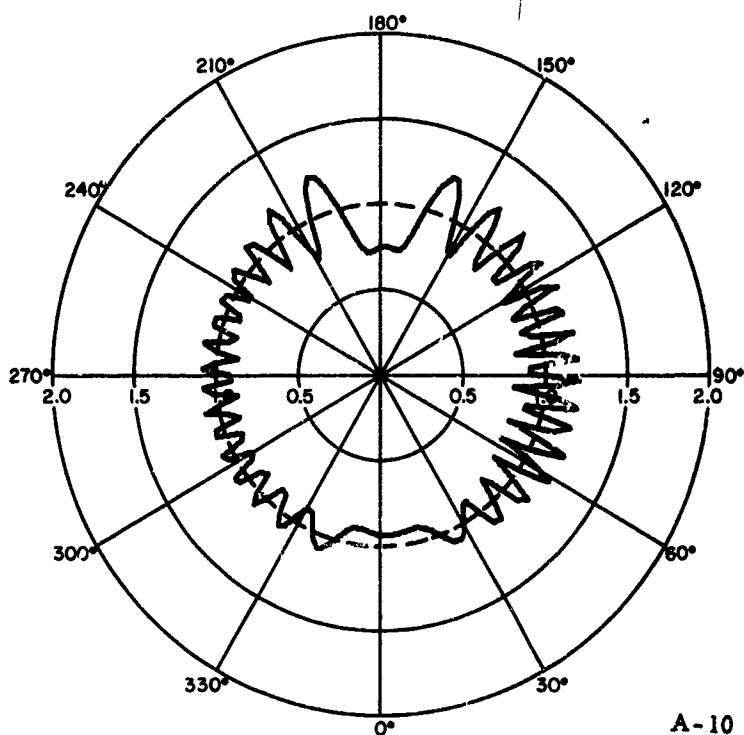
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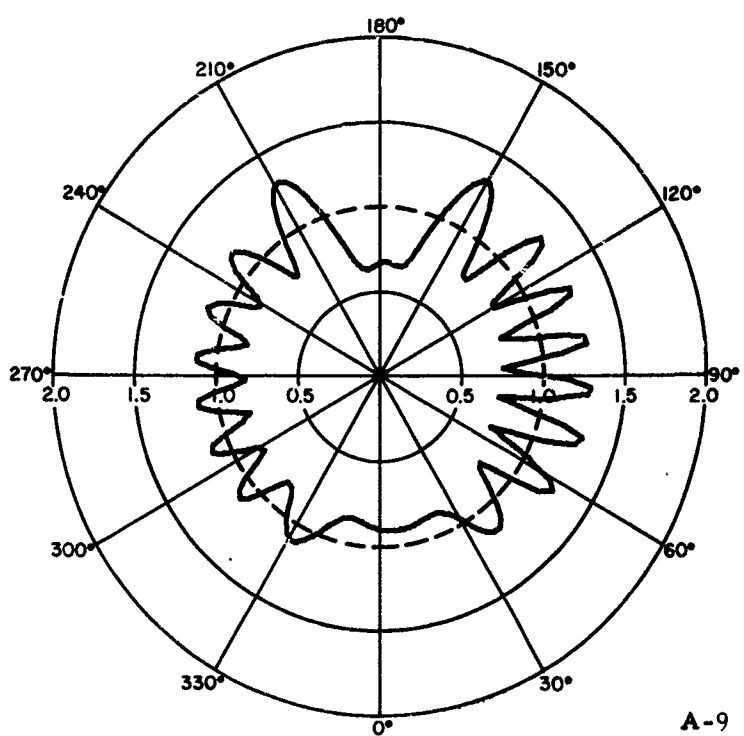
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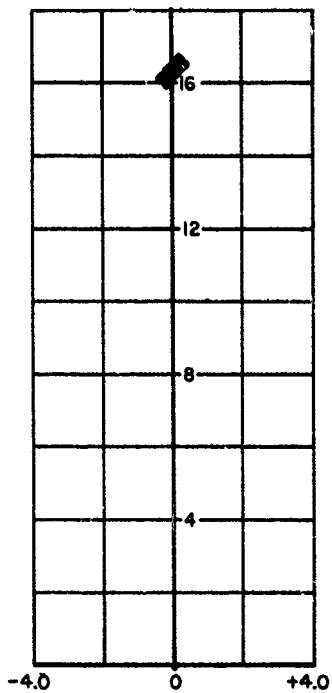


DISTANCE ~ WAVELENGTHS

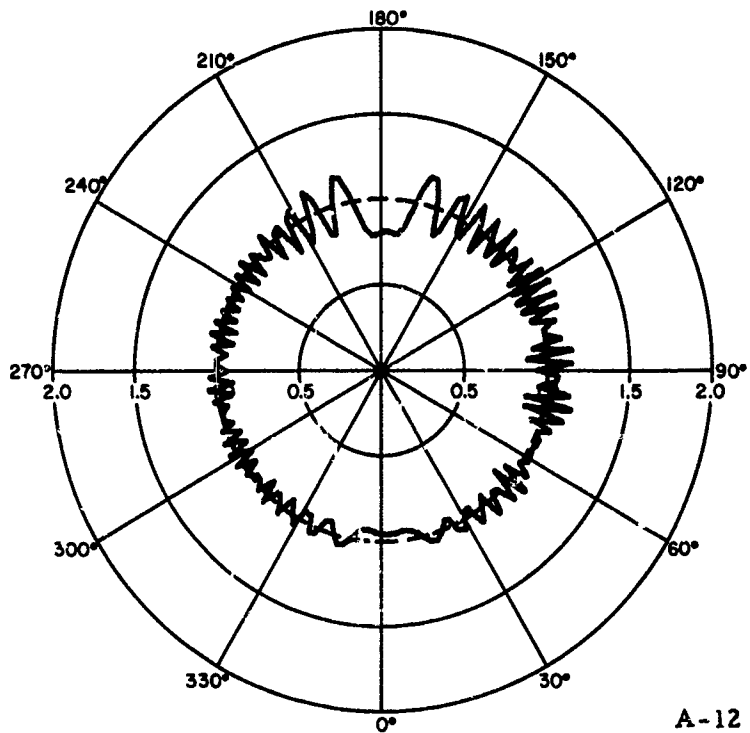


DISTANCE ~ WAVELENGTHS

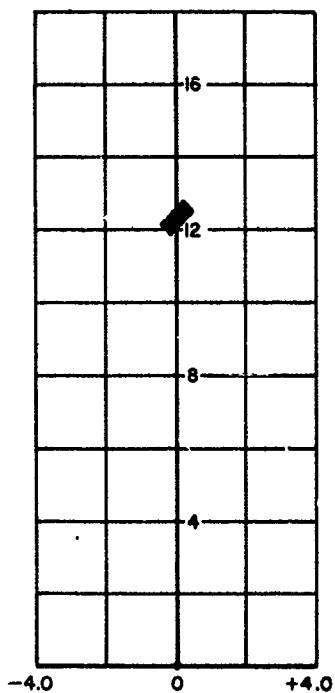




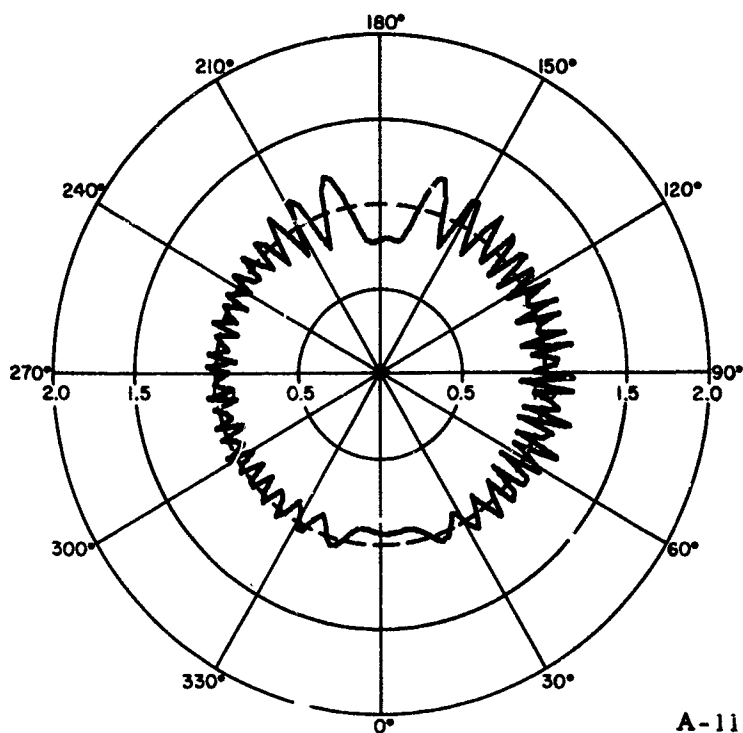
DISTANCE ~ WAVELENGTHS



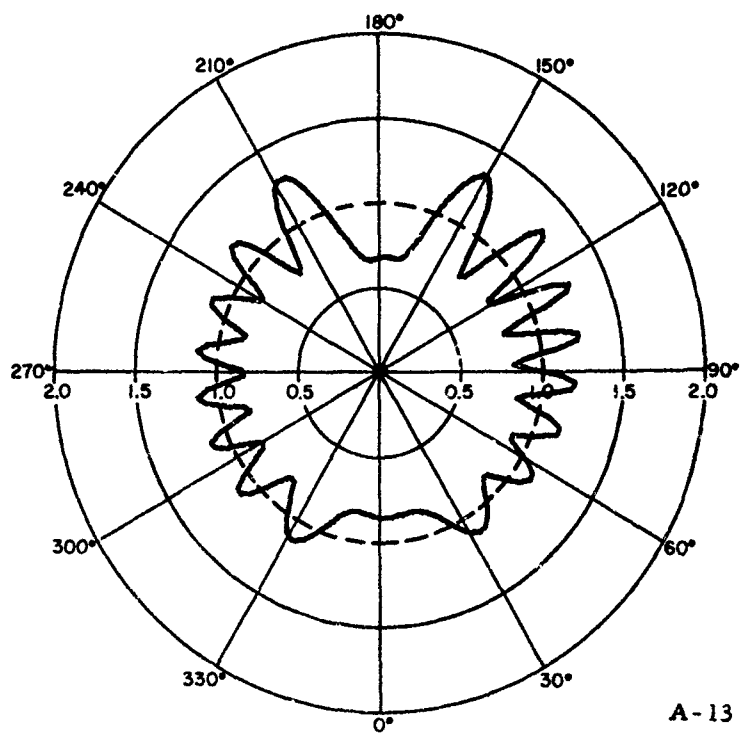
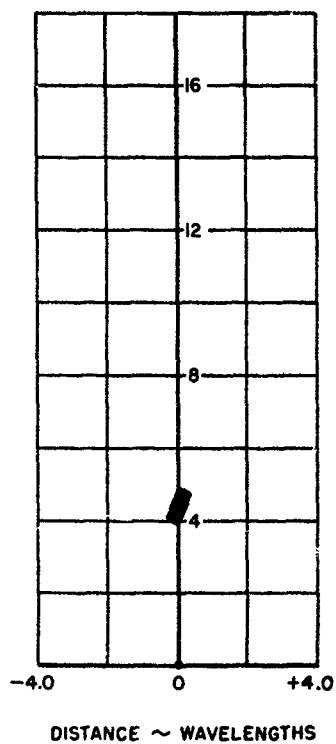
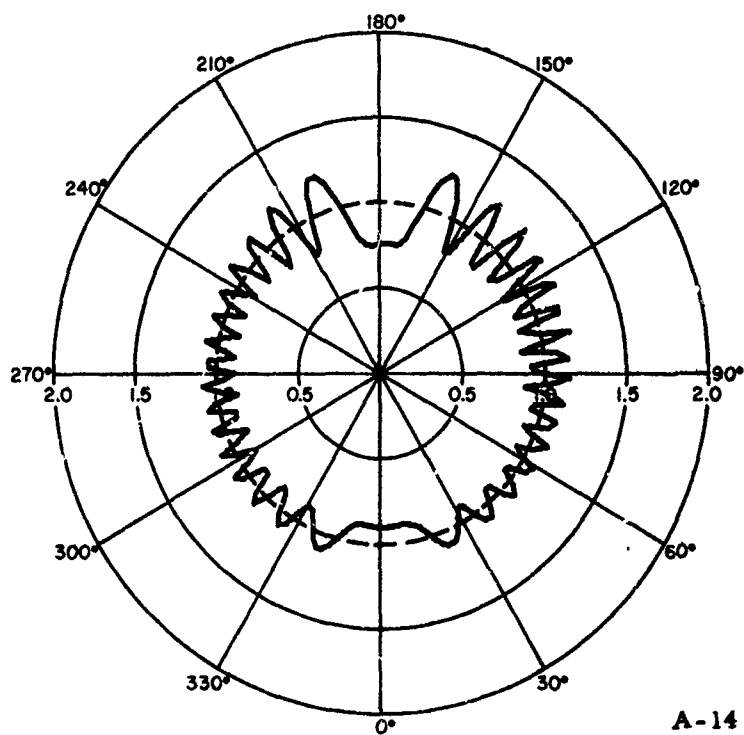
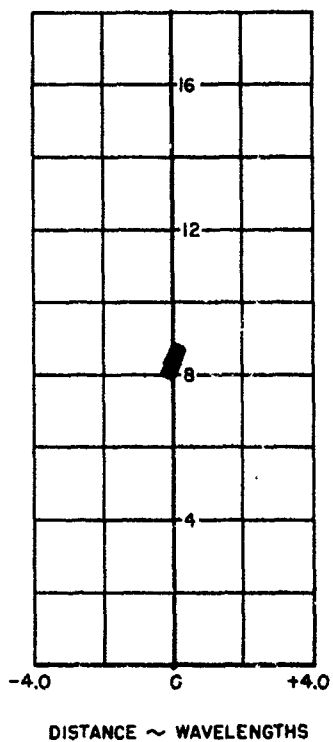
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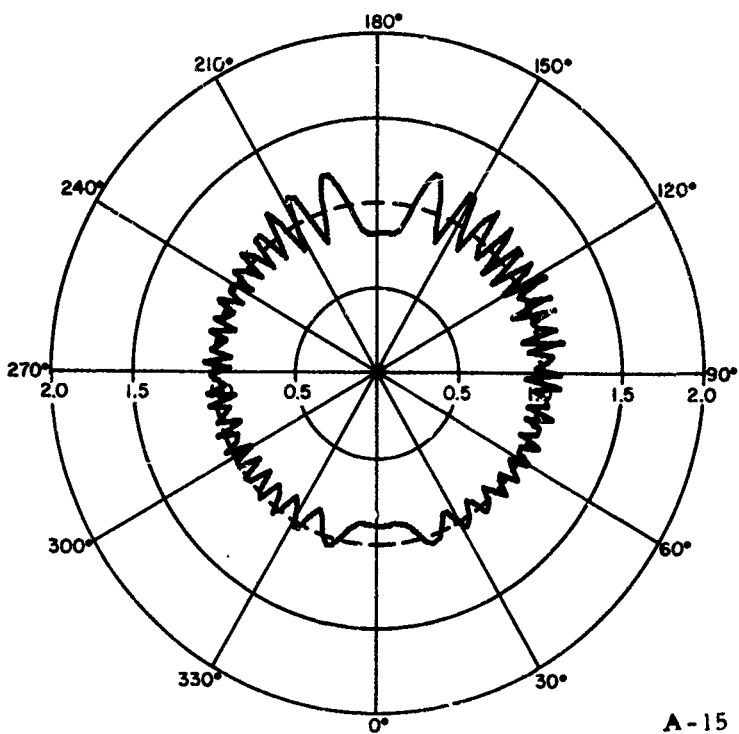
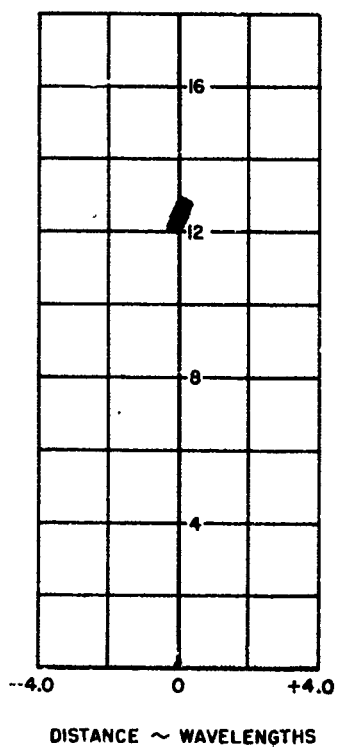
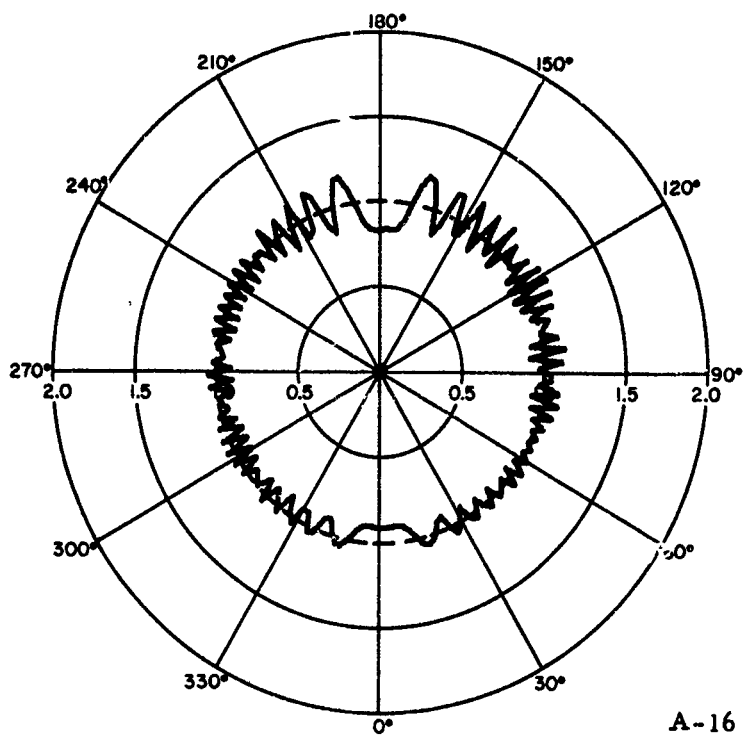
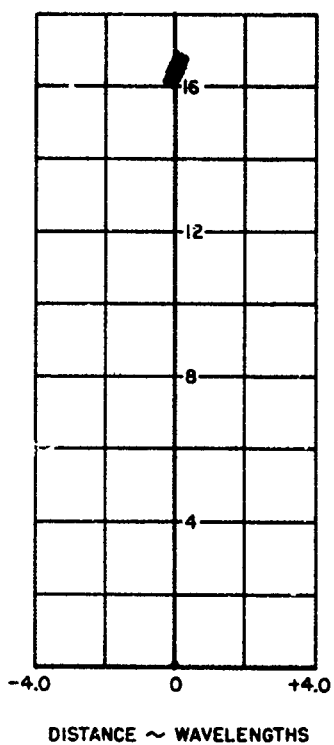


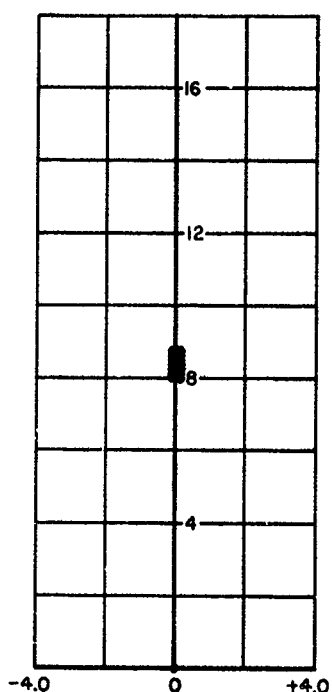
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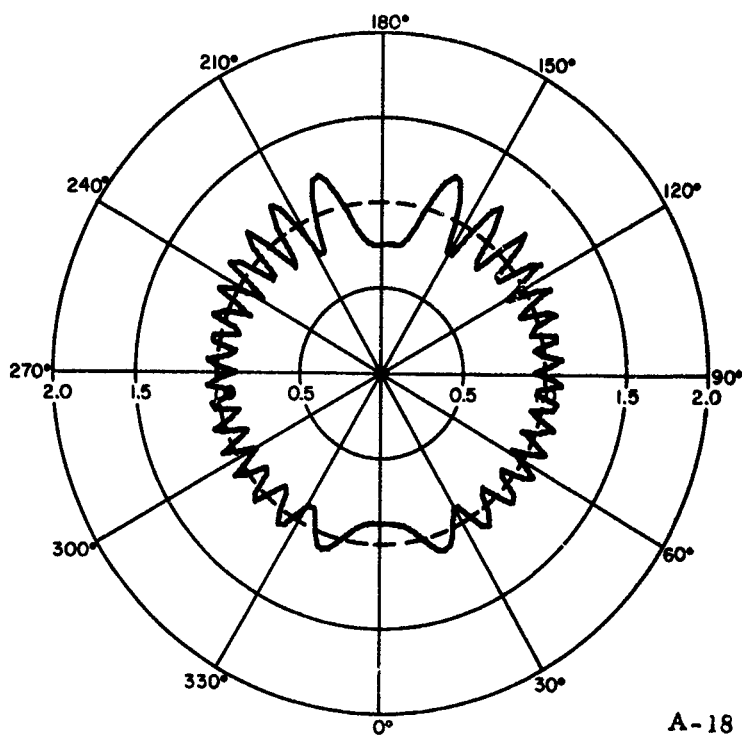
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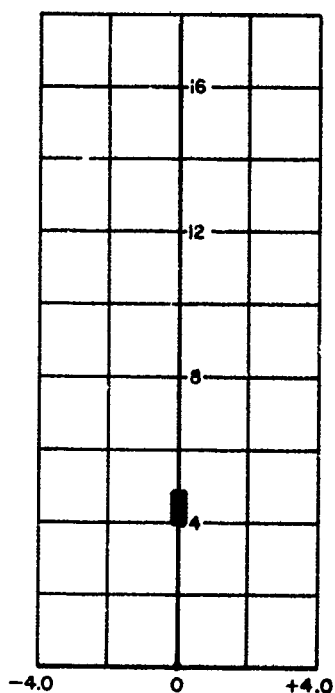




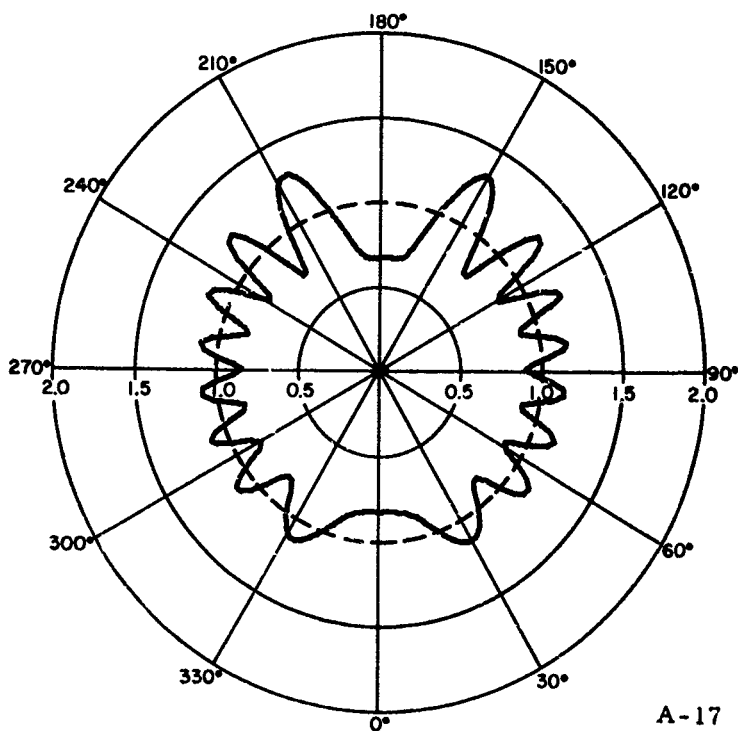
DISTANCE ~ WAVELENGTHS



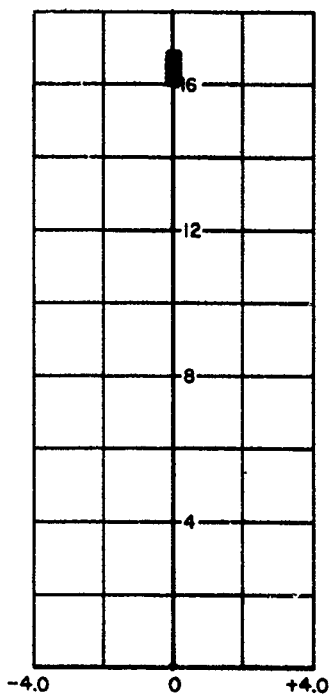
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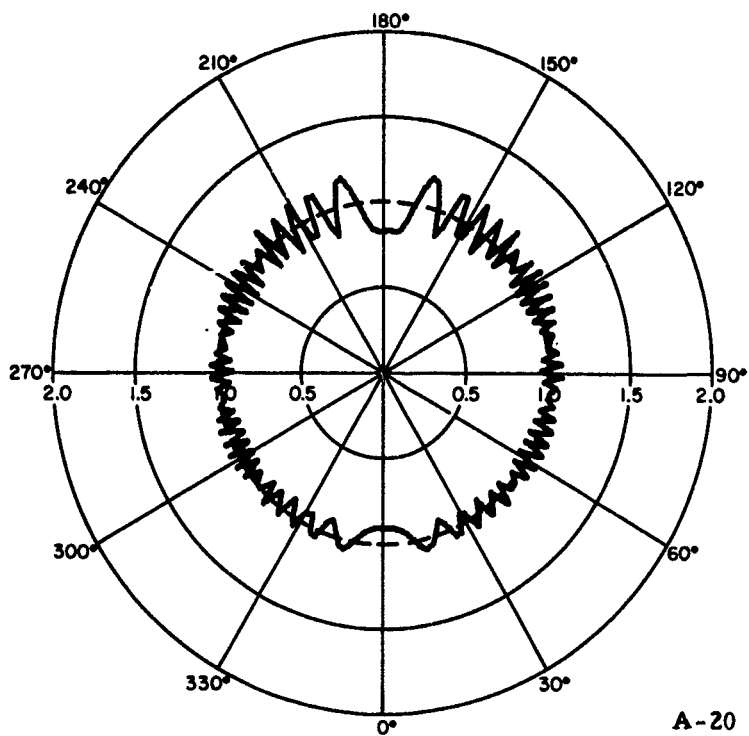
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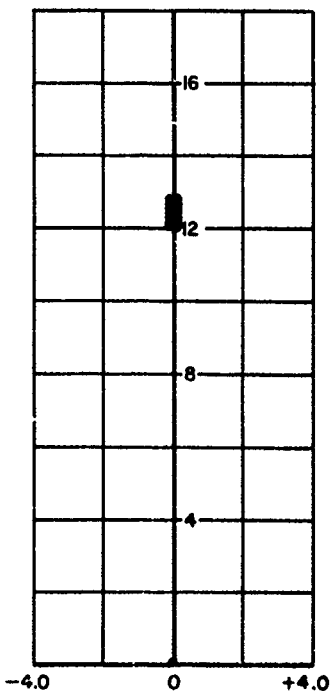
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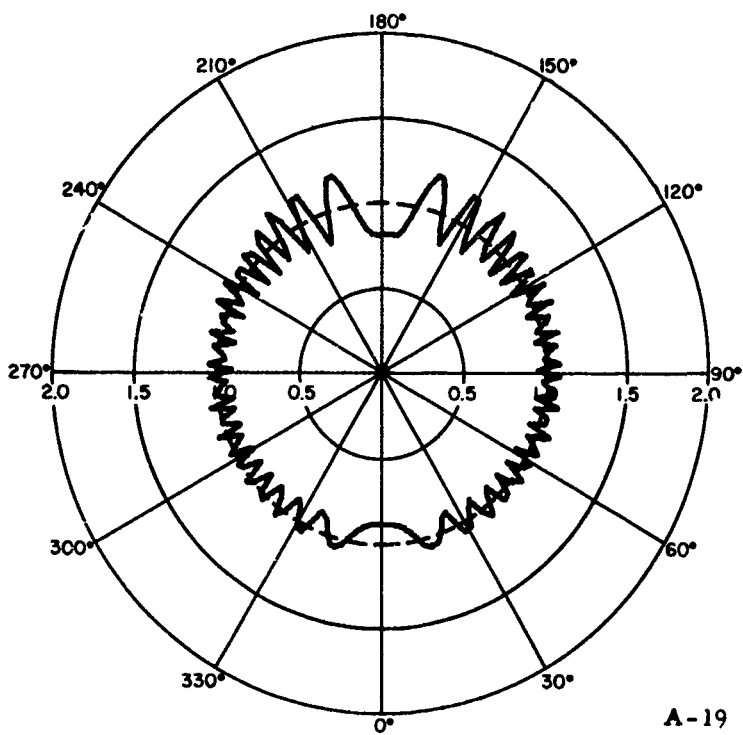
DISTANCE ~ WAVELENGTHS



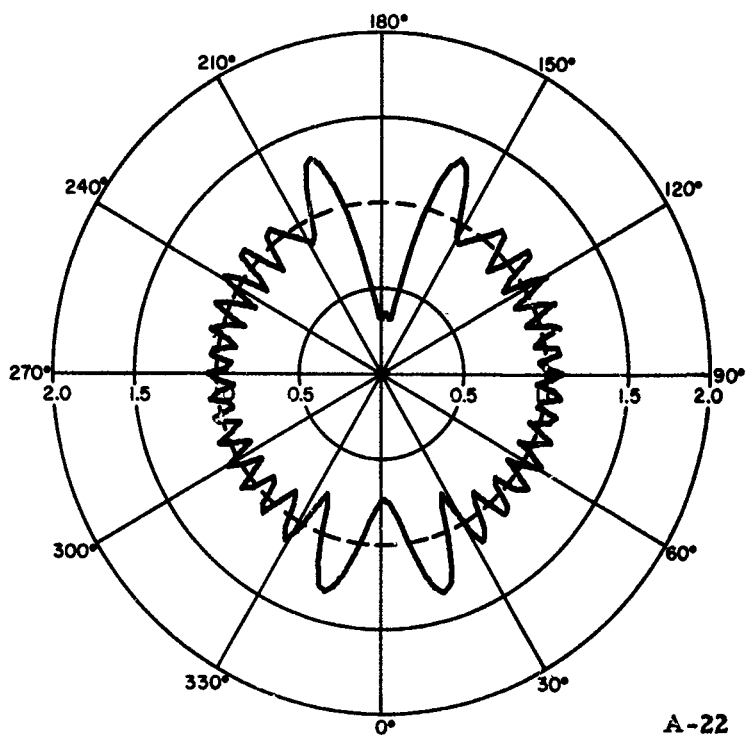
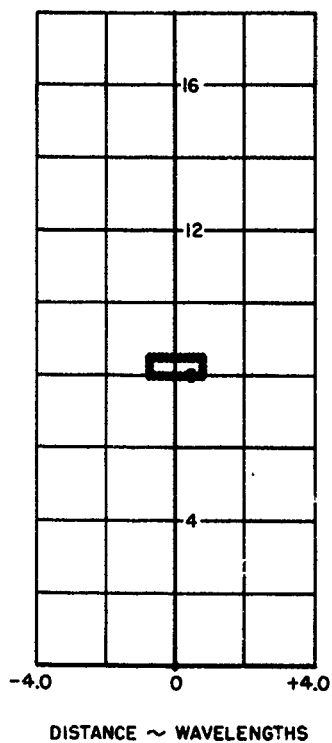
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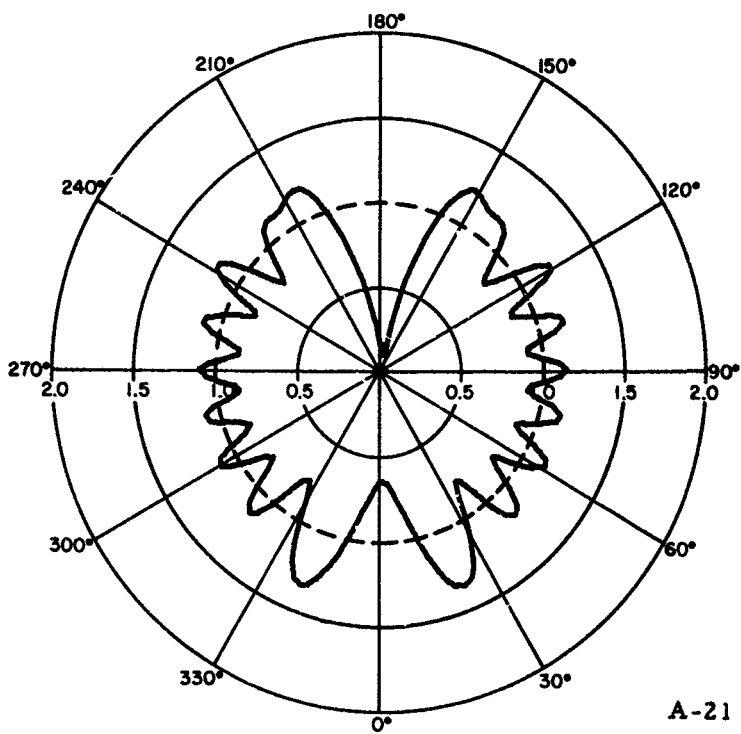
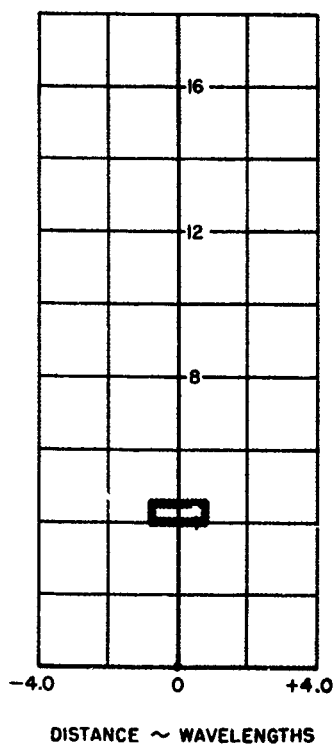
DISTANCE ~ WAVELENGTHS



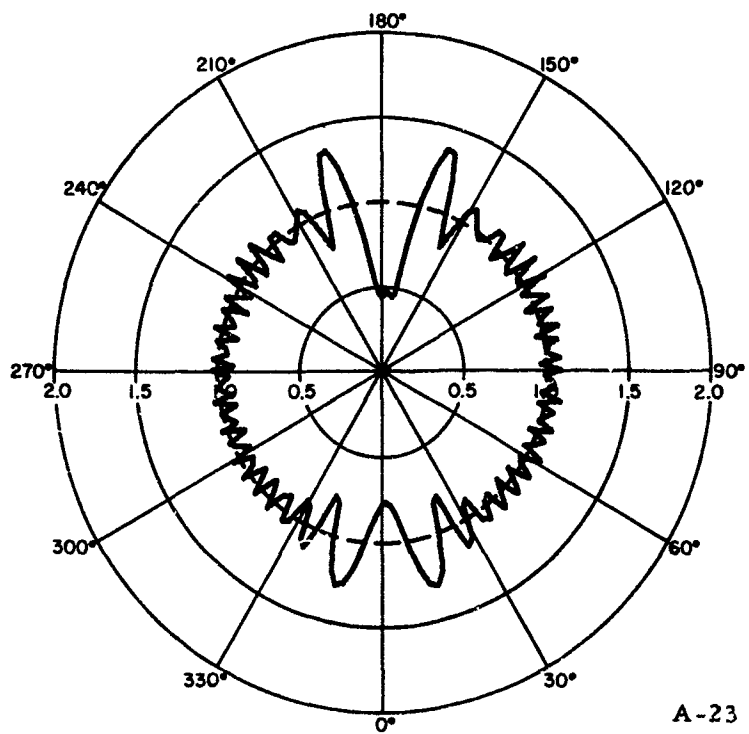
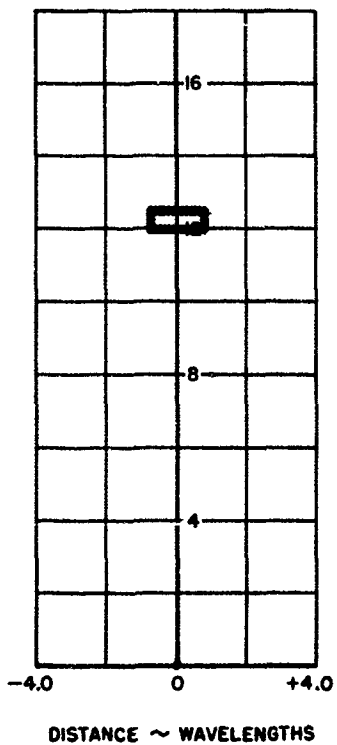
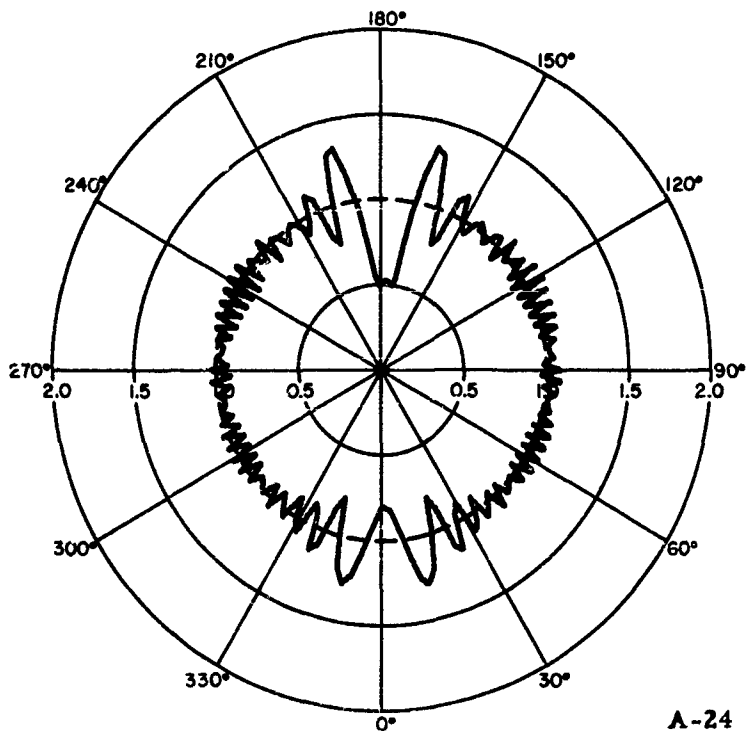
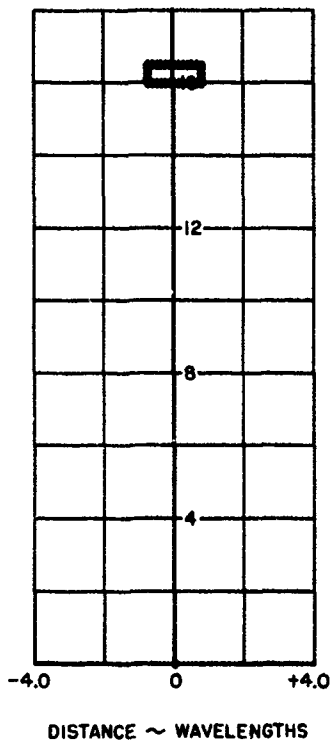
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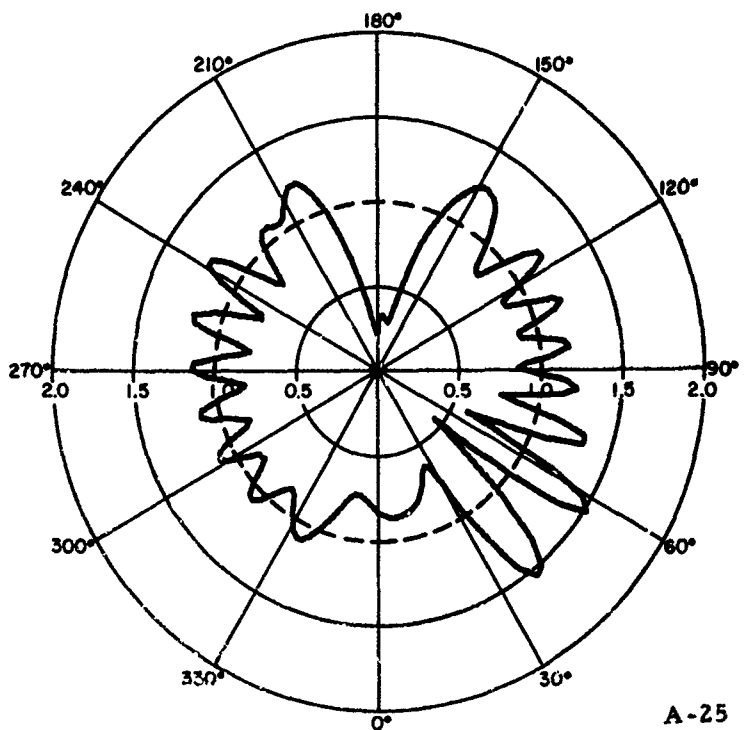
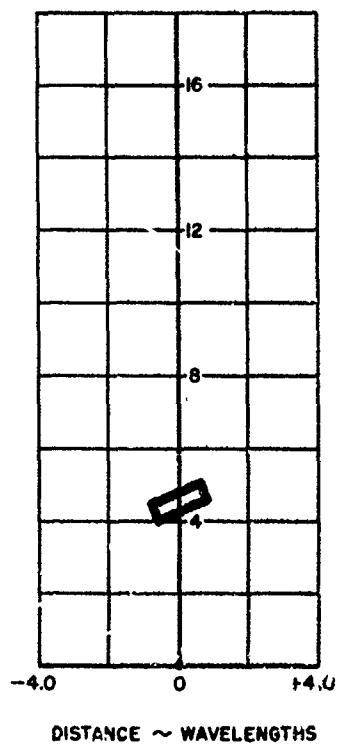
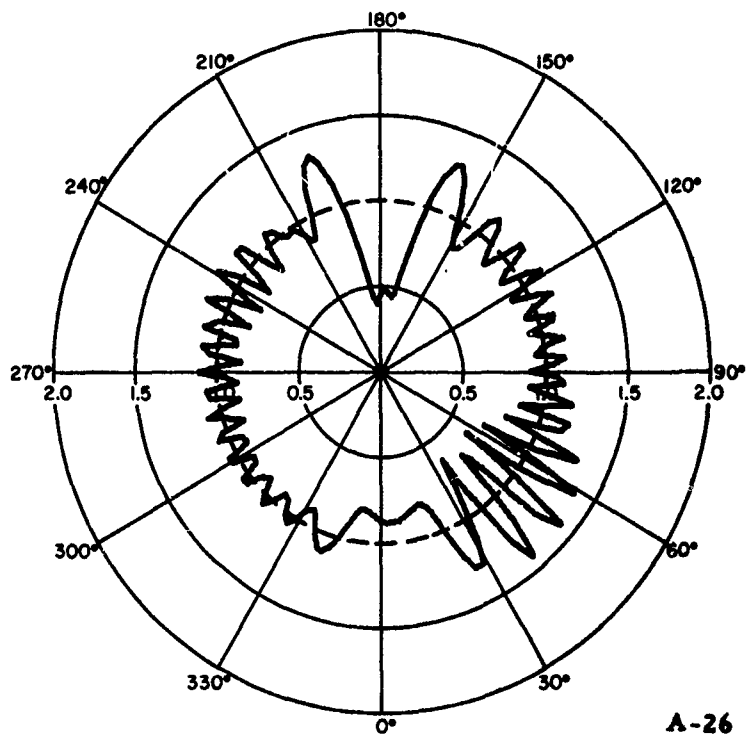
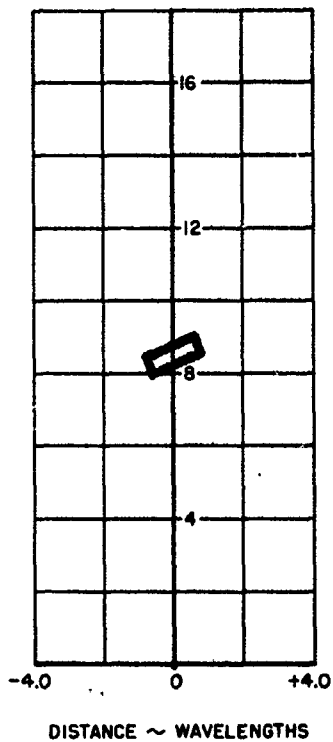


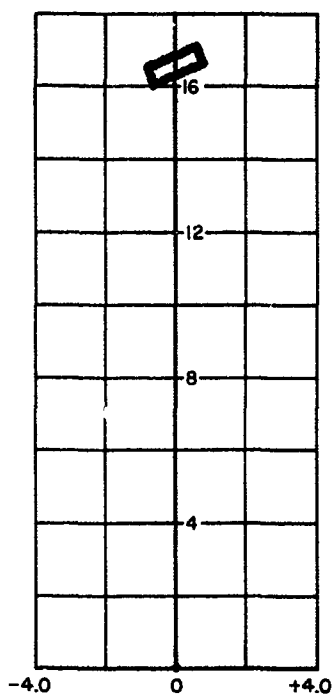
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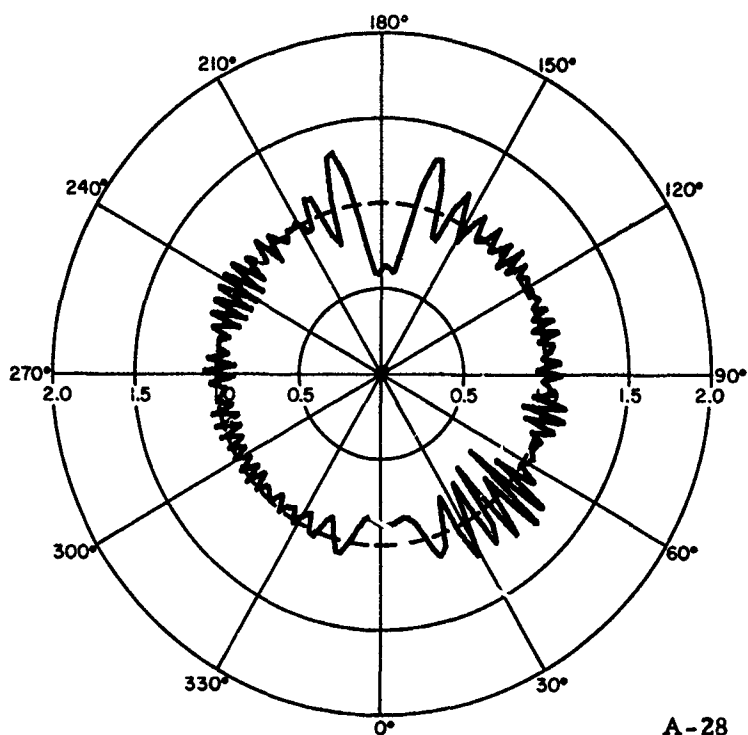
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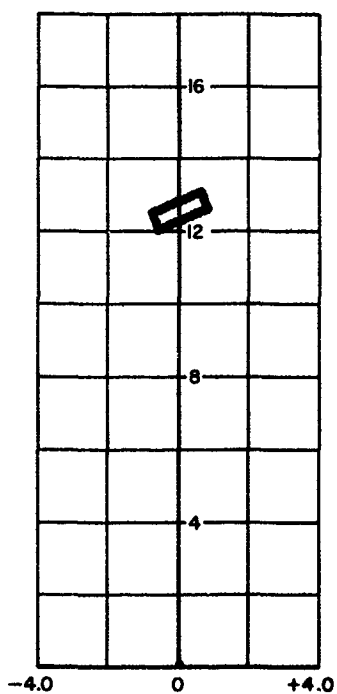




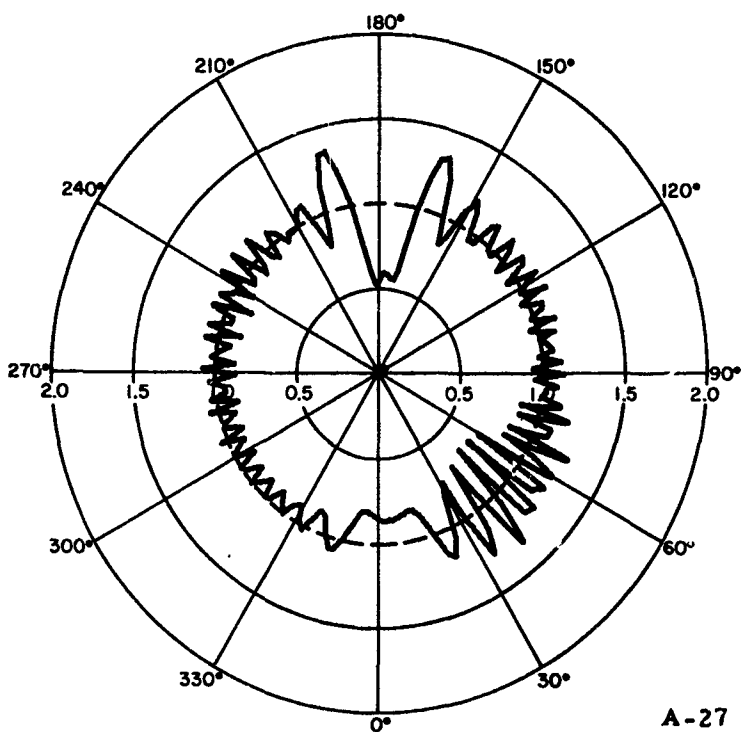
DISTANCE ~ WAVELENGTHS



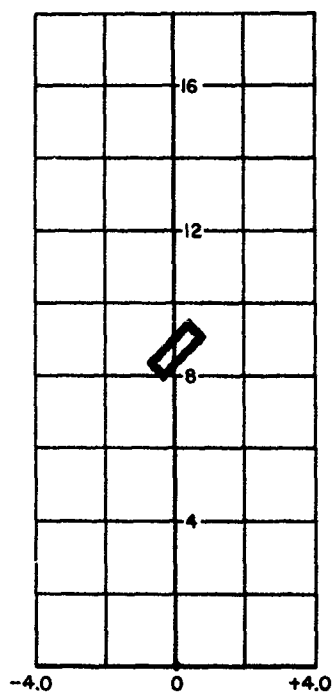
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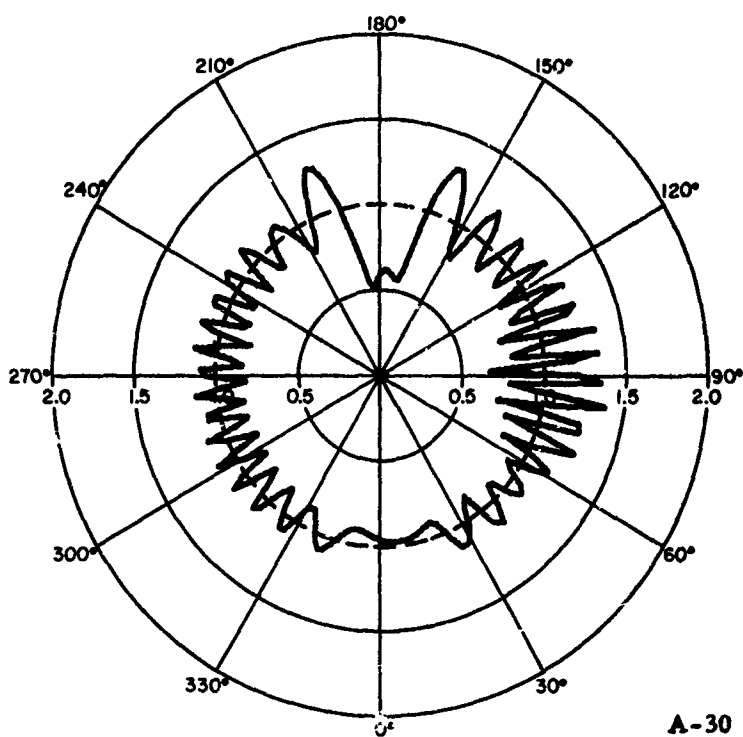
DISTANCE ~ WAVELENGTHS



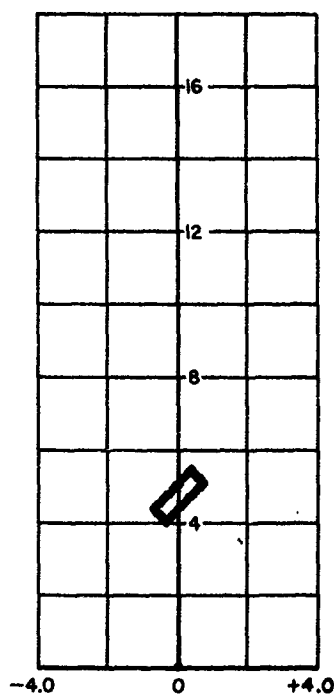
A-27



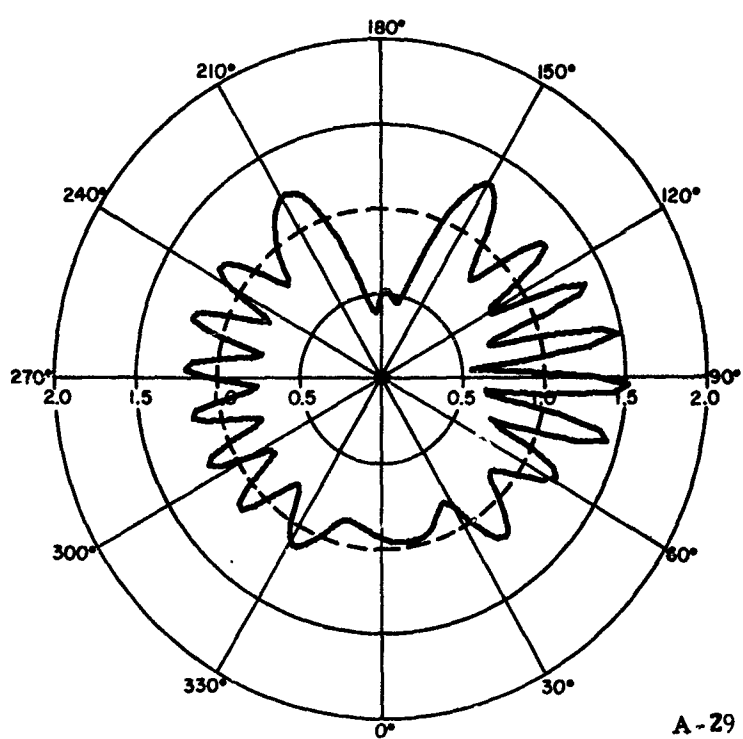
DISTANCE ~ WAVELENGTHS



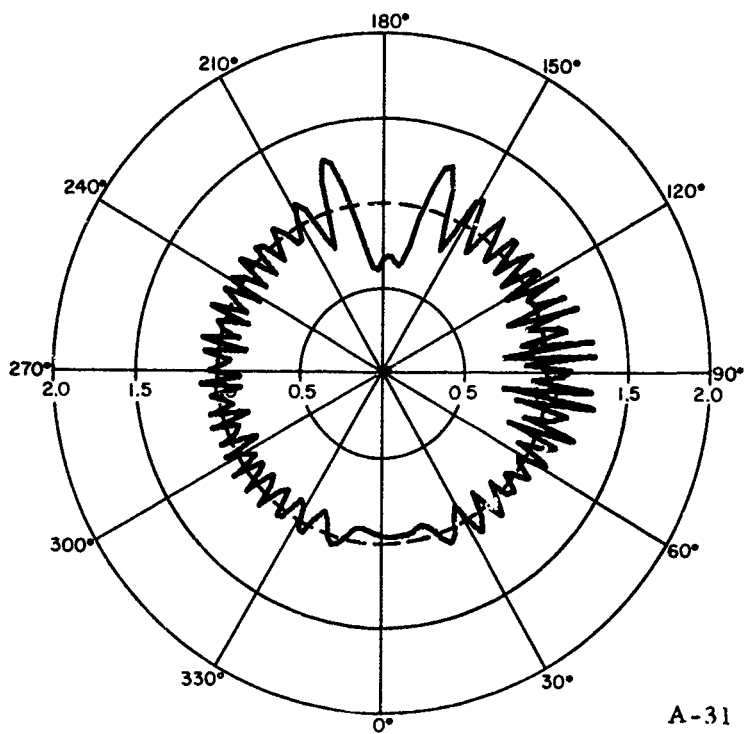
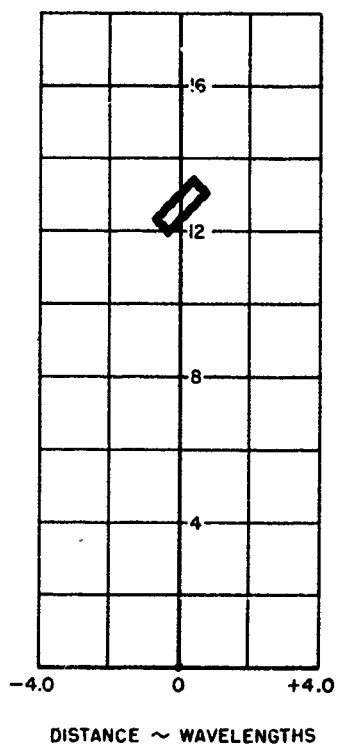
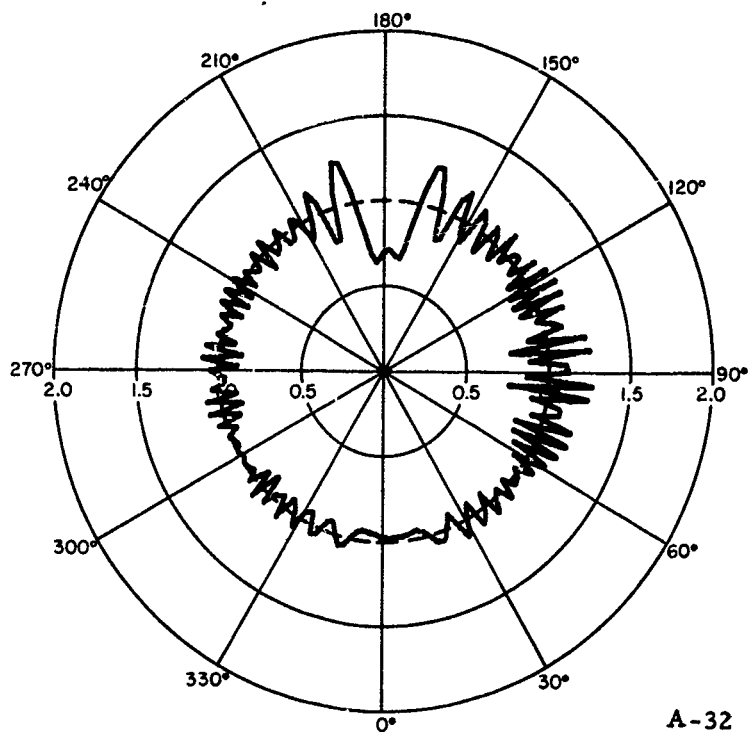
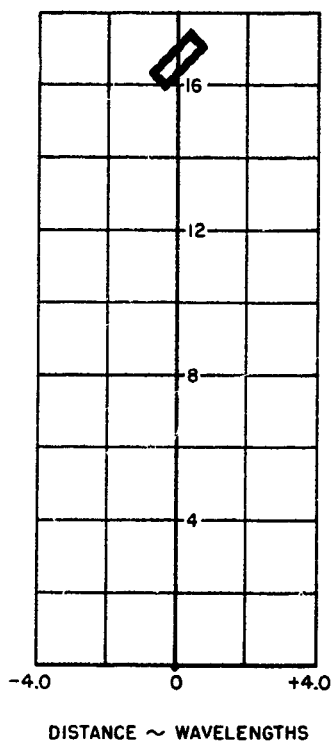
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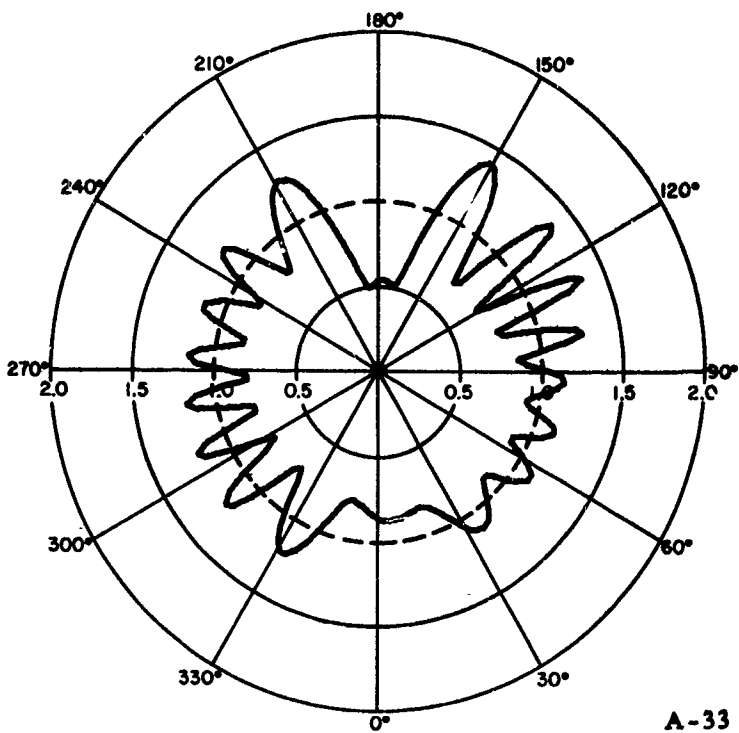
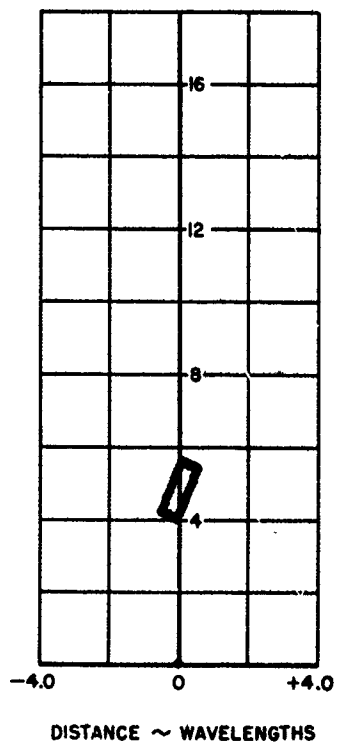
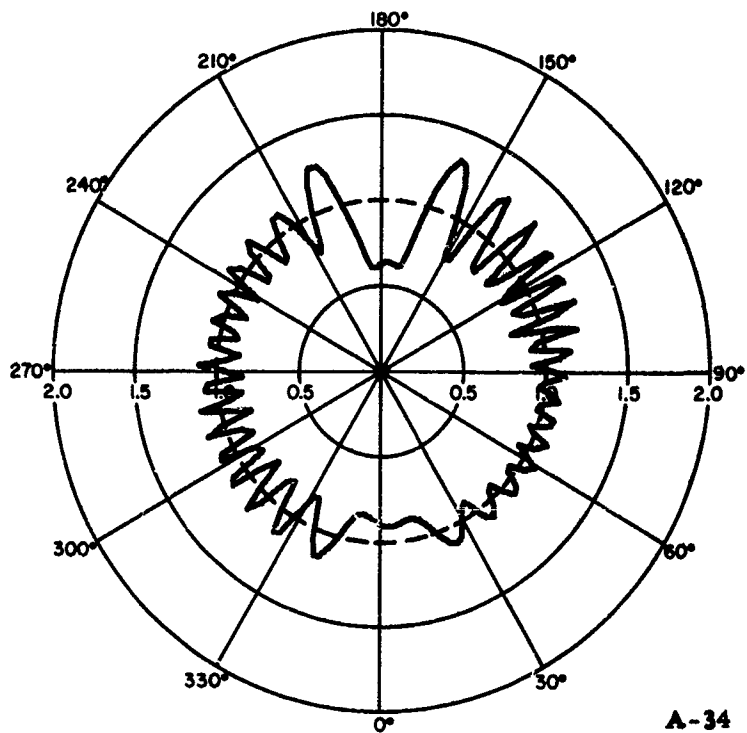
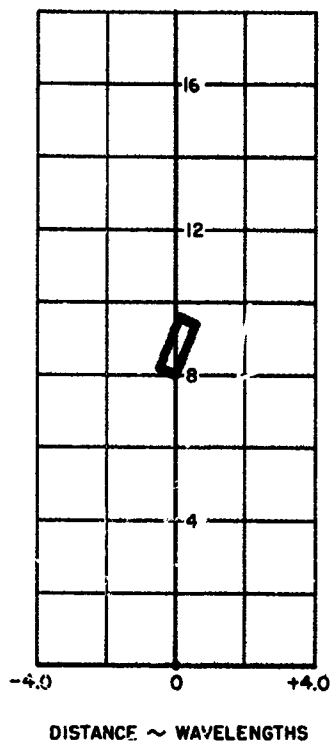


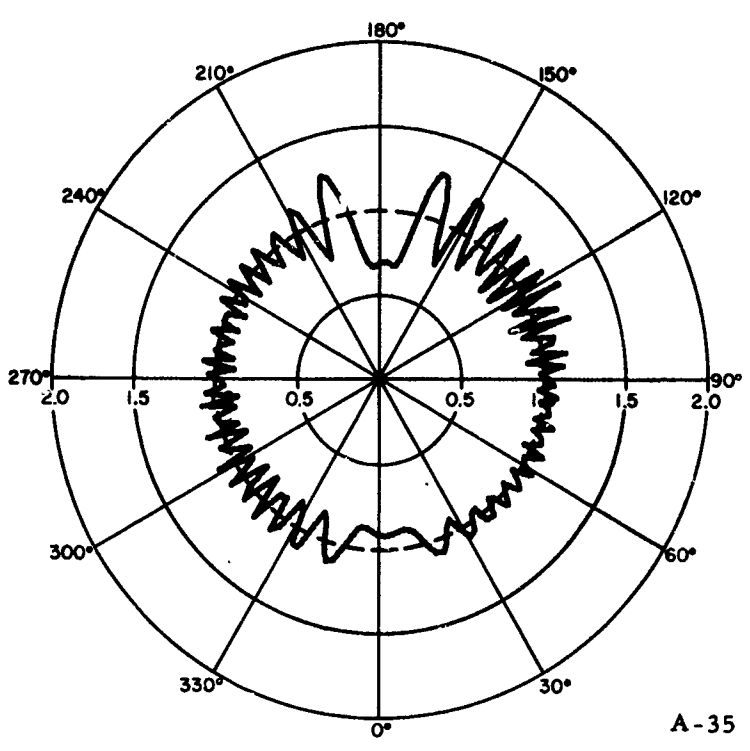
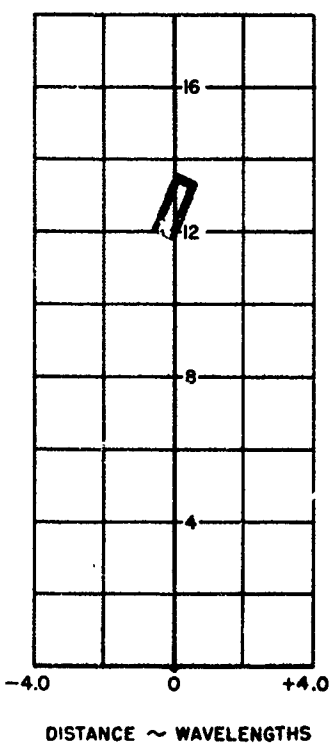
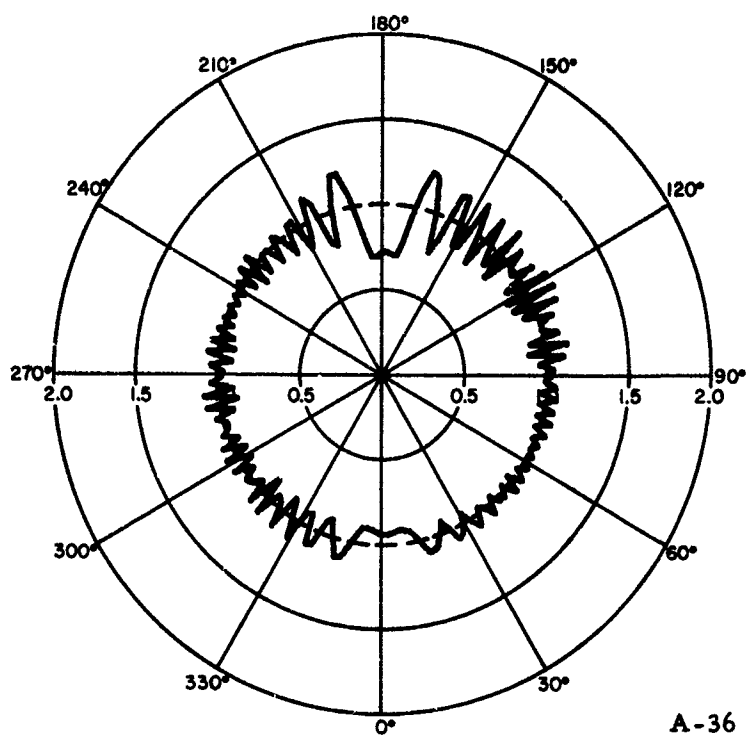
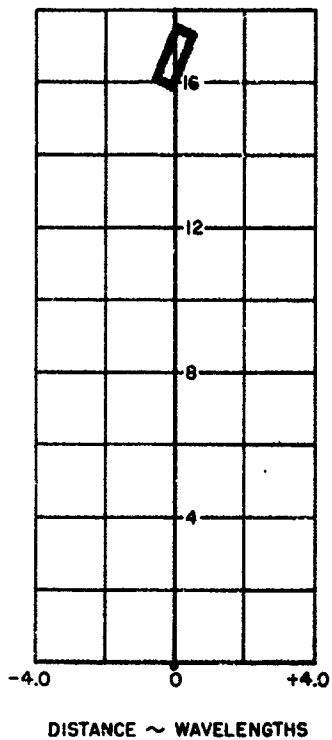
DISTANCE ~ WAVELENGTHS

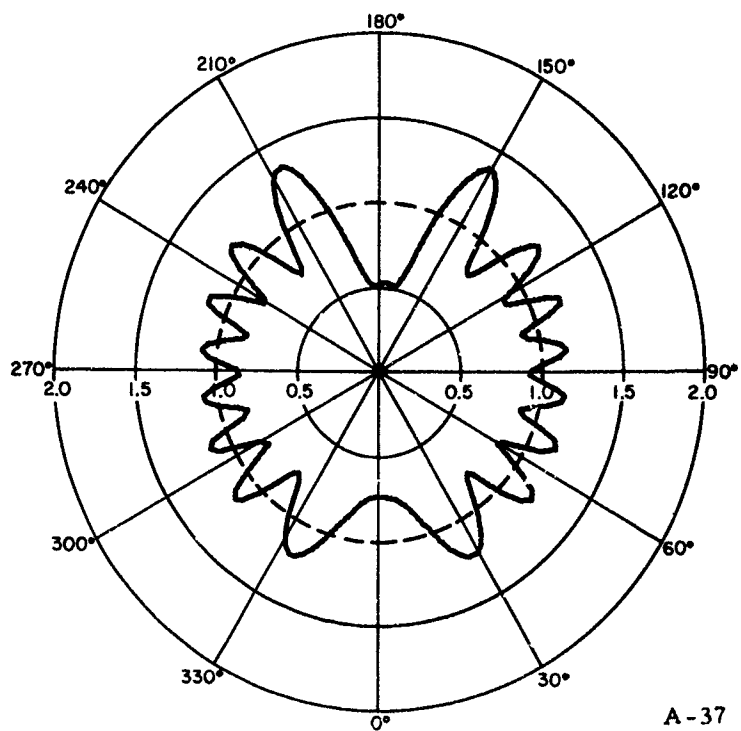
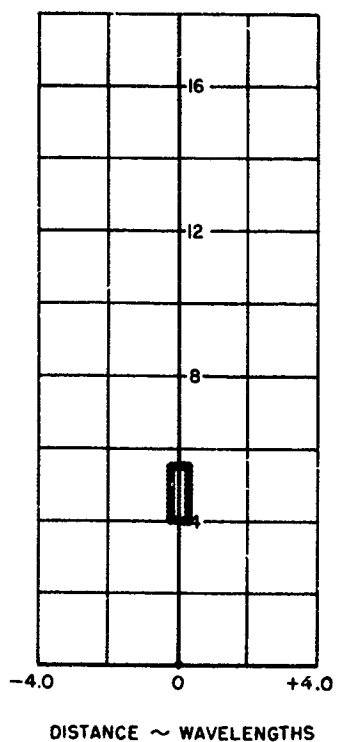
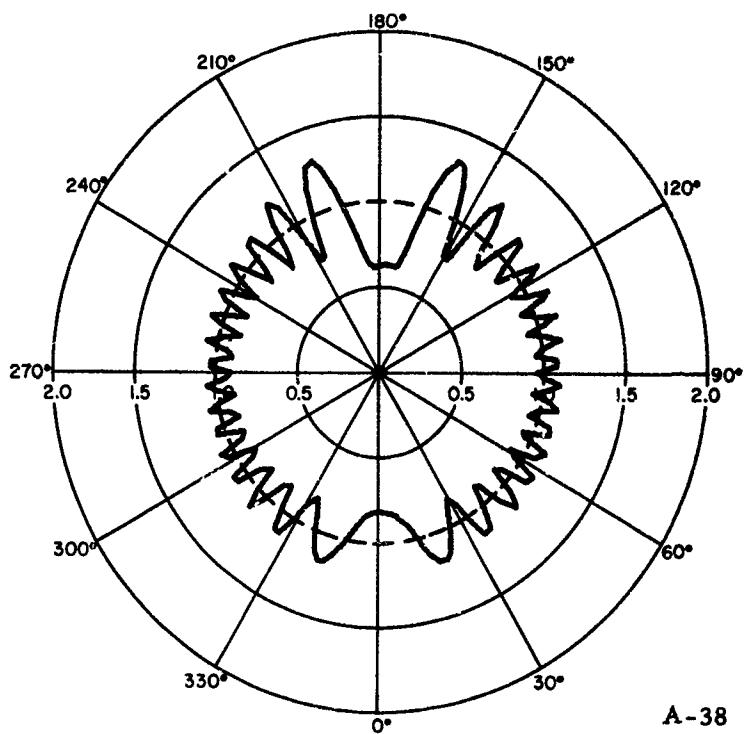
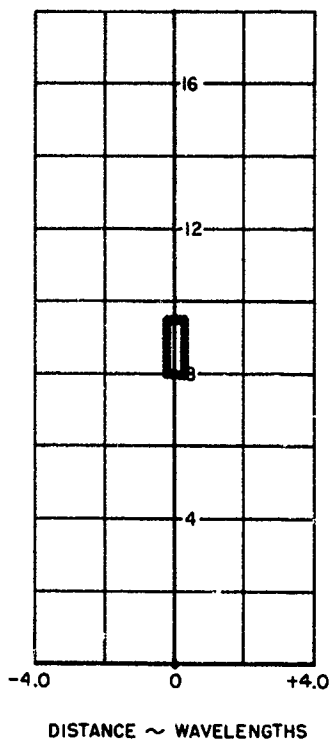


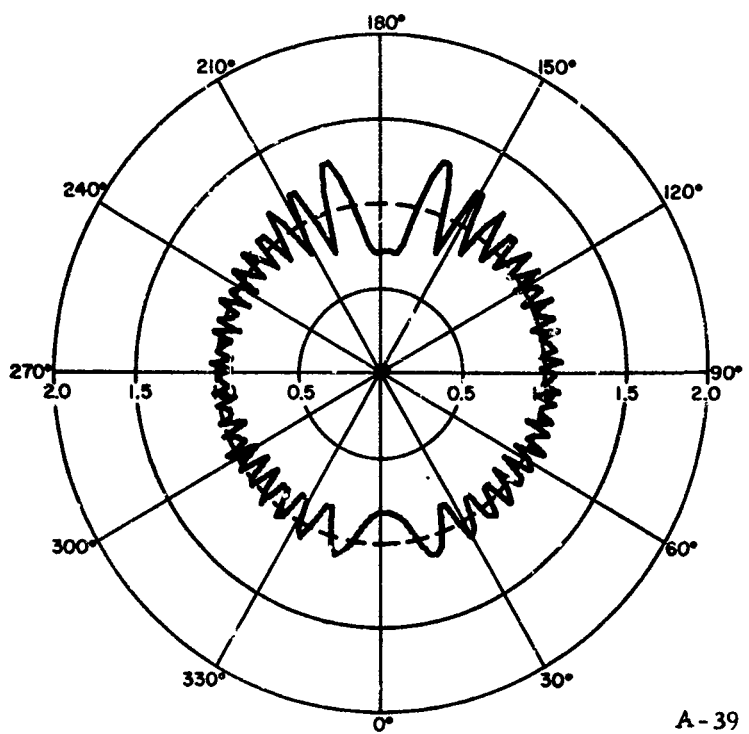
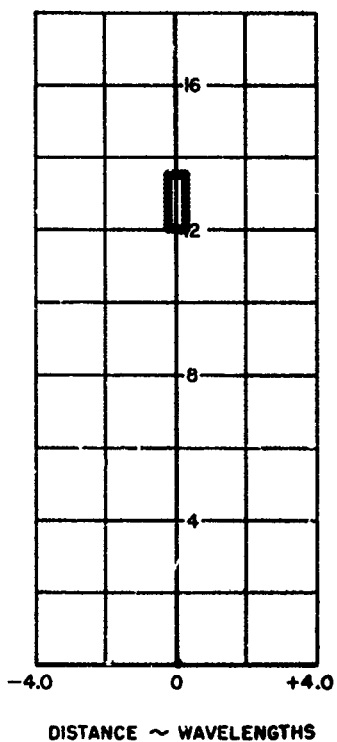
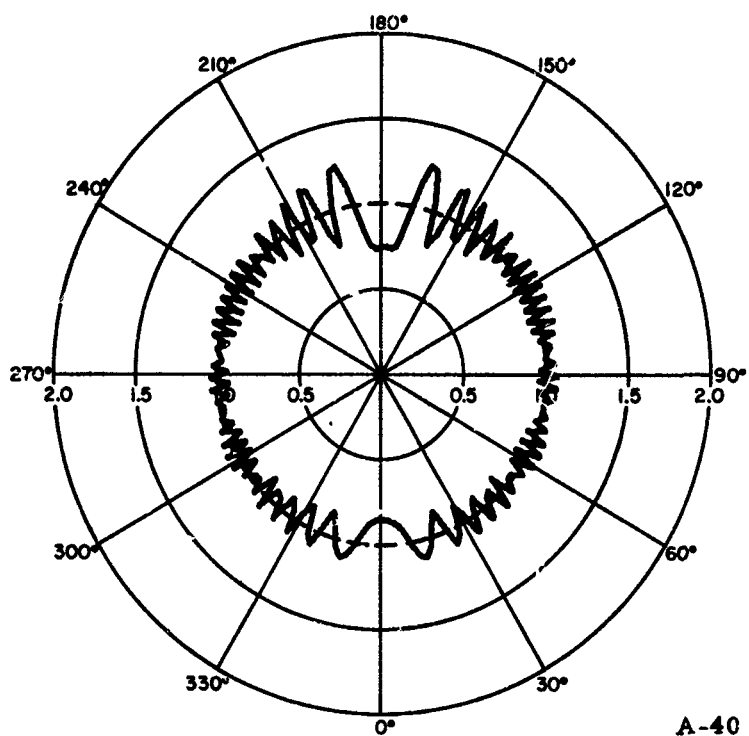
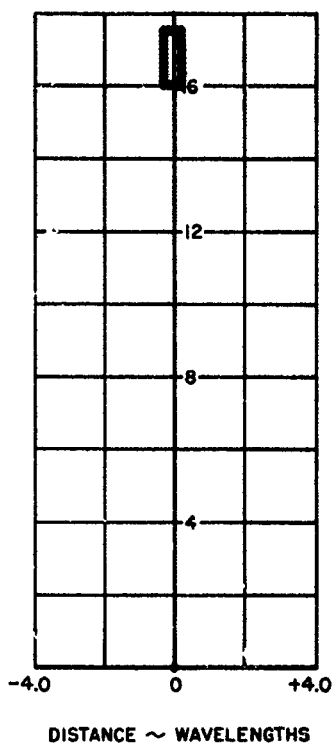
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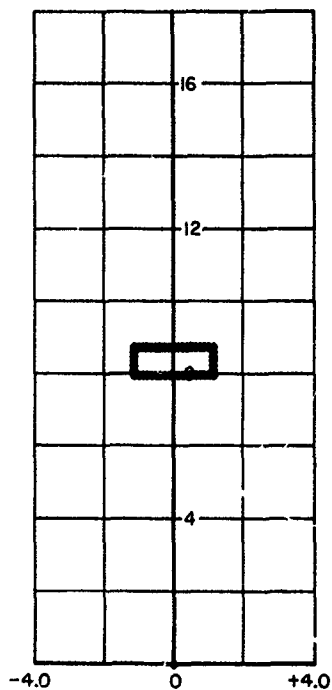




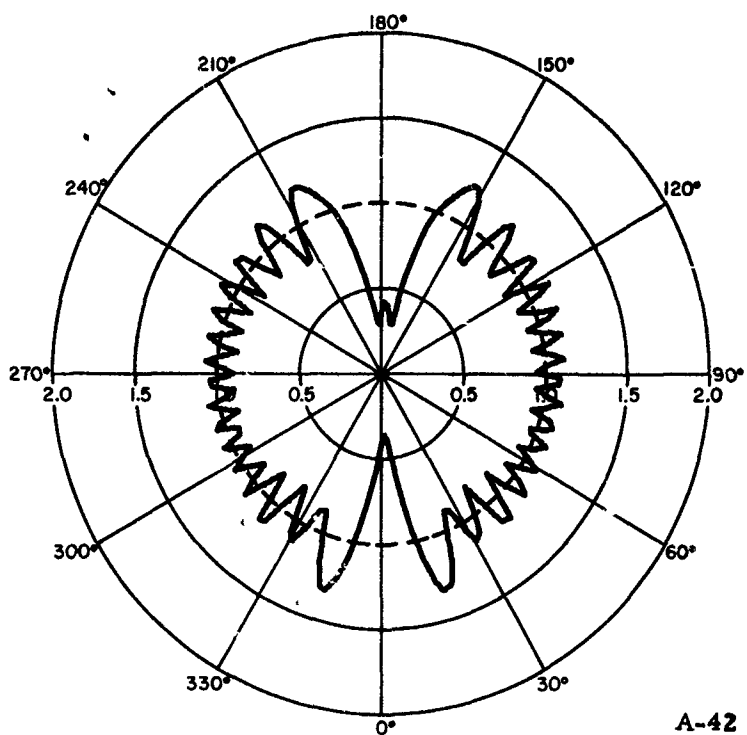




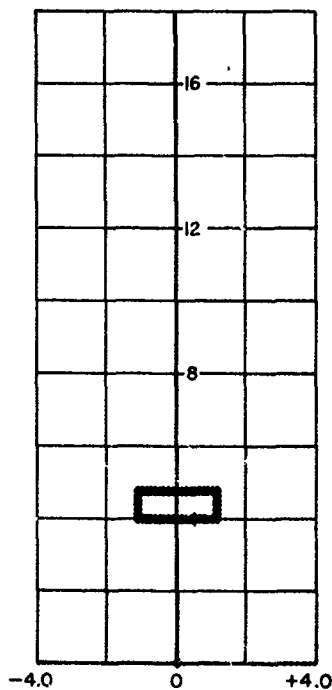




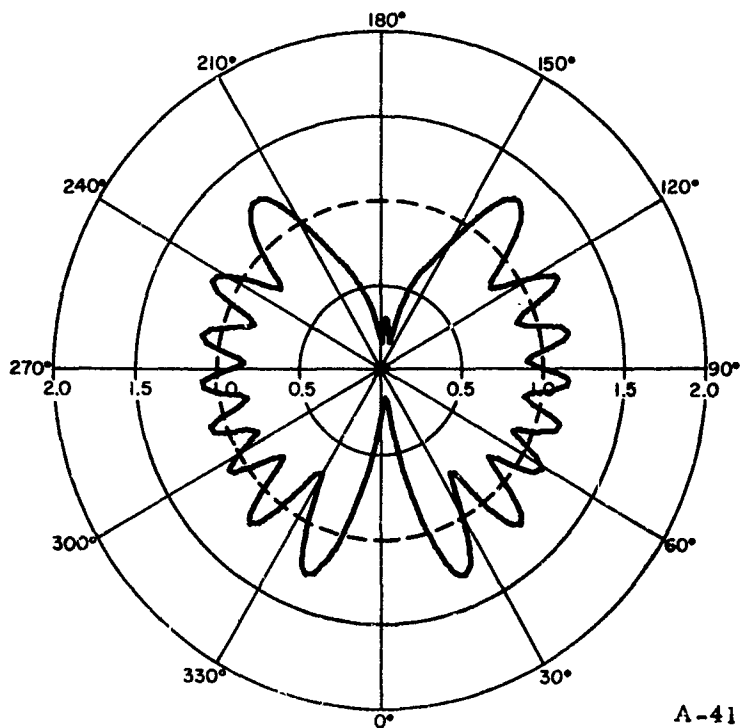
DISTANCE ~ WAVELENGTHS



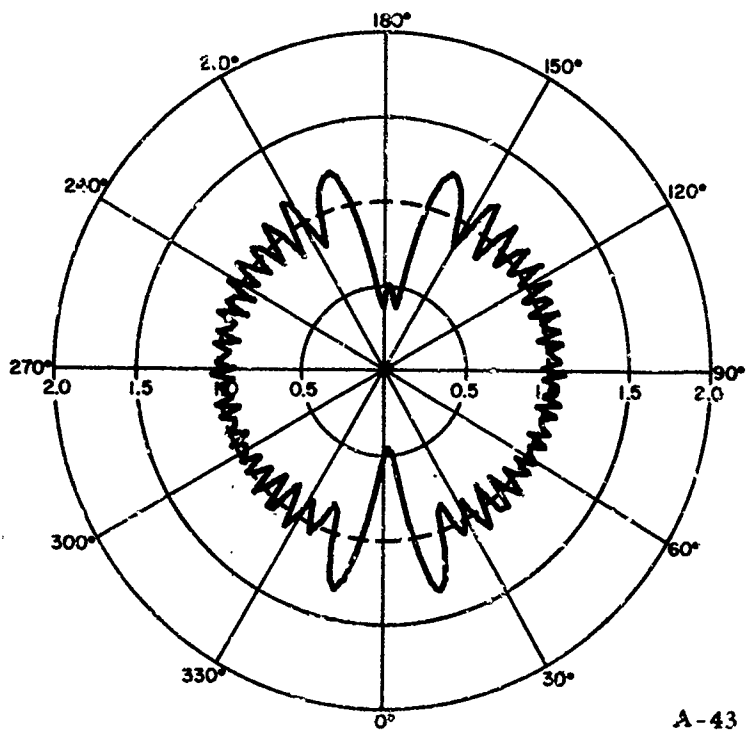
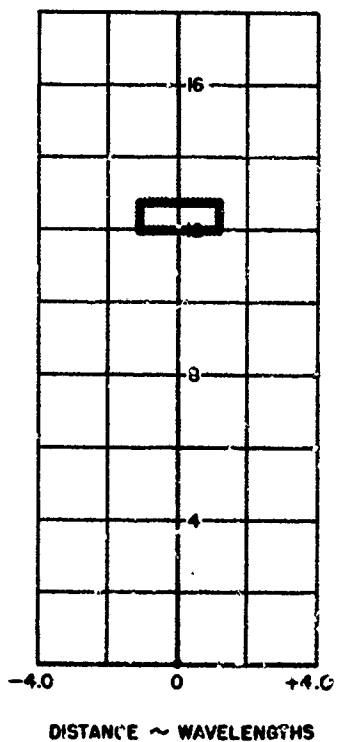
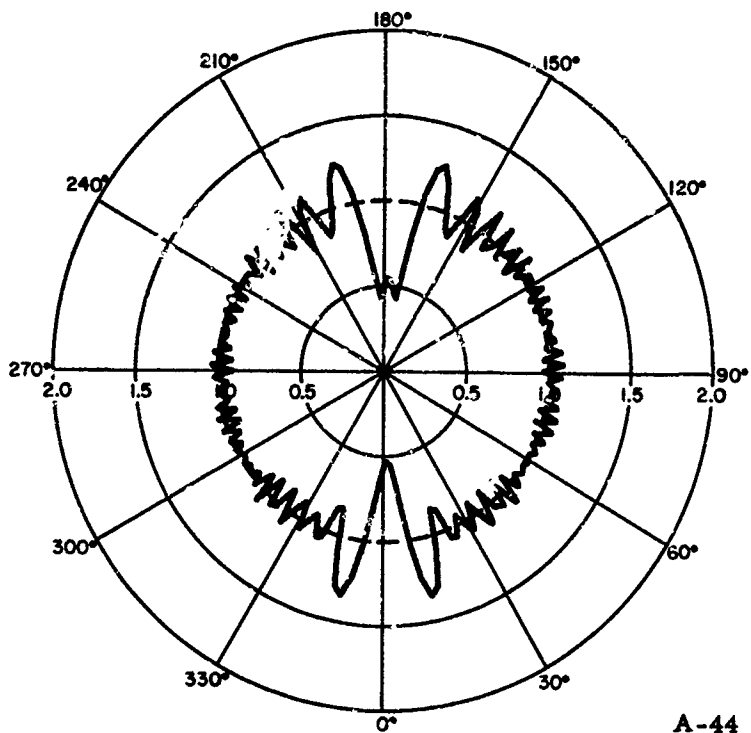
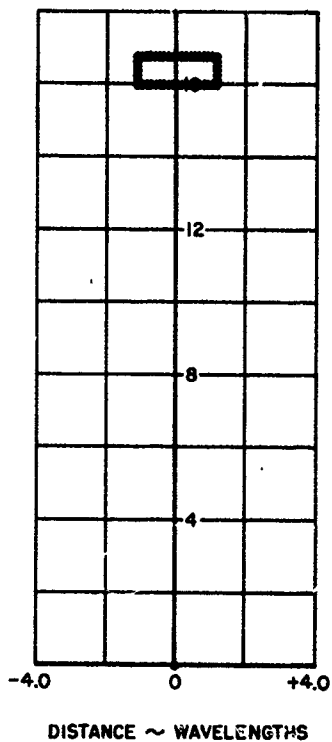
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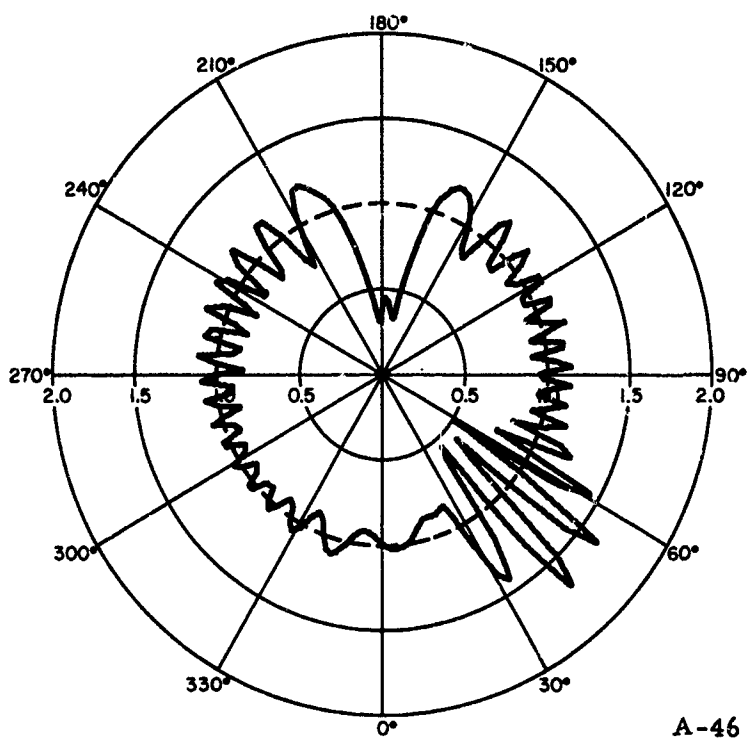
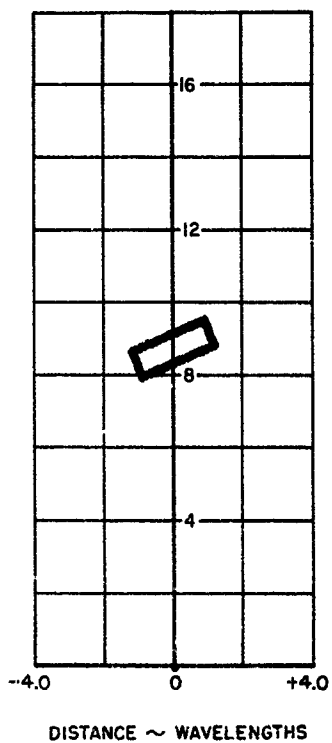


DISTANCE ~ WAVELENGTHS

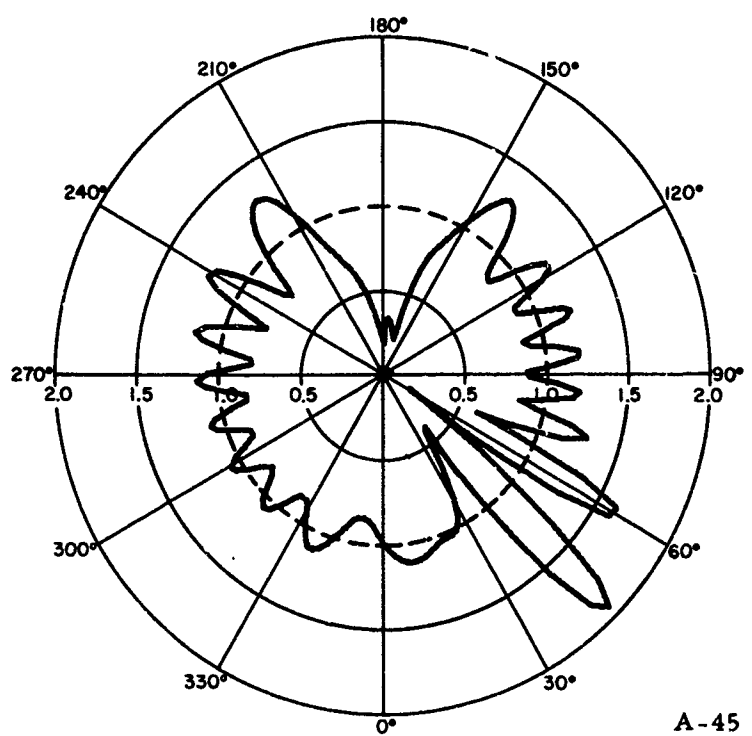
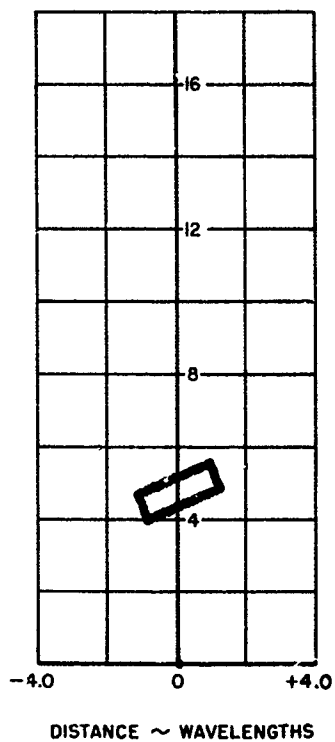


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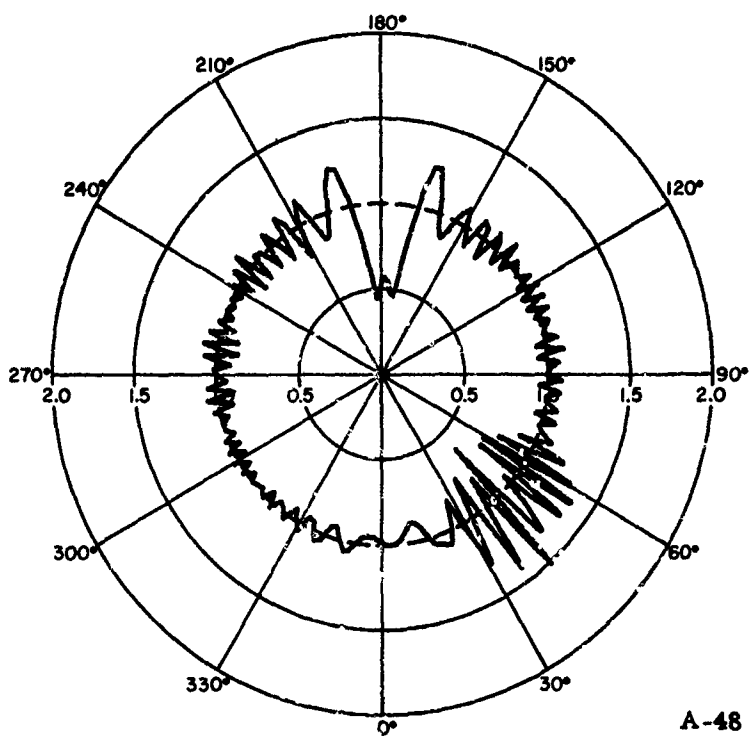
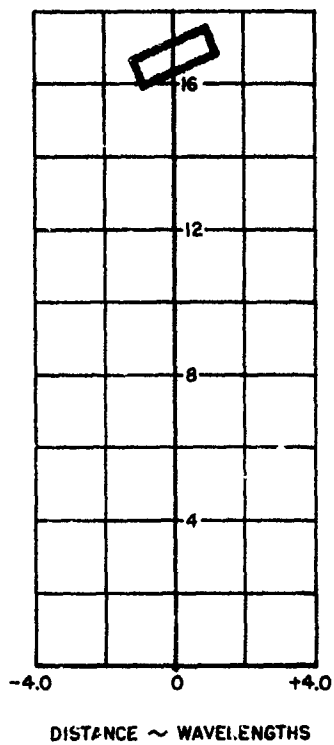




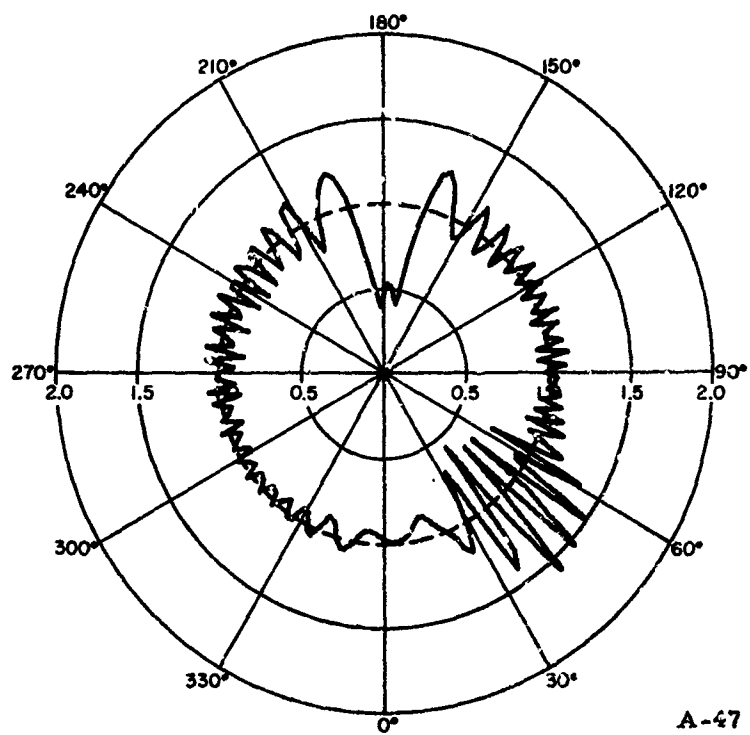
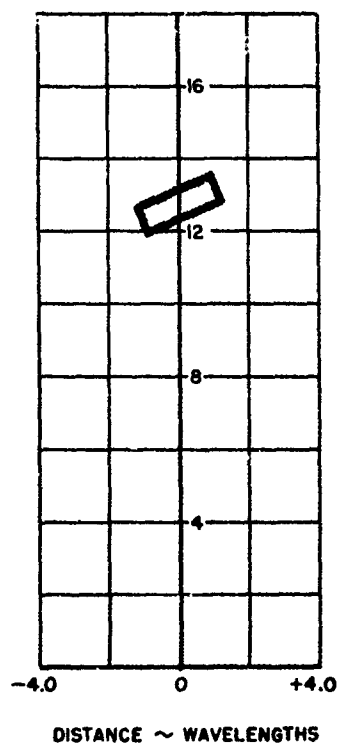
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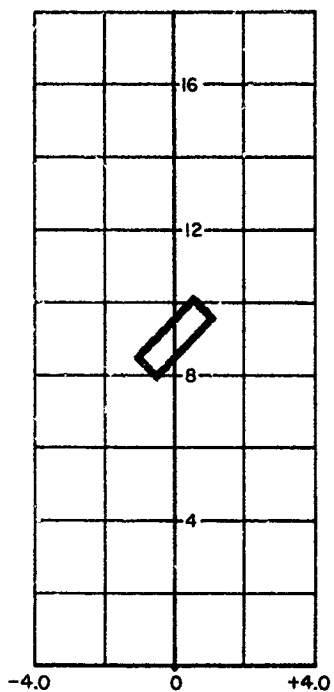
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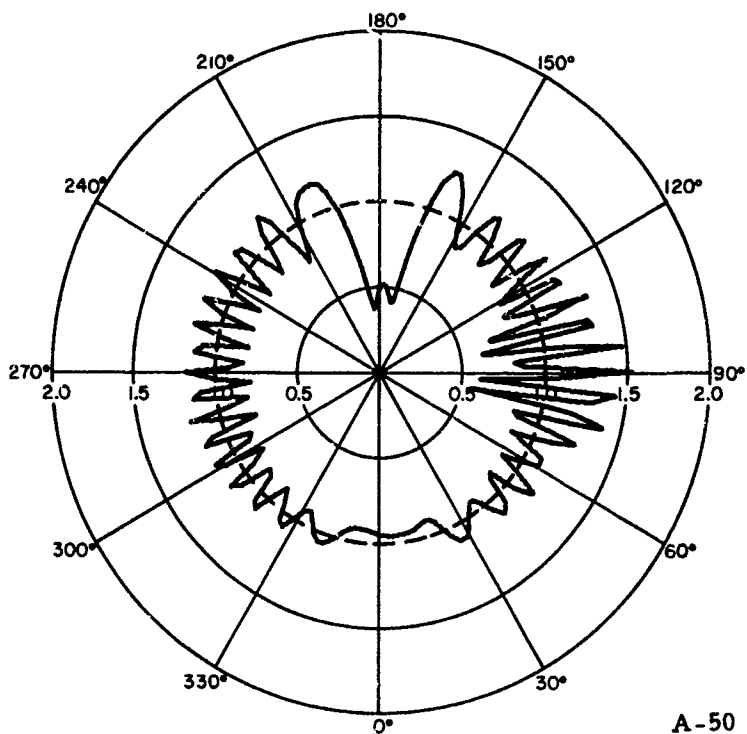
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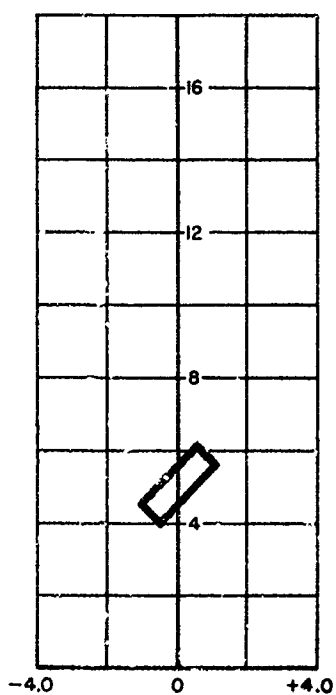
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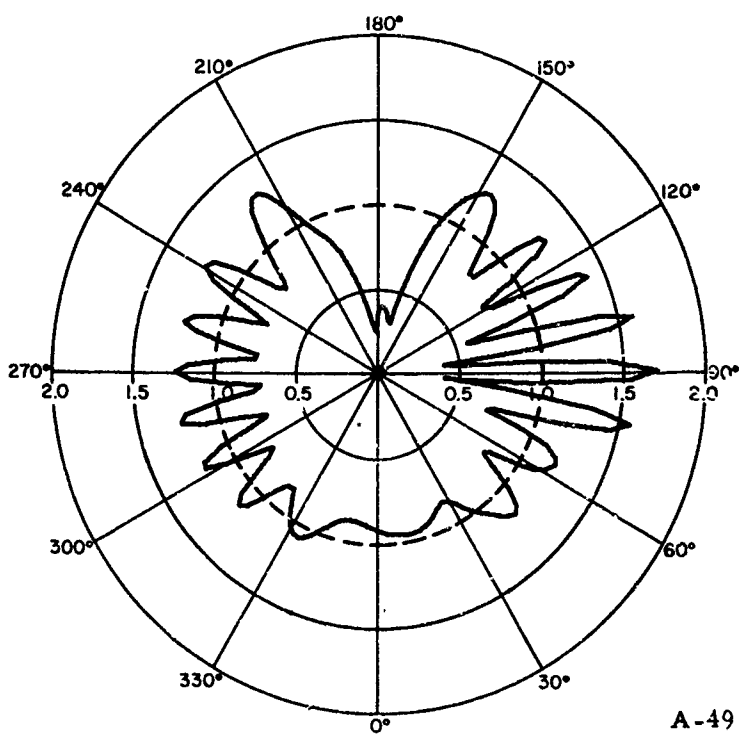
DISTANCE ~ WAVELENGTHS



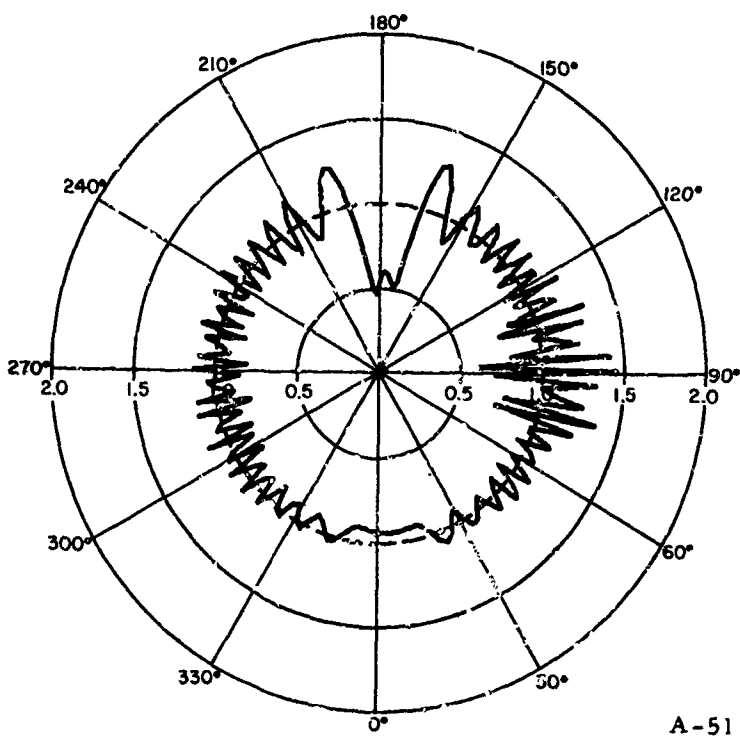
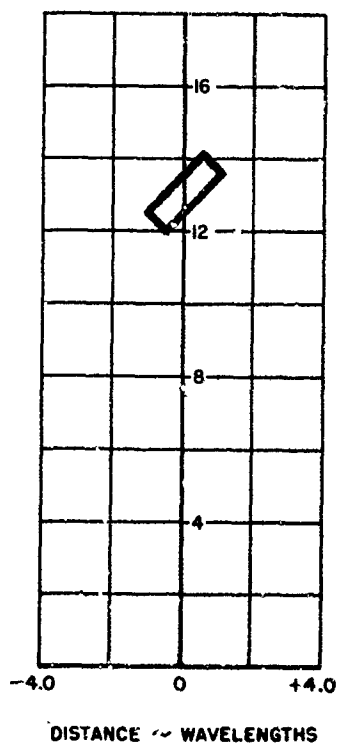
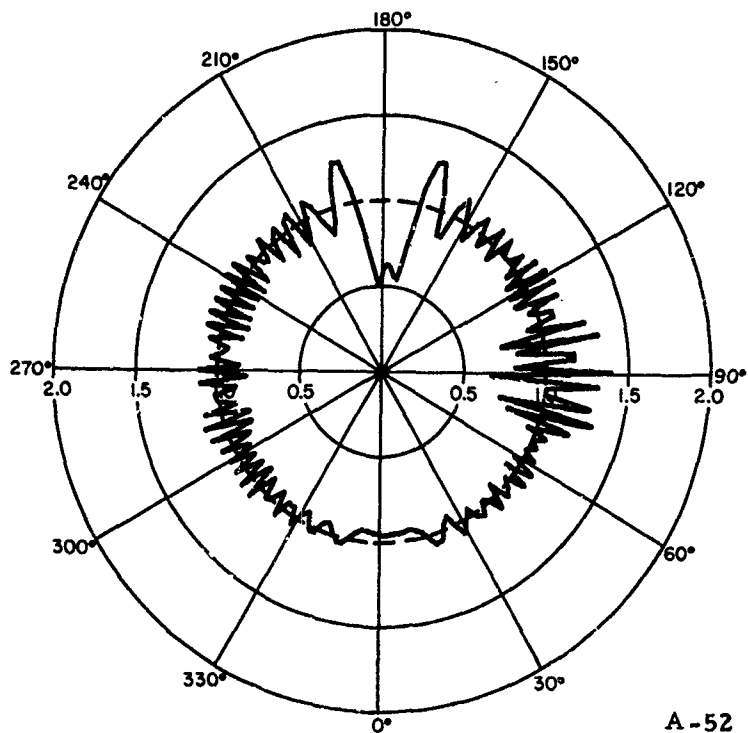
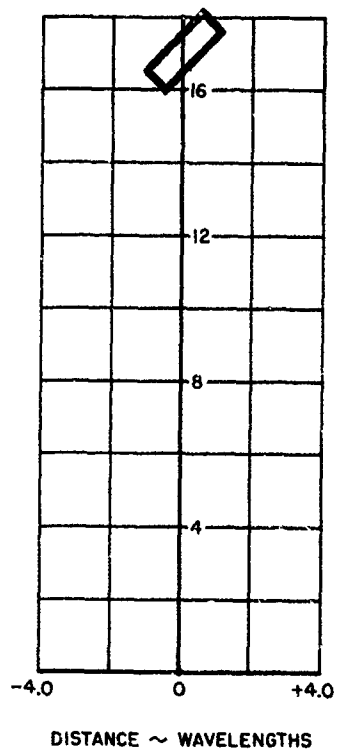
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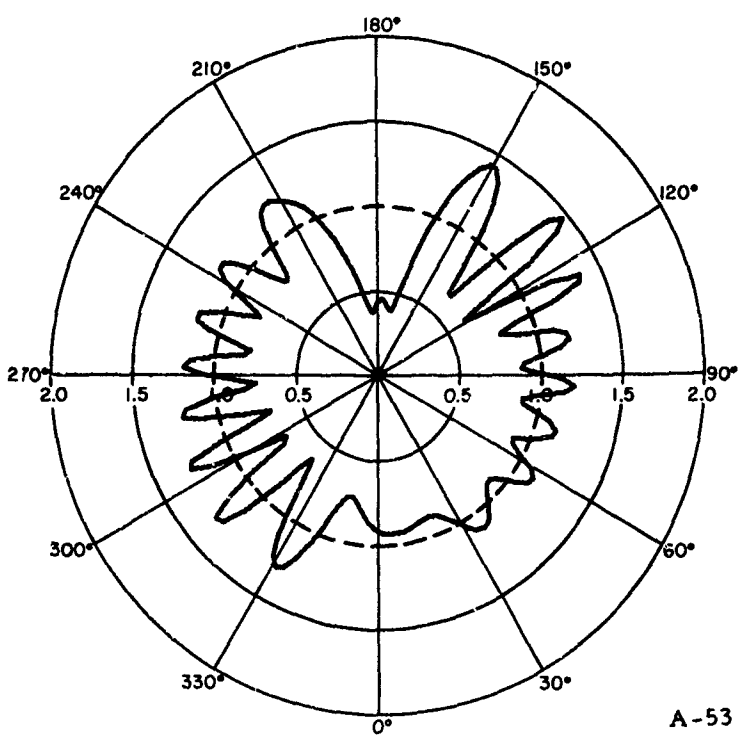
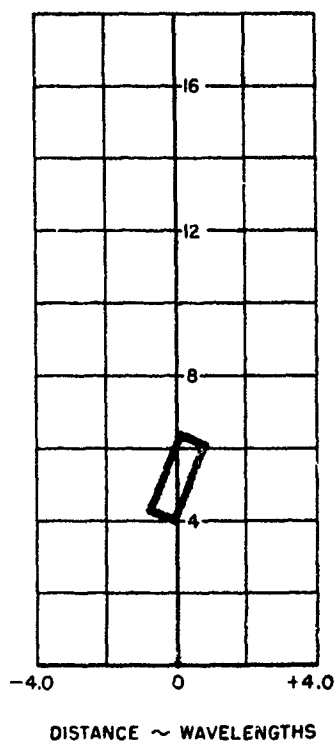
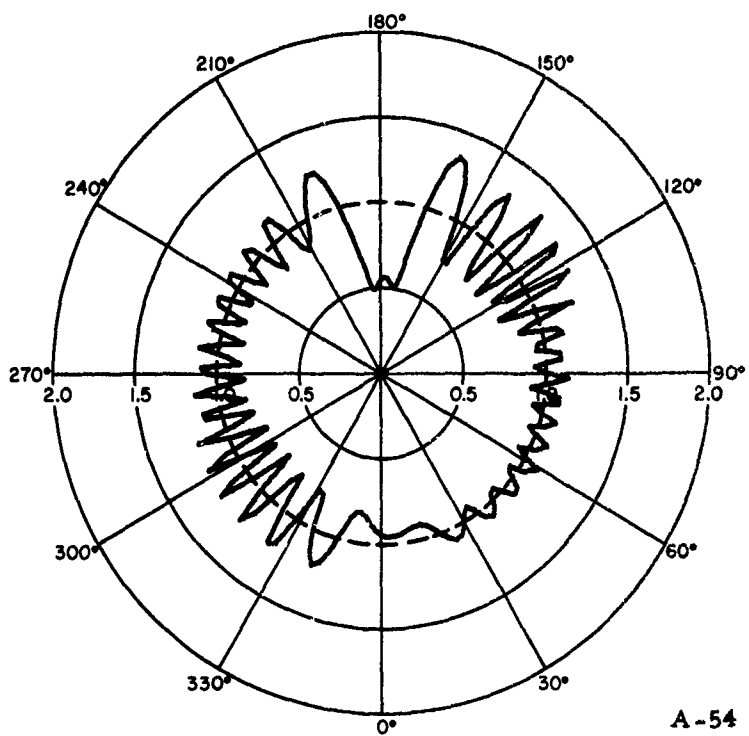
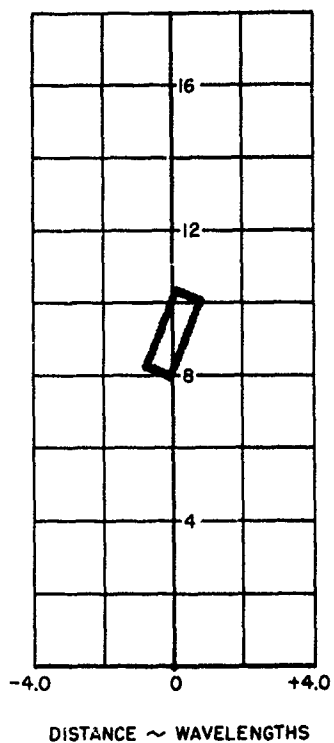


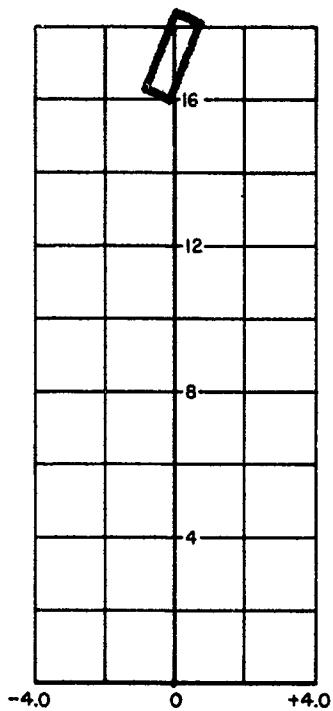
DISTANCE ~ WAVELENGTHS



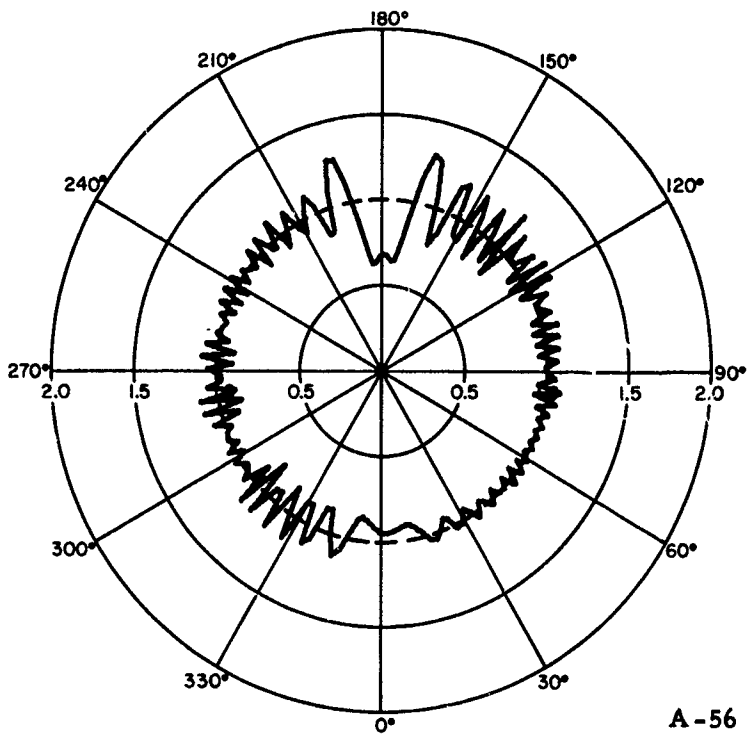
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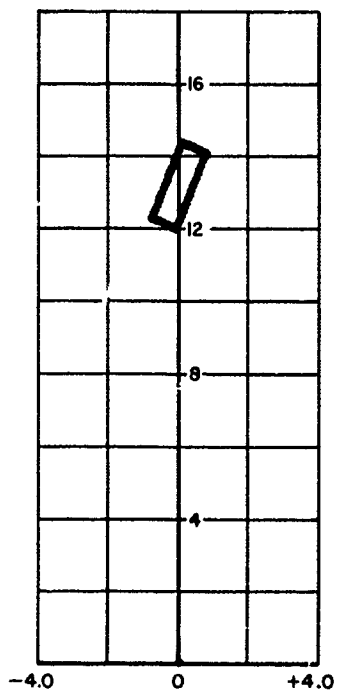




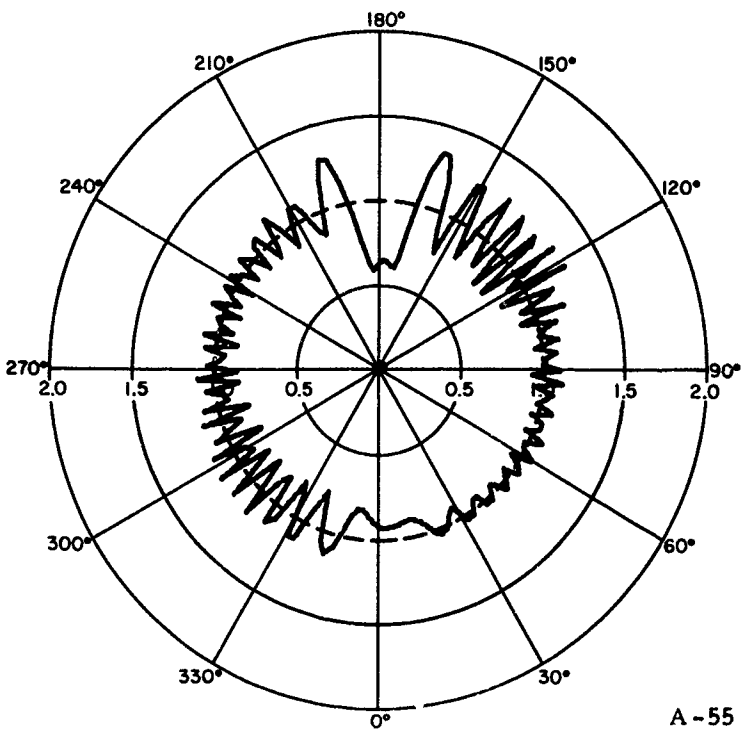
DISTANCE ~ WAVELENGTHS



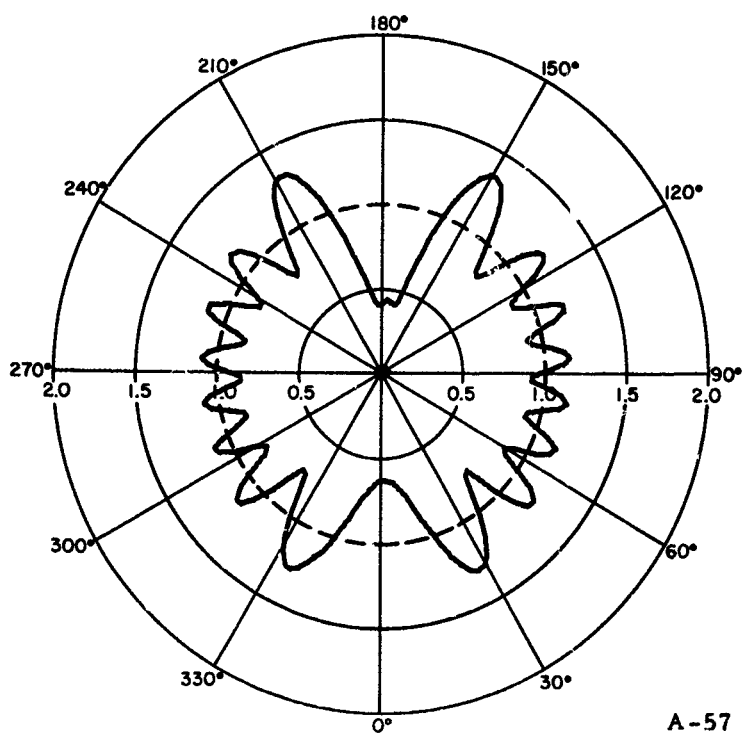
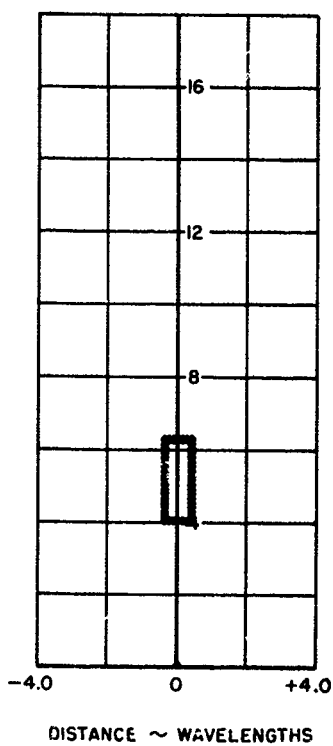
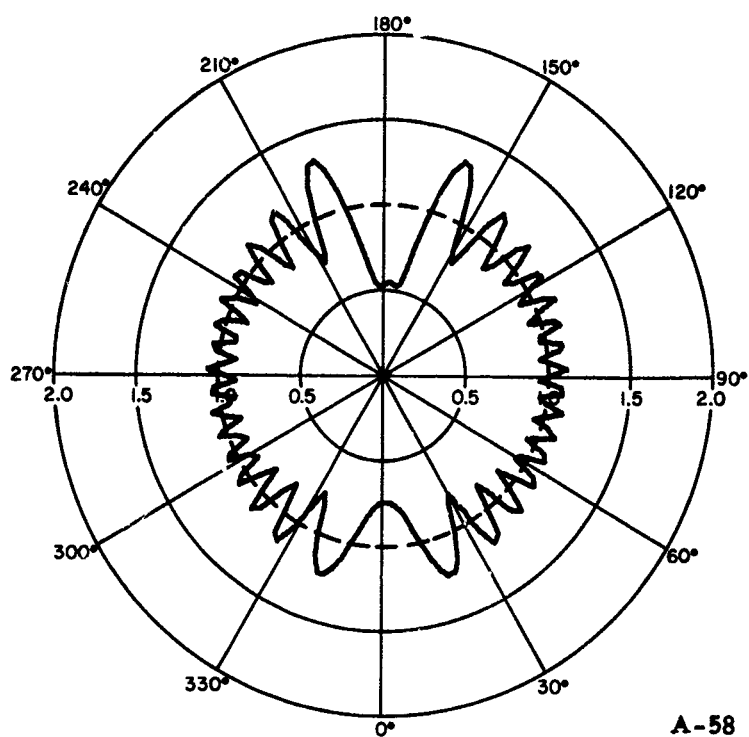
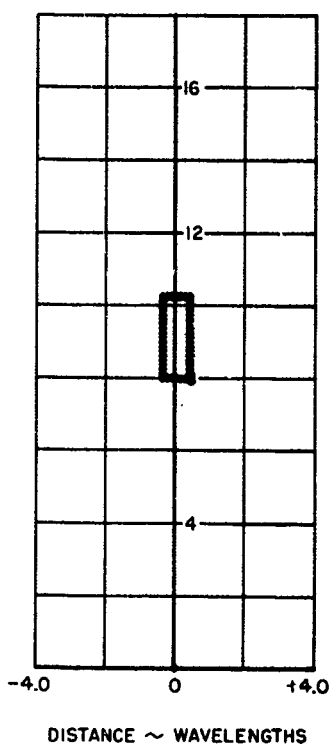
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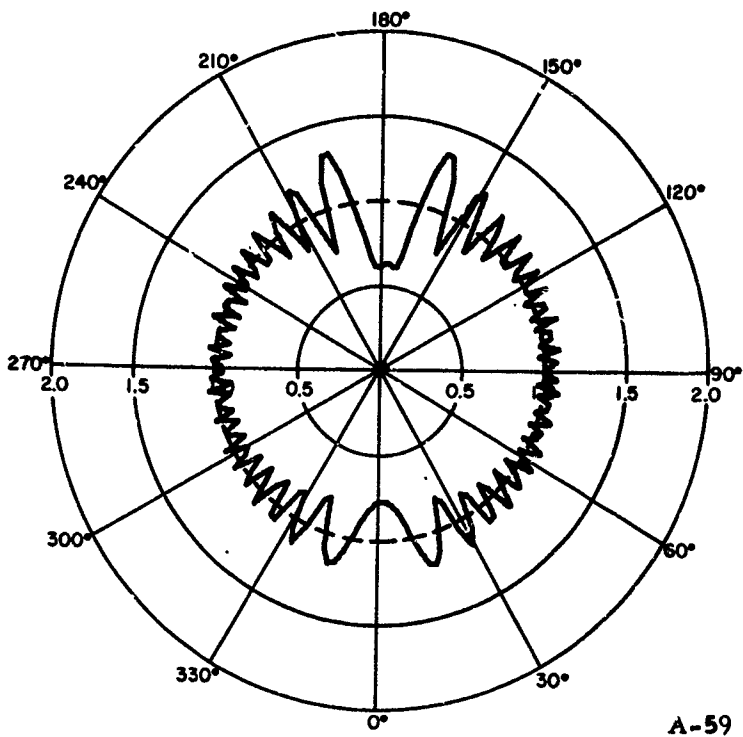
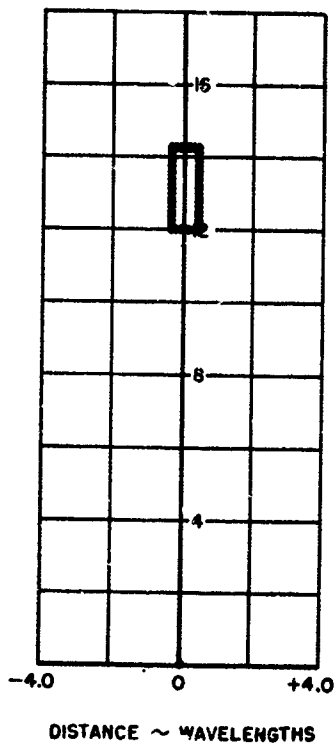
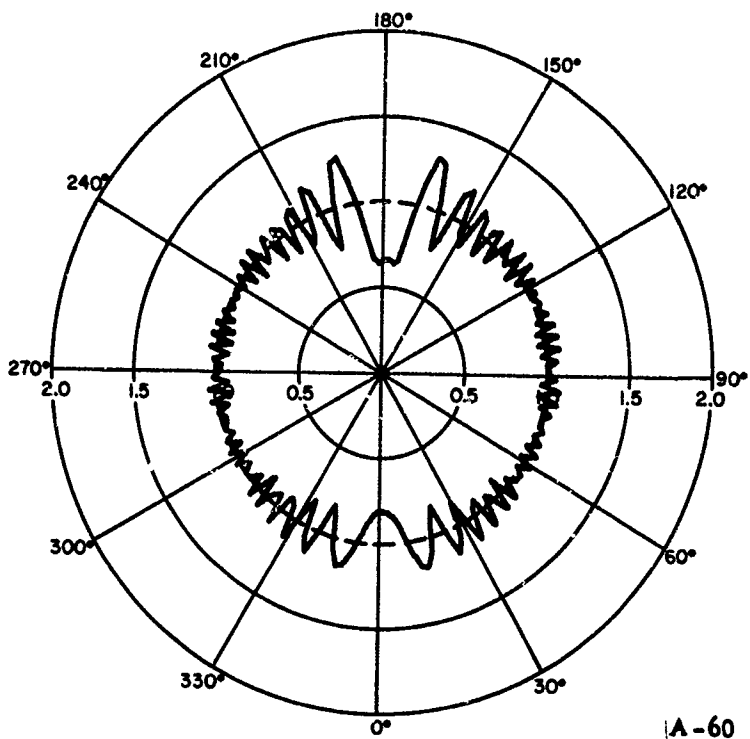
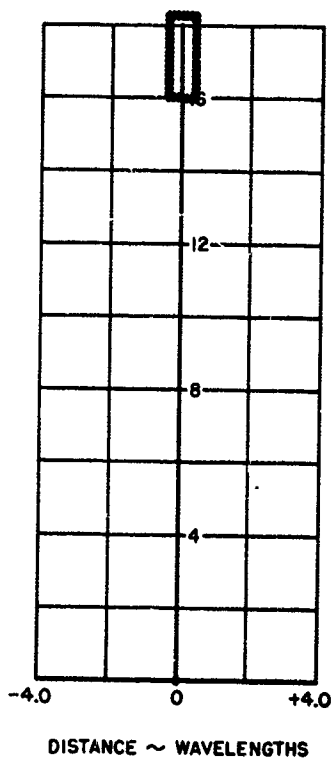


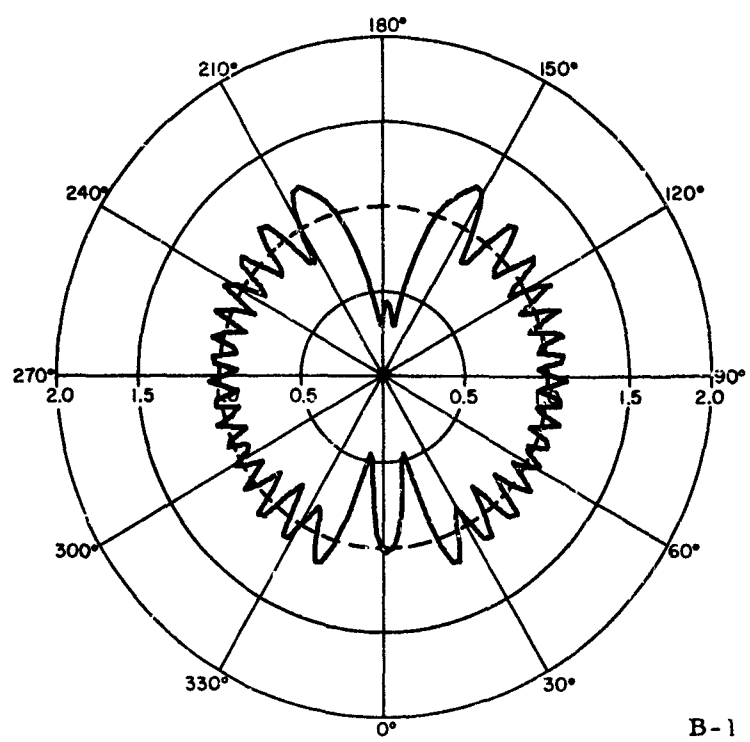
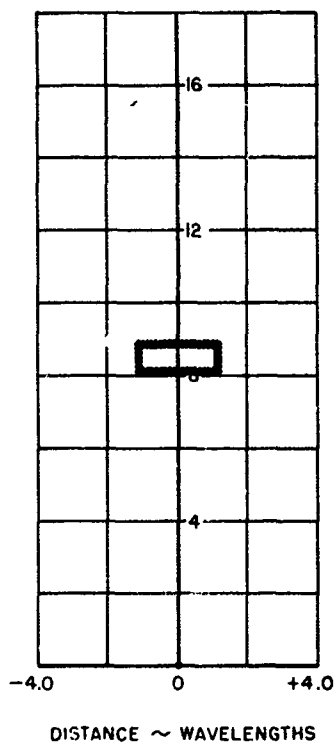
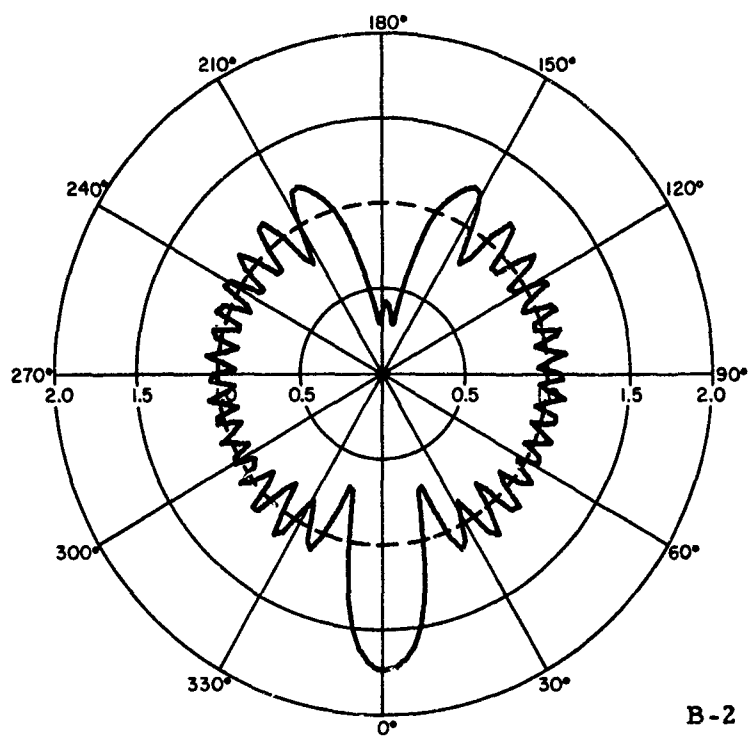
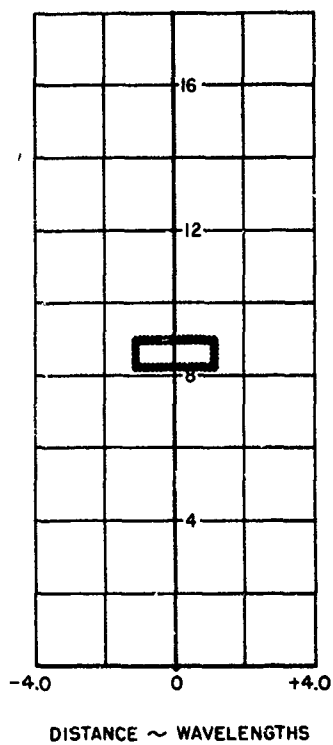
DISTANCE ~ WAVELENGTHS

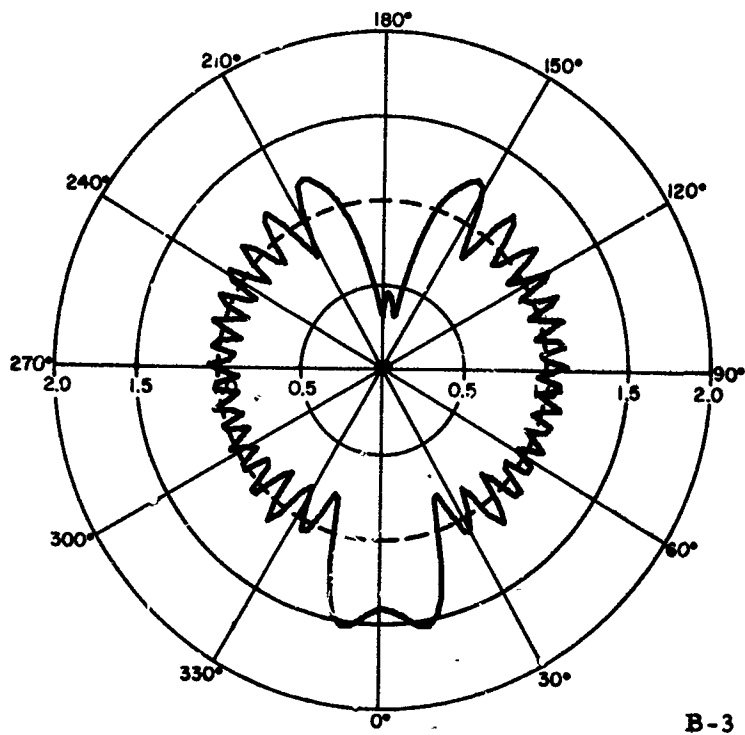
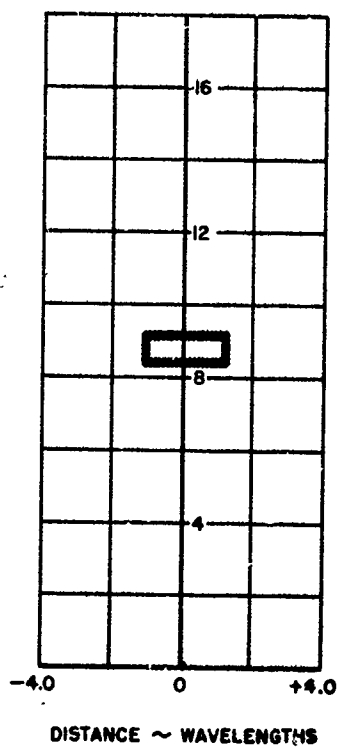
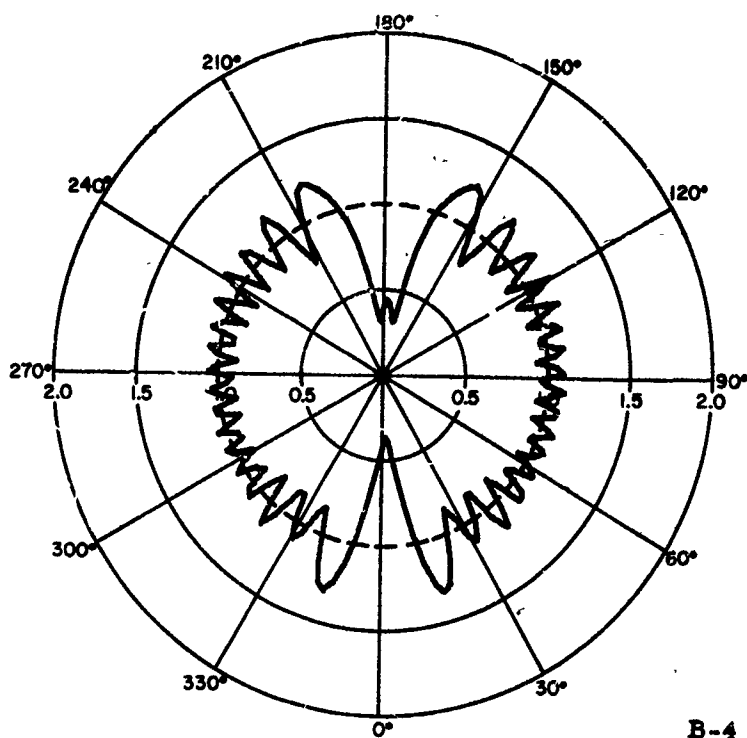
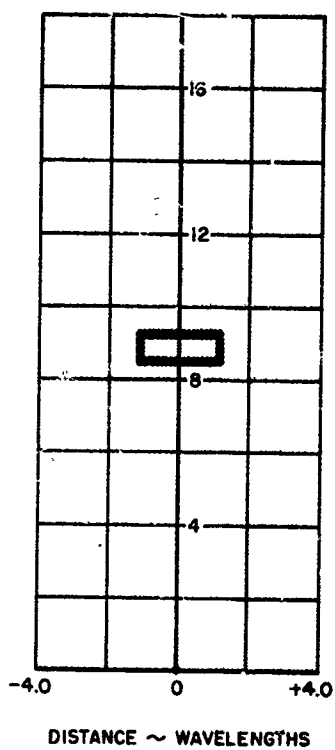


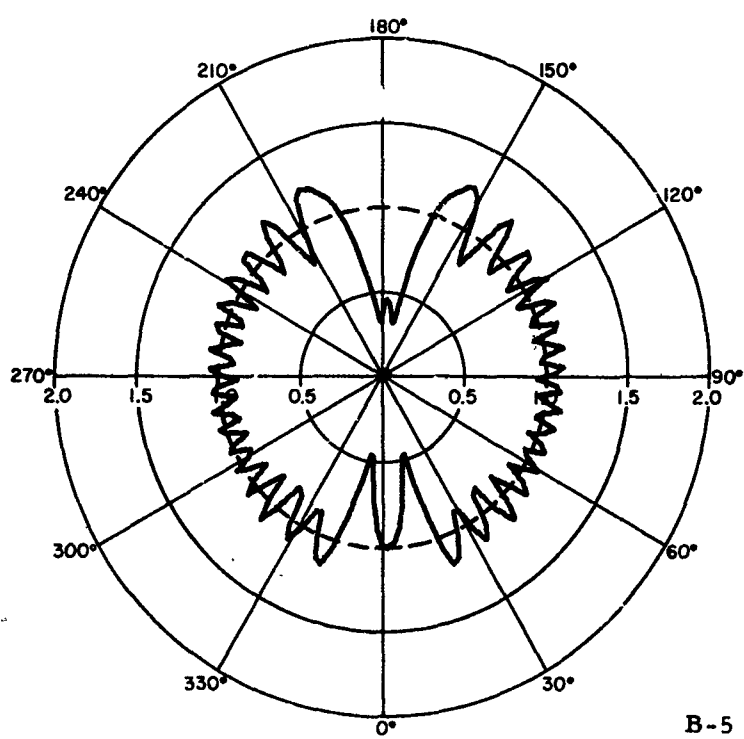
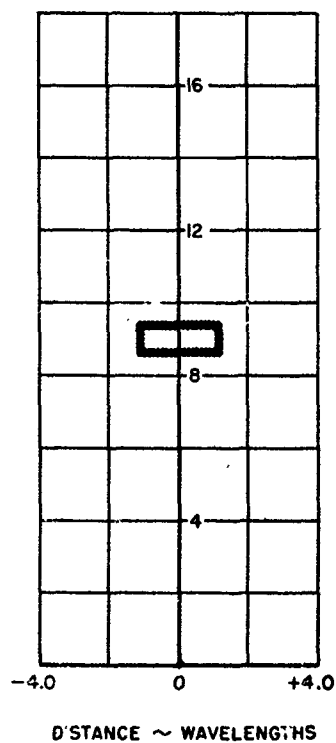
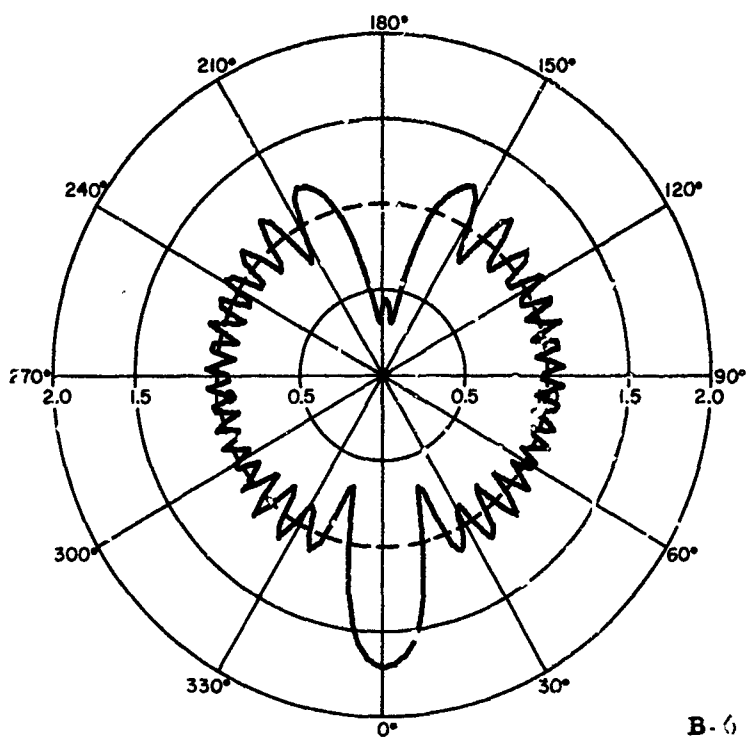
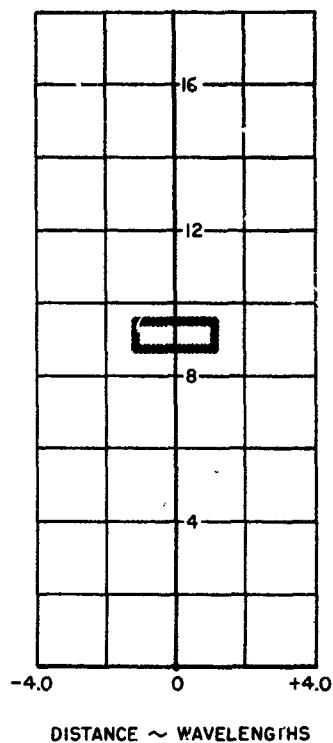
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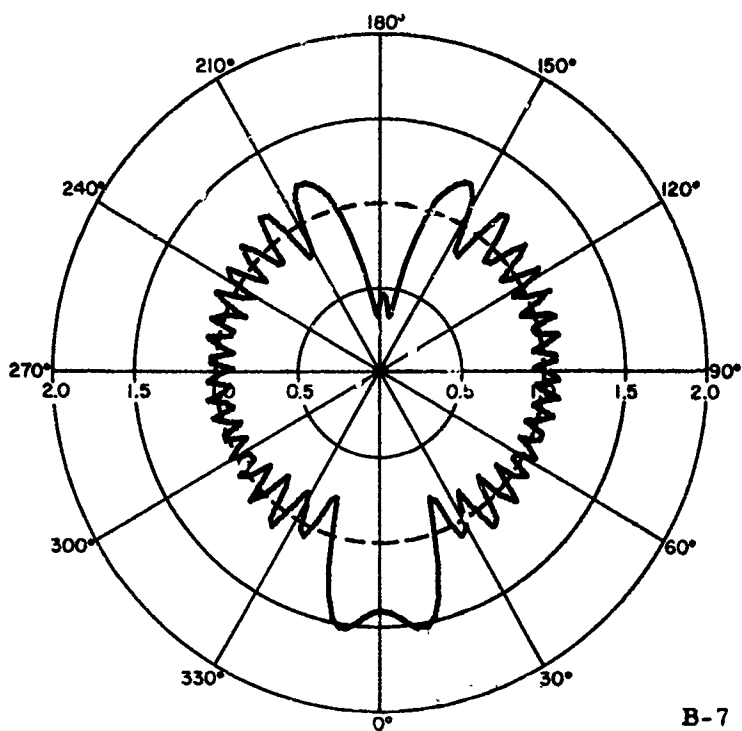
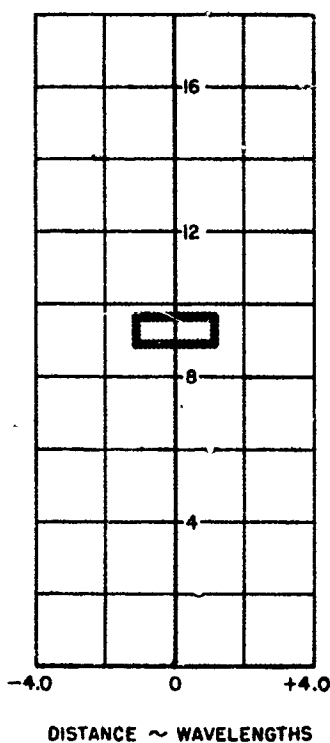
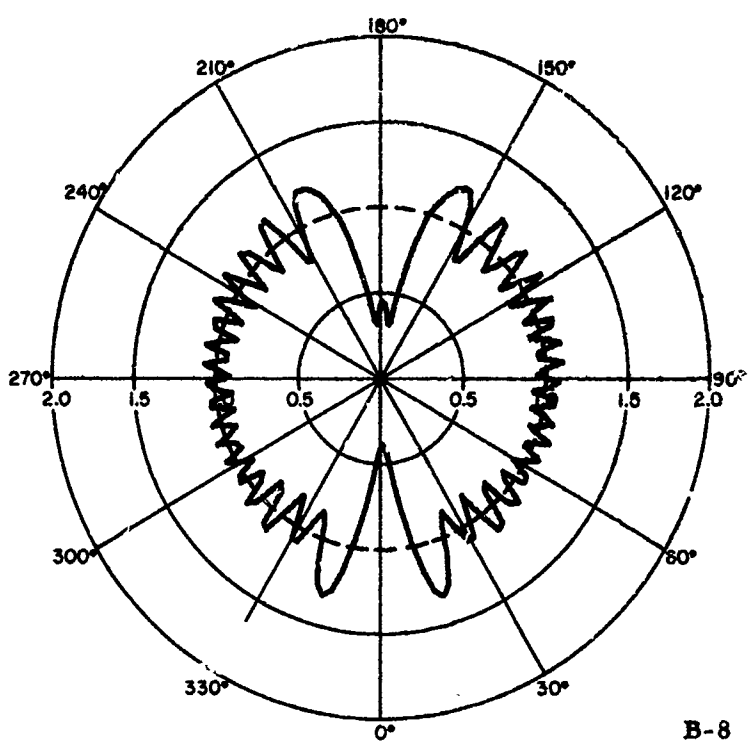
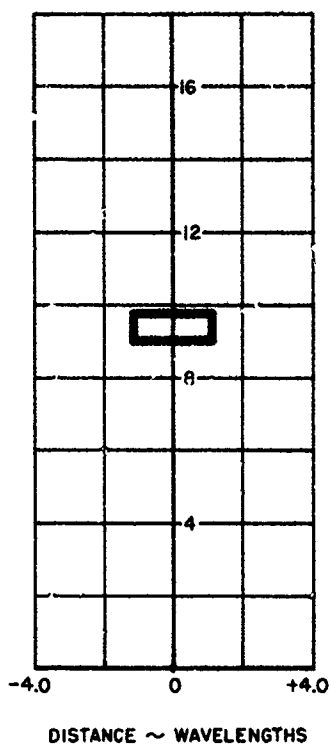


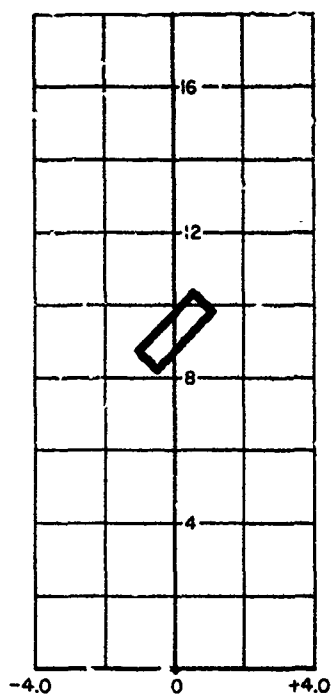




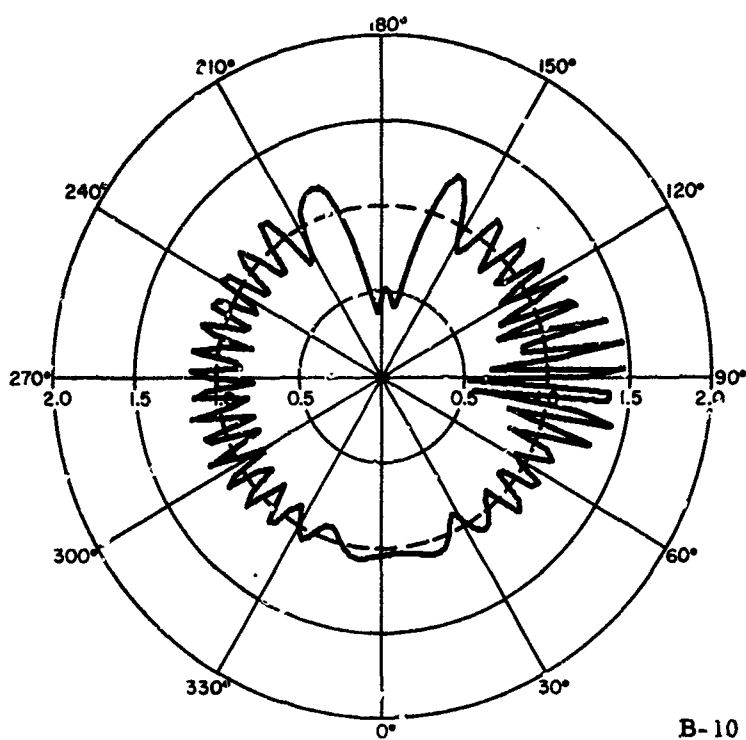




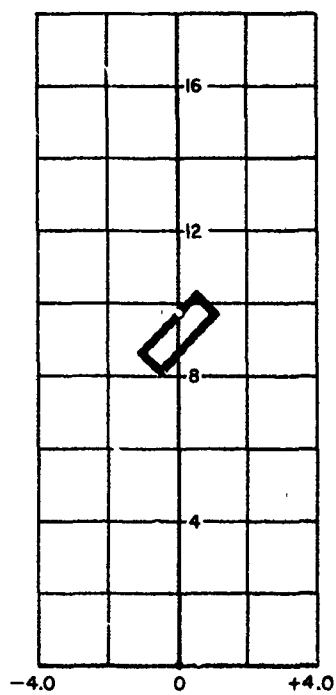




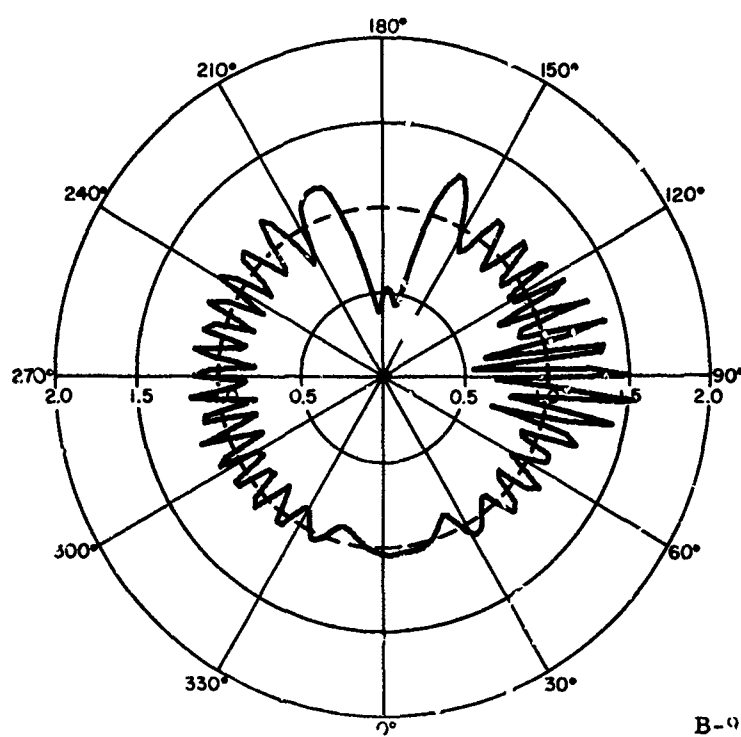
DISTANCE ~ WAVELENGTHS



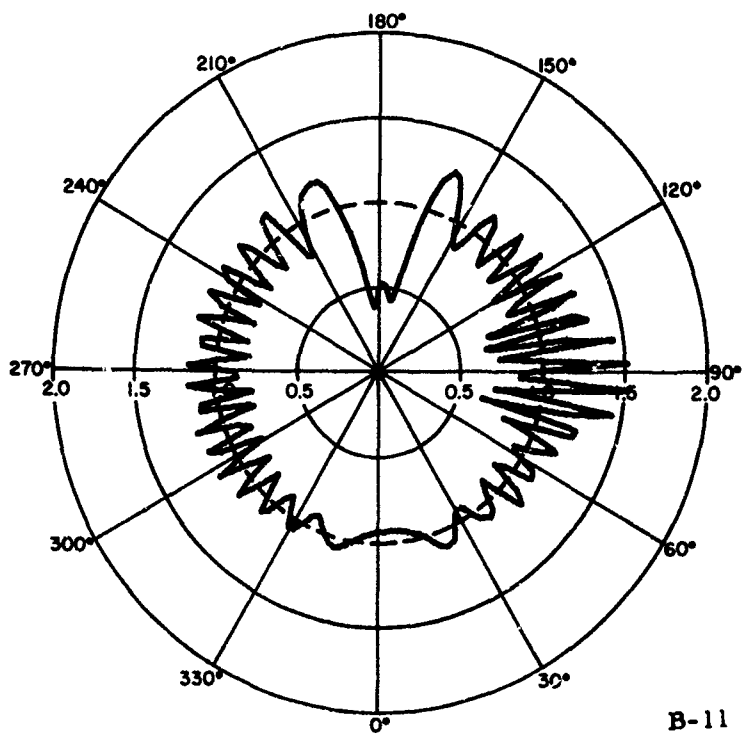
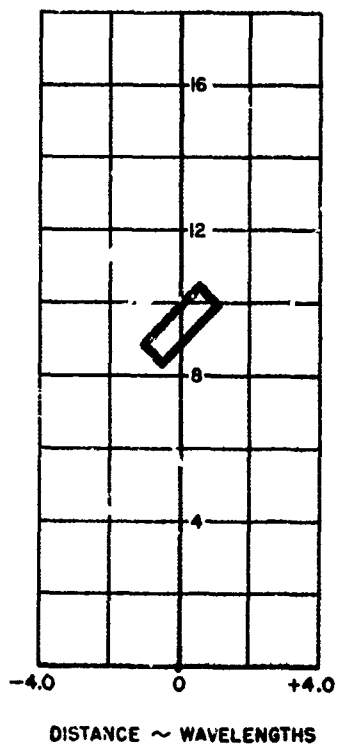
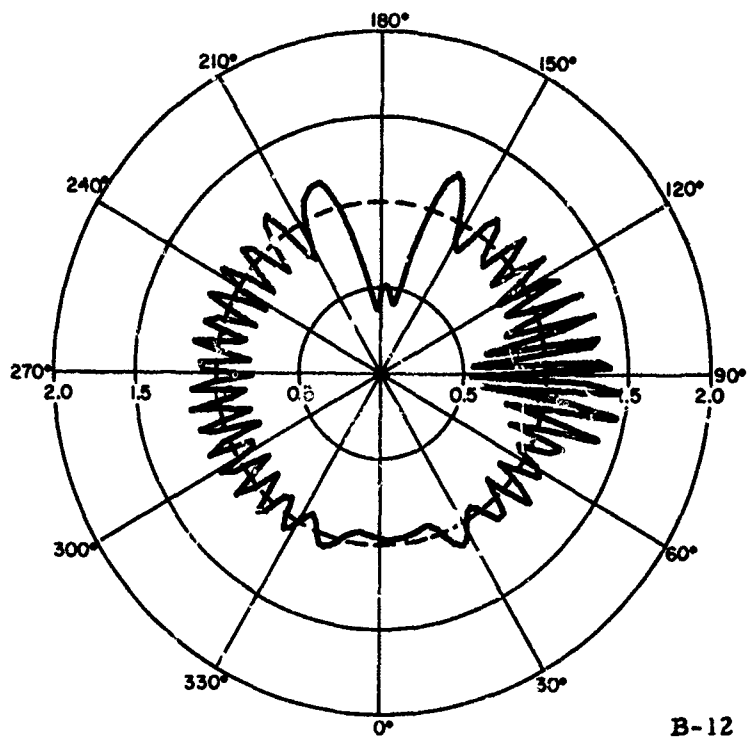
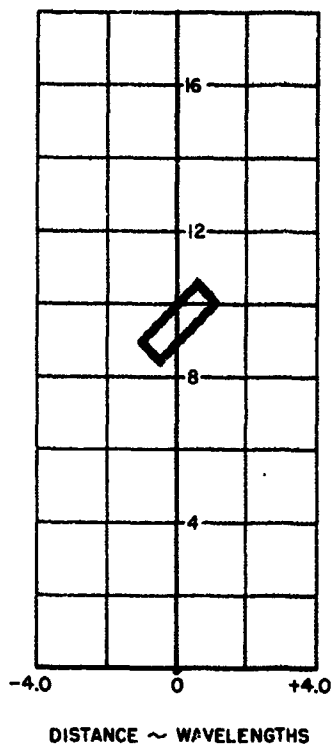
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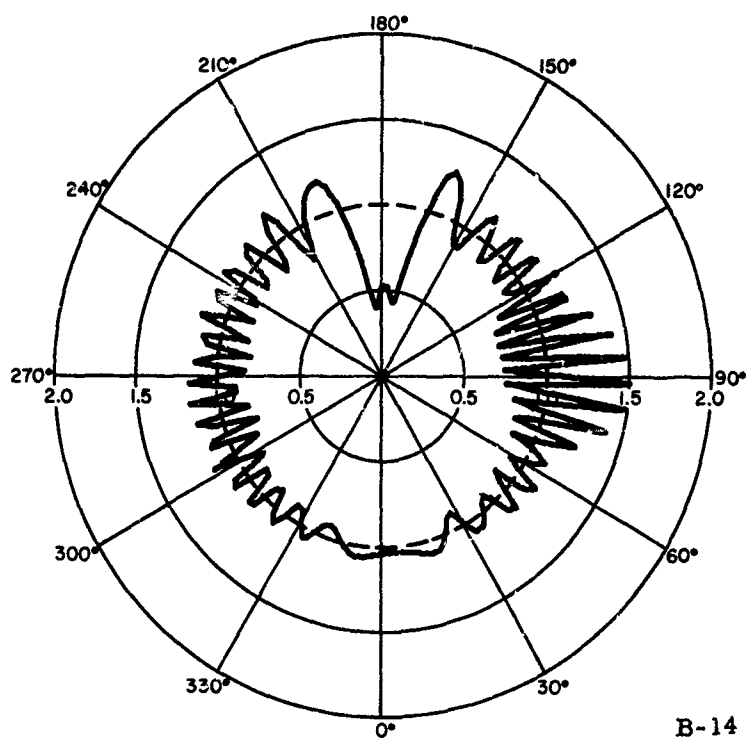
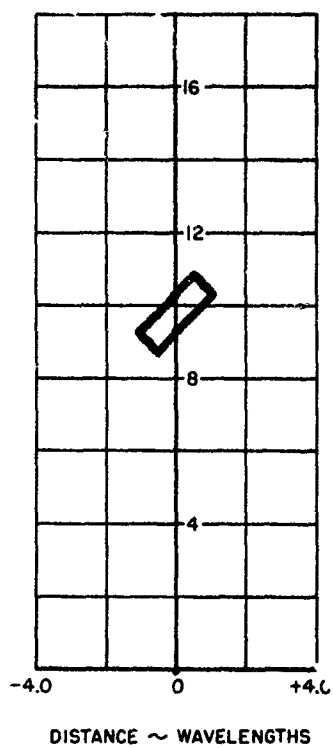


DISTANCE ~ WAVELENGTHS

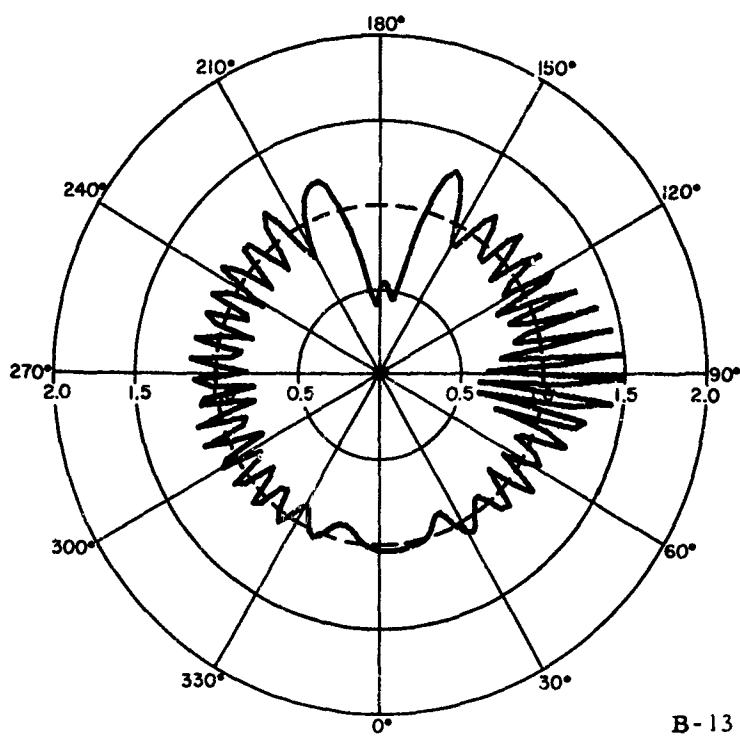
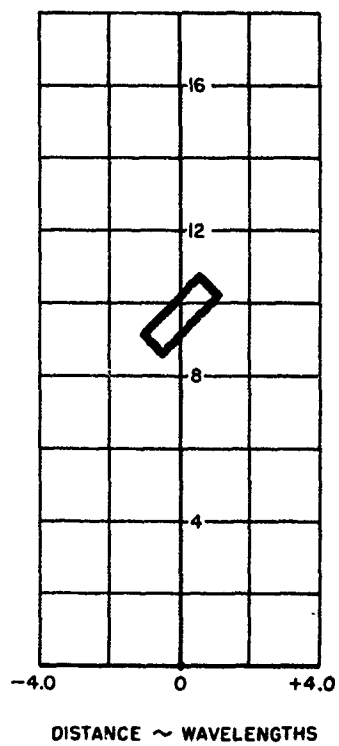


B-9

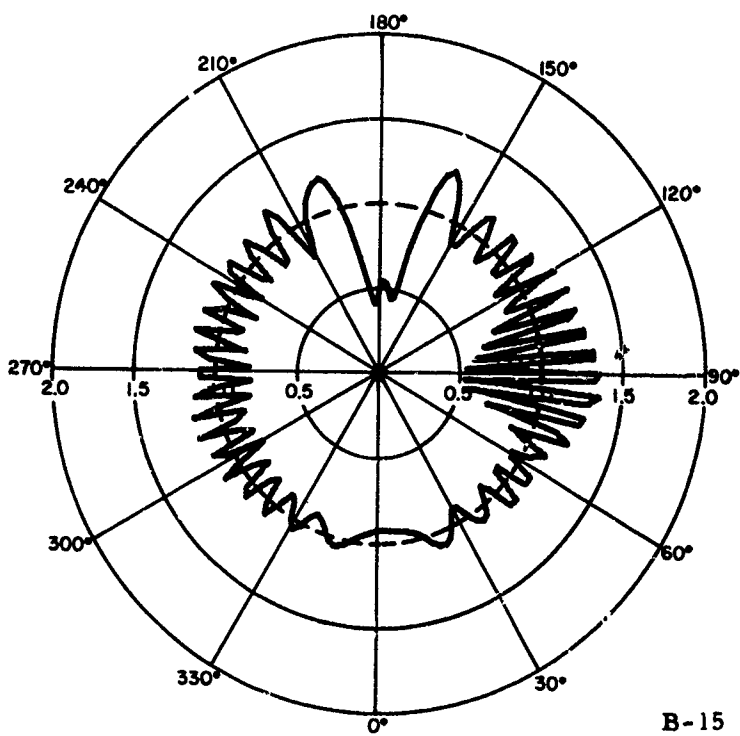
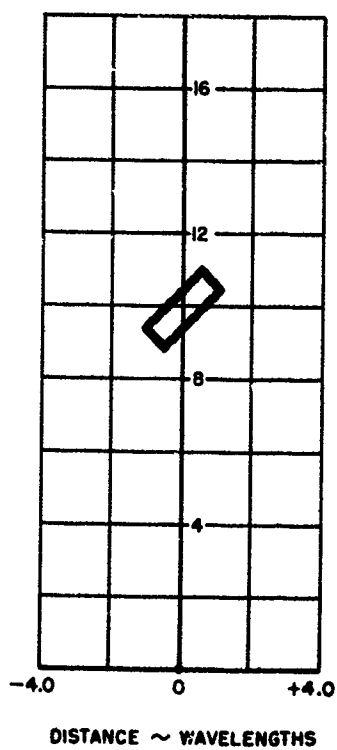
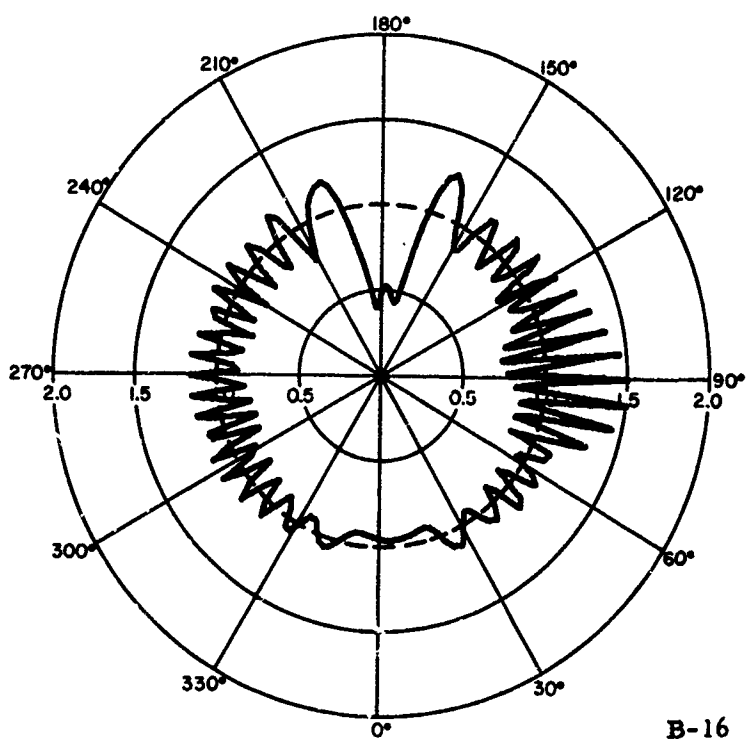
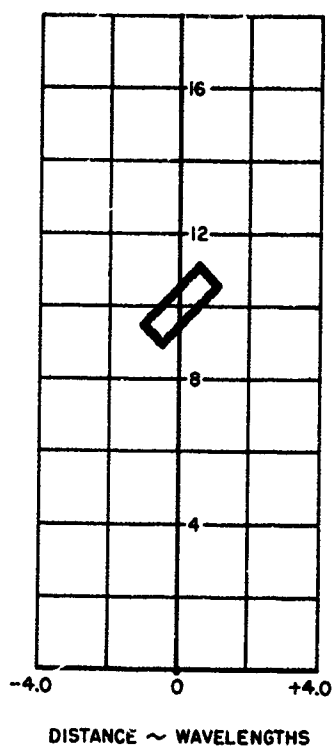


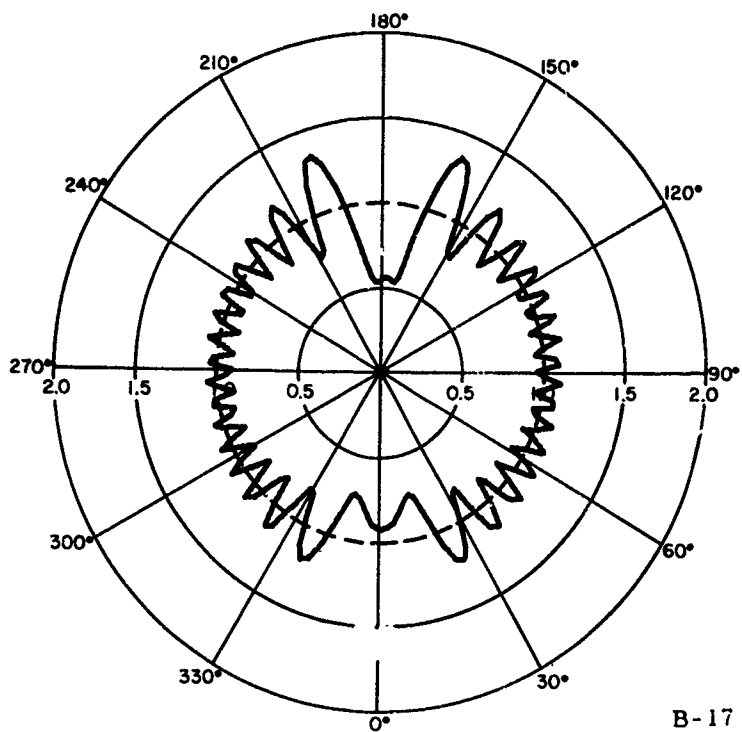
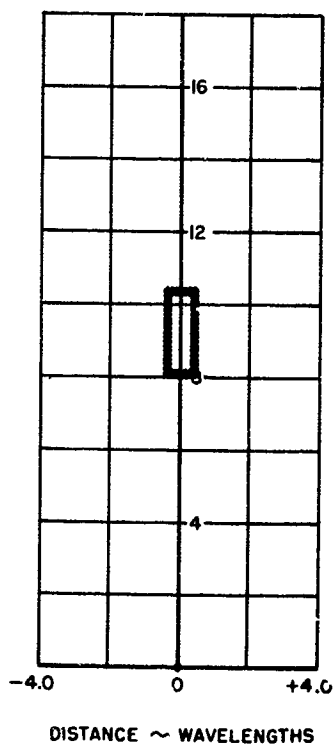
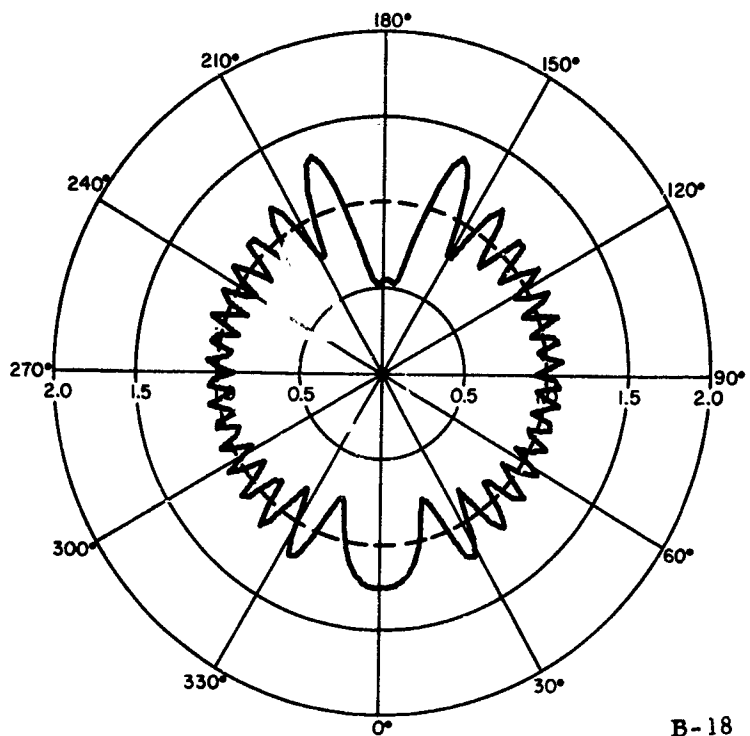
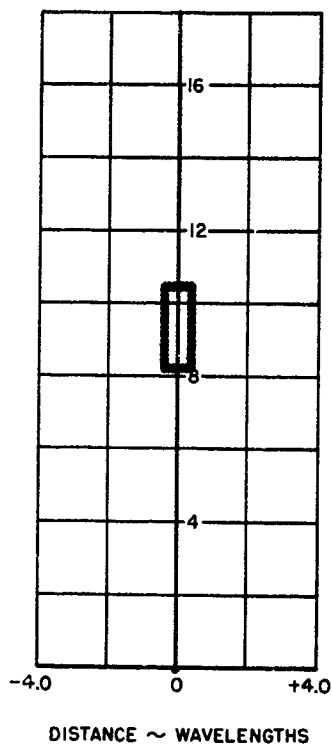


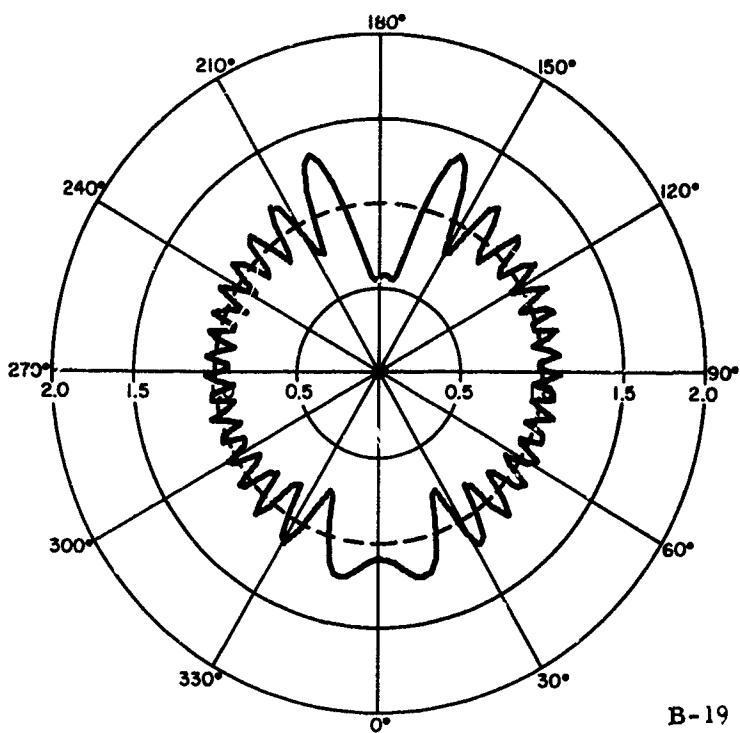
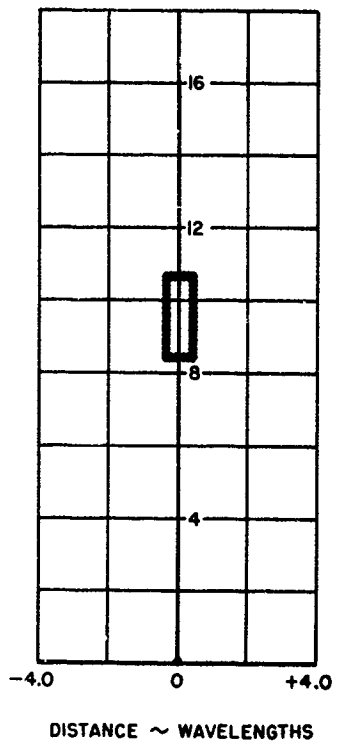
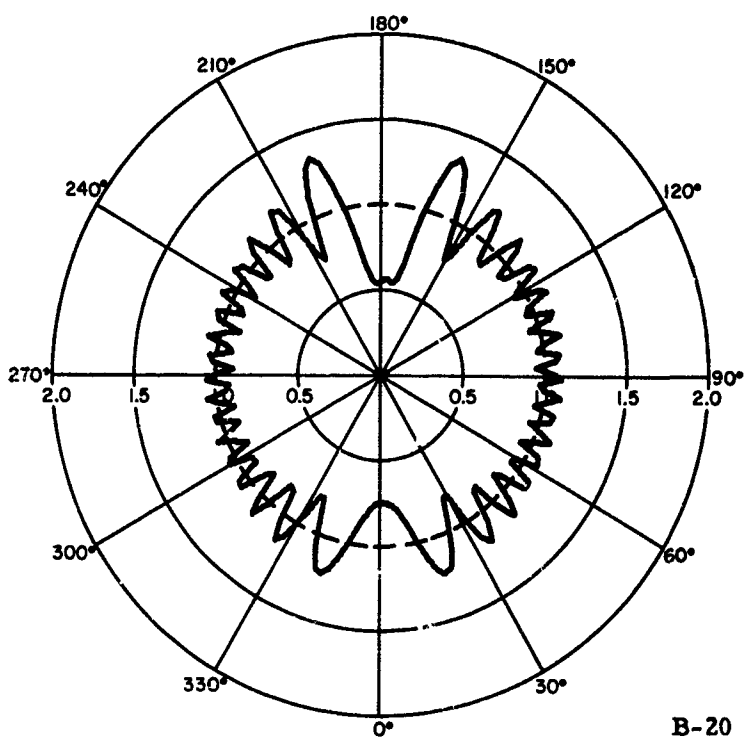
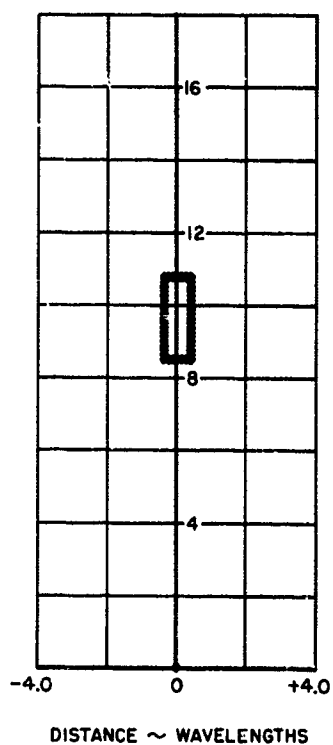
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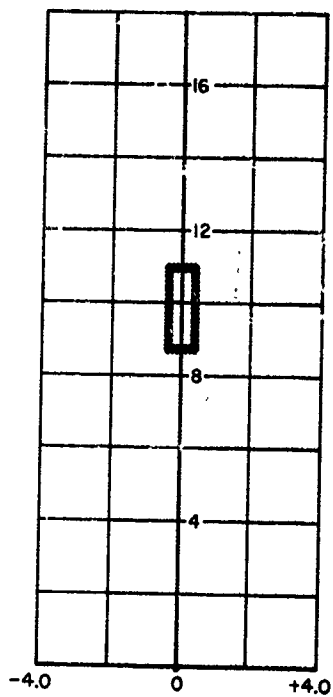


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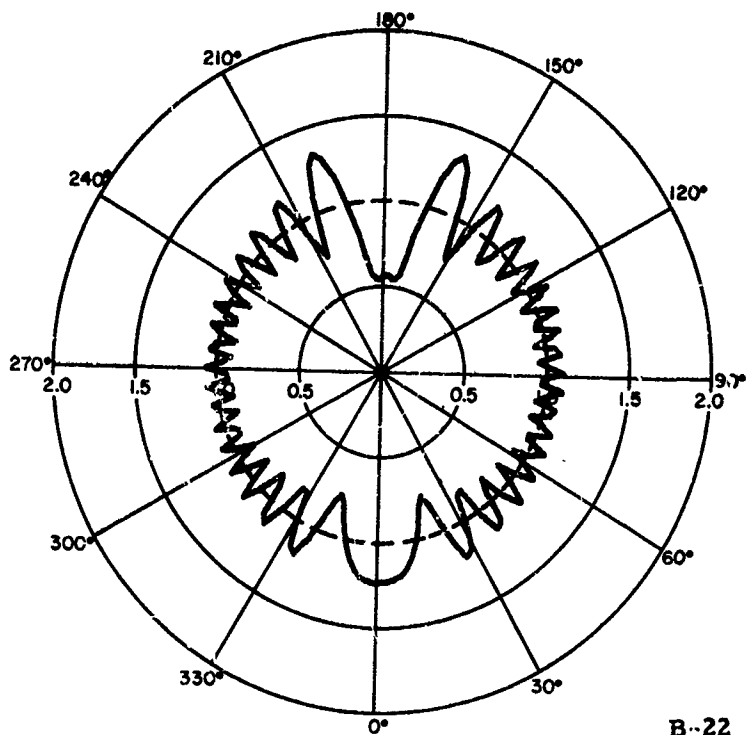




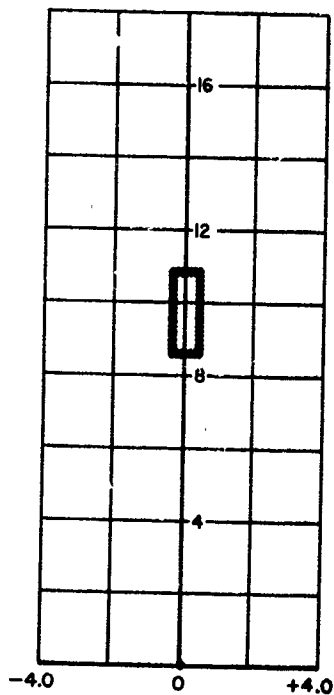




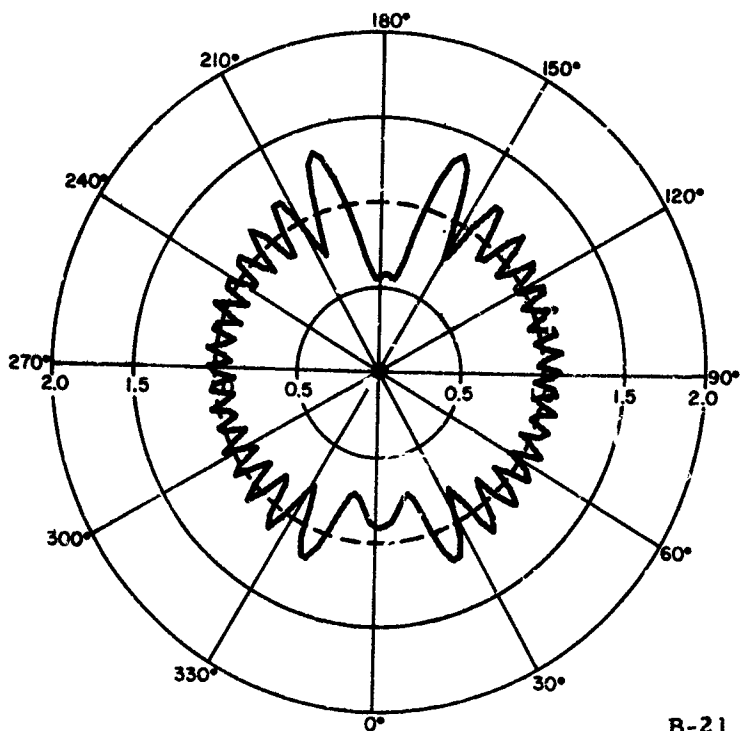
DISTANCE ~ WAVELENGTHS



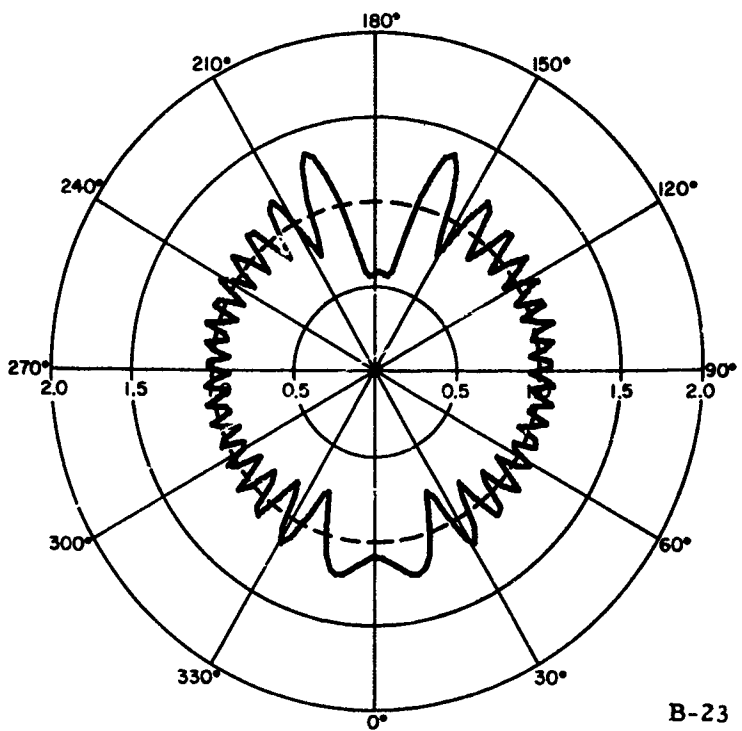
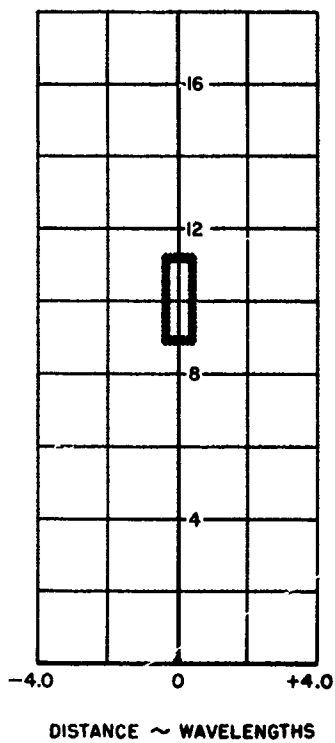
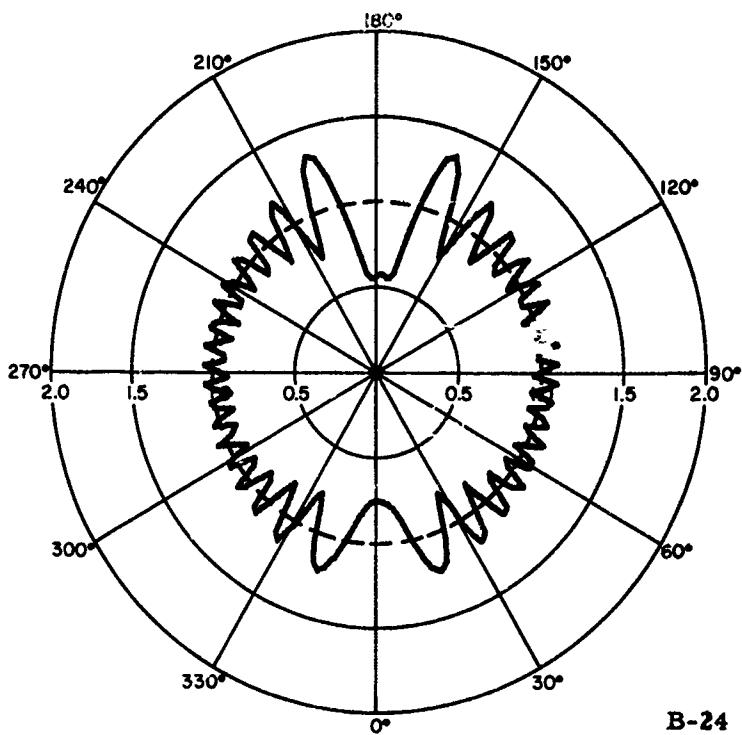
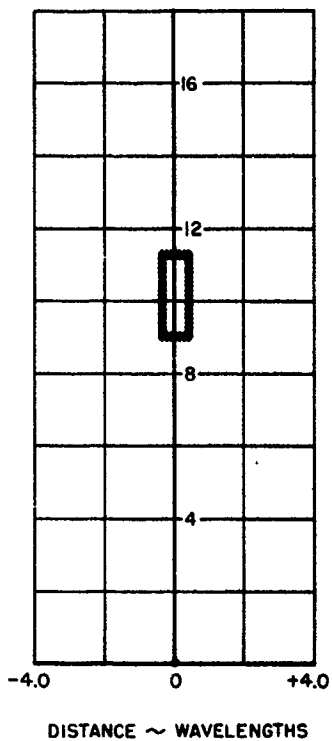
B-22



DISTANCE ~ WAVELENGTHS



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