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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

A TELEMETRY ANTENNA SYSTEM FOR A PROPULSION TEST VEHICLE

W. A. CUMMING

OTTAWA

JULY 1958

ABSTRACT

A telemetry antenna system has been developed in co-operation with CARDE, Valcartier, Que., for use on a propulsion test vehicle being developed by the latter organization. Scale-model pattern measurements and full-scale impedance measurements show that satisfactory operation can be expected by using three inclined-blade unipoles, disposed symmetrically around the circumference of the vehicle near the nose. Two of these are excited in push-pull, and the third, which is present only to preserve physical symmetry, is left open-circuited.

CONTENTS

TEXT

FIGURES

A TELEMETRY ANTENNA SYSTEM FOR A PROPULSION TEST VEHICLE

- W.A. Cumming -

INTRODUCTION

At the request of the Canadian Armament Research and Development Establishment, Valcartier, Que., a project was initiated to develop a telemetry antenna system for a proposed propulsion test vehicle. Since the telemetry equipment was to be located near the nose of the vehicle, it was hoped that the antennas could be located in this region rather than in the conventional position near the tail. It was felt that some pattern deterioration could be accepted in order to avoid the long exterior cable-run to the tail of the vehicle, and it was further decided, because of the intended purpose of the vehicle, to use exterior antennas, thereby avoiding the complexity of a flush system. In view of the location of the antennas, it was also believed that exterior antennas would give rearward coverage superior to that of flush antennas.

Since the vehicle was to have three control surfaces disposed symmetrically around its circumference, the antenna system was required to be similarly symmetrical, in order to simplify the design of the launching tower. This logically led to the choice of three unipoles, inclined at 45° to the vehicle axis in order to improve their aerodynamic properties and pattern coverage. The problem then became one of first determining the proper excitation for the three radiators, and second, matching them over the telemetry band of 215 to 235 mc/s.

RADIATION PATTERNS

The pattern study was carried out using a model of the vehicle, constructed to a scale of 1 : 13.75. Radiation patterns of the three unipoles excited with various current ratios were measured on an automatic antenna pattern recorder in the usual fashion. The scale-model vehicle with the three antennas installed is shown mounted on the model-supporting tower in Fig. 1. A number of methods of feeding the antennas were investigated, and it was found that the most uniform coverage could be obtained by feeding two unipoles in push-pull, and leaving the third open-circuited. The performance of this latter system can be seen by reference to the coordinate system of Fig. 2, and the radiation patterns of Figs. 3 to 11. A complete set of conical patterns ($0° < \theta < 180°$) was measured, using a right-hand circularly polarized source antenna. A complete set was then measured for the two orthogonal components, E_θ and E_ϕ, of the circularly polarized wave, so that the antenna gain could be determined. This operation was carried out with the aid of an automatic pattern integrator which operates in conjunction with the pattern recorder. Referring to the radiation patterns, the solid circle superimposed on the patterns measured with a circularly polarized field represents the field strength of an equivalent circularly polarized isotropic antenna. Thus the gain of the antennas referred to this standard may be easily read off the patterns. Discussion of these patterns with CARDE personnel led to the conclusion that while the coverage is less than ideal, it would be sufficient for the intended use of the vehicle. A study of the linearly polarized patterns shows that considerable null-filling could be achieved by using a dual-channel polarization diversity system, which would of course result in considerable complexity. The level of the equivalent linearly polarized isotropic antenna is noted, so that should such a system ever be considered, the antenna gain for the two component polarizations will be known.

IMPEDANCE CHARACTERISTICS

The full-scale antennas were designed and manufactured by CARDE in accordance with an approximate electrical design provided by this Division. While this approximate design called for blade antennas, CARDE developed two sets of radiators: one, a set of three tapered rod antennas, and the other, a set of three tapered blade antennas. The mechanical details of these radiators are shown in CARDE drawings A/57111301 (rod) and A/57121801 (blade). These antennas were delivered to this laboratory for impedance matching, using a full-scale mock-up of the forward portion of the vehicle, as is shown in Fig. 13. The rod antenna proved to be rather narrow-band, as can be seen in Fig. 14. Matching was accomplished by using a separate stub on each radiator to bring its impedance to a nominal 100 ohms, inserting a half-wavelength of line between them to obtain push-pull operation, and paralleling the inputs in a T-junction. In the case of the blade antenna, a satisfactory match was obtained across the entire band, as is shown in Fig. 15. This was achieved by using a length of line transformer with each radiator, inserting a half-wavelength of line as before for phasing, and paralleling the two inputs in a T-junction. Final matching was accomplished by using a one-wavelength open-circuited stub, located 0.300 wavelength ahead of the T-junction.

CONCLUSIONS AND RECOMMENDATIONS

The antenna patterns and impedance characteristics indicate that satisfactory operation of the telemetry equipment can be expected if the blade antennas are used. If future requirements should dictate a flush-mounted antenna system located near the nose of the vehicle, there is a distinct possibility that coverage to the rear would be inadequate with circularly polarized ground equipment, and that a polarization diversity system would be required. However, this could be determined only with the aid of a scale-model pattern study of the flush antenna system.

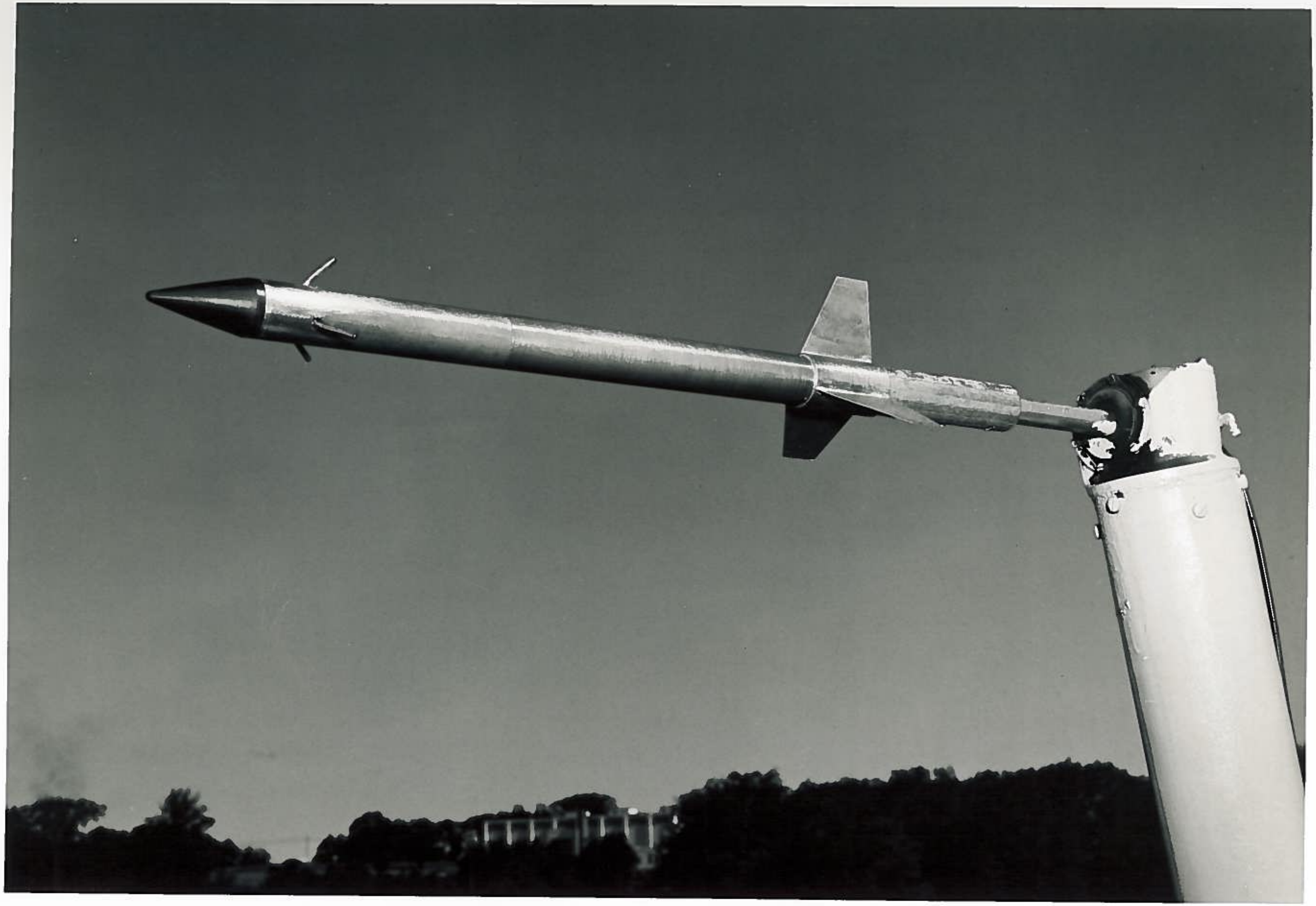
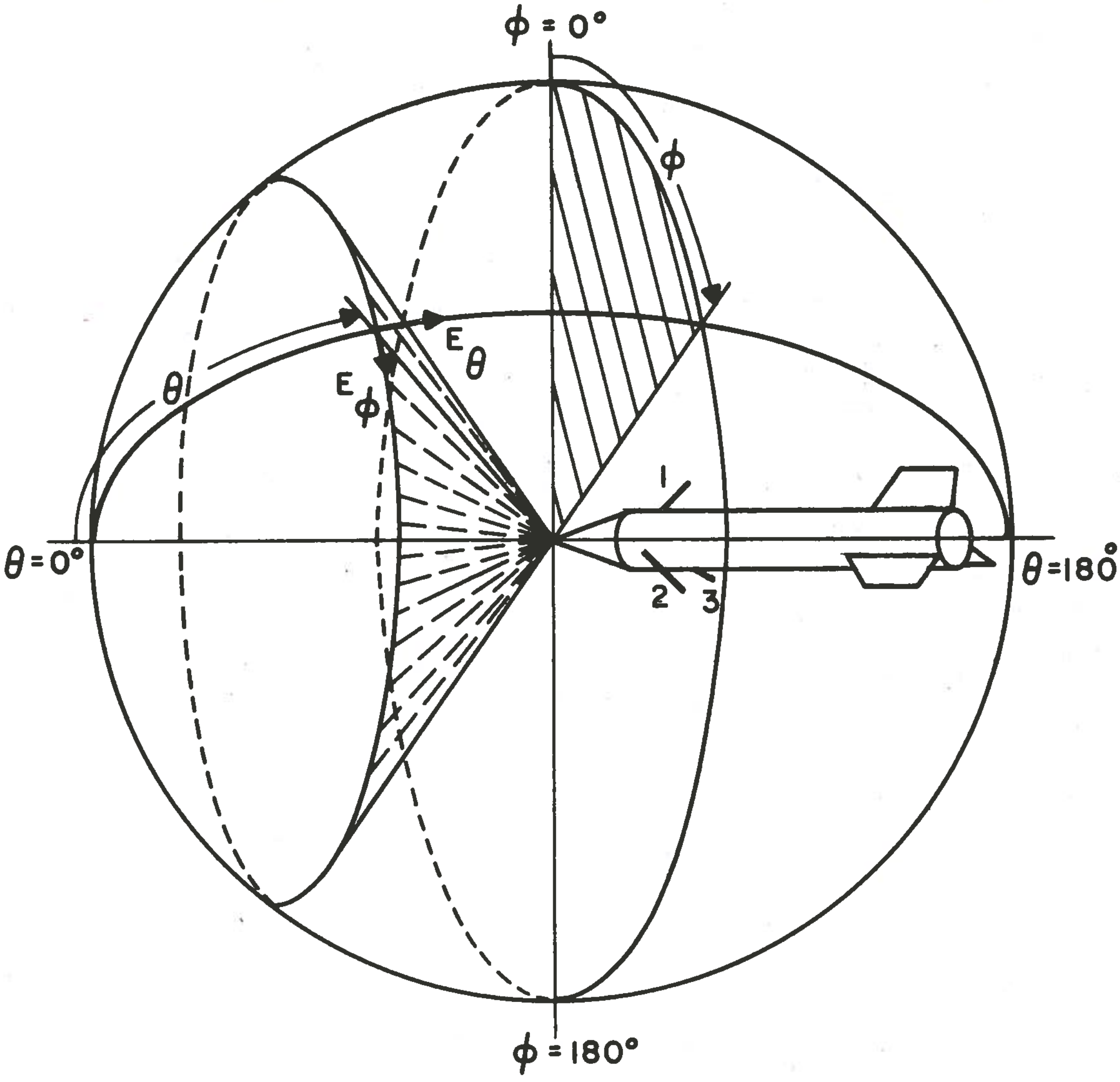


FIG. 1. SCALE MODEL MOUNTED FOR PATTERN MEASUREMENTS



NOTE : ANTENNAS 1 & 2 FED IN PUSH—PULL;
ANTENNA 3 OPEN—CIRCUITED.

FIGURE 2

COORDINATE SYSTEM

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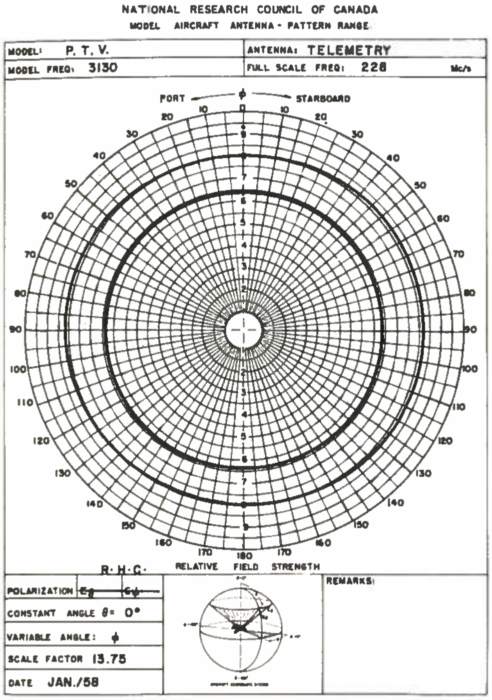
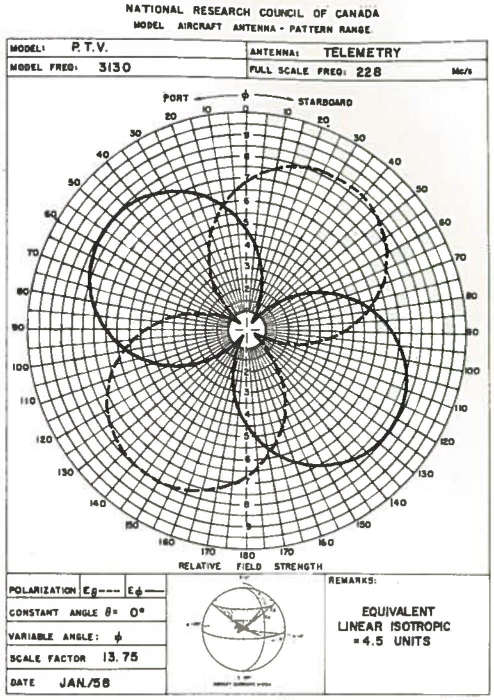
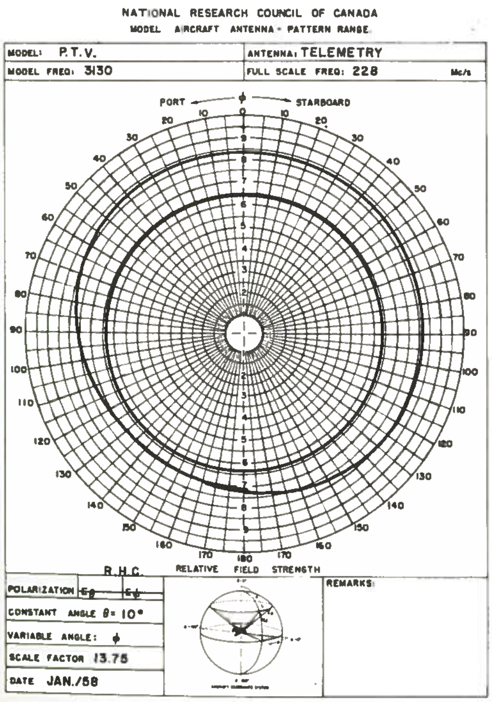
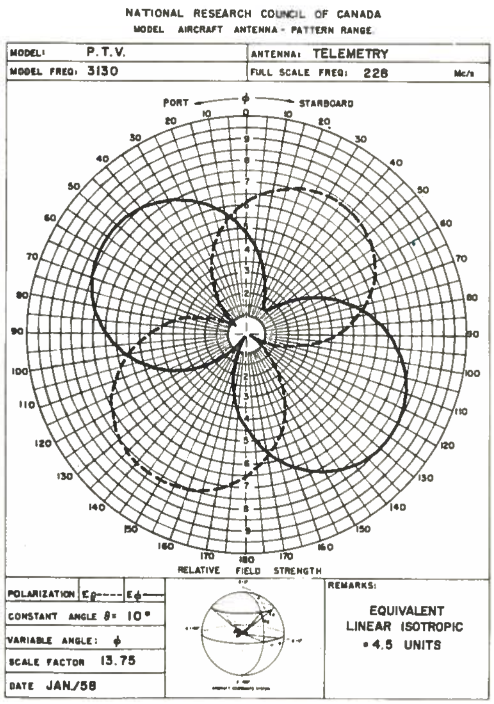




θ = 0°





θ = 10°

FIG. 3

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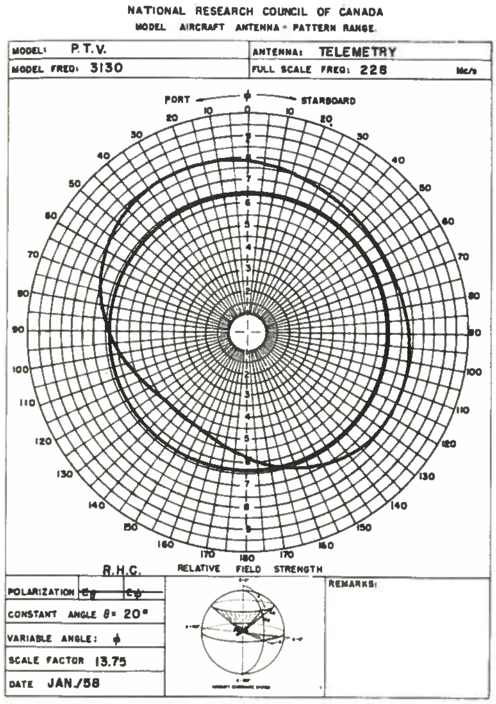
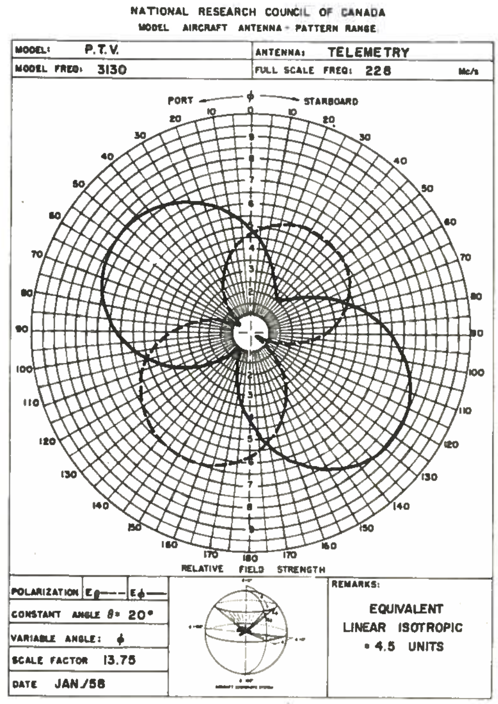
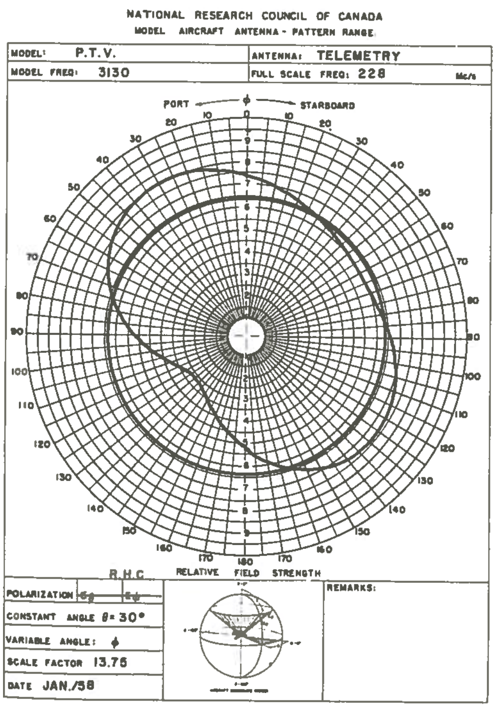
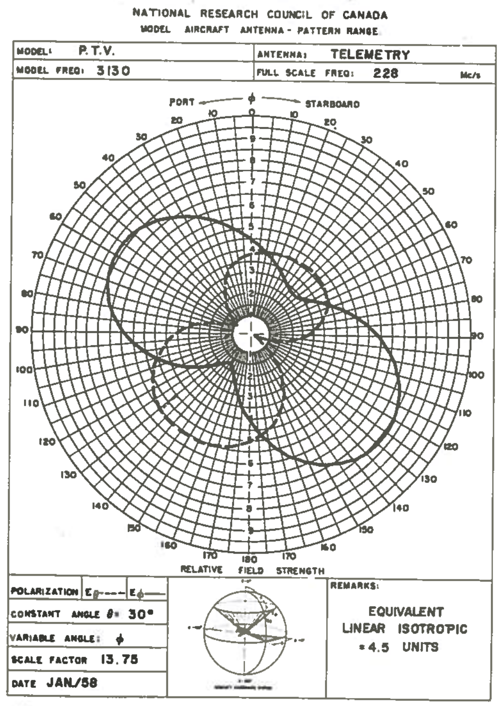




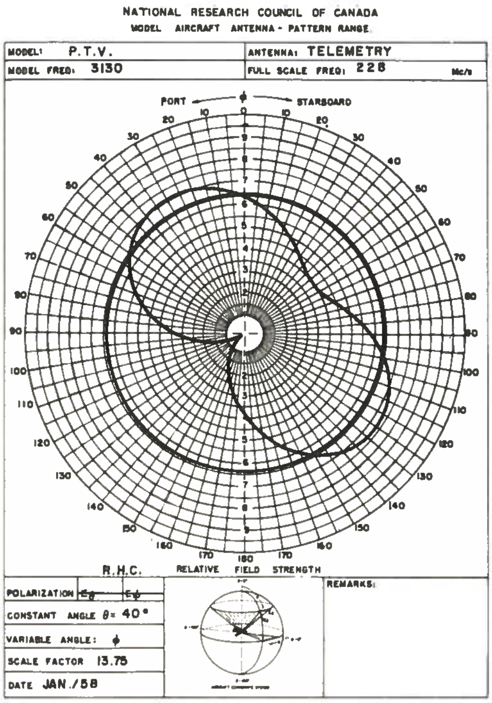
θ = 20°





θ = 30°

FIG. 4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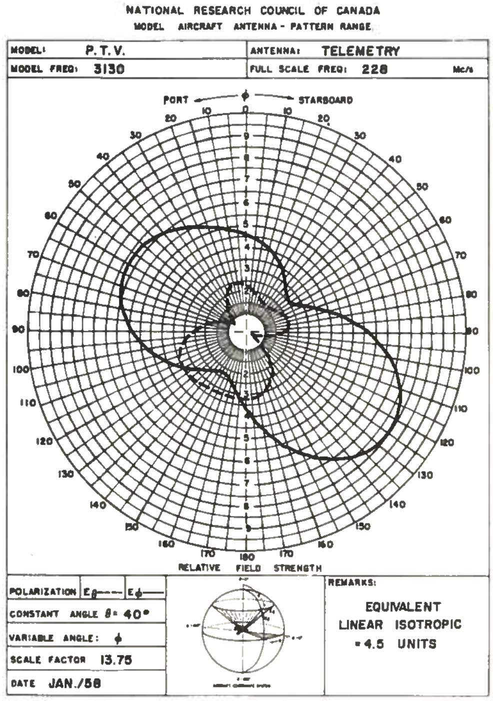
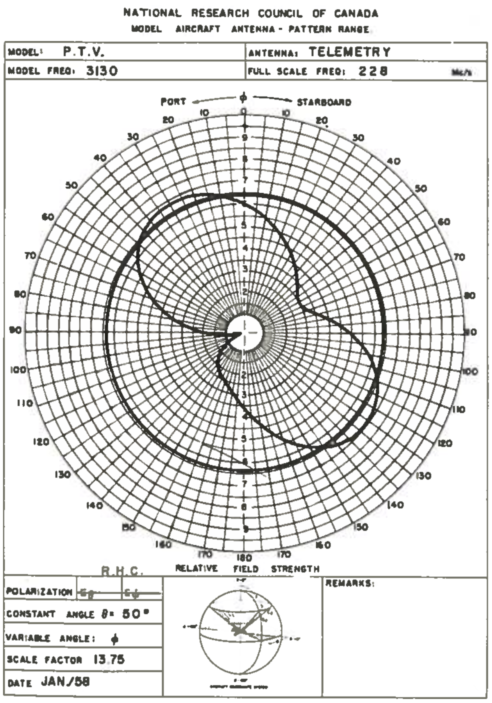
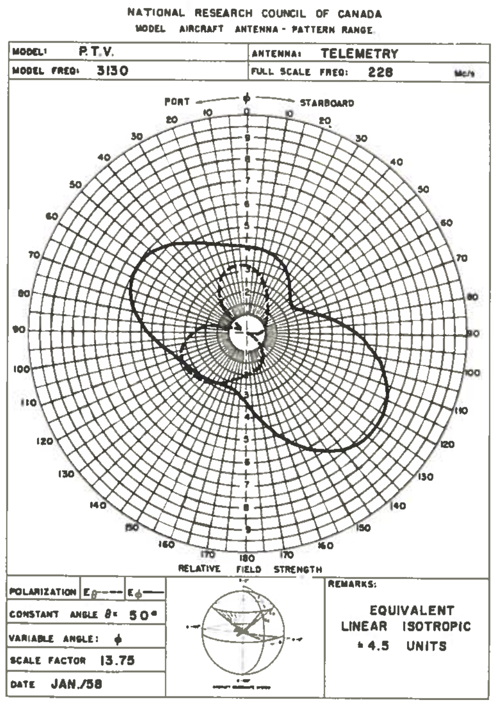
MODEL AIRCRAFT ANTENNA - PATTERN RANGE
MODEL: P.T.V.
ANTENNA: TELEMETRY
MODEL FREQ: 3130
FULL SCALE FREQ: 228 Mc/s
PORT
STARBOARD
R.H.C.
RELATIVE FIELD STRENGTH
POLARIZATION Eθ Eφ
CONSTANT ANGLE θ= 40°
VARIABLE ANGLE: φ
SCALE FACTOR 13.75
DATE JAN./58
REMARKS:


NATIONAL RESEARCH COUNCIL OF CANADA
MODEL AIRCRAFT ANTENNA - PATTERN RANGE
MODEL: P.T.V.
ANTENNA: TELEMETRY
MODEL FREQ: 3130
FULL SCALE FREQ: 228 Mc/s
PORT
STARBOARD
RELATIVE FIELD STRENGTH
POLARIZATION Eθ---- Eφ—
CONSTANT ANGLE θ= 40°
VARIABLE ANGLE: φ
SCALE FACTOR 13.75
DATE JAN./58
REMARKS:
EQUIVALENT
LINEAR ISOTROPIC
= 4.5 UNITS

θ = 40°

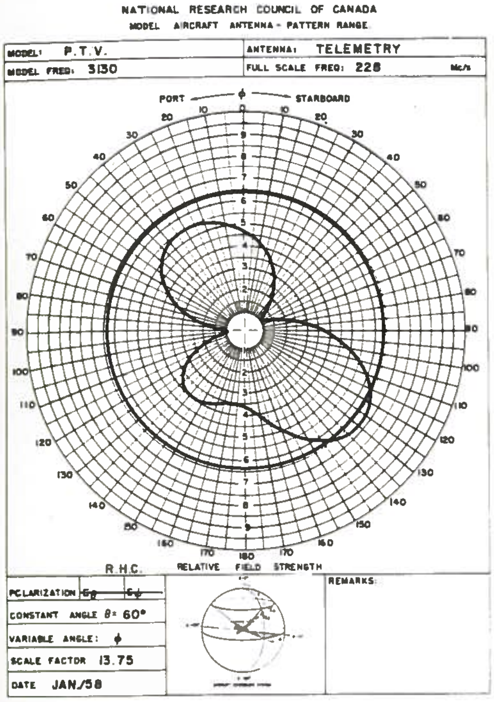

NATIONAL RESEARCH COUNCIL OF CANADA
MODEL AIRCRAFT ANTENNA - PATTERN RANGE
MODEL: P.T.V.
ANTENNA: TELEMETRY
MODEL FREQ: 3130
FULL SCALE FREQ: 228 Mc/s
PORT
STARBOARD
R.H.C.
RELATIVE FIELD STRENGTH
POLARIZATION Eθ Eφ
CONSTANT ANGLE θ= 50°
VARIABLE ANGLE: φ
SCALE FACTOR 13.75
DATE JAN./58
REMARKS:

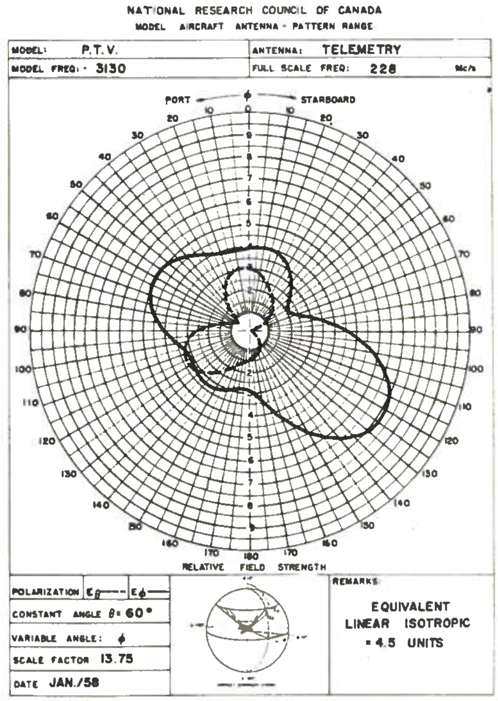

NATIONAL RESEARCH COUNCIL OF CANADA
MODEL AIRCRAFT ANTENNA - PATTERN RANGE
MODEL: P.T.V.
ANTENNA: TELEMETRY
MODEL FREQ: 3130
FULL SCALE FREQ: 228 Mc/s
PORT
STARBOARD
RELATIVE FIELD STRENGTH
POLARIZATION Eθ---- Eφ—
CONSTANT ANGLE θ= 50°
VARIABLE ANGLE: φ
SCALE FACTOR 13.75
DATE JAN./58
REMARKS:
EQUIVALENT
LINEAR ISOTROPIC
= 4.5 UNITS

θ = 50°

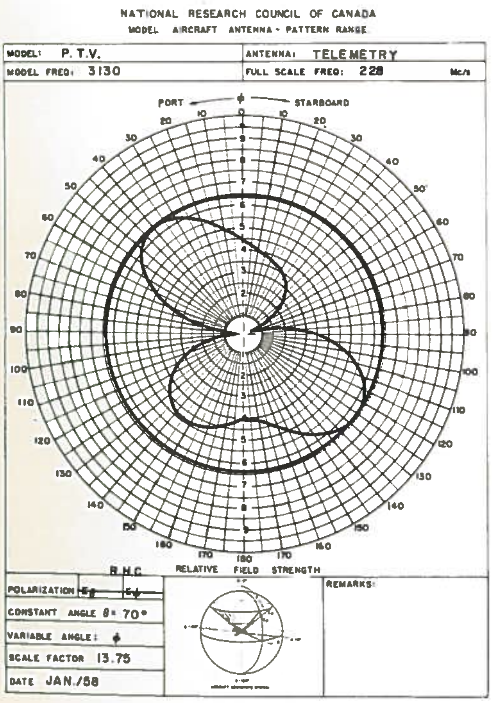
FIG. 5

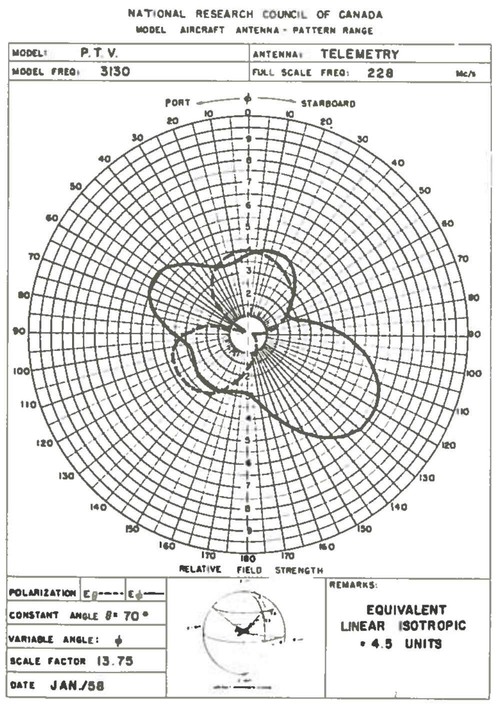
RESTRICTED





θ = 60°





θ = 70°

FIG. 6

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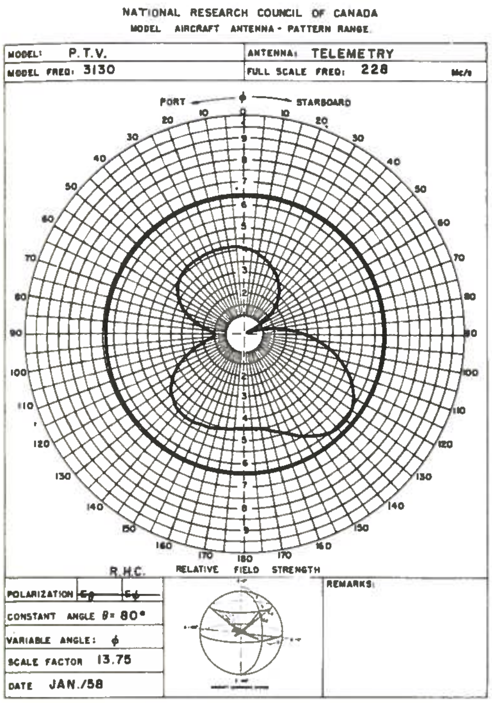
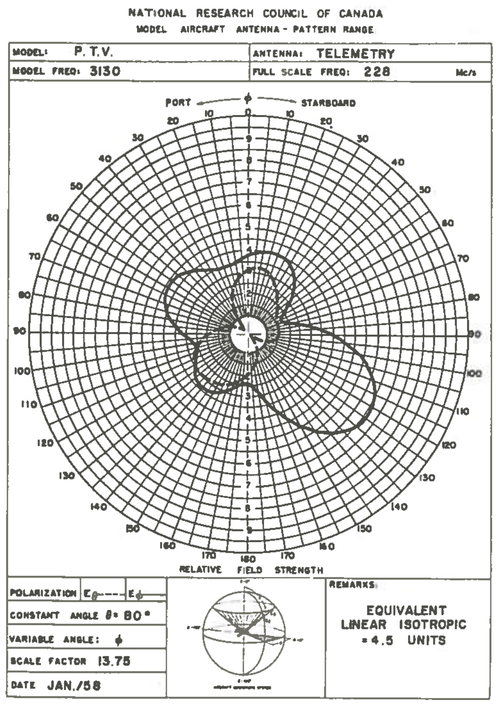
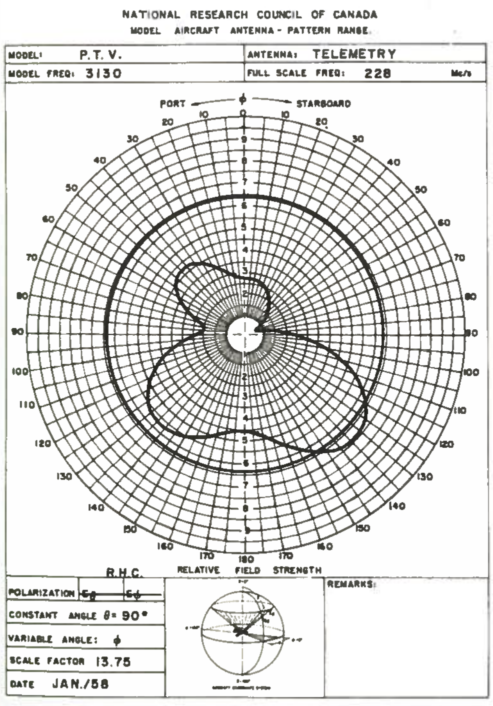
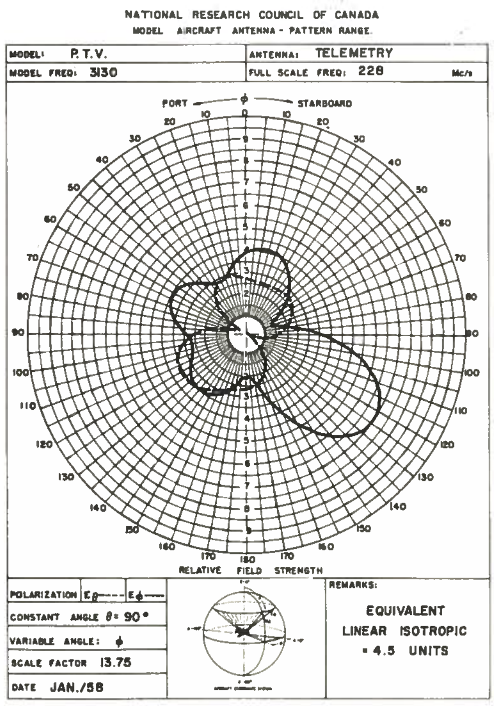




θ =80°





θ =90°

FIG. 7

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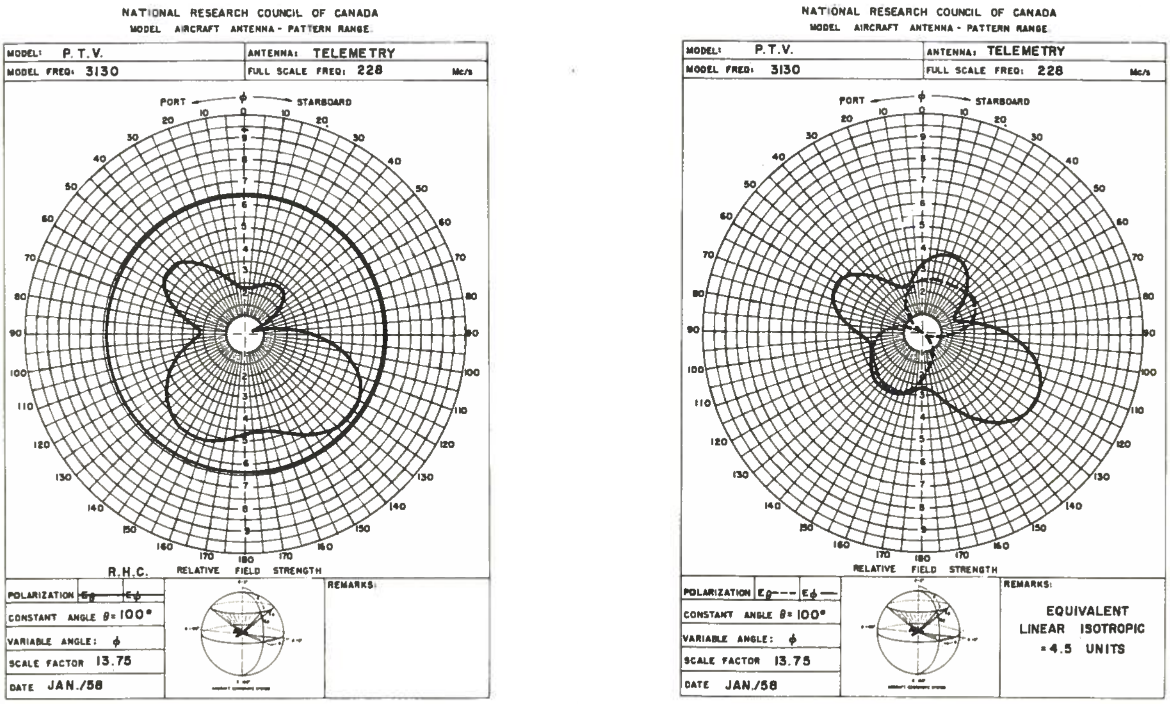
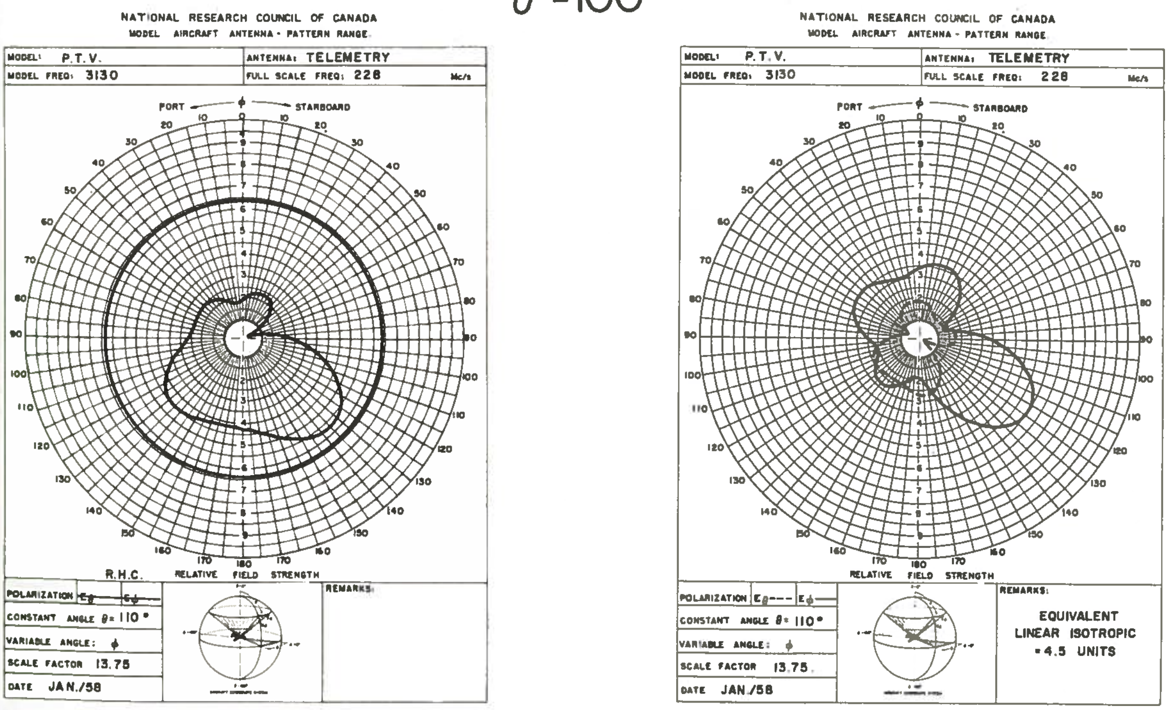


$\theta = 100°$



$\theta = 110°$

FIG. 8

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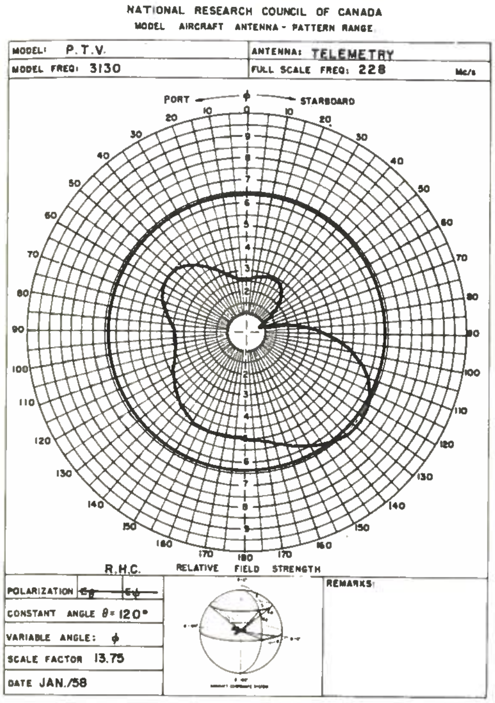
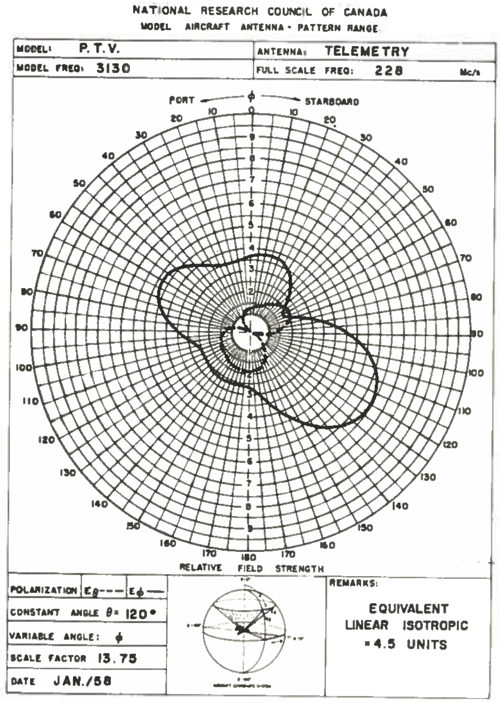
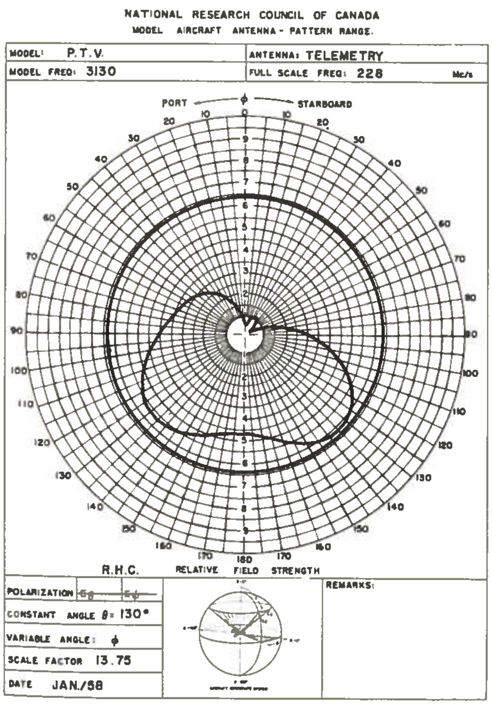
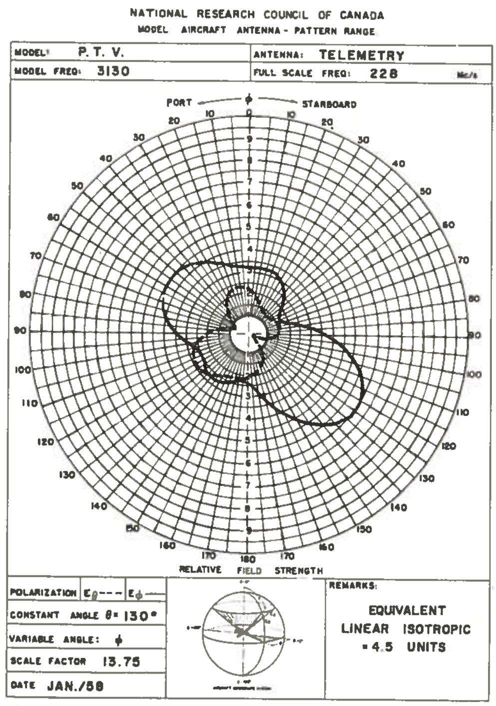




θ =120°





θ =130°

FIG. 9

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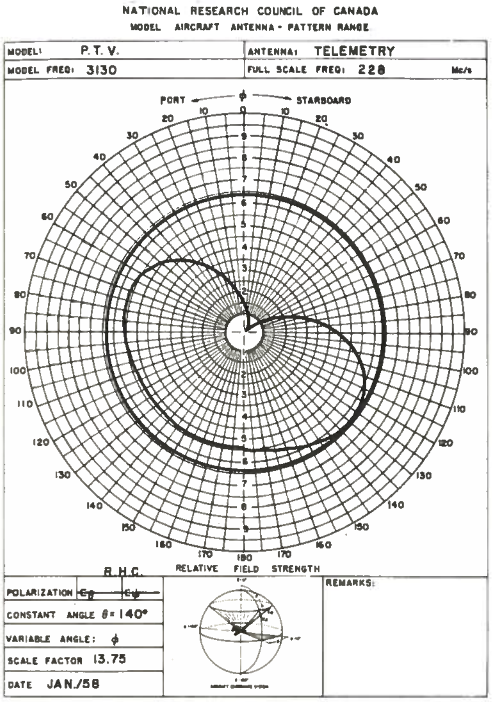
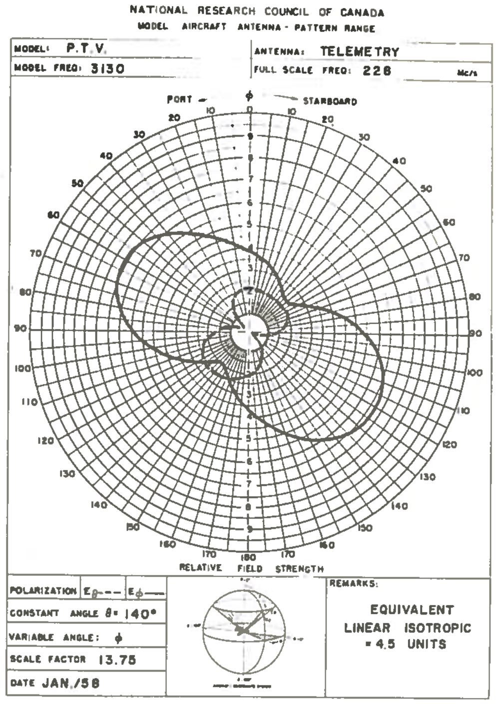
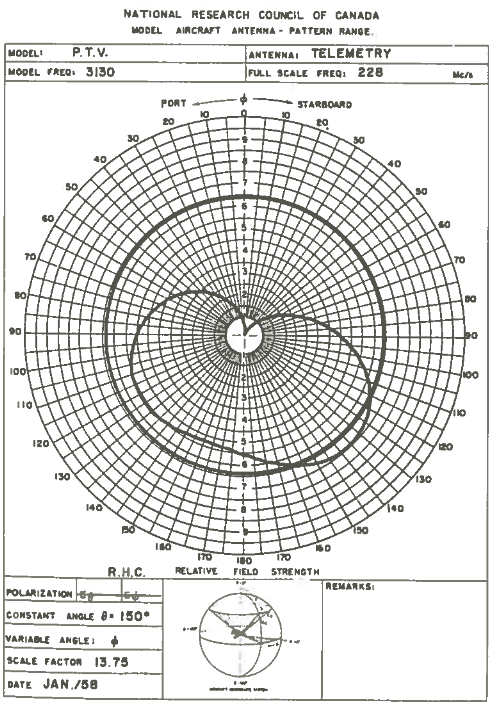
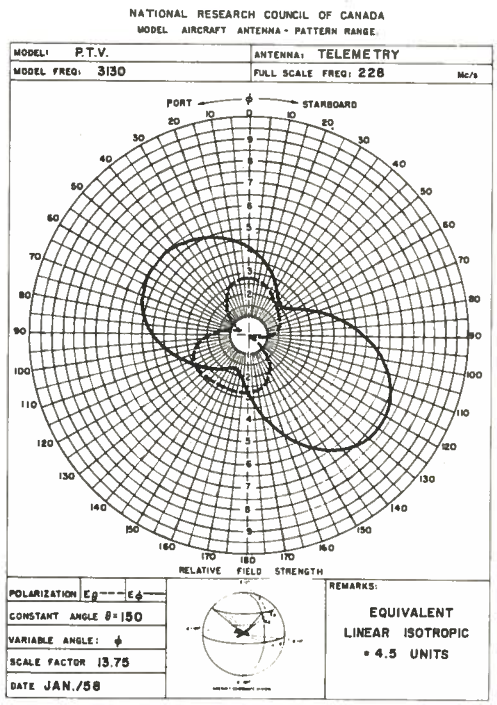




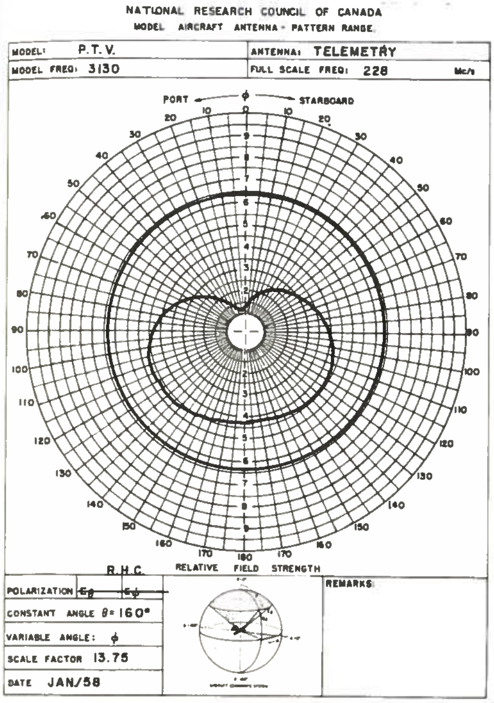
θ = 140°

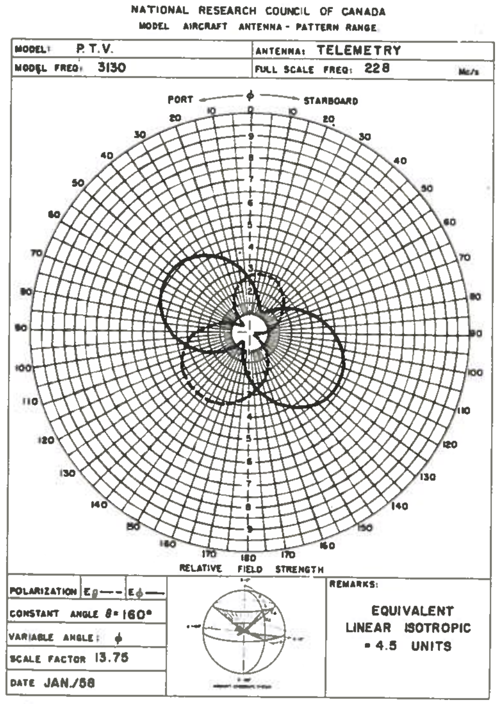




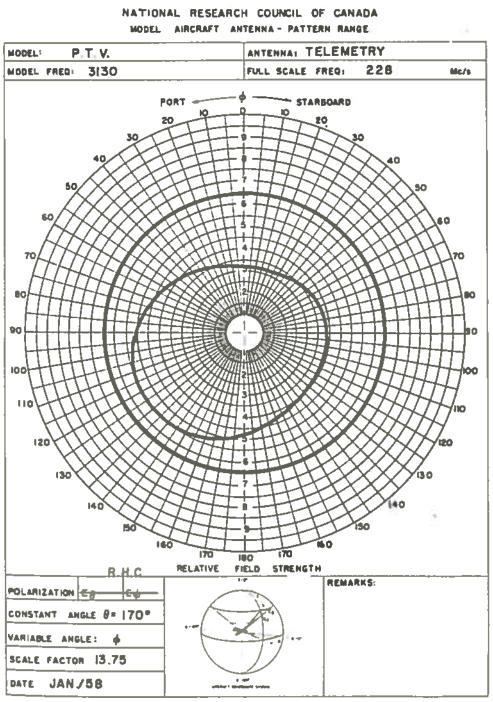
θ = 150°

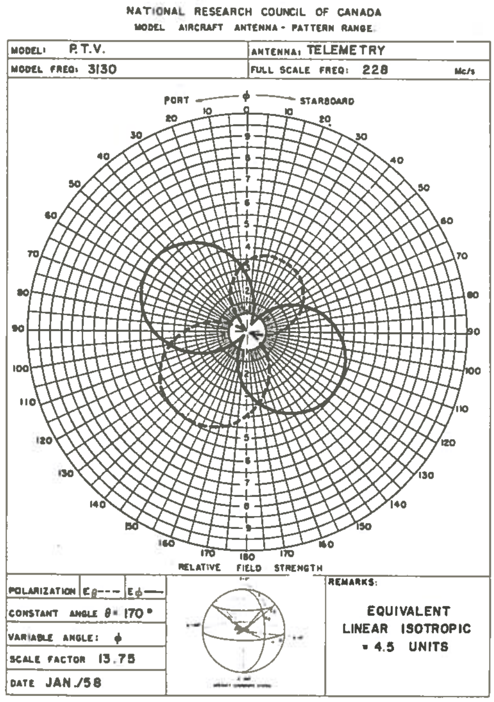
FIG. 10





θ = 160°





θ = 170°

FIG. 11

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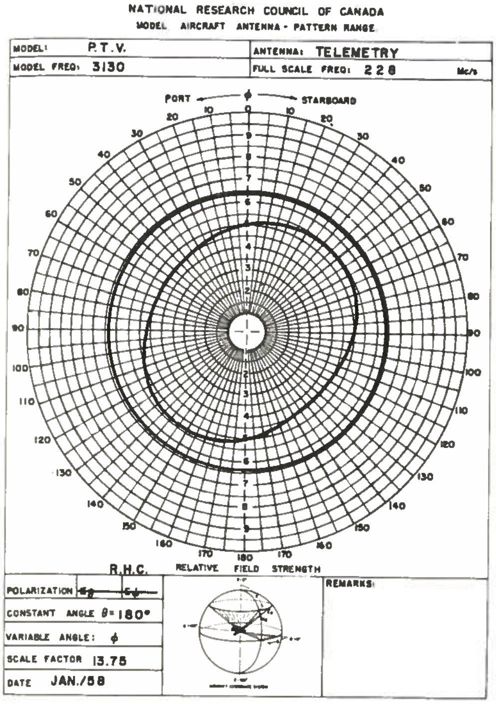

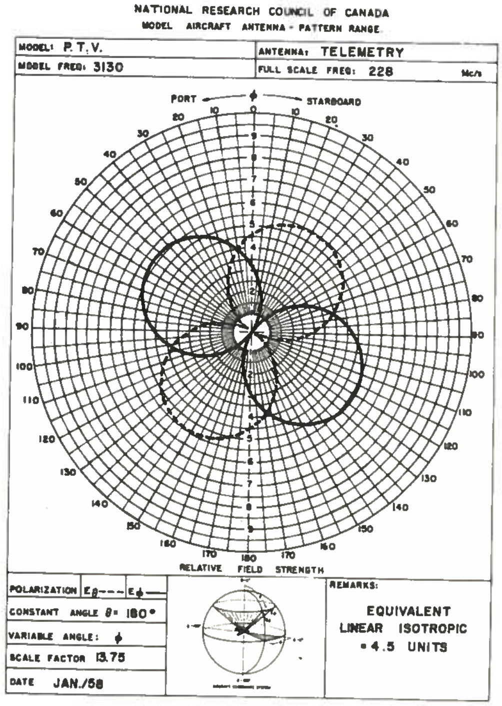

$\theta = 180°$

FIG. 12

FIG. 13. FULL-SCALE MOCK-UP OF NOSE SECTION

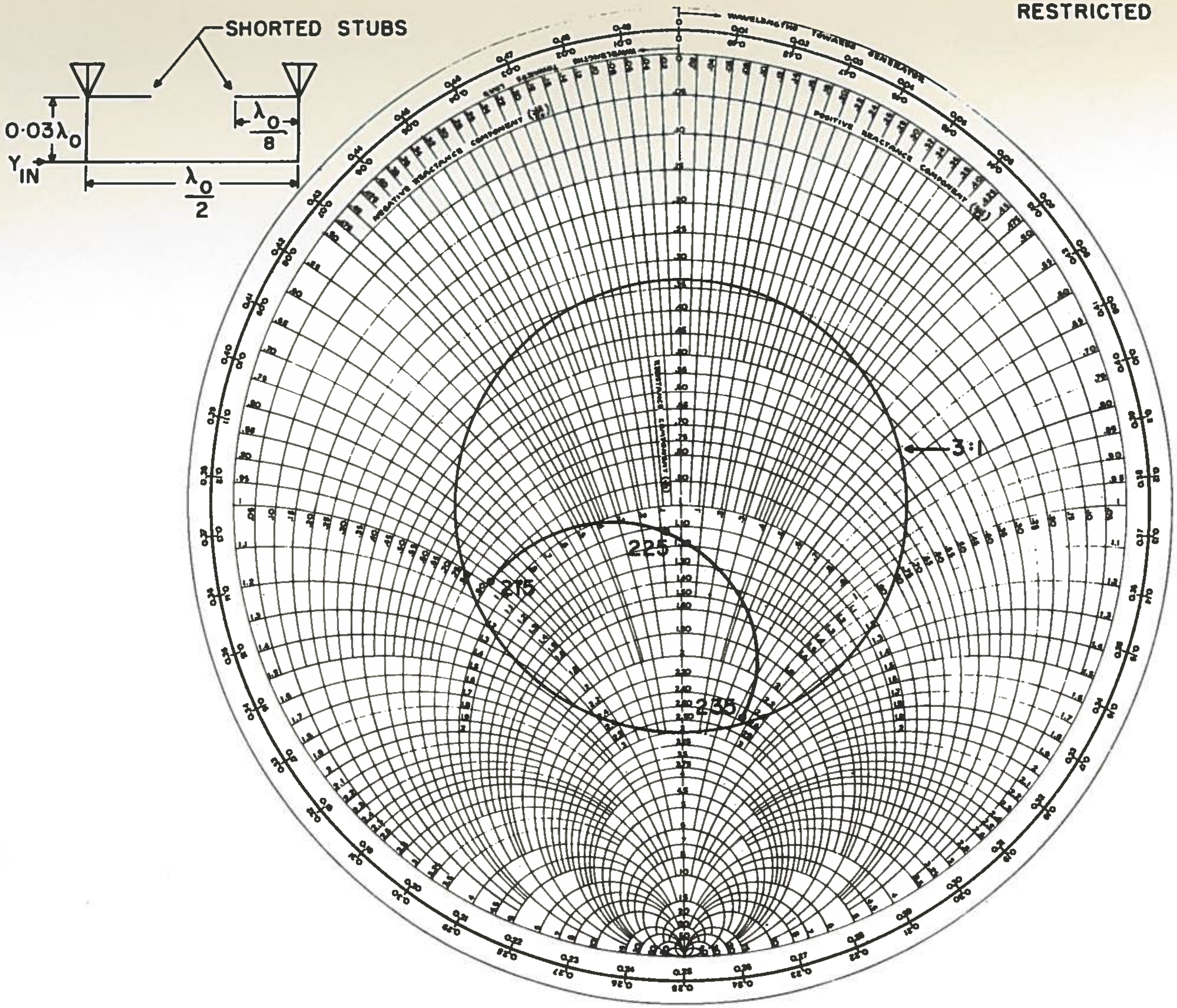

FIG. 14

INPUT ADMITTANCE OF ROD ANTENNAS

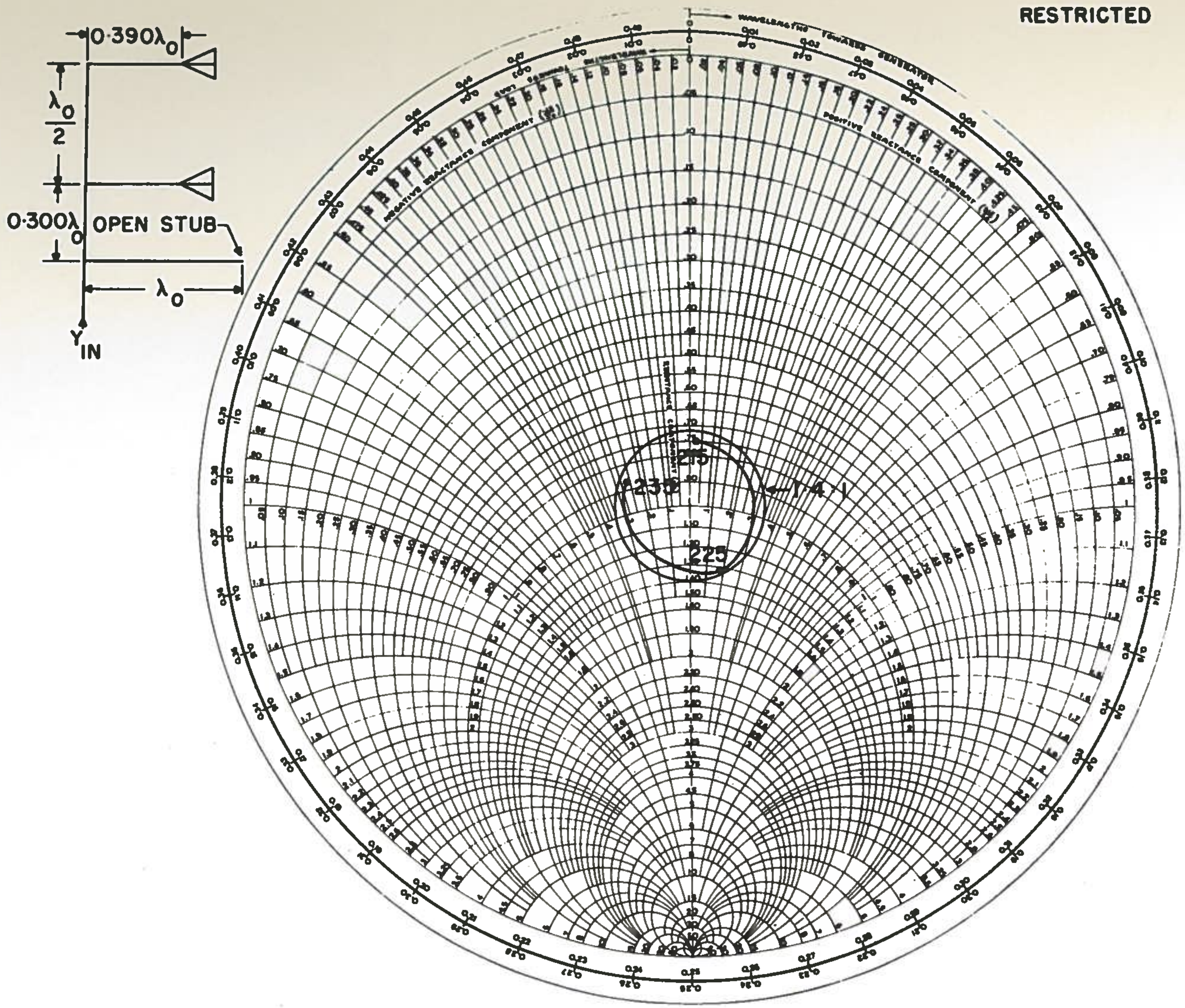

FIG. 15

INPUT ADMITTANCE OF BLADE ANTENNAS