The design of "ASV" homing arrays for Digby aircraft

MacKinnon, K. A.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/21276395
PRA, 1941-06

PRA: 13

SECRET

Copy No. 15

THE DESIGN OF "ASV" HOMING ARRAYS FOR DIGBY AIRCRAFT

NATIONAL RESEARCH COUNCIL

OTTAWA, CANADA

JUNE, 1941

SECRET

THE DESIGN OF "ASV" HOMING ARRAYS FOR DIGBY AIRCRAFT

NATIONAL RESEARCH COUNCIL

OTTAWA, CANADA

JUNE, 1941

Secret

The Design of "ASV" Homing Arrays for Digby Aircraft

The basic design requirements for the "homing" antenna arrays of ASV on Digby Aircraft were similar to those specified for the "long distance" arrays as described in a previous report by the author ("The Design of "ASV" Long Distance Arrays on Digby Aircraft"). Those specifications were that the wire should be #18 B&S Copperweld suspended between end supports; and that the arrays should be fed with Telcothene BA4C cable (two wire 70 ohms) from the transmitter, and Telcothene PT5C cable (coaxial 45 ohms) to the receiver. In addition to these basic requirements there were the following homing features:

(1) The arrays should be unidirectional (i.e. fire ahead only).

(2) The split-beam homing system should function through the standard antenna switch used in the English ASV equipment.

(3) The range should be comparable with that obtained with the "long-distance" arrays.

A further desired feature was the exclusive use of insulators of the same type as those used on the long distance arrays.

This range requirement meant that the arrays would have to be comparable in size with the long distance arrays. A solution appeared to be the use of a 6-bay collinear array with parasitic reflectors transmitting straight ahead located under one wing, and a similar array placed under the other wing, whose beam could be wobbled slightly by feeding at either end, for receiving in the split-beam manner usual with homing devices.

The Receiving Array

The split-beam feature in the single array is obtained by taking advantage of the fact that if a collinear array with correct dimensions for a given frequency is fed from one end at a frequency slightly different from the given frequency, there will be a shift in direction of the main beam. This is a direct result of the shift in the standing wave pattern along the radiating elements which, at a distant point, is equivalent to a change in space phase.

Accordingly by feeding at one, or the other end of the array in this manner the beam may be wobbled to give a split-beam suitable for homing. In the actual design detailed in the attached blueprint (No. N.R.C. ASV-4) the PT5C coaxial cables from the antenna switch are connected through trombones direct to the end suppressor stubs. The dimensions of the array are such that the input impedance of the array at these points matches the 180 ohm PT5C trombones directly. In fact the standing wave ratio on a 180 ohm line feeding one point, with the other feed point connected to the other PT5C trombone, was 1.1.

The relative field strength patterns obtained in the field and on the aircraft are also given in the blueprint. The dimensions were chosen to give a shift of the optimum magnitude. Too large a shift of course means a loss in range because the beam gets off the peak of the transmitter beam, whereas too small a shift makes homing difficult.

The gain of this end-fed collinear was compared with that of the same array center-fed. When center-fed, with 180 ohm open wire line, the PT5C coaxials were removed from the end feed points and these points shorted. When end-fed, the input end was fed with a 180 ohm open wire line on which the power input was measured, and the other end-feed point was connected to the PT5C trombone and its coaxial which was open at the antenna switch end in the usual manner. This comparison gave the voltage gain of the end-fed as 80% of the gain of the center-fed.

The Transmitting Array

The details of the center-fed transmitting array are given in the attached blueprint (No. N.R.C. ASV-5). It is seen that the dimensions are the same as those of the receiving array. Slightly larger dimensions appeared to give a more correct standing wave distribution, but experiment showed no improvement in the gain or pattern. On the other hand the practical advantages of having both arrays of identical dimensions are considerable.

In order to match the input impedance to the 70 ohm Telcothene BA4C cable, the center phasing stub has 3/8" outside diameter tubing slipped over the wires for a length of 35 cm. This gave a standing wave ratio on 70 ohm open wire line of 1.16.

The Combined Patterns

In actual practice one is not as interested in the individual receiving and transmitting field strength patterns as in the combined (receiving x transmitting) pattern. This is given in the attached polar curves. (See Fig. 1.)

It is seen that the signal is above half maximum value as long as the ship's nose is kept pointing to within ± 12° of the target.

Although the combined signal astern in the horizontal plane is negligible, yet, as one can see in the vertical plane pattern given in blueprint N.R.C. ASV-5, there is transmitted astern at angles more than 20° below the horizontal, field strengths larger than 20% of the main beam. Accordingly the plane should fly low if bothered by signals from large objects close astern.

There appear to be two possible methods of differentiating bow from stern targets. The first is achieved by raising the nose of the ship slightly which should result in diminishing the signals from objects astern, whilst leaving constant those from objects ahead. The second method is accomplished by turning the ship slightly to the right for instance. This should make the left hand signal increase if the object is ahead but decrease if object is astern.

Notes on Installation

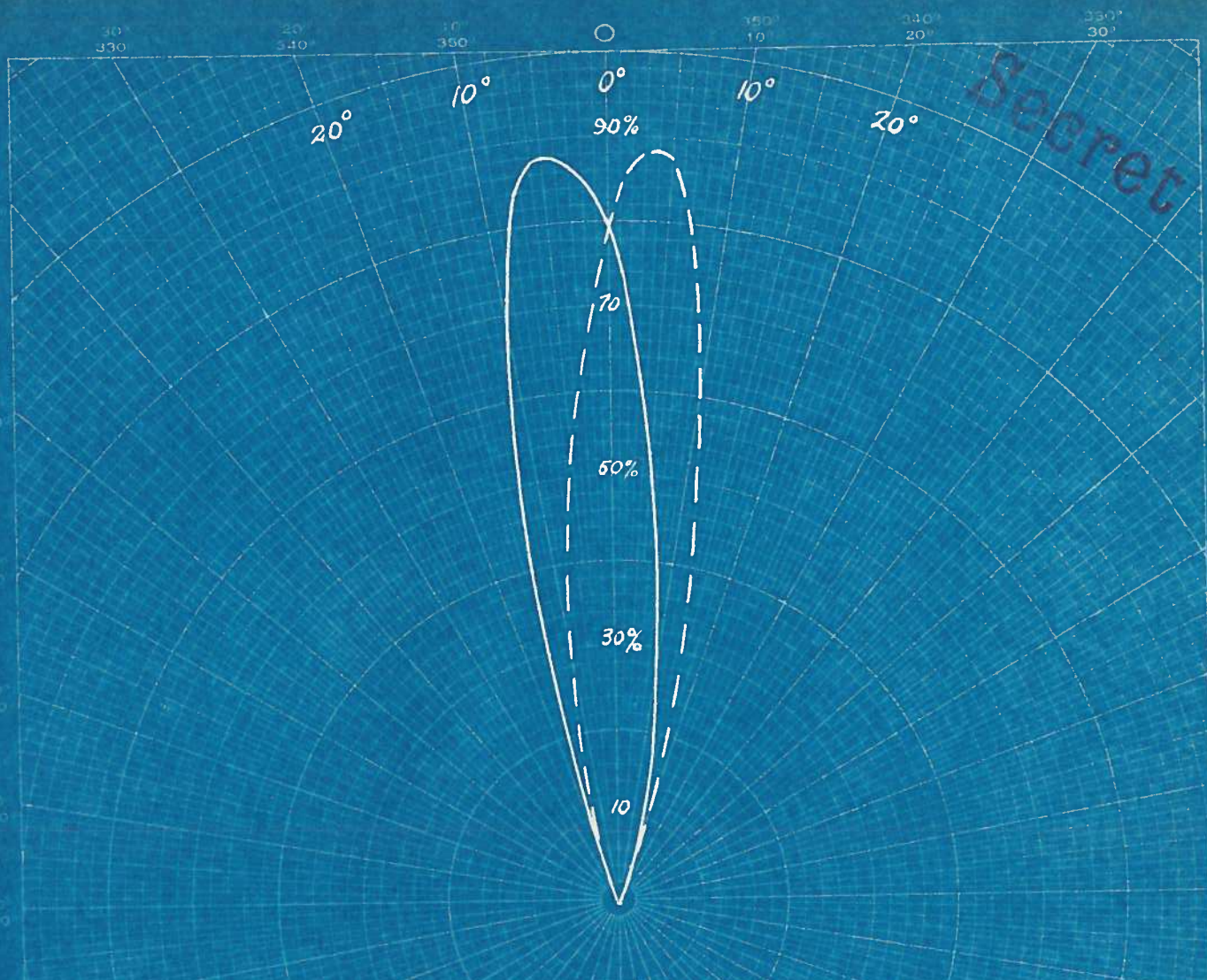
In installing these arrays under the wings of the aircraft, care must be taken to ensure that the array wires are strung exactly perpendicular to the center line of the fuselage. This precaution is necessary if the narrow field patterns are to be used correctly and efficiently for homing. A small dihedral angle (in the vertical plane) is not considered to have any disturbing effect.

The lengths of the PT5C coaxial cable from the receiving array to the antenna switch must be identical in order to equalize the received signals.

It should be noted that the spreader details given in the blueprints refer merely to the design used in the experimental models. The shape and mounting of the spreader to be used on the aircraft must, of course, be based on aerodynamic considerations.

Ottawa,
June 21, 1941.

K.A. MacKinnon



COMBINED PATTERNS IN THE HORIZONTAL PLANE

(TRANSMITTER X SPLIT-BEAM RECEIVER)

100% RADIUS = VALUE IF TRANSMITTER AND RECEIVER BEAMS COINCIDED.

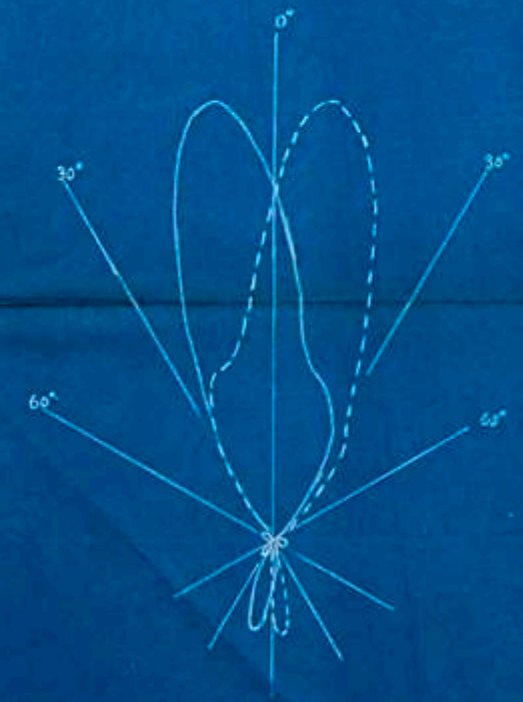
FIG. 1

HOMING RA
FOR DIGBY AIRCRAFT.

Kay

NATIONAL RESEARCH COUNCIL, RADIO SECTION, OTTAWA.

Secret



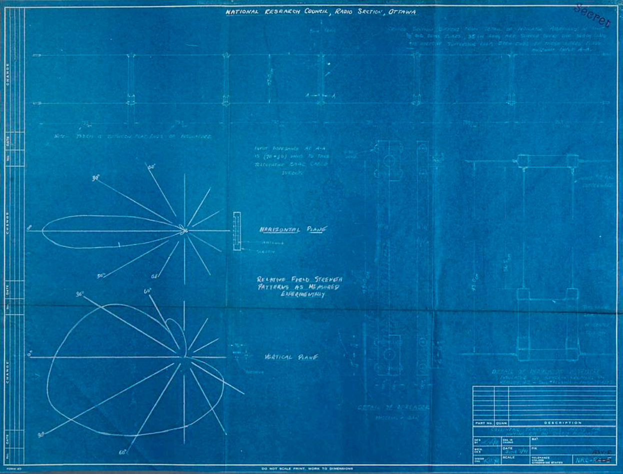
RELATIVE FIELD STRENGTH PATTERNS IN THE HORIZONTAL PLANE AS MEASURED EXPERIMENTALLY

SOLID LINE — ANTENNA SWITCH ON LEFT HAND SIDE

DOTTED LINE — ANTENNA SWITCH ON RIGHT HAND SIDE

PART No.	QUAN.	DESCRIPTION

DO NOT SCALE PRINT. WORK TO DIMENSIONS


NATIONAL RESEARCH COUNCIL, RADIO SECTION, OTTAWA
Secret
INPUT IMPEDANCE AT A-A
IS (70+30) OHMS TO TAKE
TELEPHONE BAND CABLE
DIRECT.
HORIZONTAL PLANE
RELATIVE FIELD STRENGTH
PATTERNS AS MEASURED
EXPERIMENTALLY.
VERTICAL PLANE
DETAIL OF SPREADER
PART No.
QUAN
DESCRIPTION
MAT
DATE
FIN
SCALE
TOLERANCE UNLESS OTHERWISE STATED
FORM 40
DO NOT SCALE PRINT, WORK TO DIMENSIONS