Omni-directional A.S.V. beacon antenna for the R.C.A.F.

National Research Council of Canada. Radio Branch

PRA; no. PRA-76, 1943-03

SECRET

PRA-76

COPY NO. 39

NATIONAL RESEARCH COUNCIL OF CANADA
RADIO BRANCH

OMNI-DIRECTIONAL A. S. V. BEACON ANTENNA FOR THE R. C. A. F.

OTTAWA

MARCH, 1943

C O N T E N T S

OMNI-DIRECTIONAL A.S.V. BEACON ANTENNA FOR THE R.C.A.F.

1. Requirements:

This antenna has to meet the following requirements.

(i) It is to operate on 176 Mc/s when receiving and on 177½ Mc/s when transmitting.

(ii) It must be impervious to weathering and icing; i.e. the electrical properties are to be independent of weathering and it is to be sufficiently strong mechanically to withstand all icing encountered in operation.

(iii) The radiation is to be horizontally polarized. In the horizontal plane the field strength radiation pattern is to be circular enough to make the antenna omni-directional.

(iv) The transmission line to be used is BA4M. Research Enterprises Limited specifies that the characteristic impedance of BA4M is between 88 and 102 ohms. The antenna must therefore be matched to approximately 95 ohms.

2. Antenna:

A circular pattern in the horizontal plane using horizontal polarization may be produced by a number of antennas. Some are here mentioned.

(i) A turnstile antenna
(ii) A loop antenna. There are many forms of this type.
(iii) A V-antenna

For the present project this last was chosen as it seemed by far the simplest both mechanically and electrically.

The present antenna consists of a vertical stack of five horizontal V's fed in parallel from balanced line. Each V consists of two mutually perpendicular end-fed half wave dipoles. Inter-V spacing is 82 cm; i.e. half wavelength in the feed line. All V's are fed in phase: The 180° phase difference between adjacent dipoles due to spacing along the feed line being equal to the 180° phase difference introduced by feeding from alternate sides of the feed line. The inter-V feed line is double concentric. The inner conductor consists of brass rod 1/4 inch diameter, 130 inch long. The outer conductor consists of sections of 7/8 inch O.D., 30 1/4 inch long copper pipe, screwed into and soldered to T-sections (RS-17) through which protrude the dipoles. The two concentric lines are held firmly together by brass blocks (RS-21). The ends are capped by brass screw caps (RS-16). Each half wave dipole consists of 9/16 inch

outer diameter brass pipe, 82 cm. long. It is attached to the inner conductor by a screw plug and dipole connector (RS-24, RS-25) and is supported by being press fitted through a bakelite bushing, which is screwed snugly by a tapered thread into the T-section.

3. Matching:

The stack is centre-fed with BA4M cable. A quarter wave matching transformer consisting of two 27 cm. lengths of BA4M in parallel is inserted at a point 57 cm. from the junction to the antenna. This transformer effects a match to a transmitted signal which at the following frequencies produces the following standing wave ratios (S.W.R.).

Frequency Mc/sec	S.W.R.
175	1.2
177	1.3
178.5	1.7

It is to be noted that if there be considerable BA4M between the antenna and the transmitter the attenuation in the cable (4.5 db per 100 feet at 200 Mc/s) will cause the S.W.R. at the transmitter to be smaller than at the antenna.

Matching the antenna to the transmission line results in a flat line only for a transmitted signal. On the other hand, matching the receiver and spark gap to the transmission line is necessary to produce a flat line for a received signal. The former matching problem only has been undertaken in developing the antenna at National Research Council. The latter may be the more important as may be seen below.

In the present application an A.S.V. transmitter on 176 Mc in a plane impresses a signal on the beacon receiver, triggers the latter which fires the beacon transmitter on 177.5 Mc. whose signal in turn is received by the A.S.V. receiver in the plane. For successful operation of the beacon therefore it is necessary for the plane transmitter and beacon receiver to be working well in order to trigger the beacon, and it is also necessary for the beacon transmitter and plane receiver to be working well in order that the latter display the signal. The operation of the beacon can therefore be limited in either of two ways:-

(i) The beacon transmitter and plane receiver may not be operating as effectively as the plane transmitter and beacon receiver; i.e. the beacon is triggered but the beacon's transmitted signal is not displayed by a plane receiver.

(ii) The situation may be reversed, the beacon transmitter and plane receiver may be working more effectively than the plane transmitter and beacon receiver; i.e. the beacon is not triggered even though

the plane receiver would have picked up the beacon's signal had there been one. This latter seems more often to be the case; i.e. the plane receiver receives no signal because the beacon is not being triggered but receives and displays a fairly strong signal as soon as the beacon is triggered. Should this latter be the case then the match of the receiver to the transmission line is more effective in the overall operation of the beacon than that of the antenna to the transmission line.

4. Weatherproofing:

All electrical junctures are weatherproof. Brass junction boxes (RS-30) at each end of the transformer are sealed with black bostik at the juncture of the transmission line to the antenna feed line the former is held firmly in place by a brass junction box and clamp (RS-26 -- RS-29). This juncture is also bostiked. The dipoles are bostiked to the bakelite fittings and these latter to the T-sections on the outer conductor of the feed line.

5. Pattern:

The field strength radiation pattern in the horizontal plane is given in (RS-32). The maximum field strength is 25% greater than the mean, the minimum 15% less. The greatest deviation from the mean; i.e. the maximum field strength, exists over a relatively small angle and therefore causes the field strength at all other angles to deviate only slightly from the mean. It is to be noted that a perfectly circular pattern in this application is merely an academic goal since topographical effects will cause the operational pattern to differ from the free-space pattern. It is also quite likely that the earth's curvature will be the greatest factor in determining the operational pattern. This will tend to make the operational pattern more nearly circular.

6. Suggestions for Assembling:

When all component parts are ready (dipoles with terminals and screw plugs soldered in place, sections of the outer conductor with brass annuli soldered in place, quarter-wave transformer made), the following order is suggested to facilitate the assembling of the antenna.

(i) Make the necessary soldered junctures for inserting the BA4M quarter-wave transformer. Clamp these junctures rigidly with the brass blocks (RS-30). Bostik and seal well. Silver solder the inner conductors of the BA4M to the lugs used for connecting the transmission line to the feed line, (RS-31).

(ii) Slip the middle dipole connector (RS-25) and T-section (RS-26) to the centre of the two inner conductors of the feed line. Fix the former by the set screw. Thread three polystyrene spacers (RS-20) on

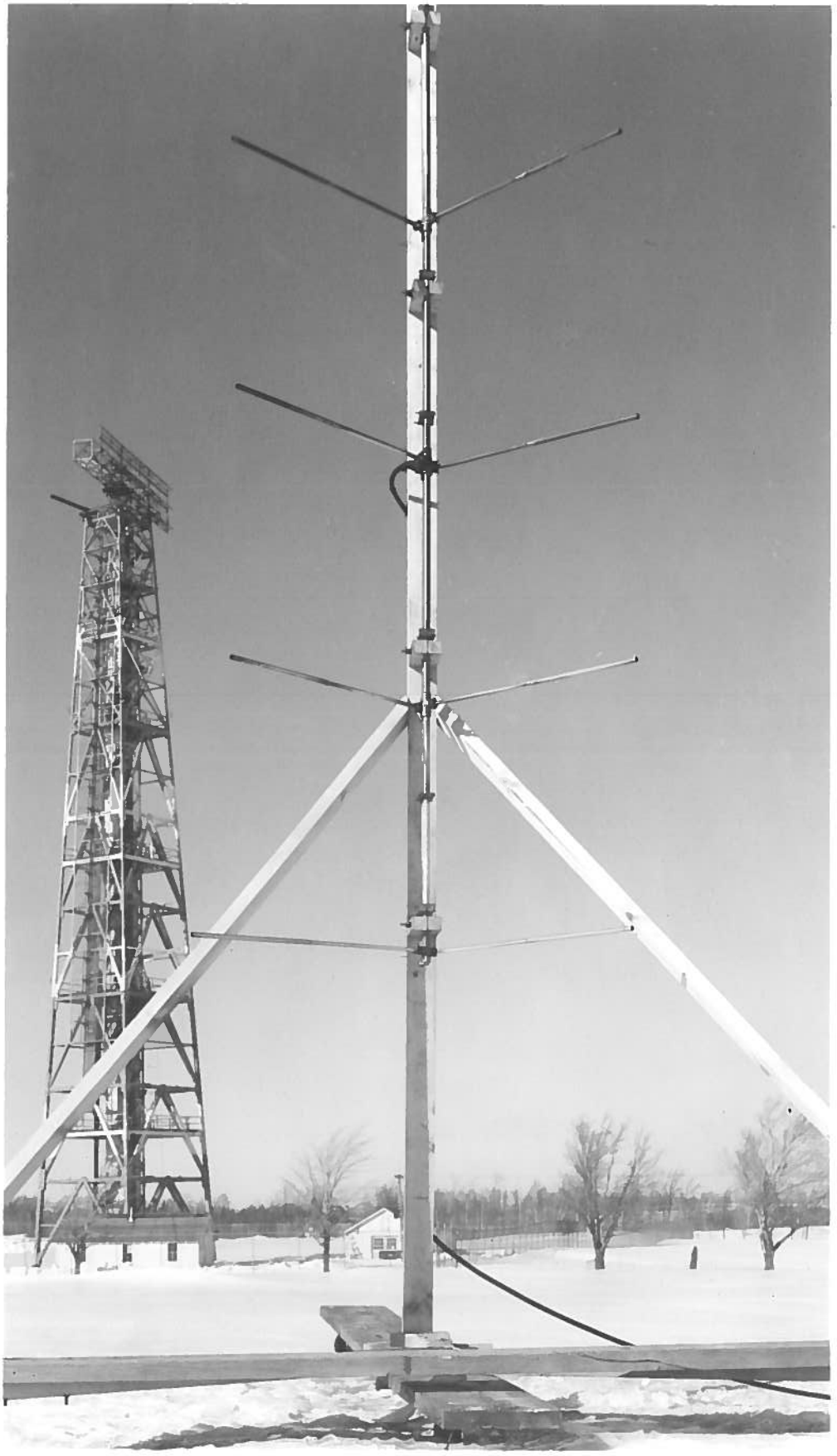
either side of this and hold these in place by short pieces of spaghetti. Screw sections of the outer conductor on either side of the T-section. Slip dipole connector and T-section on each side and screw the latter onto the outer conductor. On each end, slip three more spacers, one for the section of outer conductor, dipole connector and T-section and finally screw the feed line cap. The two feed lines are now completely assembled. Clamp those together by the brass clamp (RS-21).

(iii) Screw the dipoles into the dipole connectors, slip the bakelite bushings in place, adjust the T-sections till the angle of the V is 90°, and adjacent dipoles fed by the same side of the feed line are mutually porpendicular (photograph and RS-31). Solder the T-sections in place. Fix each dipole to the feed line using the set screws, bostik the dipole to the bushing and the latter to the T-section.

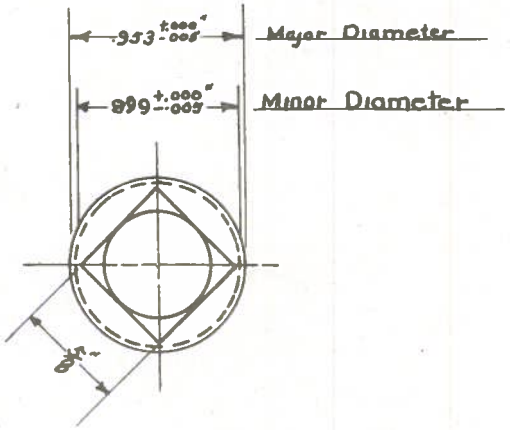
(iv) To attach the transmission line to the feed line slip the clamp (RS-29) and (RS-28) on the transmission line. Bostik and screw (RS-27) to the centre T-section. Bostik and screw (RS-28) to (RS-27). Bostik the transmission line to (RS-28) and by means of the clamp fix the former firmly in the latter. Tape the transmission line firmly to the feed line to avoid strains at the junction box.

7. List of Schematics:

AARS-16A	Cap to antenna feed line
AARS-17A	Junction box for antenna feed line
AARS-18A	Dipole bushing
AARS-19A	Annulus for coaxial fitting
AARS-20A	Spacer for antenna feed line
AARS-21A	Clamp
AARS-22A	Dipole terminal
AARS-23A	Screw plug for dipole
AARS-24A	Dipole connector
AARS-25A	Dipole connector (Center)
AARS-26A	Junction box for antenna feed line (Center)
AARS-27A	Feed junction - part 1
AARS-28A	Feed junction - part 2
AARS-29A	Feed junction clamp
ALRS-30A	Transformer junction clamp
ARS-31E	Assembly
AFIRS-32A	Horizontal radiation pattern



N.R.C.
PHOTO
FIG. 1



Mat'l:- Brass
4 Reqd./Unit
See Assy Drg. RS-31-E

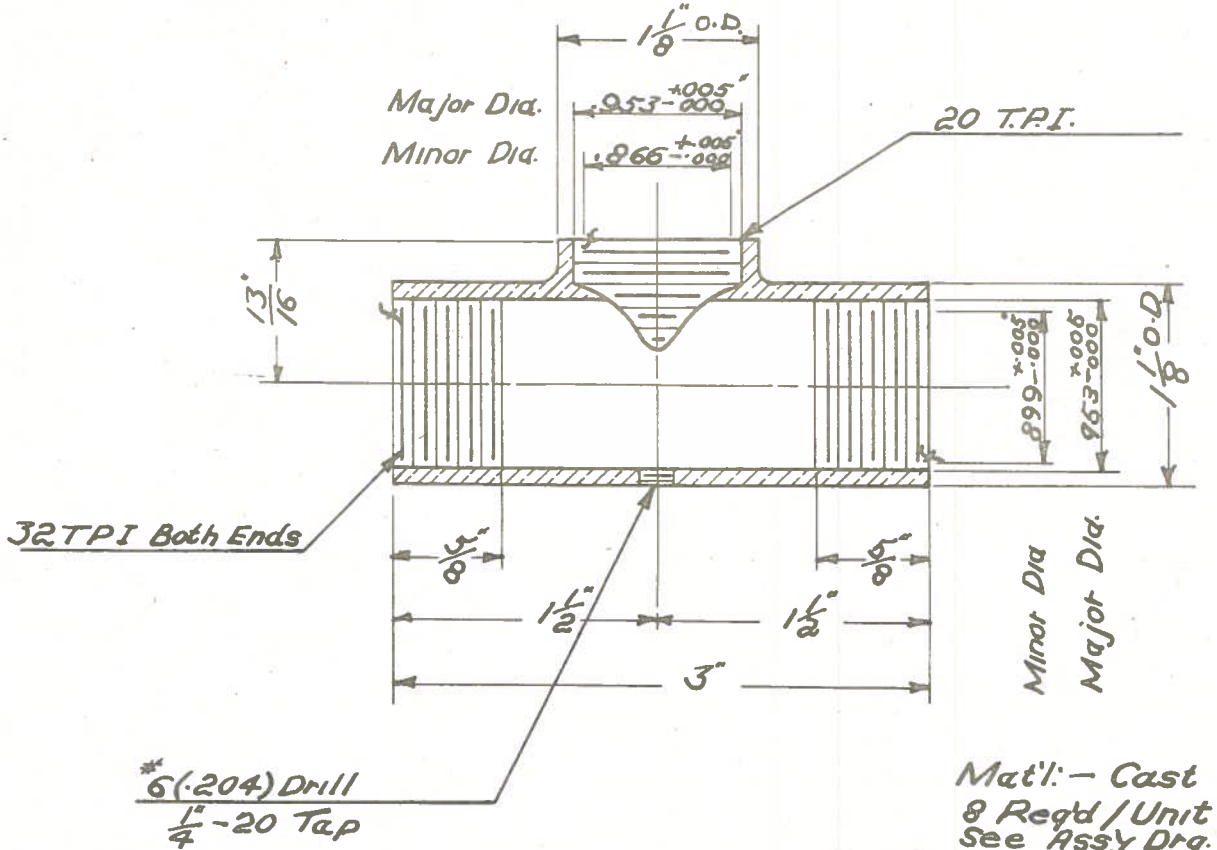
TRACED BY J.R.D 15/3/43

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY W.H.P.	DATE 4-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. J.P.T.	DATE 19/3/43	FINISH. ALL OVER

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
CAP TO ANTENNA FEED LINE	RS-16-A AR



Mat'l:- Cast Brass
8 Req'd / Unit
See Assy Drg. # RS-31-E

Traced By J.R.D 16/7/43

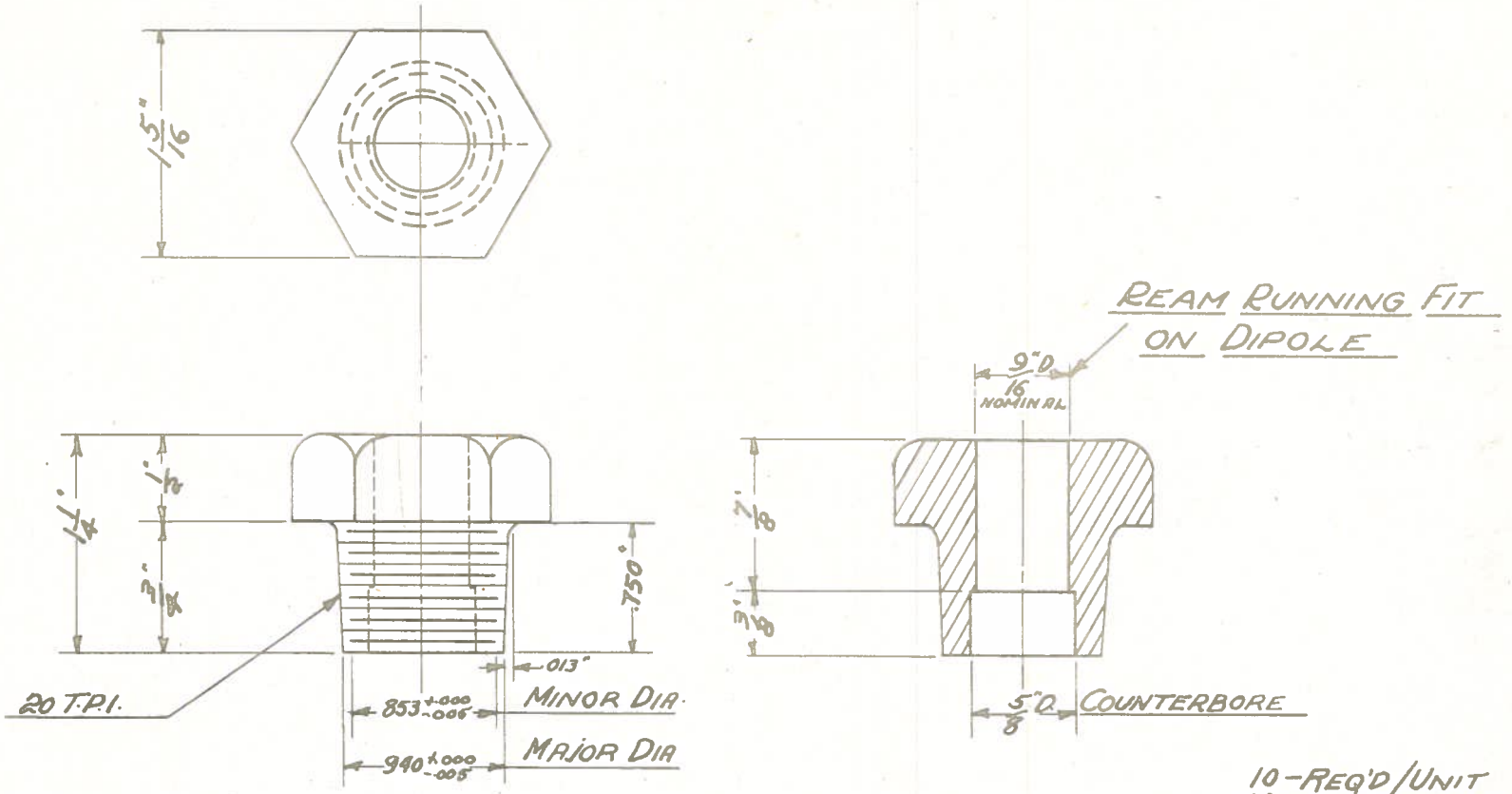
ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY J.R.D	DATE 4-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. T.P.?	DATE 19/3/43	FINISH. As Shown

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME JUNCTION BOX FOR ANTENNA FEED LINE

DWG. NO. AA RS-17-A



10-REQ'D/UNIT
MAT'L:- BLACK BAKELITE
SEE ASSEMBLY DRG.# RS31-E

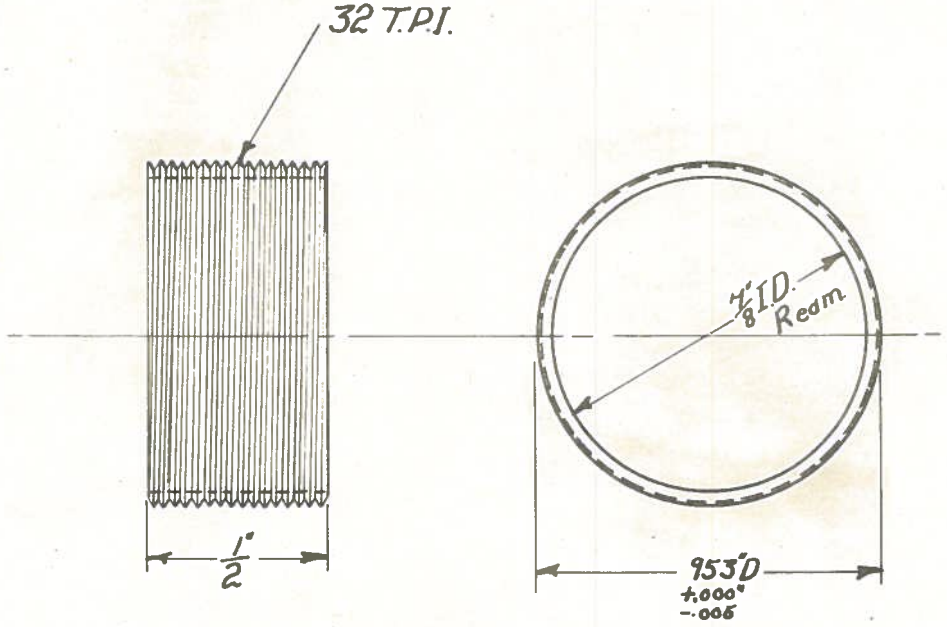
TRACED BY J.R.D 16/3/43

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY D.C.	DATE 6-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE FULL SIZE
ENG. APPROV. 2PP.	DATE 19/3/43.	FINISH. ALL OVER

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
DIPOLE BUSHING	RS-18-A A-A



Mat'l. – Brass
Req'd – 16 per unit
See Ass'y. Dr'g # RS-31-E

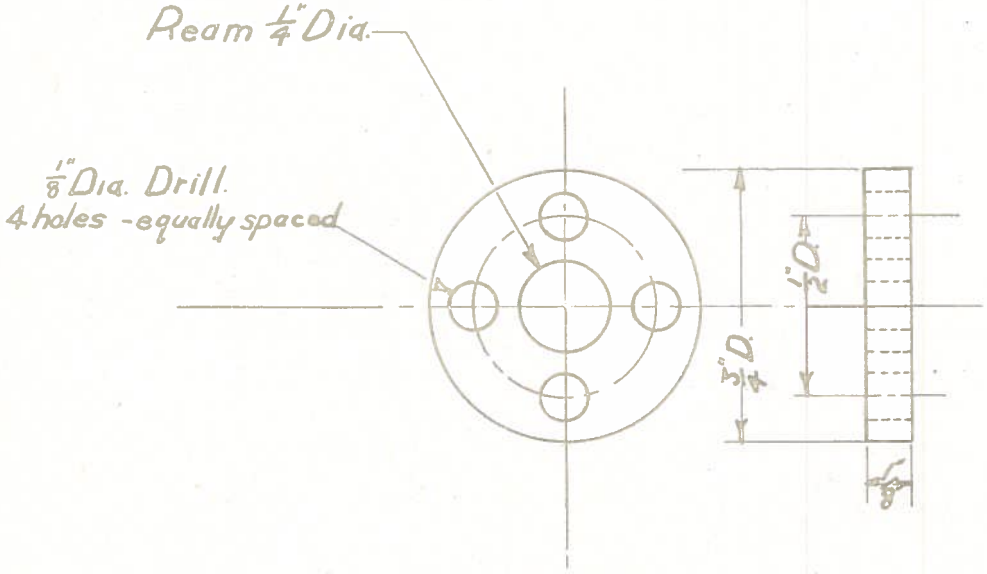
Traced By J.R.D 17/3/43

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY C.E.P.	DATE 5-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. J.R.D.	DATE 19/3/43	FINISH. All Over.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
Annulus for Coaxial Fitting	A-A RS-19-A



Mat'l. – Polystyrene.
Req'd. – 24 per unit
See Ass'y Dr'g. RS-31-E

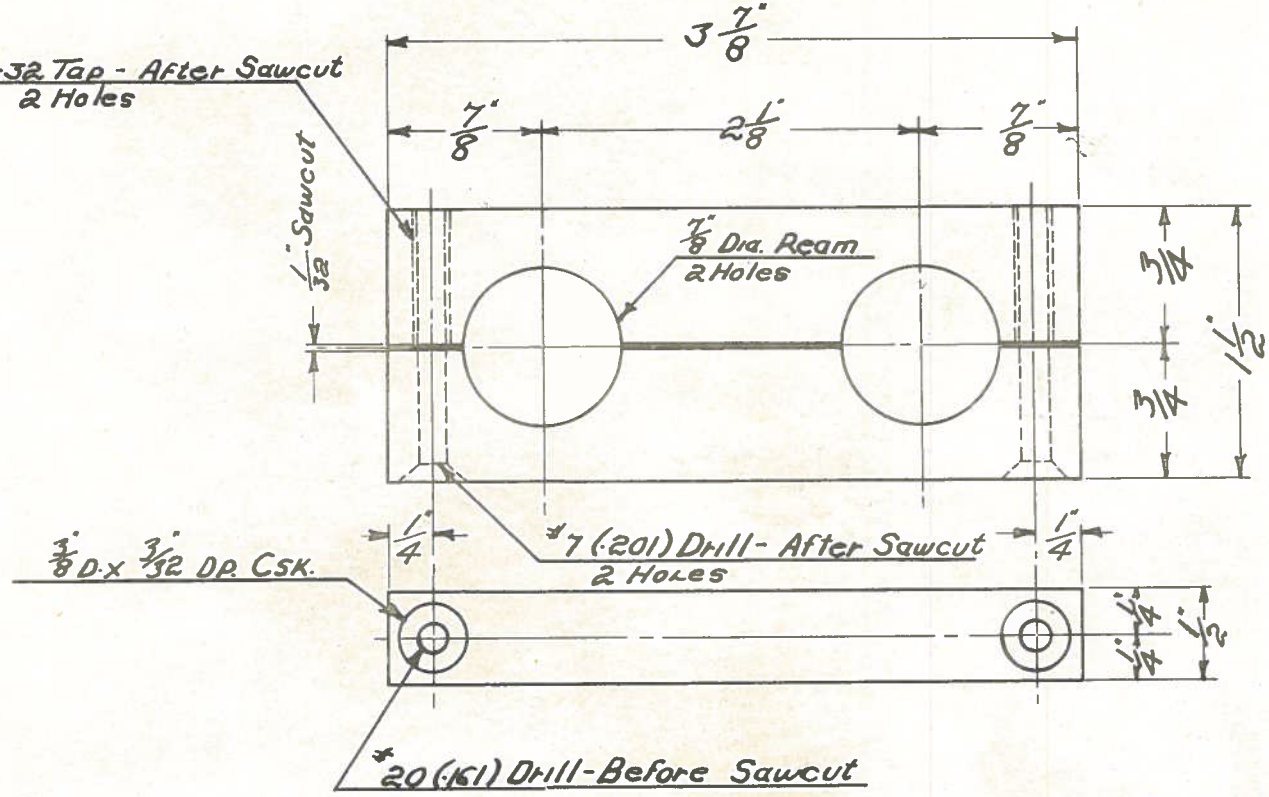
Traced By J.R.D 16/3/43

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY C.E.P.	DATE 4-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. J.R.D.	DATE 19/3/43	FINISH. All Over

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
Spacer for Antenna Feed Line	A-A RS-20-A



Mat'l:- Brass
8 Req'd. / Unit
See Ass'y. Drg.# RS-31-E

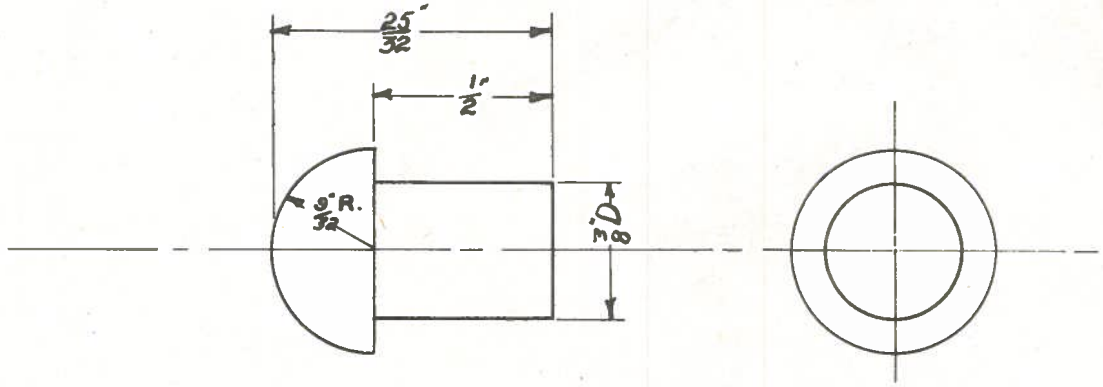
Traced By J.R.D. 16/3/43

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY J.R.D.	DATE 5-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. T.P.P.	DATE 19/3/43	FINISH. All Over

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
CLAMP	RS-21-A AA



Mat'l - Brass
Req'd - 10 per unit
See Ass'y Dr'g # RS-31-E

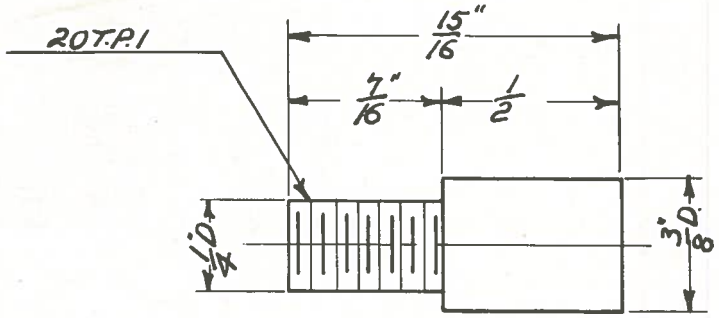
Traced By J.R.D 15/3/43

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY C.E.P.	DATE 4-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. J.R.D.	DATE 19/3/43	FINISH. All Over

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
Dipole Terminal	A A RS-22-A



10 REQ'D/UNIT
MAT'L:- BRASS

SEE ASSEMBLY DRG# RS-31-E

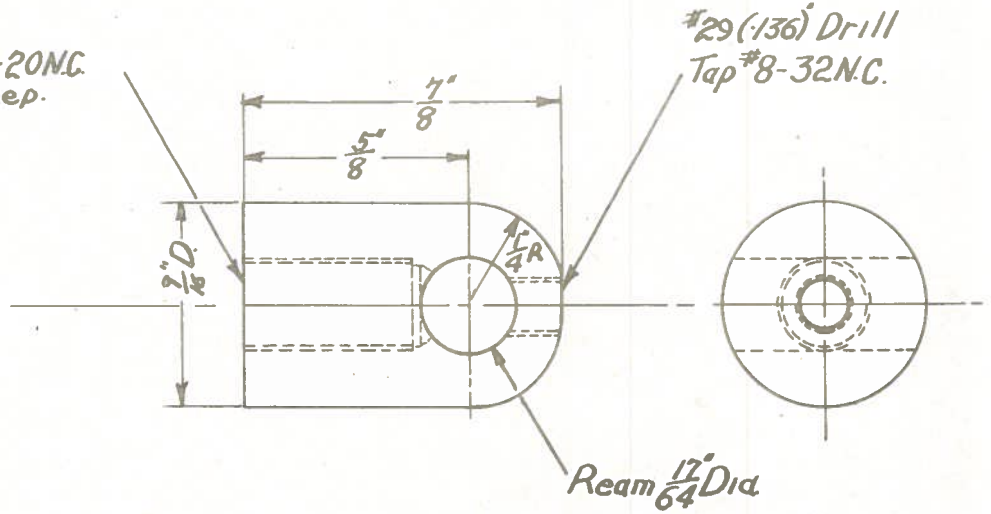
Traced By J.R.D 15/3/43

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY D.C.	DATE 5-3-43	SUPERSEDES
CHECKED A.S	DATE 8-3-43	SCALE
ENG. APPROV. J.R.C.	DATE 19/3/43	FINISH. ALL OVER

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
SCREW PLUG FOR DIPOLE	A-A. RS-23-A



Mat'l.- Brass
Req'd- 8 per unit
See Ass'y. Dr'g. # RS-31-E

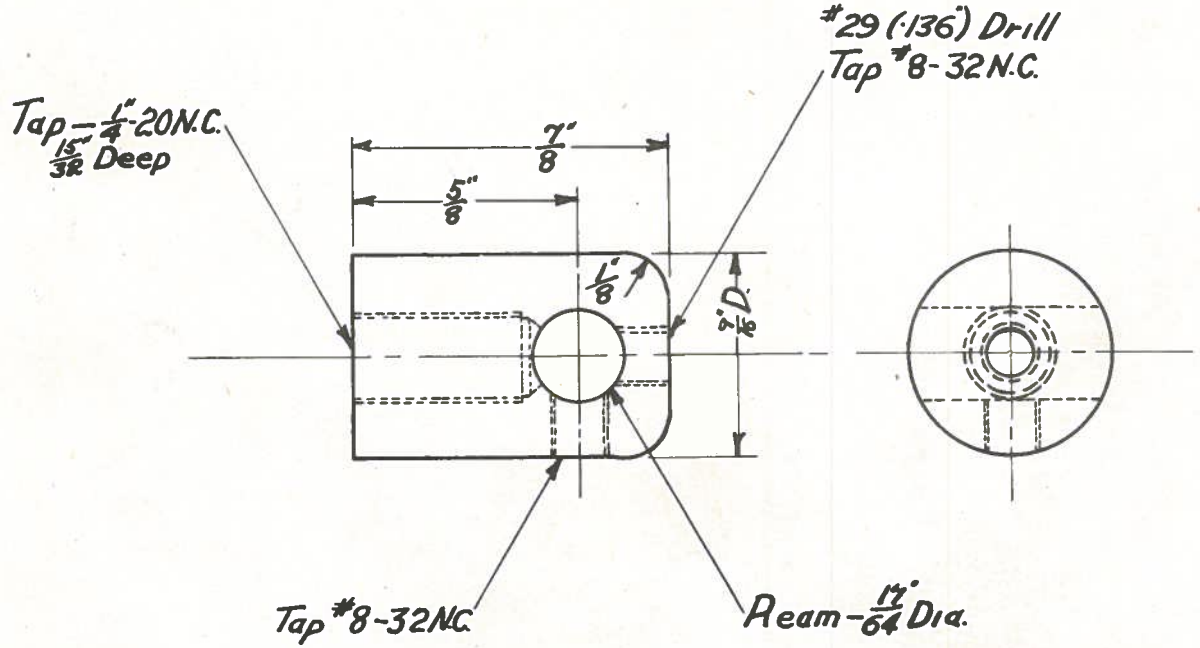
Traced B.Y T.R.D 17/3/43

ITEM	PART NO.	QUAN.	MAT'L.	DESCRIPTION

DRAWN BY C.E.P	DATE 5-3-43.	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. T.P.C.	DATE 19/3/43	FINISH. All Over

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
Dipole Connector	A-A RS-24-A



Mat'l – Brass
Req'd – 2 per unit
See Ass'y Dr'g # RS-31-E

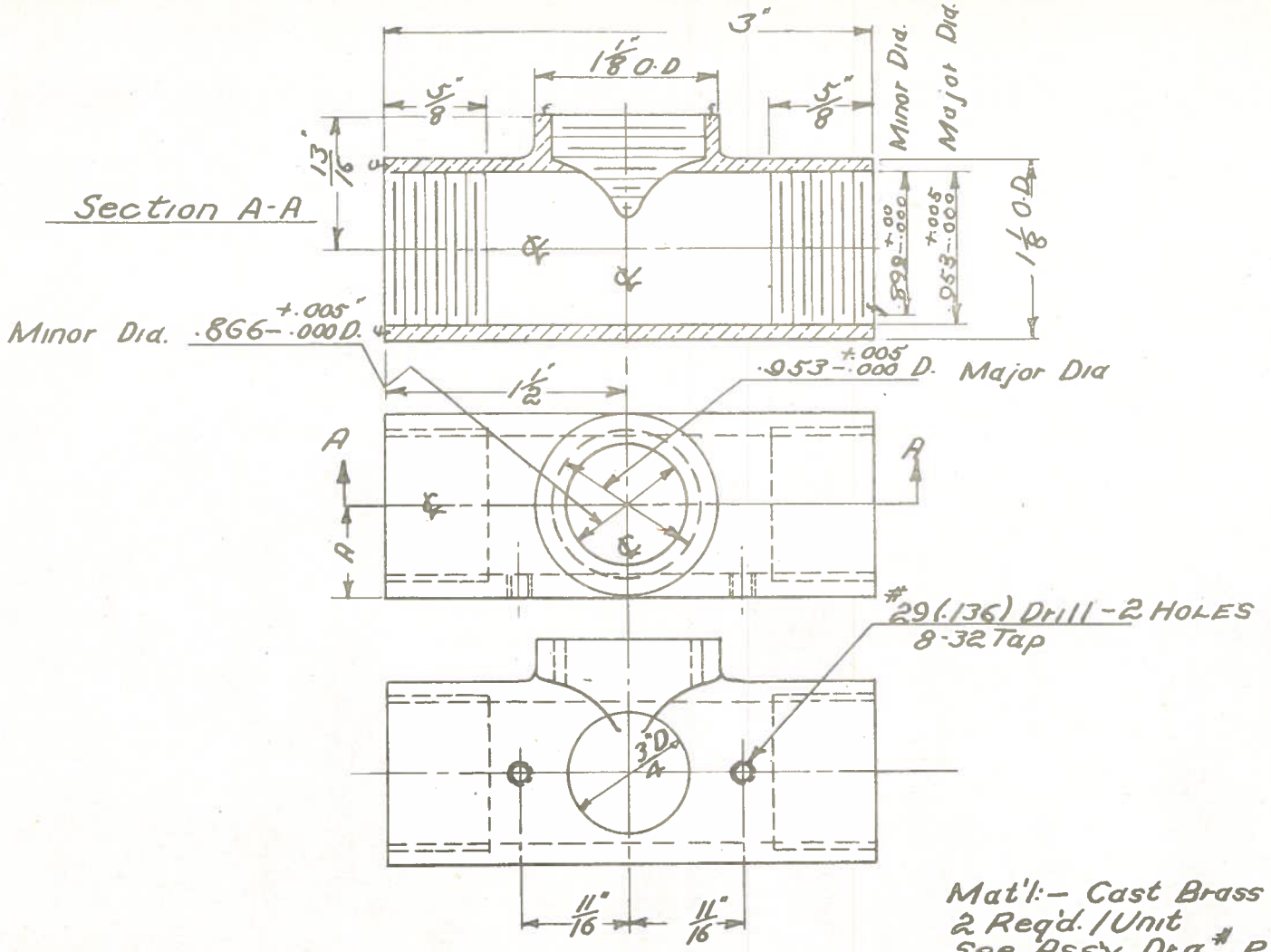
Traced By J-R-D 17/3/43

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY C.E.P.	DATE 5-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. T.R.S.	DATE 19/3/43	FINISH. All Over

NATIONAL RESEARCH COUNCIL-RADIO SECTION – OTTAWA CANADA

NAME	DWG. NO.
Dipole Connector	A-A RS-25-A



Mat'l:- Cast Brass
2 Req'd. / Unit
See Ass'y. Drg # RS-31-E

Traced By J.R.D 17/8/43/43

A: It is critical that outside surface of casting is finished parallel to ℄.

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

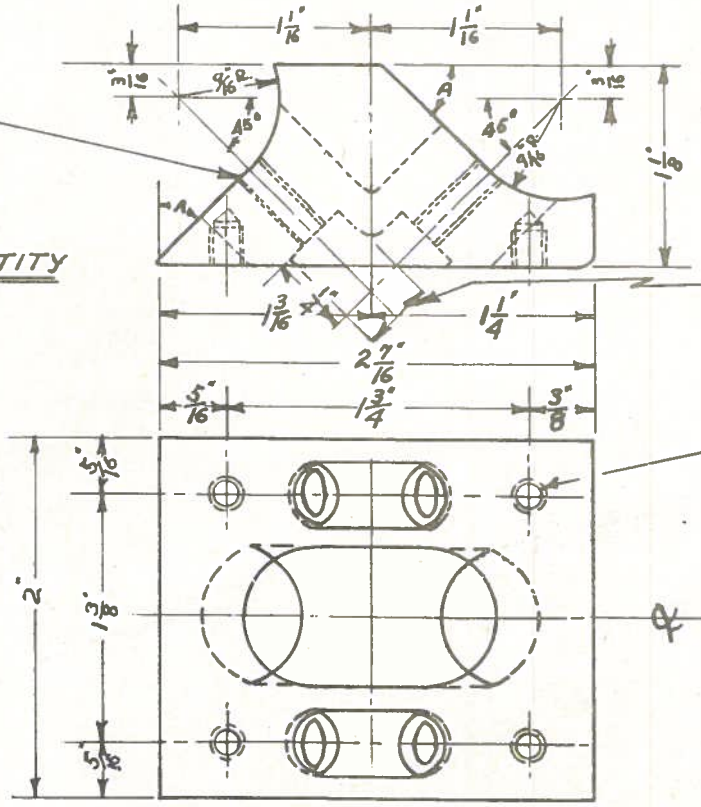
DRAWN BY J.R.D	DATE 5-3-43	SUPERSEDES
CHECKED AS	DATE 8-3-43	SCALE
ENG. APPROV. T.O.E.	DATE 19/3/43	FINISH. As Shown

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
JUNCTION BOX FOR ANT. FEEDLINE	A-A RS-26-A

#17 (.173) DRILL 4 HOLES

A:- THIS 45° IS A CRITICAL QUANTITY



MAT'L:- BRASS
1 REQ'D. /UNIT

SEE ASSEMBLY RS.-31-E

Traced By T.R.O 17/3/44

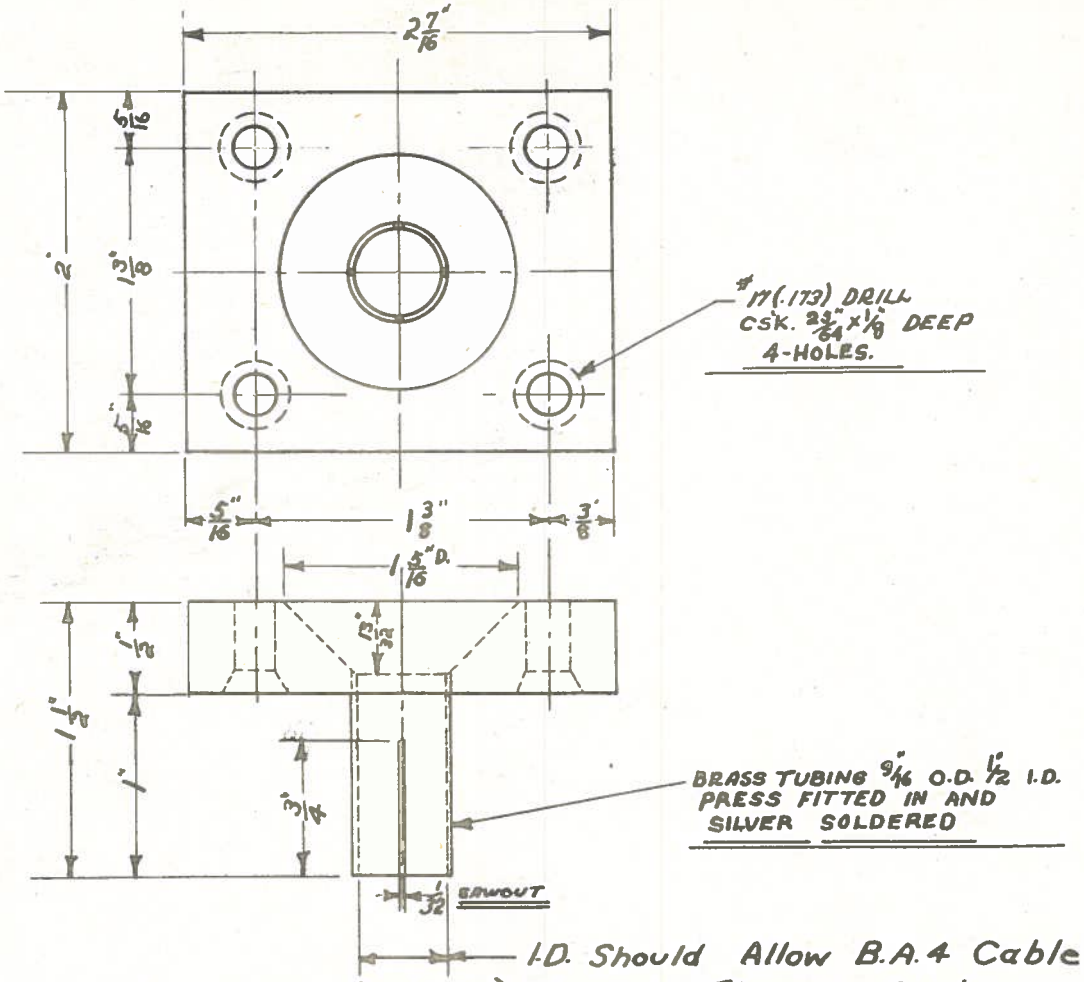
ITEM	PART NO.	QUAN.	MAT'L.	DESCRIPTION

DRAWN BY W.H.P.	DATE 5-3-43	SUPERSEDES
CHECKED AS	DATE 7-3-43	SCALE
ENG. APPROV. J.R.P.	DATE 19/3/43	FINISH. ALL OVER

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME PART ONE OF FEED JUNCTION

DWG. NO. RS- 27- A



MAT'L. - BRASS
1-REQ'D. /UNIT

SEE ASSEMBLY RS-31-E

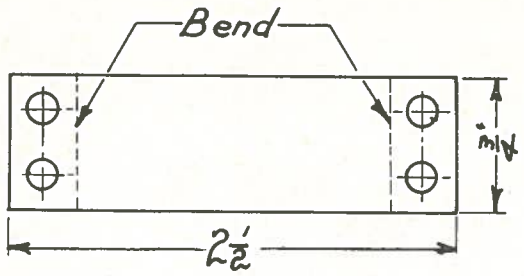
Traced By J.R.D. - 17/3/43

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY W.H.P.	DATE 5-3-43	SUPERSEDES		
CHECKED AS	DATE 7-3-43	SCALE		
ENG. APPROV. T.R.P.	DATE 19/3/43	FINISH. ALL OVER		

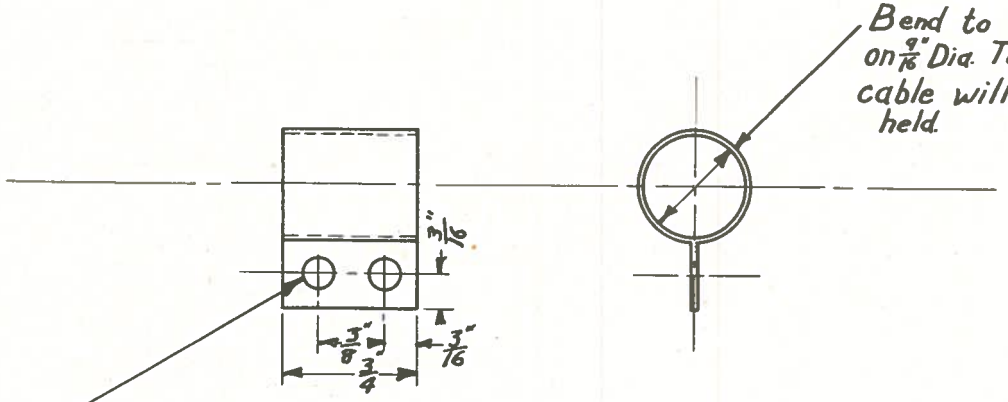
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME PART TWO OF FEED JUNCTION

DWG. NO. RS-28-A



Developed View



Mat'l - #20 Gage Brass
Req'd. - 1 per unit.
See Ass'y Dr'g # RS-31-E

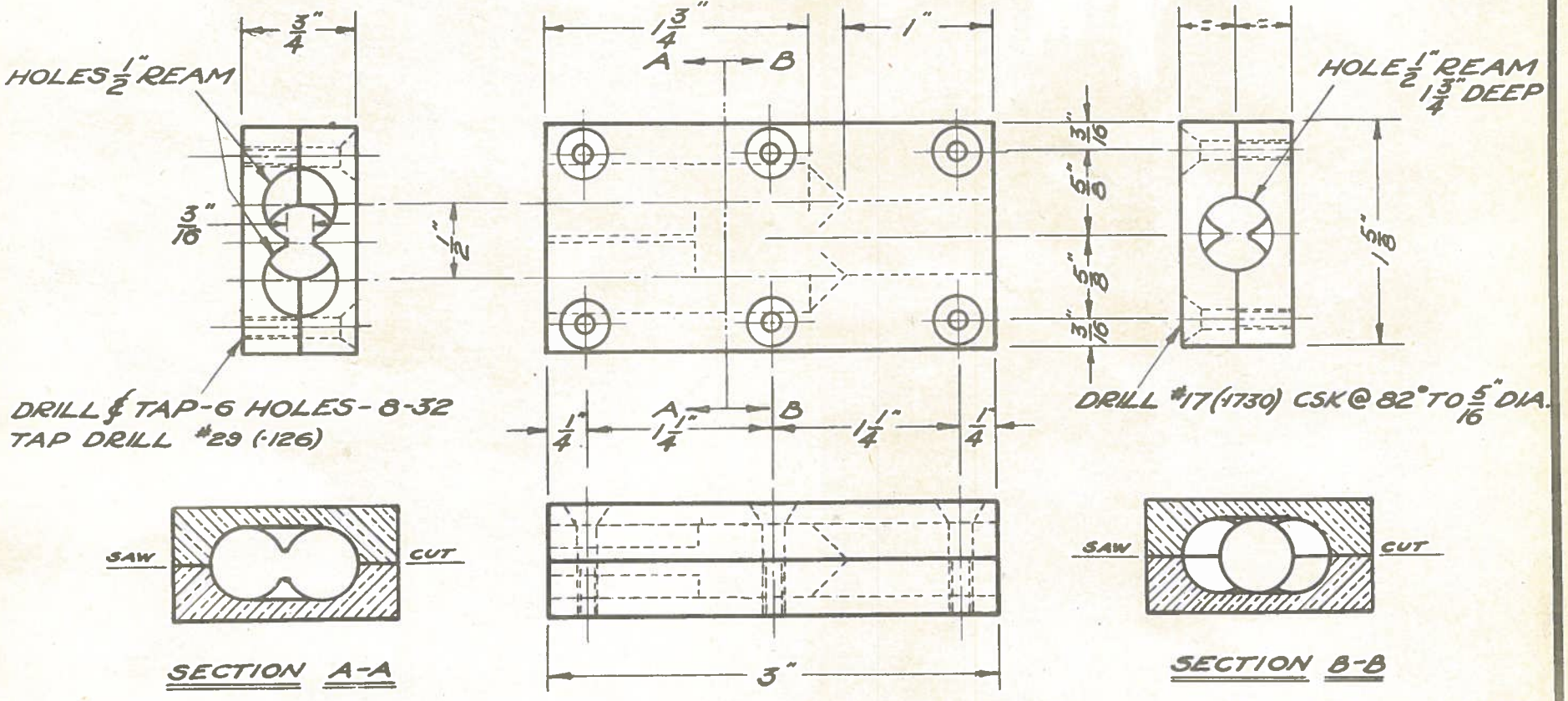
TRACED BY J.R.D. 18/3/43.

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY C.E.P	DATE 5-3-43	SUPERSEDES
CHECKED [illegible]	DATE 8-3-43	SCALE
ENG. APPROV. [illegible]	DATE 19/3/43	FINISH. All Over

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
FEED JUNCTION CLAMP	RS-29-A A A



MATERIAL - BRASS 2 REQ'D. PER UNIT

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

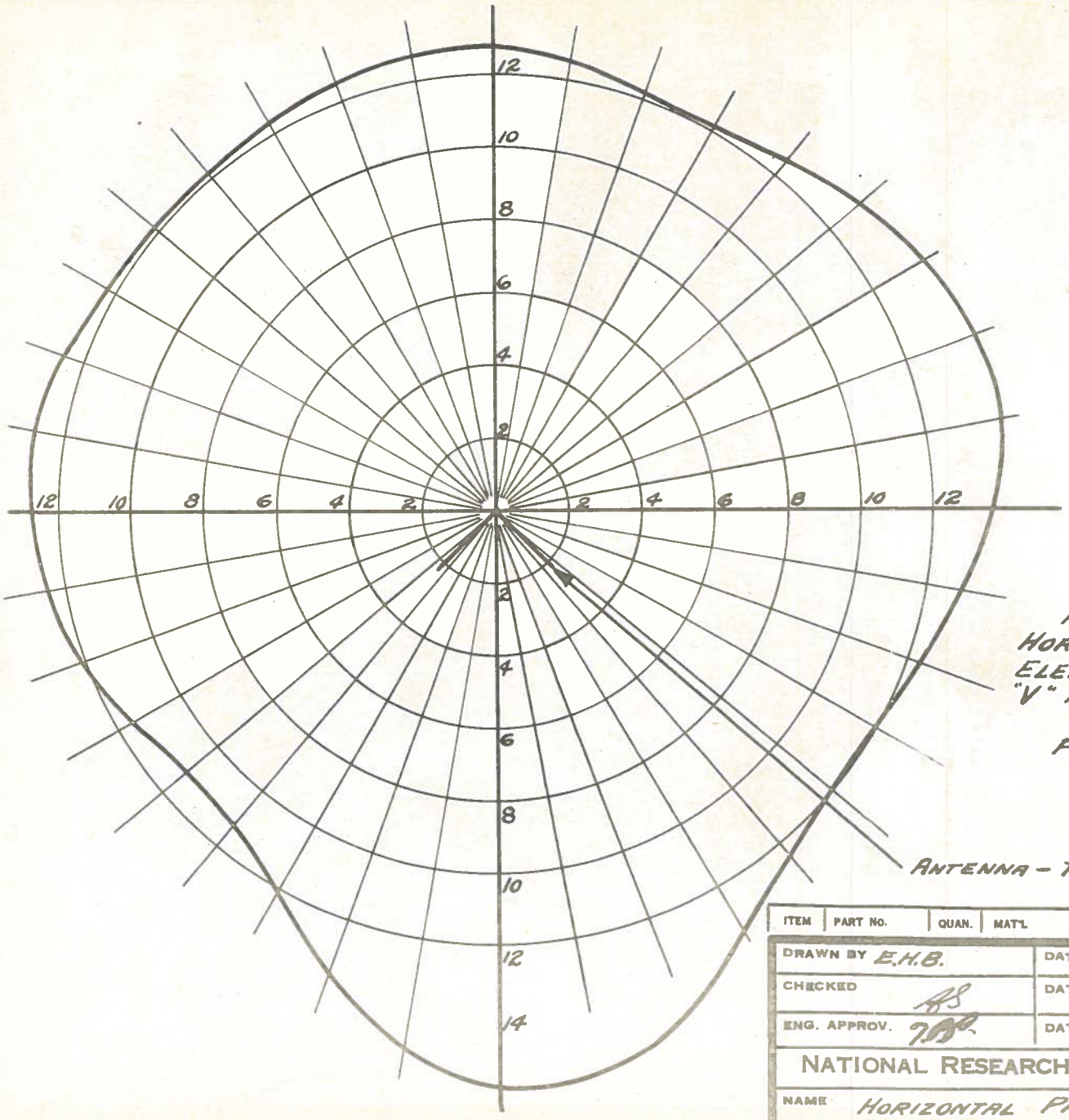
DRAWN BY F.D.E.	DATE Mar. 17, 1943	SUPERSEDES
CHECKED AS	DATE 17-3-43	SCALE
ENG. APPROV. T.R.T.	DATE 19/3/43	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
TRANSFORMER JUNCTION CLAMP	A-L RS 30-A.

NOTE - 1/32" SAWCUT AFTER DRILLING

SEE ASSEMBLY DWG. R.S. 31-E



FIELD INTENSITY IN THE HORIZONTAL PLANE OF A FIVE ELEMENT VERTICAL STACK OF "V" ANTENNAS.

FREQUENCY 177 M.C.

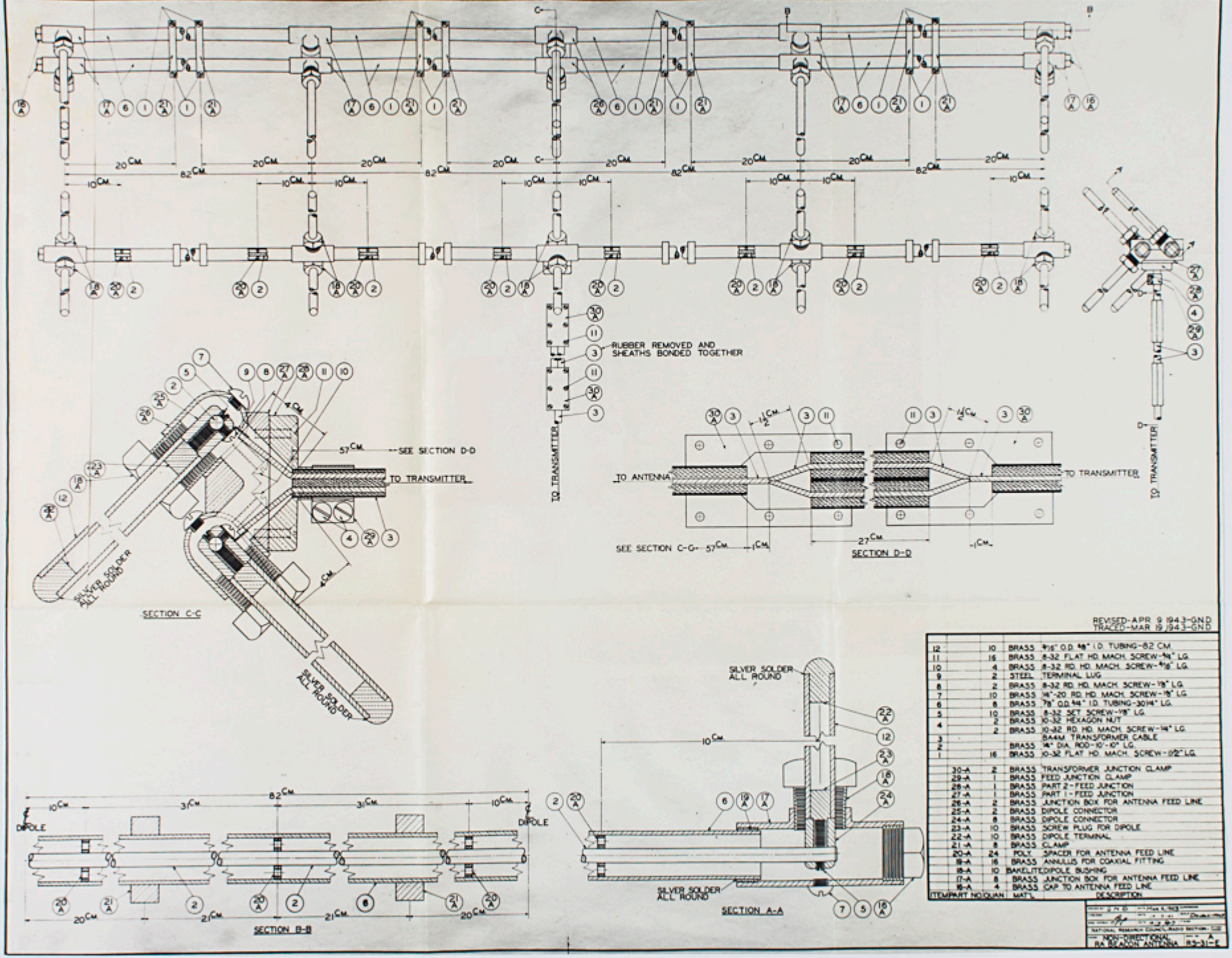
ANTENNA – TOP VIEW

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY E.H.B.		DATE MARCH 15, 43		SUPERSEDES
CHECKED AS		DATE 17-3-43		SCALE
ENG. APPROV.		DATE 19/3/43		FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME HORIZONTAL PATTERN OF OMNI-DIRECTIONAL BEACON ANTENNA

DWG. NO. A.-F.I. RS-32-A



REVISED-APR 8 1943-GND
TRACED-MAR 19 1943-GND

ITEM	PART NO.	QUAN	MAT'L	DESCRIPTION
12		10	BRASS	5/16" O.D. 4/8" I.D. TUBING-8.2 CM.
11		16	BRASS	8-32 FLAT HD. MACH. SCREW-3/4" LG.
10		4	BRASS	8-32 RD. HD. MACH. SCREW-5/16" LG.
9		2	STEEL	TERMINAL LUG
8		2	BRASS	8-32 RD. HD. MACH. SCREW-1/8" LG.
7		10	BRASS	1/4"-20 RD. HD. MACH. SCREW-1/2" LG.
6		8	BRASS	7/8" O.D. 1/4" I.D. TUBING-30 1/4" LG.
5		10	BRASS	8-32 SET SCREW-1/8" LG.
4		2	BRASS	10-32 HEXAGON NUT
		2	BRASS	10-32 RD. HD. MACH. SCREW-1/4" LG.
3				8444M TRANSFORMER CABLE
2			BRASS	1/4" DIA. ROD-10"-10" LG.
1		16	BRASS	10-32 FLAT HD. MACH. SCREW-1/2" LG.
	30-A	2	BRASS	TRANSFORMER JUNCTION CLAMP
	29-A	1	BRASS	FEED JUNCTION CLAMP
	28-A	1	BRASS	PART 2-FEED JUNCTION
	27-A	1	BRASS	PART 1-FEED JUNCTION
	26-A	2	BRASS	JUNCTION BOX FOR ANTENNA FEED LINE
	25-A	2	BRASS	DIPOLE CONNECTOR
	24-A	8	BRASS	DIPOLE CONNECTOR
	23-A	10	BRASS	SCREW PLUG FOR DIPOLE
	22-A	10	BRASS	DIPOLE TERMINAL
	21-A	8	BRASS	CLAMP
	20-A	24	POLY.	SPACER FOR ANTENNA FEED LINE
	19-A	16	BRASS	ANNULUS FOR COAXIAL FITTING
	18-A	10	BAKELITE	DIPOLE BUSHING
	17-A	8	BRASS	JUNCTION BOX FOR ANTENNA FEED LINE
	16-A	4	BRASS	CAP TO ANTENNA FEED LINE

NATIONAL RESEARCH COUNCIL RADIO SECTION - GND

NON-DIRECTIONAL RA BEACON ANTENNA

SIZE A

RS-31-E