C.D. antenna system: description and maintenance instructions

National Research Council of Canada. Radio Section

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NATIONAL RESEARCH COUNCIL OF CANADA
RADIO SECTION

C. D. ANTENNA SYSTEM

DESCRIPTION AND MAINTENANCE INSTRUCTIONS

OTTAWA

JANUARY, 1942

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INDEX

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DESCRIPTION AND MAINTENANCE INSTRUCTIONS

Note: This report refers in detail to the C.D. set installed at Duncan's Cove, N.S., only.

I. DESCRIPTION

The antenna system covered by this report comprises separate arrays for receiving and transmitting. These two arrays are mounted in the same vertical plane, the receiving array being directly above the transmitting array. The array elements(1) are mounted one-eighth of a wavelength in front of reflecting screens which, in turn are fastened to the steel rotating structure on top of the 70 ft. wooden tower. The mean height of the arrays is 168 ft. above the sea.

Each array consists of five vertical stacks of three full-wave dipoles. Cross feeders, one-half wave-length long, connect the centre dipole of each stack to the outer dipoles. A 300 ohm open wire line passes through an opening in the screen to the centre element of each stack. This line is matched to the stack with a closed stub.

Drawings #CD-80 and #CD-81, attached to this report, show the field strength patterns of the transmitting and receiving arrays, respectively. These depict the patterns actually measured at Duncan's Cove after the final array adjustments had been completed.

The combined (transmitting and receiving) patterns shown in Dwg. #CD-82 indicate, of course, the relative R.F. voltage fed to the receiver as the array swings past a target at an azimuth of 0°.

1. Transmitting Array

In the transmitting array, the lengths of the five open-wire lines between their common junction and the stacks are made equal so that the array fires straight ahead. At the junction, quarter-wave sections are

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(1) The array design is based on curves given in N.R.C. report PRA-10 entitled "Design Data for Arrays with Reflecting Screens" by K.A. MacKinnon.

inserted to adjust the power[2] distribution to the five stacks. These sections have been permanently set to give a power distribution which feeds most of the power into the centre stack, a smaller amount in each of the inner stacks, and least into each of the outside stacks. This "tapered" distribution has reduced the field strength of the largest side lobe to about 14% of that of the main beam.

The 70 ohm concentric feeder line from the transmitter is about 180 ft. long. It is connected to the common junction of the feeders through a quarter-wave "sleeve", which device converts the unbalanced concentric line to the balanced output required by the junction. A closed concentric stub matches the concentric line into the quarter-wave sleeve and its antenna load. At the transmitter, the concentric feeder line is terminated in a "trombone" which changes the 70 ohm unbalanced line impedance to 280 ohm balanced, the load into which the transmitter is designed to operate.

2. Split-Beam Receiving Array

Although the receiving array is identical with the transmitting array in front of the reflecting screen, it varies considerably in the arrangement of the open-wire feed lines. This arises from the necessity of splitting the beam in order to obtain the required accuracy in setting the azimuth.

The five feeders which are matched to the five stacks with closed stubs are terminated in a resonant line switch. This device inserts or withdraws fixed lengths of feeder line in all except the centre stack. The effect is to fire the beam either 4° to the left of straight ahead, or 4° to the right.

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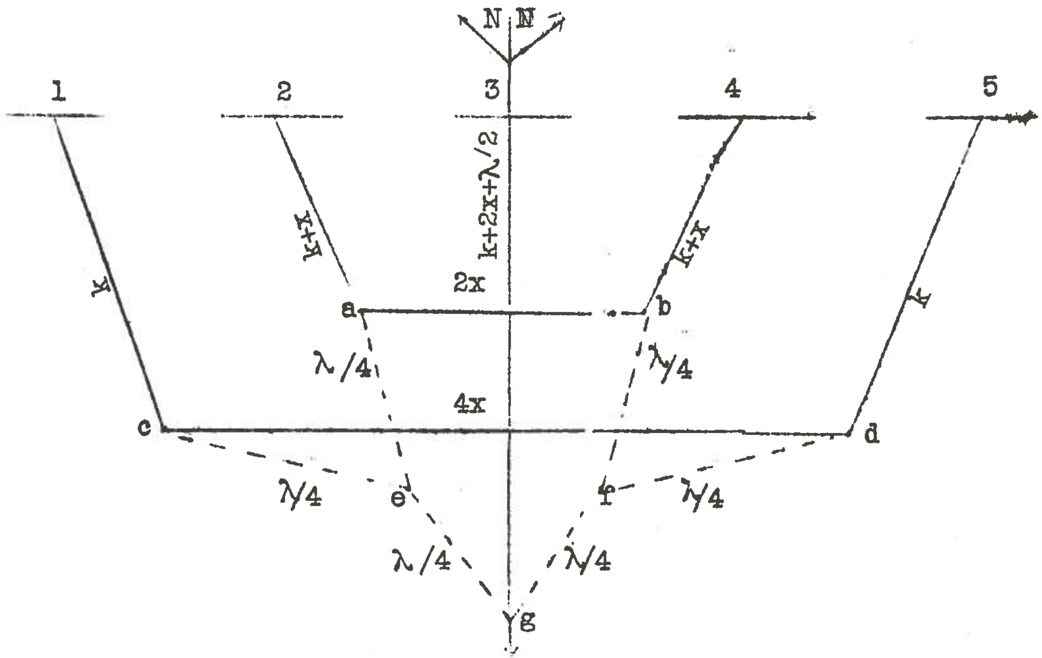
(2) The power measurement technique referred to in this report is based on methods outlined in N.R.C. report PRA-9 entitled "Measurement of Power at Ultra High Frequencies" by K.A. MacKinnon.

The following sketch illustrates the action of the switch. The five horizontal lines at the top represent



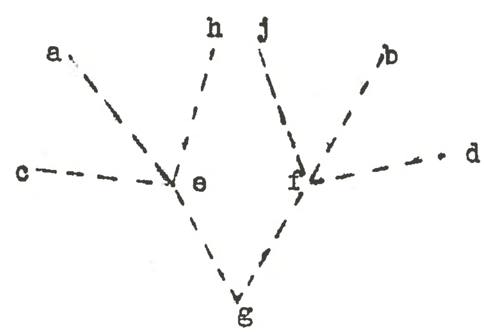
the five stacks of the receiving array in relative position. The remaining solid lines represent two-wire feeder lines, while the dotted lines indicate the two-wire lines comprising the resonant line switch. Each section of line in the switch is a quarter wavelength long.

If, at the same instant, the two-wire line at e is short-circuited and that at f is left open, then the resonant line switch at points a, c, and the "g" end of eg will be of high impedance. Consequently, signals received on all stacks except #3 will travel to the receiver through the paths ending in fg. Accordingly, the lengths of path traversed will be from #1 stack $(k + 4x + \lambda/2)$, #2 stack $(k + 3x + \lambda/2)$, #3 stack $(k + 2x + \lambda/2)$, #4 stack $(k + x + \lambda/2)$, and from #5 stack $(k + \lambda/2)$. Thus the path from each stack differs in phase from that of the preceding stack by an amount corresponding to a length of line of x units. In consequence, the receiving beam will fire to the left hand side at an angle N, equal to arc sin x/d, where d is the horizontal distance between the centres of adjacent stacks.

Similarly, when point f is short-circuited and point e is open, the beam will fire to the right hand side at the same angle N.

The length x was chosen to make N equal to about 4°, and the constant length k was determined by that length which could be most conveniently placed in position around the structural steel members comprising the rotating structure. In order to shorten the centre stack feeders as much as possible, a length equal to one-half wavelength is deleted and accounted for by reversing these particular feeders at the point of attachment at g.

For the sake of symmetry and ease of mechanical construction, the switching is not carried out directly at points e and f, but on the contrary by extra quarter-wave lines eh and fj as shown in the following sketch of the complete resonant line switch.



If the switch opens h and shorts j, it therefore effectively shorts e and opens f, which is the same situation as that assumed in the explanation outlined previously.

3. R.F. Wobble Switch

Although short-circuiting at h and j can be carried out by mechanical contacts, it is much more desirable from the standpoint of reliability and maintenance to use a rotary capacity switch which revolves freely in air. In this equipment a 60 cycle 1800 r.p.m. synchronous ball-bearing motor rotates a brass plate, set in the wall of a cylindrical piece of insulation, past two small pairs of plates attached to the lines at h and j. The air gap is only 0.008 inches and the plates are approximately ½" x 5/8". The relatively low reactance of this capacity at 200 Mc. effectively short-circuits the resonant lines.

The circumferential length of the rotating brass plate is so chosen that during one revolution of the motor the switching cycle is 40% of the time with array firing to one side, 10% array inoperative, 40% array firing to the other side, and 10% inoperative. This long length of time on each firing position is essential to provide the repeated sweeps on the cathode ray tube necessary for a clear presentation. The inoperative state of the array just mentioned is achieved by having both points h and j open during the beam-jumping portion of the cycle. This makes both lines feeding in at point j of high impedance, with consequent poor match into the low impedance feeder line to the receiver.

As in the case of the transmitting array, tapered power distribution to the stacks is necessary to cut down the side lobes which are normally increased in virtue of the slewing of the beam. This tapered distribution is achieved by constructing the various sections of the resonant line switch of different characteristic impedances. A further requirement taken care of by this choice of impedances is that of making the output impedance of the resonant line switch (at point g) equal to 70 ohms, to match the balanced output of the quarter-wave sleeve inserted between the switch and the 70 ohm concentric line feeding the receiver. This permits the omission of a concentric stub at the tower end of the receiver concentric line.

4. Rotation of Concentric Lines

The problem of twisting simultaneously the two concentric lines feeding the transmitter and the receiver is met by inserting concentric swivel joints in each line in the following manner. The transmitting concentric swivel is placed on the axis of rotation just above where it enters the rotating structure. This line is then bent away at 90° to go to the transmitting array. The receiver concentric bends around the transmitter swivel in a wide loop and returns, at a higher point, to the axis of rotation where its swivel is located. There is thus a "blind" sector in the array rotation as a result of the receiving concentric loop striking on either side of the transmitting concentric where it bends away. This blind sector is about 60° wide and is arranged, of course, to point inland where no observations are required.

To protect the concentric line from damage during rotation, safety switches are put on the main azimuth selsyn shaft in the tower. These are cam-operated microswitches and, for safety's sake, are so arranged that one switch opens when the array is about 30° away from the blind sector, and the other opens when the array is about to reach the blind sector.

These 30° sectors on either side of the blind sector are called "buffer" sectors. They also point inland. (See Dwg. #79 attached to this report). If for any reason the array enters the buffer sector, the buffer microswitch opens thus stopping the array rotation motor. In order to operate the rotation motor in the buffer sectors, it is necessary to hold in continuously the ANTENNA LIMIT SWITCH CUTOUT on the azimuth receiver rack (see Dwg. #174 attached to this report). Normally, of course, as there is no reason for entering the buffer sectors, since it covers inland points only, one should turn back out of it at once.

If, on the other hand, the operator persists in operating in the buffer region by holding in the ANTENNA LIMIT SWITCH CUTOUT and starts to enter the blind sector, the second microswitch will open, thus stopping the array rotation motor. To withdraw from this sector it is necessary for the operator to reverse the ANTENNA ROTATION CONTROL and hold in the ANTENNA LIMIT SWITCH CUTOUT while the officer in charge short-circuits terminals 23 and 25 in the main panel box (See Dwgs. NRC-RE-100A and NRC-RE-100D attached to this report).

5. Array Rotation Mechanism

The array is turned by an accurately cut hour glass-shaped worm. The backlash is so small that nowhere does the angle turned by the worm gear, as determined by the revolutions of the worm, depart from the actual angle turned by more than 1' of arc. The azimuth selsyn transmitter units are driven by a train of gears operated directly from the worm shaft. The gear ratios are such that for one revolution of the tower, the main selsyn rotates once while the vernier selsyn rotates thirty-six times. The selsyn system was checked for accuracy between the input worm gear shaft and the dials of the receiver selsyns in the azimuth receiver rack. This test revealed no errors within the accuracy of observation (about $\pm 1'$).

The azimuth receiver selsyns are mounted in the azimuth receiver rack. Provision is also made here for the connection of additional azimuth receiver selsyns.

The worm gear shaft is turned by another gear and worm assembly whose shaft has a pulley which is belt-driven by a variable speed d.c. motor of 1 H.P. rating. This motor is controlled by the ANTENNA ROTATION CONTROL on the azimuth receiver rack (See Dwg. #174) through a thyratron device mounted on the wall near the main panel. The circuits of this device are given in Dwgs. NRC-RE-100D and NRC-RE-101 attached to this report).

A study of Dwgs. NRC-RE-100D and NRC-RE-101 shows that the armature and the series field of the rotation motor are fed through the C6J 60 cycle half-wave rectifier plate circuit. The C6J grid voltage is made up of a d.c. bias voltage on which is superimposed a 60 cycle a.c. component. This d.c. bias is supplied by the 5Z3 full-wave rectifier (which also feeds the motor shunt field) and its magnitude is controlled by the ANTENNA ROTATION CONTROL variable potentiometer. The a.c. component is controlled in magnitude by the fixed potentiometer B, and in phase relative to the C6J plate voltage by the fixed potentiometer A. Two other potentiometers, C and D in the 5Z3 bleeder, are for fixed adjustments of the high and low speeds respectively. These four fixed potentiometers A,B,C, and D, project through the thyratron unit front panel so that adjustments can be readily made. They appear in a vertical stack in alphabetical order with A at the top. Once adjusted, these controls do not appear to need any further attention.

In actual operation the motor gives a maximum speed equivalent to an array rotation rate of 100 minutes of arc per second of time, and a minimum of 4 minutes of arc per second. Any tendency of the motor to "overshoot" i.e. to continue rotating after the rotation control has been returned rapidly to centre-zero, is effectively dampened by the automatic short-circuiting of the armature at the instant the control knob reaches the zero position. Also at this instant, by means of another automatic switch, the C6J grid is brought suddenly to a potential which renders the tube inoperative and thereby prevents random tube discharges.

These various automatic switching operations are all controlled by two microswitches operated by cams on the shaft of the ANTENNA ROTATION CONTROL. In turn, these microswitches control a reversing relay with eight contacts mounted on the wall directly above the thyratron control unit. The schematic is shown in Dwg.

NRC-RE-101 and the wiring in Dwg. NRC-RE-100D, both of which are attached to this report.

6. D.C. Wobble Switch

This device originates the horizontal "jump" on the azimuth tube in synchronism with the antenna R.F. wobble switch, thus producing the split-beam display. The split circuits in the receiver are described in N.R.C. report PRA-22, Section 10.

This switch consists of a pair of contacts which are opened and closed by an eccentric cam rotated by a 60 cycle synchronous motor similar to that in the R.F. wobble switch. Although these two motors rotate in synchronism, it is necessary to phase the operation of the contacts with the jump of the beam. This has been adjusted permanently as far as concerns the fastening of the eccentric on the motor shaft. But these four pole motors, although they always run in synchronism, can do so in any one of four positions, only one of which is correct for the wobble switch. Moreover, it is purely fortuitous which position they may take up after a new start. Consequently, the d.c. wobble switch must be phased with the r.f. wobble switch when either is started anew. The starting switch for the d.c. wobble switch is a push-in-to-stay button on the azimuth receiver rack (See SPLIT MOTOR SWITCH in Dwg. #174 attached to this report).

To phase the switch it is necessary to have all the equipment operating. The d.c. wobble motor will then be running synchronously but, of course, in one of the four random phase positions. The array should now be rotated until it is about 4° off the bearing of a large fixed echo. If the phase happens to be correct, the azimuth tube will display two pips, one about half the height of the other, with the smaller one on the side towards which the ANTENNA ROTATION CONTROL must be turned in order to equalize the heights of the pips. Of the three incorrect phase positions, one position will display exactly the picture described above except that the smaller pip will be on the wrong side, the two other positions will display both large and small pips superimposed and side by side. To correct the phase, one merely pulls out the starting button for a few seconds and then pushes it in again. Usually after three or four attempts the motor will slip into the desired phase position.

7. Colour Disc

A worthwhile improvement in the azimuth display can be provided by a colour disc rotating synchronously in front of the azimuth cathode ray tube. With this device, one pip appears red, the other green, and all the random noise background remains yellow.

Its use has many advantages over the usual single colour azimuth presentation. In the first place, when off the bearing of a weak signal it can be seen at a glance to which side the array must be turned in order to bring up the other pip which originally may not be discernible at all. In the second place, weak signals are more readily discovered in the yellow noise background because of their colour. Thirdly, when a number of ships are in close formation, there is far less danger of the operator's balancing one pip from one ship against one pip from another ship.

The colour disc is made up of a frame holding transparent coloured celluloid, arranged in such a way that on one side of the diameter the colour is green and on the other side red. It is rotated by a 60 cycle synchronous motor, the phasing of which is carried out in exactly the same manner as that described for the d.c. wobble switch in Part I, Section 6 of this report. However, in this case the four possible phase positions give the following colour displays: the correct position shows the left hand pip red and the right hand pip green; one undesired position reverses the colours so that the left hand pip is green and the right hand red; and the two other undesired positions make both pips yellow.

When a colour disc is used, it is necessary that the cathode ray tube should have a white screen.

8. Wiring Diagrams

The entire wiring between the array, the receiver, the transmitter, and the wall-mounted equipment is given in detail in the following drawings attached to this report:

NRC-RE-100A - Array Set Interconnections - Main Panel, Flush Panel Fuse Box - Wiring.
NRC-RE-100B - Array Set Interconnections - Tower Wiring.
NRC-RE-100C - Array Set Interconnections - Main Panel to Receiver and Transmitter - Wiring.

NRC-RE-100D - Array Set Interconnections - Array Rotation Motor Control - Wiring.
NRC-RE-101 - Array Set Interconnections - Array Rotation Motor Control - Schematic

The use of numbered terminals, colour coded wiring, and these detailed drawings should simplify the tracing of any faults which may occur.

II MAINTENANCE INSTRUCTIONS

1. Arrays and Feeders

In general the array elements, two wire feeders and their matching stubs require no maintenance. All that needs to be done to ensure continuous efficient array performance is to keep the transmitter accurately on a frequency of 200 Mc.

The matching stubs are robust and well soldered in position and should not be altered under any circumstances as their precise adjustment in length and position requires special apparatus and technique. Their misadjustment is liable to mar seriously the accurate performance of the whole installation.

The concentric feeders to the arrays require regular servicing. In order to keep dampness out of them, tanks of oil-pumped nitrogen in the basement are connected through rubber tubing to a tap in each concentric. These taps are located at the lowest point of the whole concentric system in order that any water which accidentally enters the feeders may be readily removed.

The nitrogen tank has a reducing valve attachment with two pressure gauges, one of which reads the pressure in the tank and the other the pressure in the rubber tubing. The single rubber tubing from the valve leads to two close-off taps mounted on the wall from which other tubing lengths lead to the two concentrics. These taps should be closed except during blowing out operations.

About once a week gas should be blown through the concentrics at 2 to 4 pounds pressure for about five minutes. Most of the gas leaks out through the quarter-wave sleeves at the tower ends of the concentrics, with the rest coming out the swivels. It is essential, when ordering new tanks, to specify oil-pumped nitrogen because it is the dryness of the gas which is the desired feature.

To check the concentric lines for resistance, both ends of the lines should be free. This is simply done at the operating room end. In the tower, in the case of the transmitter array, the shorting plug on the end of the concentric stub must first be removed, requiring the use of a blow torch. A small handle is attached to the plug by which it can be readily removed, when hot enough, with a pair of pliers. In the case of the receiving array this need not be done, since there is no concentric stub. With the arrays disconnected from the lines at the end of the quarter-wave sleeves, their resistance should be at least 10 megohms.

A short circuit in a line suggests an examination of the concentric insulator directly below the concentric swivel in the tower. This insulator receives the fine metal dust produced by the rotation of the swivel.

Every month the swivels should be pulled apart by removing the quarter-wave sleeves from the arrays and then lifting out the entire end of the line between the swivel and the array. This necessitates the removal of the brass blocks clamping the top part of each swivel and also a wall clamp above the transmitting sleeve. After this operation, the insulator in question can be examined with a flashlight. Any metal dust can be removed with the help of a stiff wire, the end of which is wrapped with tape. Care should be taken during this part of the work to ensure that the three small phosphor bronze contact springs on the male inner conductor are not broken off. In assembling the swivel, one should check by means of a flashlight shining through the slots in the female outer conductor to see that the inner conductors slip into each other and not beside each other. The blade of a penknife inserted through the slots is often a help at this point in the assembly.

2. Tower Rotating Gear

The worm gears are lubricated in a bath of twelve gallons of oil known as "AROX 58" made by Imperial Oil Ltd. This oil is heated by an electric heater controlled by a thermostat set at 45° F. This heater has its own fuse box on the wall in the operating building and is independent of the main switch.

On top of the casing of the pulley driven worm is the plug where the oil is put in. The oil level plug and oil level arrow are on the side of this casing. Oil should ooze out when this plug is removed.

There is a tendency for this oil to leak out at the stuffing box around the shaft behind the driving pulley, and it appears necessary to re-stuff this box every few months, depending on the rate of drip. A drip can has been placed below this stuffing box so that a check of the rate of drip can be kept. Examination of this can should be made twice a week.

In order to fix the stuffing box, it is necessary to remove the driving pulley which is keyed to the shaft and fastened with three Allen setscrews. After loosening these screws, the pulley can be readily driven off with a piece of wood and a hammer. Any type of graphited twist packing, such as "Palmetto" size 3/8", forced in with the stuffing box cap, may be used for re-stuffing.

The selsyn gear box is separate from the worm gear box. The gears run in a bath of light motor oil, "Mobiloil Arctic Special Light SAE 10W", obtained from Imperial Oil stations. The oil level should be such that the gears are completely immersed. There is no electric heater in this gear box.

The motor which turns the array is fitted with two grease cups. These take ordinary cup grease and a single turn of the cup every two weeks should suffice.

3. <u>R.F. Wobble Switch</u>

No servicing of the radio frequency part of the switch should be required because the moving parts rotate freely in air. The ballbearing driving motor, since it is running at practically no load, should not require lubrication more often than once every six months.

4. <u>D.C. Wobble Switch</u>

The driving motor for this switch requires the same servicing as that for the r.f. wobble switch.

The switch mechanism, with its mechanical contacts, requires occasional readjustment as indicated by the azimuth display tube. If, after lining up the array about 4° off the bearing of a large fixed echo, a high fuzzy pattern on top of the smaller pip is observed, it indicates that the knurled knobs on the switch need readjustment. This adjustment should be carried out with caution. Advance one knurled knob about a quarter of a turn to see if the fuzz above the smaller pip is reduced. If so, then swing the array to 4° on the other side of the target to check whether this reduction of fuzz on the smaller pip of one bearing has not, at the same time, increased the fuzz on the smaller pip of the other bearing. The knurled knobs should be so adjusted that fuzz is practically absent from the displays of both bearings. This switch is a precisely built mechanism and should be adjusted with care.

K.A. MacKinnon.

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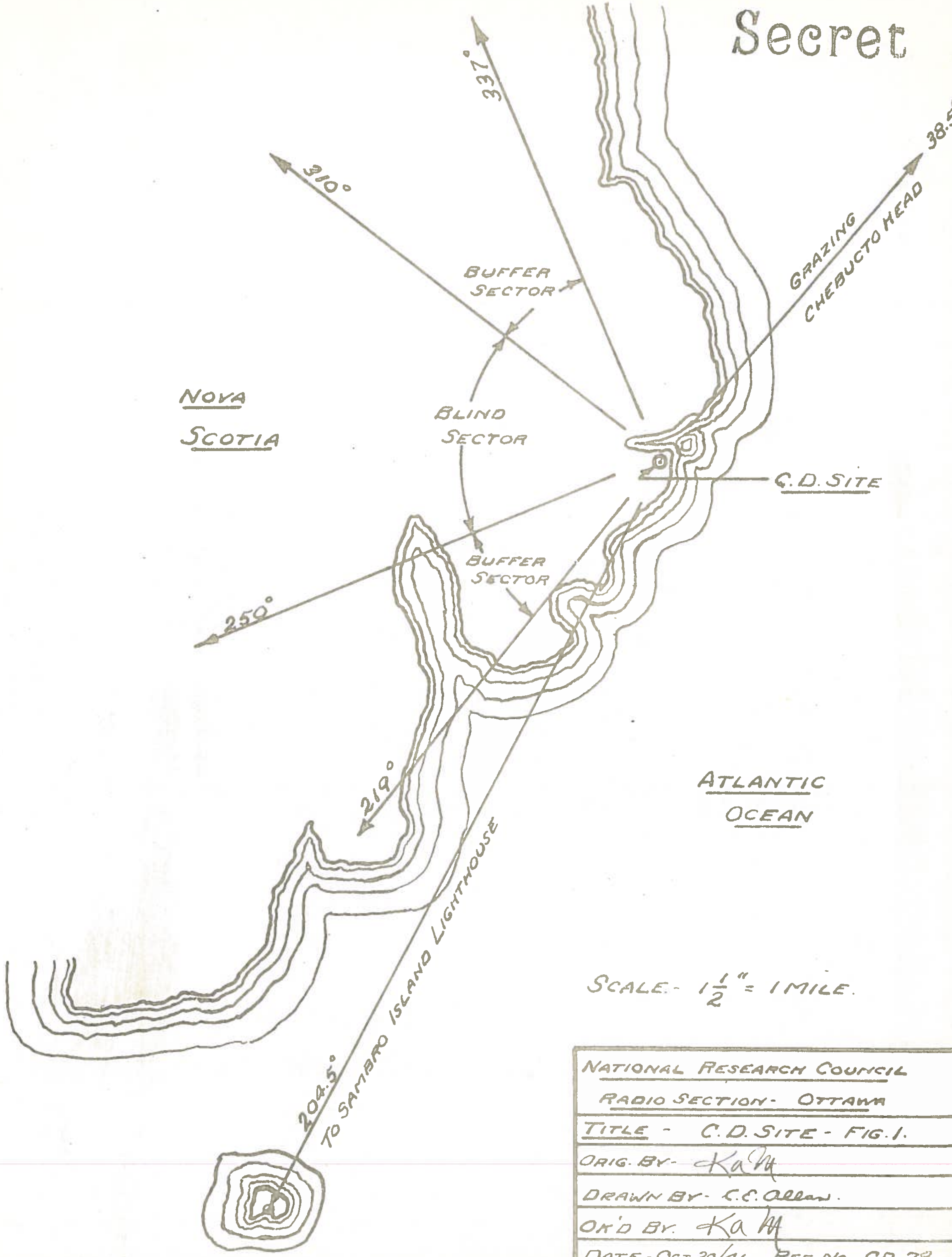


NATIONAL RESEARCH COUNCIL

RADIO SECTION - OTTAWA

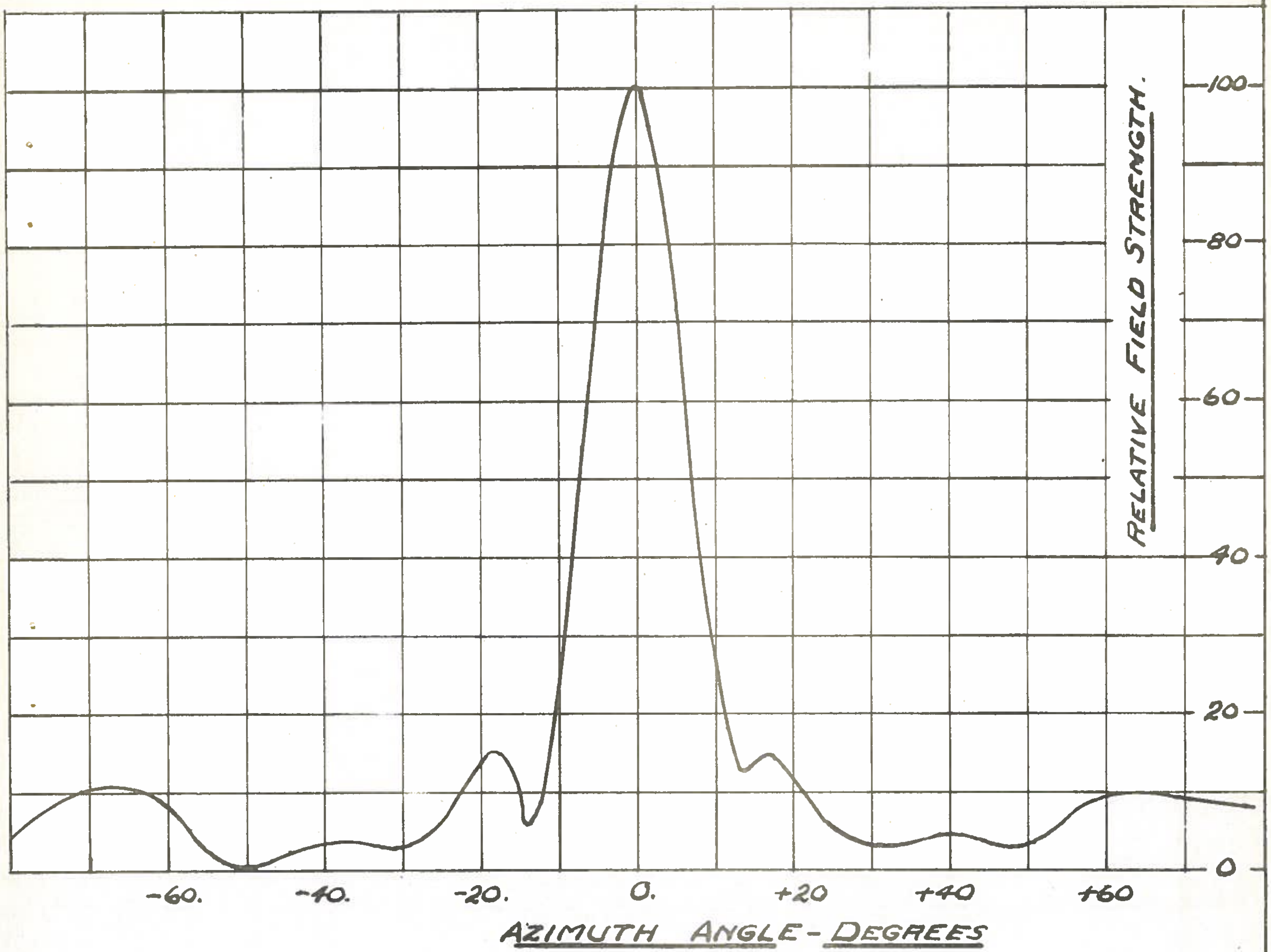
TITLE - C.D. SITE - FIG. 1.

ORIG. BY - KaM

DRAWN BY - C.E. Allan.

OK'D BY. KaM

DATE - OCT. 20/41 REF. NO. CD-79



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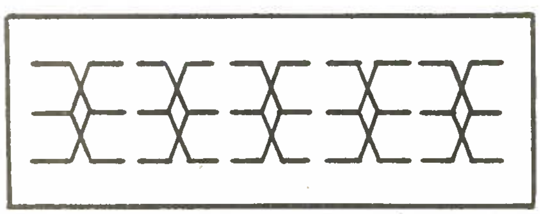
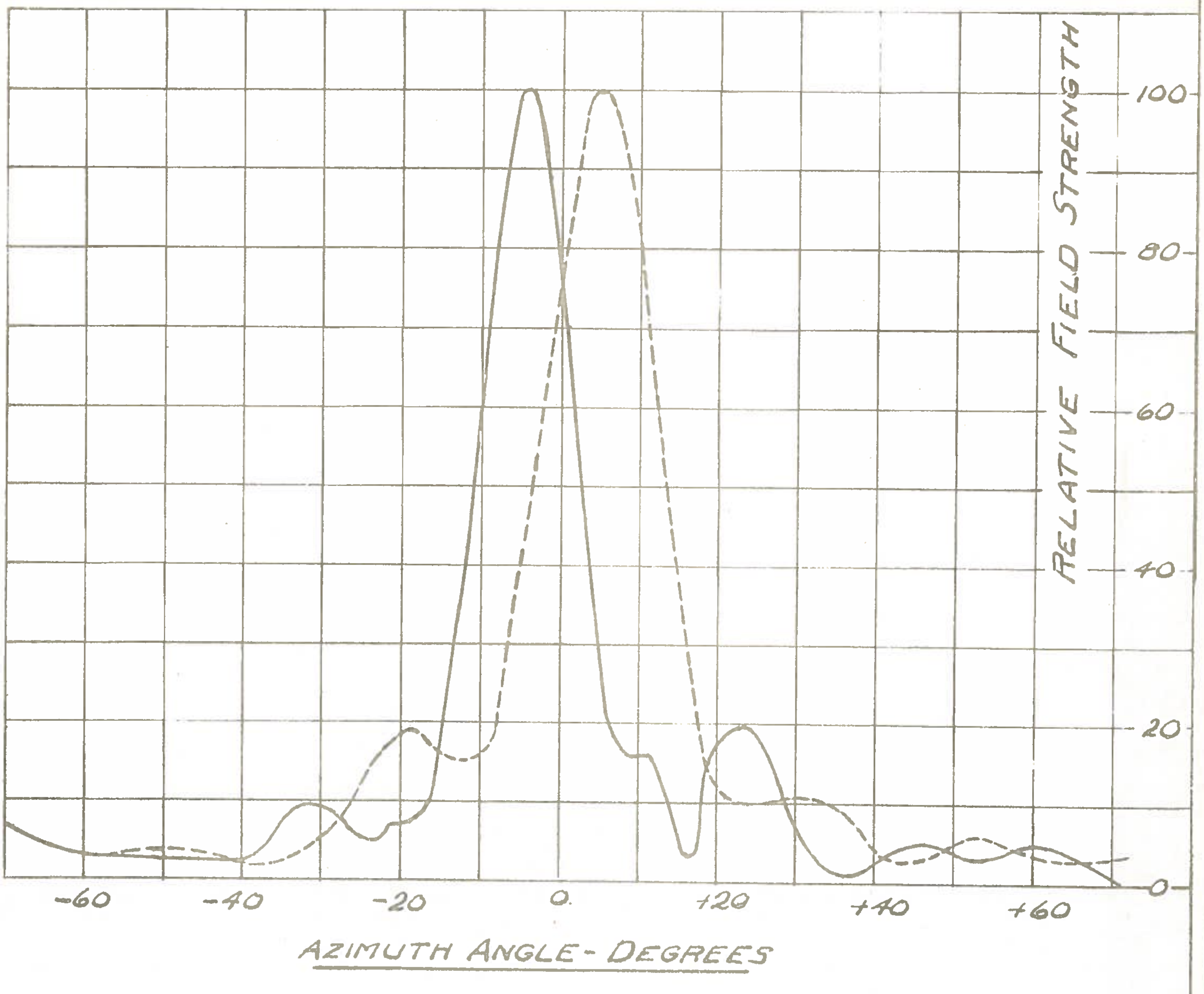


ARRAY DETAIL

NATIONAL RESEARCH COUNCIL RADIO SECTION - OTTAWA.	
TITLE - FIG. 2 - FIELD STRENGTH PATTERN OF TRANSMITTING ARRAY	
ORIG. BY.- KaM	
DRAWN BY - C.E.Allan	
OK'D BY - KaM	
DATE - OCT 20/41	REF. NO. CD-80



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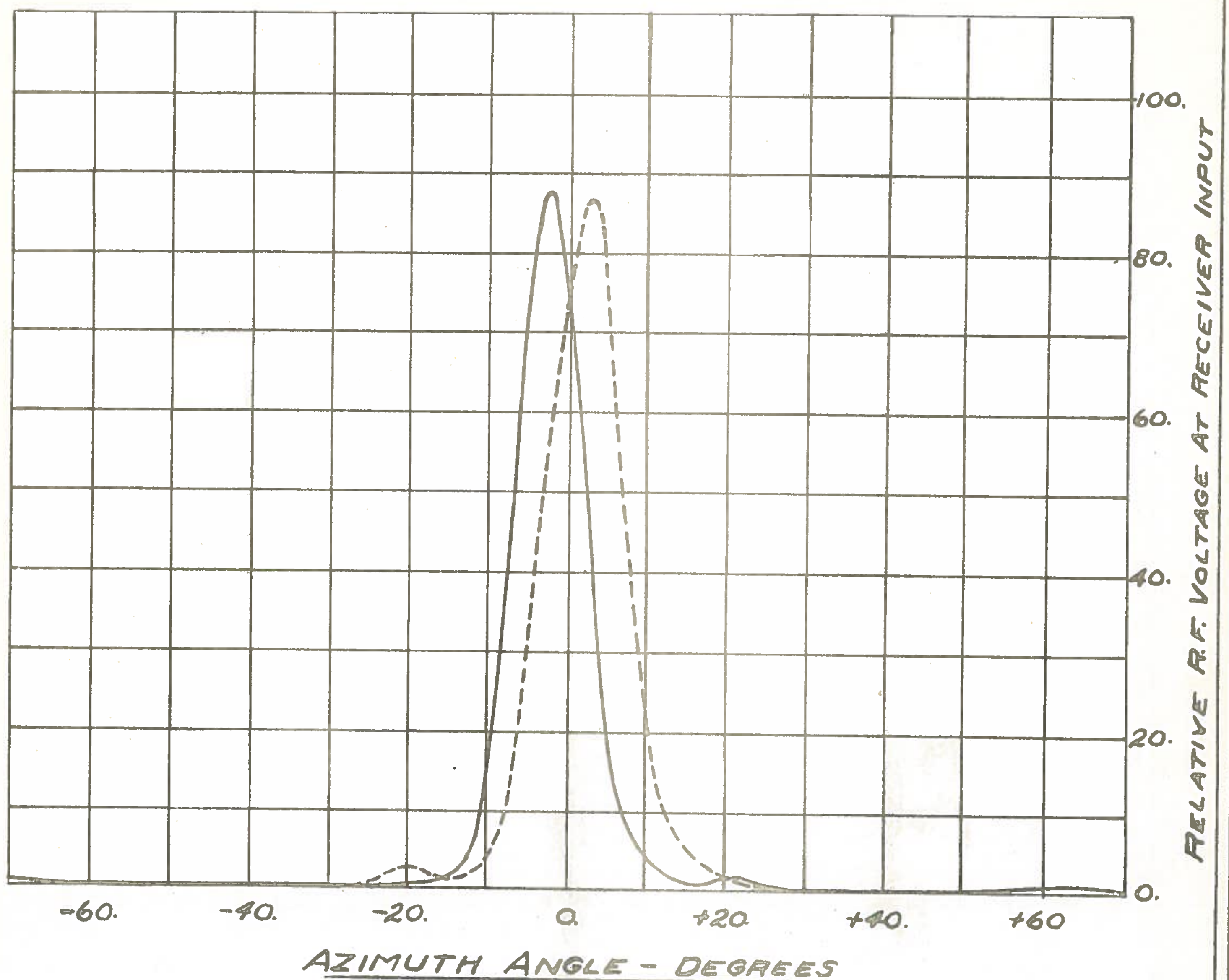
NATIONAL RESEARCH COUNCIL · RADIO SECTION - OTTAWA	
TITLE - FIG 3. - FIELD STRENGTH PATTERN OF SPLIT-BEAM RECEIVING ARRAY	
ORIG. BY - KaM	
DRAWN BY - C.E. Allan	
OK'D BY - KaM	
DATE - OCT 20/41.	REF. NO. - CD-81.



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NATIONAL RESEARCH COUNCIL
RADIO SECTION - OTTAWA

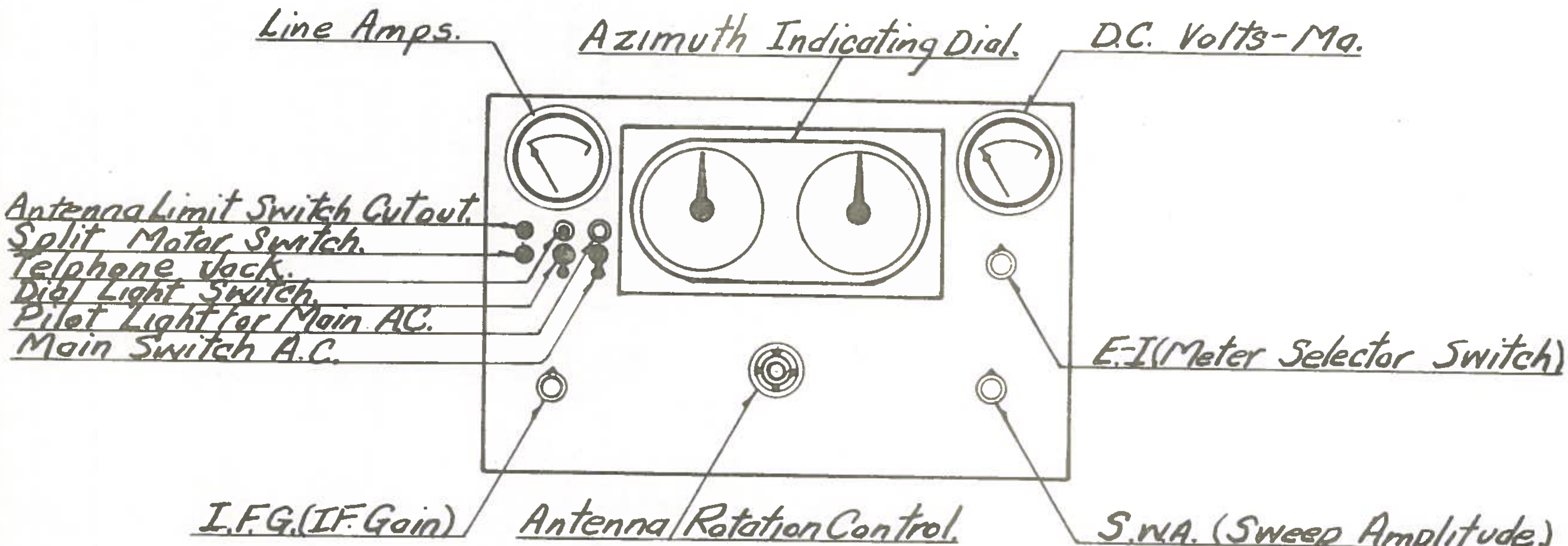
TITLE - FIG 4. - COMBINED PATTERNS (TRANSMITTING X RECEIVING)

ORIG. BY - KAM

DRAWN BY - C. E. Allan

OK'D BY - KAM

DATE OCT. 20/41 | REF. NO. CD-82



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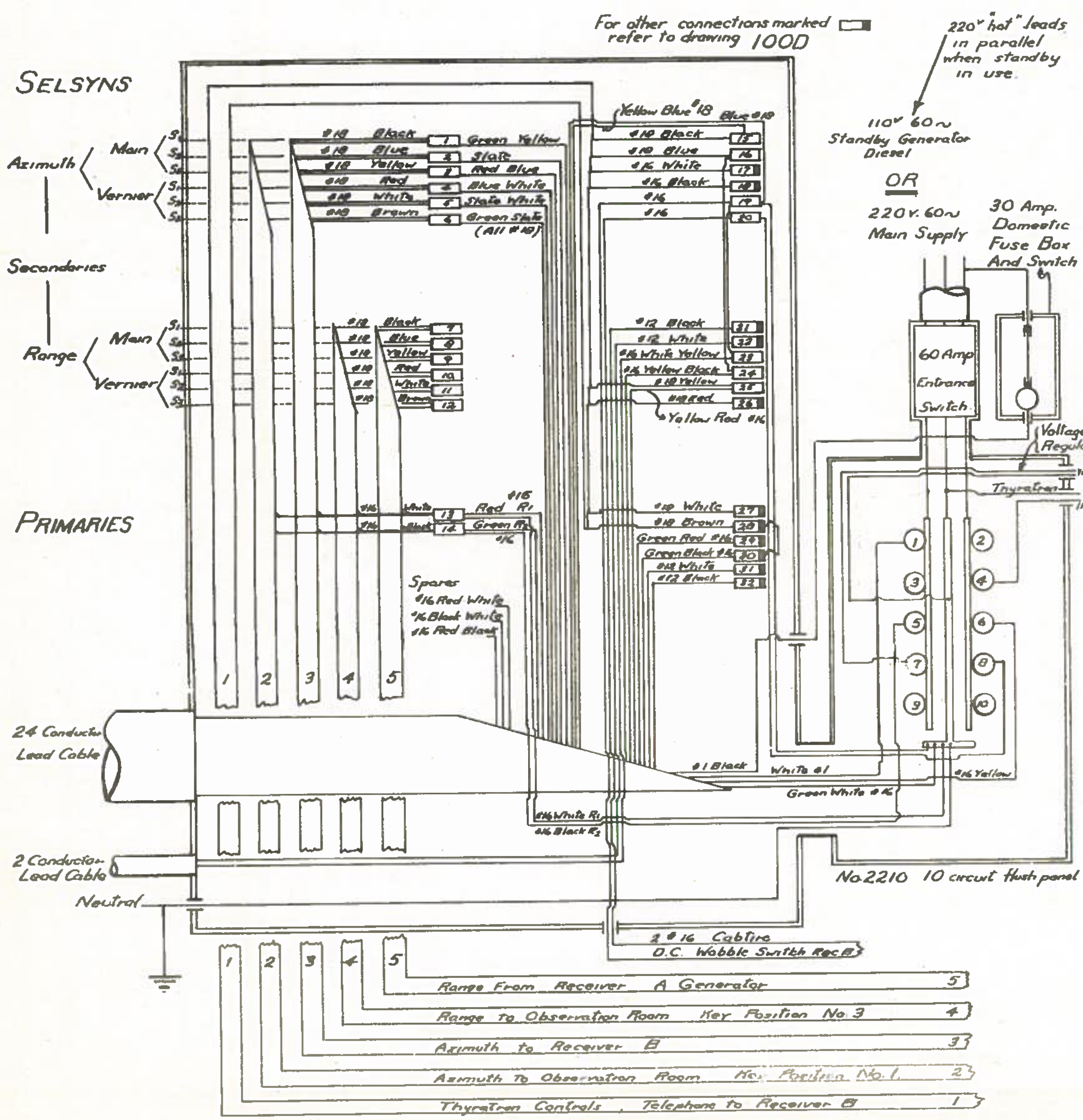
ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION	
DRAWN BY	W. J.	DATE	12/9/41	SUPERSEDES	
CHECKED	W. J.	DATE	12/9/41	SCALE	
ENG. APPROV.	H.H.R.	DATE	12/9/41	FINISH.	

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	
C.D. RECEIVER #1 AZIMUTH CONTROL PANEL	REF. #174

MAIN PANEL



B&S Gage	Colour	Tower & Other Connections	Main Panel No.	B&S Gage	Colour	8 Wire Cabtire No.
18	Green Yellow S_3	Secondary of Main	1	18	Black S_1	No's 2 & 3
18	Slate S_2	Azimuth Selsyn	2	18	Blue S_2	"
18	Red Blue S_1		3	18	Yellow S_3	"
18	Blue White S_1	Secondary of Vernier	4	18	Red S_1	"
18	Slate White S_2	Azimuth Selsyn	5	18	White S_2	"
18	Green Slate S_3		6	18	Brown S_3	"
			7	18	Black S_1	No's 4 & 5
		Range	8	18	Blue S_2	
		Selsyns	9	18	Yellow S_3	
			10	18	Red S_1	
			11	18	White S_2	
			12	18	Brown S_3	
16	Red R_1	110v. Supply To	13	16	White R_1	No's 2, 3, 4, 5 & Neutral
16	Green R_2	Selsyn Primaries	14	16	Black R_2	& Fuse #5
18	Yellow Blue	Telephone	15	18	Black	No 1.
		Micro Switch Return	16	18	Blue	" Jumper To #24
			17	16	White	" ●
		Micro Switches	18	16	Black	" ●
18	Blue	Telephone Return	19	16	2-Wire	Cabtire To (Neutral
			20	16	Synch.	Motor Rec B (Fuse #8
	S_2	Motor Series Field	21			●
	S	Lead Covered Cable Up Tower	22			●
		Limit Switches				
16	White Yellow	Blind Sector L.S.	23			Jumper To #19
16	Yellow Black	Buffer Sector L.S.	24			Jumper To #16
16	Yellow Red	Common L.S. Return	25	18	Yellow	No. 1
			26	18	Red	" ●
		Motor Control	27	18	White	" ●
		Potentiometer	28	18	Brown.	" Jumper To #30
16	Green Red F	Motor Shunt Field	29			●
16	Green Black S_1		30			●
12	White A	Motor Armature	31			●
12	Black L		32			●
16	Yellow	110v. Supply To R.F. Wobble Switch Motor (Yellow Fuse #6				
16	Green White	Joined through To Flush Panel (Green White Neutral				
1	White	Lights & Wall Sockets in Tower				
		Joined through To Flush Panel Fuse #1				
1	Black	Oil Heaters in Tower				
		Joined through separate Fuse & Switch to side of				
		220v. line opposite to Voltage Regulator				
4	White	Neutral				
16	Red White	Spares — For other connections marked "●"				
16	Black White	refer to drawing 100D				
16	Red Black					

Fuse No.	B&S Gage	FLUSH PANEL
1	1	Tower — Lights, Sockets
2		Spare
3		Spare
4	12	Thyratron Motor Control Unit
5	12	Selsyn 110v. Primary Supply
6	16	Synchronous Motor R.F Wobble
7	12	Voltage Regulator - Trans & Receiver
8	16	Synchronous Motor - D.C Wobble - Rec. B.
9		Spares
10		

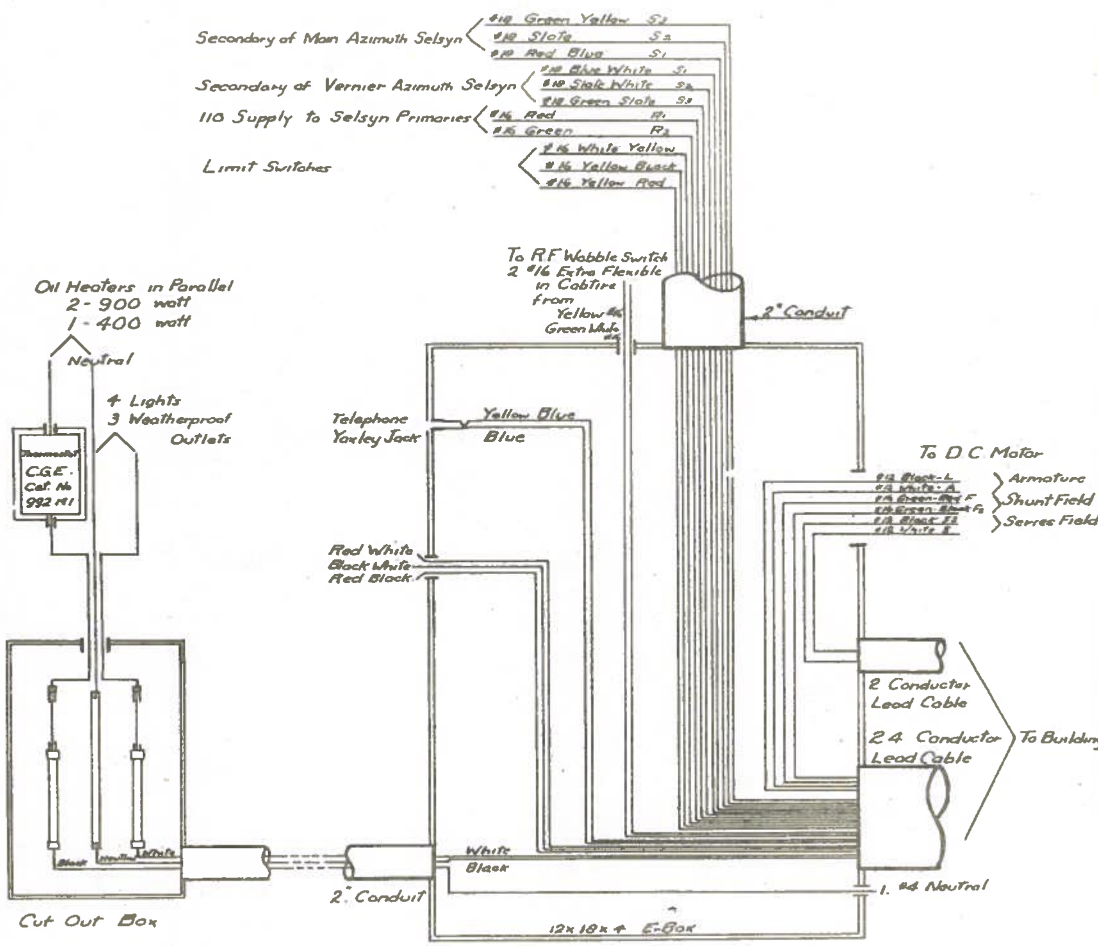
SECRET

Item	Part No.	Quan.	Mat'l	Description

Drawn by T.P.A — Traced by C.F.R — Date Oct 17/41, Jan 23/42 — Supersedes
Checked R.S.R — Date Oct 17/41 — Scale
Eng. Approv. K.A.M — Date " " — Finish

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

Name: ARRAY SET INTERCONNECTIONS MAIN PANEL — Dwg. No. NRC-RE-100 A.



B&S Gage	Colour	24 Conductor, 2 Conductor, Neutral — Lead Cable	Main Panel No.
18	Green Yellow S_3	Secondary of Main Azimuth Selsyn	1
18	Slate S_2	Leads reversed as shown to	2
18	Red Blue S_1	Insure proper direction of rotation	3
18	Blue White S_1		4
18	Slate White S_2	Secondary of Vernier Azimuth Selsyn	5
18	Green Slate S_3		6
16	Red R_1		13
16	Green R_2	110 V. Supply to Selsyn Primaries	14
18	Yellow Blue	Telephone - Tower to Receiver B	15
18	Blue	(Jack on front panel)	19
12	Black S_S	Motor Series Field. #12 from E. Box.	21
12	White S	Flat Strap Lead-Covered Cable in Tower	22
16	White Yellow	Blind Sector L.S.	23
16	Yellow Black	Limit Switches Buffer Sector L.S.	24
16	Yellow-Red	Common L.S. Return	25
16	Green Red F	Motor Shunt Field	29
16	Green Black F_2		30
12	White A	Motor Armature	31
12	Black L		32
16	Yellow	110 V. Supply to R.F. Wobble Switch Motor	
16	Green White	joined through to Flush Panel / Yellow - Fuse #6	
		Green White - Neutral	
1	White	Lights and Wall Sockets in Tower	
		joined through to flush panel Fuse #1.	
1	Black	Oil Heaters in Tower	
		joined through separate Fuse and Switch to side	
		of 220 Line opposite to Voltage Regulator	
4	White	Neutral - Tower, Array Frame, Fuse Box	
		Receivers, Transmitters	
		Grounded at base of tower	
16	Red White		
16	Black White	Spares	
16	Red Black		

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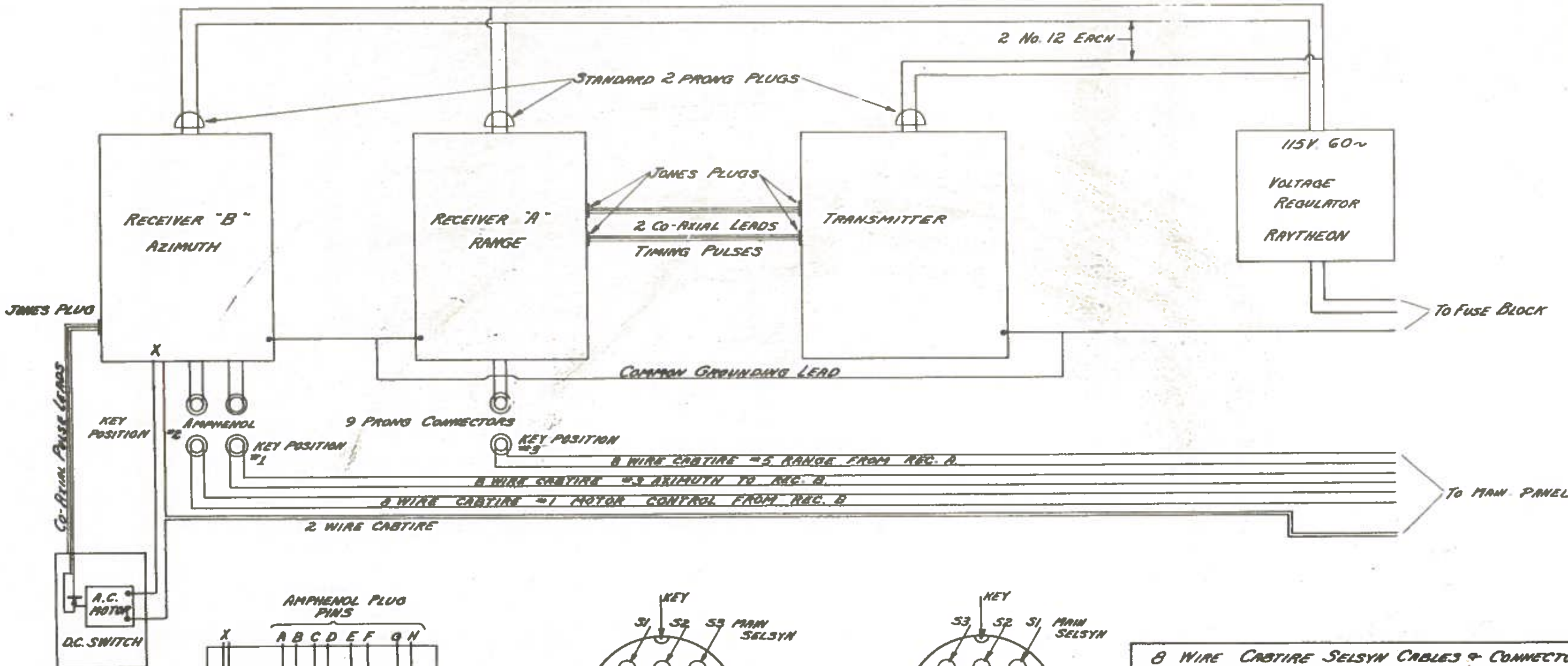
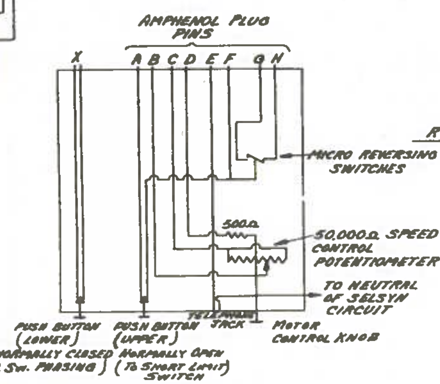
Checked R.S.R.
Eng. Approv. K.A.M.

NATIONAL RESEARCH COUNCIL-RADIO SECTION- OTTAWA CANADA

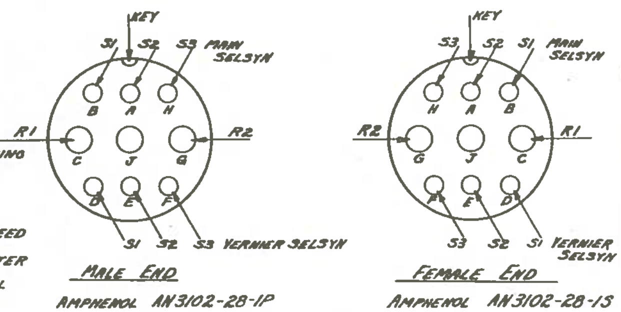
Name: ARRAY-SET INTERCONNECTIONS TOWER WIRING

Dwg. No. NRC-AA 100B





REC. B. CONTROL PANEL



BACK VIEW OF PLUG & SOCKET
KEY POSITION #1

8 WIRE CABTIRE SELSYN CABLES & CONNECTORS

ALL SELSYNS TO BE CONNECTED AS SHOWN UNLESS STATED OTHERWISE

B&S Gauge	Colour	Selsyn Lead No.	Amphenol Plug No.	
16	WHITE	R1	C	110 Volt Supply - Selsyn Primaries
16	BLACK	R2	G	
18	BLACK	S1	B	
18	BLUE	S2	A	Main Selsyn Secondaries
18	YELLOW	S3	H	
18	RED	S1	D	
18	WHITE	S2	E	Vernier Selsyn Secondary
18	BROWN	S3	F	

No. 1 - 8 WIRE CABTIRE

B&S Gauge	Colour	Amphenol Plug No.	Main Panel No.	Rec. "B" to —
16	WHITE	G	17	Micro Switches - 2 Leads to Relay Coils
16	BLACK	H	18	
18	BLACK	E	15	Telephone (Return cct. by Selsyn Neutral)
18	BLUE	F	16	Micro Switches Return - To Limit Switches
18	YELLOW	A	25	Top Push Button - To common Pt. Limit Sw.
18	RED	B	26	Variable Tap Control Pot. - To overload cont.
18	WHITE	C	27	Common Ends Control Pot. - To Thyratron Unit
18	BROWN	D	28	Center Tap (thru 500 Ω) Con. Pot. - To Relay Box

8 WIRE CABTIRE CABLES

No.	Key Position	From	To	Carries
1	2	REC. B	Main Panel	Thyratron Motor Controls, Telephone
2	1	Main Panel	Obs'n. Room	Azimuth Selsyns
3	1	Main Panel	REC. B	Azimuth Selsyns
4	3	Main Panel	Obs'n. Room	Range Selsyns
5	3	REC. A	Main Panel	Range Selsyns

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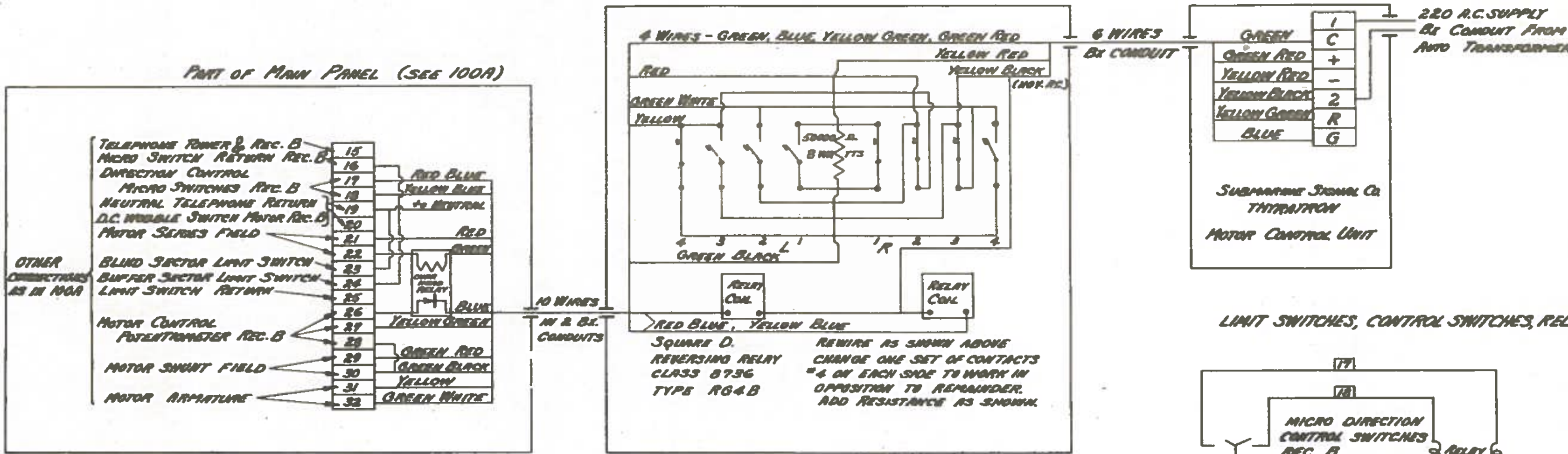
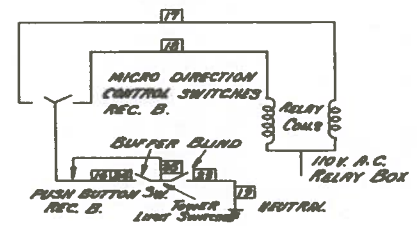
Item	Part No.	Quan.	Mat'l.	Description

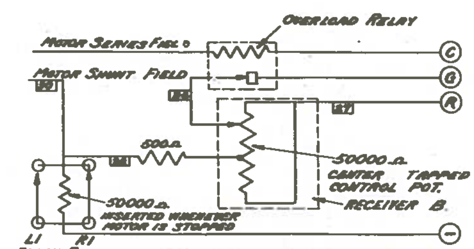
Drawn by R.S.R. / C.R.B.	Date Oct 14-41 / Jan 16-42	Supersedes
Checked	Date	Scale
Eng. Approv.	Date	Finish.
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA		
Name ARRAY-SET INTERCONNECTIONS MAIN PANEL TO RECEIVERS & TRANS.		Dwg. No. NRC-RE-100C



LIMIT SWITCHES, CONTROL SWITCHES, RELAY



Rec. B Plug	Existing Cable Color/Gauge	Main Panel No.	Conduit Color & Gauge	Relay Box No.	Thyratron Unit No.	
E	BLACK 18	15				TELEPHONE
F	BLUE 18	16				RETURN FROM MICRO SWITCHES JUMPER TO #24
G	WHITE 18	17	RED BLUE 18	RELAY		CONNECT SO AS TO MAKE POSITIVE FROM MICRO
H	BLACK 18	18	YELLOW BLUE 18	COILS		DIRECTIONS OF ROTATION AGREE. SWITCHES.
		21	RED 16	R2		SERIES FIELD S2
	TOWER	22	GREEN 16		C	SERIES FIELD S1 OVERLOAD HEATER
		23				TO BLIND SWITCH IN TOWER JUMPER TO NEUTRAL #19.
		24				TO BUFFER SWITCH IN TOWER JUMPER TO #16.
A	YELLOW 18	25				TO COMMON POINT LIMIT SWITCHES PUSH BUTTON SWITCH REC. B.
B	RED 18	26	BLUE 18		G	VARIABLE TAP, CONTROL POT. REC. B. OVERLOAD CONTACTS.
C	WHITE 18	27	YELLOW GREEN 18		R	COMMON ENDS OF CONTROL POT. REC. B.
D	BROWN 18	28				TO 500 Ω & CONTROL POT. JUMPER TO #30.
		29	GREEN RED 16		+	SHUNT FIELD F1
		30	GREEN BLACK 16	¼ FRONT		SHUNT FIELD F2
	TOWER	31	YELLOW 16	L2 3+4		ARMATURE A.
		32	GREEN WHITE 16	L2		ARMATURE A.
			YELLOW BLACK 16	R2	2	(SUPPLIES 110V. A.C. TO COILS)
			YELLOW RED 16	¼ REAR	−	



MOTOR SPEED CONTROL CIRCUIT

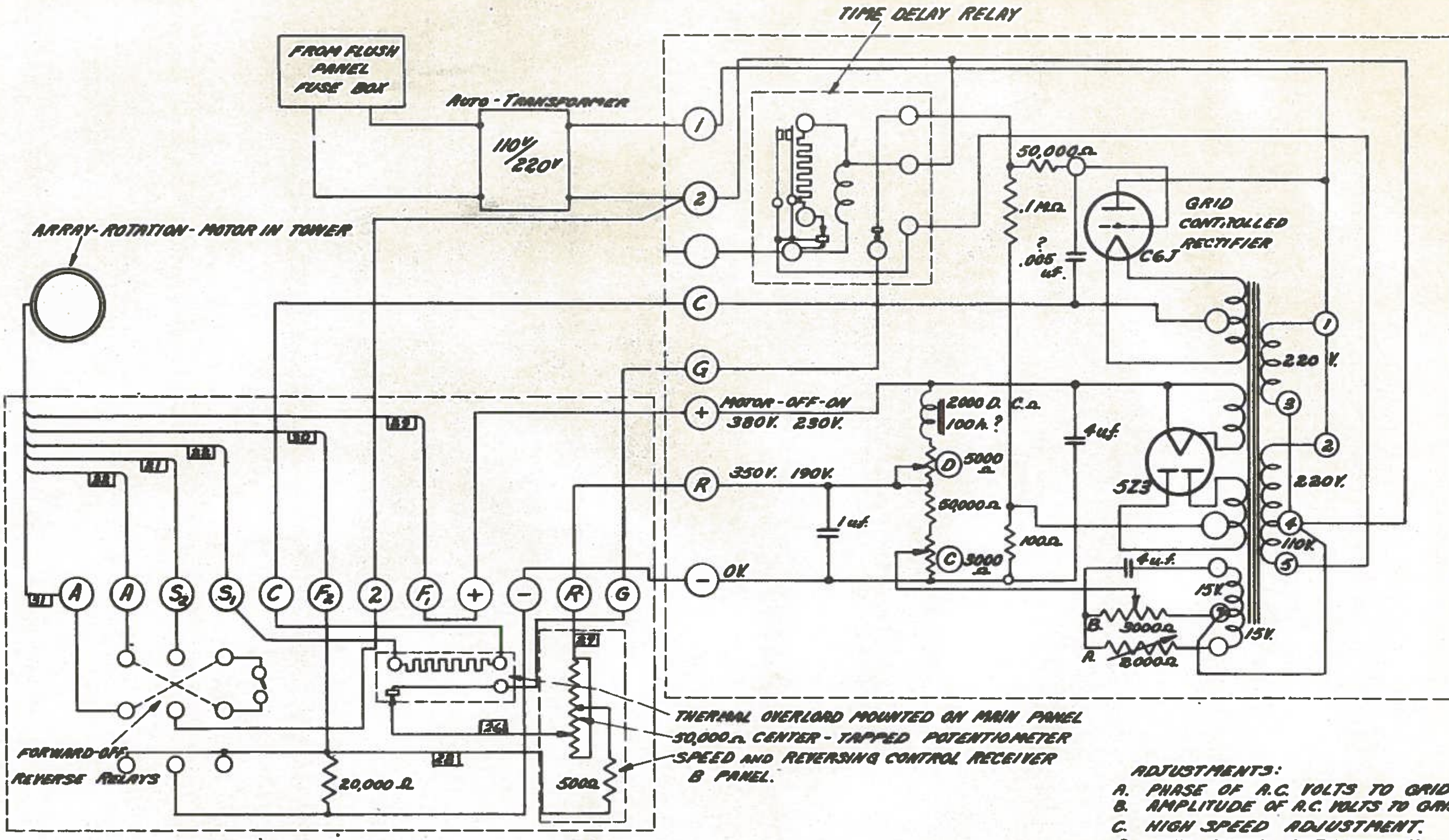
Secret

ITEM	PART NO.	QUAN.	MATL.	DESCRIPTION
DRAWN BY T.P.R.	DATE		SUPERSEDED	
CHECKED	DATE		SCALE	
ENG. APPROV.	DATE		FINISH.	

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME: ARRAY SET INTER-CONNECTIONS ROTATION MOTOR CONTROL WIRING

DWG. NO. NRC-RE-100D



ADJUSTMENTS:

A. PHASE OF A.C. VOLTS TO GRID.
B. AMPLITUDE OF A.C. VOLTS TO GRID.
C. HIGH SPEED ADJUSTMENT.
D. LOW SPEED ADJUSTMENT.

ELECTRONICS INC. 127 SUSSEX AVENUE, NEWARK

EL. RECTIFIER TUBE - TYPE C6J HALF WAVE WITH GRID.
D.C. OUTPUT: RATED AMPS. 6.4 CONTINOUS, 12.8 SURGES
PEAK AMPS 77
FILAMENT 2.5 VOLTS 18 ± 2 AMPS.
METER: RATED VOLTS - FOR. 750, INVERSE 1250, NOMINAL 110 TO 440

ESCO D.C. MOTOR 220V - 1800 R.P.M. 1 H.P.
SPEED VARIATION 1800 to {50 FULL LOAD, 20 NO LOAD} R.P.M.
ARMATURE A L 1.6 OHM
SERIES FIELD $S-S_2$ .75 OHM
SHUNT FIELD $F-F_2$ 1200 OHM

REVISION - 12/1/42 - AUTO TRANSFORMER ADDED.

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY T.P.P.	DATE 25-8-41	SUPERSEDES
CHECKED R.S.R.	DATE 25-8-41	SCALE
ENG. APPROV. K.A.M.	DATE	FINISH

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME: ARRAY ROTATION MOTOR CONTROL SCHEMATIC

DWG. NO. NRC-RE-101

Secret