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RADIO BRANCH

THREE CENTIMETRE EXPERIMENTAL SET PRELIMINARY REPORT

OTTAWA

FEBRUARY, 1944

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This report has reference to the package sets produced at the National Research Council of Canada, Radio Branch, and is not intended to describe the production sets known as RX/F.

THREE CENTIMETRE EXPERIMENTAL SET

PRELIMINARY REPORT

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NATIONAL RESEARCH COUNCIL OF CANADA
RADIO BRANCH

THREE CENTIMETRE EXPERIMENTAL SET

PRELIMINARY REPORT

I - INTRODUCTION

(1) Purpose

This is a microwave search set, operating in the three-centimetre band. It is designed primarily for use with Motor Torpedo Boats, but can readily be fitted to most types of small surface craft. Its function is the detection of other surface craft, including surfaced submarines; and it is believed that it will prove useful for navigation in coastal waters.

(2) Performance

The set is designed to give range accurate to ± 200 yards, and bearing accurate to ± 2°. Range scales of 7500 and 30,000 yards are available at the option of the operator on both a Plan Position Indicator, and a Class A display. The PPI unit is fitted with a cursor and magslip transmitter so that bearing may be set and automatically relayed to any remote point. On the basis of trials made with a laboratory model, ranges of the following orders may be expected when the aerial is fifteen feet or so above water line:

Surfaced submarines	- 5,000	- 7,000 yards
M.T.B.'s	- 5,000	- 7,000 yards
Fairmiles	- 8,000	- 11,000 yards
Corvettes	- 11,000	- 14,000 yards
Medium Merchantmen	- 15,000	- 20,000 yards

(3) Layout

The set has six components of size and weight approximately as shown below:

UNIT	APPROX. WEIGHT	APPROX. DIMENSIONS
Antenna-Rotator	100 lbs.	(Antenna: 30" x 20" x 12" high (Rotator: 14" x 11" x 12" high
R.F. and Modulator	100 lbs.	14" x 14" x 20" high
Monitor	Monitor 45 lbs. (Power Supply 50 lbs.	19" x 15" x 11" high 15" x 12" x 11" high

UNIT	APPROX. WEIGHT	APPROX. DIMENSIONS
Plan Position Indicator	50 lbs.	15" x 12" x 11" high
Control Box	10 lbs.	11" x 10" x 5" high

Antenna-Rotator - The antenna is a 30-inch parabolic cylinder, fed by an electromagnetic horn. It is mounted on a motor-driven shaft rotating at approximately 22 r.p.m. The motor, reduction gear and transmission line couplers are enclosed in a water-tight cast aluminum housing. This housing also contains a Selsyn generator which controls the rotating sweep of the PPI. The housing is equipped with holes for mounting-studs, and may be attached to a tripod or other supporting device appropriate to the vessel on which the set is to be installed. Ref. dwg. RX/F-49-E and dwg. RX/F-375-D.

R.F. and Modulator Unit - This unit consists of three chasses, r.f., Modulator and Automatic Frequency Control, mounted on a single rack in a splash-proof case. The A.F.C. unit consists of a discriminator, controlling the frequency of the beat oscillator, and contains also the power supplies for the beat oscillator and pre-amplifier. Ref. dwgs. RX/F-176-B, RX/F-173-B and RX/F-171-B.

Monitor - This unit contains the main receiver and sweep circuits. The latter generates sweep voltages for both a 5-inch type A display tube, and a 5-inch PPI tube. The linear display tube is in the monitor chassis and is intended for general tuning-up and observation of performance of the set. The range scales are 7500 and 30,000 yards, with 1000 and 5000 yard calibration pips. Ref. dwgs. RX/F-166-B and RX/F-164-A.

Monitor Power Supply - The power supply for the monitor cathode ray tube, PPI cathode ray tube, and scanning circuits is included in a separate chassis. Ref. dwg. RX/F-163-A.

Plan Position Indicator (PPI) - The PPI is a 5-inch long delay tube enclosed in a splash-proof case. It has range scales of 7500 and 30,000 yards, with 1000-yard and 5000-yard calibration circles. The latter may be turned on or off at the operator's option. Azimuth is determined from a rotatable cursor with a 180°-0-180° engraved scale. It is equipped with a Selsyn, Magslip transmitter or "M" type switch, by means of which azimuth information may be relayed to any remote point. Ref. dwgs. RX/F-167-B, RX/F-124-E and RX/F-230-D.

Control Box - This is a splash-proof unit containing a low-voltage a.c. and d.c. switch, high-voltage switch, and a Variac controlling the pulse voltage. Ref. dwg. RX/F-324-A.

Location of Units - The antenna-rotator may be mounted in any appropriate location by means of studs. On Motor Torpedo Boats it is anticipated that this unit will be mounted on a steel tripod above the cabin at an approximate height of fifteen feet above the water-line.

The r.f., Modulator, Monitor and Control Box unit can be installed below deck in any convenient location. On M.T.B.'s it is expected that this will be in the W/T room. The R.F. unit is connected to the antenna by a rectangular waveguide transmission line. To keep transmission-line losses to a reasonable figure, this distance should not exceed fifteen feet or so, and where possible should be less. Two flexible cables carrying Selsyn leads run between the Antenna-Rotator and the Monitor Unit. One of these cables also carries leads for the d.c. power to the driving motor.

The PPI unit may be located wherever desired. It is assumed that this will usually be in the wheelsman's or navigator's cabin. A flexible cable connects the PPI with the Monitor.

Operators - Two operators are required. One is a technical operator to handle the Control Box, R.F., Modulator and Monitor units. The second is an observer for the remote PPI.

Power Requirements - The total requirements of the set are 1.5 kilowatts at 115 volts, 500 cycles, and 400 watts at 110 volts d.c.; the latter being for the antenna drive, motor blowers, and spark wheel motor. Both types of power are fed to the Control Box which is the distributing centre of the set.

II - SEQUENCE OF OPERATION

(see Block Diagram RX/F-175-B)

The modulator consists of a rotary spark wheel which discharges at roughly 500 times a second, a resonantly charged line. The pulse is about 3/4 of a microsecond duration, 15 kv. at 12 amperes. This is delivered to a 2J21 magnetron which is waveguide coupled to a parabolic slice antenna through the antenna gear box. A single antenna for transmitting and receiving is used. Protection is provided by means of an RT/TR system which has the advantage over a single TR in that it is independent of the cold impedance of the magnetron. The local oscillator is a W.E. 723-A tuned by varying its reflector bias. Automatic frequency control is provided in such a way that varying frequencies through the I.F. pre-amplifier pass through a discriminator circuit of conventional design, followed by a d.c. amplifier. Depending on the direction of the frequency shift, proper compensating voltages are applied to the oscillator reflector.

The pulse to the magnetron from the modulator also triggers a multivibrator which provides a square wave pulse which is placed on the grid of a power tube acting as a cathode follower. In the cathode circuit are connected the rotor coils of a 3" Selsyn which is placed in the antenna gear box. The stator of this same Selsyn is coupled to a similar stator placed around the neck of a 5" cathode ray tube (long persistence). This is the "remote PPI" unit. The square voltage wave is thus effectively placed on the Selsyn inductance, providing a saw tooth of current which forms the sweep. As the antenna rotates, the magnetic field also rotates and moves the sweep around the tube face. Centering is provided by a negative current pulse through the Selsyn immediately after the sweep. The current sweep through a small resistance is voltage amplified to provide a saw tooth voltage sweep for monitoring purposes. The same pulse that begins the sweep shocks a tuned circuit, which provides pips for calibration purposes. There are two sweep lengths: 7500 yards and 30,000 yards.

The receiver is a wide-band (10 mc.) I.F. followed by a narrow band (.5 mc.) video.

As shown in the block diagram there are six units, each splash-proof and cable connected.

III - ANTENNA

(1) Theory (see RX/F-168-A)

The rectangular waveguide (1" x 1/2" O.D.) which emerges from the E_{01} - H_{01} transformer in the gear box is twisted through 90° and then bent in a semi-circle of 4" radius. After the bend the waveguide is terminated in a flared horn. The horn proper is 3-3/8" in depth, with inside throat dimensions of 7/8" x 3/8", and inside mouth dimensions of 4-3/8" x 0.197". The overall width of the mouth is 9/16" x 6-1/4" due to flanges on each side and end of the horn. A mica window, 0.010" ± .001 thick is clamped to the front of the horn by a brass window frame 1/8" thick which is screwed down firmly onto the mica. The edges then are soldered (so the solder runs into the edge of the mica) to prevent leakage of radiation.

The mirror is a section of a 38.8" parabolic cylinder, cut off in the plane where the diameter would be 36", and bent in at the ends to give an aperture diameter of 30". This means that the focus is outside the aperture plane and f - .315 D, where D is the diameter of the aperture. The height of the section is 6-1/4".

The front edge of the window frame on the horn - that is, the extreme front section of the horn - should be 9.640" ± 0.020 from the vertex of the mirror.

(2) Rotational Equipment (see RX/F-169-B)

(a) Electrical - A waveguide line throughout is used between magnetron and antenna. The greater part of this consists of rectangular waveguide 1" x 1/2" O.D. with 0.064" walls. At 3.20 cm. only the H_{01} mode is propagated, the guide wavelength being 4.66 cm. A rotating joint in waveguide is required, and for this section of the line circular guide transmitting the centrally symmetrical E_{01} mode is used. This requires two "wave type transformers" to transform from the H_{01} mode in the rectangular guide to the E_{01} in the circular, and back again to H_{01} in the rectangular for the short run to the antenna. The type of transformer adopted for this set is shown in Drawing RX/F-169-B.

For the circular waveguide brass tubing 1-1/8" I.D. (1-1/4" O.D.) is used. At 3.20 cm. such guide transmits a H_{11} mode (guide wavelength = λ_g = 4.24 cm.) and an E_{01} mode (λ_g = 6.21 cm.).

In the present design of rotating coupling the H_{11} mode is eliminated by making the stub end of the circular guide the proper length. If the distance from the end of the circular guide to the mid-line of the rectangular guide is 3/4 λ_g for the H_{11} mode, a high impedance will be presented to the H_{11} mode and this will not be set up appreciably unless the overall length of the rotating assembly is resonant to the H_{11} mode. To avoid this the overall length should be an odd number of quarter guide wavelengths for the H_{11} mode. Through an oversight the overall length of the present unit was made 3/8" shorter than had been intended. A careful test of this actual length showed no trace of H_{11} resonance, which in this case would be expected to occur near 3.20 cm. This presumably is because the stub ends are adjusted to the optimum length for eliminating the H_{11} mode at this wavelength. Also the band pass was not seriously worse than for the intended length so it has been left unaltered. The dimensions shown on RX/F-169-B are the dimensions the present unit actually has.

When the length of the stub end is 3/4 λ_g for the H_{11} mode, it will be at the same time approximately 1/2 λ_g for the E_{01} mode in 1-1/8" circular guide. This makes the entrance to the circular guide as viewed from the rectangular a low impedance point for the E_{01} mode. The residual reflection at the junction gives a S.W.R. of 1.38 which is matched out by inductive irises in the rectangular guide. The following tables give measured standing wave ratios for an experimental model of the present complete unit.

λ	S.W.R. (volts)
3.17	1.16
3.18	1.09
3.19	1.07
3.20	1.02
3.21	1.02
3.22	1.07
3.23	1.17

The ends of the circular guide at the joint are fitted with chokes to prevent radiation from the gap. Measurements have shown such chokes transmit 97% of the power when the gap is 1 mm. A similar choke is used for mechanical reasons at the bottom of the rotator. In each case the gap is approximately 1/32"

Measurements on a model of the complete unit have shown that, with no gaps, 95% of the power is transmitted from rectangular guide to rectangular guide, or a loss of 0.2 db.

(b) Mechanical (RX/F-49-E)

The gear box proper is totally enclosed and water-tight and is powered with a 1/10 h.p., 3500 r.p.m., d.c. motor. Output speed is approximately 22 r.p.m.

Internal Components:

(i) Motor Shaft - The motor is flange mounted in the main casting and carries a 12 P. double shaft hardened and polished steel worm, keyed to its shaft. This worm meshes with a bronze 12 P. worm wheel on the countershaft.

(ii) Countershaft - The countershaft mounts in addition, an 8 P. hardened and polished steel worm, one single row unrestrained ball bearing and a double row pre-loaded bearing to restrain the end thrush on the shaft.

(iii) Main Shaft - The main shaft carries a bronze 8 P. worm wheel and is mounted on two tapered roller bearings. Cut integral with the shaft is an 8 mm. pitch sprocket to facilitate chain drive to the Selsyn generator. Keyed and screwed to the upper end of the shaft is the antenna mounting flange.

(iv) Selsyn Mounting - The Selsyn mounting is of the flanged type, this flange being eccentric to the centre line of the Selsyn to allow proper adjustment of the driving chain. The cup shaped sprocket is pressed into a double row shielded ball bearing, which in turn is rigidly held in the mounting proper. A keyed sleeve mounted on the Selsyn shaft mates with keyways cut in the sprocket shaft, thus enabling the Selsyn to be removed without disturbing the driving mechanism.

Water-proofing:

All removable covers are sealed with "Velumoid" gaskets. The upper end of the main shaft is sealed with a "Garlock Klozure" seal. In addition the labyrinth between the main housing and the skirt of the antenna mounting flange is filled with grease. The power and Selsyn leads are taken through glands on either side of the housing.

Mounting:

The rotator may be mounted either by the four base mounting holes or by the four back mounting holes or both sets of holes. In both cases studs are to be screwed into the main casting in the holes provided. In no event should cap screws be used, as the aluminum threads will become worn through tightening and loosening of the screws.

Lubrication:

To fill the gearbox to the required level two imperial quarts of oil are required. For temperature ranges below 32°F one of the following oils should be used: DND 360-A (87-1/2%) and Kerosene (12-1/2%), 3-G.P.-26 or SAE 10W (80%) and Kerosene (20%). Above 32°F any one of the following oils may be used: DND 360-A or SAE 10W.

Note - Care should be taken to avoid attempting to mix DND 360-A with other lubricating oils than Kerosene.

IV - R.F. SYSTEM

(1) General

(a) Introduction - (see RX/F-172-A)

The magnetron transmitter is a Raytheon 2J21 which operates at about 2500 oersteds magnetic field, 10 - 14 kv., peak plate current of 10-12 amps., and output 20 kw. peak. It is supplied with a waveguide output fitting which feeds directly to the waveguide in the set through a flange and choke coupling. For the best performance of the magnetron the magnetic field must be in the correct direction. This is indicated on each data sheet (i.e. cathode south) and provision is made so that the magnet may be reversed by loosening two thumb screws which release the magnet from its mount.

The R.F. power is conducted through the TR/RT system to the gear box in rectangular brass waveguide 1" x 1/2" O.D. x .064" wall thickness. Water-tight choke couplings are used to connect various pieces of the waveguide. Fixed matching in the case of the horn, the H_{01} - E_{01} transformer, and the TR and RT is accomplished by means of inductive diaphragms.

(b) Duplexing System - (see RX/F-174-A)

The duplexing system employs both a TR and an anti-TR (or RT) switch. These switches are similar in construction except that the RT switch has no output window, and its cavity and input window are slightly larger than in the TR switch. Both switches use a Sylvania 724-A filler in a cylindrical cavity, and are window-coupled to the waveguide. They are tuned by two adjustable plungers on diametrically opposite sides of the cavity. These plungers are fitted with chokes to prevent losses, and give a tuning range of approximately 1%. A negative potential of about 600 volts on the "keep-alive" electrode of the TR switch gives, through a suitable series resistance, a "keep-alive" current of approximately 0.1 ma. No "keep-alive" potential is necessary with the RT switch.

An E-plane, series branching system is employed. The input windows of the TR and RT are approximately $\lambda_g/2$ from the inner wall of the main guide, and the centres of the TR and RT branches are about $\lambda_g/4$ apart.

On transmission the mismatch caused by the duplexing system gives a standing wave ratio of about 1.2 (power) and the leakage power to the crystals of the order of 70-100 mw. (peak).

On reception the total loss through the duplexing system is slightly less than 2 db., while the mismatch causes a standing wave ratio of the order of 1.75 (power).

(2) Local Oscillator

The local oscillator is a Western Electric 723-A oscillator which operates at a resonator voltage of 300 volts, filament voltage 6.3 volts, and reflector voltage from -20 to -300. In the present set the reflector voltage is usually between 100 and 200 volts. Local oscillator power to the crystal is controlled by the screw adjustment of the projection of the output spike into the waveguide. It has been found that a crystal current of from 300 to 500 microamps. is best for the average crystal. The 723-A may be tuned either mechanically (range: 3.16 cm. to 3.24 cm.) or electrically, by changing the reflector voltage. (Δ f is 2 to 5 mc. per second per volt). In the present set the mechanical tuner is first set so that the desired frequency can be reached with electrical tuning. Tuning in operation is then accomplished by an automatic frequency control; or by throwing a switch, tuning may be accomplished electrically by means of a potentiometer. (See A.F.C. below).

(3) Mixer (see RX/F-170-B)

The mixer consists of a standard B.T.H. crystal held in a special holder and plugged in to extend across the waveguide. Matching to the waveguide is done with a screw which can be adjusted as to length and position. The I.F. output from the crystal is soldered directly to the input of the pre-amplifier.

(4) Pre-amplifier (see RX/F-171-B)

The pre-amplifier input tuned circuit is loaded only by the crystal and first I.F. amplifier tube grid, in order to get the best signal-to-noise ratio possible. Three stages of amplification follow, employing resistor loading and unity coupled interstage transformers. Tuning is accomplished by a brass slug screwed into the centre of each interstage transformer, and into the input and output coil.

The third stage has a low impedance output to drive the concentric line feeding the remainder of the receiver in other boxes.

(5) Automatic Frequency Control (see RX/F-173-B)

Provision is made for either automatic or manual frequency control of the local oscillator. Selection of one or the other is made by the use of a switch on the front panel.

The A.F.C. input comes from the pre-amplifier as described above, through a 70-ohm concentric line, and drives a tuned circuit in the grid of a conventional 6AC7 I.F. amplifier stage (V_1). The output of this amplifier goes to a coil tuned to the mid pass band frequency of the main receiver I.F. amplifier (30 mc/s). Inductively coupled to this coil are two coils, one tuned to approximately 1 mc/s above, and the other to approximately 1 mc/s below this frequency (31 mc/s. and 29 mc/s.)

Each of these coils is coupled to the grid of a section of a 6SN7GT dual triode (V_3) through a grid leak and condenser. The plate circuit of V_3 consists of a plate-to-plate resistor load, across which is connected the input of a 6AC7 d.c. amplifier (V_4). A polarity reversing switch, and suitable decoupling circuit elements are also included in this circuit.

The action of the discriminator is as follows: Pulses produced by the transmitter beating with the local oscillator are amplified by the I.F. and applied to the I.F. and applied to the input of the discriminator. If the mean frequency of the pulse is lower than 30 mc/s., the coil tuned to 29 mc/s. has a larger induced voltage than the one tuned to 31 mc/s., and conversely. Rectification in the grids of the discriminator tubes produces a bias roughly proportional to the induced voltages in the coils. Since these applied voltages are pulses of short duration, the time constant, RC, the grid leak condenser combination in each grid, is made as long as possible to lengthen the time the d.c. bias, due to each pulse, persists. The output from the discriminator circuit is taken from plate to plate of the discriminator tubes where a voltage appears roughly proportional to the difference in the induced voltage in the two grid coils.

In the plate circuit of the d.c. amplifier, a 0-1 milliammeter (called the A.F.C. Indicator) reads the current through this resistor and hence the output voltage of the amplifier. A 2 mfd condenser connected across the 200 K resistor stabilizes the output and prevents sudden changes in voltages due to small disturbances in the equilibrium of the system. The output of the d.c. amplifier is connected directly to the reflector of the 723-A local oscillator, when A.F.C. is used. When manual tuning is employed, the reflector is connected directly to a potentiometer, and the reflector voltage under these conditions is independent of anything in the A.F.C. circuit.

The 6AC7 d.c. amplifier (V_4) utilizes a large amount of cathode degeneration in order to stabilize its operation and reduce the effect of varying tube characteristics. The screen voltage is adjustable in order to set the operating point, or d.c. output of the amplifier with zero input. The voltage from the discriminator tube varies the output voltage around this operation point.

A 6SN7GT multivibrator (V_2), having a repetition frequency of from one to two c.p.s. produces, after suitable filtering of its output, an approximately sinusoidal sweep voltage. This voltage is applied to the grid of the d.c. amplifier attenuated to a value sufficient to cause the output of the d.c. amplifier to sweep through approximately 15 volts. The meter referred to above as the A.F.C. Indicator is caused to vibrate slowly at sweep frequency. This sweep voltage is applied to the d.c. amplifier for two reasons:

1. To increase the pull-in range. The local oscillator must by some means be brought close enough to tune to produce a signal into the discriminator, enabling the A.F.C. circuit to pull the local oscillator to the correct frequency and hold it there, hence sweeping the reflector voltage and thereby sweeping the frequency of the local oscillator increases the chances of pull-in occurring.

2. To provide an indication of proper operation of the A.F.C. system. When the local oscillator is being properly held to frequency by the A.F.C. circuit, the system is in a state of equilibrium which it is difficult to upset. The sweep voltage is treated like any other small disturbance and almost completely cancelled by an opposite and equal change in voltage from the discriminator. Thus, proper operation of the A.F.C. circuit is indicated by a cessation of the sweeping of the A.F.C. Indicator.

(6) <u>Power Supply for R.F. Assembly</u> (see RX/F-173-B)

All power in the rack, exclusive of the modulator, is supplied by a 500 c.p.s. line entering the receiver section of the rack through a filter to prevent modulator hash being conveyed into this section. A transformer supplies all filaments and has a 900 volt winding. This winding is used, together with a half-wave rectifier and filtering system, to supply approximately 35 ma. to a load consisting of five VR-150's in series. The various parts of the circuit are connected in such a manner as to apply the proper regulated voltage to each component. A second 250 volt centre-tapped winding supplies, through a full-wave rectifier and RC filter, approximately 100 volts d.c. to be used as the plate supply for the discriminator tube. The latter supply is necessary to permit a single-ended output from push-pull plates.

(7) <u>Pulser</u> (see RX/F-176-B and #661)

<u>PRECAUTION - BEFORE OPERATING THE EQUIPMENT GROUND THE RACK</u>

(a) <u>Introduction</u> - The pulser consists of two artificial transmission lines which are resonantly charged from an 8 KV 13 ma. d.c. power supply, and discharged by means of a rotary spark gap turning at approximately 3720 r.p.m. producing a recurrence frequency of 500 c.p.s. The lines are charged with a 40 henry inductance to approximately 13 to 14 KV and the charge is held at this value by means of the RKR 72 diode until the gap fires.

The functions of the lines are as follows: The lines are initially charged to, say 2E (see fig. 2). When the spark gap fires a -2E unit function propagates down the line (see fig. 3) when it strikes the junction between the two lines, it is looking into an impedance of $3Z_0$, i.e. three times its characteristic impedance. Part of the unit function will be reflected reversed in sign, and part (-E) will pass into the second line (fig. 4). This will produce a voltage 3E between the winding of the second line and ground, and since the load impedance is $2Z_0$ and the line impedance is Z_0, approximately 2E will be now developed across the load.

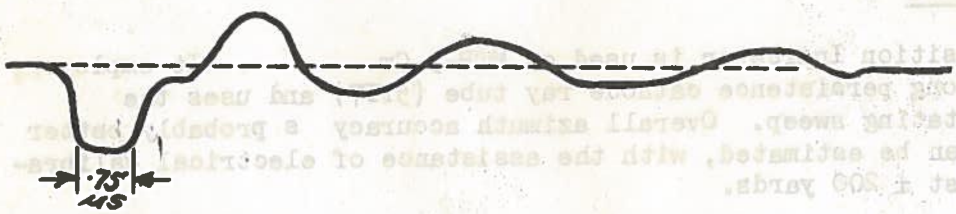
The waves will be reflected as -E and +E from the short circuited and the open end respectively (see fig. 5), and they will cancel each other out at the junction of the two lines, at which time the pulse across the load will drop to zero.

(b) <u>Line Description</u> - The lines are each approximately 500 ohm characteristic impedance, five section. Their maximum rating is 15 KV. The lines built at N.R.C. are mica dielectric whereas the Sprague Specialties lines are paper dielectric.

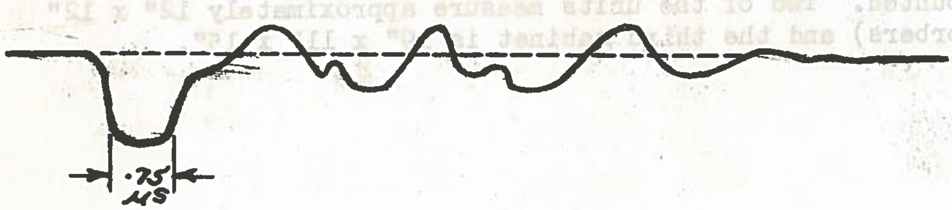
(c) <u>Pulse Shape, Voltage and Current</u> - On a 1000 ohm resistor load the pulse rises in 0.15 microseconds, has a flat top of 0.75 microseconds and fails in 0.27 microseconds.

A high speed oscillograph should be triggered from the spark gap rather than from voltage derived from the output, since the spark gap fires 3/8 of a microsecond before voltage appears at the load; this wil' aid in getting the sweep started before the pulse is applied to the vertical plates.

On a magnetron load the pulse shape is shown below. No.R.F. is put out by the magnetron on any of the past pulse oscillations.



Pulse shape when using paper dielectric network (Sprague Network)



Pulse shape using mica dielectric network (N.R.C. Network)

The mica dielectric network has a lower loss and hence the reason for the slower degree of damping on the past pulse oscillations.

On a 1000 ohm resistor load the peak voltage out should be approximately 11.4 KV at a voltage of 95 volts on the output of the variac, as read on the meter on the control unit.

On a 3 cm. magnetron load such as used in the MTB assembly, the voltage will also be approximately 11.4 KV at 95 volts on the output of the variac. It will increase only a very small amount as the variac is turned up, since the magnetron resis'ance drops rapidly with a slight increase in voltage.

At 11.4 KV across the magnetron the peak current should be approximately 10 amps.

The power supply current as read by connecting a milliammeter across the 100 chm resistor in the centre top of the H.T. transformer should be approxmately 12 to 13 ma. at 95 volts on the output to the variac at a recurrence rate of 500 cycles. It should not exceed 13 ma.

The spark wheel should be adjusted to run at 3740 r.p.m. by adjusting the rheostat in the control unit when the equipment is initially installed.

With a 500-cycle generator wave form such as used at N.R.C. the correct voltage setting is 90 to 95 volts.

V - INDICATOR SYSTEM

(1) General Information

A Plan Position Indicator is used on MTB-3 Cm. It employs a 5-inch flat-face, long persistence cathode ray tube (5FP7) and uses the Selsyn type radial rotating sweep. Overall azimuth accuracy s probably better than 1.5° and range can be estimated, with the assistance of electrical calibration rings, to at least ± 200 yards.

The indicator system follows the "package design". It consists of three units of average weight 50-60 lbs., linked together by plugs and cables. Each unit may be mounted on shock absorbers or all may be installed in a single rack which is shock mounted. Two of the units measure approximately 12" x 12" x 15" (less shock absorbers) and the third cabinet is 19" x 11" x 15".

The primary power requirement is about 250 watts and 115 volts, 500 c.p.s. A short period voltage fluctuation of ± 3 volts is allowable and the system will accept a long period fluctuation of ± 10 volts.

With the exception of the PPI unit, all cables issue from the front of the chasses which are easily serviced by removing four screws and withdrawing from the cabinet.

The PPI unit may be placed at some distance from the main equipment and contains all necessary operating control. The cables issue from the rear of this unit to allow a clear field of vision.

A 5-inch monitor c.r. tube (5AP1) with conventional linear scan is available and is used principally for initial tune-up. No provision has been made for IFF but as a compromise, IFF signals might be displayed on this tube.

(2) PPI Time Base Generator, Main Receiver, Calibration and Monitor (see RX/F-166-B and RX/F-167-B)

As before mentioned, the PPI system makes use of the Selsyn type rotating sweep. The Selsyn was retained for this service due to its ruggedness, stability and good angular accuracy. However, several limitations appeared in adapting it to a rotary spark gap modulator. These have been satisfactorily overcome for the most part and the final arrangement is considered usable in practice.

Referring to the circuit diagram for this unit, a negative trigger pulse from the modulator causes V_1 to conduct, triggering the multivibrator V_2 and V_3. A good negative wave is obtained at the plate of V_2 and a positive wave at the plate of V_3. This arrangement of tubes was chosen to give best stability and least interaction with other circuits.

The negative wave from V_2 is applied to the grid of V_4 (normally conducting) and a very good positive wave of high amplitude is produced in its inductively corrected plate circuit.

The cathode of V_4 is operated below ground merely to obtain a little more plate voltage due to limitations of power transformer at present used.

The brightening pulses for the PPI unit and monitor c.r. tube are taken from the screen of V_4 through separate capacity corrected attenuators. This was required to avoid interference with the monitor c.r. tube intensity when adjusting the intensity correction circuit in the PPI unit.

The PPI time base is produced by creating a linear base of current in the rotor of a Selsyn generator which is mechanically coupled to the rotating antenna. The 3-phase stator is directly connected to a similar stator around the neck of the PPI cathode ray tube.

A radial sweep is produced on the PPI c.r. tube which follows the angular position of the antenna with very good accuracy - usually as good as the manufacturer's claim of ± 1/2° - but also somewhat dependent on capacity unbalance of the feed wires between stators and the equality of the 5 K damping resistors across each phase. These items are not critical but should be given consideration. Tube V_4 supplies a good positive square wave to the rotor of the Selsyn generator through cathode follower V_5, and a current rises in the rotor at a rate depending on the time constant of the Selsyn and the amplitude of the square wave. Only the first part of the exponential current rise is used and is essentially linear except for the first thousand yards. (discussed later). For longer sweeps it was convenient to reduce the amplitude of the square wave and give it a rising characteristic to compensate for the exponential curvature near the end of the sweep, which would normally occur with a flat topped applied voltage wave. This corrected and attenuated wave is produced by the .02 condenser and 100 K variable resistor connected between grid and ground of the cathode follower. Two ranges are provided, 8500 yards and 30,000 yards. Since the short range is a function of the applied voltage wave (the Selsyn time constant being fixed) the 8500 yard range is about the shortest obtainable without using larger tubes and higher voltage supplies. This sweep rate requires a square wave of about 300 volts peak amplitude and the present 110 V Selsyn has so far withstood this transient voltage without failure. The start of the sweep so formed is rather non-linear within the first thousand yards, the sweep rate being 1/4 to 1/2 the rate of the succeeding ranges. This is principally due to the excessive capacity in the windings of the Selsyn and is minimized by using the cathode follower V_5 as a driving source. Also V_5 is normally cut off and its turn-on characteristic is probably super-imposed. The positive wave from V_4 must also have a certain rise time which contributes to the knee at the start. Capacity effects are the most serious however, and high surge impedance (100 ohms). Telcothene cables strapped together were found best for linking the Selsyn circuits.

Due to the transformer action of the Selsyn and consequent elimination of the d.c. component in the stator on the PPI c.r. tube, the start of the PPI sweep does not occur at the electrical centre of the tube. The certre of rotation is then some distance along the sweep from its start.

Several methods were tried to achieve centering and many were found to jitter on spark triggering because of the non-uniform repetition periods. The best arrangement consists of forcing a reverse current through the Selsyn immediately following the sweep and adjusting its amplitude or duration so that the average of the wave so formed passed through the start of the sweep. The reverse current had to return to zero well before the next sweep, or else jitter took place. This is accomplished by feeding the grid of V_8 with the positive output from V_3. Being already saturated by 500 K to +300, V_8 grid does not respond but on V_3 plate returning to normal, V_8 grid is run highly negative for a time determined by 500 K grid resistor and .002 coupling condenser. Thus a positive square wave of controllable duration is formed at the plate of V_8 and inverted in V_9 which is connected to the Selsyn and causes a reverse current to flow after the sweep wave. V_9 develops cut-off bias due to grid current and operates alternately with V_5.

With the Selsyn directly connected to ground, the centering required changing for each sweep and was somewhat critical. By inserting a series condenser (2 mfd) centering was automatic and the grid circuit of V_8 became non-critical. This is apparently due to the fact that an increased current through V_5 charges the condenser to a higher voltage and when V_{10} comes into action the condenser voltage is additive to its supply voltage and an increase reverse current results. This maintains the proper balance and the average of the current wave in the Selsyn remains the same. The beam will remain centered over a considerable range of adjustment of the grid circuit of V_8.

By connecting a 10 K resistance across the Selsyn coupling condenser by means of a switch, the start of the sweep can be caused to rotate around a small circle for better close-in azimuth accuracy. A slight reduction of sweep speed occurs but is not harmful.

The main receiver and monitor circuits consist of a three stage 30 mc. inverse feed-back I.F. and detector coupled to a single video amplifier, V_{11}, with a very low plate resistor. The output of this stage is connected by cable to a remote video in the PPI unit and also to a monitor video V_{12} to display the signals on the monitor c.r. tube. No attempt has been made to inductively correct any of these stages. A narrow pass band has been found quite adequate for PPI and there are some indications that the signal noise ratio is improved thereby.

A fairly linear monitor sweep is produced by inserting a 50 ohm resistor shunted by a .1 condenser in series with the Selsyn rotor. The resultant voltage is amplified and inverted by V_{10} and is used to provide horizontal deflection of the monitor cathode ray tube. The sweep is a good replica of the current in the Selsyn (allowing for slight distortion introduced by V_{10}).

The range calibrator is a conventional shock oscillator started by cutting off the current in V_6 and whose output is turned into a square wave by V_7. The output amplitude of V_7 is controlled by varying the screen voltage and feeds through a small condenser (25 mmf) into the low impedance input of the first video amplifier. Differentiation occurs and pips are produced which mix with the incoming signals. The pip interval on the short sweep is 1000 yards and on the long sweep the interval becomes 5000 yards. This allows fairly accurate interpolation without the confusion which would exist with a larger number of calibration rings.

(3) <u>PPI Unit</u> (see RX/F-167-B)

The PPI unit consists of a 5FP7 long persistence c.r. tube with adjustable focus coil for beam centering and using a Selsyn stator around the neck of the c.r. tube for the PPI sweep. All components are rigidly mounted and easily serviced.

A single 1852 video stage is contained in this unit and feeds negative signals into the cathode of the c.r. tube. The brightening pulse is applied to the grid circuit. Provision is made to even the picture illumination by sloping the brightening pulse by means of the variable 100 K resistor and .0025 condenser from grid to ground. A 6H6 double diode combines the function of limiter and d.c. restorer in the signal circuit.

The operating controls on this unit consist of receiver, range switch, calibration intensity c.r. tube intensity and focus. Other controls used less often were also included. These are limiter, cen re shift and intensity correction. The latter may well be screwdriver adjustments in later design.

Provision is made for a Selsyn or magslip to be driven from the cursor for remote azimuth indication.

The 5FP7 is operated with the second anode "hot" to facilitate wiring and to eliminate corona noise from the grid circuit. No trouble has been experienced with this arrangement other than a slight picture distortion for a few minutes when first switched on.

It might be noted here that a stabilized picture referred to true north instead of ship's head might be accomplished by connecting a device such as a differential Selsyn in the leads linking the Selsyn stators. The shaft of the differential Selsyn is directly driven by a gyro compass. Probably extra drive will be required from the sweep generator to make up for impedance mismatch. Also it is thought improbable that a sweep shorter than 15000 - 20000 yards will be obtained.

(4) Power Supply (see RX/F-163-A)

The power supply for the indicator system is quite straight-forward. A 5600 volt R.M.S. 5 ma. transformer with 2.5 V 5 A rectifier winding supplies the requirements of the c.r. tubes. The rectifier is a 2V3G.

The low voltages are obtained from a transformer with one winding of 375-0-375 volts RMS, 200 ma and another of 275-0-275 volts RMS 70 ma. A 6.3 V. 10 ampere filament winding supplies all heaters. The rectifiers use type 5U4G which require 5 volts, 3 amperes each.

Condensers are all oil impregnated paper and the .1 mfd 7500 V types may be reduced to .03 mfd. No smaller sizes were available for the first design.

Three VR-150 tubes are connected in series (from +350 to -100) to provide a regulated voltage for V_4. This amount of regulation was found sufficient to keep the sweep speed fairly constant for a considerable change in supply voltage.

A special filament transformer wound on a Hammond 270 core with a cross section of 1.5 square inches isolates heaters of V_4, V_5 and V_9. It consists of 72 turns of #16 D.C.C. on the primary and three separate secondaries, each of 85 turns #22 D.C.C. Insulation is rated at 500 volts d.c.

VI - OPERATING INSTRUCTIONS

A. NORMAL TURN-ON INSTRUCTION

(1) Switch on a.c. and d.c. by interlocked switches on the control box. This supplies power to all units except the modulator high voltage and the d.c. for the spinner. The monitor sweep should be in operation at this point, but running at a slow repetition rate.

(2) The high voltage is turned up slowly on the modulator to a final value of about 95 volts, as read on the control box meter.

(3) The monitor sweep should now be synchronized with the transmitter pulse and its intensity and focus adjusted by the lower left- and right-hand controls respectively, in the large service port on this chassis. Centering is obtained by means of the upper two knobs in the small service port.

(4) Make sure the "remote-near" control switch is in the down position, and the receiver gain (centre left-hand knob) may be turned up at this time. The transmitter pulse will be seen at the left edge of the sweep, and customary receiver noise will fill in the balance.

(5) The "Range-change" switch should now be operated to give the widest transmitter pulse -- this will give a sweep length of about 7500 yards. This switch must not be held in, as only a momentary contact is necessary to operate the range relay. Should this circuit be inoperative, examine the 1 A. relay fuse (just to the left of the push-button).

(6) The amplitude of the calibration pips may be adjusted by means of the right-hand centre knob. The calibration interval is 1000 yards on the 7500-yard sweep, and 5000 yards on the 30,000-yard sweep.

(7) The sweep is adjusted to give the 30,000-yard range by means of the pre-set control in the small service port.

(8) Operation Instructions for the R.F. Chassis

(a) After the power is turned on at the control box, crystal current should be observed as soon as the local oscillator tube has warmed up (usually about one minute). If crystal current is not obtained, check the oscillator current (switch S_2), and if it is satisfactory (between 15 and 25 ma.) vary potentiometer P, and crystal current will appear. Adjust the local oscillator coupling until the crystal current is about 0.4 ma. or so.

(b) With S_1 set at "manual" and the spinner off, turn on the magnetron by the variac control on the control box until the magnetron current is 3 - 4 ma. Check the R.F. output to the antenna with a neon bulb.

(c) Point the antenna in a direction to give an echo. Echoes should appear on the monitor sweep as the local oscillator is tuned manually, either by potentiometer P, or by the mechanical screw on the resonantor of the tube. With a new 723-A tube, both methods will probably be needed, but normally only the potentiometer P is needed when turning on the set.

(d) To adjust the crystal matcher, decouple the local oscillator until the crystal current is 0.1 ma. or less. If this is not done the matcher pulls the local oscillator frequency and the proper match will not be obtained unless the local oscillator is retuned at each step in the matching. With low crystal current, adjust the two matching variables (length and position of the screw) in turn, until some selected steady echo reaches a peak. Lock the position adjuster on the matcher and couple up the local oscillator to increase the crystal current until the best signal-to-noise ratio is produced on the monitor sweep. The best crystal current is usually 0.3 to 0.6 ma., depending on the crystal.

(e) Tune the T/R and R/T for maximum signal in each case, and lock the tuning slugs.

(f) To transfer to A.F.C., adjust the potentiometer P for maximum signal and throw S_1 to the up position. The A.F.C. indicating meter will now oscillate due to the sweep, and if the correct tuning voltage is within the voltage sweep, the circuit will lock in, the oscillations will cease, and the A.F.C. is operating correctly. If this does not happen, adjust potentiometer P, which varies the mid-point of the voltage sweep, until either the "notch effect" or "wall effect" is observed. (See A.F.C. Section 8). The "notch effect" means proper A.F.C. control, and the "wall effect" means that the wrong side band is being tuned. If the "wall effect" is observed, throw S_3 to the other position - this changes the polarity of the A.F.C. output voltage (other side band!), and now if potentiometer P is again varied through its range, the A.F.C. will find and control the frequency of the local oscillator.

The crystal matching may be done easily on the A.F.C. with high local oscillator coupling, since the A.F.C. will automatically correct for the pulling of the local oscillator by the matcher.

<u>NOTE</u>: - Cessation of the oscillation of the A.F.C. indicating meter means proper A.F.C. operation. If the oscillation does not stop under the above conditions, the circuit is out of adjustment. (See alignment of A.F.C. circuit).

(9) Assuming the R.F. portion has been adjusted to give proper operation (see R.F. instructions), the "remote-near" switch is thrown to the up position, and the set is now operative from the PPI unit.

The controls on the PPI, starting from the left of the bottom row are: calibration intensity, receiver gain, intensity and focus.

In the second row, similarly, we have: centre shift switch (rotate), limiter threshold, intensity (picture illumination) correction.

The range switch (momentary push) is separate, and to the lower left of the PPI part.

The beam centering knobs are near the left and right upper corners.

(10) To adjust the PPI

(a) Centre the sweep - this requires some care or azimuth accuracy will suffer. Set the spinner turning and adjust the centering controls until the centre of the beam rotation is coincident with the cursor centre. This will give fair accuracy. For best results check the beam for coincidence at two points exactly 90° apart on the azimuth indicator, and make any necessary re-adjustments to the centering controls.

(b) Adjust the intensity so the beam is barely visible.

(c) Set the R.F. portion in operation and turn up the receiver gain (with spinner stopped). A series of bright dots corresponding to any echoes present will appear on the PPI, with noise appearing as random fluctuations of intensity.

(d) The limiter and focus controls should be adjusted for best definition. In the absence of echoes, the calibration intensity may be turned up and a similar procedure used.

(e) Set the spinner rotating and a plan indication of all targets in the area should be visible. The azimuth is estimated by splitting the echo with the cursor, and range is estimated by turning up the calibration intensity and interpolating between the rings.

(f) For better azimuth accuracy on close-in targets, the centre shift switch is operated. This allows the centre to rotate about a small circle.

(g) To even the picture illumination, the intensity correction knob is adjusted to reduce the beam intensity at the start. The intensity control should be adjusted at the same time to give best results. Ultimately this may be a pre-set adjustment.

In operation receiver gain, range, calibration intensity and intensity controls will be used frequently. The remainder of the controls will seldom be adjusted.

B. LINING-UP A.F.C.

Adjustment of A.F.C. Circuit

To adjust the A.F.C. circuit first align the d.c. amplifier portion as follows. Remove the 6SN7GT sweep tube (V_2) and turn on the set, allowing two minutes at least for the tube characteristics to stabilize. With the A.F.C. indicator reading approximately in the centre of its scale, flip the side band switch (S_3). If the A.F.C. indicator changes reading, adjust the 2 K potentiometer inside the chassis (the one nearest the back) until the A.F.C. indicator reading is unaffected by throwing the side-band switch (S_3).

With the switch, S_1, in the "manual" position, turn the potentiometer P, on the control panel fully clockwise. Determine the voltage on the 723-A reflector thus applied, by pushing S_4 on the control panel, and noting the reading on the A.F.C. indicator. The reading should be approximately full-scale, or 200 volts. Throw S_1 to the A.F.C. position, and adjust the 3 K potentiometer inside the chassis until the meter reading is the same as for "manual". Turn the potentiometer P, on the control panel, fully counter-clockwise, and again make the readings on the A.F.C. indicator coincide on A.F.C. and on manual; this time by adjusting the 15 K potentiometer inside the chassis. The A.F.C. indicator reading in this case should be approximately 0.4, or 80 volts. Replace the 6SN7GT sweep tube.

The above procedure should be run through whenever the 6SN7GT discriminator tube (V_3) or the 6AC7 d.c. amplifier (V_4) is replaced.

To ascertain if the discriminator part of the A.F.C. is operating properly, connect the output of a G.R. 804B signal generator in the crystal socket. This connection may conveniently be made by soldering a spike from an old crystal to a Jones plug tip. Now remove the 6SN7GT sweep tube V_2. With the switch on A.F.C., adjust the A.F.C. indicator to a mid-scale (100 volts). Sweep the frequency of the signal generator back and forth from 27 - 33 mc., and adjust the input voltage until a maximum swing of 20 volts in either direction is obtained. If the discriminator is properly aligned, the A.F.C. indicating voltmeter will read 80 volts at 29 mc.; 120 volts at 31 mc. (or vice versa), and 100 volts at 30 mc. This swing should be produced at a reading of approximately 150 microvolts on the output of the signal generator attenuator. If the swing on the A.F.C. indicating voltmeter, produced by sweeping the frequency from 29 - 31 mc. is not symmetrical about 100 volts, or if the reading on the output attenuator of the signal generator is much different from the figure of 150 microvolts, then the A.F.C. is out of alignment and must be aligned as follows:

(1) Set the signal generator at 30 mc. and increase the signal until a deflection is produced on the A.F.C. indicating voltmeter.

(2) Tune the centre coil of the discriminator, the input coil to the I.F. amplifier (V_1) driving the discriminator, and the coils in the second and third stages of the pre-amplifier for maximum deflection of the A.F.C. indicator.

(3) Set the signal generator at 29 mc. and tune the side discriminator coil which has the greatest number of turns to maximum deflector up or down on the A.F.C. indicator.

(4) Re-set the signal generator to 31 mc. and tune the other side coil for maximum deflection down or up, on the A.F.C. indicator.

(5) Check for symmetry of the deflections for 29 mc. and 31 mc. from the 30 mc. reading. The side coils are mounted in slots in the bottom of the chassis and their position relative to the central coil must be adjusted to achieve equality of the two deflections.

The sensitivity depends to a considerable extent on the spacing of the discriminator coils. If the gain is greatly different (say 100%) from that specified above, (20 volts deflection for 150 microvolts input) it may be corrected by adjusting the positions of the two side discriminator coils; the balance of course, should be maintained. If the correct gains are not easily obtained this way, then the gain of the pre-amplifier, and the I.F. driver stage on the A.F.C. chassis should be checked.

(6) Remove the signal generator; insert the crystal and completely de-couple the local oscillator. Turn up the modulator until the magnetron draws normal pulse current. The A.F.C. indicating meter reading should not change as the modulator is turned up. If the meter tends to deflect from the central position, tune the input coil on the pre-amplifier until the deflection is a minimum.

(7) Insert the sweep tube 6SN7GT (V_2). The action of this circuit should produce about 15 volts periodic swing on the A.F.C. indicator with a period of about 1 second.

The tuning of the output coil of the pre-amplifier (third stage, V_3) should be done with a modulated signal generator, and the tuning of the first stage input coils should be checked on an echo. It should of course, be the same as that found previously by checking the influence of the transmitter pulse on the A.F.C. circuit. (See (6) above).

(8) The A.F.C. is now ready to operate. Obtain a signal with manual tuning and throw the A.F.C. switch. If the A.F.C. does not lock in, adjust the potentiometer P, since the sweep voltage may not be sufficient to reach the proper frequency. Two things may happen:

(a) "The notch effect" - the proper operation of the A.F.C.

(b) "The wall effect" - As the potentiometer is increased or decreased, the meter needle will swing up or down to a certain reading and no farther. At the same time the periodic sweep will be diminished and almost eliminated. This effect is caused by having the local oscillator operating 30 mc. <u>above</u> the magnetron; whereas it should be 30 mc. <u>below</u> (or vice versa). This may be immediately corrected by throwing switch S_3, which reverses the polarity of the input to the d.c. amplifier from the discriminator.

FIG. 1.

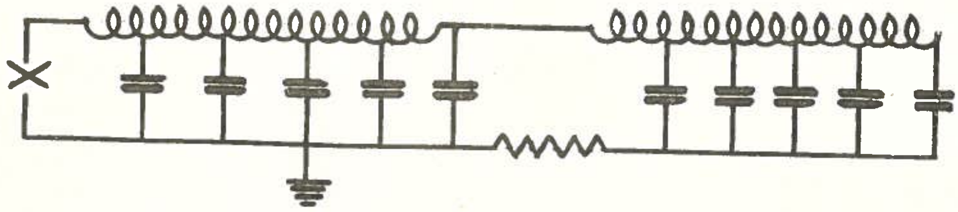


FIG. 2.

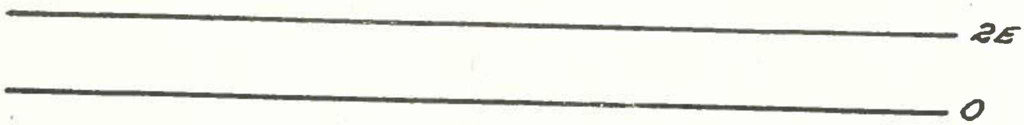


FIG. 3

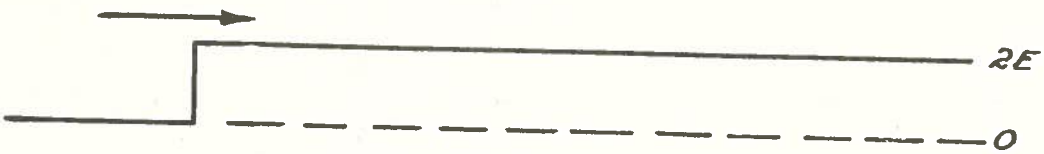


FIG. 4

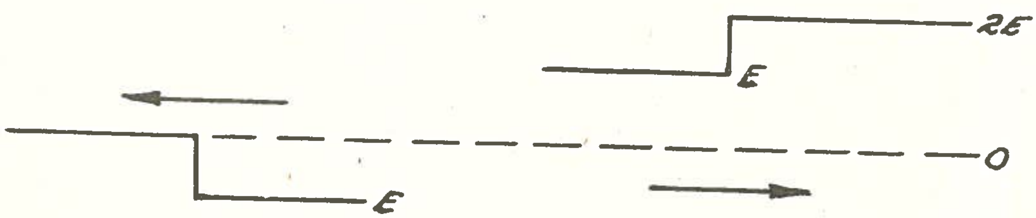
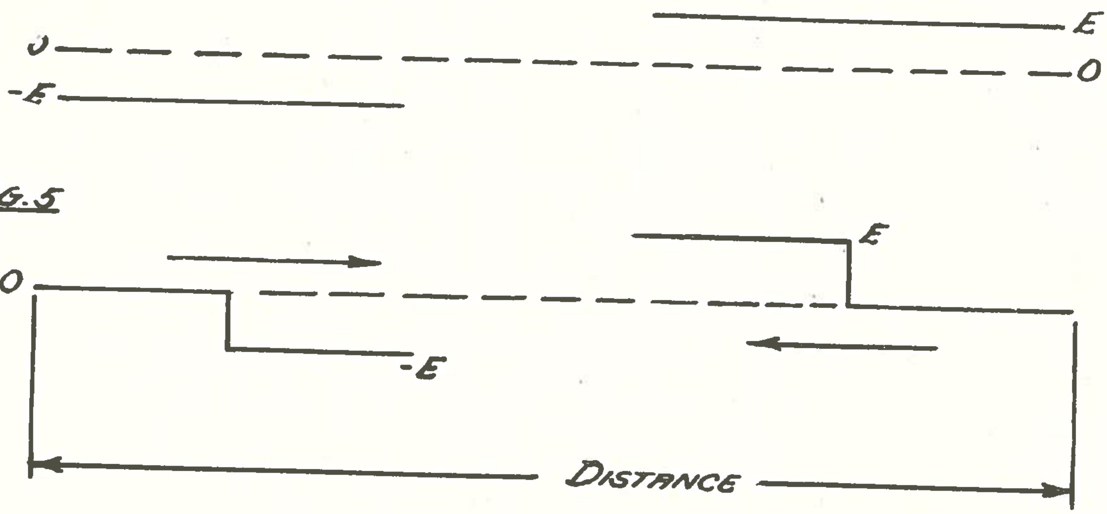


FIG. 5



NATIONAL RESEARCH COUNCIL - OTTAWA CANADA

- RADIO BRANCH. -

APPROVED H.W.M.

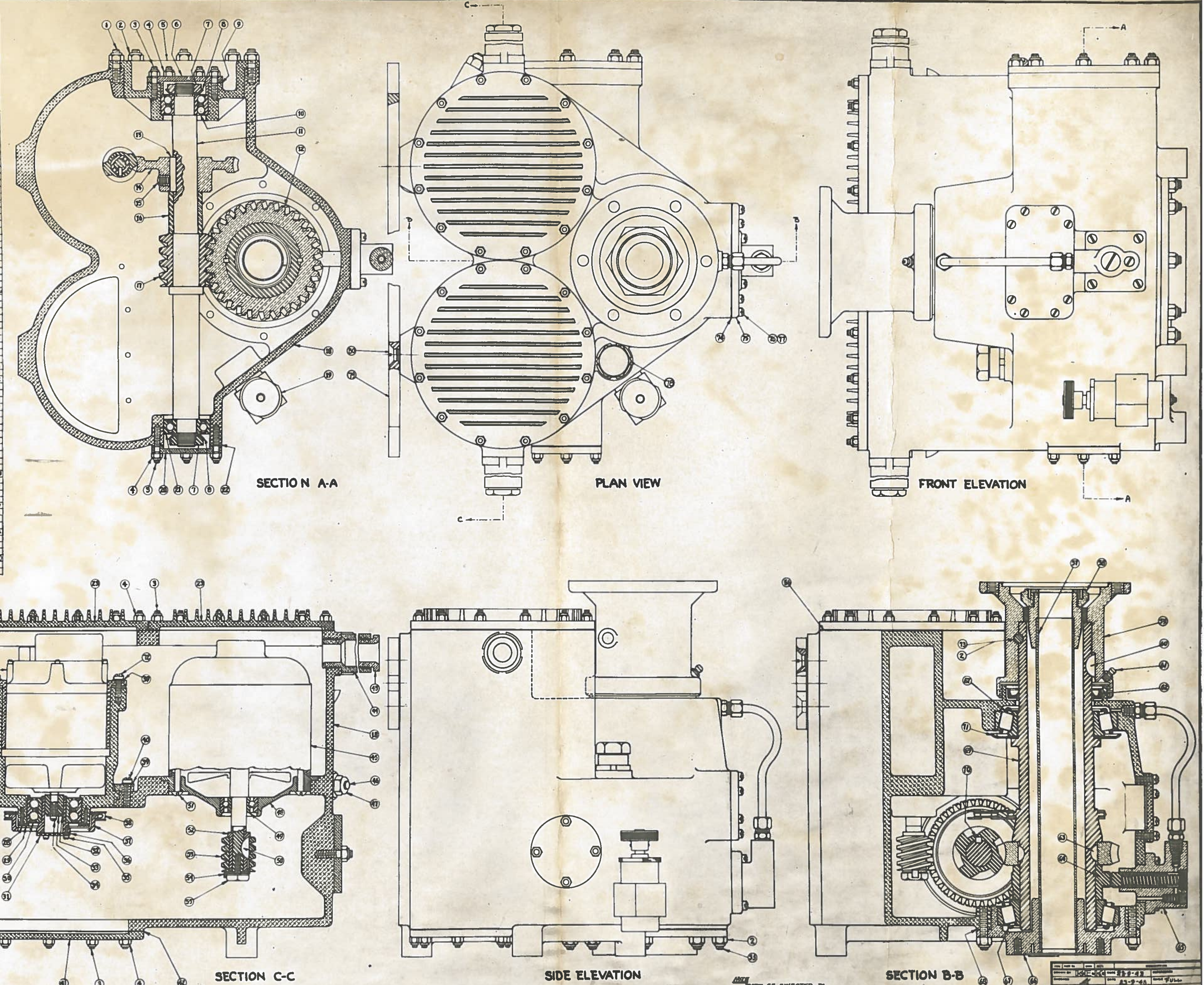
RX/F

DATE

661

PRB 122

Nº	A-M Dwg	NAME
1	37-A	STUD
2		[illegible] ELASTIC STOP NUT
3	39-A	STUD
4		10-32 ELASTIC STOP NUT
5	4-B	THRUST BRG FLANGE
6	5-A	COVER
7		N-03 LOCK NUT
8		W 03 LOCK WASHER
9	44-A	GASKET
10		ND BRG 5203
11	19-B	COUNTER SHAFT
12	17-A	WORM WHEEL 8P. 4 START
13		[illegible] KEY
14	22-A	WORM WHEEL 8P. 2 START
15		[illegible] LG SOCKET SCREW
16	21-A	SLEEVE SPACER
17		8P 4 START WORM
18	1-E	HOUSING
19	[illegible]	DRAIN COCK ASSY
20	6-A	COVER
21		ND BRG 3203
22	43-A	GASKET
23	10-B	COVER
24		SELSYN 2JD5A2
25	24-A	CLAMPING RING
26	23-B	SELSYN MOUNTING
27	25-A	SELSYN MOUNTING CLAMP
28		4-40 x [illegible] LG BRASS SCREW
29	26-A	BEARING CLAMP
30		ND BRG 55504
31	28-A	COVER
32	29-A	KEYED SLEEVE
33	30-A	LOCK WASHER
34		SELSYN SHAFT SCREW
35		4-40 x [illegible] LG BRASS SCREW
36	45-A	GASKET
37	27-A	SELSYN SPROCKET
38		8MM AIRCRAFT CHAIN
39		STEEL LOCK WASHER
40		10-32 x [illegible] BRASS SCREW
41	11-A	COVER
42	46-A	GASKET
43	9-A	GLAND NUT
44	[illegible]	PACKING NUT
45		D.C. MOTOR
46	32-A	TAPER PIN CLAMP
47		[illegible] ELASTIC STOP NUT
48	31-B	END BELL
49		NORMA BRG. 9012-D
50		[illegible] WOODRUFF KEY
51		END BELL SCREW
52	33-A	BUSHING
53		12 P. 2 START WORM [illegible]
54	35-A	TAB WASHER
55	36-A	RETAINING SCREW
56	47-A	GASKET
57	12-A	OIL SEAL TUBE
58	13-A	CHOKE COUPLING
59	14-B	SUPPORTING FLANGE
60		[illegible] WOODRUFF KEY
61		"ZERK" FITTING ([illegible]")
62		GAR LOCK" KLOZURE [illegible]
63		[illegible] WOODRUFF KEY
64	18-A	ECCENTRIC SPACER
65	[illegible]	OIL PUMP ASS'BLY
66	2-B	BEARING MOUNTING
67		TIMKEN [illegible]
68	20-A	SHIMS
69	15-B	MAIN SHAFT
70		[illegible] KEY
71	16-A	GREASE RETAINER
72		8-32 x [illegible] LG. BRASS SCREW
73	[illegible]	TAPER-PIN
74	[illegible]	GASKET
75	7-A	FRONT INSPECTION COVER
76		8-32 FIL. HD. M.SCREW [illegible] LG.
77		LOCK WASHER FOR 8-32
78	3-B	OIL FILLER.
79	[illegible]	BACK MOUNTING PLATE
80		[illegible] SCREWS (STEEL)

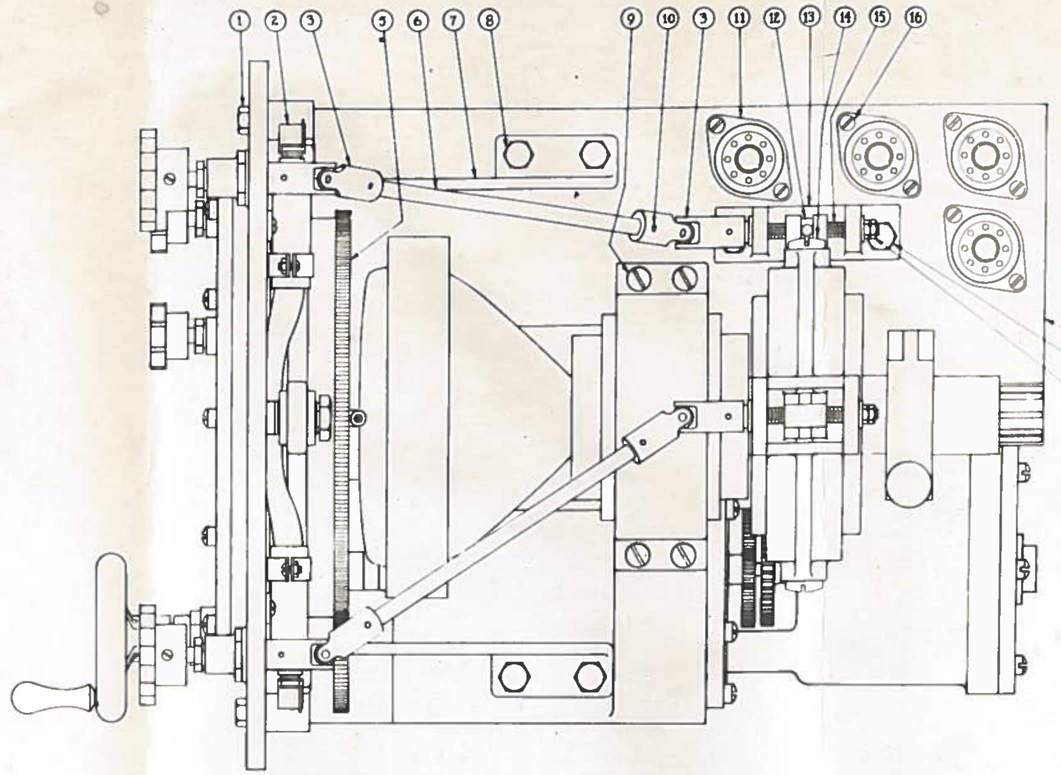


NOTE
PART 57 SWEATED TO
PART 66 ON ASSEMBLY

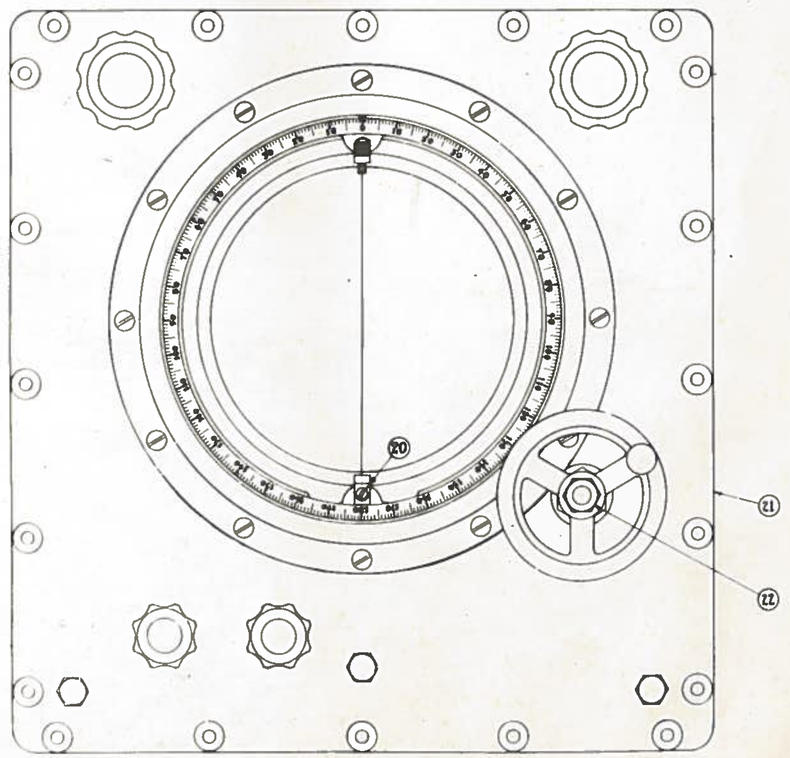
REVISED 14-11-43
REVISED - 12-11-43

DRAWN BY KIECKC	DATE 23-9-43	SCALE FULL
CHECKED	DATE 23-9-43	
	DATE 23-9-43	
NATIONAL RESEARCH COUNCIL-RADIO SECTION		
ANTENNA GEARBOX ASSEMBLY		[illegible]

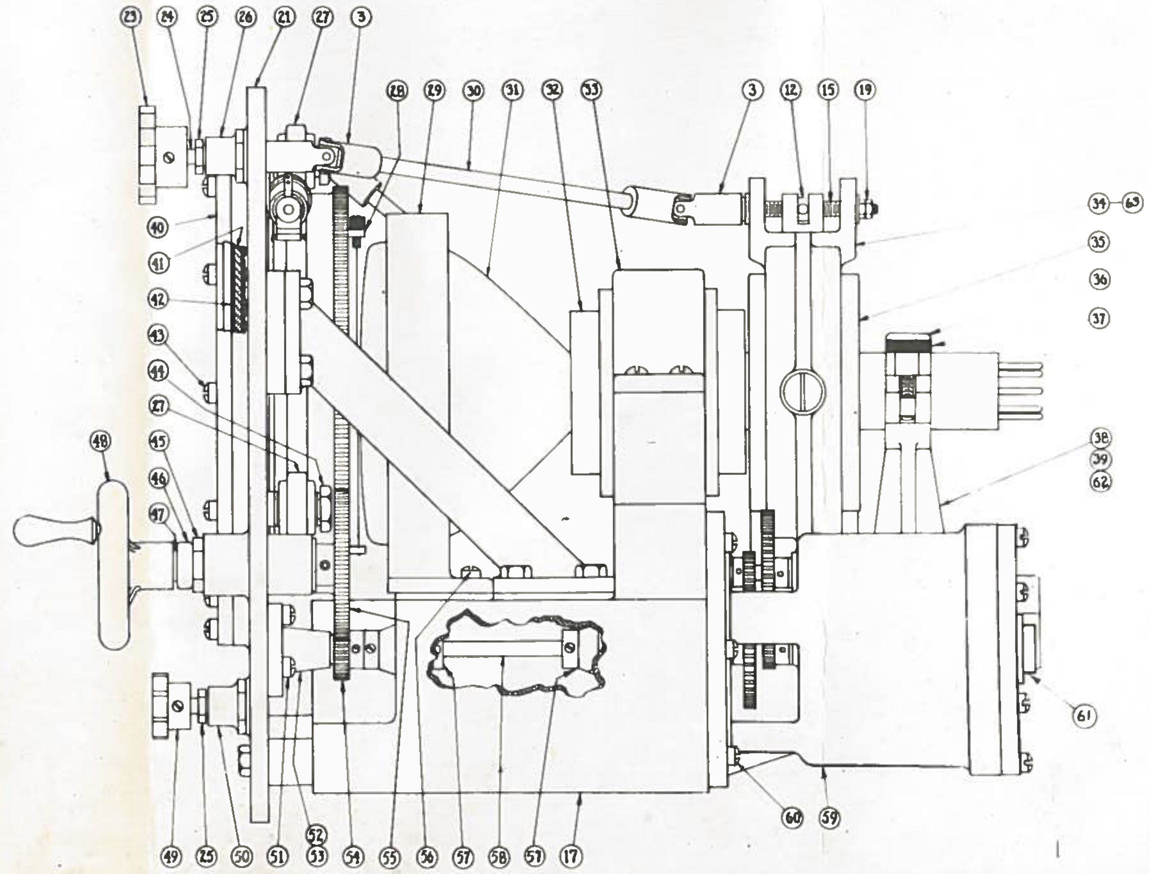
No.	DR No.	QUAN	TITLE
1		3	¼ 20 HEX HEAD M.S. 1¼" LONG
2	115 B	1	SCALE ILLUMINATION
3		4	BOSTON UNIVERSAL JOINT C-642B
4			
5	64 D	1	RING GEAR
6		1	¼ BRASS SHAFT 6¾" LONG
7	79 D	2	BRACKET
8		8	¼ 20 HEX HEAD M.S. ¾" LONG
9		4	10-32 M.S. R.H. ⅝" LONG
10		8	TAPER PIN ⅛ x ½"
11		4	BAKELITE OCTAL SOCKET 1½" DIA.
12	97-A	2	LEAD SCREW NUT
13	100-A	1	LEAD SCREW BRACKET
14	96-A	2	GYMBOL SCREW
15	98-A	2	LEAD SCREW
16		8	6-32 M.S. R.H. ⅝" LONG
17	78 D	1	MAIN CHASSIS
18		2	¼ 20 HEX HEAD M.S. ⅞ LONG
19		4	10-32 HEX NUT
20		2	6-32 M.S. R.H. ½" LONG
21	77 D	1	FRONT PANEL
22		1	⅝x18 NC-2 HEX NUT
23		2	FINGER GRIP KNOB 1⅝" DIA.
24		2	¼" BRASS SHAFT 2¼" LONG
25	81 A	4	GLAND NUT
26	113 A	2	GLAND
27		3	N.D. SEAL 88500
28	233-C	1	CURSOR WIRES AND SUPPORT
29	90 B	1	CRT FACE SUPPORT
30	123-A	1	CONTROL SHAFT
31		1	CR TUBE
32		1	SELSYN STATOR
33	91 A	1	SELSYN STATOR CLAMP
34	93 B	1	OUTER GYMBOL RING
35	94 B	1	INNER GYMBOL RING
36	102 A	1	TUBE CLAMP TOP HALF
37	103 A	1	CLAMP ACCESSORIES
38	101 A	1	TUBE CLAMP
39		1	¼ 20 HEX HEAD M.S. 1" LONG
40	108 B	1	CLAMPING RING
41	109 A	1	FLASH SCREEN
42	110 A	1	GASKET
43		12	10-32 FIL.H. M.S. ½" LONG
44	112 A	3	STUD AND NUT
45	111 A	1	GLAND NUT
46	114 A	1	COLLAR
47	85 A	1	HANDWHEEL SHAFT
48		1	ATLAS HANDWHEEL M6-23
49		2	FINGER GRIP KNOB 1⅛" DIA.
50	80 A	2	GLAND
51		3	10-32 FIL.H. M.S. ⅝" LONG
52	87 A	1	PEDESTAL
53	86 A	1	TT DRIVE SHAFT
54	88-A	1	TT GEAR
55	89 A	1	HANDWHEEL GEAR
56		2	10-32 FIL. H. M.S. ⅝" LONG
57		2	LORD COUPLING No. 1
58		1	¼ BRASS SHAFT 3" LONG
59	325 B	1	M-MOTOR DRIVE ASSEMBLY
60		6	10-32 FIL.H. M.S. 1" LONG
61		1	M-MOTOR Mk VI PATT. No 9527
62		1	10-32 FIL. H. M.S. ⅝" LONG
63	95-A	2	FOCUS COIL MTG LOCK NUT



PLAN VIEW



FRONT ELEVATION



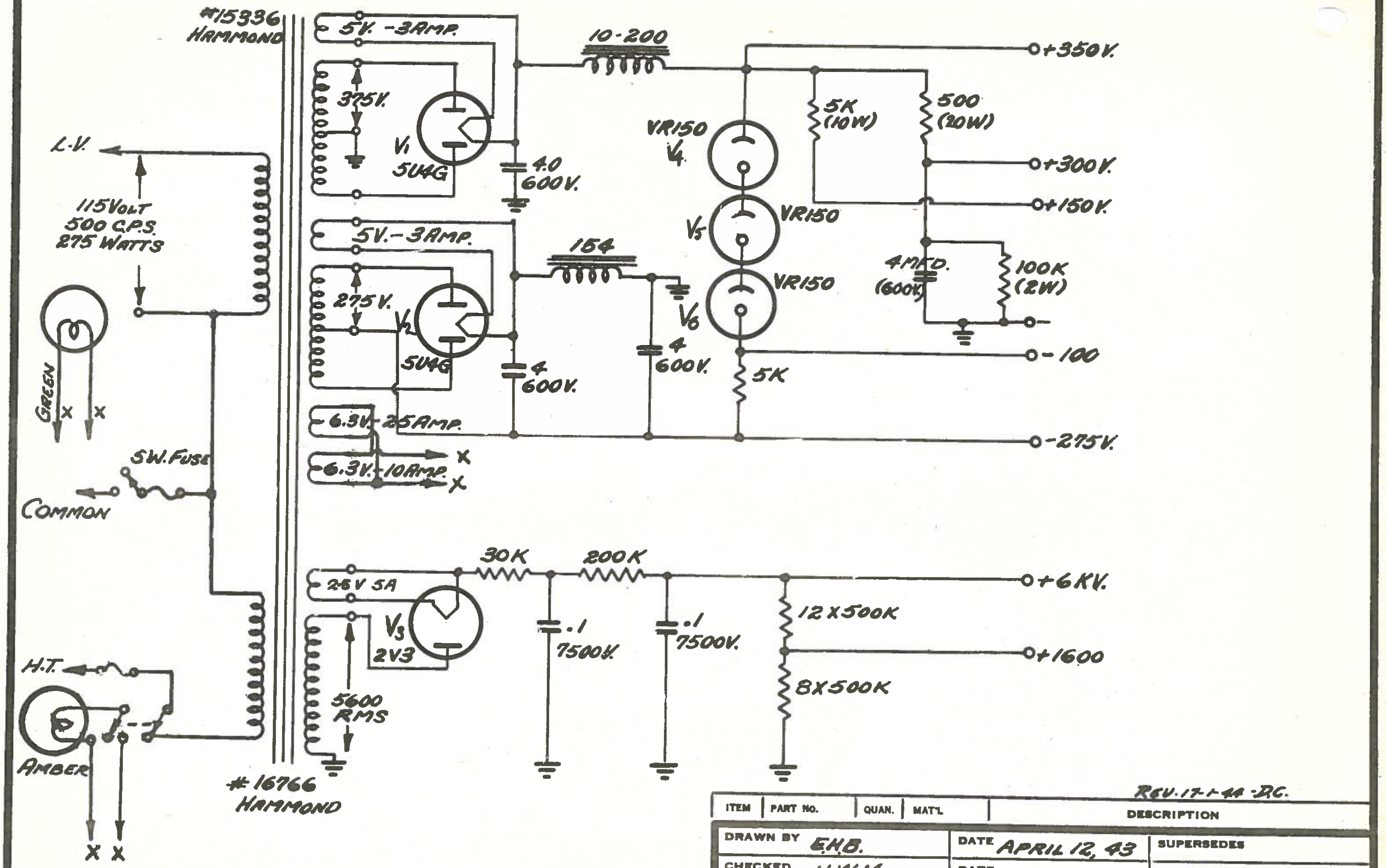
SIDE ELEVATION

SELSYN CHANGED TO M-MOTOR
AND 6 CONTROLS REMOVED
K.E.K. 28-9-93

(28) REVISED - K.E.K. - 15-5-43

(38) REVISED - K.E.K. - 15-5-43

K.E.K.	DATE 26-2-43		
	DATE 5-6-43	SCALE FULL SIZE	
	DATE 26-2-43		
NATIONAL RESEARCH COUNCIL-RADIO SECTION			
WATERPROOF PPI ASSEMBLY		Ra/m 184-B	



REV. 17-1-44 -D.C.

NOTE: VALUES MAY ALTER IN FINAL MODEL.

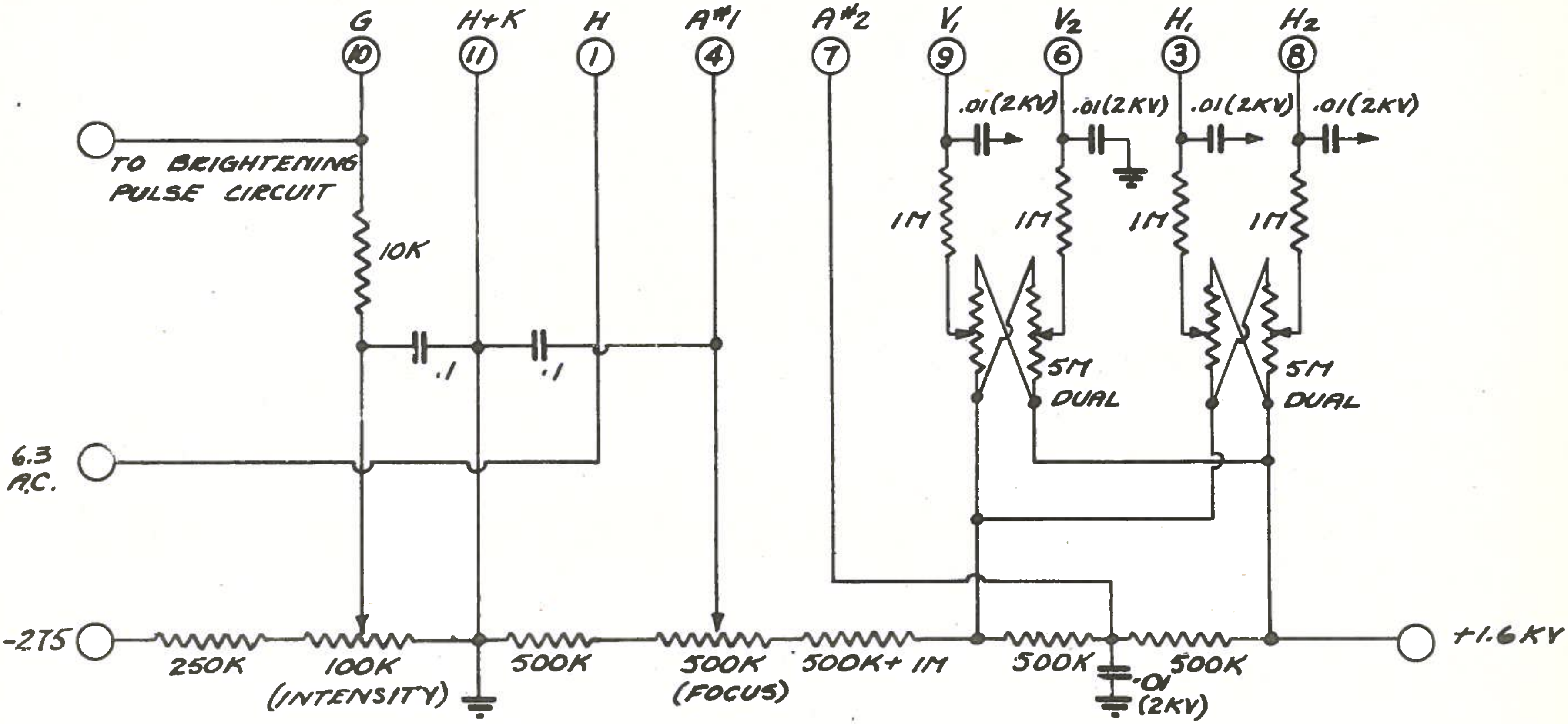
ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY E.H.B.	DATE APRIL 12, 43	SUPERSEDES
CHECKED H.W.M.	DATE	SCALE
ENG. APPROV. H.W.M.	DATE 16-4-43	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME CIRCUITS CONSTANTS OF POWER UNIT FOR RX/F. INDICATOR CHASSIS TYPE #2

DWG. NO. D-P3 RX/F-163-A.



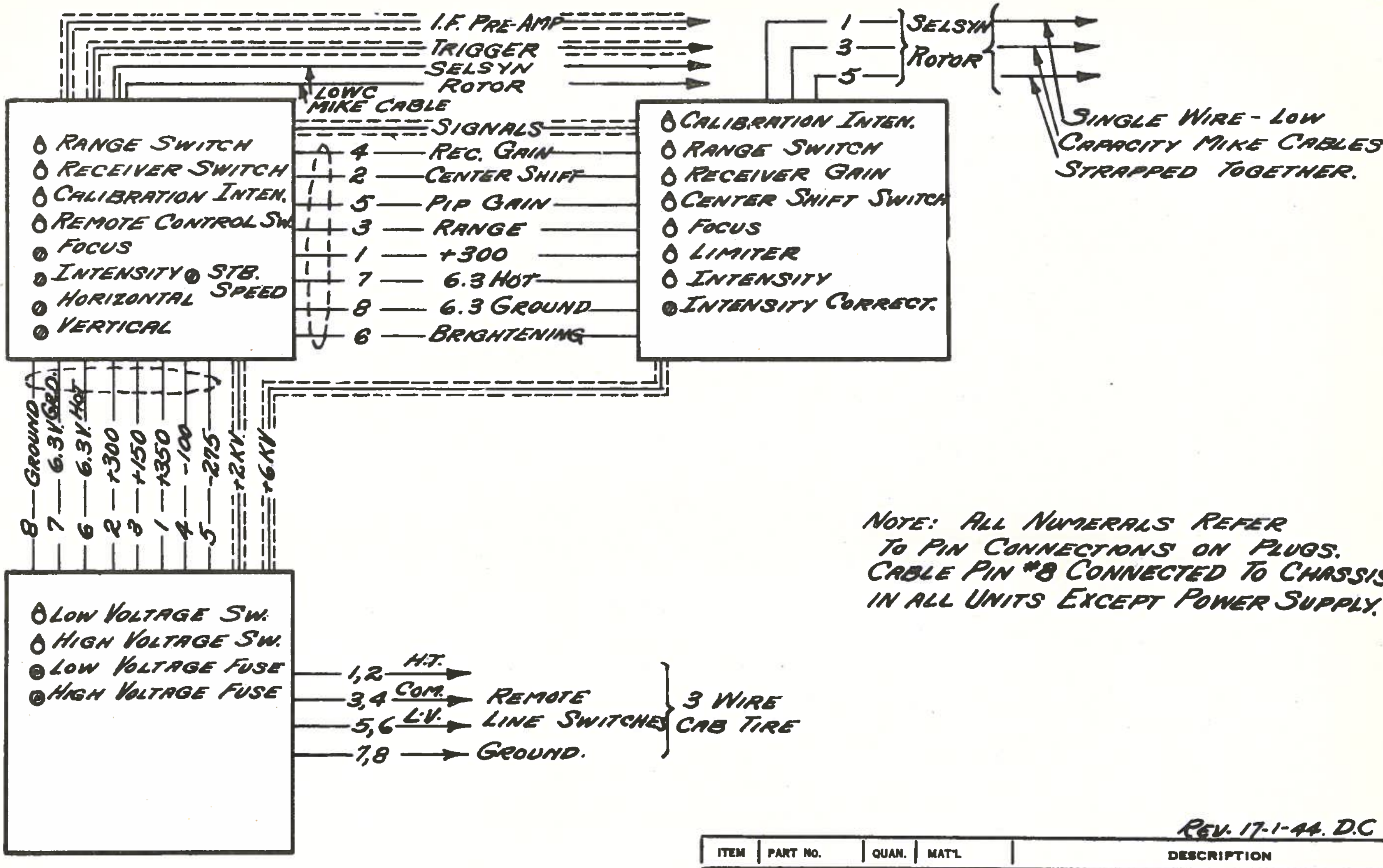
ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY D.L.S	DATE 14-4-43	SUPERSEDES
CHECKED H.W.M.	DATE	SCALE
ENG. APPROV. H.W.M.	DATE 16-4-43	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME RX/F MONITOR C.R.T. CIRCUIT

DWG. NO. D-CR RX/F-164-A



NOTE: ALL NUMERALS REFER TO PIN CONNECTIONS ON PLUGS. CABLE PIN #8 CONNECTED TO CHASSIS IN ALL UNITS EXCEPT POWER SUPPLY.

REV. 17-1-44. D.C

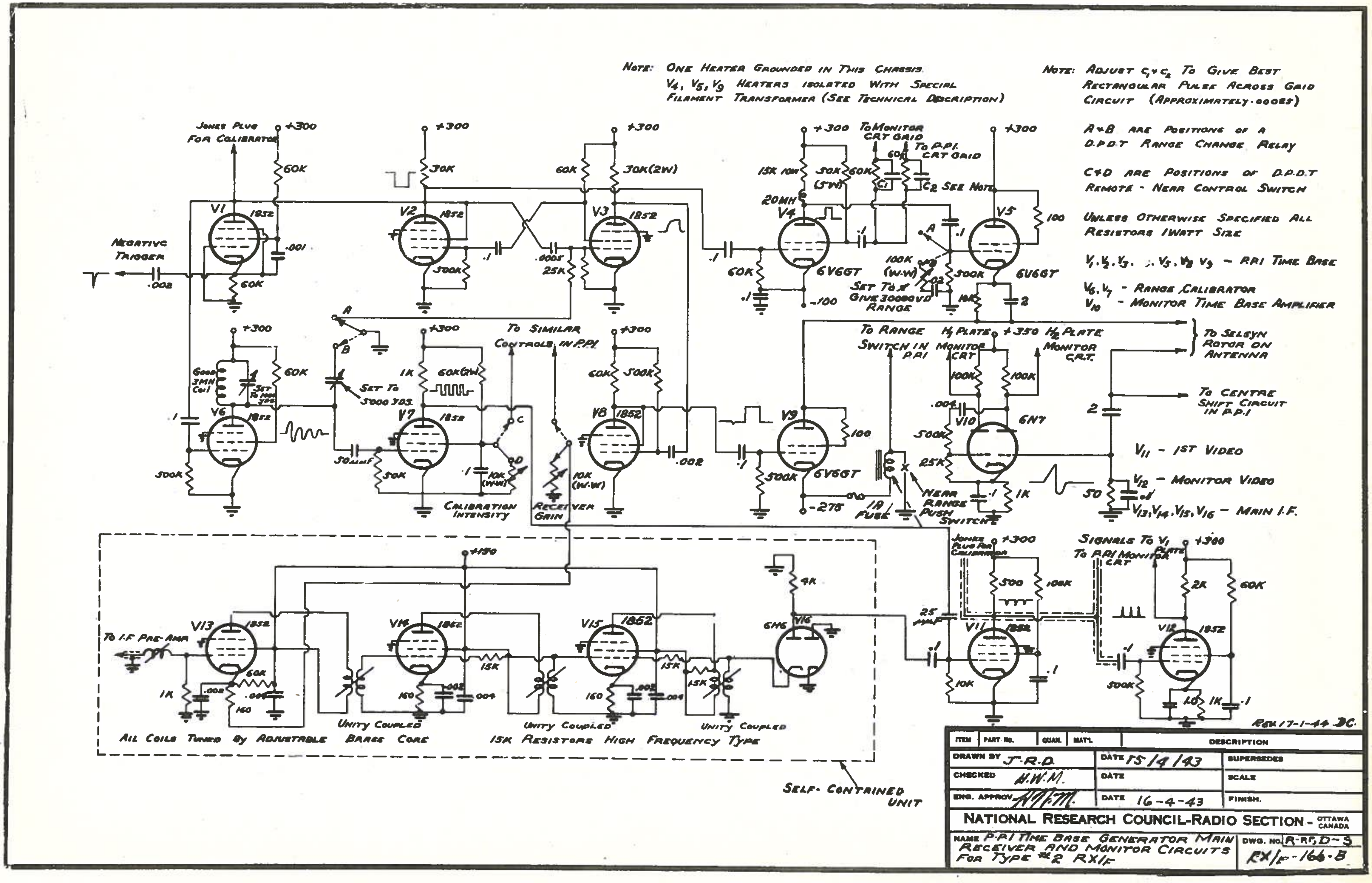
ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY E.H.B.	DATE APRIL 10, 1943	SUPERSEDES
CHECKED H.W.M.	DATE	SCALE
ENG. APPROV. W.H.M.	DATE 16-4-43	FINISH.

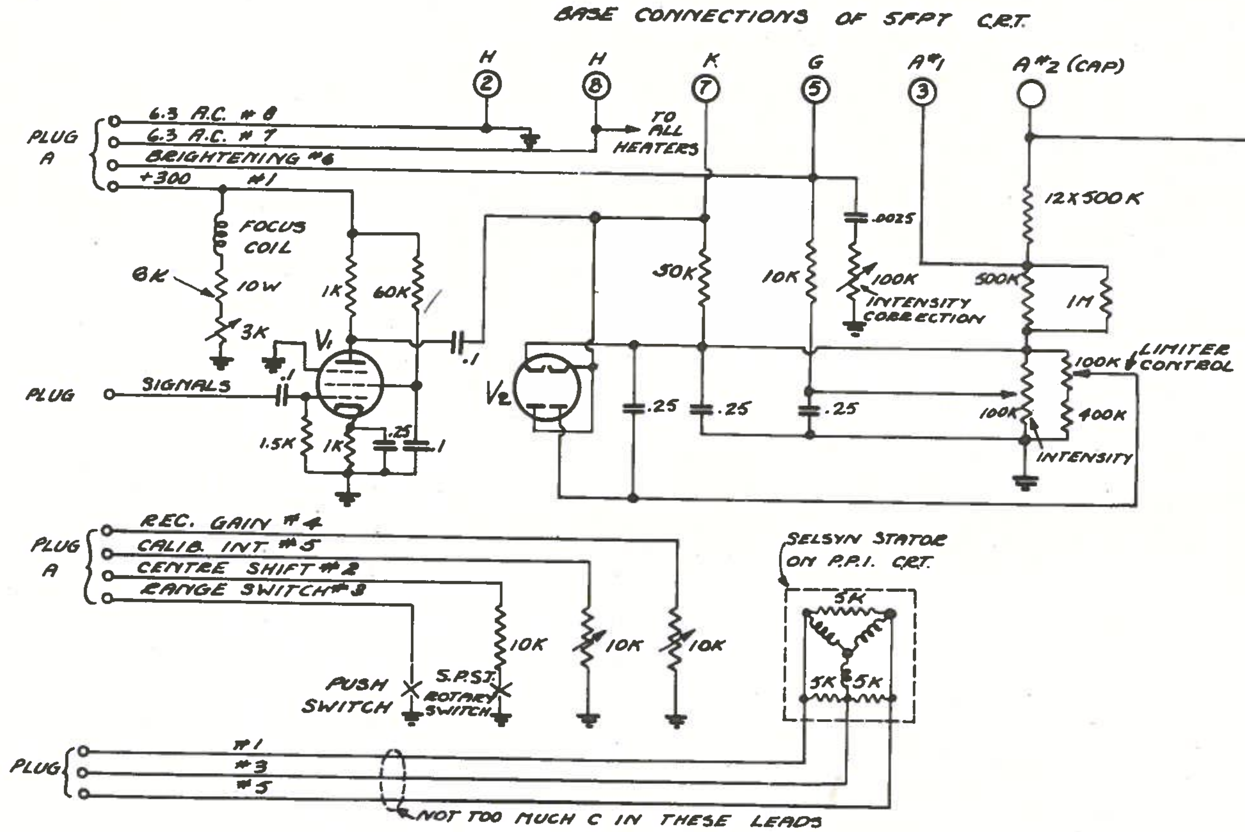
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME CHASSIS INTERCONNECTIONS RX/F UNIT #2

DWG. NO. -D- RX/F-165-A



NOTE: ONE HEATER GROUNDED IN THIS CHASSIS
V4, V5, V9 HEATERS ISOLATED WITH SPECIAL FILAMENT TRANSFORMER (SEE TECHNICAL DESCRIPTION)
NOTE: ADJUST C1 + C2 TO GIVE BEST RECTANGULAR PULSE ACROSS GRID CIRCUIT (APPROXIMATELY .0002 5)
A + B ARE POSITIONS OF A D.P.D.T RANGE CHANGE RELAY
C + D ARE POSITIONS OF D.P.D.T REMOTE - NEAR CONTROL SWITCH
UNLESS OTHERWISE SPECIFIED ALL RESISTORS 1WATT SIZE
V1, V2, V3, V4, V5, V8, V9 - P.P.I TIME BASE
V6, V7 - RANGE CALIBRATOR
V10 - MONITOR TIME BASE AMPLIFIER
V11 - 1ST VIDEO
V12 - MONITOR VIDEO
V13, V14, V15, V16 - MAIN I.F.
JONES PLUG FOR CALIBRATOR
NEGATIVE TRIGGER
SET TO 5000 YDS.
CALIBRATION INTENSITY
TO SIMILAR CONTROLS IN P.P.I
RECEIVER GAIN
SET TO X GIVE 30000 YD RANGE
TO MONITOR CRT GRID
TO P.P.I. CRT GRID
C2 SEE NOTE
TO RANGE SWITCH IN P.P.I
H1 PLATE MONITOR CRT
+350 H2 PLATE MONITOR C.R.T.
TO SELSYN ROTOR ON ANTENNA
TO CENTRE SHIFT CIRCUIT IN P.P.I
1A FUSE
NEAR RANGE PUSH SWITCH
TO I.F. PRE-AMP
SIGNALS TO V1
TO P.P.I MONITOR CRT
ALL COILS TUNED BY ADJUSTABLE BRASS CORE
UNITY COUPLED
15K RESISTORS HIGH FREQUENCY TYPE
SELF-CONTAINED UNIT
REV. 17-1-44 DC.
DRAWN BY J.R.D.
DATE 15/4/43
CHECKED H.W.M.
ENG. APPROV. H.W.M.
DATE 16-4-43
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA
NAME P.P.I TIME BASE GENERATOR MAIN RECEIVER AND MONITOR CIRCUITS FOR TYPE #2 RX/F
DWG. NO. R-RF,D-5
RX/F-166-B



NOTE: ALL RESISTORS 1 WATT UNLESS OTHERWISE SPECIFIED.

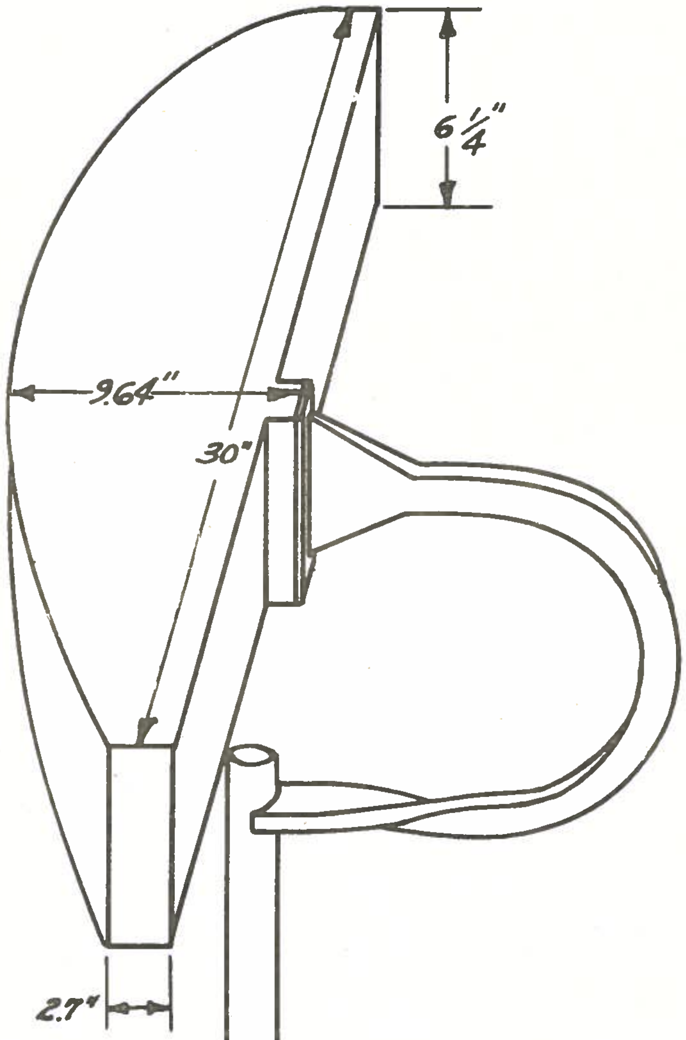
5K RESISTORS ON SELSYN STATOR MUST BE EQUAL IN VALUE.

ONE HEATER GROUNDED IN THIS CHASSIS.

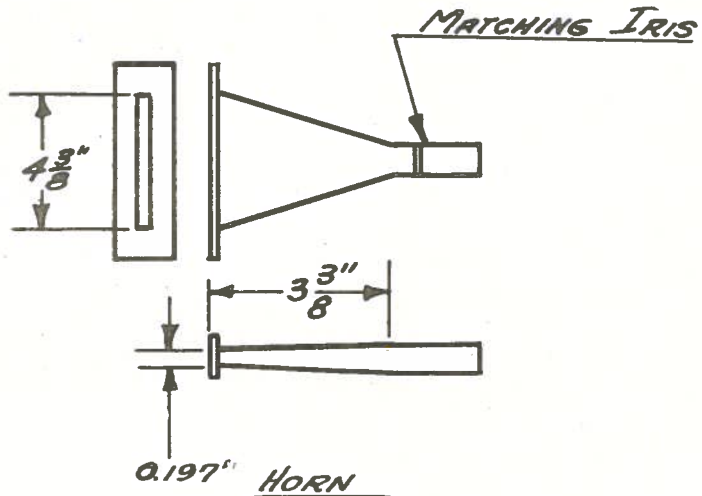
ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY D.L.S.	DATE 14-4-43	SUPERSEDES		
CHECKED H.W.M.	DATE	SCALE		
ENG. APPROV. A.M.M.	DATE 16-4-43	FINISH.		

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
ESSENTIAL CIRCUITS OF P.P.I. UNIT FOR RX/F TYPE #2	D-CR RX/F-167-B



ANTENNA



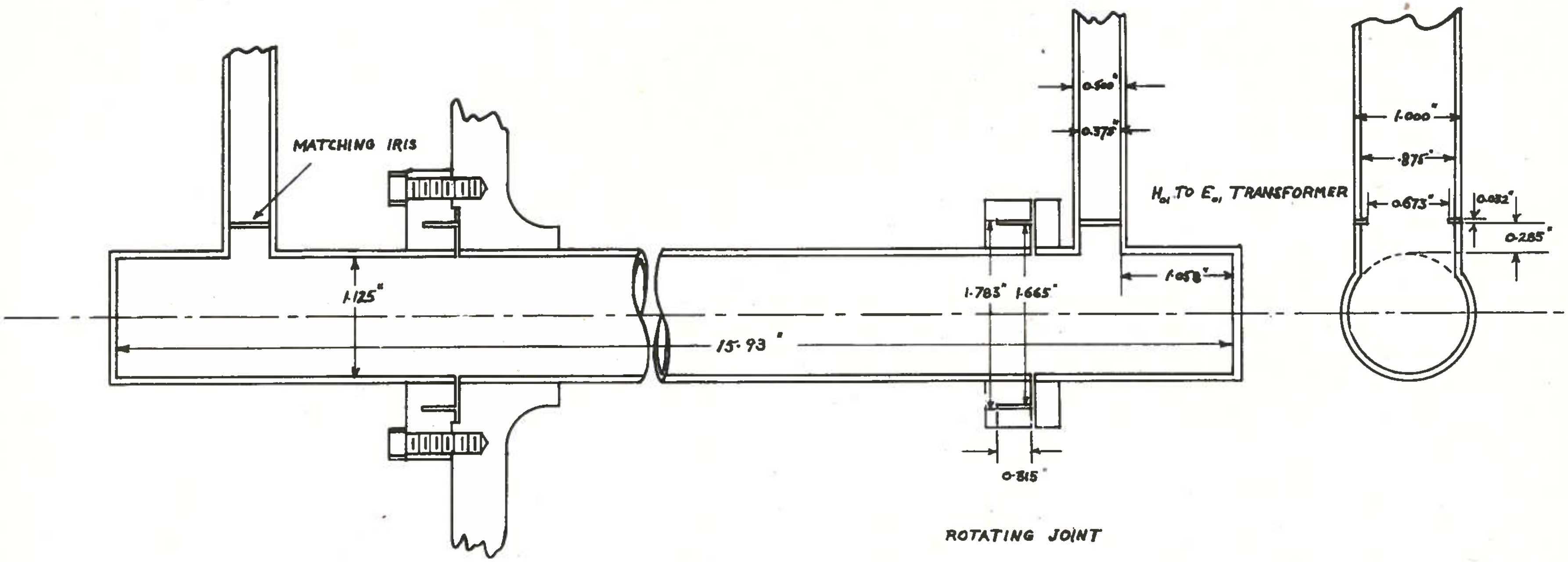
HORN

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY E.H.B.	DATE FEB 21, '44	SUPERSEDES
CHECKED	DATE	SCALE
ENG. APPROV.	DATE	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO. A-A
SKETCH OF RX/F ANTENNA AS'MBLY.	RX/F -168A

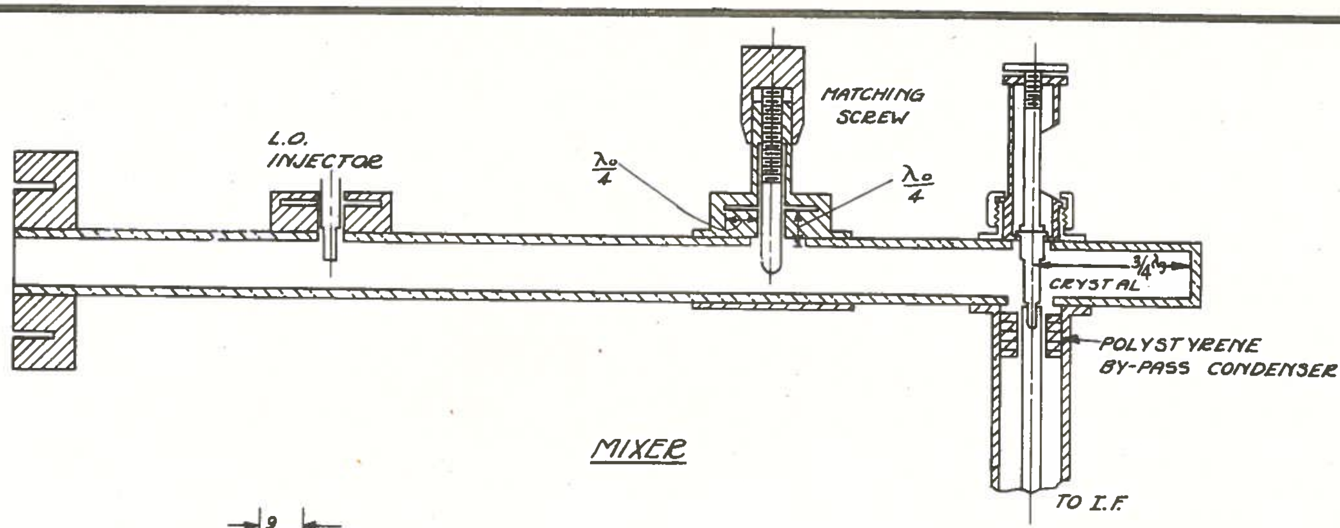


ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

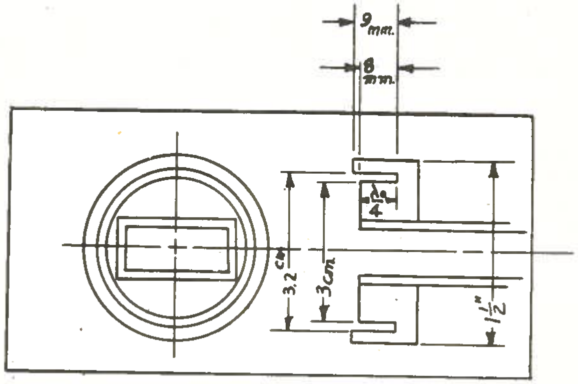
DRAWN BY C.H.M.	DATE 18/1/44	SUPERSEDES	
CHECKED H.W.M.	DATE	SCALE	
ENG. APPROV. W.L.C.	DATE	FINISH.	

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

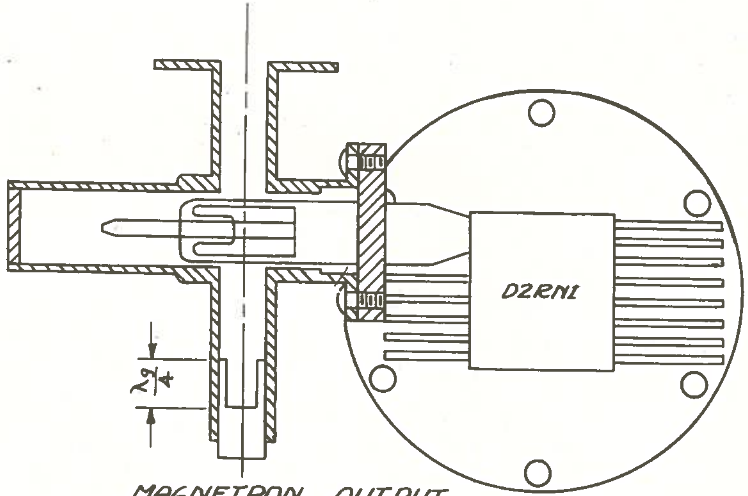
NAME	DWG. NO.
RX/F ROTATING COUPLER.	RX/F-169-B.



MIXER



WAVE GUIDE COUPLER

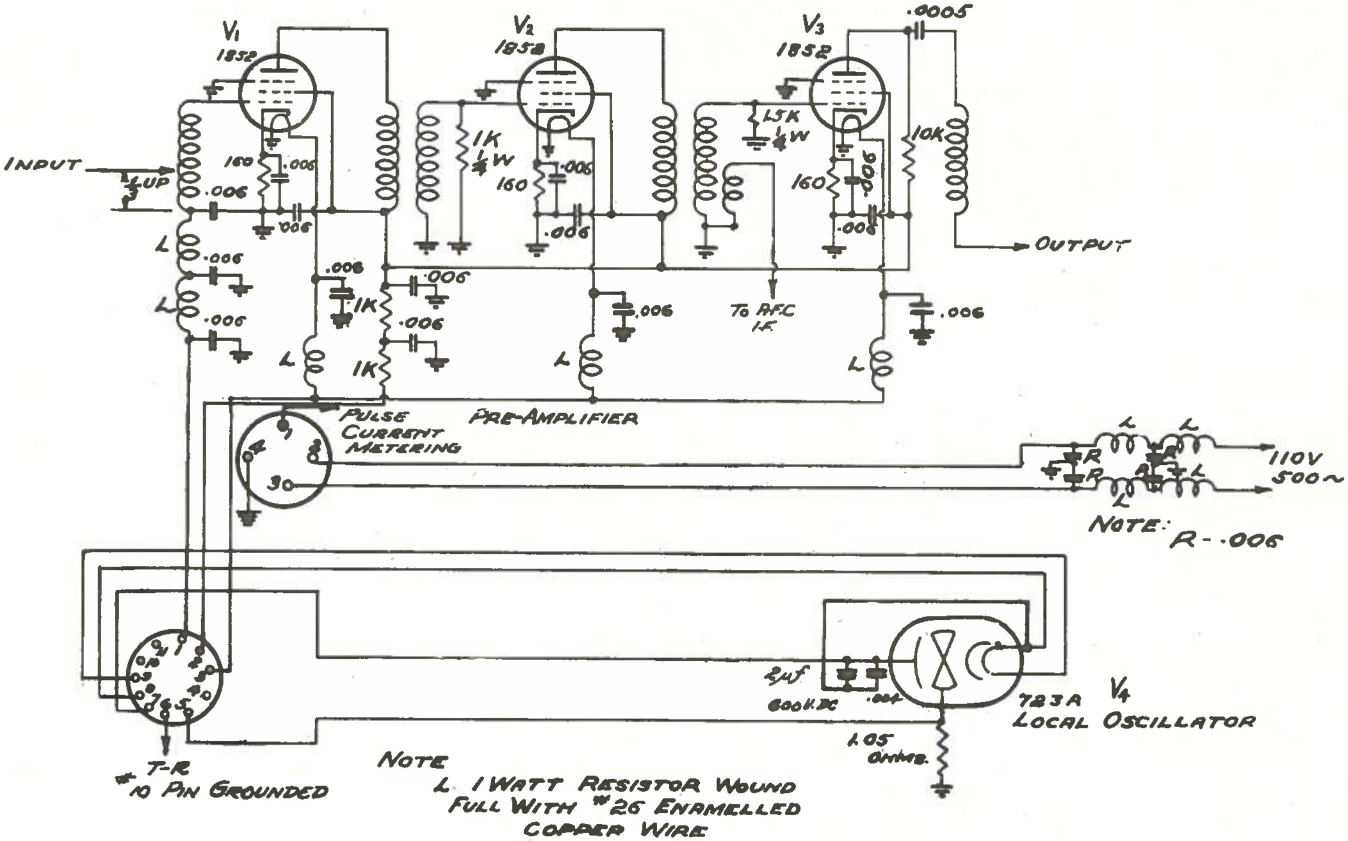


MAGNETRON OUTPUT

O.K. FOR. P.R.B. 122 only

ITEM	PART NO.	QUAN.	MAT'L.	DESCRIPTION

DRAWN BY D.L.S.	DATE 16-4-43	SUPERSEDES	
CHECKED	DATE	SCALE	
ENG. APPROV. W.J.H.	DATE	FINISH.	
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA			
NAME MAGNETRON OUTPUT AND MIXER.		DWG. NO.	A-L. RX/L-170-B

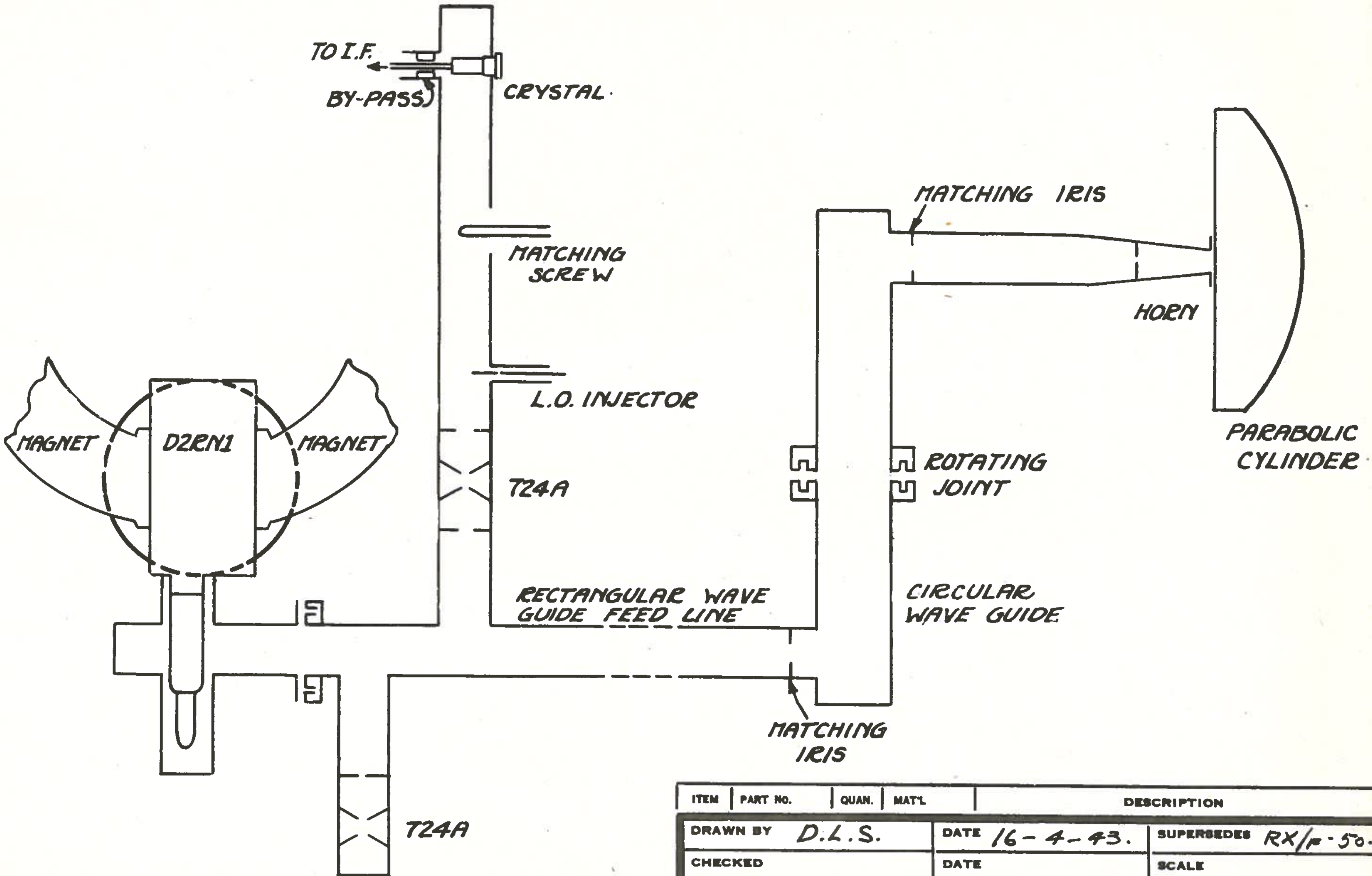


ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY J.R.D		DATE 17/4/43		SUPERSEDES
CHECKED H.W.M.		DATE		SCALE
ENG. APPROV. G.R.M.		DATE		FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME: PRE-AMPLIFIER

DWG. NO. R-D R-IF RX/F 171-B

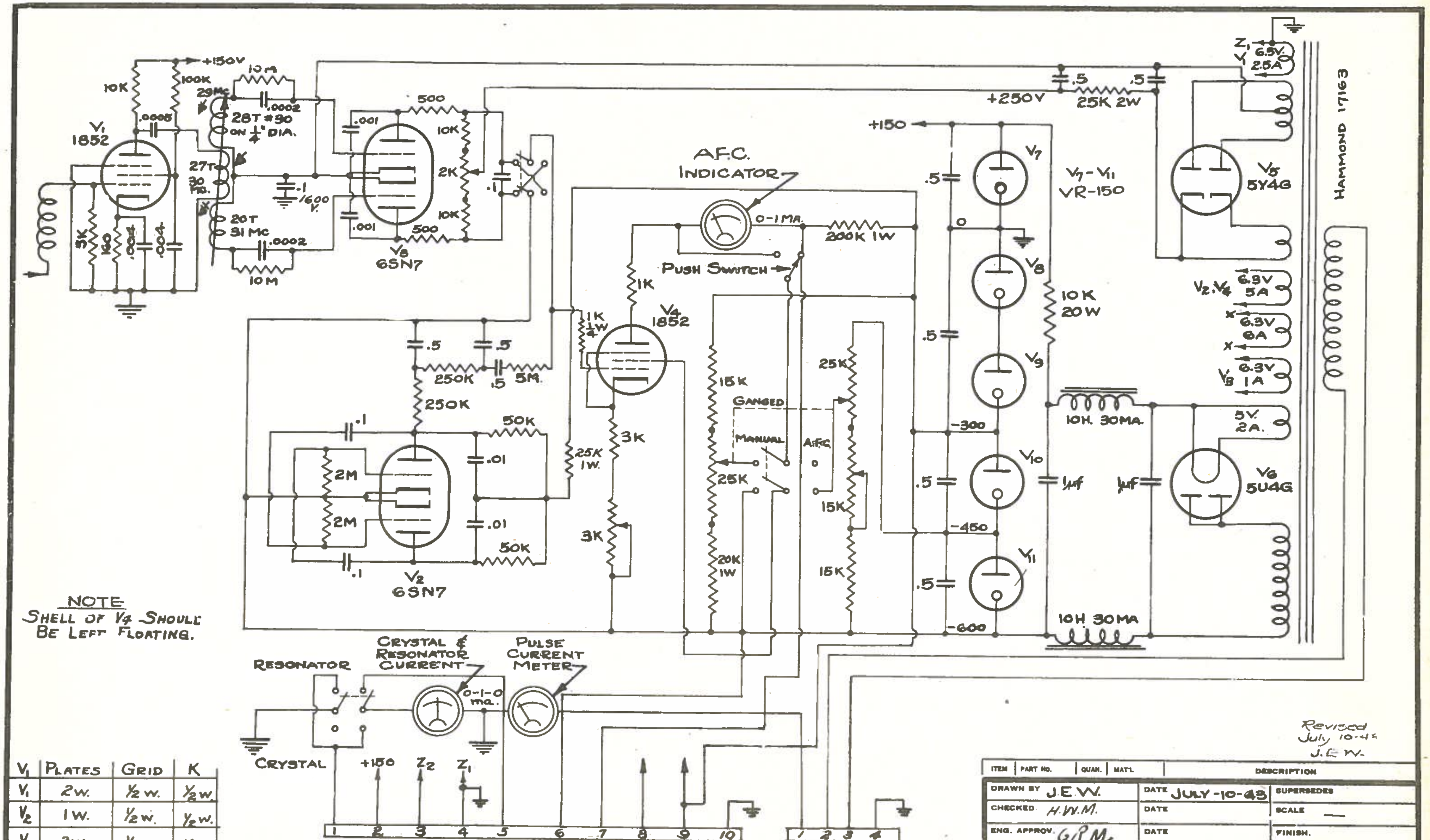


ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY	D.L.S.	DATE	16-4-43.	SUPERSEDES	RX/F-50-B
CHECKED		DATE		SCALE	
ENG. APPROV.	[illegible]	DATE		FINISH.	

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	SCHEMATIC DIAGRAM OF R.F. SYSTEM	DWG. NO.	-A- RX/F-172-A



NOTE
SHELL OF V4 SHOULD BE LEFT FLOATING.

V	PLATES	GRID	K
V1	2W.	1/2 W.	1/2 W.
V2	1 W.	1/2 W.	1/2 W.
V3	2W.	1/2 W.	1/2 W.
V4	1/2 W.	1/2 W.	1/2 W.

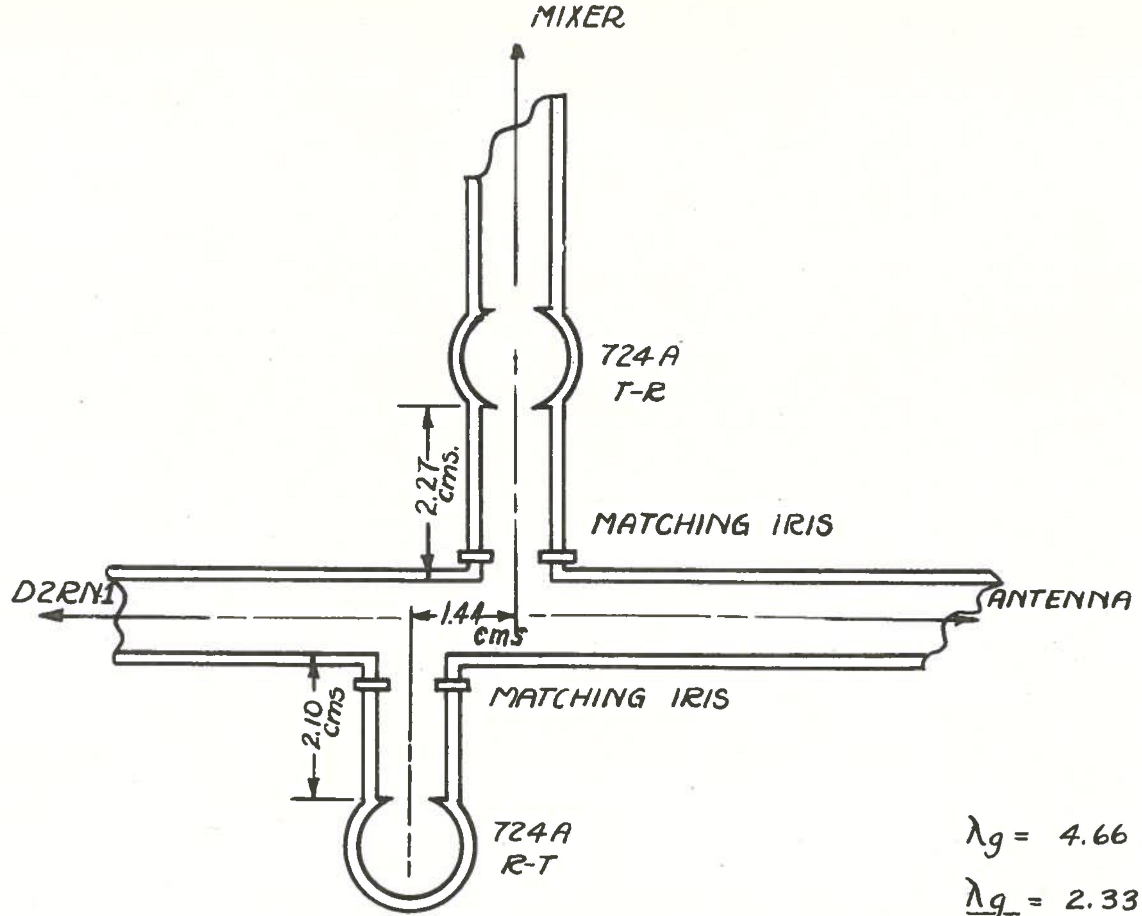
Revised July 10-45 J.E.W.

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY J.E.W.	DATE JULY-10-43	SUPERSEDES
CHECKED H.W.M.	DATE	SCALE —
ENG. APPROV. G.R.M.	DATE	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO. R-0
AUTOMATIC FREQUENCY CONTROL	RX-F-173-B



$\lambda_g = 4.66$ cm.

$\frac{\lambda_g}{2} = 2.33$ cm.

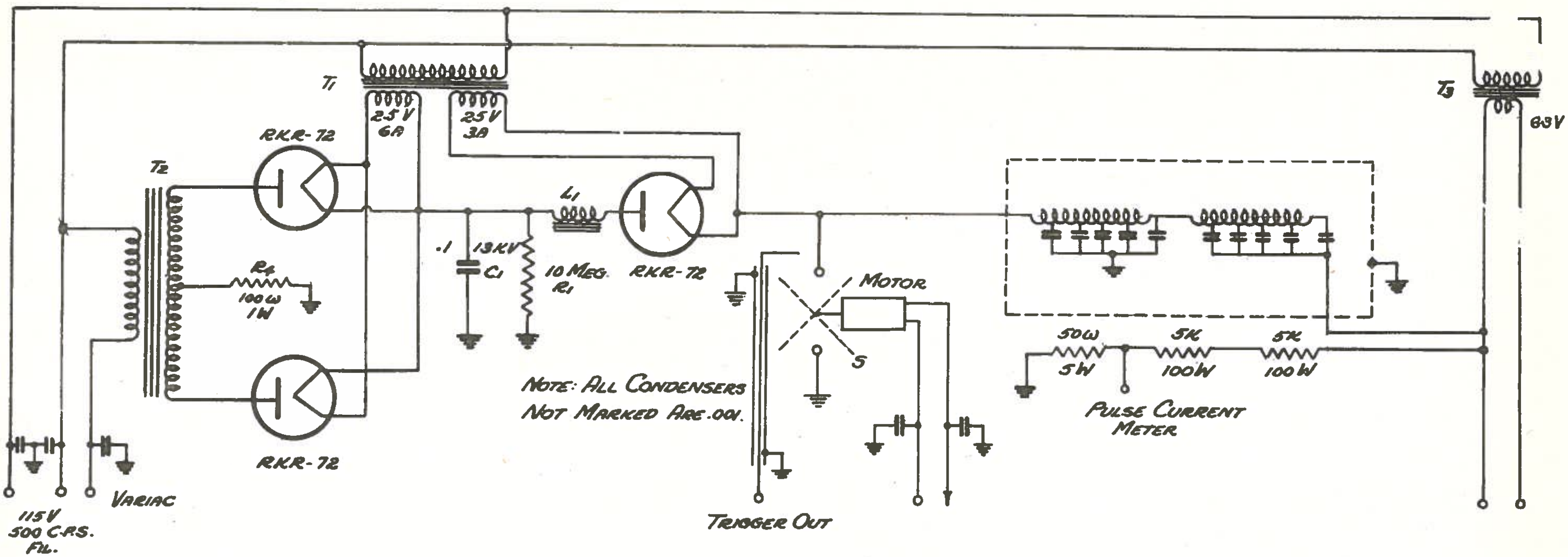
$\frac{\lambda_g}{4} = 1.17$ cm.

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY D.L.S	DATE 15-4-43	SUPERSEDES
CHECKED	DATE	SCALE
ENG. APPROV. C.H.M.	DATE	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME DUPLEXING SYSTEM	DWG. NO. R-RF RX/F-174-A.

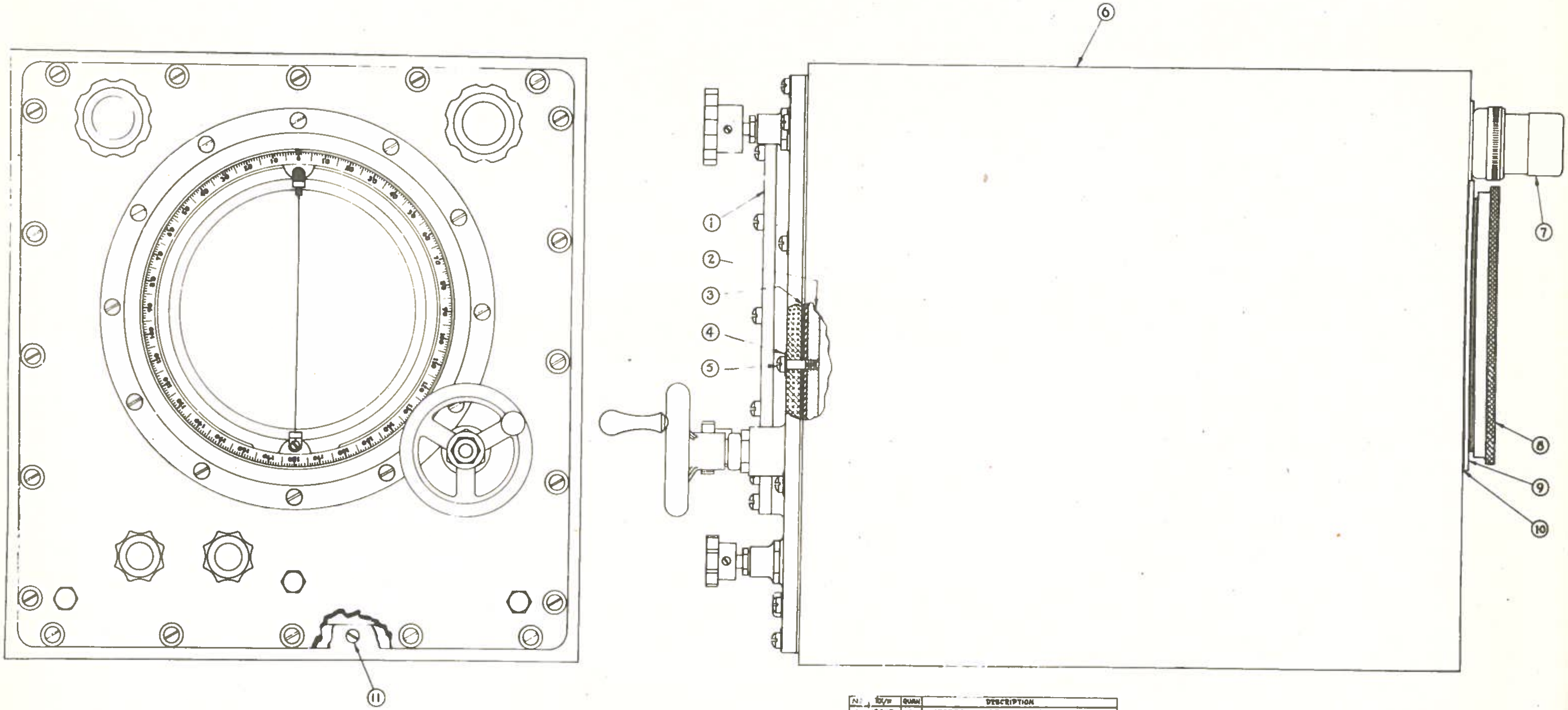


Item	Part No.	Quan.	Mat'l	Description

Drawn by	D.C	Date	4-2-44	Supersedes	
Checked	H.W.M.	Date		Scale	
Eng. Approv.	W.R.W.	Date		Finish.	

National Research Council-Radio Section - Ottawa Canada

Name	Dwg. No. 7-12
RX/F Pulser and Control Unit	RX/F-176-B



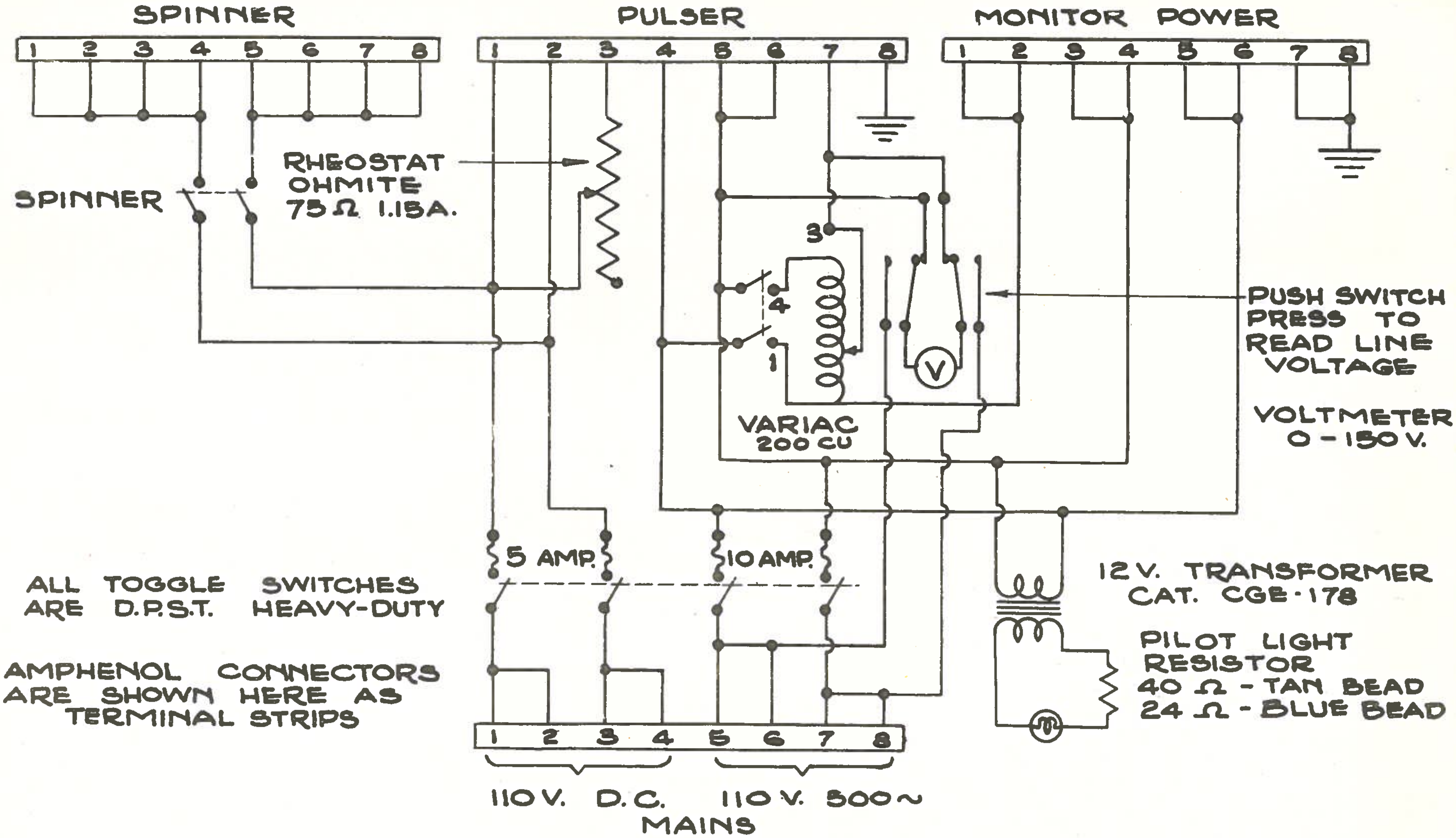
No.	DWG No.	QUAN	DESCRIPTION
1	124-E	1	WATERPROOF P.P.I. ASSEMBLY
2	106-B	1	FRONT PANEL MOUNTING RING
3	221-B	1	GASKET FOR FRONT PANEL MOUNTING RING
4		20	FLAT WASHER ½" D
5		20	10-32 FILLISTER HEAD M.S. ¾" LONG
6	107-B	1	WATERPROOF P.P.I. CASE
7	51-B	1	CABLE COUPLING ASSEMBLY
8	104-A	1	HAND HOLE COVER
9	105-B	1	HAND HOLE FLANGE
10	220-B	1	HAND HOLE FLANGE GASKET
11		2	6-32 FLAT HEAD M.S. 5/16" LONG

REVISED-13-10-43 - [illegible]

K.K.K.	4-5-43	
	5-5-43	
F.E.W.W.	6-5-43	

NATIONAL RESEARCH COUNCIL-RADIO SECTION

WATERPROOF P.P.I. IN CASE — D.M. 230-D



ALL TOGGLE SWITCHES ARE D.P.S.T. HEAVY-DUTY

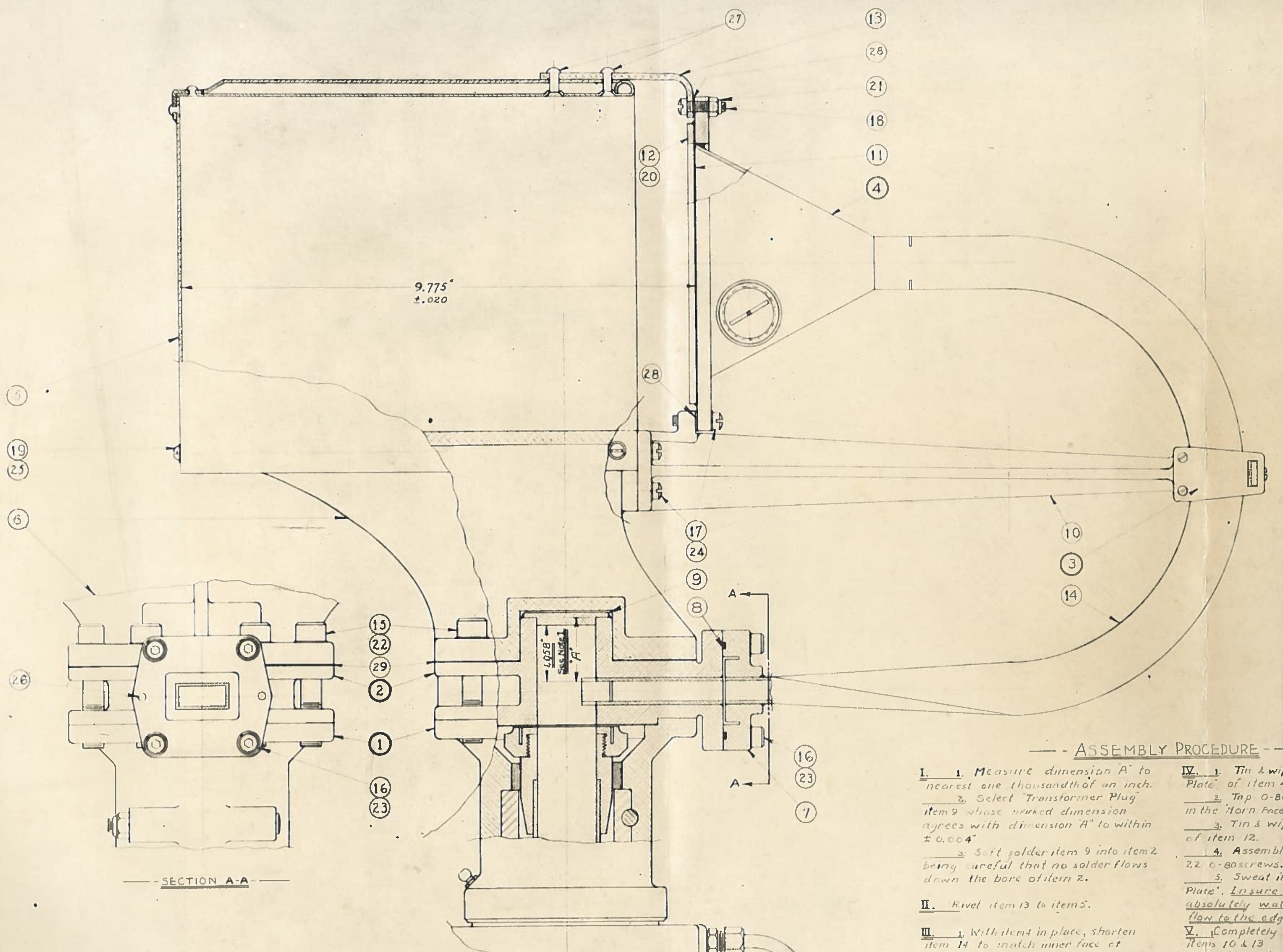
AMPHENOL CONNECTORS ARE SHOWN HERE AS TERMINAL STRIPS

ITEM	PART No.	QUAN.	MAT'L.	DESCRIPTION

DRAWN BY J.E.W.	DATE AUG. 11 - 43	SUPERSEDES
CHECKED H.W.M.	DATE	SCALE
ENG. APPROV. J.E.W.	DATE	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO. G-W
POWER CONTROL PANEL	RX-F-324-A



***** *All items marked with an asterisk are to be zinc plated.*

ASSEMBLY PROCEDURE

I. 1. Measure dimension "A" to nearest one thousandth of an inch.
2. Select "Transformer Plug" item 9 whose marked dimension agrees with dimension "A" to within ± 0.004"
3. Soft solder item 9 into item 2 being careful that no solder flows down the bore of item 2.

II. Rivet item 13 to item 5.

III. 1. With item 4 in place, shorten item 14 to match inner face of item 7.
2. Silver solder item 7 to item 14 with face of item 7 at rt angles to axis of item 14.
3. Remove excess solder on recessed face of item 7.

IV. 1. Tin & wipe smooth the "Horn Face Plate" of item 4.
2. Tap 0-80 NF-2 the 22 holes in the "Horn Face Plate."
3. Tin & wipe smooth back face of item 12.
4. Assemble items 4, 11 & 12 with 22 0-80 screws.
5. Sweat item 12 to "Horn Face Plate". Insure that this joint is absolutely watertight. Solder must flow to the edge of the mica.

V. 1. Completely assemble item 4 to items 10 & 13
2. Place item 8 in slot of item 7 and drive in "Dowel Pins" item 26 to align flanges of items 2 & 7.
3. Tighten down the 4 cap screws so that the flanges fit tightly together.

ITEM	PART No.	REQ.	MAT'L	DESCRIPTION
29	391-A	1	Paper	Gasket.
28		2	St. Steel	7/32 I.D. × 1/2" O.D. × 1/32 Thick Washer
27		2	Alum.	1/8 D × 3/8" Lg. [illegible] Rivet.
26		2	Brass	Dowel Pin 0.125" D. [illegible] × 7/8 Lg.
25		39	Brass*	0.245 O.D. × [illegible] Lock Washer.
24		5	St. Steel	0.325" O.D. × [illegible] Lock Washer
23		4	Brass	0.453" O.D. × [illegible] Lock Washer.
22		6	Steel*	0.640" O.D. × [illegible] Lock Washer.
21		1	Brass	10-32 Elastic Stop Nut
20		22	Brass	0-80 × 1/4 Lg. Fillister Hd. Mach. Screw.
19		39	Brass*	6-32 × 3/8 Lg. Round Hd. Mach. Screw.
18		1	St. Steel	10-32 × 3/4 Lg. Fillister Hd. Mach. Screw
17		5	St. Steel	10-24 × 3/4 Lg. Fillister Hd. Mach. Screw
16		4	Steel*	1/4-20 × 5/8 Lg. Hex. Socket Cap Screw
15		6	Steel*	3/8-16 × 2" Lg. Hex. Socket Cap Screw
14	367-C	1	Brass	Horn - Waveguide.
13	370-A	1	Alum.	Horn - Top Support.
12	369-A	1	Brass	Horn - Window Frame.
11	368-A	1	Mica	Horn - Window.
10	371-B	1	Alum.	Horn & Waveguide Support.
9	374-A	1	Brass	Transformer - Plug.
8	373-A	1	Neoprene	Waveguide Coupling - Seal.
7	372-A	1	Brass	Waveguide Coupling.
6	42-D	1	Alum.	Parabolic Reflector - Casting
5	41-C	1	Alum.	Parabolic Reflector - Top.
4	361-B	1	—	Horn - Assy.
3	390-B	1	—	Waveguide Clamp Assy.
2	357-B	1	—	Upper Transformer Assy.
1	49-E	1	—	Antenna Gearbox Assy.

V	ROUGH FINISH
VV	FINE FINISH
VVV	EXTRA FINE FINISH
G	GRIND
P	POLISH

STANDARD TOLERANCES
UNLESS OTHERWISE SPECIFIED

INCHES	FRACTIONAL	DECIMAL
0-6	± 1/64	±.005
OVER 6-24	± 1/32	±.010
OVER 24	± 1/16	±.015

DRAWN BY FEWW	DATE 26-10-43	SUPERSEDES MF 130-C
CHECKED	DATE 1-11-43	SCALE FULL
ENG. APPROV. [illegible]	DATE 3-11-43	FINISH —

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

R.F. & ANTENNA ASSY. — DWG. No. RXF-375-D