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A.S.D. 2023

Manual Of R.D.F. Test Equipment

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ASD 2023

MANUAL OF R.D.F. TEST EQUIPMENT

1. Wavemeter
2. Portable Dipole
3. Attenuator and Diode Voltmeter
4. Battery Test Oscillator
5. Field Intensity Receiver
6. Calibrator Unit
7. Impedance Measuring Set
8. Cathode Ray Oscillograph
9. Signal Generator
10. Bridge Type Switching Motor
11. A.W. Test Set

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AMENDMENT SHEET

Amendment List		Amendment made by	Date
Number	Date		

This sheet is to be inserted in ASD 2023 immediately following the title page.

R.D.F. TESTING EQUIPMENT

WAVEMETER

(RD15/42).

R.D.F. TESTING EQUIPMENT

WAVEMETER

WAVEMETER.

Service Designation.

P.M.G. Unit 18 Wavemeter, type A (Aust)	R.A.N. - A.M.F. - ZCA4411 R.A.A.F. - Wavemeter type AW4 Y10T/70002 Serial No.
P.M.G. Unit 19	Wavemeter, type F (Aust) R.A.N. - Patt. No. (Aust) 212 A.M.F. - R.A.A.F. - Wavemeter type AW3 Y10T/70001 Serial No. -

The wavemeters are being supplied with a frequency calibration chart. The operating frequency of the particular system for which the wavemeter is intended is indicated by a red line on the chart. The key to the absolute value of the frequency ordinate on the chart is as follows:

Unit T.18 - 200 megacycle wavemeter

Graduations appear at 1 megacycle intervals between the range 195 to 205 mC/s. The red line is on the 200 mC/s graduation.

Unit T.19 - 176 megacycle wavemeter

Graduations appear at 1 megacycle intervals between the range 170 to 180 mC/s. The red line is on the 176 mC/s graduation.

214 megacycle wavemeter

Graduations appear at 1 megacycle intervals between the range 210 and 220 mC/s. The red line is on the 214 mC/s graduation.

Specification.

1. Frequency Range

   Unit T.18...190 - 210 mC/s approximately
   Unit T.19...166 - 186 mC/s "

2. Input - Inductive pick-up by proximity to the transmitter or aerial array.

3. Description.

   Variable 1/4 wavelength resonant line with a diode voltmeter coupled to the high voltage end. The line is tuned for maximum voltage indication as read on a 100 microamp meter in the diode circuit.

4. Frequency Indication

   A pointer driven off the main driving screw makes one complete revolution and indicates on a dial, which has 20 equi-spaced divisions. Each division is further sub-divided into 10 by means of a small subsidiary pointer, which rotates once for each division of the main dial and indicates on a dial which has 10 equi-spaced divisions. A chart is provided, on which dial readings are plotted against frequency.

5. Power Supply

Four 1½ volt type X (Army) cells connected in series.

6. Controls.

A. Frequency variation - radio knob fastened to the driving screw.
B. Battery on - off switch (radio knob)
C. Meter zero adjusting potentiometer.

7. Valves.

EA50 ... 1 off

References - P.M.G's Department Drawings Nos. CX.68, Sheets 1 to 29.

Description

1. General (See Figure 1)

The essential parts of the wavemeter are an outer brass tube x, Figure 1, 2 inches diameter with an inner concentric brass tube C, ½ inch diameter. The inner tube protrudes at one end and is bent around at right angles and brazed to an extension on one side of the outer tube. This provides an external pick-up loop and also shortcircuits this end of the concentric line. A WT22 spacer Y is fitted at this end to keep the inner conductor supported in a central position. The other end of the line is open-circuited and the inner conductor is made telescopic in order to provide an adjustment for the length of the line. Good contact between the fixed and moving portions of the telescopic inner tube is ensured by fitting a brass shim on the moving portion B. An EA50 diode is mounted with its anode pin extending into the space between the inner and outer tubes at a point near the open-circuited or high voltage end of the concentric line. The diode itself is mounted in a cylindrical brass tube which fits into a side tube brazed on to the main tube at right angles. The voltages on the diode are supplied by four 1.5 volt dry batteries and a 0 - 100 micro-ammeter is inserted in the cathode circuit to measure the diode current. The standing current through the diode is adjusted by means of a potentiometer controlling the voltage applied to the cathode.

The measurement of frequency is obtained by varying the length of the open-circuited concentric line until it is an equivalent quarter wave-length of the frequency being measured. In this position, resonance occurs and R.F. voltage is picked up by the anode of the diode causing an increase in diode current as measured on the microammeter in series with the cathode. A maximum reading on the meter indicates that the setting is correct. The moving portion of the inner tube is connected by a trolitul connecting piece to a tube A which extends through the end of the outer tube opposite to the pickup loop.

2. Tuning Mechanism.

The main driving screw W has a square thread of 11 turns per inch and consequently turning this screw 20 times alters the length of the transmission line by approximately 1¾". This gives a frequency variation of approximately 20 mC/s. V is a small pointer driven from the driving screw by suitable gearing at the same speed as the driving screw. P is a large pointer geared down to a speed 1/20th that of the small pointer and the driving screw. There are stops in the mechanism (collars E and T) which limit the movement of this large pointer to one revolution in one direction, and the small pointer and driving screw are limited to 20 revolutions in one direction. The driving screw drives a vertical shaft through a 1 : 1 helical gear. The vertical shaft drives the small pointer V through another 1 : 1 helical gear and the large pointer P through a worm and pinion. The driving screw moves a brass tube A (Figure 1) along the line of its axis. Tube A has a longitudinal slot, in which a fixed pin slides and prevents the tube from turning. This tube is coupled to the rod B which forms the variable end piece of the transmission line by means of a piece of trolitul rod.

3. Diode Container.

The diode and associated components are mounted inside a cylindrical copper container and the whole is free to slide inside a cylinder which is at right angles to and brazed to the transmission line. The sliding cylinder is fixed by means of a screw in the position giving optimum coupling of the diode to the transmission line.

Operation.

1. Initial adjustments (initially done by manufacturer).

A. The extension of the EA50 anode lead is such that it projects into the transmission line to within approximately 1/8" of the centre conductor. This separation can be varied by sliding the diode compartment after loosening the holding screw. It should not be altered after the frequency calibration has been made.

B. Turn the driving screw knob in a counter clockwise direction until the centre conductor of the transmission line has its maximum length (an internal collar T on the moving piece of tube A limits the length of the line). Then set the large pointer until it reads 0 and 20 (for this adjustment loosen the main shaft coupling F situated between the helical gear and the square thread, when it will be found that turning the knob turns the pointer without turning the driving screw). Incidentally the small pointer should also read 0 and 10. Re-tighten the coupling.

C. Turn the driving screw knob until the centre conductor of the transmission line has its minimum length. The large pointer should have moved through just one revolution so that it again reads 0 and 20. If it does not, adjust the stop (a collar E on the moving tube A) until the limit reading is 0 and 20. A grub screw holding the collar is available for this adjustment.

D. Switch the batteries on and adjust the potentiometer until the meter reads zero. If greater sensitivity is required the initial reading on the meter should be greater than zero.

E. Bring the instrument near a source of U.H.F. and alter the frequency adjustment until a peak reading is obtained on the meter. If the frequency of the source is variable and accurately known, further readings can be taken, and a graph of frequency versus dial reading made.

2. Operation in the field.

A. Turn the switch on and adjust the meter reading to zero or greater, according to the sensitivity required.

B. Bring the pick-up loop near the unknown source of voltage and turn the frequency knob until a maximum peak is obtained on the meter. Adjust the distance between wavemeter and source until an easily determined peak is obtained on the meter. Then the frequency can be determined from the dial reading and the graph supplied with the instrument.

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R.D.F. TEST EQUIPMENT

Addendum to technical bulletin entitled "Wavemeter"

The wavemeters are being supplied with a frequency calibration chart. The operating frequency of the particular system for which the wavemeter is intended is indicated by a red line on the chart. The key to the absolute value of the frequency ordinate on the chart is as follows:-

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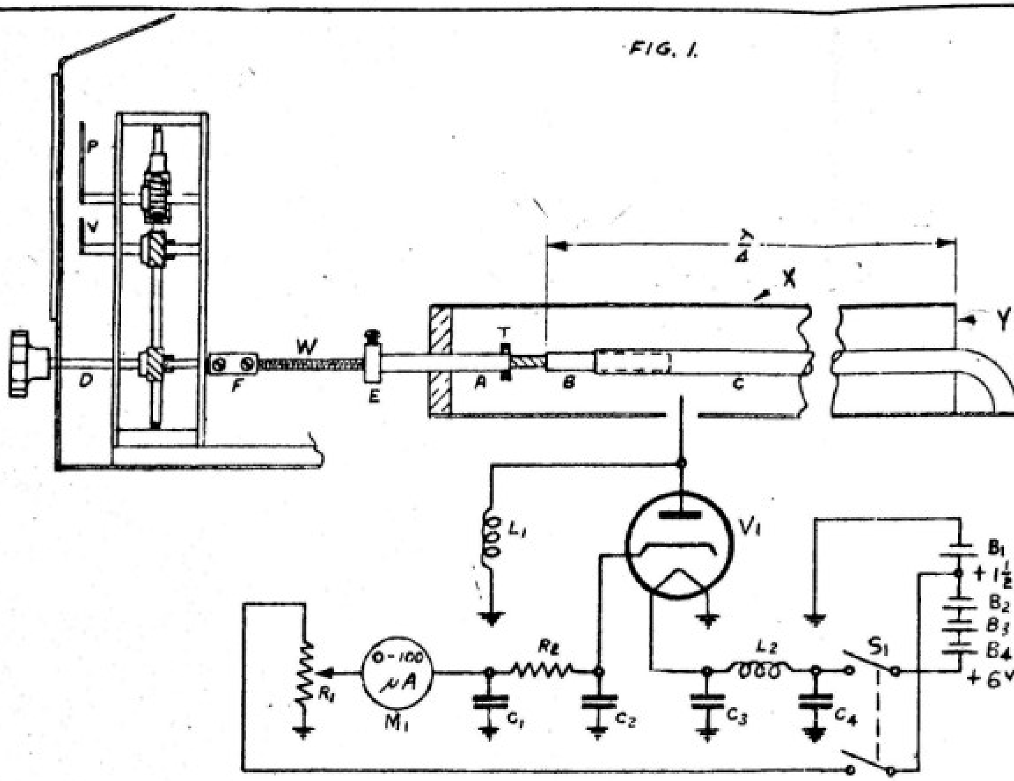
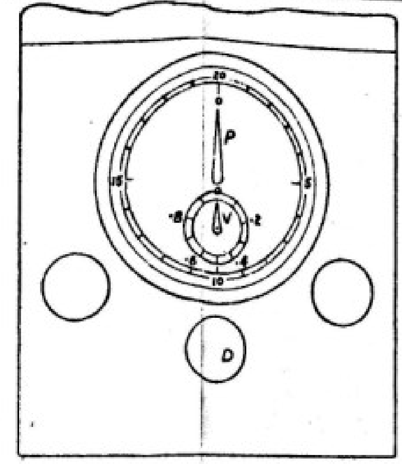
214 megacycle wavemeter

Graduations appear at 1 megacycle intervals between the range 210 and 220 mC/s. The red line is on the 214 mC/s graduation.

(R.D.15/42)

FIG. 1.





STOCK LIST.		
ITEM.	DESCRIPTION.	R.P. ITEM No.
R1	1000 ohms. pot. 1 W.	
R2	1000 Ohms. 1/2 watt resistor.	19/72.
C1.	100 mmf. silvered mica.	10/540.
C2.	" " " "	"
C3.	" " " "	"
C4.	" " " "	"
L1.	Choke.	
L2.	Choke.	
V1	EA50.	1/25
B1, B2, B3, B4.	1 1/2V. TYPE "X" DRY BATTS.	
M1.	PALEC 100/uA METER MODEL K.35.	11/16A.
S1	ROTARY 2 POLE ON-OFF SWITCH.	64/7.

R.D.F. TESTING EQUIPMENT

DESCRIPTION OF PORTABLE DIPOLE

(RD18/42).

R.D.F. TESTING EQUIPMENT.

DESCRIPTION OF PORTABLE DIPOLE.

CONTENTS.

(KD18/42)

PORTABLE DIPOLE

SERVICE DESIGNATION.

P.M.G. Unit T.9 Dipole, portable - Type A (Aust.)
R.A.N. -
R.A.A.F. - ZCA 4409
R.A.A.F. - Test Set type A15
Y10S/60024
Serial No.

P.M.G. Unit T.10 Dipole, portable - Type F (Aust.)
R.A.N. - Patt, No.(Aust.) 210
R.A.F. -
R.A.A.F. - Test Set Type All
Y10S/60019
Serial No. -

SPECIFICATION.

1. Description (both types)

This unit comprises a centre fed half wave aerial connected to a balance to unbalance transformer. The unbalanced coaxial transmission line is brought out to a type 93C Amphenol connector mounted on the transformer. The unit can be mounted at the top of a two or three section pole, pegged to the ground by means of three guy ropes and a coaxial cable is used for connecting the dipole with the terminal equipment.

2. Frequency

Unit T.9 resonates at 200 mC/s
Unit T10 resonates at 176 mC/s
Unit T.11 resonates at 75 mC/s

3. Input impedance (unbalanced) - approximately 75 ohms

4. Height of dipole above ground

A. Two pole assembly - Approximately 13½ feet
B. Three pole assembly - " 19½ feet

References - P.M.G. Drawing No. CX.63, Sheets 1, 2 and 3.

DESCRIPTION

Figure 1 is a schematic indicating the action of the balance to unbalance transformer. If the dipole is placed in a horizontally polarized electromagnetic field, voltages are induced in the horizontal dipoles at some particular instant having polarities as shown. These voltages tend to send currents to earth along the outside of $\lambda/4$ pieces and L and M in directions as shown by the arrows P and Q. These currents would be in opposite directions and equal in magnitude, and therefore would cancel at the point X, so that no current flows to earth from the point X via the outside of the coaxial cable. Actually, the opposite direction currents on the outsides of L and M are negligibly small, because L and M is a short circuited $\lambda/4$ twin transmission line. Due to the potential difference between E and F currents flow in the coaxial cable via the centre conductor and the inside of the coaxial shield, and hence we have a balance to unbalance transformation. Now as regards impedance matching, consider the various impedances across EF:

A. The impedance of a centre fed half wave aerial which is approximately 75 ohms.

B. The characteristic impedance of the coaxial cables which can be selected to have an impedance of 75 ohms.

C. The input impedance of the short circuited $\lambda/4$ stub LM, which is infinite.

Hence, we see that in this simple case, the load impedance can be chosen equal to the aerial impedance by the choice of coaxial cable. Maximum pick up by the aerial is obtained when the line of the horizontal dipoles is at right angles to the direction of the field and conversely the direction of maximum radiation from the dipoles is at right angles to the line of the dipoles. For transportation purposes the dipoles can be unscrewed at the points E and F and screwed into the short circuiting plate X.

OPERATION.

1. Assembly (with two supporting poles) See figure 2.

A. Screw the six foot threaded pole A into the base plate B.

B. Slide the anchoring plate C on to the unthreaded 6 foot pole D, with the boss on the plate facing away from the end of the pole.

C. Slide pole D into the end of pole A as far as it will go, and adjust plate C so that it is butting against the top of pole A.

D. Cut the 30 yards of rope supplied into 3 ten yard lengths and fasten the rope to the three holes provided in plate C.

E. Slide the dipole assembly (with its coaxial cable attached) into the top of pole D and erect the whole assembly so that the line of the horizontal dipole is approximately at right angles to the direction from which a signal is expected, or toward which a signal is to be radiated.

F. The spike at the bottom of the pole A can then be driven into the ground and the whole assembly secured by driving the three pegs into the ground and fastening the ropes to them. The spare rope should not be cut off as the increased length may be required when three poles are being used.

G. A little oil should help the various sliding operations described above.

2. Measurement of the strength of a strong field.

   A. Terminate the coaxial cable in a diode voltmeter (PMG Unit T.16B) and a deflection should be obtained on the meter.

   B. Twist the pole D until the maximum deflection E is obtained on the meter. The fit of pole D in pole A and plate C should be sufficiently free for D to move without moving A and C appreciably.

   C. The field strength is given by:

$$F = \frac{2\pi}{\lambda} E$$

where E = meter reading in volts peak
F = field strength peak in volts per metre
λ = wavelength in metres

   D. If a weak continuous wave field is being measured a type T4 or T5 field strength receiver can be used in place of the diode voltmeter.

3. Plotting polar diagrams of an aerial array.

   A. In this case, the dipole is usually connected to a battery test oscillator set to the appropriate frequency.

   B. A field strength receiver is connected to the array, and the dipole held in position with the horizontal dipoles at right angles to the line from the dipole to the array. The field strength receiver is set to the A.V.C. position, the array is rotated through 360 degrees, and the maximum and minimum decibel readings on the receiver noted. If the minimum reading registered on the receiver is 70 - 75 decibels, the dipole can be pegged down ready for the polar plot. If not, the dipole should be brought closer or moved away from the arrays and the process repeated until the proper location is found. With the Sh.D. array, it is desirable that the distance between dipole and array be at least 150 yards and that the line joining the centres of the dipole and the array makes an angle of not greater than 5 degrees with the horizontal.

   C. The array is then turned slowly through 360° and decibel readings on the receiver taken at suitable intervals, and the angular positions plotted against the decibel readings, or the decibel readings can be converted to voltage ratios before plotting.

4. Other uses of the portable dipole include:

   A. Monitoring of the radiation from the array in conjunction with a Type T.15 C.R. Oscillograph and a pulse from the transmitter.

B. As a source of radiation from a distant point to an aerial array for checking the bearing accuracy of the array. A battery test oscillator is used at the dipole, and a field strength receiver and a theodolite at the array.

C. The dipole and battery test oscillator can be used in conjunction with a second dipole for measuring the gain of an aerial array.

5. If greater altitude is required for the dipole, a third pole similar to pole D is available. In this case the third pole fits into the top of pole D, and the plate C is attached to the junction of the middle and top poles for best stability.

FIG. 2

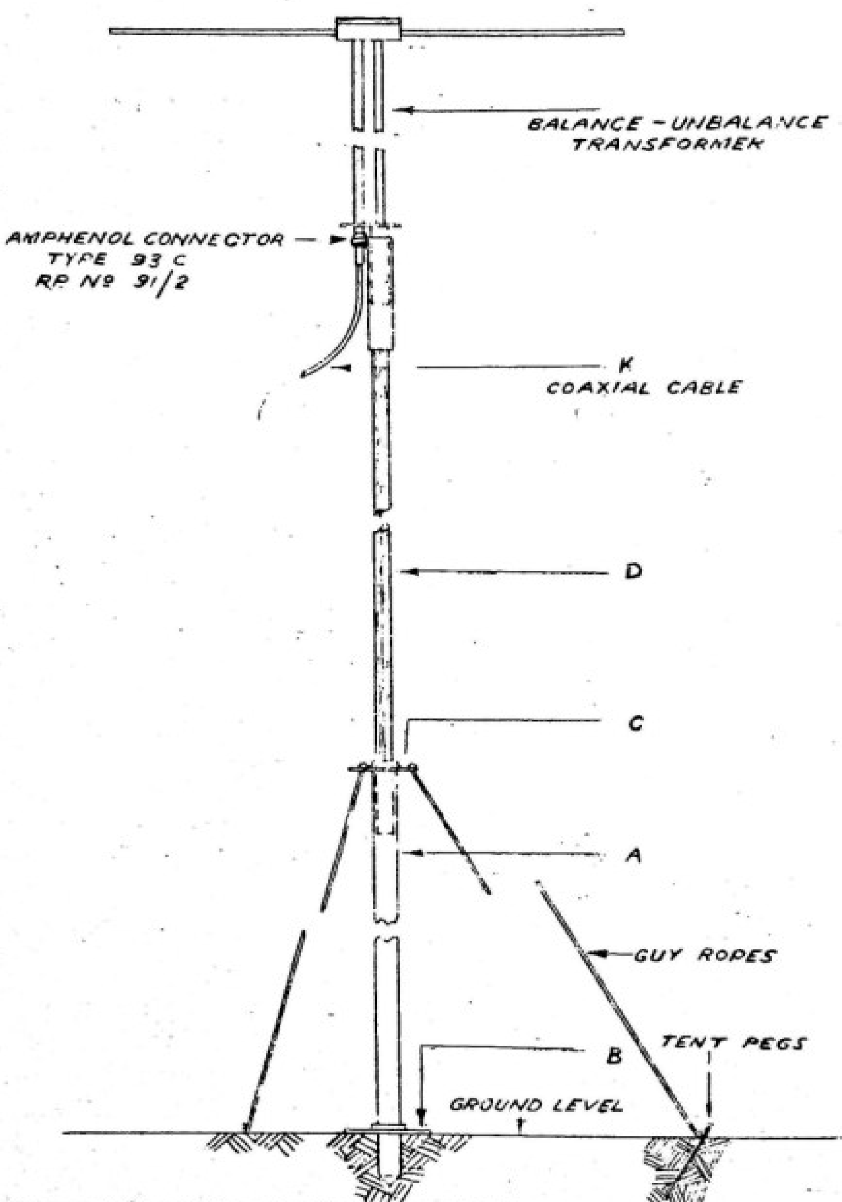
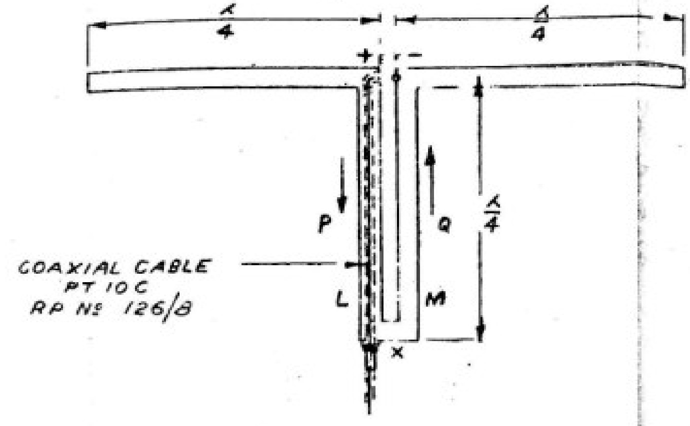

BALANCE - UNBALANCE TRANSFORMER
AMPHENOL CONNECTOR TYPE 93 C RP. No 91/2
K COAXIAL CABLE
D
C
A
GUY ROPES
B
TENT PEGS
GROUND LEVEL

FIG. 1


λ/4
λ/4
λ/4
+
-
P
Q
L
M
X
COAXIAL CABLE PT 10 C RP No 126/8

R.D.F. TESTING EQUIPMENT.

ATTENUATOR AND DIODE VOLTMETER

(RD13/42)

R.D.F. TESTING EQUIPMENT

DESCRIPTION OF ATTENUATOR AND DIODE VOLTMETER

CONTENTS

(RD13/42)

SERVICE DESIGNATION

P.M.G.Unit T.16A. Attenuator,R.F. type M/D32 - (Aust).

R.A.N. - Patt. No. (Aust.) 219
A.M.F. - ZCA 4419
R.A.A.F. - Test Set Type A8 Y10S/60015
Serial No.

P.M.G.Unit T.16B. Voltmeter, diode type M/D32 (Aust).

R.A.N. - Patt. No. (Aust). 221
A.M.F. - ZCA4405
R.A.A.F. - Test set type A4 Y10S/60004
Serial No.

SPECIFICATION

1. Description - A dummy load simulating the load presented by an aerial array to the transmitter with a tap near the low potential end of the load Diode voltmeter (Unit T.16B) measures the voltage "V" at the tap, and the transmitter peak output voltage is 6.3 V. Actually the dummy load comprises two high attenuation short circuited transmission lines connected in parallel.

2. Input impedance - approximately 75 ohms.

3. Frequency characteristics. The input impedance is approximately resistive for frequencies from 75 - 200 mC/s.

4. Average Power Dissipation - 60 watts.

5. Output. The tap is connected to Unit.T.16B by means of a coaxial cable, which is terminated at the T.16B end in 75 ohms.

6. Construction (See Fig.1). The transmission lines are concentric in form and comprise centre conductors of resistive material (each 6⅝" long x. 1⅜" diameter, and 150 ohms D.C. resistance), and a containing metal box 3¼" square and 16" long, which forms the outer conductor of the transmission line. The two resistors are colinear, being fed at the centre and shorted to the case at the ends. The centre feed and the tap (which is connected to only one of the transmission lines) are each brought out to . coaxial connectors. The input impedance of each line is 150 ohms, the two in parallel being 75 ohms.

SPECIFICATION (Unit T.16B).

1. Description (See Fig.2.). The unit comprises an EA50 diode reading peak volts of U.H.F. carriers (pulse modulated or un-modulated).

2. Input impedance - 75 ohms via a coaxial socket.

3. Frequency characteristics - see description later.

4. Display - 100 micro-amp direct current meter in the cathode of the diode circuit.

5. Power Supply - Five Army type "X" cells connected in series.

(RD13/42).

6. Switches.

S_1......Four position switch, the positions being respectively Off, 500 volt range, 100 volts range, and a position for measuring the heater battery voltage.

S_2......A safety switch which opens the battery circuit when the case closes.

7. Voltage Ranges......0-100 volts peak and 0-500 volts peak.

8. Valve. One EA50.

DESCRIPTION. (Unit T.16A).

A very brief description of the attenuator is given under Specification. A detailed account of the considerations involved in making the input impedance of a short circuited transmission line approximately constant and non-reactive over a wide range of frequencies is given in "Electronics, April, 1941." Broadly speaking a thin coating of resistive material on a ceramic tube forms the inner conductor of each transmission line, whose length should not exceed 1/20th of the "free space" wavelength of the highest frequency being used. The resistive coating is so thin that the U.H.F. resistance per unit length is substantially the same as the D.C. resistance per unit length. The input impedance of this short circuited line is approximately equal to the D.C. resistance of the line, which is made 150 ohms so that two in parallel have an input impedance of 75 ohms to match the transmitter. A tap is made on one of the transmission lines at a point near the short circuited end, and the voltage at the tap is always 16 db. below the input voltage. The unit is air cooled and provision is made for a thermometer to be inserted down the centre of the transmission line. The temperature rise above ambient when the resistor has "warmed up" can then be plotted against the power being dissipated by the resistor. The actual unit has transmission lines 1/10th the length of a 200 megacycle "free space" wavelength.

DESCRIPTION. (Unit T.16B).

CIRCUIT. The circuit is shown in Figure 2. The condenser (C_2 + C_3) charges up to approximately the peak value of the RF voltage a pplied across the 75 ohm resistance and the value of the voltage is measured by the voltmeter consisting of the 100 μA meter and resistances R_1, R_2, R_3. The switch SW_1 provides two ranges of voltage 0-100 V. and 0-500 V. When the instrument is used to measure the peak voltage of RF pulses, a considerable voltage drop occurs across the diode due to the relatively high peak current. The peak current through the diode depends on the value of the leakage resistance R_1, R_2, R_3, pulse length and repetition frequency. A set of calibration curves is given in figures 4 and 5.

The switch SW_1 includes an "Off" position to disconnect the battery supply to the EA50 filament and a "Batt." position to measure the filament voltage. The switch SW_2 in series with the filament supply lead is opened when the lid of the instrument is closed. The filament supply is provided by five 1.5 V. Type X batteries connected in series.

GENERAL DESCRIPTION

The terminating resistance, diode and cathode condenser are enclosed in a shielded cylinder mounted immediately behind the RF input chassis connector. Filament and cathode leads are brought out throughttwo terminals in the base of the cylinder.

The shielded cylinder range switch SW_1 and safety switch SW_2 are all mounted on the front panel.

The batteries are mounted in the base of the box itself and are connected to the front panel components by means of two long leads which enable the back of the front panel to be inspected without disconnecting any leads.

BATTERY VOLTAGE

Over the normal range of operation as covered by the calibration curves, it is necessary to maintain a filament voltage greater than 5.3 volts. Below this value, the voltage drop across the valve (on 100 V. range) increases very rapidly with decrease in filament volts resulting in a large decrease in the meter reading. Insufficient battery life would be obtained with a supply of 4 cells, so that 5 cells are used.

OPERATION.

1. The use of T.16A and T.16B conjointly for measuring the peak power output of a transmitter.

   A. Join the tap on the attenuator to the input of the diode voltmeter by means of the coaxial cable supplied.

   B. Set the voltmeter switch to "500" range and connect the unkown source of power to the coaxial input of the attenuator. If the output voltage is small the switch can be changed to "100" position.

   C. Take the reading on the meter, correct it to "Peak" voltage by means of the chart supplied, and multiply the result by 6.3, and we have the output peak voltage of the pulse from Tx. Knowing also the load resistance (75 ohms) the peak power output of the transmitter can be readily calculated.

EXAMPLE

Pulse duration 4 u/secs. P.R.F. 500. then the total time of power radiated per second is 4 x 500 = 2000 u/secs. If the reading on the voltmeter is 94 volts then, referring to the graph, it will be seen that the peak volts for 2000 u/secs. is 140 volts. The absolute peak volts in then 140 x 6.3 = 882.

2. The use of T.16A and C.R. Oscillograph T.15 for observation of the pulse shape and length.

   A. Connect the transmitter to the input of the attenuator and connect the output of the attenuator to the coaxial "U.H.F." input connector of the monitoring C.R.O. A video pulse must also be connected from transmitter to C.R.O. By adjusting the "Y shift" control of the C.R. Oscillograph, the highest peak pulse likely to be encountered can be accommodated on the screen. The length of the pulse can then be measured by comparing with the calibrator in the C.R. Oscillograph.

3. Other uses of the diode voltmeter T.16B.

A. It can be connected to a portable dipole for measuring the absolute field strength of a strong field.

B. Connected in place of a receiver in an R.D.F. set for measuring the magnitude of the transmitter voltage being applied to the receiver.

ACCURACY OF INSTRUMENT (Unit T.16B).

The inductance of the diode leads, and the plate cathode capacity resonate to produce an error depending on frequency. The order of the error is as follows:

Frequency	Error
200 Mc/s	10%
176 "	7%
75 "	1.3%

Owing to "electron inertia" and the appreciable distance (.15 mm) between cathode and plate, an error depending on voltage and frequency is obtained. Assuming negligible leakage error such as is obtained during calibration (see below), the "electron inertia" error is as follows:

200 & 176 Mc/s

Peak Volts	Error
300	-1.7%
200	-2%
100	-3%
50	-4.3%
25	-6%

At 75 Mc/s the error is negligible.

These errors can be neglected when making calculations as set out in previous example.

CALIBRATION.

The calibration curves were calculated and checked experimentally. For the experimental check, a slide back type of voltmeter was used as shown in figure 3.

The reading on the voltmeter V, for zero current through the galvanometer G, then gives the true peak volts applied to the diode but not including errors due to resonance and the spacing of the electrodes. The curves given should be correct to within 10% on the 0-100 volt range and 5% on the 0-500 volt range.

(RD 13/42).

FIG. 2

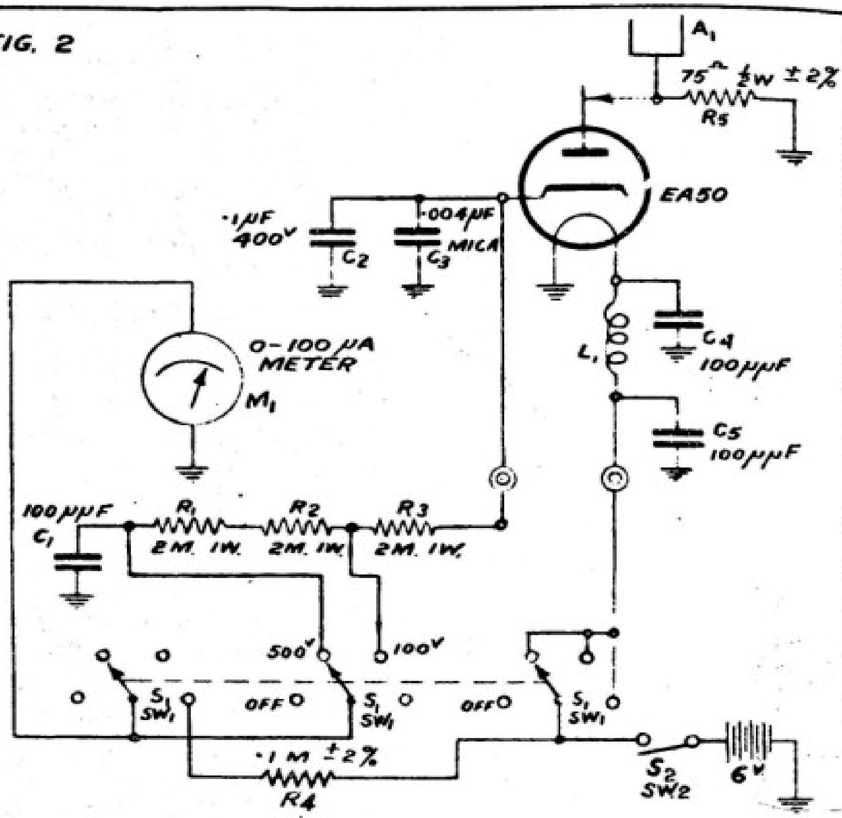


FIG. 1

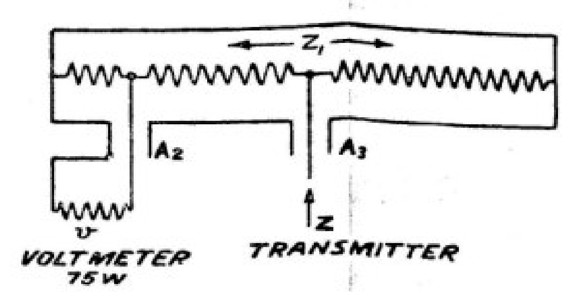
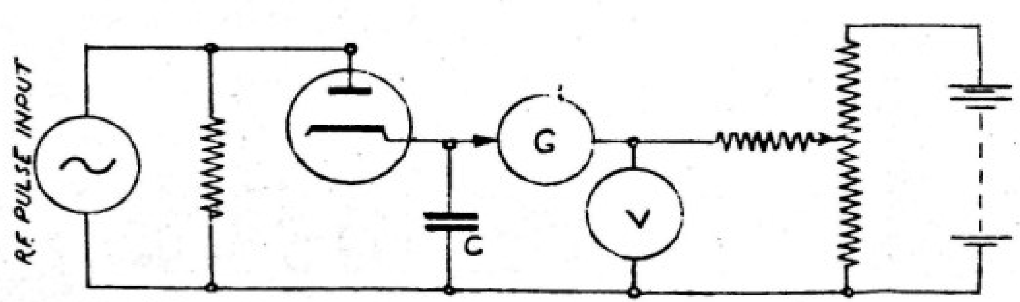
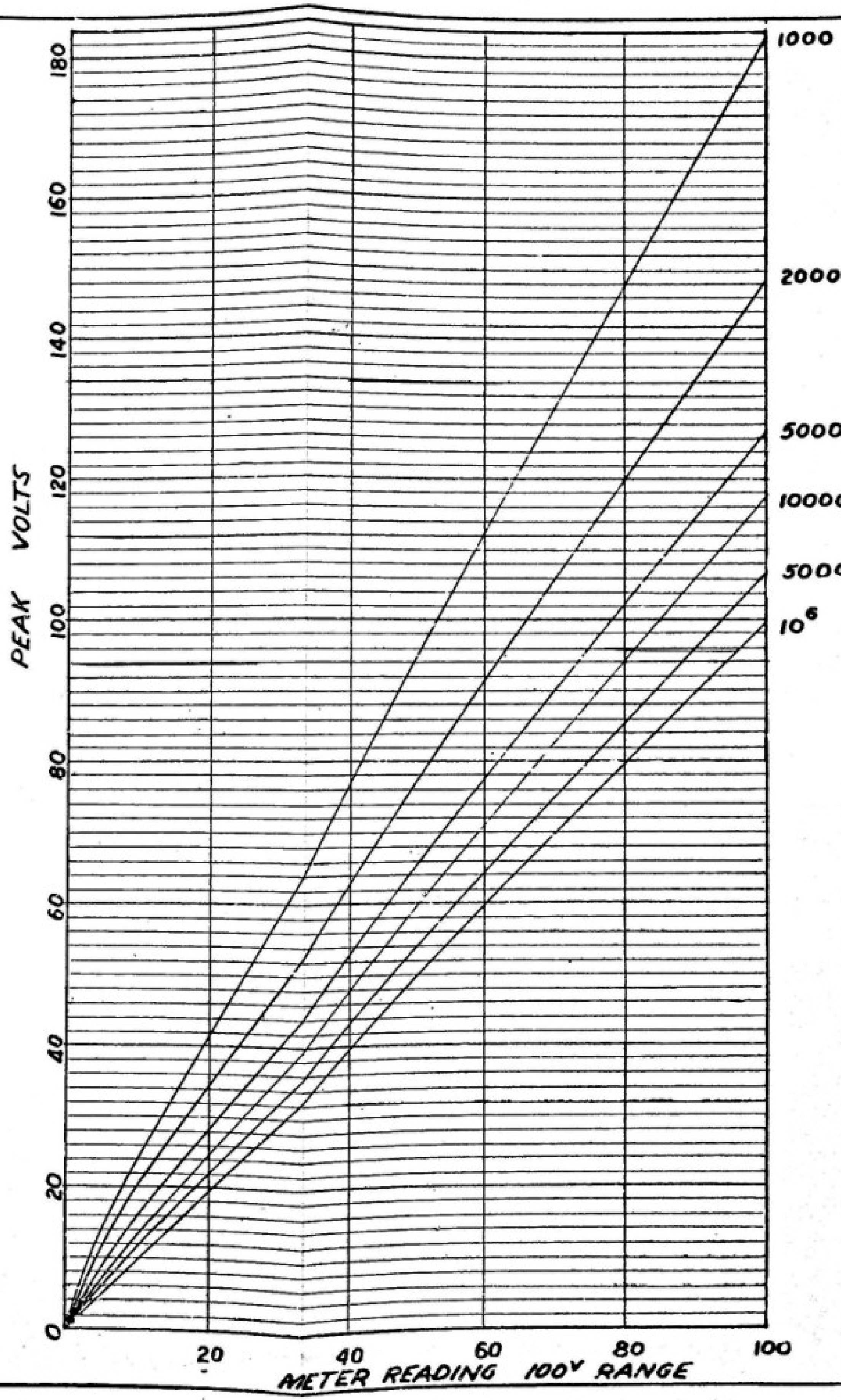


FIG. 3



STOCK LIST.

ITEM	DESCRIPTION.
R1	2 MEG. 1 W. ± 5%
R2	2 MEG. 1 W. " 5%
R3	2 MEG. 1 W. " 5%
R4	·1 MEG. " 2%
R5	75 Ohms.1/2W. " 2%
C1	100 μμF.
C2	.1 μF. 400V PAPER.
C3	.004 μF. MICA.
C4	100 μμF.
C5	100 μμF.
S2 (SW2)	CASE SWITCH.
L1	CHOKE 37 CMS. OF 22 S.W.G. ENAMEL ON FORMER (1/2 W.)
M1	METER 0-100/uA.
S1 (SW1)	YAXLEY SWITCH 3POLE 4 POS.
V1	TYPE EA50 VALVE
A1, A2, A3	AMPHENOL TYPE 93 C (F)



PEAK VOLTS
0
20
40
60
80
100
120
140
160
180
METER READING 100V RANGE
1000
2000
5000
10000
50000
10^6
PULSE LENGTH IN µS x REPETITION FREQ. IN C/S

FIG. 4

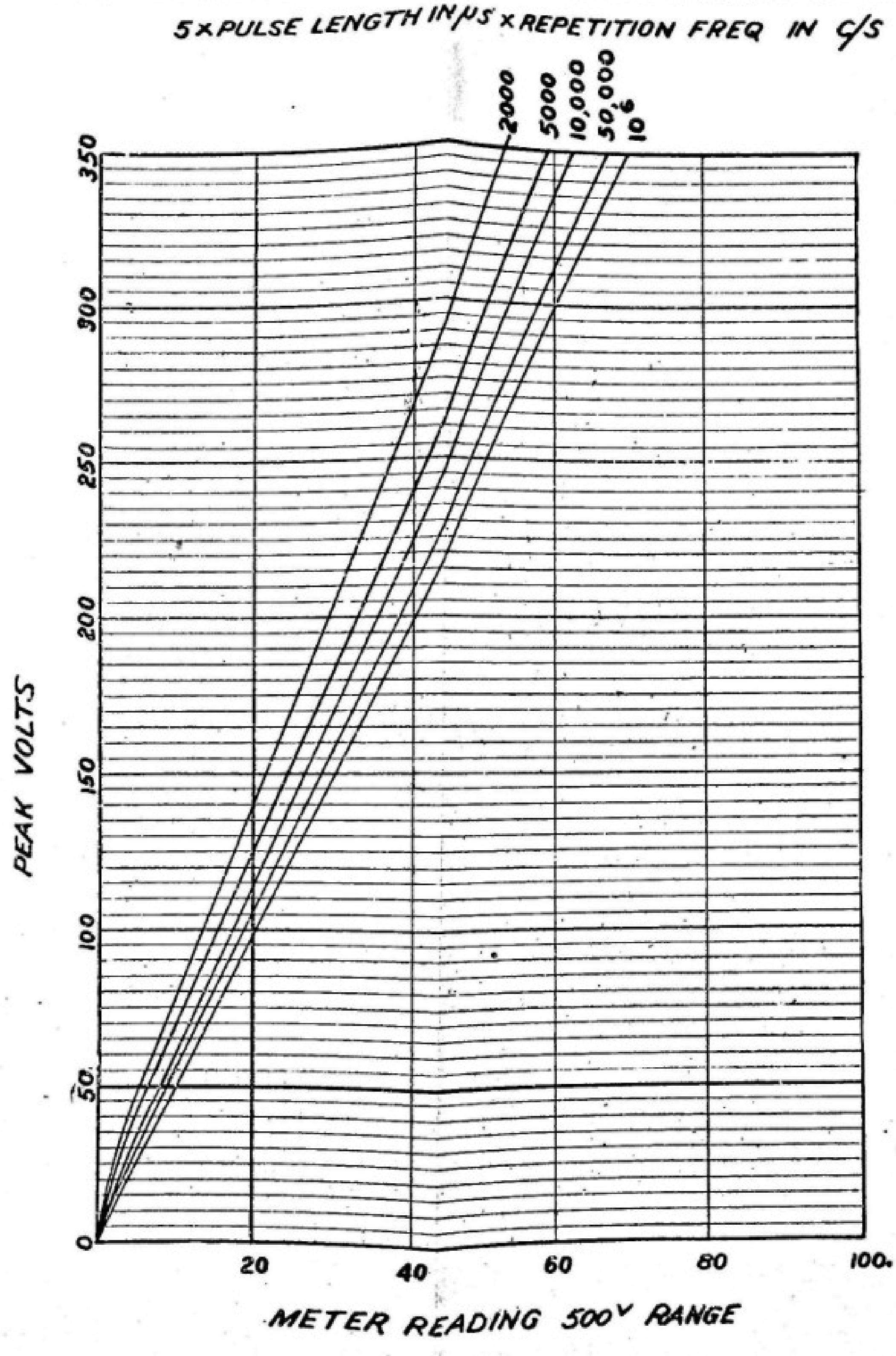

5 x PULSE LENGTH IN µS x REPETITION FREQ IN C/S
2000
5000
10,000
50,000
10^6
PEAK VOLTS
0
50
100
150
200
250
300
350
20
40
60
80
100.
METER READING 500V RANGE

FIG. 5

R.D.F. TESTING EQUIPMENT.

DESCRIPTION OF BATTERY TEST OSCILLATOR.

(RD 11/42).

R.D.F. TESTING EQUIPMENT.

DESCRIPTION OF BATTERY TEST OSCILLATOR.

CONTENTS

BATTERY TEST OSCILLATOR.

SERVICE DESIGNATION

P.M.G.Unit T1 Oscillator, test, battery-type MA (Aust).

R.A.N. - Patt. No. (Aust) 202
A.M.F. - ZCA 4400
R.A.A.F. - Test Set type A12 Y10S/60021
Serial No.

P.M.G. Unit T2 Oscillator test, battery - type P (Aust.)

R.A.N. - Patt.No. (Aust) 201
A.M.F. -
R.A.A.F. - Test Set type A1 Y10S/60001
Serial No.

SPECIFICATION

1. Frequency range - Unit T1 - 180-220 Mcs.continuously variable

Unit T2 - 160-190 Mcs. continuously variable.

2. Frequency Indication (Both types) - On straight line calibrated scale marked every 2 megacycles.

3. Frequency Variation - Unit T1 - by knob on front panel. Plate calibrated in degrees to 360 attached to knob.

Unit T2 - by screwdriver adjustment from front panel.

4. Power Supply (Both types) - Self-contained dry batteries.

(a) Anode supply - 60 volt 12½ mA (Eveready type WP-60 or Diamond type WD-21)

(b) Heater Supply - 1½ volt 0.2 amp. Four Army type "X" cells connected in parallel

5. Electron tubes (both types) - Two type 958.

REFERENCES

P.M.G's Department Drawing No. CX-61 :-

(A) Sheet 1 - Assembly and Circuit.

(B) Sheet 2 - Details.

(C) Sheet 3 - Details.

(RD11/42.)

INTRODUCTION.

The main uses of these instruments are for obtaining directional diagrams of aerial arrays, and as a convenient source of power for the Impedance Measuring Set. In the former case the power is led out via a concentric connector on the front panel. In the latter case the Impedance Measuring Set plugs into a hole on the left hand side of the box.

DESCRIPTION.

A portable, low power, self-contained test oscillator operating from dry batteries. It has a push-pull plate tuned circuit and covers the frequency range 180-220 mC/s (Unit T1) and 160-190 mC/s (Unit T2). The frequency is indicated by a travelling indicator traversing a straight line scale, which is graduated every 2 megacycles per second. Tuning is accomplished by rotating a threaded spindle, which engages a threaded hole in a brass shorting bar and slides the bar along the plate tuning lechers, thereby altering their resonant frequency.

Figure 1 is a circuit diagram.

OPERATION

(1) The frequency calibration of each oscillator is initially checked against a heterodyne frequency meter. If, however, any adjustments are made in service, such as tube replacement the desired operating frequency of the oscillator should be checked with a signal generator or wavemeter or any other available means.

(2) Anode batteries - Positive is connected to red lead and negative to black.

(3) Heater batteries - Shielded lead is connected to positive and orange to negative.

(4) The 958 tubes can be inserted in two ways. The correct way is to have the domes of the tubes on the sides of the sockets remote from the 60-volt battery as shown in Figure 2. If inserted the reverse way, the tube may be damaged.

(5) Three metering jacks are provided on the front panel for measuring -

(a) Anode volts	- 60 volts
(b) Heater volts	- $1\frac{1}{2}$ volts
(c) Anode current	- .. milliamps

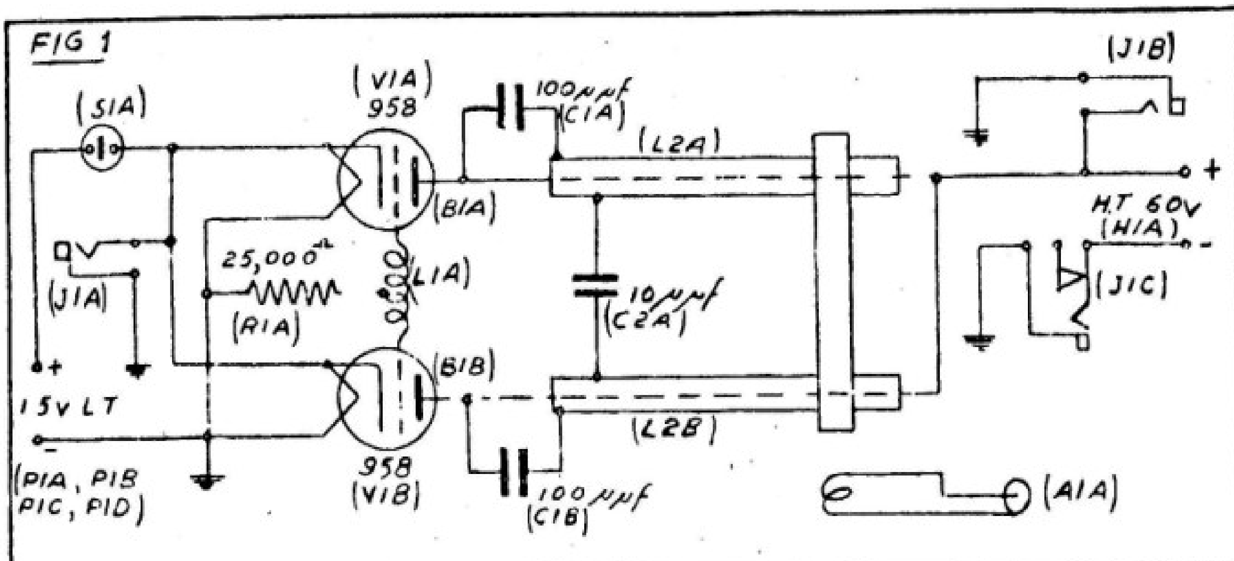
Note that in cases (a) and (b) the tip of the plug is connected to positive on the testing meter, but in case (c) the leads to the meter should be reversed so that the tip now connects to negative.

(6) Care should be taken to switch off when not in use, even if only for a few minutes, to preserve the batteries.

(7) Service notes - When operating normally the anode current should be within the approximate range 10-15 milliamps. When oscillation is prevented by touching the finger on to the centre tap of the coil, anode current should rise from 10-15 milliamps to 15-19 milliamps respectively. If the current does not change, it of course indicates that the tubes are not oscillating. The most obvious causes of failure of the equipment may be -

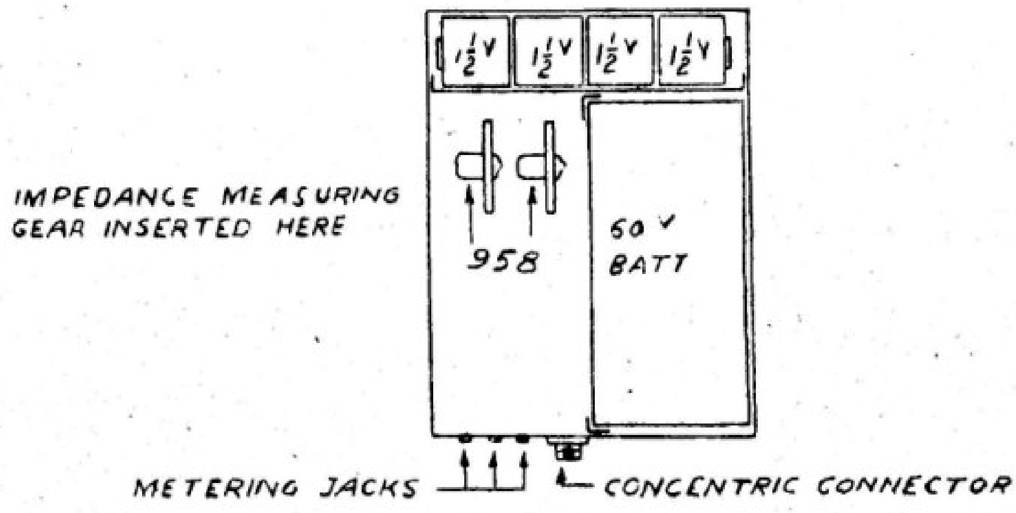
(a) Low anode or heater battery volts;
(b) Poor contacts in tube sockets.

FIG 1



ITEM NO.	ITEM & RATING	MANUFACTURERS' TYPE NO.
C1A, C1B	CONDENSER 100 mmf TEMP. COMPENSATED	BRITISH CERAMIC "CUP" TYPE
C2A	" 10 " "	" " "DISC" "
R1A	RESISTOR, 25,000 OHM 1/3 W.	"DUCON" OR "IRC" METALLIZED
V1A, V1B	TUBE 958	R.C.A.
J1A, J1B, J1C	JACK	P.M.G's DEPT. SERIAL 24, ITEM 10A
B1A, B1B	SOCKET - 'ACORN' TYPE	AWA MOULDED TUBE SOCKET (PMG 54/13)
S1A	SWITCH	H & H SINGLE POLE TOGGLE SWITCH
A1A	COAXIAL CABLE CONNECTOR (FEMALE)	AMPHENOL No. 93C
P1A, P1B, P1C, P1D	BATTERY 1-1/2 VOLT DRY	ARMY TYPE "X"
H1A	" 60 " "	EVEREADY WP60 OR DIAMOND WD21

FIG 2



CX5-47

R.D.F. TESTING EQUIPMENT.

DESCRIPTION OF FIELD INTENSITY RECEIVER.

(RD12/42)

R.D.F.TESTING EQUIPMENT.

DESCRIPTION OF FIELD INTENSITY RECEIVER.

C O N T E N T S.

SERVICE DESIGNATION.

P.M.G. Unit Type T4 Receiver field strength - type MA (Aust).
R.A.N. - Patt.No.(Aust) 206
A.M.F. - ZCA 4401
R.A.A.F. - Test set type A13
Y10S/60022.
Serial No.-

P.M.G.Unit Type T5 Receiver field strength - type P (Aust)
R.A.N. - Patt. No. (Aust). 207
A.M.F. -
R.A.A.F. - Test set A2 Y10S/60002
Serial No.

P.M.G.Unit Type T5A Receiver field strength - Mains unit type M/D32 - (Aust).
R.A .N. - Patt. No.(Aust.) 208
A.M.F. - ZCA 4418
R.A.A.F. - Mains unit type A2A
Y10S/60020

SPECIFICATION.

1. Frequency range -

Unit T.4.180-220 mC/s
Unit T.5.160-190 mC/s
Unit T.6. 65- 84 mC/s

2. Sensitivity (all types)

7 microvolts for signal equal to noise.

3. Bandwidth (all types)

± 0.30 Mc/s for 3 db off resonance.

4. Range of inputs (all types)

100 millivolts to 7 microvolts

5. Signal metering (all types)

(a) Contracted decibel scale - 0 db (100 millivolts) to 80 db (10 microvolts
(b) Extended decibel scale - 0 to 10 decibels

6. Input impedance (unbalanced input)

Unit T4	-	$67\frac{1}{2}$ ohms
Unit T5	-	80 ohms
Unit T6	-	88 ohms

7. Power supply - One of the following may be used:

(a) Separate A.C.power supply unit, with built in voltage regulator.

(b) 240 volt "B" batteries and 6 volt accumulator

(c) 240 volt vibrator supply and 6 volt accumulator

(RD.12/42)

8. Power consumption (all types).

(A) A.C.mains - Approximately 50 watts.

(B) Batteries - 240 volts 60 mA & 6.3. volts 2.7 amps.

(C) Vibrator - 240 volts 60 mA & 6.3. volts 2.7 amps.

9. Controls -

(A) "Manual" to "automatic" gain control switch
In "manual" position, read the extended decibel scale on the meter.
In "A.G.C." (A.V.C.) position read contracted decibel scale on the meter.

(B) Manual gain control with graduated scale.

(C) Preset gain controls (two).
These are screwdriver adjustments, used to adjust the contracted decibel scale when using automatic gain control.

(D) Main tuning control.
Variable condenser varying the oscillator frequency only.
A scale with graduations at 1 megacycle intervals rotates through nearly 360 degrees.

(E) Input tuning control.
A midget variable condenser tuning the mixer grid circuit to the signal frequency
A pointer indicates on a graduated scale, with graduations at 5 mC/s intervals.

(F) Metering switch - 9 active positions for the following purposes:-

(A) Six positions for measuring the plate currents of the six main valves.

(B) One position for measuring the oscillator grid current.

(C) One position for measuring the B - voltage.

(D) The normal position for signal metering, for which the output diode current is measured. i.e. the switch is turned to "Det" position when setting up for operation.

(E) Switch is turned to off position when it is necessary to reset needle to zero.

Each position of the switch is suitably marked on a plate.
The one meter is used for all functions.

10. Meter. -

One milliamp full scale. Resistance 100 ohms. Pelec type K475 (panel mounting).

There are three graduated scales on the meter:-

(A) The 1 milliamp scale is subdivided into 50 equal parts. Each increment represents 20 microamps on a 1 milliamp scale. In addition, there are marks at 55% and 85% of full scale. The marks are tolerance limits for the six anode current and the B + voltage readings. Initially the shunts are adjusted so that these readings are 75% of full scale.

(B) Contracted db scale 0 - 80 db.

(C) Extended db scale 0 - 10 db.

11. Valves -

955	-	2 off (Units T4 and T5) only
1852	-	4 off
6H6	-	1 off
5V4G	-	1 off

On Unit T6 the 955's are replaced by 1852's.

12. Circuit -

(A) Superheterodyne with 955 mixer, 955 separate oscillator.

(B) 30 Mc/s intermediate frequency channel, comprising four 1852 I.F. amplifiers with single variable condenser tuned circuits.

(C) Diode detection (6H6) with milliameter in plate circuit.

(D) 5V4G full wave rectifier for power supply when operating from A.C. mains.

INTRODUCTION

This field intensity receiver was designed primarily for two purposes:

1. As a sensitive voltage comparator calibrated in decibels for use in conjunction with the impedance measuring set. For further details refer to Impedance Measuring Set.

2. As a voltage comparator for plotting the directional diagram of aerial arrays. Refer later to OPERATION.

If used to determine the absolute field strength of a continuous wave field, it should be used in conjunction with a Signal Generator. The Signal Generator should be either at the place where the field strength measurement is desired, or the absolute calibration of the receiver should be checked with the power supply with which it is to be used immediately before taking the measurement. For reliable accuracy, of course, the signal generator should be present where the field strength measurement is being made.

DESCRIPTION.

Fig. 2A and 2B are the circuit and code respectively. The receiver can be described under the following sectional headings:-

1. Aerial pad and input tuned circuit (Fig. 1). The pad serves two useful purposes.

   (A) Variations of R3, the resonant input impedance of the tuned circuit, have only a small effect on the input impedance at A, which can thereby be held to reasonable limits of accuracy. If R3 alone were the input impedance of the receiver it would be a difficult matter (sliding the tap on the coil) to get an accurate input impedance.

   (B) If it is desired to alter the input impedance due to a change external to the receiver, it is a very simple matter to change R1 and R2.

The pad usually causes a loss of about 6 decibels which in the present receiver is unimportant. The input impedance at A is adjusted to the correct value by means of the impedance measuring set, for which measurement only the 955 mixer should be hot and in working condition.

The coil L is of silver plated copper construction and tuned to signal frequency resonance by means of the variable condenser C, which must tune the range 180 - 220 Mc/s (Unit T4) and 160 - 190 mc/s (Unit T5). For the adjustments necessary to cover the range, see under OPERATION.

2. Local Oscillator - type 955 (Units T4 and T5) Type 1852 (Unit T6).

This is a modified Colpitts oscillator using a split stator condenser, the rotor of which can be earthed or not earthed with little change of performance. It is resistance stabilized through the anode supply resistor, which is connected to the centre tap of the coil so that it will have negligible damping effect on the tank circuit. This connection also means that less filtering is required to prevent the oscillator leaking out of its shielded compartment. The oscillator frequency is always 30 megacycles <u>lower</u> than the corresponding signal frequency. The adjustment of the oscillator frequency range is described under OPERATION.

The coupling of the oscillator to the mixer is through an 80 ohm line terminated with a resistor at the mixer end and terminated at the oscillator end with a one turn loop, which is inductively coupled to the oscillator tank circuit. The final adjustment of this coupling should be made before the final adjustment of the oscillator frequency spectrum, to avoid detuning effects of the coupling. For adjustment of the coupling see the following remarks on "mixer".

3. Mixer - 955 (Units T4 and T5) and 1852 (Unit T6).

Cathode injection of the oscillator is used. As the driving impedance into an unbypassed cathode resistor is lower than the value of the cathode resistor, this cathode resistor will have to be greater than the usual 80 ohm for the line to be correctly terminated. The criterion for correct injection is that the mixer plate current is approximately 30% greater when the oscillator is oscillating than when not oscillating. Oscillation can be stopped by touching the finger to the grid of the oscillator. The coupling of the one turn loop to the tank circuit is altered until this criterion is reached. This should hold over the full tuning range of the receiver.

4. Four stage I.F. amplifier.

The load in the plate circuit is a single parallel resonant circuit, the inductance of which is composed of two inductances effectively in parallel, one of the inductances carrying the plate current and the other serving as the grid return for the following tube. The condenser is variable for I.F. alignment purposes. Unbypassed 80 ohm resistors are used in the cathode circuits to limit the change of "effective input capacity" of the valve with change of gain. This limits the detuning of the I.F.amplifier with change of gain. To prevent overload of the last I.F. stage, its plate circuit inductance is mid-tapped for connection to the low impedance diode circuit, which is then nearly matched to the tuned circuit, and so the maximum gain is being obtained from this last stage and the tendency to overload is at a minimum. An extra decoupling section is needed in the plate circuit of the last I.F. valve, as the signal level is highest here and consequently the tendency to I.F. feed-back is greatest at this point. Chokes are inserted in the "hot" heater lead of all valves to prevent leakages (in or out) of the various frequencies.

The manual control of gain is a 400 ohm potentiometer common to the cathodes of the first three I.F.valves and with a few milliamps bleeder current from the B + supply. Its range is such that 100 millivolts input can be reduced to zero on the meter. With this control in operation, the grids of the controlled valves are at earth potential. When the switch is thrown to automatic gain control the 400 ohm potentiometer is thrown out of circuit and replaced by a 250 ohm preset potentiometer, and at the same time the grids of the 3 controlled valves are taken to the A.G.C.line(a line of negative D.C. potential, which is merely rectified signal voltage from the output diode). The proportion of negative bias applied to these three grids in the form of A.G.C. volts can be controlled by a 25,000 ohm variable resistor from the A.G.C.line to earth. This latter control is predominantly effective in altering the gain of the receiver at high levels of input, whereas the 250 ohm potentiometer is predominantly effective at low levels of input, with the result that for fixed low level and high level inputs from a signal generator the readings on the contracted decibel scale can always be adjusted to the correct absolute values, and it should invariably be found that when these two limiting values are adjusted, the intermediate values will be right. In adjusting this calibration, a little "hunting" may occur due to the 250 ohm potentiometer adjustment slightly altering the high level reading and vice-versa, but it will come right after a few adjustments at either end.

5. Diode output stage with headphones.

This has a low value load resistor in order to give a suitable deflection on an 0 - 1 mA meter connected in its anode circuit. A jack is provided across the diode load to which a pair of headphones may be connected if desired. The diode anode circuit is suitably filtered to prevent leakage and possible feedback of the 30 mC/s. signal. A potential divider connected across the diode load provides a source of negative A.G.C. voltage.

6. Metering Unit.

This is a multi-section switch and moving coil meter as described under Specification. A tabulation of readings are given in Table 1. The metering shunts have been so adjusted that for the six anode currents and the B + voltage, normal readings fall at 75% of full scale in each case. This is for maximum gain on manual operation. As tolerances on these readings two marks are placed at 55% and 85% of full scale reading. If and when one of the readings falls outside these tolerances, the valve concerned should be regarded with suspicion.

7. Power Pack (Separate Unit).

This comprises a voltage regulator, followed by a conventional transformer, rectifier and filter. It is connected to the receiver by means of a 3 core cable, which plugs into an 8 pin male A.W.A.socket.

OPERATION

Initial Adjustments - These will normally have been done by the manufacturer.

1. Voltage and current checks. (See Tables I and II) See also DESCRIPTION - Section (6).

Most of the important measurements such as anode currents and oscillator grid current are measured as described by means of the metering switch. In other cases such as cathode and screen voltage measurement, an external universal meter is required with D.C. voltage ranges of at least 1000 ohms per volt.

2. I.F.alignment.

The metering switch is set to "detector output" and the other switch to "manual" and a signal generator set to 30 Mc/s is connected via the coaxial aerial input connector. The manual gain control and the attenuator of the generator are set to give a suitable reading on the meter. The five I.F. variable condensers are then adjusted in turn for maximum output on the meter, at the same time reducing the output from the gnerator if necessary. Lock the condensers.

3. Bandwidth.

Without altering the set-up, tune carefully to resonance with the tuning control of the signal generator, and note the reading "I" on the scale of the receiver. Turn up the attenuator on the signal generator by 3 db, and the reading on the receiver meter will rise. Re-tune the signal generator to either side of 30 Mc/s in each case until the reading on the receiver meter falls back to "I" and in each case read the frequency of the signal generator. If the two readings were 29.85 and 30.15 then the bandwidth of the receiver is $\pm \frac{30.15 - 29.85}{2} = \pm$ 15 Mc/s.? (1.5 mc/s) In tuning through the two frequencies 29.85 and 30.15 tune in the same direction and so avoid errors due to back lash of the signal generator. This bandwidth measurement can be done at signal frequency as well but it is much more difficult to get an accurate result.

4. R.F.alignment (initially done by the manufacturer).

A. Oscillator frequency adjustment.(For Unit T6 see p.13) The oscillator is always at a frequendy 30 mc/s lower than the signal, and hence varies from 150-190 mc/s (Unit T4) and from 130 - 160 mc/s (Unit T5). Adjustments are as follows:-

(1) Set the stops on the dial mechanism until the range of movement is limited to the graduations on the rotating dial (main tuning dial).

(2) Alter the mesh of the condenser plates relative to the movement of the rotating dial until the oscillator frequency ratio between the dial indications 220 and 180 mc/s is $\frac{190}{150} = 1.273$ to 1. This oscillator frequency ratio is measured

by noting the signal generator readings f1 and f2 for maximum receiver output at these two points on the dial and dividing (f1-30) by (f2-30). This is for Unit T4, for Unit T5 the desired oscillator frequency ratio is $\frac{160}{130}$ to 1.

(3) Having adjusted for the correct oscillator frequency ratio, adjust the oscillator tank circuit inductance until these oscillator frequencies are 190 Mc/s and 150 Mc/s (Unit T4) as well as their ratio being $\frac{190}{150}$ to 1.
This of course, will be indicated when the signal generator readings f1 and f2 are 220 and 180 Mc/s respectively. Readings on the dial intermediate between 180 and 220 Mc/s should now be the same as the corresponding signal generator readings when maximum output is indicated on the receiver.

B. Signal frequency adjustment.

(1) A signal from the signal generator such as 220 Mc/s (Unit T4) is tuned on the receiver for maximum output by using the main tuning control (oscillator). Then the signal tuning control is adjusted for maximum output and if the indicating mark on the knob does not indicate 220 Mc/s on the scale, the knob can be adjusted (by means of a grub screw) until it does indicate 220 Mc/s.

(2) This tuning process is now repeated but with the signal generator set to 180 Mc/s. If the mark on the pointer now indicates a frequency on the scale greater than 180 Mc/s, the signal tuning inductance should be decreased, or if an indication less than 180 Mc/s. is obtained, the inductance should be increased. The inductance can be increased by pushing the turns closer together, and decreased by pushing them apart.

(3) Then operations (1) and (2) are repeated. If the scale still does not indicate correctly at the two points, the inductance is altered again, and so on.

C. Signal to Noise ratio measurement.

When the receiver has been correctly adjusted, tune in a 200 kc/s signal (Unit T4) from the signal generator and adjust the signal frequency tuning control for maximum output on the receiver output meter. Note the reading on the output meter and then switch off the signal at the signal generator by means of the carrier switch. If the reading on the output meter does not fall to half, the signal generator attenuator setting is altered and the process repeated until the output reading is just half (with carrier off) its value with carrier on. The reading of the signal generator attenuator is then the signal input at the receiver terminals for which the signal is equal to the noise in the receiver output. It should be not more than 10 microvolts. The measurement should be made with the switch set for "manual" operation.

5. Check of extended decibel scale.

With settings as for R.F. alignment, tune in a signal from the signal generator, and turn the manual gain control until the receiver meter reads 0 db. Reduce the generator output by 3 db and meter reading should decrease by 3 db and so on until the input has been reduced by 10 db when the meter should read 10 db.

6. Adjustment of contracted decibel scale.

Change by means of the switch to automatic gain control position, and set the signal generator attenuator to 80 decibels. After tuning both frequency controls of the receiver, the receiver output meter should read 80 decibels on the contracted scale. If it does not, remove the instrument from its case and adjust the preset potentiometer with a screw driver. The present adjustments will be found on the left hand side of the receiver; adjust the one nearest to the back of the receiver. Then reset the generator attenuator to 0 db, and the receiver should read 0 db on the same scale. If it does not, adjust the preset potentiometer nearest to the front of the receiver. Repeat these 0 - 80 db adjustments until both are registering correctly on the meter. Then it should be found that intermediate readings are correct also. When changing the input to the receiver from 80 to 0 db and vice versa, it is a wise precaution to re-check the tuning controls of the receiver for maximum peak.

Some of the uses of the Field Intensity Receiver are as follows:

1. As a sensitive voltmeter in connection with the impedance measuring set. See "Impedance Measuring Set".

2. For plotting the directional diagrams of aerial arrays.

Set up the receiver near the aerial array and run a feeder from the aerial to the receiver. Place a portable dipole at a distance of about 150 yards from the array and at a convenient elevation and orientated so that its maximum radiation is toward the array. Connect a battery test oscillator to the dipole and switch on. Switch the receiver to the automatic gain control position and tune in the signal from the portable dipole. Turn the array through 360 degrees and note the variation in decibels as indicated on that contracted decibel scale. If the minimum reads less than 80 db on the receiver dial, the dipole should be brought closer to the array.

Then plot decibel readings as against angular position of the array for a complete revolution of the array. Or alternatively, convert from decibels to voltage ratios by means of the attached conversion - chart before plotting.

3. Field strength measurement.

A. An approximate value for the strength of a field can be obtained by connecting a portable dipole to the receiver through an 80 ohm feeder. The receiver is switched to "automatic" and the dipole is orientated for maximum output on the receiver output meter, and the receiver tuning controls are peaked for maximum output The decibel reading of the receiver is then taken and a correction made for the loss in the feeder (approximately 3 db per 100 feet). The decibel reading is then converted to microvolts, "E", and the field strength can be calculated from -

$$F = E \frac{2\lambda}{\lambda}$$

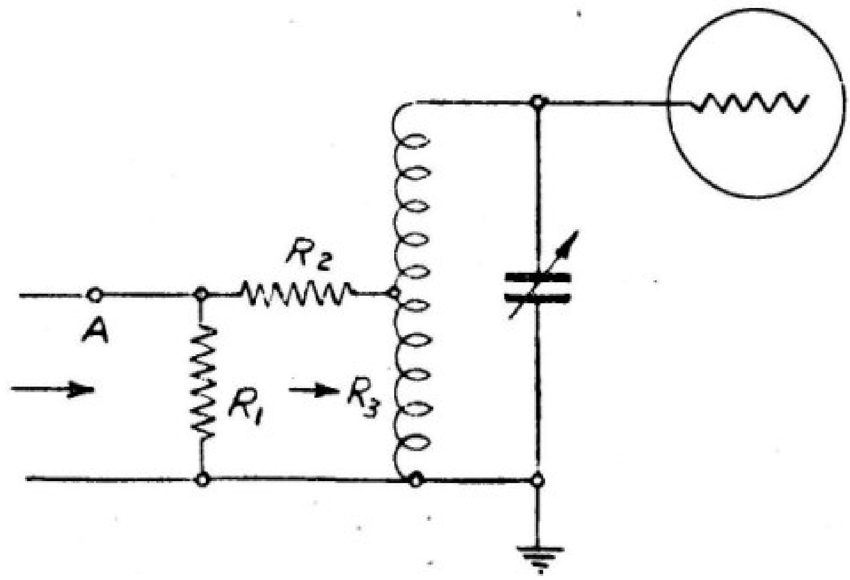
where F = field strength in microvolts per metre.
"E" = receiver reading in microvolts.
λ = wavelength in metres

B. Where the field strength is required more accurately, a signal generator should be used in conjunction with the receiver. Proceed as in Section A and note the reading "V" on the receiver output meter. Then disconnect the feeder from the dipole and attach to the signal generator, the attenuator of which is adjusted until the same reading "V" is obtained on the output meter. "E" is then obtained from the attenuator reading of the generator and the field strength is calculated from the formula in Section A.

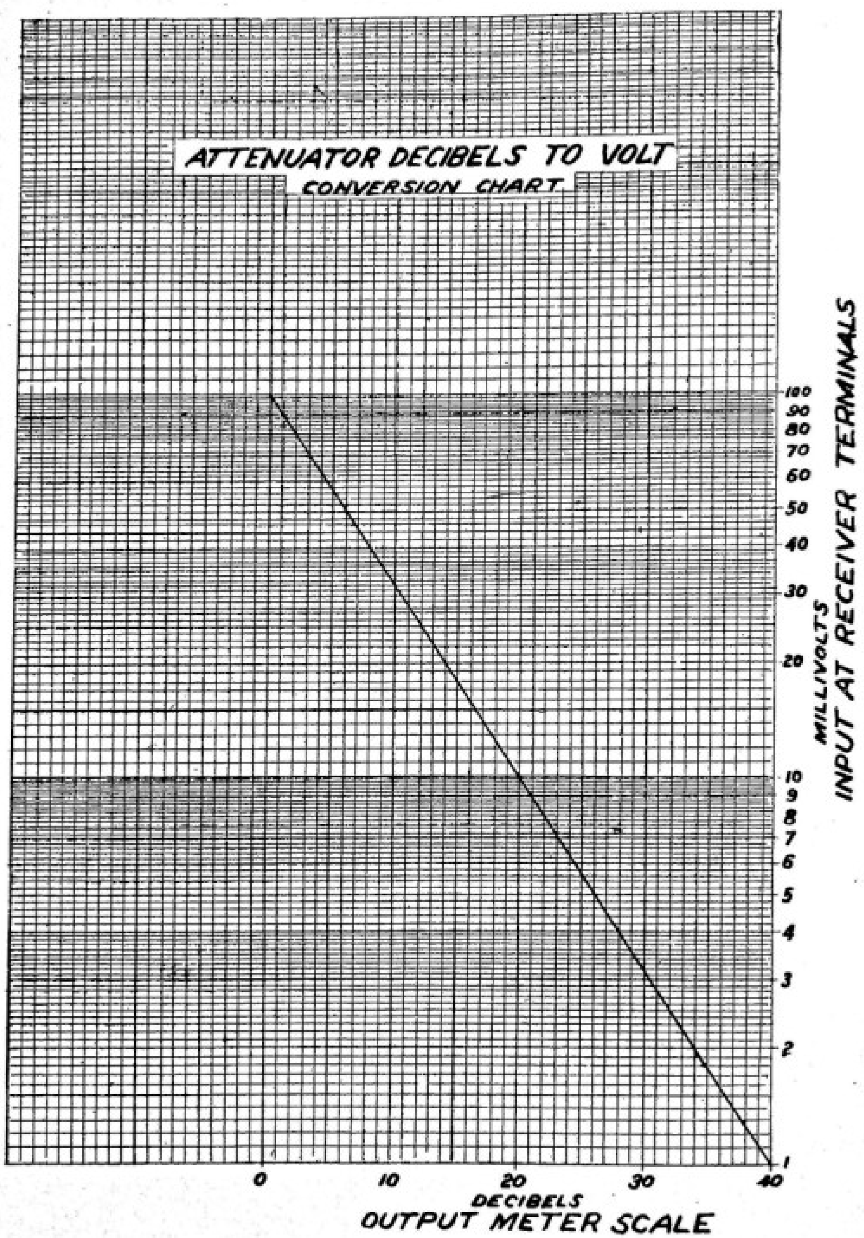
Oscillator Frequency of Unit T6.

The Oscillator frequency of Unit T6 is higher than the signal frequency and it varies from 95 Mc/s to 114 Mc/s. Otherwise the description on page 7 for Units T4 and T5 applies also to Unit T6.

FIG I



CXS-77


ATTENUATOR DECIBELS TO VOLT
CONVERSION CHART
MILLIVOLTS
INPUT AT RECEIVER TERMINALS
100 90 80 70 60 50 40 30 20 10 9 8 7 6 5 4 3 2 1
0 10 20 30 40
DECIBELS
OUTPUT METER SCALE

CXS-71

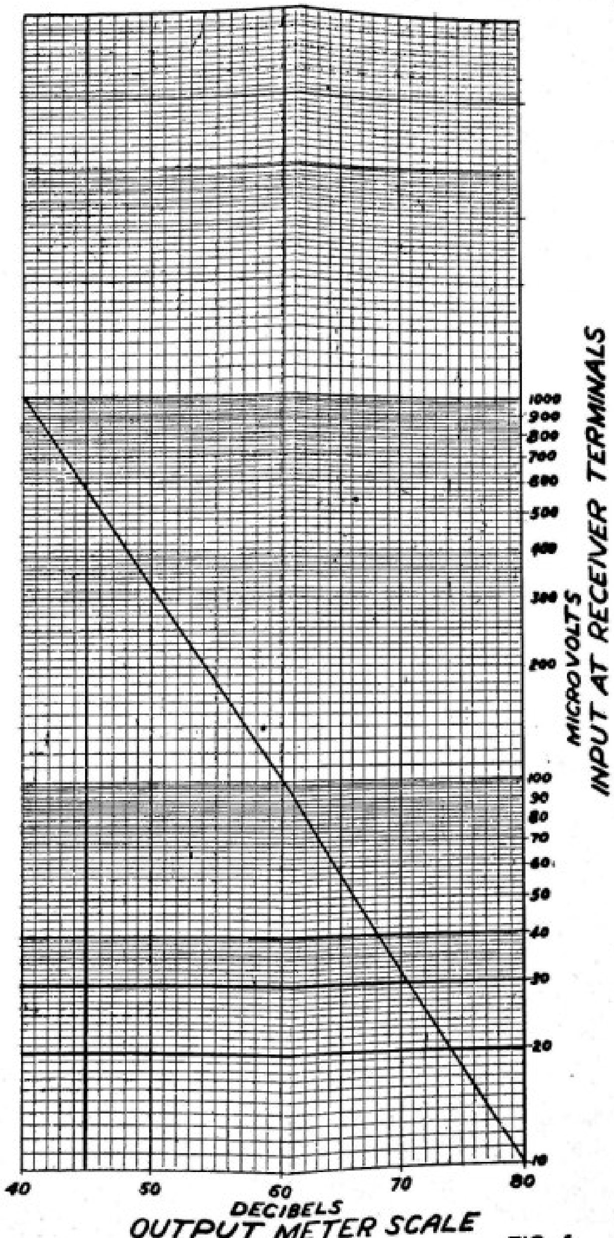

MICROVOLTS
INPUT AT RECEIVER TERMINALS
1000 900 800 700 600 500 400 300 200 100 90 80 70 60 50 40 30 20 10
40 50 60 70 80
DECIBELS
OUTPUT METER SCALE

FIG. 4

ISSUE	APPROVED
1.	N.S.S.
2.	W.R.R.

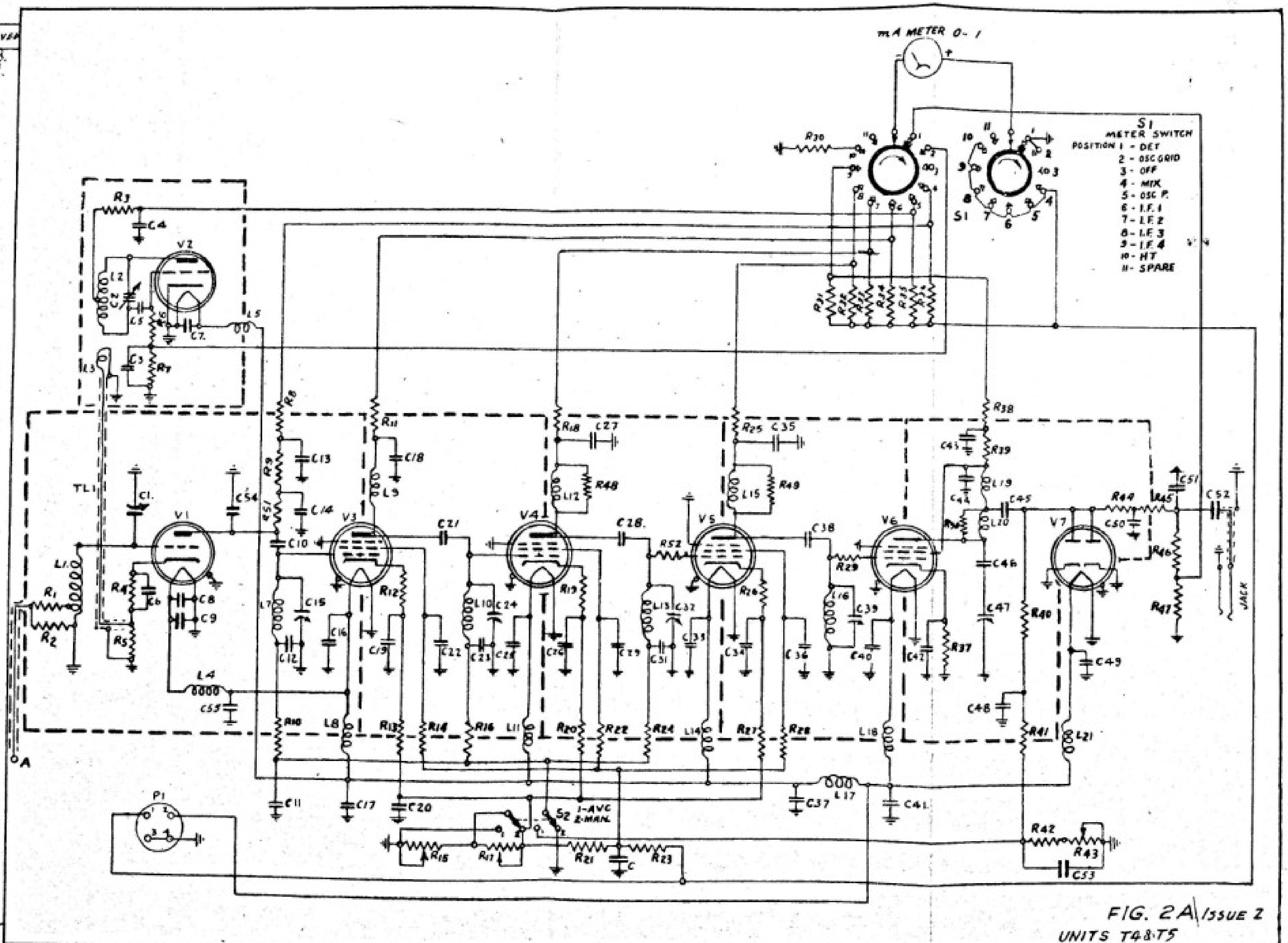


FIG. 2A | ISSUE 2

UNITS T48 & T5

CXS-49