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Obsolete ?

B.R. 1771(5)

COMMON NAVAL RADIO TEST EQUIPMENT

Handbook for

A.P. 67921

VOLTMETER, VALVE, CT.54

(JOINT - SERVICES DESIGNATION:
'BALANCED VALVE VOLTMETER, PORTABLE, CT.54')

1952

PART 1

CHAPTER 1

★

TECHNICAL DESCRIPTION

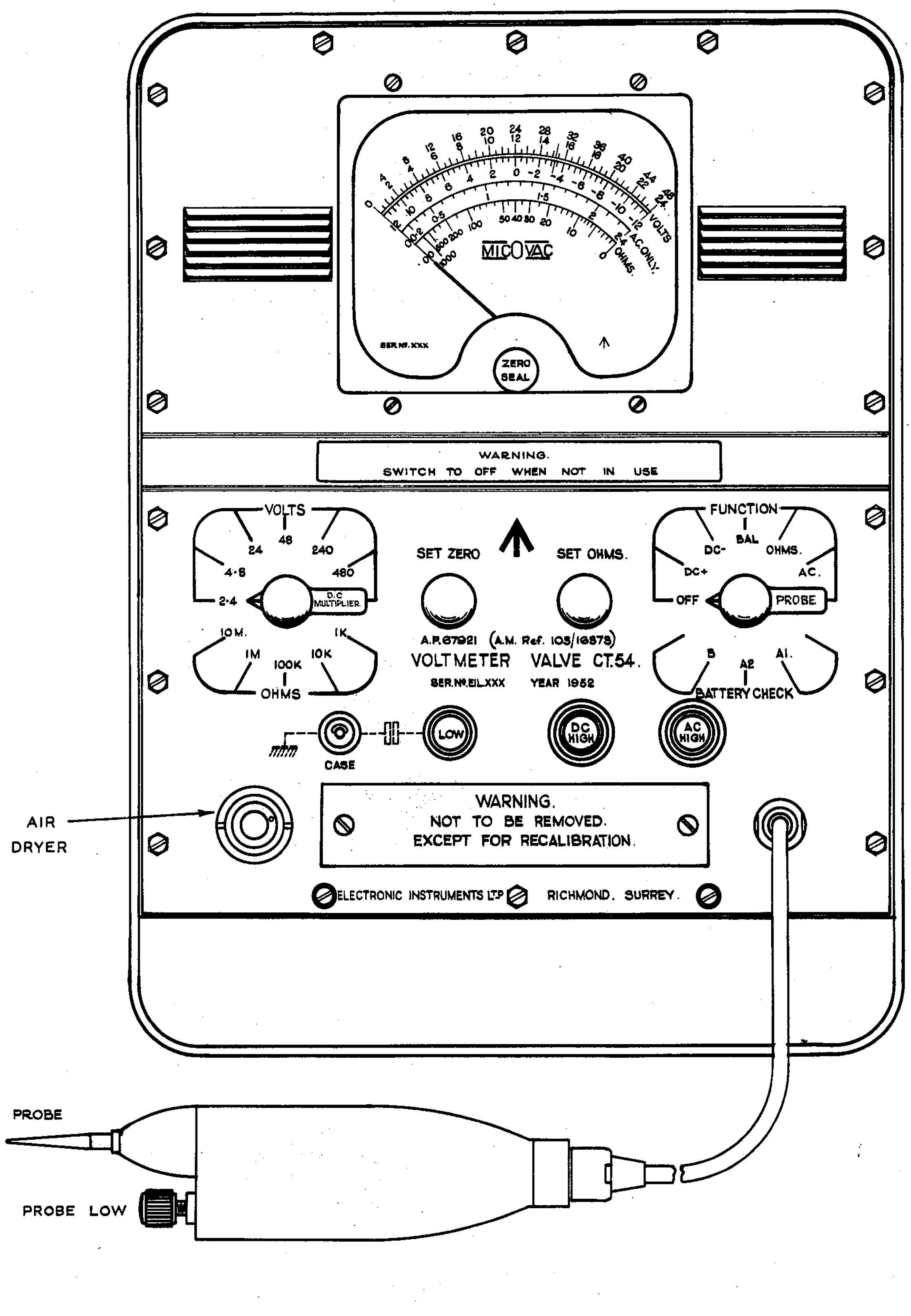

DIAGRAM 1.1
VIEW OF PANEL

B.R. 1771(5)

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ANY SUGGESTIONS FOR AMENDMENTS OR ADDITIONS TO THIS BOOK SHOULD BE SUBMITTED THROUGH THE USUAL CHANNELS.

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RADIO EQUIPMENT DEPARTMENT . ADMIRALTY
DECEMBER 1952 . (R.E. 1335/52

CHANGE RECORD SHEET

★ AMENDMENTS ★

When an amendment to this handbook is promulgated the brief details required below are to be filled in.

AMENDMENT Nº	AUTHORITY (A.F.O. Nº ETC.)	DATE OF INSERTION	INITIALS
2.	A.F.O. P402/55.	22/7/57.	R. R.
3	AFO P.214/56.	22/7/57.	D. R.
5	AFO P202/60	13/10/60	B May. REM.
CHANGE No			
No 1	P211/62	25/7/62	[illegible]

ADMIRALTY, S.W.1.

DECEMBER, 1952

R.E.1335/52

B.R.1771(5) "Handbook for A.P.67921 Voltmeter, Valve, CT54 - 1952" having been approved by My Lords Commissioners of the Admiralty, is hereby promulgated for information and guidance.

By Command of Their Lordships

J G Lang

To:-
Flag Officers and
Commanding Officers
of H.M. Ships and
Vessels concerned

HANDBOOK

FOR

A.P. 67921 VOLTMETER, VALVE, CT54

(Joint-Services Designation; Balanced Valve Voltmeter, Portable CT54)

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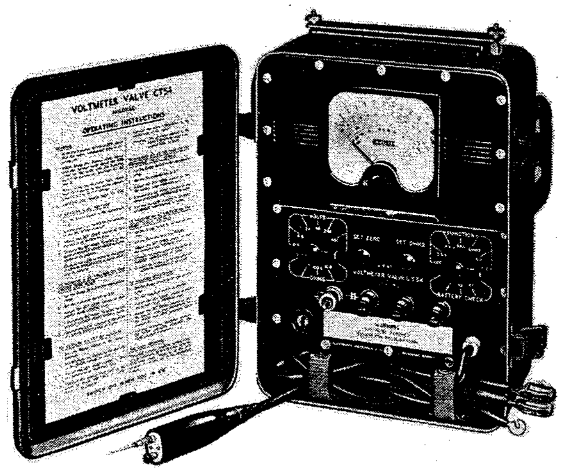
A.P.67921 VOLTMETER, VALVE, CT.54

(Joint-Services Designation; Balanced Valve Voltmeter, Portable, CT.54)

SUMMARY OF DATA

PURPOSE

Used for measuring D.C. voltages 0 to 2,400V and A.C. voltages 0 to 480V R.M.S. (over frequency-range 20 c/s to 200 Mc/s) and resistance 0 to 10 megohms. The voltmeter imposes a negligible load on the voltage source to which it is connected; this source may therefore possess high resistance or high impedance. Provision is made for the instrument to function as a centre-zero meter on the D.C. voltage range.



A.P.67921 VOLTMETER, VALVE

DESCRIPTION

The instrument consists essentially of a meter in a bridge circuit containing a valve operating as a triode. When measuring D.C. voltages, the input voltage is applied to a resistor chain from which a tapping is taken to the grid of the triode; a special high-voltage range (0 to 2,400V) is obtained with the aid of an external Multiplier consisting of a resistor-chain which reduces the input voltage to one-thousandth of its value. For A.C. measurements, the A.C. is first rectified by a diode valve; for R.F. voltages measurements, a probe unit is provided, this containing a separate diode valve. For resistance measurements, a 1.5V battery passes a current through the unknown resistance and a selected reference resistor in the instrument; the voltage developed across the reference resistor is then measured as in D.C. voltage measurement.

PERFORMANCE

Measurement	Range	Remarks	Accuracy
DC volts	0-2.4V or 1.2-0-1.2V	Input resistance 20 megohms	
	0-4.8V or 2.4-0-2.4V 0-24V or 12-0-12V 0-48V or 24-0-24V 0-240V or 120-0-120V 0-480V or 240-0-240V	Input resistance 40 megohms	Errors do not exceed ± 3% of full-scale reading on range in use.
	0-2,400V or 1,200-0-1,200V	Input resistance approximately 20 megohms. External multiplier is required for these ranges.	
AC volts	0-2.4V RMS 0-4.8V RMS 0-24V RMS 0-48V RMS 0-240V RMS 0-480V RMS	AC HIGH terminal may be used for frequencies of 20 c/s to 20 Mc/s; PROBE is preferable for RF measurements, and may be used over the frequency range 10 kc/s to 200 Mc/s.	At audio frequencies errors do not exceed ± 3% of full-scale readings on range in use.
Resistance	0-1K 40 ohms mid-scale 0-10K 400 ohms mid-scale 0-100K 4,000 ohms mid-scale 0-1M 40,000 ohms mid-scale 0-10M 400,000 ohms mid-scale	The test voltage for resistance measurements is 1.5V	Accuracy cannot be expressed simply, because of reciprocal scale. Accuracy is better than ± 3% but this depends on accuracy of zero adjustment.

POWER REQUIREMENTS AND CONSUMPTION

When the instrument is battery-operated, a dry battery of 75V (tapped at 15V) is used in conjunction with two dry batteries of 1.5V. The A.C. mains unit (A.P.67922 Rectifier Unit CTA2) is insertable in instrument, if battery block is removed; it operates off the following A.C. mains voltages; ~~115,~~ 180, 200, 210, 220, 230, 240, 250V, a selector being provided. The 180V tapping is intended for 400 - 500 c/s and the others for 50/60 c/s.

Consumption: 15 watts (approx.).

PHYSICAL DATA

Height: 13 in.
Width: 10½ in.
Depth: 5 in.
Weight: 17 lb (approx.)

ACCESSORIES

Probe Unit, Design 3. (Patt. 61418) - permanently attached to instrument.
Three test leads two black, one red with interchangeable prod/crocodile clips.
Rectifier Unit CTA2, in stowage box. (Patt. 67922)
D.C. Multiplier CTA25. (Patt. 61417)
Box, for batteries, dry, CTA24. A.P.61833
Cell, dry, 1.5V. A.P.21060 (two)
Battery, dry, 75V. A.P.14221
TEST PROBES (1 PAIR) AP. 64159.

PROD TEST, red 6625-99-943-9047
" ", black 6625-99-943-9048.

REMARKS

Replaces Valve Voltmeter A.P.54706 and Electrostatic Voltmeter 0 - 3 kV A.P.W5078.

HANDBOOK	B.R.1771(5)
ESTABLISHMENT LIST	E.1015 Testing Outfits TKA/D/E/F/G.
PRODUCTION SPECIFICATION	13684R
OTHER SERVICE AND COMMERCIAL DESIGNATIONS	JOINT-SERVICES: Balanced Valve Voltmeter, portable, CT.54.
	AIR MINISTRY: AM Ref. 10S/16373.
	COMMERCIAL: ELECTRONIC INSTRUMENTS LTD. MICOVAC M22A.

HANDBOOK FOR

A.P. 67921 VOLTMETER, VALVE, CT.54

(Joint-Services Designation: Balanced Valve Voltmeter, Portable, CT.54)

PART 1

CHAPTER 1

TECHNICAL DESCRIPTION

INTRODUCTION

1. This instrument will perform the following functions:-

(a) Measurement of D.C. voltages 0 to 480V and, with the aid of an external Multiplier, 0 to 2,400V.

(b) Measurement of D.C. voltages over half these range values (omitting 0 to 2,400V), the meter pointer reading zero when at its normal mid-scale position; a positive input voltage will cause the pointer to swing to the left and a negative voltage will cause it to swing to the right.

(c) Measurement of A.C. voltages 0 to 480V r.m.s. at frequencies between 20 c/s and 200 Mc/s.

(d) Measurement of resistance 0 to 10 megohms, the test voltage being 1.5V.

(e) Measurement of output power (A.C.) by using the Valve Voltmeter to measure the A.C. voltage developed across a load resistor of known value (say 600 ohms). See Operating Instructions for details.

2. For D.C. voltage measurements, the input voltage is applied across a very high resistance (not less than 20 megohms) from which a tapping is taken to the control-grid of a valve operating as a triode in a bridge circuit; a meter is associated with the bridge circuit. For measuring D.C. voltages between 480V and 2,400V an external Multiplier Unit is used; it is essentially a tapped resistor-chain which reduces the input voltage to one-thousandth of its value.

3. For A.C. voltage measurements, the input is applied to a diode valve rectifier whose D.C. output is then measured as above. For the higher frequencies (up to 200 Mc/s) a probe is used, a separate rectifying diode being housed in the probe unit.

4. When measuring resistance, a 1.5V D.C. source passes a current through the unknown resistance in series with which is a selected reference resistor in the instrument; the voltage developed across this resistor is measured in the usual way and is a measure of the unknown resistance; the meter has a scale calibrated in ohms.

VOLTAGE RANGES AND MISCELLANEOUS DATA

5. See Summary of Data sheet.

VALVES:	V1	(A.C. diode)	CV.753
	V2	(Probe diode)	CV.753
	V3	(Connected as triode)	CV.784
RECT UNIT. V1.	~~V4~~	~~(Neon stabilizer)~~	CV.286
	V5	(Neon indicator)	X961101

PANEL CONTROLS, TERMINALS, ETC. (See Diagram 1.1)

Terminals

6. The use of the various terminals is given in the Operating Instructions.

CASE: This terminal MUST be connected to a good earth.

Note: The LOW terminal is used for both D.C. and A.C. measurements; when the probe is used, the separate LOW terminal on the probe case must be used. It must be emphasised that the terms HIGH and LOW in the case of D.C. refer to the respective resistances to earth of the terminals, and in the case of A.C. to the respective impedances to earth of the terminals. The terms HIGH and LOW in no way refer to potential.

Function Switch (SWA)

7. The Function Switch may be turned to the following positions (in clockwise order):-

OFF
D.C.+
D.C.-
BAL
OHMS
A.C.
PROBE
Battery Check:
A1 (diode battery BY1)
A2 (triode battery BY2)
B (75V H.T. battery BY3)

Polarity is disregarded when connecting the instrument to the voltage source and the Function Switch is turned to D.C.+ or D.C.- (whichever gives a pointer movement to the right). The position BAL (for BALANCE) is used only when measuring D.C. voltages and the pointer is to be normally at the mid-scale position which now represents zero; a positive input voltage on D.C. HIGH will move the pointer to the left whereas a negative input voltage will cause it to move to the right. The position "OHMS" is used when measuring resistance. Position "A.C." is used for lower-frequency A.C. voltages, whereas "PROBE" is used for radio-frequency measurements. Note that the correct terminals must be used in conjunction with the Function Switch when measuring A.C. The Battery Check positions A1, A2, B are for measuring the dry-battery voltages; the pointer reading must not fall below the red line on the scale.

Range Switch (SWB)

8. The engraved marks on this switch correspond to the voltage and resistance ranges given in the Summary of Data.

The first six ranges in clockwise rotation are applicable to D.C. and A.C. (For BAL operation (D.C. only) these voltages must be halved.) When the 2,400V range is used, not only must the range switch be in the correct position D.C. MULTIPLIER but the external MULTIPLIER must be used. The last five positions are concerned with resistance measurement.

Set Zero (RV5)

9. This knob sets the zero of the instrument for voltage measurements.

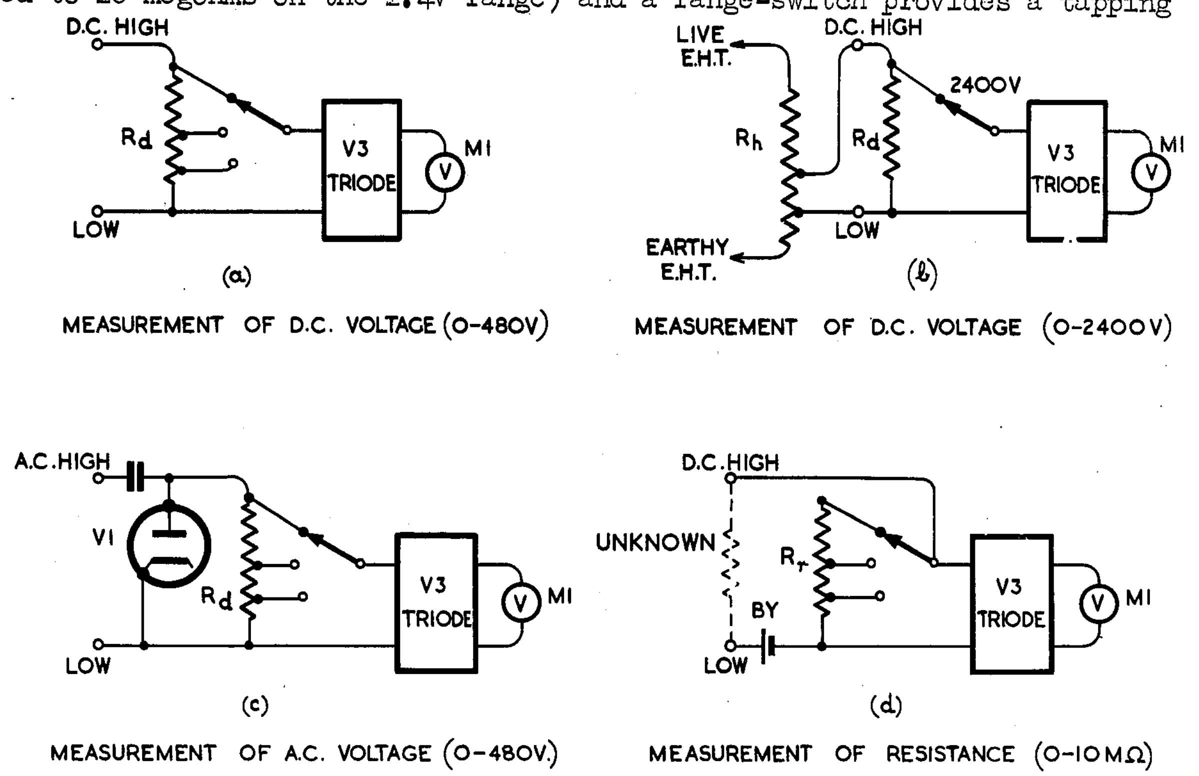
Set OHMS (RV4)

10. This knob sets the OHMS zero of the instrument for resistance measurements, RV5 (SET ZERO) having been previously set.

DETAILED TECHNICAL DESCRIPTION

11. The heart of the instrument is a valve V3 connected as a triode, a 0 - 80 μA ammeter being associated with its cathode circuit. This combination is employed in all applications of the instrument, minor modifications being introduced according to whether D.C. volts, A.C. volts, or OHMS are to be measured. Four applications are illustrated in the much-simplified circuits of Diag. 1.2.

12. Diag. 1.2(a) shows the arrangement for measuring D.C. voltages 0 - 480V. The input voltage is applied across a resistor chain R_d of 40 megohms (reduced to 20 megohms on the 2.4V range) and a range-switch provides a tapping



DIAG. 1.2 SIMPLIFIED FUNCTIONAL DIAGRAMS.

which is connected to the control-grid of the triode V3; the grid circuit throws no extra load on the input, whatever range is used; the change in the grid voltage is very small and produces a change of anode current which operates the meter M1 which has previously been set to zero by adjusting a variable resistor in a bridge circuit.

13. Diag. 1.2(b) shows the arrangement (simplified) for measuring D.C. voltages up to 2,400V. An external D.C. Multiplier Unit R_h greatly attenuates the high voltage (e.g. 2,400V becomes 2.4V) and the reduced voltage (actually one thousandth of the input voltage) is applied across the normal resistor chain R_d.

14. Diag. 1.2(c) shows the arrangement for measuring A.C. voltages 0 - 480V. The input A.C. is now rectified by a diode V1, the D.C. output being applied to the resistor chain R_d which is the same as that used in Diag. 1.2(a). The range-switch is set to the appropriate position. Instead of the A.C. HIGH terminal, a probe (provided with the instrument) may be used, the Function Switch being turned to PROBE; the A.C. input is now fed to a separate diode V2 whose D.C. output is applied to the resistor chain as before. As the probe diode circuit is substantially the same as Diag. 1.2(c) a separate simplified circuit is unnecessary. The probe is recommended for use on all R.F. frequencies but it may be used as an alternative to the A.C. HIGH terminal at lower frequencies, but not below 10 kc/s.

15. Diag. 1.2(d) shows the arrangement for measuring resistance. The unknown resistance is connected across the D.C. HIGH and LOW terminals and current from a 1.5V battery BY passes through the unknown resistance and part or all of R_r (which is (apart from R20, R21) a separate resistor chain tapped for different ohms ranges by the range-switch). The voltage developed across the used portion of R_r will be a measure of the unknown resistance, and is applied in the grid circuit of the triode V3.

Before the circuits are considered in detail, several special features of the instrument may be mentioned.

Input Resistance and Impedance

16. When D.C. voltages are measured the instrument presents a load of 20 megohms on the 2.4V range, 40 megohms on the other ranges except the 2,400V range when the load is approximately 21 megohms. The instrument, therefore, will consume negligible power from a circuit under test; any normal circuit under test will remain substantially unaffected by the instrument. When measuring A.C. voltages the input impedance is about 2 megohms up to a frequency of 100 kc/s. Above this frequency the impedance falls progressively, reaching about 200 kilohms at 10 Mc/s; in most cases, therefore, the load thrown on the circuit under test is slight.

Means for Dealing with Positive or Negative Input Voltages

17. When measuring D.C. voltages, the Function Switch is normally set to either D.C.+ or D.C.- according to the polarity of the input voltage. The external connections to the circuit under test need not be chosen with regard to polarity. The Function Switch does not reverse these connections within the instrument; it reverses the ammeter connections. The meter-reading depends on the change of anode current, not its actual value; the change depends on the grid voltage change and therefore on the magnitude of the voltage applied to the instrument by the circuit under test. If the input polarity is unknown, the Function Switch is set to, say, D.C.+ and, if the pointer moves the wrong way, the switch is changed to D.C.-.

18. The instrument provides a "balance" reading of the meter. When the Function Switch is in the position BAL. (Balance), the meter connections are reversed, taking up the position as for D.C. (i.e. negative input deflects the pointer up-scale) and the normal small negative bias on the grid (with respect to the cathode) is increased by short-circuiting resistor R43. With no input voltage, the anode current is decreased and the meter pointer takes up a half-way position on the scale; this becomes the new zero and it may be accurately set to the half-way position by means of the SET ZERO potentiometer RV5. A positive input voltage will increase the anode current and the pointer will move to the left; a negative input voltage will decrease the anode current and the pointer will move to the right. In the BAL. position, therefore, the meter indicates the input voltage and the polarity of the voltage applied to the HIGH terminal. As only half the scale is available for each polarity, the voltage range is reduced to one-half of the normal range. The BAL. facility is available on all D.C. voltage ranges excluding 2,400V.

Negative Feedback

19. The presence of negative feedback increases the accuracy of the meter readings over the whole scale and reduces the effect of a falling-off in H.T. voltage.

20. In a negative feedback arrangement of this kind the sensitivity of the valve voltmeter as a whole is almost independent of changes in valve gain. The instrument is therefore not materially affected by changes of valve, of valve characteristics or of valve power supplies.

21. The anode current of V3 will depend (other conditions being fixed) on the potential of the control-grid with respect to the cathode. This potential is the input voltage (taken from a tapping on an input resistor chain) minus the feedback voltage developed across a resistor chain passing anode current. Fig. 1 - the circuit of the instrument when measuring D.C. voltages - illustrates the negative-feedback action; the change in grid voltage produces a change in anode current which is divided between two branches. One branch is the following circuit: the meter M1, R37, the D.C. range correction resistors R38 and R39 (if used), R40 and RV3; the other branch includes R36. Most of the change in anode current flows through the branch that includes the meter. If the input voltage across the arm of SWBe and J3 makes the grid positive, there will be an increase of anode current which will cause an increase of voltage across J1 and J2; the cathode of V3 will thus become more positive with respect to the wiper of RV5 (i.e. with respect to J3). This is equivalent to inserting in the grid-cathode circuit a voltage which will oppose the voltage across the arm of SWBe and J3; the grid will still go-positive (become less negative) but to a less extent than if there were no negative feedback. Similarly, a negative input voltage would be reduced by the negative-feedback action. The change in grid volts (relative to the cathode) is therefore always small, being the input voltage to the grid minus the feedback voltage. Only a small linear part of the grid-volts - anode-current characteristic curve is used. The SCALE LENGTH is adjusted by altering, with RV3, the value of the feedback; this ensures that the full-scale deflection shall correspond to the correct input voltage to the instrument; the same applies when A.C. voltage is to be measured. The feedback arrangements of Fig. 2 are similar to those of Fig. 1. When the instrument is used for measuring resistance (Fig. 3) a similar variable resistance RV4 is used to alter feedback so that full-scale deflection is obtained when the "unknown" resistance across the D.C. HIGH and LOW terminals is zero (a short-circuit); the meter reads backwards when a resistance is being measured.

22. The normal negative bias of the grid is about -2.4V with respect to the cathode, the anode current being about 500 µA. The external voltage inserted in the grid circuit is derived from the input resistor-chain and is 2.4V for a maximum scale reading; as a result of negative feedback, this voltage produces a change of only about 0.5 to 0.6V (plus or minus, according to the polarity of the input voltage) in the grid-to-cathode voltage. The anode current rises from 500 µA to, say, 610 µA or falls to, say, 390 µA.

23. The amplifier valve used in this instrument is chosen for its high slope at a low anode current. The gain is substantially dependent on the anode current and the circuit tends to keep the anode current constant (when no input voltage is applied); as the anode voltage drops as a result of running-down of the H.T. battery, the negative grid-bias is automatically reduced and this keeps the anode current substantially constant. (See para. 24.)

24. The H.T. battery consists of a 60V and a 15V section; the 60V section is more heavily loaded than the 15V section and the voltage of the 60V section drops several times as rapidly as that of the 15V section. When the H.T. battery voltage drops to a value at which the battery requires replacement, the 15V section has a voltage very close to its original value. A drop in the anode voltage will tend to cause a decrease in anode current but this change of current flowing through R36 and R32 would produce a rise in grid potential relative to the cathode; the anode current therefore remains nearly constant in spite of the running-down of the 60V section; as a result, the sensitivity of the valve remains nearly constant. It is to be noted that as R41 is large (160 kilohms) a fall in the value of the 60V section produces only a small change in voltage across the RV5 wiper and J1 and therefore in the bias in the grid circuit; any fall in voltage across the 15V section would appear in full in the grid circuit, but as the load across the 15V section is small, the voltage remains near 15V throughout the useful life of the H.T. battery as a whole.

Checking Battery Voltages

25. Within wide limits the voltages of the three batteries are of little importance if the setting adjustments have been correctly made. The function Switch has three positions for checking the condition of the batteries; A1 for the diode battery BY1, A2 for the triode battery BY2 and B for the H.T. battery BY3. End-of-life of a battery is indicated by failure to pass a calibration mark on the meter scale. The two L.T. Batteries are tested on their normal load and the rejection mark corresponds to 1.2V; the H.T. battery is tested on a load heavier than normal and is rejected when its voltage falls below 1.2V per cell or when the internal resistance rises unduly.

CIRCUIT FOR D.C. VOLTAGE MEASUREMENT

26. The circuit of the instrument when used for D.C. voltage measurement is given in Fig. 1. The same circuit is used when the Function Switch is set to any one of the three positions D.C.+, D.C.- and BAL. The only change effected by altering the switch from D.C.+ to D.C.- is to reverse the connections to the meter. For reasons already explained, this ensures that the meter pointer shall move the right way. It therefore does not matter whether the input positive or negative is connected to D.C. HIGH. When the switch is on BAL. the resistor R43 is short-circuited; with no input voltage, the negative bias on the grid of V3 is increased and the anode current falls bringing the meter pointer to approximately the mid-scale position. The exact mid-position is then obtained by altering the bias with the SET ZERO potentiometer RV5; this is the new zero and a positive input voltage

will move the pointer to the left while a negative input will move it to the right. As only half the scale is used for a given input polarity, the maximum voltage for each position of the VOLTAGE RANGE switch will be halved. In the BAL. position the maximum voltage the instrument will measure is 240V D.C. When the 2,400V range is employed (using the D.C. Multiplier) the BAL position is not used.

27. When D.C. voltages up to 480V are to be measured, the input terminals are D.C. HIGH and LOW. Across these terminals is a chain of resistors (R15, R22, R14, R19, R25, R16, R23, R17, R24, R20, R21); consideration of R10 (470 ohms) may be omitted at this stage. These series resistors have a total value of 40 megohms. The Range Switch SWBe connects the control-grid of V3 (through R31) to appropriate tappings on the resistor chain. It is to be noted that on the 2.4V range R15, R22, (totalling 20 megohms) are short-circuited, the chain being reduced from 40 megohms to 20 megohms for this range; the reason for this is that the resistance in the grid circuit should not exceed 20 megohms as otherwise a reverse grid current (resulting from slight ionisation in the valve) would produce a perceptible voltage which would affect the zero setting; in the other ranges the tapped portion of the resistor chain could never exceed 20 megohms.

28. The D.C. Range Correction resistors R38 (470 ohms) and R39 (470 ohms) call for comment. There are seven voltage ranges concerned, 2,400V being included. As will be seen from the complete circuit (Fig. 4) a switch SWBb (ganged with SWBe) may insert for each range the resistor R39 or both R38 and R39 into the feedback branch circuit (which includes the meter) across the points J1 J2 (Fig. 1); in an appropriate case neither resistor is inserted. The object of altering, if necessary, the total feedback resistance is to correct for slightly incorrect resistance values (i.e. differing from nominal values) in the input resistor chain. On the 2.4V range no intermediate tapping is taken and the accuracy of the resistors is unimportant; R39 only is kept in circuit; the inclusion of R39 is regarded as normal, i.e. when no correction is required. A correction of +2.5% is obtained by omitting R38 and R39, while a -2.5% correction is applied by including both R38 and R39. The appropriate connections are made by the manufacturer and normally do not concern the user.

29. One side of the circuit under test is usually earthed or "earthy"; this side should be connected to the LOW terminal, the "live" side (which may be either positive or negative) being connected to D.C. HIGH.

30. Before the input voltage is applied, the SET ZERO potentiometer is adjusted so that the meter reads zero. When the BAL. position is used, the same potentiometer is employed to set the meter pointer to exactly half-way on the scale.

31. When high D.C. voltages (over 480V) are to be measured the external D.C. Multiplier Unit is used and the Range Switch is turned to D.C. MULTIPLIER. The Function Switch is turned to D.C.+ or D.C.- as found necessary; the BAL. position may also be used if the maximum voltage to be measured does not exceed 240V. <u>It is absolutely essential that the earthy lead of the Multiplier Unit should be connected to the earthed or earthy end of the circuit under test</u>, the "live" lead being connected to the live side of the circuit under test. This precaution is <u>essential</u> if the risk of shock and/or damage to the instrument is to be avoided. The CASE terminal (which is connected to the metal case) <u>must</u>

be connected to a thoroughly reliable earth. It is immaterial whether the "live" side is positive or negative; it is unnecessary to find out the polarity but it is essential to find out which is the live side and to connect to it the live lead from the external D.C. MULTIPLIER UNIT.

32. The external D.C. Multiplier Unit consists of the following resistors: R2 R3, R4, R1, R6, R5, R7. Resistors R1 and R6 are in parallel and the terminals across them are connected to the D.C. HIGH and the LOW terminals on the main instrument. The resistor chain is thus tapped off to give a reduction to one thousandth of the input voltage. This attenuated voltage (2.4V when the input is 2,400V) is applied by the range-switch (when set to D.C. MULTIPLIER) to the 2.4V range of the main instrument.

CIRCUIT FOR A.C. VOLTAGE MEASUREMENT

33. The circuit of the instrument for A.C. voltage measurements is given in Fig. 2. The input voltage (up to a maximum of 480V r.m.s.) is applied to the A.C. HIGH and LOW terminals or across the PROBE and the LOW terminal on the probe case, this terminal being permanently connected to the LOW terminal on the panel. The circuit modifications involved in the use of the PROBE will be discussed later, but are of a minor character. The Function Switch is turned to A.C. (or PROBE) and the Range Switch to the voltage range required.

34. Virtually the full A.C. input voltage is applied across the anode and the indirectly-heated cathode of the diode V1, the capacitor C2 being inserted where shown. The rectified output is a D.C. voltage which is applied via a voltage-divider to the grid of the triode V3; the resistor chain is the same as that used for D.C. voltage measurements up to 480V D.C., with R17 (4.7 megohms) added. The resistor R12 (4.7 megohms) and capacitor C5 (0.01 μF) serve to filter out in large measure any A.C. component in the D.C. output of the diode; R31 (4.7 megohms) and C8 (0.01 μF) contribute to the filtering process. The D.C. output voltage very rapidly reaches a steady-state value which nearly equals the peak A.C. voltage; this D.C. voltage makes the diode anode negative with respect to its cathode and the D.C. voltage applied in the grid circuit of V3 is always negative. The meter M1 is calibrated to read the r.m.s. value of the A.C. input which is assumed to be of sine waveform. If the input to the instrument is A.C. superimposed on a D.C. voltage (e.g. an H.T. voltage) the D.C. component is removed by the capacitor C2.

35. The rest of the circuit is substantially the same as that employed for D.C. voltage measurement. Two additions may be mentioned. The D.C. output voltage from the diode is not directly proportional to the A.C. voltage; the ratio of D.C. voltage to A.C. voltage falls-off as the A.C. input voltage is reduced below about 5V. This effect is compensated for by an appropriate change in negative feedback on the 2.4V and 4.8V ranges. The switch SWBa (ganged with SWBe) inserts in the feedback circuit a preset resistor RV1*(max. 2.5 kilohms) on the 2.4V range and a preset resistor RV2 (max. 2.5 kilohms) on the 4.8V range; on the other ranges a fixed resistor R35 (2.2 kilohms) is inserted. The D.C. Range Correction arrangements are retained as they compensate for small errors in the values of resistors in the main resistor chain and are still required. The second special feature is the provision of a potential-divider R10, R11 across the diode battery BY1; its purpose is to reduce the change in instrument zero when switching from D.C. to A.C. on ranges where the contact potential would indicate on the scale.

* RV1. MAY BE 5 KΩ. SEE NOTE ON PAGE 25.

36. The PROBE provides an alternative input for A.C. voltages. For the lower A.C. frequencies (provided they are above 10 kc/s) either the PROBE or the A.C. HIGH terminal may be used but for R.F. measurements the PROBE should be employed. The PROBE point should (like the A.C. HIGH terminal) be connected to the live side of the circuit under test, the earthed or earthy side of the circuit under test being connected to the LOW terminal on the probe case. When the PROBE is used the circuit is substantially the same (Fig. 2) as when the A.C. HIGH terminal is employed although a separate diode V2 is used (see Fig. 4 for details). The differences are:

(a) C2 (now C3) has a reduced value (470 pF instead of 0.05 μF).

(b) C5 (now C6) has a reduced value (470 pF instead of 0.01 μF).

(c) A bypass capacitor C4 (470 pF) is connected across the heater connections of the diode V2.

37. These changes are made to enable accurate results to be obtained on radio frequencies. To bring the probe diode close to the R.F. source, the diode is included in the probe case and not in the main body of the instrument.

CIRCUIT FOR RESISTANCE MEASUREMENT

38. The circuit of the instrument for measuring resistance is given in Fig. 3. The resistance to be measured is connected across the D.C. HIGH and LOW terminals. The battery BY1 (1.5V) drives a current through the unknown resistance and a resistance selected by the Range Switch SWBe. This switch may be set to the marks 1K, 10K, 100K, 1M or 10M according to the range of ohms required. The voltage across the selected resistance depends on the value of the "unknown" resistance and is inserted in the grid circuit of V3 which measures it. The polarity of BY1 is such that the grid is made to go-positive (i.e. it becomes less negative) and the anode current increases. The procedure for measuring resistance is as follows: With no external resistance across D.C. HIGH and LOW the SET ZERO potentiometer RV5 is adjusted to a position where the meter reads zero at the left of the scale. The D.C. HIGH and LOW terminals are now short-circuited and the SET OHMS potentiometer RV4 (which varies the amount of negative feedback) is adjusted until the meter pointer is at full-scale deflection which therefore corresponds to zero ohms. The resistance to be measured is now connected across the D.C. HIGH and LOW terminals and will cause the pointer to move to the left; full-scale deflection to the left corresponds to infinite resistance. The meter therefore reads backwards for ohms. The instrument zero must be very carefully set.

THE COMPLETE CIRCUIT

39. The complete circuit is given in Fig. 4 and shows the various switches which provide the circuits already discussed with reference to Figs. 1, 2 and 3. All the SWA switches are ganged and so are all the SWB switches. The circuits are not conductively connected to the case. A capacitor C1 (0.01 μF) joins the LOW terminal to the case. The CASE terminal (internally connected to the case) must be connected to a reliable earth. The purpose of the capacitor C1 is to prevent the case from acquiring unwanted potentials by acting as a receiving "aerial" when the case is not earthed; although in some circumstances and provided the voltages to be measured are low, it is not technically essential to earth

the case, the grave risks (outlined in the next section) that may arise make it necessary to lay down, as a definite instruction, that the case must be properly earthed in all circumstances. When using the Multiplier, if the circuit under test has one side that is earthed (or is earthy), this side must be connected to the earthy lead (black lead) from the external D.C. MULTIPLIER.

WARNING: It is essential to earth the terminal marked CASE before the instrument is used; as earth connections may become faulty (e.g. broken wire, dry joint, bad earth), the operator should satisfy himself that the earth connection is satisfactory.

The earthing of test equipment is often recommended but with the present instrument failure to earth the case may result in a shock to the operator.

40. The Operating Instructions given in Chapter 2, paragraphs 2, 3, 4, 5, 6 should be carefully noted before making connections to the source of the D.C. or A.C. voltage to be measured.

41. The connections to the external circuit should be as given in the Operating Instructions: One does not need to be concerned with polarity, as the function switch is moved to the + or - position, whichever gives a forward deflection of the meter. Any concern about polarity of input may lead to a reversal of connections.

42. At the time this handbook is being prepared, the D.C. Multiplier (Fig. 5) and the Rectifier Unit (Fig. 6) have not received official approval but no changes in circuit are expected. The design of the D.C. Multiplier (Fig. 5) has been developed to minimise the risk of a shock to the operator and a breakdown of the capacitor C1 (Fig. 4) - or of insulation elsewhere. These risks could be very considerable if the D.C. Multiplier consisted simply of a tapped resistor.

43. It is instructive to study what could happen if the resistors R5R7 were removed from their present position and inserted above R2 and if the Neon indicator V5 were omitted. Suppose now, the LIVE lead were connected in error to the earthy point of a 2,400V source and the EARTHY lead (i.e. the LOW terminal, as R5R7 are supposed to be removed) were connected to the live end of the 2,400V source. If the CASE terminal were earthed, the full 2,400V would be applied across C1 which would break down; in any case, the insulation-to-earth of the wiring of the instrument would no doubt break down. If the CASE terminal were not earthed, the capacitor C1 would not be involved but the insulation-to-earth of the wiring would still probably break down; moreover, if the operator touched the metal case of the instrument he might receive a severe shock. These effects would be obtained, but in less degree, if the input voltage were less than 2,400V.

44. The instrument has been made safer and more reliable by using the circuit of Fig. 5. The resistors R5R7 provide a path of nearly one megohm which increases safety if the LIVE and EARTHY leads of the D.C. multiplier are reversed by mistake. The Neon indicator V5 prevents the voltage across LOW and CASE terminals exceeding 180V because at this voltage the Neon lamp conducts; as the lamp lights-up under these conditions, the operator becomes aware that he has the external connections the wrong way round.

45. Although the possible danger to operator and instrument is more obvious when the 2,400V range is in use it may still exist at lower voltages.

THEREFORE SEE THAT:

(a) CASE TERMINAL IS CONNECTED TO A SOUND EARTH.

(b) EXTERNAL CONNECTION TO "LIVE" SIDE IS CORRECT.

(c) REMEMBER TO SWITCH-OFF THE GEAR TO BE TESTED BEFORE CONNECTING TEST LEADS. (MOST IMPORTANT.)

Rectifier Unit

46. The voltmeter normally operates from dry batteries but an A.C. mains unit

RECTIFIER UNIT

46. This rectifier unit may be used to replace the batteries entirely, and will function on 200–250V, 50 c/s or 180V, 500 c/s supplies with a consumption of about 15 watts. It consists of a normal voltage doubler H.T. supply giving 75V (stabilised) tapped at 60V and 15V, a thermistor-stabilised L.T. output of approximately 1·4V to supply the filament of V3, and an unstabilised output of 1·4V to supply V1 or V2, or for use in resistance measurements, as determined by the function switch on the instrument.

47. No mains switch or fuse is fitted.

(Amendment No. 2)

BY2 and BY1 [illegible]

47. The fixed mains plug PLB is fitted to the Rectifier Unit, SWC being the on-off switch. A voltage selector enables the primary of the mains transformer to be tapped for 115, 180, 200, 210, 220, 230, 240 and 250V. A 200 mA fuse FS1 is provided.

PART 2

CHAPTER 1

★

OPERATING INSTRUCTIONS

CHAPTER 2

★

MAINTENANCE, CALIBRATION AND

FAULT-FINDING

APPENDIX

★

LIST OF COMPONENTS, ETC.

PART 2

CHAPTER 1

OPERATING INSTRUCTIONS

GENERAL

1. (a) With the Function Switch at OFF, check that the meter mechanical Zero is correctly set. If not, remove the meter cover labelled ZERO SEAL, adjust the zero and replace the cover.

   (b) When using the Battery Unit, check that the pointer reads above the RED LINE on the meter scale with the Function Switch set to battery test positions A1, A2 and B.

   (c) When using the Rectifier Unit, check that the tapping on the voltage selector is set to the correct voltage.

   (d) The terminal marked CASE should be earthed whenever possible and ALWAYS when the voltage in any part of the circuit being measured exceeds 50 volts to earth, whatever its polarity. There is no D.C. path between CASE terminal and the rest of the instrument circuit.

   (e) SWITCH OFF WHEN NOT IN USE. When using the battery unit, the Function switch on the panel should be used. When the rectifier unit is used it should be plugged into or unplugged from a power socket as required, the Function switch on the CT54 only isolates the instrument from the batteries or rectifier unit, depending on which is inserted in the instrument. Thus, setting the Function switch to OFF when the voltmeter is mains operated will not interrupt the A.C. supply to the rectifier unit and could result in the unit being run unnecessarily for prolonged periods.

(*Amendment No. 2*)

TO MEASURE A D.C. VOLTAGE

2. (a) Set the Range Switch to the appropriate range.

   (b) Set the Function Switch to the polarity of the D.C. HIGH terminal, i.e. to DC+ or DC-. If the polarity is unknown, the wrong choice of DC+ or DC- is possible as indicated by a movement of the pointer to the left when the voltmeter is connected; in this case use the alternative setting of the Function Switch.

   (c) Adjust the SET ZERO control so that pointer reads NORMAL (i.e. left-hand) zero.

   (d) Connect the D.C. HIGH terminal to the point of HIGHER RESISTANCE to earth, whatever its polarity.

   (e) Connect the LOW terminal to the point of LOWER RESISTANCE to earth, whatever its polarity.

Examples: To measure voltage of an H.T. source (with negative earthed) the D.C. HIGH terminal would be connected to HT+. To measure the voltage across a resistor inserted between a valve anode and HT+ the D.C. HIGH terminal would be connected to the anode end and the LOW terminal to HT+.

TO MEASURE A D.C. VOLTAGE ON THE CENTRE ZERO SCALE

3. (a) Set the Range Switch to the appropriate range.

(b) Set the Function Switch to BAL.

(c) Adjust the SET ZERO control so that pointer reads CENTRE zero.

(d) Connect the D.C. HIGH terminal to the point of HIGHER RESISTANCE to earth.

(e) Connect the LOW terminal to the point of LOWER RESISTANCE to earth.

TO MEASURE A D.C. VOLTAGE BETWEEN 480V AND 2,400V

4. (a) Connect the special D.C. Multiplier to the HIGH and LOW terminals.

(b) Unscrew the knurled knobs on the ends of the Multiplier and push the spades of the test leads as far as they will go into the sockets of the Multiplier. Do up the knurled knobs to clamp the spades. The RED lead should be inserted in the RED socket and the BLACK lead in the BLACK socket.

(c) Connect the CASE terminal to an effective earth. This is most important (chiefly to avoid risk of shock).

(d) Set the Range switch to the D.C. MULTIPLIER position.

(e) Set the Function switch to the polarity of the HIGH voltage with reference to earth, i.e. to DC+ or DC-. If the polarity is unknown, the wrong choice of DC+ or DC- is possible as indicated by a movement of the pointer to the left when the voltmeter is connected; in this case, turn the Function Switch to the other D.C. position.

(f) Adjust the SET ZERO control so that the pointer reads NORMAL zero.

(g) Having switched-off the gear being tested, connect the RED test lead to the point of HIGH VOLTAGE to earth, whatever its polarity. This is extremely important; reversed connections may, in certain circumstances, cause risk of shock to operator. The live high-voltage point to which connection must be made is not necessarily positive.

(h) Connect the BLACK test lead to the earthy side of the input, and then switch-on the gear being tested.

Warning: The potential applied to the LOW terminal must never exceed 500V to earth.

TO MEASURE AN A.C. VOLTAGE ON THE TERMINALS (30 c/s - 20 Mc/s

5. (a) Set the Range switch to the appropriate range.

(b) Set the Function switch to A.C.

(c) Join A.C. HIGH and LOW terminals together by external wire. Adjust the SET ZERO control so that the pointer reads NORMAL zero. Disconnect external wire from A.C. HIGH and LOW terminals.

(d) Connect the A.C. HIGH terminal to the point of HIGHER IMPEDANCE to earth.

(e) Connect the LOW terminal to the point of LOWER IMPEDANCE to earth.

TO MEASURE AN A.C. VOLTAGE ON THE PROBE (10 kc/s - 200 Mc/s)

6. (a) Set the Range switch to the appropriate range.

(b) Set the Function switch to PROBE.

(c) Adjust the SET ZERO control so that the pointer reads NORMAL zero; during this operation probe point should be temporarily joined to probe LOW.

(d) Connect the probe point to the point of HIGHER IMPEDANCE to earth.

(e) Connect the probe LOW terminal to the point of LOWER IMPEDANCE to earth.

TO MEASURE A.C. VOLTAGE ACROSS A CENTRE-TAPPED COMPONENT WHEN TAP IS EARTHY

7. This should be done by taking separate measurements across each half and adding the results. The measurements must be taken keeping the LOW terminal connected to the earthy tap and moving the A.C. HIGH terminal connection to the live ends in turn.

TO MEASURE A RESISTANCE

8. (a) Set the Range switch to the appropriate range.

(b) Set the Function switch to OHMS.

(c) Adjust the SET ZERO control so that the pointer reads NORMAL zero.

(d) Short-circuit the D.C. HIGH and LOW terminals with a piece of wire and adjust the SET OHMS control so that the pointer reads zero OHMS. Remove the short-circuiting wire.

(e) Connect the unknown resistance between D.C. HIGH and LOW terminals.

TO MEASURE OUTPUT POWER

9. The A.C. output power to be measured is fed to a load resistance of, say, 600 ohms which may be obtained by shunting a Z215592 (620 ohms, $\frac{3}{4}$ watt, $\pm$ 2 per cent tolerance) by a Z222152 (15 kilohms, $\pm$ 20 per cent tolerance).

The A.C. voltage across this load is then measured by the Valve Voltmeter. The conversion graph of Figure 7 may be used for obtaining the result in milliwatts or for obtaining power ratios in decibels. This curve is obtained from the formula

$$W = \frac{V^2}{600}$$

where W is in watts and V in volts. Other load resistances could be used, the figure 600 being then replaced by the new load resistance.

In the measurement of milliwatts the error may amount to as much as ± 8 per cent (approx.).

PART 2

CHAPTER 2

MAINTENANCE, CALIBRATION AND FAULT-FINDING

MECHANICAL FEATURES

1. To service the instrument, the Battery Unit or Rectifier Unit must first be withdrawn by undoing the two knurled screws which retain the unit. The 18 bolts securing the panel are next removed and the instrument may then be lifted out of the case. The meter, resistance strips and components are readily accessible and may be identified from the component layout diagram. No special instructions are required for replacing any of the components, but care must be taken if a terminal is removed to ensure that the several parts which are associated with it are replaced in their correct order. Failure to do so will cause incorrect operation.

2. Changing either of the valves or the meter is a simple matter, but care should be taken to ensure that the rubber sealing gasket around the meter is replaced; also that the rubber seals around the spindles of the switches and potentiometers, and the rubber gasket which runs in a groove on the underside of the panel, are in good condition and correctly positioned before screwing the panel back in the case.

PROBE UNIT (See Figure 8)

3. The probe case is made in two almost symmetrical halves, one half forming the body on which the components are mounted, and the other half forming the cover. To service the probe it is only necessary to remove the screws securing the cover, when the valve and its associated components can be replaced without disturbing the cable clamp and seal.

4. Care should be taken when reassembling the probe, to ensure that there is adequate clearance between the components and the side of the case, and that dirt and moisture have been excluded. The sealing sheath must be replaced after reassembling the unit.

D.C. MULTIPLIER

5. This accessory is moulded in two halves, and removing the cover provides access to the resistors which form the voltage divider. Replacement of resistors should rarely be required. The gasket between the cover and the body of the multiplier must be replaced to ensure hermetic sealing.

BATTERY REPLACEMENT

6. When fitting or replacing batteries in the Battery Unit, loosen the two knurled nuts on top of the instrument and withdraw the box; the sliding cover, which is secured by screws, should then be removed. Connections to the batteries are made through an 8-pole output socket. The leads from poles 1, 2 and 3 of the socket terminate in a 4-pole plug which connects to the H.T. Battery A.P.14221.

The leads attached to poles 5 and 8 are secured to the positive terminals of the L.T. cells A.P.21060 and the leads from poles 4 and 6/7 respectively should be connected to the negative terminals of these cells. Suitable packing strips should be inserted between the sides and the sides of the battery box to secure these from excessive movement.

7. Transparent windows are provided on the end of the Battery Unit so that the batteries may be seen without having to remove the unit. Before putting this into storage, all batteries must be removed.

SILICA-GEL DRYER

8. The panel of the CT.54 Valve Voltmeter is hermetically sealed and an air dryer is fitted, A.P.61043, in the bottom left-hand corner. This is provided with a coloured indicator visible through a transparent window. When the indicator (normally blue) turns pink, the dryer requires regenerating and may be removed by means of a coin. The dryer is regenerated by heating in an oven until the silica-gel turns blue. The dryer is provided as a precautionary measure to keep the interior of the instrument free from condensation and damp, and if circumstances make it impossible to replace and regenerate the dryer, no permanent damage will be caused to the instrument, and little if any change will occur in its performance.

MAINTENANCE INSTRUCTIONS - ELECTRICAL

9. No routine maintenance is required on the CT.54 Valve Voltmeter. When using the Battery Unit an occasional check should be made to ensure that the meter reads above the red line on the scale in each of the battery test positions. At prescribed intervals, the instrument should be checked to ensure that the accuracy remains within the required limits.

10. For this purpose measurements may be made at known fixed points, using the A.C. voltage of the ship or shore mains, with Function Switch at "A.C.", or the voltage of new dry cells with Function Switch at "DC+" or "DC-". A check on the resistance ranges may also be made with known resistors. If the instrument requires re-calibration, through receiving accidental damage or after changing some major component, this must be carried out in accordance with the detailed instructions given below, and no attempt should be made to alter the setting of the preset controls under the warning plate near the terminals unless the necessary facilities (mentioned in Calibration Procedure below) are available.

11. It should be noted that no re-calibration is required on changing batteries or when substituting the rectifier unit for the battery unit. Likewise changing a valve will in general have no appreciable effect on the calibration, as the circuit is specially designed to cater for this.

RE-CALIBRATION PROCEDURE (Re-calibration is normally to be carried out by Dockyards)

12. If the accuracy of the instrument is found to be outside the specified limits, re-calibration will be required. In the absence of special test equipment provided for the purpose, a reference standard of known accuracy should be connected across the CT.54 valve voltmeter, so that the two instruments read simultaneously. Suitable reference standards are Avo meter H.R. A.P.12945,

The leads attached to poles 5 and 8 are secured to the positive terminals of the I.T. cells A.P. 21060 and the leads from poles 4 and 6/7 respectively should be connected to the negative terminals of these cells. Suitable packing strips should be inserted between the sides and the sides of the battery box to secure these from excessive movement.

7. Transparent windows are provided on the end of the Battery Unit so that the batteries may be seen without having to remove the unit. Before putting this into storage, all batteries <u>must</u> be removed.

SILICA-GEL DRYER

8. The panel of the CT.54 Valve Voltmeter is hermetically sealed and an air dryer is fitted, A.P. 61043, in the bottom left-hand corner. This is provided with a coloured indicator visible through a transparent window. When the indicator (normally blue) turns pink, the dryer requires regenerating and may be removed by means of a coin. The dryer is regenerated by heating in an oven until the silica-gel turns blue. The dryer is provided as a precautionary measure to keep the interior of the instrument free from condensation and damp, and if circumstances make it impossible to replace and regenerate the dryer, no permanent damage will be caused to the instrument, and little if any change will occur in its performance.

MAINTENANCE INSTRUCTIONS - ELECTRICAL

9. No routine maintenance is required on the CT.54 Valve Voltmeter. When using the Battery Unit an occasional check should be made to ensure that the meter reads above the red line on the scale in each of the battery test positions. At prescribed intervals, the instrument should be checked to ensure that the accuracy remains within the required limits.

10. For this purpose measurements may be made at known fixed points, using the A.C. voltage of the ship or shore mains, with Function Switch at "A.C.", or the voltage of new dry cells with Function Switch at

11. It should be noted that no re-calibration is required on changing batteries, or when substituting the rectifier unit for the battery unit. When it is necessary to replace V3, the new valve must be aged in the CT54 for about two and a half hours (i.e. the CT54 must be left switched on and not used) in order to stabilise its performance, a process customary with any electronic measuring equipment. The stability after ageing may be checked by a simple grid current test. The instrument is switched to 2·4V range and D.C.+ and the zero off-set to 0·4V. On switching to the 480V range, a zero shift of not more than 1½ divisions (i.e. 3% of f.s.d) is permissible. (The above range-change causes a change of grid circuit resistance from 24·7 megohms to 4·9 megohms. Thus a resistor of 20 megohms in the grid of V3 should not have more than 0·15 volts across it due to grid current.)

If after ageing the valve, the above test still gives an unsatisfactory result, another CV784 must be tried. Though technically the valve may be aged on a battery operated instrument, mains operation would be an obvious economy. A calibration check of the instrument would be advisable after replacing V3.

When replacing R8 in the rectifier unit, a resistor of 7·6–8·4 ohms should be selected from a batch of Z243455, 8·2 ohms, ± 10%, 1½ watt resistors, in order to obtain the most stable performance from the unit. (During manufacture an 8 ohms ± 5% resistor is used as R8. This resistor is most unlikely to become faulty, as it is lightly loaded, and rather than patternise a new article, a selected component will be used for replacement purposes.)

(Amendment No. 2)

12. If the accuracy of the instrument is found to be outside the specified limits, re-calibration will be required. In the absence of special test equipment provided for the purpose, a reference standard of known accuracy should be connected across the CT.54 valve voltmeter, so that the two instruments read simultaneously. Suitable reference standards are Avo meter H.R. A.P. 12945,

~~Multimeter Type X and~~ Avo meter Model 40 A.P.47A. The yellow warning plate situated below the row of terminals should be removed and three preset controls will be found, marked SCALE LENGTH, 2.4V A.C. and 4.8V A.C.

13. The fundamental adjustment for all ranges is made on the 0-2.4V D.C. range. For this purpose, a suitable voltage source such as a single 2V accumulator, should be connected to the DC HIGH and LOW terminals. After the warming up period, the SET ZERO control on the panel should be carefully adjusted and the function switch set to DC+.

14. The SCALE LENGTH PRESET control is then varied until the CT.54 gives the same indication as the reference instrument. If for any reason the adjustment cannot be carried out, the instrument should be returned to the workshop.

15. The accuracy of the remaining D.C. voltage ranges may be checked in the same manner, by connecting the instrument to some suitable voltage source in parallel with a standard reference instrument. If, on any of these ranges, an error greater than ± 3% of full scale is discovered, the instrument should be returned to the workshop; errors on these higher ranges <u>must not</u> be corrected by the SCALE LENGTH control the use of which is restricted to the 0-2.4V D.C. voltage range.

16. The adjustment of the SCALE LENGTH control on the 0–2·4V D.C. range also determines the general accuracy of the instrument when measuring A.C. voltages ; individual adjustments are, however, provided for the two lowest A.C. voltage ranges and special attention should be paid to these when either of the diode valves is changed. The principle of adjustment is the same as before ; the instrument should be connected to a variable A.C. source, of pure sinusoidal waveform, in parallel with a standard reference instrument. The A.C. source should be adjusted to read 2·4 volts (for the 2·4V range) or 3·6 volts (for the 4·8V range) on the reference instrument. The appropriate A.C. preset control (RV1 or RV2) should then be adjusted until the CT 54 agrees exactly with the reference instrument. These calibration voltages for the A.C. ranges must be adhered to, if the stated accuracy of the instrument is to be maintained on the A.C. ranges. The order in which these two controls are adjusted is not important, but care should be taken to readjust the SET ZERO control when changing over from one range to another, and care should also be taken not to disturb the setting of the SCALE LENGTH control, which must already have been adjusted on D.C. as described in the previous paragraph. The waveform of the A.C. source should be sinusoidal and the reference instrument should have the same A.C. frequency characteristics as the CT54 or errors will result. In general, a mains supply and variac can be used to check the various A.C. ranges. In larger ships the Oscillator G205 A.P.W7252 can be used as an A.C. source to check the lower A.C. ranges. Dockyard re-calibration involves further precautions against error.

(Amendment No. 2)

~~A.C. source should be sinusoidal and the A.C. frequency characteristics as the CT.54 or errors will result. In general, a mains supply and Variac can be used to check the various A.C. ranges. In larger ships the Oscillator G205 A.P.W7252 can be used as an A.C. source to check the lower A.C. ranges. Dockyard re-calibration involves further precautions against error.~~

17. The adjustment of the SCALE LENGTH control also determines the accuracy of the five resistance ranges; they can be checked by connecting suitable known resistors to the instrument and observing the reading. A convenient resistance value to use is 1/20th of the full scale reading of each range; for example, 50 ohms should be used when checking the 1 K (0 to 1,000 ohms) range. No individual adjustments are provided, and if the instrument reads inaccurately after the SET ZERO and the SET OHMS controls have been correctly set, the instrument should be returned to the workshop.

FAULT-FINDING (See Fig. 4)

18. Should an instrument become faulty, the following schedule of tests will indicate the probable section of the circuit in which the fault lies. This schedule assumes that preliminary tests have exonerated the meter, power unit and valves; it is classified under the four main probable symptoms.

Meter does not read

D.C. volts	Open circuit in meter line, SWA e, SWA f, SWB b, R37, R38, R39, R40, RV3.
A.C. volts	As for D.C. volts with addition of: RV1 on the 2.4V range RV2 on the 4.8V range R35 on all other ranges.
Resistance	Open circuit in meter line, SWA e, SWA f, RV4.

Meter reads up scale

D.C. volts	(when switched to DC+ with no input) SWB e, R14 to 25, R31, R42, R43, RV5. Grid and anode or cathode and anode of V3 short-circuited.
A.C. volts	As for D.C. volts under the heading "Meter reads down scale" (see below)
Resistance	SWB e, R20, R21, R26, R28 to 31, R33, R42, R43. Grid and anode or cathode and anode of V3 short-circuited.

Meter reads down scale

D.C. volts	(when switched to DC+ with no input) SWA aa, SWA ab, R32, R41, RV5. Any pin of V3 except grid.
A.C. volts	As for D.C. volts under heading of "Meter reads up scale" (see above)
Resistance	As for D.C. volts under heading of "Reading unaffected by input" (see below)

Reading unaffected by input

D.C. volts	SWA ga, R10, R14 to 25, C8.
A.C. volts (terminals)	As for D.C. volts with addition of: SWA d, SWA ga, R12, C2, C5.
A.C. volts (probe)	As for D.C. volts with addition of: SWA d, SWA ga, C6, C3, R13.
Resistance	SWA ca, SWA ga, SWB c, C8, wiper of RV4 not making contact.

APPENDIX NO. 1

A.P.67921 VOLTMETER, VALVE, CT.54

LIST OF COMPONENTS

NOTE: A.P.67921 includes Multiplier Unit A.P.61417 and Probe Unit, Design 3 A.P.61418 but excludes Rectifier Unit CTA2 A.P.67922.

RESISTORS

Circuit Ref.	NAME	Joint-Service Ref.	Value (ohms)	Rating (W)	Tol. (%) ±
	Resistors, Fixed,				
R1	Composition, Grade 2, Insulated	Z223143	680 k	½	10
R2	" " 1, Non-insulated	Z216698	6.8 M	1½	2
R3	" " 1, " "	Z216698	6.8 M	1½	2
R4	" " 1, " "	Z216698	6.8 M	1½	2
R5	" " ~~2, Insulated~~ 1, NON-INSULATED.	~~Z223315~~ Z216739.	470 k	~~1~~ ¾	5 ~~10~~
R6	" " 1, NON-INSULATED.	"Z216041".	22 k	~~⅛~~ ¼.	2
R7	" " ~~2,~~ 1, NON-INSULATED.	"Z216739"	470 k	~~1~~ ¾	5 ~~10~~
R8	" " 2, "	Z223290	10 M	½	10
R9	" " 2, "	Z223290	10 M	½	10
R10	" " 2, "	Z221194	470 ~~k~~	¼ ~~½~~	10
R11	" " 2, "	Z221194	470 ~~k~~	~~½~~ ¼	10
R12	" " 2, "	Z223248	4.7 M	½	10
R13	" " 2, "	Z223248	4.7 M	½	10
R14	" " 1, Non-insulated	Z216702	8.2 M	1½	2
R15	" " 1, " "	Z216706	10 M	1½	2
R16	" " 1, " "	Z216670	1.8 M	1½	2
R17	" " 1, " "	Z216668	1.5 M	1½	2
R18	" " 2, Insulated	Z223248	4.7 M	½	10
R19	" " 1, Non-insulated	Z216698	6.8 M	1½	2
R20	" " 1, Insulated	Z219883	200 k	⅛	2
R21	" " 1, "	Z219883	200 k	⅛	2
R22	" " 1, Non-insulated	Z216706	10 M	1½	2
R23	" " 1, Insulated	Z219883	200 k	⅛	2
R24	" " 2, "	Z223038	100 k	½	10
R25	" " 2, "	Z223164	1 M	½	10
R26	" " 1, "	Z219404	82	¼	2
R27	" " 1, "	Z219779	36 k	⅛	2
R28	" " 1, "	Z219635	3.6 k	⅛	2
R29	" " 1, "	Z219491	360	⅛	2
R30	" " 1, "	Z219404	82	¼	2
R31	" " 2, "	Z223248	4.7 M	½	10
R32	" " 1, "	Z219701	10 k	⅛	2

LIST OF COMPONENTS

Circuit Ref.	N A M E	Joint-Service Ref.	Value (ohms)	Rating (W)	Tol. (%) ±
	Resistors, Fixed,				
R33	Composition, Grade 1, Insulated	Z219749	22 k	1/8	2
R34	" " 1, "	Z219965	910 k	1/4	2
R35	" " 1, "	Z219136	2.2 k	1/8	5
R36	" " 1, "	Z219217	30 k	1/8	5
R37	" " 1, "	Z219112	1 k	1/8	5
R38	" " 2, "	Z221194	470	1/2	10
R39	" " 2, "	Z221194	470	1/2	10
R40	" " 1, "	Z219169	6.2 k	1/8	5
R41	" " 1, "	Z219271	160 k	1/8	5
R42	" " 1, "	Z219142	2.7 k	1/8	5
R43	" " 1, "	Z219154	3.9 k	1/8	5
R44	" " 1, "	Z219743	20 k	1/8	2
~~R45~~	" " 1, "	Z219743	20 k	1/8	2
~~R46~~	" " 1, "	Z219743	20 k	1/8	2
~~R47~~	" " 1, "	Z219698	8.2 k	1/8	2
~~R48~~	Resistor, Wire-wound, Lacquered	Z245007	3.3	1/2	5
R49	Resistor, Fixed, Composition, Grade 2, Insulated	Z221089	68	1/2	10
~~R50~~	Resistor, Wire-wound, Lacquered	Z245061	16	1/2	5
~~R51~~	Resistor, Wire-wound, Vitreous-enamel	Z244237	6.8 k	3	5
~~R52~~	Resistor, Fixed, Composition, Grade 2, Insulated	Z223080	220 k	1/2	10

CAPACITORS

Circuit Ref.	N A M E	Joint-Service Ref.	Value	Rating	Tol. (%) ±
C1	Capacitor, ~~Paper~~ Moulded Mica	Z124409	0.01 µF	750V	20
C2	Capacitor, Paper	Z115585	0.05 µF	350 at 100°C	20
C3	Capacitor, Ceramic	Z132628	470 pF	500V	20
C4	" "	Z132628	470 pF	500V	20
C5	Capacitor, Moulded Mica	Z124409	0.01 µF	750V	20
C6	Capacitor, Ceramic	Z132628	470 pF	500V	20
C7	" "	Z132628	470 pF	500V	20
C8	Capacitor, Moulded Mica	Z124409	0.01 µF	750V	20
~~C9~~	~~Capacitor, Electrolytic~~	~~Z145025~~	~~4.0 µF~~	~~150V~~	~~20+100~~
~~C10~~	~~" "~~	~~Z145025~~	~~4.0 µF~~	~~150V~~	~~20+100~~

VARIABLE RESISTORS

Circuit Ref.	NAME	Joint Service Ref. or A.P. No.	Value (ohms)	Rating (W)	Tol. (%) ±
RV1	Resistor, Variable, Wire-wound	A.P. 67644	2.5 k	½	10
RV2	" " " "	A.P. 67644	2.5 k	½	10
RV3	" " " "	A.P. 67847	5 k	½	10
RV4	" " " "	Z272142	10 k	1	10
RV5	" " " "	Z272142	10 k	1	10

METAL RECTIFIERS

Circuit Ref.	NAME	Joint Service Ref. or A.P. No.
~~MR1~~	~~Rectifier, Selenium iron~~	~~A.P. 60113~~
~~MR2~~	~~" " "~~	~~A.P. 61320~~
~~MR3~~	~~" " "~~	~~A.P. 61320~~

SWITCHES

Circuit Ref.	NAME	Joint Service Ref. or A.P. No.
SWA	11-way, 4-wafer, Special	A.P. 61034
SWB	12-way, 3-wafer, "	A.P. 61035
~~SWC~~	~~Switch, D.P.S.T.~~	~~Z510302~~

PLUGS AND SOCKETS

Circuit Ref.	NAME	Joint Service Ref. or A.P. No.
PLA	Plug, moulded 8-way	A.P. 60412
~~PLB~~	~~Plug, Fixed, 3-pole~~	~~Z560565~~
SKA	Socket, moulded, 8-way	A.P. 60717
~~SKB~~	~~" " "~~	~~A.P. 60717~~

MISCELLANEOUS

PROD TEST, red 6625-99-943-9047

PROD TEST, black 6625-99-943-9048.

APPENDIX 1 LIST OF COMPONENTS

MISCELLANEOUS

Circuit Ref.	NAME	Joint Service Ref. or A.P. No.
~~TR1~~	~~Transformer~~	~~A.P. 61678~~
~~TR2~~	~~Transformer (auto-transformer)~~	~~A.P. 61679~~
~~FS1~~	~~Fuseholder~~	~~Z590170~~
~~FS2~~	~~"~~	~~Z590170~~
	~~Fuse-link 200 mA (2 off) Patt. No. not yet allocated~~	-
	~~Valveholder, B7G, Grade 2, Class H2 (for V4)~~	~~Z560127~~
	Valveholder, B7G, Grade 1, Class H1 (for V1, V2, V3)	Z560094
	Valve Screen (for V1, V3, ~~V4~~)	A.P. 60796
	Ammeter, Moving Coil, 0-80 μA, Special Scale	A.P. 61324
	Knob, Finger (2 off)	Z970181
	" " " "	Z970182
	Plug, Battery, 4-pin, with cover	A.P. 61038
	Air Dryer	A.P. 61043
	Terminal	A.P. W7483
	Strap, Webbing	A.P. 5890
	~~Connector, Flexible Screened (mains lead for Rectifier Unit)~~	~~A.P. 67384~~
	Test Lead, Black, with clip	A.P. 62097
	" " Red " "	A.P. 62098
	Multiplier Unit	A.P. 61417
	Probe Unit, Design 3	A.P. 61418
	Box, for Batteries, Dry, CTA 24	A.P. 61833
	TEST PROBES (1 PAIR)	A.P. 64159

BATTERIES

Circuit Ref	NAME	Joint Service Ref. or A.P. No.
BY1	Cell, Dry, 1.5V	A.P. 21060
BY2	" " "	A.P. 21060
BY3	Battery, Dry, 75V/15V	A.P. 14221

310-7171

VALVES

Circuit Ref.	NAME
V1	Diode CV.753
V2	" CV.753
V3	Diode-pentode CV.784
~~V4~~	~~Stabilizer CV.286~~
V5	Neon indicator X961101 (in Multiplier)

COMPONENTS FOR MULTIPLIER UNIT (A.P. 61417)

(See details in above list)

R1, R2, R3, R4, R5, R6, R7
V5

COMPONENTS FOR PROBE UNIT, DESIGN 3 (A.P. 61418)

(Repeated from main list which gives details).

V2 Diode CV.753
Valveholder, B7G, Grade 1, Class H1 Z560094 (for V2)
C3, C4, C6, C7
R9, R13

~~COMPONENTS FOR A .P. 67922 RECTIFIER UNIT CTA2 IN STOWAGE BOX~~

~~(Repeated from main list which gives details)~~

~~V4 Stabilizer CV.286~~
~~R45, R46, R47, R48, R49, R50, R51, R52~~
~~C9, C10~~
~~Switch SWC~~
~~Plug PLB~~
~~Valveholder, B7G, Grade 2, Class H2 Z560127~~
~~MR1, MR2, MR3~~
~~SKB~~
~~Valve Screen A.P. 60796~~
~~Fuseholder Z590170 - 2 in No.~~
~~FS1 Fuse-link, 200 mA~~
~~FS2 " " " "~~
~~Connector, Flexible, Screened, A.P. 67384~~
~~TR1 Transformer A.P. 61678~~
~~TR2 " A.P. 61679~~

APPENDIX 1

A.P. 67922 RECTIFIER UNIT CTA2

(See Figure 6)

LIST OF COMPONENTS

Circuit Ref.	Name	Joint Service Cat. No. or A.P. No.	Value (Ohms)	Rating Watts	Tol ±%
	RESISTORS				
R1	Resistor, Wire-Wound, Vitreous Enamelled	Z243391	750	3	5
R2	Resistor, Wire-Wound, Vitreous Enamelled	Z243391	750	3	5
R3	Resistor, Fixed, Composition, Grade 2	Z223080	220K	½	10
R4	Resistor, Wire-Wound, Vitreous Enamelled	Z243325	33	3	5
R5	Resistor, Wire-Wound, Vitreous Enamelled	Z244237	6·8K	3	5
R6	Resistor, Fixed, Composition, Grade 2	Z221089	68	½	10
R7	Resistor, Wire-Wound, Lacquered	Z245011	4·7	½	10
*R8	Resistor, Wire-Wound, Vitreous Enamelled	Z243455	8·2	1½	10
R9	Resistor, Fixed, Composition, Grade 1	Z219743	20K	⅛	2
R10	Resistor, Fixed, Composition, Grade 1	Z219689	8·2K	⅛	2
R11	Resistor, Fixed, Composition, Grade 1	Z219743	20K	⅛	2
	*Resistor to be selected to have value between 7·6 and 8·4 ohms.				
	CAPACITORS		μF		
C1	Capacitor, Electrolytic	Z145025	4	150V	+100 − 20
C2	Capacitor, Electrolytic	Z145025	4	150V	+100 − 20
	MISCELLANEOUS				
V1	Valve, stabiliser	CV286			
T1	Transformer	64387			
MR1	Rectifier, Selenium Iron	60113			
MR2	Rectifier, Selenium Iron	61320			
MR3	Rectifier, Selenium Iron	61320			
X1	Thermistor	64386			
SKTA	Socket, Moulded 8 pole	60717			
SKTB	Voltage selector panel	64385			
PLA	Plug, Fixed 3 pole	Z560565			
	Valveholder, B7G, Grade 2, Class H2	Z560132			
	Retainer, Valve	61456			
	Connector, flexible, screened	67384			

APPENDIX NO. 2

SPECIFICATION OF SWITCHES

FUNCTION SWITCH SWA

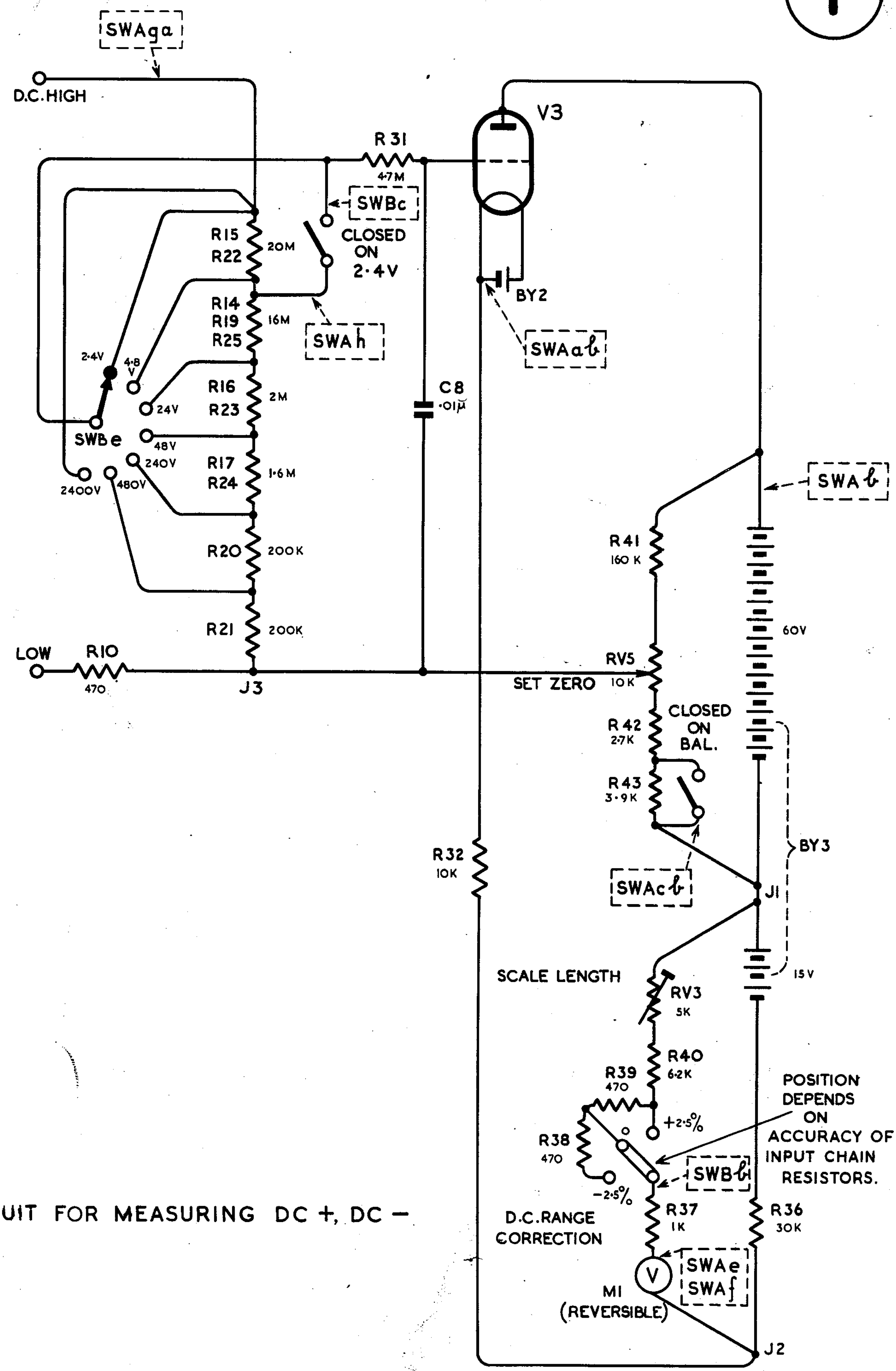
First Wafer carries:	(SWAaa & SWAab on front side (SWAb on rear side
Second Wafer carries:	(SWAca & SWAcb on front side (SWAd on rear side
Third Wafer carries:	(SWAe on front side (SWAf on rear side
Fourth Wafer carries:	(SWAga & SWAgb on front side (SWAh on rear side

RANGE SWITCH SWB

First Wafer carries:	(SWBa on front side (SWBb on rear side	
Second Wafer carries:	(SWBc on front side (SWBc on rear side	)Both sides)are common
Third Wafer carries:	(SWBe on front side (SWBf on rear side	

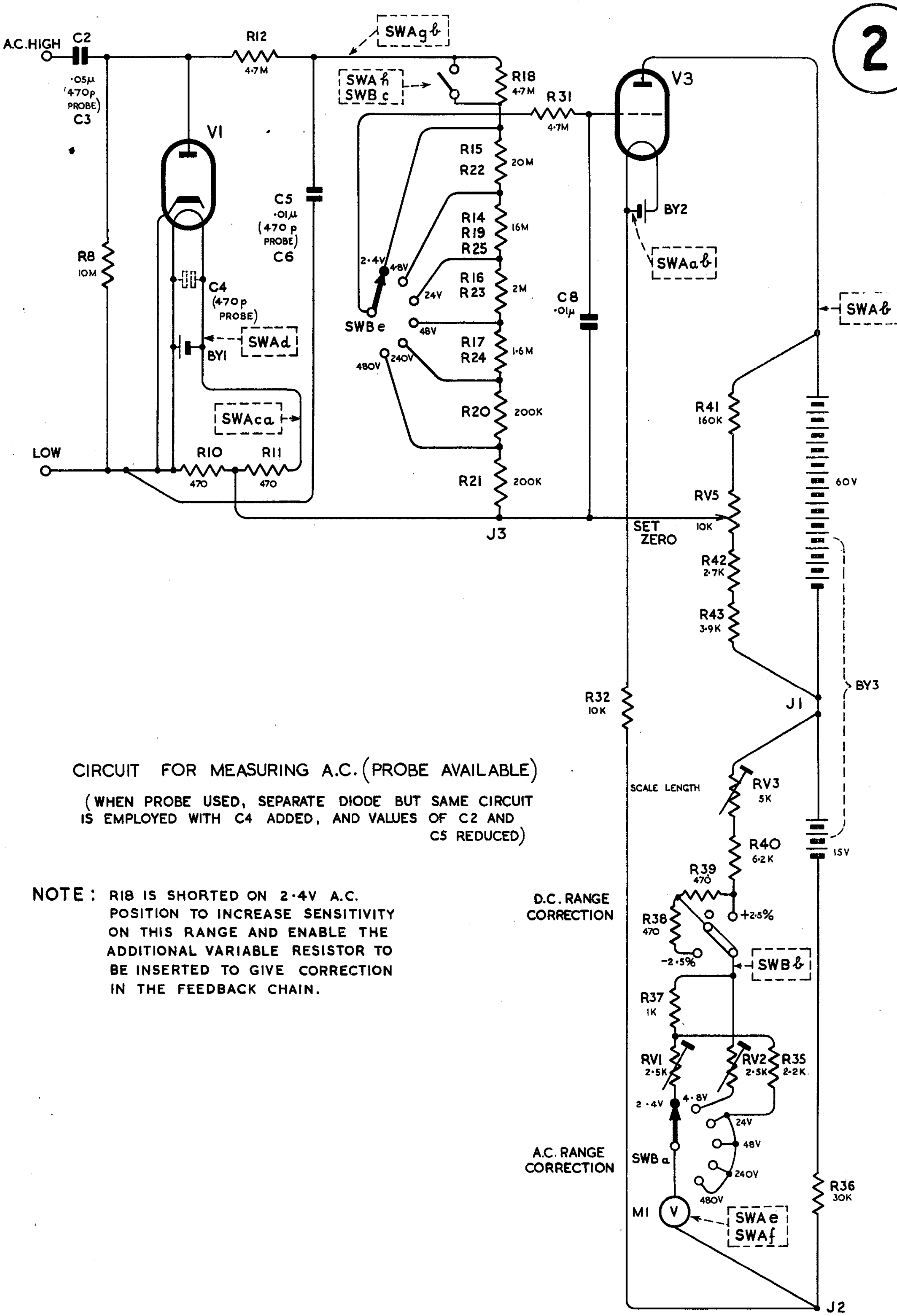
The second wafer of SWB i.e. SWBc has the tags on the front and rear sides of the wafer connected together.

FIG. 1



CIRCUIT FOR MEASURING DC +, DC −

FIG. 2

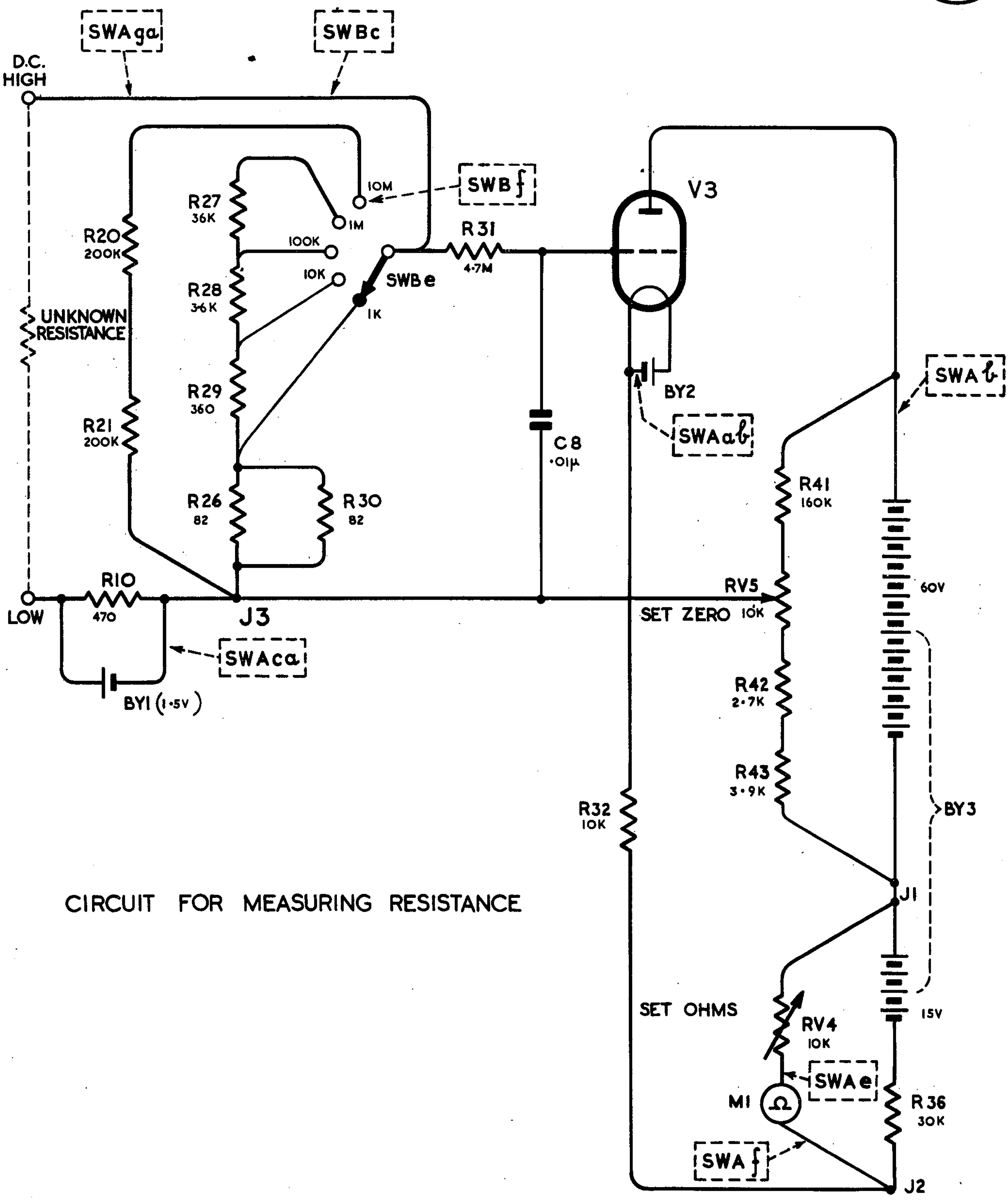


CIRCUIT FOR MEASURING A.C. (PROBE AVAILABLE)

(WHEN PROBE USED, SEPARATE DIODE BUT SAME CIRCUIT IS EMPLOYED WITH C4 ADDED, AND VALUES OF C2 AND C5 REDUCED)

NOTE: R18 IS SHORTED ON 2·4V A.C. POSITION TO INCREASE SENSITIVITY ON THIS RANGE AND ENABLE THE ADDITIONAL VARIABLE RESISTOR TO BE INSERTED TO GIVE CORRECTION IN THE FEEDBACK CHAIN.

FIG. 3

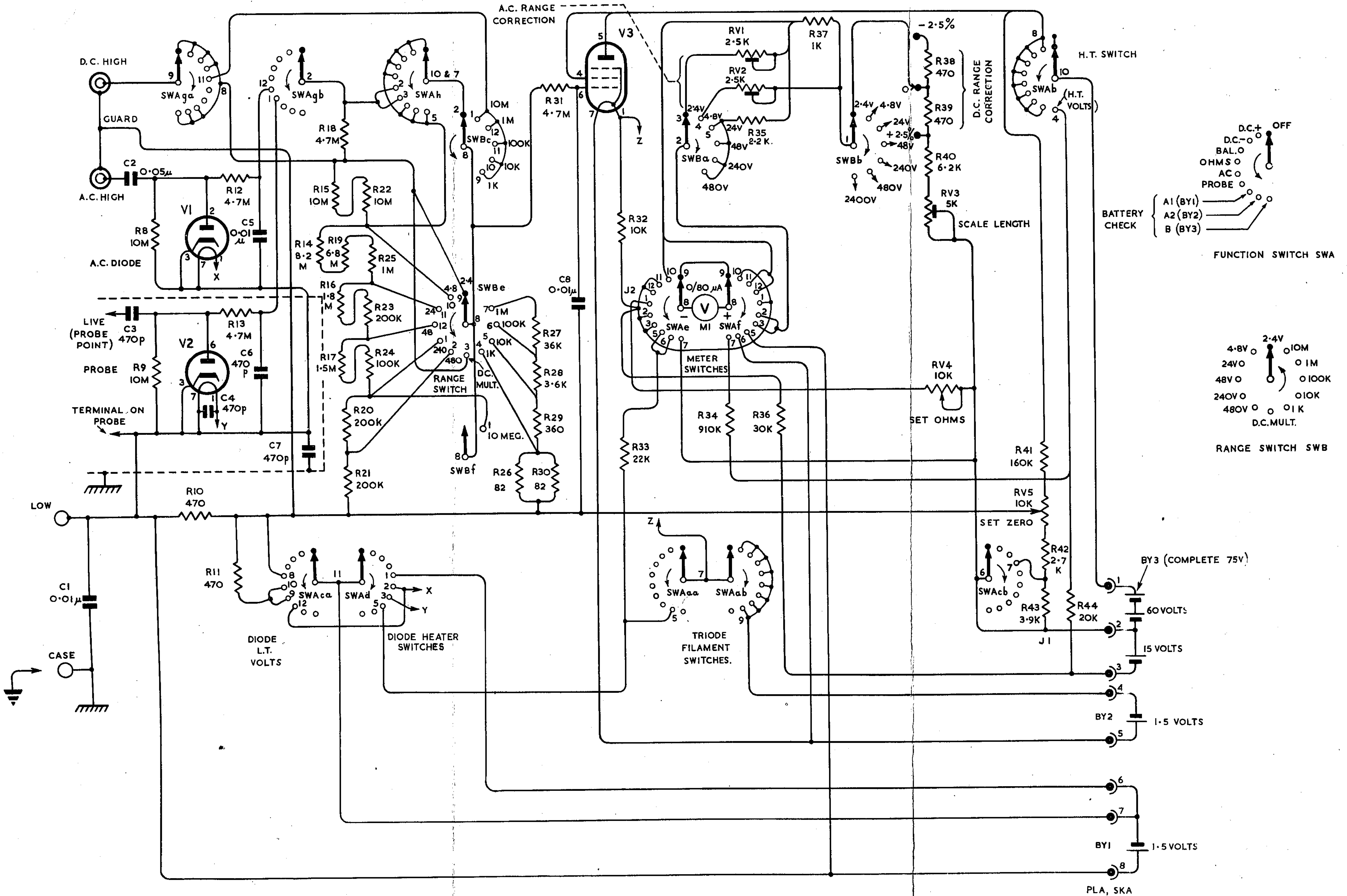


CIRCUIT FOR MEASURING RESISTANCE

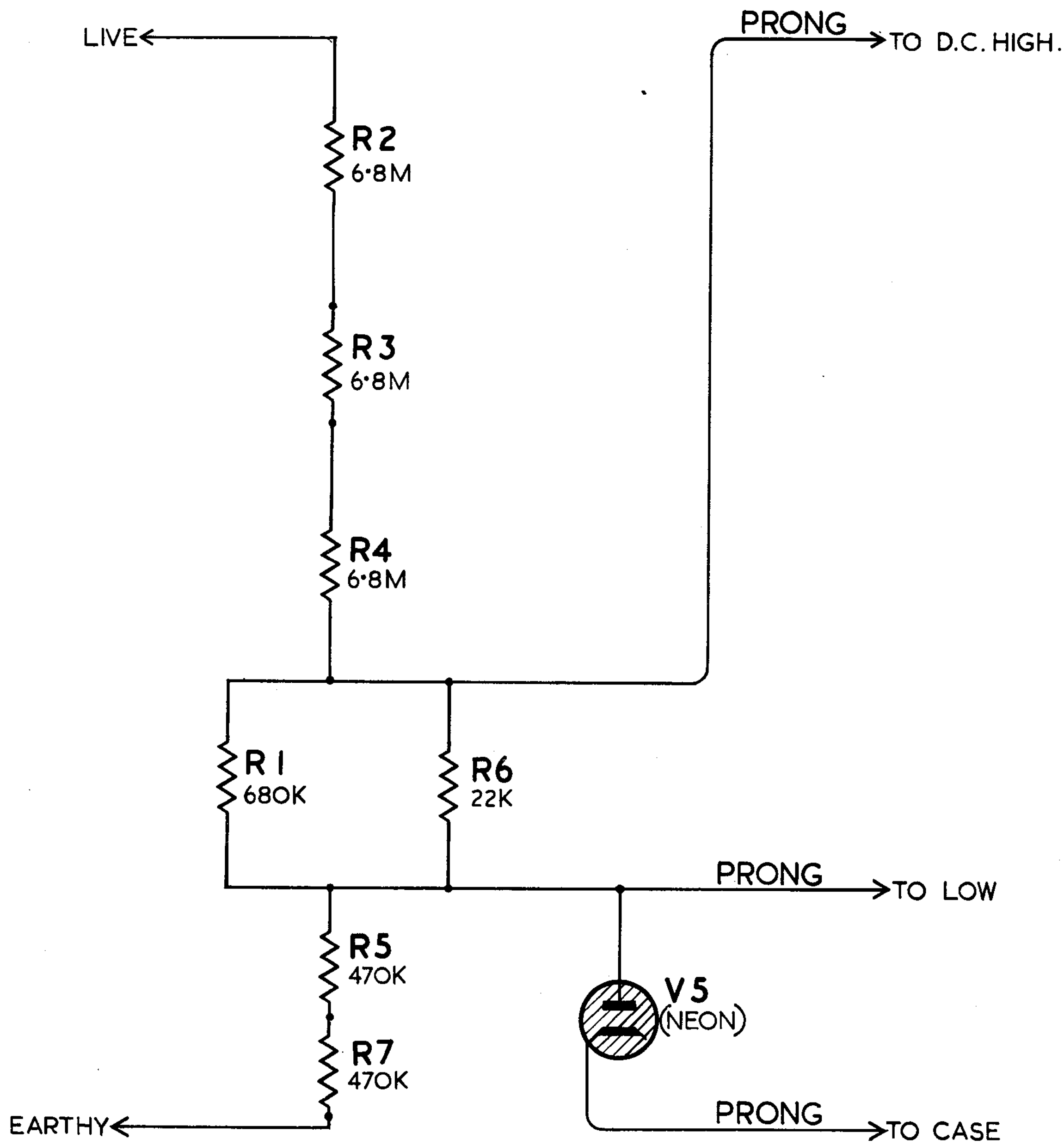
VALVE VOLTMETER CT54

CIRCUIT DIAGRAM.

R.	8 9 10 11 12 13 14, 15, 16, 17 18, 19, 20, 21 22 23, 25, 24 26 27 28 29 30 31, 32, 33 34 35 36 37 38 39 40 41 42 43 44,	R.
C.	1 2 3 4 5 6 7 8	C.
MISC.	SWAga V1, V2, SWAgb SWAca SWAd SWAh SWBc SWBe V3 SWAe SWAaa SWBa SWAf SWAab RV1 RV2 SWBb RV3 RV4 SWAcb RV5 SWAb PLA SKA BY3 BY2 BY1	MISC.

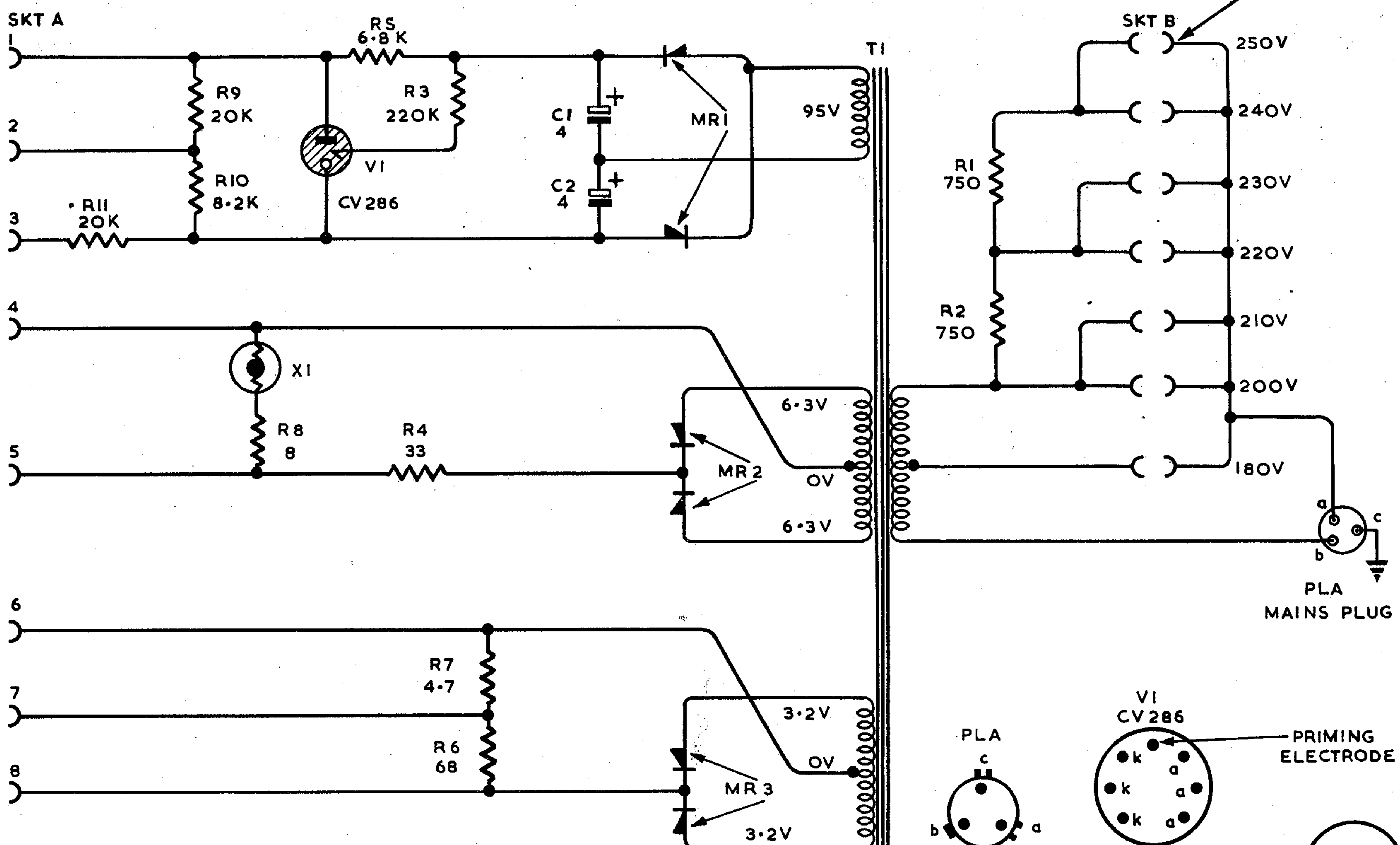


VALVE VOLTMETER CT 54.
CIRCUIT OF D.C. MULTIPLIER.



VALVE VOLTMETER CT 54

CIRCUIT OF A.P. 67922 RECTIFIER UNIT CT A2

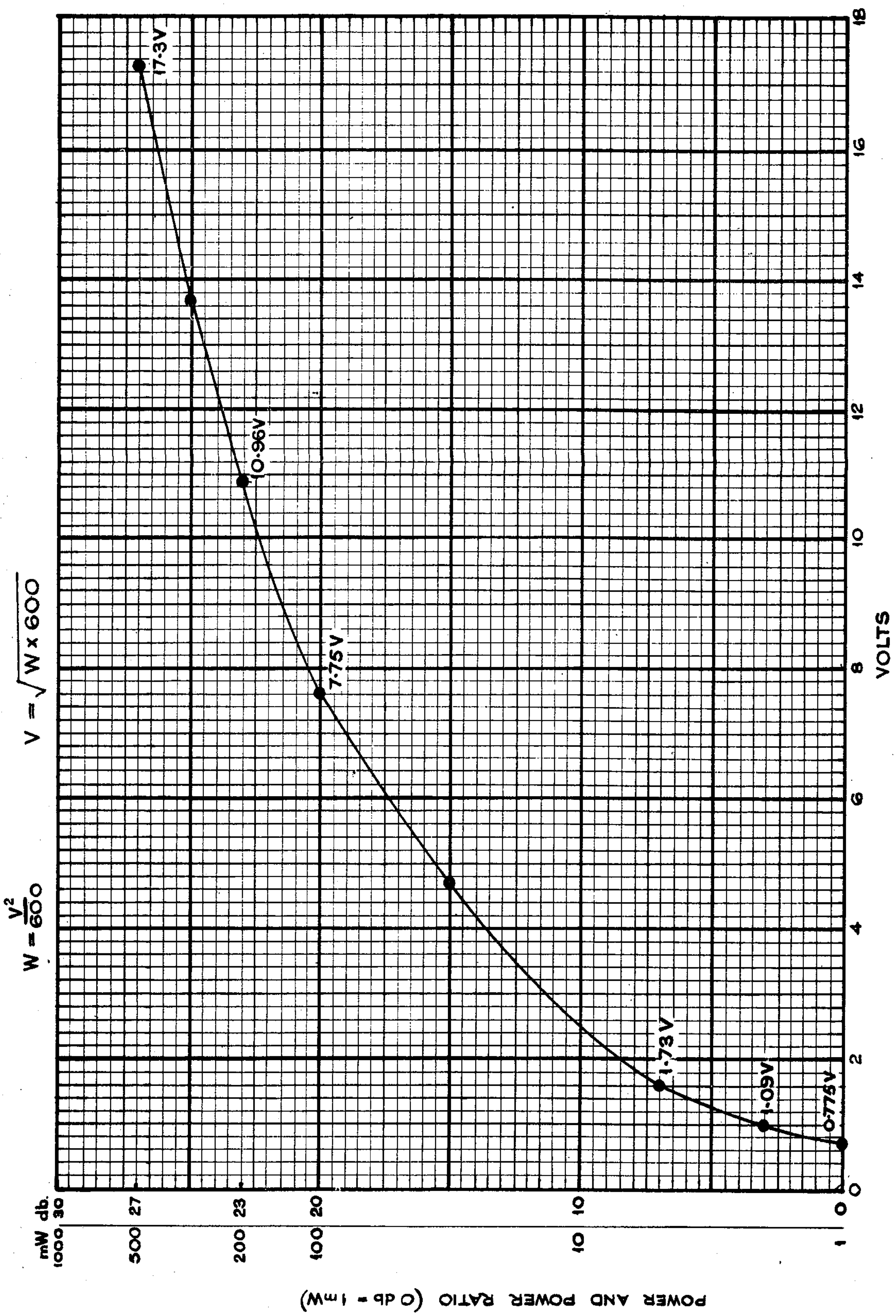


78/55 (1) N.C.

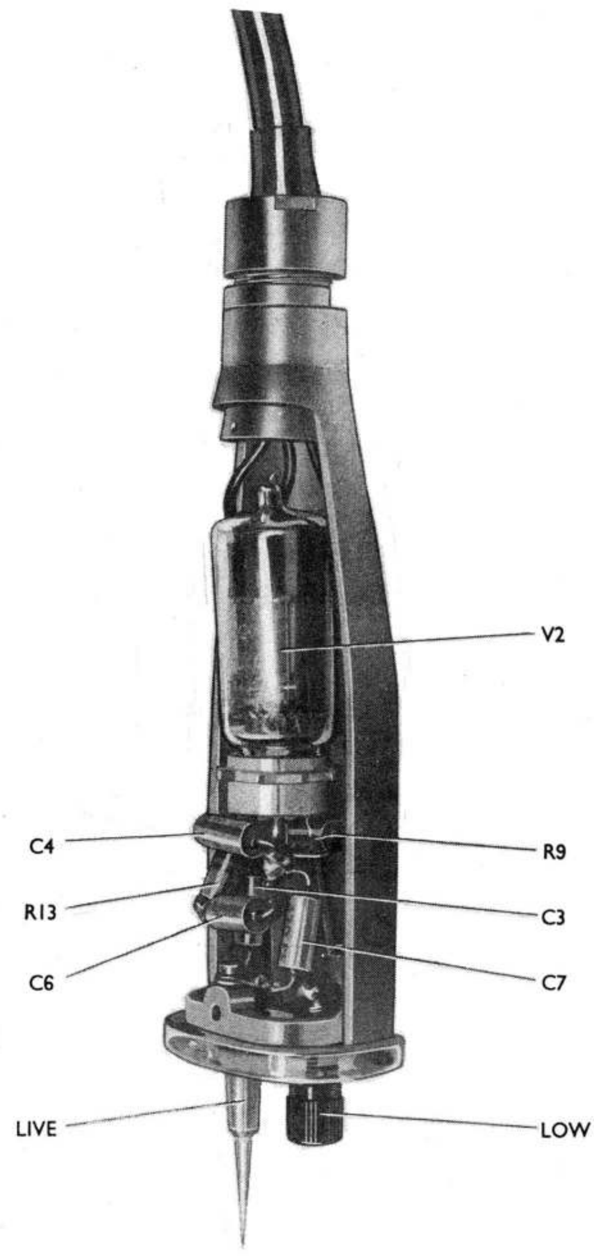
A.F.O. "P" SERIES DIAGRAM 15/55 (UNCLASSIFIED)

CT. 54 VALVE VOLTMETER

CONVERSION GRAPH VOLTS TO POWER FOR 600Ω TERMINATION

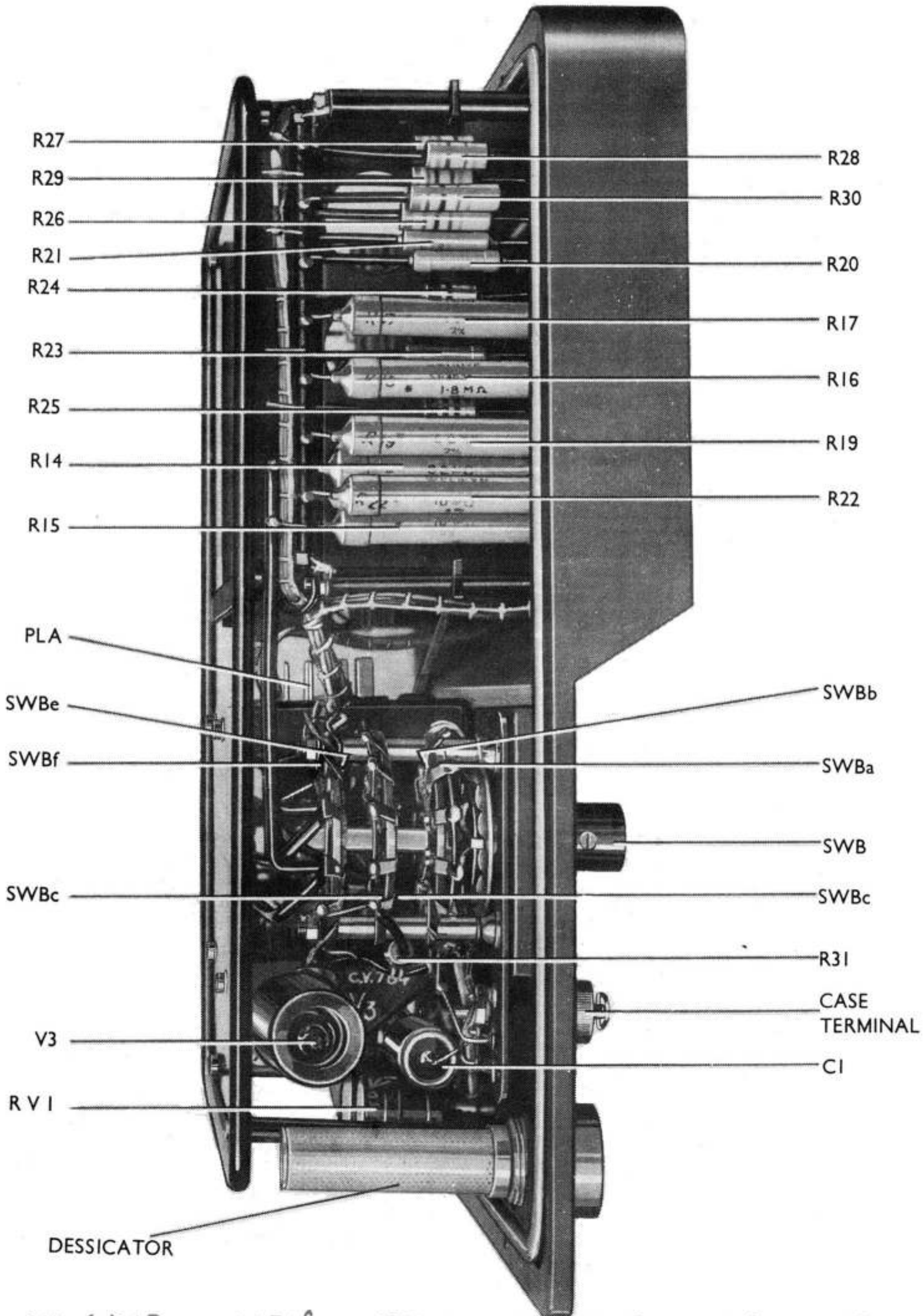


A.P. 67921 VOLTMETER, VALVE, CT.54
COMPONENT LAYOUT (PROBE)



A.P. 67921 VOLTMETER, VALVE, CT.54

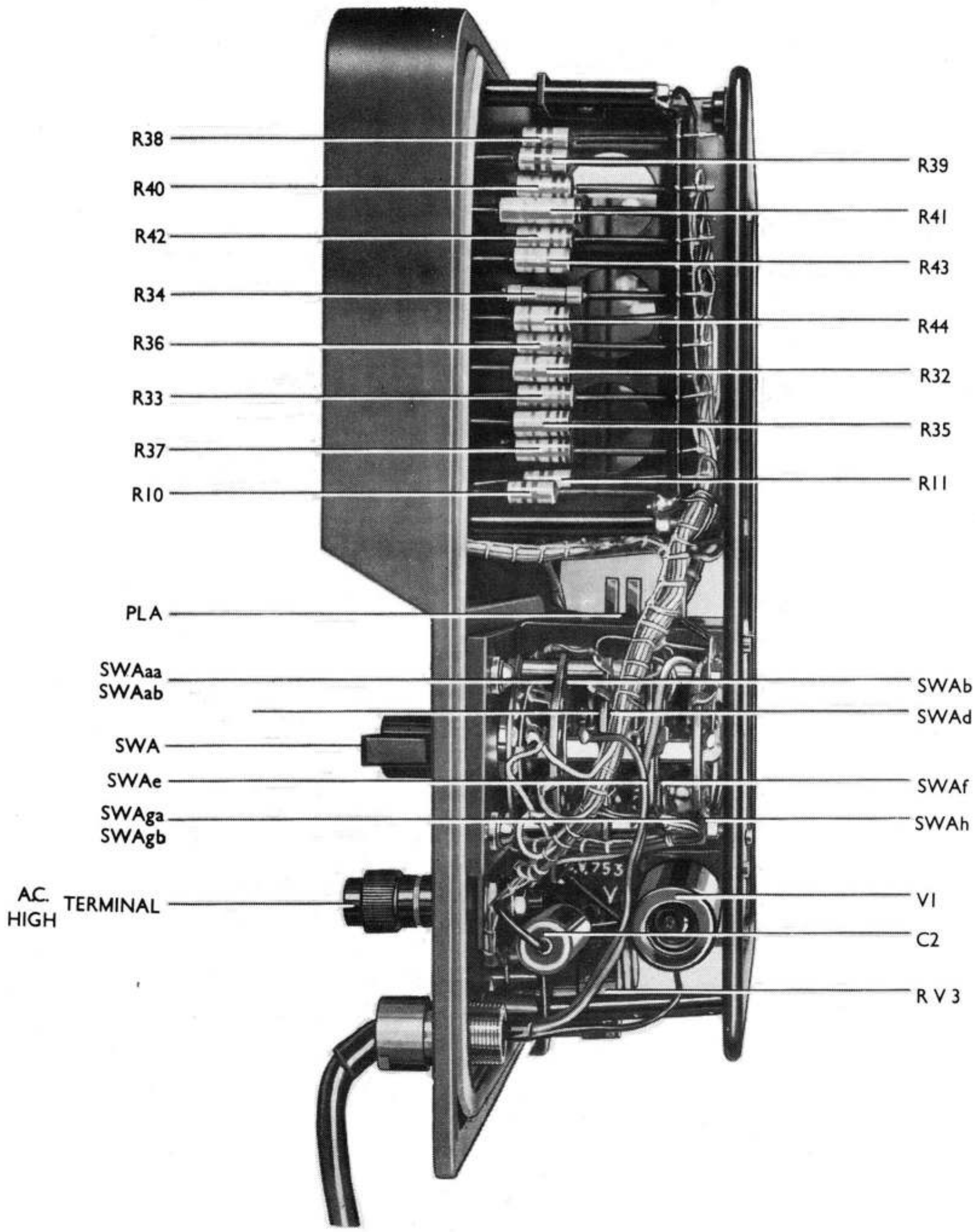
COMPONENT LAYOUT
(LEFT-HAND SIDE VIEW)



NOTE. ON SOME MODELS, CERAMIC TAG STRIPS ARE USED ON THE RESISTOR BANKS.

A.P. 67921 VOLTMETER, VALVE, CT.54

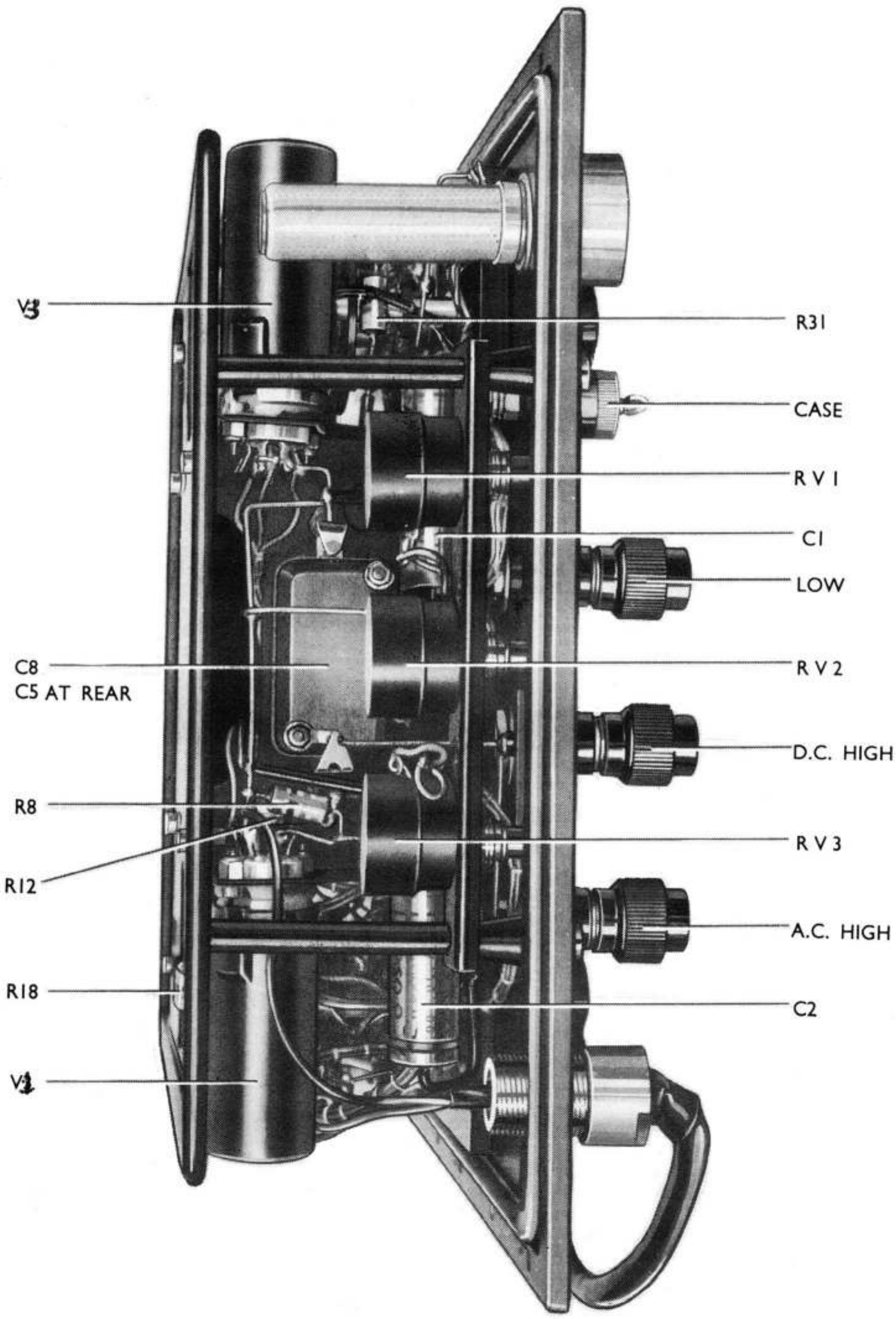
COMPONENT LAYOUT
(RIGHT-HAND SIDE VIEW)



NOTE. ON SOME MODELS, CERAMIC TAG STRIPS ARE USED ON THE RESISTOR BANKS.

A.P. 67921 VOLTMETER, VALVE, CT.54

COMPONENT LAYOUT
(FRONT VIEW)



A.P. 67921 VOLTMETER, VALVE, CT.54

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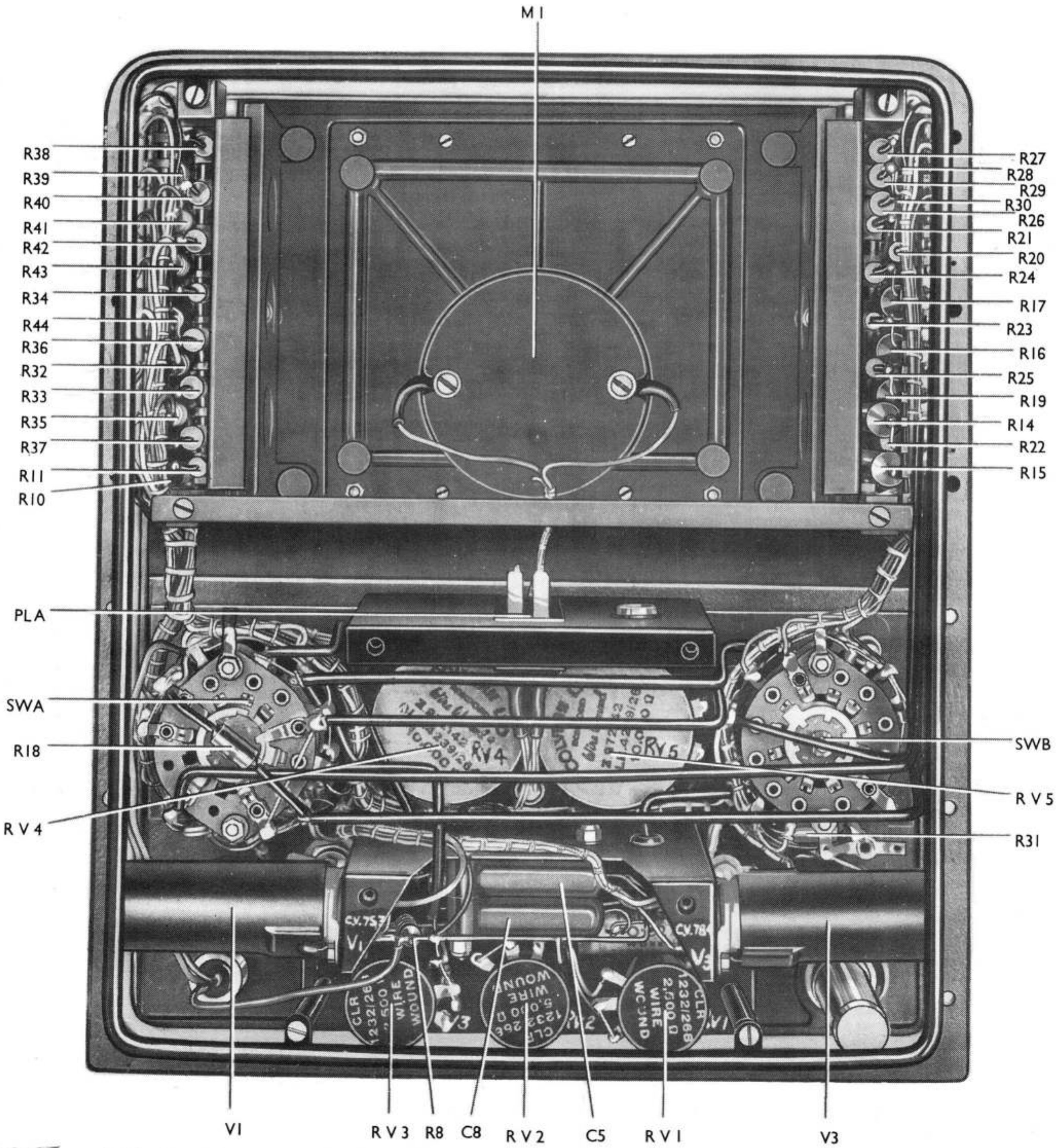
COMPONENT LAYOUT (UNDERSIDE)

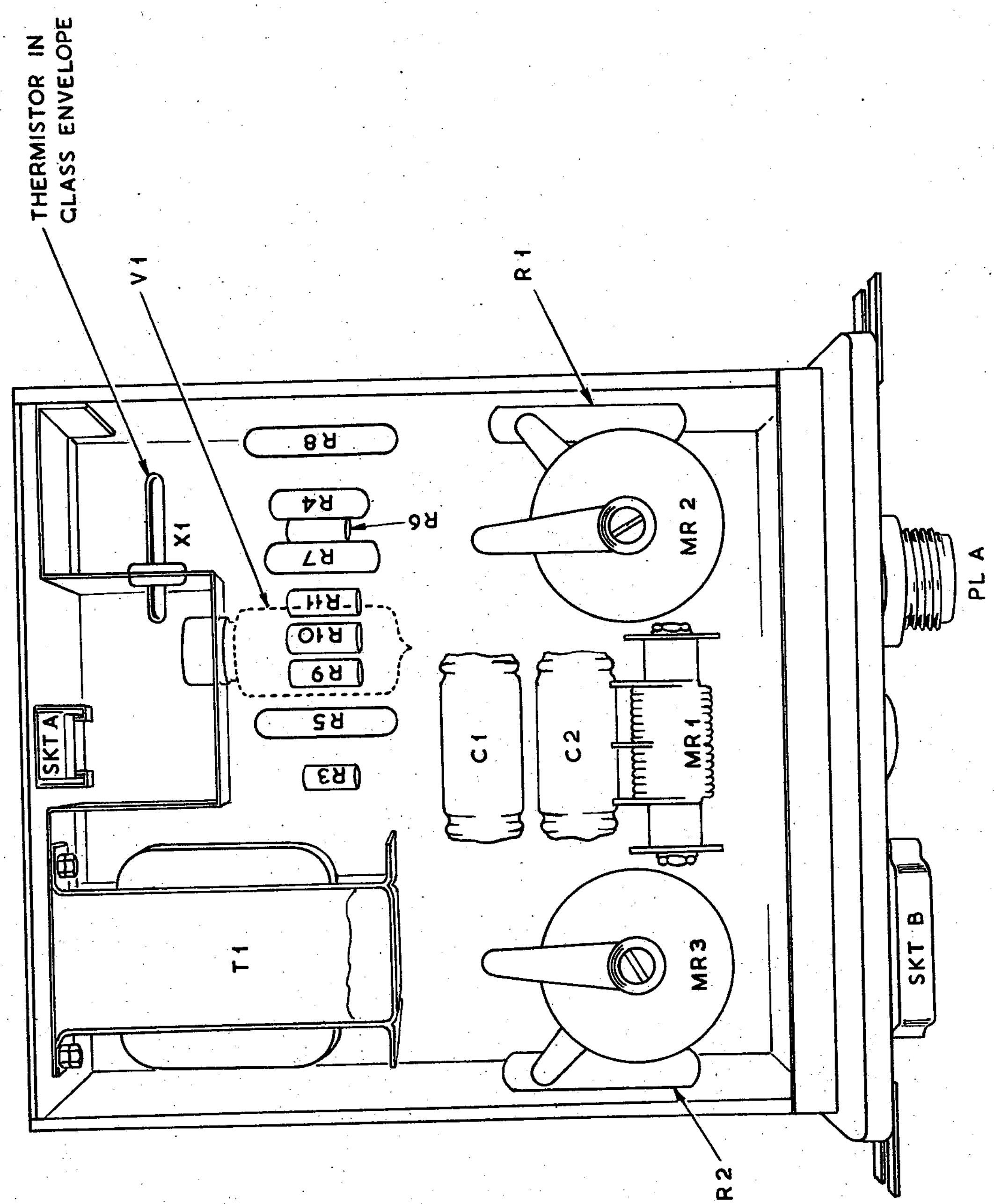


NOTE, ON SOME MODELS, CERAMIC TAG STRIPS ARE USED ON THE RESISTOR BANKS.

A.P. 67921 VOLTMETER. VALVE. CT 54

COMPONENT LAYOUT

(RECTIFIER UNIT CTA2)



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ANKS.


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