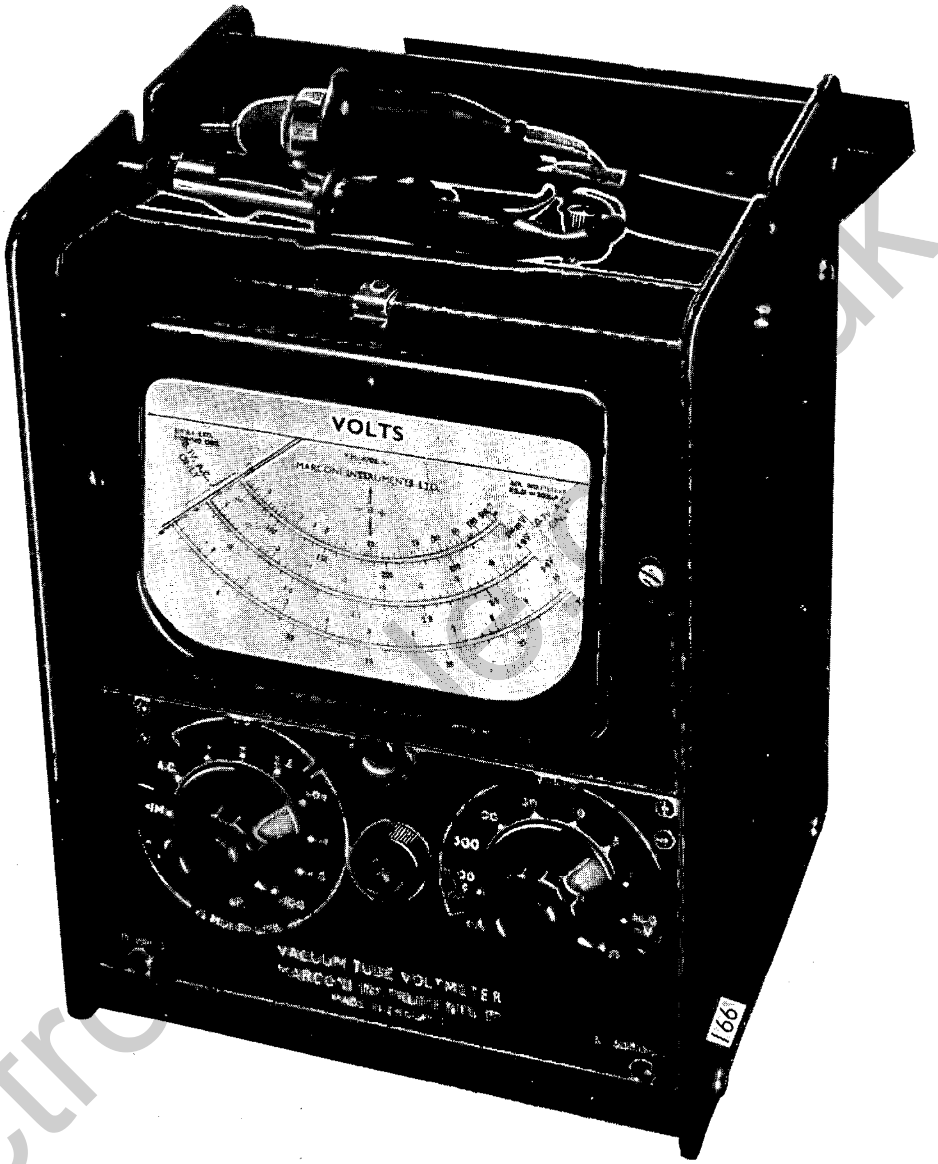


OPERATING
AND
MAINTENANCE
HANDBOOK
No. OM 1041B

Vacuum Tube Voltmeter

TYPE TF 1041B

(*Serial Nos. JA741/001 to JA741/400*)

NOTE: The data on page 14 refers to Voltmeter Serial No. ..A..741\045.......... A.E.L. 1761

MARCONI INSTRUMENTS LTD., ST. ALBANS, HERTS., ENGLAND

W.S. 5c. 2/61

OM 1041B
1**—2/61

Contents

CONTENTS

ILLUSTRATIONS IN TEXT

Schedule of Parts Supplied

The complete equipment comprises the following items:—

1. One Vacuum Tube Voltmeter Type TF 1041B, complete with attached mains lead, a.c. and d.c. probes, and with valves etc., as under:—

   Valves: One: Type EA52, Diode.
   One: Type EB91, Double Diode.
   Two: Type 6BS7, Pentodes.
   One: Type 12AT7 (B309), Double Triode.
   Two: Type XB1, Barretters.
   Lamp: One: 6·3-volt, 0·15-ampere, M.B.C., Pilot Lamp.

2. One Grounding Clip, Type TC 23535/3C, to fit a.c. probe.

3. One R.F. Grounding Sleeve, Type TC 23533/3, to fit a.c. probe.

4. One Operating and Maintenance Handbook, No. OM 1041B.

Data Summary

A.C. Measurements

RANGES:	25 mV to 300 volts in seven ranges. Full-scale deflections: 300 mV, 1, 3, 10, 30, 100, and 300 volts.
ACCURACY:	1, 3, 30, and 100 V ranges: ± 2% of f.s.d. ± 10 mV. Other ranges: ± 3% of f.s.d. ± 10 mV.
FREQUENCY RESPONSE:	Typical characteristic, relative to response at 1 kc/s, is flat to within: − 0·5 dB at 20 c/s, ± 0·2 dB from 50 c/s to 500 Mc/s, + 1 dB at 1 000 Mc/s, + 3 dB at 1 500 Mc/s. (See Fig. 2.2 for frequency characteristic curve.)
INPUT CONDITIONS:	Shunt Capacitance: approx. 1·5 μμF. Resistance: greater than 5 MΩ at 1 kc/s, greater than 500 kΩ at 10 Mc/s, and approx. 150 kΩ at 100 Mc/s. (See Fig. 2.3.)

D.C. Measurements

RANGES:	10 mV to 1 000 volts in eight ranges. Full-scale deflections: 300 mV, 1, 3, 10, 30, 100, 300, and 1 000 volts, positive or negative. Centre-zero facility on all ranges.
ACCURACY:	± 2% of f.s.d. ± 10 mV, except for inputs greater than 100 volts when the accuracy is ± 3% of f.s.d.
INPUT CONDITIONS:	Resistance: 100 MΩ, plus 1 MΩ isolating resistor in probe. Capacitance to ground: approx. 2 μμF.

Meter Zero: A supply mains variation of 6% will cause a deflection change not exceeding 30 mV at f.s.d. on all a.c. ranges and 20 mV on all d.c. ranges.

Resistance Measurements

RANGE: 0·02 ohm to 500 MΩ in eight ranges. Full-scale deflections: 50 ohms, 500 ohms, 5 kΩ, 50 kΩ, 500 kΩ, 5 MΩ, 50 MΩ, and 500 MΩ.

Power Supply: 200 to 250 volts, or 100 to 150 volts after adjusting internal link, 40 to 100 c/s; 30 watts.
Models supplied ready for immediate 100- to 150-volt use if specified at time of ordering.

Dimensions (over projections):	*Height*	*Width*	*Depth*
	10¾ in (26·5 cm)	7¾ in (20 cm)	6¾ in (17·5 cm)

Weight: 10½ lb (4·8 kg)

OM 1041B
1—7/59

1 Description

1.1 GENERAL

The TF 1041B is a high-grade voltmeter which can be used for a wide range of a.c., d.c., and resistance measurements.

A.C. voltages can be measured from 20 c/s to 1 500 Mc/s; a special grounding sleeve is supplied with the a.c. probe for making the necessary low-reactance earth connection at u.h.f. For d.c. measurements the meter can be switched to give forward deflection with either positive or negative voltages, and a centre-zero facility is available to aid the precise determination of null point in, for example, bridges and discriminators.

Both a.c. and d.c. inputs are isolated from chassis. The filament supply to all valves is stabilized and the meter circuit is temperature compensated. The meter is automatically protected from gross overload by the characteristics of the circuit; as a further precaution for the most sensitive ranges, overload rectifiers are fitted across the meter.

The measurement capabilities of the instrument may be considerably extended by the use of the optional accessories described below.

1.2 OPTIONAL ACCESSORIES

Two multipliers, a coaxial " T " junction, and a 50-ohm coaxial dummy load are available for use with the Voltmeter. For stowing the multipliers and " T " junction, a polished hardwood carrying case, Type TM 4935, can also be supplied. (See illustration, Fig. 2.6. *Note:* The latest version of connector TM 5749 takes the form of a flexible lead with an appropriate mating socket at each end.)

1.2.1 D.C. Multiplier Type TM 5033A (with Connector TM 5749)

This enables high voltages, such as in television receivers, to be measured with safety. When connected to the Voltmeter, it gives a voltage reduction ratio of 30:1 and is usable up to 30 kV. The calibration of the Multiplier is accurate to within $\pm 2\%$ and it has an input impedance of 3 000 MΩ.

1.2.2 A.C. Multiplier Type TM 5032

Transmitter voltages up to 2 kV r.m.s., at frequencies of 10 kc/s and above, can be measured with this auxiliary probe cap which fits readily over the normal a.c. probe head. It comprises a capacitive divider with a ratio of 100:1, and places a capacitance of 2 μμF across the circuit under test. The unit is accurate to within $\pm 2\%$.

1.2.3 Coaxial " T " Connector Type TM 5031A

This device can be fitted to the a.c. probe head to facilitate voltage measurements on 50-ohm coaxial cables. For this purpose one of the two series arms of the " T " is terminated in a type N plug and the other in a type N socket. The v.s.w.r. of the connector is of the order of 1.1 at 800 Mc/s.

1.2.4 5-watt Dummy Load Type TM 5582

This 50-ohm, wide-band coaxial load is particularly useful as a well-matched termination in coaxial line measurements. It has a type N input socket, at which the v.s.w.r. is better than 1.1 up to 500 Mc/s and better than 1.2 up to 1 200 Mc/s. It is of robust, fully enclosed construction and completely non-radiating.

Electrojumble.org.uk

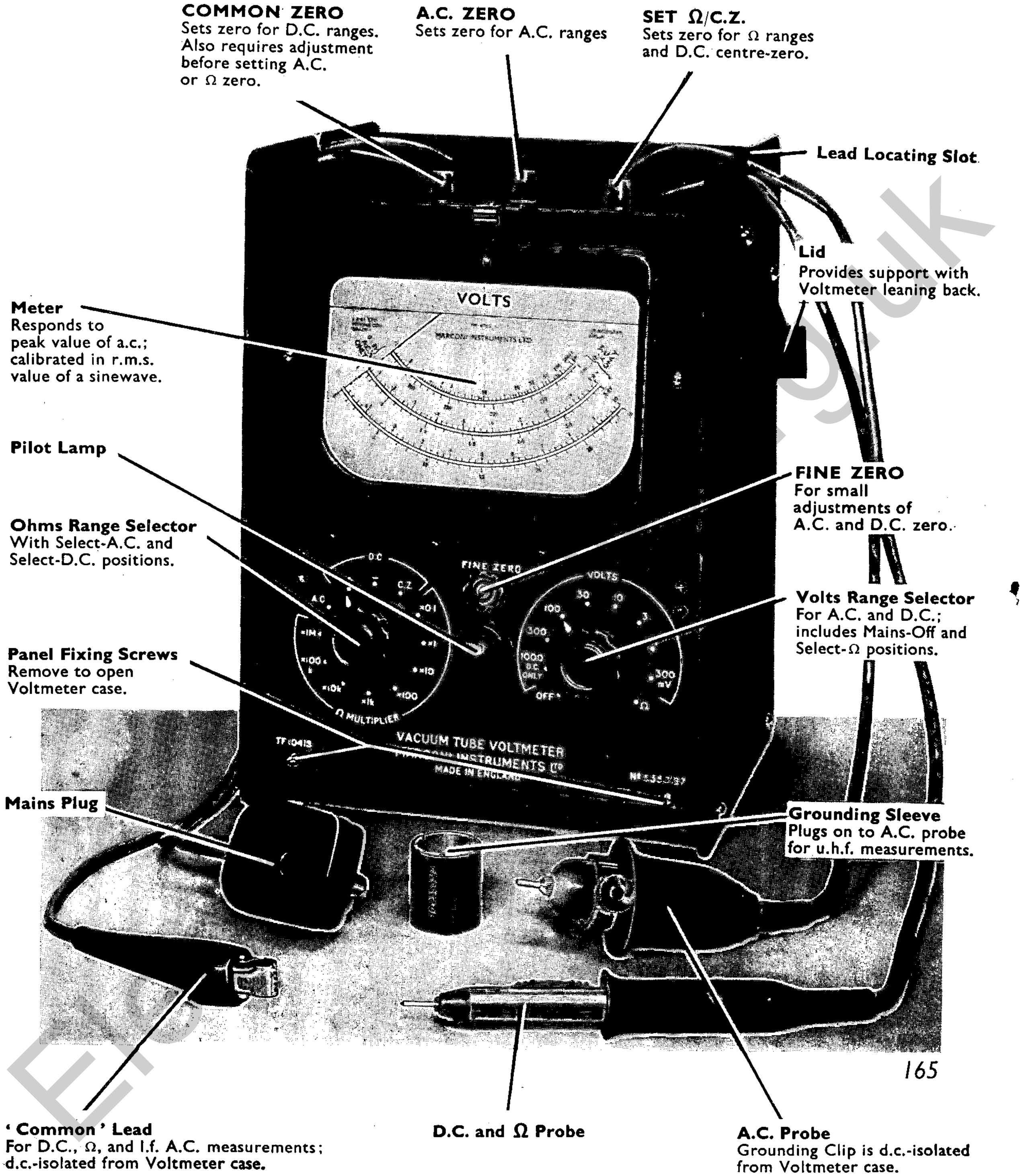


Fig. 2.1 Controls and Operating Facilities.

OM 1041B
1*—10/60

2 Operation

2.1 INSTALLATION

The TF 1041B is normally despatched ready for immediate use with 240-volt, 40- to 100-c/s mains supplies. Before using the instrument, check the mains transformer tapping, or adjust to suit the local supply, as described in Section 5.2.

2.2 PRELIMINARY ADJUSTMENTS

(1) Set the mechanical zero adjuster on the meter.

(2) Open the lid by lifting its front edge to disengage the spring clip above the meter, using gentle pressure with the thumbs on the top of the meter surround panel if necessary. Pull out the mains lead and slip it into the slot at the top of one of the side panels.

(3) Switch on by turning the right-hand Selector switch from the OFF position. Allow the instrument to warm up for at least 10 minutes, but preferably for half an hour.

With the lid hinged back to form a support, the Voltmeter may, if desired, be operated in a sloping position.

2.3 A.C. MEASUREMENTS

2.3.1 Procedure

When the instrument has warmed up, first set zero as follows:—

(1) Turn the left-hand Selector switch to D.C.+ or D.C.− and the right-hand Selector switch to 300 mV.

(2) With the D.C./Ω probe and COMMON lead temporarily connected together, adjust the COMMON ZERO control to bring the meter pointer to zero.

(3) Turn the left-hand Selector switch to A.C. and, with the a.c. probe needle and Grounding Clip temporarily connected together, adjust the A.C. ZERO control to again bring the meter pointer to zero.

Any subsequent small variations in a.c. zero may be offset by means of the FINE ZERO control (or the A.C. ZERO control on earlier models without a FINE ZERO control).

Having set zero, make the measurement as follows:—

(1) Turn the left-hand Selector switch to A.C.

(2) Set the right-hand Selector switch to the range appropriate to the expected level of voltage to be measured.

If the level of the voltage to be measured is unknown, always set the Selector switch to the least sensitive range, i.e. 300 volts, before connecting the Voltmeter to the equipment under test. (The 1 000-volt range is for d.c. measurements only.)

(3) Connect the A.C. probe to the voltage source (for details see Sections 2.3.2 or 2.3.4), and read the voltage from the appropriate scale. Readings should be taken from one or other of the two bottom meter scales except when the 300-mV, 1-volt, or 3-volt range has been selected; for these ranges use the special meter scales marked 0—3V A.C. ONLY.

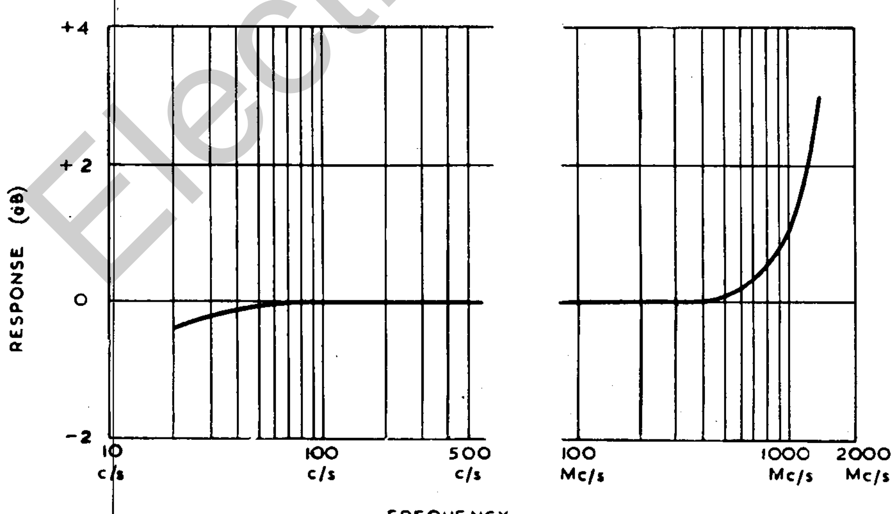


Fig. 2.2

Typical Frequency Characteristic of A.C. Probe.

2.3.2 Connections

The meter is calibrated in terms of the voltage that exists between the base of the probe needle (Hi) and the ground band of the probe casing (Lo). The probe casing is a.c. coupled to the Voltmeter chassis and directly coupled to the COMMON lead. For l.f. measurements on other than the 300-mV to 3-volt ranges the COMMON lead can be used as the " Lo " connection.

Since the " Lo " input is d.c. isolated from the Voltmeter chassis by a 50-MΩ resistor, the point to which it is to be connected on the equipment under test need not be at earth potential; however, it should preferably have a low impedance to earth. This will prevent hum being introduced into the test circuit and will also prevent errors due to the building-up of a d.c. potential across the decoupling capacitor which connects the Voltmeter COMMON line to chassis.

At the lower radio frequencies—up to about 250 Mc/s—the " Lo " connection is made with the aid of a short fly-lead; this is attached to the Grounding Clip which fits over the ground band of the a.c. probe.

Above about 250 Mc/s the use of a fly-lead to make the " Lo " connection may introduce appreciable reactance between the equipment under test and the Voltmeter COMMON line. For this reason a special low-inductance Grounding Sleeve is supplied with the instrument; this sleeve, which replaces the normal probe clip and fly-lead, should be used for high-frequency measurements requiring a high absolute accuracy. Full instructions for using the sleeve are given in Section 2.3.4.

Approximate measurements at r.f. may be made without the use of either earth clip or COMMON lead; the " Lo " a.c. earth return is made automatically via the decoupling capacitor to chassis in the Voltmeter or by the self-capacitance existing between the probe casing and the chassis of the equipment under test.

2.3.3 Probe Input Impedance

The probe presents to the source under test a capacitance of approximately 1·5 μμF and a shunt resistance which varies with frequency. This variation is shown in Fig. 2.3.

2.3.4 U.H.F. Measurements—Use of Special Grounding Sleeve

As explained in Section 2.3.2, the use of the probe clip in conjunction with a fly-lead is not satisfactory for high-accuracy measurements at frequencies above about 250 Mc/s. So that direct connection may be made to the voltage source under test, a special Grounding Sleeve, Type TC 23533/3 is supplied with the instrument. This consists of a low-inductance sleeve which fits over the probe ground band and is concentric with the probe needle. It is stowed, when not in use, in the case-top recess.

In the base of the sleeve are three holes, tapped 6 BA. These enable the sleeve to be bolted to the chassis of the equipment under test. The sleeve should be mounted so that it is concentric with the " live " point to be measured. The " live " point itself should be arranged so that it protrudes just above the level of the chassis.

To connect the probe, unscrew the probe needle and push the probe into the grounding sleeve until contact is made with the " live " point. With this arrangement, the input capacitance is approximately 4 μμF.

Note: The maximum voltage which can be measured is limited above 100 Mc/s—see Section 2.3.8.

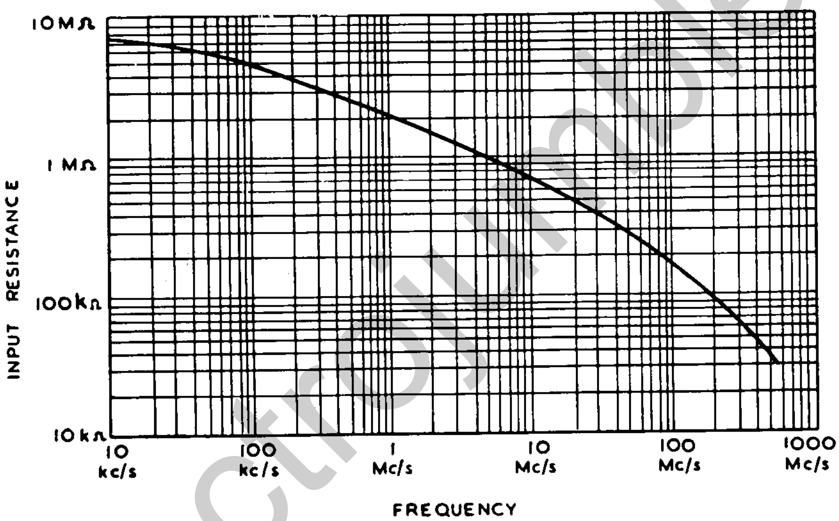


Fig. 2.3

Variation of Probe Input Resistance with Frequency

2.3.5 Indication

The meter is calibrated to read the r.m.s. value of a sinusoidal voltage. When appreciable distortion is present in the waveform, the meter reading differs from the r.m.s. value by an amount depending on the magnitude and phase of the harmonics. When one harmonic predominates, the percentage difference in either direction can be as high as the percentage distortion.

On the higher ranges, the peak value of both simple and complex waveforms is obtained by multiplying the meter reading by 1·414.

2.3.6 Error due to High Source Resistance

The probe-charging capacitor can only charge up to the peak value of the applied voltage if the source resistance is zero. As the source resistance will inevitably have a finite value, the probe capacitor will only charge to a voltage dependent on the relative values of the source resistance and the probe-diode load resistance; this effect is known as peak clipping. The theoretical aspect of this phenomenon is fully described in an article by M. G. Scroggie, B.Sc., M.I.E.E., in the *Wireless Engineer*, Vol. 32, 1955, page 53.

Peak clipping produces a reading error which is dependent on the value of the source resistance. The degree of error at audio frequencies is shown graphically in Fig. 2.4. The error increases at higher frequencies, but the effect is of less significance in view of the lower source resistance usually encountered.

It should be remembered that the value of source resistance is the total effective resistance between the probe connections; for example, when measuring the voltage developed across the anode load resistor of an amplifier stage, the effective source resistance is given by the anode load in parallel with the r_a of the valve.

2.3.7 Voltage Limitations

The peak voltage applied between the " Hi " and " Lo " probe connections must not exceed 425 volts. Allowance must be made for this fact when measuring pulsed signals or a.c. superimposed on d.c.; in the latter case, the peak voltage is given by the d.c. plus the peak a.c.

The combined d.c. plus peak a.c. voltage applied between the " Lo " connection and earth must not exceed 375 volts.

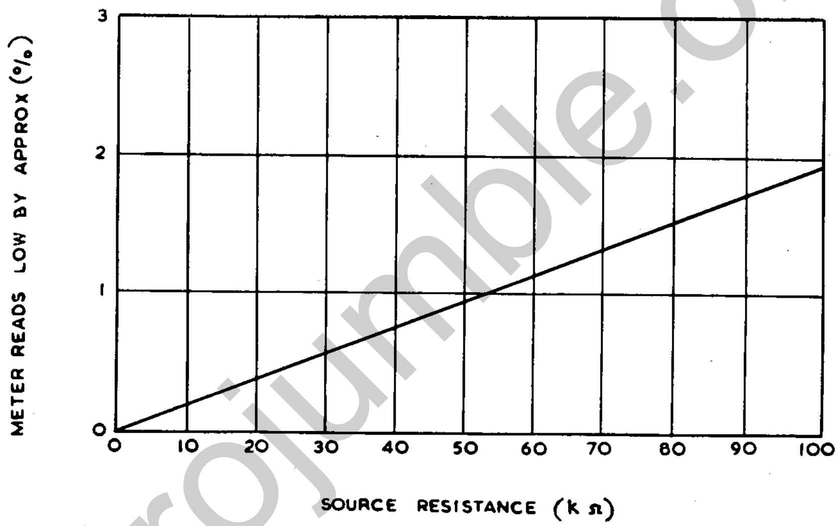


Fig. 2.4 Reading Error at A.F. as a Function of Source Resistance

2.3.8 Limitation on Input Level Above 100 Mc/s

Up to 100 Mc/s the maximum r.m.s. voltage that may be applied to the probe is 300 volts. Above 100 Mc/s, the diode is subject to a peak-inverse voltage limitation which is given by the expression

$$\textit{Maximum p.i.v.} = \frac{10^5}{f\,(Mc/s)}\ \textit{volts}$$

From this expression, the maximum r.m.s. voltage that may be applied to the probe is given by

$$\textit{Maximum applied voltage} = \frac{10^5}{2\sqrt{2}f}\ \textit{volts}$$

From this second expression Fig. 2.5 has been drawn. This graph shows the maximum permissible r.m.s. voltages for application to the probe at frequencies above 100 Mc/s.

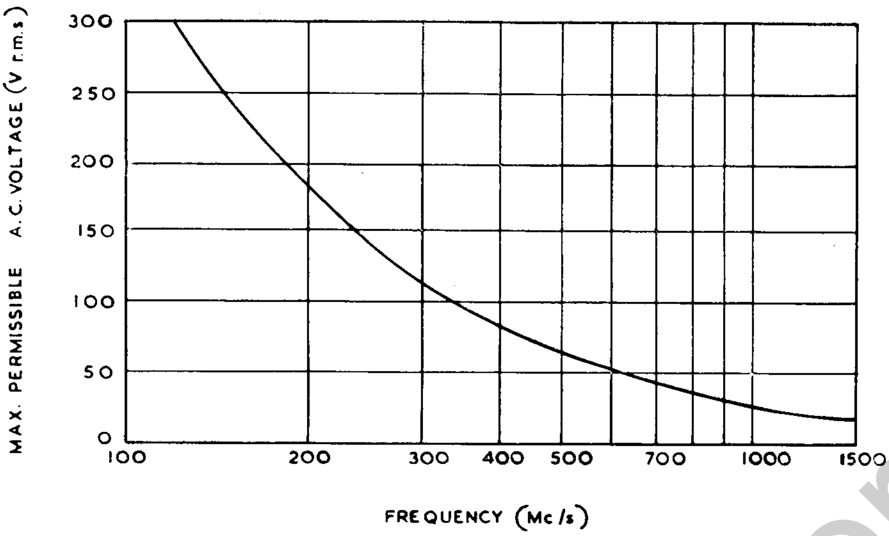


Fig. 2.5

A.C. Probe Derating Characteristic

2.4 D.C. MEASUREMENTS

2.4.1 Procedure

When the instrument has warmed up, first set zero as follows:—

(1) Turn the left-hand Selector switch to D.C.+ or D.C.— and the right-hand Selector switch to 300 mV.

(2) Temporarily connect the D.C./Ω probe and COMMON lead together and adjust the COMMON and FINE ZERO controls to bring the meter pointer to zero.

Having set zero, make the measurement as follows:—

(1) Turn the left-hand Selector switch to D.C.+ and the D.C./Ω probe switch to V.

(2) Set the right-hand Selector switch to the range appropriate to the expected level of the voltage to be measured. If the level of the voltage to be measured is unknown, always set the Selector switch to the least sensitive range, i.e. 1 000 volts, before connecting the Voltmeter to the source under test.

(3) Connect the D.C./Ω probe and COMMON lead to the voltage source (for details see Section 2.4.2) and read the voltage from the appropriate meter scale. Readings should be taken from one or other of the bottom pair of meter scales as appropriate to the setting of the right-hand Selector switch.

The combined d.c. plus peak a.c. voltage applied between the " Lo " connection and earth must not exceed 375 volts.

2.4.2 Connections

The TF 1041B will measure unbalanced voltages up to 1 000 volts d.c. Connection to the voltage source to be measured is made by means of the D.C./Ω probe and the COMMON lead. Since the COMMON lead is isolated from the Voltmeter chassis by a resistance of 50 MΩ it does not necessarily have to be connected to earth on the equipment under test; it must, however, always be connected to the point nearer to earth potential to prevent the input resistance being shunted by the 50-MΩ isolating resistor.

It is also advisable to connect the COMMON lead to a low-impedance point on the unit under test; this prevents hum being introduced into the test circuit and also prevents measurement errors due to the building-up of a d.c. potential across the decoupling capacitor which connects the Voltmeter COMMON line to chassis.

Use the " + " position of the left-hand Selector switch when the D.C./Ω probe is connected to the more positive point, and the " — " position when connected to the more negative.

When making voltage measurements, the finger-tip D.C./Ω selector on the d.c. probe must be towards the base, or lead end, of the probe, revealing the engraving " V " (volts) on the probe body. With the selector in the " V " position, an isolating resistor of 1 MΩ is introduced in series with the probe lead to shield the circuit under test from the effects of probe-lead capacitance.

2.4.3 Input Impedance

The Voltmeter D.C./Ω probe has an r.f. capacitance to ground of approximately 2 μμF. The input resistance, that is, between the probe and the COMMON line, is 103 MΩ; the COMMON line itself is isolated from the Voltmeter chassis by a resistance of 50 MΩ in parallel with a capacitance of 0 01 μF.

2.4.4 Centre-Zero Measurements

With the left-hand Selector switch at C.Z. (Centre-Zero) a biasing voltage is automatically applied to the meter, causing the pointer to take up a centre-zero position. This facility may be used on any of the d.c. ranges for the precise determination of null point in bridges, discriminators, or similar equipment.

The centre-zero point is indicated by a small vertical red line above the meter scales. Positive voltages produce a deflection to the right and negative voltages a deflection to the left. The magnitude of the voltage is indicated by the reading on the appropriate d.c. scale relative to the mid-scale reading, although with lesser accuracy than in normal d.c. measurements.

(1) Turn the left-hand Selector switch to C.Z. and the right-hand Selector switch to the range appropriate to the expected level of the out-of-balance voltage, bearing in mind that full-scale deflection in the centre-zero condition corresponds to half that indicated by the setting of the Selector switch.

(2) Temporarily connect the D.C./Ω probe and COMMON lead together and adjust the SET Ω/C.Z. control to bring the meter pointer to the centre-zero mark above the meter scales.

On the most sensitive range (300-mV), it may be found that the SET Ω/C.Z control has insufficient coverage to bring the meter pointer to the centre-zero mark. In this case,

(i) Set the SET Ω/C.Z. control at mid-travel.

(ii) Adjust the COMMON ZERO control to bring the pointer close to the centre-zero mark.

(iii) Adjust the SET Ω/C.Z. control to bring the pointer exactly to the centre-zero mark.

(3) Connect the D.C./Ω probe and COMMON lead to the source under test (for details see Section 2.4.2). The meter pointer will deflect to the right if the D.C./Ω probe is connected to the more positive point, and to the left if it is connected to the more negative point.

As the null point is approached, the right-hand Selector switch may be turned to a more sensitive range in order to obtain a higher discrimination. When switching to a new range it is advisable to reset the centre-zero; when switching to or from the 300-mV range it is essential to do so.

2.5 RESISTANCE MEASUREMENTS

2.5.1 Procedure

When the instrument has warmed up, first set zero as follows:—

(1) Turn the left-hand Selector switch to × 10 and the right-hand Selector switch to Ω.

(2) Temporarily connect the D.C./Ω probe and COMMON lead together and adjust the COMMON and FINE ZERO controls to bring the meter pointer to zero.

Note: On the " × 1 " and " × 0·1 " resistance ranges a different measurement system is used—see Section 4.3*—and step* (2) *is omitted.*

(3) Open-circuit the D.C./Ω probe and COMMON lead and adjust the SET Ω/C.Z. control to bring the meter pointer to the full-scale infinity mark.

Having set zero, make the measurement as follows:—

(1) Connect the D.C./Ω probe and COMMON lead across the unknown resistance (for details see Section 2.5.2) and set the left-hand Selector switch to obtain a convenient meter deflection.

The resistance value is then the product of the meter indication on the top meter scale and the multiplying factor indicated by the Ω MULTIPLIER sector of the left-hand Selector switch.

2.5.2 Connections

The TF 1041B measures resistance up to 500 MΩ. Connection to the unknown resistor is made by means of the D.C./Ω probe and COMMON lead. The COMMON lead is isolated from the Voltmeter chassis by a resistance of 50 MΩ and should be connected to the side of the unknown having the lower resistance to earth.

Where the unknown is not isolated but forms part of a circuit, it is necessary to switch off any power supplies to this circuit.

Ensure that the finger-tip D.C./Ω selector switch on the d.c. probe is towards the front or needle end of the probe, revealing the engraving " Ω " (ohms) on the probe body. With the switch in this position the 1-MΩ resistor used for voltage measurements is short-circuited.

2.6 USE OF OPTIONAL ACCESSORIES

2.6.1 D.C. Multiplier Type TM 5033A

Full instructions for using the Multiplier are given in handbook EBM 5031A-5033A supplied with the Multiplier.

The D.C. Multiplier is fitted by inserting Connector Type TM 5749 between the Multiplier and the d.c. probe of the Voltmeter. The Voltmeter is then operated as for normal d.c. measurements.

When using the Multiplier it must *always* be held by the low-potential section behind the guard ring.

Voltmeters and Multipliers may be paired indiscriminately, and, by applying a nominal multiplying factor of 30, high voltages up to 30 kV can be measured with an accuracy of the order of ± 5%. It will be appreciated that, for the greatest accuracy, each combination will require the application of a slightly different multiplying factor depending on the individual values of the Multiplier resistance (Rm) and the Voltmeter d.c. input resistance (Rv).

The value of Rv for the particular Voltmeter with which this handbook is supplied is given below; the value of Rm, together with the expression for calculating the multiplying factor, is given in the Operating Instructions for the Multiplier.

TF 1041B Serial No. A 741/045

Rv ....104........ MΩ

2.6.2 A.C. Multiplier Type TM 5032

Full instructions for using the Multiplier are given in handbook EBM 5031A-5033A supplied with the Multiplier.

The Multiplier plugs directly on to the a.c. probe for measurements up to 2 kV r.m.s. It introduces a multiplying factor of 100 at frequencies of 10 kc/s and above. As with the normal probe, ground connection is made with the clip and the Grounding Sleeve supplied with the Voltmeter.

2.6.3 Coaxial " T " Connector Type TM 5031A

Full instructions for using the " T " Connector are given in handbook EBM 5031A-5033A supplied with the " T " Connector.

The " T " Connector plugs on to the a.c. probe after removing the probe point. The series arms of the " T " are fitted with type N 50-ohm connectors.

This accessory is not intended for use with the A.C. Multiplier.

2.6.4 5-Watt Dummy Load Type TM 5582

This is fitted with a type N 50-ohm socket and provides a well-matched 50-ohm coaxial termination usable up to 2 000 Mc/s.

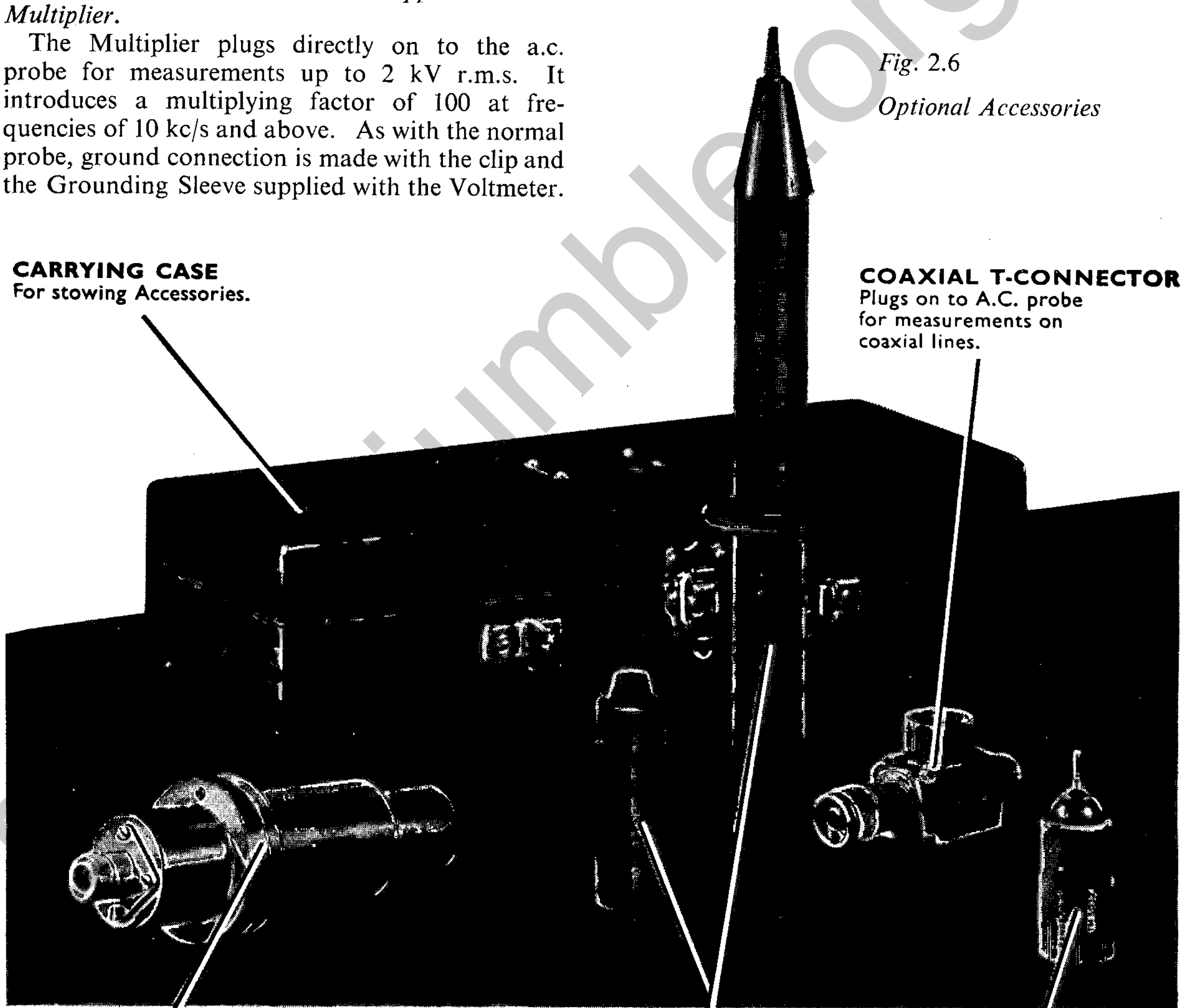


Fig. 2.6
Optional Accessories

3 Operational Summary

Once the user is familiar with the principles and techniques of operation detailed in Section 2, the following abridged instructions may be found convenient.

BEFORE SWITCHING ON

(1) Check that the power transformer is correctly adjusted.

(2) Set the mechanical zero of the meter.

A.C.

Setting Zero

Set Selector switches to 300 mV, D.C.+ or D.C.—. Connect D.C./Ω probe to COMMON lead and adjust COMMON ZERO. Set Selector to A.C. and connect a.c. probe tip to Grounding Clip; adjust A.C. ZERO. For small adjustments use FINE ZERO.

Measurements

Turn Selector switches to appropriate A.C. range. Connect probe to voltage being measured: at frequencies up to 250 Mc/s, make the " Lo " connection with a short fly-lead attached to the Grounding Clip; above 250 Mc/s, use Grounding Sleeve. Meter reads r.m.s. voltages. Peak voltage between " Hi " and " Lo " points must not exceed 425 volts; that between " Lo " and earth must not exceed 375 volts.

D.C.

Setting Zero

Set Selector switches to 300 mV, D.C.+ or D.C.—. Connect D.C./Ω probe (set to " V ") to COMMON lead and adjust COMMON and FINE ZERO. If centre-zero required, set selector to C.Z. and, with probe and lead connected, adjust SET Ω/C.Z.

Measurements

Turn Selector switch to appropriate D.C. range. If centre-zero is in use, f.s.d. is only half that shown by switch.

Combined d.c. plus peak a.c. voltage between " Lo " and earth must not exceed 375 volts.

RESISTANCE

Setting Zero

Set probe D.C./Ω slider to " Ω ", and Selector switches to " Ω " and " × 10 ". Connect D.C./Ω probe and COMMON lead together and adjust COMMON and FINE ZERO to bring meter to zero. Open-circuit D.C./Ω probe and COMMON lead and adjust SET Ω/C.Z. for infinity on meter.

Measurements

Connect D.C./Ω probe and COMMON lead across unknown resistance and set left-hand Selector to obtain convenient deflection.

OM 1041B
1 —10 60

4 Technical Description

The following detailed description is intended to be read in conjunction with the complete Circuit Diagram, Fig. 8.1.

4.1 D.C. MEASURING CIRCUIT

The d.c. section of the voltmeter consists basically of two bridge networks arranged one inside the other. Each of these balanced networks embodies two cathode followers—V3a, V3b, and V2, V4, respectively. The moving-coil indicating meter, M1, is connected in series with one of a number of precision range resistors between the cathodes of V3a and V3b; a.c. range resistors are associated with switch wafer S2e and those for d.c. ranges with switch wafer S2c. The change from one voltage range to another is made by switching in a different-value resistor, except on the higher voltage ranges where the change in sensitivity is made by feeding the input to the d.c. section via a potential divider.

D.C. voltages are measured using the D.C./Ω probe and COMMON lead. The COMMON lead is isolated from the voltmeter chassis by the 50-MΩ resistor, R58. At the d.c. position of the D.C./Ω selector, an isolating resistor, R2, is introduced within the probe to shield the circuit under test from the effects of probe lead capacitance. During d.c. measurements, the a.c. probe is disconnected from the bridge circuit by switch wafer S1*l*, but the heater supply to the a.c. probe diode is maintained in order to prevent delay when switching between a.c. and d.c. ranges.

In the centre-zero condition, a biasing voltage derived from the mains transformer T1, via the bridge rectifier MR7, is applied to the meter via switch wafers S1g and S1e; centre-zero adjustment is made with the aid of the SET Ω/C.Z. potentiometer.

In order to ensure maximum zero stability, all valve heaters are stabilized by means of the two barretters, RB1 and RB2; thermistors TH1 and TH2, together with shunt resistors R53 and R54, are added to prevent the initial switching-on surge from damaging the barretters.

Four selenium rectifiers, MR 1 to MR 4, are connected across the meter to provide overload protection on the most sensitive voltage ranges. A thermistor, TH3, with shunt resistor R48, is connected in series with the meter to compensate for changes in meter resistance due to temperature; R48 prevents the total compensating resistance exceeding 100 ohms when switching on from cold.

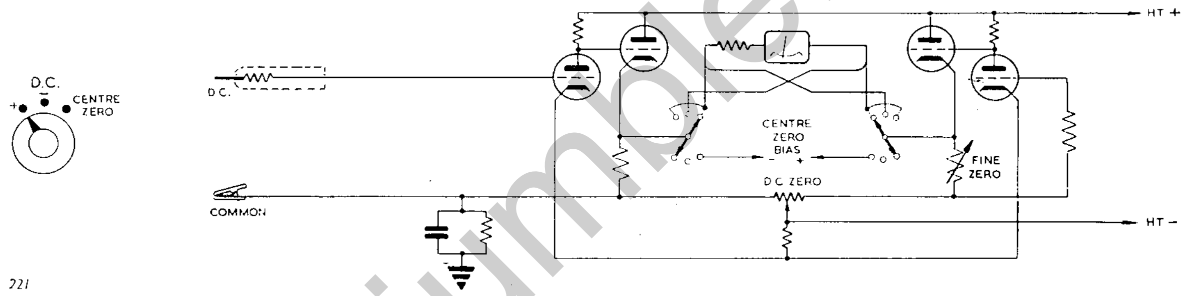
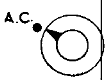
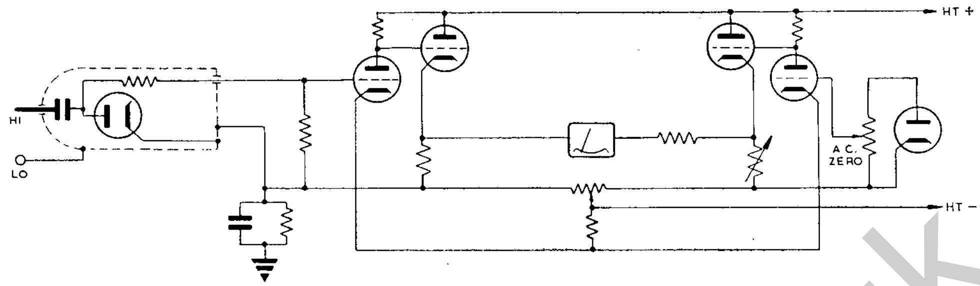


Fig. 4.1 Basic D.C. Measuring Circuit

4.2 A.C. MEASURING CIRCUIT

The probe unit used for a.c. measurements houses a special disk-seal diode which has a short transit time and low shunt capacitance of the order of 1.5 μμF; these factors are responsible for the wide frequency response of the instrument and the low capacitance presented by the probe to the circuit under test. As a precaution against errors due to





220

Fig. 4.2 *Basic A.C. Measuring Circuit*

pick-up when the voltmeter is used on its most sensitive ranges, the probe unit is coupled to the main body of the instrument via a screened non-microphonic cable.

Also in the probe unit housing is a resistor (R1) which forms part of the diode load, the remainder of which is made up of the chain of resistors between switch wafer S1*l* and the COMMON line. The rectified voltage from the diode probe unit is applied direct to one input point of the d.c. measuring circuit on all except the two highest ranges. On the 100-volt and 300-volt ranges, a reduced input to the measuring circuit is taken from a tapping on the load-resistance chain, in order to prevent overloading.

To balance the " splash current " or initial velocity current of the rectifier diode V1, double diode V5 is connected to the opposite input point of the bridge circuit. The " backing-off " current from this diode is controlled by the A.C. ZERO potentiometer. As a result of the tapping down of the bridge input from the diode probe unit on the two highest ranges, the effect of the diode splash current is reduced; to compensate for this, the " backing off " current from V5 is also reduced by shunting the A.C. ZERO potentiometer with resistor R 55.

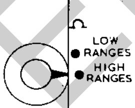
4.3 RESISTANCE MEASURING CIRCUIT

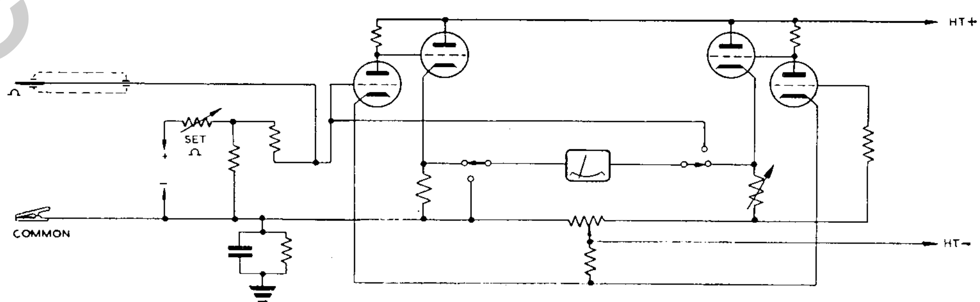
On all except the two lowest resistance ranges, the unknown resistor is connected across a reference source derived from rectifier MR7 in series with the SET Ω/C.Z. potentiometer, RV2, and one of six range resistors, R10 to R15; this reference voltage is also applied to the input of the d.c. measuring section via switch wafers S1*l* and S2a. Before connecting the unknown resistor, the meter reading is standardized at full scale, or infinity ohms, by means of the SET Ω/C.Z. control. With connection made to the resistor under test, the voltage across the d.c. measuring section is reduced and the meter reading falls to indicate the value of the unknown resistor.

On the two lowest resistance ranges a different measuring system is used which dispenses with the bridge circuit. The unknown resistor and the reference voltage source are connected directly across the meter.

4.4 POWER UNIT

The voltmeter has a built-in power unit using metal rectifiers. Tappings on the mains transformer primary windings allow operation from any 40- to 100-c/s a.c. supply within the ranges 100 to 150 volts and 200 to 250 volts.





222

Fig. 4.3 *Basic Resistance Measuring Circuit*

5 Maintenance

5.1 GENERAL

It is strongly recommended that the user should become familiar with the principles described in Section 4 before commencing the adjustment or replacement of component parts of the instrument.

The Circuit Diagram shows all the electrical components contained in the instrument. The descriptions of these components—their types, values, ratings, etc.—are given in the Spares Ordering Schedule; the Schedule also lists certain selected mechanical components.

The physical locations of the electrical components are shown in the Component Layout Illustrations.

5.2 MAINS INPUT ARRANGEMENTS

The instrument can be adjusted to operate from any 40- to 100-c/s supply within the ranges 100 to 150 volts and 200 to 250 volts.

The mains transformer has a double-wound primary with its two tapped sections connected in series for 200- to 250-volt operation or in series-parallel for 100- to 150-volt operation.

The high (200- to 250-volt) or low (100- to 150-volt) range is selected by links on the coil of the transformer. Selection of intermediate voltages within either range is made by means of fly leads on the transformer tags. These tags are common to both ranges and are, therefore, annotated with two voltages; the applicable voltage depends on the position of the range links.

To get at the mains transformer, remove the two front-panel fixing screws (see Fig. 2.1), slacken the top and bottom screws near the front edge of each side panel, and swing the panel assembly outwards and upwards from the bottom.

Compare the transformer connections with the diagrams below.

(a) 200- to 250-volt range

Only one fixed link is used, as shown; this connects the two primary windings in series. One fly-lead must be connected to either " 0 " or " 10 " and the other lead to the tag whose designation, added to 0 or 10 as appropriate, matches the supply voltage.

(b) 100- to 150-volt range

Two fixed links are used, as shown; this connects the two primary windings in parallel. One fly-lead must be connected to either " 0 " or " 10 " and the other lead to the tag whose designation, added to 0 or 10 as appropriate, matches the supply voltage.

5.3 ACCESS TO COMPONENTS

5.3.1 Removal of Meter Surround

To obtain access to the preset components, valve

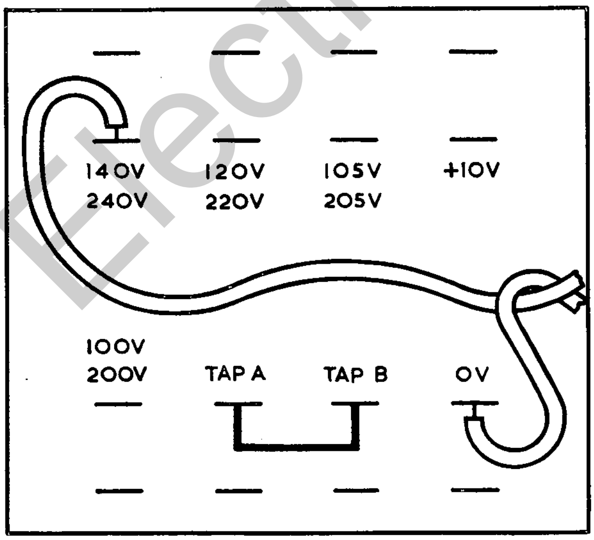


Fig. 5.1 240-*volt Connections*

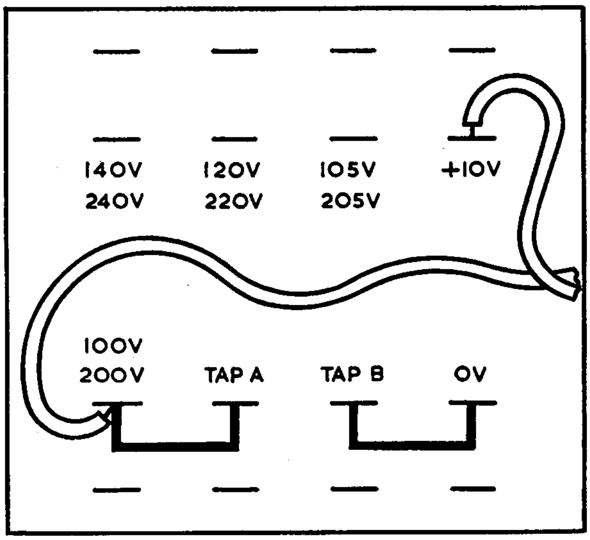


Fig. 5.2 110-*volt Connections*

bases, and associated wiring :—

(1) Lay the instrument on its back, or support it in the sloping position by means of the recess lid.

(2) Extract the two 4-BA screws, one on each side of the meter, and remove the meter surround.

Caution: *The meter is held in position only by this surround; take care that the meter does not fall out if the instrument is stood upright again.*

5.3.2 Access to Internal Components

To gain access to the interior of the instrument:—

(1) Slacken, but do not remove, the top and bottom screws near the front edge of each side panel.

(2) Remove the two round-head screws at the bottom of the front panel (see Fig. 2.1).

(3) Having checked that all leads are free of the locating slots in the top of the side panels, swing the complete front panel assembly outwards and upwards from the bottom. The front panel is pivoted about two screws which protrude through the top of the side panels.

5.3.3 Dismantling the A.C. Probe

To gain access to the components within the a.c. probe assembly :—

(1) Remove the probe clip. Hold the probe cap pointing downwards and separate the two halves of the probe by unscrewing the main casing from the probe-cap ferrule, *not* by unscrewing the ferrule.

The ceramic disk capacitor, C1, has a small hole in the centre and fits on to the anode connector of the probe diode, V1. It is held in position by a small piece of p.v.c. sleeving which fits over the protruding end of the diode anode connector. When replacing C1, always keep the side with the red spot uppermost, i.e. towards the probe point.

Referring to Fig. 6.4, reassemble the probe unit as follows:—

(1) Check that the compression spring and cover inside the polythene probe cap are seated centrally and are free to move in the housing when compressed.

(2) Insert the sleeved tip of the diode anode connector, complete with C1, into the compression spring inside the probe cap.

(3) Locate the edges of the printed circuit board in the two slots in the threaded flange of the probe cap ferrule.

(4) Hold the ferrule and screw the probe casing onto it. *Do not* twist the ferrule.

5.3.4 Removal of Probe Diode

To remove the probe diode :—

(1) Dismantle the a.c. probe as described in Section 5.3.3.

(2) Unsolder the heater wires from the copper contacts on the printed circuit board.

(3) Remove the ceramic disk capacitor, C1, after removing the small piece of sleeving holding it in place.

(4) Unsolder the resistor, R1, from the collet on the diode anode connector and remove the collet. The valve can now be withdrawn.

When replacing resistor R1, make sure that its sleeved end-wire, connected to the printed circuit board, sits well down in the groove cut in the brass ring forming the valve cathode contact.

5.3.5 Dismantling the D.C. Probe

To dismantle the d.c. probe :—

(1) Slide the blue p.v.c. sleeve back down the lead and remove the exposed counter-sunk screw from the rear of the probe body.

(2) Unscrew and remove the knurled nut from the needle end of the probe.

(3) Remove the finger-push switch after extracting the screw, covered by red paint, from its centre.

(4) Ease the probe body off the front end of the probe.

Reassemble the probe in the reverse order to that given above.

5.4 WORKING VOLTAGES

The voltages given in this section are for guidance when servicing the instrument; they were obtained from a representative TF 1041B. The voltmeter used for making the measurements was an Avometer Model 8 which has a resistance of 20 000 ohms per volt.

Measurements were made with the mains transformer set for 240 volts, using a 240-volt supply.

5.4.1 Power Supply Voltages

TABLE 1

Supply	*Measured Between*	*Voltage*
H.T. a.c.	H.T. tags on T1	180 V a.c.
H.T. d.c.	Pin 1 or 6 on V3 and COMMON	270 V d.c.
H.T. d.c. (—ve)	V3 centre-post and COMMON	—140 V d.c.
L.T.1. a.c.	L.T. tags on T1	32 V a.c.
L.T. 2. a.c.	L.T. tags on T1	7.5 V a.c.
L.T.2. d.c.	Across MR7	5.0 V a.c.

TABLE 2

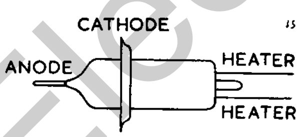
Any valve which becomes faulty should preferably be replaced by a valve of the type originally supplied in the instrument. If this is not possible, the additional data given by the table may be used as a guide to suitable alternatives.

Valve	*Type*	*Base*	*British Commercial Equivalent*	*British Services Equivalent*	*U.S. Equivalent*
V1	Mullard EA52 Diode	a	—	—	EA52 is available in U.S.A. from Marconi Instruments, New Jersey
V2 **V4**	Brimar 6BS7 Pentode	b	—	—	6BS7
V3	Brimar 12AT7 Double Triode	c	ECC81 B309 M8162† 6060†	CV455 CV4024†	12AT7 12AT7WA†
V5*	Mullard EB91 Double Diode	d	6AL5 6D2 D77 DD6 M8079† 6058†	—	6AL5 5726†
RB1 **RB2**	Hivac XB1 Barretter	e	UD143	CV2293	XB1 is available in U.S.A. from Marconi Instruments, New Jersey

† *High-reliability type.*

* *Equivalents to EB91 may require selecting for adequate emission for a.c. zero setting.*

a



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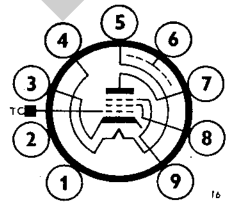

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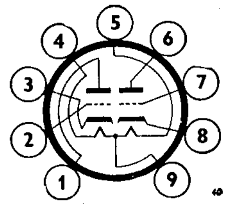

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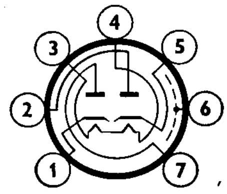

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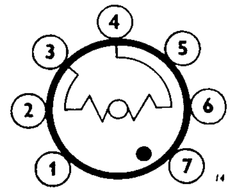


(B7G)

5.4.2 Valve Electrode Voltages

The table shows d.c. electrode voltages *with respect to the* COMMON *line;* the COMMON lead provides a convenient point for connecting to this line. The voltages are given only for guidance; between individual instruments some variation may be expected due to normal tolerances of valve performance and component values.

TABLE 3

Valve No.	*Anode Volts d.c.*	*Cathode Volts d.c.*
V2	100	4
V3a	270	5
V3b	270	5
V4	100	4

5.5 REPLACEMENT OF VALVES

The types of valves used in the instrument, their base connections, and some guidance as to suitable alternatives if the types originally fitted are not readily available, are given in Table 2.

With the Voltmeter opened to reveal the underside of the front panel as described in Section 5.3.2, all valves, except the a.c. probe diode, are immediately accessible. To obtain access to the probe diode, carry out the procedure described in Section 5.3.4.

With the possible exception of V2 and V4, valves may normally be replaced without special selection, although in certain cases replacement may necessitate some readjustment to associated preset components; Table 4 lists those valves whose replacement is more likely to involve some readjustment and indicates the appropriate realignment procedure.

In order to obtain reasonable zero stability it is advisable to age new valves at their normal working voltage for at least 72 hours before use.

TABLE 4

Valve No.	*Check or Readjust*	*Section Describing Readjustment*
V1	A.C. Zero	5.7.6
	A.C. Full-Scale Deflection	5.7.11
V2	D.C. Zero	5.7.4
V3	D.C. Centre Zero	5.7.5
V4	D.C. Full-Scale Deflection	5.7.8

If replacement barretters are not obtainable, the instrument may still be operated, though in the unstabilized condition, by making the following modification:—

(1) Replace each barretter by a through connection, that is, by linking pins 3 and 4 on each holder.

(2) Replace the two parallel circuits TH1, R53 and TH2, R54 by a through connection.

(3) Disconnect the lead to pin A on the LT1 winding of T1 and connect it to the adjacent 12·6-volt tap.

5.6 PRESET AND SPECIALLY SELECTED COMPONENTS

During the factory calibration of the instrument, certain of its performance characteristics are brought within close limits by means of preset or selected components.

Following the replacement or aging of certain fixed components, it may become necessary to repeat the calibration procedure by which the presets were adjusted or the value of the selected components chosen.

Certain padding resistors are also included which, in the manufacturing procedure, are short circuited; the short circuits are removed as necessary to obtain the required resistance.

Six of the preset potentiometers, mounted on flat bakelite strip, have their sliders fixed, after adjustment, by the application of a small amount of polystyrene cement. No attempt should be made to move the potentiometer sliders before dissolving the cement with a drop of acetone or other suitable solvent.

All preset potentiometers are immediately accessible on removal of the meter surround—see cautionary note in Section 5.3.1; their relative positions and circuit references are shown in Figs. 6.1 to 6.3.

TABLE 5

Preset Component	*Section Describing Adjustment*	*Selected Component*	*Section Describing Selection*
RV1	5.7.8	R5	5.7.8
RV3	5.7.4	R6	5.7.8
RV4	5.7.11	R7	5.7.8
RV5	5.7.8	R8	5.7.8
RV7	5.7.8	R51	5.7.6
RV8	5.7.11	R56	5.7.6
RV9	5.7.11		

Section 5.7 gives a range of tests by which the main points of performance of the instrument can be checked; this section also deals with the adjustment of the preset potentiometers and specially selected components. Table 5 lists the circuit references of these components, together with the numbers of the sections in which their adjustment

or selection is described. The procedure referred to should also, of course, be carried out in the event of replacement of any of these components.

5.7 SCHEDULE OF TESTS

The following information is based on extracts from the internal Factory Test Schedule.

5.7.1 Apparatus Required

(a) 750-volt Insulation Tester.

(b) Resistance Bridge, measuring up to 100 MΩ; Marconi Type TF 868B or TF 936.

(c) Circuit Magnification Meter, tunable to 10 Mc/s and with incremental-capacitor-adjustment facilities; Marconi Type TF 329 (Series) or TF 1245 in conjunction with 2·5-μH loading inductor Type TM 1438C, 200-μH loading inductor Type TM 1438Q, and Dielectric Loss Test Jig Type TJ 155 (Series); or Marconi Dielectric Test Set Type TF 704 (Series).

(d) Circuit Magnification Meter, tunable to 100 Mc/s; Marconi Type TF 1245 or TF 886 (Series).

(e) Source of d.c. voltage, standardized to within ± 0·5% at 0·3, 1, 3, 10, 30, 100, 120, 300, and 1 000 volts.

(f) Source of 1 000-c/s undistorted sinusoidal a.c. voltage standardized to within ± 0·5% at 0·3, 1, 3, 10, 30, 100, and 300 volts r.m.s.

(g) Signal Source, covering the range 25 c/s to 10 Mc/s; Marconi Type TF 885A/1.

(h) Signal Generator, covering the range 10 to 1 500 Mc/s; Marconi Type TF 801C-D, 10 to 470 Mc/s—in conjunction with Marconi Type TF 1060, 450 to 1 250 Mc/s.

(i) Valve Voltmeter, standardized; Marconi Type TF 428 (Series), TF 1300 or TF 1041 (Series).

(j) Crystal Voltmeter, covering the range 10 to 1 500 Mc/s.

(k) Variable Mains Transformer, e.g. Variac.

5.7.2 Insulation (*Apparatus required: Item a*)

Measure the insulation resistance between chassis and each " live " pin of the mains supply plug, the Selector switch being at any position other than OFF. The reading should normally be approximately 40 MΩ or above.

5.7.3 Probe Capacitor Leakage

(*Apparatus required: Item e*)

(1) Set the Voltmeter zero as described in Section 2.3.1, and turn the Voltmeter Selector switches to A.C. and 300 mV respectively.

(2) Connect the a.c. probe unit to a source of 120 volts d.c. The Voltmeter pointer will " flick-over " to f.s.d. but should return quickly to a steady deflection which is not normally greater than 15 mV. If the steady deflection is much greater than this, it is necessary to replace capacitor C1 in the probe unit.

5.7.4 Adjustment of D.C. Zero

(*Apparatus required: Item k*)

Meter zero on the d.c. ranges is adjusted by means of preset potentiometer RV3 and the COMMON ZERO control. RV3 is adjusted as follows :—

(1) Check, and if necessary correct, the mechanical zero setting of the Voltmeter.

(2) Connect the Voltmeter to the mains supply via the variable mains transformer.

(3) Using the variable transformer, adjust the mains supply voltage to exactly the value indicated by the mains transformer primary connections.

(4) Ensure that the finger-push switch on the D.C./Ω probe is set for voltage measurement; connect the D.C./Ω probe and COMMON lead together.

(5) Set the Voltmeter Selector switches to 300 mV D.C.+.

(6) Turn the SET ZERO control to its mid position and, if necessary, adjust preset potentiometer RV3 to bring the meter pointer to zero.

(7) Check that the meter pointer remains at zero when the left-hand Selector switch is set to D.C.—, and at all voltage range positions of the right-hand Selector switch.

(8) Vary the mains voltage by ± 6% and check that the meter reading does not change by more than 0·02 volt.

5.7.5 D.C. Centre-Zero Check

Check the operation of the centre-zero facility as follows :—

(1) Set the left-hand Selector switch to C.Z.

(2) Check that, on the 1 000-, 300-, 100-, 30-, 10-, and 1-volt ranges, it is possible to bring the meter pointer to the centre-zero mark above the meter scales with the aid of the SET Ω/C.Z. control.

(3) Turn the right-hand Selector switch to 300 mV and set the SET Ω/C.Z. control to about mid-travel.

(4) Check that it is possible to bring the meter pointer to the centre-zero mark with the aid of the SET ZERO control and slight adjustment to the SET Ω/C.Z. control.

5.7.6. Adjustment of A.C. Zero

(*Apparatus required: Item k*)

On the a.c. ranges, meter zero is set by the A.C. ZERO control and, if necessary, by removing or replacing the shorting link across R56. It may also be necessary to select a new value for R51.

(1) Check, and if necessary adjust, the mechanical zero setting of the Voltmeter.

(2) Connect the Voltmeter to the mains supply via the variable mains transformer.

(3) Using the variable transformer, adjust the mains supply voltage to exactly the value indicated by the mains transformer primary connections.

(4) Connect the D.C./Ω probe to the COMMON lead and set the Voltmeter Selector switches to 300 mV D.C.+; adjust the SET ZERO control to bring the meter pointer to zero.

(5) Connect the a.c. probe tip to the COMMON lead and set the left-hand Selector switch to A.C.

(6) Adjust the A.C. ZERO control to bring the meter pointer to zero.

(7) If the A.C. ZERO control is near the end of its travel, or if it has insufficient cover, either remove or replace the shorting link across resistor R56, and select a new value for R51; again check the A.C. ZERO control.

(8) Check that the meter pointer remains at zero at all voltage range positions of the right-hand Selector switch.

(9) Vary the mains voltage by ±6% and check that the meter reading does not change by more than 0·03 volt.

5.7.7 A.C. Input Impedance

(*Apparatus required: Items c, d, and g*)

Impedance at 10 Mc/s

(1) Set the Q-meter (item c) to a frequency of 10 Mc/s; connect the 2.5-μH standard inductor across the INDUCTOR terminals and the Dielectric Test Jig across the CAPACITOR terminals.

(2) Set the Voltmeter Selector switch to A.C. Connect the a.c. probe between the sockets of the Test Jig and adjust both micrometer capacitors to about mid-travel.

(3) Tune the Q-meter to resonance by means of its capacitance controls; note the magnification factor (Q).

(4) Adjust the cylindrical capacitor so that the Q reading is exactly halved; this occurs at two settings, one higher and the other lower than the setting at resonance. Note these two settings carefully; let the difference between them be $2\delta B_{in}$.

(5) Reset the cylindrical capacitor for resonance.

(6) Remove the probe from the Test Jig; readjust the plate capacitor for resonance and note the new magnification factor.

(7) Readjust the cylindrical capacitor and again note the two settings at which the Q value is exactly halved; let the difference in these settings be $2\delta B_{out}$.

(8) Using the conversion factor given in the Test Jig case convert the readings $2\delta B_{in}$ and $2\delta B_{out}$ to capacitance changes $2\delta C_{in}$ and $2\delta C_{out}$ respectively. The input resistance, Rp, of the Voltmeter is given by the expression

$$Rp \text{ at } 10\ Mc/s = \frac{0{\cdot}055}{(2\delta C_{in} - 2\delta C_{out})}\ M\Omega$$

where δC_{in} and δC_{out} are in μμF. The value of resistance obtained should be not less than 0·5 MΩ.

(9) Reset the cylindrical capacitor for resonance and note the setting, B_{out}.

(10) Replace the probe across the socket connections of the Test Jig: readjust the cylindrical capacitor for resonance and note the new setting, B_{in}.

(11) Convert the difference in reading between B_{in} and B_{out} to a capacitance change. This represents the shunt input capacitance of the Voltmeter and should be approximately 1·5 μμF.

Impedance at 100 Mc/s

(1) Set the Q-meter (item d) to a frequency of 100 Mc/s, and connect an inductor of about 0·15 μH across the INDUCTOR terminals.

(2) Tune the Q-meter to resonance; measure the magnification factor, Q_1, of the inductor and note the reading C_1 on the capacitance dial.

(3) Set the Voltmeter Selector switch to A.C. and connect the probe across the CAPACITOR terminals of the Q-meter.

(4) Retune the Q-meter to resonance. The change in capacitance required will be approximately 1·5 μμF, i.e., the input capacitance of the probe.

(5) Note the new value of the magnification factor, Q_2. The input resistance, Rp of the Voltmeter is given by the expression

$$Rp\ k\Omega\ at\ 100\ Mc/s = \frac{1{\cdot}593}{C_1} \times \frac{Q_1 Q_2}{Q_1 - Q_2}$$

where C_1 is in μμF. The value of resistance thus obtained should be about 150 kΩ.

Impedance at 1 kc/s

At l.f., the probe input impedance can be regarded as a pure resistance. Its measurement is given last in this series of checks because it is of relatively minor significance, giving little guide as to the more important r.f. performance.

The most satisfactory method of measuring the input resistance at 1 kc/s is to adopt a procedure similar to that described for the test at 10 Mc/s. The difficulty is to obtain a circuit, resonant at 1 kc/s, of sufficient magnification to enable an accurate determination of the probe input resistance to be made.

In the factory, an inductor is wound on a ferrite core, the inductance being 0·5 henry, and resonated with 0·05 μF. The constituent parts of this tuned circuit are connected to the INDUCTOR and CAPACITOR terminals of a Q-meter which has been specially modified to allow the injection of an external l.f. signal.

When determined by this method, the measured input resistance should be greater than 5 MΩ.

The above procedure is somewhat complex; if desired, a far simpler method can be employed to evaluate a " figure of merit " for the a.c. probe input resistance. This method does not yield the true value of input resistance because of peak clipping—see Section 2.3.6.

To determine the " figure of merit ", first connect a 3-MΩ resistance in series with the probe and then connect the resultant circuit to the video oscillator. The voltage indicated on the TF 1041B should then be noted with the added resistance (i) in circuit and (ii) short circuited.

If the true imput resistance is greater than 5 MΩ, the rise in Voltmeter reading when the 3-MΩ resistor is shorted will be less than 2:1.

5.7.8 D.C. Calibration

(*Apparatus required: Items e and k*)

Full-scale deflection on the d.c. ranges is set up by adjustment of potentiometers RV1, RV5 and RV7. The procedure is as follows :—

(1) Connect the D.C./Ω probe to the COMMON lead and set the Voltmeter zero as described in Section 2.4.1.

(2) Set preset potentiometer RV5 about mid-way.

(3) Set the Voltmeter Selector switches to D.C. + and 300 mV respectively.

(4) Connect the D.C./Ω probe and COMMON lead to the standardized source of 300 mV d.c., observing the conditions stated in Section 2.4.2. Adjust preset potentiometer RV7 for full-scale deflection on the meter. (See Section 5.6 for information regarding cementing of potentiometer sliders.)

(5) Turn the right-hand Voltmeter Selector switch to 3 V and increase the standardized source voltage to 3 volts d.c. Adjust RV5 for f.s.d.

(6) Turn the Voltmeter Selector switch to 100 V and increase the standardized source voltage to 100 volts. Adjust preset potentiometer RV1 and the links across resistors R5 to R8, as necessary, to give f.s.d.

(7) With appropriate values of voltage from the standardized source, check that the Voltmeter indication is accurate to within ±2% of f.s.d. ±0·01 volt on the 0·3-, 1-, 10-, 30-, and 100-volt ranges, and within ±3% of f.s.d. on the 300- and 1 000-volt ranges.

(8) Vary the mains supply voltage by ±6% and check that on all d.c. ranges the indication does not vary by more than ±0·02 volt.

5.7.9 D.C. Probe Input Resistance

(*Apparatus required: Item b*)

Measure the d.c. input resistance between the D.C./Ω probe and COMMON lead as follows :—

(1) Disconnect the Voltmeter from the mains supply and set the Selector switches to D.C.+ and 1 000 volts respectively.

(2) Check that the finger-tip switch on D.C./Ω probe is set for voltage measurement.

(3) Measure the resistance between the D.C./Ω probe and COMMON lead; this should be of the order of 100 MΩ. Between the COMMON lead and chassis the resistance should lie between 25 MΩ and 60 MΩ.

5.7.10 D.C. Probe R.F. Capacitance

(Apparatus required: Item c)

Measure the r.f. capacitance between the D.C./Ω probe and ground as described below. Measurement is made between the probe needle and casing; the casing is connected to the Voltmeter COMMON line, but as the decoupling capacitor between this line and ground is 0·01 μF it may be ignored for the purposes of this test.

(1) Set the Q-meter to a frequency of 1 Mc/s; connect the 200-μH standard inductor across the INDUCTOR terminals, and the Dielectric Test Jig across the CAPACITOR terminals.

(2) Adjust both the Test Jig capacitors to mid-travel and tune the Q-meter to resonance by means of its capacitance controls. Note the setting of the Test Jig cylindrical capacitor, B_{out}.

(3) Set the Voltmeter Selector switch to D.C.+ and connect the D.C./Ω probe between the sockets of the Test Jig.

(4) Readjust the cylindrical capacitor of the Test Jig for resonance and note the new setting, B_{in}.

(5) Convert the difference in reading between B_{in} and B_{out} to a capacitance change using the conversion factor given in the Test Jig case. This represents the r.f. capacitance of the D.C./Ω probe of the Voltmeter and should be approximately 2 μμF.

5.7.11 A.C. Calibration

(Apparatus required: Items f and k)

Full-scale deflection on the a.c. ranges is set up by means of preset potentiometers RV4, RV8 and RV9. The adjustment procedure is as follows :—

(1) Short circuit the a.c. probe and COMMON lead and set zero as described in Section 2.3.1.

(2) Set the Voltmeter Selector switches to A.C. and 30 volts respectively.

(3) Connect the a.c. probe to the 1 000-c/s standardized source of 30 volts r.m.s. observing the conditions stated in Section 2.3.2.

(4) After the Voltmeter has warmed up, adjust preset potentiometer RV4 to give full-scale deflection on the meter. (See Section 5.6 for information on cementing of potentiometer sliders.)

(5) Reduce the 1 000-c/s standardized voltage source to 1 volt r.m.s., set the right-hand Voltmeter Selector switch to 1 volt and adjust preset potentiometer RV9 to give full-scale deflection on the meter.

(6) Reduce the 1 000-c/s standardized voltage source to 300 mV r.m.s., set the right-hand Voltmeter Selector switch to 300 mV and adjust preset potentiometer RV8 to give full-scale deflection on the meter.

(7) With appropriate values of voltage from the standardized voltage source, check that the Voltmeter indication is accurate to within ± 2% of f.s.d. ± 0·01 volt on the 1-, 3-, 30-, and 100-volt ranges, and within ± 3% of f.s.d. ± 0·01 volt on the 300-mV, 10-, and 300-volt ranges.

(8) Vary the mains supply voltage by ±6% and check that on all a.c. ranges the full-scale deflection does not vary by more than ±0·03 volt.

5.7.12 Frequency Response

(Apparatus required: Items g, h, i, and j)

(1) Set the Voltmeter Selector switches to 1 volt A.C.

(2) Connect the output of the Video Oscillator to the Voltmeter a.c. probe and to the input of the standardized reference voltmeter (item i).

(3) Adjust the Video Oscillator to give a frequency of 10 Mc/s at a level which produces a convenient meter deflection, say 0·6 volt, on the Voltmeter. Note the reading on the reference voltmeter.

(4) Vary the frequency in steps down to 20 c/s readjusting the Video Oscillator output for a constant meter deflection on the TF 1041B, and noting the reading on the reference voltmeter.

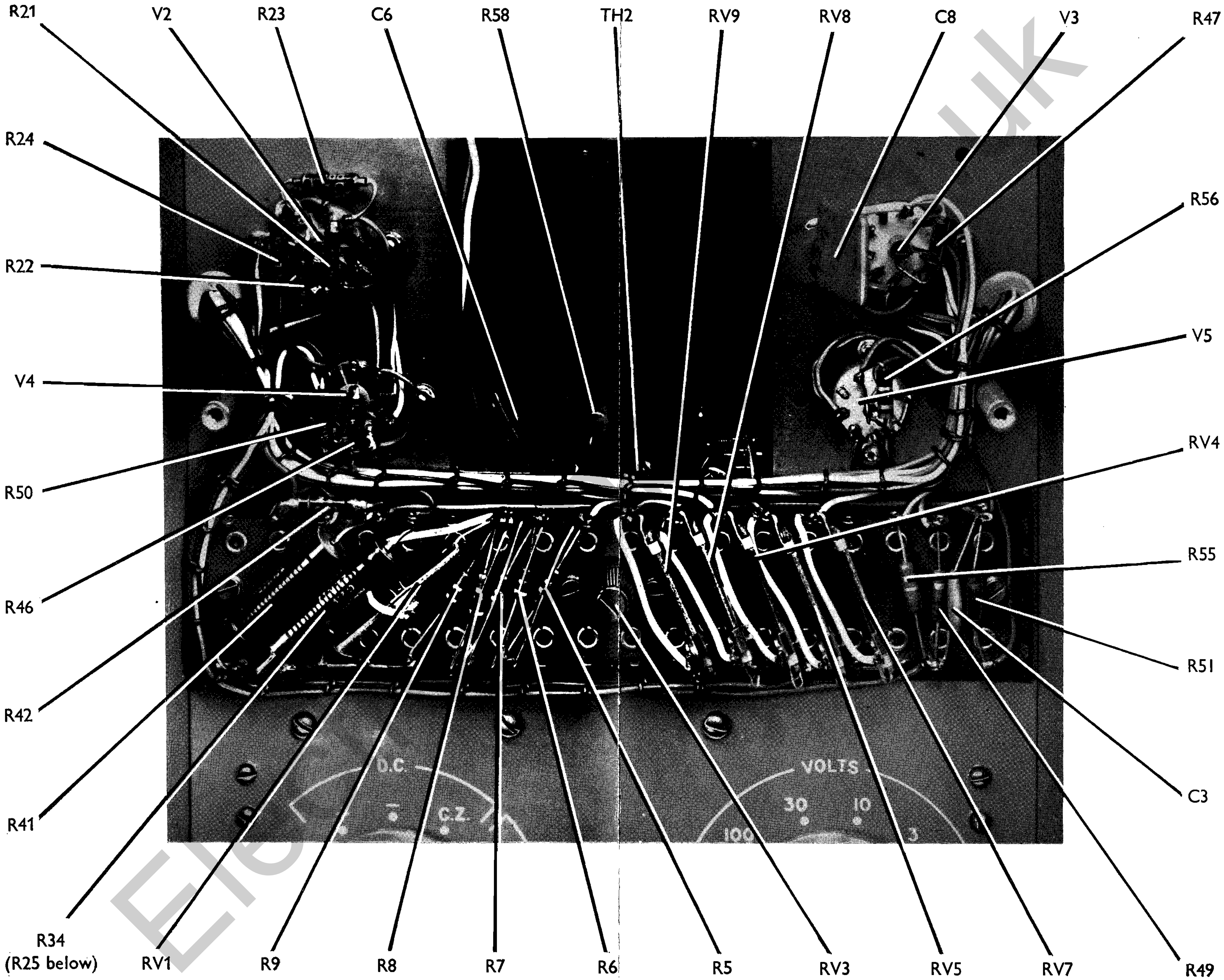
(5) Standardize the crystal voltmeter against the reference voltmeter at 10 Mc/s, and use the former in conjunction with the Signal Generator (item h) to check the frequency response from 10 to 1 500 Mc/s.

A typical frequency characteristic, relative to 1 kc/s, is flat to within ± 0·2 dB from 50 c/s to 500 Mc/s, falling to within − 0·5 dB at 20 c/s and rising to within + 1 dB at 1 000 Mc/s and + 3 dB at 1 500 Mc/s—see Fig. 2.2 on page 9.

5.7.13 Resistance Calibration

With the Voltmeter set to measure resistance as described in Section 2.5, check that, for each resistance range, sensibly accurate indications are obtained when known values of resistance are connected between the D.C./Ω probe and the COMMON lead.

6 COMPONENT LAYOUT ILLUSTRATIONS

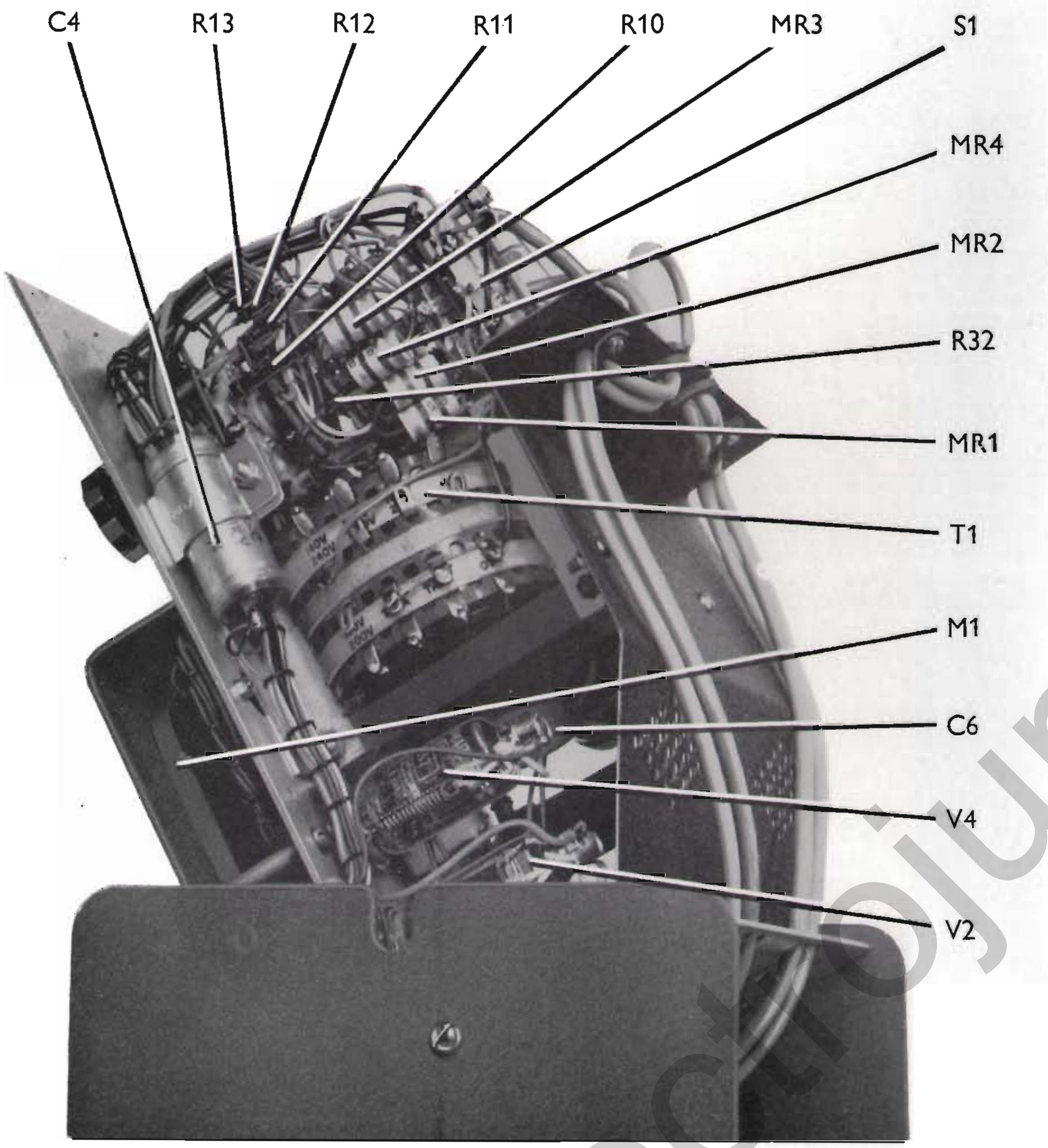


R59 is connected between Pins 1 and 6 of V3

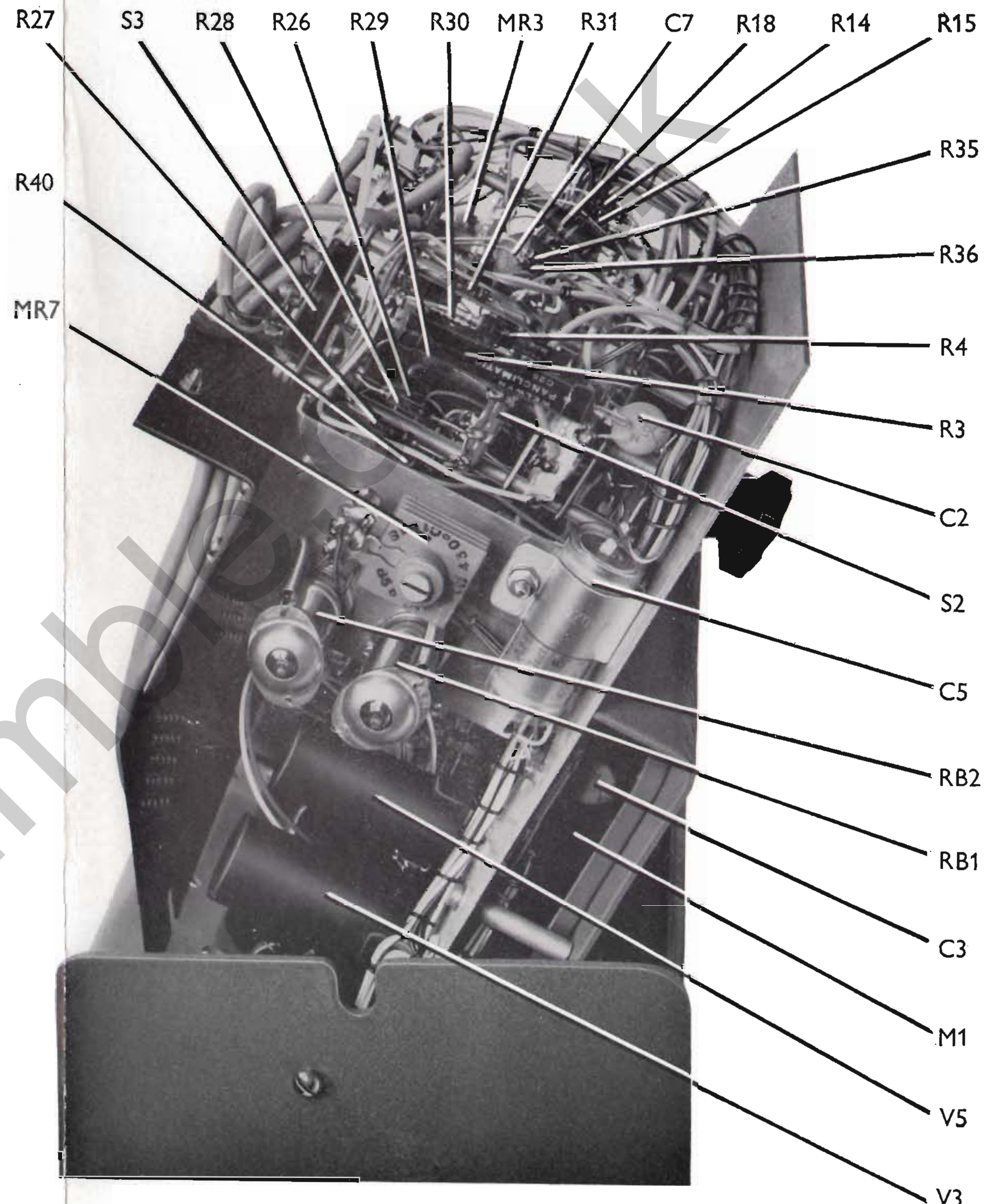
FRONT
WITH METER PANEL REMOVED

Fig. 6.1

OM 1041B
1—7/59



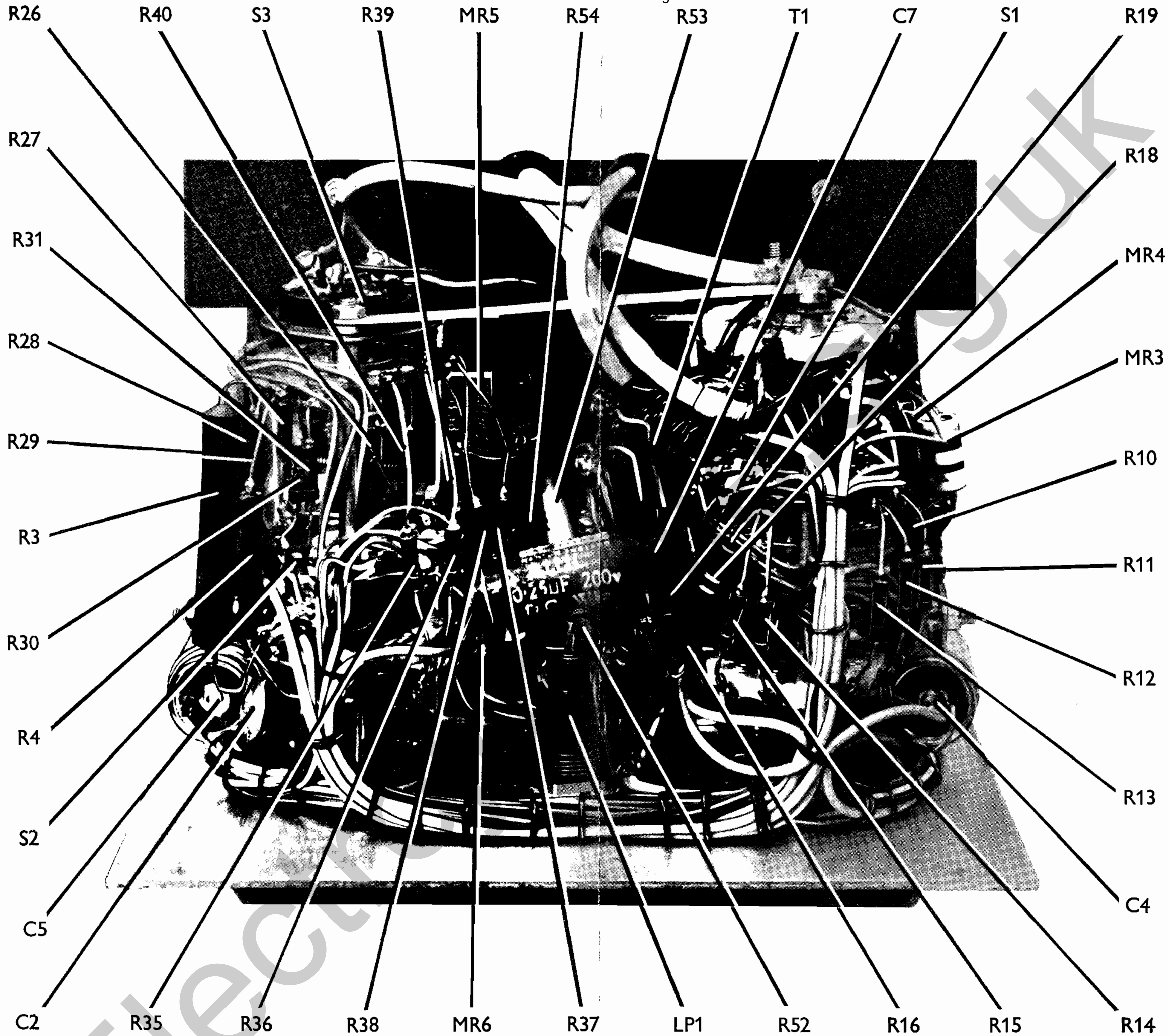
INTERIOR VIEW FROM LEFT



INTERIOR VIEW FROM RIGHT

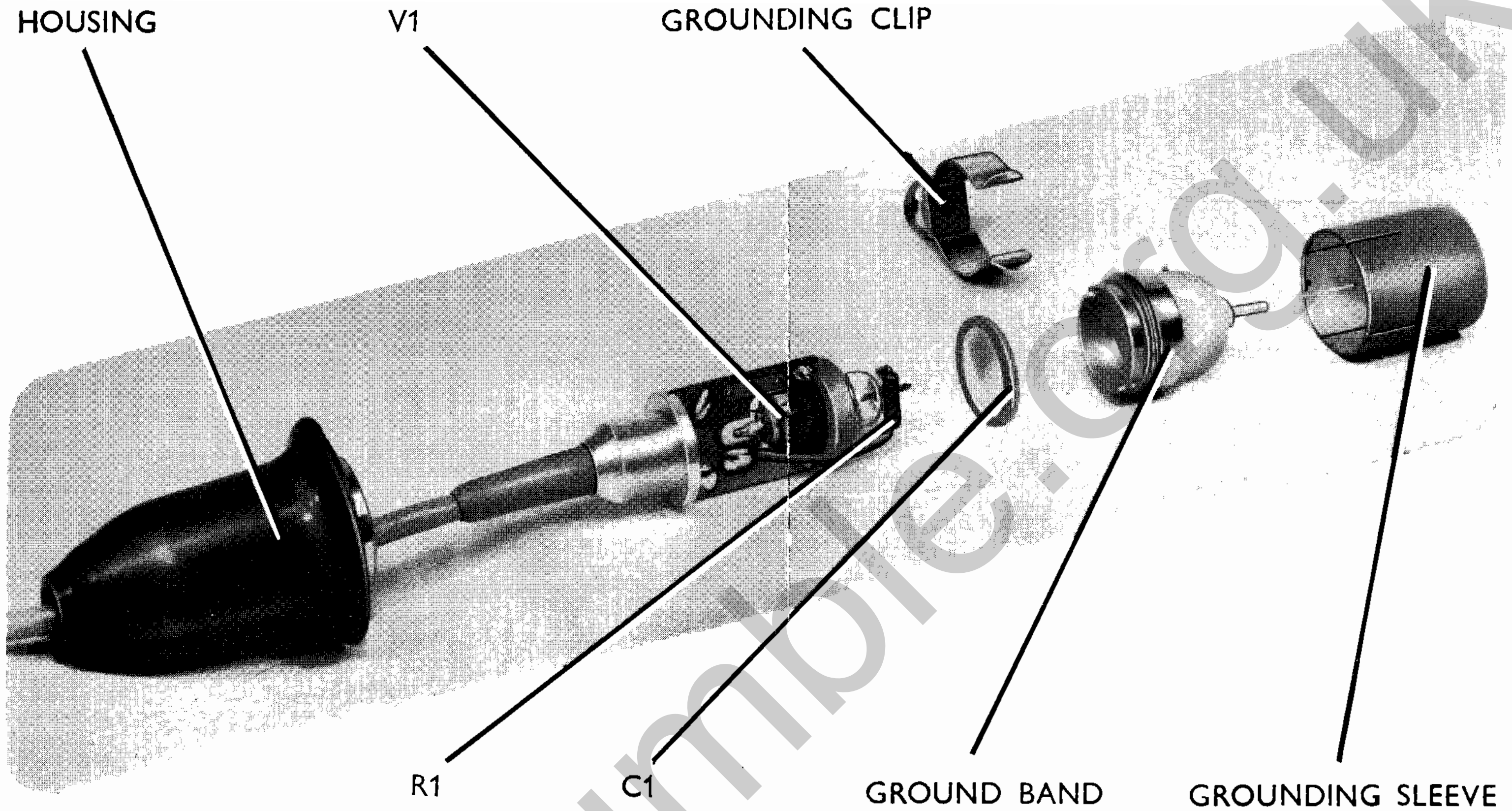
INTERIOR VIEWS

Fig. 6.2



INTERIOR VIEW FROM TOP

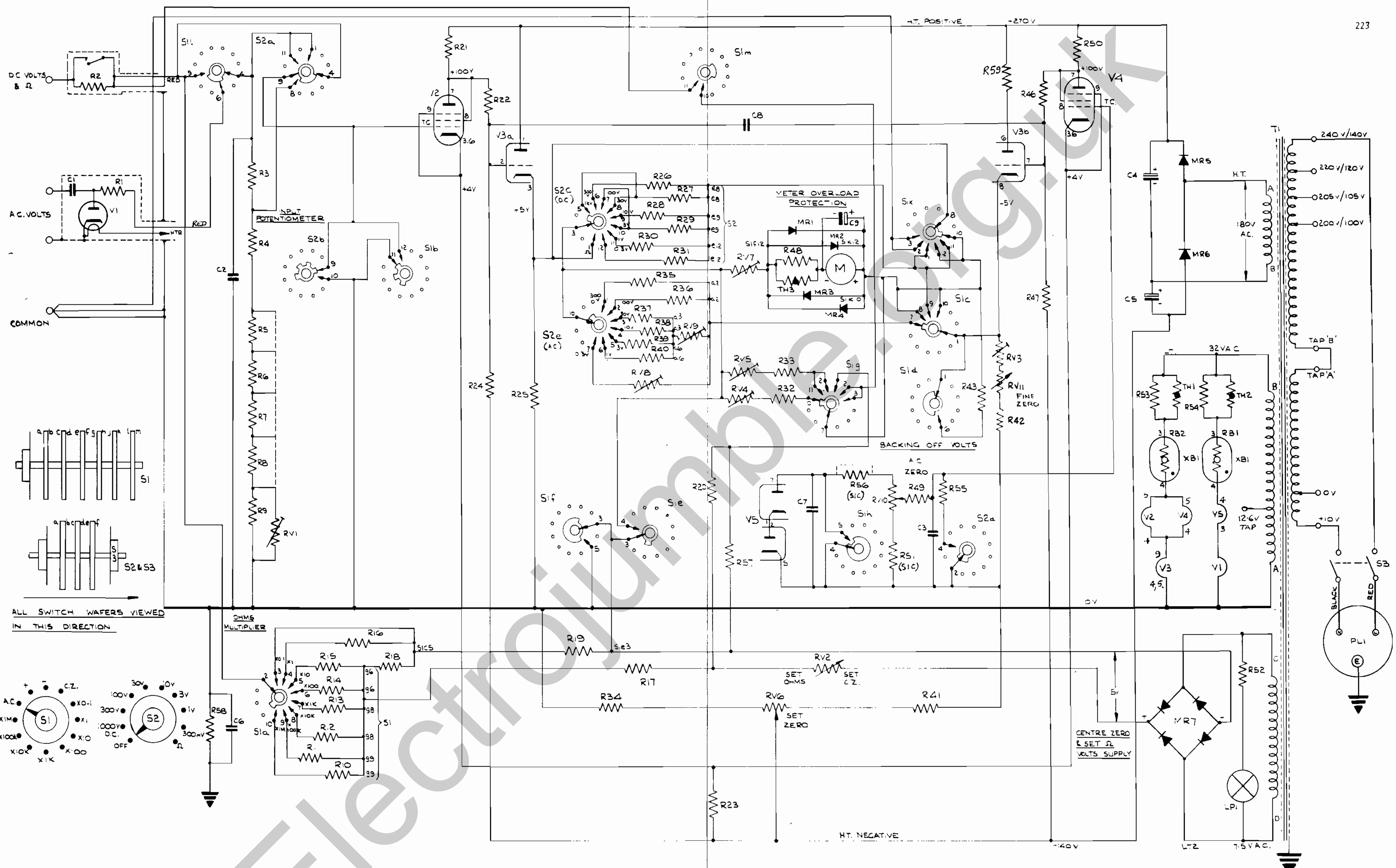
Fig. 6.3



PROBE UNIT

Fig. 6.4

OM 1041B
1 7/59



NOTES

1. For component values see Spares Ordering Schedule.
2. Earlier models have potentiometers RV3 and RV11 in the cathode circuit of V3a.

CIRCUIT DIAGRAM

Fig. 8.1

OM 1041B
1**—2/61
(Ex TD 28042 Issue 15)

7 Spares Ordering Schedule

No. SOS/1041B

for VACUUM TUBE VOLTMETER, TYPE TF 1041B

When ordering replacement parts, always quote the TYPE NUMBER and SERIAL NUMBER of the instrument, the QUANTITY required and the appropriate SOS ITEM NUMBER.

For example, to order replacements for the 1-MΩ resistor, R2, and the 0·01-μF capacitor, C6, quote as follows :—

Spares required for TF1041B, Serial No. 000000

1 off, SOS Item 2

1 off, SOS Item 78

It is important that the distinguishing code " SOS " preceding each item number should not be omitted.

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		RESISTORS	
1	R1	Composition, 7·5 MΩ ± 5%, ½W. Included in Item 121.	15–TM5776
2	R2	Composition, 1 MΩ ± 10%, ½W. Included in Item 126.	10–TM5731
3	R3	Carbon, High-Stability, 100 MΩ ± 5%, 2W.	43–TF1041B
4	R4	Carbon, High-Stability, 2·9 MΩ ± 1%, ¾W.	44–TF1041B
5	R5	Composition, 100 kΩ ± 10%, ½W.	2–TM5730
6	R6	Composition, 100 kΩ ± 10%, ½W.	2–TM5730
7	R7	Composition, 100 kΩ ± 10%, ½W.	2–TM5730
8	R8	Composition, 47 kΩ ± 10%, ½W.	3–TM5730
9	R9	Composition, 220 kΩ ± 10%, ½W.	4–TM5730
10	R10	Carbon, High-Stability, 10 MΩ ± 2%, ¾W.	45–TF1041B
11	R11	Carbon, High-Stability, 1 MΩ ± 2%, ¼W.	46–TF1041B
12	R12	Carbon, High-Stability, 100 kΩ ± 2%, ¼W.	47–TF1041B
13	R13	Carbon, High-Stability, 10 kΩ ± 2%, ¼W.	48–TF1041B
14	R14	Carbon, High-Stability, 1 kΩ ± 2%, ¼W.	49–TF1041B
15	R15	Carbon, High-Stability, 95Ω ± 2%, ¼W.	50–TF1041B
16	R16	Carbon, High-Stability, 9Ω ± 2%, ¼W.	51–TF1041B
17	R17	Composition, 15Ω ± 5%, ½W.	52–TF1041B
18	R18	Wirewound, 5·1Ω ± 5%, ½W.	53–TF1041B
19	R19	Wirewound, 0·85 Ω ± 0·05 Ω	54–TF1041B
20	R20	Composition, 22 kΩ ± 5%, ½W.	55–TF1041B
21	R21	Carbon, High-Stability, 200 kΩ ± 1%, ¼W.	56–TF1041B
22	R22	Carbon, High-Stability, 680 kΩ ± 1%, ¼W.	57–TF1041B
23	R23	Carbon, High-Stability, 100 kΩ ± 5%, ¼W.	58–TF1041B

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
24	R24	Carbon, High-Stability, 1 MΩ ± 1%, ¼W.	59–TF1041B
25a	R25	Carbon, High-Stability, 750 Ω ± 2%, ¼W.	5–TM5730.
26	R26	Carbon, High-Stability, 34·8 kΩ ± 1%, ¼W.	60–TF1041B
27	R27	Carbon, High-Stability, 118 kΩ ± 1%, ¼W.	61–TF1041B
28	R28	Carbon, High-Stability, 38·75 kΩ ± 1%, ¼W.	62–TF1041B
29	R29	Carbon, High-Stability, 11·15 kΩ ± 1%, ¼W.	63–TF1041B
30	R30	Carbon, High-Stability, 3·29 kΩ ± 1%, ¼W.	64–TF1041B
31	R31	Carbon, High-Stability, 532 Ω ± 1%, ¼W.	65–TF1041B
32	R32	Carbon, High-Stability, 2 kΩ ± 2%, ¼W.	66–TF1041B
33	R33	Carbon, High-Stability, 3·3 kΩ ± 2%, ¼W.	67–TF1041B
34 a	R34	Carbon, High-Stability, 21 kΩ ± 1%, 1W.	6–TM5730
35	R35	Carbon, High-Stability, 43·9 kΩ ± 1%, ¼W.	68–TF1041B
36	R36	Carbon, High-Stability, 14·1 kΩ ± 1%, ¼W.	69–TF1041B
37	R37	Carbon, High-Stability, 143 kΩ ± 1%, ¼W.	70–TF1041B
38	R38	Carbon, High-Stability, 45·76 kΩ ± 1%, ¼W.	71–TF1041B
39	R39	Carbon, High-Stability, 12·01 kΩ ± 1%, ¼W.	72–TF1041B
40	R40	Carbon, High-Stability, 2·68 kΩ ± 1%, ¼W.	73–TF1041B
41a	R41	Carbon, High-Stability, 21 kΩ ± 1%, 1W.	6–TM5730
42a	R42	Composition, 300 Ω ± 10%, ½W.	7–TM5730
43	R43	Composition, 3 kΩ ± 5%, ½W.	75–TF1041B
44	R46	Carbon, High-Stability, 680 kΩ ± 1% ¼W.	57–TF1041B
45	R47	Carbon, High-Stability, 1 MΩ ± 1%, ¼W.	59–TF1041B
46	R48	Composition, 100 Ω ± 10%, ½W.	78–TF1041B
47	R49	Composition, 1·5 MΩ ± 10%, ½W.	8–TM5730
48	R50	Carbon, High-Stability, 200 kΩ ± 1%, ¼W.	56–TF1041B
49	R51	Composition, 2·7 MΩ*, ½W.	15–TM5730
50	R52	Composition, 22Ω ± 10%, ½W.	80–TF1041B
51	R53	Wirewound, 75Ω ± 5%, 6W.	81–TF1041B
52	R54	Wirewound, 75Ω ± 5%, 6W.	81–TF1041B
53	R55	Composition, 68 kΩ ± 10%, ½W.	9–TM5730
54	R56	Composition, 2·7 MΩ*, ½W.	79–TF1041B
55	R57	Composition, 5·1 kΩ ± 5%, ½W.	82–TF1041B
56	R58	Composition, 50 MΩ ± 20%, 1W.	84–TF1041B
57	R59	Carbon, High-Stability, 10Ω ± 20%, ½W.	74–TF1041B

**Nominal value: actual value determined during calibration.*

THERMISTORS

58	TH1	Brimistor Type CZ3, 200 mA.	108–TF1041B
59	TH2	Brimstor Type CZ3, 200 mA.	108–TF1041B
60	TH3	Mullard Varite Type VA1040.	109–TF1041B

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		POTENTIOMETERS AND KNOBS	
61	RV1	Carbon, 100 kΩ ± 20%, ¼W, Linear.	13–TM5730
62	RV2	Wirewound, 50 Ω ± 10%, 3W, Linear.	88–TF1041B
63a	RV3	Wirewound, 1 kΩ ± 10%, 3W, Linear.	89–TF1041B
64	RV4	Wirewound, 2 kΩ ± 10%, ½W, Linear.	14–TM5730
65	RV5	Wirewound, 2 kΩ ± 10%, ½W, Linear.	14–TM5730
66a	RV6	Wirewound, 3 kΩ ± 10%, 3W, Linear.	90–TF1041B
67	RV7	Wirewound, 330 Ω ± 10%, ½W, Linear.	11–TM5730
68	RV8	Wirewound, 330 Ω ± 10%, ½W, Linear.	11–TM5730
69	RV9	Wirewound, 1 kΩ ± 10%, ½W, Linear.	12–TM5730
70	RV10	Carbon, 5 MΩ ± 20%, ½W, Linear.	91–TF1041B
70/1	RV11	Wirewound, 10 Ω ± 10%, 1W, Linear.	87–TF1041B
71		Knob Insulator for RV2 or RV6.	92–TF1041B
72		Knob Insulator for RV10.	85–TF1041B
72/1		Knob for RV11.	TB23920/1
		CAPACITORS	
73	C1	Ceramic, 0·01 μF + 80% − 20%, 350 V d.c.; included in Item 121.	14–TM5776
74	C2	Ceramic, 0·01 μF + 80% − 20%, 2 kV d.c.	95–TF1041B
75	C3	Ceramic, 0·01 μF + 80% − 20%, 350 V d.c.	10–TM5730
76	C4	Electrolytic, 8 μF + 50% − 20%, 450 V d.c.	96–TF1041B
77	C5	Electrolytic, 8 μF + 50% − 20%, 450 V. d.c.	96–TF1041B
78	C6	Ceramic, 0·01 μF ± 25%, 2 kV d.c.	95–TF1041B
79	C7	Paper, 0·25 μF ± 20%, 200 V d.c.	98–TF1041B
80	C8	Ceramic, 0·03 μF + 80% − 20%, 500 V d.c.	99–TF1041B
81	C9	Electrolytic, 50 μF, 25 V d.c.	100–TF1041B
		SEMICONDUCTORS	
82	MR1	S.T.C. Unistor Type MQ8/1.	103–TF1041B
83	MR2	S.T.C. Unistor Type MQ8/1.	103–TF1041B
84	MR3	S.T.C. Unistor Type MQ8/1.	103–TF1041B
85	MR4	S.T.C. Unistor Type MQ8/1.	103–TF1041B
86	MR5	S.T.C. Type C2D, Selenium Rectifier.	104–TF1041B
87	MR6	S.T.C. Type C2D, Selenium Rectifier.	104–TF1041B
88	MR7	S.T.C. Type 430–SC–1B1–S (Series 400), Selenium Rectifier.	105–TF1041B

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		VALVES, VALVEHOLDERS AND RETAINERS	
89	V1	Diode, Type EA52; included in Item 121.	26–TM5776
90		Holder and Lock Ring for V1; included in Item 121	1–TM5776
91		Anode Connector for V1; included in Item 121	9–TM5776
92	V2	Pentode, Type 6BS7.	123–TF1041B
93		Holder for V2, B9A, less skirt.	30–TF1041B
94		Retainer for V2.	38–TF1041B
95		Top-Cap Connector for V2.	39–TF1041B
96	V3	Double Triode, Type 12AT7.	124–TF1041B
97		Holder for V3, B9A with skirt.	29–TF1041B
98		Screening Can for V3.	33–TF1041B
99	V4	Pentode, Type 6BS7.	123–TF1041B
100		Holder for V4, B9A, less skirt.	30–TF1041B
101		Retainer for V4.	38–TF1041B
102		Top-Cap Connector for V4.	39–TF1041B
103	V5	Double Diode, Type EB91.	125–TF1041B
104		Holder for V5, B7G with skirt.	31–TF1041B
105		Screening Can for V5.	34–TF1041B
		BARRETTERS	
106	RB1	Hivac Type XB1.	107–TF1041B
107		Holder for RB1, B7G less skirt.	28–TF1041B
108		Retainer for RB1.	37–TF1041B
109	RB2	Hivac Type XB1.	107–TF1041B
110		Holder for RB2, B7G less skirt.	28–TF1041B
111		Retainer for RB2.	37–TF1041B
		SWITCHES AND KNOBS	
112	S1	Rotary, 12 section, 12 way.	TC4428/472
113	S2 and	Rotary, 6 section, 10 way.	TC4428/471
	S3	Rotary, double-pole, on-off; fitted to rear of S2	
114		Knob for S1 or S2.	22–TF1041B
		TRANSFORMER	
115	T1	Mains Transformer.	TM5149/7

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		METER ASSEMBLY	
116	M1	Moving-Coil Panel Meter, 200 μA f.s.d., 500 Ω.	TM4702/6
		PILOT LAMP AND HOLDER	
117	LP1	Tubular, 6·3-volt, 0·15-ampere, M.C.C.	117–TF1041B
118		Holder for LP1, M.C.C.	TB25073/2
		CONNECTORS, PROBES AND LEADS	
119	PL1	Mains Plug, 3-pin, 5-ampere; included in Item 131.	1–TM2560/AQ
120		Crocodile Clip; included in Item 130.	TB27958
121		A.C. Probe; includes Items 1, 73, 89, 90, 91, 122, 123 and 124.	TM5776
122		Prod Tip for A.C. Probe; included in Item 121.	TB28720
123		Connecting Lead for A.C. Probe, 54 inches long, 2-core, anti-microphonic; included in Item 121.	21–TM5776
124		Grounding Clip Assembly; included in Item 121.	TC23535/3C
125		Grounding Sleeve; for use with a.c. probe.	TC23533/3
126		D.C./Ω Probe; includes Items 2, 127, 128 and 129.	TM5731
127		Prod Tip for D.C./Ω Probe; included in Item 126.	TB28052
128		Finger Push Moulding for D.C./Ω Probe; included in Item 126.	TB28053
129		Connecting Lead for D.C./Ω Probe, 4 ft long, 2-core, anti-microphonic; included in Item 126.	15–TM5731
130		COMMON Lead Assembly; 4 ft long; includes Item 120.	110–TF1041B
131		Mains Lead, 3-core, 6 ft long; includes Item 119.	TM2560/AQ
		MISCELLANEOUS	
132		Front Panel, Aluminium Alloy.	17–TF1041B
133		Case Back, Alumium Alloy.	12–TF1041B
134		Case Lid, Aluminium Alloy.	16–TF1041B
135		Side Panel (left or right), Aluminium Alloy.	TC27948
136		Lid Clip, Mild Steel.	TB27960
137		Meter Panel, Aluminium Alloy.	TC28046
138		2-BA Hexagonal Socket Wrench in Linen Bag.	102–TF1041B
139		Operating and Maintenance Handbook.	OM1041B

SOS Item No.	Circuit Ref.	Description	Works Ref.
		OPTIONAL ACCESSORIES	
140		Coaxial " T " Connector; includes Items 141 and 142.	TM5031A
141		Fixed Plug, Coaxial, 50-ohm; included in Item 140.	3–TM5031A
142		Fixed Socket, Coaxial, 50-ohm; included in Item 140.	2–TM5031A
143		A.C. Multiplier.	TM5032
144		D.C. Multiplier; includes Item 145.	TM5033A
145		Connector for D.C. Multiplier.	TM5749
146		Dummy Load, 5-watt; includes Items 147 and 148.	TM5582
147		Fixed Socket, Coaxial, 50-ohm; included in Item 146.	1–TM5582
148		Resistor, Carbon, 50 $\Omega \pm 5\%$, linear to within $\pm 10\%$; included in Item 146.	6–TM5582
149		Carrying Case, polished hardwood, for stowage of Multipliers and " T " Connector; includes Items 150, 151 and 152.	TM4935
150		Case Handle; included in Item 149.	TB22190
151		Case Catch; included in Item 149.	TC10433/8
152		Case Foot (one of eight); included in Item 149.	17–TM4935