TRANSISTOR D.C. MULTIMETER

By W. CLELAND

In this, the final part of the "Transistor D.C. Multimeter", we give mounting details of the components and boards inside the diecast case, final wiring details and setting up instructions.

CASE DETAILS

The multimeter is housed in a diecast case of outside dimensions $8\frac{3}{4}$in $\times$ $5\frac{3}{4}$in $\times$ $2\frac{5}{32}$in. The box is used upside down, since the screws of the lid prevent the lid from being used as the top panel. The lid, therefore, becomes the underside of the instrument, to which four rubber feet are screwed, and the bottom of the box makes a satisfactory top panel. Top panel dimensions are $\frac{1}{16}$in less than the overall dimensions, because, with a diecast box, the sides taper slightly inwards. When drilled, as in Fig. 9, the case is painted to protect it; paint has to be removed from openings and from the edges and interior of the case when dry.

The neon signal lamp is mounted just under the edge of M1 and is raised $\frac{1}{8}$in, by fitting a piece of black Bakelite under it as shown in Fig. 10. This is positioned on the top panel between the milliammeter and the Perspex switch escutcheon. On final assembly, the signal lamp is fastened from the inside, by pushing on a spire nut, over the plastic lampholder.

SWITCH ESCUTCHEON

The Perspex switch escutcheon is shaped to fit between the signal lamp and terminals, and is dimensioned as shown in Fig. 11. Two $\frac{3}{4}$in diameter holes enable it to fit around the nuts securing the range switches, and it is held in place by two 8B.A. countersunk screws. These are situated under the knobs of the range switches.

To set the switch knobs accurately, a small depression has to be drilled in the shaft for the grub screw. The smooth end of the grub screw can be scored with a file, so that the grub screw will leave a mark on the shaft at the required position. An indentation is made on this spot with a small drill.

NOTE: It is recommended that a suitable meter be obtained before drilling the box. Modifications to layout and drilling may be necessary to accommodate other meters such as the MR-65P

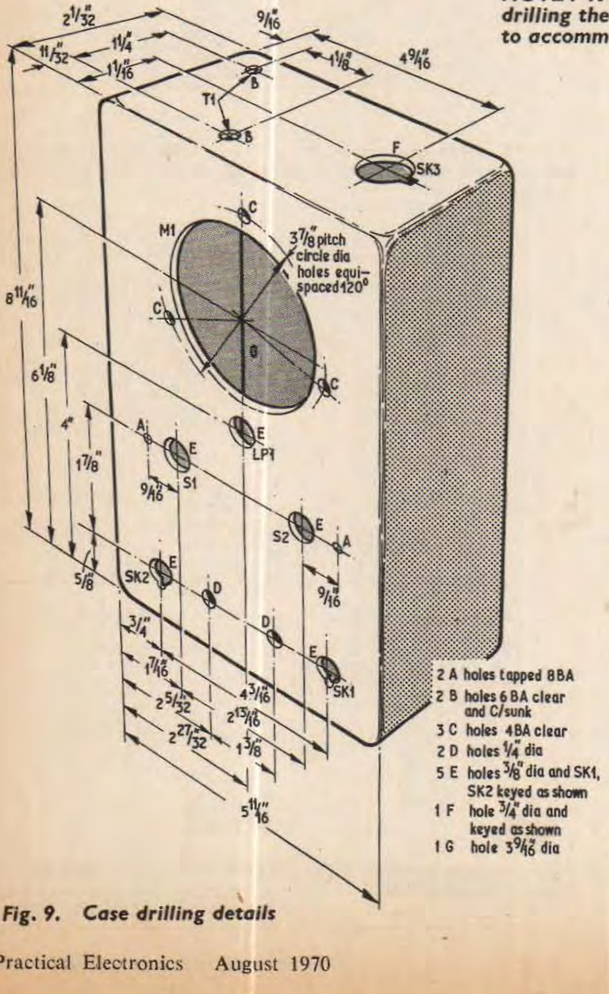


Fig. 9. Case drilling details

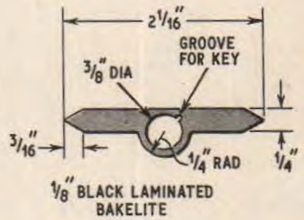


Fig. 10. Signal lamp surround

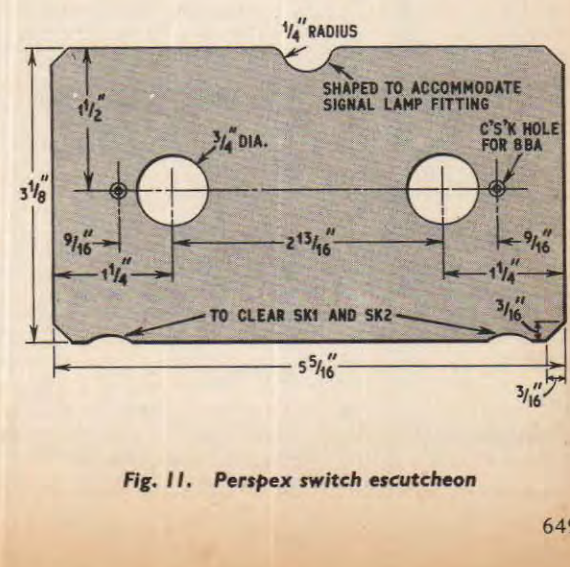
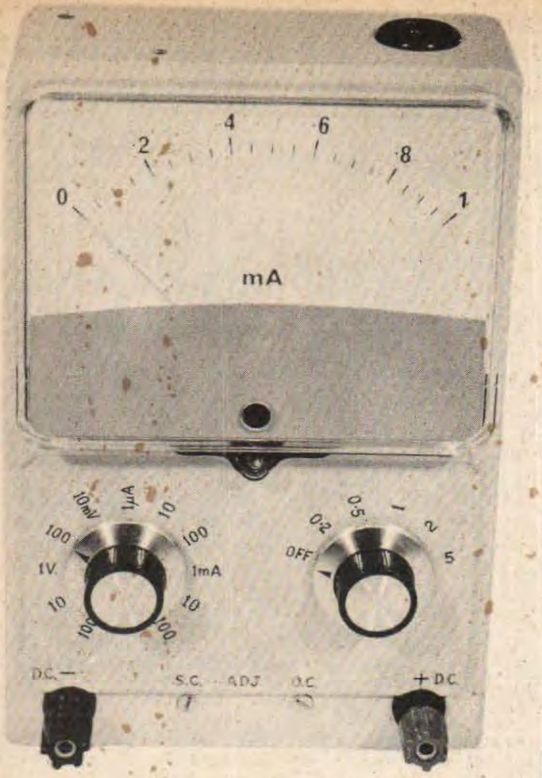
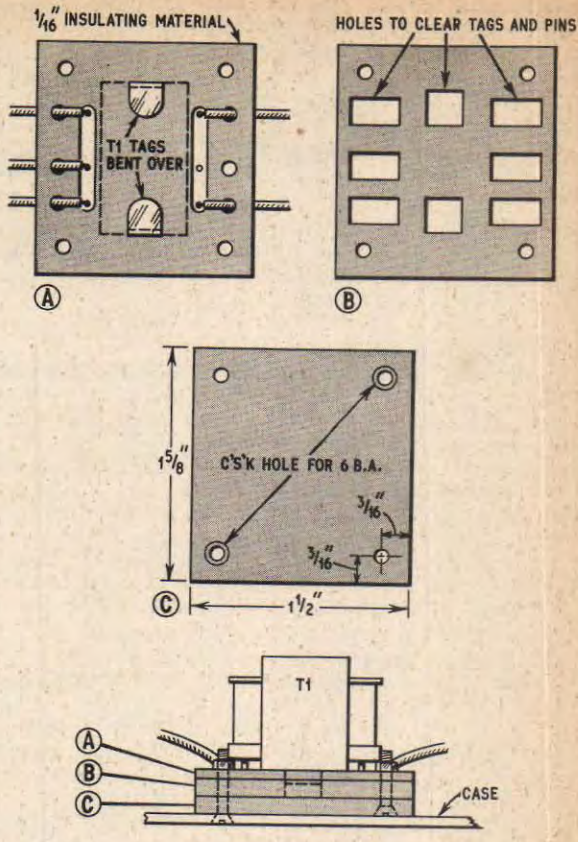


Fig. 11. Perspex switch escutcheon





Adequate clearance has to be ensured between the knobs and the Perspex escutcheon. The escutcheon can be marked, as shown in the photograph, to give switch positions and potentiometer designations.

Fig. 12. Insulated mounting for T1, holes are arranged to clear transformer tags. Sections B and C are ⅛in thickness Bakelite

MAINS WIRING

The metal case of the testmeter has to be earthed to the mains earth via SK3. *The circuit of the testmeter is in no way connected to the metal case or to mains earth.*

The insulated mounting for the miniature mains transformer T1 (Fig. 12) insulates it from the metal case, and provides a junction box for the transformer connections. The p.v.c. insulation of the connecting leads is carried into the insulated mounting, which consists of three rectangular pieces of insulating material sandwiched together. Parts B and C are of ⅛in laminated Bakelite, and can be bonded with adhesive. These are bolted at two corners to part A, which is of $\frac{1}{16}$in material. A pair of 6 B.A. countersunk bolts at the other corners, secure the mounting to the inside of the case.

The insulated leads from the signal lamp are hardly long enough to reach the mains switch S26, and to avoid running these wires very close to the range resistors, it is necessary to increase the length of the existing leads.

Details are given in Fig. 13 of a special insulated cover for the mains switch, which ensures safety if tests have to be made on the low voltage wiring with the unit turned on. All the mains wiring is double insulated, by wrapping each pair of p.v.c. covered wires with cloth insulation tape, avoiding an excessive thickness.

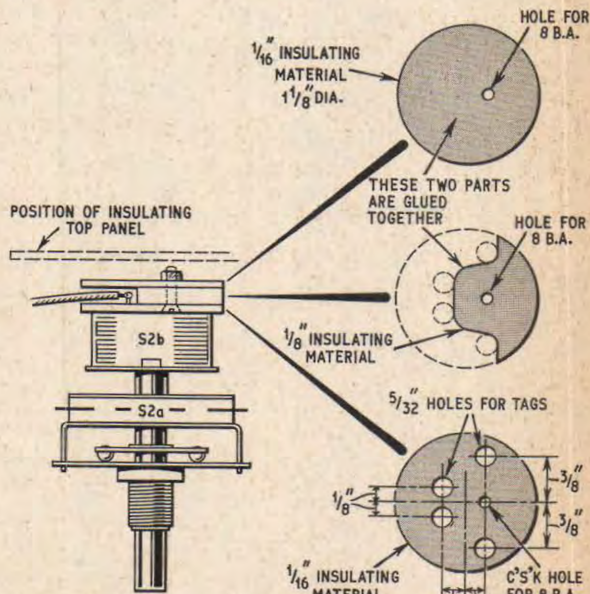


Fig. 13. Insulated cover for S2b. The lower section with the screw in position should be fitted before the wiring is connected to the switch

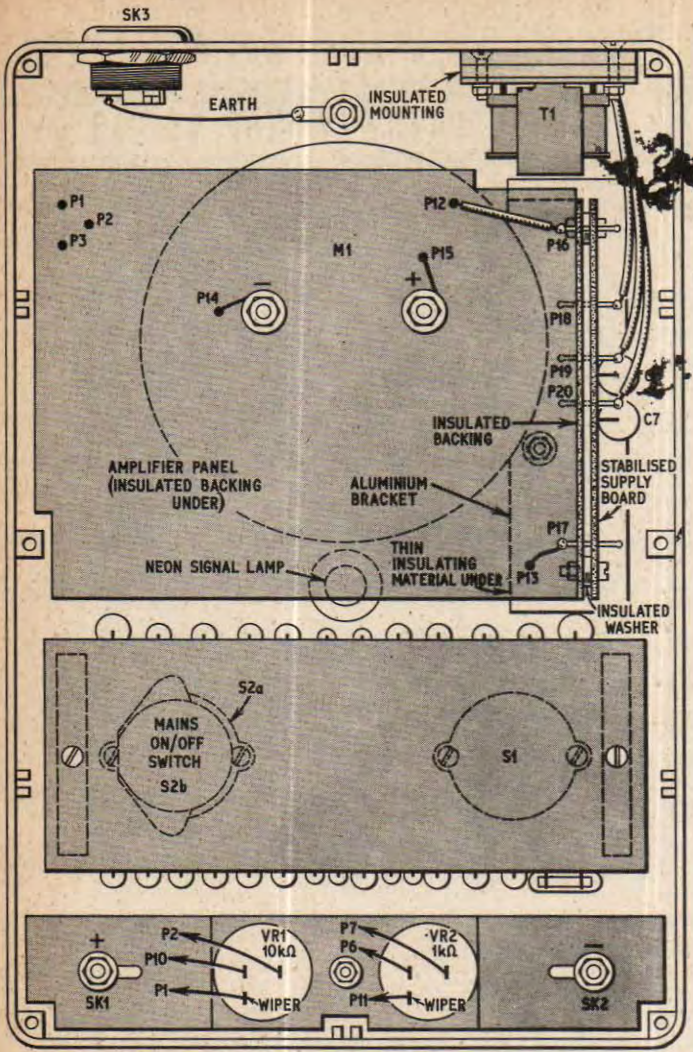


Fig. 14. Interior of the multimeter showing component positioning and potentiometer wiring

COMPONENTS . . .

Potentiometers
VR1 10kΩ miniature carbon
VR2 1kΩ miniature carbon

Sockets
SK1 Red insulated screw terminal
SK2 Black insulated screw terminal
SK3 Miniature three pin mains connector

Transformer
T1 Miniature mains, primary 0–220/240V, secondary 12–0–12V, 40mA, type P9005 (Electroniques)

Meter
M1 Moving coil milliammeter, B.P.L. type S40–V1 (1mA f.s.d.) *or* SEW type MR-65P

Miscellaneous
LP1 Neon signal lamp type SGF9/A (Electroniques)
Knobs pointer (2 off)
Diecast case 8¾in × 5¾in × 2 5/32in
Bakelite; 1/8in thickness, 5 7/16in × 3 1/8in, 1/16in thickness 4in × 1½in, 1/8in thickness black 2 1/16in × ½in
Perspex 3 1/8in × 5 5/16in × 1/8in thickness
6B.A. and 8B.A. fixings

CONNECTING UP

The Veropins on the amplifier board are connected up with reference to the pin numbers on the circuit diagram (Fig. 2), the switch connection diagram (Fig. 8), and Fig. 14, the plan of the interior of the multimeter. The two Veropins adjacent to the meter terminals are connected to the terminals by short leads, and the Veropins nearest to the stabilised voltage supply, are connected to the two on the vertical panel as shown in Fig. 14. The row of Veropins on the left of the amplifier board are connected by flexible p.v.c. covered wires to the range switching assembly, and to the two potentiometers that are mounted as shown in Fig. 15 by means of strips of 1/8in insulating material.

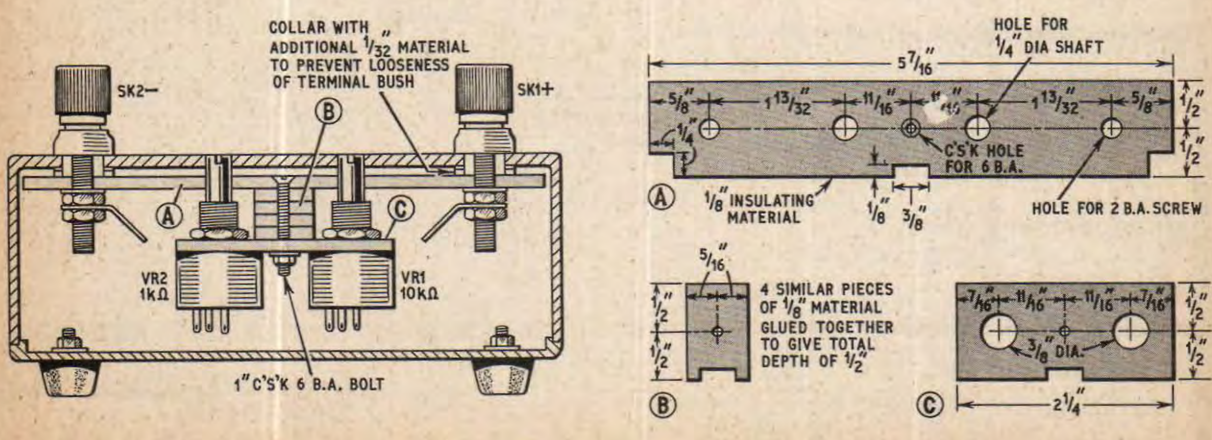


Fig. 15. Potentiometer mounting details, the ends of the spindles should be flush with the top of the case when fitted

The three secondary connections from the mains transformer are joined to the terminal pins on the voltage stabiliser panel.

Positioning of all components is shown in Fig. 14 and once the various sections have been mounted and wired up as described previously the meter can be connected to the mains supply ready for setting up and testing.

OFFSET ADJUSTMENT

A high gain differential d.c. amplifier needs pre-set adjustments to take up the mismatch in transistors and other components; adjustment is at the input stage where the sensitivity is greatest.

In the absence of an applied input, the terminals of the testmeter should be at the same potential. A small difference of potential at the input is called offset voltage, and arises from mismatch in the base-emitter potentials of the two input transistors. It can be balanced out by adjusting VR2, thus bringing the two input terminals to the same potential.

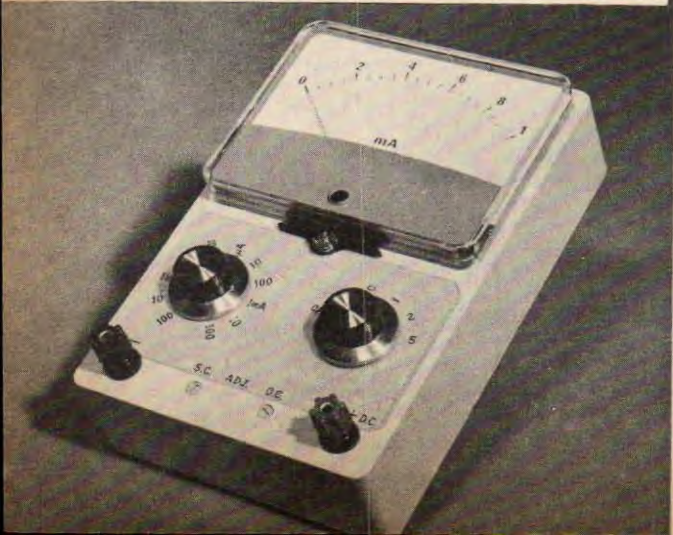
There is also an offset in the bias current of the two input transistors. The bias currents—less than a microampere—flow through the two 1MΩ feedback resistors and produce a small potential drop between output and input. The bias current adjustment is carried out indirectly by VR1 in the collector circuit of the input stage. When both offsets have been balanced out, there will be no potential difference, either at the input or at the output.

METER ZEROING

The two adjustments are not independent of each other. Each potentiometer has to be adjusted in turn to bring the pointer of the meter exactly to zero. A short insulated wire is connected between the input terminals each time that VR2 is adjusted, and temporarily disconnected when adjusting VR1. The potentiometer VR1 is thus the open circuit adjustment, and VR2 the short circuit adjustment, and the two are marked "O.C." and "S.C." respectively on the Perspex escutcheon.

Successive adjustments become smaller and should be continued on the most sensitive 2mV range until the pointer is at zero under both input conditions. The short circuit adjustment (VR2) is rather critical on the 2mV range, and it is probably advisable to solder a 470 ohm carbon film resistor permanently across it to make adjustment easier, providing that the narrower range of adjustment contains the required setting.

Once the above adjustments have been made and the meter has been tested on all ranges it is ready for use.★



OSCILLOSCOPE CALIBRATOR

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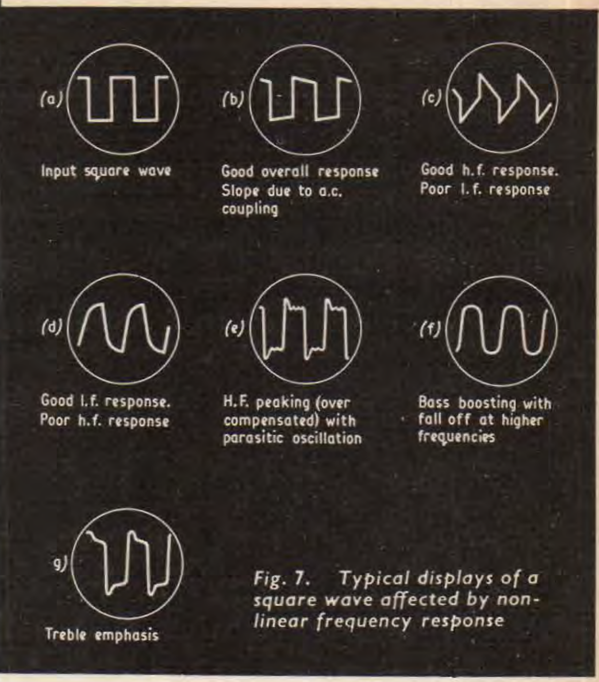

Fig. 7. Typical displays of a square wave affected by non-linear frequency response

maximum amplitude is 1 unit the average is 0·637 and this is what the meter will read.

However, we are usually more interested in the r.m.s. value which is, for sine waves, 0·707. If we divide the r.m.s. value by the average, we find the form factor, in this case 1·11. This is the amount by which the meter is scaled or calibrated. So the meter is known as average reading, r.m.s. calibrated. The form factor is obviously different for other waveforms, this calibration is therefore true only for sine waves.

AMPLIFIER TESTING

Square wave testing of amplifiers has the advantage of time saving. Plotting a frequency response curve is a tedious business. It involves changing the frequency of the signal generator point by point along the frequency base, and noting the amplifier's output reading. From this the output voltage versus frequency graph is drawn.

It is obvious that examining the effects of tone controls of an audio amplifier can be a long and dreary process. But, by applying a square wave to the amplifier input, and monitoring the output on an oscilloscope, the effects of tone controls and filters can be seen by the alteration to the wave shape. See Fig. 7.

Treble boost will show up as overshoot of the leading edge and treble cut as a rounding off. Bass boost will tilt the flat top left to right and bass cut right to left.

Checking a pre-amplifier with a square wave for the first time you may be dismayed to find that the output appears to be distorted. Even at the mid-point of the controls, the leading edge will probably display a slight kink and the top a slight curve. This is due to the type of tone control circuit which is common to many pre-amplifiers. However, the basic square shape, and the variation as the tone controls are adjusted is quite clear. ★