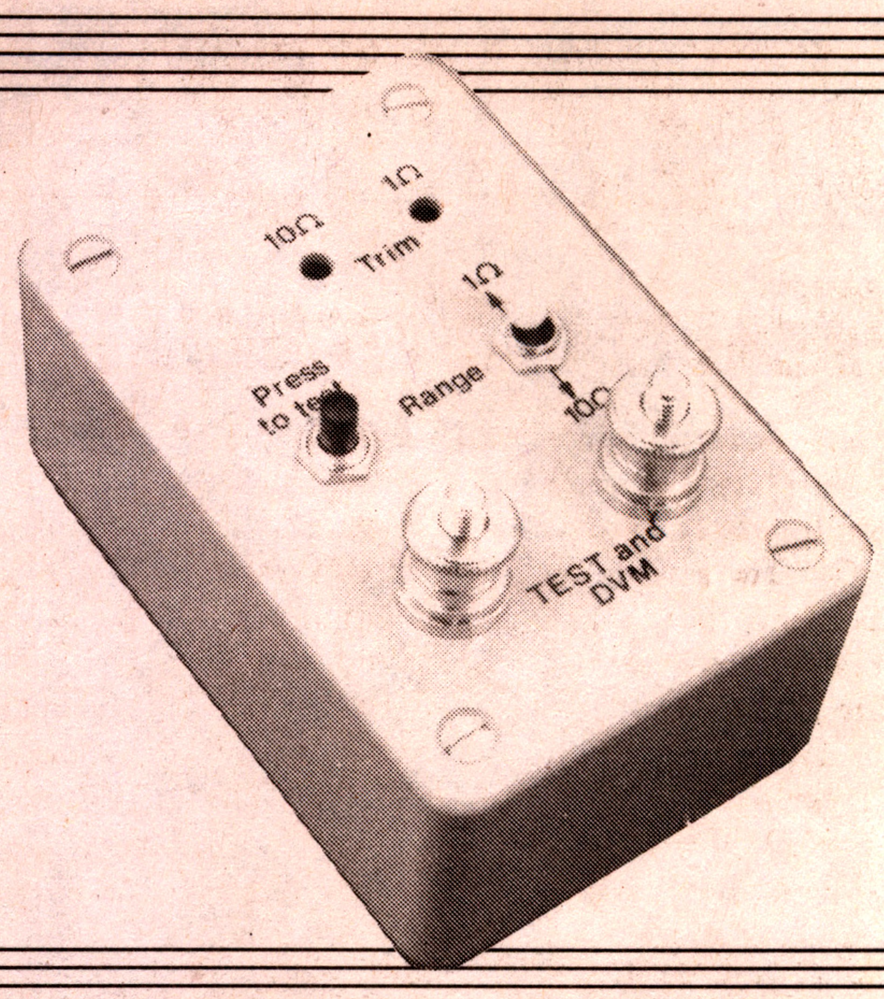
# LOW RANGE OHMMETER ADAPTOR




STEVE KNIGHT

*Increase the accuracy of low value resistance readings on your DVM.*

IT IS sometimes necessary to find the value of a resistor or, more particularly perhaps, the resistance of a length of wire, or a small coil, or a current meter shunt, where the actual resistance lies below ten ohms and may well be a fraction of an ohm.

This is where a low range ohm-meter is useful. Such an ohmmeter is also very handy for checking the resistance of printed circuit board tracks, especially where the tracks have to carry appreciable currents, and soldered connections where an extremely small resistance should be expected.

## SCALE ACCURACY

If reasonable accuracy in the measurement of a low resistance is needed it is wise not to depend upon analogue ohmmeters unless these have been specifically designed to have a low-resistance range. Ordinary analogue multimeters of good quality such as the Avometer used on the lowest resistance range will certainly provide an indication of values below ten ohms.

However, once the test resistance falls between the scale divisions or gets below one ohm, the eye is forced to judge the position of the pointer against a fraction of the scale length that is devoid of identifying lines.

For example, the author needed to find the value of a shunt resistor which was known to be approximately 0·7Ω; on the Avometer he had to judge the value indication on a blank section of the scale which was about 5mm long and represented zero to one ohm, see Fig. 1.

After taking the test lead resistance into consideration and allowing (again by eye) for the scale non-linearity, the reading *looked* to be somewhere about 0·7Ω, but it could well have been anything from 0·6Ω to 0·8Ω, clearly a hit and miss measurement.

For those who now wonder about using a digital meter, the answer is that a similar problem can arise in general purpose instruments in spite of their much superior resolution over analogue meters. For instance, a 3·5-digit display type of digital meter with a basic 199·9 indication on its lowest resistance range is perfectably readable down to an ohm or so without too much questioning. When going below an ohm, though, some doubt can creep in.

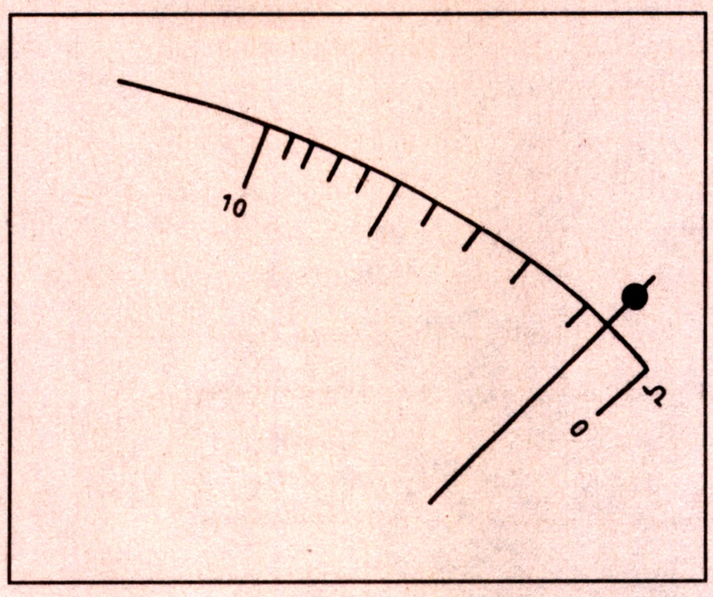


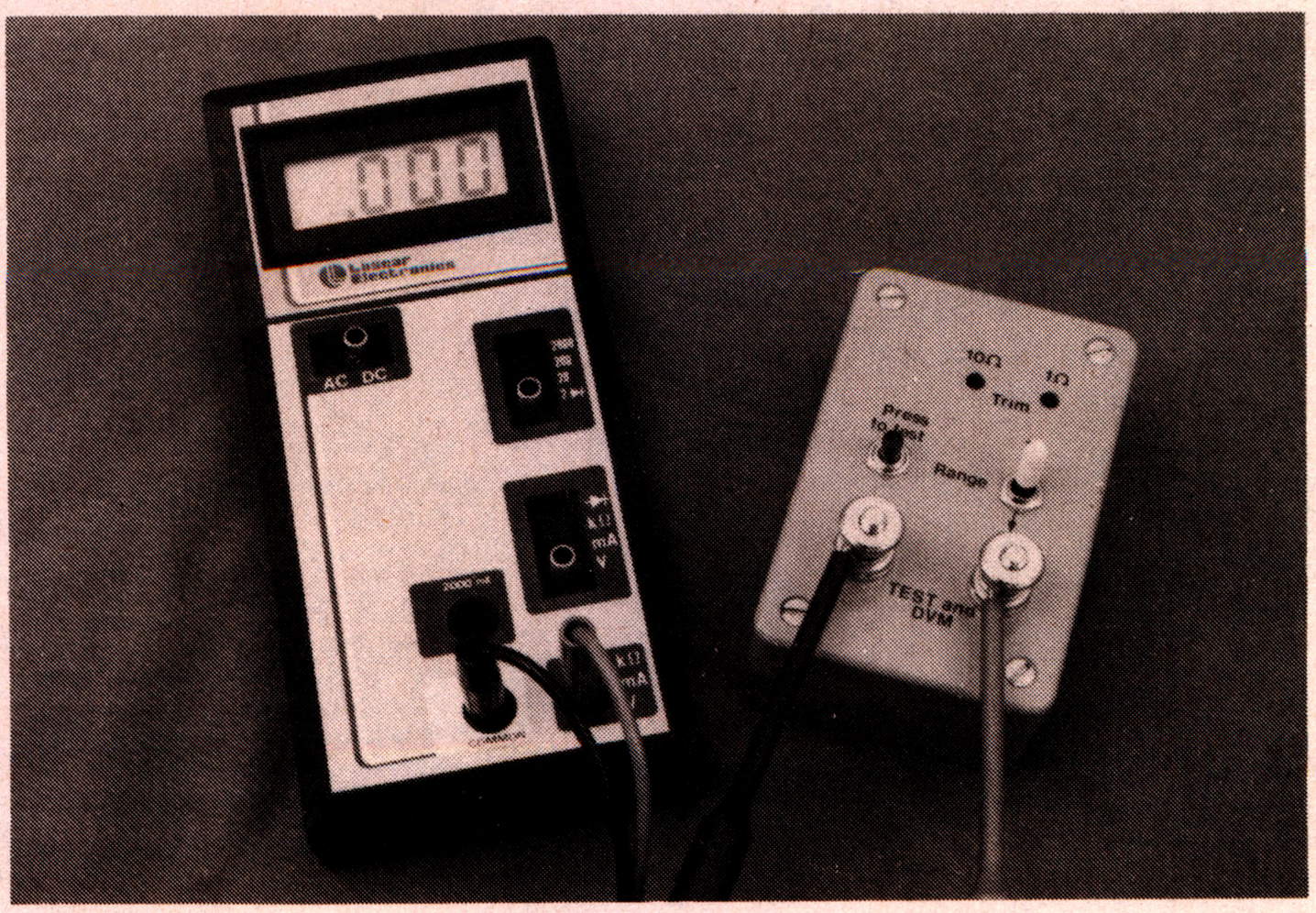

*Fig. 1. Low ohms scaling of typical analogue multimeter.*

As an example, a reading of 000·5 on the 200Ω range does not mean that the test resistance is exactly 0·5Ω; its value could well lie between 0·45Ω and 0·55Ω, and the display may often be found to flicker between readings of 000·4 and 000·5 or 000·5 and 000·6 on such occasions. Using the digital instrument on the author's shunt resistor simply gave such a result, and once again the actual value could have been between 0·65Ω and 0·75Ω. This was no improvement on the guess-work associated with the Avometer.

Using a very accurate bridge the author actually found the resistor to be 0·737Ω, but it was while pondering on the points discussed above that he got an idea for a simple adaptor which could be used with a digital meter to provide more reasonable accuracy of this sort.

## ADAPTOR CIRCUIT

Of course, it is possible to measure the current through, and the voltage across an unknown resistor and then use Ohm's law to calculate the value. This is a bit troublesome since a large current is needed to produce a measureable voltage drop. The problem is then simply switched from the ability to read a small resistance accurately to that of measuring a small voltage accurately.



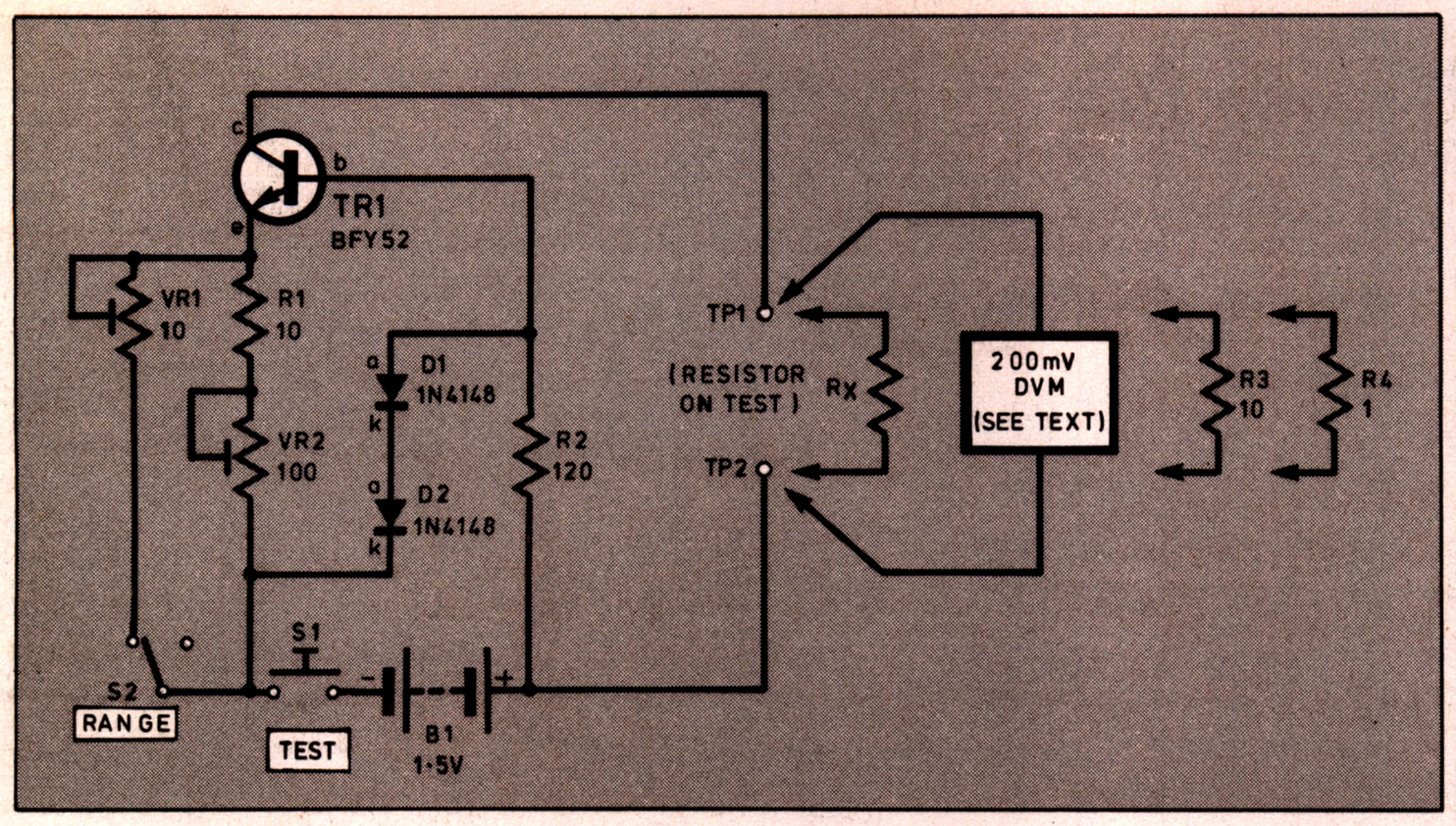



*Fig. 2. Full circuit diagram for the Low Range Ohmmeter Adaptor.*

With the very simple adaptor described here, an existing 3·5-digit DVM used in the millivolt mode can be made to read between zero and 10Ω in two ranges: 0 to 1Ω and 0 to 10Ω with two (and possibly three) decimal place indication. Using this adaptor, the shunt resistor value was found to be 0·73(4)Ω within the stated accuracy of the voltage range used and that of the calibration resistor used.

The full circuit diagram for the *Low Range Ohmmeter Adaptor* is shown in Fig. 2, where its simplicity is immediately apparent. The source of power supply is a single 1·5V cell and only a single transistor is needed, plus a few resistors and diodes and a couple of multi-turn potentiometers, all readily available and inexpensive.

Transistor TR1 is a constant current generator producing a known current through the test resistor $R_X$. The voltage developed across the test resistor is then measured by an external DVM which is switched to the 200mV range. Thus, unless Ohm's law has been deceiving us all these years, this voltage will be directly proportional to the value of the test resistance since the current is constant.

The level of the current is set for the two ranges, 1Ω and 10Ω respectively by adjustment of the multi-turn potentiometers VR1 and VR2. Multi-turns are used since the ordinary carbon rotary types are insufficiently "smooth" to be able to adjust with any accuracy, especially on the 1Ω range.

Once these are set up, no further attention is needed until the battery voltage has changed sufficiently to affect the readings. A couple of "trimmer" holes are provided in the case lid so that small correcting adjustment can be made to the multi-turn pots each time the adaptor is used. When drilling the case lid, position these trim holes so that they are directly above the multi-turn screwheads.

The on-off switch S1 is a push-to-make button type. This type is used because in operation it is pressed *only* when a reading is being taken and so prevents the adaptor from being inadvertently left on after use, the current drain from the cell being quite heavy.

## CONSTRUCTION

The adaptor is built on a small printed circuit board which is shown in Fig. 3. There should be no problems in making this up, just make sure of the orientations of the transistor and diodes, with the usual care in soldering. When completed, this board slips vertically into the internal wall grooving at one end of the small case.

There is nothing critical about positioning things inside the case, except that the access holes to the potentiometers should be correctly placed. The switch wire lengths are not important but keep the two test terminal leads as short as you possibly can without any tightness or straining.

The test terminals, TP1 and TP2, should be of the all metal types so that the test resistor can be clamped firmly and closely to them. Avoid terminal plugs and sockets as these can introduce small but significant resistance. Terminals could, alternatively be made using a couple of 2BA screws about one inch in length, with nuts and washers as appropriate.

The cut-out pattern for the lid components and the lettering legends are shown in Fig. 4. If you use an alternative case there should be no problem in placing the parts in roughly the same positions. The simple cell is an AA type battery clipped into a conventional holder (with tags) which is glued or screwed to the base of the case. Because of spacing requirements with the small listed case, mount the cell holder diagonally.

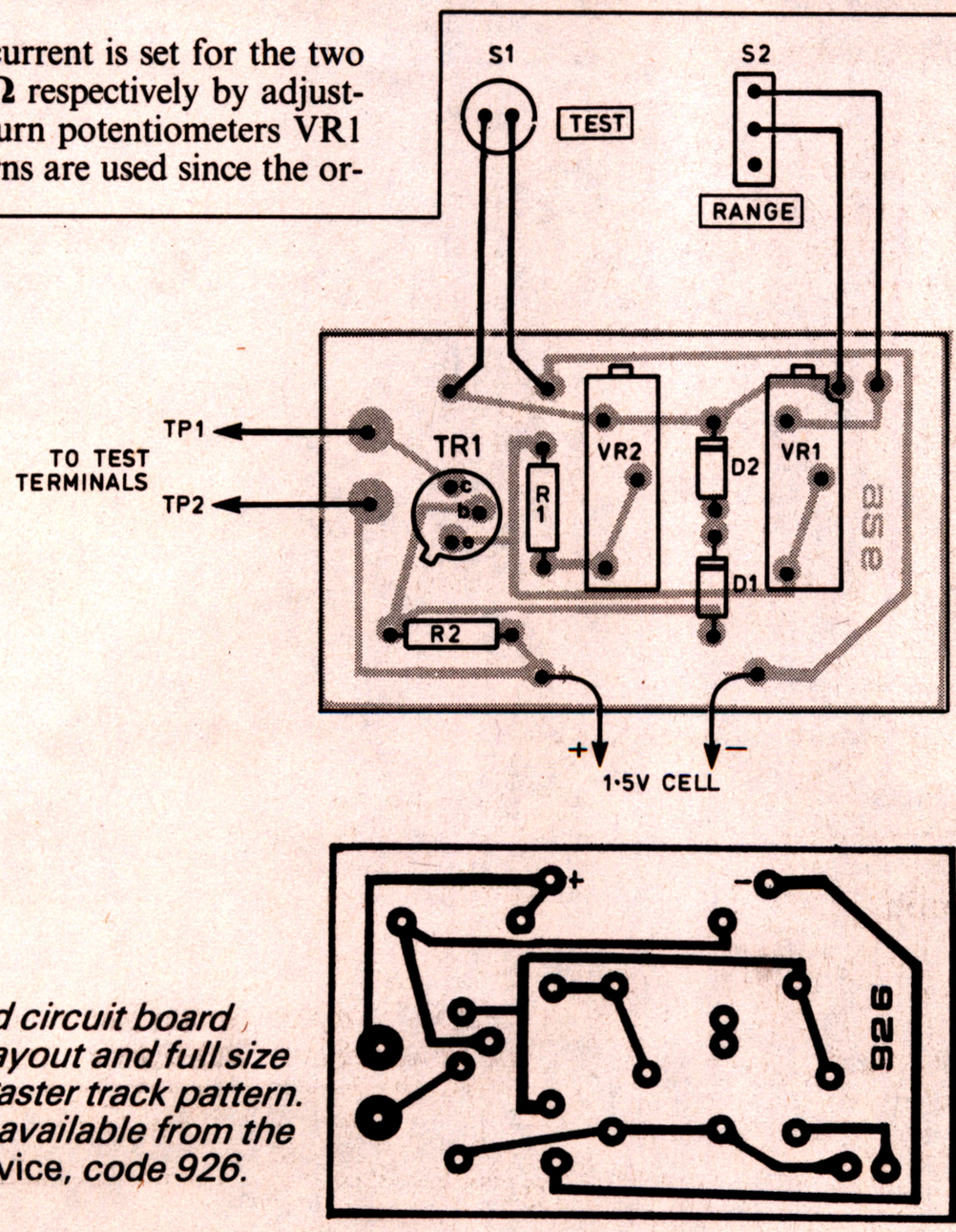



*Fig. 3. Printed circuit board component layout and full size copper foil master track pattern. This board is available from the* EPE PCB Service, *code 926.*

## COMPONENTS

**See SHOP TALK Page**

**Resistors**

| | |
|---|---|
| R1 | 10 5% or better |
| R2 | 120 5% or better |
| R3 | 10 1% or better |
| R4 | 1 1% or better |

All resistors metal film or better

**Potentiometers**

| | |
|---|---|
| VR1 | 10 0·75in multi-turn |
| VR2 | 100 0·75in multi-turn (20 turns or more) |

**Semiconductors**

| | |
|---|---|
| D1, D2 | 1N4148 signal diode (2 off) |
| TR1 | BFY52 *npn* transistor |

**Miscellaneous**

| | |
|---|---|
| S1 | push-to-make momentary action switch |
| S2 | s.p.s.t. min. toggle switch |

Printed circuit board available from *EPE PCB Service,* code 926; plastic box 85mm x 56mm x 40mm; single AA size cell holder with tag ends; 4mm screw terminal post (2 off); solder tag (2 off); connecting wire; solder.

*Approx cost guidance only* **£10**

## CALIBRATION

Calibration is quite simple, but care is needed on the 1Ω range. You will need two accurate test or calibration resistors of 1Ω and 10Ω in value at a minimum one per cent tolerance, but better if you can get them. If you happen to have a standard resistance box (the author has an old ex-Army one which contains a total of 100Ω which can be adjusted in precise 0·1Ω steps) each range can be thoroughly checked with the best possible accuracy.

Set both multi-turn potentiometers, VR1 and VR2, to about mid-travel, set the Range switch to 10Ω and clamp an accurate 10Ω calibration resistor firmly across the test terminals. Now connect your digital meter, switched to the 200mV

d.c. range, across the test resistor (lead length here is not important). Although the 200mV range of the DVM is being used, it is only used as far as the 100mV point. The reading obtained then corresponds to the unknown resistance value from 0 to 10Ω. Now adjust preset VR2 to give this 100mV meter reading while pressing the button switch. The reading (although strictly in millivolts) corresponds to a resistance value of 10Ω.

You can check the linearity of the scale by connecting one or more intermediate values of resistance to the test terminals. The positioning of the decimal points for any reading has, of course, to be mentally adjusted to suit the scaling.

Repeat the above procedure on the 1Ω range, using your accurate 1Ω calibration resistor at the test terminals, and this time adjusting preset VR1 to give a reading of 100mV, which will now represent a 1Ω resistance value. A reading of, say, 47·5mV would therefore indicate a resistance of 0·475Ω.

It is a bit trickier to set the DVM exactly to 100mV on this smallest range than it is on the larger. This comes about because of slight fluctuation in the otherwise constant current from transistor TR1 and the finite resolution of preset VR1. A flickering of the last decimal place in this case within the range 000·2 does not impede the usefulness of the adaptor, particularly if the calibration resistor is not better than a one per cent type.

## OTHER METERS

Some DVMs have a lowest d.c. range of 400mV. These can still be used, adjusting the multi-turn presets to provide a full scale at the 100mV point.

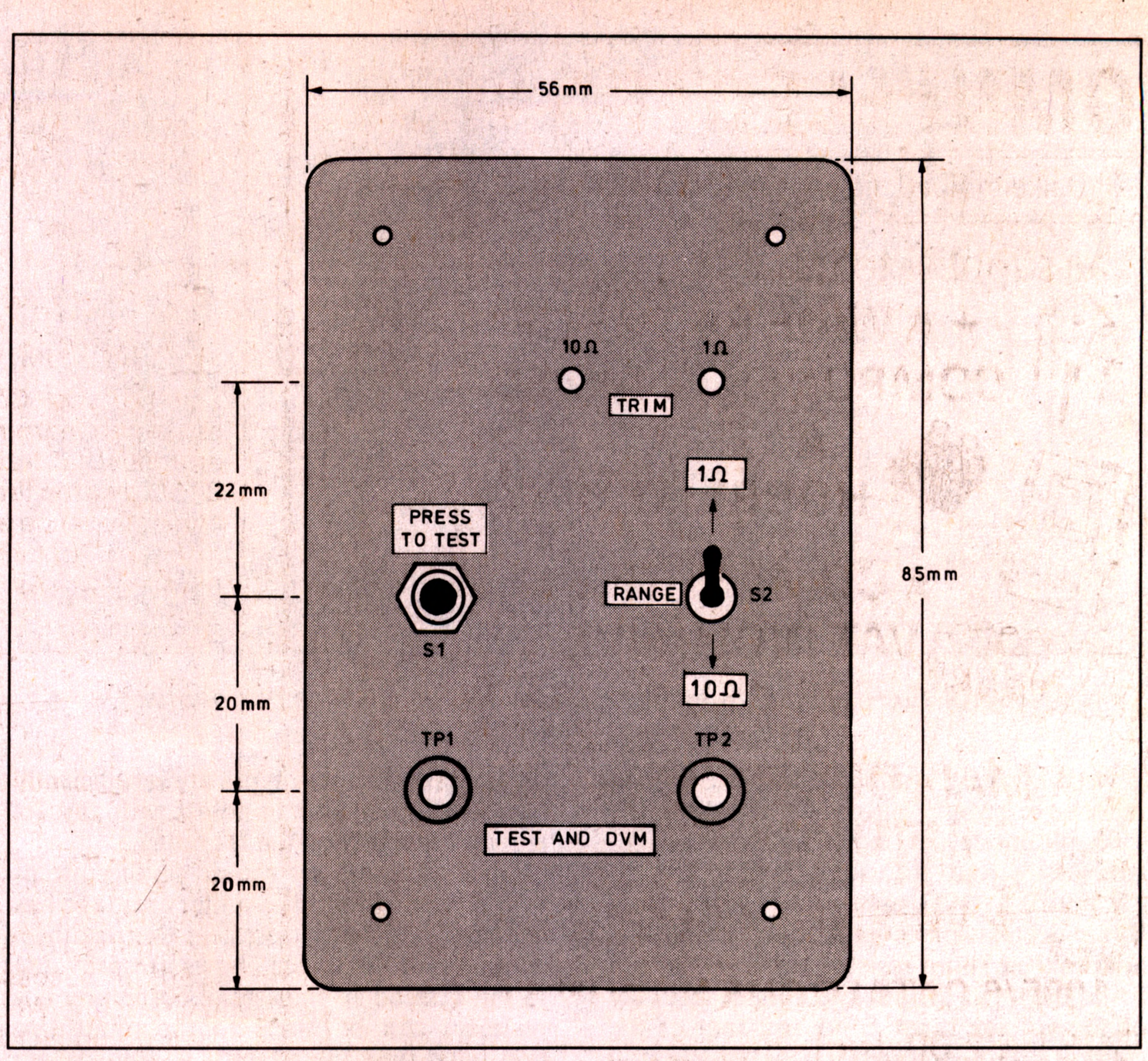
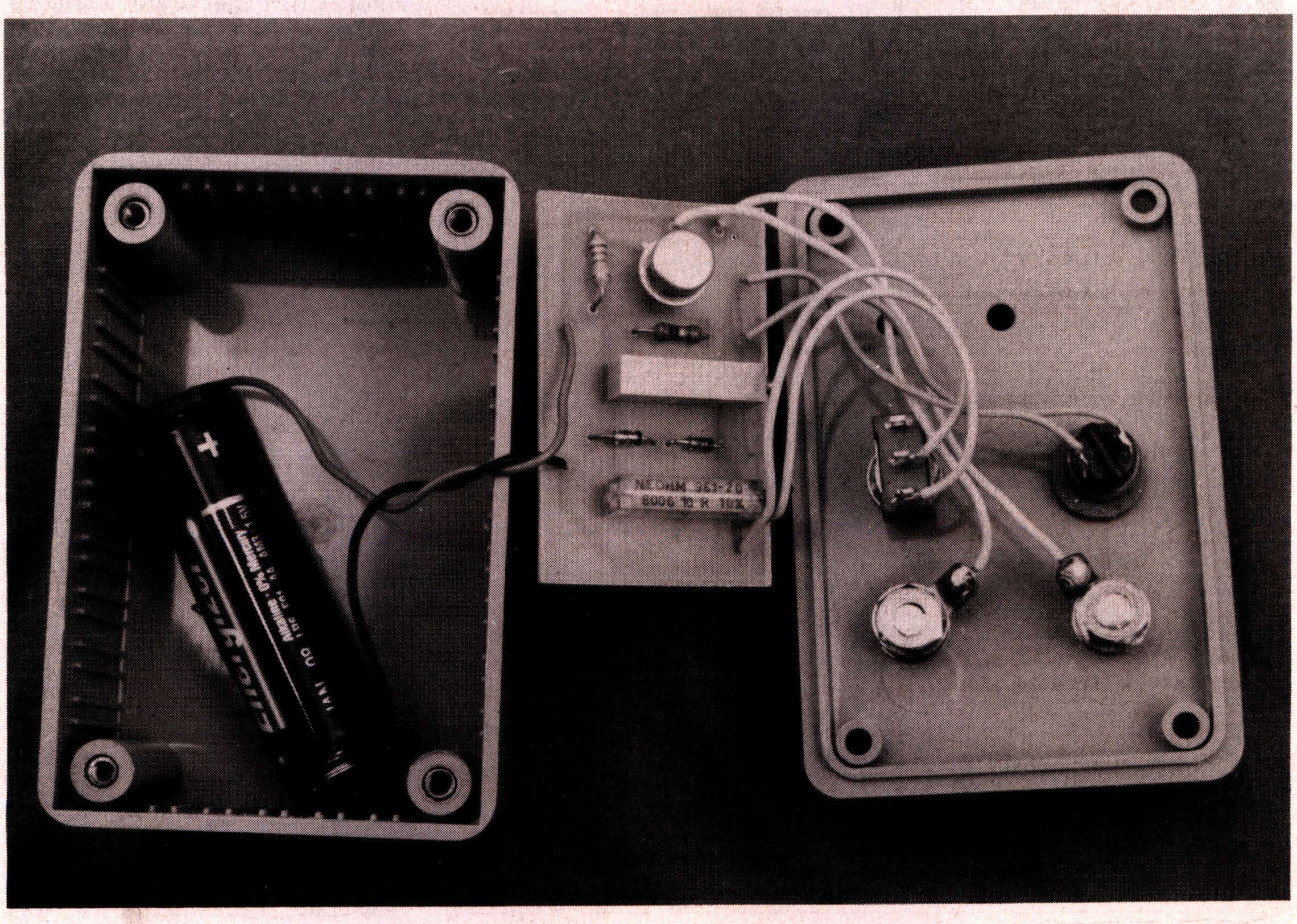



*Fig. 4. Layout and drilling details for the case.*

There is no reason why an analogue meter, possibly with an f.s.d. of 100μA to 500μA cannot be used in place of a DVM. However, a lot depends upon the internal resistance and it is possible that anything above a few hundred ohms may not enable f.s.d. to be obtained.

If you have a meter with a lowest range of 100mV, it is worthwhile doing a bit of experimenting with it. By using a larger case, such a meter could be built into it, so making up a compact low range ohm-meter. □