# Using Surplus Meters

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PERIODICALLY, SUPPLIES OF METERS, VOLTmeters, milliammeters and ammeters appear to be released on to the surplus market and are advertised at reasonable prices in the magazine. Some of them have ranges which are extremely useful to the experimenter; but others have ranges which, except in odd cases, have little apparent practical use.

One of the more useful types is the meter having a full scale deflection current of 1mA with a meter resistance of 100 ohms. Such a movement may be used in conjunction with suitable shunt and multiplier resistors to build up a useful multi-range meter which, in addition to resistance measurements, has the following d.c. ranges:

| *Volts* | *Current (mA)* |
|---|---|
| 0–1 | 0–1 |
| 0–10 | 0–10 |
| 0–100 | 0–100 |
| 0–500 | 0–500 |

Suitable values of shunt and multipliers may be easily made up. Fig. 1 shows a suggested layout for such a meter.

The scale of the meter will, of course, be marked 0–1mA; therefore the scale reading will have to be multiplied by the appropriate factor when using the meter for higher current and voltage readings.

| *Range* | *Multiply scale reading by* |
|---|---|
| 0–1 | — |
| 0–10 | 10 |
| 0–100 | 100 |
| 0–500 | 500 |

For resistance measurements first connect the test terminals together and adjust $R_2$ for full scale deflection on the meter. In calibrating the meter for resistance measurement, the actual pointer position on the scale for different values of resistance may be calculated or, alternatively, a number of known value resistors may be measured and the scale calibrated accordingly.

**Components Required**

| | |
|---|---|
| M | 0–1mA, 100 ohm moving coil meter |
| $R_1$ | 3.3kΩ ½ watt, 20% tolerance |
| $R_2$ | 2kΩ wire-wound variable resistor |

*Shunts*

| | |
|---|---|
| $R_3$, $R_4$, $R_5$ | 11.11Ω, tapped at 1.01 and 0.2004Ω |

*Multipliers*

| | | |
|---|---|---|
| $R_6$ | 400kΩ | Close tolerance resistors |
| $R_7$ | 100kΩ | Close tolerance resistors |
| $R_8$ | 9.9kΩ | Close tolerance resistors |
| $R_9$ | 900Ω | Close tolerance resistors |
| $SW_1$ | 2-pole, 9-way switch (Bulgin, type S.206) | |
| B | 4.5 volt battery | |

The Planet Instrument Co., 25 Dominion Avenue, Leeds, can supply a made-up shunt resistor and also the close tolerance multiplier resistors. The arrangement shown in Fig. 1 will permit the shunt connections and the multiplier resistors to be wired directly on to the tags of the switch.

Previous reference was made to those meters which would appear to have little practical use to the experimenter. However, many of the more "awkward" range meters can be adapted for other uses by the simple application of Ohm's Law. In general terms this law states that the current in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance of the circuit. Symbolically, this may be shown as $I=\frac{E}{R}$, where I is the current, measured in amperes, E is the applied voltage and R is the resistance, measured in ohms. Mathematically, this formula may be altered to $R=\frac{E}{I}$, and $E=I\times R$, and it is from here that one may set about altering the ranges of both voltmeters and ammeters.

With the exception of electrostatic, moving-iron and hot-wire type meters, those advertised are moving coil instruments having a basic full scale deflection current of, perhaps, one or two milliamps and a coil resistance varying between a few ohms and a hundred or so. If this basic movement is being used to measure a higher value of current, the current in excess of that required to give full scale deflection on the meter is shunted through a parallel resistor, as in Fig. 2 (*a*). Thus with a suitable shunt value, a meter may be adapted to read any value of current. The same type of meter may also be used to read voltages if a suitable current limiting resistor is connected in series with it, as in Fig. 2 (*b*).

The correct values of shunt and/or multiplier resistors necessary to extend the range of any meter may easily be determined if

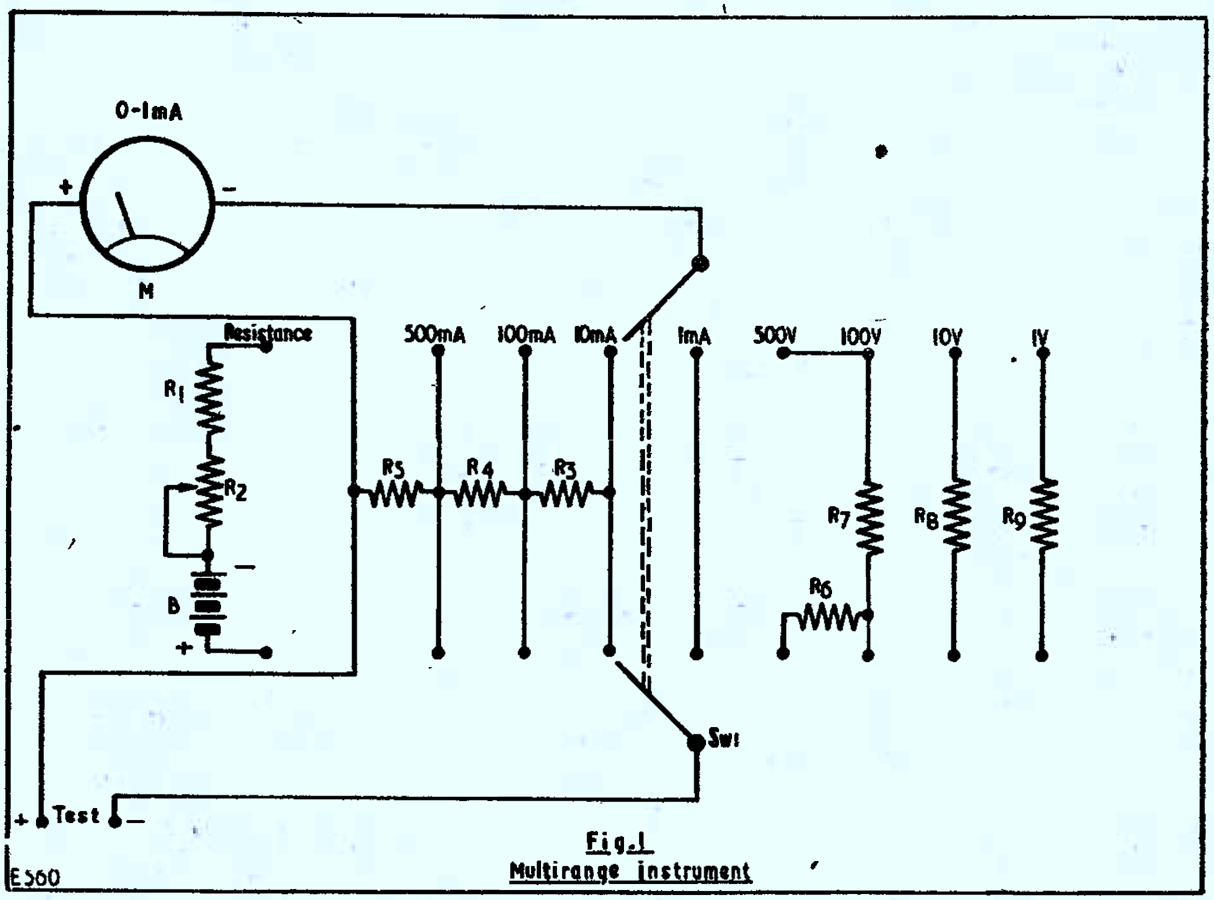


Fig. 1
Multirange instrument

the full scale deflection current and coil resistance of the meter are known.

**To Calculate Shunt/Multiplier Values**

*Shunt Resistors*

Since the meter and shunt are to be connected in parallel, the product of the current through the meter ($I_m$) and the resistance of the meter ($R_m$) must equal the product of the current through the shunt ($I_s$) and the resistance of the shunt ($R_s$) . . . . $I_s \times R_s = I_m \times R_m$

hence, $$R_s = \frac{I_m \times R_m}{I_s}$$

*Example:* What value of shunt will be required to enable a meter having a full scale deflection (f.s.d.) of 1mA and resistance of 100Ω to read 0–10mA?

Since the meter required only 1mA for f.s.d., 9mA must pass through the shunt,

$$\text{Shunt resistance } (R_s) = \frac{(1 \times 10^{-3}) \times 100}{9 \times 10^{-3}}$$

$$= 11.11 \text{ ohms}$$

*Multiplier resistors*

Suppose the meter of the previous example is now required to measure up to 10 volts. The f.s.d. of the meter is 1mA and so, when measuring 10 volts, the current through the meter must not exceed this value The total value of the resistance required to limit the current to the required value can be found by application of Ohm's Law—$(R = \frac{E}{I})$

therefore, $$R = \frac{10}{1 \times 10^{-3}} = 10{,}000\Omega$$

But the meter has a resistance of 100Ω, therefore an additional series resistor of 10,000−100=9,900Ω will be required.

In both examples, the actual meter reading will, of course, have to be multiplied by 10.

A multi-range meter, similar to that described previously can be made up quite easily with a basic moving coil movement and a suitable selection of shunts and multipliers.

The meter may also be used to measure resistance in addition to current and voltage by the inclusion—in series—of a battery of, say, 4½ volts and a current limiting resistor. For example, suppose we connect such a battery in series with the meter used in the above example, together with a fixed resistance of 3.3kΩ and a variable resistor of 2kΩ, as in Fig. 2 (*c*). If $T_1$ and $T_2$ are joined, $R_2$ should be adjusted so that the meter shows f.s.d. If now a resistor of unknown value is connected in series between $T_1$ and $T_2$, a reduced current will flow through the meter. A number of known value resistors may be used and the scale calibrated accordingly.

resistor of about 50kΩ set to full resistance, and a small cell of about 1½ volts—as in Fig. 3 (*a*)—and gradually reduce the resistor value until the unknown meter is reading f.s.d. The value of current flowing may now be read off the calibrated meter. To measure the resistance of the unknown coil, disconnect

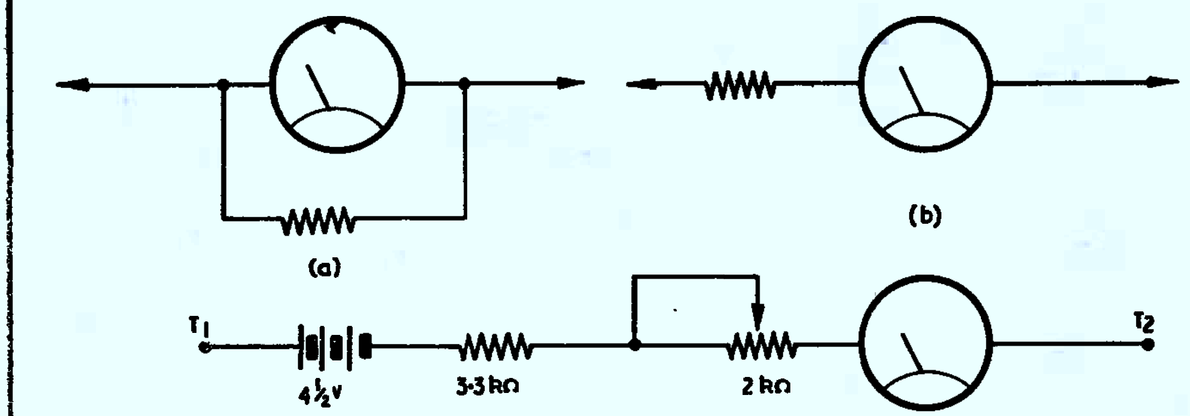

Fig.2

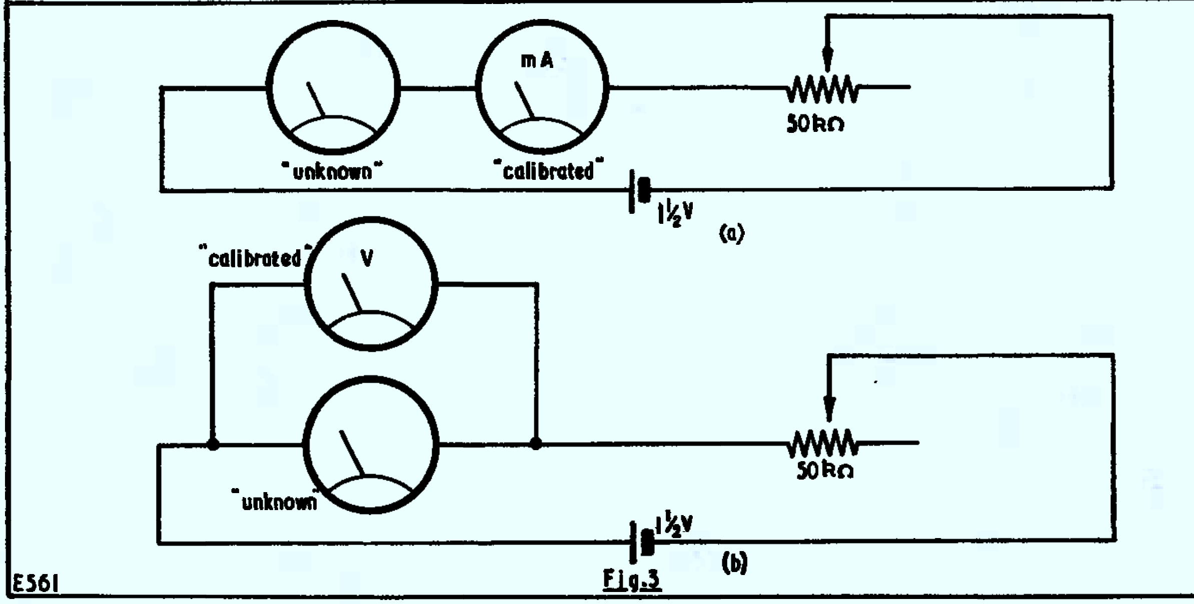

Fig.3

Meters previously used for measuring high voltage or current values may be used in multi-range instruments provided that they are dismantled and the internal shunt or multiplier resistance removed. Great care should be exercised when carrying out this operation since the coil, bearings and pointer are very easily damaged. In many cases the meter full scale deflection current and resistance are marked on the scale towards the bottom. If this information is not given, however, both values may be calculated if an accurately calibrated milliammeter and voltmeter can be borrowed. First connect the unknown meter together with the borrowed milliammeter in series with a variable

the calibrated meter, reconnect the unknown meter in the circuit without altering the resistor setting, and measure the voltage drop across the coil (Fig. 3 (*b*)). If this voltage drop is divided by the current, the resistance of the coil will be known.

Thermo-coupled ammeters may be used for multi-range meters or other purposes if the thermo-couple is carefully removed from inside the meter. Access may be obtained to the meter movement by removing—usually—three small screws located at the front or rear of the meter casing. Very often these thermo-conpled meters have a basic f.s.d. of about 2.5mA and a coil resistance of 6 to 10 ohms.