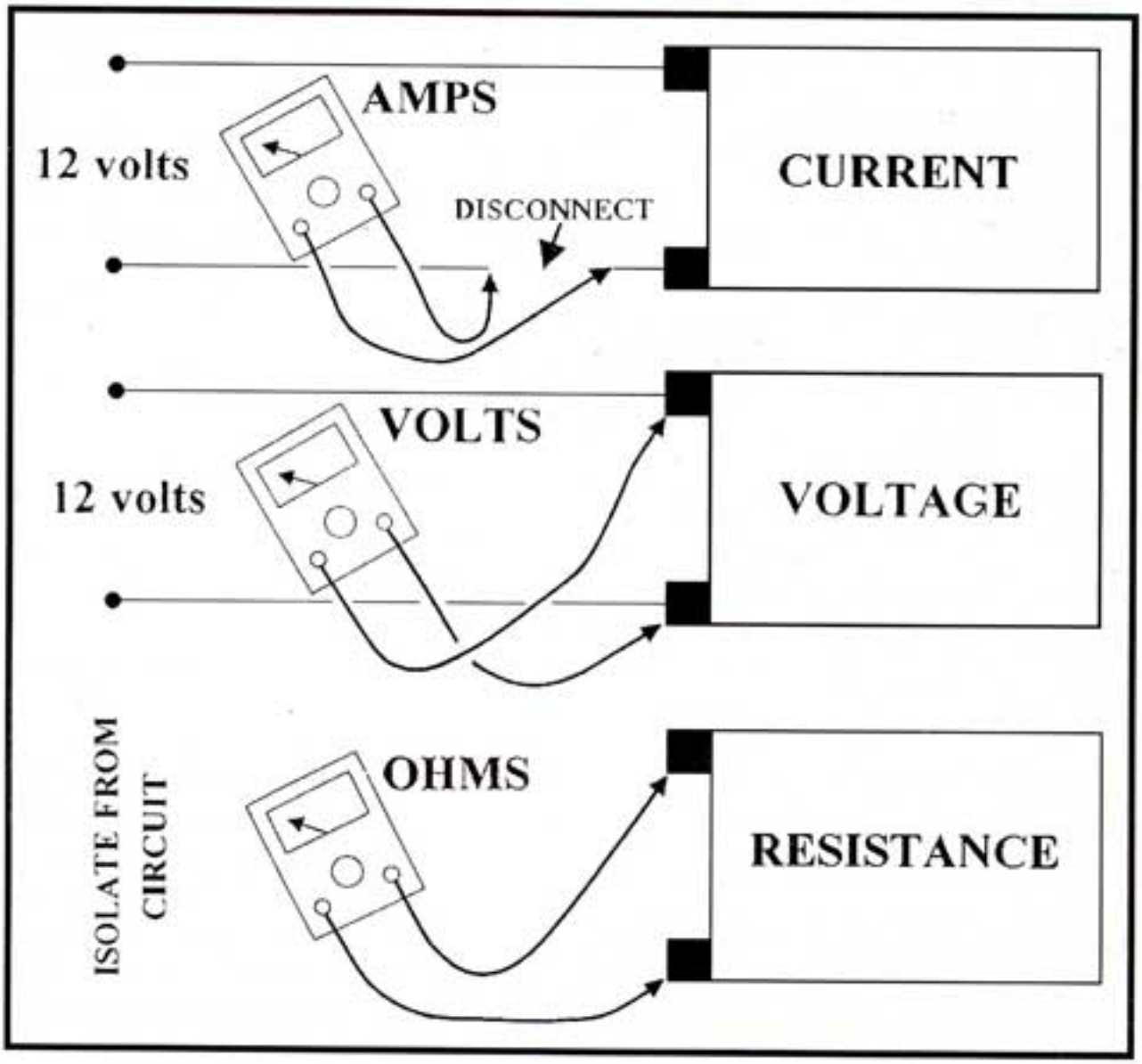
I have no electrical knowledge but I understand that a test meter is very useful in diagnosing many faults in my SD1. Are you able to give me some idea on how to use one?
David Pedder Mem. No. 496

How long is a piece of string? It would take the whole magazine even to give you only part of the story, but here I go!.
There are many types of meter for automobile use but the best one to start with is probably a simple unit that will measure amps, volts and ohms. The simplest being the analogue type, - i.e. it is read by the position of a pointer on a dial rather than by means of three or four digits on a readout, as in a digital meter. With either type there is usually a rotary switch to select the appropriate amps, volts or ohms range, and later on I will give you some indication on how to choose the range required.



Method of 'Multi-Meter' connection

The cost of a meter can vary from a few pounds to several hundred (a professional Avometer model 8 with a 'Namas' certificate of accuracy and carrying case will set you back by £757.28) but don't spend too much until you know what you are doing, - at the time of writing this I found good digital meters at less than £30 including delivery and VAT. Suitable meters are available from Maplin, Tandy or your local auto accessory shop. (A test lamp is a useful purchase where only voltages are being checked. There is a unit like a pen with the bulb in the body and a long lead having a crocodile clip at the end to connect it to earth.)

Amps range. *Most meters have four or five ranges enabling currents from less than 1 milliamp (1/1000th of an amp) to one or two amps to be measured and on some meters 10 amps or more via a separate socket or the top position of the range switch. All meters read D.C. amps and some also read A.C. although for car use A.C. readings are not usually required. The amps range is the hardest to use since many prospective car currents are greater than the capacity of the highest amps range on the meter and it can be damaged easily.* ***Always start with the highest meter range and go down to a lower setting if necessary to obtain an accurate reading.***

For amps measurements the meter must be connected ***in series*** *with the wire to the item whose current is to be measured. (The mere insertion of the meter in the circuit will lower the reading slightly on the higher current ranges because the meter and its leads have a small resistance.)*

(A special meter for the measurement of heavy currents is available that is merely held close to the wire carrying the current.)

The following list gives an indication of the expected current taken by various items: -

Headlamp	*60 watts*	*5 amps*
Side lamp	*6 watts*	*½ amp*

Note; - The switch on current of a lamp is much higher than the running current.

Relay	*1/8 to 1/4 amp*
Heated rear window	*12 amps*
Windscreen wiper	*5 to 10 amps*

If the reading is a negative one or the pointer goes off the left of the scale reverse the two meter leads. - This applies to the volts ranges also.

(Note; - The 'wattage' of an item may be calculated by multiplying the applied voltage by the current it is taking, - thus a 12 volt bulb consuming 5 amps will have a rating of 60 watts; - i.e. Watts = Volts x Amps.)

Volts range. *The voltages normally encountered on a car range from a few tenths of a volt to about 15 volts D.C., - choose a meter that will give clear readings around these voltages. (It is not possible to measure the high peaky voltages round the ignition circuits with a normal meter. - Special equipment is required.)*

Voltage measurements are taken by connecting the meter leads ***across*** *the item whose voltage is to be measured, - set the meter to a D.C. voltage range that includes 12 volts.*

connect the black probe to the negative connection. (possibly the car body or the Black wire of the unit concerned.)
Most items will have about 12 volts across them when operating, but this will vary slightly depending on the state of the battery and the current taken by the unit being tested.
There are a few places where voltages differing from the nominal 12 volts are to be found, so I have listed some of these below: -

1. ***Battery***

11.8v. – (or less) totally discharged, recharge immediately.
12.5v. – fully charged. (but off charge.)
13.8v. – being charged by the alternator

if over 14.2 or always less than 13.4 volts the charging system may need attention. (High voltage will cause the battery to 'gas' with a consequent loss of water and battery damage and low voltage means that the battery will not be fully charged.)

2. ***EFi Throttle pot.*** *(Ignition on, engine stopped.)*

*0.325v. +/- .025v. between **G**reen (-) & **R**ed (+)*
*4.3v. +/- 0.2v. between **G**reen (-) & **Y**ellow (+)*

*When the throttle is slowly opened, the voltage across the **G**reen and **R**ed wires must steadily increase from 0.325 volts to about 3.6 volts.*

3. ***EFi air flow meter****. (Ignition on, engine stopped.)*

.30v. +/- 0.2v. between pins 6 (UR) & 9(-) (UW)
1.55v. +/- 0.1v. between pins 8 (UW) & 9(-)
1.60v. +/- 0.1v. between pins 7 (U) & 9(-) – open.
3.70v. +/- 0.1v. between pins 7 (U) & 9(-) – closed.

When the air flap is slowly opened the voltage between pins 7 and 9 must decrease smoothly.

There is an air temperature sensor connected between pins 27 (RB) and 9 (UW) whose resistance varies with intake air temperature, this will be explained later, - see 'Ohms range'

4. ***Coil ballast resistor.***

*Some of our ignition systems have a ballast resistor between the positive wire (**W**hite) from the ignition switch to the positive terminal on the coil, this resistor is shorted out (**W**hite/**Y**ellow wire) when the starter motor is in operation to compensate for the lower battery terminal voltage that momentarily exists due to the very high current load imposed on the battery by the starter motor. The value of this resistor is usually about 1.8 ohms and it is often built into the loom in the form of a length of resistance wire so it is hard to find. This means that only 7 or so volts will be measured on the **W**hite wire at the + terminal of the coil when the distributor 'contacts' are closed. (The internal structure of the ballast unit used with the 'Opus' system is shown on page T54 of issue43.)*

5. Voltage between (–) return and car body.

*Faulty operation of equipment is often caused by a poor 'earth' return and this may be detected by measuring the voltage between the negative wire of the unit (usually **B**lack) and the car body. The maximum voltage to be expected should be less than a few tenths of a volt.*

*The car body ends of the **B**lack earth return wires are connected to the body in five positions by means of 5mm. bolts whose locations are as follows ; -*

a. Front right side inner wing near and slightly to the rear of the battery.

b. The mirror position on the left side inner wing.

c. On the left side bulkhead behind the end of the glove box, - under one of the bolts holding the fascia panel fixing bracket. (On EFi cars the 1.2 Ohm pump resistor is mounted in this bracket.)

d. Behind the carpet at the rear right hand corner of the boot.

e. The mirror position at the left -hand corner of the boot.

A common earth fault symptom is when the side lights or rear lights go out or dim when the headlamps or brake lights are switched on.

***Ohms range.** Every item of equipment, wire or connector has resistance to some degree and the magnitude of that resistance is measured in **Ohms** using a suitable resistance range of your meter. Most meters have two or three ranges to cover from around 1 to about 1M (Megohm) or more, and have internal batteries to enable these ranges to function. (Incidentally 'm ' with a small m means milli-ohm or 1/1000 of an ohm, - a metre of the wire used in the SD1 has a resistance of 20mOhms or less and a good pair of connector contacts around 2mOhms .– These very low resistance values cannot be read with a normal A.V.O. meter. but see later.)*

When measuring the resistance of a component it is necessary to isolate at least one end of it from the rest of the system to prevent the reading from being influenced by voltage or resistance in the rest of the circuit.

The meter can be damaged if it is connected to a source of voltage while set to a resistance range.

Before taking any resistance measurements with the meter always touch the two probe tips together and set the reading to read '0' ohms by rotating the zero adjuster: - Some digital meters are self zeroing.

As with the Amps and volts ranges I will now list a few useful resistance values;-

1. ***Relay***

75 Ohms - there are several types of relay employed and this is the typical resistance value to be found between energising coil pins marked 85 and 86. (60 to 100)

0 Ohms - This is the reading that should be obtained between pins 30/51 and 87A (Some relays don't have this latter pin.) This reading must go to a very high resistance when the coil (pins 85 &86) has been energised with 12 volts.

*0 Ohms - this reading should be obtained between pins 30/51 and 87 – but **only** when the coil has been energised with 12 volts.*

2. Water and air temperature sensor.

The measured resistance of these items varies with temperature in accordance with the following tables; -

TABLE 1	*Temperature*	*Resistance*
	-10°C.	*9000 Ohms*
	0°C.	*5900 Ohms*
	20°C.	*2500 Ohms*
	40°C..	*1150 Ohms*
	60°C.	*600 Ohms*
	80°C.	*330 Ohms*

The above table applies to all the water sensors and the EFI air temperature sensor mentioned earlier but not to the air sensor used with HIF 44E carburettors which should give the following readings; -

TABLE 2	*Temperature*	*Resistance*
	-10°C.	*6100 Ohms*
	+20°C.	*1250 Ohms*
	+50°C.	*400 Ohms*

*3. **EFi Throttle Pot.***

*This unit has three wires **G**reen (G), **R**ed (R) and **Y**ellow (Y) and should give the following resistance readings; -*

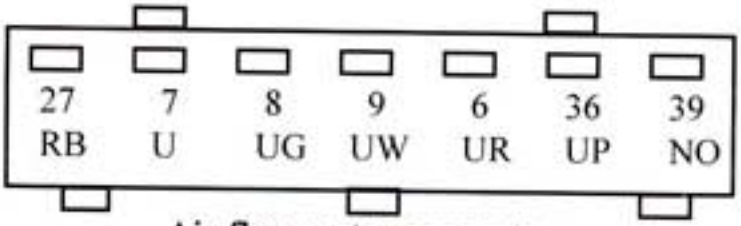
0 Ohms between green & red. - spindle fully anti clockwise
5000 Ohms between green & red. - spindle fully clockwise.
500 Ohms between green & yellow.

*When the spindle is rotated, the resistance **must** vary in a completely smooth manner without **any** glitches, otherwise a replacement pot. is required.*

*4. **EFi Air flow Meter.***

This unit has seven connections and the following resistance readings should be obtained between the various pins:-

High	*between 36 & 39*	*-(fuel switch) flap closed.*
Low	*between 36 & 39*	*-(fuel switch) flap 5° open.*
77	*between 6 & 7*	*-flap closed. (Approx.)*
366	*between 6 & 7*	*-flap fully open. (Approx.)*
200	*between 8 & 9*	*-internal resistor (Approx.)*
Vary	*between 6&27*	*-Air temp sensor. (Table 1 above.)*



Air flow meter connector

5. Fuel level sensor.

*In the case of carburettor equipped cars, there are four wires but with EFi models there are only three. (The **W**hite/**P**urple wire to the pump being omitted.)*

*a. The **G**reen/**B**lack wire goes to the **fuel level sensor** and the resistance between this wire and the **B**lack earth return wire varies between about 20 Ohms when the tank is full and 360 Ohms when it is empty.*

*b. The **W**hite/**G**reen wire goes to the **fuel level warning switch** and the resistance between this wire and the **B**lack earth return wire is high until the tank is nearly empty, the switch closes and the resistance reading becomes 0.*

6. Low resistance.

It is possible to estimate resistance in some circumstances if both the current through and voltage across the component being measured is within the range of your meter by the use of Ohms law.

***Ohms Law** says that the resistance of an item is equal to the voltage across it divided by the current through it.*

$$R = \frac{V}{C}$$ *where* ***R*** *= resistance(ohms)*, ***V*** *= voltage(volts)*, ***C*** *= current(amps)*

7. ***Diodes***

Diodes are one way electrical valves and when tested on a low resistance range of your meter will have a low resistance in one direction but when the meter leads are reversed will show a very high resistance in the opposite direction.

Diodes are used in several places in the SD1, apart from various complicated devices, they are to be found in the white unit associated with the headlamp circuit, the red 'steering' module used in the EFi circuit and the single diode unit used on 1985 carburettor models. The diodes (Type 1N4006) used in the red and white modules cost only a few pence each so if you find a faulty one get a new one from Maplin or Tandy and solder it in. – the right way round!

I hope this has been of some help.

Carl Heinlein
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