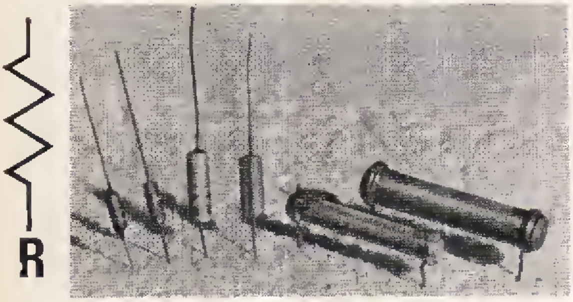
BEGINNERS start here... 2

An Instructional Series for the Newcomer to Electronics



CARBON RESISTORS

A word or two now about *practical* resistors as used in electronic equipment. Last month we mentioned that wire wound resistors are not usually made in values greater than 100,000 ohms. In fact, the kind of resistor most commonly encountered in electronics is of the *carbon* fixed value variety.

Wire wound resistors have rather limited and specialised applications: they are used whenever a *precise* value of resistance is required; also as "voltage droppers" in power supply circuits, where high currents and voltages are involved. And of course, wire wound resistors suit our requirements perfectly in the present series of experiments.

One important thing to remember. All the basic laws that we are demonstrating for ourselves in this series of experiments hold good for all types of resistors —no matter whether they be made of wire, or of carbon or any other substance.

Last month we showed a group of typical wire wound resistors. This month our photograph shows a selection of carbon fixed-value resistors. These are the kind of components you will constantly be handling as you become involved in building electronic devices. A word or two about their characteristics—physical and electrical—will not be out of place at this stage.

There are two main types; carbon composition and carbon film.

Carbon *composition* resistors consist of a rod of carbon black or graphite. Connecting wires are wrapped around the ends of the rod and the latter is given a protective coating of paint. This type is known as *non-insulated.*

There are also insulated composition resistors. These are made by enclosing the rod of resistive material in a plastics moulding or ceramic tube. The connecting wires emerge straight out from the ends of the tube.

The film type of resistor is made by depositing a thin film of a carbon mixture upon a glass or ceramic tube or rod. The rod is encased in moulded plastics or in a ceramic tube. Outwardly, these resistors resemble the insulated composition type.

Most carbon resistors are colour coded. This colour code indicates the value in ohms and sometimes provides additional information. You will find the Practical Electronics Colour Code Calculator (presented with our first number) an extremely useful tool. If you have access to an assortment of resistors, it is a good idea to practice reading off the colours of a randomly selected component. Take our word for it—this will be to your benefit in the future.

RESISTORS IN PARALLEL

Our next exercise is to find out what happens when we connect resistors in parallel, that is, side by side instead of end to end. To do this you will need to connect the "shorting wire" of the last experiment to points A and C of the resistor and the slider contact to point B (see Fig. 2.1). You will find that the slider can be moved along the resistor from end to end and the bulb will now light all the time. Why is this so?

To enable you to understand quite clearly the present circuit arrangement, we have drawn an "intermediate" diagram: imagine the end A of the resistor bent back so that it nearly touches end C (Fig. 2.2), as you move the slider from the central position towards one end you are reducing the resistance of that branch and so increasing the current flow. The circuit is shown in its final and conventional form in Fig. 2.3.

As the bulb lights now at all positions along the resistor, it follows that the total resistance must be much less than the original short section (11cm) measured in the first experiment. Once again, we can calculate the value of the total resistance using a formula:

$$\frac{1}{\text{R total}} = \frac{1}{\text{R1}} + \frac{1}{\text{R2}}$$

Your resistance element has an approximate value of 75–80 ohms and hence you can mark the baseboard into divisions of, say, 5 ohms each. By setting the slider at any random point you can now read off the value of resistance either side of it. If the slider is set at 20 ohms (R1), the remaining resistance (R2) will be 60 ohms. Substituting these values in the above formula we get

$$\frac{1}{\text{R total}} = \frac{1}{20} + \frac{1}{60} = \frac{3+1}{60} = \frac{4}{60} = \frac{1}{15}$$

$$\text{R total} = 1/\tfrac{1}{15} = 15 \text{ ohms.}$$

We would like you to work out half a dozen calculations (one has already been done for you!) taking the value of R1 as 5 ohms, 10 ohms, 15 ohms, etc. and make a small list showing the values of R total, R1 and R2. You should find that the value of R total goes from $17\frac{1}{2}$ ohms down to nearly 1 ohm.

You will see from this list that, when R1 is much smaller than R2, the total resistance or *equivalent* *resistance* is nearer R1 in value than R2. This can be very important in electronic circuits when you have a component with a resistance of perhaps 1,000 ohms in parallel with another component of 1 megohm.

Let's do another calculation to show why:

$$\frac{1}{\text{R total}} = \frac{1}{1{,}000} + \frac{1}{1{,}000{,}000} = \frac{1{,}000+1}{1{,}000{,}000}$$

$$= \frac{1{,}001}{1{,}000{,}000}$$

Thus

$$\text{R total} = \frac{1{,}000{,}000}{1{,}001} = 1{,}000 \text{ ohms approximately.}$$

You can see then that if the value of one resistance is very high you can ignore it and consider only the value of the small one.

SECOND RESISTANCE ELEMENT

Now it is necessary to add the second resistance element to our apparatus. Here we use a 1,000 watt (1 kilowatt, or 1kW) fire element. Push the spare plastics knitting needle through the vacant hole in one of the wooden support pieces, thread it through the coiled element and insert in the hole provided in the second support. Ensure that the turns of wire are evenly spaced along the length of the needle.

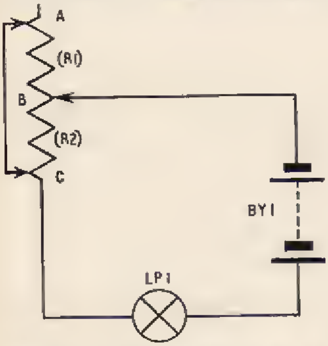


Fig. 2.1. The shorting wire is connected across the resistance element and sections R1 and R2 are thus in parallel

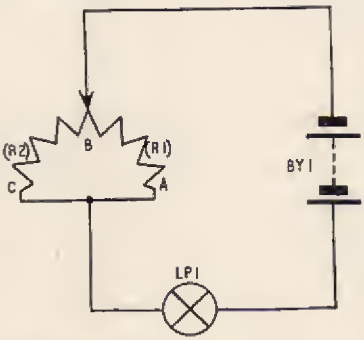


Fig. 2.2. This is the same set-up as Fig. 2.1 but the diagram has been redrawn to show more clearly the fact that R1 and R2 are in parallel

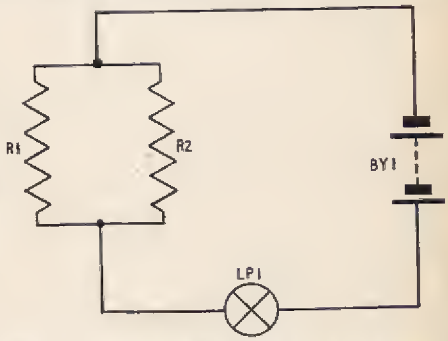


Fig. 2.3. Here, finally, the circuit is drawn in the normal, conventional manner

THE UNIT OF POWER

You may be wondering at this moment: what is meant by a kilowatt?

The basic unit of a watt is the unit of power that is the rate of doing work. To calculate the power in an electrical circuit you must multiply the voltage by the current; this is shown by the formula:

$$W = V \times I$$

where W stands for watts, V for volts, and I for current in amperes.

If you are unable to measure the voltage but know the resistance then you can use a second formula, which is

$$W = I^2 \times R \text{ (or } W = I \times I \times R\text{)}$$

A third form of the equation is

$$W = V^2 \div R \left(\text{or } W = \frac{V \times V}{R}\right)$$

If you look at the list of components in other articles in PRACTICAL ELECTRONICS, you will notice that resistors are quoted at ¼W, ½W, 1W, etc. This is as important in electronic circuits as having the correct value of resistance (in ohms). Say, for example, you had a resistance of 100 kilohms and a voltage of 300V, then the current flowing through it would be

$$\frac{300}{100{,}000} = 0{\cdot}003 \text{ amperes or 3mA.}$$

Working out the power as above ($W = V \times I$) would give

$$300V \times 0{\cdot}003A = 0{\cdot}9W$$

You would thus need a resistor rated at 1 watt and if you used one of perhaps ½ watt or ¼ watt then it would quickly overheat and break down. This heat is caused by the current flowing through the resistor and we use this to our advantage in electric fires, water heaters and electric light bulbs.

The higher the wattage rating of a carbon resistor, the larger its physical size. Refer to the photograph: the two smallest sized resistors are ¼W types, the next pair are ½W, and the other two 1W and 2W respectively.

Now to return to the experiments. If you have the two fire elements or coils wound on the needles you can experiment on your own by connecting them in different ways, shorting out sections of them and calculating the value of resistance in circuit. The 1kW coil will have a resistance between 50 and 55 ohms so you can mark out the base board in equal sections and measure off the resistance values direct.

You may also like to see the effect of increasing and decreasing the voltage to 6 volts and 3 volts respectively by substituting other batteries for the present 4½ volt battery. If you increase the voltage you will need more of the resistance in circuit to get the bulb just glimmering as compared with the amount needed with the 4½V supply. Obviously then you will have less resistance in circuit when a 3V battery is used.

We have used a bulb to indicate that current is flowing through the circuit and our next project is to make a simple type of meter that also tells us current is flowing. Many of you may have seen and used meters at school and know that there are many different types to measure voltage, current, resistance, etc.

Next month we will show you how to make a simple meter that you can set up with your battery and use for approximate measurements in later experiments.

SHOPPING LIST

One 1,000 watt electric fire replacement element.