39

Ohm's Law

Ohm Sweet Ohm

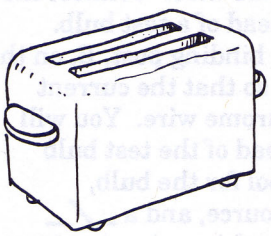
Purpose

To investigate how the current in a circuit varies with voltage and resistance.

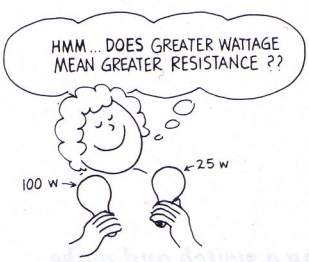
Required Equipment and Supplies

Nichrome wire apparatus with thin and thick wires and bulb (Arbor Scientific)
four D-cells and holder (variable voltage supply)
ammeter (optional)

Discussion



Normally it is desirable for wires in an electrical circuit to stay cool. Red-hot wires can melt and cause short circuits. There are notable exceptions, however. Nichrome wire is a high-resistance wire capable of glowing red-hot without melting. It is commonly used as the heating element in toasters, ovens, stoves, hair dryers, and so forth. In this experiment, it's used as a variable resistor. Doubling the length of a piece of wire doubles the reisistance, tripling the length triples the resistance, and so forth.



Tungsten wire is capable of glowing white hot and is used as filament in light bulbs. Light and heat are generated as the current heats the high-resistance tungsten filament. The hotter the filament, the brighter the bulb. For the same voltage, a bright bulb has a *lower* resistance than a dimmer bulb. Just as water flows with more difficulty through a thinner pipe, electrical resistance is greater for a thinner wire. Manufacturers make bulbs of different wattages by varying the thickness of the filaments. So we find that a 100-W bulb has a lower resistance and a thicker filament than a 25-W bulb.

In this lab, the brightness of the bulb will be used as a *current* indicator. Glowing brightly indicates a large current is flowing through it; dimly lit means a small current is flowing.

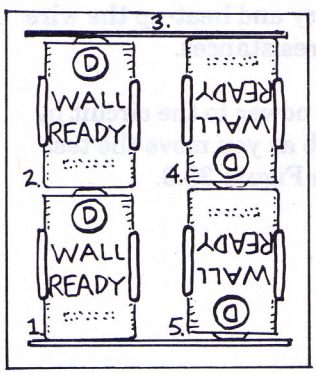


Figure 39.1

Procedure

Step 1. Connect four D-cell batteries in series, so that the positive terminal is connected to the negative terminal in a battery holder as shown in Figure 39.1. This arrangement, with terminal #1 as ground, will provide you with a variable voltage supply as follows:

Terminal #s	Voltage
1-2	1.5
1-3	3.0
1-4	4.5
1-5	6.0

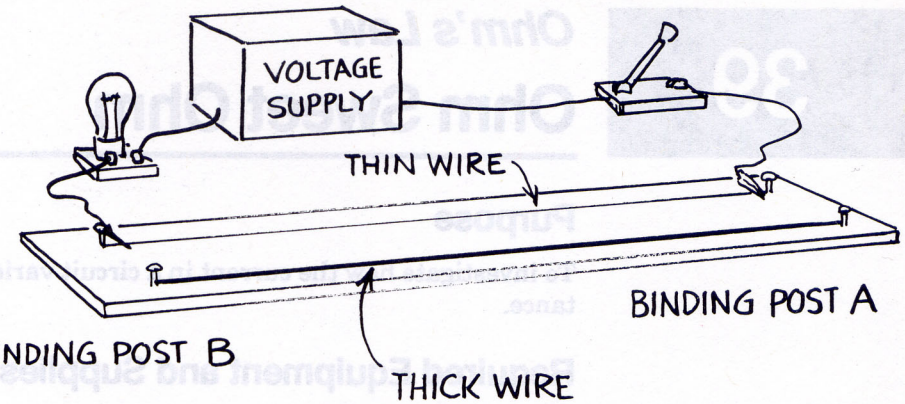


Figure 39.2

Step 2. Assemble the circuit as shown in Figure 39.2. Label one binding post of the Nichrome wire "A" and the other "B". Attach the ground lead (#1) of the voltage supply to one side of a knife switch. Connect the other side of the switch to binding post A of the thin Nichrome wire. Connect the 3-volt terminal (#3) from the voltage supply to a clip lead of a test bulb. Attach the other clip lead of the test bulb to the other binding post, B, on the Nichrome wire. The voltage supply is now connected so that the current passes through two resistances: the bulb and the nichrome wire. You will vary the resistance in the circuit by moving the clip lead of the test bulb from binding post B to A. First, using a –∿∿– symbol for the bulb, –∿∿– symbol for the wire, ‖ symbol for the voltage source, and a ⎯/⎯ symbol for the switch, draw a diagram that represents this *series* circuit.

Note: *Always apply power from the battery by closing a switch and make your measurements quickly.* Leave the power on just long enough to make your measurements and then open the switch. Leaving the power on in the circuit for long periods of time will drain your battery and heat-up the wire and filaments in your bulb, thereby changing their resistances.

After carefully checking all your connections, apply power to the circuit by closing the switch. Observe the intensity of the bulb as you move the test bulb lead from binding post B toward A as shown in Figure 39.3.

Figure 39.3

1. What happens to the brightness of the bulb as you move it from B to A?

Step 3. Repeat, using the thick Nichrome wire. Observe the relative brightness of the bulb as you move the bulb's lead closer to binding post A.

2. How does the brightness of the bulb with the thin wire compare to the brightness of the bulb when connected to a thicker wire?

3. What effects do the thickness and length of the wire have on its resistance?

4. Does the current of the circuit increase or decrease as you move the lead closer to binding post B? As you move the lead from B to A, does the resistance of the circuit increase or decrease?

Step 4. Repeat Steps 2 and 3 using the 4.5 and 6-volt terminals instead of the 3-volt terminal.

5. How does the brightness of the test bulb compare for the two Nichrome wires using the 4.5-volt instead of 3-volts?

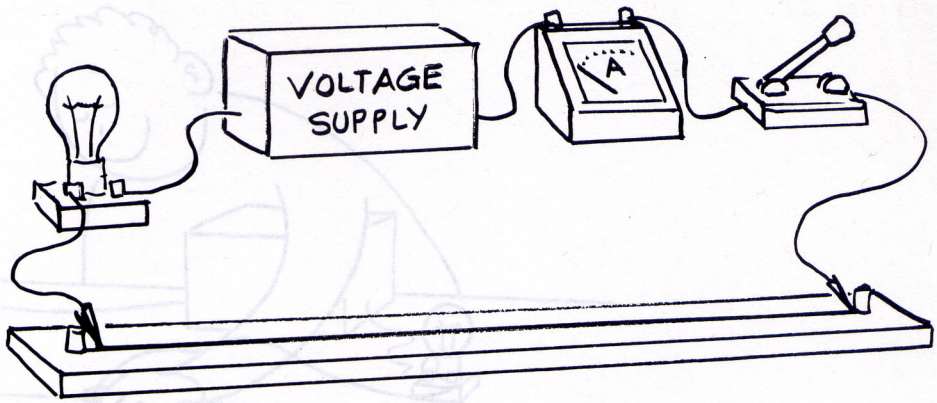


Figure 39.4

Going Further

Step 5. Insert an ammeter into the circuit as illustrated in Figure 39.4.

Note: If you are not using a digital meter, you may have to reverse the polarity of the leads if the needle of the meter goes the wrong way (–) when power is applied.

With the thick piece of Nichrome wire in the circuit, place the ammeter in series with the voltage supply between terminal #1 of the voltage supply and the switch. The ammeter will measure the total current in the circuit. Measure the current in the circuit at equally spaced positions as you move the test bulb lead from B to A. Be sure to apply power *only* while making the measurements to prevent draining the battery. Record your data in Data Table 39.1. Repeat using the thin wire.

Data Table 39.1

THICK WIRE VOLTS = _____		THIN WIRE VOLTS = _____	
CURRENT (A)	LENGTH (cm)	CURRENT (A)	LENGTH (cm)

Step 6. Repeat Step 5 using a different voltage. Record your results in Data Table 39.2.

Data Table 39.2

THICK WIRE VOLTS = _____		THIN WIRE VOLTS = _____	
CURRENT (A)	LENGTH (cm)	CURRENT (A)	LENGTH (cm)

Analysis

7. Do your results show a decrease in current as the length of the wire (or resistance) is increased?

8. Do your results show an increase in current as the voltage is increased?

9. How does the current in the thick wire compare to that when the same voltage is applied to the same length of thin wire?