38 Resistance
Voltage Divider

Purpose

To investigate how the resistance of a bulb varies with temperature.

Required Equipment and Supplies

Nichrome wire apparatus with bulb (Arbor Scientific)
two D-cells and holder (voltage supply)
knife switch
two voltmeters
ammeter
plastic ruler

Discussion

As electrical current flows through a wire, the atoms and other electrons in the wire provide resistance, similar to the resistance you would encounter if you tried to run through a crowd of people. Some of the electrons' energy is dissipated as heat as the electrons jostle atoms in the wire. The greater the interaction between the current and the lattice of atoms that forms the wire, the greater the energy dissipated as heat. Tungsten is used as the filament wire in light bulbs because it has these physical properties: high resistance, high melting point, and relatively low chemical reactivity. In this experiment, you will be able to measure how the resistance of a bulb varies with temperature.

Procedure

Step 1. Place a ruler underneath the Nichrome wire and tack it down with masking tape. Assemble the circuit as shown in Figure 38.1. 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 Nichrome wire. Connect the 3-volt lead (#3) from the voltage supply to binding post B. Attach one clip lead of the test bulb to binding post B and the other to binding post A. The voltage supply is now connected so that the current splits into two branches;

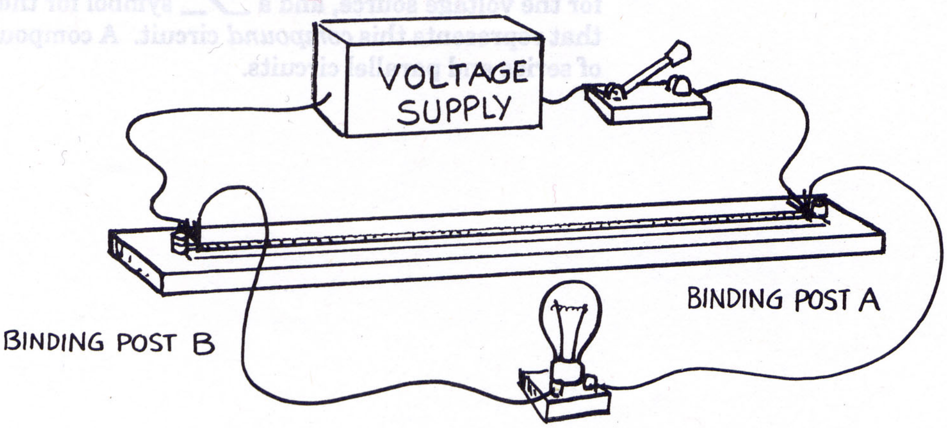

Figure 38.1

one through the bulb and the other through the Nichrome wire. 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 *parallel* circuit.

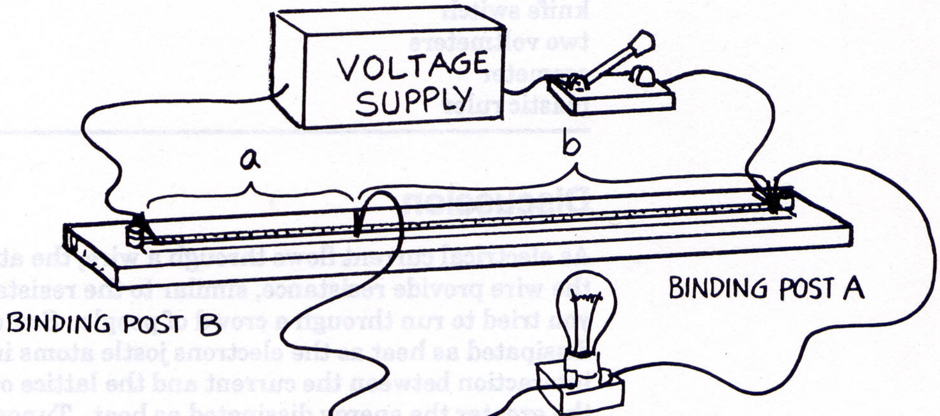

Figure 38.2

As you move the clip lead of the test bulb from binding post B to A you vary the amount of current that flows through each branch. This circuit is frequently encountered in electronics. Let's take a look at what's happening in more detail. The total current passes from the voltage supply through the wire segment "a" in Figure 38.2. As you move the lead from the bulb towards the other binding post, the total current in the circuit splits into two branches. One branch flows through the bulb; the other flows through segment "b" of the Nichrome wire. The branch currents combine at the end of the nichrome wire and return to the voltage supply to complete the circuit. Because the voltage drops as you move the lead towards binding post B, less voltage is applied across the bulb. Since the circuit "divides" the voltage between the remaining wire segment and the bulb, it is commonly known as a "voltage divider."

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 *compound* circuit. A compound circuit is a combination of series and parallel circuits.

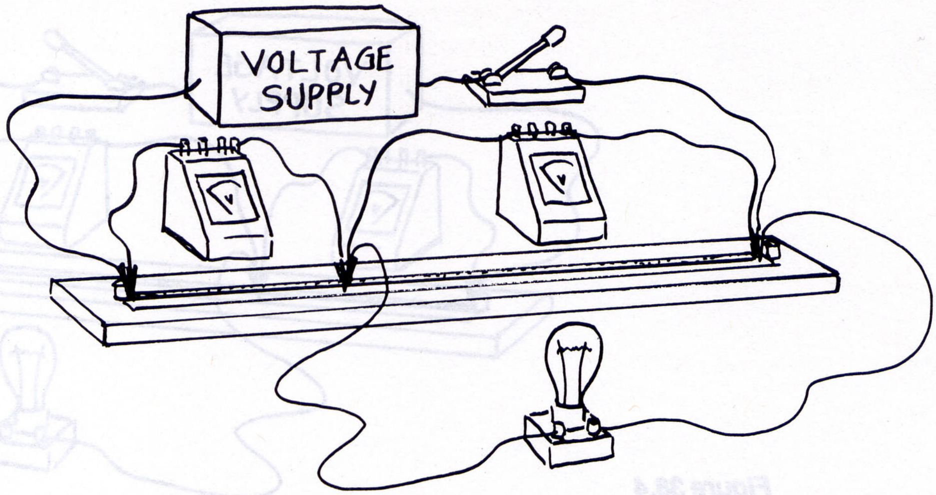

Figure 38.3

Step 2. Measure the voltage across segment "a" of the nichrome wire and the bulb starting with the bulb leads connected to each binding post ($L = 0$). Do this by connecting the voltmeter in parallel as shown in Figure 38.3. Then move the bulb lead from binding post B to a point one-third the length ($l = 1L/3$) of the wire from the binding post B. Measure the voltage across segment "a" and across the bulb. Note that the voltage across segment "b" is the same as the voltage across the bulb. Record your measurements in Data Table 38.1. Now move the bulb lead to a point two-thirds the length of the wire ($l = 2L/3$) and measure the voltages. Repeat so that the bulb leads span the length of the wire.

1. What happens to the voltage as you move the bulb lead closer to binding post B? How are the voltage drops across segment "a" and the bulb related?

Data Table 38.1

DISTANCE from B	VOLTAGE (V)		
	a	bulb	a+bulb
0 L			
⅓ L			
⅔ L			
L			

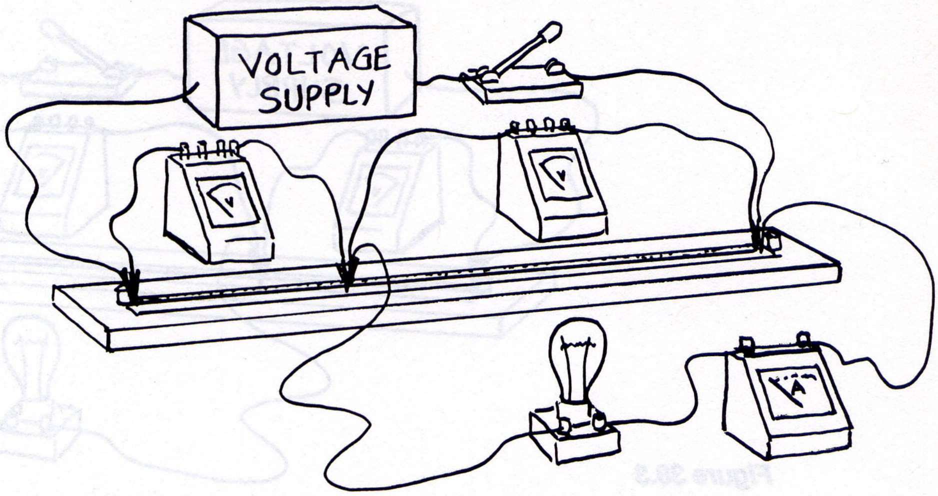

Figure 38.4

Step 3. Repeat Step 2, but this time measure the current *through the bulb* as well as the voltage *across it*. Do this by connecting an ammeter in *series* with the bulb as shown in Figure 38.4. This will enable you to compute the resistance of the bulb (voltage/current) as it dims. Record your results in Data Table 38.2.

Data Table 38.2

DISTANCE	VOLTAGE (V)	CURRENT (A)	RESISTANCE (Ω)
0 L			
1/3 L			
2/3 L			
L			

Analysis

2. Compute the resistance (voltage/current) of the bulb in the four different positions.

3. Does the resistance of the bulb increase or decrease with brightness? Is the change in resistance significant? Can you offer an explanation why? How do you think engineers must take this into account when designing light bulbs?

4. Make a graph of the voltage across the bulb as a function of current. Is the graph a straight line? Why or why not? Explain.