40

Series and Parallel Circuits

Cranking Up

Purpose

To observe the work done in a series circuit compared to a parallel circuit.

Required Equipment and Supplies

Genecon hand-held generator
4 D-cells and holder (variable voltage supply)
parallel bulb apparatus (Arbor Scientific)
voltmeter
ammeter

Discussion

Have you ever unplugged one bulb of a string of Christmas tree lights only to have all the bulbs go out? If so, that's because the bulbs were wired in series. The wall receptacles around the house, however, are wired differently—and for good reason. It would never do to have the refrigerator go off every time you turned off the vacuum cleaner! Such circuits are wired in parallel. Series and parallel circuits each have advantages and disadvantages. In this experiment, you will learn about both.

Part A: Qualitative Investigation

Step 1. Assemble four bulbs in a series configuration as shown in Figure 40.1. Screw all the bulbs into their sockets. Connect the sockets with clip leads or wires.

Connect one lead of a Genecon to one end of the string of bulbs and the other lead to the other end of the string. Crank the Genecon so that all the

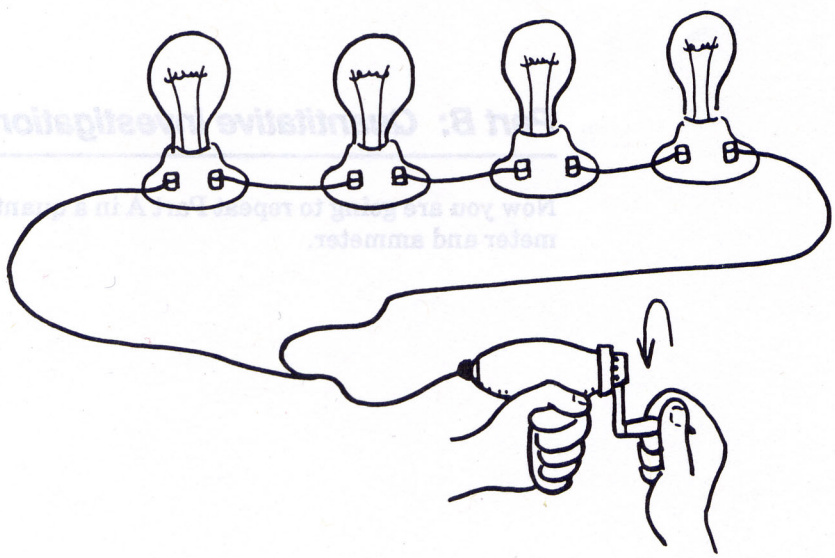

Figure 40.1

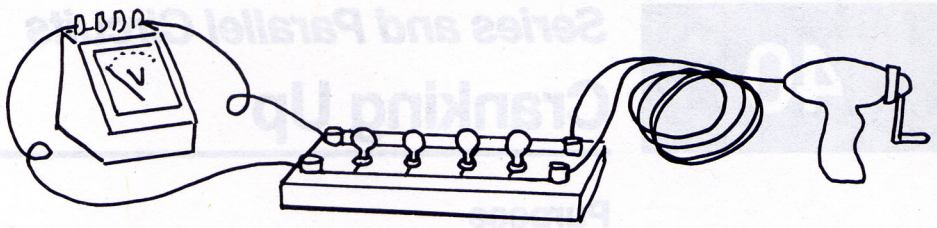

Figure 40.2

bulbs light up. Now disconnect one of the bulbs from the string and reconnect the Genecon. Crank the Genecon so that the three remaining bulbs are energized to the same brightness as the four-bulb arrangement. How does the crank *feel* now? Repeat, removing one bulb at a time, comparing the cranking torque each time.

Step 2. Assemble the circuit with the parallel-bulb apparatus as shown in Figure 40.2. Each end of the bulb apparatus has two terminals. Connect the leads of a voltmeter to one pair of terminals on one end of the apparatus.

Connect the leads of the Genecon to the terminals on the other end of the apparatus. Crank the Genecon with all the bulbs unscrewed in the sockets so they don't light. Then have your partner screw them in one at a time as you crank on the Genecon. Try to keep the bulbs energized at the same brightness as each bulb is screwed into its socket.

Analysis

1. What do you notice about the *torque* required to crank the Genecon at a constant speed as more bulbs were added to the circuit?

2. How would you describe the amount of torque required to crank the Genecon to energize four bulbs in series compared to that required for four bulbs in parallel?

3. If four bulbs in series are glowing as brightly as four bulbs in parallel, is the energy expended (required torque on the crank of the Genecon) the same?

Part B: Quantitative Investigation—Resistors in Series

Now you are going to repeat Part A in a quantitative fashion using a voltmeter and ammeter.

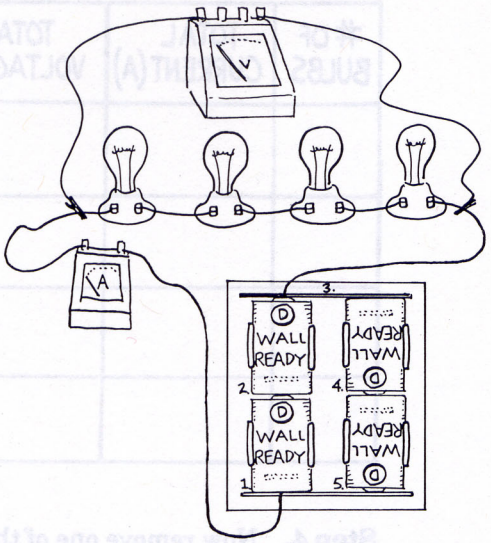

Figure 40.3

Note: It's important to use a voltage source between 3 and 4.5 volts for the specified bulbs. Voltages greater than 4.5 volts will significantly reduce the lifetime of the bulbs.

Step 3. Assemble four bulbs in a series circuit and connect the meters as shown in Figure 40.3. Connect the voltmeter in parallel with the bulbs so you can measure the total voltage applied to the circuit as well as the voltage across each bulb. Connect the 3-volt terminal from the voltage supply to one terminal of the bulbs and the ground connection to one lead of an ammeter. Connect the other lead of the ammeter to the second terminal of the bulbs. The ammeter will measure the current in the circuit.

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

Close the switch, apply power to the circuit, and measure:

- the current in the circuit
- the voltage applied to the circuit
- the voltage across each bulb

Record your results in Data Table 40.1.

Data Table 40.1

# OF BULBS	TOTAL CURRENT (A)	TOTAL VOLTAGE (V)	VOLTAGE ACROSS EACH BULB (V)

Data Table 40.2

# OF BULBS	TOTAL CURRENT (A)	TOTAL VOLTAGE (V)	VOLTAGE ACROSS EACH BULB (V)			

Step 4. Now remove one of the bulbs from the string and repeat your measurements for three, two, and then one bulb. Record your data in Data Table 40.1.

Step 5. Repeat, using the 4.5-volt terminal of the voltage supply instead of the 3-volt terminal. Record your data in Data Table 40.2.

Analysis

4. Do you observe any change in brightness as the number of bulbs in the circuit changes?

5. Does the voltage applied in the circuit change as you add more bulbs?

6. How are the voltages across each bulb related to the voltage applied in the circuit?

7. How does the current in the battery change when more bulbs are added?

8. Did any of the relationships you discovered between voltages and currents change when 4.5 volts was applied to the circuit instead of 3 volts?

Part C: Quantitative Investigation—Resistors in Parallel

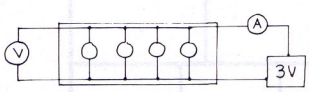

Figure 40.4

Step 6. Assemble the circuit and connect the meters as shown in Figure 40.4. Connect the voltmeter in parallel with the bulbs by connecting the voltmeter to two terminals on one end of the parallel-bulb apparatus. Connect the 3-volt lead from the voltage supply to one terminal of the parallel-bulb apparatus. Connect the ground lead from the voltage supply

Data Table 40.3

# OF BULBS	TOTAL CURRENT (A)	TOTAL VOLTAGE (V)	VOLTAGE ACROSS EACH BULB (V)			

to one lead of an ammeter and connect the other lead of the ammeter to the second terminal of the parallel-bulb apparatus. The ammeter will measure the *total current* in the circuit.

Make sure the bulbs are not loose in their sockets. Close the switch and apply power to the circuit. Observe the brightness of the bulbs, then unscrew the bulbs one at a time.

Step 7. Screw the bulbs back in, one at a time, each time measuring:

- the current in the circuit
- the voltage applied to the circuit
- the voltage drop across each bulb

Record your data in Data Table 40.3.

Step 8. Repeat Steps 3 and 4 using the 4.5-volt terminal of the voltage supply instead of the 3-volt terminal. Record your data in Data Table 40.4.

Analysis

9. Do you observe any change in brightness as the number of bulbs in the circuit changes?

Data Table 40.4

# OF BULBS	TOTAL CURRENT (A)	TOTAL VOLTAGE (V)	VOLTAGE ACROSS EACH BULB (V)			

10. Does the voltage across each bulb change as more bulbs are added to or subtracted from the circuit?

11. Does the applied voltage to the circuit change as you add more bulbs?

12. How does the current in the battery change as the number of bulbs in the circuit changes?

13. Did the ratio of voltage and current change when you applied 4.5 volts instead of 3 volts?