chapter 7 Magnetism and Its Uses

section 3 Producing Electric Current

Before You Read

Name three things you used today that use electrical energy to make them work. Where do you think the electrical energy came from?

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What You'll Learn

- what electromagnetic induction is
- how a generator produces an electric current
- the difference between direct and alternating current
- how to change the voltage of an alternating current

Read to Learn

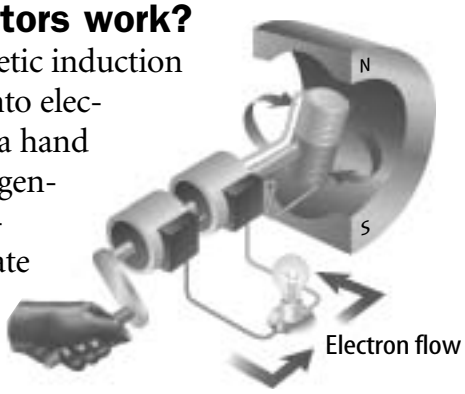
From Mechanical to Electrical Energy

In 1831, scientists discovered that if they moved a loop of wire through a magnetic field, it caused an electric current to flow in the wire. They also found that moving a magnet through a loop of wire produced a current in the wire. In both cases, the movement caused an electric flow in the wire. In other words, mechanical energy was changed into electrical energy.

The loop of wire or the magnet has to move to make an electric current. This makes the magnetic field inside the loop change. When the magnetic field changes, it causes an electric current to flow in the wire. The current change in the wire can start a current in a nearby coil. **Electromagnetic induction** is the making of a current by a changing magnetic field.

How do electric generators work?

Generators use electromagnetic induction to change mechanical energy into electrical energy. The figure shows a hand turning the handle of a simple generator. The turning handle provides mechanical energy to rotate the coil between the poles of a permanent magnet producing a current in the coil.

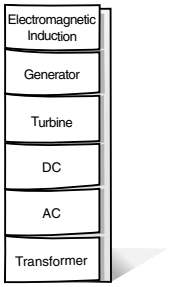


Study Coach

Sticky-Note Discussions
Place sticky notes at parts of the section you find interesting or that you have a question about. Write the question on the sticky note.

FOLDABLES™

Build Vocabulary As you read th is section, make a vocabulary Foldable to show that you understand the vocabulary terms.



Picture This

1. **Explain** What provides the original mechanical energy for the simple generator in the figure? *(Hint: It is not the handle.)*

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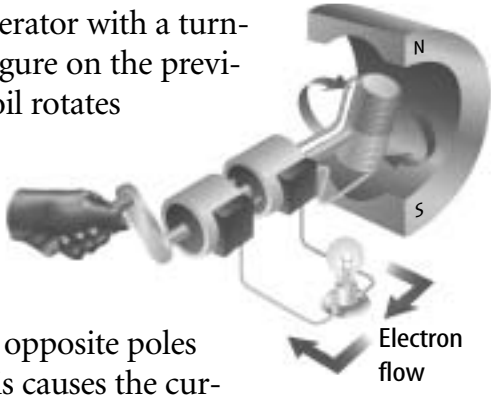
Current Flow A simple generator with a turning wire coil is shown in the figure on the previous page and this page. The coil rotates through the magnetic field of the permanent magnet. This makes a current flow through the coil. Each time the coil makes half of a turn, the ends of the coil move past opposite poles of the permanent magnet. This causes the current to change direction. The current in the coil changes direction twice each time it makes one full turn. You can control how often the current changes direction by controlling how fast the generator rotates. In the United States, generators rotate 60 times per second to produce electric current. This is equal to 3,600 turns per minute.



How are electric generators used?

Generators are used in cars. They are called alternators and provide electrical energy for the car's lights. They also provide electrical energy to the spark plugs in the car's engine. The spark plugs ignite (cause a spark that burns) the fuel in the cylinders of the engine. Once the engine is running, the fuel provides the mechanical energy to turn the coil in the alternator.

How is electricity produced for your home?

Electric power plants produce most of the electrical energy. The huge generators in electric power plants operate in a different way from the alternator. The coil does not rotate. Instead, the permanent magnet rotates. Mechanical energy rotates the magnet, and electrical current is produced in the coil.

The electrical energy you use in your home comes from a power plant with huge generators. These generators have many coils of wire wrapped around huge iron cores. The magnets are connected to a **turbine** (TUR bine), a large windmill-like wheel. The turbine rotates when it is pushed by steam, water, or wind, and the rotating magnets produce the electric current in the wire coils.

Power plants use three different kinds of energy to make electricity. They use thermal, wind, or water energy. For thermal energy, power plants burn fossil fuels such as oil, natural gas, and coal, or use heat made by nuclear reactors. The thermal energy is used to heat water and produce steam. When the steam pushes the turbine blades, the thermal energy is changed into mechanical energy. The generator then changes the mechanical energy into the electrical energy you use.

Reading Check

2. **Identify** What are three types of energy used by power plants?

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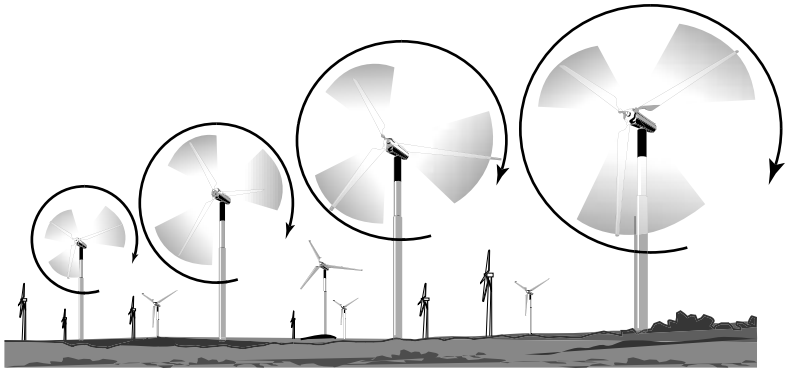
Wind Energy Some power plants use the mechanical energy in falling water to turn the turbines. Other power plants use wind energy. Fields of windmills, like those in the figure below, use mechanical energy in wind to turn the generators. The propeller on each windmill is connected to an electric generator. The turning propeller rotates a coil or a permanent magnet.



Direct and Alternating Currents

Have you ever had a power outage in your house? The electrical devices do not work because electrical energy is not coming into your house. Some electrical devices use batteries as a primary source of energy. A battery-operated radio is an example of this type of device. The current produced by a battery is different from the current from an electric generator.

A battery produces a direct current. A **direct current** (DC) is a current that flows in only one direction through a wire. A CD player or any other appliance that plugs into a wall outlet uses alternating current. An **alternating current** (AC) reverses or changes the direction of the current twice during each rotation of the coil. Electronic devices that use batteries for backup energy, such as a radio, usually need direct current to operate. When the radio is plugged into a wall outlet, electronic parts in the radio change the alternating current to direct current.

Transmitting Electrical Energy

Have you ever seen power lines along a highway? They carry electrical energy from a power plant to buildings. When electrical energy travels through wires, some of the electrical energy changes into heat because of electrical resistance in the wires. As wires get longer, there is more electrical resistance and the heat increases. One way to reduce the heat produced in a power line is to send the electrical energy at high voltage. This voltage in the lines is too high for appliances to use. A transformer is used to decrease the voltage before it enters your home.

Picture This

3. **Make Connections** What do the propellers rotate?

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Think it Over

4. **Apply** List two devices that use DC only and two devices that use AC only.

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Reading Check

5. **Explain** Why can some radios work on both batteries and when plugged into a wall outlet?

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Reading Check

6. **Identify** What causes the magnetic fields in the primary coil to change direction?

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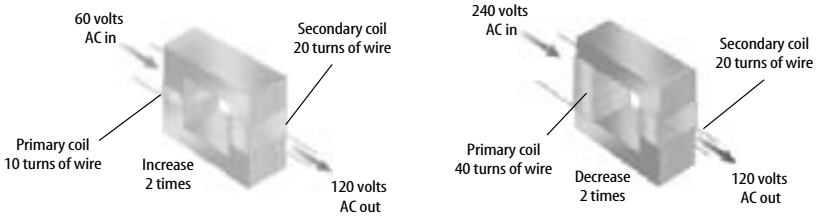
Picture This

7. **Identify** In the two figures, circle the labels that are the same.

Transformers

A **transformer** is used to increase or decrease the voltage of an alternating current. A transformer has a primary coil and a secondary coil. Both coils are wrapped around the same iron core. An input voltage of alternating current passes through the primary coil. This causes the coil's magnetic field to magnetize the iron core. When the current in the primary coil changes direction, this causes the magnetic fields in the primary coil and the iron core to also change directions. This causes an output voltage in the secondary coil.

The figures show two kinds of transformers, a step-up transformer and a step-down transformer.



Step-up Transformer Step-down Transformer

Step-Up Transformer A step-up transformer increases voltage so that the output voltage is greater than the input voltage. The secondary coil then has more turns than the primary coil. In the first figure, an input voltage of 60 volts in the primary coil provides an output voltage of 120 volts in the secondary coil. The secondary coil has twice as many turns as the primary coil has. Therefore, the output voltage is twice as large as the input voltage.

Step-Down Transformer A step-down transformer decreases voltage so that the output voltage is less than the input voltage. The secondary coil then has fewer turns than the primary coil. In the second figure, the input voltage of 240 volts in the primary coil is changed to an output voltage of 120 volts in the secondary coil. The secondary coil has half as many turns as the primary coil has. Therefore, the output voltage is one-half of the input voltage.

What path does an alternating current follow?

Power plants usually make alternating current because the voltage can be increased or decreased with transformers. As the electrical energy leaves the power plant, a step-up transformer increases the voltage. This electrical energy is carried along power lines. When the electrical energy leaves the power lines to enter a building, a step-down transformer decreases the voltage. Even though the voltage is changed, the amount of electrical energy is not changed.

After You Read

Mini Glossary

alternating current (AC): electrical current that changes its direction twice during each rotation of a coil

direct current (DC): electrical current that flows in only one direction through a wire

electromagnetic induction: a changing magnetic field producing an electric current in a wire

generator: a device that uses electromagnetic induction to change mechanical energy into electrical energy

transformer: a device that increases or decreases the voltage of an alternating current

turbine: a large wheel that rotates when it is pushed by water, wind, or steam

1. Review the definitions of the vocabulary words in the Mini Glossary. Choose one of the words and write what it means in your own words.

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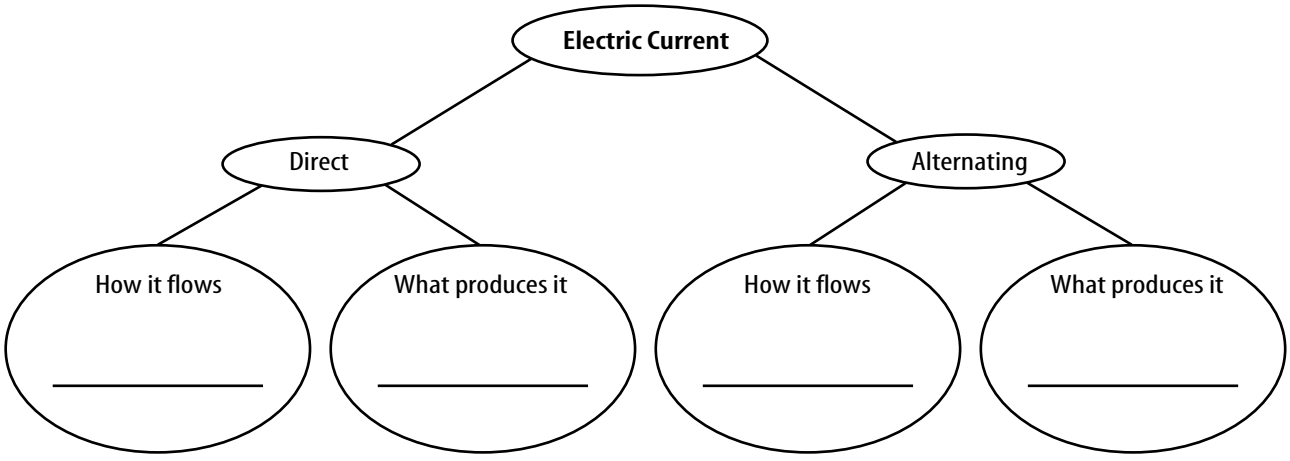
2. Complete the chart below to organize information you have learned about electric current.



3. Study Coach Think about what you have learned in this section. Look at the parts you marked with sticky notes. How did these notes help you learn?

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End of Section