



LEARN ABOUT

Electromagnets

FIND OUT

- how electricity and magnetism are related
- ways to change the strength of an electromagnet
- uses of motors and generators

VOCABULARY

electromagnet

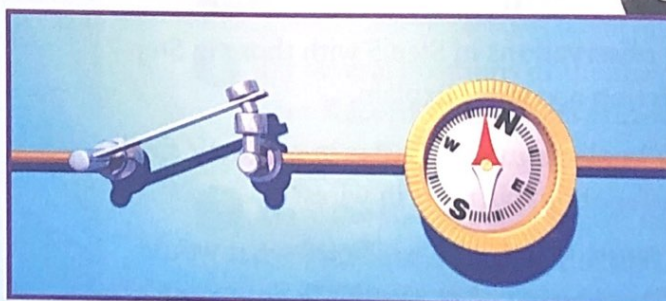
Currents Make Magnets

In the past, scientists wondered if electric charge and magnetism were related. They knew that charged objects and magnets both produce a force that can pull or push without touching. The discovery that an electric current can turn a compass needle proved that the two forces are related.

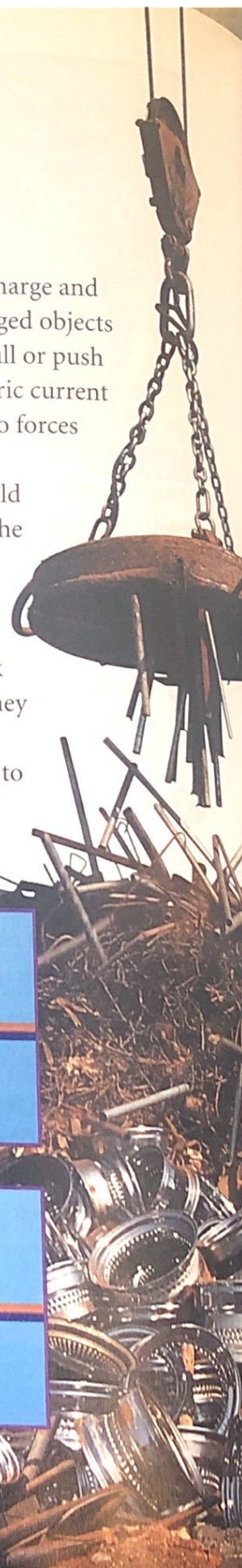
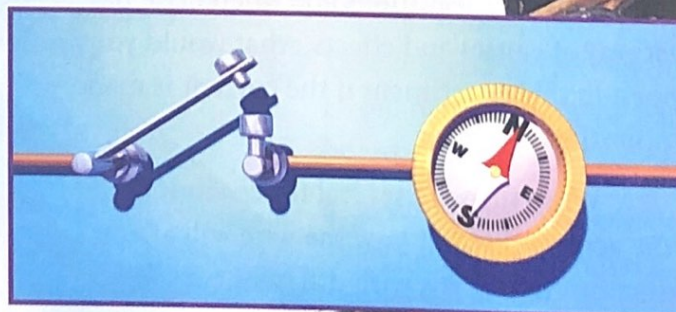
A current in a wire produces a magnetic field around the wire. You saw evidence of this in the investigation. The magnetic field produced by current moved the compass needle.

If you could see them, the field lines around a wire that carries current would look different from those around a bar magnet. They circle around the wire instead of looping out from the wire ends. A compass needle moves to point along magnetic field lines. So, it moves to point at right angles to the wire.

When current flows in the wire, it produces a circular magnetic field. The compass needle lines up with the field lines by turning at right angles to the wire. ►



When the switch is open, current no longer flows and the magnetic field goes away. The compass needle swings back to its original position. ►



This coil of wire is carrying an electric current. Iron filings show the shape of the magnetic field inside the coil. The lines of filings are closest together where the field is strongest. ▶



Compared with bar magnets, current-carrying wires produce weak magnetic fields. But there's a way to put a lot of wire in one place. When a current-carrying wire is coiled, the fields of the loops overlap. The strengths of the fields add up. The more loops you put together, the stronger the field gets.

The fields produced by many wire coils add up to make a field like that of a bar magnet. Iron filings line up along the middle of the coil. Outside the coil, the magnetic field lines loop out from one open end and back to the other.

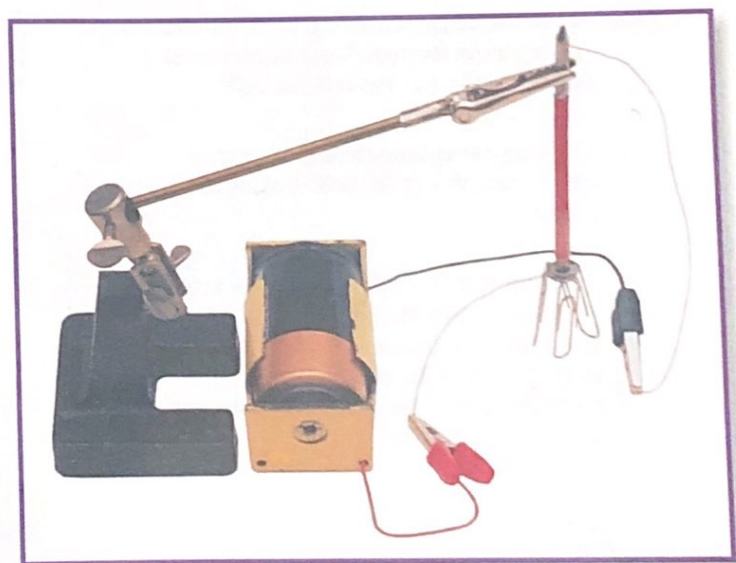
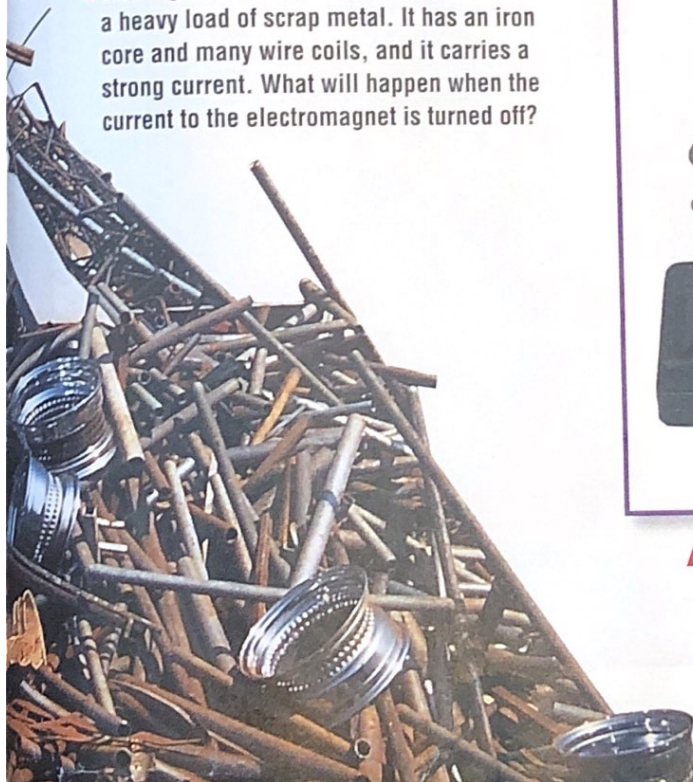
Alone, a coil of wire easily bends. To make it stiffer and easier to use, the coil is wrapped around a solid material called a

core. This arrangement of wire wrapped around a core is called an **electromagnet** (ee•LEK•troh•mag•nit). An electromagnet is a temporary magnet. There is a magnetic field only when there is an electric current in the wire.

If the core of an electromagnet is made of iron, the core also becomes a magnet when there is current in the wire. This makes the electromagnet stronger.

✓ **Why is an electromagnet a temporary magnet?**

◀ This big electromagnet on a crane can lift a heavy load of scrap metal. It has an iron core and many wire coils, and it carries a strong current. What will happen when the current to the electromagnet is turned off?



▲ When current flows through an electromagnet, the electromagnet acts like a bar magnet. This one is strong enough to hold three paper clips.

Controlling Electromagnets

A magnet and an electromagnet have one main difference. An electromagnet is a temporary magnet. You can turn it on and off with a switch. A bar magnet is a permanent magnet. It doesn't have an *off* switch. Electromagnets are a useful tool because you can control them. You can learn how one is used in The Inside Story.

Turning an electromagnet on and off is one way to control it. You can also control the strength of an electromagnet. One way to do this is to add or remove coils of wire. The more coils an electromagnet has, the stronger it is.

The amount of current also affects the strength of an electromagnet. The more current that is flowing, the stronger the electromagnet is.

Electromagnets today are made to use large amounts of current to lift large amounts of weight. Smaller and weaker ones are also made. Small electromagnets work out of sight inside computer disk drives, video players, television screens, and other electronic devices.

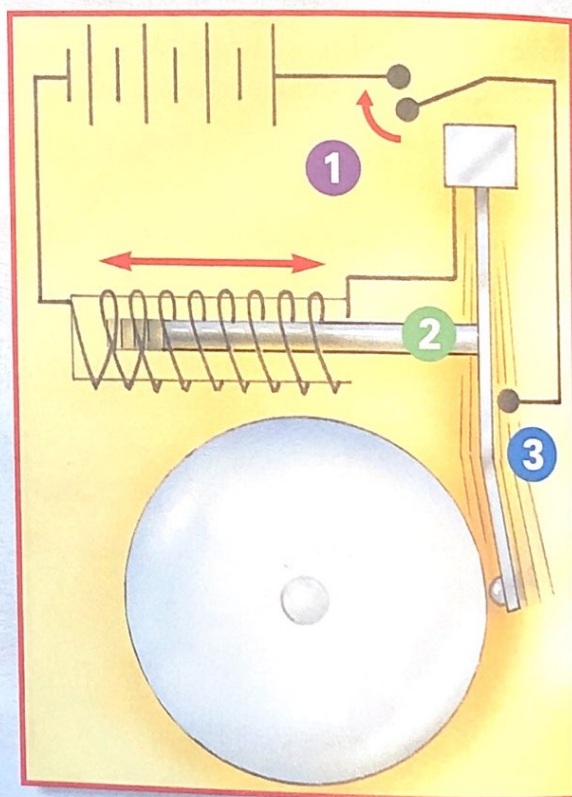
✓ **What is the main difference between a bar magnet and an electromagnet?**

THE INSIDE STORY

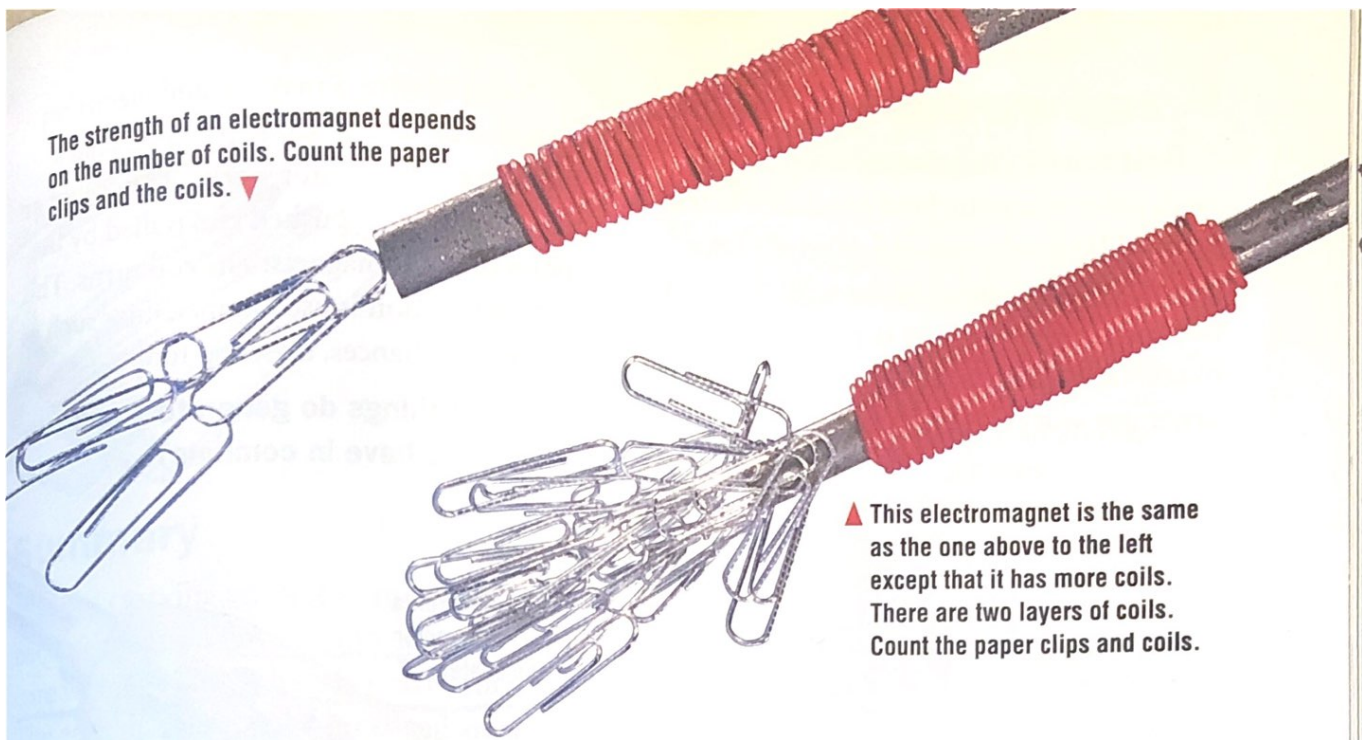
Alarm Bell

The bells used in fire alarms, doorbells, and telephones work because electromagnets can be turned off and on very quickly. The picture and diagram on the right show you how an electric bell works.

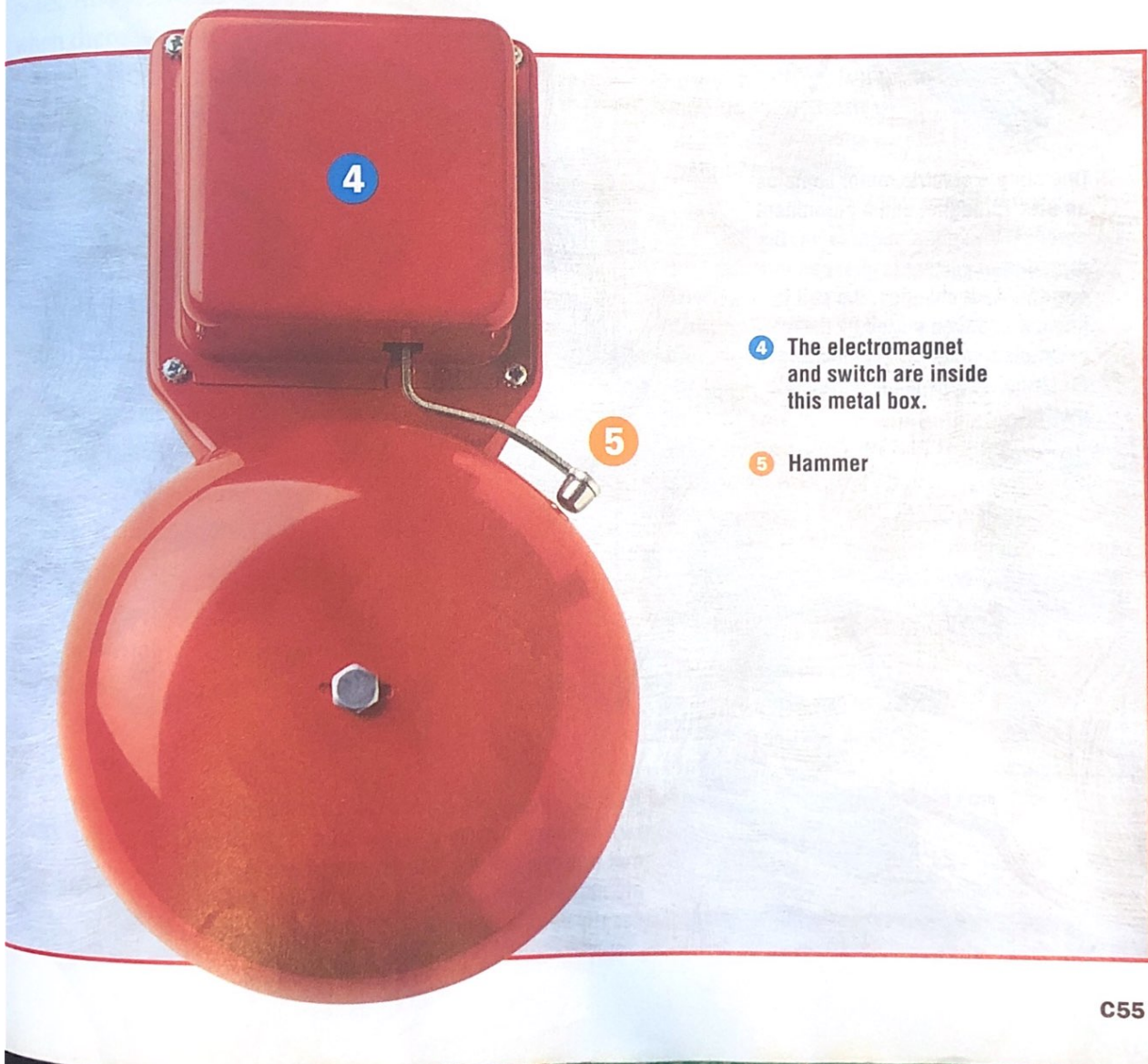
- 1 When the bell is turned on, current flows in the electromagnet. The electromagnet pulls the long iron rod into the coils.
- 2 The hammer is connected to the rod. It moves and strikes the bell, making a sound.
- 3 The strip of metal with the hammer acts like a switch. As the hammer moves to strike the bell, the switch opens. No current flows in the circuit. The electromagnet is turned off. The hammer returns to its original position.



The strength of an electromagnet depends on the number of coils. Count the paper clips and the coils. ▼



▲ This electromagnet is the same as the one above to the left except that it has more coils. There are two layers of coils. Count the paper clips and coils.



4 The electromagnet and switch are inside this metal box.

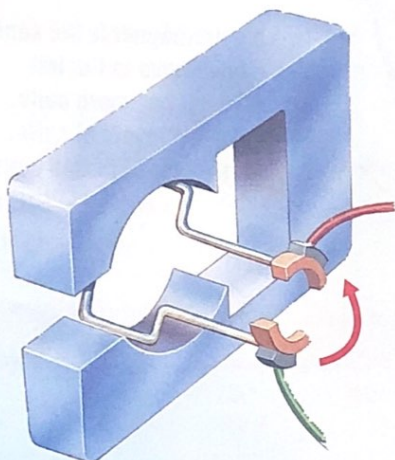
5 Hammer

Motors and Generators

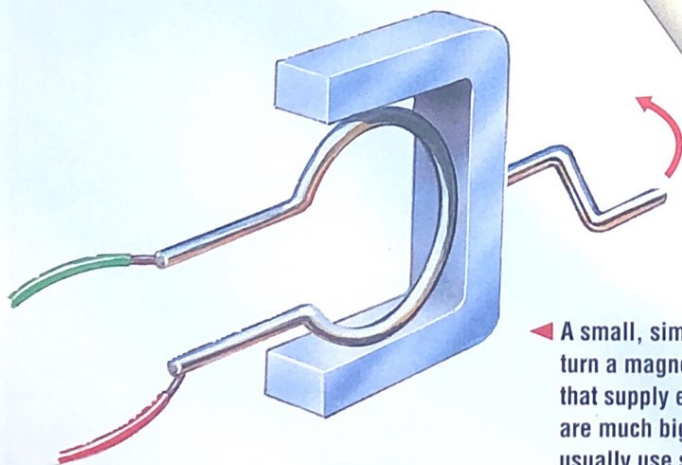
If electricity can produce a magnetic field, can a magnetic field produce electricity? Yes! If you move a coil of wire near a magnet, current flows in the wire. Current flows as long as the wire is moving through magnetic field lines. This is how an electric generator works.

A coil of wire, a magnet, and electricity can also be used to cause motion. That's how an electric motor works. The coil of an electromagnet is pushed and pulled by the poles of other magnets. The coil turns. This turning motion is used in machines such as kitchen appliances, toys, and tools.

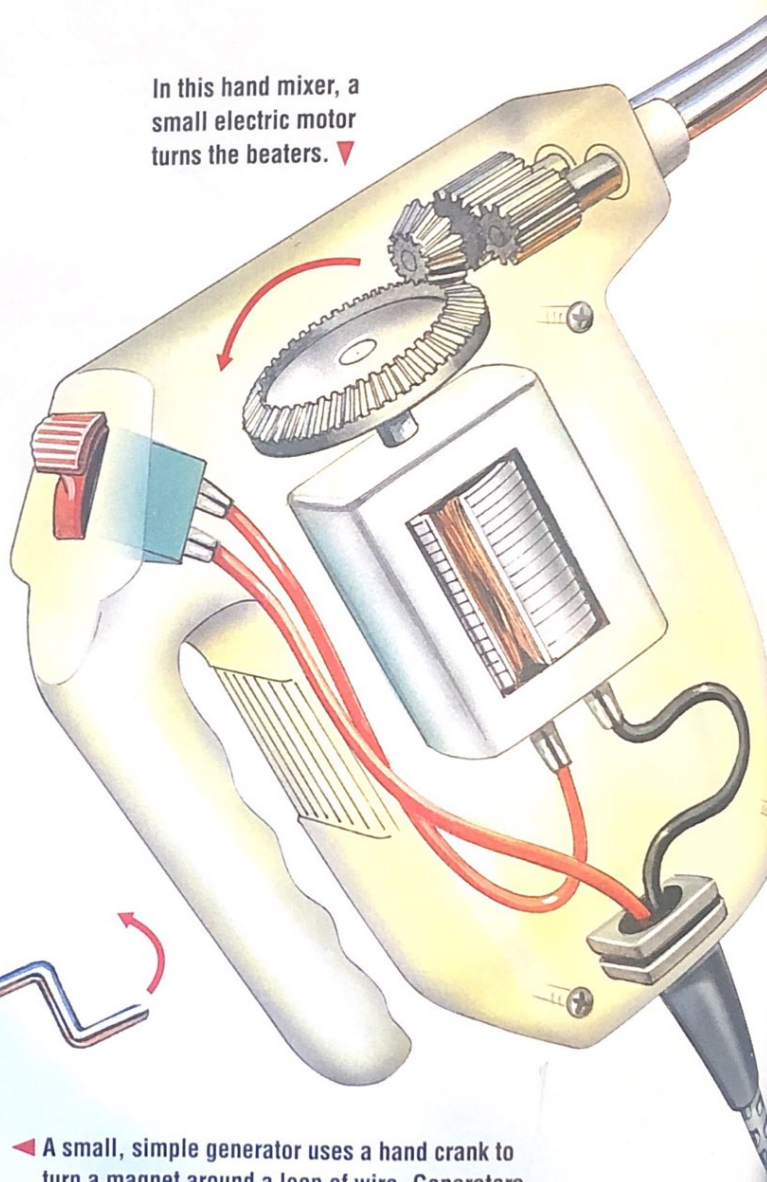
✓ **What things do generators and motors have in common?**



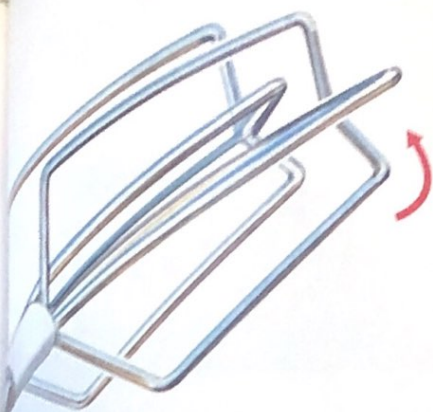
▲ One simple electric motor contains an electromagnet and a permanent magnet. When the motor is on, the direction of current is changed in a pattern. As it changes, the coil is pushed and then pulled by the permanent magnet. The coil turns. Electrical energy is converted into motion.



In this hand mixer, a small electric motor turns the beaters. ▼



◀ A small, simple generator uses a hand crank to turn a magnet around a loop of wire. Generators that supply electric power for homes and factories are much bigger, about the size of a bus. They usually use steam or water power to turn a coil.



Summary

Wires carrying an electric current become magnets. An electromagnet is a core wrapped with wires that carry current. The ends of the electromagnet coil are its poles. An electromagnet is magnetic only when there is a current in the wire. Generators use electromagnets to produce current from motion. Motors use electromagnets to convert electricity to motion.

Review

1. What do magnets and electric charges have in common?
2. Name two ways that you can make an electromagnet stronger.
3. What is a motor?
4. **Critical Thinking** Why is it useful to have a magnet that can be turned on and off?
5. **Test Prep** The ends of an electromagnet that are useful are called —
A cores
B loops
C poles
D wires



LINKS



MATH LINK

Strength of an Electromagnet An electromagnet with 10 loops of wire can pick up 5 paper clips. With 20 loops it can pick up 10 paper clips. Make a line graph of the data. Interpret the graph to predict how many paper clips the electromagnet can pick up if it has 40 loops.



WRITING LINK

Informative Writing—Description Think of an appliance in your home that has an electric motor. Write a description for a younger child, telling what the appliance does. If there were no electric motors, how would you do what the appliance does?



LANGUAGE ARTS LINK

Making Words The word *electromagnet* was made by joining two words. What are they? Research these two words to find out where they came from and how old they are. Why do you think this word is used to describe the device you learned about in this lesson?



TECHNOLOGY LINK

Visit the Harcourt Learning Site for related links, activities, and resources.

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