ENERGY, GENERATORS, AND MOTORS

INTRODUCTION

In World War II, the abundant use of electronics was of great importance. Every plane, tank, and boat was filled with switches, coils, and tubes. Although electricity had been discovered much earlier, the 1920s and 1930s were the time when the technology started to catch up to its promise.

In addition, an understanding of the use of the electromagnetic spectrum to send and receive information had grown. The adoption of radio and radar pushed electronics further.

Electricity and magnetism can seem like separate topics, but their similarities are what really leads to an understanding of each. Electricity generates magnetic fields and vice versa. Manipulation of magnetic fields creates electromagnetic waves, and electromagnetic waves can induce a current.

Thus, the innovations of World War II electronics and the stories of how they were used are a great way to supplement the electricity and magnetic curriculum.

In Energy, Generators, and Motors, students will learn about the interactions between electricity and magnetism with some demonstrations. Students will explore power generation and the structure of motors and generators. Then they will compare the relationship between electricity and magnetism, the similarity in structure between motors and generators, and finally compare radio transmitters and receivers.

MATERIALS

+ Aluminum pipe, copper pipe and neodymium magnets
+ Hand-powered generator
+ Fan that has been taken apart to show workings
+ Coil around screwdriver, battery
+ AA battery, aluminum screw, copper wire, neodymium magnets (homopolar motor)

STANDARDS

NGSS 4 PS3-2
Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

NGSS 4 PS3-4
Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

NGSS MS PS2-3
Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

NGSS MS PS2-5
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

NGSS MS PS3-2.
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

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This is one the most challenging conceptual developments for students from elementary to middle school—the interrelationship of electricity and magnetism, and force at a distance. This activity connects the design of motors to generators, and radio transmitters to receivers. They mirror each other. While working on their development of these concepts, with its emphasis on diagrams, the activity helps students with the Science and Engineering Practice of Developing and Using Models. It also engages in the Crosscutting Concepts of Energy and Matter, and Systems and System Models.

NAME: DATE:

ENERGY, GENERATORS, AND MOTORS

Just look around you to see how much we depend on electricity today. Lights, heating, cooling, cooking—today electricity is often needed for all of these. Even cars, which run on gasoline, won't work without electricity.

One hundred years ago, things were quite different. It's very likely that back then people, whether they lived in towns or cities, used gas lights, oil lamps, and candles for light. They used wood or coal for heat and cooking. Cooling meant opening the window. Cars were started with a crank, not a battery.

World War II happened at the time that all that changed. Electricity was invented and put to use before then, but it was easier and cheaper to meet energy needs the way people had been doing for centuries than to change. To make all the materials needed for the war effort, manufacturers learned all sorts of ways to include fancy electronics. And after the war, they learned how to use those fancy electronics to make TVs and home radios, better cars, clothes washers, and refrigerators.

Where does all that electricity come from? And how do we make things that can put it to use? Here is one answer to those two questions: Magnets and circuits are put together.

When a magnet moves inside a coil of wire (or when a coil of wire moves inside a magnetic field) an electric current is generated in a wire. That process produces something called a generator.

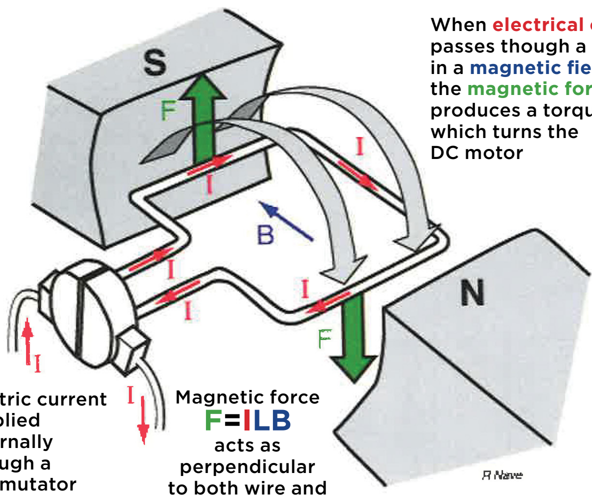
A generator generates electricity. That statement is not completely correct. Energy can't be made ("generate" is a fancy word for "make"). Energy can only be changed from one form to another. In the case of a generator, movement of a wire or magnet (mechanical energy) produces a current (mechanical energy).

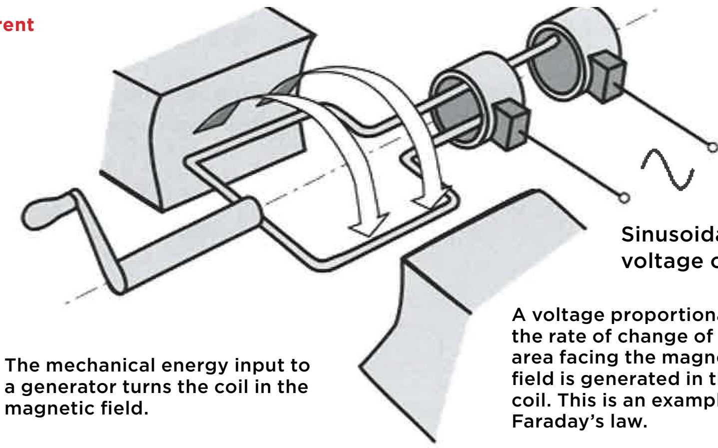
When a magnet is around a wire carrying current, the magnet will move. Or, if the magnet is stuck in place, the wire carrying the current inside the magnet will move. The result is called a motor. A motor turns electric current (electrical energy) into motion (mechanical) energy.

So a generator is a motor going backwards and a motor is a generator going backwards.

Why does this happen? Because an electrical current generates a magnetic field. If a compass is held near a wire carrying current, the compass will point in the direction of the current. If the wire is made into a coil, the magnetic field is even stronger, which is why there are so many coils inside of fancy electronic devices.

Take a look at these diagrams of a motor and a generator. Put notes on them that explain how they work.



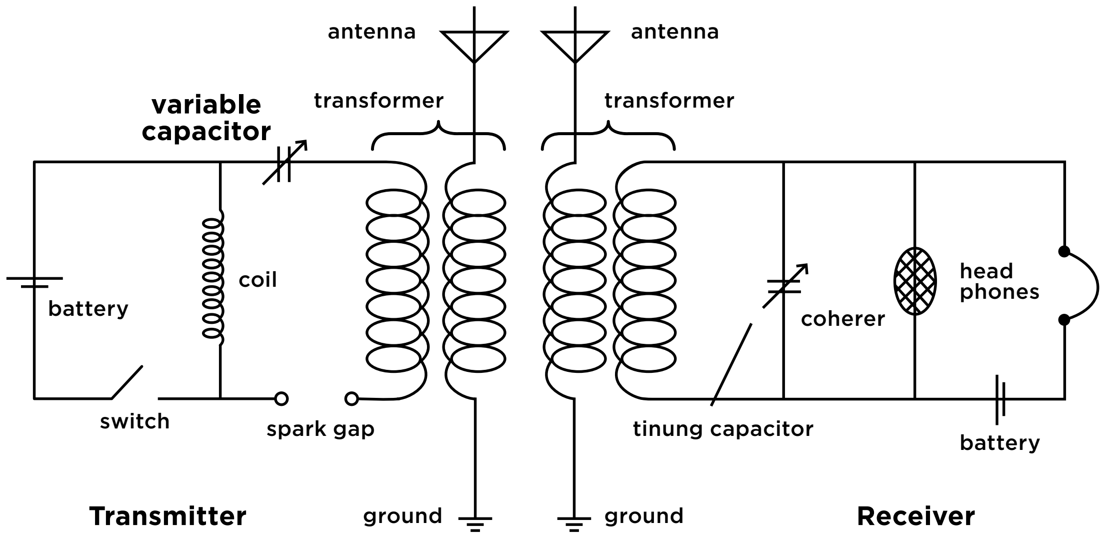


Electrical currents make magnetic fields that can't be seen. They make something else that can't be seen either—they make electromagnetic waves. The most common places these waves can be seen in the home are in microwave ovens. Cell phones make electromagnetic waves too, but the parts are too small to see easily.

A microwave oven has two strong magnets that spin around a bunch of wires. The magnets and wires together cause a changing current that makes a pattern of changing magnetic fields. This changing field sends out electromagnetic waves.

Microwaves were first used in World War II, but not for cooking. They were used to send signals for communication and radar. A microwave oven is a form of radio transmitter (but its waves are tuned to cook not send signals). A radio transmitter and a radio receiver are very similar, just like motors and generators are similar.

Make notes on the following diagram to explain how the various parts work. How are the two devices similar? How are they different?



Observe the demonstrations of how magnets and current interact.
Draw diagrams of the demonstrations and describe in the space below: