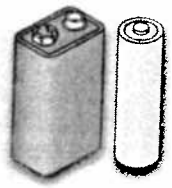
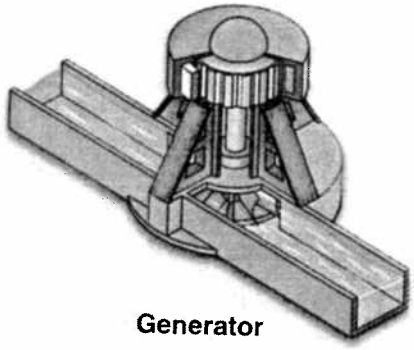
CHAPTER 1: BASIC COMPONENTS & CIRCUITS

Learn By Doing®

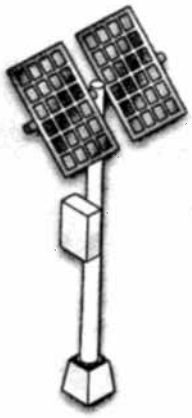
What is electricity? Nobody really knows. We only know how to produce it, understand its properties, and how to control it. It can be created by chemistry (batteries), magnetism (generators), light (solar cells), friction (rubbing a sweater), and pressure (piezoelectric crystals).



Batteries



Generator



Solar Cells

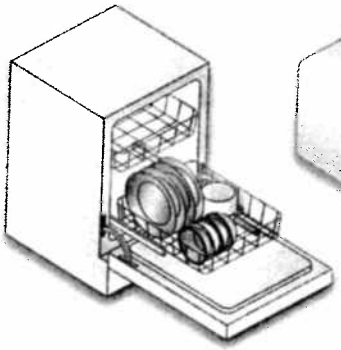
Rubbing a Sweater

Piezoelectric Crystal

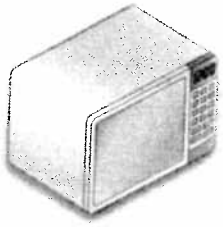
In this section you will learn about basic electrical components and circuits. By building circuits using Snap Circuits®, you will begin to understand the electrical world.

Electricity is energy that can be used to save us effort (electric toothbrushes and dishwashers), heat things (electric heaters and microwave ovens), make light (light bulbs), and send information (radio and television). But electricity can also be dangerous if abused (electric shock).

Electric Toothbrush



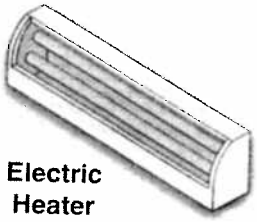
Dishwasher



Microwave Oven

Light Bulb

Radio



Electric Heater

Television

Electric Shock

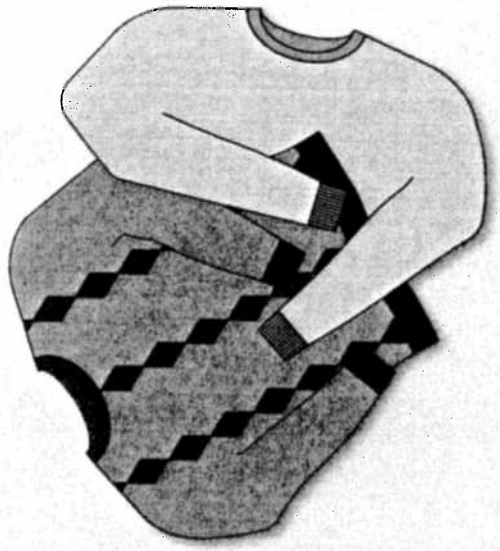
1-1 Electricity

The name electricity came from the Greek name for amber, the material in which electrical effects were first observed. What do you think of electricity as being? Electricity is one of the fundamental forces of nature. At its most basic level, it is an attraction and repulsion between sub-atomic (very, very, very, very tiny) particles within a material. This attraction/repulsion is referred to as an electrical charge; it is similar to and closely related to magnetism. These attractions/repulsions are extremely powerful but are so well balanced out at the sub-atomic level that they have almost no effect on our lives.

As an example, electrical attraction is about 1,000,000,000,000,000,000,000,000,000,000,000,000,000 times more powerful than gravity (gravity is what causes things to fall to the ground when you drop them). However electrical attraction is so completely balanced out that you don't notice it, while gravity effects are always apparent because they are not balanced out.

Gravity is actually the attraction between objects due to their weight (or technically, their mass). This effect is extremely small and can be ignored unless one of the objects is as big as a planet (like the earth). Gravity attraction never goes away and is seen every time you drop something. Electrical charge, though usually balanced out perfectly, can move around and change quickly.

For example, think about how two sweaters can cling to each other when you take them out of the dryer. This is due to an electric charge that has built up between them. There is also a gravity attraction between the sweaters, but it is always extremely small.



Electronics is the science of working with and controlling electricity. Many work-saving appliances like dishwashers, hairdryers, and drills are electrical but not electronic. Electronic products use electricity to control themselves, using parts like resistors, capacitors, and transistors. Electrical appliances are only controlled mechanically.

A good way to think of the difference between electrical and electronic products is to think about moving into a new house. Most products in the empty house are electrical (such as all the wiring and switches in the walls, rotary phones, dishwashers, electric ovens, air conditioners, most types of thermostats).

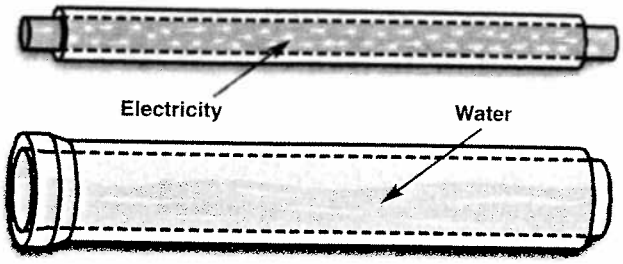
Most products you bring from your old house to your new house are electronic (such as TVs, computers, touch-tone phones, radios, most battery operated products), but not all (such as hairdryers, electric power tools).

Electricity is the movement of sub-atomic particles (with their electrical charges) through a material due to an electrical charge outside the material. Electricity will be easier to understand if you think of the flow of electricity through circuits as water flowing through pipes.

1-2 Wires

Wires can be thought of as large, smooth pipes that allow water to pass through easily. Wires are made of metals, usually copper, that offer very low resistance to the flow of electricity.

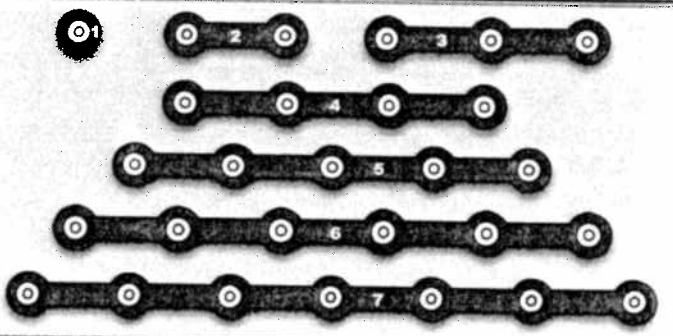
The **electric current** is a measure of how fast electricity is flowing in a wire, just as the water current describes how fast water is flowing in a pipe. It is expressed in **amperes** (A, named after Andre Ampere who studied the relationship between electricity and magnetism) or **milliamps** (mA, 1/1000 of an ampere).



With Snap Circuits® the wires you will use have been shaped into snap wire strips, to make interconnection easy. These work the same as any other wires you might find in your house, since they are made of metal.

Introducing New Parts

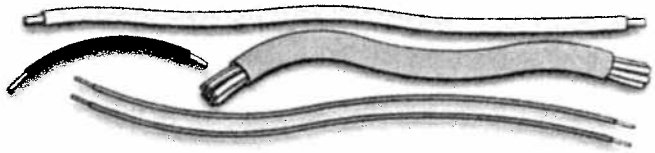
If you have the Snap Circuits® parts nearby then pull out the wires and look at them. They have numbers such as 2, 3, 4, 5, 6 or 7 depending on the length of the wire connection. There is also a 1-snap wire that is used as a spacer or for interconnection between different layers.



Wires can generally be as long as desired without affecting circuit performance, just as using garden hoses of different lengths has little effect on the water pressure as you water your garden. However there are cases where the length and size of a pipe does matter, such as in the water lines for your entire city or in an oil refinery. Similarly, wire length and size are important for electric power lines transporting electricity from a power plant in a remote area to a city, and in circuits used in radio or satellite communication.

If you were to look inside an electronic device in your home (make sure it's not plugged in) you might see a lot of wires of different colors. The actual wires are all the same color of metal, but they have a protective covering over them. The colors are used to easily identify which wire is which during assembly and repair of the circuit.

The covering is also used to prevent different parts of a circuit from connecting accidentally.

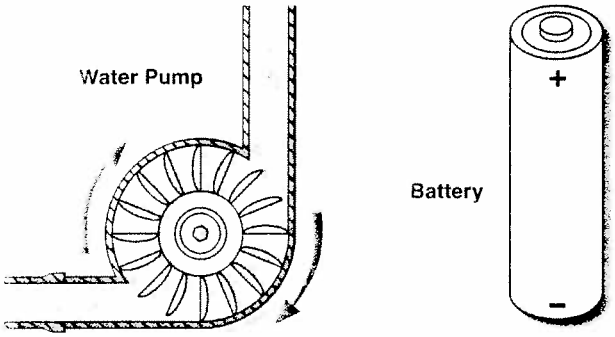


Try to imagine the total length of wire used in all the products in your home!

1-3 Batteries

To make water flow through a pipe we need a pump. To make electricity flow through wires we use a battery. A battery creates an electrical charge across wires. It does this by using a chemical reaction and has the advantage of being simple, small, and portable.

Voltage is a measure of how strong the electric charge from your battery is, and is similar to the water pressure. It is expressed in volts (V, and named after Alessandro Volta who invented the battery in 1800). Notice the "+" and "–" signs on the battery. These indicate which direction the battery will "pump" the electricity, similar to how a water pump can only pump water in one direction.

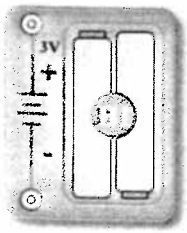


The 0V or "–" side of the battery is often referred to as "ground", since in house or building wiring it is connected to a rod in the ground as protection against lightning.

Battery power is much easier to use in electronics than the electricity that powers your home. This is because most electronic circuits only need a low voltage source to operate; all the electricity produced by your electric company comes at a higher voltage, which must be converted down. If a circuit is given too much voltage then its components will be damaged. It is like having the water in your faucet come out at higher pressure than you need, and it splashes all over the room. If water in a pipe is at too high of pressure then the pipe may burst. Batteries are selected to give your circuit just the voltage it needs.

Introducing New Parts

Your Snap Circuits® uses two sets of two 1.5V batteries in a holder (snap part B1, actual batteries are not included). Notice that just to the right of the battery holder pictured below is a symbol, the same symbol you see on the battery holder. Engineers are not very good at drawing pictures of their parts, so when engineers draw pictures of their circuits they use symbols like this to represent them.



Battery Holder (B1)

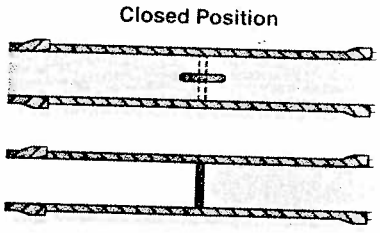
Battery Symbol

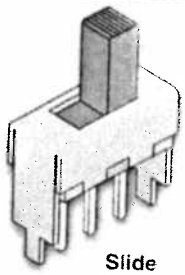
Batteries are made from materials like zinc and magnesium dioxide, electricity flows as these react with each other. As more material is used up by the reaction, the battery voltage is slowly reduced until eventually the circuit no longer functions and you have to replace the batteries. Some batteries, called rechargeable batteries (such as the batteries in your cell phone), allow you to reverse the chemical reaction using another electric source. That way the batteries can last through years of use.

Try to count how many batteries are in your home, your count will probably be low. Many products that use your house power also have batteries to retain clock or programmed information during brief power outages (such as computers and VCRs).

1-4 The Switch

Since you don't want to waste water when you are not using it, you have a faucet or valve to turn the water on and off. Similarly, you use a switch to turn the electricity on and off in your circuit. A switch connects (the "closed" or "on" position) or disconnects (the "open" or "off" position) the wires in your circuit.




Slide Switch

Introducing New Parts

Just as the plumbing industry has a wide range of valves for different situations, there are many types of switches used in electronics. The type shown below is called a slide switch, because you slide it back and forth to turn it on and off. Snap Circuits® includes one of these (part S1), shown below. As with the battery, the slide switch is represented by a symbol, shown to its right. If you have the snap circuits parts nearby, take out the switch and look at it.

Slide Switch (S1)


Slide Switch Symbol

Introducing New Parts

Another type of switch is the press switch, and Snap Circuits® also includes one of these (part S2). When you press down the two pieces of metal touch, so electricity can flow. When you let go of it, the electricity stops. Its symbol is marked on the snap part, though on many professional electronics drawings both slide and press switches use the symbol for the slide switch because they really perform the same function.

Press Switch (S2)

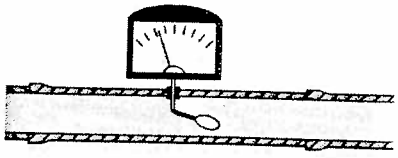

Press Switch Symbol

You can think of slide and press switches like the water faucet in your kitchen (which pours out water until you turn it off) and a water fountain in a school or movie theater (which only squirts out water as long as you are pressing the button).

Switches in modern electronics come in many diverse forms. Try to count how many are in your home or car; you will be amazed. There are slide, press, membrane, rotary, push-button, and other switches controlling nearly everything.

1-5 The Lamp

In a lamp electricity is converted into light, the brightness of the lamp increases as more electric current flows through it. You can think of a lamp as a water meter, since it is showing us how much current is flowing in a circuit just as a water meter shows how much water is flowing in a pipe.


Water Meter

Introducing New Parts

Snap Circuits® includes two different lamps (parts L1 and L2, shown below). If you have the parts with you, take them out and look at them.

2.5V Lamp (L1)

6V Lamp (L2)

Just as there are different types of water meters to work with different pressures and volumes of water, there are also different lamps. Lamp L1 is a low-pressure meter, and works with voltages (electrical pressures) of up to 2.5V. Higher voltages than that will damage the bulb, so always make sure to use the correct lamp. Lamp L2 is for higher pressures of up to 6V, and won't be nearly as bright as L1 if the pressure is only 2.5V.

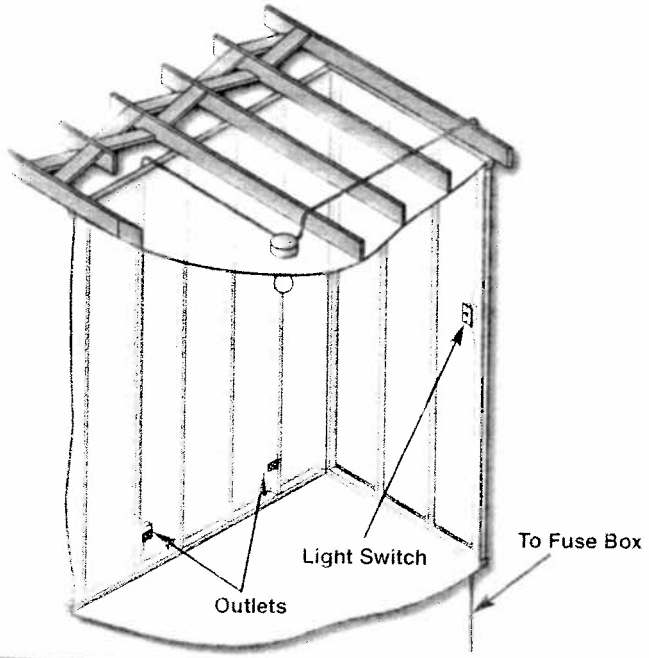
The electrical symbol for a lamp is shown here, it is the same for both lamps but the voltage will be indicated as needed. The lamp sockets are the same for both parts; only the bulbs and markings are different.

Lamp Symbol

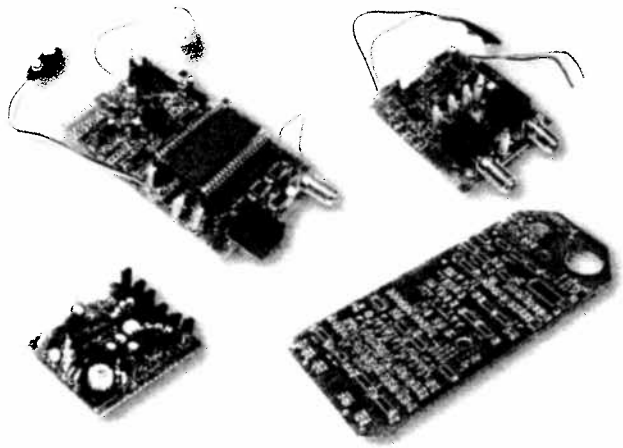
While occasionally lamps are used to indicate how much electricity is flowing in a circuit, they are mostly used to light our homes, businesses, and streets. Although scientists had been experimenting with electricity for years, the first practical use of electricity occurred when inventor Thomas Edison used it to light a bulb similar to these. For many years electricity was used almost exclusively for lighting. That has since changed. Now only a small percentage of the electricity produced in the United States is used for lighting with the rest going to a vast range of uses in everyday life that Edison would never have imagined.

1-6 The Base Grid

The water in your home flows through pipes mounted in the walls and floors of your home, and similarly the electricity in your house flows through wires mounted in the walls and ceilings of your home. But the wires in your walls take a lot of hard work to install and then can't be moved.



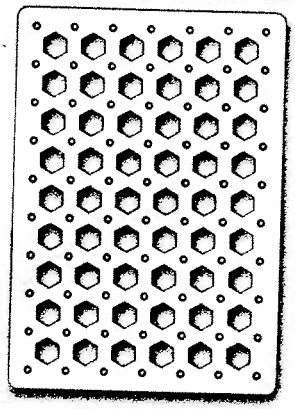
Most products that use electricity are small, easy to move, and easy to build. That is because they have almost all of their components and wires mounted on "circuit boards" such as these:



Boards like these are used in almost all electronic products, look inside any radio or computer and you will find them. Note that the "wires" connecting parts mounted on the circuit board are literally "printed" on the surface of the board; hence circuit boards all are called "printed circuit boards" or PCBs.

Introducing New Parts

In the same manner Snap Circuits® uses a clear plastic base grid with evenly spaced posts to mount the snap parts and wires and to keep them together neatly. It has rows labeled A-G and columns labeled 1-10 to easily identify points in your circuit. You don't need the base to build your circuits, but just try building one of the larger circuits without it! The base grid is shown here, next to a picture of a typical circuit industry board before parts are mounted.

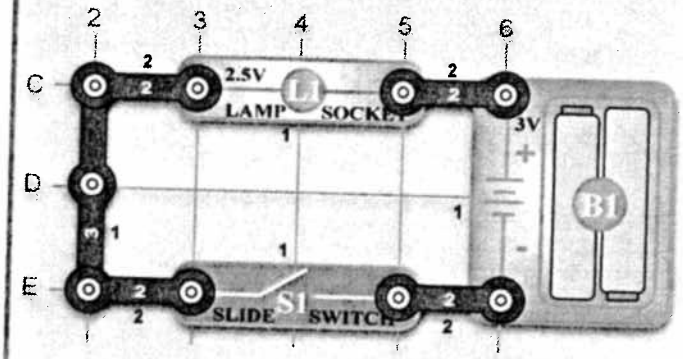


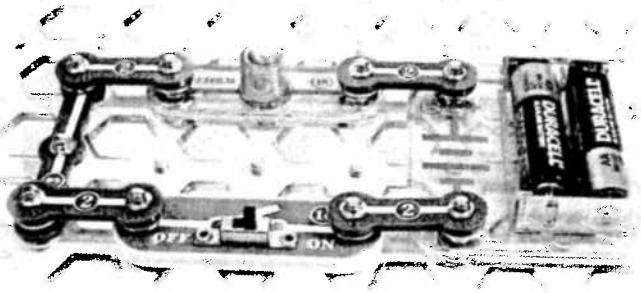
Base Grid

PC Board

Experiments

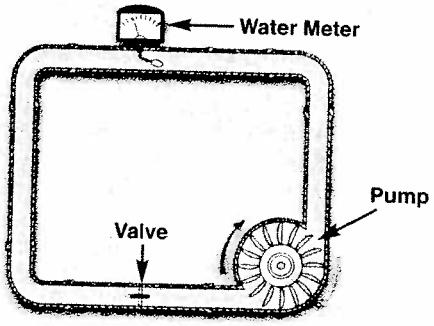
So far we've talked about wires, batteries, switches, lamps, and circuit boards; now it's time to put them together to form a circuit. Consider this circuit (which is project 1 on page 8 of the first project manual):





Turning on the switch turns on the lamp. This circuit is the same circuit used to turn on a lamp in your home. The only differences are the batteries are really power from the electric company, the lamp is larger and bright enough to light up the room, the switch is really a switch on the wall, and the snap wires are really wires in the wall and the cord to the lamp.

You can think of the electricity flowing through the battery, lamp, switch, and wires in the above circuit as if it were water flowing through a pump, water meter, valve, and pipes:



Note that each of the Snap Circuits® in the project manuals has a box next to it ☐ so that you can mark off the circuits as you build them.