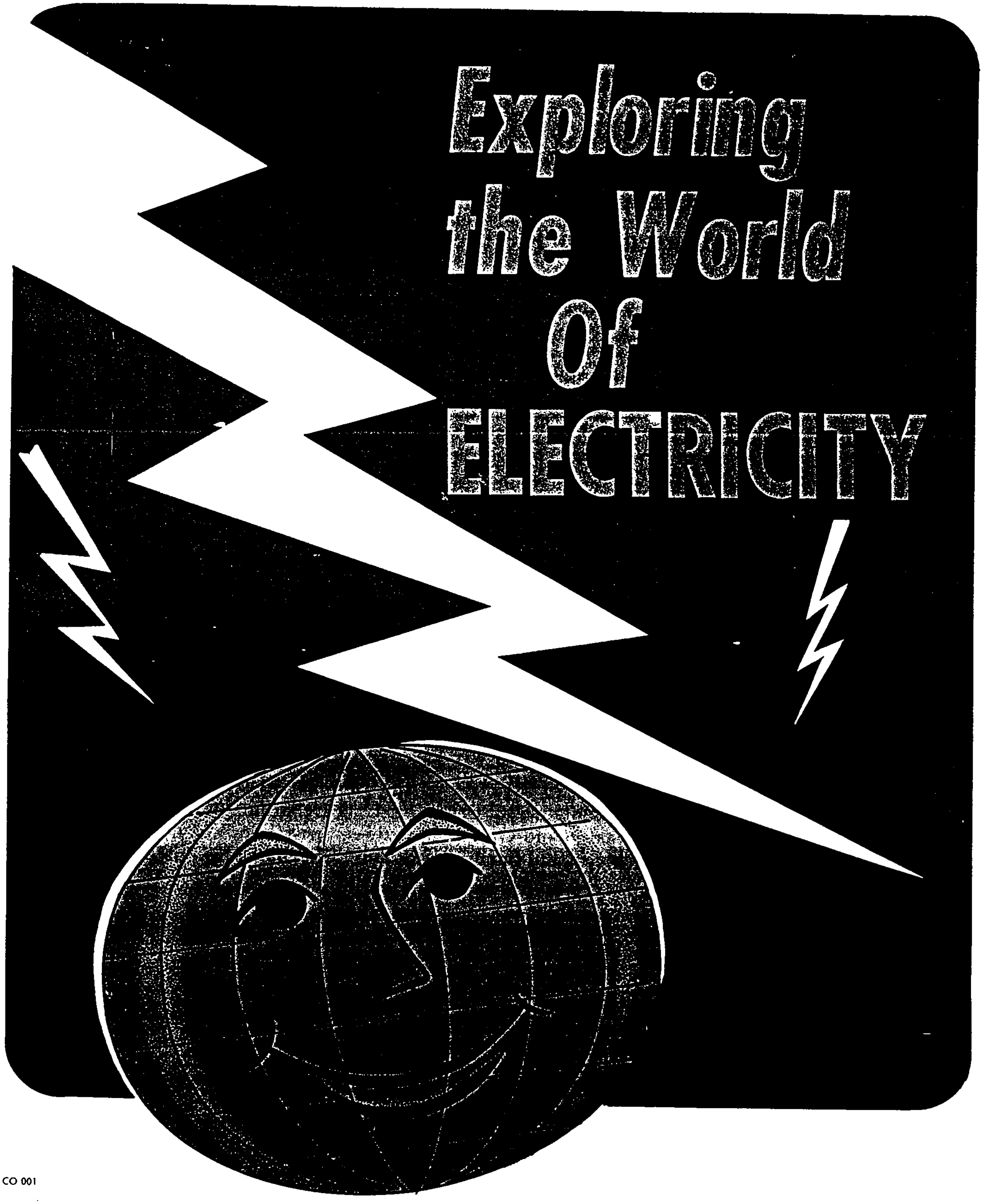
4H ELECTRIC ENERGY PROGRAM

Unit 1

MEMBERS' MANUAL



CO 001

NAME ______________________________

ADDRESS ______________________________

CLUB ______________________________

EXPLORING THE WORLD OF ELECTRICITY

(Fundamentals of Electricity—Part I)

CONTENTS **Page**

ACKNOWLEDGMENTS

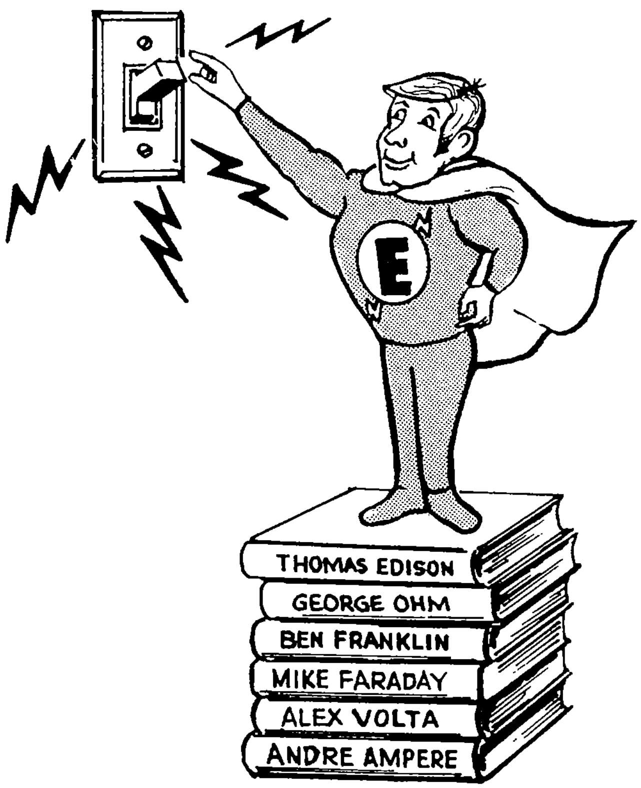
This educational material has been prepared for 4-H use by the National Electric Energy Program Development Committee, composed of representatives of Extension, U. S. Department of Agriculture and the Cooperative Extension Service of the State Land-Grant Universities. Special appreciation is given to Westinghouse Electric Corporation for technical and financial assistance. The manual is published by the National 4-H Council, 7100 Connecticut Avenue, Chevy Chase, MD 20815.

Special appreciation for technical assistance is given to William T. Cox, Glenda L. Pifer and Kemp L. Swiney, all of Extension U. S. Department of Agriculture.

50-12-76/50-10-77/50-11-78/20-10-83

I. Fundamentals of Electricity

Throw a switch and a darkened room bursts into brightness from an electric light bulb! Push a button and your favorite program springs to life on the television set! You are enjoying the results of man's efforts to make one of nature's basic forces of service to him.



The work of many gives you superpowers through electricity today.

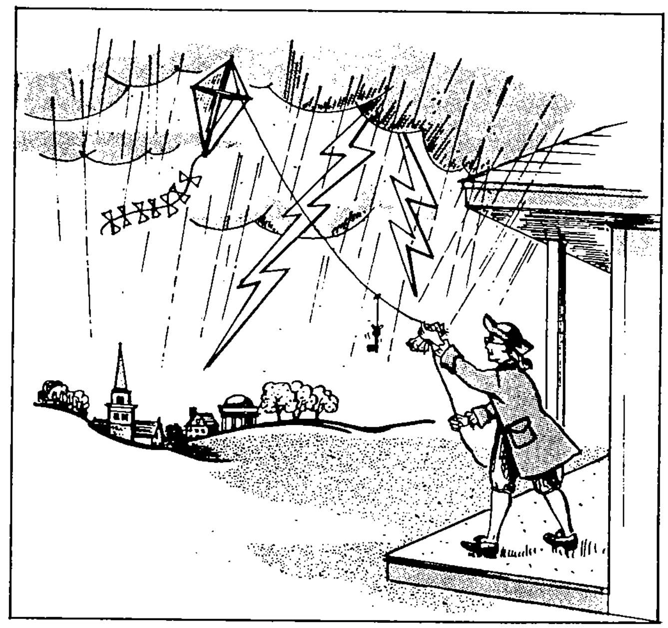
The flick of a switch places power at your disposal!

Perhaps you have wondered just what flows into that light bulb to light your way? Where it comes from? How it works?

If so, you are about to begin a journey through a mysterious and exciting world of electricity. And along the way, you will learn to use secrets that took man thousands of years to uncover and to perfect.

Electricity is all around us. We usually can't see it, smell it or hold it in our hands—but we can see what it does. We enjoy its convenience in hundreds of different ways every day. In fact, can we get along without it in our modern world?

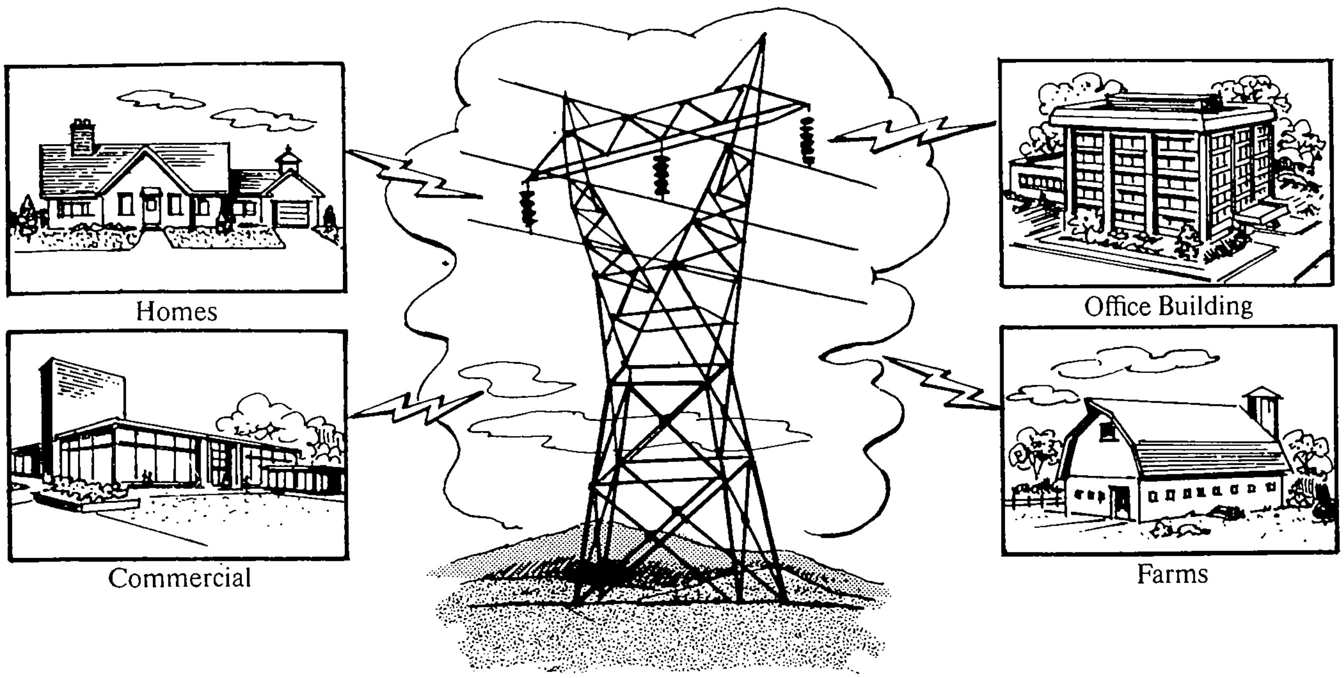
Electricity is not one of man's inventions; it is a part of nature. After all, the brilliant blue-white flashes of lightning from a thunderstorm are electricity. Benjamin Franklin proved that by flying a kite on the end of a long wire during a storm some 200 years ago. The practice was not advisable for Mr. Franklin, who didn't know the danger of electrical shock.



Benjamin Franklin found that lightning was electricity.

The really exciting story of electricity is in its power to perform chores for man. Never in their wildest dreams could the rich and noble kings and queens of yesteryear have envisioned electricity and what it can do in today's society.

Electricity does more than entertain. It works hard for you, too. It keeps you and your home comfortable. Even while you sleep, electric motors are doing the work of thousands of men. They help make appliances, automobiles, bicycles, television sets and airplanes. Electricity helps move and preserve fruits and vegetables from far-off farms. Think how electricity helps you work more easily at home, as it performs daily chores quickly and efficiently.



Electricity's Many Uses

Electricity is amazing in its adaptability. It can cook your food, run a pump to move water and operate a television set. Electricity can heat water, power a food freezer and spin your records. In how many more ways can electricity help you live better and more easily?

Electricity has become a necessity of modern life, and it provides the power for even more wonders for the future!

Usually, all you'll ever have to do is flip a switch!

Things to Do

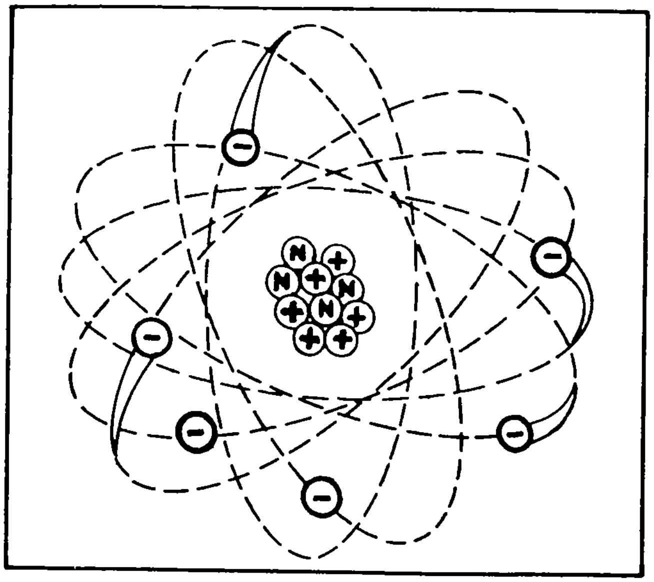
1. Make a list of all the appliances and devices in and outside your home that use electricity. Check those which use batteries for power. Those which plug into the wall.
2. List some of the ways electricity is used in other 4-H projects.
3. Talk to a parent or other adult and list some of the ways electricity is used at his or her place of work.

II. Atoms and Electricity-The Greeks Had a Word for It

Electricity is a big subject. However, it begins very small—with atoms. Everything in the world, including this booklet—and yes, even you—is made up of atoms. You cannot see them because they are so tiny. However, if all the millions of people in the world were the size of atoms, you could put all of them on the head of a common pin with plenty of space left over.

As tiny as atoms are, they are made up of even smaller particles. These are: "protons," "neutrons" and "electrons."

If you could see an atom, it might look like a miniature solar system. The protons and neutrons are bunched together to form the "sun" of the miniature system. Scientists call this the "nucleus." The electrons, which are smaller than either protons or neutrons, constantly whirl around the nucleus like tiny planets.



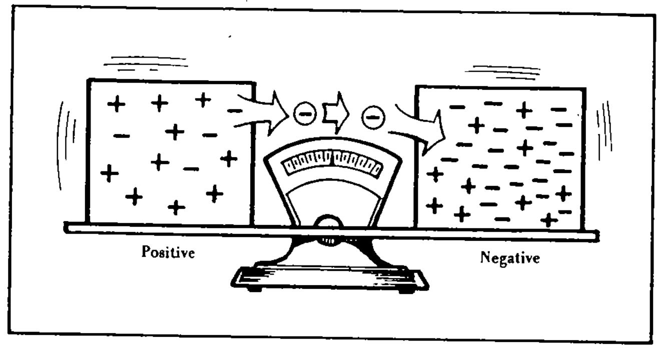
The atom is like a tiny solar system with electrons as planets.

Protons and electrons are electrical in character. Protons are said to be positively charged (+). Electrons are negatively charged (−). Positive and negative charges attract each other. So protons and electrons attract each other. Neutrons have no charge at all. Since there is an equal number of protons and electrons in every atom, the charges cancel so that the whole atom has no charge of electricity.

Some atoms have many electrons whirling around, those farthest from the nucleus are not attracted very securely to protons in the nucleus. And an outside force can sometimes knock the outermost electrons away from the atom.

The ancient Greeks discovered this when they rubbed a piece of amber with a piece of fur. The amber was left with an overall positive charge and the fur with a negative charge. The amber attracted bits of paper or other light objects. What the Greeks noticed is called "static electricity." "Static" means "still," or "not moving." The early Greek discoveries also provided the basis for the word "electricity." Their name for amber was "Elektron."

When an object has more or less electrons than normal, it has static electricity, or is electrically "charged." It is positively charged if electrons have been taken away, leaving behind extra positively-charged protons. It is negatively charged if electrons have been added.



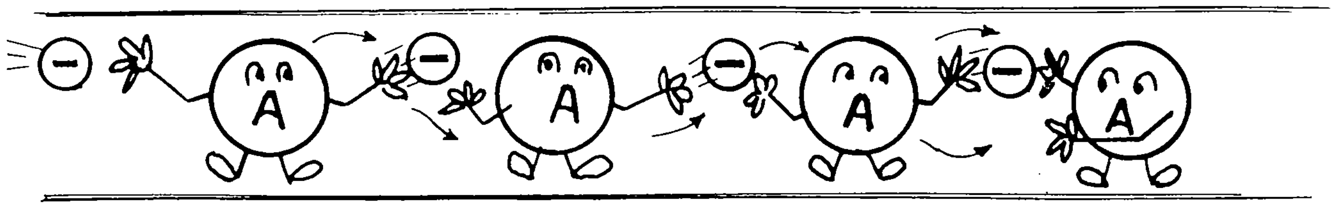
When electrons flow from one object to another to equalize the number of electrons and protons in each of the materials, a small electric spark may be visible.

You can create static electricity, too. Gather together a glass rod, a piece of silk, about 10 inches of thread and a pair of scissors. Cut the thread into about a dozen pieces. Rub the glass rod vigorously for a few moments with the piece of silk. Then move the rod very close to the pieces of thread. You will see that the glass rod attracts the threads. Why? The silk cloth rubbed some of the electrons from the surface of the glass rod, creating a "positive" charge on the rod. When you brought the rod close to the threads, the rod "pulled" at the electrons in the thread.

Lightning is caused by static electricity. One part of a cloud may build up more negative charges than another. The difference in charge may become so great that the charges seek to get back together. The result is a bolt of lightning.

The fact that some atoms hold their electrons rather loosely is important to us. In some materials, loosely-held electrons can jump with ease from one atom to another within the material. If an atom has too many electrons, the extras are attracted to another atom which may have too few, and so on.

Let's say the material containing atoms with the "jumpy" electrons is a piece of wire. With a lot of electrons jumping from atom to atom inside the wire in generally the same direction,



Atoms pass electrons along from one to the other to cause a flow of electric current.

the overall result is a flow of electricity.

Therefore, the movement of a vast number of electrons from atom to atom is referred to as *electric current.* In using electricity, we are controlling the flow of electrons.

Man has seen uncontrolled electron flow for ages in the form of lightning which he knew could do great damage. The electricity we use in homes, stores, factories and farms is supplied by the same kind of electrons—except these electrons are under control.

Things to Do

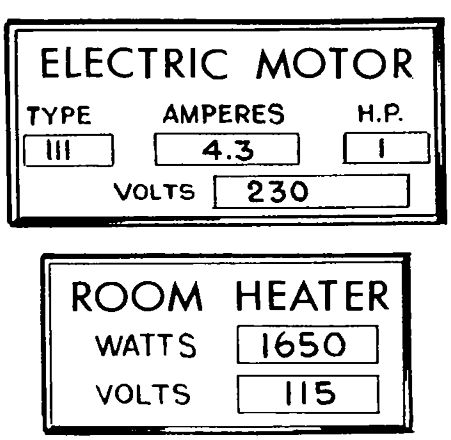
1. Draw a picture of an atom and label its parts.

2. Note some ways you can make static electricity—rubbing your shoes on a carpet then touching an object; petting an animal; others.

3. Make dancing dolls from static electricity. Support a piece of clean, dry, warm glass between two books. Cut some small dolls or animals from tissue paper and place them under the glass. Rub the glass briskly with a piece of silk. The figures will jump up to the glass, then down to the table, up to the glass and then down again. Why do the figures jump to the glass? Why don't they stick to the glass?

III. Current and Voltage

If you look closely at a home appliance — usually in a spot that isn't easy to see—you'll find some numbers. These are on a small chart, stamped directly onto the appliance, or on a small plate or sticker attached to the appliance, called a nameplate. Besides giving model number, and serial number, you may see terms like "Volts: 110," "Amperes: 2.1" or "Watts: 1350." These numbers are important. They tell how much electricity is needed to make the appliance work properly.

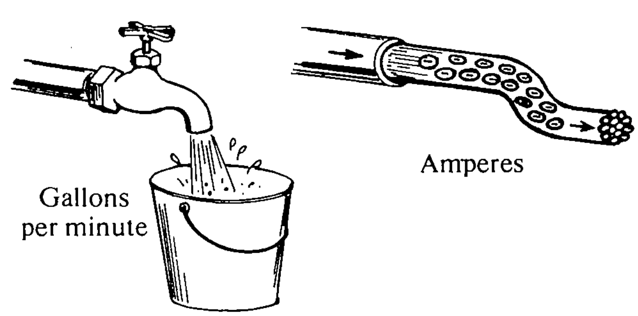


Using these names and numbers, let's see how electricity performs for you.

First, let's consider how we can define a flow of electrons so we can tell someone else just how large that flow is.

The word "flow" may suggest water. And, there are many similarities between the flow of water and the flow of electricity. In fact, a water system is very much like an electrical system.

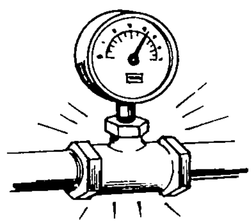
For example, the flow of electricity through a wire is similar to the flow of water through a pipe. The rate of flow in each case can be measured—water in gallons-per-minute and electric current as amperes, or amps, for short.



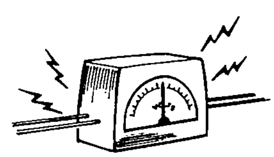
These terms are substituted for the billions of water droplets and electrons which move through pipes or wire. One "ampere" is 6,300,000,000,000,000,000 (more than six billion billion) electrons passing a point each second. As you can see, this number of electrons is pretty difficult to work with! Obviously, it's a lot easier to use a unit of measure like the ampere or amp! "Amps" are thus the measure of the rate of flow of electricity.

Earlier you saw the numbers on your appliances at home. Often the nameplate will say how many amps the appliance needs to do its work properly. Some appliances like radios need as little as a fraction of an amp, while some heating appliances or air conditioners may need as much as 10 amps or more. Generally, the more amps required, the larger the wire you will need to supply the electricity.

Just as water needs some pressure to force it along in a pipe, electricity needs a force to make it flow. This force is known as "voltage." We measure water pressure in pounds-per-square-inch and electrical pressure in units called "volts." Therefore, volts are the measure of electrical pressure.



Pounds per square inch



Volts

Unless power is interrupted, a constant voltage is maintained in the wiring circuits of your home. When a switch is turned on, voltage moves the electrons along so they do their work.

Circuits in your home are supplied with 110 to 120 volts for lighting and small appliances. Appliances with nameplates indicating 110-120 volts can only be used on these circuits. Check the nameplates on several appliances to find voltage and ampere numbers. You may find a piece of equipment labeled 120 volts, 1/4 amp. This means when it is connected to a 120-volt circuit, electric current of 1/4 ampere will flow into it.

Your home probably also is supplied with 220-240 volt electricity for use in large appliances like electric ranges, clothes dryers and large air conditioners.

An appliance designed for 120 volts should never be plugged into a 240-volt outlet. Nor should an appliance requiring 220-240 volts be plugged into a 120-volt circuit. Such errors can result in extensive damage to the equipment.

To help you avoid these costly mistakes, electrical outlets that supply high voltages are specially designed. The outlets will accept only special plugs. Ordinary two-pronged household electric cords will not fit into these outlets.

With your parents, observe the different types of electrical outlets (receptacles) and plugs you have in your home.

Two Kinds of Current

There are two ways in which electrons flow through a wire. One is called "direct current," because the electrons always travel in the same direction. We usually refer to direct current as "DC." DC current is the kind of electric current produced by batteries, as we shall see later.

Voltage in direct current always pushes the electrons in the same direction. That is, positive (+) is always in the same direction, as well as negative (−). And voltage has the same "polarity" at all times.

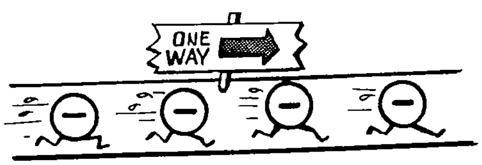
DC is important. It was the first kind of electric current put to use, and was for a long time the only current anyone knew anything about. DC is the kind of current used in your family car, and in any electrical system powered by a battery like flashlights, toys, portable radios, etc.

DC is no longer the principal kind of electric current. It loses much of its energy when carried over long distances—such as from a powerhouse to your home.

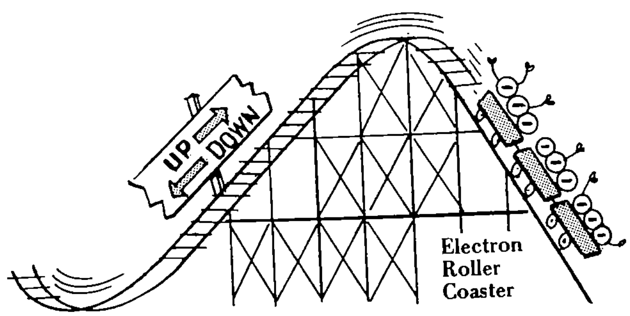
Another kind of electricity is called "alternating current" or "AC."

Instead of always traveling in the same direction, AC causes electrons to travel first one way and then the opposite way. It changes direction many times a second.

Therefore, the voltage in an AC system changes the direction in which it pushes the electrons—that is, its polarity—an equal number of times per second. Each change of polarity from plus to minus and back to plus again is called one "cycle."



DC Current always flows one way at the same strength.



AC Current flows first one direction, then another.

In the United States, with AC current, voltage makes this complete turnabout, or one cycle, 60 times each second. So, it's called "60-cycle" AC.

Sixty-cycle AC is the kind of electricity used in your home—as well as in business and industry. Because electric power suppliers maintain the 60-cycle value, your electric clock keeps accurate time.

The rate of alternation is so fast that we don't notice the flickering of our lights as the current stops very briefly between each cycle.

AC is capable of doing almost all the things DC does, including the delivery of power to a circuit.

AC, however, does things that DC cannot do. For one thing, AC allows for easier transmission of electricity. It also allows us to change voltage nearly anywhere along the circuit by using devices called "transformers."

AC is not produced from batteries. It is produced by large machines called "generators," which use magnetism. We will learn more about how generators work later. While generators also can make DC electricity, this is done only for very special uses.

For now, it is enough to know the difference between AC and DC, and why the current used in your house is not the same as the current that comes from a battery.

Things To Do

1. Draw a rough diagram of an electric system and a water system. Relate as many elements in each as you can. Tell why voltage is like pressure and amperage like flow.
2. Make a list of the appliances in your home which use 220-240 volts instead of 110-120.

IV. Electricity and Chemical Energy

Electricity is a form of energy—just as heat, light, motion or chemical reactions are forms of energy.

Our use of electricity involves changing of electricity into another form of energy.

However, to produce electricity in the first place, it is necessary to change some form of energy into electricity. This is done at generating plants by electric power companies.

But each of us probably has several little energy converters of our own around our homes. These common sources of electricity, known as batteries, or electric cells, change chemical energy into electricity.

The burning of wood or natural gas to produce heat, or the combustion of gasoline in automobile engines to produce motion also are forms of chemical energy.

Batteries use much slower acting, less obvious chemical energy to produce electricity. Done on a small scale, we can carry this source of electricity around with us. Thus, we can think of batteries as "portable electricity."

Batteries: Storage Tanks for Electrons

Remember how we compared an electrical system to a water system? You could compare electron flow (current) to the flow of water through a pipe, and also water pressure to electrical voltage. We can take this a step further.

As we must have a source of water, we also must have a source of electrons. Therefore, we can compare a water tank, or reservoir, to a source of electricity—like a battery, or an "electrical cell."

Batteries as a common source of electricity are used by almost everyone every day. They are in flashlights, lanterns, hearing aids, bicycle lights, automobiles, tractors, trucks, aircraft, boats, portable radios—and many other items.

An electric cell consists of two plates of unlike metals (or a metal and carbon) known as "electrodes," a chemical (usually an acid) called an "electrolyte" and a case or container.

The first electric cell was invented by an Italian scientist named Volta, and today simple electric cells are still called "voltaic cells" in his honor. A voltaic cell is also called a "wet cell," because the electrolyte is a liquid.

In one type of voltaic, or wet, cell the positive electrode is zinc while the negative electrode is copper. The electrolyte, or chemical which surrounds the plates, is sulfuric acid diluted with water. The case for wet cells is usually glass or hard rubber. The electrodes are suspended into the electrolyte-filled case from an insulating cover which separates the electrodes from one another.

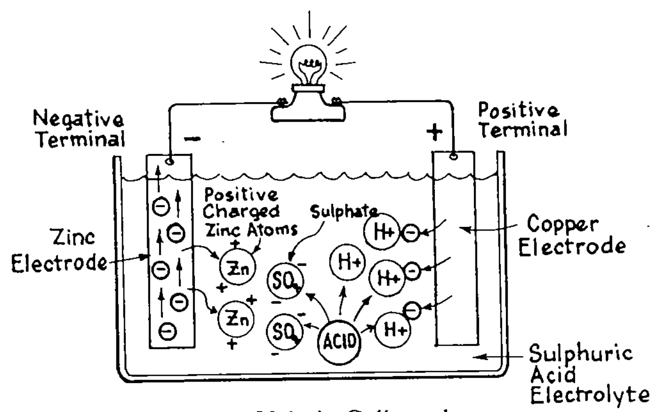
How does such a cell produce electric current?

The secret is chemical energy.

The acid electrolyte attacks the zinc electrode, and in effect, pulls the atoms of zinc away from the electrode, dissolving the zinc. As the atoms of zinc are pulled away from the zinc strip, they each leave two electrons behind on the strip. These electrons build up as the zinc dissolves, leaving the strip with a negative charge.

Meanwhile, the sulfuric acid breaks apart into its components—hydrogen atoms and sulfur and oxygen (which stay stuck together as "sulfate"). This happens in such a way that the hydrogen atoms have too *few* electrons, leaving them with a positive charge.

These positively charged hydrogen atoms then attract electrons off the copper strip, leaving that strip with a positive charge.



How a Voltaic Cell works

So, the result is that the chemical action of the electrolyte has left one electrode (zinc) with a negative charge (too many electrons), and the other electrode (copper) with a positive charge (too few electrons).

If a wire is connected between the terminals, an electric current will flow. This will go on as long as the acid has enough strength to keep the action going—and as long as the zinc strip isn't completely dissolved. Current produced like this by a battery will always be DC, or Direct Current—it always flows in one direction.

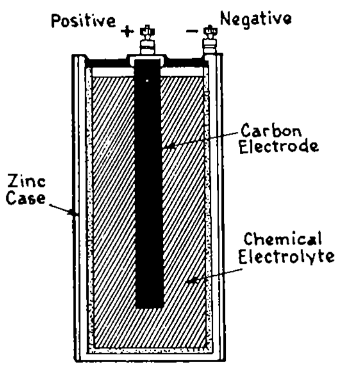
Thus, chemical energy has been converted to electrical energy.

Some wet cells can be "recharged," since the chemical action within the cell can be reversed. This is done by sending an electric current through the cell in the opposite direction from the normal current flow which occurs when the cell is powering some device. Most wet cells commonly used today, like in car batteries, use electrodes of lead and lead oxide.

The highest voltage of a wet cell is about two volts. The actual voltage depends on the strength of the acid and the condition of the electrodes.

Most batteries we use from day to day, however, are not wet cells. These small batteries, used in things such as flashlights and radios, are called "dry cells."

In a dry cell, one electrode is made of carbon. This is the positive electrode, and usually is the center post or center button of the battery. The negative electrode is made of zinc and usually is the outside shell, or case, of the dry cell. The electrolyte or chemical between the electrodes is in the form of a paste, instead of a liquid. In some dry cells, screws are added to the top of each electrode to help in attaching a wire.



A dry or primary cell

The chemical action of dry cells is similar to that of wet cells, except it cannot be recharged easily.

Dry cells are intended for short, on-and-off service like flashlights. The highest voltage of such cells is about 1.5 volts, regardless of the size of the cell. However, larger cells can supply electric current for a greater length of time than small ones.

Batteries are very important. They can do many things for us to make our work easier and our lives more fun. Scientists are developing better batteries that can supply more power and last longer. Such batteries one day may let us use things like electric cars that can go as far and as fast as our present cars—and with no air pollution.

Electroplating

Batteries aren't the only way electrical energy and chemical energy work together. Just as we can produce electricity from chemical energy, we can also produce chemical energy from electricity!

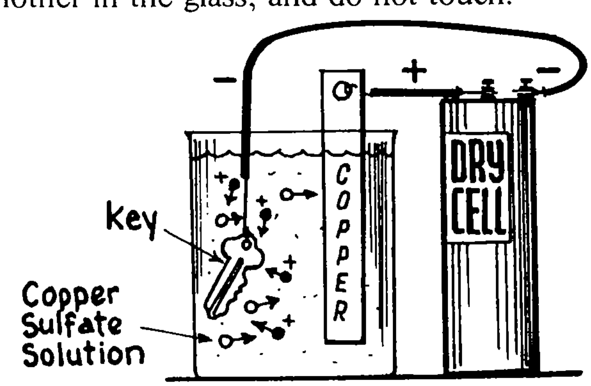
We can use electricity to put a thin coat of metal on a key, a ring or any metal object with a simple electroplating process. This is possible because electrons flow through certain chemical solutions just as they do through wire.

Electroplating is very important in industry. It is used when metals need to be coated to prevent rust or improve their appearance. Copper, nickel, silver, chromium, zinc, cadmium and gold are the materials most commonly used in electroplating. The shiny chrome finish on many automobile accessories is electroplated onto steel.

Actually, electroplating works much like a battery in reverse. In a battery a chemical reaction causes electricity to flow. In electroplating, electricity is used to cause a chemical reaction. In fact, electroplating is very much like recharging a wet-cell battery.

Let's electroplate something—like a key.

The object to be plated is attached to a wire, which in turn is connected to the *negative* terminal of a dry cell. A wire from the positive terminal is then attached to a strip of metal such as copper, nickel or silver that is being used for the plating process. Both the metal strip and the object are now placed (with the wires still attached) into a glass filled with an electroplating solution. Make sure the metal strip and the object are across from one another in the glass, and do not touch.



Electroplating

Electroplating solutions are usually made of metallic-salt solutions, such as copper sulphate for copper plating or nickel sulphate for nickel plating. When DC electricity is connected to the two metals in the solution, a current starts to flow. The plating metal is dissolved into the solution. This gives the solution an excess of metal particles which are pulled toward the materials to be plated. As the metal particles reach the object, a thin plating of the metal is placed on the object.

You can try this with several different objects and several kinds of plating material if you wish. Just be sure it's OK to plate something before you do it! Also, you'll probably want to use copper or nickel as the plating material, since silver or gold are very expensive.

Things To Do

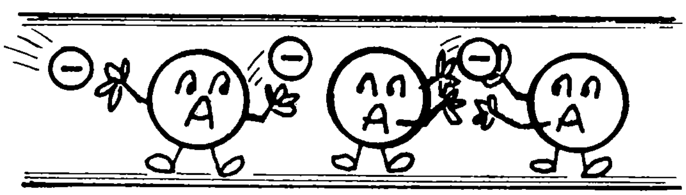
1. List the appliances or toys you have at home which use batteries. Are any of them wet cells? By counting the number of cells each item uses, you can tell what voltage it needs to operate. Tell what voltage some of the appliances use.
2. Using the material described above, electroplate some metal objects around the house such as a key, safety pin, bolt, etc. (Get permission first!)

V. Conductors and Non-conductors

Materials whose atoms hold their outermost electrons loosely, and allow them to jump from atom to atom and cause a flow of electrons, are rather important. If it were not for these materials, there would be no electricity. The wires that bring electricity to your home, or from the wall outlet to the television or other appliance, are made of these materials. They permit electrons to flow with ease. These are called *conductors.*

Materials like silver and gold are good conductors, but they cost far too much to be used for this purpose. Copper is not quite as good, but is widely used as a conductor because of its lower cost. In general, most metals are at least fair conductors of electricity, with some better than others.

Some other materials do not let electrons flow easily through them. In these, atoms hold all their electrons so firmly that they cannot jump from atom to atom. And they won't allow free electrons to pass either. As electricity cannot flow, these materials are called *insulators.*



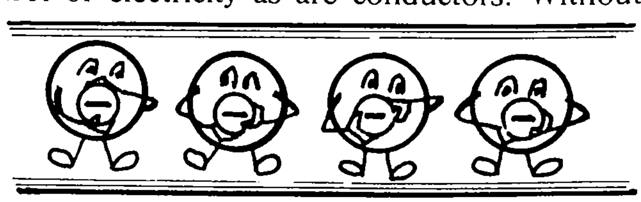
Conductors

Good insulators are materials like glass, plastic, rubber and porcelain. Wood, paper and even air tend to be insulators, but can break down and allow electricity to pass under some conditions. Any insulator can let electricity pass if there is enough voltage. People working with electricity must know how to use conductors and insulators.

Generally, the thicker the insulation, the higher the voltage it can hold. A water pipe with thin walls subjected to too much pressure may burst. So may insulation on a wire break down if it is forced to hold in too much voltage. When poor insulating material is used, a thicker layer is required.

Even with an insulator present, it is still important to be careful with electricity around water. Water can soak into or cover an insulating material and turn it into a conductor as quickly as you can say "ouch!"

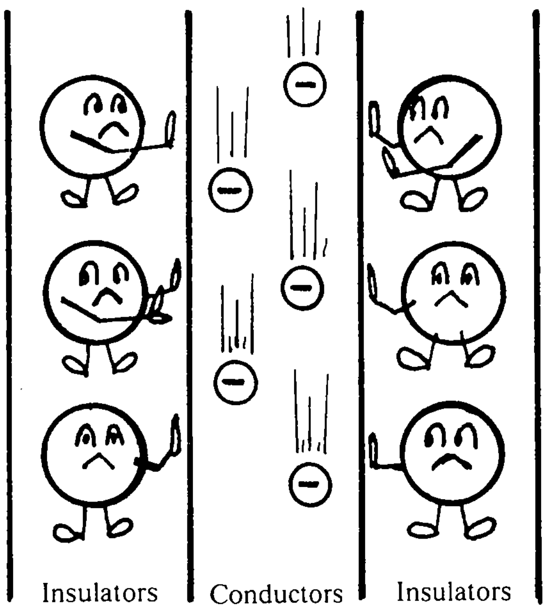
Even though insulators don't allow electricity to flow, they are just as important in the control of electricity as are conductors. Without



Non-conductors

them, the electrons would tend to "leak" out of the conductors into any metal object the conductor touches. Wrapping insulation around a conductor keeps the electron flow in the proper path. Insulators keep the electron flow from straying or getting out of control.

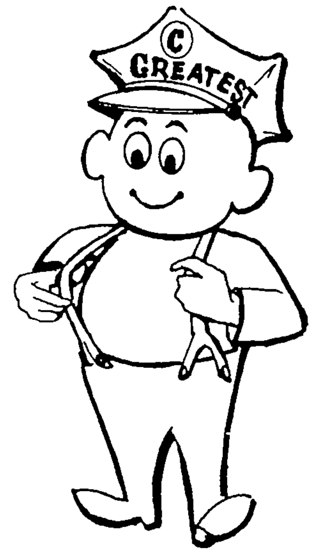
The electric cords to your lamps and appliances include conductors and insulators. Near the center are wires made of a good conductor such as copper. Separating the wires and around the outside of the cord is a layer of insulation such as rubber or plastic. The cord keeps the electrons in the wires "in line" so they will all get to their destination and do the work for which they were intended.



Electricity, despite its power, is really pretty lazy. It tends to take the path of least resistance and it usually tries to get to ground. To get to ground, a current flowing in a conductor (such as a wire), will always seek out the easiest path. Given a choice between traveling through two materials, *most* of the current will flow through the better conductor.

Birds don't get a shock when they land on an electric wire. Electricity continues along the wire rather than entering the bird. However, if the bird were to put one foot on the wire, and the other foot on another wire connected to ground, it would be killed. This is because electricity finds it easier to get to ground by going through the bird than by continuing on its way. As long as the bird perches only on the current-carrying wire, however, it is perfectly safe.

Obviously, the safe thing for you to do is not to take chances. Always assume you are the best conductor around! In fact, you actually are a better conductor than many other materials.



Treated with care and respect, electricity can be your friend.

Things To Do

1. Let's test some different objects to see if they are conductors or insulators. Connect a wire between one terminal of a dry cell and one terminal of a small light socket with a 1.5 volt bulb. Attach one end of another wire to a dry-cell terminal.

Attach a third wire to the other terminal of the socket. The ends of the two wires should be free.

Touch the two free ends of the wire together briefly.

You have now provided a complete path, or "circuit," for the electrons to flow, and the light should go on.

Touch the two free ends of the wires to opposite ends of an iron nail. The light will go on. This is because the iron in the nail is a conductor.

Touch the two wires to the opposite ends of a piece of rubber. The light will not go on. This is because rubber is an insulator and will not let electrons pass.

Test a number of other materials in this

manner to see which ones let the light go on.
Make a list of the items you test, separating conductors from insulators.

Do any of the conductors allow the light to burn more brightly than others? If so, note which ones? Can you tell why?

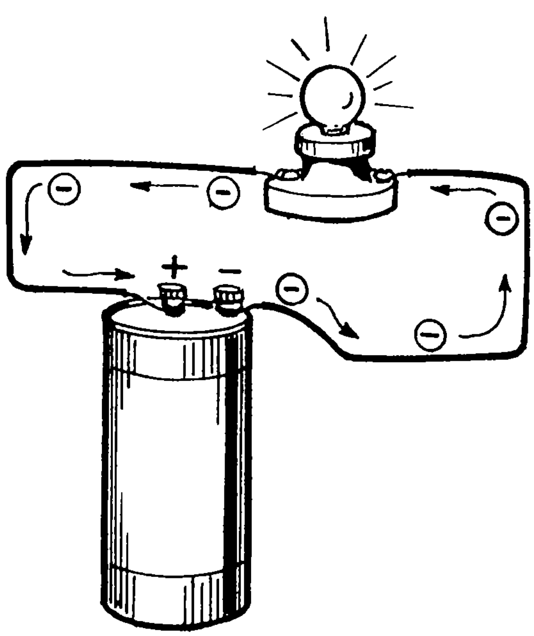
VI. Circuits

For electricity to do its work, it must have somewhere to start, someplace to go, and then a way to flow back to where it started or to ground. This last point is important. If the electrons have no place to go after flowing through a wire, they tend to bunch up at the end of the wire and the flow stops.

In your home, electron flow (electric current) must make a complete path, returning to the starting point. Such a path is called a "circuit." The word circuit comes from the word circle, since the electrons must travel in a circle, a complete path, to keep flowing.

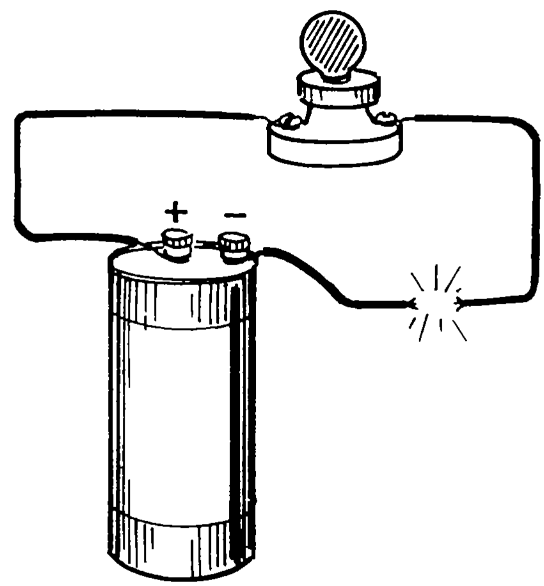
The flow of current in a circuit is from negative to positive, or "−" to "+." This is most easily seen with a simple circuit attached to a battery.

The sketch below shows an electric circuit. The battery causes electrons to flow through the wire, through the light bulb, causing it to glow, and then back to the battery. The circuit is complete. This is a "closed circuit."



An electric circuit—closed

Now, let's cut one of the wires. The electron path has been broken and no electrons can flow. The light bulb goes out. This is an "open circuit."



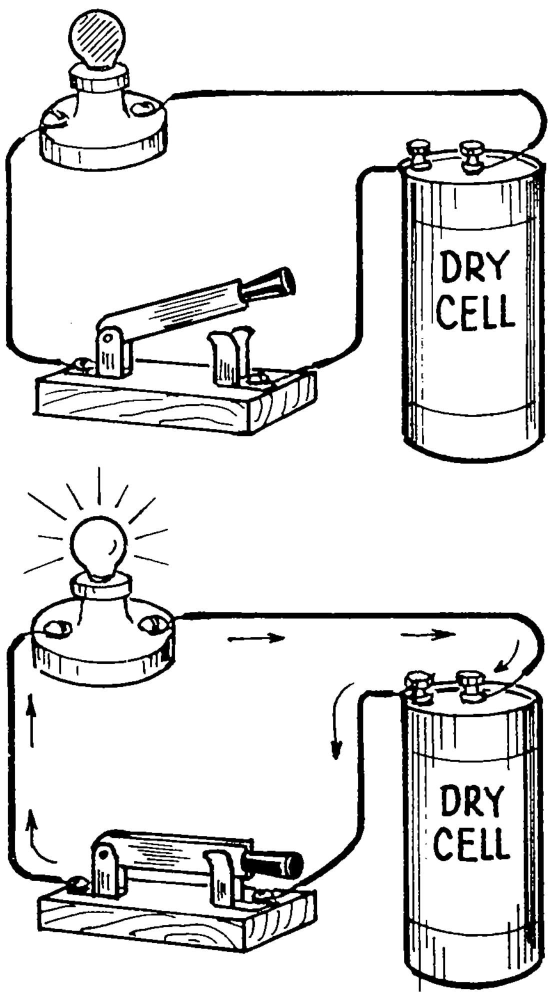
An open circuit

Obviously, it is desirable to have a circuit open or closed at different times, just as you want light bulbs in your home on or off at different times.

It would be silly and dangerous to cut the wires each time we wanted the lights off and to repair the wires whenever we want them on. Therefore, we use a switch.

A switch is a piece of conductor that can be moved between two contacts so that the circuit can be opened or closed.

You turn the lights on or off in your home in the same way. When you flip a switch "on," you make a closed circuit and the light burns. When you turn the switch "off," you make an open circuit and the light goes out.

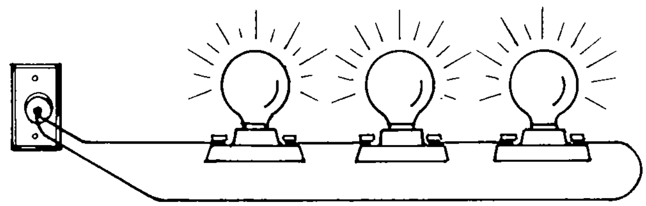


Using a switch to open and close a circuit.

In a normal circuit, the electron path should be continuous and unbroken. A broken wire can cause an unwanted open circuit. A burned-out light bulb also causes an open circuit. When a bulb burns out, the tiny piece of wire inside is burned in two. There is no longer a complete path for the electrons, causing the flow to stop.

If you have just one battery and one light bulb, it's pretty easy to see how to connect them together to make a circuit. But what if you have more than one bulb (or appliance) or more than one battery? How should you connect them to make a circuit?

There are two basic ways to make a circuit. One way is hook the lights or other devices one after another in a line. As the sketch below shows, the electricity must flow through the first device and then into the second. As long as each light bulb burns, and passes the electrons on to the next bulb, the circuit is complete and the flow continues. If one bulb burns out, it cannot pass on the electrons and the flow stops all along the line.



Lamps in series

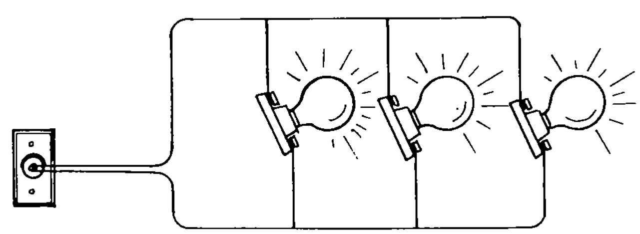
This is called a "series" circuit. Remember during Christmas when you were trimming the tree? You may have had a string of lights in which if one bulb went out, they all did. So, you had to replace each bulb along the line with a new one until you found the bad one—then they all lit up. That string of lights was wired in series.

In a series circuit, the same amount of current flows through each device in the circuit. And each device must share the voltage applied to the circuit.

Such a circuit is not very practical for ordinary home uses. Imagine having to light up your whole house just to read the newspaper! You would, if it were wired in series and had only one circuit.

There is another way we can hook up devices in a circuit. We can hook each device between the main wire from the battery and the main wire back to the battery. In this circuit, electricity can flow through any one device without having to flow through any others. Each one works on its own.

For example, if one lamp burns out, this does not affect the other lamps. This is called a "parallel" circuit.



Lamps in parallel

Throughout your home, appliances and lights are wired in parallel circuits. This allows you to use only those appliances you want to use at one time.

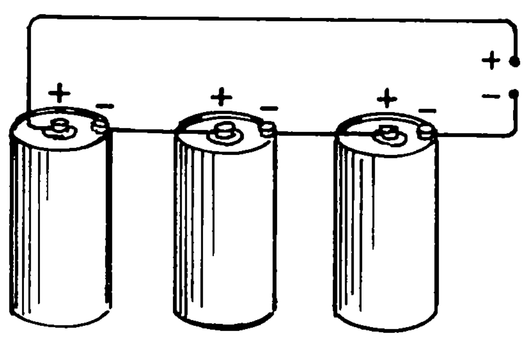
Sources and Circuits

If more than one light bulb (or other device) can be operated in a series or parallel circuit (or some combination of the two), what about electrical sources—like batteries? What happens when we connect them in different ways?

If a single battery has a voltage of only 1½ volts (for a dry cell) or 2 volts (for a wet cell), how can we get more voltage from batteries when the device we plan to use requires higher voltage? For example, most electrical devices in your family car require 12 volts to operate. How can you get this from a cell whose maximum voltage is only about 2 volts?

The answer is to connect several batteries or cells together. But you have to be careful how you do it!

To get *more* voltage, you can connect the cells together in *series*. This means that the positive terminal of one cell is connected to the negative terminal of the next cell. You can form a "chain" of cells or batteries this way—always connecting negative to positive. The leftover negative and positive terminals at the end of the chain are then connected to the device you wish to operate. The total voltage you will have then is the sum of the voltages of all the cells.



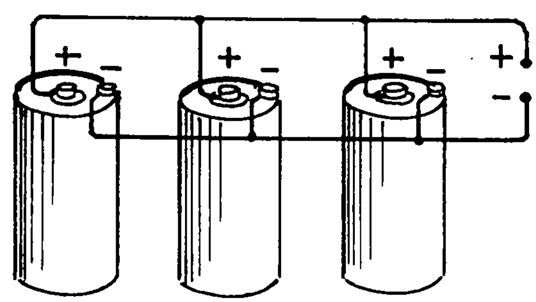
Cells connected in series

The cells of the kind that make up a car battery produce about 2 volts each. How many cells must be connected in series to make a battery that will produce a total of 12 volts? That's right, 6.

In fact, you can verify this by looking at your car battery. How many little caps does it have on top? Probably 6. Each cap represents a single cell in the battery. Through each cap, water can be added to the battery to keep the electrolyte in each cell full to the needed level. If your car operates on a 6-volt system, there will be only 3 cells in the battery, and thus only 3 caps on top.

What if you need more current than your battery can provide—or if you want your battery to last longer?

You can do this by again connecting several batteries together. This time, however, you have to connect them differently than you did when you only wanted more voltage. This time you have to connect the batteries in "parallel." This means that all the positive terminals of the batteries are connected together and all the negative terminals. You can then connect the device you wish to operate to any single positive and negative terminal. In parallel, the total voltage you will have will remain exactly the same as the voltage of any one of the batteries, but the batteries will last longer.



Cells connected in parallel

A good rule to remember is: batteries in series, voltage increases; batteries in parallel, voltage stays the same as for one battery alone.

Short Circuits

In connecting different devices to an electric circuit, you have to be careful to avoid a "short."

Earlier we said that electricity seeks the fastest or easiest path from negative to positive or to ground. If electricity can avoid travel