FUN WITH LOW VOLTS

Federal Cooperative Extension Service ✓ **Oregon State College** ✓ **Corvallis**

FEDERAL COOPERATIVE EXTENSION SERVICE ✓ OREGON STATE COLLEGE ✓ CORVALLIS

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Club Series V-7 **September 1959**

FUN WITH LOW VOLTS

4-H Electricity II

This project is for boys and girls 10 to 14 years of age who want to learn more about electricity and its use. It continues work with safe, low voltage electricity. Ten- and eleven-year-olds not having previous experience with electricity would profit by taking Electricity I first. Thirteen- and fourteen-year-olds having had some science in school could start with this project. However, they would find it interesting and helpful to study and do some of the "Jobs" in Electricity I along with their work in Electricity II.

This project will help you:

- Learn more about electricity and its use.
- Build electrical models that work.
- Give better talks and demonstrations.
- Use your own ideas to do and make things.

Project Requirements

This project includes thirteen "Jobs." Some are individual and some are club jobs. You need not do all of them. You and your club have some choices. The "Jobs" do not need to be done in the order listed. Be sure you complete all individual requirements and help with club requirements. The whole club can do the club requirements as one group, or in several smaller groups.

To complete the project, you need to do Jobs 1, 2, and 3; your choice of Jobs 4 or 5; help do Jobs 6, 7, and 8; and help choose and do any 2 of the following club options: 9, 10, 11, 12, or 13.

Fun and success will be yours if you complete each "Job" carefully. The jobs are explained more fully in the following pages.

Before you start know:

- The purpose of the "Job." (What you expect to learn.)
- What you are to do.
- How to do it. (Follow directions on Job sheet.)
- What materials are needed to do the job.

Here are the "Jobs." Have them initialed as you complete them:

Individual requirements

Do all of these:

Job 1. Make a simple electric motor, or assemble one from a kit.

Job 2. Light a study desk.

Job 3. Give an electrical demonstration.

Individual options or electives

Do one of these:

Job 4. Make an electrical game or gadget.

Job 5. Help install or make a low voltage electrical signal or communication system using dry cells or a transformer, such as a doorbell system, buzzers, or code set.

Club requirements

All members should help do each of these:

Job 6. Present "Minutes of a Ghost Convention," (a safety skit).

Job 7. Make a bright and dim board.

Job 8. Make series and parallel circuits.

This bulletin was prepared by M. G. Huber, Extension agricultural engineer, in cooperation with the Central 4-H Club staff at Oregon State College.

Club options

Help do any 2 of these:

Job 9. Make an electric current.
Job 10. Make a simple battery.
Job 11. Make a light-a-light transformer.
Job 12. Make an electric meter.
Job 13. Make an educational display of the club's electricity work at some local event, achievement program, or in a store window.

Privileges

Exhibit

To exhibit something you have made in this project is considered a privilege. It will give you a sense of accomplishment. It is a reward for having completed your project.

You have your choice of exhibiting any *one* of the following items *that you have made yourself:*

1. Electric game or gadget
2. Bright and dim board
3. Series and parallel circuits
4. Electric motor (not assembled from a kit)
5. Communication board (doorbells, buzzers, light flasher, code set)

NOTE: Overall dimensions of exhibit are not to exceed 18 inches wide, 24 inches long, and 18 inches high.

Activities

Following are some suggested activities for your club or yourself:

Enter the electricity demonstration contest at your community or county fair.

Take part in the National 4-H Electricity Awards program. See your County Extension Agent for details.

Tour a local industry or power plant.

Prepare an educational display of the "Jobs" you have done in this project.

Check your home doorbell system to see how it works. Repair it if necessary.

Invite your local electric company fieldman to demonstrate some electrical equipment, proper lighting, or other uses of electricity at one of your club meetings. He might be able to demonstrate some of the jobs in this project before you do them.

Invite your County Home Extension Agent to demonstrate good study-desk lighting to your club.

Build an Electric Motor

Job No. 1
(Individual Requirement)

The purpose of this job is to learn how electricity makes a motor go; that is, how electricity is put to work.

Each Electricity II member will build an electric motor, or assemble one from a kit.

Toy electric motor kits are available. See your leader or Extension Agent regarding where to obtain them. A motor assembled from a kit is not eligible for the exhibit in this project.

The electric motor has revolutionized our way of living. Motors are at work for us everywhere—in factories, on farms, on ships, in locomotives, far below the earth's surface in mines, high above us in airplanes and, of course, in our homes. You may be surprised how many motors are in your home. They power your refrigerator, vacuum cleaner, phonograph, fans, oil burner, and many other household devices. Even your electric clock is run by a simple kind of motor. And don't forget the powerful little motor that starts your car.

So it's an interesting and exciting adventure to make a motor yourself—even a crude one—to learn something about this marvelously useful and versatile servant.

The same thing that makes a compass point north—magnetism—makes a motor go. Any magnetic field (including that of our earth) has two poles, usually called the north and south poles. If you bring 2 magnets close to each other, you will find that the "like" poles (north and north, south and south) repel each other, while the "unlike" poles (north to south, south to north) attract each other.

This is the principle you will use in the motor you are about to make. You will be making 2 electromagnets. One (called the field) will stand still and the other (called the armature) will rotate. By reversing the magnetic poles in the armature at just the right moment as it spins, the poles of the field push the armature around. The part of your motor that reverses the poles in the armature is called a commutator. Figure 1 will help you see the relationship of these parts to each other.

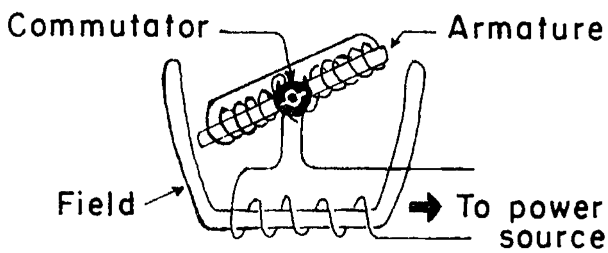


Figure 1

Tools and materials

Tools and materials you will need to make your motor are simple and few. You should have a pair of pliers, a wire cutter, a tack hammer, a knife, and a pair of scissors.

For power you will need 1 or 2 batteries. Bell batteries are the best but flashlight batteries will do. If you have 2 batteries, use them in series to try your motor the first time and to adjust it.

To connect 2 flashlight batteries in series, put the "nose" of one against the base of the other. Then place the wires (ends scraped clean) from your motor against the base of the rear battery and against the nose of the other. To connect 2 bell batteries in series, use a short length of wire (ends scraped clean) and connect the center terminal of one with the side terminal of the other. Then connect your motor wires (ends scraped clean) to the 2 remaining terminals of the 2 batteries. Series connection of your batteries will give you 3 volts. Your motor should run well on 1 battery ($1\frac{1}{2}$ volts) when properly adjusted.

You may also use a bell transformer or a toy train transformer for power if you wish. Your motor is designed to work on either batteries (Direct Current) or a transformer (Alternating Current). *But do not use over 6 volts* or your motor will overheat rapidly.

Materials you will need to use a transformer probably are available in your home, with the exception of the magnet wire. You will need a spool of No. 24 enameled magnet wire, and can buy it at an electrical store. Light, insulated bell wire will do, but magnet wire is much better. The enamel on the magnet wire is an insulator and must be scraped off at any point where an electrical connection is to be made.

Besides the magnet wire, you will need about 7 feet of plain steel or iron wire. It may be galvanized or ungalvanized, but for easy cutting and bending it should be about half the thickness of the lead in a pencil. Also, have a roll of friction tape handy (surgical tape will do); some tacks; 2 staples; a nail about 2 inches long; and a piece of wood, about 4 by 6 inches, for a base.

Procedure

To make the field, cut 8 or 10 lengths of your steel wire about $6\frac{1}{2}$ inches long. Put them in a bundle, with the ends even, as shown in Figure 2. Hold the bundle together with a

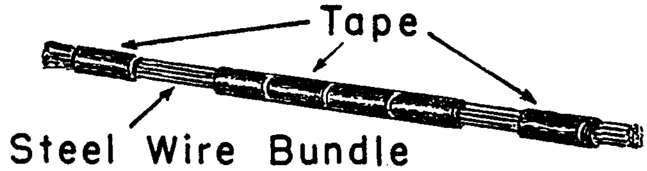


Figure 2

couple of turns of friction tape close to each end and wrap 2 inches of the center with a layer of friction tape.

Now bend your bundle into a semicircle (a little flat at the base) as shown in Figure 3, and clip off any uneven ends of wire. Over the center taped section, wind 5 or 6 layers of

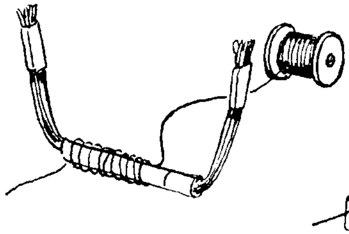


Figure 3

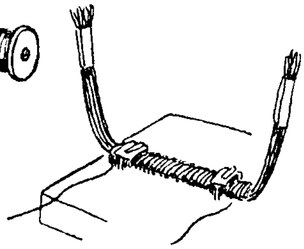


Figure 4

magnet wire. Leave 8 or 10 inches of magnet wire for connection leads. Scrape the ends of the leads and test your field for magnetism with your power source. It should be attracted to any steel object or pick up tacks. Attach the field to the center of the wood base with 2 staples. Put a bit of tape under the staples where they grip the field wires (Figure 4).

To make the armature, cut 8 or 10 lengths of steel wire, each $2\frac{1}{2}$ inches long. Bundle them together and tape the ends. Push the nail through the center of the bundle, with an equal number of wires on each side (See Figure 5).

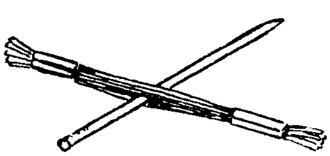
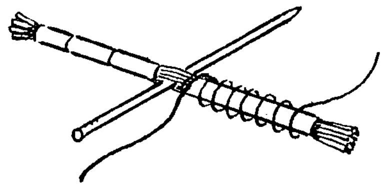


Figure 5

Push it in until two-thirds of the pointed end is on one side. With pliers, press the wires together on both sides of the nail. *Be sure the nail is in the center of the bundle.* It will be the shaft, or axle, of the finished motor. Wrap a layer of tape around the rest of the bundle.

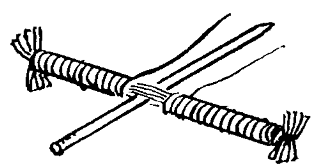
Now study Figure 6 and start winding magnet wire on your armature. Start at the center and wind toward the end. When you have wound almost to one-fourth of an inch

Figure 6



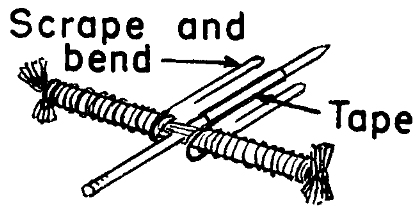
from the end, start winding back. Keep winding, *always in the same direction,* until you reach the nail. Loop over the nail and wind the other side of the armature in the same direction and in the same way. Wind to one-fourth of an inch of the end and wind back to the nail. Cut your magnet wire, leaving several inches on both leads. Bend the tips of the armature bundle wires apart, if you wish, to help keep the magnet wire from slipping off the ends (See Figure 7).

Figure 7



Next, you make the commutator. Starting one-fourth of an inch from the armature windings, scrape the enamel off both lead wires for about an inch. Cut off the rest of the leads. Wrap a layer of tape around the nail, starting

Figure 8



at the armature and covering the nail to within one-half of an inch of the pointed end (See Figure 8). Bend the lead wires as shown.

Look at Figure 9 carefully. It shows how you should use 2 thin strips of tape to bind down the looped lead wires to form the commutator contacts. The 2 exposed contact wires

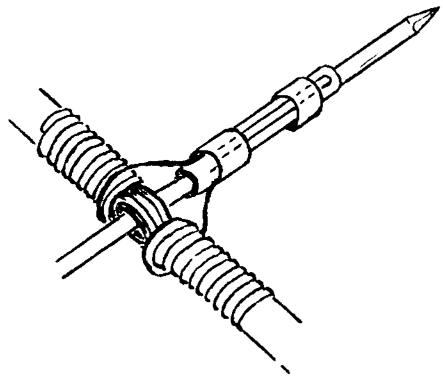


Figure 9

formed by the loop from each side of the armature winding should lie along the taped nail, exactly as shown, half way between the armature windings. Four, evenly spaced wires will show.

The next step is to assemble the parts. Make 2 armature supports from steel wire as shown in Figure 10. They should be just high enough to hold the armature inside the field

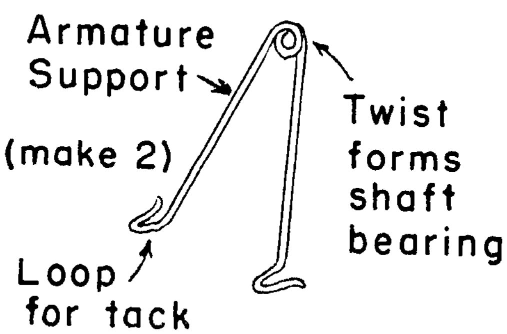


Figure 10

and centered so there is no contact when the armature is turned. A twist of the wire supports around the nail forms the bearings. Make sure the twists are loose enough to permit the nail to turn freely. Put a drop of oil on both bearings. Now tack the supports in place (See Figure 12). A strip of tape near the head of the nail will keep the shaft from slipping back and forth. Bend the field ends so the ends of the armature just miss as they pass.

Contacts for the commutator are made from pieces of magnet wire formed as shown

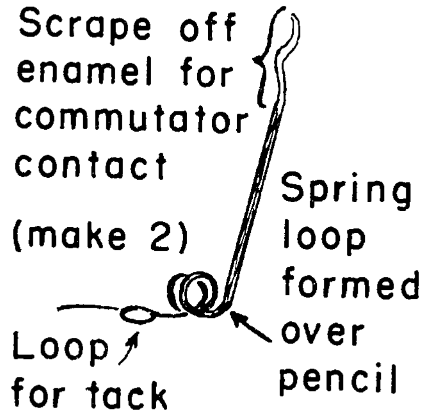


Figure 11

in Figure 11 and mounted as shown in Figure 12. Be sure the ends are well scraped and be sure they rest firmly against the commutator after mounting.

Take the lead leading from one of the commutator contacts you have mounted and connect it to one of the leads from the field coil. The other commutator contact lead and the other field coil lead connect to your battery or transformer. Make sure all connections are made with scraped wire ends.

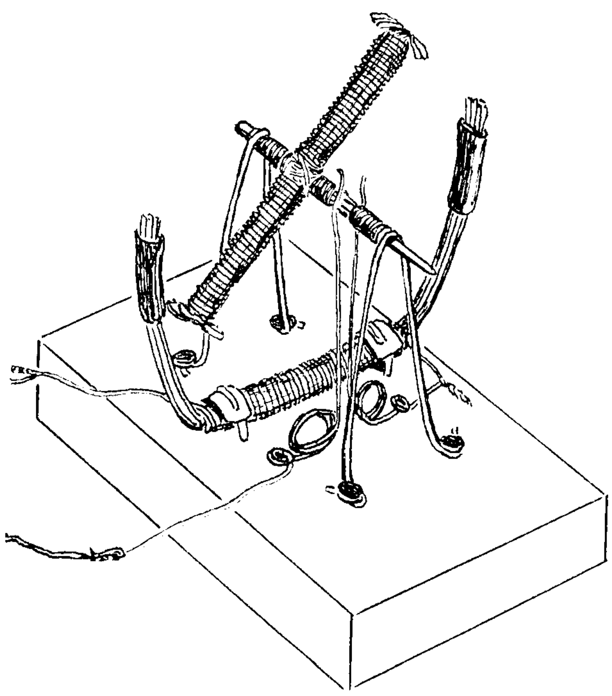


Figure 12

Depending on the position of the armature, it may need a little push to start it once you have connected the motor. To adjust your motor to get most power and speed, try twisting the commutator assembly very slightly, first one direction and then the other, around the shaft nail. If rotation is jerky, try moving slightly the commutator loop wires together or apart. With experimentation and patience, your motor should spin satisfactorily with only $1\frac{1}{2}$ volts of battery power.

The electric motor you have made works on the same principle as those in your refrigerator, electric fan, vacuum cleaner, the starter on your car, and all of the many others used today. Through an electric motor, we are able to transform electrical energy into mechanical energy to move things.

Questions

1. Show your leader the electro magnet...... the armature...... and commutator...... on your motor. ....Leader's initials

2. Are there north and south poles in your electric motor?........... If so, where are they located? ....

....

3. How many electric motors are there in your home?.......... List them:

....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

Light a Home Study Desk

Job No. 2
(Individual Requirement)

The purpose of this job is to learn how to provide good light for your desk or table.

There is a section called "Help Yourself to Lighter Desk Work" in your 4-H Electric Program Members' Idea Book. Study this section. Then, arrange a good study lamp, or lamps, for your desk or study table.

Show your lighting arrangement to your club leader and to the other club members when they meet in your home.

Can you answer these questions?

1. Does your own desk or study lamp conform to the suggestions made in the folder on lamps?........... If not, what changes must you make? ....

....

2. What size bulb should be used for desk lamps? ....

3. How high above the desk should a desk lamp be located? ....

4. What is the desirable diameter of the shade? ....

5. What shade or color should the desk surface have? ....

6. Should a lamp be placed to the right or left of a person? ....

7. Should a book lie flat on a desk for easiest reading? ....

....

Give an Electrical Demonstration

Job No. 3

(Individual Requirement)

The purpose of this job is to share your electrical knowledge and to learn how to show and tell others.

Did you show anyone else how to do any of the electrical tricks learned in Electricity I? Did you show and tell at the same time? If you did, you gave a demonstration. It is as simple as that.

You can show and tell your club, parents, or other groups how to do or make something that you have learned in your electricity work. It will be fun. Besides, it will help you learn how to do it better and develop your ability to think and speak before other people.

You can give a demonstration by yourself or team up with another club member.

If you need help, ask for it from your club leader, junior leader, and County Extension Agent. Your leader may have a booklet on electrical demonstrations. Here are a few suggestions to help you get started.

What to demonstrate

Demonstrate something you have enjoyed doing in your electricity club.

Make the demonstration simple. Use one main idea. Choose something you can show and tell how to do it step by step.

Do something you think others would like to know about and could use.

How much time to take

A successful demonstration by a club member can be given in 2 to 5 minutes. Team demonstrations may take a little longer.

Use the time you need and make each step clear.

How to plan a demonstration

Make a list of the steps or processes you want to show and tell about.

Arrange the steps in the order you do them.

Use your own words. Tell what you are doing and why. Act as if your audience knows very little of what you are demonstrating, so don't skip any details.

Make a list of all the supplies and equipment you will need.

Get to know all the up-to-date facts about your subject.

If posters, charts, or diagrams will help make important parts clear, make them and use them.

Choose a "catchy" title for your demonstration.

The parts of a demonstration

In the introduction tell who you are, give title of demonstration, why you chose it and what you are going to do.

In the "do" part show and tell what to do, how to do it, and why you do it, as you go along.

In the summary go over the main points briefly. Show finished article. Ask for questions. Thank audience and invite members to inspect the finished product.

Answer these questions about your demonstration:

1. What did you demonstrate? ....

....

2. Give reason for your choice......................

....

....

3. What title did you give your demonstration? ....

....

4. Did you give it by yourself?............ or team up with another member of your club? ....

5. To whom did you demonstrate? Name the groups: ....

....

6. How many times did you present it?

....

7. About how much time did it take to present your demonstration? ....

..................................(minutes).

8. Record your demonstrations in your Permanent 4-H Record.

Make an Electrical Game or Gadget

Job No. 4
(Individual Option)

The purpose of this job is to learn and demonstrate simple uses of electricity.

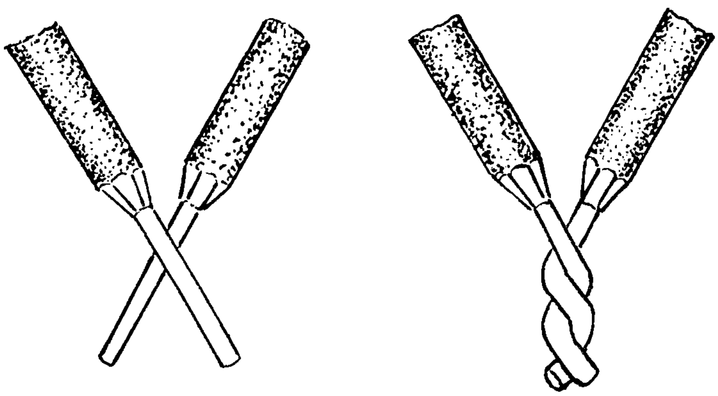
If you made an electrical gadget in Electricity I, make a different one this time. Any game or gadget that shows how electricity works and uses batteries or magnets will qualify for this job. You may use plans from other sources or use your own ideas and draw your own plans.

A well made, neat, and attractive game or gadget can be used for a long time. Then, too, it may be your Electricity II exhibit. If so, be sure it is not more than 24 inches long, 18 inches wide, and 18 inches high.

You may use switches, light sockets, buzzers, motors, or other items you have made as a part of your game or gadget.

Make all connections clean and tight.

Pigtail Splice



Be sure to remove insulation. Scrape enameled wire carefully with a knife before making splices or connections.

Figure 13

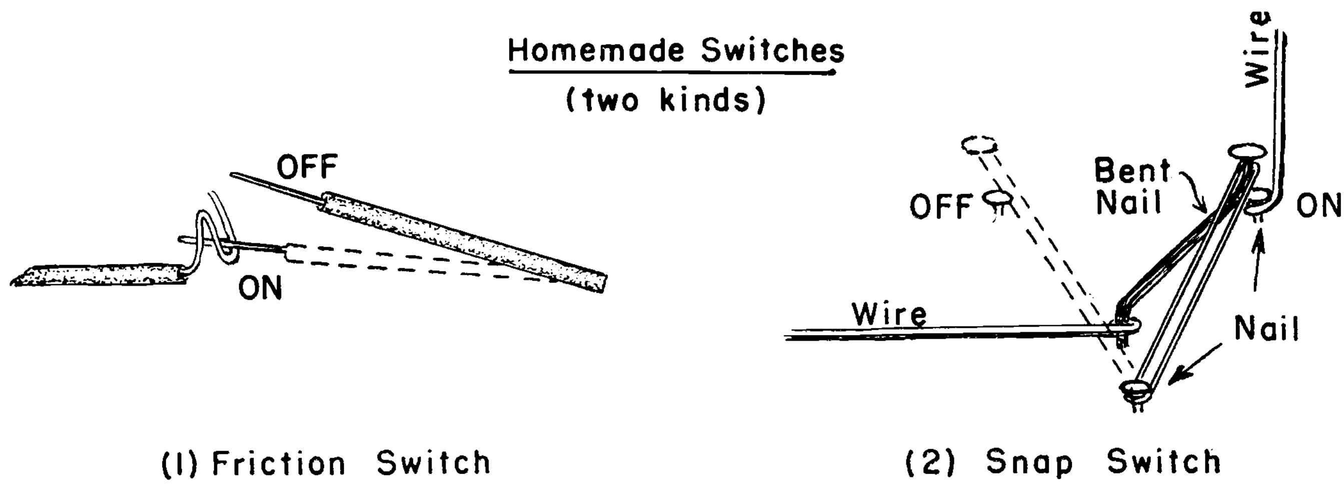


Figure 14

Help Install or Make a Low Voltage Signal System

Job No. 5
(Individual Option)

The purpose of this job is to learn practical uses of low voltage direct current.

A basic doorbell circuit is probably one of the simplest, yet one of the most useful, applications of electrical energy you can make.

An electric circuit consists of a source of voltage that is connected by means of conductors to the equipment that is to use the electrical energy. The basic doorbell circuit includes a doorbell or buzzer, a power source such as dry cell batteries or a doorbell transformer, a push button to close the circuit when you want the doorbell to ring, the bell wire conductors to carry the electrical energy. The basic circuit is shown in Figure 15.

The push button is the switch in the circuit and keeps the circuit open. When you push the button the electrical pathway is completed and electrical energy rings the bell.

The doorbell or buzzer is an electromagnet that can operate on direct current, such as you get from batteries, or alternating current from a doorbell transformer. An electromagnet is a soft iron core wound around with a coil of insulated wire. When electricity flows through the coil it magnetizes the core. When the electrical flow ceases, the core loses its magnetism.

When you push the button you start a make and break cycle in the doorbell. When electric

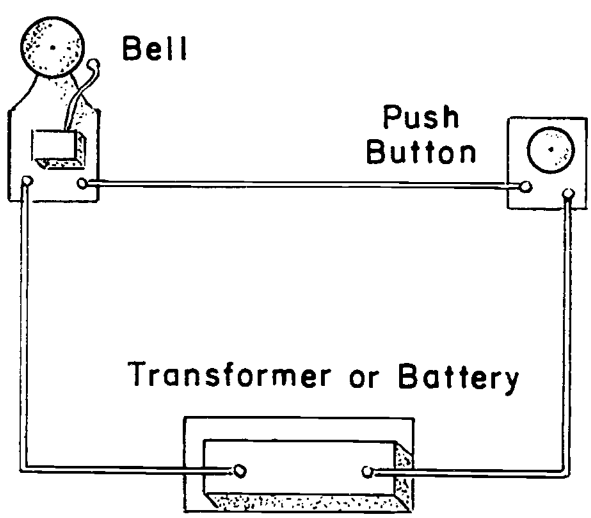


Figure 15

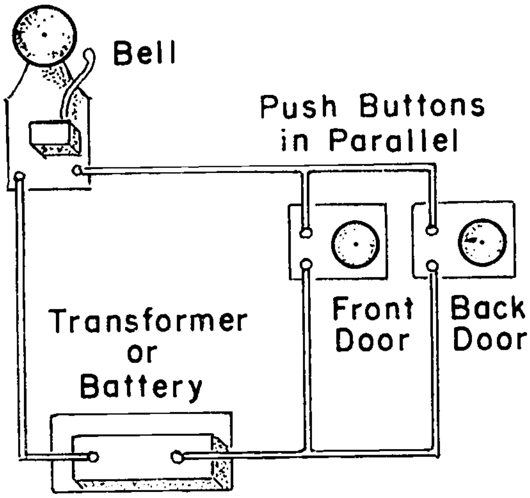


Figure 16

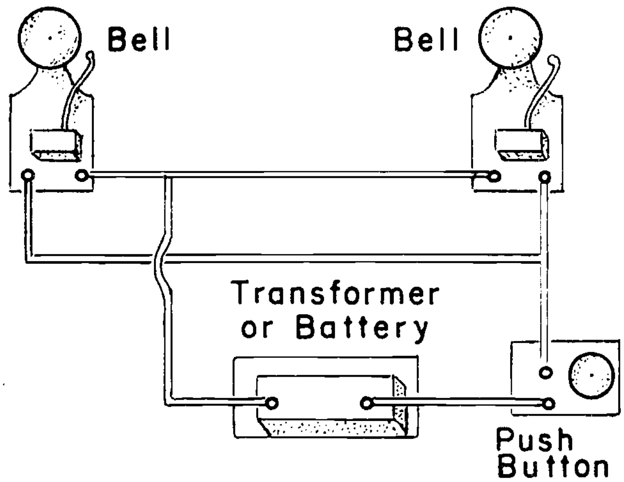


Figure 17

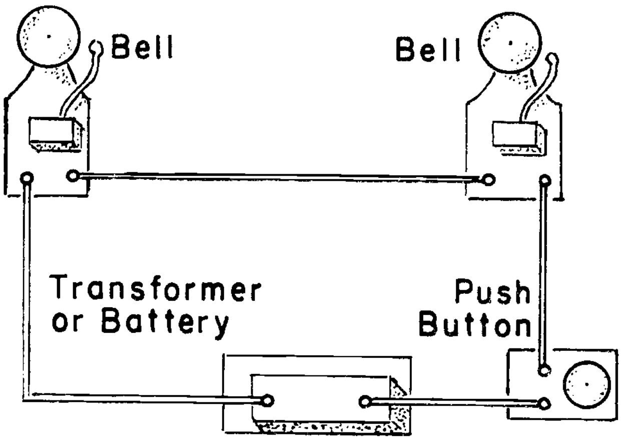


Figure 18

current flows through the coil of wire in the bell, the electromagnet moves the striker and at the same time disconnects the circuit. The electromagnet stops pulling the striker. The striker springs back and makes contact. The electromagnet is energized, pulls the striker over, disconnects the circuit to shut off the electromagnet, and the striker moves back to reconnect the magnet. This happens almost faster than you can see it.

Sometime you may want to wire a doorbell so it can be rung from 2 or more locations, such as the front and back door. Figure 16 shows the basic circuit for ringing the bell from 2 locations. The push buttons are wired in parallel. In a parallel circuit electrical energy can flow through 1 or more circuit sections located side by side like railroad tracks. When you wire 2 or more buttons to operate one bell or buzzer, they may not seem to be side by side, but if you have wired them properly and draw a diagram, you will see that they actually are parallel. The electric current can take a path through any 1 button, depending on which one is pushed.

You can ring 2 bells with 1 button by putting the bells in a parallel circuit as shown in Figure 17. When you push the button the current divides and flows over 2 paths through the 2 bells. The same electrical pressure or voltage is applied to each bell and causes current to flow through both bells.

In a series circuit current flows through one bell and then the next, as in Figure 18. You cannot use push buttons in series unless you can push all the buttons at once. Figure 18 is a series circuit with the current flowing through the push button, then through the first bell and the second. If one bell is disconnected or has a break in its windings, the circuit is broken and neither will ring.

If you want a doorbell for the front door and a buzzer for the back door, you can easily wire up these circuits. They would be 2-series circuits, one with a doorbell and push button in series and the other with a buzzer and a push button. These 2-series circuits would be wired in parallel with the common power

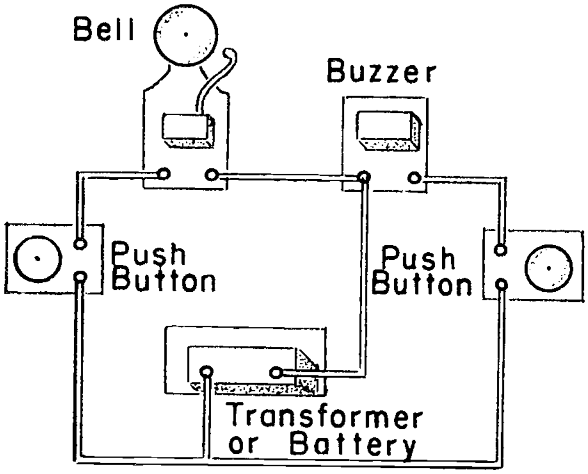


Figure 19

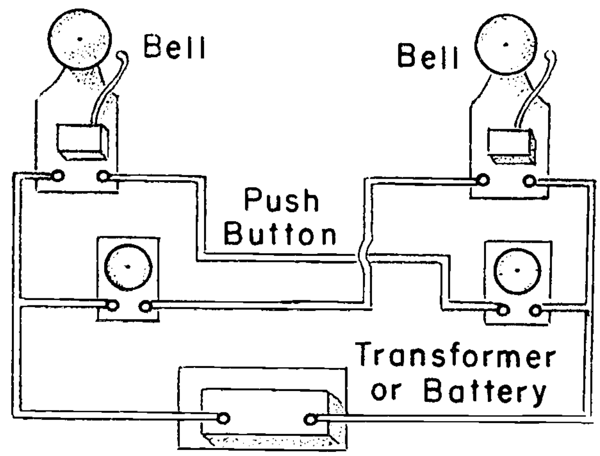


Figure 20

source, as shown in Figure 19. Two wires would run from the front door button, one going to the doorbell and one to the batteries or the doorbell transformer. Two wires would run from the back door button, one going to the buzzer and one to the batteries or transformer. If the doorbell and buzzer were located near each other one additional wire would have to run from the unconnected side of the buzzer to the batteries or transformer. If the bell and buzzer are not close together you have to run a wire from each of them to the batteries or transformer.

There may be an occasion when you want a signal-and-answer system. Figure 20 shows the basic circuits.

If you install a signal-and-answer system between 2 buildings you need 3 wires between the buildings. One wire will connect the batteries or transformer in building A to the bell and one side of the push button in building B. The second wire is connected to the other side of the bell in building B and to the push button in building A. The third wire connects one side of the bell in building A to the second terminal on the push button in building B. You also will need another piece of wire to connect the other side of the transformer or batteries to the bell and push button in building A. The same type of system can be installed between 2 rooms or between upstairs and a downstairs workshop.

An exhibit board showing methods of wiring doorbell or signal circuits could be an interesting fair exhibit.

Draw a diagram of the signal system you helped install. Label parts.

Present "The Minutes of a Ghost Convention"

Job No. 6

(Club Requirement)

The purpose of this job is to learn to "respect" electricity and how to "play safe."

Present the play, "The Minutes of a Ghost Convention." It is in your 4-H Electric Program Members' Idea Book. This is a club requirement. Every member should have a part.

The job is to present the play to an audience sometime during the club year. You can adjust this play to fewer members by leaving out some of the ghosts or you may add extra ghosts by writing additional script for them. This play should be presented with a discussion of safety.

Questions

What safety lesson is taught in the case presented for each ghost?

Pappy Ghost ....

Ghost No. 1 ....

Ghost No. 2 ....

Ghost No. 3 ....

Ghost No. 4 ....

Ghost No. 5 ....

Ghost No. 6 ....

Ghost No. 7 ....

Ghost No. 8 ....

Ghost No. 9 ....

Make a Bright and Dim Board

Job No. 7

(Club Requirement)

The purpose of this job is to show the necessity of using wire of correct size.

This is a club requirement. The whole club may work together to make one bright and dim board. If your club is large, you may want to divide into several smaller groups with each group making a bright and dim board.

Materials needed

1 dry cell
100 feet No. 18 bell wire
100 feet No. 24 enamel covered wire
1 flashlight bulb (single cell)
1 board about 12 inches x 18 inches

Procedure

The job will demonstrate why lights sometimes become dim. The principles shown by this bright and dim board apply to electrical wiring in the home, farm, or factory. If wires aren't big enough to carry the current needed the equipment will not operate properly. Lights will dim, motors will turn more slowly, or may not even start.

The double throw or 3-way switch permits you to use either No. 18 bell wire or No. 24 wire circuit. You can make the switches and socket as you did in Electricity I.

Make certain that all wire connections are properly made. The insulation or enamel must be removed from the wire for satisfactory con-

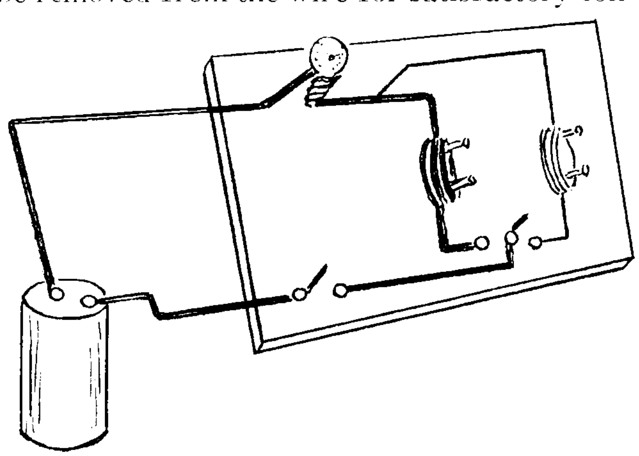


Figure 21

nections. A knife edge serves well for cleaning the ends of the wire.

The board consists of 2 circuits to supply electrical energy to the flashlight bulb. One circuit is through 18-gauge copper bell wire and represents adequate wiring. The other circuit is through No. 24 wire and represents inadequate wiring. Switching from adequate wiring to inadequate wiring causes the light to dim.

Wire 1 battery terminal directly to the light. Wire the other terminal to a single pole switch, which you can make. Wire the other side of the single pole switch to a 3-way switch. Connect 1 of the coils to each pole of your 3-way switch. Connect the other ends of both coils of wire to the same terminal of the light socket. You can make your own light socket.

Adequate wiring (No. 18 bell wire) permits the bulb to burn brightly. Flip the 3-way switch and inadequate wiring (No. 24 wire) causes the light to dim.

This equipment will help you demonstrate why adequate wiring is essential.

Questions

1. What happened to the light when the circuit was changed from the fat wire to the thin wire? ....

....

2. How does this experiment apply to our everyday uses of electricity? ....

....

....

3. If we turn on more and more lights and appliances, such as the iron, toaster, deep fryer, motors, and other appliances until the lights become dim, what is the cause? ....

....

4. What happens to a wire when an overload of electricity is forced through it? ....

....

5. How are our homes protected from overloaded circuits? ....

....

Series and Parallel Circuits

Job No. 8

(Club Requirement)

The purpose of this job is to show the change in voltage by connecting dry cells or light bulbs by 2 different methods.

Members may work as a group to demonstrate series and parallel circuits.

Materials needed

4 dry cells or flashlight batteries
3, 2-cell flashlight bulbs
Bell wire for making connections

Procedure

The average dry cell, such as you have been using, is about $1\frac{1}{2}$ volts. Sometimes it is desirable to increase the voltage. This is done by connecting 2 or more dry cells in a certain way. The connection in the center of the cell is positive and usually is marked with a plus sign (+). The connection on the outer edge or bottom is the negative (—) pole. You will find these stamped or raised signs on the terminals of storage batteries used in automobiles.

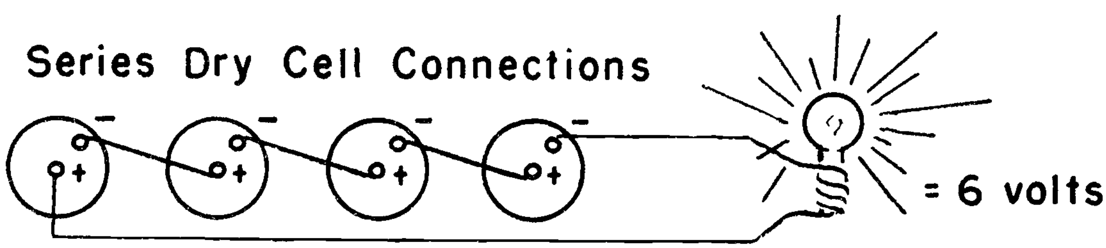


Figure 22

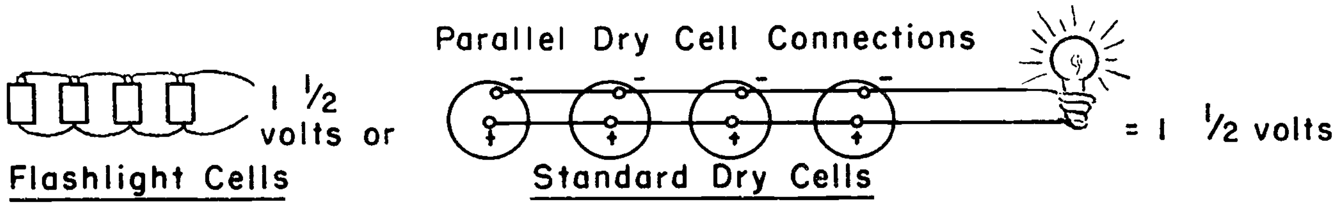


Figure 23

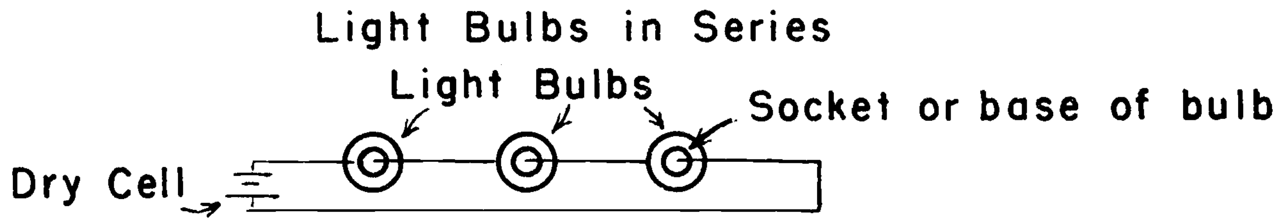


Figure 24

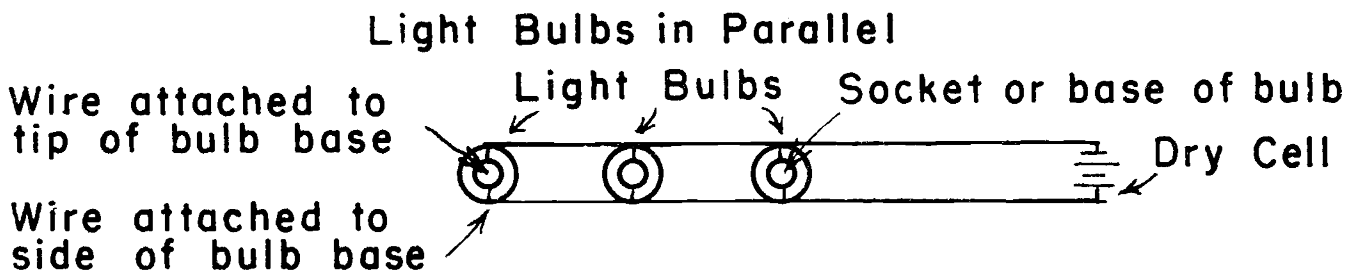


Figure 25

In a series connection each cell has $1\frac{1}{2}$ volts. This connection will increase the total voltage in the sum of the 4 dry cells, or to 6 volts. A 6-volt bulb will burn brightly. Electric light bulbs and appliances are made for certain voltages. A 2-cell flashlight bulb will burn out quickly in a 3- or 5-cell flashlight. A 5-cell flashlight bulb glows dimly in the 2-cell flashlight. Flashlight cells are connected in series.

In a parallel connection all plus terminals are connected together and all negative or minus terminals are connected together. The voltage for the 4 cells in this case remains the same as for 1 dry cell or $1\frac{1}{2}$ volts. A 6-volt bulb will burn dimly. The extra cells will keep a light burning for a longer time.

A circuit is the wire or electrical path that takes the electricity to the place where you want to use it. In your home the electrical path is concealed in the walls and pokes a "finger" out through a hole in the wall or ceiling to a light, outlet, or switch so you can turn on a light or plug in a toaster, electric motor, or other electrical appliance.

Connect 3 flashlight bulbs to 1 dry cell, or use 2 cells from a standard size flashlight in series, as shown in Figure 24, and note the brightness of the lights.

Connect 3 flashlight bulbs to 1 dry cell, or use 2 cells from a standard size flashlight, in parallel, as shown in Figure 25, and note the brightness of the lights.

Questions

1. Flashlight batteries are connected in series?.............. parallel?.............. What is the bulb voltage of a 2-cell flashlight?....................

2. What is the voltage for a standard 2-cell flashlight bulb?.............. You may have to visit a store selling the bulbs and obtain this information from a voltage table or display box.

3. Take a look at the battery terminals in a car or tractor. Can you see the plus (+) and minus (—) markings?........... Are they raised or stamped?.................... Are the terminals the same size or is one larger than the other? ....

4. What information is found on the light bulbs used in your home?....................................
....

5. When one light goes out in a set of Christmas tree lights and all the others go out, the lights are connected in..........................cir-cuit. Check your set of Christmas tree lights. Are they in series or parallel circuit?.............. What is the voltage of each bulb?.................... How many bulbs in your set?............... What is the total voltage of your set?...............volts.

6. In Job 5 what kind of circuits did you use? Parallel...................., series....................., or both..................................

Make an Electric Current

Job No. 9
(Club Option)

The purpose of this job is to demonstrate how electric current is generated.

Materials needed

Cardboard tube about 1 to 2½ inches in diameter

Bar or horseshoe magnet

Either bell wire or enameled wire, 24 to 28 gauge

Compass

Procedure

An electric current is made by passing a wire or wires through a magnetic or electrical field. In this experiment the wire coils do not move. Instead the magnetic field is moved, causing a current to flow in the wire. Electric particles (electrons and protons) in motion produce electric current. In solid conductors, such as wires, only electrons move.

Wind about 50 turns on the cardboard tube and about 8 or 10 turns on the compass. The connections should be scraped with a knife edge or cleaned with sandpaper before twisting together. Be sure all connections are tight.

You have learned in previous experiments that when a current flows through a coil of wire it has a north and south pole. Can you tell which experiment you performed that showed this fact? We already know that a coil has a north and south pole when a current flows through it. If the coil is wound around a compass a deflection will be noted if there is a current, provided the north pole of the coil and north pole of the compass are not pointing in the same direction. Why would you notice

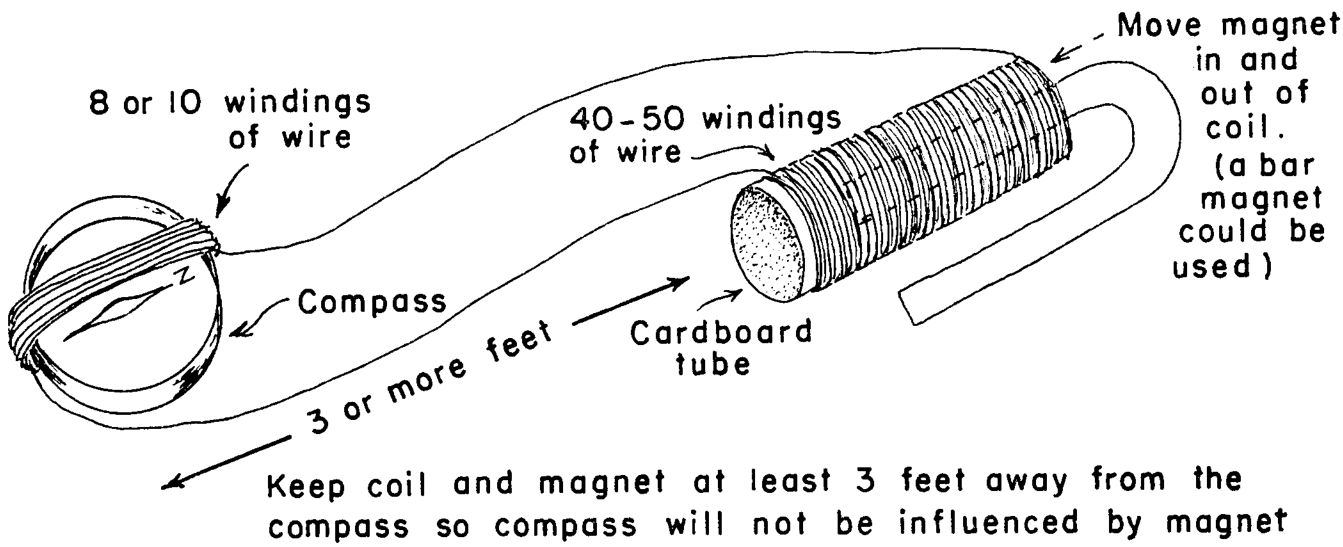


Figure 26

no deflection if the above statement were true?

The next step is to perform the experiment and see what happens. Place the magnet inside the tube if it is a bar magnet, or one leg if it is a horseshoe magnet. Watch the compass needle or have someone else watch it. Remove the magnet with a quick jerk. Did the compass needle move?

If the compass needle does not move, the magnet may be too weak or some wire connection may be poor.

Refer to Job 12, Simple Electric Meter, for the explanation of another way to generate an electric current.

An electromagnet may be substituted to produce the field. Wind a $\frac{1}{2}$-inch round bar or bolt with about 25 to 50 turns and insert it in the tube connected to one or more dry cells. Jerk the same as recommended with a magnet. Do not leave the wire connected to the dry cells for any length of time as this will rapidly weaken the dry cells.

Questions

1. What is an electric current? ....

....

2. Name some sources and some special uses for direct current electricity. ....

....

....

3. How is a magnetic field, caused by an electrical current, made strong and useful?

....

....

4. Can you name several kinds of magnetic devices that are useful?..................

....

5. What practical use does this experiment have in our everyday uses of electricity?..........

....

....

....

Make a Battery

Job No. 10
(Club Option)

The job purpose is to learn how chemical energy is converted into electrical energy.

Technically a battery is 2 or more dry or wet cells connected together. A single cell often is called a battery. Actually a single flashlight cell is not a battery, but when 2 or more are put together they become a battery.

Your leader should have or can get a leaflet, "Making a Simple Battery," that has instructions and diagrams for making a battery. Make sure you do your part and learn all of the steps in making a battery.

If your club selects this Job as one of its options be sure you answer the following:

Questions

1. What is the difference between an electric battery and a single dry or wet cell? ....

....

....

2. Explain why the compass needle moves or deflects when the wire leads are pressed against the coils. ....

....

....

....

3. Why must a simple battery "rest" for a longer period of time than the length of time it is in use? ....

....

....

4. What kind of a battery did you make in your club? ....

.... Did it work? ....

5. Do batteries produce direct .... or alternating .... current?

Make a Light-a-Light Transformer*

Job No. 11
(Club Option)

The purpose of this job is to demonstrate how a transformer works; that is, to illustrate the principle of electromagnetic induction.

Materials needed

An iron bolt or rod about ½ inch x 3 inches

A flashlight bulb	Rough file
Bell wire	A dry cell

Procedure

Some tricks with electricity are as interesting as the best tricks of a magician. For instance, lighting a bulb without connecting it to a battery or plugging it into a circuit. Yes—it's possible!

Wrap 150 turns of bell wire into a coil at one end of the bolt. Leave about 4 inches of wire at the beginning and end of the coil. Remove about one-half of an inch of insulation and solder the wires from the coil to a flash-

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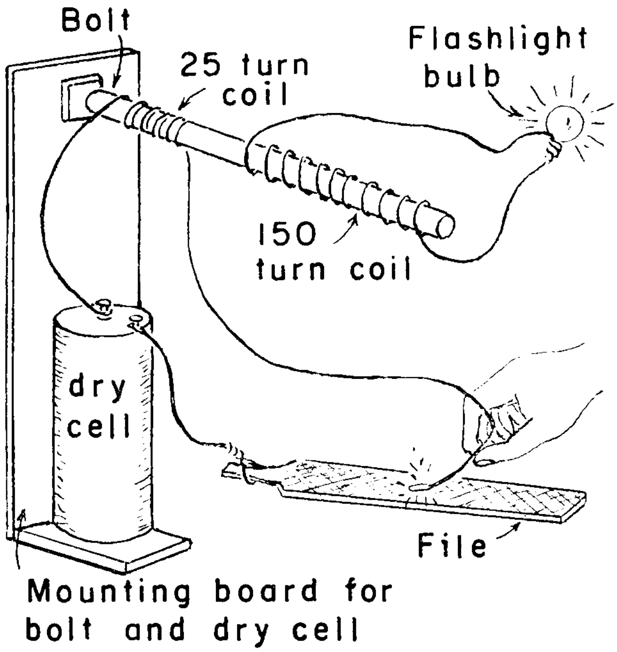

Figure 27

light bulb. One wire should be soldered to the side of the bulb base, and the other wire to the tip of the base. Be careful not to overheat the base of the bulb.

Wrap 25 turns of bell wire around the bolt beside the first coil. Leave about 12 inches of wire at the beginning and at the end of this coil. You may want to leave a space between the 2 coils so you can show there are no connecting wires. Remove about one-half of an inch of insulation from the wires and connect one end of the coil to one terminal of the battery.

Cut another piece of bell wire about 12 inches long. Remove enough insulation from one end of the wire to connect it to the handle of the file. Be sure this connection is as tight as you can make it without breaking the wire. Remove enough insulation from the other end of this wire to connect it to the other battery terminal.

You can now amaze your friends by lighting the bulb—even though it is not connected to the battery. Rub the loose wire from the small coil very rapidly up and down the file, using short, fast strokes. The flashlight bulb will glow brightly.

If you are asked how this "magic" takes place, you can explain that this trick works on the same principle as a transformer. Rubbing the wire on the file causes current to start and stop flowing in the 25 turns of wire. When current flows in a wire, a magnetic field is created around the wire. Every time the current starts flowing in the smaller coil a magnetic field builds up—just as a balloon expands when you blow it up. When the current stops flowing in the coil the magnetic field collapses—just as a balloon collapses when you let the air out. This magnetic field building up and collapsing moves past the other coil and by a process known as induction causes a current to flow in the 150 turns of wire. This current—called an induced current—lights the flashlight bulb.

Transformers are a vital part of your electric company's system for delivering electric power to your home and farm. They are used to step up the voltage so electric power can be sent over many miles of wire. Then, before electric power is delivered to your home, a transformer is used to reduce the voltage to the 110 and 220 volts needed for standard equipment.

Each transformer has a primary coil and a secondary coil. In your light-a-light transformer the small coil—where the electric energy is put into the transformer—is the primary. The larger coil—where electric energy is tapped off for the bulb—is the secondary. If there are more turns of wire in the primary coil than in the secondary, the transformer steps the voltage down. If there are more turns in the secondary than in the primary, the transformer steps the voltage up. The transformer you have built is a step-up transformer.

Hold the wire from your smaller coil on the file for just a moment. The bulb will not light. The battery delivers direct current—current that flows in one direction and does not stop or start unless the circuit is broken. The magnetic field is around the coil when direct current flows through it, but it does not build up and collapse except when the contact is first made and when it is broken. When you rub the wire rapidly over the file, the current starts and stops in the primary coil and the magnetic field builds up and collapses and moves past the secondary coil.

The current flowing in the electric circuits in your home and on your farm, and all through the power company lines, is alternating current. The current flows first in one direction and then in the other. Thus in a transformer on the power company's lines the magnetic field builds up as the current flows in one direction and collapses when the current stops flowing in that direction. When the current flow is reversed the magnetic field builds up around the coil, only to collapse again when the current stops flowing in that direction.

Say slowly: "One-one-hundred."

That takes you a second, and the current flowed one way and then the other 60 times. That is what is meant by 60-cycle alternating current.

Your "transformer" for your light-a-light trick is not engineered as carefully as the transformers used by your power supplier. You cannot move the wire along the file fast enough and smoothly enough to produce a 60-cycle alternating current. But your little trick works on the same principle as the transformer that is on a pole somewhere near your house, and the transformer near the generating station that steps the voltage up to many thousands of volts.

Questions

1. How many coils has a transformer? ....

2. What are they called? ....

3. How can you identify a step-up transformer? ....

4. On a step-down transformer, which is the smaller coil and is it the secondary or primary in this case? ....

5. The coil on the ignition system on cars is a transformer. Would this be a step-up or step-down transformer? ....

6. Can you name other uses for transformers? ....

Make a Simple Electric Meter

Job No. 12

(Club Option)

The purpose of this job is to learn how an electric current is measured.

Your leader can provide a leaflet that shows and tells how you can make an instrument to measure the flow of electricity.

This is another option which you and your club may choose to do together as a group.

If you choose to do this option be sure to answer the following:

Questions

1. What is an electric meter used for? ....

2. What makes an electric meter work? ....

3. What does a galvanoscope do? ....

Is the modern voltmeter and ammeter used for the same purpose? .... Explain purpose of each. ....

4. Why does the compass needle of your voltage "meter" swing in the opposite direction when you reverse the position of the leads connected to your dry cells? ....

5. List several things an electric meter is used for in your home and shop. You might check with your local electric company, electric, or radio shop for other uses.