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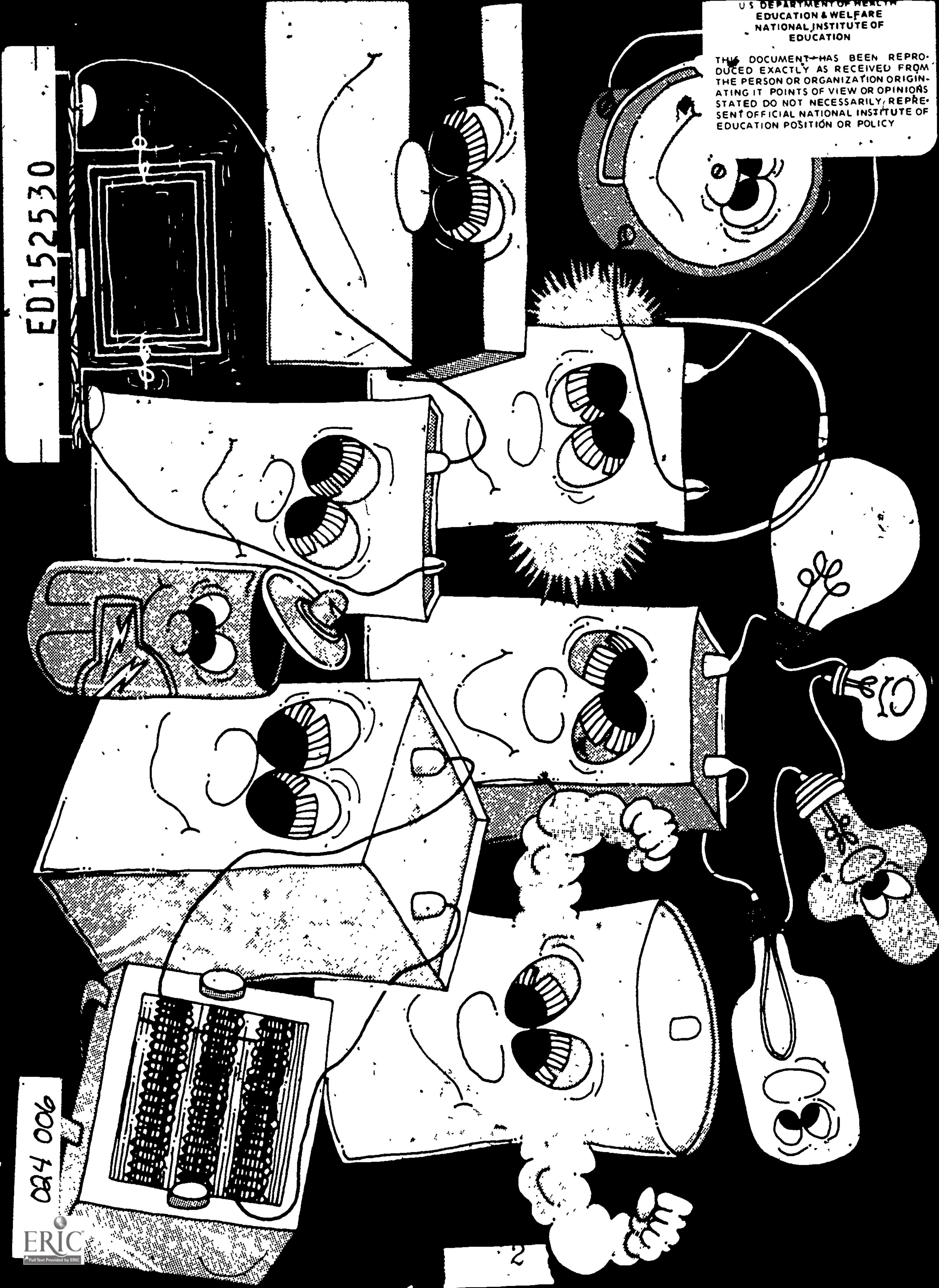
ABSTRACT

Presented is a science activities in energy package which includes 16 activities relating to electrical energy. Activities are simple, concrete experiments for fourth, fifth and sixth grades which illustrate principles and problems relating to energy. Each activity is outlined in a single card which is introduced by a question. A teacher's supplement is included. (SL)



SCIENCE ACTIVITIES IN ENERGY

Science Activities in Energy is a series of simple, concrete, revealing experiments that was developed by the American Museum of Atomic Energy especially for fourth, fifth, and sixth graders but can be just as useful in community programs.

The purpose of the series is to illustrate certain principles and problems related to various forms of energy and to their development, use, and conservation.

More important, it is an effort to help you and other teachers involve students directly in exploring intriguing questions—in making discoveries on their own.

You needn't be an expert in science to use this material. In fact, teachers shouldn't be expected to know the "right" answer to every question posed. What's more, many of the activities involve not just science but art, economics, arithmetic, reading, and other skills and disciplines as well—and need not be used in sequence.

Each unit in the series forms a coherent program of instruction on a single topic: solar energy, electricity, conservation, and the like.

Most activities in the series can be completed in the classroom with materials readily available in any community: pots and pans, paper cups, water, salt, thermometers, and cardboard boxes. A few require purchases from local or national suppliers.

Each project is introduced as a question: How much warmer do objects get in the sun than in the shade? What is the best color to paint a house to keep it cool in the summer? Which stores solar energy better—water or rock?

At the outset of an experiment, try to get your students to predict outcomes, even when they have no experience to justify their projections. Urge them to make a guess. They'll become more interested, feel more involved, if they do.

In order to answer each question, a student (or the class as a group) follows instructions on an activity card that lead him or her through a specific experiment.

This kind of direct student participation leads easily to other related questions—some suggested on the activity cards themselves, others generated by the students and their teacher—and to further exploration by the experimenters on their own.

The American Museum of Atomic Energy has purposely used metric measurements throughout the experiments, believing that this would be part of the learning process for many young people and for some adults as well.

Because the activities are outlined on single cards, you can easily photocopy them for distribution or project them on a screen or wall.

As the developers of the series, we are anxious to learn how you and your students use the materials, what variations you develop, and any results you find extraordinary. Please let us know your reactions to the materials, and feel free to ask for more information on any energy-related topic.

ELECTRICAL ENERGY

Until the oil embargo of 1973, the use of electricity in the United States had been doubling just about every ten years. The rate slowed in '73 and '74 but has again speeded up in the past couple of years.

Considering the enormous use of electricity today, it is hard to realize that America will be using three to four times as much electricity as it is today by the end of the century. That is the projection, though—5½ per cent growth per year—*if* certain conservation measures are taken over the next 20 years.

Electricity, unlike oil, natural gas, and coal, cannot be discovered or mined. It must be manufactured, and the most prevalent means of generating it is the burning of those very fuels. Sixteen per cent of our petroleum, 15 per cent of our natural gas, and 46 per cent of the coal we use is burned to make electricity. Other methods of generating electricity are hydropower, geothermal power, and nuclear fission reactors.

Some experts believe that we waste one-quarter of the energy we use. A 100-watt lightbulb wastes about one fluid ounce of oil (or about 1 1/3 ounces of coal) for every hour it operates unnecessarily. Multiply that by the millions of needlessly lighted bulbs throughout the country on a given day and the amount of waste is staggering.

Another sort of waste takes place in the generating process itself. It takes three units of fossil fuel energy to produce one unit of electricity. When coal is used to power an electrical generating plant, for example, only 38 per cent of its energy is converted to electricity; the rest is lost. Heating a home electrically rather than by some other means can, consequently, be expensive and wasteful.

Although electricity is odorless, quiet, and easily transmitted, it does create problems of air pollution and heat emission in the immediate vicinity of a generating plant.

Experiments in this unit on electricity focus on how electricity is made, how it is used, and how it is measured.

This series, Science Activities in Energy, was developed by Oak Ridge Associated Universities under contract from the U.S. Department of Energy, with assistance from teachers and staff from the Lawrence Hall of Science, Berkeley, California. This publication was prepared as an account of work sponsored by the United States Government. Neither the United States nor the U.S. Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

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HOW MUCH STRONGER IS AN ELECTROMAGNET MADE ON A BOLT THAN ON A PENCIL?

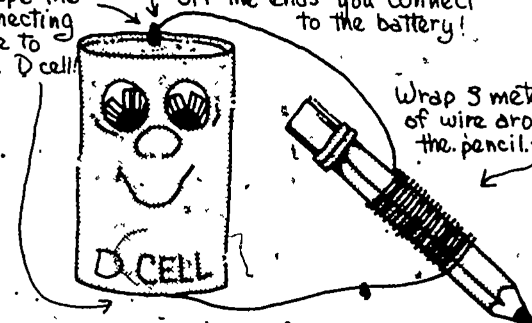
1

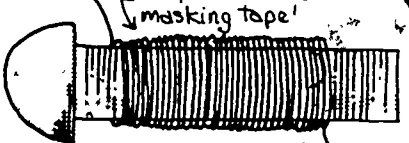
MATERIALS:

6 Meters #24 enameled copper wire, fine sandpaper, 1 D cell, masking tape, brads or tacks, 3" bolt, pencil, compass

Make an electromagnet on the pencil like this:

Test its strength with brads or tacks!



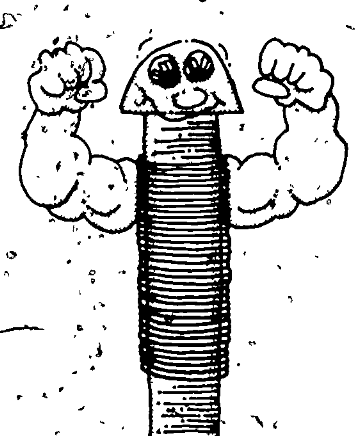


Make an electromagnet on the bolt like this. Test it, too!

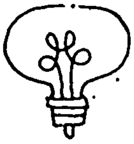
Try this experiment with a permanent magnet instead of your electromagnet— Compare the strength of each!

Can you think of ways to make your electromagnet stronger?

See how far away from a compass you can hold either and get results.



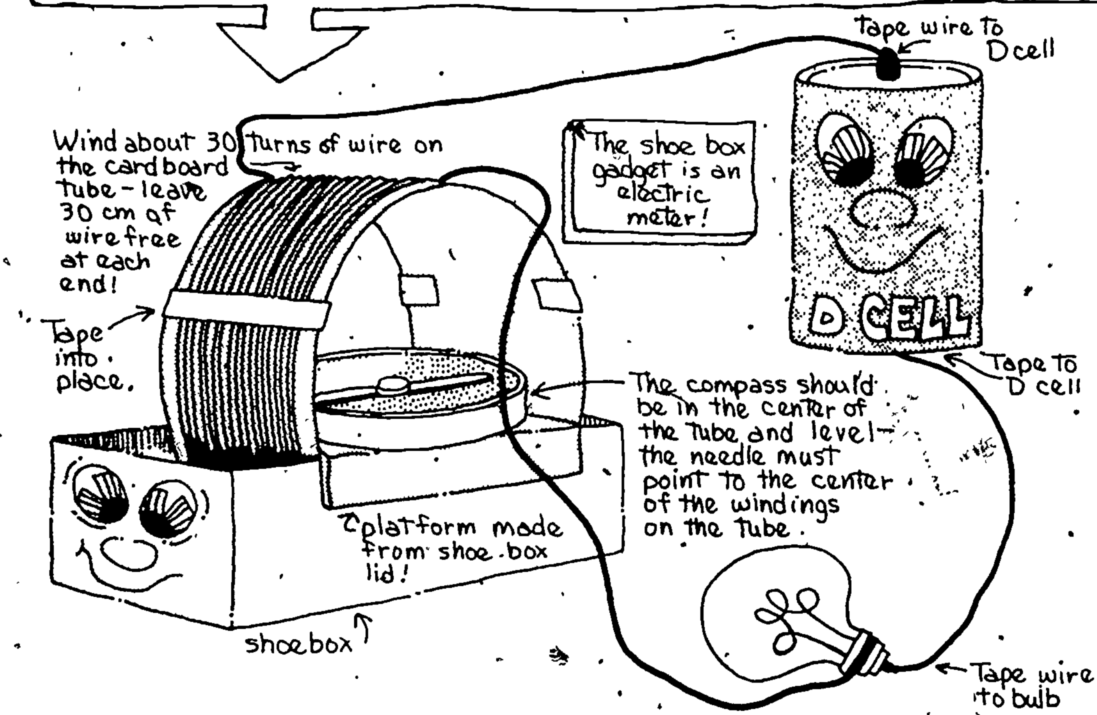
Save your electromagnet for future activities

WHICH USES MORE ELECTRICITY: AN ELECTROMAGNET OR A SMALL  FLASHLIGHT BULB?

2

MATERIALS:

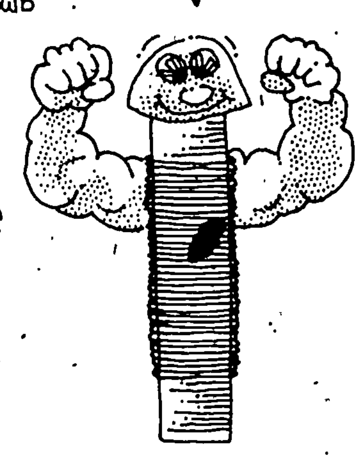
Electromagnet from Activity 1, fine sandpaper
Flashlight bulb, masking tape, compass
5 Meters #24 enameled copper wire
D cell, cardboard tube (about 5cm diameter), shoe box with lid



Do this first:

Connect the pieces as shown. The compass needle moves and then stops at a certain point. Now replace the bulb with the electromagnet. Does it move further? Which uses more electricity?

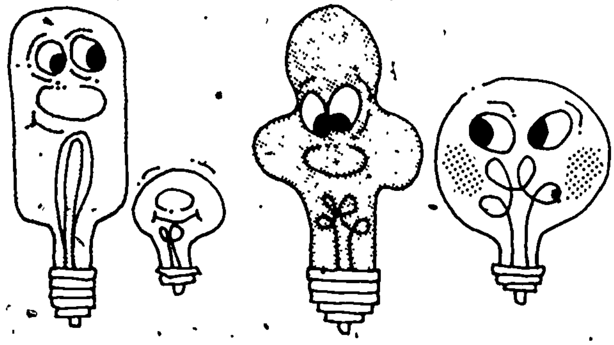
Electromagnet from Activity 1!



Save your meter for future experiments

OTHER IDEAS TO EXPLORE:

Try using different flashlight bulbs: do they all use the same amount of electricity?



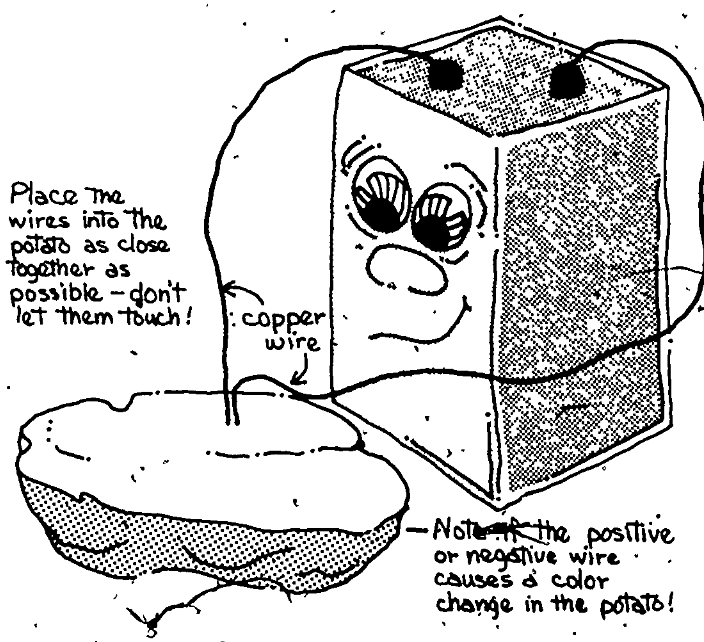
HOW CAN YOU TELL WHICH POLE OF A BATTERY IS POSITIVE IF IT'S HIDDEN IN A SHOE BOX?

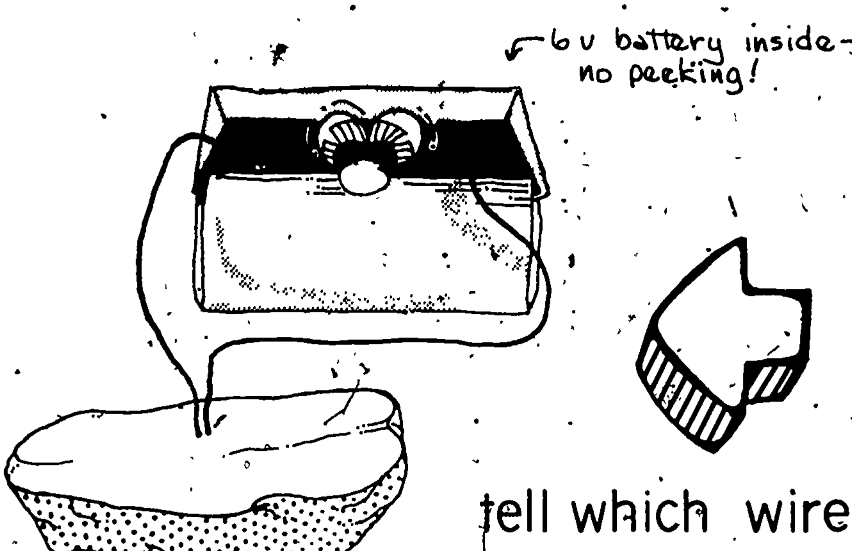
3

MATERIALS:

2 Lengths of bare copper wire, shoe box, potato, masking tape, 1 6v lantern battery

Set up your experiment like this.

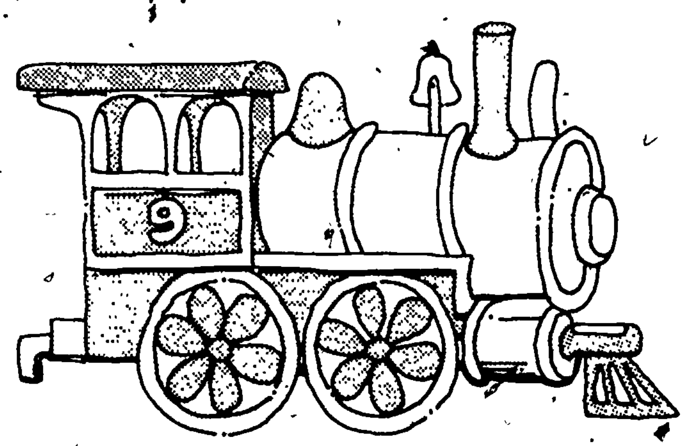




Have your friend put the battery in a closed shoe box. Can you tell which wire is positive?

OTHER IDEAS TO EXPLORE:

Try placing the bare copper wires from a toy train transformer into a potato. Does it do the same thing a battery does? Why?



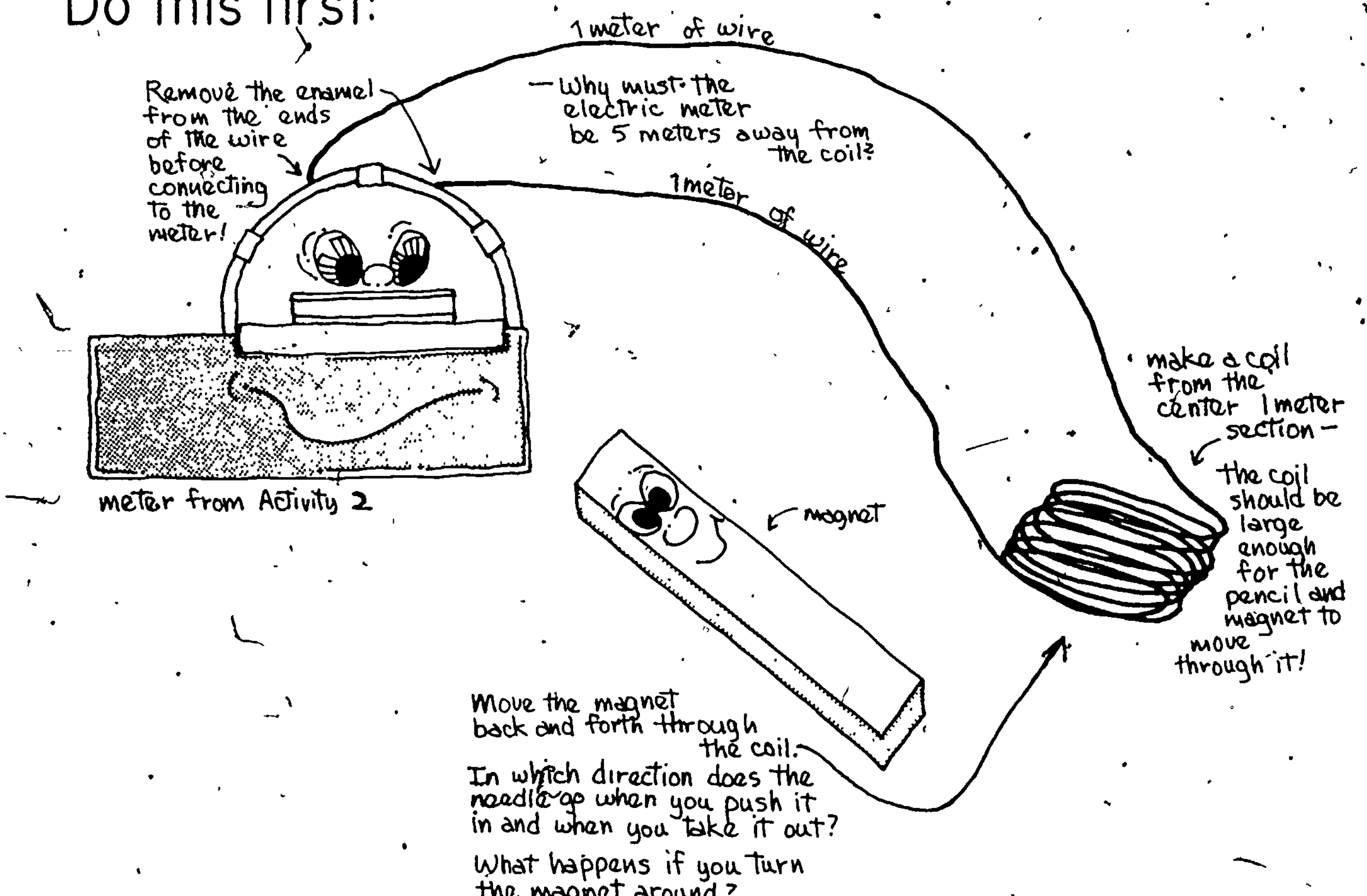
WHAT IS THE MOST ELECTRICITY YOU CAN MAKE USING A MAGNET AND A COIL?

4

MATERIALS:

Electric meter from Activity 2
Small bar magnet; masking tape, fine sandpaper
3 Meters # 24 enameled copper wire

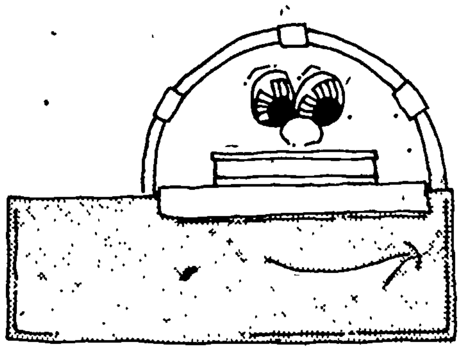
Do this first:

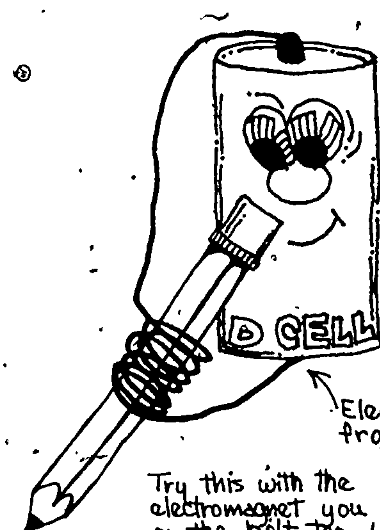


What happens to the compass needle? Try any way you can think of to make the needle swing. How far can you make it go?

OTHER IDEAS TO EXPLORE:

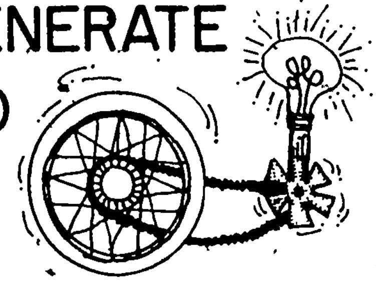
Substitute your electromagnet for your coil. Can you make the needle go further this way?





HOW FAST DO YOU HAVE TO TURN A BICYCLE WHEEL TO GENERATE ENOUGH ELECTRICITY TO LIGHT A SMALL LAMP ?

5

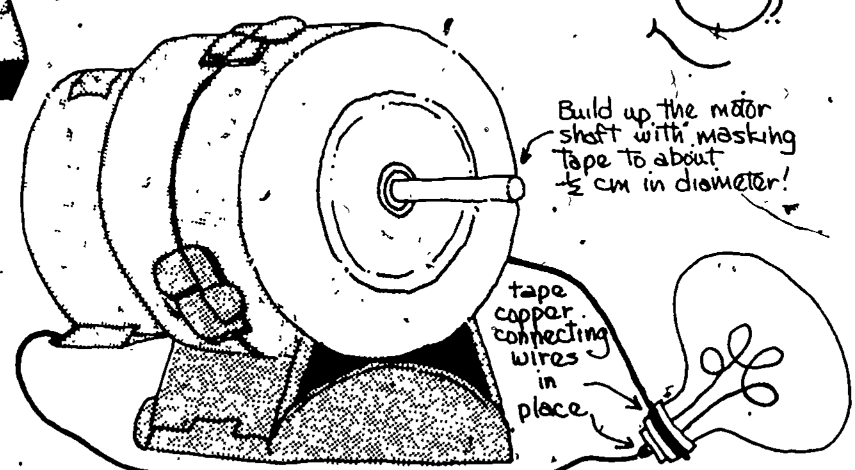


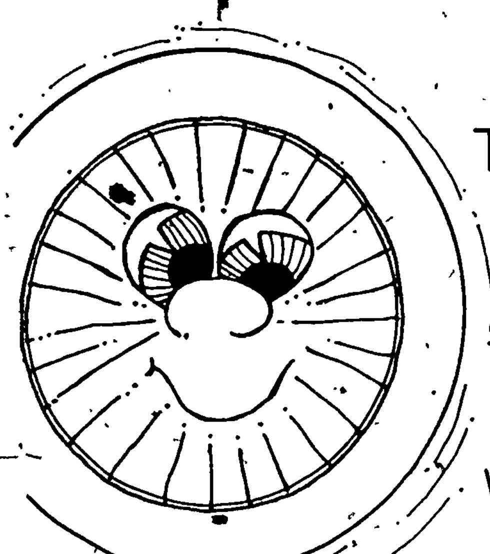
MATERIALS:

buy from the American Museum of Atomic Energy's Discovery Shop — see inside back of "Electricity" folder!

Bicycle, small D.C. motor, flashlight lamp, copper wire for connectors, masking tape.

Do this first:





Turn the bicycle upside down so you can turn the pedals with your hand. Hold the motor shaft so it just touches the rear tire.

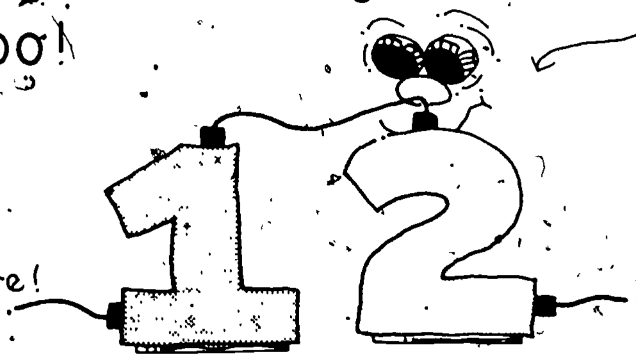
What happens to the light if you speed up the wheel ?

OTHER IDEAS TO EXPLORE:

connect them together!

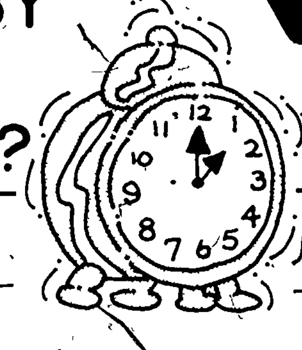
If you used 2 generators, would the light be brighter? Try it with different light bulbs- try it with an LED, too!

* an LED is a light-emitting diode— you can purchase one from a local electronics supply store!



HOW MUCH HYDROGEN AND OXYGEN CAN YOU MAKE IN 5 MINUTES BY SPLITTING WATER WITH ELECTRICITY FROM A BATTERY?

6

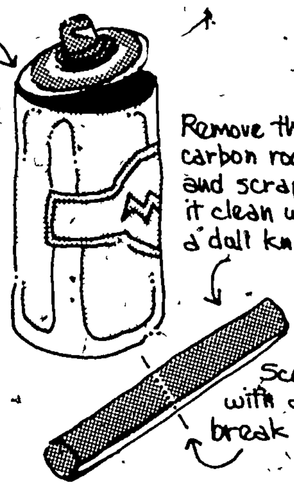


MATERIALS:

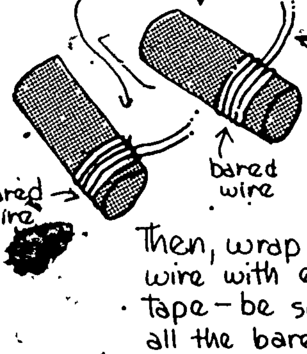
2 45 cm Pieces of #24 enameled copper wire
1 6v Lantern battery, electrician's tape, file
Drinking glass, 2 paper clips, 2 test tubes (ask a local high school!)
1 Used flashlight battery, can opener
1 Tbsp. baking soda, dull knife

Open the used battery first.

Note: If you are concerned about your students opening batteries, substitute pencil lead for the carbon rods!



Bare each piece of wire for 5 cm. Wrap one bared wire around the end of each carbon rod half.

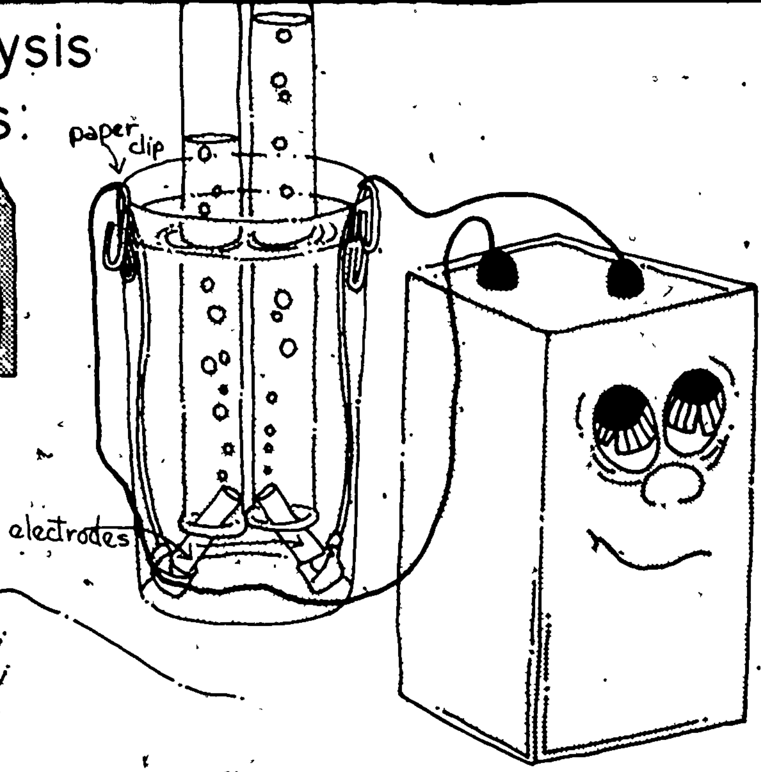


Then, wrap the bared wire with electrician's tape – be sure you cover all the bared wire!

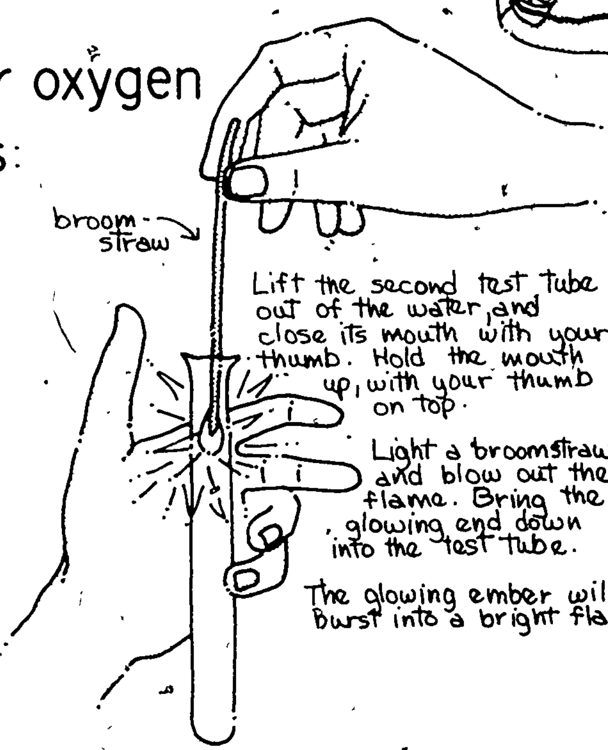
Then, make electrodes.

Set up you electrolysis experiment like this:

Electrolysis— the splitting or taking apart of a chemical (water in this case), by electrical energy.



Test for oxygen like this:

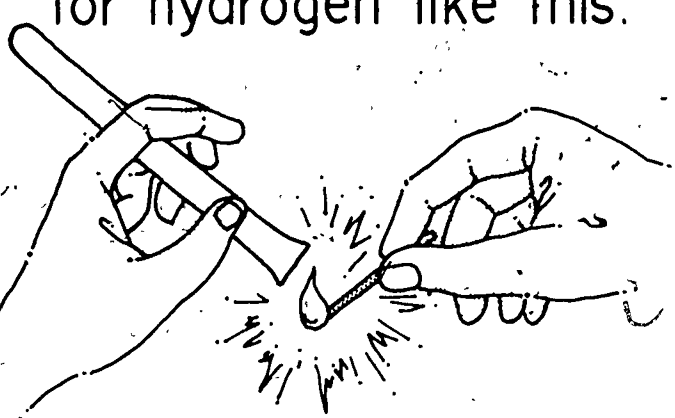


Lift the second test tube out of the water, and close its mouth with your thumb. Hold the mouth up, with your thumb on top.

Light a broomstraw and blow out the flame. Bring the glowing end down into the test tube.

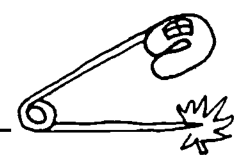
The glowing ember will Burst into a bright flame!

Test for hydrogen like this:



Remove one test tube carefully, and cover the top with your thumb – don't let the gas out!

Hold a lighted match to the mouth of the test tube – the gas should burn with a soft "pop"!

HOW LONG DOES IT TAKE TO COPPERPLATE A  ?

7

MATERIALS:

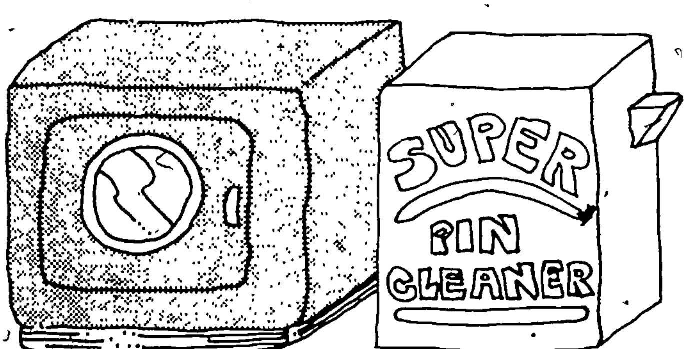
or clear plastic cup!

1 6v lantern battery, glass, warm water

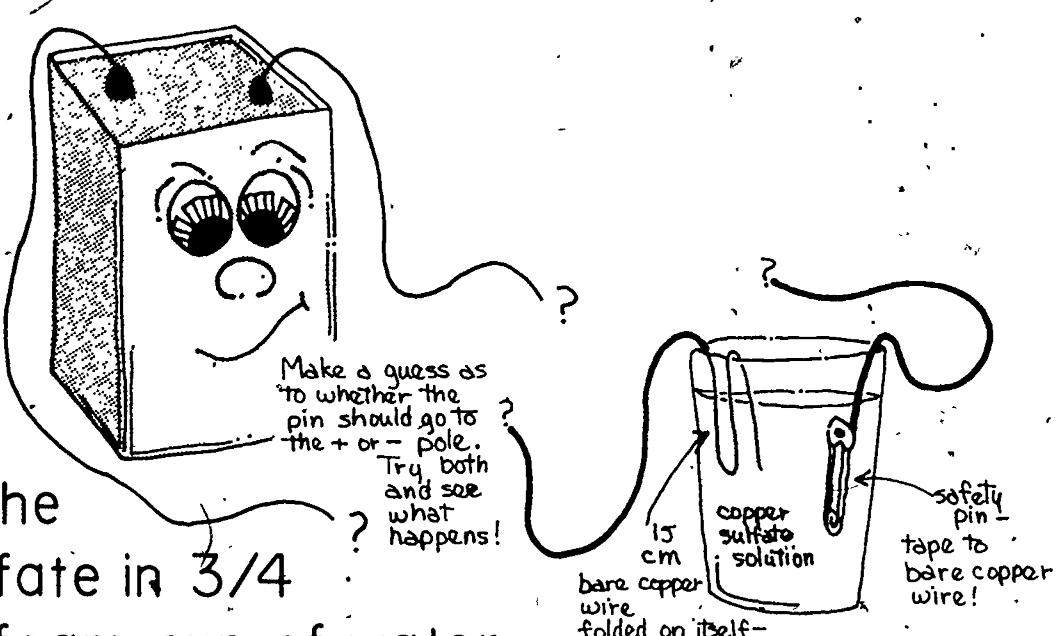
1 Meter copper wire, # 20

28 Grams copper sulfate ← ask a high school chemistry Teacher!

Safety pin, masking tape



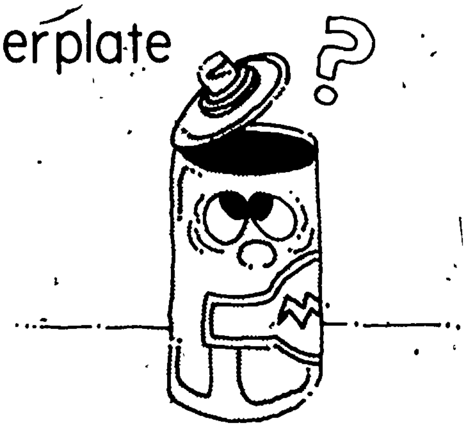
Clean the safety pin very well with soap and water.



Dissolve the copper sulfate in 3/4 of a styrofoam cup of water. Connect as shown.

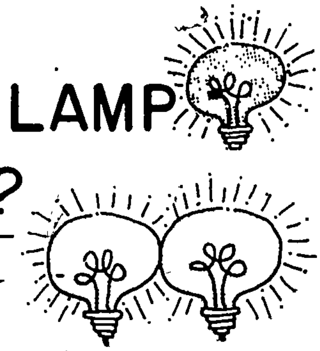
OTHER IDEAS TO EXPLORE:

Could you copperplate the center of a dead battery?



WILL 2 CELLS MAKE A LAMP LIGHT TWICE AS BRIGHT?

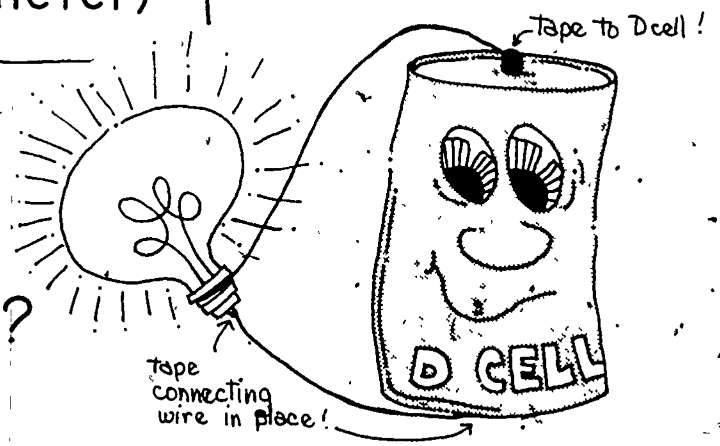
8

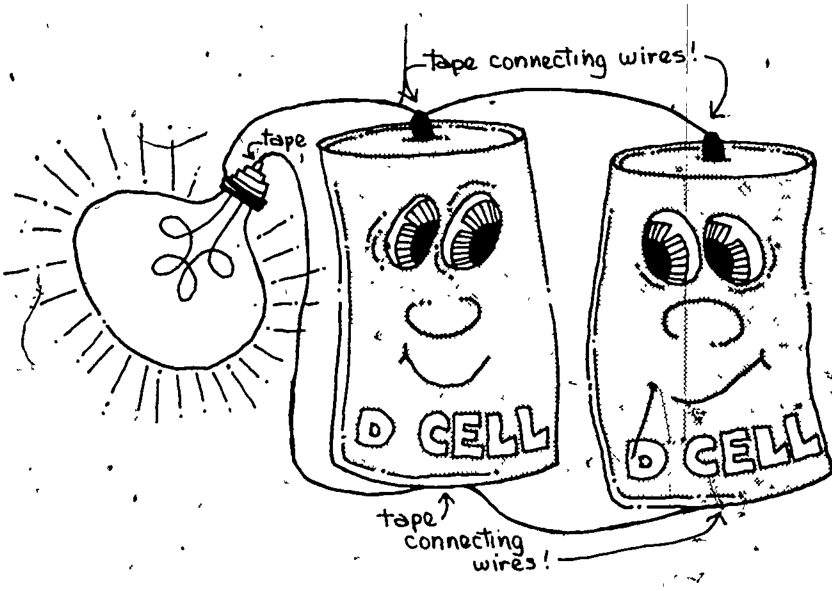


MATERIALS:

2 D cells, masking tape
Flashlight lamp
Bare copper wire (1 meter)

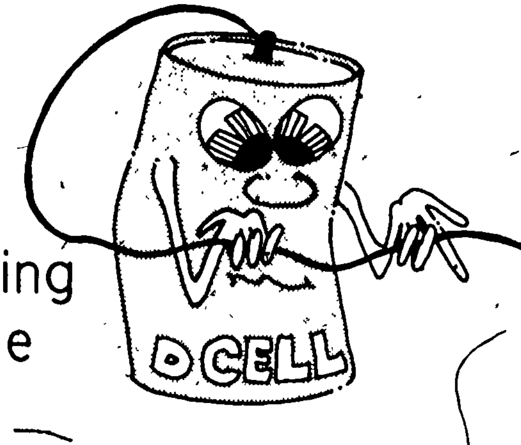
Connect the lamp to 1 cell as shown: How strong is the light?



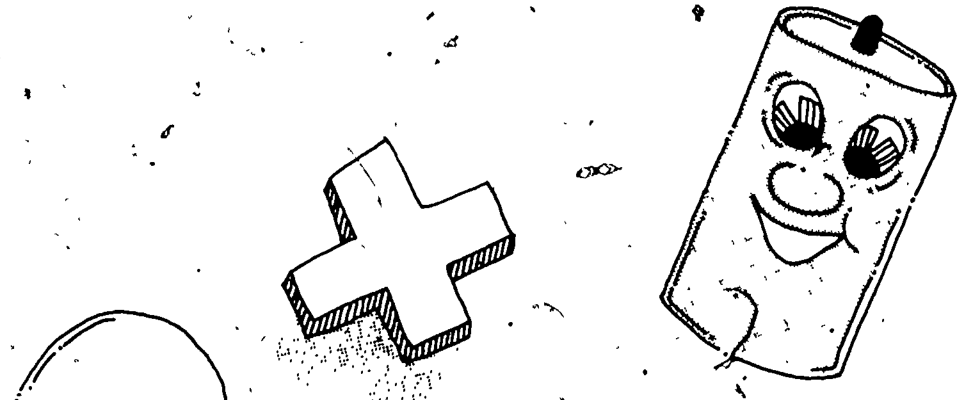


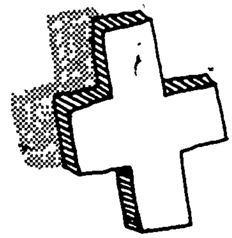
Now connect another cell like this. Is there any difference in light?

Can you find a way of connecting the cells so there is a difference in the light?

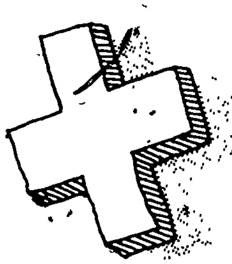


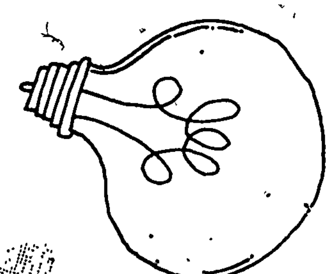
OTHER IDEAS TO EXPLORE:

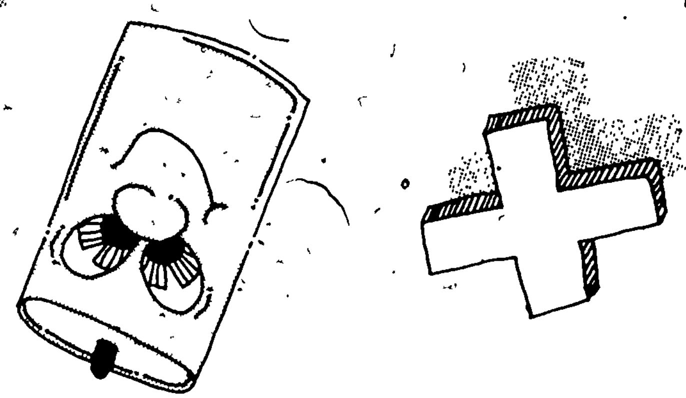




Can you connect 2 lamps to 2 D cells so they'll both be equally bright or equally dim?







HOW MUCH MORE LIGHT DOES A 40 WATT FLUORESCENT LAMP GIVE OFF THAN A 40 WATT INCANDESCENT LAMP?

9

MATERIALS:

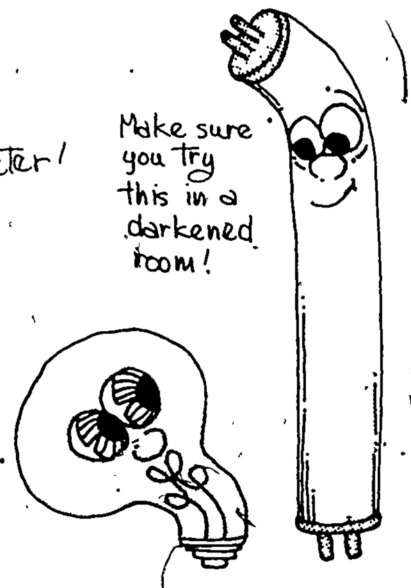
borrow from a photographer!

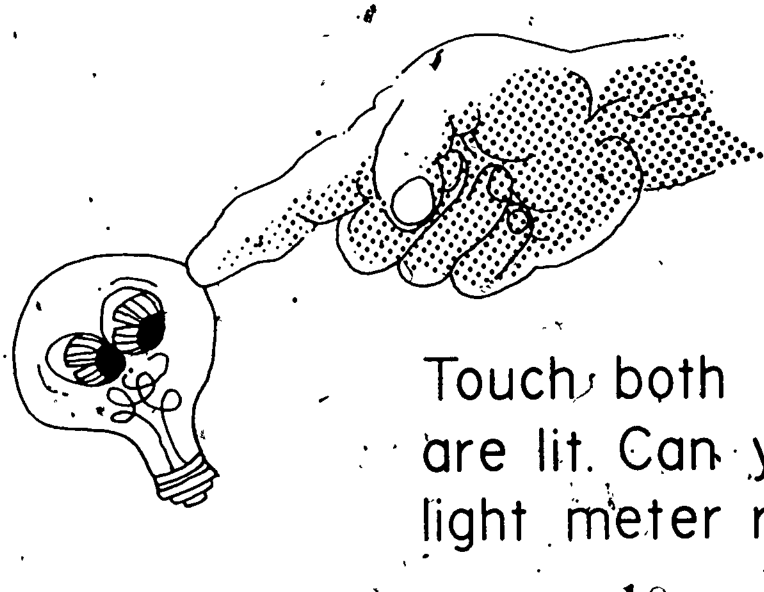
Exposure meter or light meter
Variety of lamps to test

Measure the amount of light given off at a distance of 1,2, and 3 meters from a 40 watt fluorescent lamp, and then from a 40 watt incandescent lamp.

use the light meter!

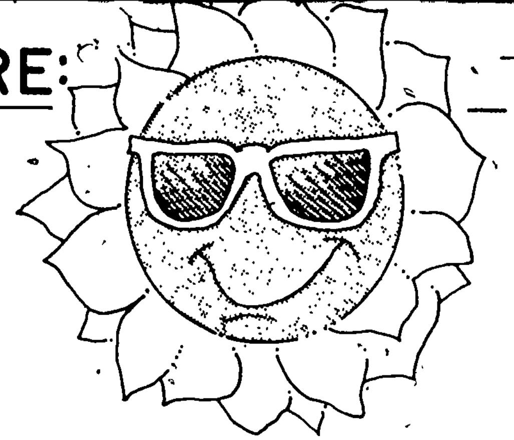
Make sure you try this in a darkened room!



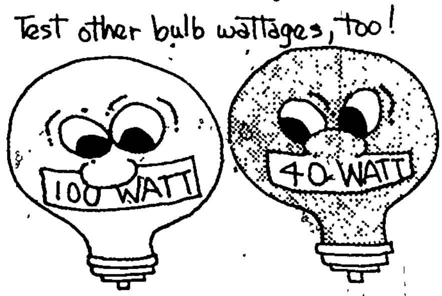


Touch both lamps while they are lit. Can you explain your light meter results?

OTHER IDEAS TO EXPLORE:

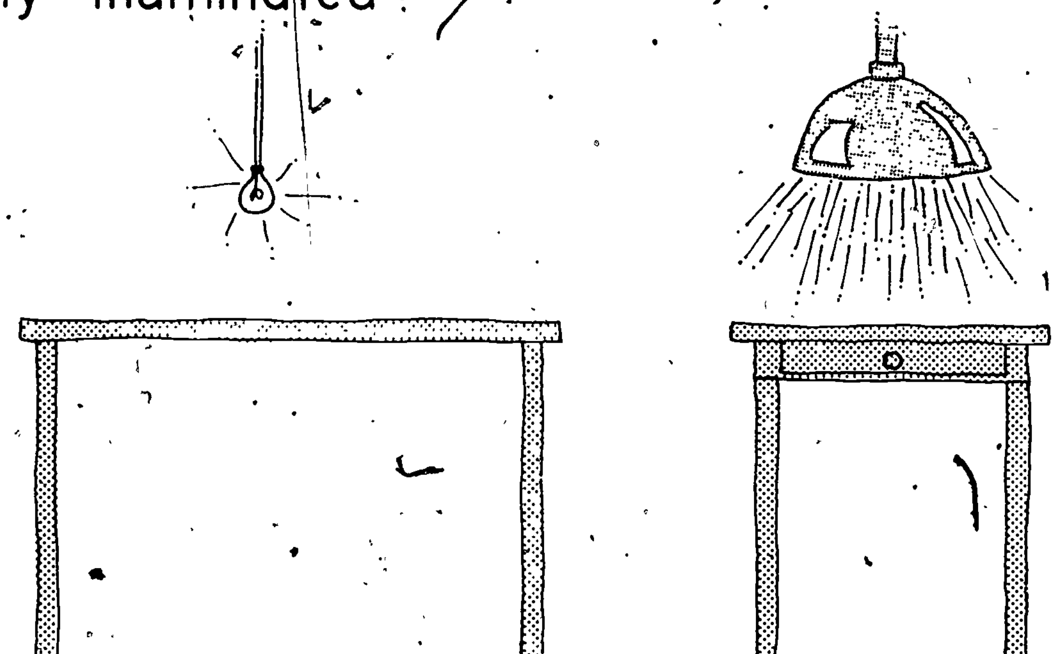


How much brighter is it outside in the sun compared to your classroom?



How much brighter is a 100 watt lamp than a 40 watt lamp? Why?

Are all the stations where students work equally illuminated?



HOW MUCH ELECTRICITY DOES AN LED (light emitting diode!) USE COMPARED TO A SMALL ELECTRIC LAMP?

10

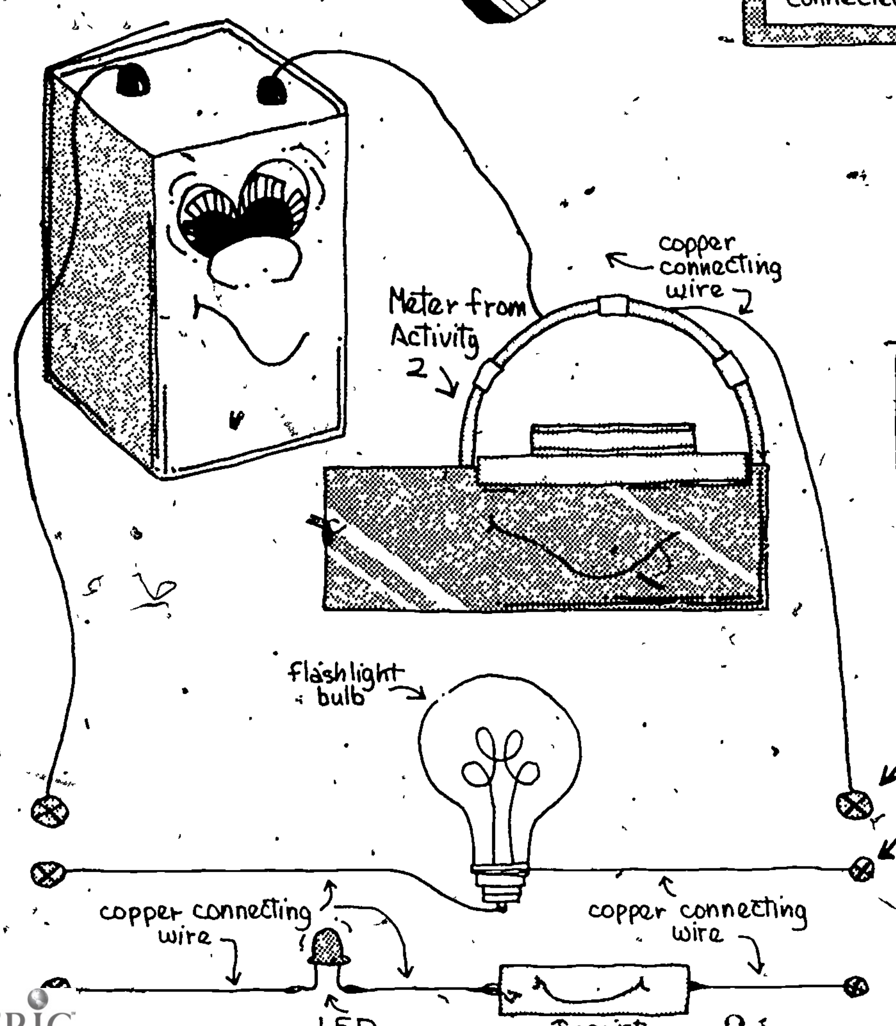
MATERIALS:

#40 Flashlight lamp, masking tape, 25 cm copper wire, Meter from Activity 2, LED, 1/2 watt resistor, 270 ohms; 1 6v lantern battery

You can purchase LED's from a local electronics supply store!

NOTE: LED's are solid-state devices. They must be protected with a suitable resistor and they only work when connected to the proper pole of a battery!

Do this first:



Then, connect ⊗'s. Hook up the flashlight bulb. Record the results from your meter. Now connect the LED. Record the results. What can you do if your LED doesn't light?

HOW WARM DOES A 1/4 CUP OF COLD WATER GET WHEN A SMALL LAMP IS PUT IN IT FOR FIVE MINUTES ?

11

MATERIALS:

Styrofoam cup, thermometer, 1 6v lantern battery
6v Lantern lamp, masking tape, bell wire
Timer, 1/4 cup cold water

Do this first:

WATER TEMPERATURE	
before	after
°C	°C

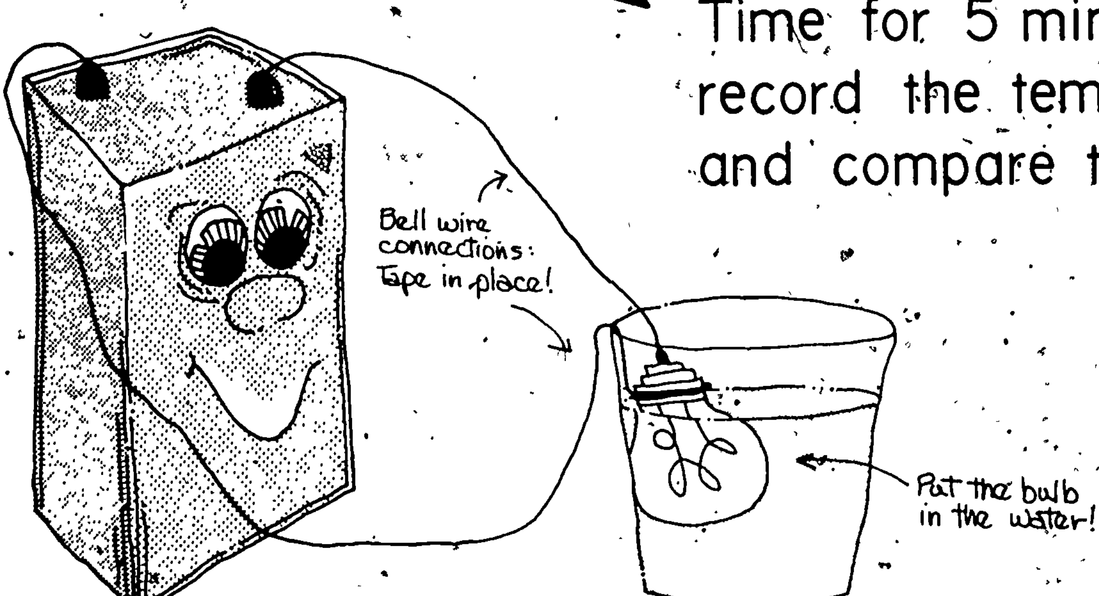
Record the temperature of the cold water!

Connect your experiment like this.

Try this experiment only with a battery!

Time for 5 minutes, then record the temperature and compare the results.

Where does the heat come from?



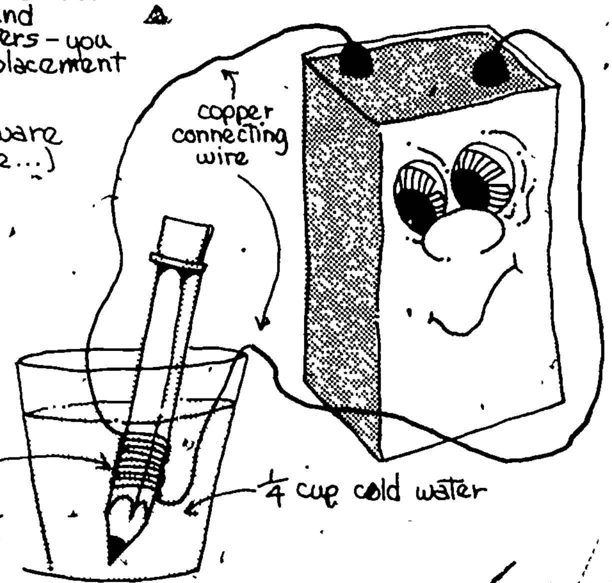
OTHER IDEAS TO EXPLORE:

Get a small amount (about 10cm) of thin nichrome wire. — the wire that's used in toasters and electric heaters – you can buy replacement elements! (Try a hardware store...)

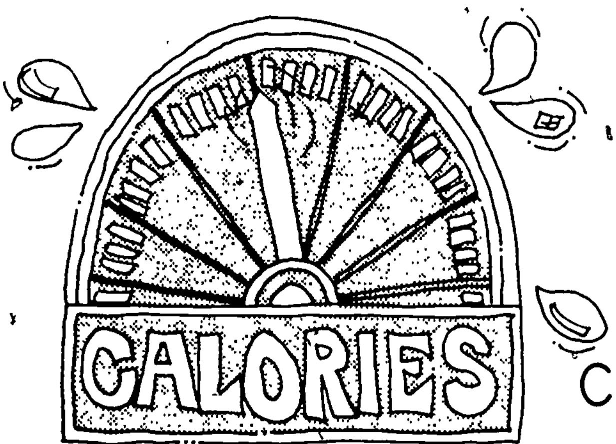
Set up an experiment like this.

Check the results in the same way as the first experiment!

Does this water get hotter?



Time this experiment for 5 minutes, too!



Can you measure the number of calories of heat produced by the lamp or wire?

1. Measure the volume of water in the cup with a graduated cylinder or test tube.
2. Multiply the volume of water (number of ml) x the change in temperature.

   This is the number of calories!
3. Compare the 2 experiments you timed for 5 minutes.

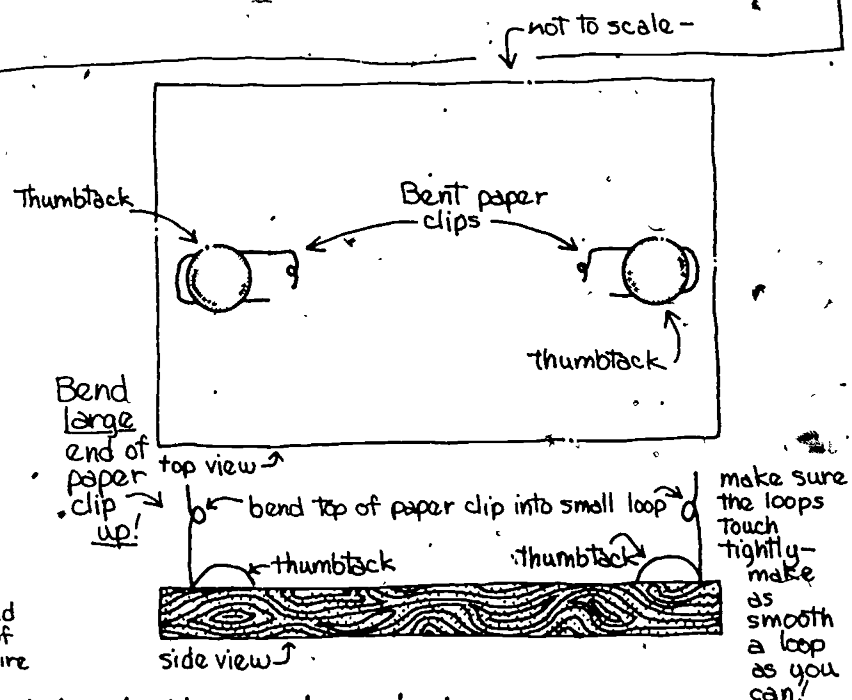
If you time your experiment for 10 minutes will you produce twice the number of calories?

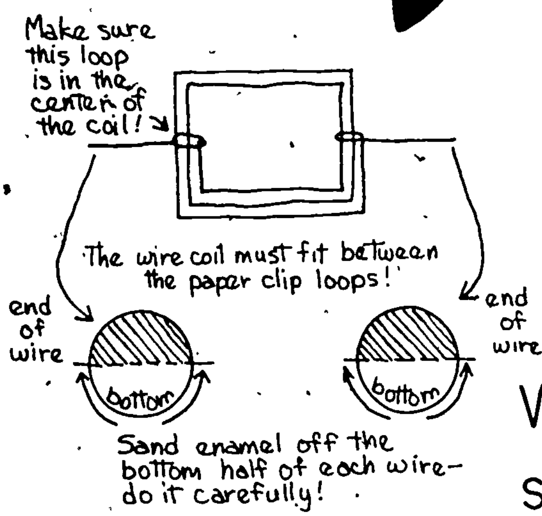
DOES A 6-TURN ARMATURE GO FASTER THAN A 3-TURN ARMATURE? 12

MATERIALS:

20cm #20 enameled copper wire, fine sandpaper, paper clips, thumbtacks, 2 pieces copper connecting wire, 10cm x 10cm piece of wood, 1D cell

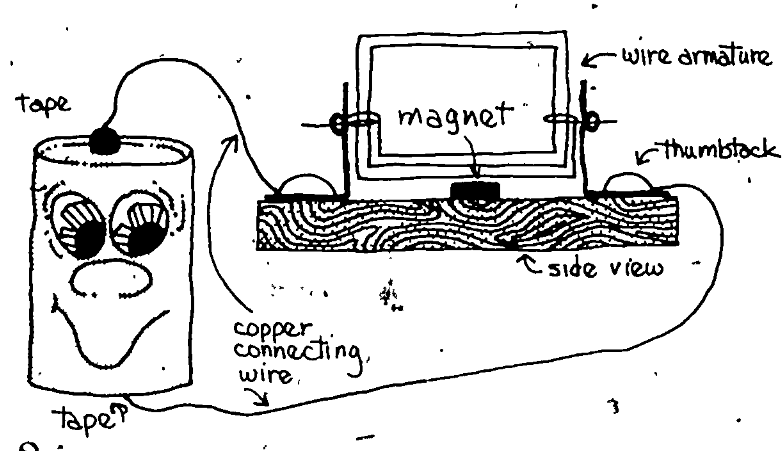
Do this first



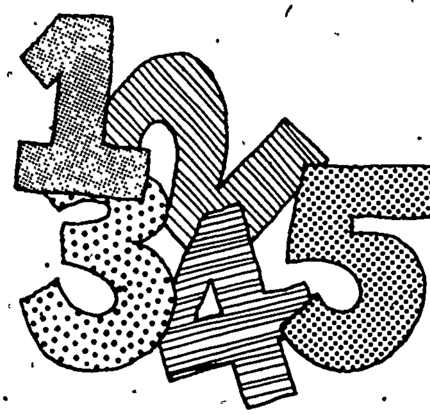


Wind the wire into a square coil as shown.

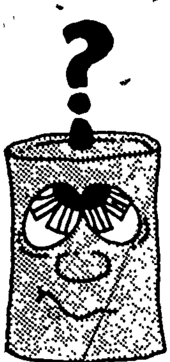
Then sand off the enamel. Now put the wire armature into the paper clip frame and start it spinning.



OTHER IDEAS TO EXPLORE:



What is the smallest number of turns in the wire armature you can use to make your motor work?



Can you figure out how the motor works? Try this experiment using a 6v lantern battery. What happens?

[redacted]

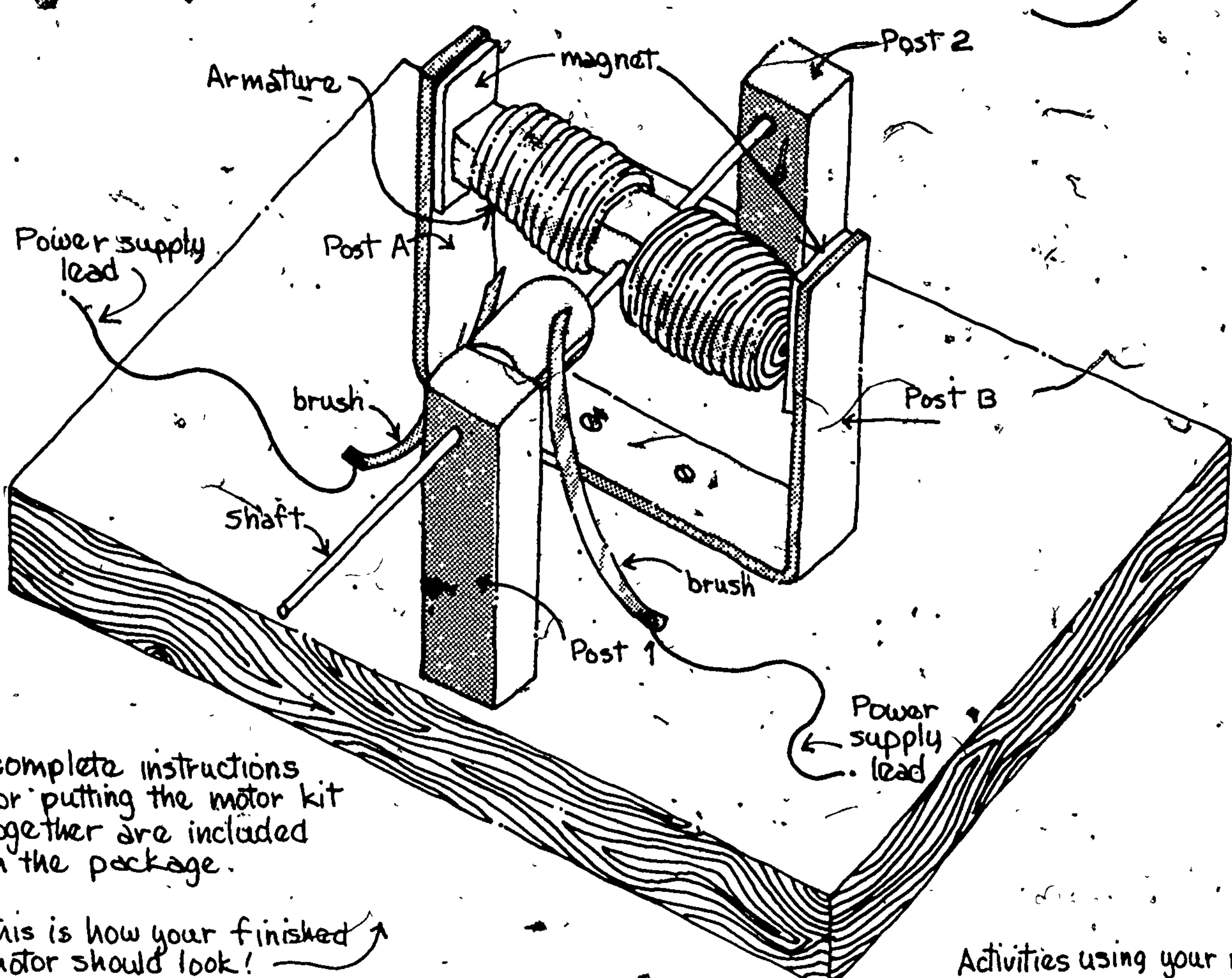
YOU DISCOVER FOR REVERSING THE DIRECTION A D.C. MOTOR TURNS?

REVERSING

MATERIALS:

Motor kit ← available from The American Museum of Atomic Energy's Discovery Shop — see inside back folder for mailing address, etc.

Put the motor kit together like this:



Complete instructions for putting the motor kit together are included in the package.

This is how your finished motor should look!

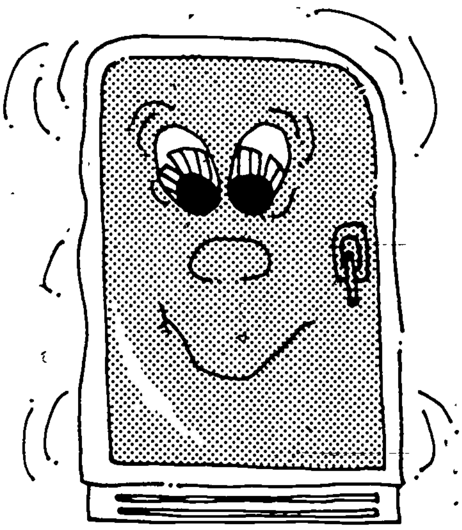
Activities using your motor are on the back!

all the bared wire!

[redacted]

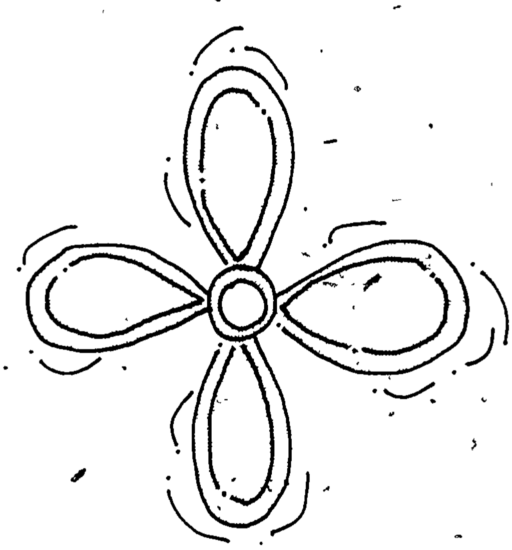
OTHER IDEAS TO EXPLORE:

How many motors do you have in your house?



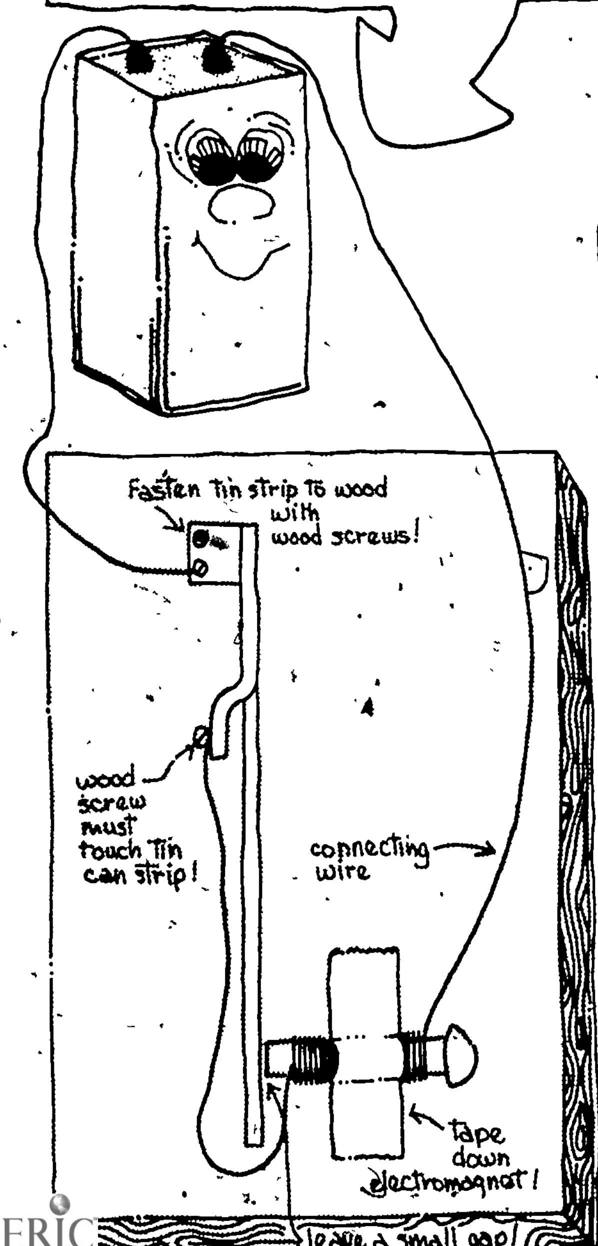
Can you discover how to change the direction a motor rotates? Can you predict which direction the motor will rotate? Test your hypothesis! Can you discover how to make the motor go as fast as possible with the same power source?

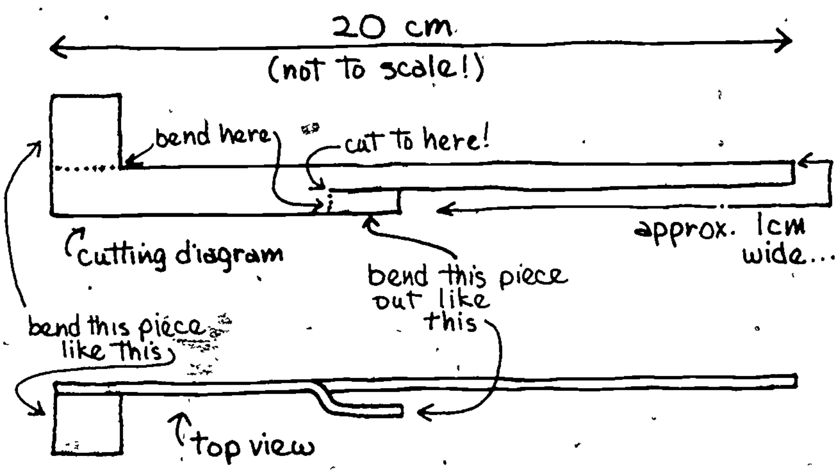
Make a propeller out of balsa wood or paper and attach the shaft.



WHAT CAN YOU DO TO MAKE A BUZZER LOUDER? 14

Electromagnet from Activity 1, tin can, old scissors or tin snips, 6v lantern battery
Small wood screws, piece of wood ← about 10cm x 30cm
Masking tape, copper connecting wire





Cut a strip of metal from the tin can like this.

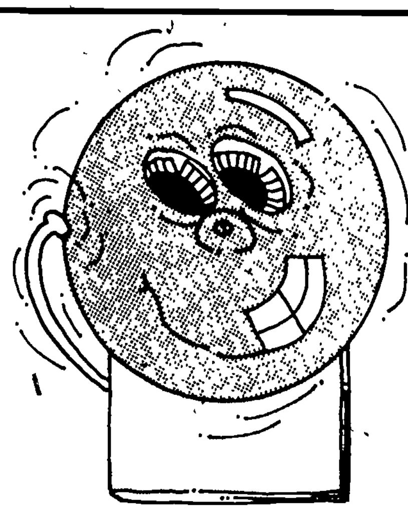
Put your buzzer together like this.

How can you make your buzzer louder?

Connect as shown. 15

OTHER IDEAS TO EXPLORE:

Look at a commercial buzzer or bell. Can you see how it works?



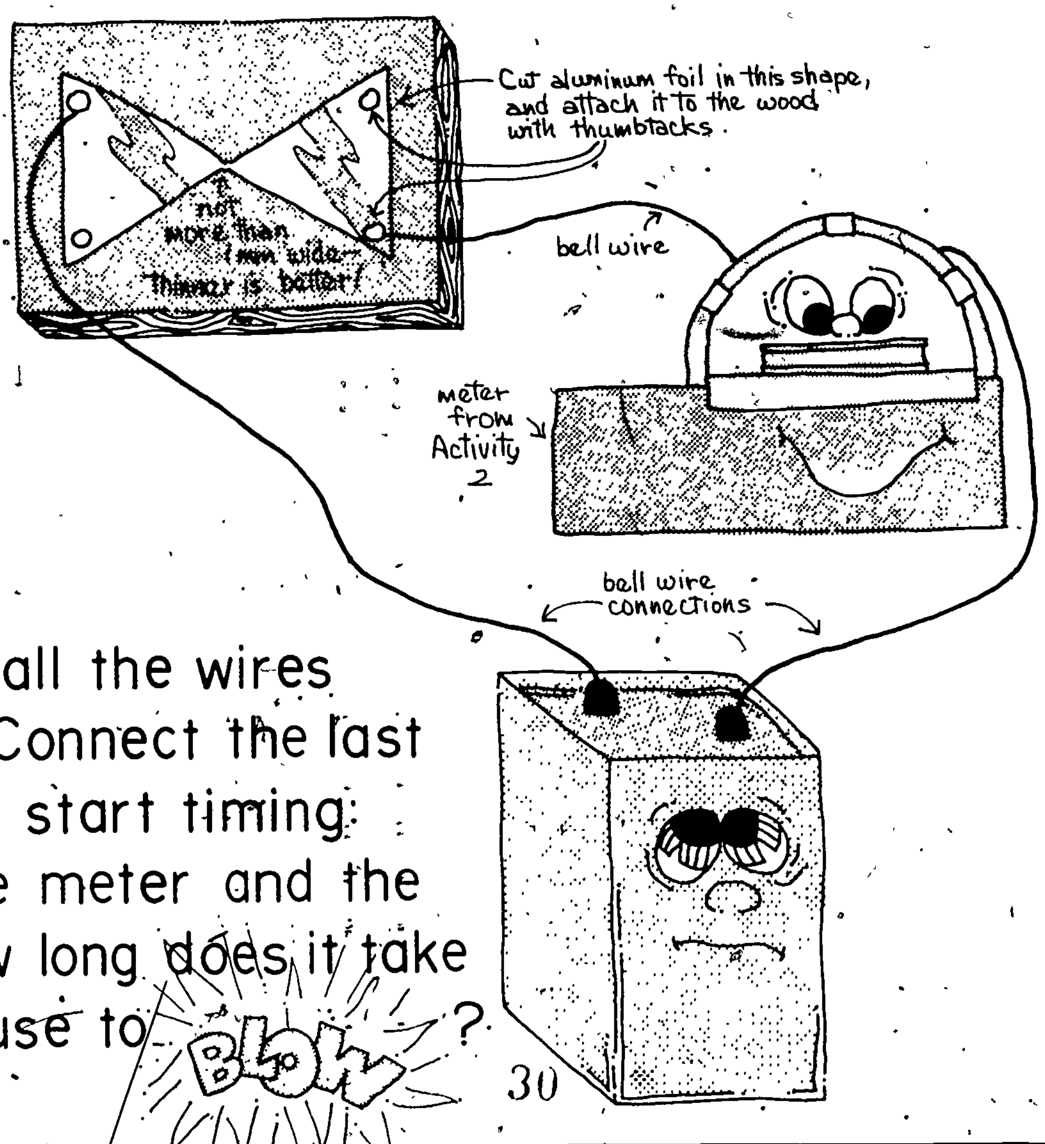
HOW LONG DOES IT TAKE A FUSE TO STOP THE FLOW OF ELECTRICITY THROUGH A METER ?

15

MATERIALS:

Piece of wood 10 cm x 12 cm, 2 thumbtacks
Sheet of thin aluminum foil
1 6-volt lantern battery, watch with second hand
25 cm bell wire, meter from Activity 2

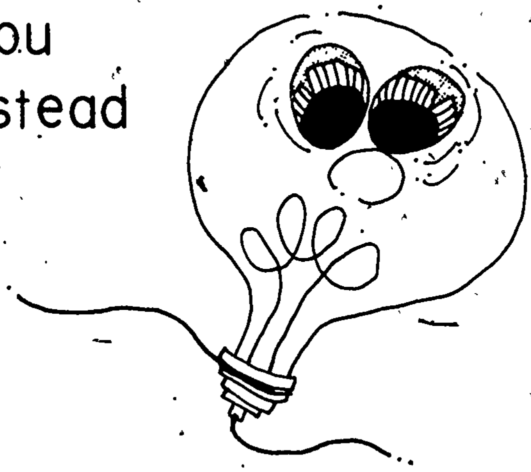
Do this first to make a fuse:

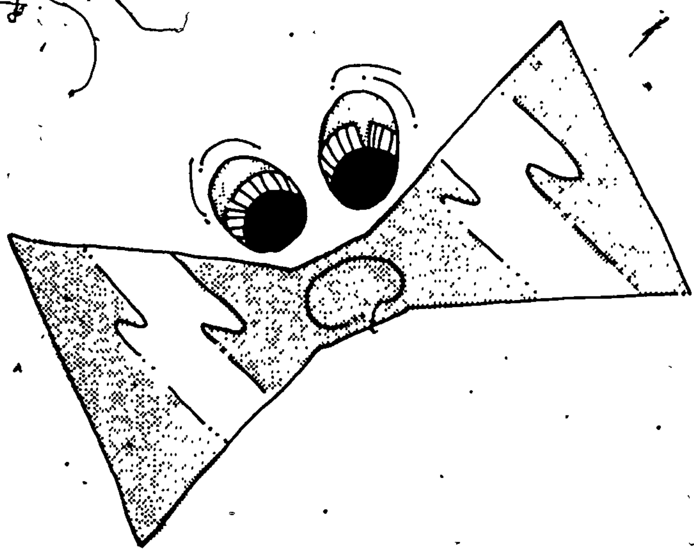


Connect all the wires but one. Connect the last wire and start timing: watch the meter and the fuse! How long does it take for the fuse to BLOW?

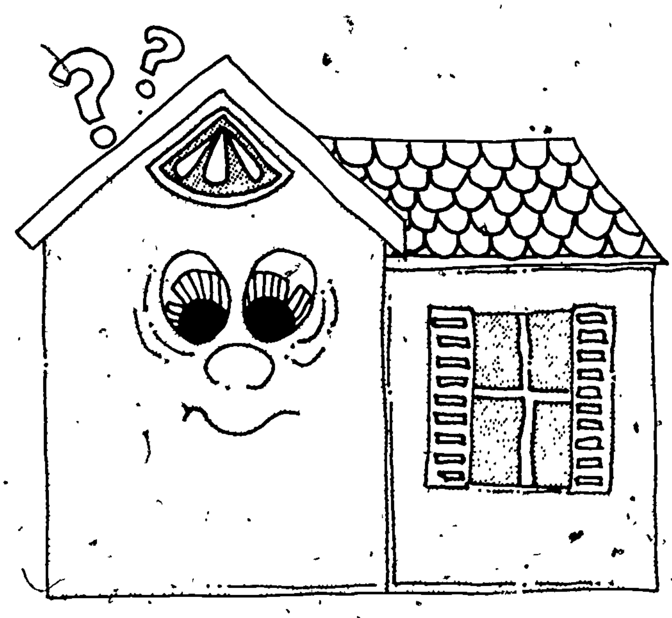
OTHER IDEAS TO EXPLORE:

Would the fuse blow if you used a flashlight lamp instead of a meter in the circuit?





Would the fuse blow faster if the middle part were wider?

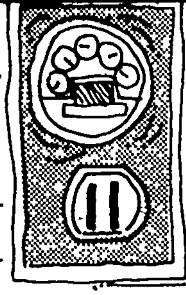


Does your house have fuses or circuit breakers to

otect it ?

HOW MUCH ELECTRICITY DOES YOUR FAMILY USE AT HOME IN 1 DAY?

16



MATERIALS:

Kwh = kilowatt hour!

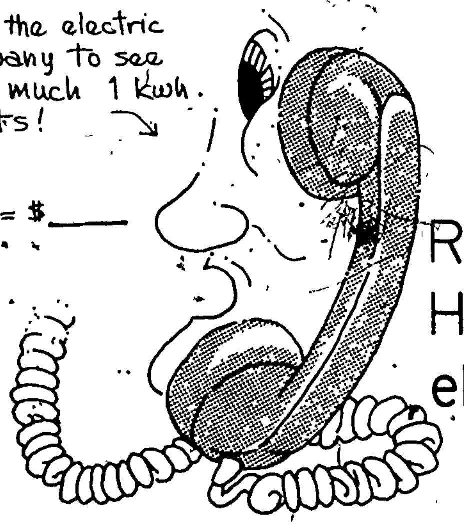
- Kwh meter at home
- Demonstration kwh meter for teacher

sample meter on back!

Practice reading a meter, then find the one in your home. Record the readings for 2 days. Subtract: how many kilowatt hours did you use? How does your use compare with that of other families?

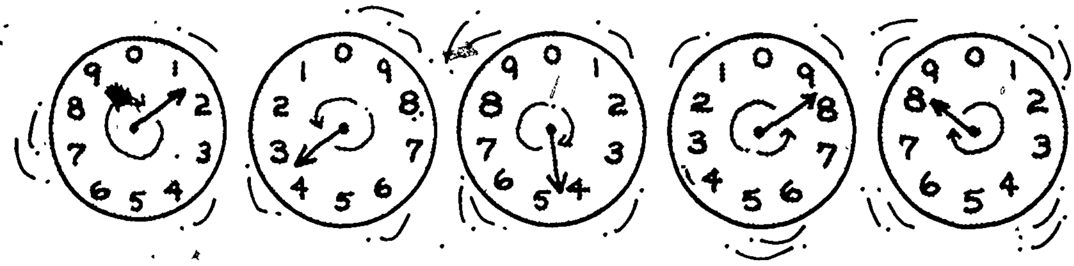
Call the electric company to see how much 1 kwh costs!

1 kwh = $____



Record electric use for 1 week. How much did one day's electricity cost?

HOW TO READ
YOUR
ELECTRIC METER



Read the dials from right to left and copy the numbers in the same order.

When the indicator lies between two numbers, record the number it just passed. (It will always be the smaller number!)

The number above would be recorded like this: * 13488 !

Note: The teacher should have each student make a model meter with movable hands or make one large meter for the whole classroom to practice reading.

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TEACHER'S SUPPLEMENT—CHEMICAL ENERGY

1. **How much stronger is an electromagnet made on a bolt than on a pencil?**

This experiment introduces the student to the concept of the magnetic field and the use of electromagnets. Familiarity with both is required to understand how electricity is made and how it is measured. Iron concentrates the magnetic field and produces a heightened effect.

2. **Which uses more electricity: an electromagnet or a small flashlight bulb?**

In order to gauge the amount of electricity used by one instrument or another, a measuring instrument must be used with each device. The simple but burn-out proof meter used in this experiment operates on the principle that the more electricity going through a coil, the stronger the magnetic field produced.

3. **How can you tell which pole of a battery is positive if it's hidden in a shoe box?**

There are two kinds of electricity direct current (D.C.) and alternating current (A.C.) When D.C. electricity is applied to a potato, it electrolyzes the salt in the potato and produces copper chloride on the positive wire.

4. **What is the most electricity you can make using a magnet and a coil?**

This experiment demonstrates one fundamental way of making electricity by using mechanical energy. The relative motion between a magnet and a coil generates electricity.

5. **How fast do you have to turn a bicycle wheel to generate enough electricity to light a small lamp?**

This approximates the way most electricity is made today, namely, through mechanical motion. In the experiment, the movement of the bicycle wheel turns the generator which produces electricity. In "the real world" steam and falling water turn the generators.

6. **How much hydrogen and oxygen can you make in five minutes by splitting water with electricity from a battery?**

One of the major industrial uses of electricity is in making aluminum, magnesium, and refined copper by electrolysis. One possible means of storing solar energy is to convert it to electricity and then use the electricity to make hydrogen by electrolysis of water. The hydrogen so produced is an excellent fuel for internal combustion engines and may consequently be used to power cars.

7. **How long does it take to copperplate a safety pin?**

Another important industrial use of electricity is the plating of metals. This requires direct current electricity and a suitable chemical solution. Car bumpers are a common example of electroplated metal.

8. **Will 2 cells make a lamp light twice as bright?**

The most common use of electricity is for illumination. There are only two ways to connect lights. in series or parallel. Students can explore both of these ways.

9. **How much more light does a 40 watt fluorescent lamp give off than a 40 watt incandescent lamp?**

Fluorescents are much more efficient than incandescents in converting electricity to light. You can prove this to yourself by carefully touching a 40 watt fluorescent lamp and then a 40 watt incandescent lamp. A large part of the electrical energy is wasted in an incandescent lamp.

10. **How much electricity does an LED use compared to a small electric lamp?**

LEDs (light emitting diodes) are extremely efficient solid state devices for converting electricity into light. If lamps could be devised using the LED principle, an enormous saving in electricity would be possible.

11. **How warm does a 1/4 cup of cold water get when when a small lamp is put in it for five minutes?**

This experiment demonstrates that a great deal of the electricity used by an incandescent lamp generates heat, not light.

12. **Does a 6-turn armature go faster than a 3-turn armature?**

This is a very simple, inexpensive motor requiring almost no special materials. It is not self-starting. Electricity flows in the coil only half the time. The coil is attracted or repelled by the magnet when electricity flows, and coasts when electricity cannot go through the coil. Power is very limited.

13. **How many different ways can you discover for reversing the direction a D.C. motor turns?**

There are many ways of controlling the speed and direction a D.C. motor turns. D.C. motors have many uses in both homes and industry. (Purchase motor kits from The Discovery Shop, American Museum of Atomic Energy, P.O. Box 117, Oak Ridge, TN 37830.)

14. **What can you do to make a buzzer louder?**

Buzzers, bells, and relays all make use of the same basic principle: electricity passing through a coil thereby creating an electromagnet. One way to make the buzzer louder is to increase the strength of the electromagnet.

15. **How long does it take a fuse to stop the flow of electricity through a meter?**

In order to protect homes, cars, and buildings from fire, a metal that melts is used to interrupt the flow of electricity in case too much electricity is being used.

16. **How much electricity does your family use at home in 1 day?**

Students should learn how to read the electric meter.