THE EXPERIMENTALIST

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Editorial

In today's modern world, everyone should know something about electricity, especially if you have electricity supplied to your home. It is also true if you have no electricity supply, but have a cell phone and want to charge the battery.

Future editions of The Experimentalist will give details of simple methods of charging batteries without a supply of electricity to your house. If you are a school student, you also need to understand electricity for your exams.

Of course you learn the theory in school books, but you probably do not have practical work experience. This edition of "The Experimentalist" demonstrates practical experiences to complement your theoretical studies.

This edition presents the first part of a series of lessons on electricity. Future editions will continue to follow the course and will include electronics. You must do experiments for yourself.

You will find it interesting to make a model of an electric motor, described in these pages. Make one; you can easily get the necessary things.

This magazine is written by the Grupo Faísca (The Spark Group). An article in this edition describes some of the work of the Group.

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Electricity Course - Part 1

Introduction

This article is part of a series - a practical course of electricity for use by people interested in science and technology. It is in large part a course of practical activities generally taking advantage of simple materials, local resources, etc.. It begins with simple ideas and practices fundamental for beginners. That is, people who have never actually connected an electrical circuit.

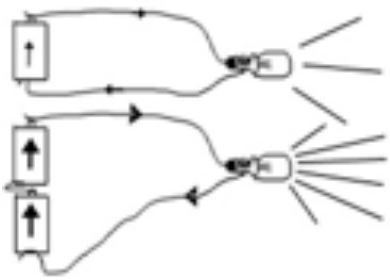
Fundamentals of Electricity

A metal seems solid, but actually consists of particles (molecules) and spaces between the particles. In these spaces, there are other very tiny particles. These are particles of electricity, 'free electrons' (electrons can flow between the molecules) that always exist in large quantities in metals.

Batteries

A battery works like a water pump. A pump does not produce water, it only pumps water. (Water enters and leaves.)
A battery doesn't produce electricity, it only pumps the electrons. Many people don't know this, but it is a fundamental concept.
A stream of electrons flows in a wire when there is a complete circuit. They run in the wires of the 'circuit' (which is a metallic path between the output and input of the battery). Always the same electrons circulate.
We use the name 'current' (without writing 'electricic').
Inside the battery a chemical action forces the free electrons to move.

A cell has a 'voltage' produced by the chemicals inside the cell.
The voltage indicates the strength, 'Electric Motive Power' ('EMF') that the cell has to force the current through a wire. If the force is large (high voltage), it sends a higher current through the wire and through the filament of a bulb (if the circuit includes a lamp).
The arrow represents the current.



If we double the EMF (for example, if we use 2 batteries) we double the current flowing in the circuit.
The unit of voltage is the 'Volt', named for Alessandro Volta (born 1745), an Italian who invented several batteries.

< Alessander Volta

The original type of a battery of Volta. It has 30 cells. >

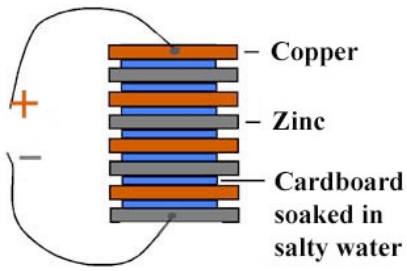


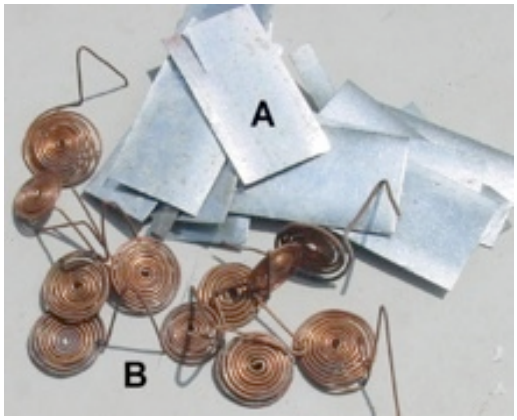
Diagram of a 4-cell Volta battery.
Each 'cell' of this battery consists of:
- A plate of zinc (negative contact).
- Cloth or paper soaked in salt water

or lemon juice (an acid).
- Copper Plate (positive contact)

Any two different metals work, but the best are copper and zinc (or carbon can be substituted for copper).

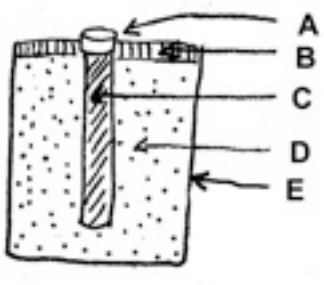
Make yourself a Volta battery

A - zinc plates cut from an old battery.
B - Spirals of thick copper wire (from old cables). (Copper plates are difficult to obtain).
You also need some pieces of cardboard soaked in salty water.
Assemble them like the diagram on the previous page.



George Leclanché

A modern battery ('dry cell') has a voltage of 1.5 volts.
The interior (simplified) is as shown in the diagram. >
A - Positive Contact
B - Cover of tar and plastic
C - carbon rod
D - mass of black manganese dioxide and ammonium chloride (a 'salt')
E - Zinc



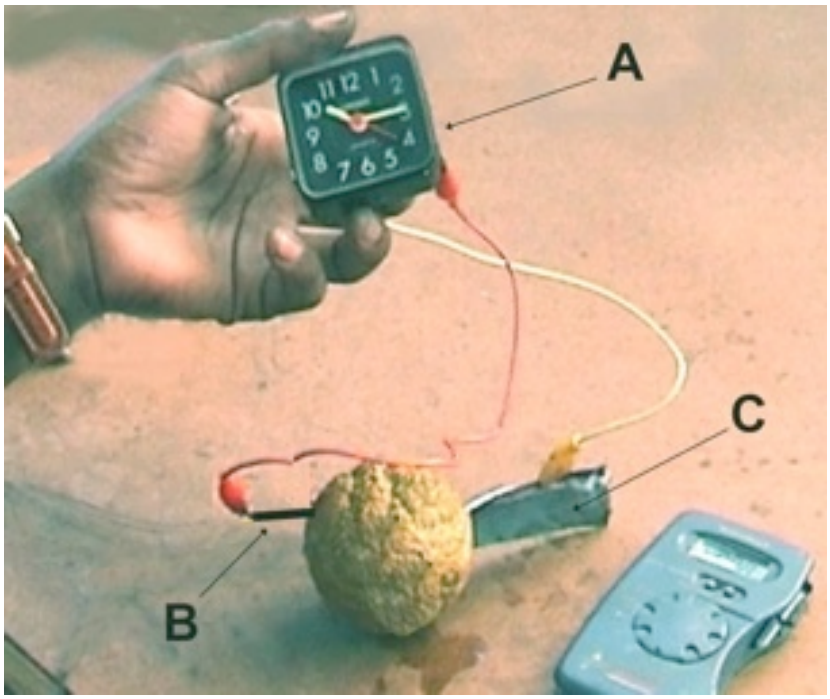
The original version of this battery type (wet cell), was invented by George Leclanché (1866) >

A battery made from a lemon

A - Clock that usually works with a battery.

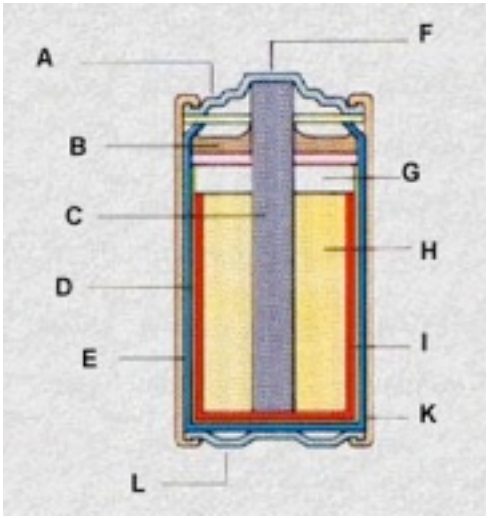
B - Carbon rod from an old battery. Clean it well, scraping with a knife or sandpaper. Insert deeply into the lemon. (Carbon is better than copper.)

C - Sheet of zinc (zinc roofing sheet or from an old battery well cleaned). Insert deeply into the lemon.



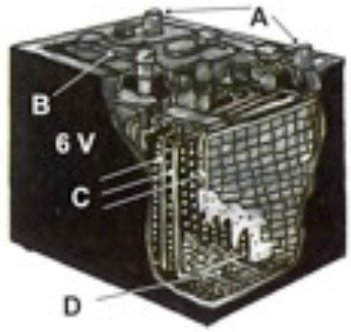
Instead of a lemon, you can use a fruit that has an acidic juice, or a potato (which has a high salt).
Voltage = 1.4 Volts. Maximum current = 0.05 Amperes*. The carbon is positive.
Two of these cells can operate an electric clock.
* The unit of current is the 'Ampere', (or 'amp' or simply 'A' when abbreviated).

A modern dry cell - a more detailed diagram.



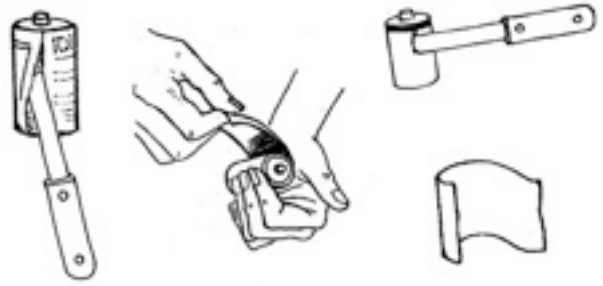
A - Cover
B - Tar to cover.
C - Carbon rod
D - Separator
E - zinc container
F - Metal Cover (positive contact)
G - Air Space
H - Black Mass. Manganese dioxide and coke, mixed with:
I - Electrolyte. Salt solution (ammonium chloride)
K - Cover of paper or metal
L - Tampa lower and negative contact

A cell of a rechargeable battery has 1.2 volts. Other cells are, for example, 9-volt (6 cells have, each of 1.5 volts). There are many types of batteries.



Experiment

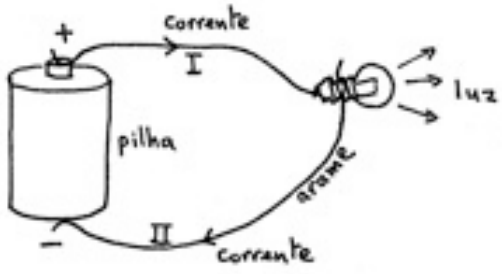
Dismantle a battery to see the components inside.

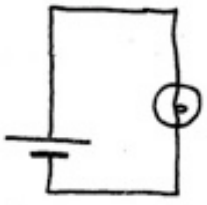


A car battery

A car battery of 12.6 volts (it has 6 cells, each of 2.1 volts). Or 6.3 V (3 cells).

A - Terminals. (Lugs)
B - Connection between two cells
C - Plates. Networks filled with lead sulphate and lead peroxide.
D - All filled with sulfuric acid diluted with distilled water.





Electric Current

Electricity runs through a 'conductor' (usually a metal wire).
If the wire is connected between the output and input of a cell (via a lamp for example), the chemical action on the battery forces the free electrons along the wire, bulb and battery. In the diagram below' the current is indicated by arrows.

The current is equal in both wires, the battery and the bulb. It does not leave the sides of the wires because the air does not conduct. The air has no free electrons.

In the diagram, the current passes along the wire I, then through the lamp filament, and then along the wire II: through the battery again, and so on.

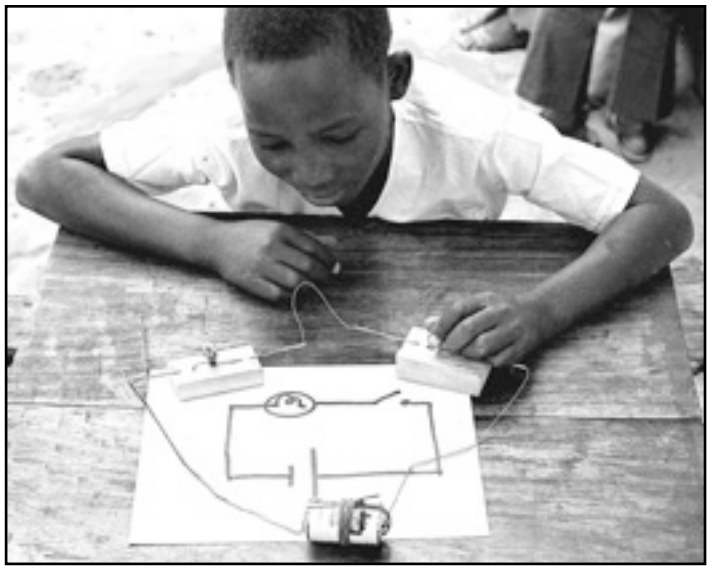
Below,the same circuit in symbols.
The current unit is 'Ampere', (or 'amp' or simply 'A').

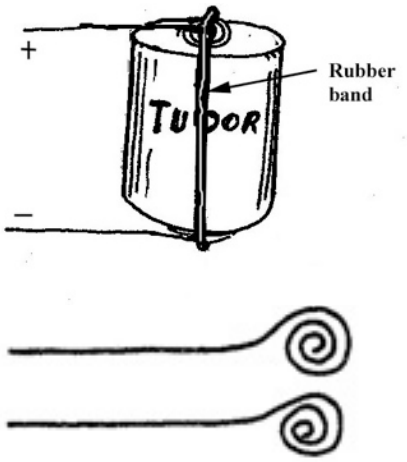
Units such as 'A' and 'Volt' and 'Ohm' have initial capital letters because they are the names of people. (And the abbreviations 'A', 'V' and 'Ω'). Other units such as 'cm' (cm) or 'liter' (l), use small case letters.

Experiment
With wire, battery and lamp, you can make your own circuit like this. The current direction makes no difference.

A current that goes in any direction heats up the filament.

Generally, you use copper wire or aluminum to conduct a current, but to experiment you can use galvanized iron wire because it is cheaper.





To hold the wires to the battery, cut a rubber ring from a bicycle inner tube. Or use a strip of rubber or a length of cotton thread.

The wires are shaped in a spiral for better contact with the battery.

Today, in the market, a lamp and a battery cost little. It is worth buying these components to experiment making electrical circuits. It costs very little to learn a lot.

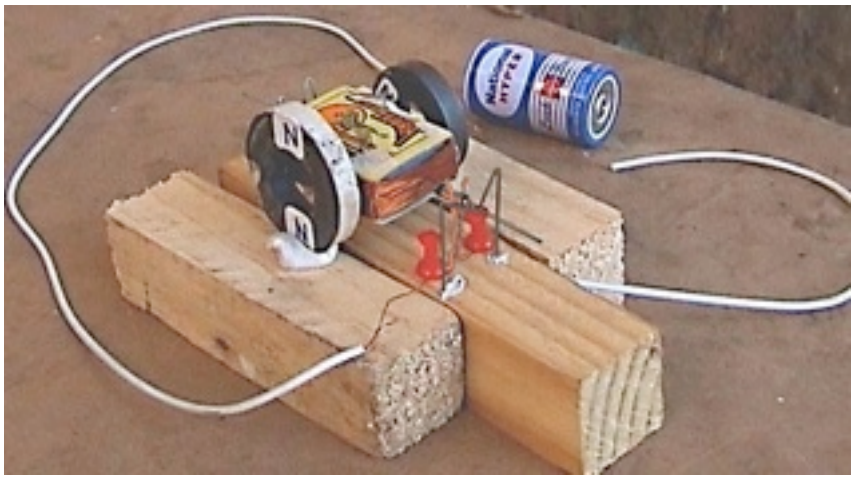
Caution! Do not connect the positive (+) cell to the negative (-) directly with wire. The chemicals inside the battery get used up very quickly. It's called a 'short circuit'.

Dirt on the wires
Sometimes, the wires are rusted on the surface. This ‘oxide’ does not conduct well. It is sometimes necessary to scrape the edges that contact the battery and bulb.

An Electric motor

Next comes an interesting experiment; the directions for how to make a model of an electric motor that works well. It shows very well the electro-magnetic principles that connect the magnetic field, electric current and movement.

It is made of easily obtained materials.



How to make an Electric Motor

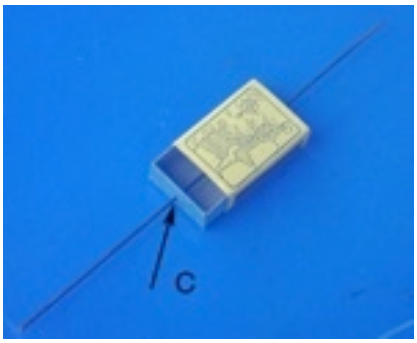
Preparating the axle

Exactly in the center of each end of an empty matchbox make a small hole with a piece of thin stiff wire. To find the centre, see the photo.

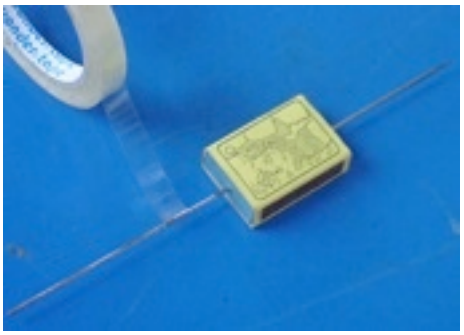
Straighten a piece of thin wire on a flat surface, hitting it lightly with a hammer.

To make the 'axle' of the motor, use the same type of wire you used to make the holes. You need a piece of about 10 cm long.

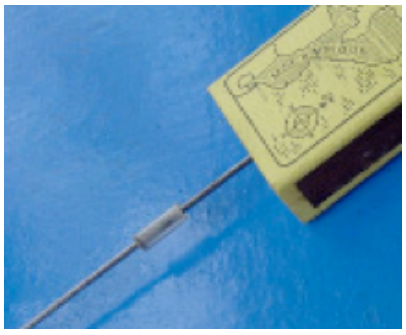
If it has irregularities or rust, remove them with sandpaper, steel wool, or a cloth and sand. Instead of a wire, you can use a piece of bicycle wheel spoke.



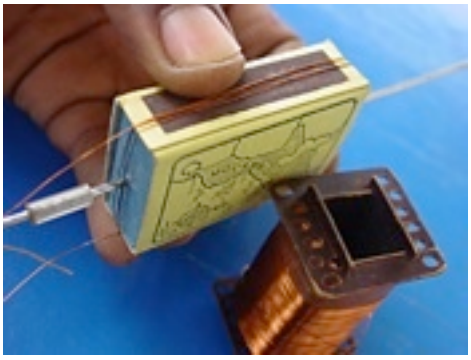
Insert the axle through the holes and secure it with chewing gum (or BlueTack) (C) as shown. (Chewing gum is better than glue because it allows small future adjustments of the commutator.)



Wrap a bit of sticky tape around the shaft.
(The adhesive tape is to isolate the wires from the coil that you will put on later.)

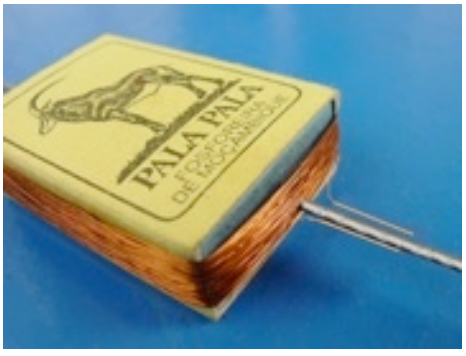


Preparing the coil



Arrange 5 meters of wire covered with thin varnish, (which you can get from an old transformer).

Wrap this wire around the box, making a coil of approx. 30 turns.



Put 15 turns of wire on each side of the axle. Leave a few centimetres of the wires sticking out. This coil is called the ‘armature’.

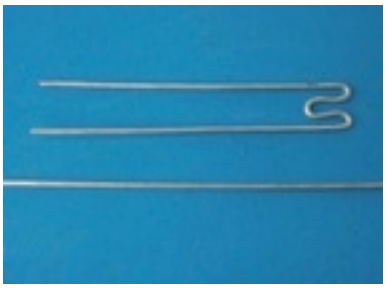
Secure the ends of these wires on the tape with sewing thread. Put some glue on the threads to hold them.

Note that these wires on the tape are not in just any position. They should be in the same plane as the coil. These wires and the tape are called the 'commutator'.

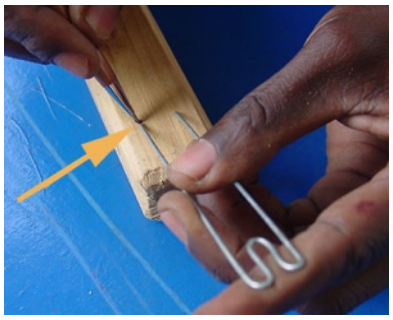
Scratch the brushes lightly to remove the varnish (to allow the 'brushes' to be in good contact with the copper as described later).

Scrape carefully so as not to damage the wire.

Base and supports for the armature



Mark the positions on the base of where to put the axle supports.

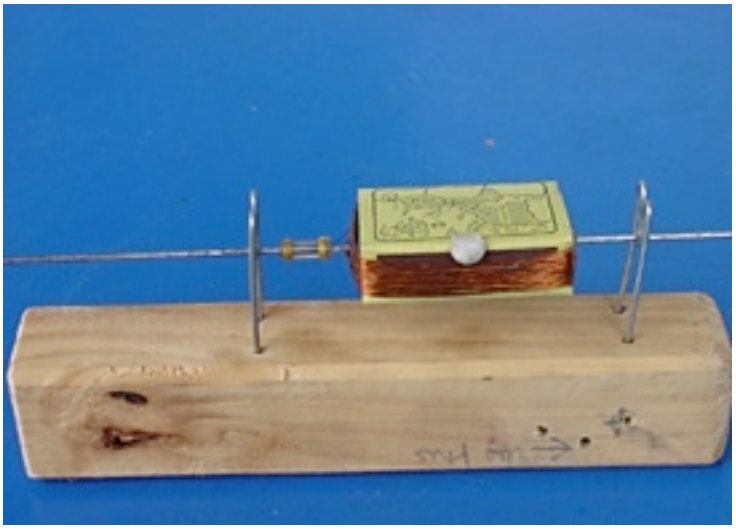


Prepare blocks of wood, 2 about 4x4x5 cm and one of 4x4x10. The midddle one is the base of the motor.

With wire, make supports for the axle.

With a thin nail, make small holes in the block to insert the axle supports.

Then take out the nail and insert the supports.

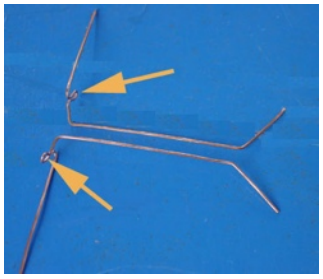


Put the armature in the supports.

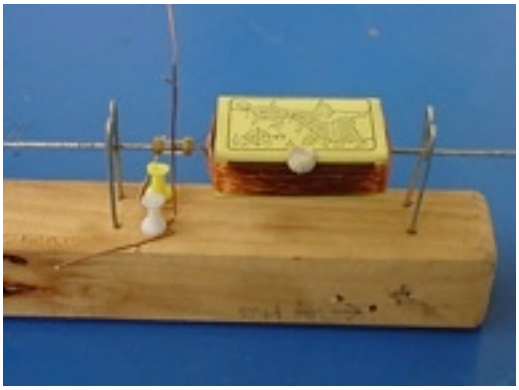
Check that the armature rotates well. If it isn’t balanced, place a piece of chewing gum to balance it.
Rotate it to see that doesn’t always stop in the same place (which indicates that one side is heavier). This is important: it must not have one side heavier than the other. Adjust the piece of gum until you manage to get it well balanced.

The brushes

You have to arrange two thin wires of copper to touch lightly on the commutator. These copper wires can be obtained from the interior of an electrical cable.



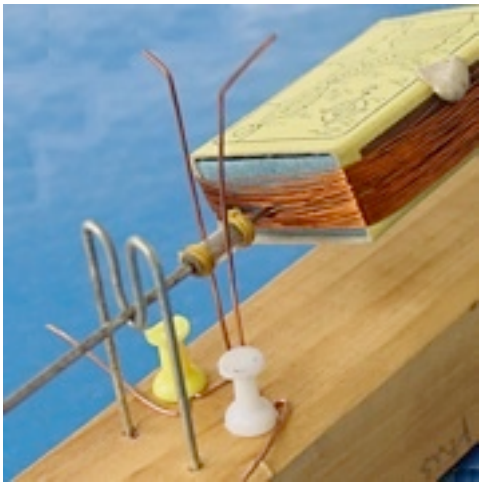
Bend them to the form shown in the figure.
These wires are called the 'brushes'. Can you see the loops for the small nails that will later fix the brushes?
The length of the brushes depends on the size of the magnets that will be put in later.



Fix the brushes in the position shown in the photo.

The brushes should be placed so as to contact wires of the commutator to supply electric current to the coil.
Fasten these wires at the base with small nails. The picture shows small nails with plastic heads, but any small nails will serve.

The brushes must be strong enough to maintain contact with the wires of the commutator, but should not press so hard that they impede the rotation of the armature.

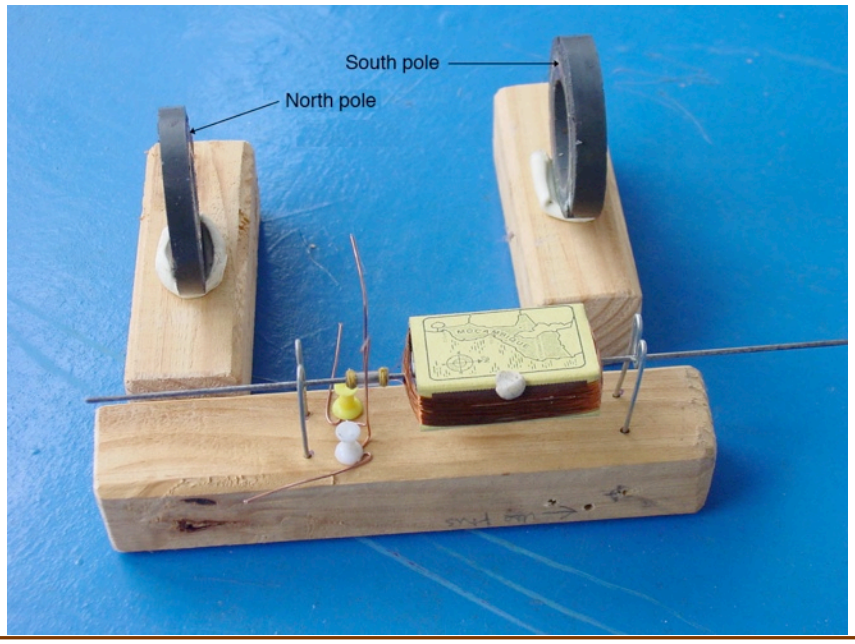


The magnets

The magnets used are taken from old speakers.

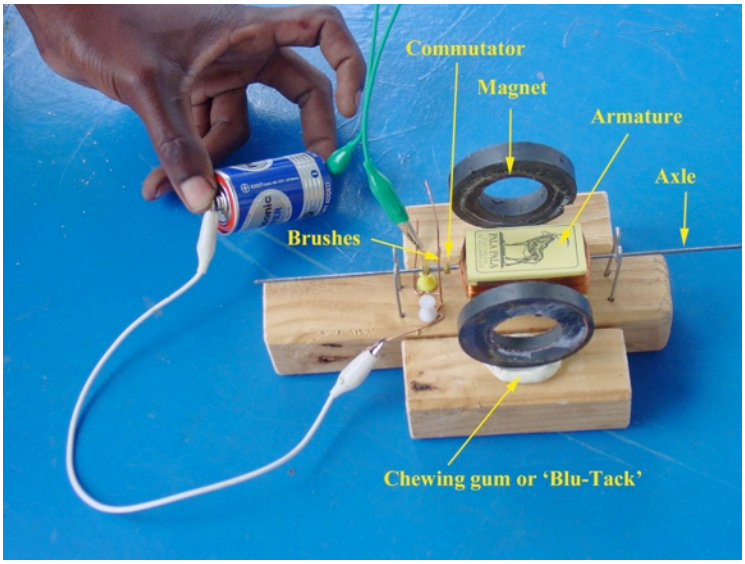
The photo shows how to take them out of the speaker with a knife and hammer. Be careful, they are fragile.
(They are made of a type of ceramic.)

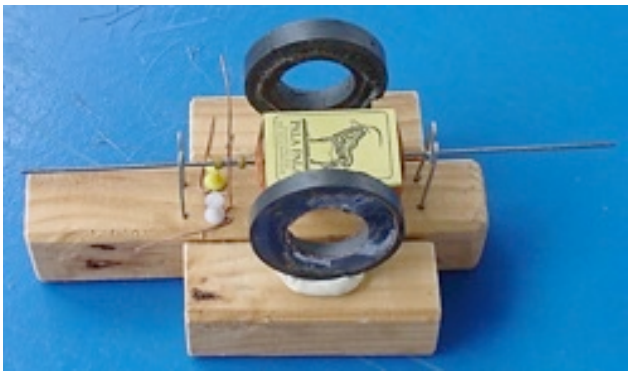
Fix the two magnets on a wooden base with chewing gum and place them near the sides of the armature. The north pole of one magnet faces the south pole of the other. The picture shows everything ready before putting the magnets in position.



The motor ready

Finally, the motor is ready.
Connect the wires of the brushes to one or two batteries.
Give it a slight boost with your finger to start the movement of the armature.
If the armature does not turn, the problems can be:





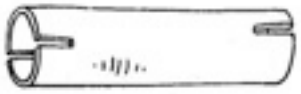
- South of one magnet does not face North of the other.
- The armature wires are oxidized or dirty. Clean them lightly with a knife.
- The wires of the commutator are in the wrong position. Hold the shaft with your fingers and turn the coil a little. The correct position is when the wires of the commutator are in line with the sides of the coil.
- There is more friction between the axle and the supports. Clean them and put a drop of thin oil on them.

How to make a Bamboo Torch

Get a piece of bamboo that will fit two big batteries inside.

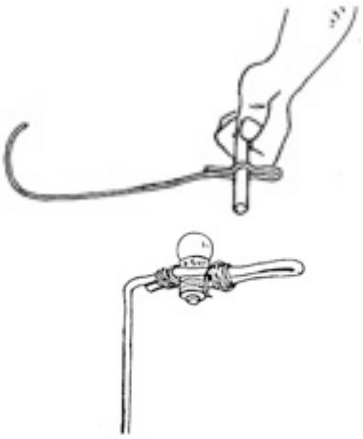
Cut a strip of paper. Wrap it around the bamboo. With a pencil, trace along the edge of the paper so that you have a line around the bamboo.
Remove the paper and cut it along the line. Cut it the length of two batteries plus another 4 centimetres. Use a hacksaw blade because it has small teeth and cuts neatly, without leaving a 'beard'.

First, make a shallow cut around the bamboo. This is a guide for the saw. Then cut through the bamboo. Try to do it very neatly.



Cut two slits in each end. We are going to put wire in these.

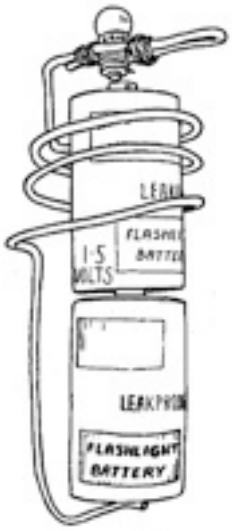
Use thick, galvanized wire. (Wire that can bend fairly easily with pliers, not steel as it is hard to bend. Neither must the wire be too thin.) You need half a metre. (50cms)



Bend the wire in two semicircles with the diameter of a 2.5 volt bulb. It is difficult but not too hard. Do not bend it round the bulb or the bulb will break. Bend it round a stick or a pencil.

Secure the bulb to the wire with cotton thread. Bend the wire to make it fit into the slots at the upper end of the bamboo.

Then bend the end so that it fits into the slot at the other end of the bamboo.
Now, it almost touches the bottom of the battery.

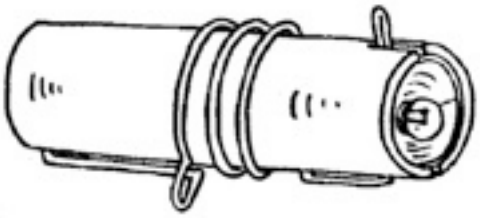


The drawing shows the wire, batteries and bulb without the bamboo.

Experiment to see if it works without the bamboo. The bottom should not touch the battery before pressing the wire up. Note that this wire has a small loop in it.
This is to press up to put the bottom of the wire in contact with the base of the battery.

Then bend the wire so that a part goes straight along the side of the bamboo.
Then bend the wire around the bamboo - three neat turns.

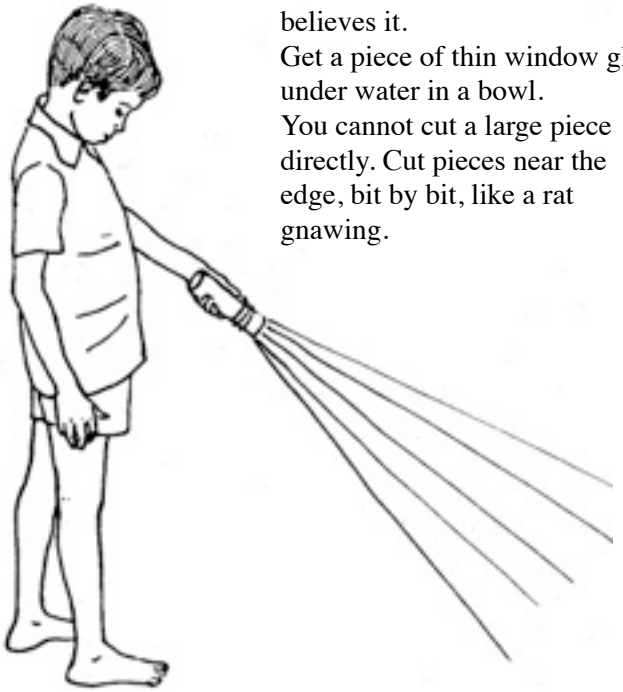
Cut a reflector from silver paper from a pack of cigarettes or sweets. Secure it around the bulb.

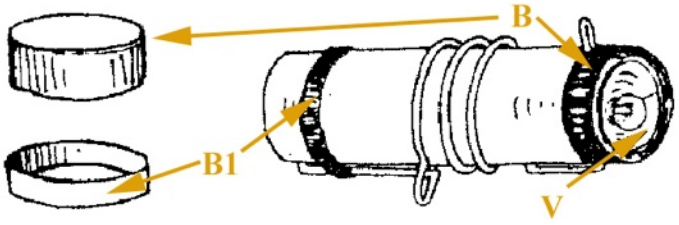


Now the torch is basically complete.

Improvements
Bind the top of the wire with thread or with a band of bicycle inner tube to hold the wire and bulb in place.

Cutting glass
Did you know that you can cut glass with normal scissors? Almost nobody believes it.
Get a piece of thin window glass. Cut it under water in a bowl.
You cannot cut a large piece directly. Cut pieces near the edge, bit by bit, like a rat gnawing.





Cut slowly to make a circle the same diameter as the bamboo. Then cut a piece of a bicycle inner tube to fix the glass to the bamboo. 'V' = glass. 'B' and 'B1' = Rubber.
Now when you put the batteries in, it acts as a real flashlight.

Here is the flashlight complete. Press the wire to the battery at the end, and the light comes on.

Talk to your friends - with video!

Skype is a software that allows Internet communication.

Skype is a global Internet communications business, allowing free voice and video communication between users of the software. Skype is available in 27 languages and is used in almost all countries. Skype allows communication to and from landlines and mobiles, voicemail, call forwarding and personalization including ringtones and avatars.

To transmit video, your computer must have a camera. Otherwise, you can only use voice.

Or buy a camera to connect to the PC with a USB connector. >

Or use a video camera. >

Skype also offers the services 'SkypeIn' and 'SkypeOut', which are paid and operate at reduced rates. The SkypeIn is an access code that allows people to use standard telephones and cell phones to call their Skype. Conversely, SkypeOut is an easy and economical alternative to call landlines and mobiles worldwide via Skype.

Features

Unlimited communication and free to other Skype users worldwide.

Sound quality

The contact list shows you when your Skype friends are online and available to talk.
With Skype you can chat, send archives and talk to many people at once at a conference.

Skypecast is a free service that allows Skype conversations with up to one hundred people at once.

Share and work the same file between two Skype users.

To register Skype, go to http://www.skype.com/intl/pt/welcomeback/

Skype is available for certain cell phones that have the Windows Mobile program.

Demonstrations in schools

The young 'Spark Group' take demonstrations of science experiments to schools, such as electromagnets, windmills with electric generators, solar cookers, etc.. The members are: Manuel, Lawrence, Alves, Pedro, Acacio, and Teresa Laquidino. In 2008, they gave eight of these demonstrations in and near Maputo and Katembe.

The photos show the group in action.

In fact, these demonstrations are important in the education system. In most of our schools, the students have never seen practical science experiments.

Car Protection?

Nowadays in Mozambique, cars suffer many accidents. Many have damaged bodywork. It costs a lot to fix them. How to avoid this situation?

The idea came when we crossed the water in the boat 'Mapapai' Maputo/ Catembe. Many local boats have old car tires hanging on the sides. When the boat bumps into another boat or barge, the tires protect it against damage.

Why not apply the same idea to our cars? It costs nothing, the garages have many old tires.

We experimented with a car in the hope that all the world will copy the idea. We took a photo.