

THE EXPERIMENTALIST

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Technology: Wind Turbines and Generators - 2

Construction: The Galvanometer

Community: Mosquito Trap

World Technology: The Large Hadron Collider

Editorial

Less than five percent of households in Mozambique have electricity supplied to the house. To provide for all within the next few years would be impossible; imagine the amount of posts, cables and transformers that would be needed! But today, energy is essential for anyone who wants a more modern life.

All the world wants at least light in the home - a candle or a kerosene tin with a wick in it, which are too dim to study by. How can our children study at night? Batteries for torches are too expensive to use for a long time. Perhaps you have sufficient money to buy a rechargeable battery, but how can you charge it?

A solar panel would be good but it costs too much. Are there alternatives? The photos above show members of the Spark Group developing their wind generator, and a small wind generator on a Mozambican house.



(Rev: 2011/09/22 15:45)

In several countries, wind generators of electricity are used. In general, these also cost a lot, but it is possible to produce cheaper versions.

The Spark Group of KaTembe already have wind turbines that cost very little. In this edition of The Experimentalist, we describe one of these. They can be made by a carpenter in a village or even a boy at the secondary level that has simple tools. They are not powerful – not able to operate a stove or a water heater but are suitable for operating a radio and providing light at night and charging a cell phone.

But for many families it would be better to buy one already made by a commercial firm. Unfortunately, commercial manufacturers want to sell at high prices. But the manager of a factory should have a different ‘philosophy’.

Instead of building and selling generators at high prices to a few people he should think about making the simple versions to sell at low prices to thousands of families. The "market" is big.

Wind Turbines and Generators - Part 2

Recently, we made another turbine.

Here are our first pictures, taken as we were making it.

You can see what we did, looking at the pictures below. These are not perfect and complete instructions. We are still trying to make the best turbine. Therefore you should consider this as a turbine experiment. You must be an experimentalist. You will be doing practical research.

We hope eventually to make a larger turbine (say two meters in diameter) which we hope will produce enough electricity to power a small television set.

Of course, the generator must charge a battery so that there is a store of energy when there is no wind. (We describe how to connect the generator to a battery at the end of this article.)

How to make the turbine

Cut a bucket in 2 equal halves.

Cut a disk of hardboard, 55 cm in diameter.

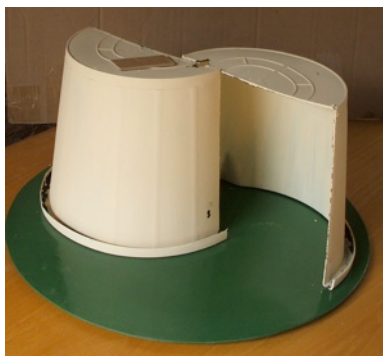
In the centre, cut a hole slightly wider than the “shaft”.

The shaft is an aluminum tube (the kind used to mount TV antennas, about 2.5 cm diameter.) Or it may be bamboo.

The lower end of the shaft is fixed in the ground in the experiments shown here, but in practice it is fixed at the top of a tall mast so that it catches a good wind.

The second photo shows the halves of the bucket (the "blades" of the turbine) mounted on the disk.

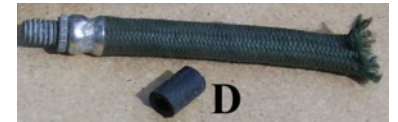
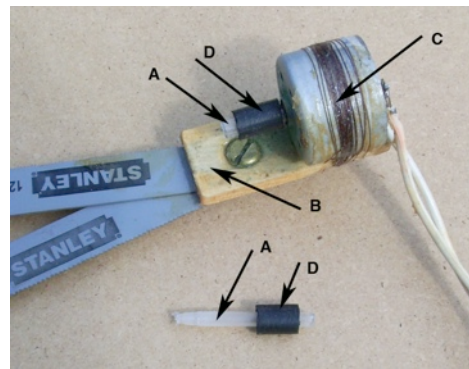
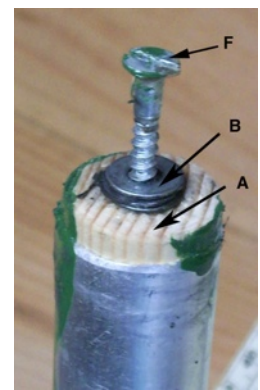
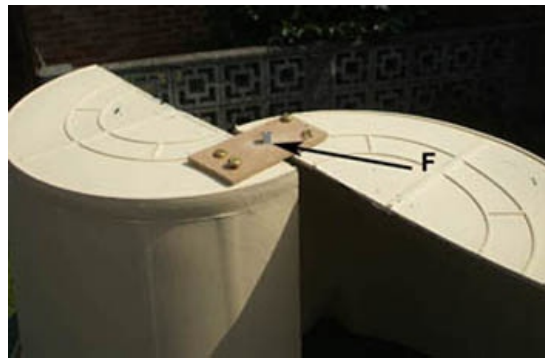
Attach the blades to the disk by screws
Make sure that everything is symmetrical.



The halves of the bucket are joined on top with a small piece of hardboard and bolts and nuts. Before attaching the bit of hardboard, make a hole in the middle of it. The hole must be exactly vertically above the hole in the disk.

The screw **F** goes through the bit of hardboard into a wooden plug **A** in the top of the shaft. Notice that the shaft does not rotate. Only the disk and the blades rotate. There are washers **B** (and Vaseline) on top of the plug so that there is almost no friction between the plug and hardboard.

The shaft must be slightly loose in the hole in the disk so the disk can rotate freely. Use a bit of Vaseline to lubricate the hole.



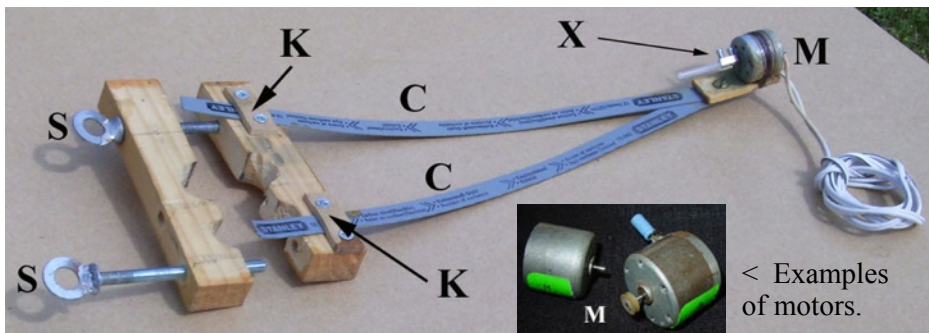
The generator

The generator is a motor from a toy car or an old tape recorder. Such motors also work as generators and produce about 6 volts.

Try to get a motor with a pulley. Then you can stick a bigger wheel to the pulley. It is very difficult to fix a wheel directly on the thin shaft of a motor.

In our experiment, **D** is the generator pulley. It is made from a piece from the inner tube of a ballpoint pen **A**. Then, on the top of that is a piece of pipe cut from the connector between a bicycle pump and a tire valve, secured with Super Glue.

X is another attempt at making a pulley. You will have to experiment making an appropriate pulley.



Now we have to put the generator in contact with the disk. It goes below the disk, and is held in place with two springs. The springs are hacksaw blades. They should be bent so that they maintain the generator firmly in contact with the disk.

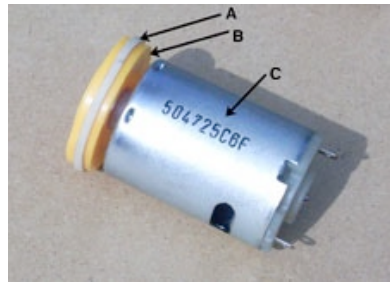
In the photo, the two blocks of wood are clamped around the shaft. They are tightened onto the shaft with the screws **S** and **S**. **C** and **C** are the saw blades. **K** and **K** are two clamps to fasten the blades. They are hardboard pieces, fastened with screws.



Views from below and above before and after painting.



The photo shows a bigger generator, **C**, - the motor from a faulty electric drill - which gives more power. The wheel '**B**' is the cap of a bottle attached to the shaft with Super Glue. It has an elastic band glued (with Super Glue) to ensure good contact with the disc. Wheel **B** is big so that it turns at a slower speed, but with more power. The wheel on the shaft of the generator should not be too small or it will spin too fast in a high wind.



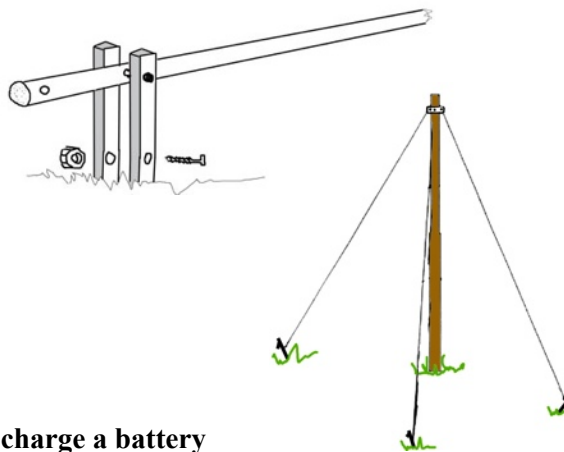
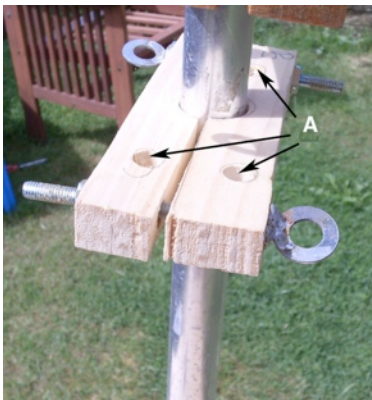
In the photo, the motor **C** is from a 12 volt portable drill.

A is an elastic band, glued with Super Glue, to stop the wheel slipping on the big disk.

Of course you should place the turbine on a high mast or on top of your house to catch a good wind.

The photo shows a clamp to hold the mast below the generator. Strings come from holes **A** to pegs in the ground.

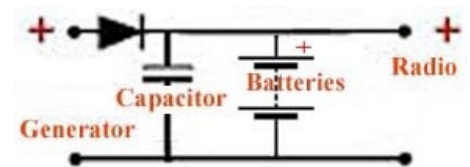
You should try many experiments to get the best performance. It will take a long time to get a good result. Practical research takes a long time.



How to connect the generator to charge a battery

Sometimes there is no wind, so it is necessary to store energy in a rechargeable battery. Use the number of cells suitable for the voltage you want. A single rechargeable cell provides 1.4 volts. Therefore 5 batteries give 7 Volts. The voltage from the little generator from a toy car is too low to charge a 12V car battery but the motor from a portable drill will give the 14 Volts necessary.

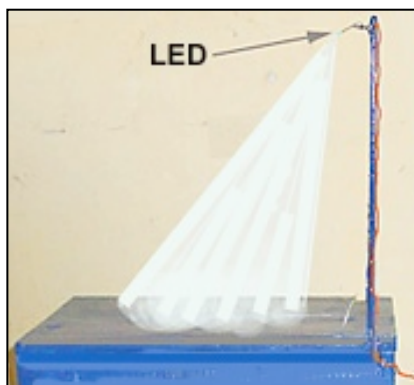
You must put in a diode, a device that allows current to flow in one direction, so that when there is no wind a current does not flow from the batteries to the generator. Without a diode, current will flow to the battery, discharging it.



Symbol of the Diode



Diode



Do not forget to connect a capacitor across the wires. Without it, you will hear noise from the radio rather than music. The value of the capacitor is not important but it should be more than one microfarad.

Now you can connect a radio or light up a table at night. (The lamp must be an LED.) Or you could charge your cell phone.



Condenser

A MOSQUITO TRAP

How to kill mosquitoes ecologically

To fight against mosquitoes, one idea is to bring them into a trap that can kill many of them.

You need:

200 ml of water,
50 grams of brown sugar
1 gram of yeast.
A 1.5 litre plastic bottle

1. Cut a plastic bottle in the middle. Save the neck part - this will serve as a funnel in Step 4.

2. Mix the brown sugar with hot water. Allow to cool and then pour in the bottom half of the bottle.



3. Add the yeast. No need to mix it.
It will create carbon dioxide that attracts mosquitoes.

4. Place the funnel part, upside down, inside the other half of the bottle.

5. Wrap the bottle with something black (leave the top open) and put it in some corner of your house.



In two weeks you will see
the number of mosquitoes
that died inside the bottle.



How to make a Galvanometer

A "galvanometer" is a device for detecting an electrical current.

E1 and **E2** - magnets attached to the piece of iron '**D**' which is in the form of a "U".

F - A coil of fine wire wound on a matchbox.

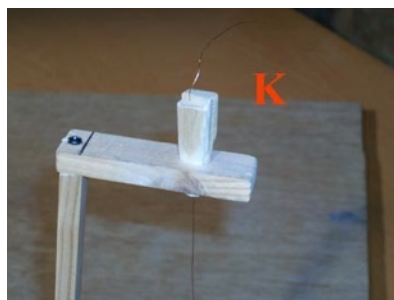
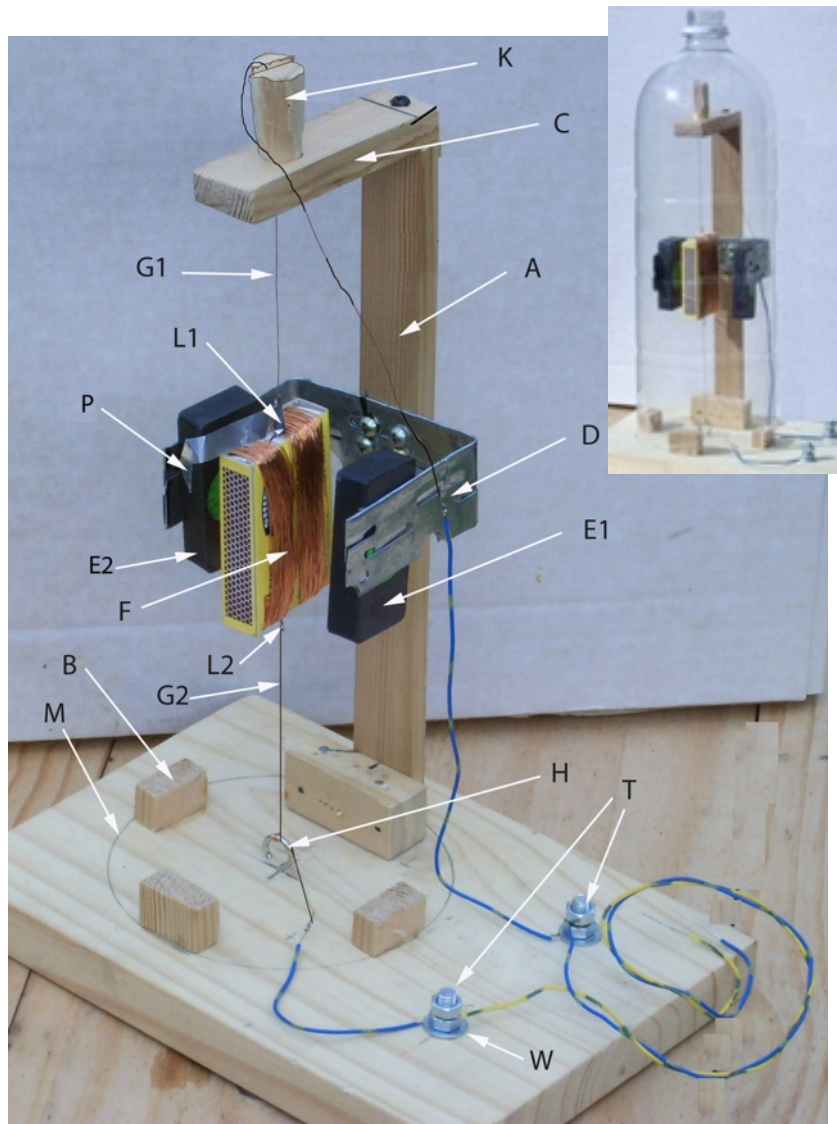
G1 and **G2** - A coil is supported by these two very thin wires, upper and lower. Each one is a continuation of the ends of the coil. The wires are thin to allow the coil to rotate easily. These wires are the connections for the current. They go to the terminals **T**.

When an electric current passes through the coil, the coil turns. (In fact, it oscillates for a few seconds, but gradually stops.)

Thus, one can detect an electrical current. On disconnecting the battery, the coil goes back to where it was - the "zero".

P - pointer so you can see how the coil moves. It is made of aluminum foil.

A - The vertical support about 15 cm high.



C - Arm support. It has a hole that must be exactly vertically over the hook **H**. The wire is passed through a circular wedge, split in half, that holds the wire **K**.

T - Terminals - bolts and nuts.

In the small photo on top of the main photo you can see that the galvanometer is protected by a large plastic bottle with the bottom cut off.

On the side of the bottle there are calibrations to measure the movement of the pointer.

M - Circle on the base where the bottle will fit. Mark the center and put in a hook or nail **H**, to hold the wire coming from the lower coil.

B - Small blocks of wood to hold the bottle in the right place.

L1 and **L2** - Pieces of rigid wire glued into holes in the matchbox. Araldite glue is good because it solidifies quickly.

How to make the coil

Mark the centre of the ends of a matchbox and make holes with a pin.

Through these holes, glue short stiff wires with loops at the ends.

To make the coil you need about 12 metres of very thin wire, enameled (painted with varnish). You can get it from an old transformer.

Leave about 20 cm of wire out before you start winding. First wrap some of this wire around the short stiff wire to fix it.

Then wind 30 turns on each half of the box.

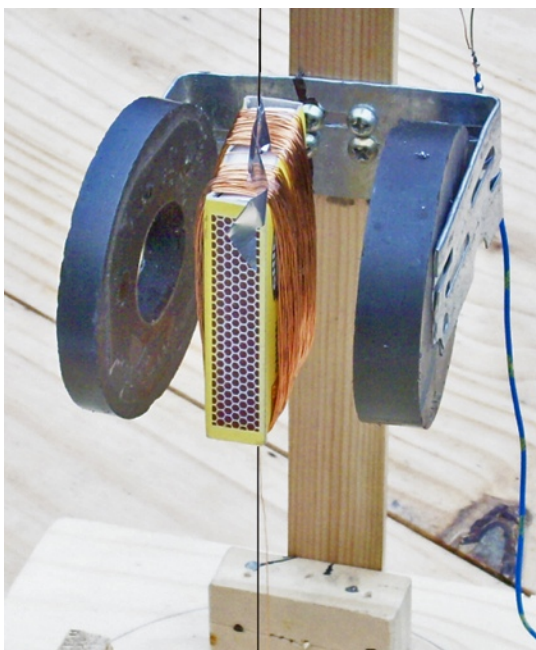
Pull the free ends of the wire through the loop of the short stiff wire as you did at the other end. Leave about 20 cm of the wire sticking out.

Now the coil is finished.



Place a small hook or bent nail (**H**) at the base in the center of the circle in the wooden base. The bottom of the wire is fixed there.

Now you need two magnets. I used old speaker magnets for the first version of the galvanometer, but later I bought rectangular magnets.



The support for the magnets

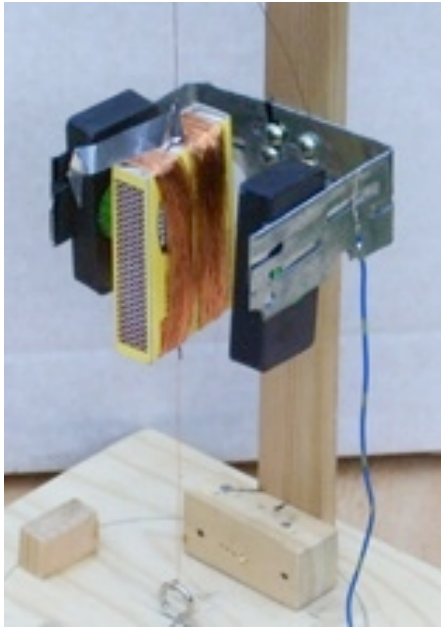
The photo shows the support for the magnets. (We used an old piece of iron.)

Secure the support to the vertical wood with small screws.

The coil should be positioned as seen in the photo. The magnets must be in the correct position, as shown. When the coil rotates it should be very close to the magnets, but not touching them.

If necessary, bend the support until the magnets are in the correct position.

The North pole of one magnet must face the South of the other. Fix the magnets with glue.



Hanging the coil

Suspend the coil by the top wire. This wire is held between the two parts of the wedge. (See **K** two pages above.) Slightly pull the bottom wire and fasten it to the hook and then connect it to the other terminal.

Scrape the varnish off the wire to make good contact with the terminals. The terminals must have washers to hold the wire without cutting it.

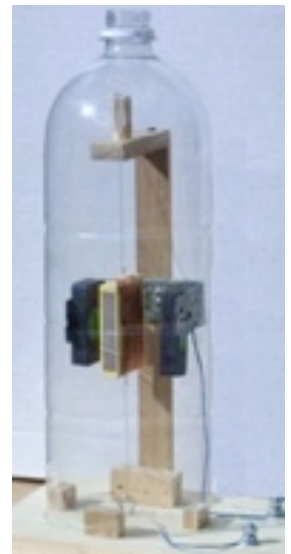
Cut a thin strip of aluminum foil with a point at the end. Attach it to the top of the coil. This is the pointer. >



Turn the wedge **K** that holds the top wire until the sides of the coil are facing the centres of the magnets. This is the position "zero" of the pointer.

Put the cover (the bottle) over the galvanometer to protect it from the wind.

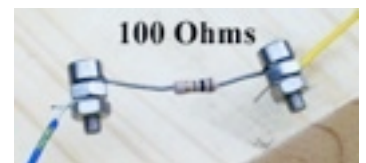
With a fibre pen, mark on the bottle the position where the pointer indicates. This is the zero position when no current flows through the galvanometer.



Connecting to a battery

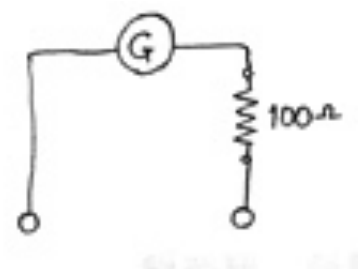
Do not connect the galvo directly to a battery (or it will move very violently).

Decrease the current by putting a resistance of 100 Ohms in series with the galvo. Thus, the current is limited and the galvo works with 1, 2 or 3 batteries.



If you do not have a normal resistor, you can make one with half a pencil. Half an HB pencil has a resistance of about 10 Ohms. The picture shows a resistor with such a connector made of a clothes peg.

A diagram of the galvo with a resistance in series: >



If you connect a battery in the opposite direction, the coil moves in the opposite direction.

With two batteries, the coil moves more.

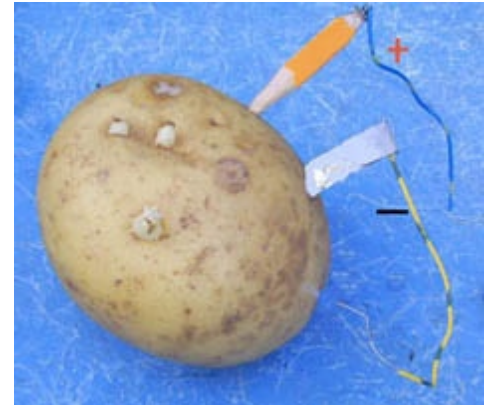
Thus, the galvanometer detects electric current.

A small demonstration:

Insert the graphite from a pencil and a piece of zinc (or tin) into a potato and connect them to the galvo. >

The galvo shows a movement.

In fact this 'potato battery' gives about half a volt.

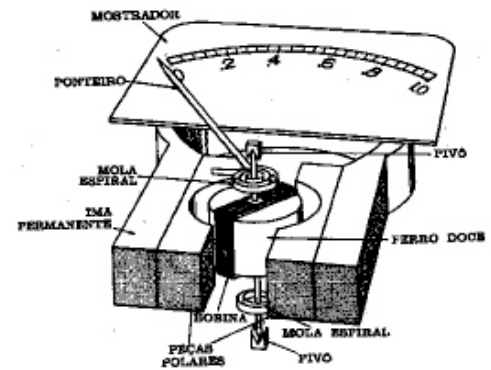


<< The first photo below shows an old galvanometer.

The second and third photos show more modern galvos.

The interior of a more modern galvo. >>

They work on the same principles, but the suspension consists of fine bearings (needles) and coil springs.



A modern electronic digital galvanometer >>



The definition of a galvanometer in the dictionary is:

A device for detecting small currents. A thin coil of wire is suspended between two magnets. One end of the coil connects to a long thin wire hanging from a support. The other end of the coil goes to another long thin wire that goes to a terminal at the base. When a voltage is connected to the terminals, the coil rotates and moves a pointer.

A small mirror glued to the coil is usually used to reflect a ray of light that acts as a pointer and makes a more sensitive and accurate galvanometer.

The galvanometer is very sensitive and will detect a current much less than 1 milliAmpere.



The Autogyro

The photo shows Mr. 'Wing Commander' Ken Wallis flying the plane he built. It is a type called an 'autogyro'. Ken Wallis is an Englishman, ninety-four years old.

The LHC

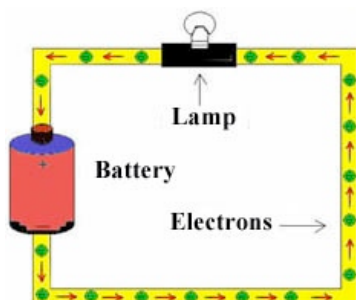
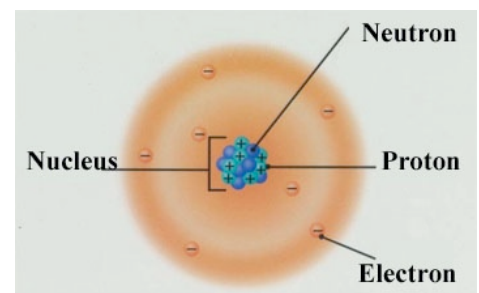
The Large Hadron Collider

The LHC is the largest particle accelerator ever built. It is at the European Organization for Nuclear Research (CERN, acronym in French) operating near Geneva, Switzerland. It causes the collision of two beams of protons at an energy of 7 teraelectron volts, something never observed in the laboratory. The result amounts to a kind miniature Big Bang. Scientists consider the experiment as the beginning of a new era of modern physics.

The LHC is designed to study the behavior of atomic particles at a speed very close to the speed of light.

How the LHC works

Basically, an atom consists of electrons, protons and neutrons. The protons and neutrons are the nucleus. Protons are positively charged and neutrons have no charge. Electrons, negatively charged, orbit the nucleus.



A current of electricity consists of electrons flowing in a conductor.

At normal temperatures, electrons are inside the conductor, but if the conductor has a high temperature (eg the filament of a lightbulb) the electrons go out of the filament a short distance and then fall back like droplets dancing over a pan of boiling water.

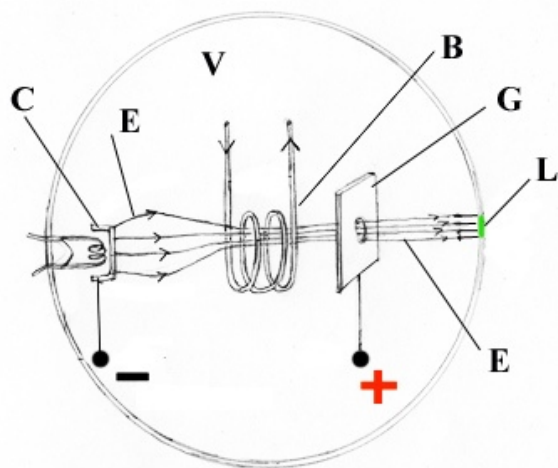
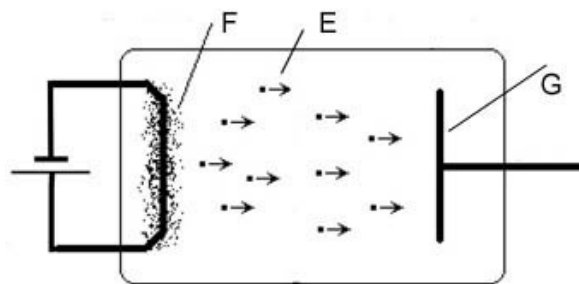


A positive plate nearby can attract these electrons. (This must be in a vacuum because air impedes electrons.) This plate is called the anode.

G - Positive anode.

F - Filament surrounded by a cloud of electrons. It is negative relative to the anode, and is called the cathode.

E - Electrons.



V - Vacuum. **B** - Coil with current to concentrate electrons.

In fact, the cathode is not a wire but a small plate heated by an electric current. **C** - Cathode.

If the anode has a hole in the center, some electrons pass through the hole and reach the glass. When they hit the glass, there is a small explosion where the electrons expel small particles of light (photons) **L** but the light is weak.

An electric current passes through the coil **B**. This creates a magnetic field that focuses the electrons into a narrow and more intense beam, thus expelling more photons when they hit the glass

More powerful collisions

Scientists began to think, "Perhaps the protons and neutrons in nucleus of an atom are composed of other particles. Let's hit them very hard to see if we can explode them and see if they are composed of even smaller particles."

They wanted to create more energetic collisions (not only electrons hitting glass), but collisions strong enough to disintegrate atoms and thus discover it are smaller particles that make up the nucleus of an atom. So, instead of a cathode, they substituted a source of more massive particles (created in a separate unit).

They decided to use protons. Protons are one of a range of particles called 'hadrons'. Hadrons are emitted by various substances (radioactive 'isotopes' of certain elements, such as the isotope of lead, ^{205}Pb).

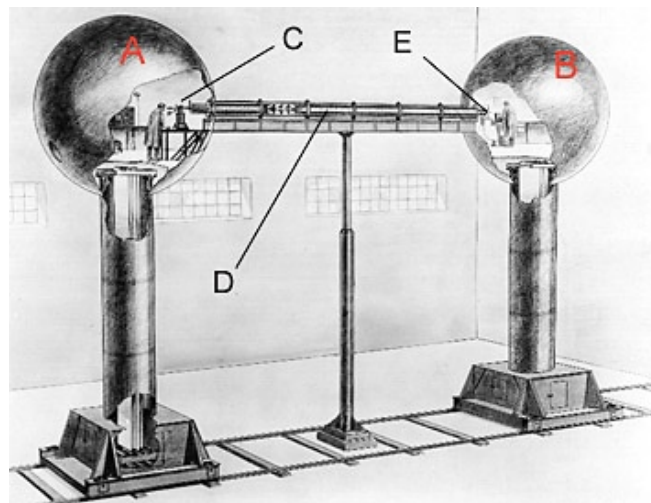
It was also necessary to achieve much higher speeds, and so they invented the device shown in the diagram below. They built long tubes and used very high voltages. This type of machine is called a 'particle accelerator'. But even so, they could not achieve high enough speeds. The tubes were too short to accelerate the hadrons sufficiently. (Hundreds of metres is required.)

A and **B** - electrodes with a voltage of a million volts between them.

C - Hadrons source.

D - Evacuated tube.

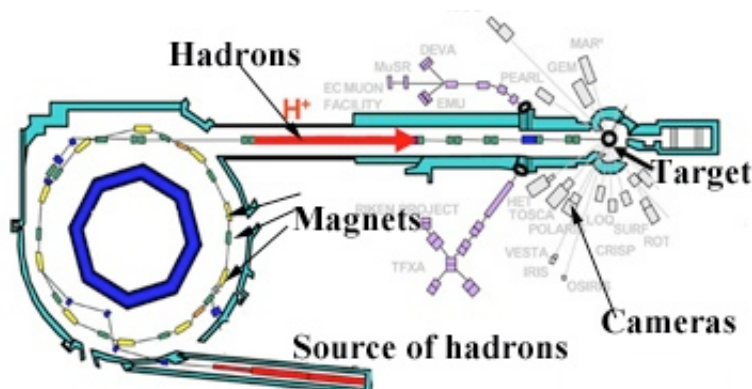
E - The target.



(Can you see the figures of the men in the photo?)

More energetic collisions

So they decided to force the hadrons to go in circles, not straight lines. That way they can accelerate hadrons for many turns ... like a boy accelerates a stone with a slingshot.



The synchrotron

They invented a new machine in which the hadrons travel hundreds of times around in a tube before hitting the target (a proton or other hadron). They are forced into a circle by enormous electromagnets spaced along the tube.

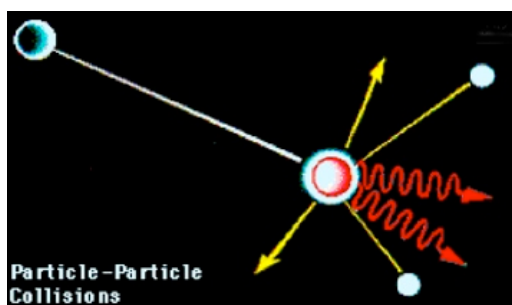
Head-on collisions

To create an even more energetic collision they use two tubes of hadrons traveling in opposite directions. At the last moment, the hadrons are diverted from their own tube and into the other tube, so that they hit each other head on.



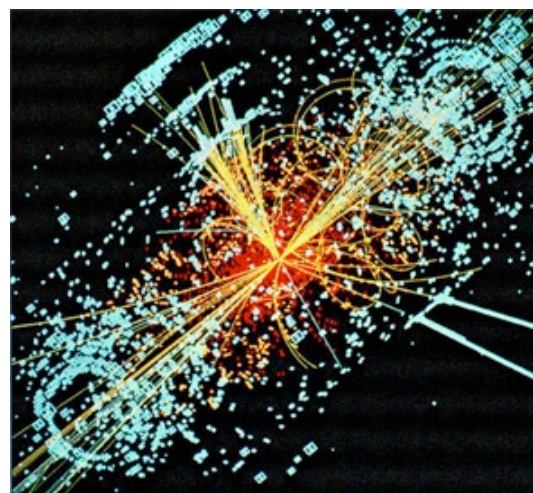
It is like a collision of locomotives. (Can you see the particles coming out of the locomotives in the picture?)

The tubes are evacuated and surrounded with huge electromagnets to direct the hadrons in their circular path. There are 1,296 magnets in the LHC. The total weight of the magnets is 47,000 tons. They operate in a temperature of minus 273.3 degrees C, two degrees above absolute zero.



The collision of hadrons is like this (simplified diagram.)
There are many cameras focused on the collisions in the LHC.
A more realistic picture taken by one of the cameras. >

The collision expels a spray of particles that are photographed with various cameras. Then the pictures are analyzed and the characteristics of the particles determined.

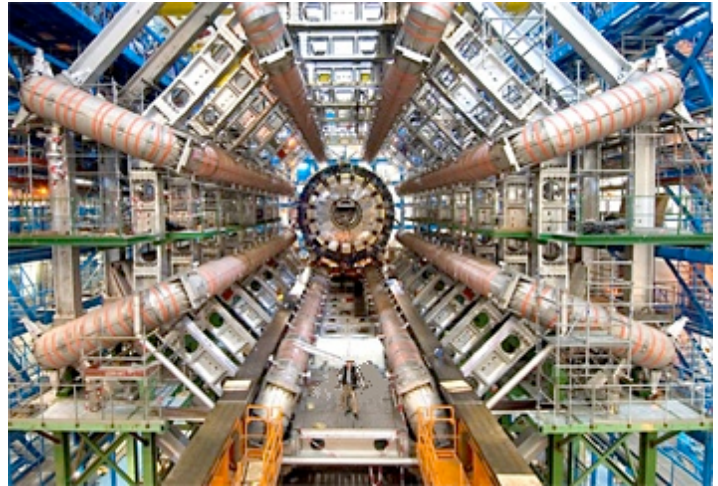


The cameras are digital cameras. They are very special and fast because the particles emitted from the collision have lives of a millionth of a second. The cameras can take 40 million pictures per second.



The two tubes are inside a large circular tunnel with a circumference of 27 kilometers, buried in a district on the border between France and Switzerland, as shown in the photo on the next page. In the picture, you see a place ("Atlas") where the hadrons traveling in one direction in one of the tubes, cross with the hadrons in the other tube and they collide head on.

The first photo shows a view taken during the construction of the Collider.



The second photo shows the inside of a tube. Can you see the man?

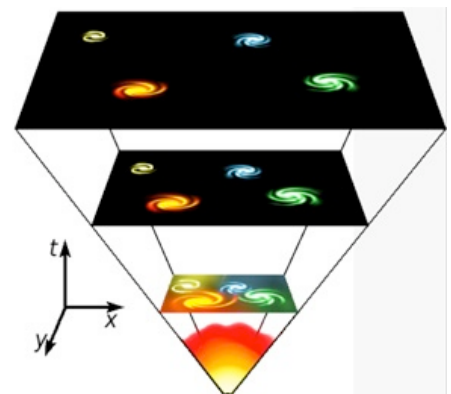
The LHC scientists hope to understand the situation at the beginning of the universe in its first few seconds .*

It is the largest and most complex scientific machine in the world. Its experiments are planned to last ten years or more. The organization responsible is the European Organisation for Nuclear Research. (In French: Organisation Européenne pour la Recherche Nucléaire, CERN). It is the same organization that invented the Internet. Twenty countries are involved in the operation and financing of CERN.

* The Big Bang (the Great Explosion) is the theory of the beginning of the universe. Cosmologists use the term "Big Bang" to refer to the idea that around 13.3 to 13.9 billion years ago the universe was originally very hot, very small and very dense and since then has expanded and cooled and is still expanding today.

A common analogy explains that space is expanding in all directions, carrying galaxies with it, like raisins in a cake cooking.

An artist's conception that illustrates the expansion of the Universe. >



Extravagant and costly projects

In today's world, while poor Maria in Mozambique cultivates her field with a hoe and there are many schools without supplies and districts with no clinic, the first world spends trillions of Meticaïs in many projects that seem extravagant and costly.

Spending on space exploration by developed countries is one example. Trillions and trillions of dollars.



Scientists are happy but the farmers here in Mozambique should be angry ... But they do not know anything about the topic. However, it does not seem fair.

The Hadron Collider, the "LHC" is another example .. It is an enormous experiment to discover whether certain subatomic particles exist or not. In this review, we describe it.

To this day, for more than 20 years, the LHC has spent more than 350 billion Meticaïs - almost 10 billion USD.

Is it fair or not? There is much controversy on the subject.
