

THE EXPERIMENTALIST

An Encyclopedia of Science and Technology for Young People

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Here in Mozambique there is a need for smaller industries. The country imports many things that could be made here, taking advantage of local resources. We have many resources that are not made use of. Many raw materials are exported instead of being worked here in making products that could be sold locally. For example, tools and other metal instruments necessary for trade and agriculture.

We import hammers and machetes from China and hoes from Vietnam, saws and pliers from India and ploughs from South Africa.

However, we have a lot of old metal in the country that could be converted to these items.

We have a large number of bright young men and women who are unemployed but who could be trained as artisans making metallic devices.

If they had initiative and were creative and had the imagination to realize how much money they could make, they could employ and create other industries



in small towns (or even at village level where there would be a big market for such things).

In this edition of our “Experimentalist” we show some tools of the type that small workshops may need. In future editions we will show examples of small village industries that we think may be useful in Mozambique.

Thermometers - Part 1

Temperature

We use the word "temperature" to tell if something is cold, warm, hot, very hot, etc. Melting ice has a temperature of zero. In the early morning, air has a temperature of perhaps 20. Your body has a temperature of 37. A black car put in the sun for an hour reaches a temperature of perhaps 50. The melted wax of a candle has a temperature of 50 also. Boiling water has a temperature of 100. The red hot charcoal in a stove has a temperature of about 500.

Temperature units are "degrees" or more exactly "degrees Celsius" which is written: C. Thus the temperature of boiling water is "100 C" which is pronounced "one hundred degrees C" or "one hundred degrees Celsius". Or you can write "degrees" with a symbol: "100 °C"

"

The human body can detect hot or cold things.

You can judge the heat with your fingers, but they are not very sensitive and are easily fooled.

To prove this, get 3 bowls, one with cold water, one with normal water and another with hot water. Put one hand in cold water and the other hand in hot water.

After a minute put both your hands in normal water. Result? The hand that was in cold water feels that the normal water is hot, and the hand that was in hot water feels that the normal water is cold. It's a strange experience.

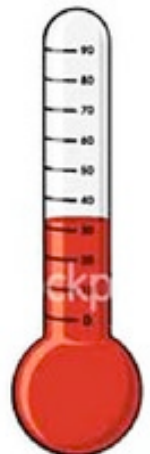


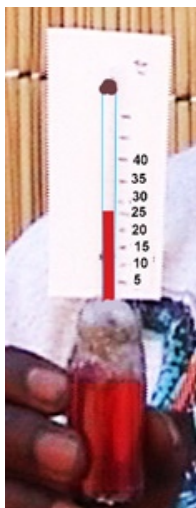
Rub your palms together and then press them on your cheeks. You will feel that they are hot.

The human body can measure temperatures approximately, but not in degrees. You can recognize if something is hot or cold, by touching or holding your hand near it. At least you can tell if something is too hot or too cold.

Thermometers

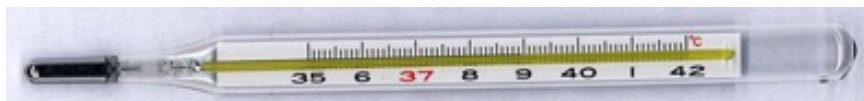
To accurately measure the temperature there is a "thermometer", but few schools have one. It is a glass tube with a very thin inner diameter. One end has a bulb filled with red or silver liquid. The other end is closed. A column of liquid in the thin tube moves to indicate the temperature. The space above the liquid is a vacuum - it has no air.





The photos show a normal thermometer and a homemade thermometer made of a small bottle (described below).

Have you ever seen a thermometer in the Health Center or hospital? The nurse puts it under your armpit to measure your body temperature. It reads only from about 35°C to about 42°C. Above or below those temperatures, you are probably dead.



When healthy, the human body has a temperature of 37 °C. The thermometer helps the nurse know if you have a fever (a temperature above 37°C).



How to make a thermometer and understand how it works

You will need a ballpoint pen without ink in it. Remove the nozzle from the little tube inside. If the tube still has ink, clean it out with a piece of grass.



Now you need one of the little bottles that contained penicillin etc. that doctors use in syringes (and then throw away). Remove the lid and rinse the bottle well with water.

Colour some water by putting coloured balls of chewing gum into it. (Or maybe you know a flower or a plant that you can use to colour the water.)



Thermometers

Put some well-chewed gum around the little tube like a collar, as you see in the photo. >>



Fix the tube in the mouth of the small bottle with the chewing gum and push it in so that there are two inches of the tube in the bottle. There should be no air bubbles in the water.



Press lightly on the chewing gum and the tube until the water rises in the tube. Adjust it until the water level is in the middle of the tube. This is difficult, but try and try until you succeed.

Now, you have made the thermometer.

To try it out, warm the bottle over a candle flame or a match. But only for a moment or the heat will break the bottle. As the water in the bottle heats up, it expands and moves up the tube, indicating a higher temperature.

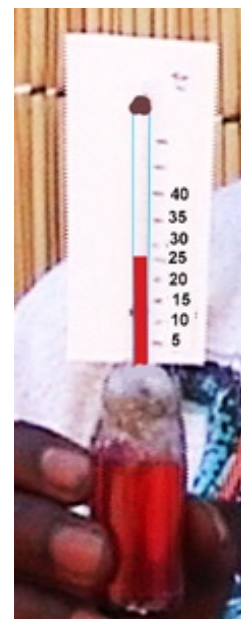
Put it in cold water (with ice if possible) and see that the water level drops, indicating a lower temperature. We can make a scale on the tube. First, place a piece of cardboard or paper behind the tube. Invent a method to do this, perhaps using a needle and thread or chewing gum.



Now, try to put numbers on the paper to indicate certain temperatures. These numbers are not exact, but are not bad and you will see better how a thermometer works in actual use. Like this ▼.

After fixing the cardboard, place the thermometer (the bottle) in the armpit of a friend for five minutes to let it reach the temperature of his body. Then remove it and quickly mark a line and "37" on the paper next to the water level in the tube.

Insert the thermometer in a mixture of ice and water. Leave it 5 minutes and remove it quickly and mark it zero degrees, 0 C. Finally, put it in a can of boiling water, but only for a brief time, (otherwise the water in the thermometer will boil). Remove it and mark "100" a little above the position of the water in the tube. Of course, it will not be accurate because it does not have time to reach the true temperature of the water. The temperature of boiling water is 100°C as you know.



Next put the thermometer outside at the end of the day and inspect it in the morning. You will see that the water is in a position between zero and 37. Try to estimate what the temperature is in this position. It is perhaps 22. At 10 o'clock you will see that the water level is above the first position, and at 12 o'clock, when the day is hot, the water in the tube will be higher, perhaps 28°C. So we speak of temperatures being "high" or "low".

To show the simple idea of a thermometer

Instead of a little bottle, you can use a beer bottle full of water. It is easier to see but it takes a long time to warm up and display the temperature. For example, it may take all night to cool down to the temperature in the morning.



The movement of the water in a large bottle is much visible than a thermometer that uses a small bottle. It is good for a teacher demonstrating the first idea of a thermometer. You can heat it with a candle to show the effect quickly.

Make a thermometer; try it and have fun!



Knowledge about Thermometers in the Schools of Mozambique

The National Institute for the development of Education conducted a survey of the knowledge of pupils in the 4th and 5th classes. ("The Teaching of Natural Sciences and Conceptions of the Child", INDE, Maputo. 1997) investigated the knowledge of students about heat, temperature and the thermometer, and found that few students understood them. The survey reported:

"The thermometer was chosen as the first subject in the test carried out ... It was explained to the students that a thermometer showed, during a hot day, 30 degrees. Then they were asked to respond how much the thermometer would show at night when it is "nice and cool"... The explanation of the task was made both in Portuguese and in their native tongue.

... overall, only 35% of students knew that a thermometer at night shows less degrees than during the day ...

"Schools in Nampula have the lowest results with about 18% of correct answers for boys and 12% for girls ... The notion of "temperature" related to using a thermometer appears as an object of study in the first Science classes of 3rd Grade. The student should know the function of the thermometer and learn to read it through applied exercises. Given the general lack of teaching materials in schools, these exercises rarely or never take place using a real thermometer (it would be possible, according to the teacher's manual, to make a cardboard model of a thermometer, but this practice is poorly developed, among other reasons because of lack of cardboard ... "



Tools for Metalwork

Some tools used in metalworking:

Electrician's pliers are used when you need to hold a thing firmly or to cut thin wires. >>

A pair of pliers has two handles (**E1**, **E2**) and a pivot (**D**). When you grip the handles with a certain force, the force is great between the jaws **A**.

The curved jaws **B** are best for tightening nuts because the teeth grip the nut more firmly, and the force is greater because they are closer to the pivot. (But it is better not to use pliers on nuts, because if the nut is difficult to turn, it can slide in the jaws and the edges of the nut will be damaged. It is better to use a spanner of the correct size.)

The jaws (**C**) are for cutting wire. Here the force is even greater, especially very close to the pivot. This is where the wire is placed to cut it.

There are sometimes jaws (**D**) which are also for cutting wire. Open the pliers wide, put in the wire and press the handles together.

The handles of the pliers are usually covered with rubber so as not to hurt your hand. They also insulate it from electricity.

When you buy a pair of pliers, choose them carefully. Place them against the light to see if the wire cutting jaws meet without any space between them. If there is a space they are poorly made and instead of cutting the wire, they will just damage it.

<<<<

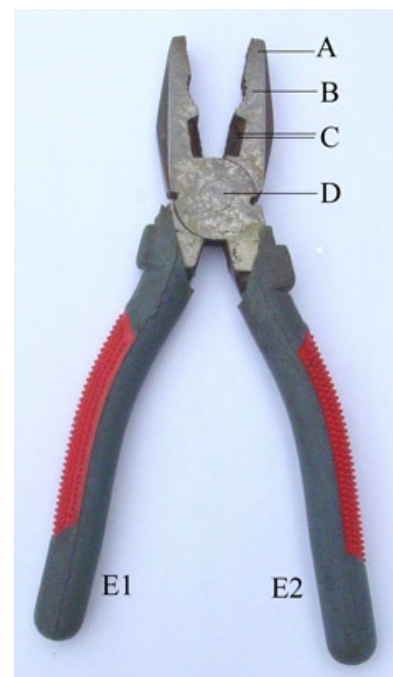


The third thing to check (but it is very difficult), is that the pliers should be made of steel, not iron. Steel cuts iron, but iron will not cut iron. After trying to cut iron wire with iron pliers, the wire is merely damaged and, worse, the jaws have small cuts in them where the wire has slightly damaged the jaws. (See the **yellow arrows** on the photo)

A good pair of pliers can cut a bicycle spoke (which is steel) without damaging the jaw (because the pliers are made of harder steel).

The rule for buying tools, is to buy from the shop that sells the most expensive tools. They are usually the best.

There are many other types of pliers, suitable for various professions. For example an electrical engineer uses pliers with long thin jaws for holding thin wires, small nuts, etc..



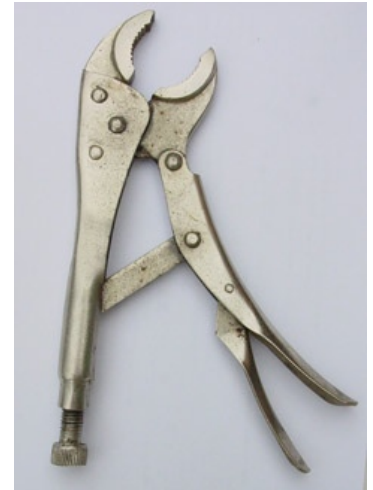
Diagonal cutters are used for general wire cutting (the second photo). The maximum diameter that they will cut is about two millimeters of iron. Of course they easily cut softer metals such as copper or aluminum.

The first photo is of "long-nosed pliers".



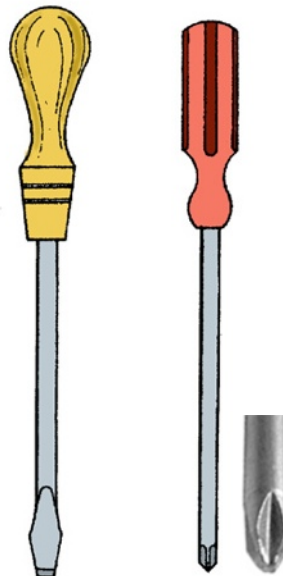
Compression pliers can grip things with great force and have adjustable jaws with a gripping device that continues after you remove your hand. They are so convenient that they are sometimes called 'your third hand.' >>

Bolt-cutters cut with extreme force because the jaws are very close to the pivot and the handles are long. They are used by thieves to cut padlocks and chains. >>

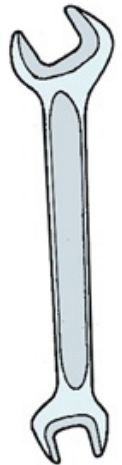


Tools to tighten nuts and bolts

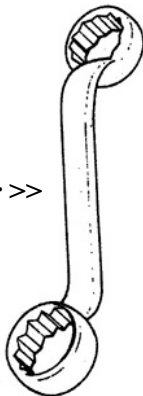
Screwdrivers are used to tighten or loosen screws. The red screwdriver is a "cross-point" or "star" or "Phillips".



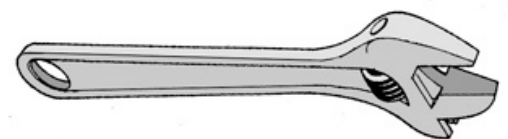
Spanner (open spanner) is to grip the sides of the nuts and bolts to loosen or tighten them. >>



Ring Spanner >>



Adjustable spanner to use for nuts of all sizes. ▼



Socket spanner

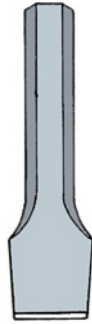


The Plumber's Wrench grips on iron pipes with great force. The pressure between the teeth is so great that they bite into the metal. ▼

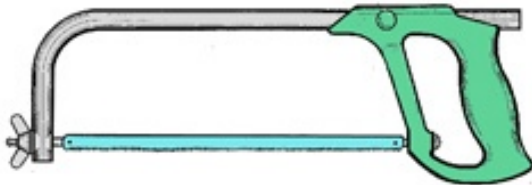


Other useful tools

A **Cold Chisel** is used with a hammer to cut metal bars or thick wire. >>



A **File** is a hard steel rod with a rough surface, used for smoothing or filing other pieces of softer metal.



A **Hacksaw** consists of a strong metal frame with a toothed hard steel blade stretched in it. This can cut any type of metal except hard steel.



To cut small pieces of metal or wood, use a '**Junior Hacksaw**.' ▲

Note the direction of the teeth. >>



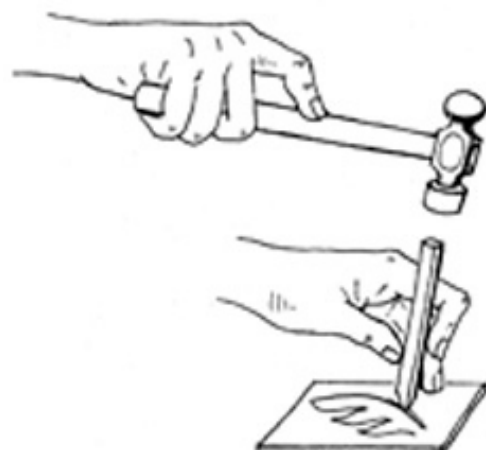
Embossed metal

Low relief' is a flat type of sculpture. >>

Get a thin piece of tin. (eg sides of a can of condensed milk). Cut out a piece with a pair of scissors and clean the surface with very fine sand on a damp cloth. Do a drawing in pencil on this surface (known as the 'right' side). Then, with a small hammer and a piece of iron shaped in the form of a small screwdriver, beat along the lines of the drawing.

Beat with care, with just enough force to be able to see the lines on the other side (the back side) of the tin. Then turn the piece of tin (so that its back side is up) and place it on a piece of soft wood (or hard thick leather or rubber).

Now you need a light hammer and some tools to beat this side so that it can settle and you can see the design on the right side. Figure 7.1 shows a tin foil engraved in this way. You need lots of practice to make some nice pictures - triangles, rectangles, stars, circles, etc.



The picture shows the ends of a tool kit of different sizes and shapes. You can file your rods of iron tools (eg the thick wire that is used within concrete, or large nails).



You can make tools of very hard wood with a knife, but the metal tools are better.

The picture shows a face engraved in this way on a piece of aluminum, made by the Mozambican artist, Zeferino.



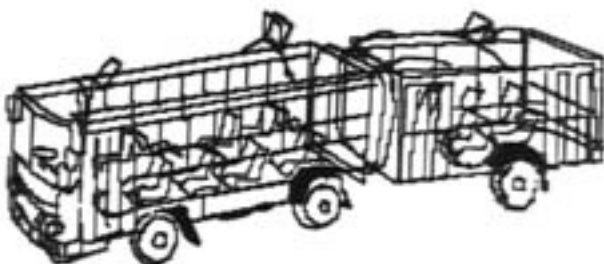
You can cut the engraved metal and make a necklace to hang around your neck, or you can combine pieces to make a decorative belt like Michael Jackson used to wear.



Making wire toys

Make some wire toys. Most Mozambican children can do this. The easiest wire to work with is the thick aluminium wire from the massive overhead cables that the national electricity company uses.

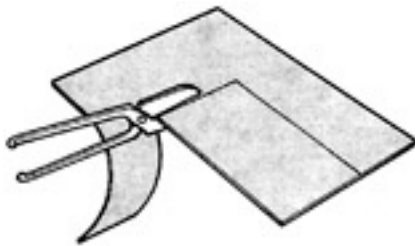
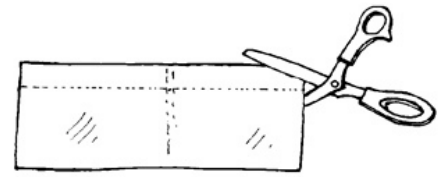
The photo shows an example of a bicycle made in this way. The main tools that are needed for this work are electrician's pliers and fine-tipped pliers to make small bends in the wire. It is also helpful to have diagonal cutting pliers to cut wires that are already in the model and are difficult to cut with bigger pliers.



Making tin toys

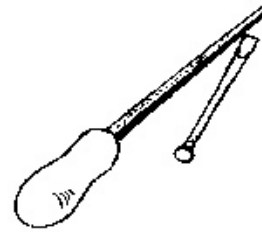
The other way of making toys is: using tin plate, for example cut from a can of condensed milk.

Open an empty can of condensed milk with an old pair of scissors, as you see in the diagram.



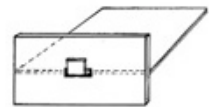
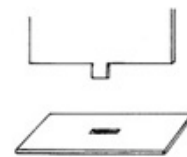
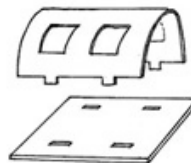
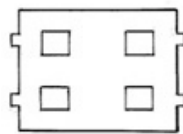
(A tinsmith uses 'tin snips' but normal scissors work well to cut a tin can.)

After cutting, flatten the piece of tin, hammering it with a piece of wood on a flat surface.



You can make a chisel from a big nail, filing its tip in the form of a chisel.

Try joining one with another piece of tin by cutting a 'tongue' in one part and a slot in another. After introducing the 'tongue' in the slot bend it over until it is tight as can be seen in the figure.



You can cut the tongues with scissors, but to make the cut (or any inner hole), you need a chisel.



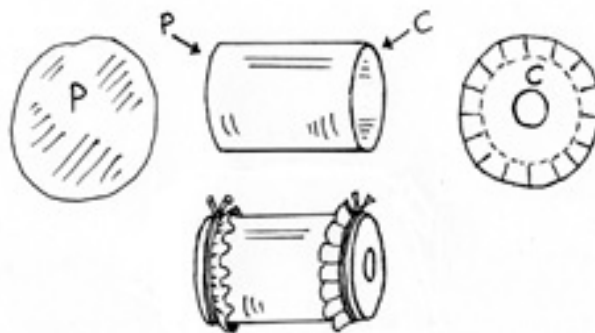
A toy made from tin.

Roberto Mayasse in Lichinga with the saxophone and plane he made from tins.

How to Make Smoke Rings

Use an empty can. Cut off both ends. At one end, place a piece of thin plastic. Bind it with wire or tape.

On the other end, place a circle of cardboard. In the center cut a circle (C) of diameter 2.5 cm.



Or instead of plastic, you can use a piece of a balloon, and instead of cardboard, a plastic cup.

Hit the plastic. A spinning ring of air comes out of the hole.

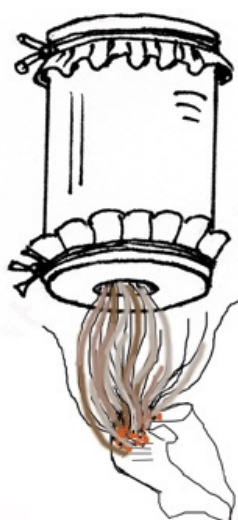
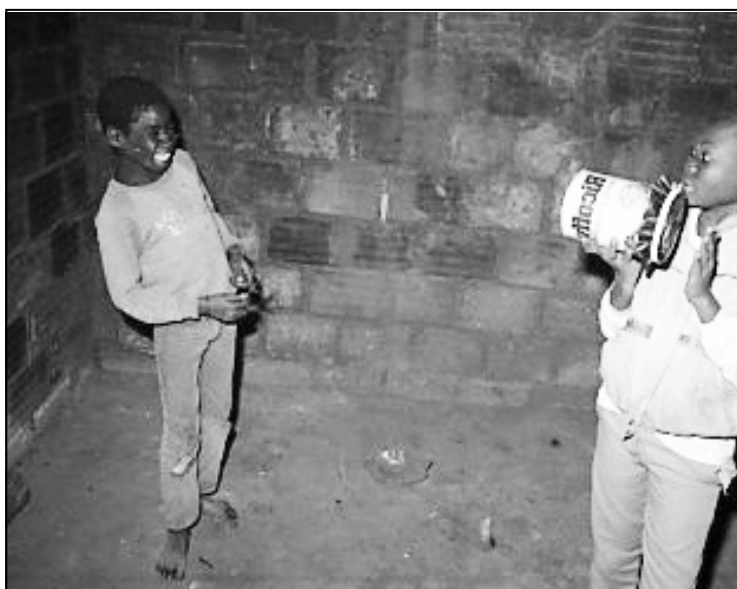


Bring the hole close to a person's face and give a quick blow with your hand on the plastic.

The person will feel a pressure on his face. Put a match or candle near the hole and make another hit on the plastic of the can. With care you can blow out the candle.

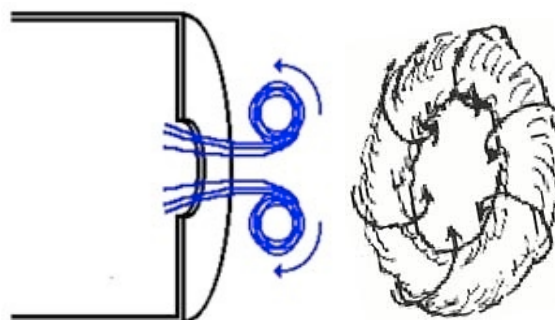
Place a Styrofoam ball on the table and repeat the experiment aiming at it. The ball moves.

You can fill the tin with smoke and make smoke rings



<< To produce smoke, you can take a rag and light it. Then put out the flames and let the smoke rise into the hole and fill the can.

The smoke comes out well when you hit the plastic, forming rings, called "vortices".
>>



Tap gently and smoke rings will be launched. Tap harder, and the smoke rings will move so fast that you only see a gray blur. Tap it too hard and you generate air turbulence, but no smoke rings.

With a little practice you will get good smoke rings that will travel several metres from the hole.

Watch the video: <http://www.youtube.com/watch?v=gjg04wuvVYg>

An alternative is: use a plastic bottle full of smoke, and tap it as you can see in the photos:



Or you can use a bucket to throw rings a greater distance.

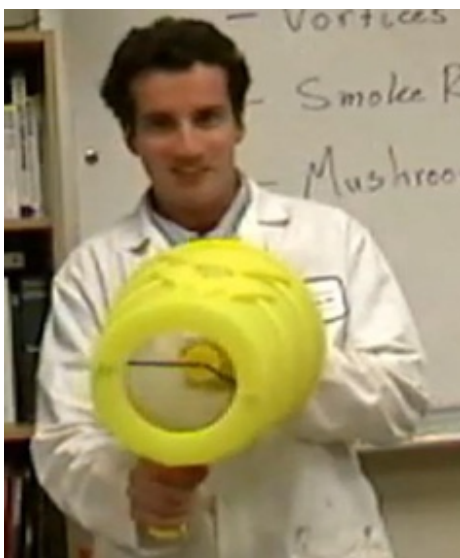
Instead of using smoke, to help see where the ring goes, hang a page of a newspaper, so you can see where the ring hits the newspaper.



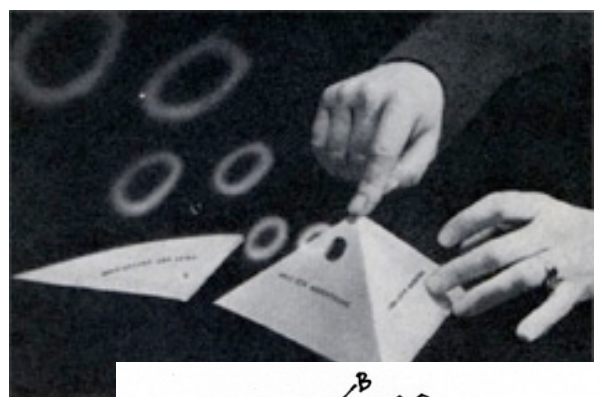
Try shooting a slow smoke ring and then immediately shoot another, faster after it. The faster one will pass through the middle of the slower. The slower will open to allow a quick pass.

Instead of using a smouldering rag, you could use perfume. Try putting perfume in the tin. When you throw your ring (which will be invisible) to a distant target (your friend's nose), he will know when he is hit.

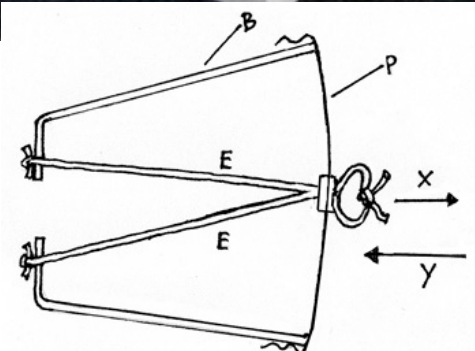
Another device is a paper pyramid full of smoke and tapped on the top. >



A bucket produces bigger rings and is more effective.



B - Bucket.
E - Elastic.
P - Plastic.
X - Pull and let go.
Y - It returns rapidly and pushes the air..

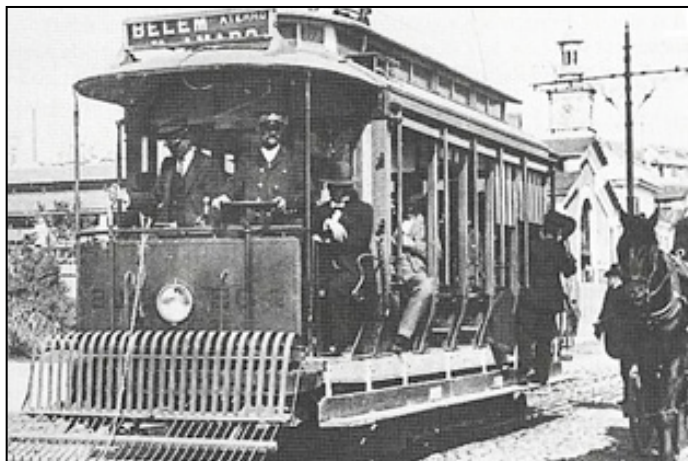


Electric Vehicles

Electric vehicles are propelled by electric motors.

One of the first electric vehicles to be produced was the streetcar. This drew its energy from wires suspended over the street. The photo shows a tram in Portugal in the 19th century.

The car shown in the photograph ▼ was made in



Germany in 1905. It got its electricity from batteries in the car body.

These cars were much simpler to manufacture and cheaper than petrol cars then, but as gasoline became cheaper in the following years, streetcars and “trams” have become unfashionable.

But in recent years, as global fuel prices increase, there is an interest in electric cars again and many new types have been produced.

The electric car system is composed of a primary energy system (battery), an electric motor and a drive system and speed control. The photos show the battery and the motor of an electric car. >>

These are very much smaller and simpler than a modern car gasoline engine. ▼



An electric vehicle has far fewer components in the engine, and is much less complicated compared to a gasoline car that has hundreds of parts in its internal combustion engine as you can see in the picture.

<<<<<<

Electric cars are generally more expensive than gasoline or diesel at the moment (2011). The primary reason is the high cost of the batteries. An electric car with a range of 160 km costs approximately U.S. \$ 33,000.

A big advantage is that an electric car emits no pollution to the atmosphere.



The batteries are rechargeable. A modern Renault car being recharged.



A tiny electric car trial in England.

Electric bicycles

You can put an electric motor on a bicycle, but it doesn't look good.

Better is a commercial electric bicycle.



A Scooter is a motorized two-wheeled vehicle in which the driver arranges his legs in front of his body on a platform, instead of at the sides, such as in motorcycles. The first photo shows a gasoline powered Honda.

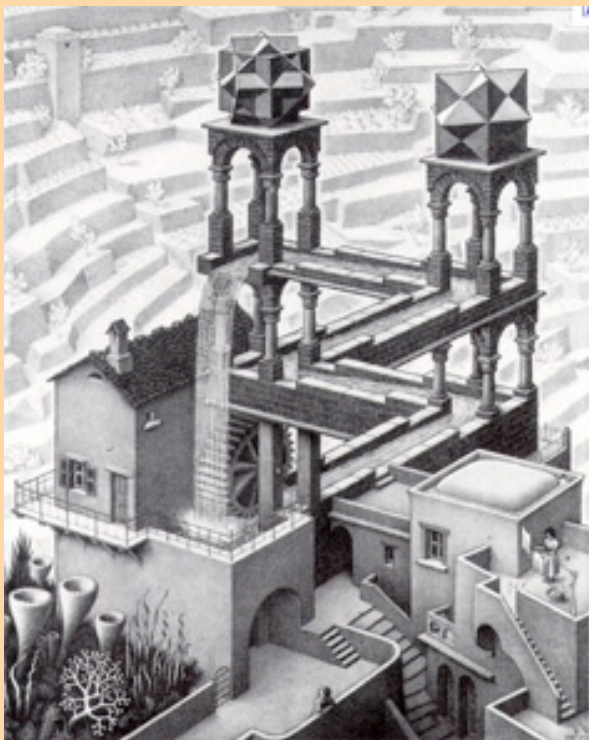
The scooters had "two stroke" engines, requiring a mixture of oil and gasoline to lubricate the piston and cylinder. This mixture produced large amounts of pollutants. The growing environmental constraints have forced manufacturers to cease production in 1985.

To meet this challenge, the factories began to produce electric scooters in the years to follow. A problem is that it has to return home to recharge the batteries.

Later, some innovators invented electric scooter batteries which were charged with solar cells. The first picture shows the position of the panels ready to go, and the second when parked to recharge the batteries.



For people with disabilities, there are electric scooters that have batteries that must be charged at home.



A Curiosity

Maurits Cornelis Escher (1898 – 1972), who drew this work, was a Dutch graphic artist known for his woodblock prints (woodcuts) and lithographs, which tend to represent impossible constructions.

