

THE EXPERIMENTALIST

Mozambique 2010

The Science and Technology Magazine for young people

Volume 1 Nº 4



Technology:

The Story of KaTembe's Crane

Construction:

Magnets and Electromagnets - Part 2

Community:

Turbines and Wind Generators - Part 1

World Technology

Global Warming

The teaching of science and technology in our schools is often dry and boring. Not only because it is taught only on the blackboard and in textbooks, without practical classes, but also because our teachers rarely have practical experience and cannot teach it. But without practical experience almost nobody can understand science. So, they do not like science.

To help in this situation, this *Experimentalist*, our magazine, features articles of a practical nature which we hope will help teachers to experiment in school and encourage pupils and students to do experiments at home. In these experiments we use common materials that you probably have at home, or you can buy cheaply in the village market or even find it in the garbage on a street corner in a town.

Sometimes in this magazine we provide practical articles on technology in real life. The article in this issue "The story of the crane in KaTembe" is one example.

We often describe something of the modern world of science and technology that affects our own lives in Mozambique, but often the details are not known. "Global Warming" is an example.

Usually we try to include something that relates to science and technology and is a little strange, interesting or funny. "The Chinese Car" is an example.

We have included articles on topics of science in schools with more detail than is covered in textbooks. An example of one of our articles on the technology that can help communities and homes is "Turbines."



A turbine made from sticks and scooped-out halves of lemons

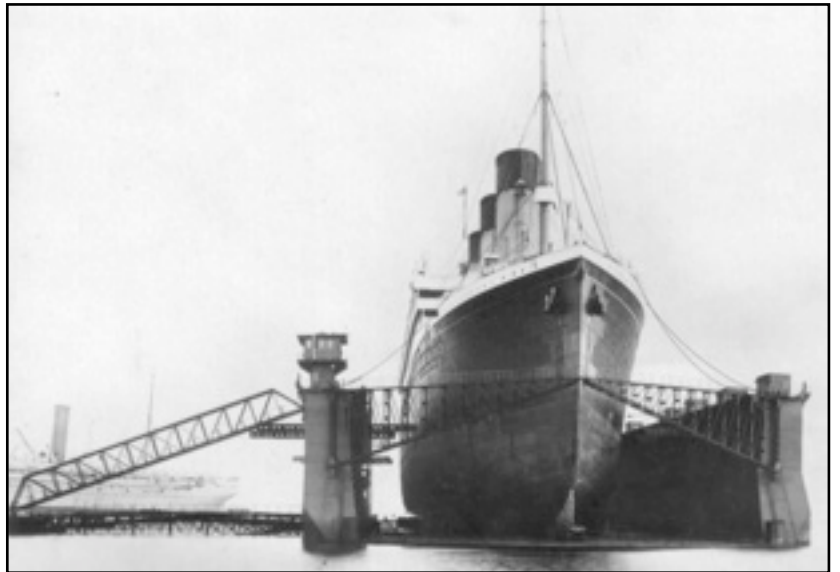
Many of the articles in "The Experimentalist" also appear on our Web Page <experimentalista.org> Keith Warren.

The Story of the KaTembe Crane

1

For many years, the KaTembe horizon seen across the estuary from the capital Maputo, has been dominated by a crane mounted on a "floating dry dock." This is a big ship with a deep space in the middle where ships come in to be repaired while the dock is deep in the water. Then, water is pumped out of tanks within the ship and the whole thing rises, so that the bottom of the ship can be repaired.

A floating dry dock in action. >



The dry dock in KaTembe with its two cranes

The dock was a gift from the Soviet Union in 1981. In January 1996, it sank. It was never repaired, and rested on the bottom. The upper decks were well above the water level and above them were two cranes, one small and one larger. The cranes were on rails so they could move along the length of the ship. Gradually, over the next ten years, the dock was so rusted that it could never be repaired. The cranes, cables, beams, brackets and ladders had become skeletons, rusted by the sea air. Some of the pieces fell to the deck and others were still hanging up, precariously rusty.

It was good for nothing but scrap. Recently, around our coast, wreckage of scrap iron and steel have been removed - part of the collection of metal to supply the expanding industries of China and India.

The ferry between Maputo and KaTembe often carries truckloads of material. From there, it goes to South Africa and then to India.

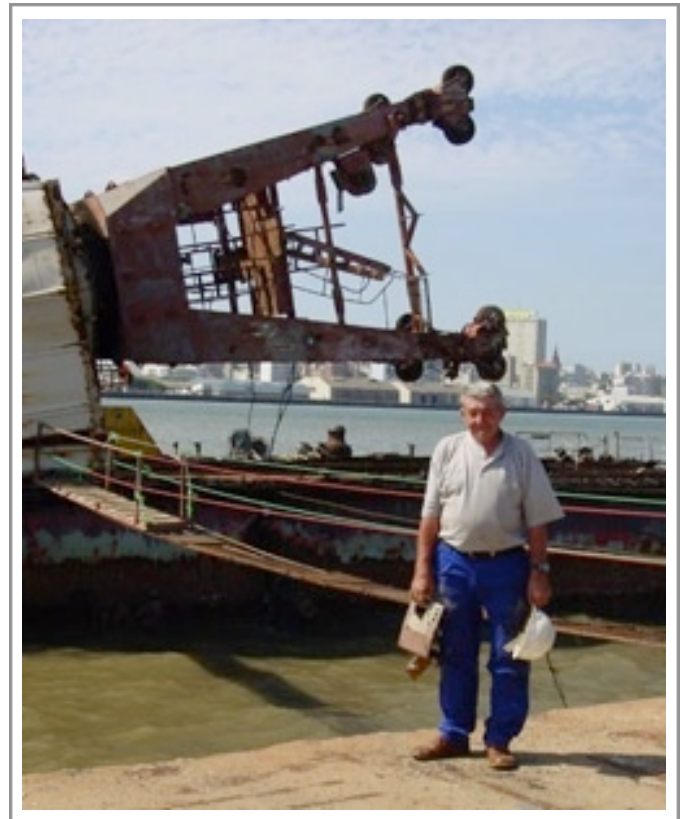
Thus, attention turned to the dry dock and how to turn it into transportable pieces. But the knowledge necessary to take down such a monster is rare. Especially to take it down safely and in such a way that it could lie along the narrow strip of the deck and could easily be cut with oxyacetylene. It must not fall into the water because to cut metal immersed deep in mud and water is a very difficult and expensive.

As it happened, there was a specialist in KaTembe with extensive experience in the dismantling of large structures. Tom Stickland, a retired British Royal Navy engineer (and my best friend). He was given a contract to oversee the dismantling of the dry dock.

I saw this as a good opportunity to observe and film the operation for our project of science and technology for young people. This process would show hundreds of examples of real world technology: the principles of cranes, the use of pulleys, sheaves, blocks, ropes and winches. And the oxy-acetylene method of cutting iron, the use of motorized cutting discs, and a kind of cable car to bring the iron parts of the ship to the quayside, and so on.

We could look at dozens of objects in the ship - motors, control panels, voltmeters, generators, winches. In short, many things whose use can be explained by these examples. We hoped we could convince the workers to give us examples of many things to put in our future Museum of Science and Technology. A wonderful opportunity, although we had no place to store the larger machines.

There were many young workers who worked under the supervision of Tom. I always said he should send them to do the high and dangerous work, not do it himself with his 68 years. But he liked to do things himself.



They attached a cable to the top of the front of the large crane and tried to pull it over with an electric winch, but the first attempt failed. Some parts of the cables and the machines were working with a force of about one hundred tons. Cables snapped and pulley blocks exploded. The contractors did not give Tom machines and cables quite strong enough, but he worked with what he had. This is often necessary in Mozambique, where we often have to work with 'local resources'. This is good for young people to learn and it should be one of the lessons we should give emphasis to when editing the film.

I shot a lot of activities and have video film of pulleys, winches, anchors and so on. It was very interesting and educational to see the failures and successes.

They tried five times to pull the crane to make it fall, and failed five times.

Finally, a strategy was devised that later proved successful. This was to cut the rails behind the crane, then to pull it back and cut the rails near the wheels and also cut holes in the deck below them. So by pulling the crane along the rails (which does not need much force), the front wheels would fall into the holes and everything would fall.

I suggested this method and they decided to try it, humorously calling it 'Operation Keith.' It worked.

My film shows the rotating winch and cable tension and pulley blocks rising as the tension rises. Then the crane rolls forward until the front wheels reach the holes.



Then, after a first shiver, the whole structure and pieces of rusty stairs and supports fell with a great bang. A huge mixture of dust, dirt and rusty metal rose in a cloud around it. I filmed everything.

On the dock, standing out of the way, those who had worked on the operation and had seen five failures, shouted, jumped up and down and danced with joy.

The calmer spectators were also very pleased with the success, and clapped each other on the shoulders.

I shot Tom coming towards the camera singing with pleasure and then crossing the precarious bridge to the ship to verify that the crane had fallen exactly where we wanted. He complained: "Not bad, not bad, but I would have liked to see it ten centimeters to the left ...", and laughed.

I thought it would make a good film for young people who want to understand the real world of practical technology. We intended to make many movies of this type.

Now came the job of cutting up the fallen crane. We thought this would be easy work. I gave Tom a photo of the crane and he marked on it where he wanted to cut it. He gave the photo to the workers who could make the cuts without much supervision.

The dock was about 20 metres from the dockside, and a sort of cable winch was necessary to take the pieces from the ship to where a truck would take them on the ferry to Maputo. To do this, we proposed to fix a cable from the smaller crane on the other side of the ship and put a 'cablecar' on it with a pulley with a hook and a rope to pull it. Tom agreed. He went early next morning to decide where to connect the cable to the smaller crane and then went home for breakfast. He returned later when his workers arrived and he climbed the crane to fix the cable.

Around ten o'clock, on top of the crane, looking for where to connect the cable, he stepped down to a rusty little platform that collapsed under him, and he fell to the metal deck far below.

With broken legs and a broken arm and bleeding profusely, he was taken to hospital across the estuary, but died later from internal injuries.

We intended to shoot more video film to illustrate how the cranes work. But now, with the death of Tom, we must rethink the entire project.



A worker shows where Tom fell from.

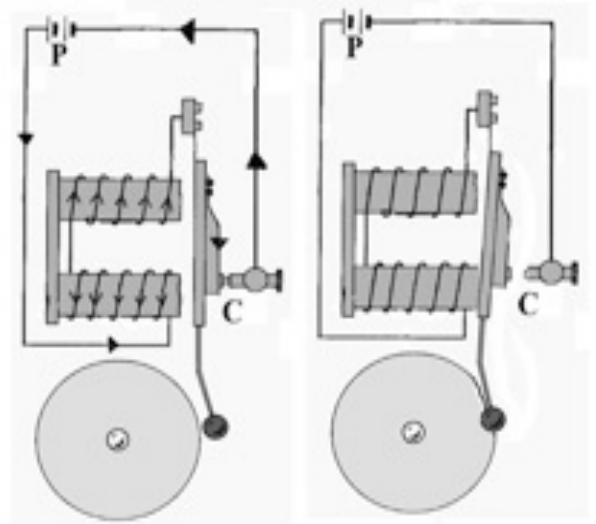
Magnets and Electromagnets - Part 2

There are many types of electromagnets.

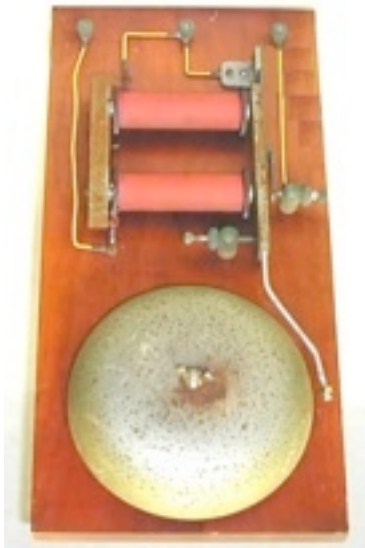
A radio and a tape recorder have electromagnets; a TV has several, and so does an electric motor (combined to make one). A car has several strong ones and a plane has hundreds of one form or another.

The 'transformer' that you use to power your radio has two electromagnets, one wound on the other.

An electric bell has an electromagnet. The coil and the core are fixed and pull a piece of iron that moves a small contact (C) and disconnects the battery. Then the iron moves back, because it has a spring, and reconnects to the battery ... Thus, the iron goes back and forth very quickly and hits a bell. The earphones of old radios used to have an electromagnet.

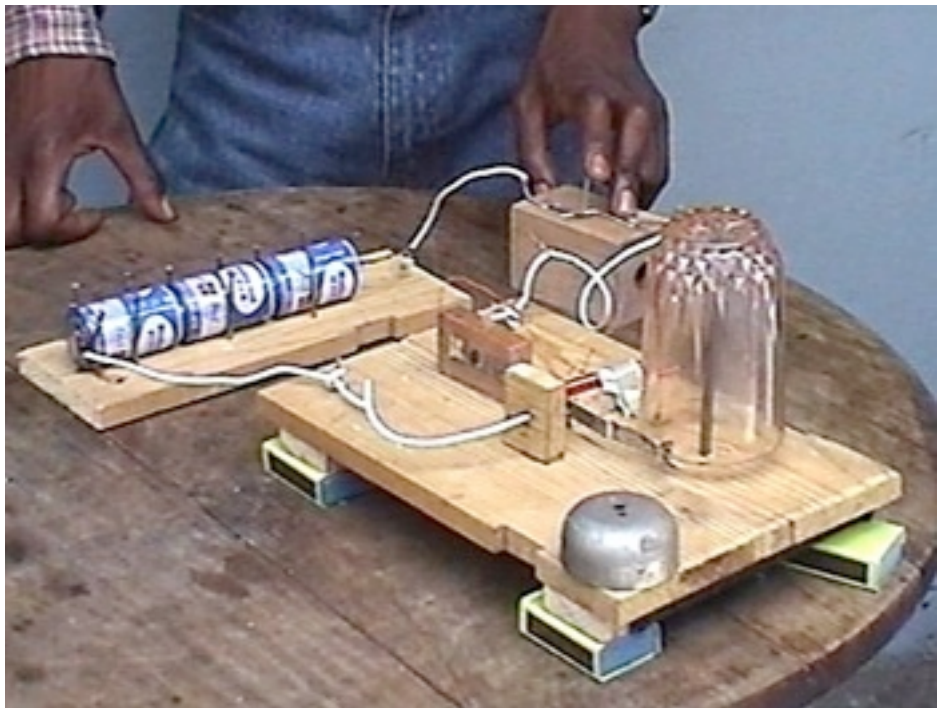


P is a battery ▲



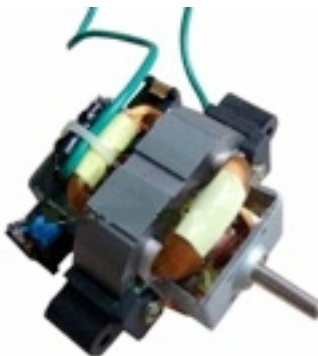
See the video at:

<http://vimeo.com/8368128>



It was a small loud speaker. (Today, the earphone is usually made of a special crystal.)

Electric motors have electromagnets. Here is an example of a hair dryer motor.



A magnetic compass

If you have made a permanent magnet from a nail, (see “Magnets and Electromagnets - Part 1”) you can make a magnetic compass. A compass is a small magnet balanced on the point of a needle or hanging from a thin fibre. The picture shows a type used in schools. It rotates to indicate the North-South direction of the Earth.



For more than a thousand years sailors used compasses to find the direction of North, right in the middle of the ocean when you can see nothing but sea and sky.



How to make a compass

Get a single long strand of hair (or a strand of nylon from a girl's false hair). Tie it in the middle of your nail magnet and adjust it until the magnet is horizontal. It is best to fix it with a small piece of chewing gum.

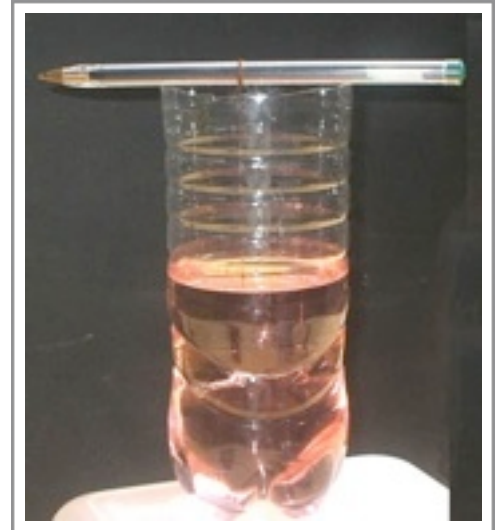
Hang it from your fingers. Try to keep your hand still. The magnet will turn one way and another, but will gradually stop when one end points North. This is the 'North Pole' of the magnet. The other end is the South Pole.

But perhaps the wind moves the magnet and it never comes to rest. So tie the hair in the middle of a pencil and hang the nail inside a plastic bottle with the top cut off. Secure the knot with a piece of gum.

After a while, the magnetic needle will stop swinging and point North-South. Now you have made a magnetic compass. (In a compass, a magnet is called the 'magnetic needle'.)

But you will see that the magnetic needle still takes a long time to settle. So put water in the bottle until it covers the needle. The water slows the movement of the needle almost immediately and goes to the North-South direction.

At first, you do not know which is the north pole of the needle. It could be the head or the point of the nail. It depends on how the battery was connected when you made the magnet. It also depends on how the wire was coiled (but do not think about it now. You will learn this later in school).



Using a compass

Look at a map of Mozambique. The black lines going from top to bottom of page are the North-South lines.

Do you know where the North and the South are where you live?

A method to find North, South, East and West is this: In the early morning the sun rises in the East approximately. This is not a very accurate method, but will help you know where are the East and the West and so, where are the North and South.

It would be useful if you could paint the north pole of your compass needle red so you always know which it is. If you do not have paint, put some lipstick on the N end to recognize it. Now, your compass is ready for use.

Actual compasses

Suppose that the captain of a ship wants to sail from Beira to Madagascar. He uses the compass and the map and he can see which way to go.

A sailor's compass is balanced on the point of a needle or floats in oil instead of being hung from a fibre, but it works in the same way.

If you want to orient yourself in unfamiliar terrain, you can use a handheld compass and a map. The photo below shows a compass that you can use.



Sometimes a person puts a compass in a car to see where North is. But that does not work well because the car is made of iron. Iron influences the compass, and it does not indicate North. Try putting some iron objects close to your compass and check this.

Today a captain uses the same kind of idea to guide his ship, but his 'compass' is a modern electronic device that knows its North-South directions by using information from a satellite in the sky. It is part of the Global Positioning System (GPS) that is also used in cars.

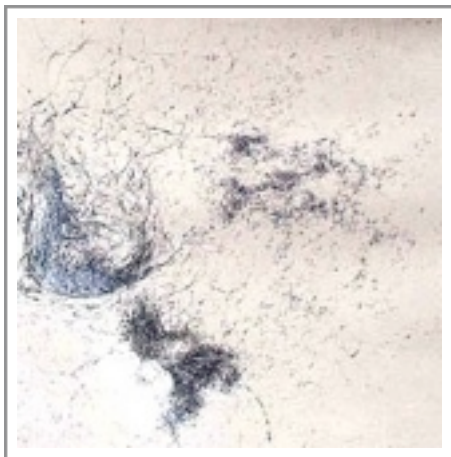
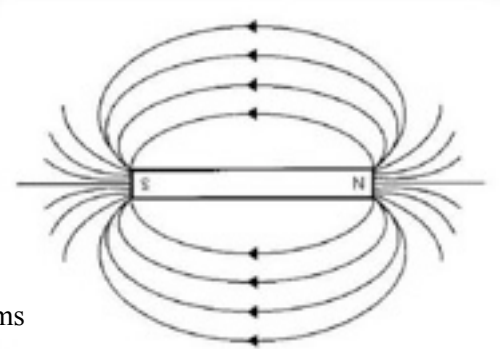


Seeing a magnetic field

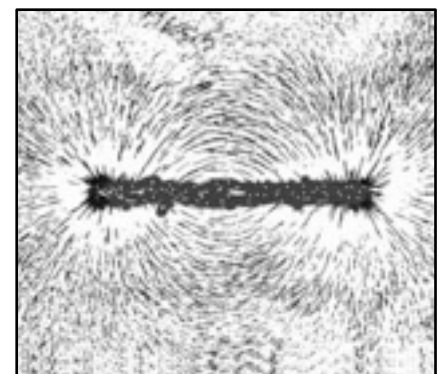
A magnetic field is a region where there is magnetism.

You can portray a magnetic field like this >>

The lines and arrows indicate the direction that a North pole would move if it was free. (In fact a free North Pole without a South does not exist.)



Rub steel wool between the palms of your hands to produce particles.
Put a magnetized nail on the table.
Put a sheet of paper on top of it.
Spread the steel particles on the paper. The particles arrange themselves in the pattern of the magnetic field of the magnet.
Bang lightly on the table so that the particles move into the correct position.
Now you can see a picture of the 'lines of force' of the magnetic field. >>

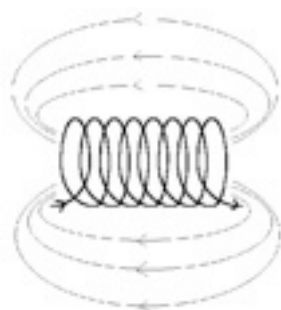


If very small compasses were placed beside the magnet you would see this: >



The magnetic field of a coil with a current through it. >

The magnetic field of a coil is similar to the field of a magnet.



A compass made of a paper clip

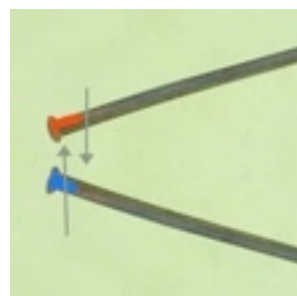
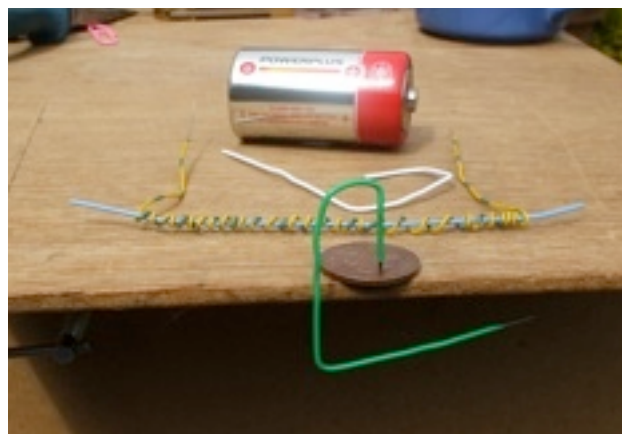
Get a paper clip. (A clip is made of steel.) Straighten it.

Wind insulated wire around it, like the yellow and green wire round the straightened clip in the photo. >

Connect the wire to a battery for 2 seconds. Take the clip out of the coil. Now the clip is a weak magnet.

Bend it as shown in the photo (the green clip). Then balance the clip carefully on the surface of a coin on the edge of a table or a book. The end of the clip must be sharp to move freely.

The clip will turn and indicate the North (or South, depending on the direction you that you coiled the wire and connected the battery).



Attraction and Repulsion

Dissimilar poles attract. (N and S attract.)

Similar poles repel. (N repels N. S repels S.)

A test of magnetism

Try this:

Bring a magnet (a magnetized nail) near your compass to verify that a North pole attracts a South pole and repels a North pole.

A non-magnetized nail attracts both ends of the compass. There is no repulsion. The test of magnetism is repulsion, not attraction.

The reason why a magnet attracts a piece of iron that is not magnetized is: it makes a temporary magnet of the iron. This is called "magnetic induction".



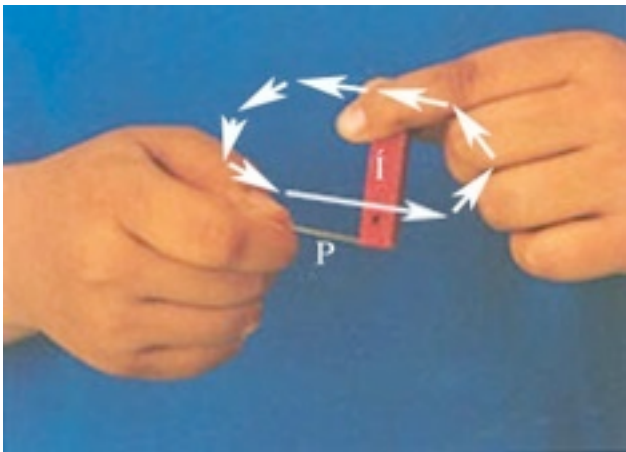
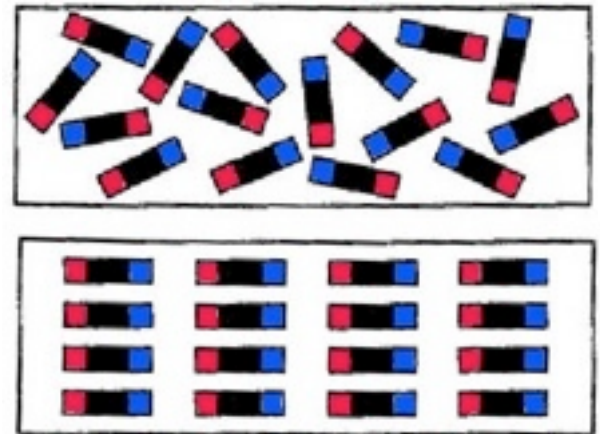
Domains

Iron and steel contain very small magnetised particles called 'domains'. They are so small that they can rotate inside the iron. Normally, these domains are disordered.

But when they are magnetized, they line up like this >

In steel, the domains remain aligned when the source of magnetization is taken away. But if it is iron, the domains return to disorder.

If a magnet is cut in half, you get two smaller magnets, each with a North pole and a South pole. >



How to make a magnet with a magnet

Move a strong magnet from one end of a steel nail to the other. The domains line up.

P = Nail. í = Magnet

If the nail is steel, the domains remain aligned. Thus, the nail remains a permanent magnet.



Using the Earth's magnetic field to make a magnet

Another way to magnetize a nail is: Line up the nail with the North-South of the Earth's field and hit it sharply with a hammer six times. This makes the domains jump in line with the earth's magnetic field.

Sometimes this works. Sometimes it does not.

A story - tetrahedra are useful

There once was a man who had a stool four legs that rocked because one leg was shorter than the others. He was irritated. When reading his Bible, suddenly the stool rocked and he lost his place in the book. He sought help from a neighbour who was a carpenter.

"My stool rocks. It's not stable and when I am reading I lose my place in the Bible. Can you help me? "

The carpenter said, "Yes. It must be because one leg is longer than the others." And took his saw and cut a piece off the longer leg.

But he wasn't a good carpenter. He cut too much off the leg and when the man tested the stool, it still rocked.

"Sure," the carpenter said: "I made a small mistake, but no matter ... I'll cut some off the other three legs." And he cut them. But unfortunately, not being a good carpenter, he again cut a little too much off the other legs and when the neighbour tried it still rocked.

"I apologize," the carpenter said: "I cut a little too much, but no matter, the solution is to cut a little more off the other foot ..." And so it continued, cutting a bit off one leg and a bit off another until the legs were so short that the man almost sat on the ground.

And he lamented, saying: "It would be better to have a stool with three legs. A stool with three legs cannot rock."

Can you see that a stool with three legs is a tetrahedron?

The same man made brandy in his backyard. The servant who controlled the the device that made the liquor (the 'still') was lazy. He sat on a chair to control the fire, but after a few minutes he fell asleep and left the brandy to burn.

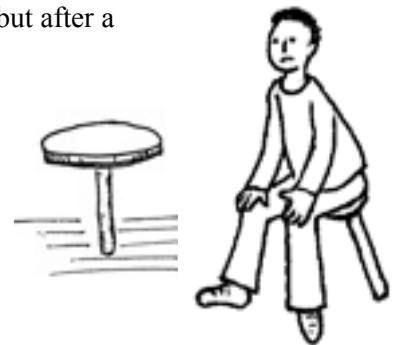
To solve the problem, the owner of the still took away the servant's chair and replaced it with a one-legged stool.

It worked very well. The servant watched the device, sitting on the one-legged stool.

The leg of the stool and the two legs of servant, were a tetrahedron.

It was stable while the servant was awake and watching well, but when he fell asleep, he fell over and woke up.

It was thus that the owner of the still solved the problem of lazy servant.



Chinese Recycling

A car made from local resources.

Wind Turbines and Generators - Part 1

Mozambique is a rich country. We have minerals, forests, gas, coal and oil. We have fertile soil, rivers, a long coast for fishing, and so on.

But we do not take advantage of some of our potential. For example, the wind. In many places in Mozambique, there is plenty of wind, especially near the sea.

The wind

It is an obvious fact that the wind has the power and ability to work. It is an invisible source of power.

In the old days in Mozambique there were many windmills pumping water for irrigation, but nowadays most of them do not work.

Sail Boats

Of course, some of our fishermen here in Mozambique take advantage of wind as an alternative 'engine' for their boats. A sail with an area of 10 square metres produces about 2.5 horsepower (equivalent to almost 2 kW). So if people could use this source to operate a generator to make electricity, they could do many things, such as charging a battery and having light at night, operating a radio, or charging the battery in a cell phone.

How to make a wind turbine to generate electricity

With a knife, cut a tin can in half.



Join the two halves as shown. Solder them together if you have a soldering iron. If not, glue pieces of hardboard on the top and bottom,

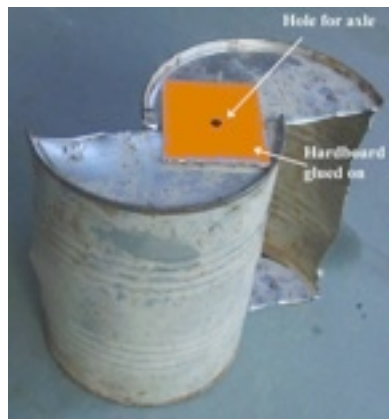


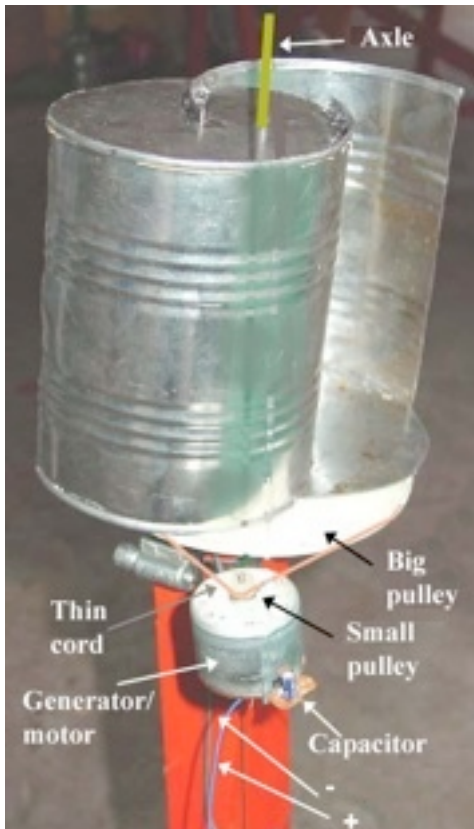
Drill holes in the middle of the top and bottom. Get a piece of strong wire or an iron rod. This is the axle. Pass it through the holes and mount the whole thing on a wooden vertical support, as shown.



The turbine has a big pulley attached underneath. A thin string goes around this to turn the generator.

You can make a pulley of two lids or a tin lid glued to a piece of circular wood.





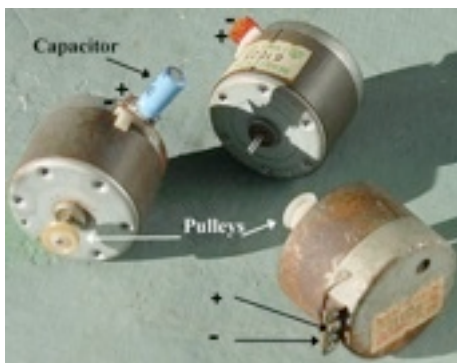
< The picture shows the pulley connected to the generator by a loop of thin cord. When you put it in the wind, the turbine rotates and makes the generator rotate.

Alberto is testing it with an electric fan to create an artificial wind. (In the days when we tested the turbine, there was no wind.)



The Generator

To serve as a generator, use the motor of a broken toy or old tape recorder. These motors work as generators. When we bought one, a radio repairman sold it to us very cheaply. It is best to get a motor with a pulley. Otherwise, you should arrange a pulley. (This is not easy on such a thin axle.)



Electric toys (for example model cars) usually have motors.

< The picture shows some generators/motors.



You should experiment to find which connection is positive. Sometimes it has the + symbol. (and the negative -). But this depends on the direction that the pulley rotates. Experiment with a radio. (It will not damage the radio if you connect it backwards.)

To operate a radio, the generator must have a capacitor connected between the contacts. Without this, the radio just makes a noise and you cannot hear the music. So choose a generator that has a condenser. The generator produces approximately 3 to 6 volts. When you connect it to a radio, the radio plays.



If you cannot find a generator with a capacitor, you can take one from an old radio. The picture shows capacitors that we took from a radio. You must connect it the right way (capacitor "+" to generator "+"). It will not be damaged if you connect it wrongly. Try to make everything work. The photo shows how to connect the generator to the radio in place of batteries. >



The Wind

To operate a small turbine connected to a generator needs a rather strong wind. The power of the turbine depends on the area of the 'sails' facing the wind. So the sails should be as big as possible. The power also depends on wind speed. The power is proportional to the speed cubed. Wind power = (wind speed)³.

To operate a turbine, the wind speed must be higher than 4 metres per second (15 km/hour).

If the wind speed is 4 m/s (which is a light wind) it gives a certain power. If the speed is 8 m/s, it will give eight times more power. So put the generator turbine in a position that has a strong wind.

Wind speeds at airports in Mozambique:

Beira 17 km/h
Chimoio 7 km/h
Inhambane 6 km/h
Lichinga 28 km/h
Nampula 6 km/h
Pemba 13 km/h
Quelimane 17 km/h
Maputo 17 km/h



A larger turbine



Obviously, a larger turbine will give more power. So we used two sheets of hardboard, 60 x 60 cm, and, little by little, we curved them around a large bucket. We poured boiling water over them and tightened them with string, then let them dry. Thus, they were semi-cylindrical.

We fastened them to two pieces of wood, as shown in the photo. The edges of the hardboard are placed into grooves in the wood pieces.

We cut a big circle of hardboard with a hole in the middle. We nailed it below the bottom piece of wood. You can see the details in the picture.

Then we made holes in the middle of the wood pieces to allow us to introduce an axle. The turbine turns on this axle.



We made a support, as shown in the photo below. The axle descends through the upper support, through the turbine, and reaches the bottom support.

We pushed a thin plastic tube onto the axle of a small generator. This tube was the thin tube from inside a ballpoint pen. Upon this we pushed a short piece of rubber tubing. This all serves as a small wheel on the axle of the generator - a wheel that should not slide on the wheel of hardboard, or slip on the shaft of the generator.



A - Axle of generator
B - Piece of plastic tube on axle
C - Rubber tube cut from the connection of a bicycle pump

When you put it in a strong wind, the turbine rotates very well and produces six volts or more. We connected it to the radio instead of batteries. It worked very well.

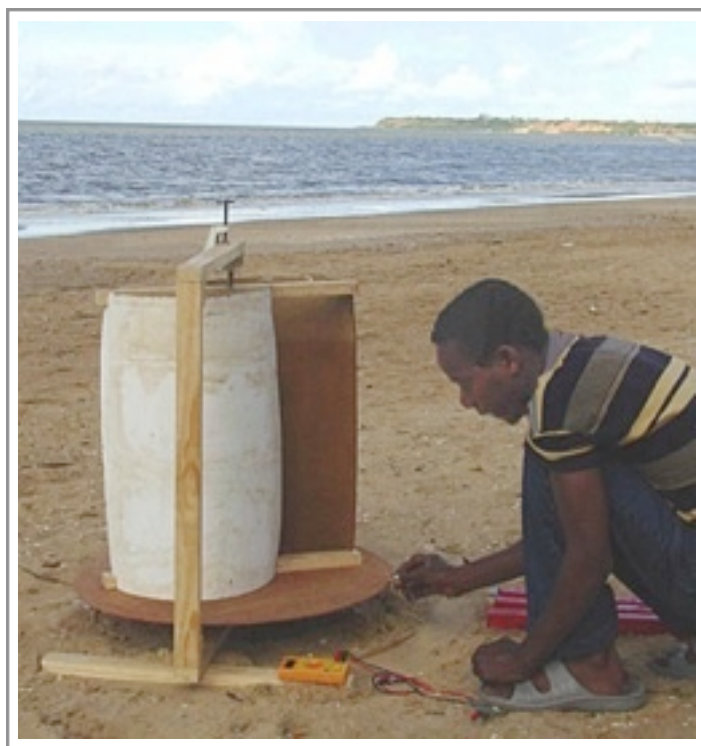
The only difficulty we found was that the hardboard warped in the heat of the sun so the generator jumped up and down and the voltage was not constant. It would be better to replace the hardboard with a wooden wheel.



The photo shows Alberto on the beach pressing the generator on to the big wheel and measuring the voltage with a multimeter. >>

For a continuous operation you need an 'arm' to hold the generator in a fixed place.

In the next edition of this magazine, in the second part of the article on turbines, we show how to make such an arm.



Global Warming

14

The Earth's average temperature is slowly rising year by year. This can result in droughts and other problems. In Mozambique for example it is noticeable that there have been more frequent droughts in recent years, and the level of the ground water and in wells is going down. It is a subject of debate among scientists whether the temperature increase of the earth is due to natural causes or to human activities. Most meteorologists and climatologists believe that human action is causing the temperature rise.



In a recent report, the United Nations says that most of the warming observed over the last 50 years has most likely been due to an increase in the greenhouse effect*, caused by increased concentrations of gases produced by mankind, such as carbon dioxide from domestic cooking fires and the gases produced by cars, lorries, aircraft and industries.

These basic conclusions have been agreed to by at least 30 scientific societies and communities, including all national academies of science of the major industrial countries. However some people disagree, including many whose work is connected to the oil industries.



But natural phenomena such as variation in the power of the sun and the gases from volcanoes probably had a small warming effect from pre-industrial times until 1950.

Some scientific studies show that it is possible that global surface temperatures will increase by between 1 and 6 degrees Celsius between the years 1990 and 2100.



An increase in global temperatures can in turn cause other changes, including raised sea levels and changes in rain periods, resulting in floods and droughts.

There may also be changes in the frequencies and intensities of extreme weather events, despite it being difficult to connect specific events to global warming. Other events may include changes in agricultural yields, the retreat of glaciers, reduced flow in rivers during the summer, animal species extinctions and increases in disease (eg malaria from mosquitoes).

* The greenhouse effect is a process that occurs when a part of the sun's radiation is reflected by the earth's surface and is absorbed by certain gases high in the atmosphere. As a result, the heat is retained in the atmosphere around the earth and is not released into space.

The greenhouse effect within a certain range is vital because without it, life as we know it could not exist. It serves to keep the planet warm, and thus ensure the maintenance of life.



But what can become catastrophic is the occurrence of a greenhouse effect that is too great and that will destabilize the energy balance on the planet and worsen the phenomenon known as global warming.