ElectricityWorks

Teacher's exhibition notes

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CONDUCTORS

Some materials will let electricity flow through them - they are called conductors
Some materials do not - they are called insulators

DESCRIPTION

The exhibit consists of two parts. One side has two circular metal plates connected to a dial. Children can place their hands on the plates to measure conductivity as shown on the meter. Various other materials are provided for children to investigate conductors and insulators.

The other side of the exhibit has a probe which can be used to test other nearby items.

KEY WORDS

Conductors, conductivity, current, light, dial, plates, probes, flow, circuit, insulator, materials, metal.

RELATED EXHIBITS

Human battery

Between you and plates of different material you can create electricity, not just conduct it.

Resistance

Different materials have different degrees of resistance to the flow of electricity.

WHAT TO DO

Place your hands on the plates.

Q: **What happens to the meter?**
(A: It should give quite a low reading.)

Q: **What happens if your hands are wet?**
(A: You get a higher reading. Water is a good conductor - so never touch anything electrical with wet hands.)

Place the materials provided across the plates.

Q: **What happens to the dial now?**
(A: Metal gives a higher reading, other materials show no reading which means they are non-conductors i.e. insulators.)

MORE THINGS TO DO

Use the probe to test other materials for conductivity.

Q: **What happens when you hold the probe on a metal object?**
(A: The bulb in the handle lights up which means the metal is a conductor.)

Q: **Does the probe light up when it touches your skin?**
(A: It only gives a very low glow as you are not a very good conductor.)

THINGS TO THINK ABOUT

What kind of things do you think electricity will pass through? Make a list.

What makes a good conductor? How did you make this decision?

Try testing the lead (graphite) in a pencil. It is one of the few non-metals to conduct electricity.

CONDUCTORS: FURTHER INFORMATION

Conductors

Some materials lose charge almost as soon as they gain it because electrons flow to surrounding materials until the balance of negative and positive charge is restored. Other materials have a molecular structure that allows large numbers of free electrons to move rapidly along them - these are conductors. Most are metals (along with graphite which is non-metallic carbon). Copper is one of the best conductors and is most commonly used in wire because it is so malleable. Aluminium is also very good and lighter, so is used in overhead power cables. Steel is not as good and stainless steel a lot worse. Silver is the best but is too expensive except in localised use. It is usually a constituent of solder. (The same properties make metals good conductors of heat as well.)

Certain types of liquid also conduct. Obviously a metallic liquid like mercury will, but most water solutions do as well. Water and dissolved substances like salts ionise into positively and negatively charged particles and will thus conduct electricity. When your skin is dry it is a poor conductor but when wet it transmits electricity well. (So don't sit in your bath holding live electrical devices!) This property is used in lie detector machines. The conductivity of skin will rise with the sweating induced by anxiety about lying. The device has to be calibrated first because everyone has different tendencies to sweat.

Semi-conductors

There is another type of material like silicon which will conduct but not as well as metals. This property is much used in the electronic industry at the heart of which is the silicon chip.

Insulators

Insulators on the other hand do not conduct electricity at all and if placed between two parts of a circuit will break it and prevent the flow of electricity. Both conductors and insulators are required in the electrical industry. Surrounding a copper wire conducting electricity there is a sheath of plastic, rubber or similar material which insulates everything from it. Most wire and electrical equipment is double insulated.

CIRCUITS

Circuits need a complete pathway for electricity to flow
In direct current some devices only work in one direction

DESCRIPTION
This consists of a low voltage, direct current power supply and a circuit made of steel strips. There are three large circular gaps to place components into. The components available are: a bulb, a buzzer, a motor, a meter, a push-button switch, simple switches and a straight connector. These can be placed in various combinations to make complete circuits and allow the current to flow. The meter is provided to make simple measurements of current.

KEY WORDS
Complete circuit, metal, pathway, switch, bulb, motor, meter, connecting wire, direct current.

RELATED EXHIBITS
Circuit tester
You can test to see which wires are connected with which terminals and if there is a break in a circuit.
Conductors
Shows that only certain materials can be used to connect up a circuit.

WHAT TO DO
Place discs into the three spaces to complete a circuit.

Q: Which combination gives the brightest bulb?
(A: One bulb and two switches.)

Q: Which gives the dimmest bulb?
(A: Two bulbs and a motor.)

Q: What happens when you put the buzzer in a circuit?
(A: The buzzer only works if it placed the right way round because it is a one-way direct current.)

Q: Which units use the most current as displayed on the meter?
(A: The bulb uses the most electricity and the buzzer the least. The motor's requirement varies, surging particularly when it starts.)

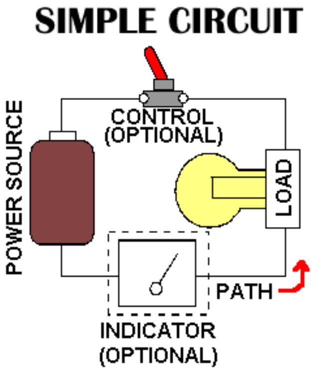
OTHER THINGS TO DO
This exhibit has spaces for the components to fit into but you can make your own circuits using connecting wires, batteries, bulbs, holders, motors and buzzers.

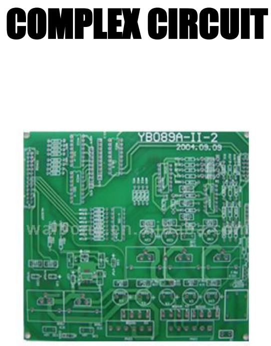
Use symbols to draw your circuits. Remember you need the pathway to be complete.

CIRCUITS: FURTHER INFORMATION

What is a circuit?
James Thurber, the American writer, had a grandmother who worried about her light sockets. She would always make sure that each had a bulb tightly screwed in for fear of the electricity that would otherwise escape into the room and harm her. Actually it is perfectly reasonable if you do not know that a circuit must exist for a current to flow. A bird is not electrocuted when it sits on a wire carried by a pylon because it does not make a circuit. If it were to carry a very long worm that reached to the ground then the current would earth through the worm to the ground and it would be a late bird!

We commonly use the analogy of water systems to explain electricity but this is one point where it breaks down. If you leave a tap turned on the water will flow, which does not happen if an empty socket is left on. A live wire must be connected to the neutral to get a current. The only time a current will flow is if the gap between wires is very small and the potential difference (i.e. voltage) is very high - then a spark can leap across the gap. This is the principle of the car sparkplug.





A.C./D.C.
Circuits can be of two different kinds. The simple direct current (D.C.) in use here flows in one direction only. For most of the devices present this does not matter - but the buzzer will work only one way round. LEDs are similar as can be seen in the **Circuit tester** exhibit. Batteries operate as D.C., whether in a car or a radio.

Mains supply on the other hand is an alternating current (A.C.). The current changes direction at a rapid rate and thus it rarely matters which way round a device is arranged. The power supply from the mains is 240volt A.C. In the small black box it is *transformed* into 6 or 12 volts and *rectified* to D.C. Electricity at these voltages is harmless to us and you would have to use a wet tongue to detect a current.

Meters
The type used in this exhibit is called an ammeter because it records amps (amperes) - a measure of current. The other common type is called a voltmeter, which measures the potential difference between two parts of a circuit, in volts.

CIRCUIT TESTER

Electricity needs a complete circuit to flow round The circuit tester sounds a buzzer when there is a complete circuit, and can check for blown fuses

DESCRIPTION
This exhibit has two parts. On the left are two sets of terminals, one side with letters, and the other side with numbers. They are connected by tangled blue wires. Two probes are used to find out which letter is connected to which number, which causes a buzzer to sound.

On the other side is a box with bulb and fuses- one of which is blown. The probes can test the bulb and fuses. There is also an LED which only works if the probes are the right way round.

KEY WORDS
Bulb, fuse, fuse tester, circuit, terminal, blown, probe, light, LED (light emitting diode), buzzer

RELATED EXHIBITS
Circuits
Create a circuit using various components.

WHAT TO DO
LEFT: Use the probes to find out which lettered terminal is connected to numbered terminal.

Q: What happens when a complete circuit is made?
(A: A buzzer will sound.)

Test the numbers 1234567 to decode secret agent Mathers' favourite pet.

Q: What is it?
(A: Hamster.)

MORE THINGS TO DO
RIGHT: Use the probes to find out if the bulb works.

Q: What happens when the bulb is tested?
(A: It will light up and a buzzer will sound.)

Now try the two fuses.

Q: What is the difference and why?
(A: A buzzer will sound with one but not the other. If you look closely you will see that the second is 'blown' and therefore will not conduct electricity)

Q: Why do you think the red bulb (the LED) will not light when the probes are the wrong way round?
(A: A direct current created by a battery will only flow in one direction (D.C.) and the LED has to be the right way round.)

OTHER THINGS TO DO
Try making your own tester out of a bulb, a battery and some wire for probes.

CIRCUIT TESTER: FURTHER INFORMATION

Testing a circuit
A break anywhere in an electrical circuit will prevent the current flowing. Often it is obvious where the break is visually but sometimes it can be difficult to find. This is where circuit-testing comes in handy. Electrical testers (pictured right) work just like the probes here. They can be moved around until the precise point of break in the circuit can be found.

When looking for the reason a piece of electrical equipment has failed, the first place to start is with the power input. If it is a separate lead like this one - is it pushed in fully? Have the wires pulled off their terminals in the plug? Has the fuse blown - the one in the plug, the one in the push-in socket or one inside the exhibit?

Fuses
Fuses are weak points in the system deliberately designed to create a break in a circuit in preference to more sensitive parts which are difficult or expensive to repair.

Care must be taken with fixing electrical things - even changing a plug properly has to be learnt. On one occasion a volunteer at a public exhibition put on a new a plug for us. Checking on it before use we found they had connected the live wire to the earth, etc. However it would not have presented any danger as they had not stripped the wires of their insulation! But most people can learn the simpler elements - it is just a matter of being shown how.

More complicated problems can also be diagnosed by testers - they can also determine resistance (in ohms), potential difference (in volts) and current (in amps).

LEDs
These are light emitting diodes. Traditionally they were red but now they can be made in almost any colour including white. Even with low voltage batteries they require a resistor to reduce the current or they will blow. The resistor is a small colour and bar-coded item in series (line) with the LED.

RESISTANCE

Electricity is reduced by materials which resist its flow
Conductors have low resistance and don't stop the flow
Insulators have high resistance and can stop the flow

DESCRIPTION
On the left is a box with 4 terminals. They are connected to a variable resistor, two different resistors and a section of pencil. Each can be connected to a motor, on which is a disk with a spiral pattern, using a wire with a probe.

On the right is an electronic box putting out music. It is connected to a loudspeaker via a variable resistor. This has two terminals, one of which is connected to a slide which can be moved along a coil of high resistance wire. The amount of wire the current has to pass through and thus the resistance can be altered.

KEY WORDS
Circuit, resistance, resistor, variable resistor, insulator, conductor, flow, current, terminal.

RELATED EXHIBITS
Conductors
Some materials will conduct electricity though there is still some resistance to the flow.
Circuits
For electricity to flow you require a circuit, though all elements in it will offer some resistance.

WHAT TO DO
LEFT: Connect the motor using the probe to the four terminals in turn. Some have resistors in their circuits. Start with the variable resistor with the silver knob.

Q: What happens when you turn the knob?
(A: The motor changes speed.)

Q: What happens when you connect the motor to the pencil?
(A: The disk turns fast - pencil lead (graphite) has little resistance.)

RIGHT: Listen to the loudspeaker. Move the knob of the resistor along its slide.

Q: What happens to the sound?
(A: It gets louder or quieter depending on which direction you move it.)

Q: What do you think this is?
(A: The electricity going to the speaker has more or less wire to go through. The more coils of wire - the more the resistance - the less the current - the quieter the sound.)

The same thing is happening in the knob on the left or on a radio. Variable resistors are called *potentiometers*.

OTHER THINGS TO DO
Create a ‘circuit’ using a loop of rope. Hold it loosely while someone pulls it through your hands. If you grip the rope more tightly, offering resistance to its movement does it feel hotter? Think of a use for an electrical device in which the wire gets hot as a result of its high resistance?

RESISTANCE: FURTHER INFORMATION

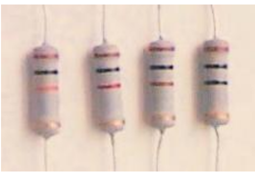
Resistance

Although many materials are classed as good conductors even the best offer some resistance to the flow of electricity. Steel has more resistance than copper but even this latter has some. Usually the thinner and longer the wire the greater will be the resistance. Like a small bore pipe in a water system or a narrow road in a traffic system the flow will be impeded. If the resistance is great and the electrical flow high, the wire will glow red (a bit like a driver caught in a traffic jam). Electric fires and light bulbs make use of this principle. If you put two bulbs together in line (series) each will act as resistor for the other and they will both glow less brightly.

Resistance is calculated by the division of the voltage (in volts) by the current (in amps.) - the answer is given in ohms.

Resistors

In other circumstances resistance is a useful property. For example the flow from a battery is often too great for a LED so a resistor is placed in the circuit with it. This is a small colour and bar-coded item in series (line) with the LED.



Variable resistors

Being able to control the flow of electricity is necessary in such devices as dimmer switches for lights and volume controls on audio equipment. They work like those used here. Commonly they are rotary like the one on the left, but this basically the same as that on the right - a linear variable resistor or rheostat. The contact made by the slide alters the number of coils of wire the current has to pass through and thus the amount of resistance it has to face. The common name for these devices, potentiometers, reflects their ability to alter the potential difference i.e. voltage.

National grid

The electricity that flows from the power stations to our homes and workplaces travels great distances. Despite the quality and thickness of the wire there is considerable loss of power. Thus it is carried at very high voltages indeed - between 132 and 400 thousand volts - and has to be *transformed* to the mere 240 volts at sub-stations before it reaches us.

Super-conductors

When certain materials like aluminium, though not copper, are super-cooled to very low temperatures far below zero they lose all resistance to current flow.

GENERATOR

A generator is a machine which produces electricity
Human energy is used in this exhibit
Inside is a coil of wire which turns inside magnet

DESCRIPTION

A small hand-wheel turns a generator which can be connected to a digital thermometer, radio and/or torch. Each item can be switched on and off independently.

The amount of electricity being produced is closely related to:
(i) how fast the wheel is turned.
(ii) how much effort is required to turn it and
(iii) how many devices are on at the time.
The wheel is hard to turn when more current is needed.

KEY WORDS

Generator, wheel, speed, dynamo

RELATED EXHIBITS

Magnets and electricity
Moving a magnet in a coil of wire generates electricity.
Electro-magnet
Applying an electrical current to a coil of wire around a piece of steel makes it magnetic.

WHAT TO DO

Make sure all the switches are off then turn the wheel on the generator.

Q: Is it easy to turn?
(A: Yes, very easy.)

Q: What happens when you turn on the radio or thermometer?
(A: It is slightly harder to turn the wheel.)

Q: What happens when you turn on the torch?
(A: The wheel is much harder to turn.)

Try spinning the wheel at different speeds.

Q: What happens to the brightness of the bulb?
(A: It is brighter when you turn the wheel faster.)

MORE THINGS TO DO

Does it make any difference which direction you turn the wheel?

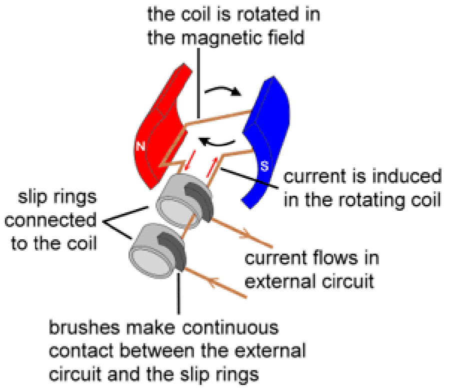
THINGS TO THINK ABOUT

Where is the energy coming from to run the three items? Does is come from your own muscles?

The generator is like the dynamo on a bicycle. Can you think of anywhere else generators are used?

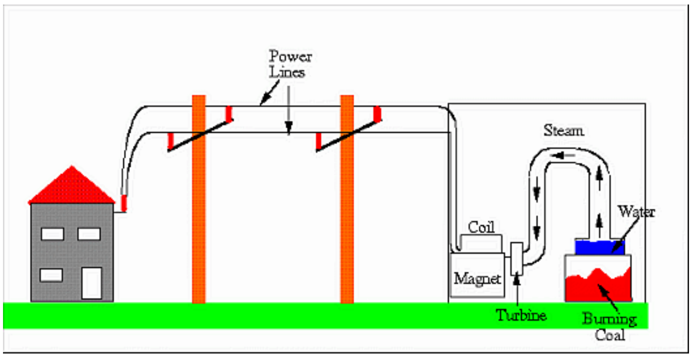
GENERATOR: FURTHER INFORMATION

Generator
It is impossible to create energy; it can only be converted from one form into another. A generator is really a device which enables this to happen. The word "generator" is more accurately used for a special device which converts energy stored as a particular fuel, into a form which is easy to distribute and can be used conveniently in a variety of ways.



In simple terms, an electrical generator works by turning a wire coil in a magnetic field. This action creates a current. (See **Magnets and electricity**.)

Power stations
The construction of a generator depends on the type of fuel used and the form in which the energy is to be distributed. In this exhibit the "power station" is being driven by muscle power whose fuel is food - the output is electricity.



National power generation requires very high rates of energy production. While alternative forms of power stations exist which use wind, water or solar energy, the majority use fuel. They include: coal, natural gas, oil and nuclear (uranium).

A power station must control this process, and convert the energy into motion - boiling water to produce jets of pressurised steam, which are used to turn turbines. Like the generator in this exhibition, the power station then converts the turning movement into electricity.

Fuel for the exhibit's generator
The conversion of energy carried out by the generator in the exhibit can be traced back through various stages. The wheel is turned using energy from the muscles in the arm. These are powered by food which directly or indirectly comes from plants which in turn utilise the light energy of the sun. The nuclear power of stars, in particular the sun, provides all the possible sources of power for electricity generation.

MAGNETS & ELECTRICITY

Electricity can be produced by a magnet passing through a coiled wire

DESCRIPTION

There is a clear tube held vertically. A coil of wire wound round the tube is connected to a small red LED. There are two rod-shaped samples to drop through the tube. One is a magnet, the other is steel.

When the magnet is dropped down the tube the LED lights up as it passes through the coil. The other rod has no effect. The movement of the magnet through the coil generates electricity

KEY WORDS

Electricity, generate, magnet, coil, copper, LED

RELATED EXHIBITS

Generator

A coil of wire is rotated in a magnetic field to generate electricity.

Electro-magnet

An electrical field around an iron core makes it magnetic.

WHAT TO DO

Pick up one of the short rods on a string and drop it fast through the tube.

Q: What happens to the red LED?

(A: In one case it lights up and in the other it doesn't.)

Try the rods against the small steel plate.

Q: What is the difference between the two rods?

(A: One is a magnet and sticks to the plate.)

THINGS TO THINK ABOUT

Which material makes the bulb light up?

Where do you think the electricity comes from?

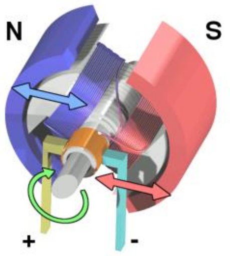
What is happening here is similar to what goes on inside the **Generator** exhibit. In both cases electricity is produced by making a coil of wire and magnets move in relation to one another.

MAGNETS & ELECTRICITY: FURTHER INFORMATION

Magnets and Electricity
The relationship between magnetism and electricity is at the core of understanding the nature and uses of electricity.

Electrical generators or dynamos
A magnet that passes through the coils of insulated wire creates a current which in this case is sufficient to light a LED. On this principle most of electricity generation depends, from the alternator in a car to giant power stations. In these a wire coil is rotated in a magnetic field. Fuels like coal, gas or nuclear power are used to turn water into steam to drive an engine to turn it. With oil it is like a giant diesel engine. But generators can also be turned directly by water or wind.

Electric motors
Equally if a current is applied to a coil surrounded by magnets then it will move. If it is arranged in the right way the two magnetic fields react to cause the magnet to rotate. Then you have a motor, whose rotary power can be harnessed.



Electric motors are ubiquitous - all over the house from washing machines to DVD players. A modern car has dozens from the starter motor to the door locks, from washers and wipers to fans and sound systems.

ELECTRO-MAGNET

When a current flows through coils of copper wire a magnetic field is formed
The electro-magnet can be turned on and off

DESCRIPTION
An electro-magnet with a push-button on top can slide along two rods so it passes over four trays containing a selection of small metal objects. The sample trays contain: steel nails, aluminium and steel nuts, a circuit consisting of a battery, magnetic switch and LED, and finally a tray with small compasses. When the electro-magnet is turned on it attracts some of the metals in the tray, activates the switch and attracts the compasses.

KEY WORDS
Magnet, attract, steel, iron, switch, coil, magnetic switch, LED, electro-magnet

RELATED EXHIBITS
Magnets and Electricity
Dropping a magnet through a coil of wire generates electricity.

WHAT TO DO
Move the slider over each of the plastic trays and press the green button.

Q: What happens to the small metal objects?
(A: The steel nuts and the iron nails are attracted to the electro-magnet.)

Q: What happens to the aluminium nuts?
(A: They are not attracted by the magnet.)

Q: What happens to the circuit?
(A: The magnet activates the switch and the LED lights up. The magnet pulls up the hinged steel plate into contact with a terminal, creating a circuit.)

Q: What happens to the compasses?
(A: They are attracted to the magnet even at a distance.)

Q: Which things are attracted to magnets? Are they all made of the same material?
(A: Only iron and steel objects are attracted to the magnet.)

Q: What happens when the green button is not pressed?
(A: Nothing. When no current flows there is no magnet.)

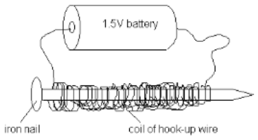
OTHER THINGS TO DO
Try making your own electro-magnet out of a battery, a coil of wire and an iron nail (see over).

Find out about the use of electromagnets in industry.

ELECTRO-MAGNET: FURTHER INFORMATION

How do electro-magnets work?

When electricity is run through a single wire, a small magnetic field is created. It is much increased if insulated wire is in a coil, especially wound round an iron core. When the current flows through it the core becomes magnetic and will attract ferrous metals as long as it is switched on. When it is turned off the iron core does not retain its magnetism and no longer attracts the metal.



Home-made electromagnet

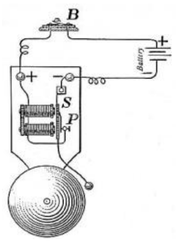
You can make a simple one using a battery, a coil of wire and an iron nail. By connecting the battery the magnet will attract pieces of iron or steel; when disconnected it will drop the metal.

Uses

Some of the uses to which this vital property can be put are present in this exhibit. Imagine a gigantic version in a recycling plant, separating the iron and steel from other materials such as aluminium.

Relay switches and solenoids

Perhaps the most pervasive use is in the application of switches. Being able to turn a switch on and off simply by means of an electrical current is immensely useful. They can also be used in relays where a switch designed to operate with a low current can trigger a magnetic switch for a circuit taking a much higher current. Such an arrangement is used in a car starter solenoid where an iron plunger is attracted to the centre of a coil (against a spring) when the current is switched by the key. It then bridges the heavy duty contacts which allows a high current to flow to the starter motor.



Electric bell

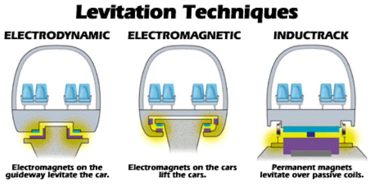
When the button of a doorbell or fire alarm is pressed, a current flows to the electro-magnet, which pulls the clapper arm towards it. The clapper strikes the bell. Having been pulled forward, the contact to the current is broken and the electromagnet is switched off. The clapper arm springs back, contact is re-established, the magnet pulls the clapper, the bell is struck etc.

Telephone

Another device that uses the principle is the telephone. Speaking into the mouthpiece vibrates a diaphragm which alters the current flowing down the wire. At the earpiece an electro-magnet responds to the current variation in the pull it has on another diaphragm. The movement of this produces sound.

Maglev trains

These have no wheels and rely on magnetic levitation to ride friction-free above the track. A linear induction motor is the drive mechanism. Coils on the train produce magnetic fields both on the train and the track which interact to pull the train forward.



STATIC ELECTRICITY

Static electricity can be released by rubbing two materials together

DESCRIPTION
There are two clear domes. One has polystyrene beads inside; the other has small pieces of aluminium foil. There is a cloth to rub on the domes. Rubbing the domes produces a static charge on them and the particles inside. The exact balance of charges causes the particles to be attracted or repelled by the charges on the domes.

This exhibit does not work as well in damp conditions. Most classrooms should be sufficiently warm and dry.

KEY WORDS
Static, charge, jumping, particles, polystyrene, foil, attract, repel.

WHAT TO DO
Rub one of the domes with the cloth.

Q: What happens to the polystyrene particles?
(A: They jump up and stick to the inside of the dome.)

Q: What happens to the pieces of foil?
(A: After a while they jump up and down.)

Touch the domes with your finger.

Q: What happens to the particles?
(A: They fall away because the static charge has discharged through you.)

MORE THINGS TO DO
Use different materials such as your sleeve or a polythene bag. Rub faster or slower.

What is the effect of rubbing your feet on carpet or your hands on your hair and then touching the domes?

THINGS TO THINK ABOUT
You can get a static shock when you walk over nylon carpet, sitting on some car seats, or taking some materials out of the tumble drier and then touching something metal. You are being charged up just like the particles in the domes. Have you tried rubbing a balloon on your sleeve and making it stick to the wall?

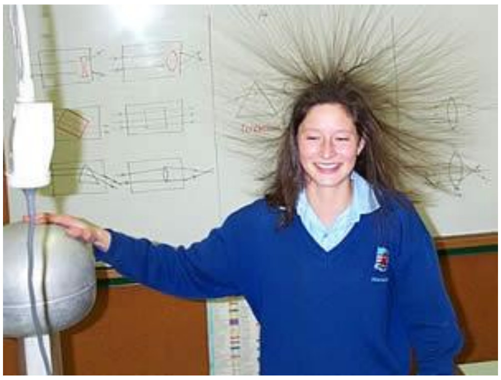
Have you ever seen a van der Graaff generator? When it is charged up and someone touches it their hair stands on end. The charge covers the person’s body - all the hairs are charged up the same, repel each other and move as far away as possible.

STATIC ELECTRICITY: FURTHER INFORMATION

What is electricity?
The word comes from the Greek *electron* for amber - hardened tree resin much prized by the ancients for decoration. They found that when they rubbed it with fur or cloth they could get tiny sparks (visible in the dark) and pick up small pieces of wool. All materials are made of atoms which consist of a positively-charged nucleus around which is a "shell" of electrons which is negatively-charged. If some of these electrons are rubbed off, the material becomes positive and will attract negative particles. The electrons will stick to the material that was used to rub which then becomes negative.

Lightning
Static electricity builds up in rain clouds and can only be discharged by earthing to other clouds or to the ground as lightning. Lightning rods are positioned on the tops of tall buildings designed to conduct the electricity to the ground without damage to the structure.

Van der Graaff generator
This device consists of a stalk with a large metal sphere which acts as an output terminal creating large amounts of static electricity for use in experiments. Unlike a battery which maintains a constant voltage while providing a variable current, this arrangement will produce a constant current but the voltage will vary. It can generate such high voltages that it will make your hair stand on end – literally.



HUMAN BATTERY

Electricity can be made by using two different metals and an electrolyte

DESCRIPTION
This exhibit has four hand-shaped pieces of metal - two aluminium and two copper. They are connected to a meter, which indicates if a current flows. Pupils place their hands on two different plates to create electricity.

KEY WORDS
Battery, metals, aluminium, copper, plates, electrolyte, current, flow, meter.

RELATED EXHIBITS
Conductors
Because both the plates are of similar material you can conduct electricity but not create it.

WHAT TO DO
Put your hands on two different plates - copper and aluminium. Look at the meter.

Q: Does the needle move?
(A: Yes - it will move to the left or right, showing a tiny flow of electricity.)

Q: What happens if you put your hands on two similar plates?
(A: The needle does not move.)

Q: What is the source of electricity in this exhibit?
(A: You are - in combination with the two different plates. There is no battery or mains supply in the circuit.)

MORE THINGS TO DO
Dampen your hands before putting them on the plates.

Q: What difference does this make?
(A: It will usually make the needle move further, indicating greater current flow.)

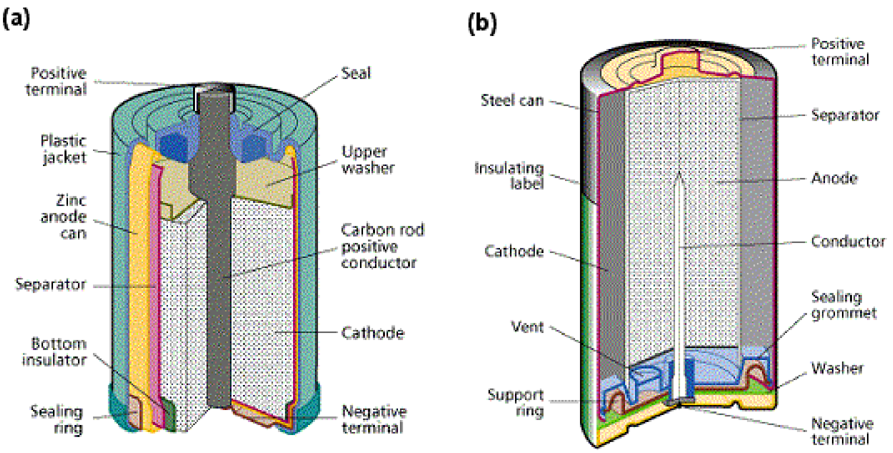
Compare this with the **Conductors** exhibit.

Q: What is the source of electricity in that one?
(A: There is a battery which provides the power. The two plates are the same and you just connect them.)

THINGS TO THINK ABOUT
Have you ever experienced a bit of silver paper reacting with a metal filling in your tooth? This is the same effect. (These days many fillings are no longer metal.)

HUMAN BATTERY: FURTHER INFORMATION

How batteries work
A battery works when two different materials usually metals or their oxides or carbon act as the electrodes (cathode - positive; anode – negative). They are connected by a material called an electrolyte which is a liquid or a paste containing charged ions, e.g. salt (NaCl) which separates into Na+ and Cl - ions.



Old style batteries (a) have a carbon core surrounded by an electrolyte paste within a zinc case. Zinc-manganese dioxide batteries (b) which have an alkaline paste last longer and are used for long-life ones. Rechargeable ones usually use nickel and cadmium. Car batteries have lead and lead peroxide plates with a liquid sulphuric acid electrolyte.

All batteries have two terminals - one positive (+) and one negative (-). Many like the C, D, AA or AAA batteries you put in a torch or remote control have the terminals at each end. Those like ones in use in some of the exhibits or in a car have them both on top.

Inside the battery the chemicals produce electricity in the form of sub-atomic particles called electrons which flow to the negative terminal. If an appropriate device requiring power is connected to this terminal and then to the positive, a current will flow and the device will work. (The power remains in the battery until it is connected up.)

The power is always D.C. - direct current - which flows only in one direction. They are usually low powered (voltage) and therefore not dangerous. You can rarely feel the effect of putting a finger between the terminals, but a wet tongue will definitely feel a tingle!

Human batteries
In this exhibit it is aluminium and copper which are the terminals and your body fluid is the electrolyte. The same effect can be observed when a piece of silver paper in your mouth gives you a little electric shock. It is acting as one terminal in a battery with the zinc amalgam of your filling as the other and saliva as the electrolyte. Children have many fewer fillings these days because of fluoridation of tooth pastes and drinking water and those they do have are often non metallic.

NB. If the meter registers a very small current when you have your hands on two similar plates it is probably because there is some contamination from the other plate that has been transferred by numerous hands.

MORSE CODE

Henry Morse invented a simple code to send messages over long distances
Each letter and number has a code of dots and dashes

DESCRIPTION
There are two Morse code units. Each one consists of a tapper with a light and two buzzers. When the tapper is held down the circuit is completed and a buzzer sounds in the unit being used and a light and buzzer come on in the other unit. Messages can be passed from one to the other. Use the chart to decipher the messages.

KEY WORDS
Transmit, tap, close, receive, circuit, Morse code, switch.

RELATED EXHIBITS
Circuits
Circuit tester

A	•—	**U**	••—
B	—•••	**V**	•••—
C	—•—•	**W**	•——
D	—••	**X**	—••—
E	•	**Y**	—•——
F	••—•	**Z**	——••
G	——•		
H	••••		
I	••	**1**	•————
J	•———	**2**	••———
K	—•—	**3**	•••——
L	•—••	**4**	••••—
M	——	**5**	•••••
N	—•	**6**	—••••
O	———	**7**	——•••
P	•——•	**8**	———••
Q	——•—	**9**	————•
R	•—•	**0**	—————
S	•••		
T	—		

WHAT TO DO
Try tapping your name, using the code.

Q: Can you see what happens to the bulb?
(A: The bulb in the other unit lights up.)

Q: How is the message transmitted?
(A: Along the wires which connect the two units.)

Q: When is the circuit complete?
(A: When the tapper is pressed down it closes a switch so electricity can flow round the circuit to your buzzer and the other unit's bulb and buzzer.)

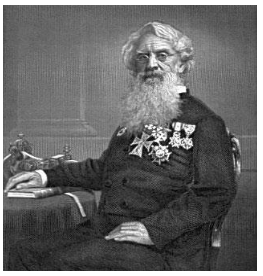
THINGS TO THINK ABOUT
Can you think of any other ways messages have been passed across long distances before the invention of electricity?

How is information passed today? Does it also rely on a code system?

Can you invent your own code using these tappers? Try to create your own circuit that could be used to transmit a message.

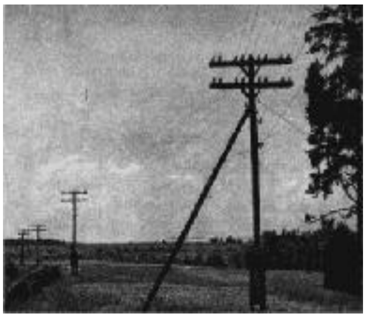
MORSE COSE: FURTHER INFORMATION

The history of Morse Code



The code was invented by Samuel F.B. Morse in 1836. Though not identical to the one used today it established the basic principles. The telegraph (Greek: "distance writing") was born. An electric circuit can be intermittently connected to produce short or longer bursts of sound or light. These circuits, with the use of relays, could traverse the globe and "Nation shall speak unto nation".

It may seem surprising that a code made only of two symbols could encompass any message no matter how long or complicated. It is a digital system. The computer on which this is written and the emails and text messages which are today's methods of communication work in a similar way - everything in the universe is reduced to a series of 1s or 0s. (And all of life is based on the four-lettered code of DNA.)



Electric telegraph

The potential of the electric telegraph was immediately realised and thousands of miles of cable was quickly laid, criss-crossing the world. Like all such wonderful new developments people went mad for it and investors soon overloaded the market to create a stock bubble which of course eventually had to burst. The lesson was learnt that new technology can be valuable but it can't guarantee everyone a fortune.....until the next time (bubble.com).

Telegramese

This was the text message of its day. Telegrams were paid by the word so these were minimised often by simply joining words together. The telephone began to come in at the end of the nineteenth century and largely superseded the telegraph, but it remained in existence until the 1970s. The Queen's congratulations on your 100th birthday no longer come by telegram.

SOLAR POWER

Light is a form of energy
A solar cell collects light energy and converts it into electrical energy

DESCRIPTION
A panel of solar cells can be illuminated by a light bulb, representing the sun. Solar cells are made of special materials that convert light energy falling on them into electricity.

The electricity is used to power an electric motor turning a disc, which spins faster when more electricity is being produced.

The panel of cells can be raised and lowered to alter the amount of energy collected. The amount of light falling on it can also be changed by placing screens, which allow different amounts of light through, in front of the light.

KEY WORDS
Bulb, solar power, generate, current, electric motor, connecting wires.

RELATED EXHIBITS
Wind power
This exhibit shows electricity being generated by moving air.

WHAT TO DO
Raise and lower the panel of solar cells, holding it at different angles to the lights.

Q: What happens?
(A: The speed of the spinning disc changes according to how much light is falling on it. The disc is powered by a small electric motor which turns faster if it gets more electricity.)

Hold different screens between the lights and the solar panels.

Q: What happens?
(A: The amount of electricity being produced by the solar panels alters.)

Q: What is the difference between the screens?
(A: One is transparent but coloured and allows quite a lot of light through. The other is translucent - some light passes through. They can represent different types of cloudy days.)

MORE THINGS TO DO
Shade half of the solar cell panel with your hand.

Q: What happens?
(A: The solar cell produces less electricity - the disc spins more slowly. All the cells in the panel must all be exposed to light for it to work fully.)

If it is a bright day, place the exhibit near a window.

Q: What happens?
(A: The disc spins fast showing that more electricity is being generated. This is because sunlight carries more energy than artificial light.)

SOLAR POWER: FURTHER INFORMATION

Solar energy

Solar energy is limitless as long as the Sun keeps on shining which by most calculations is at least another five billion years. Energy from the Sun is created by nuclear reaction turning hydrogen into helium. The energy given off in the form of light is used by plants for growth and metabolism and to build up their food resources. Animals need plants for food so their lives also depend on the Sun. The fossils fuels such as coal and oil are made from fossilised plants and tiny animals so that their energy too comes ultimately from the Sun.

Solar cells

The Sun's energy can also be converted into electricity which is useful as a pollution-free method of generating electricity compared to burning fossil fuels. This can be done by photo-voltaic solar cells as in this exhibit. They are not particularly efficient as yet. Although they work in cloudy weather they perform best in direct sunlight. A lot of the electrical energy is not used directly. It is often stored in batteries or other devices such as heat sinks for later use, often at night. They are best used in places that get a lot of sun. They can be arrayed in vast numbers in unpopulated near-desert conditions.

Solar thermal power station in Spain

The alternative method of using the power of the sun is to use mirrors to focus light on a single point, turning water into steam or heating air to drive a turbine as in a conventional station. The sun’s light can be used to heat a fluid like oil or molten salt which can be used as a temporary energy store to drive turbines when the sun goes down.

The lights in the exhibit mimic the Sun and the solar panel can be lifted up at different angles to see whether the energy generated is affected by the angle of the "sun" to it. The screens or a pupil's hand can mimic clouds or haze.

WIND POWER

Moving air has energy
It can generate electricity by rotating a propeller whose efficiency depends on its size, shape and position

DESCRIPTION
A fan provides an air flow or "wind" across the exhibit. Three movable wind tunnels can be placed in the air stream. They contain propellers, each of different size and shape, and can be connected to a small generator and connected to a meter showing the rate at which electricity is being generated.

The effect of placing obstacles in front of and behind the tunnel and changing its angle and position can be tested.

KEY WORDS
Wind power, generate, electric current, meter, connecting wires.

RELATED EXHIBITS
Solar power
This exhibit shows electricity being generated from light.

WHAT TO DO
Place a wind tunnel in front of the fan and watch what happens to the propeller and the meter.

Q: **What happens if the wind tunnel is placed straight in line with the air flow and close to the fans?**
(A: The propeller spins fast and the meter shows a high reading for the energy being generated.)

Q: **What happens if the wind tunnel is placed at an angle to the air flow?**
(A: The propeller will turn more slowly. At large angles the propeller will stop.)

Q: **What happens if an obstacle such as a hand is placed in front or behind the tunnel?**
(A: The propeller stops turning because the air flow is interrupted. Even when the object is behind the propeller it prevents through-flow of air along the tunnel.)

OTHER THINGS TO DO
Look at pictures of old windmills and modern wind turbines or better still at the real thing.

Q: **Are windmills like the models in this exhibit?**
(A: Fairly similar. They have four large blades angled to the wind. Usually they turn quite slowly. They have devices like slats that can be opened or sails furled in case of high winds.)

Q: **Are wind turbines like the models in this exhibit?**
(A: Yes and no. They work on the same principle but they have long thin blades, aerofoil-shaped like a plane wing.)

WIND POWER: FURTHER INFORMATION

Wind energy

Wind is one of the renewable sources of energy. Winds are caused by the Sun heating up the Earth differentially over its surface. Hot air on the equator rises and cold air from the poles moves in to take its place. The wind patterns are much more complicated than that because of other factors such as the Earth's spinning, the presence of mountain ranges, etc. The wind's energy can be used to turn the sails of a windmill or can be converted into the more useful modern form of electricity by using a wind turbine.

Windmills

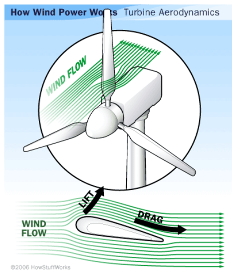
The first windmills appeared in Persia and were horizontal like the first water wheels. By the 1100s the vertical mill was developed in Europe. It was more powerful but needed gears to turn horizontal millstones and had the disadvantage of being dependant on a particular wind direction. The invention of the Post mill which could be turned round a central hub to face the wind by a long pole increased the use of the wind's energy. The later Tower mill allowed just the top part to be moved.

The sails were originally made of cloth and could be let out or furled to take account of the power of the wind and the needs of the mill. They were later replaced by wooden slats which could also be adjusted.

Windmills were mainly used for grinding grains but by the later Middle Ages were also designed to pump water. This was important in draining marshy, low-lying land such as the Fens for agriculture. In no other place was it as vital as Holland, much of which lies below sea-level. This is why the windmill has become a symbol of the country.

Wind turbines

Strong winds are needed to turn the blades of a real turbine so they are usually sited on top of hills or at the coast in particularly windy areas. The faster the wind speeds the more electricity can be generated. There are wind farms in Wales and Scotland where many turbines are erected together. The turbine blades have to be very carefully designed to catch the maximum energy from the wind and be able to turn into wind whatever direction it comes from.



They work on the same principle as windmills but the blades are not large and angled to the wind, but instead are long and thin. They are aerofoil-shaped like a plane wing. Trials have shown this form to be the most efficient. By relying on the lift generated by the wings they can extract the maximum amount of wind energy over the circle created by the diameter of the blades. They appear to turn quite slowly but the blade tips are moving at high speed.