Chapter 14 – Electricity and its Circuit

ELECTRIC CURRENT

What is this ?

Electric current is flow of electric charges

What are electric charges? They are the flow of particles called electrons . How fast or slow they are moving defines the amount of current flowing.

- **Electric Current is defined as the flow of energy or charges through a conductor.**
- There are various devices such as Cells, Batteries, Generators etc. which can be used to produce this electric current. Such devices that produce electric current are called sources of Electric Current.

Electric Current can be produced in a number of ways..

-In nature Clouds display electricity in lighting when a charge jumps from one cloud to another…

-Electrostatic charge moves through hair and comb

-In car, the battery does it

-In homes the electricity comes from the one generated in Hydro power plants / coal power plants/ wind power plants

ELECTRIC CELLS

- A cell is a device that is used to generate electricity.
- It consists of a container which is made out of a metal called Zinc.
- It has a metal cap which is called the positive terminal '+'.
- It has a metal disc on the opposite side which is called the negative terminal '-'.
- Cells produce electric current by a chemical reaction that changes the chemical energy into electrical energy.
- There are two types of cells : Primary and Secondary Cells.

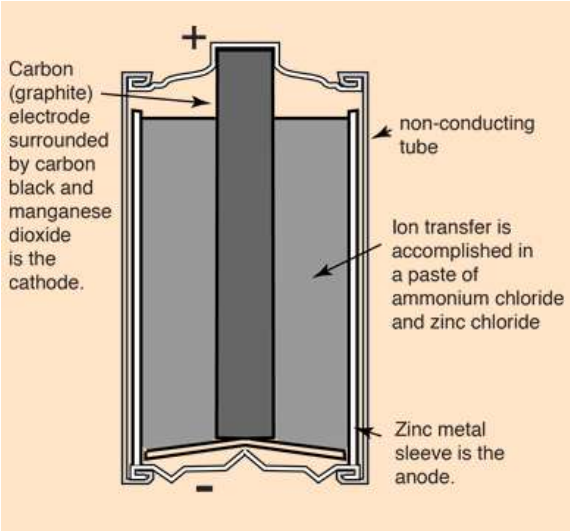
1. Primary Cells :

- Primary cells produce electricity from the chemical stored in them. When the chemicals are all used up these cells stop working. That is, they stop producing electricity and cannot be used again.
- Such cells are used in Torches, Wall clocks etc.

2. Secondary Cells :

- Secondary cells provide electrical energy to the gadget as a result of chemical reaction taking place in them
- In such cells chemical reaction is reversible and electrical energy can be restored in them.
- Such cells are also called Rechargeable Cells.
- Mainly used in mobile phones, Car batteries etc.

STRUCTURE OF A DRY CELL



1). The Dry cell consists of a carbon Rod surrounded by a layer of carbon black and Manganese Dioxide and these constitute the ANODE (-)
2). The next layer outside it is an aqueous paste of Ammonium Chloride & Zinc Chloride which is the electrolyte and where the ion transfer takes place.
3). The Cell is finally sealed inside a Zinc Container which acts as an Anode.
4). When the Current flows through the circuit, Zinc reacts with the lectrolyte, produces excess amount of electrons and then pases them to the electron deficient cathode. From here the current flows from the cathode (positive) to the anode . This process continues till the substances inside get depleted and can no longer produce electrons

SOLAR CELLS

Now a days another kind of cells called solar cells is being used :

- A solar cell converts solar energy to electrical energy and hence also referred to as a photo-voltaic cell. Here photo stands for light (Solar) energy and voltaic stands for electrical energy.
- These cells are used in calculators, Traffic signals, Satellites and are also used to provide electricity in areas where the laying of power cables is not easy.

BUTTON CELLS

- It is small, almost size of a button.
- It is used in small electronic devices like, wrist watches, calculators, hearing aids.

ELECTRICAL CIRCUIT

- **The complete path of flow of electric current from one (+ve) terminal of the cell to the other(-ve) terminal through all the components like wire, bulb, switch etc. is called an Electric Circuit.**
- If the contact between any of the component in the electric circuit gets broken then the circuit becomes an open circuit.
- If the electric current flows between the terminals of the cells then the circuit is called a closed circuit.
- Hence we see that :

There are various components of an Electric Circuit:

1) A source of electric current e.g. a Cell or a Battery
2) Connecting wires that conduct electricity
3) A key or a switch (which helps to break or close the circuit)
4) A device or an appliance (e.g. bulb) that uses the electric current in the cell for some useful purpose.

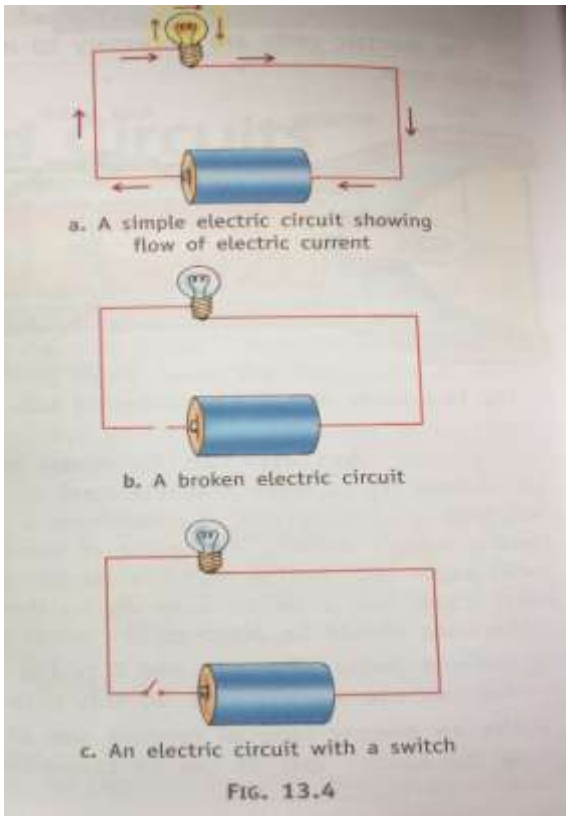


FIG. 13.4

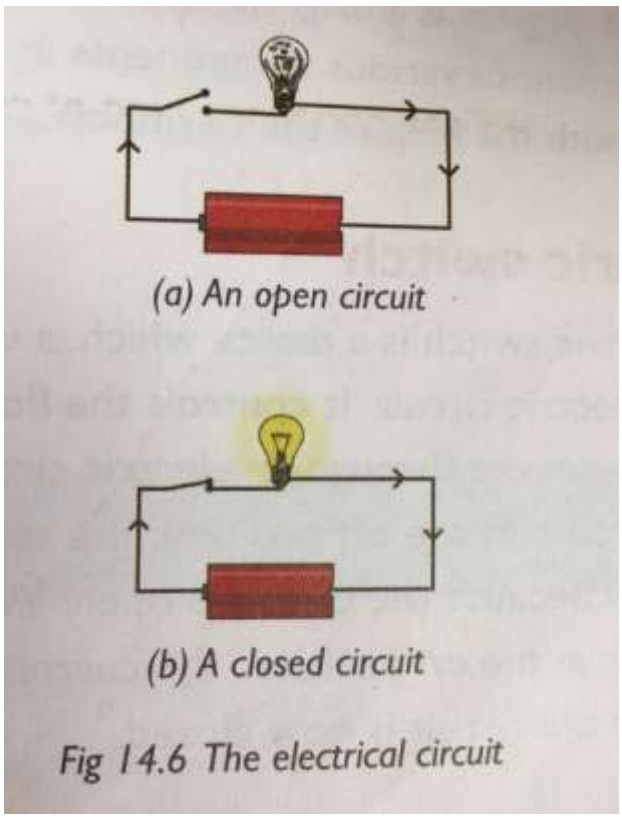


Fig 14.6 The electrical circuit

BATTERY

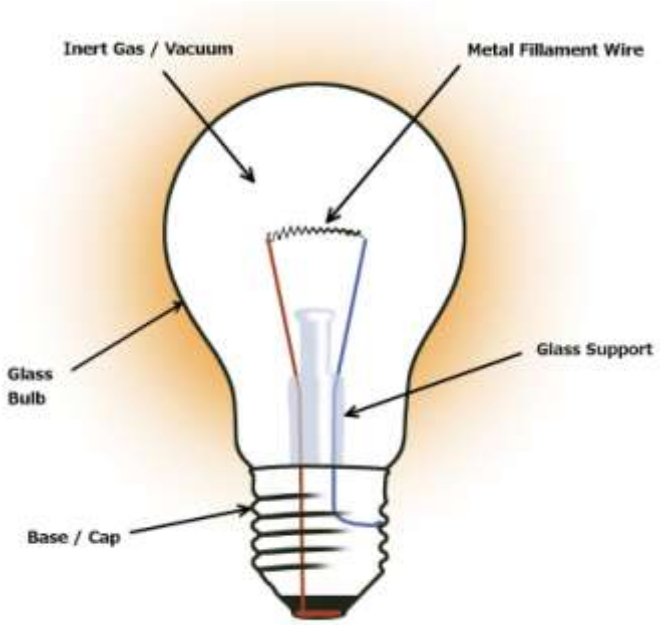
Sometimes when the energy provided by a single cell is not enough then two or more dry cells are placed together so that the extra energy can be generated. **The combination of cells placed together in such a manner that the positive terminal in one cell remains in contact with the negative terminal of the other cells is called a Battery. It is a combination of 2 or more cells.**

ELECTRIC WIRE – This is usually made up of copper, aluminium& tungsten (Since they are good conductors of electricity) and are covered by plastic (Since plastic is a bad conductor of electricity) and the user does not get an electric shock.

ELECTRIC KEY/ SWITCH

- An electric switch is a device which is used in every electric circuit.
- It controls the flow of electric current through the circuit.
- When the switch is in off position then the current will not flow as the circuit is open.
- When the switch is in on position then the current will flow as the circuit is closed.

BULB

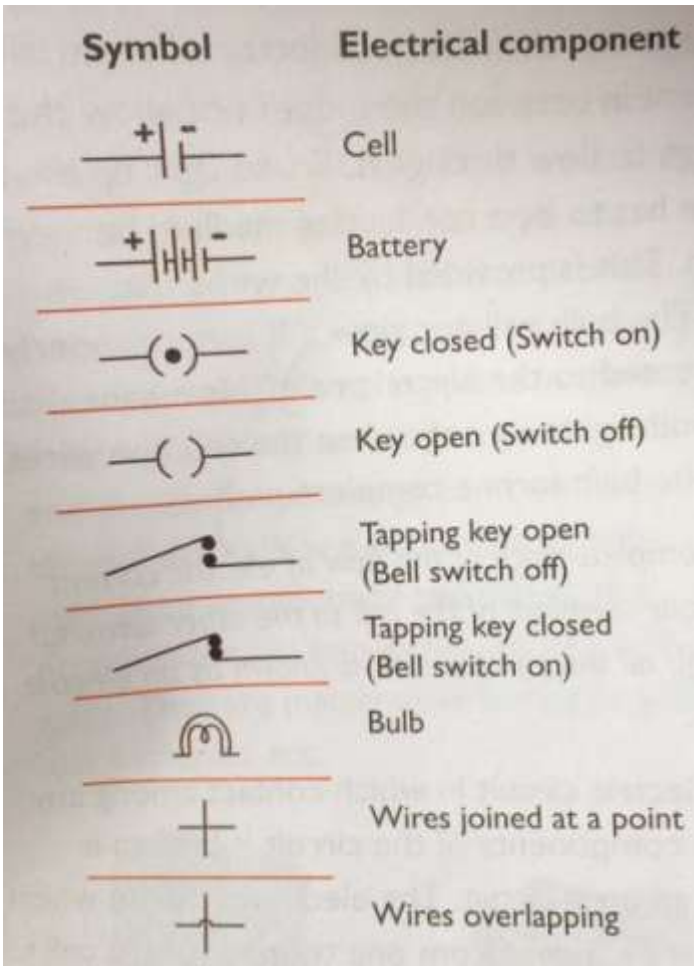


- A bulb consists of a glass fixed on a metal base.
- Inside the glass is a thin wire called filament (which is often made of tungsten which has a very high melting point and will not melt easily. But this filament can catch fire if it interacts with oxygen. Hence this filament is cased in a glass container which glows when current flows through it..
- The filament is fixed with two thick wires which also provide support to it.
- One of these thick wires is connected to the metal case at the base of the bulb while the other thick wire is connected to the metal tip at the center of the base . These are the two terminals of the bulb.
- The two terminals are fixed in such a way that they do not touch each other.
- Hence both the electric cell and the bulb have two terminals each.
- A bulb does not glow when the filament gets broken because the broken filament breaks the circuit of the current.

AMMETER – Ammeter is another circuit element and is an instrument which is used to measure an electric current flowing in a circuit.

SYMBOLS OF A FEW ELECTRICAL COMPONENTS

- Cells, Batteries, Bulbs, Switches and wires are some components of electric circuits.
- A circuit diagram is a diagram which shows the arrangement of various components in an electric circuits with the help of their symbols.



CONDUCTORS AND INSULATORS

CONDUCTORS

- Materials which allow electric current to pass through them are called conductors. For e.g. Metals like gold, silver, copper, aluminium, iron.
- Water is also a good conductor of electricity.
- Graphite is the only material which is not a metal but is a good conductor of electricity.

INSULATORS

- Materials that do not allow electric current through them are called insulators. All non metals except graphite are insulators.
- Other Examples of insulators are plastic, wood, rubber, paper, glass.

NOTE : The handles of an electrician's screw driver are made up of plastic because plastic is an insulators which protects the person from getting an electric shock while working with live wires.

OPEN AND CLOSED CIRCUITS

CLOSED CIRCUIT

An electric circuit is closed or complete if there are no breaks in it.

OPEN CIRCUIT

An electric circuit is open or incomplete if there are breaks in it.

A circuit could get a break because of :

- A broken wire
- A fused bulb
- An expired cell
- A faulty or open switch / key
- Presence of an insulator in the path of the circuit.

When will current not flow in a circuit?

1. When bulb is fused / appliance is faulty.
2. When the cell / battery is all used up and has no chemical left.
3. When the connection amongst the components is not proper.
4. When the connecting wire is broken / the medium is an insulator.
5. When the key is open and not closed.
6. When an insulator is kept in the path of the circuit.

POTENTIAL DIFFERENCE

Just like water flows continuously because the 'Pressure difference' between the two containers is maintained by the pump,

So too,

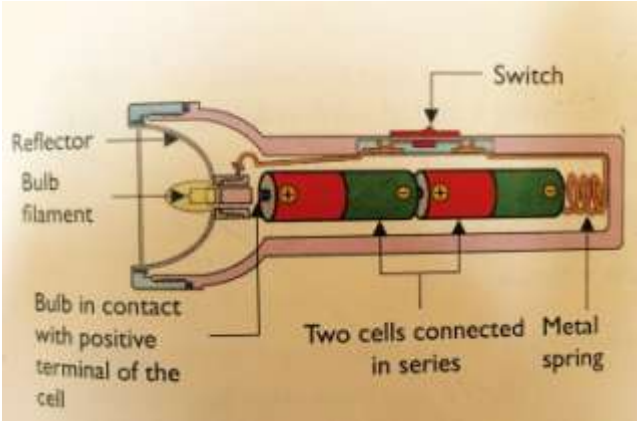
In order to make electric current flow continuously we need a device that can constantly pump the current in the same way so as to create a 'Pressure difference' in electricity this difference is known as **POTENTIAL DIFFERENCE.**

Hence, if current flows from point A to point B in a wire, we say that A is at a higher potential than B, or that there is a potential difference between A and B.

An electric cell or battery is a device that can make current move continuously in a wire by creating a potential difference. A cell has two terminals – one marked positive (+) and the other marked negative (-). The positive terminal is at a higher potential than the negative terminal. When these terminals are connected by a metal wire, current flows from the positive terminal to the negative terminal in the wire.

To make water flow with more pressure we release it from a greater height. Similarly to make more current, you use more cells/ stronger battery to flow from a higher energy to a thing at lower energy.

ELECTRIC TORCH



An electric torch is a simple device which converts electric energy into light.

WORKING OF AN ELECTRIC TORCH

- A torch has a bulb, electric cells, a switch and a outer body.
- The group of cells or battery act as a source of electricity.
- Its bulb consists of a thin tungsten wire called filament and this filament is enclosed in glass case.
- The bulb has two terminals.
- The battery (group of cells) which is placed in a torch have one of their negative terminal touching a metal spring at the opposite end of the torch.
- The positive terminal of the battery touches the bulb at the other end.
- A switch is present on the outer body of the torch and this switch can be turned on and off to complete or break the circuit between the wire, spring, cells and the bulb.
- When the switch is turned on the current flows through the filament it heats up and start glowing. This glow is the source of light from the bulb.
- The body of the torch has a reflector and lens, which focus the light that is given out by the bulb.
- Hence the bulb glows when the switch is open and circuit is closed and does not glow when the switch is closed and the circuit is open.

EFFECTS OF ELECTRIC CURRENT

-Electricity and its effects help, in the running of many gadgets.
-When current flows through a circuit we see various effects of this current depending on the components that are being used in the circuit.
-Accordingly there are various effects of current.

1. Lighting effect of current.
2. Heating effect of current.
3. Magnetic effect of current.
4. Chemical effect of current.

1. **Lighting Effect of Current:-** The lighting effect of current is visible when the current passing through the bulb leads to glowing of the bulb.

2. **Heating Effect of Current: -**
   The production of heat when Electric Current passes through a material is called the Heating Effect of the Current. There are many applications of this heating effect:
   e.g. An Electric Bulb

-When the circuit is closed, the current flows through the filament in the bulb, which heats up the filament.

-The temperature of the filament rises to such an extent that it starts glowing.
-When the circuit is complete the bulb lights up and becomes hot.
-When the circuit is open the bulb does not light up and not hot.
-Therefore it is dangerous to touch the bulb when it has just been switched off.

FUSED BULB

-If the electricity flowing through the bulb is too high, a large amount of heat is produced.
-Since the filament is thin the heat is enough to melt the wire, causing the filament to break.
-Since the circuit gets broken such a bulb is called a fused bulb and does not light up.

FUSE

-Fuse is a safety device that is used in electrical circuits to protect appliances. It prevents appliances from getting burnt out in case excess current flows through the circuit.
-A fuse is a small piece of wire of an alloy which has an adequately low melting point (usually 63% tin and 37% lead).
-There is maximum limit of current that can safely flow through a circuit.
-If the current exceeds the safe limit, then the fuse wire gets hot and melts / breaks.
-This creates a gap (break) in a circuit, the current stops flowing and the appliance is saved from getting burnt.
-Fuse is always connected in series with an appliance so that excess flow of current is prevented from spoiling the appliance (e.g refrigerator etc) connected to it .
-So if a fuse is of 1Ampere then if current more than 1 Ampere flows through it then it breaks.
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MCB 's (Miniature Circuit Breakers)

-MCB's are switches used in household circuits, which break or go OFF automatically on being heated by the overload (excessive) electric current.
-On being switched off the circuit gets broken and this prevents the appliances from getting burnt.
-They can be reset manually and this completes the circuit again.
-In fuse the wire melts and breaks but in MCB, as soon as the current gets excessive, the entire circuit just gets disconnected by a switch getting switched off and hence we can just lift it back again and restore the circuit. Unlike a fuse in which a wire has to be replaced but here in MCB it is only about switches as it senses the amount of current flow and switches off.(the switch goes up and then we just need to put it down back again to restore it.
-Also, another advantage of the MCB is that it is easy to identify the faulty zone as only the zone that is faulty trips and hence the problem zone can be located.

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OTHER ELECTRICAL APPLIANCES THAT RUN ON THE HEATING EFFECT OF CURRENT…

-Many other electrical appliances run due to the heating effect of electric current.
-Some electrical appliances contain a coil of wire known as the element.(usually made of nichrome or tungsten)
-When current passes through this element it becomes red – hot and gives off heat.
-Some of such appliances are :-

o **Iron** – This has a frame which is made of Nichrome- mixture of Nickel and Chromium and have a high melting point and don't catch fire when heated and interacted with oxygen in the air. When current flows, it heats up this plate.

a. **Geyser**- It has heating element in it made of COPPER and this heats up and makes the water around it hot.

b. **Immersion Rods**-They also when put into water , heat the water

c. **Hair Dryer** – also have a thin nichrome wire which heats up and heats up the air around it

d. **Electric heater** - This also has heating elements which transfer the heat to the room

e. Electric Kettles

These all work upon the heating effect of electricity.

NOTE:

There are various factors that affect the heating effect produced by the electrical current:

1. Material of the wire.
2. Length of the wire.
3. Thickness of the wire.

1. **<u>Material of the wire</u>** – If a wire is made up of a material which offers high resistance to the flow of current then it gets more heated .e.g. tungsten and nicrome offer high resistance and hence get heated up quickly.

-If a wire is made up of a material which offers less resistance to the flow of current then it gets less heated .e.g. copper wires which offer very little resistance and do not get heated up. Hence they are used in households and commercial establishments.

2. <u>Length of the wire</u>

The greater the length of the wire greater will be the heat generated. (for explanation only: resistance of the wire is directly proportional to the length)

3. <u>Thickness of the wire</u>

Greater the thickness, less will be the heating effect.

NOTE: Excessive electric currents get produced due to

a. Improper or worn out insulation on the wires which can lead to the wires getting touched with one another and causing a short circuit

b. If many devices are connected to a single socket which may cause overload in the circuit

c. Short circuits and overload of circuits have caused severe accidents of fire.

<u>3. Magnetic Effect of Current</u>

An electric current flowing through a wire can produce the same effect that magnet can produce.

-Oersted performed an experiment where he observed that when an electric current flows through a wire, there seemed to be a magnetic effect around it.

-A magnetic compass is a device which is used to determine direction and it was mostly used by people who used to travel, esp in sea.

<u>Oersted's Experiment</u>

-The magnetic effect of a current was first observed by a Danish Physicist called Hans Christian Oersted.

- He observed that a magnetic compass needle showed deflection when it passed through a wire carrying current

- Thus, a current-carrying wire behaves like a magnet and carries a magnetic field around it . This is also the magnetic effect of an electric current. The direction of the deflection of the needle changes if the direction of the current is reversed by connecting the wire into reverse terminals.

- This property of an electric current is used to change magnetic materials like soft iron into magnets by passing electricity through them. This is used widely in various applications.

Magnetic Field

This is the region around a magnet in which the magnetic force can be experienced.
So when a magnetic compass is brought near the magnetic field it shows deflection.

ELECTROMAGNET

i.e a magnet that shows association with an electric current.
So it is an object/magnet in which electric current produces a magnetic field .
The object on the which wire is coiled is called the core. If the core is of a magnetic material like iron , then the magnetic field produced will be stronger. The benefit of the electromagnet is that when the current is ON then the magnetic filed is ON and when the current is OFF then the magneticfield will be OFF. We can change the strength of the magnetic field by changing the amount of current that is made to pass through it . However in case of other normal magnets, we can't control or change their strength**.**

Electromagnet is a coil of wire wound around a magnetic material like soft iron which behaves like a magnet when current is passed through it. The electromagnets can be made very strong so as to lift very heavy loads.

SOLENOID

Solenoid is a loop of a long insulated wire wrapped or wound many times around a rod-shaped metallic core. It behaves like an electromagnet when electric current is passed through it.
It finds application in automobiles, motors, fuel injectors, dot matrix printers, etc.
The strength of a solenoid can be increased by:

- increasing the number of turns in the solenoid
- increasing the current in the solenoid
- winding the solenoid around a magnetic material

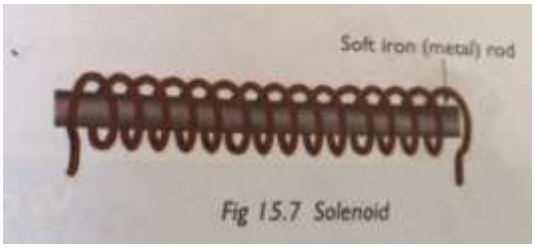
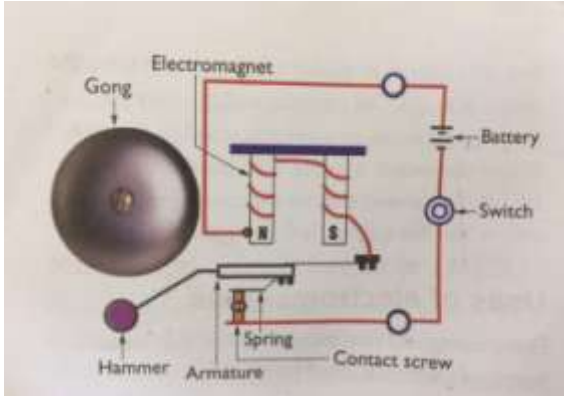


Fig 15.7 Solenoid

USES OF ELECTROMAGNETS

1. They are used in Cranes, to pickup heavy magnetic materials from junkyards. It gets easy to lift them through electromagnet attached at its end
2. Magnetic separators are used to separate the ferro magnetic materials like scrap iron/ steel etc by switching on the current and it starts acting like a magnetic separator.
3. They are used in loud speakers
4. They are used in electric motors
5. They are used in fans, washing machines, air-conditioners, refrigerators etc.
6. Used by doctors to remove iron splinters from eyes
7. Used in electric bell

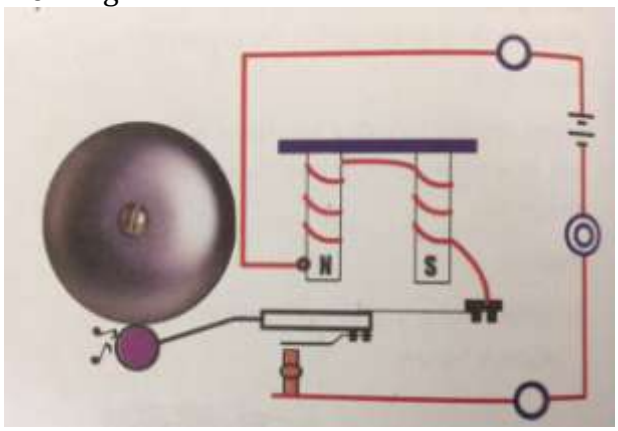
ELECTRIC BELL



Structure :

1. It consist of 2 soft iron rods with wire coiled over them (these iron rods and wire will behave like an electromagnet)
2. These iron rods are mounted on a non-metallic strip.
3. One end of the wire which has been coiled is connected through a switch and a battery to a contact screw in the end.
4. The other end of this wire is connected to the lower end of a hammer made up of a soft iron which is also known as Armature
5. This armature rests on the contact screw.
6. A metallic gong is placed in front of the hammer but is not connected anywhere in the circuit.

Working :



Electric Bell Ringing

1. When the switch is pressed as 'ON' , the circuit is complete and electricity flows through the wire.
2. This flow of electricity makes the iron rods to behave like electromagnets.
3. This electromagnetic pull attracts the armature towards these magnets.
4. Due to this two things happen simultaneously:

a. The armature when pulled towards the electromagnet causes the hammer to strike the gong which produces a sound.

b. When the armature gets pulled away it loses its contact with the screw which leads to a break in the circuit.

5. As a result of a break in the circuit the current stops flowing and hence the iron bars also stops behaving as electromagnets.
6. The armature then returns to its original position due to the spring on it and touches the contact screw.
7. This process begins again whenever the switch is pressed ON again and the electricity flows.