Energy: Energy may be defined as the capacity to do work. Energy exists in various forms, such as Mechanical Energy, thermal energy, electrical energy, solar energy etc. Electricity is the only form of energy, which is easy to produce, easy to transport, easy to use and easy to control.

Power plant is that assemblage of equipment, permanently located on some chosen site which receives raw energy in the form of a substance capable of being operated on in such a way as to produce electrical energy for deliver from the power plant.

Sources of energy:-

There are two main sources of energy. They are conventional and non-conventional sources of energy.

i) Conventional sources of energy :- The sources of energy which have been in use for a long time, e.g., coal, petroleum, natural gas and water power.

ii) Non-conventional sources of energy :- The resources which are yet in the process of development over the past few years. It includes solar energy, wind energy, biomass energy, ocean energy (tidal energy, wave energy, ocean thermal energy), geothermal energy, nuclear energy etc

Disadvantages of Conventional Sources

- They are exhaustible except water.
- They cause pollution when used, as they emit smoke and ash.
- They are very expensive to be maintained, stored and transmitted as they are carried over long distance through transmission grid and lines.

Advantages of Non - Conventional Sources

- They are inexhaustible.
- They are generally pollution free.
- Less expensive due to local use and easy to maintain.

Types of Energy sources

1. Non-renewable energy sources:- Non-renewable energy sources are those, which cannot be replaced continuously. Examples: Oil, Coal, Petroleum and natural gas
2. Renewable energy sources:- Renewable energy is a source of energy that can never be exhausted and can be replaced continuously. We can obtain renewable energy from the sun, from the water, from the wind, from crop residues and waste

Domestic Wiring

A network of wires drawn connecting the meter board to the various energy consuming loads (lamps, fans, motors etc) through control and protective devices for efficient distribution of power is known as electrical wiring. Electrical wiring done in residential and commercial buildings to provide power for lights, fans, pumps and other domestic appliances is known as domestic wiring.

Types of Wiring System

- Tree system - In the house mains, after passing through the main fuse, the main switch, and the meter, are taken straight through the house; and branches of the same size as the mains are taken from the mains at convenient places and connected to the main terminals of local distributing boards. This system should only be used in small buildings, as it is impossible to divide up the single mains for testing purposes, which makes it very difficult to localize a fault. This system branches are tapped from the main circuit at required points. This involves many joints making the location of the fault point difficult. Though the method is economical it is visually unappealing with scattered fuses and is affected by large voltage drops.
- Distribution system - This system is more organized in the sense that the main circuit is drawn to several distribution centers and connected to the distribution boards. Branches are tapped from these distribution boards. This system of wiring has an aesthetic appeal, as they are without joints and also makes the location of the fault point easier. All the points are maintained almost at the same potential. Each circuit is provided with an independent fuse. Provides flexibility for repair and maintenance. This system is widely preferred for indoor wiring though expensive.
- Ring system - Wiring starts from the main fuse - box, run around all the main rooms of the house and then come back to the fuse box again. The fuse box contains a fuse of rating about 30A. A separate connection is taken from the live wire of the ring for each appliance. The terminal of the appliance is connected to the live wire through a separate fuse and a switch. If the fuse of one appliance burns out, it does not affect the other appliances.

Wiring System at Home

The mains supply is delivered to houses using a three core wiring called the live neutral and the earth. The live wire is brown in color and brings in the current. The neutral colored Blue is the return wire. The earth is colored green or yellow. These wires supply electricity to separate circuits within the house. The earth wire is usually connected to a metal plate deep in the earth

near the house. It is a safety measure and does not in any way affect the supply. The live wire and neutral wire, coming from the electric pole, enter a box fitted just outside our house which has a main fuse F1.The fuse is connected in series with the live wire. This is done so because it is only the live wire which has a high potential of 220 volts unlike the neutral wire which carries zero potential. The fuse F1 has a high rating of about 50 amperes. Thus it prevents any damage such as fire to the entire electrical wiring entering the house due to short-circuit or overloading. The two wires then enter the electricity meter which records the electrical power consumed by us in kilowatt-hour (kWh). This meter is installed by the electric supply department of our city. These two wires coming out of the meter are then connected to a main switch which is placed in a distribution box. Another fuse F2 is placed in series with the live wire in this box for the sake of consumer safety.

There are two separate circuits in a house namely lighting circuit and power circuit. The lighting circuit with a 5 A fuse is used for running electric bulbs, fan, radio, TV, tube lights etc. and the power circuit with a 15 A fuse is used for running electric heater, electric iron, geyser, refrigerator etc as it draws more current. The distribution circuits are always connected in parallel combination. In a parallel circuit even if there is a fault or short-circuiting in any one line, the corresponding fuse blows off leaving the other circuits and appliances intact and prevents damage to the entire house.

Light and Fan Sub-Circuit :- The sub circuit of the electrical installation feeding supply to various light points, i.e. lamps, tubes etc and to fan points, i.e. ceiling, table fans etc. is termed as light and fan sub-circuit respectively.

◦The number of light and fan points in one sub circuit should not exceed 10.

◦The total load connected in a sub-circuit should not be more than 800 W

◦Control of light and fan points in any sub circuit should be carried out by 5 A switches fitted on a switchboard

◦Socket outlets provided in the sub circuits should be of 5 A rating

◦Only a single phase supply should be fed to the sub-circuits.

Power Sub-Circuit :- The part of the complete installation that supplies power to appliances like hot plate, electric iron, microwave oven, washing machines, refrigerators etc is called the power sub circuit.

◦The number of power points connected in one sub circuit should not exceed 2.

◦The load connected to a sub circuit should not be greater than 3 kW.

◦Control of the sub circuits should be by 15 A switches.

◦Socket outlets provided in the circuits should be of 15 A rating.

◦The sub circuits must be used on single phase supply.

Factors affecting the choice of wiring system:

Durability: Type of wiring selected should conform to standard specifications, so that it is durable i.e. without being affected by the weather conditions, fumes etc.

Safety: The wiring must provide safety against leakage, shock and fire hazards for the operating personnel.

Appearance: Electrical wiring should give an aesthetic appeal to the interiors.

Cost: It should not be prohibitively expensive.

Accessibility: The switches and plug points provided should be easily accessible. There must be provision for further extension of the wiring system, if necessary.

Maintenance Cost: The maintenance cost should be a minimum

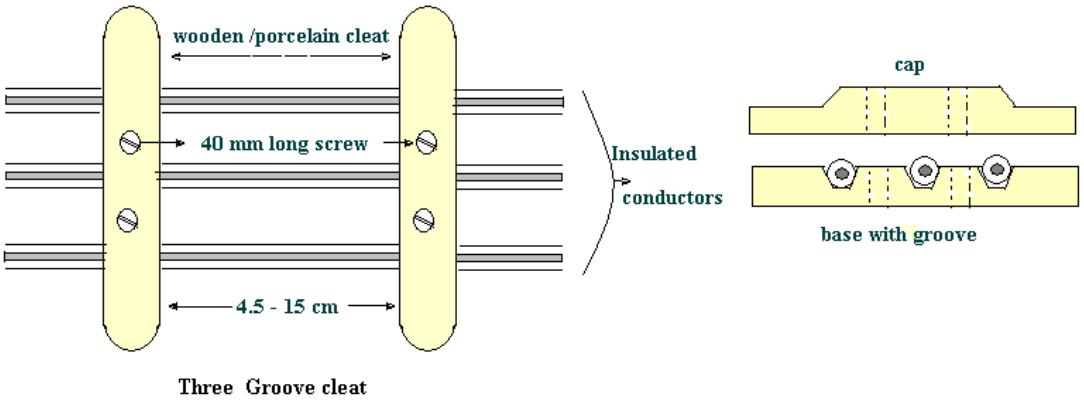
Mechanical safety: The wiring must be protected against any mechanical damage

Types of Wiring

- Cleat wiring
- CTS wiring or TRS wiring or batten wiring
- Metal sheathed wiring or lead sheathed wiring
- Wooden Casing and capping
- Conduit wiring

1. Cleat wiring:

In this type of wiring, insulated conductors (usually VIR, Vulcanized Indian Rubber) are supported on porcelain or wooden cleats. The cleats have two halves one base and the other cap. The cables are placed in the grooves provided in the base and then the cap is placed. Both are fixed securely on the walls by 40mm long screws. The cleats are easy to erect and are fixed 4.5 – 15 cms apart. This wiring is suitable for temporary installations where cost is the main criteria but not the appearance.



Three Groove cleat

Advantages:

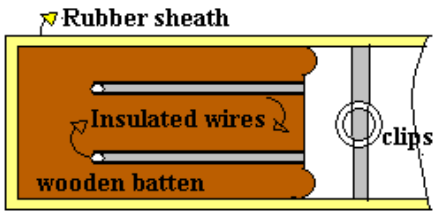
1. Easy installation
2. Materials can be retrieved for reuse
3. Flexibility provided for inspection, modifications and expansion.
4. Relatively economical
5. Skilled manpower not required.

Disadvantages:

1. Appearance is not good
2. Open system of wiring requiring regular cleaning.
3. Higher risk of mechanical injury.

2. CTS (Cable Tyre Sheathed) / TRS (Tough Rubber Sheathed) / Batten wiring:

In this wiring system, wires sheathed in tough rubber are used which are quite flexible. They are clipped on wooden battens with brass clips (link or joint) and fixed on to the walls or ceilings by flat head screws. These cables are moisture and chemical proof. They are suitable for damp climate but not suitable for outdoor use in sunlight. TRS wiring is suitable for lighting in low voltage installations



CTS/TRS WIRING

Advantages:

1. Easy installation and is durable

2. Lower risk of short circuit.
3. Cheaper than casing and capping system of wiring
4. Gives a good appearance if properly erected.

Disadvantages:

1. Danger of mechanical injury. Hence should not be used in workshops.
2. Should not be exposed to direct sunlight or rain.
3. Skilled workmen are required.

3. Lead sheathed wiring - The wiring is similar to that of CTS but the conductors (two or three) are individually insulated and covered with a common outer lead-aluminum alloy sheath. The sheath protects the cable against dampness, atmospheric extremities and mechanical damages. The sheath is earthed at every junction to provide a path to ground for the leakage current. They are fixed by means of metal clips on wooden battens. The wiring system is very expensive. It is suitable for low voltage installations.

Advantages:

1. Easy installation and is aesthetic in appearance.
2. Highly durable
3. Can be used in damp places or in places exposed to sun and rain

Disadvantages:

1. Requires skilled labor
2. Very expensive
3. Unsuitable for chemical industries

4. Wooden Casing and capping - It consists of insulated conductors (either VIR or PVC cables) laid inside rectangular wooden casing of seasoned teakwood having grooves inside it. A rectangular strip of wood called capping having same width as that of casing is fixed over it. Both the casing and the capping are screwed together at every 15 cms. Casing is attached to the wall by means of wooden blocks or porcelain discs to safeguard from dampness. Two or more wires of same polarity are drawn through different grooves. The system is suitable for indoor and domestic installations.

Advantages:

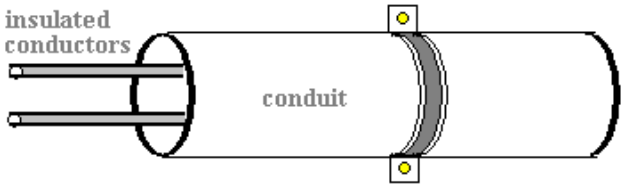
1. One of the cheapest types of wiring.
2. Provides good isolation as the conductors are placed apart reducing the risk of short circuit.
3. Easily accessible for inspection and repairs.
4. Easy to install.

Disadvantages:

1. High risk of fire hazard.

2. Does not give a good appearance
3. Suitable only for voltages upto 250 V
4. Cannot be used in damp places

5. Conduit wiring - In this system PVC or VIR insulated cables are run through mild steel pipes called conduits providing good protection against mechanical injury and fire due to short circuit. They are either embedded inside the walls or supported over the walls, and are known as concealed wiring or surface conduit wiring (open conduit) respectively. The conduits are buried inside the walls on wooden gutties and the wires are drawn through them with fish (steel) wires. The system is best suited for domestic and commercial installations.



CONDUIT WIRING

Advantages:

1. No risk of fire and good protection against mechanical injury.
2. The lead and return wires can be carried in the same tube.
3. Earthing and continuity is assured.
4. Waterproof and trouble shooting is easy.
5. Shock- proof with proper earthing and bonding
6. Durable and maintenance free
7. Aesthetic in appearance

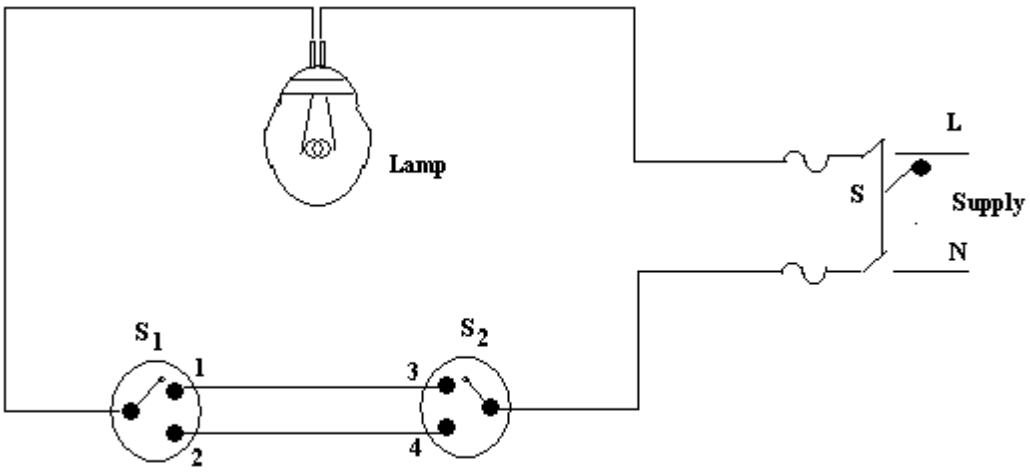
Disadvantages:

1. Costliest system of wiring.
2. Requires good skilled workmanship.
3. Erection is quiet complicated and is time consuming.
4. Risk of short circuit under wet conditions (due to condensation of water in tubes).

Typical House Wiring Circuits

Two-way Control of lamp or Staircase lighting - Two-way control is usually used for staircase lighting. The lamp can be controlled from two different points: one at the top and the other at the bottom - using two- way switches which strap wires interconnect. They are also

used in bedrooms, big halls and large corridors. Switches S1 and S2 are two-way switches with a pair of terminals 1&2, and 3&4 respectively. When the switch S1 is in position1 and switch S2 is in position 4, the circuit does not form a closed loop and there is no path for the current to flow and hence the lamp will be OFF. When S1 is changed to position 2 the circuit gets completed and hence the lamp glows or is ON. Now if S2 is changed to position 3 with S1 at position 2 the circuit continuity is broken and the lamp is off. Thus the lamp can be controlled from two different points.



Two -way control of lamp

Position of S1	Position of S2	Condition of lamp
1	3	ON
1	4	OFF
2	3	OFF
2	4	ON

Three-way Control of lamp or Corridor lighting:- In case of very long corridors it may be necessary to control the lamp from 3 different points. In such cases, the circuit connection requires two; two-way switches S1and S2 and an intermediate switch S3. An intermediate switch is a combination of two, two way switches coupled together. It has 4 terminals ABCD. It can be connected in two ways

a) Straight connection

b) Cross connection

In case of straight connection, the terminals or points AB and CD are connected as shown in figure 1(a) while in case of cross connection, the terminals AB and CD is connected as shown in figure 1(b). As explained in two –way control the lamp is ON if the circuit is complete and is OFF if the circuit does not form a closed loop.

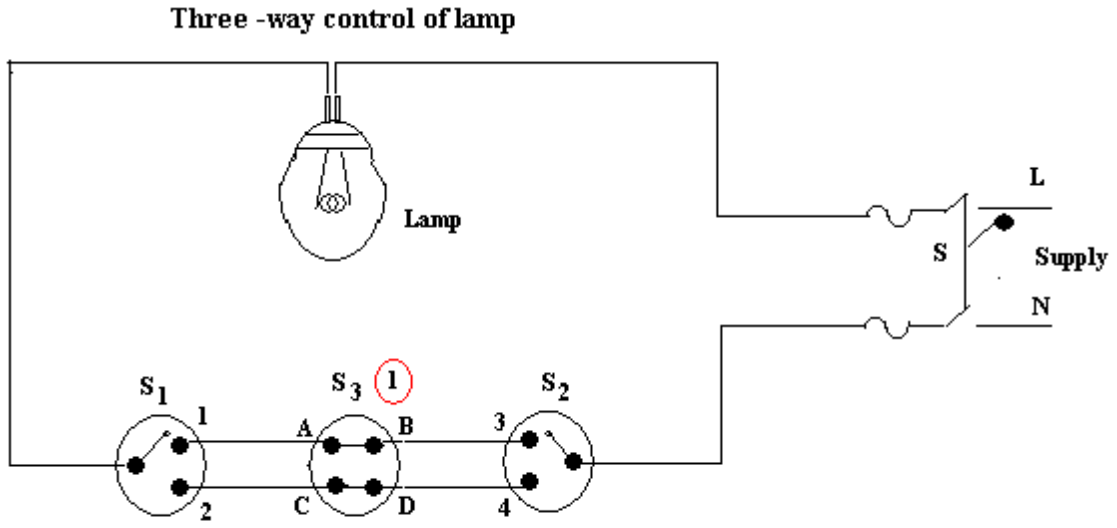


Figure 1 (a) Straight connection

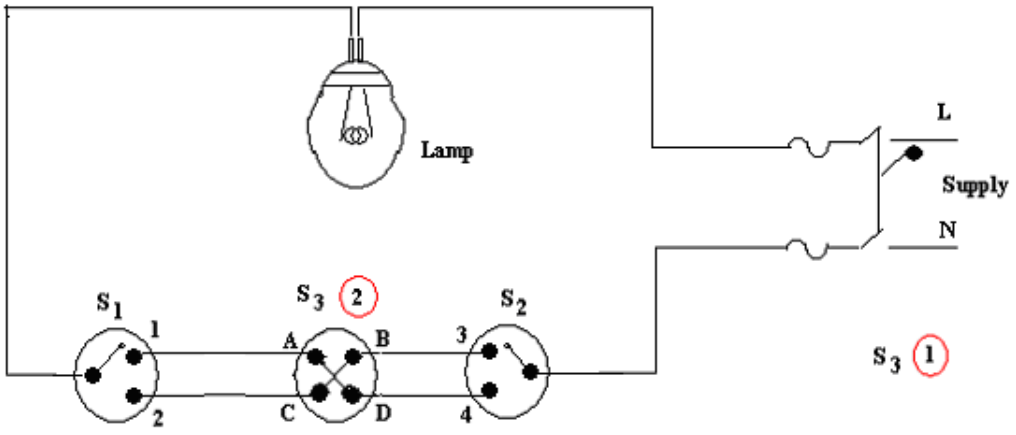


Figure 1 (b) Cross connection

The condition of the lamp is given in the table depending on the positions of the switches S_1, S_2 and S_3.

Position of S3	Position of S1	Position of S2	Condition of the lamp
1 **Straight connection**	1 1 2 2	3 4 3 4	**ON** **OFF** **OFF** **ON**
2 **Cross connection**	1 1 2 2	3 4 3 4	**OFF** **ON** **ON** **OFF**

Earthing

- The potential of the earth is considered to be at zero for all practical purposes as the generator (supply) neutral is always earthed.
- The body of any electrical equipment is connected to the earth by means of a wire of negligible resistance to safely discharge electric energy, which may be due to failure of the insulation, line coming in contact with the casing etc.
- Earthing brings the potential of the body of the equipment to ZERO i.e. to the earth's potential, thus protecting the operating personnel against electrical shock. The body of the electrical equipment is not connected to the supply neutral because due to long transmission lines and intermediate substations, the same neutral wire of the generator will not be available at the load end. Even if the same neutral wire is running it will have a self-resistance, which is higher than the human body resistance. Hence, the body of the electrical equipment is connected to earth only.
- Thus Earthing is to connect any electrical equipment to earth with a very low resistance wire, making it to attain earth's potential. The wire is usually connected to a copper plate placed at a depth of 2.5 to 3meters from the ground level

❖ **Necessity of Earthing**:

1. To protect the operating personnel from danger of shock in case they come in contact with the charged frame due to defective insulation.

2. To maintain the line voltage constant under unbalanced load condition.
3. Protection of the equipments
4. Protection of large buildings and all machines fed from overhead lines against lightning.

❖ **Methods of Earthing**:

The important methods of earthing are the plate earthing and the pipe earthing. The earth resistance for copper wire is 1 ohm and that of G I wire less than 3 ohms. The earth resistance should be kept as low as possible so that the neutral of any electrical system, which is earthed, is maintained almost at the earth potential. The typical value of the earth resistance at powerhouse is 0. 5 ohm and that at substation is 1 ohm.

1. **Plate earthing**
2. **Pipe earthing**

▪ **Plate Earthing**

In this method a copper plate of 60cm x 60cm x 3.18cm or a GI plate of the size 60cm x 60cm x 6.35cm is used for earthing. The plate is placed vertically down inside the ground at a depth of 3m and is embedded in alternate layers of coal and salt for a thickness of 15 cm. In addition, water is poured for keeping the earth electrode resistance value well below a maximum of 5 ohms. The earth wire is securely bolted to the earth plate. A cement masonry chamber is built with a cast iron cover for easy regular maintenance.

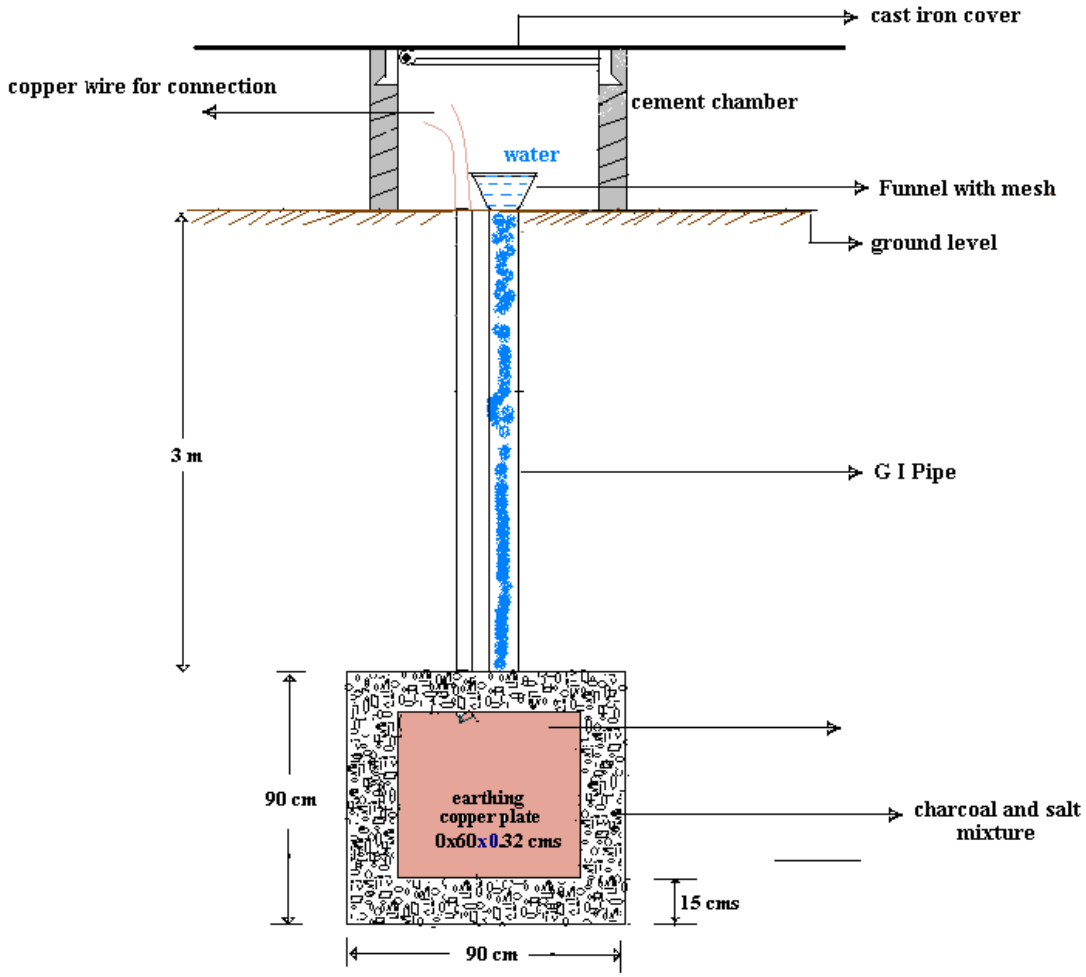
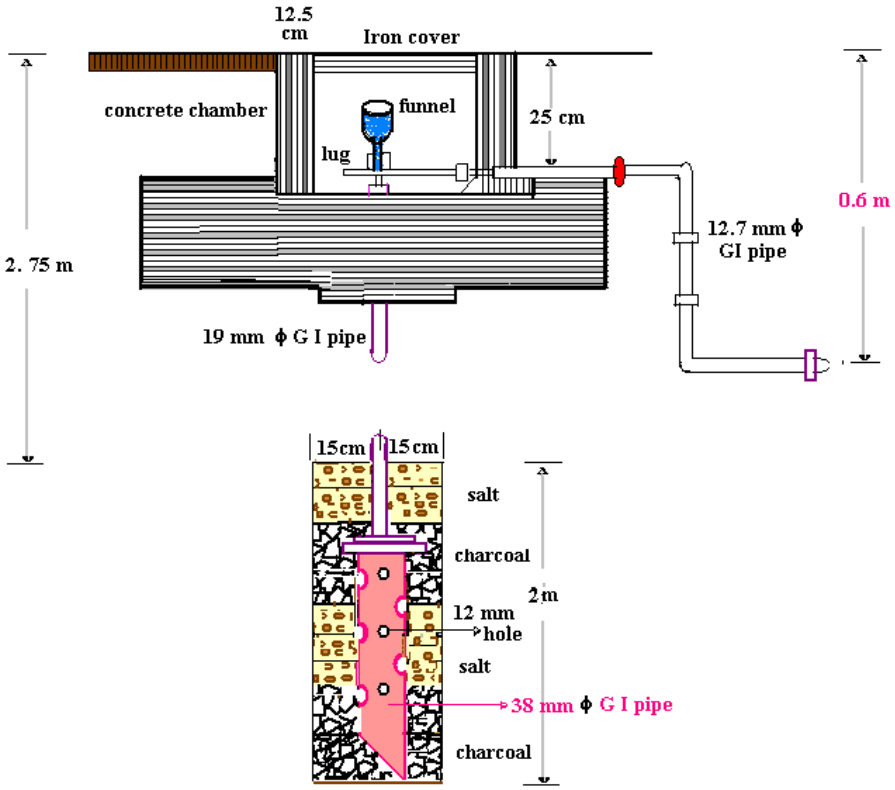


PLATE EARTHING

❖ **Pipe Earthing**

Earth electrode made of a GI (galvanized) iron pipe of 38mm in diameter and length of 2m (depending on the current) with 12mm holes on the surface is placed upright at a depth of 4.75m in a permanently wet ground. To keep the value of the earth resistance at the desired level, the area (15 cms) surrounding the GI pipe is filled with a mixture of salt and coal.. The efficiency of the earthing system is improved by pouring water through the funnel periodically. The GI earth wires of sufficient cross- sectional area are run through a 12.7mm diameter pipe (at 60cms below) from the 19mm diameter pipe and secured tightly at the top as shown in the following figure.



PIPE EARTHING

When compared to the plate earth system the pipe earth system can carry larger leakage currents as a much larger surface area is in contact with the soil for a given electrode size. The system also enables easy maintenance as the earth wire connection is housed at the ground level.

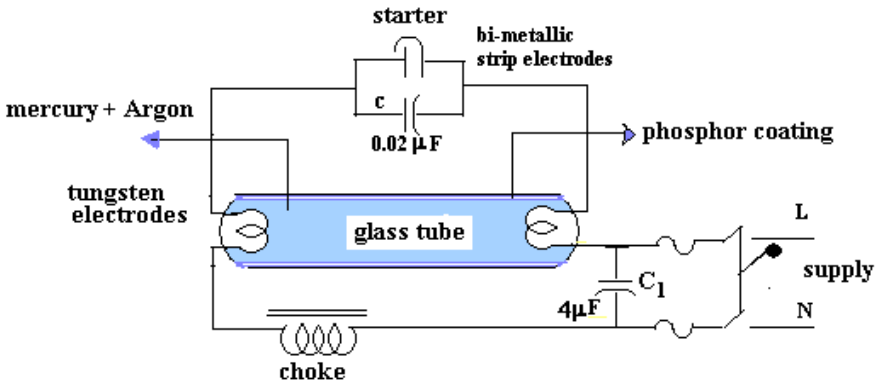
❖ **FLUORESCENT LAMP**

The fluorescent lamp is an energy saving device. It consumes less power for a given output lumens when compared to an incandescent lamp.

Construction:

It consists of a long glass tube filled with Argon an inert gas, at low pressure (2.5mm) and a small amount of mercury. The initial ionization voltage is reduced, as the ionization potential of argon is low. Two tungsten electrodes are placed at the ends, which are coated with rare earth oxides. These oxides having a low work function emit the ionizing electrons. A choke is connected in series with the electrode, which provides the voltage impulse of nearly 1000volts to start the discharge, and also limits the flow of current through the circuit. It also acts as **ballast** when the lamp is ON. The filament is connected to

starter switch, a cathode glow lamp that has a bi-metallic strip as its electrodes. The capacitor C (0.02 µF) improves the power factor of the circuit while the capacitor C_1 (4 µF) suppresses the radio interference.



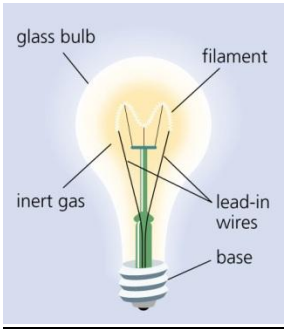
FLUORESCENT LAMP

Working:

When the switch is closed the supply voltage comes across the starter electrodes initiating a glow discharge between them. This heats the bi-metallic strip electrodes, which expand and make contact completing the circuit. The resulting current flows through the tungsten electrodes and the electrons are emitted from the oxide coating (low work function), which initiate ionization of the gas molecules present in the glass tube. At this instant the bi-metallic strip electrodes cool and the starter opens. Thus there is a sudden interruption of the current, which induces a high voltage (`≅1000volts) in the choke.

This impulse strikes an arc between the electrodes lighting the lamp. The vaporized mercury gets ionized and emits radiations partly in the visible range and partly in ultraviolet range. The phosphor coating gives the required color and also absorbs the ultra violet light and re-radiates in the visible spectrum.

❖ **INCANDESCENT LAMP**



When electric current flows through the filament made up of tungsten, it heats up emitting visible light. The entire assembly is housed in an envelope of glass. The shape of the glass is responsible for giving directionality to the light. The outer glass is attached to the lower casing with the help of a stick material. The environment inside the glass is made inert by filling with a gas like argon. This prevents oxidation of filament at such high temperatures.