GOVERNMENT POLYTECHNIC FOR GIRLS

CIVIL ENGINEERING DEPARTMENT

SUBJECT : BUILDING SERVICES (3360604)

TOPIC : ELECTRICAL SERVICES AND LAYOUT (PART I)

GOVERNMENT POLYTECHNIC FOR GIRLS

AHMEDABAD

COURSE: BUILDING SERVICES

COURSE CODE : 3360604

TOPIC: ELECTRICAL SERVICES AND LAYOUT (PART I)

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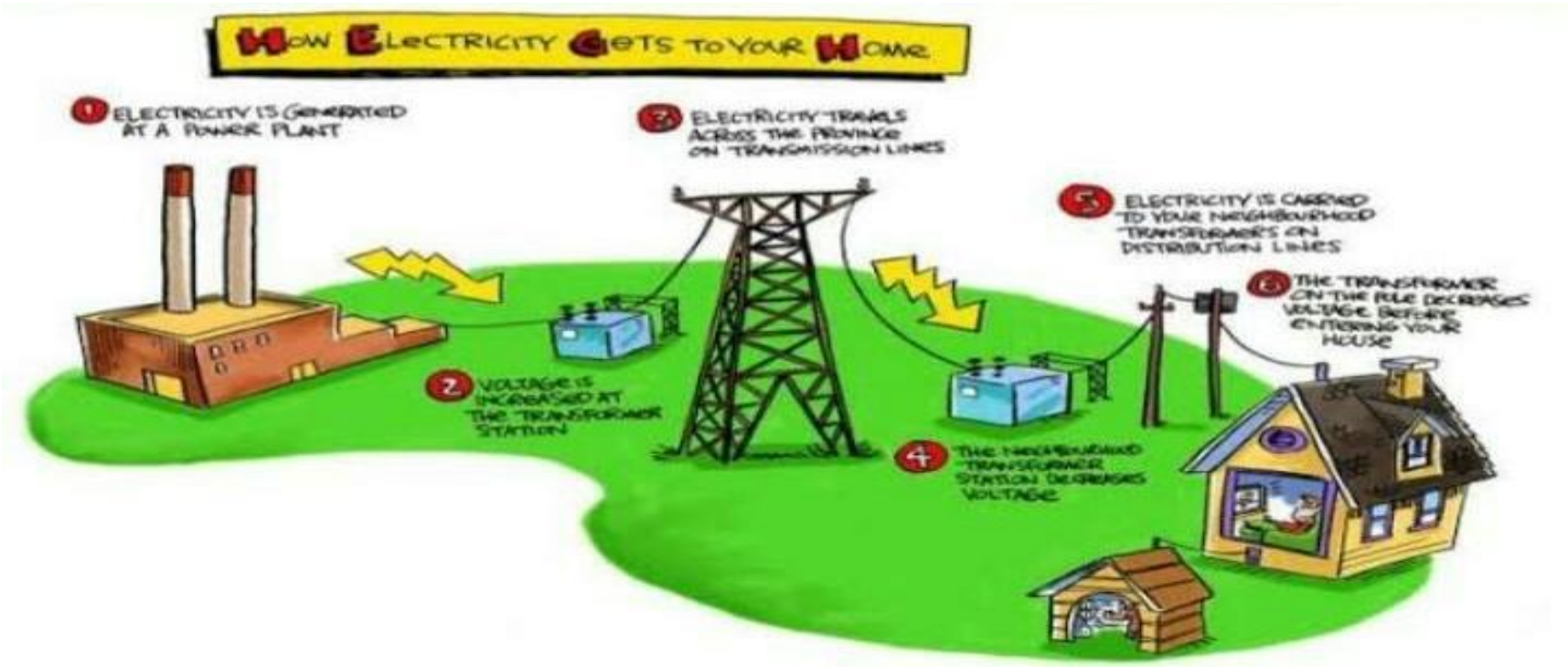
INTRODUCTION

Electricity is one of the important sources of energy. Electricity may be defined as the flow of electrons in any conductor. Materials which allow the current to flow easily through them are called the conductors. Metals are good conductors of current. Silver, copper and aluminium are good conductor. Metals, salt solutions, acids are also good conductors.



Uses of Electric Energy

- For running lighting, fans, iron, heater, grinding mill, T.V., refrigerator, washing machine, etc. in a building.
- In industries for - running machines, heating, welding, electroplating, etc.
- Commercial - Cinema, lift, water pump, lighting, advertising display, etc.

Schematic flow diagram of Electricity Generation, Transmission and Distribution

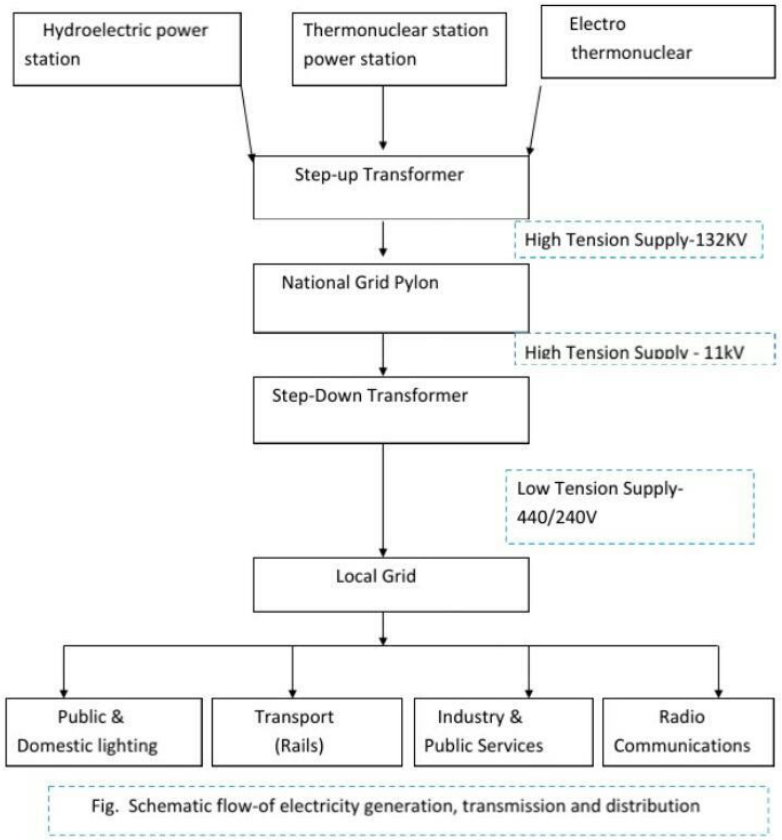
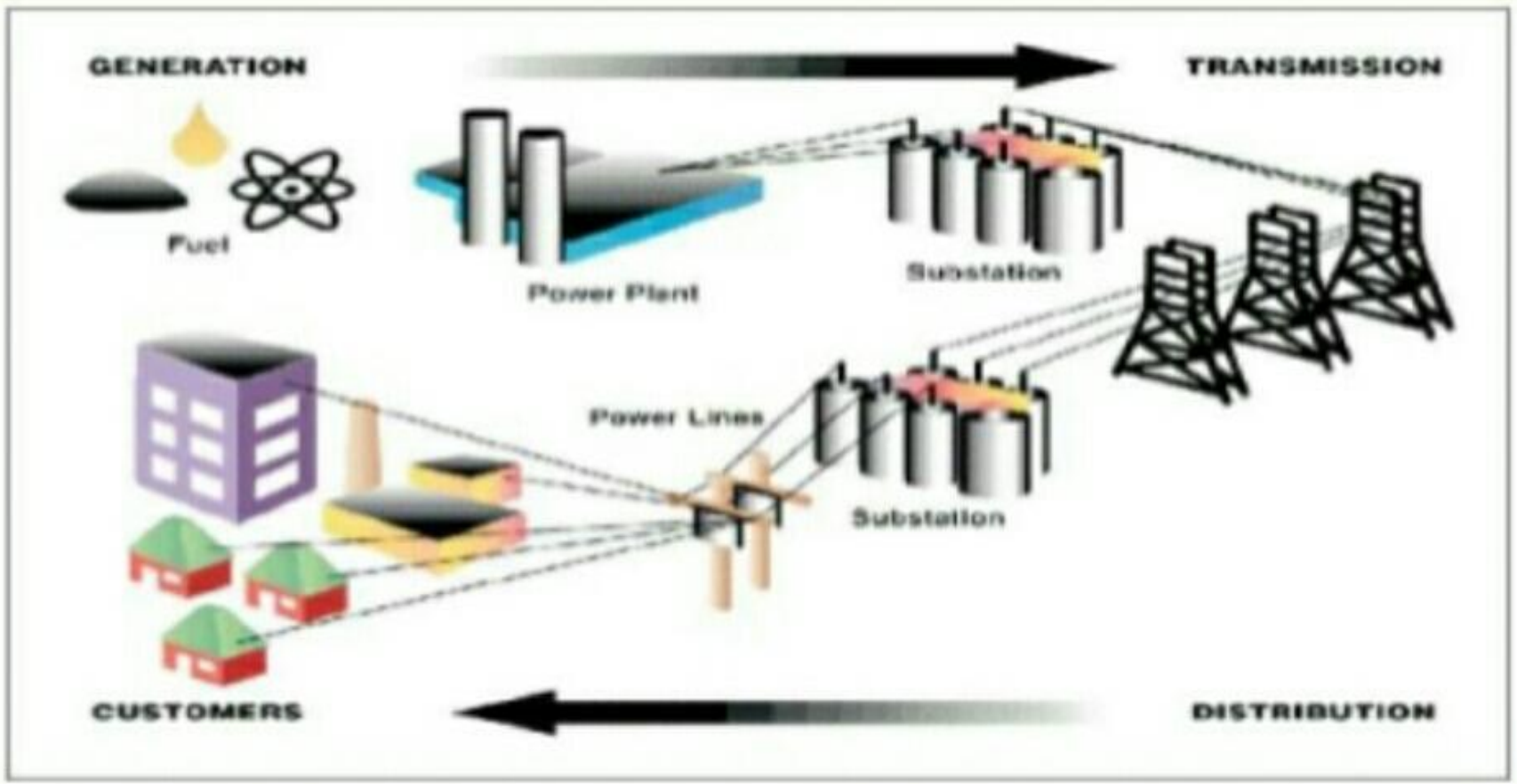
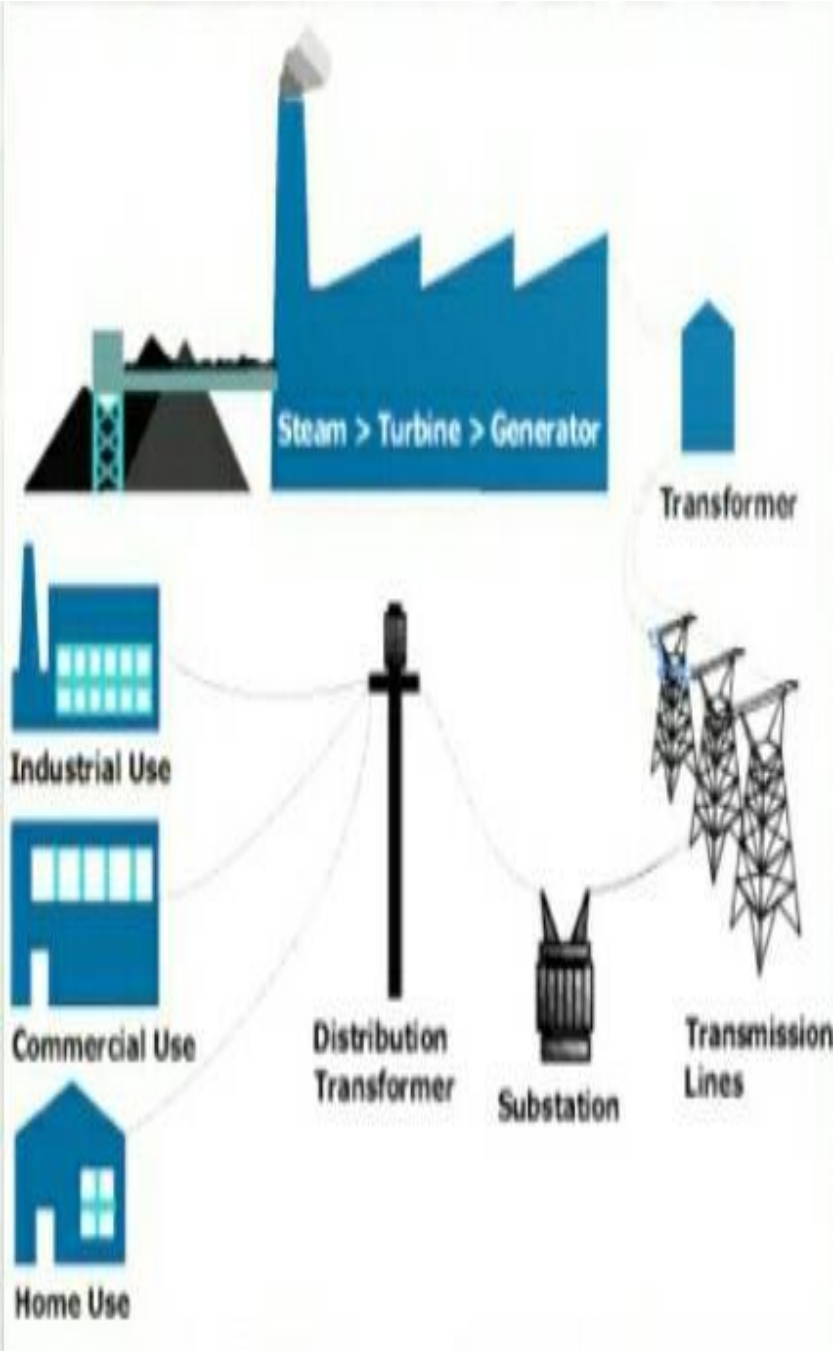


Fig. Schematic flow-of electricity generation, transmission and distribution

Electricity Generation, Transmission, and Distribution.





Electricity Generation, Transmission and Distribution:

- Various sources of electricity generation are :
- Water
- Coal
- Diesel, gas
- Nuclear, etc.
- Dams are constructed to store huge quantity of water. Turbines are fitted near the dam at lower elevation. Water from the dam is brought to the turbine through penstock. The impact of water makes turbines to run and generate electricity.
- The other methods include fuels like coal, diesel, gas, etc. to fire boiler and pass steam and generate electricity through generators. Transformers steps up several thousands of volts before it is supplied to the transmission lines By transmitting electricity at high voltages, less power is lost in the cables. At the receiving end the voltage is stepped down by transformers in local sub- stations and supplied to the consumers at 240 - volts.

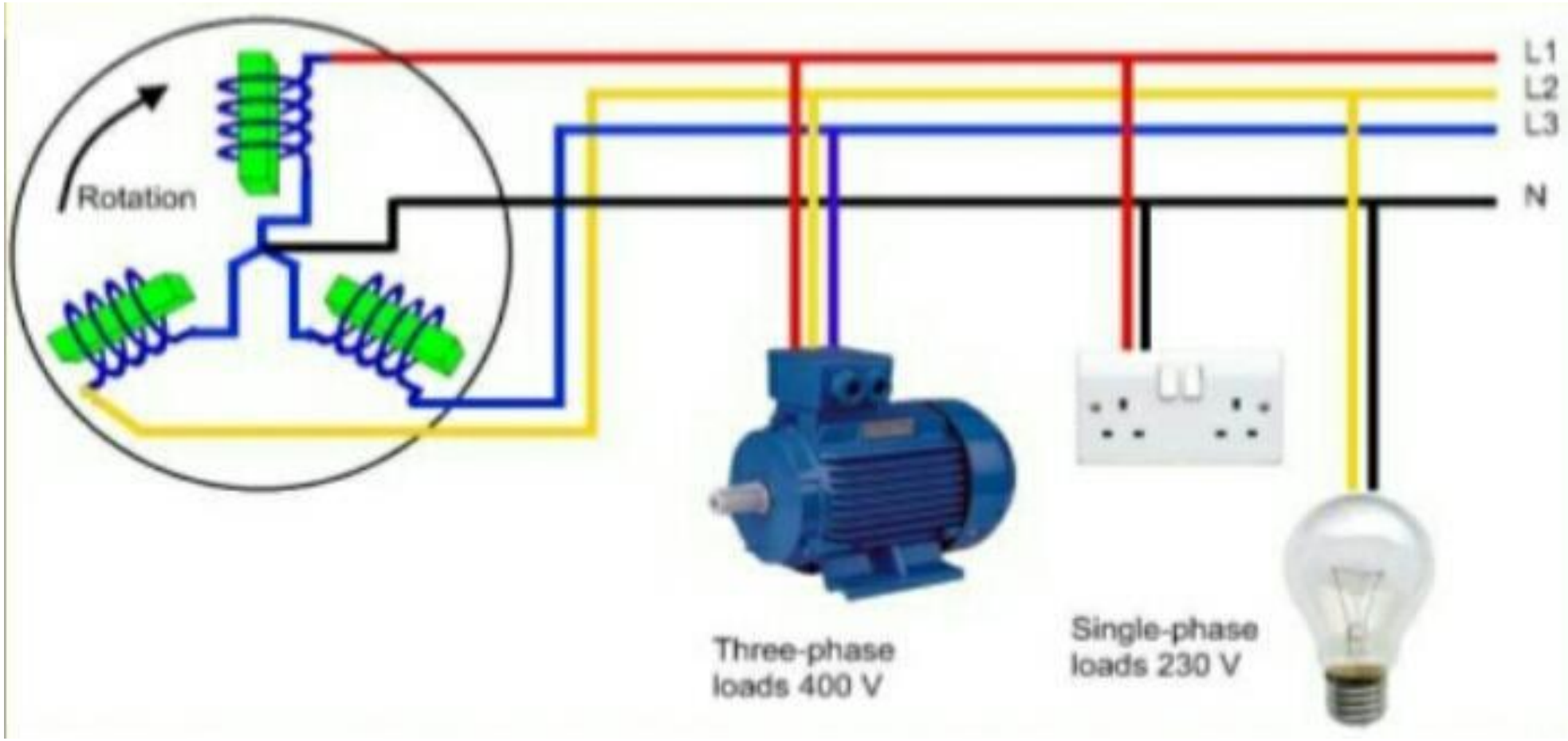
Domestic power supply

- In urban areas electrical cables are usually laid underground and are brought up to an entry point at ground level. Service cable can not be bent to small radii and this should be borne in mind when considering points of entry. In small buildings the cable run is kept as short as possible, terminating in a distribution board (D.B). In these buildings distribution board is fitted with a sealing box to prevent moisture from entering the insulation of the service cable, a main fuse for the premises in a box sealed by the supply authority, main switch and the energy meter. In larger buildings, the distribution board will become a main board (MBD) serving a series of other boards located throughout the building. The boards will be linked by large capacity cable and the final sub-circuits run from local distribution boards.

Domestic power supply

- Domestic electricity supply normally effected through distribution system and described as single and three phase. Normally small buildings are supplied with electricity by two wires, one phase wire and the other neutral. This is 53 single phase supply and gives a voltage for the premises of known as a 240 volts. In large buildings electricity is supply in three phase. In three phase, 4 wires bring in 420/240 volts, 50 cycles per second. The voltage between any two of the phase wires is 415 - volts, and between any phase wire and the neutral is 240 volts. Electric motors are usually designed for three-phase system. When electrical appliances like refrigerator, air conditioner, washing machine, grinding mill are to be operated in a building, three phase supply is necessary

Single and Three Phase Distribution.



Different terms related to electric circuit :

1. Electric Current:

- When electric potential is applied across the two ends of a conductor, the free electrons move from one end to the other. Electron has electric charge. So charge move from one end to the other. **Flow of these electrons or charge is called electric current.** Its symbol is I and its unit is ampere
- Current $I=Q/t \times A$

2. Ampere :

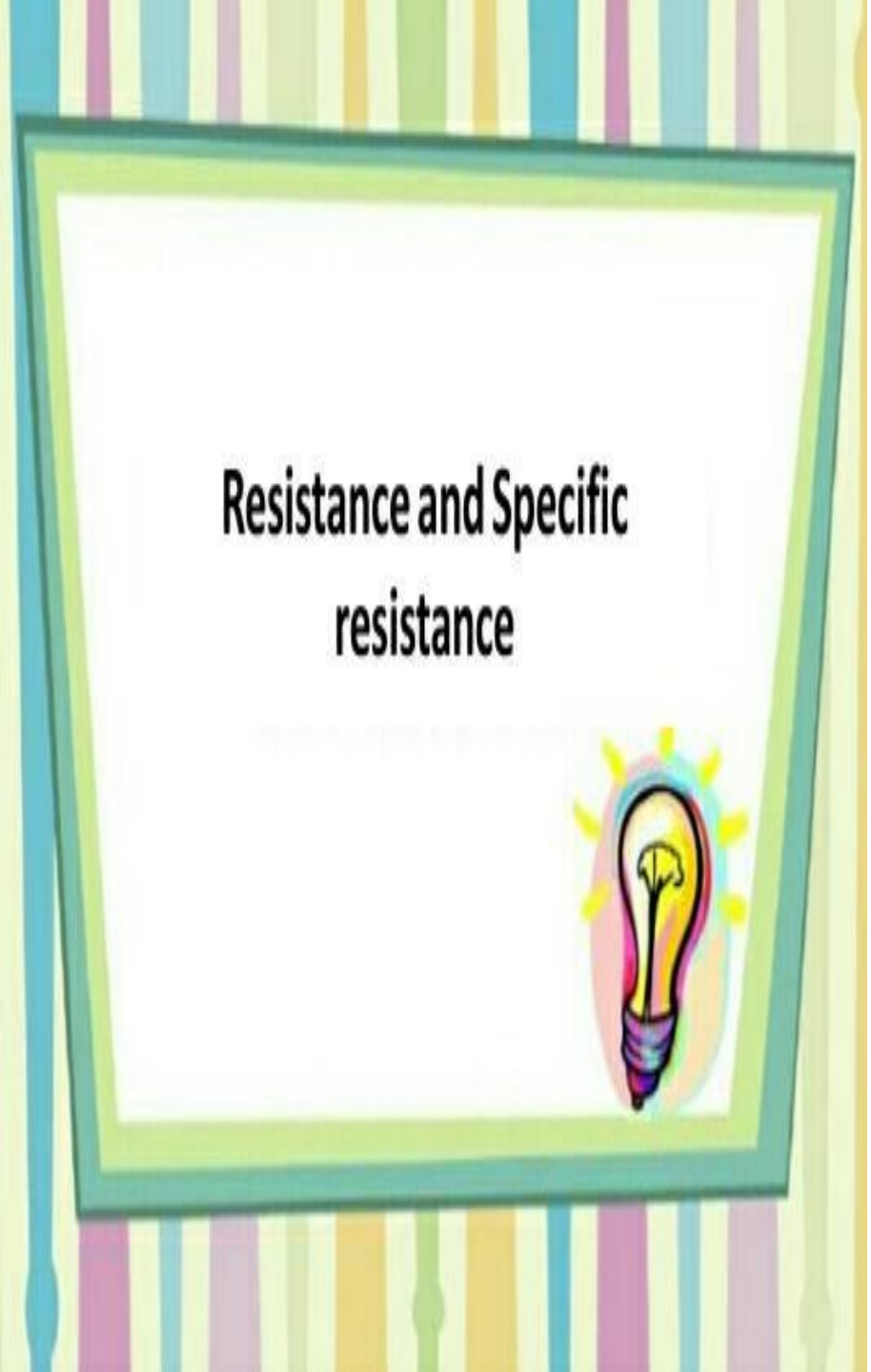
- **When charge of 1 Coulomb passes through a point in 1 second, it is said that a current of 1 ampere is flowing.**
- Coulomb Ampere = Ampere=Coulomb/Second

3. Electro motive force (emf):

- Flow of electric charge is essential to make current to flow through a conductor. So it is necessary to do work. And to do work, energy is required. This energy is supplied by battery. This is called electro motive force-emf. e.m.f. is available from d.c. generator or a.c. generator also. Symbol of emf is E and its unit is volt.
- **Thus electro motive force is the energy required to be given for the flow of current through the circuit.**

4. Potential energy difference or potential difference :

- Voltage or potential energy difference between two points can be defined as follows.
- **Work required to be done (or energy needed) to move unit positiv. charge from one point to another in the circuit is called voltage or the potential difference.**
- Voltage or potential difference =W/Q
- If work is 1 joule and charge is 1 coulomb, then potential difference is 1 volt.
- 1 volt = 1joule/1 coulmb
- Hence joule per coulomb is volt.

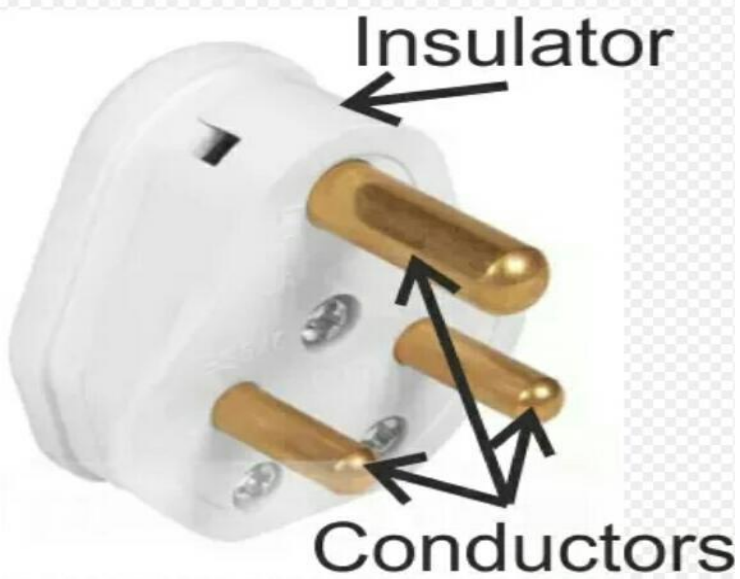


5. <u>Resistance :</u>

- **Property of material to oppose the flow of electric current through it is called resistance.** We studied that when a conductor is given emf, electric current flows due to the flow of free electrons. When these electrons move. they collide with the atoms. So flow of electric current is opposed. Due to this collision, some kinetic energy is converted in to heat energy. Crystalline structures of different materials are different. So all materials do not oppose the flow of electric current equally. That means resistance of different material is different.
- Symbol of resistance is R and its unit is ohm. Symbol of unit is Q (Greek letter omega). If a potential of 1 volt is applied across two leads of a conductor and if a current of 1 ampere flows through it, the resistance of that conductor is said to be one ohm.
- R = V/I
- 1ohm = 1volt/1 ampere

6. <u>Specific resistance :</u>

- **Resistance of conductor of 1 m2 cross sectional area and Im length is the resistivity or the specific resistance of the conductor.**
- In other words specific resistance of conductor is 55 the resistance between two opposite faces of a cube 1 having 1 m side of that material.

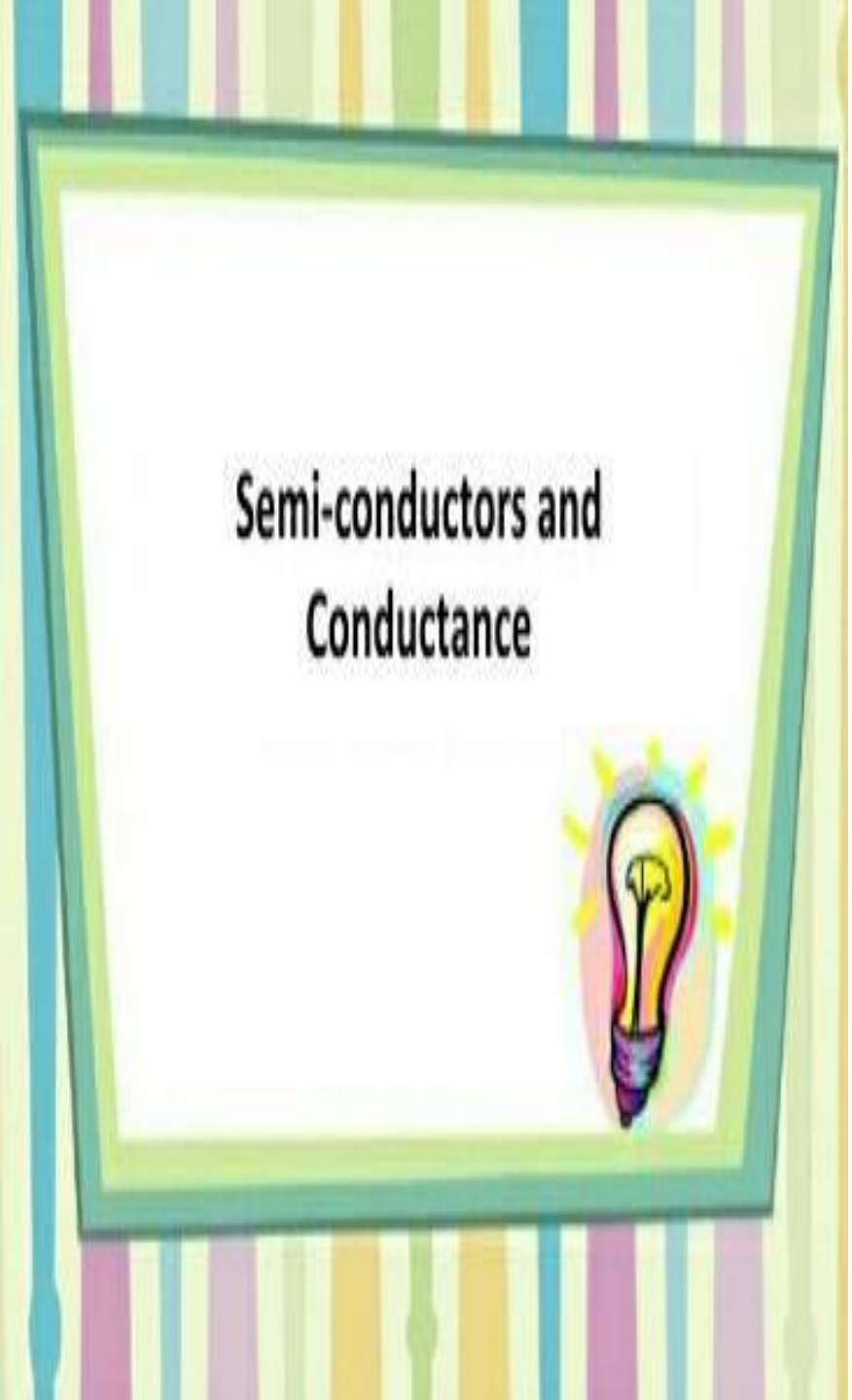


7. Conductor :

- Materials which allow the current to flow easily through them are called the conductors. Metals are good conductors of current. In this also, silver, copper and aluminium are good conductors. Metal, salt Fig solutions, acids also are good conductors. In atom of conductors there are less than four electrons in the outermost orbit. Resistivity of conductor is low.

8. Insulator :

- **Material which greatly opposes the current flow i.e. do not allow the current almost to flow through them are called insulator.** Dry wood, rubber, porcelain, mica, PVC are all insulating materials. In insulators, the outermost orbit of atom is completely filled. Resistivity of insulating material is very high.

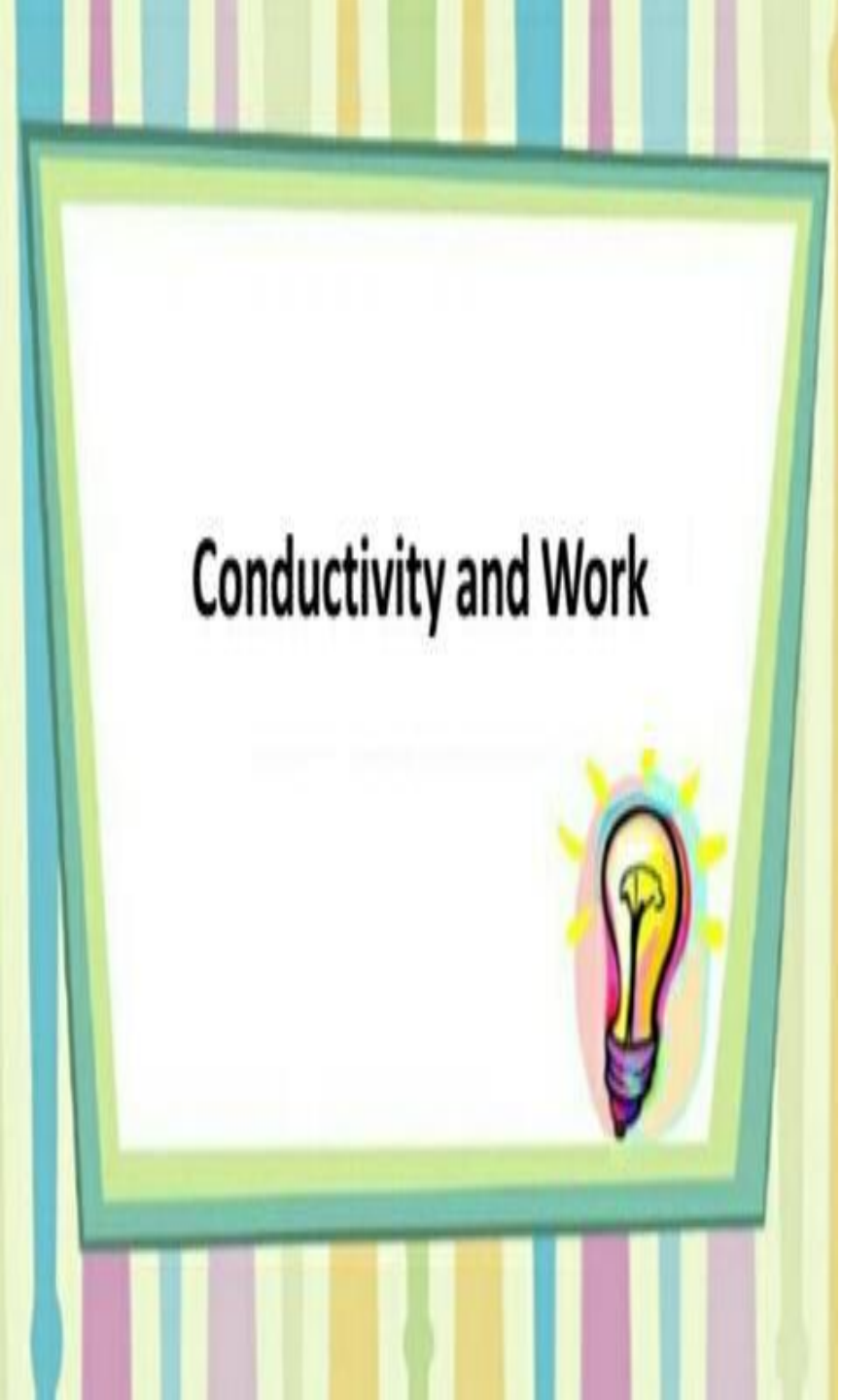


9. <u>Semiconductor :</u>

- **Some materials do not allow the current to flow easily through them like conductors and do not oppose the flow of current like insulators. These materials are known as semiconductors.** Germanium, silicon etc. are semiconductors. There are four electrons in the outermost orbit of atom of this material. Resistivity of semiconductor is between that of conductor and insulator.

10. <u>Conductance :</u>

- **Reciprocal of resistance of a conductor is called its conductance**.
- It is denoted by G.G = 1/R. The symbol for unit is ʊ e.g. if the resistance of a wire is 5Ω its conductance will be G=1/5 =0.02ʊ.
- Unit of conductance in SI system is siemens. It is denoted by S.



11. <u>Conductivity :</u>

- **Reciprocal of resistivity is known as conductivity. Its** symbol is σ (sigma). It a is also known as the specific conductivity.

12. <u>Work :</u>

- When force of 1 newton moves the body through a distance of 1m in direction of force, 1 joule work is done.
- **Work done - Force x distance**

= 1 N x 1 m

= 1 Nm

= 1 Joule

- Nm is mechanical unit of work.
- Electrical work W = V I t

If, V = 1 Volt

I = 1 Ampere

and t = 1 Second, then

w = 1 x 1 x 1 - 1 joule

13. Power :

- **Rate of doing work is called power.**
- work = work/time
- P = W/t
- If W = 1 joule and t = 1 second, then $P = 1\ J / 1\ s = 1$ Watt
- This means, to do same work if time taken is more or less, the power less or more. For example if a person does a work of 100 joule in 1 second, then his power is 100 watt. If another person does the same work of 100 joule in 4 second, then his power becomes 100/4 = 25 watt.
- 1 hp =735.5 W
- Electrical Power : $P = VI = I^2 R = V^2 / R$

14. <u>Energy</u> :

- Energy = Power x Time

  = P x t

  = VIt joule

- There are different units of energy depending upon the units of power and time.

- Energy = Power x Time

  = Watt x second... watt second Ws

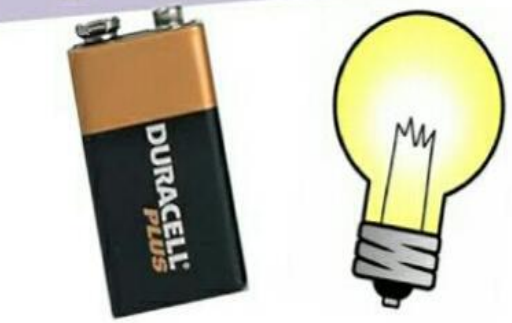
  or watt x hour.. watt hour Wh

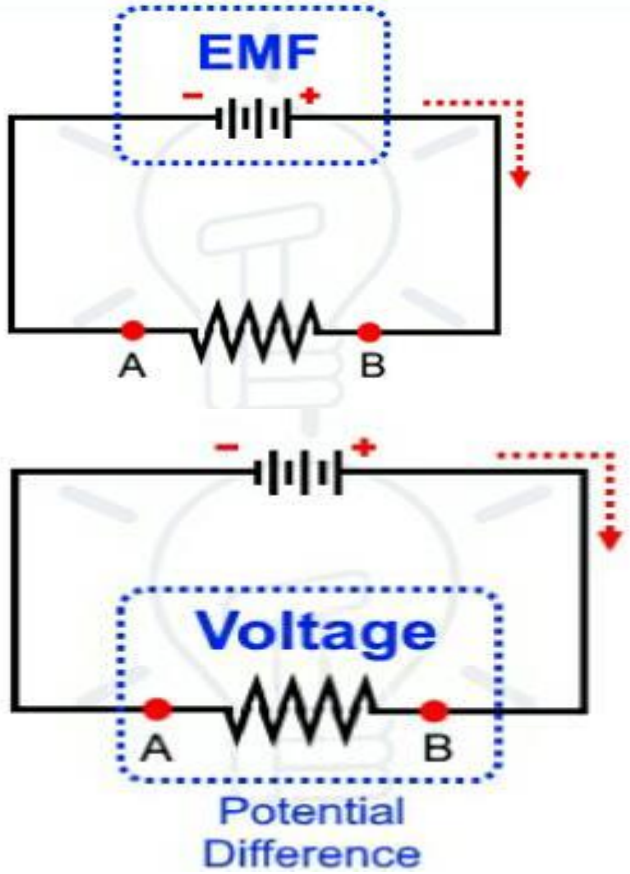
  or kilowatt x hour ... kilowatt hour kWh

  Popular unit is kWh

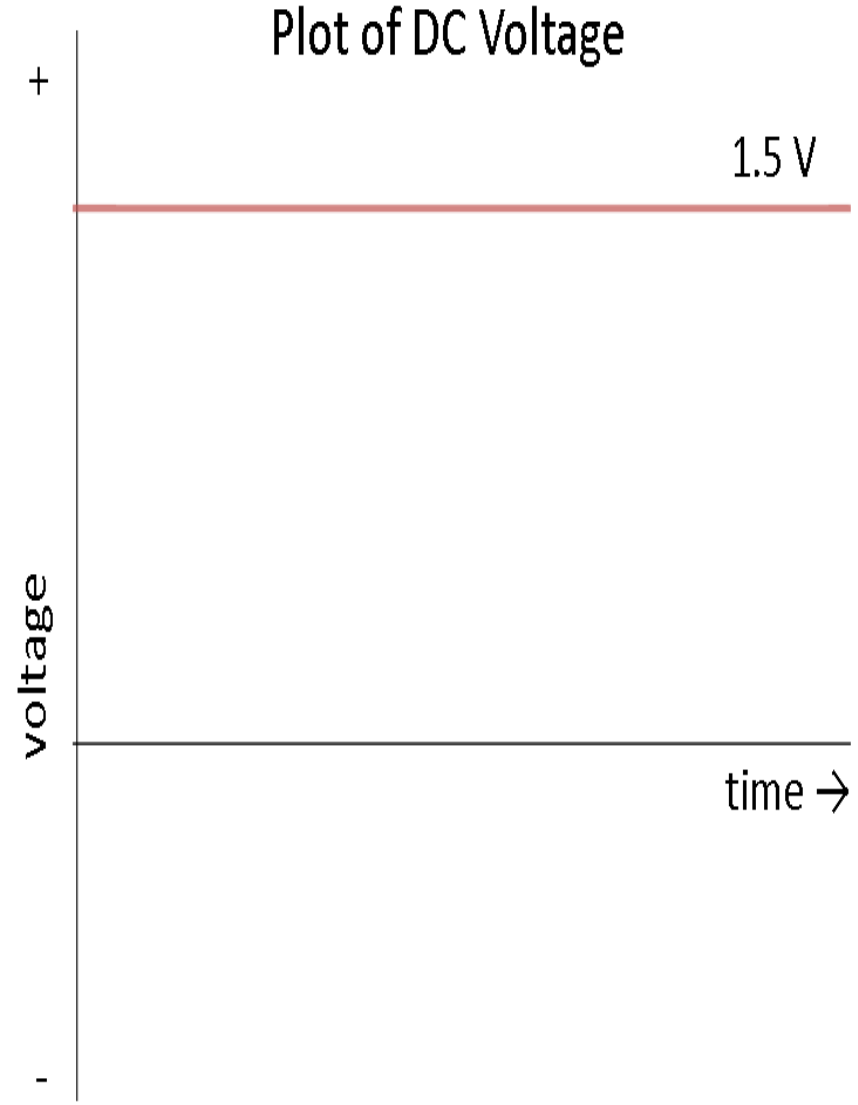
  1 kWh = 1 kW x 1 h

Potential Difference and Electromotive Force





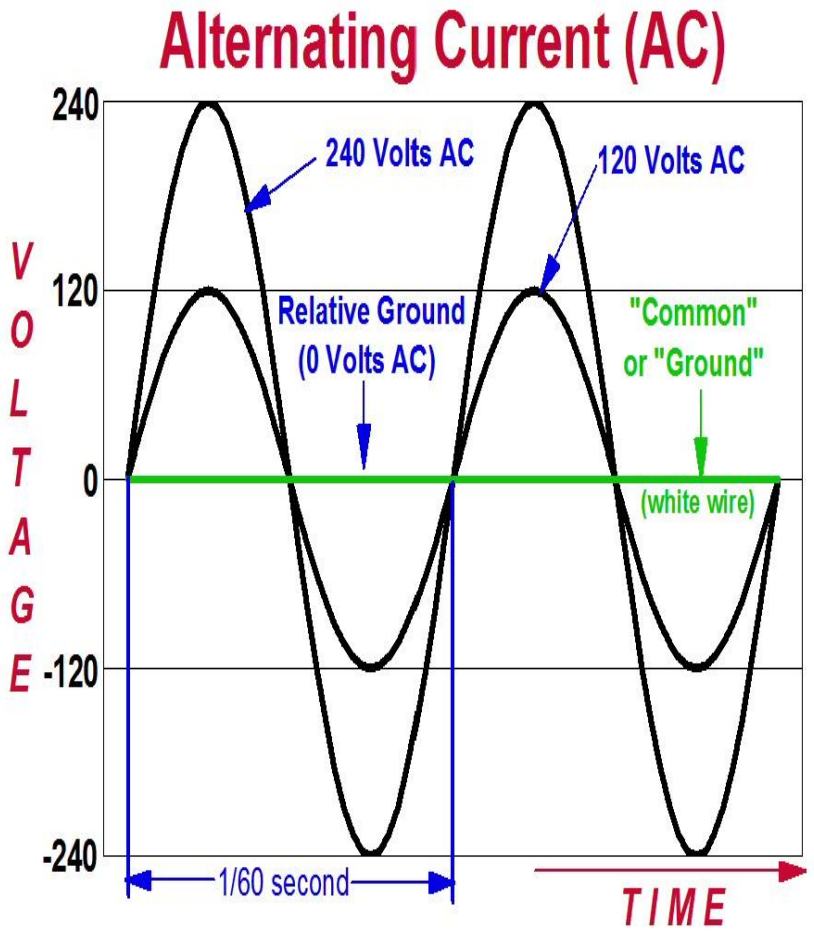
Electromotive force (e.m.f)	Potential difference
1. E.M.F. means force required to pass current circuit	1. Potential difference means difference of potential energy between two points in circuit.
2. E.M.F. is the cause because current flows in circuit due to e.m.f.	2. Potential difference is the effect pass current in circuit current flows in circuit due to because potential difference is produced due to flow of current. e.m.f
3. Its unit is volt	3. Its unit is volt.



Direct current and alternating current :

Direct current (D.C.):

- In the direct current, the direction of current does not change, but the magnitude of the current may increase or decrease. Fig. shows a graph between current versus time. In case of curve remains constant, while for curve B, The magnitude of the current decreases A, the magnitude of current with time. But, in both the cases, the direction of current does not change. The sources of D.C. current are batteries and D.C. generators.



Alternating current (A.C.)

- In case of A.C. current, the magnitude and direction both changes with time. Fig. shows a graph of A.C. From the graph it can be seen that in one direction the magnitude of current increases from zero to maximum and then again becomes zero. Then, in the opposite direction, the magnitude of current increases from zero to maximum and then again becomes zero. This process is repeated in the subsequent cycles. The source of A.C. current is A.C. generator. The A.C. current is represented by.
- In A.C. the value of current becomes zero twice in one cycle. Therefore, when a person suffered an electric shock, there are chances of contact disconnection. While in case of D.C. during electric shock, no chance to disconnect.
- Nowadays, everywhere A.C. system is used. For some special uses, D.C. is used. In that case, A.C. is converted in to D.C. by rectifier and then used.

- **Some Fundamentals:**
- We pay for our electricity charges in kilowatt hours (KWH).
- In electrical engineering, the power of an item is expressed in watts (W).
- The relation between watt (W), volts (V) and current (A) is given by:
- W = V x A
- Thus, if we use a 15 A fuse with a current of 220 V, the fuse can stand up to a power of

  220 x 15 =3300 = 3.30 kW.
- Therefore, we generally do not allow the total concentrated load per fuse to be more than 3 kW.

Hence, we divide the building in different circuits and use only 13 A - 15 A fuse in each of the circuits.

- **Load rating of lighting devices :**
- The electricity bill is paid in KWH.
- Let, 25 W lamp burns for 40 hours.
- Power consumption = 25 x 40

  = 1000 watt

  = 1.0 kwH

  = 1.0 unit

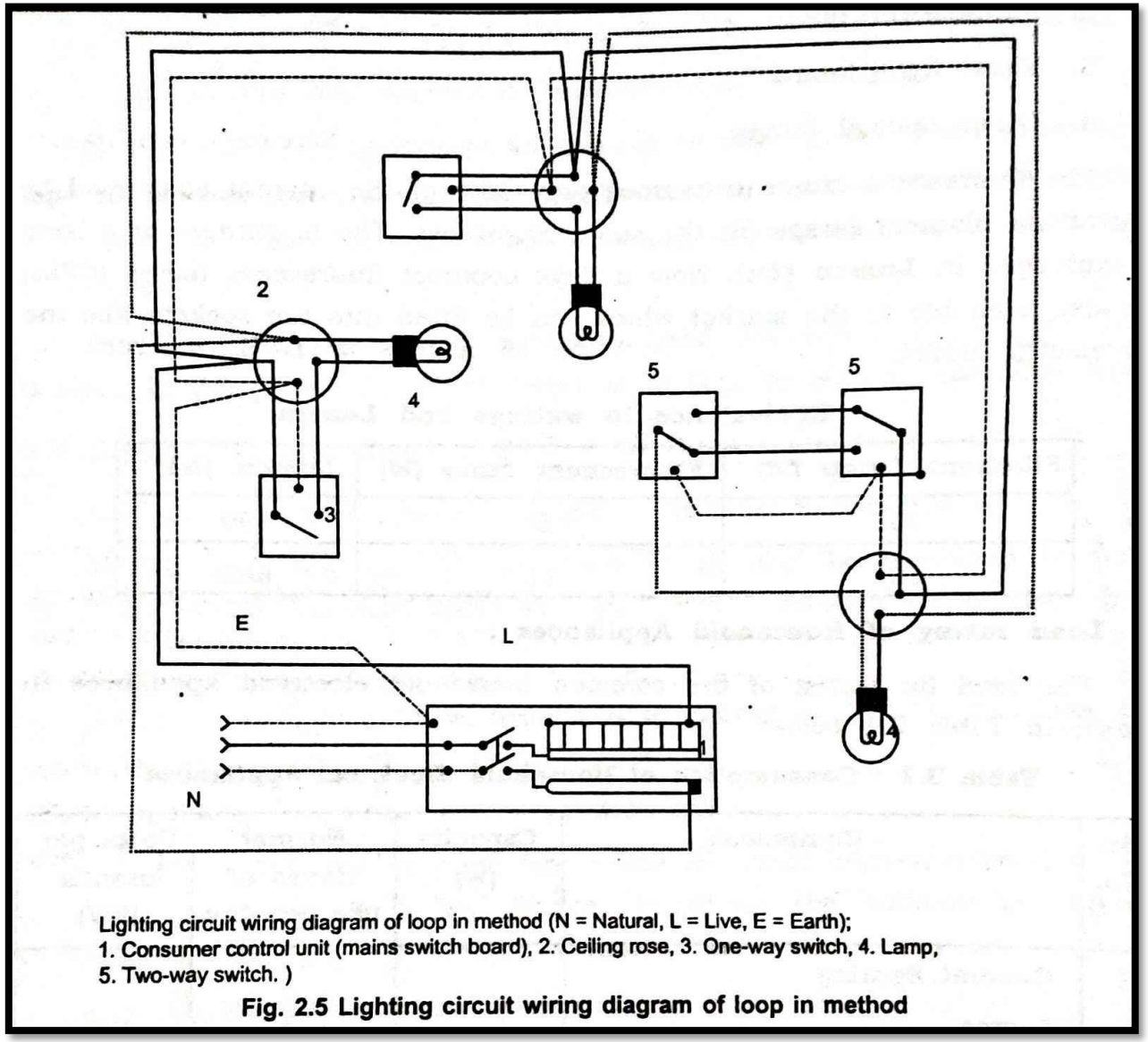
- **For lighting in building, we use**
- 1. Tungsten lamps
- 2. Fluorescent lamps
- 3. Flood light lamps
- 4. Other special lamps
- The fluorescent lamps consumes only 20% of the current consumed by that of the filament lamps for the same brightness. The brightness of a lamp is expressed in **Lumen (lm).** Now a days compact fluorescent lamps (CFLS) are also available in the market which can be fitted into the sockets like the old electric bulbs.

FILAMENT LAMP (W)	FLUORESCENT LAMP (W)	LUMEN (l m)
40	5	390
60	11	665

- **Load rating of Household Appliances :**
- The load (in watts) of the common household electrical appliances in shown in below table.

Consumption of Household Electrical Appliances

Sr. No.	Equipment	Capacity (W)	Normal Hours of use per day	Units per month (kW)
1.	**General lighting**			
	Lamps	60	5	9.0
	Fluorescent lamp (equivalent to 60 W filament lamp)	11	5	1.65
2.	**Ceiling Fans**			
	Medium size	60	12	21.60
3.	**Refrigerator (165 litre)**	120	14	50.40
4.	**Window Airconditioner (1 ton)**	1275	10	382.50
5.	**Electric iron**	750	1	22.50
6.	**Immersion water heater**	1000	1	30.00
7.	**Washing Machine**	300	1/2	4.50



Lighting circuit wiring diagram of loop in method (N = Natural, L = Live, E = Earth);
1. Consumer control unit (mains switch board), 2. Ceiling rose, 3. One-way switch, 4. Lamp,
5. Two-way switch.)

Fig. 2.5 Lighting circuit wiring diagram of loop in method

For Example :

Calculation of Power consumption by refrigerator @ 14 hours per day for one month,

= 120 x 14 x 30

= 50400 W

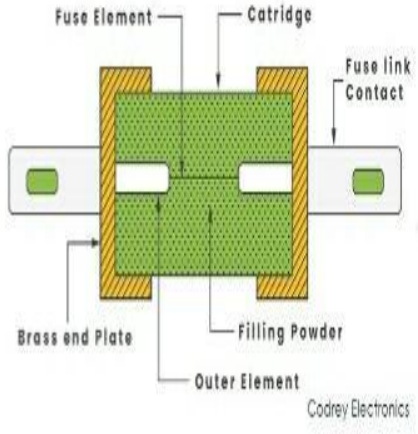
=50.40 kW

- **<u>Consumer service unit in a Building :</u>**
- The consumer service unit from which the electricity board takes readings for electricity bill, consists of the following items in the order of the electric flow :
- 1. 100 A fuse (three fuses for three phase supply)
- 2. Earth connection
- 3. Current meter – from which reading of power consumption is taken
- 4. ELCB – switches off the current if there is any leakage in the electrical circuit.
- 5. Main switch – to switch off or on the supply
- 6. Fuse chamber – which contains 15 A fuse or MCB to distribute current in each circuit.

Rewireable Fuse

Cartridge Type Fuse (Totally Enclosed Type)

Catridge type fuse (Totally Enclosed Type)



Construction of Catridge Type Fuse

- **Technical Terms Related to wiring :**

1. Fuse :

- A fuse is a thin piece of wire with low melting point fixed at its ends in a fuse plug. The function of a fuse wire is to protect the electrical appliances from heavy current. Thus whenever a high voltage is passed through a fuse wire, it automatically melts and breaks the circuit. Fuse is always provided in the live wire and not on the neutral and earth wire.
- The fuse wire is called fuse element. It is made of copper, lead or tin alloy. Simple fuse is called cut-out. Nowadays, miniature circuit breakers (MCB) are used instead of fuses in higher class buildings. The current rating of fuses should be lower then that of the cable it has to protect.
- **There are mainly two types of fuses** ;

(i) Rewirable fuses

(ii)Cartridge fuses

(i) Rewirable fuses are cheap. It takes twice the current rating of a rewirable fuse to blow it. Thus, a 5A rewirable fuse requires a current of 10 A to blow it. In one circuit usually 15A fuse is used which can stand upto a load of 3.3 kW.

2. MCB : Miniature Circuit Breaker :

- In old buildings, fuses were used to provide protection against overload. Themodern practice is to use MCB instead of fuses. The MCB will switch off if there is excess flow of current in the circuit. It has many advantages over fusses but initial costs are high and hence, they are not generally used forlow-cost construction.
- An MCB trips at 1.25 times its rated current capacity. Thus, a 30 A MCB trips at 37.5 A, compared to 60 A in case of a rewirable fuse.

ELCB

RCCB

3. ELCB : Earth Leakage Circuit Breaker:

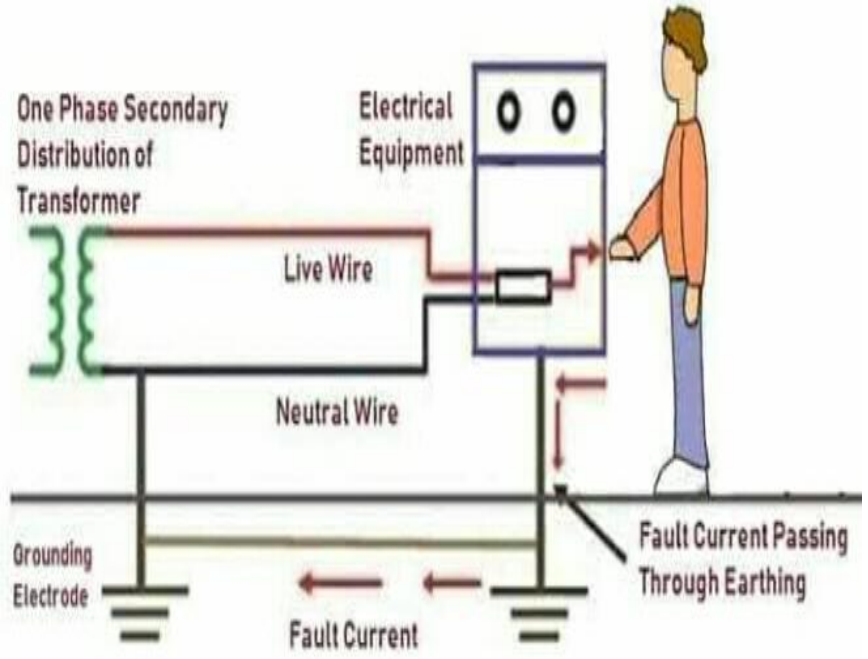
- If an electric appliance with a fault is connected to the line and if itsmetal parts are not earthed, the metal may becomes live without the fuse blowing, Such a situation can produce an electric shock to the person touching it. However, the metal body is earthed then current will flow through the earth wire. For such a condition, it is common to use a tripping device called ELCB.
- It is like a main switch which automatically trips even when only a small leakage of current flows through the earth wire and the current supply will be cut off completely. It is placed in the neutral line before main switch in the main distribution board.

4. RCCB : Residual Current Circuit Breaker :

- This is a much more positive protection device that can be provided instead of ELCB to avoid electric shocks and also current leakage in wiring of buildings. An RCCB is connected to all the three phases and the neutral. It is more expensive then ELCB and provides good protection against even minor defects in the wiring of a building.

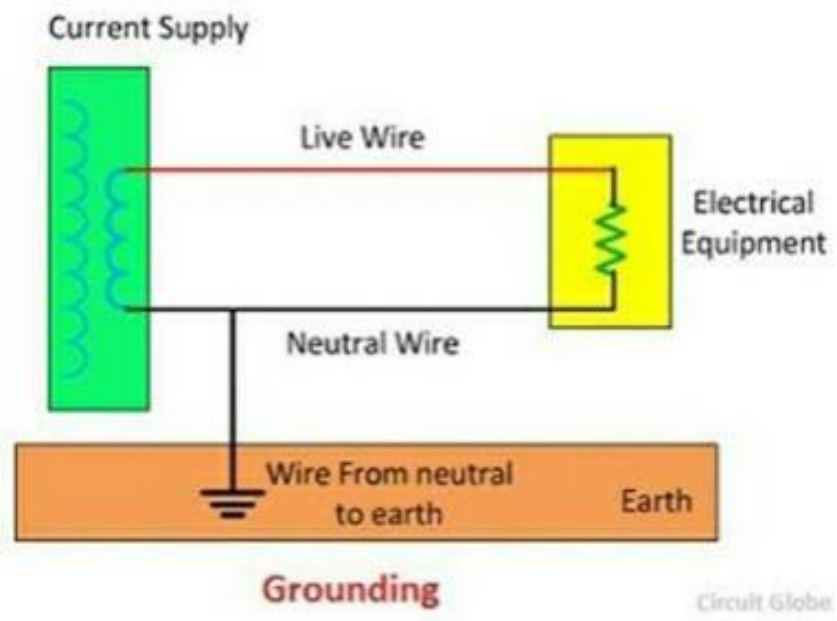
5. <u>Cables</u> :

- Cables consists of conductors surrounded by insulation: The conductors should be preferably of copper. Aluminium conductors are sometimes used to reduce cost but they are inferior to copper cables as uninsulated portions such as connections to switches tend to oxidize and become brittle thus giving trouble in the long run. If possible, aluminium cables should not be used for wiring.
- Even though rubber was once considered as the standard insulating material, nowadays, plastics (especially PVC covered cables) are very much popular. In moist or wet conditions, PVC insulation is far better than rubber.
- The sizes of cables are referred by the number and diameter of the conductor. Thus, cables designated as 1/1.13 contains one conductor of diameter 1.13 mm giving an area of 1.0 sq.mm.
- **<u>Flexible wire</u> :**
- In this type of wire instead of using thick conductor, many thin copper conductors of 16 gauge are used. This is called stranding. These wires are available in sizes of 14/36, 23/36, 40/36 etc. These strands are twisted and PVC insulation is provided over it.
- Such two wires of different colours of insulation are twisted together and coil is prepared. Flexible wire can be bent in any direction. This type of wire is used in giving connections to table lamp, fan, tube light, etc.
- Colour coding of flexible wires
- Live (phase) wire…….. Red, brown
- Neutral wire…… blue, black
- Earth wire…… green, yellow

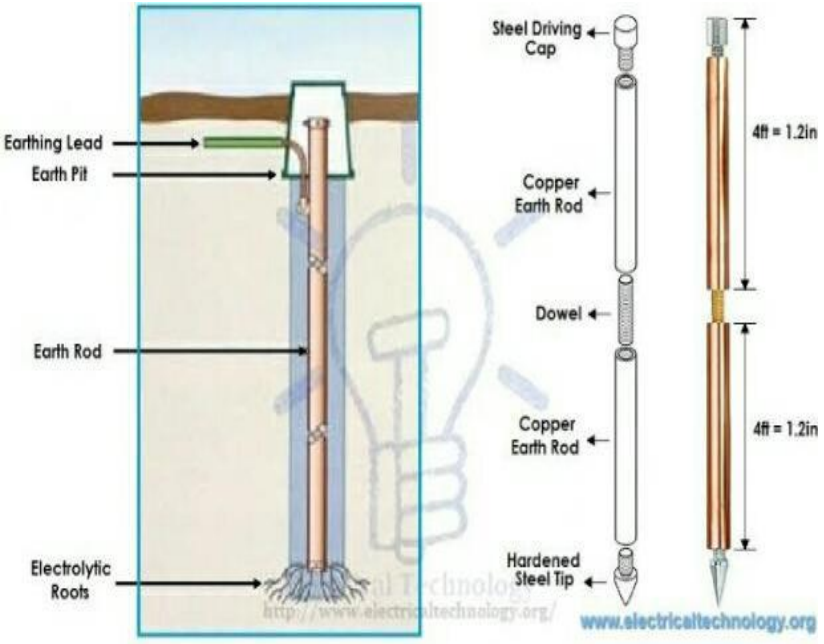


6. Earthing :

- Earthing is the process of connecting the electrical appliances to the ground so that any unforeseen current such as leakages, faults, etc. is immediately discharged to the earth. The purpose of earthing is to avoid electric shock to the human body. All metallic casing parts of portable equipment's like heater, electric iron, refrigerator, hair drier, etc. are required to be earthed.
- For example, in an electric iron three wires are used. Red and black wire (phase and neutral) are connected to the coil of an electric iron while green wire is connected to its body. Red and black wires are connected to two small o pins of three pin plug top while green wire is connected



Wire Earthing



Copper Rod Electrode Earthing System

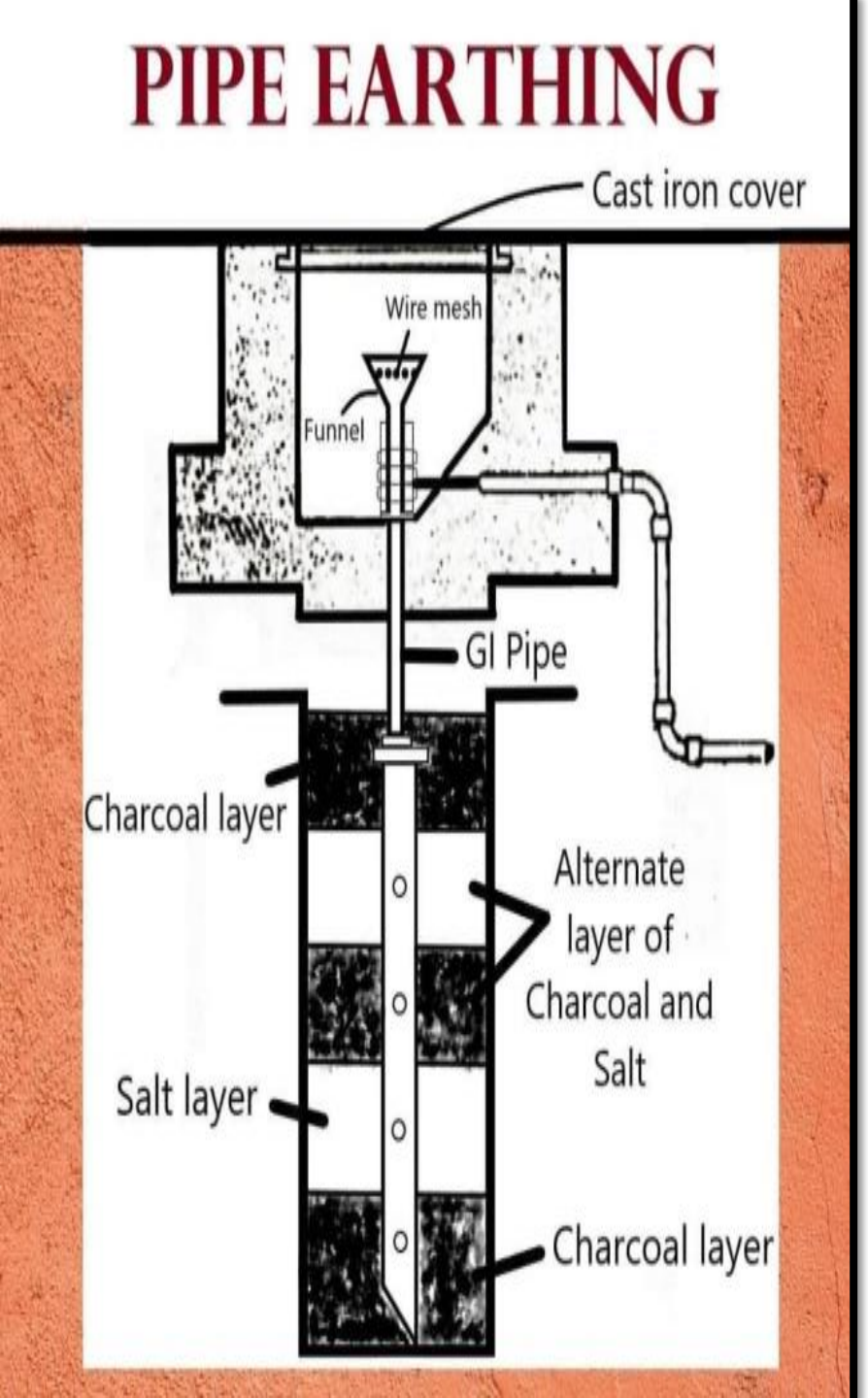
- **<u>Types of earthing :</u>**
- There are various methods of earthing like :
- Wire earthing
- rod earthing
- Pipe earthing
- Plate earthing

(i)Wire earthing:

- This type of earthing is usually adopted in a rocky terrain. In this method, copper wire of enough length is buried in a horizontal trench.

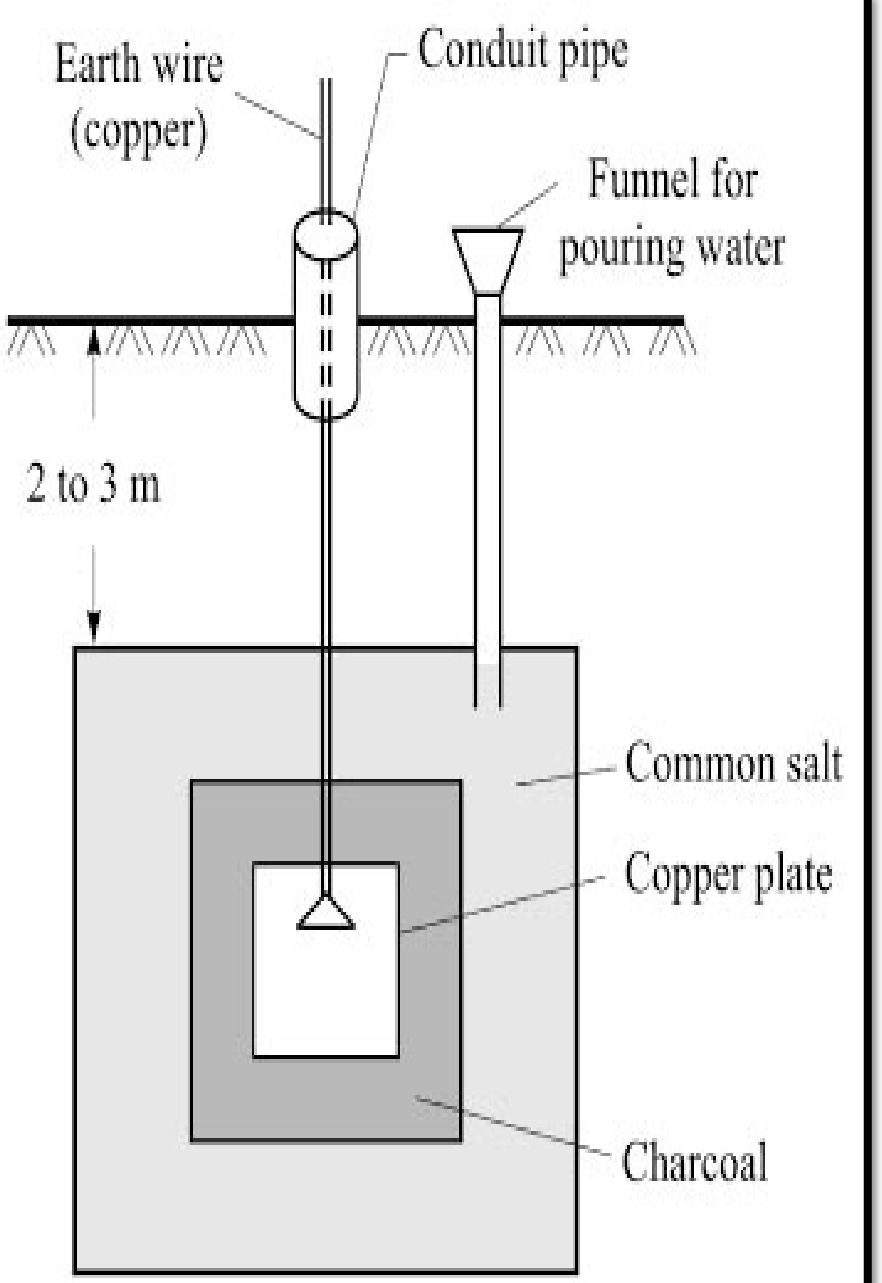
(ii) Rod earthing:

- In this type of earthing, a G.I. rod of about 20 mm diameter is laid vertically to a depth of 200 cm to 300 cm. The conductor is tied to the rod with



(iii)<u>Pipe earthing</u> :

- In this method G.I. pipe of 38 mm diameter and 2.00 m long is used as an earth electrode. A hole of about 30 cm diameter and 3.75 m deep is dug into the ground using auger. The pipe is placed into the hole. The pipe is covered with 80 mm of charcoal with a laver of common salt 30 mm all around it. Charcoal and salt are used to decrease the resistance offered by the earth mass to the current coming towards it. Top portion of hole is filled with soil. The pipe is connected to the earth wire.

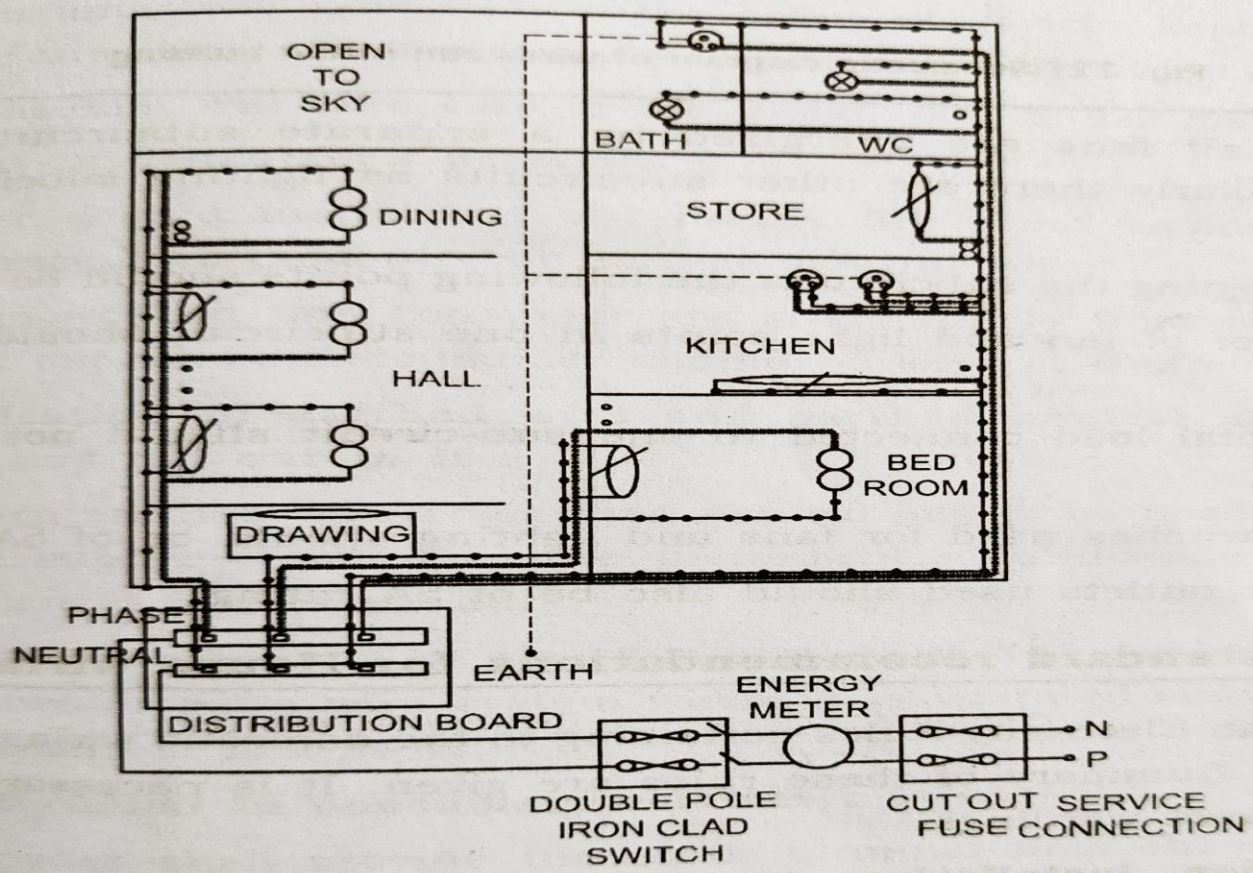


(*a*) Plate earthing.

(iv) Plate earthing :

- In this method a G.I. plate or a copper plate is used as an earth electrode. If a G.I. plate is used then a size of 0.3 m x 0.3 m with 6.35 mm thick plate is adopted. If a copper plate is used then a size of 0.3 m x 0.3 depth of not less than 2.0 m into the ground. The plate is completely covered by 80 mm of charcoal with a layer common salt of 30 mm all around it, keeping the plate in a vertical position.

...e phase and neutral are branched out into required number of ...s. The phase and neutral leading from each respective terminal is called ...rcuit and each subcircuit will be independent of other subcircuits.



LEGEND

Phase	———	Tubelight	⊘
Neutral	——•——•——	Fan	∞
Earth	– – – – – – –	Lamp	⊗
○	Switch		
○	Two pin socket 5 A	Three pin socker 5 A	⊙

Fig. 2.20 Layout of a typical house wiring

The best way to predict the future is to create it.

- Peter Drucker

THANK YOU