EE3105PE: Electrical Installation and Estimation

III YEAR I SEMSTER

Dr.K.Eswaramoorthy

- **Prerequisites:**
- A course on —Electrical basics and power systems.

- **Course Objectives:**
- To emphasize the estimation and costing aspects of all electrical equipment, installation and designs on the cost viability.
- To design and estimation of wiring
- To design overhead and underground distribution lines, substations and illumination.

COURSE OUTCOMES (CO'S)

CO1	Understanding the electrical system wiring, accessories and safety procedures required.
CO2	Understanding the OH lines. Design, estimate and applying the wiring layout of wiring schemes.
CO3	Understand , estimate and applying the OH lines & earthing
CO4	Understand the maintenance of Electrical Devices and Equipment Estimating and Estimating the costing of Repairs
CO5	Understand the importance electrical rules and survey the rural electrifications

UNIT – I
Wiring Systems and Safety Procedures

- Introduction, importance of electrical wiring, uses of cables, standard wire gauge, size and current carrying capacity of a wire/cable, systems of wiring, electrical wiring accessories, safety accessories, safety procedures, reason for not using fuse in neutral wire, electric shock, procedure for first-aid in case of electric shock.

UNIT – II
Estimation of Lighting and Power Loads

- Introduction, types of service mains, selection of service main, selection of system wiring, drawing a wire/cable through a conduit, list of electrical materials & their approximate rates, problems on internal wiring scheme, wiring layouts of a office building, work shop, industry,/cement factory/sugar factory, hotel with a 4-storied with lift arrangement, estimation of power load, single line diagram, types of wiring system, size of cable/wire, materials used in power wiring and their rates, estimation of irrigation pump sets, submersible irrigation pump sets, material used in irrigation pump sets.

UNIT - III
Estimation of Overhead Lines and Earthing

- Introduction, main components of overhead lines, conductors, insulators, cross-arms and clamps, guys and stays, steps to solve problems on estimation of OH lines, estimation of pole and plinth mounted substations, construction of pole and plinth mounted substations, estimation of materials electrical accessories of pole and plinth mounted transformers, earthing, selection of earthing, earth resistance, methods of reducing earth resistance, estimation of materials for pipe and plate earthing.

UNIT - IV
Estimating and Costing of Repairs and Maintenance of Electrical Devices and Equipment

- D.O.L. starter, small motor, mono block pump, automatic electric iron, table/ceiling fan, ICDP/ICTP Switch, Preparation of detailed drawing work of the product, Preparation of material quantity sheet for the product, Materials and cost required for maintenance work, Estimation of repairing cost and overall cost, Tools used for repairs & maintenance work Preparation of cost schedule for repair and maintenance of electric fan, automatic electric iron, single phase transformer, mixer grinder, D.O.L starter.

UNIT - V
Departmental Test, REC and Electrical Act 2003

- Introduction, departmental procedure for obtaining a service connection, insulation resistance desirable for electrical installation, earth resistance to be maintained for an electric installation, testing of wiring installation, rural electrification scheme, survey of load in a village, capacity of transformer, location of transformer, estimation of electrification of a village, economic feasibility of the scheme, Indian electricity(I.E) rules, general conditions for supply and use of energy, electric supply lines, systems and apparatus for low and medium voltages.

- **TEXT BOOKS:**
- K. B. Raina, S. K. Bhattacharya‖, —Electrical Design Estimating and Costing‖, New Age International Publisher, 2010.
- Er. V. K. Jain, Er. Amitabh Bajaj‖, —Design of Electrical Installations‖, University Science Press.

- **REFERENCE BOOKS:**
- Electrical installation and estimation, by K. Manjunath, Falcon publications.
- Gupta J. B., Katson, Ludhiana‖, —Electrical Installation, estimating and costing, S. K. Kataria and sons, 2013.
- Bureau of Indian standards, Electricity supply act-1948.
- Code of practice for Electrical wiring installations,(System voltage not exceeding 650 volts), Indian Standard Institution, IS: 732-1983.
- Guide for Electrical layout in residential buildings, Indian Standard Institution, IS: 4648-1968.

Unit-I

Wiring Systems and Safety Procedures

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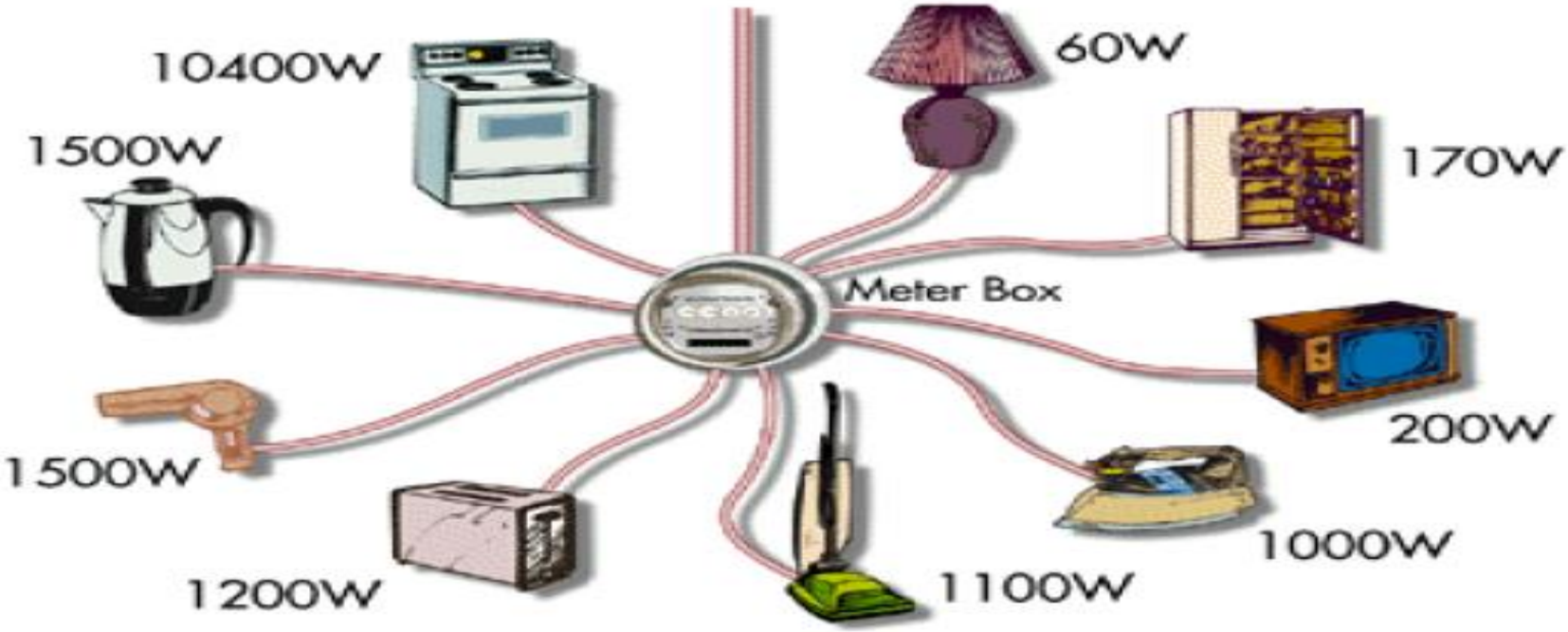
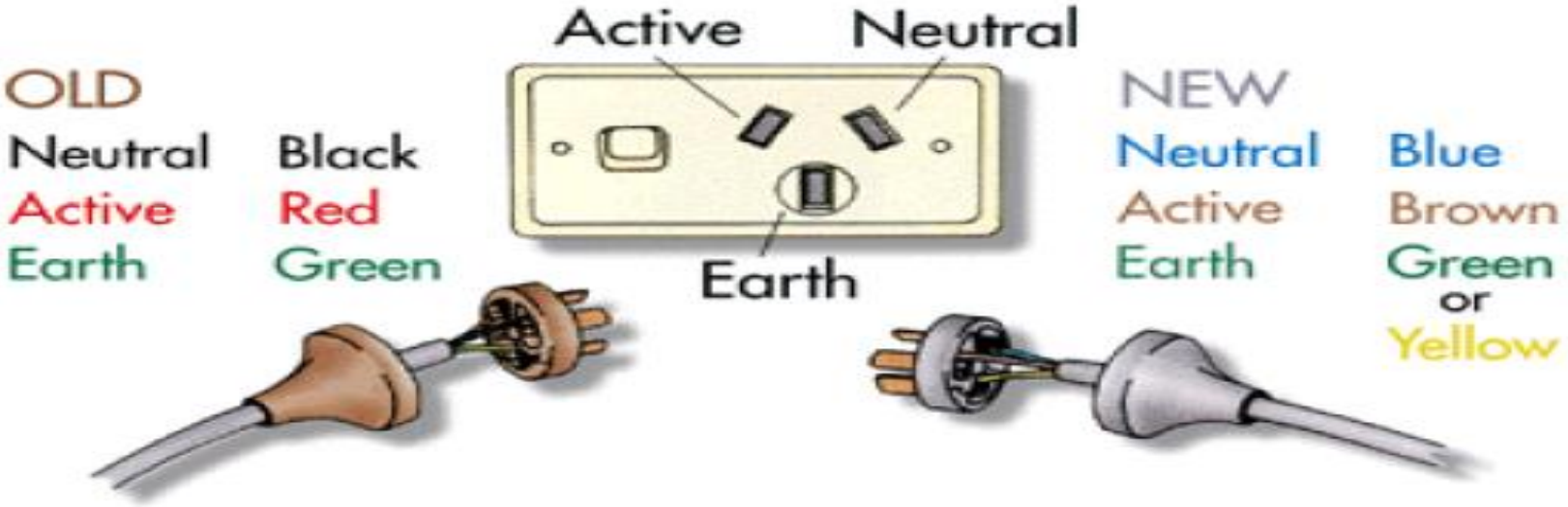
UNIT – I
Wiring Systems and Safety Procedures

- Introduction, importance of electrical wiring, uses of cables, standard wire gauge, size and current carrying capacity of a wire/cable, systems of wiring, electrical wiring accessories, safety accessories, safety procedures, reason for not using fuse in neutral wire, electric shock, procedure for first-aid in case of electric shock.

1.Introduction

- Electricity has comprehensively affected our daily life in all spheres.
- It lights our cities, powers our vehicles, runs machinery in factories, cooks our food, plays our music and gives picture on television.
- It is difficult to imagine a world without lights, computers, stereos or microwave ovens.
- It has made life easy and comfortable, but on other side it may cause dangerous situations like shock, electrical accidents and even in some cases may lead to death also.


10400W
60W
1500W
170W
Meter Box
200W
1500W
1000W
1200W
1100W

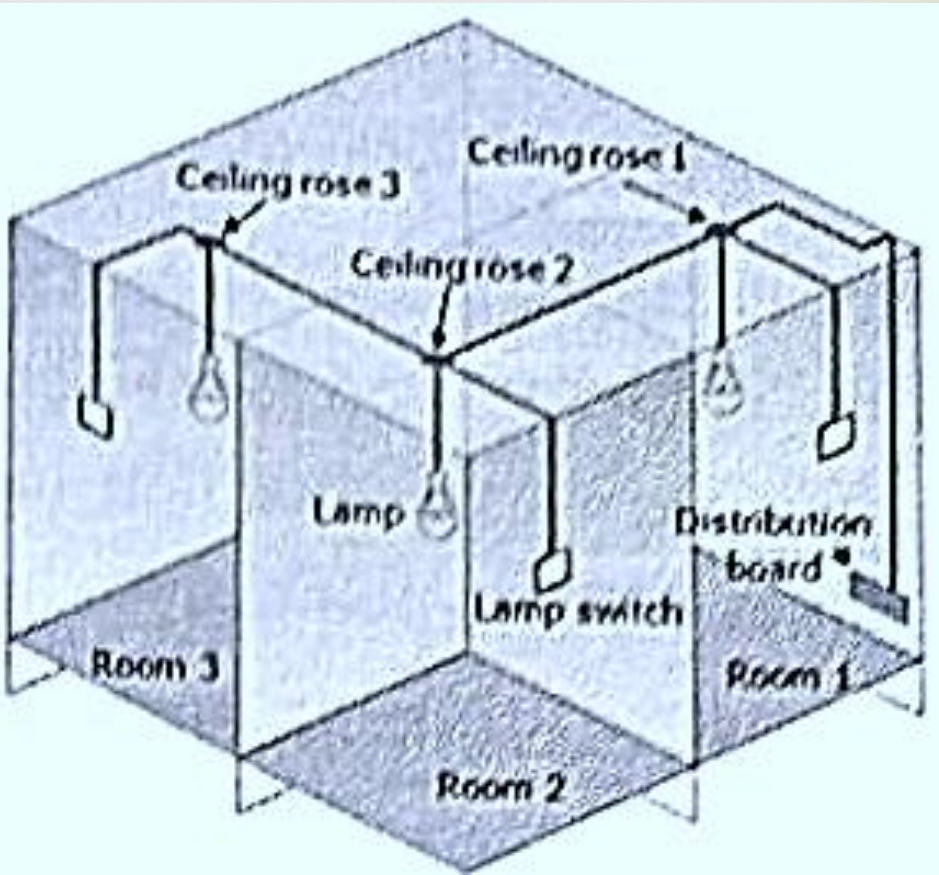

Active
Neutral
OLD
Neutral
Black
Active
Red
Earth
Green
Earth
NEW
Neutral
Blue
Active
Brown
Earth
Green
or
Yellow

- Electricians have a thorough understanding of electricity.
- They are very familiar with electrical equipment as well as the safety requirements for performing specific tasks.
- To minimize above dangerous situations, Electrician requires a special tool kit as his job involves a lot of occupational hazards.
- Electrician work is a specialized job i.e. he installs, maintains and repairs electrical machinery, equipment and fittings in factories, work- shops, power houses, business and residential premises etc.
- Hence, an electrician always should strive to form safe working habits because safe working habits always save men, money and material.
- Here, an electrician should remember the famous proverb **"Electricity is a good servant, but a bad master".**
- **An 'Electrical installations' means an assembly of associated electrical equipment or machinery placed in a position or connected for use of electricity or to fulfill a specific purpose and having certain co-ordinate characteristics.**
- Installing electrical wiring is an integral part of an electrician's job.
- Working with electrical wiring involves working with devices, accessories, conductors and cables.
- **An 'Estimation' means to determine the quantity of various materials required to execute a job and to assess the cost of the execution.**
- Before taking the work.in hand for execution, it becomes necessary to chalk out a list of quantity of various materials, its cost and labour involved for the completion of the work satisfactorily.

2.IMPORTANCE OF ELECTRICAL WIRING

- Whenever we flip a switch, plug in an appliance, or adjust a reading light, we interact with the electrical system in a house.
- A good electrician can make those interactions easier in a hundred little ways.
- Is electrical wiring important?
- It sounds like an obvious question, but it simply can't be underestimated.
- Electrical wiring is more than important, it is a vital and necessary part of our life.
- With wiring, we enjoy lighting for our home, heating and cooling to keep ourselves comfortable, and access to the countless appliances that make our lives better.

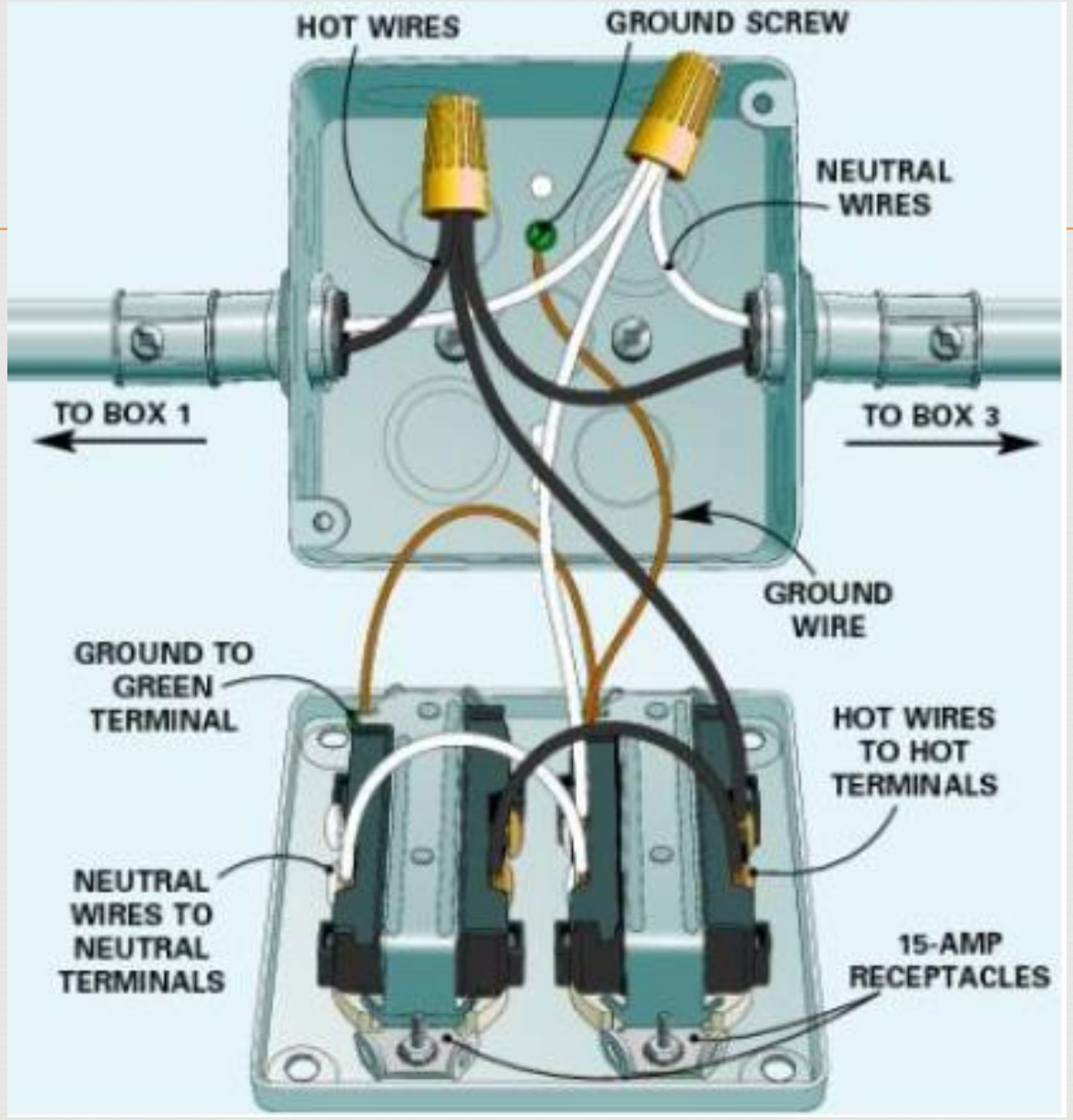
Fig.1.1 Layout of Electrical Wiring



- By powering television and computers, it keeps us in touch with the outside world, by powering alarms and security systems, it keeps our homes and our families safe. Without it, we would literally be in the dark.
- Electrical systems can appear like a confusing mess of wires, connections and hidden boxes.
- If a little care and necessary precautions have been taken, we can easily and ,safely handle most home wiring projects.
- If we learn more about electricity and wiring, we will become more confident.
- When wiring is properly installed, an electrical system will provide years of service, but wear and tear always causes problems from time to time.
- The real dangers of electric use have been minimized with the use of quality materials like switches, wires and cables etc.

2.1. WIRE SPLICING AND TERMINATION

- The use of conductors and their insulation is regulated by I.E. regulations and I.S. code of practice.
- Wires and cables are the most common forms of conductors.
- They carry electric current through all types of circuits and systems.
- A conductor is a wire or cable or other form of metal, suitable for carrying current from generating station to the point where it is used.
- All wires are conductors, but all conductors may not wires. For example bus bars in sub-stations are conductors but not wires.


HOT WIRES
GROUND SCREW
NEUTRAL WIRES
TO BOX 1
TO BOX 3
GROUND WIRE
GROUND TO GREEN TERMINAL
HOT WIRES TO HOT TERMINALS
NEUTRAL WIRES TO NEUTRAL TERMINALS
15-AMP RECEPTACLES

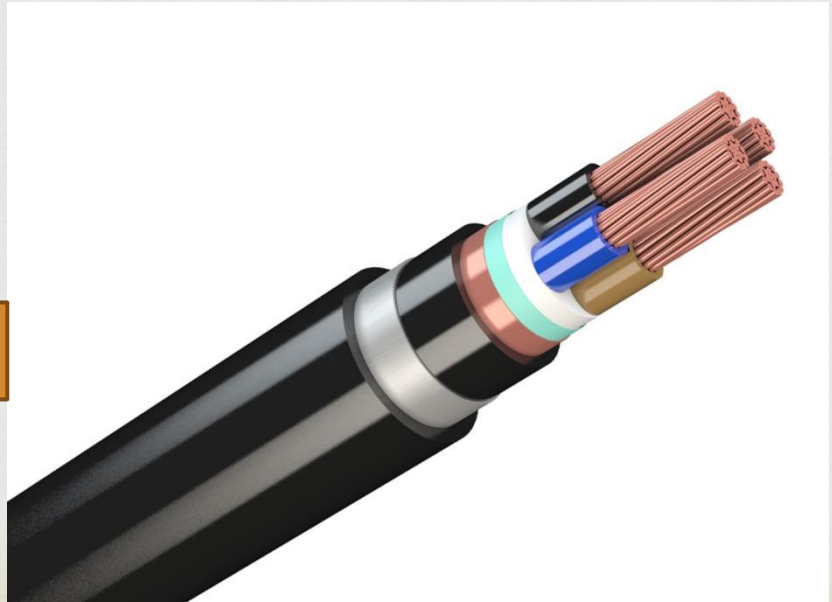
2.2. DISTINGUISH BETWEEN WIRE AND CABLE

- We can define wire and cable according to B.I.S (Bureau of Indian Standards) as follows.
- **Bare Conductor :** They have no covering. The best example is overhead transmission and distribution lines.
- **Wire :** If bare conductor is provided with insulation, then it is known as wire. The insulation separates the conductor electrically from other conductors. It allows conductor to be grouped without danger.
- **Cable :** If two or more insulated conductors are provided inside a single covering, *then it is called Cable*.
  - Cable consists of two or more number of cores insulated separately and there is an overall insulation around the covers.
  - Usually cable are provided with different layers such as metallic sheath, bedding, armouring and serving to protect the cable from moisture, mechanical injury and corrosion.
  - Basically there is no difference between a cable and a wire. It is the relative term.
  - The term "cable" is used for all heavy section insulted conductors, whereas a "wire" means a thin (i.e. smaller) section insulated conductor used for carrying current from one point to another point.

Transmission line Conductor

Wire

Cable



2.3.CLASSIFICATION OF WIRES CABLES

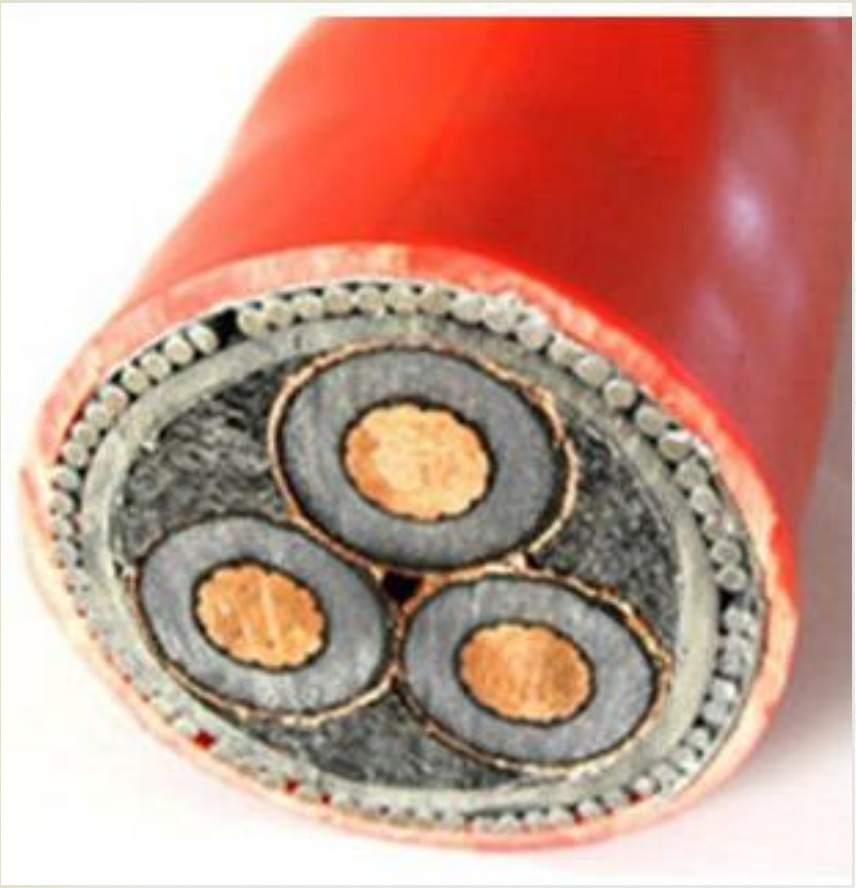
- The wires/cables used for domestic/industrial wiring are classified into different groups as under.
- **1. According to conductor material used**
  - (a) Copper conductor cables.
  - (b) Aluminium conductor cables.
- **2. According to number of cores**
  - (a) Single core cable {SCC).
  - (b) Double core or Twin core cables {DCC).
  - (c) Three core cables.
  - (d) Four core cables.
  - (e) Two core with earth continuity conductor cable.
- **3. According to Voltage grading**
  - (a) Low-Tension (LT) or Low Voltage cables - upto 1000V.
  - (b) High-Tension (H.T) or High Voltage cables :....upto llkV.
  - (c) Super-Tension (S.T) cables - from llkVupto 33kV.
  - (d) Extra-High-Tension (E.H.T) cables - from 33kV to 132kV.
  - (e) Extra-Super-Tension/Voltage cables - beyond 132kV.

- **4. According to type of insulation**
  - (a) Vulcanized Indian Rubber (V.1.R) insulated wires/cables.
  - (b) Tough Rubber Sheathed (T.R.S) or Cab-Tyre Sheathed (C.T.S) cables.
  - (c) Polyvinyl Chloride (P.V.C) cables.
  - (d) Lead Sheathed cables.
  - (e) Weather Proof cables.
  - (f) Flexible cords and cable.
- **5. According to the construction**
  - (a) Belted cable
  - (b) H-type cables (designed by H.Hochstader)
  - (c) S.L (separate Lead) type cables.
  - (d) H.S.L type cables (combination of H-type and S.L type cables).
- **6.According to type of wires used for winding of machines**
  - (a) Single cotton covered (SCC)
  - (b) Double Cotton Covered(DCC)
  - (c) Enamel coated wires
- **7. According to use of dielectrics to withstand electrical stress**
  - (a) Oil filled cables
  - (b) Gas Pressure cables.
    - Internal Pressure Cables
    - External Pressure Cables

1. According to conductor material used:

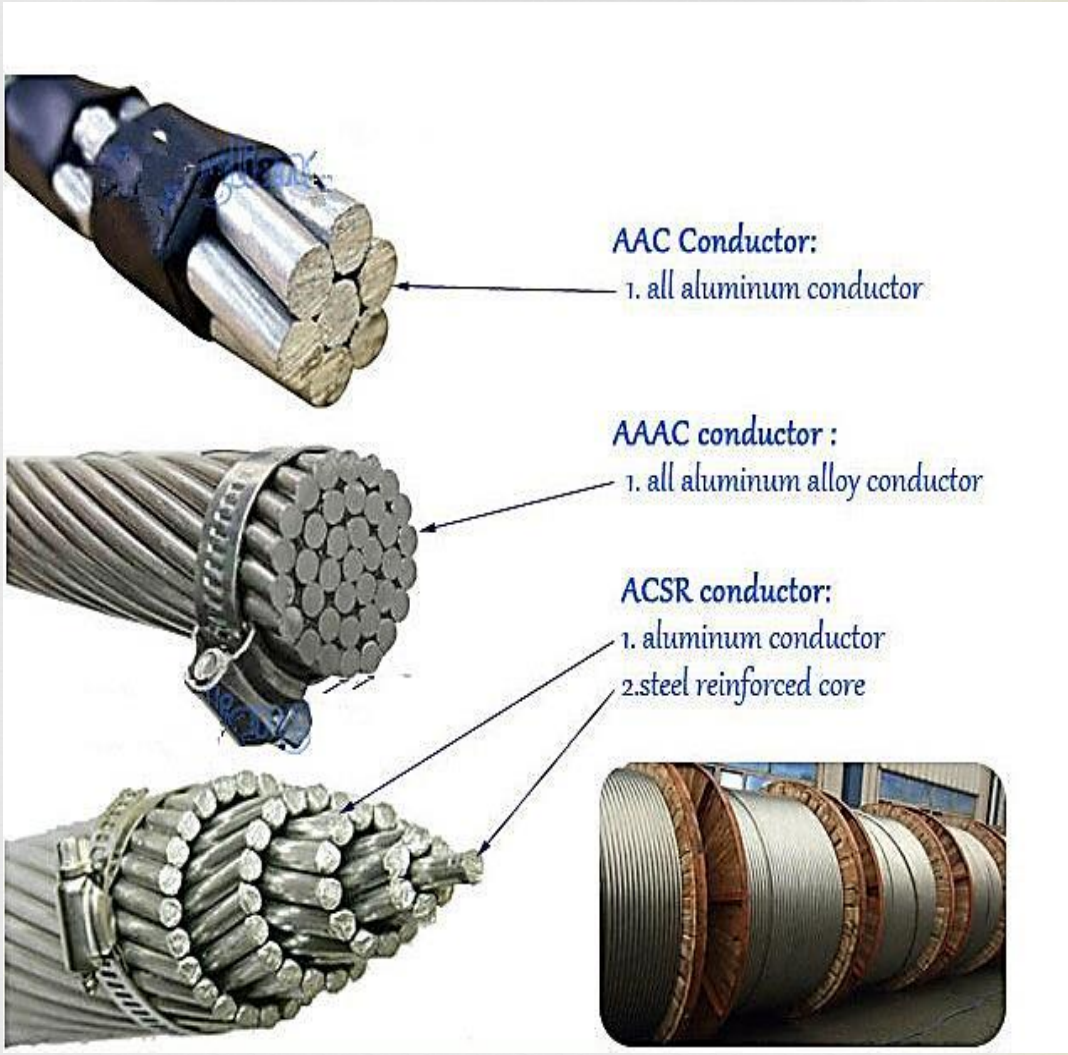
- The function of conductor is to carry electrical current.
- In electrical work, in both power and lighting cables the conductors are made with Copper or Aluminium.
- **i) Copper conductor cables:**
- Though silver is better conductor than copper, due to its high cost it is rarely used.
- Copper is cheaper than silver and conductivity next to silver.
- **The copper used should have a very high degree of purity, say 99.9%, such a copper has a resistivity of 1.786x10-8 W-m at 200c.**
- It is mechanically strong, hard, durable and ductile.
- It has a high resistance to atmosphere corrosion and oxidation, hence can serve for long time.
- It can be easily soldered, welded and can be drawn into thin wires and sheets.
- It has larger current density, hence requires less volume to carry current.

- Copper conductors may be annealed or hard drawn.
- Annealed copper conductors are soft and suitable for indoor and outdoor wires/cables, whereas hard drawn copper conductors have high tensile strength and used as overhead conductors.
- However, due to its high cost and non-availability, it is rarely used as overhead conductors.
- **ii) Aluminium conductor cables:**
- Aluminium has good conductivity, next to copper.
- **The conductivity of aluminium is 60.6% of that of copper.**
- **The resistivity of aluminium is 2.87x10-8 W-m at 200c.**
- **For the same resistance and length aluminium required will be 1.61 times that of copper in volume and 1.26 times that of copper in diameter.**
- It is cheaper and lighter in weight than copper.
- It can be drawn into thin wires and sheets, but it loses its tensile strength.
- In order to increase the tensile strength, the aluminium conductors are reinforced with a core of galvanized steel and such a conductor are known as Aluminium Conductor Reinforced and is abbreviated as A.C.S.R which is extensively used for overhead transmission and distribution lines.



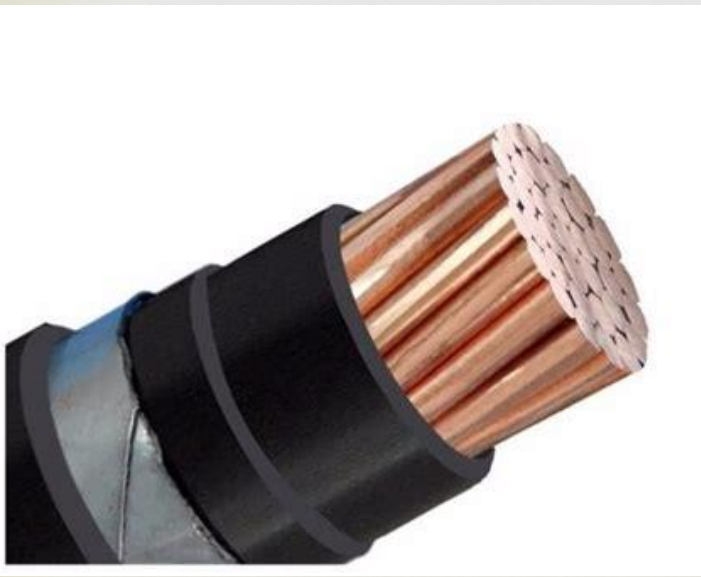
Copper Conductor Cable

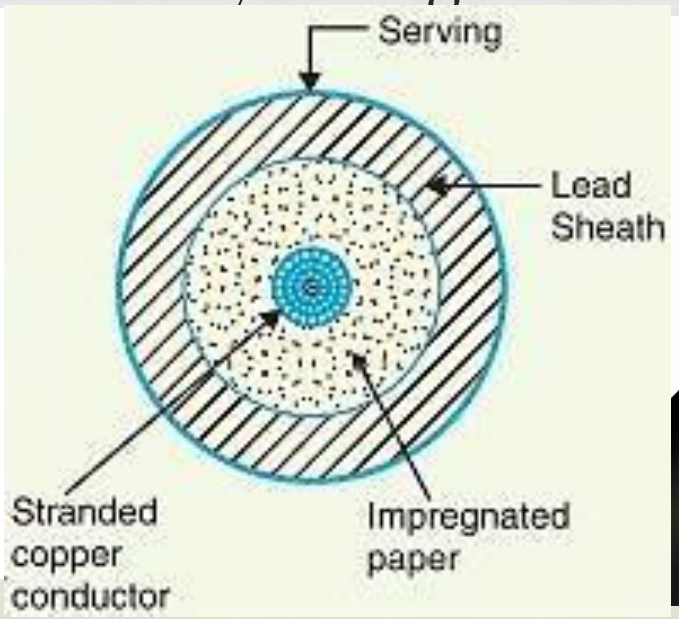
Aluminium Conductor Cable

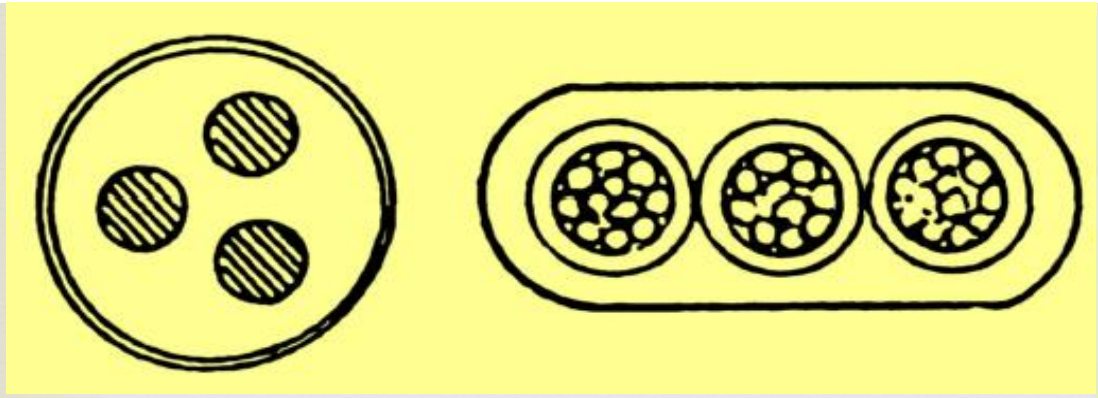


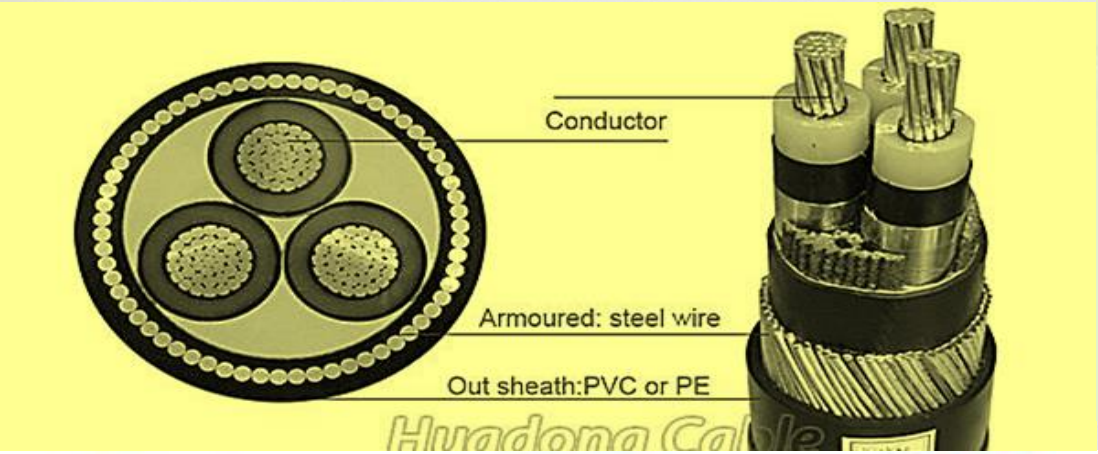
2. According to number of cores:

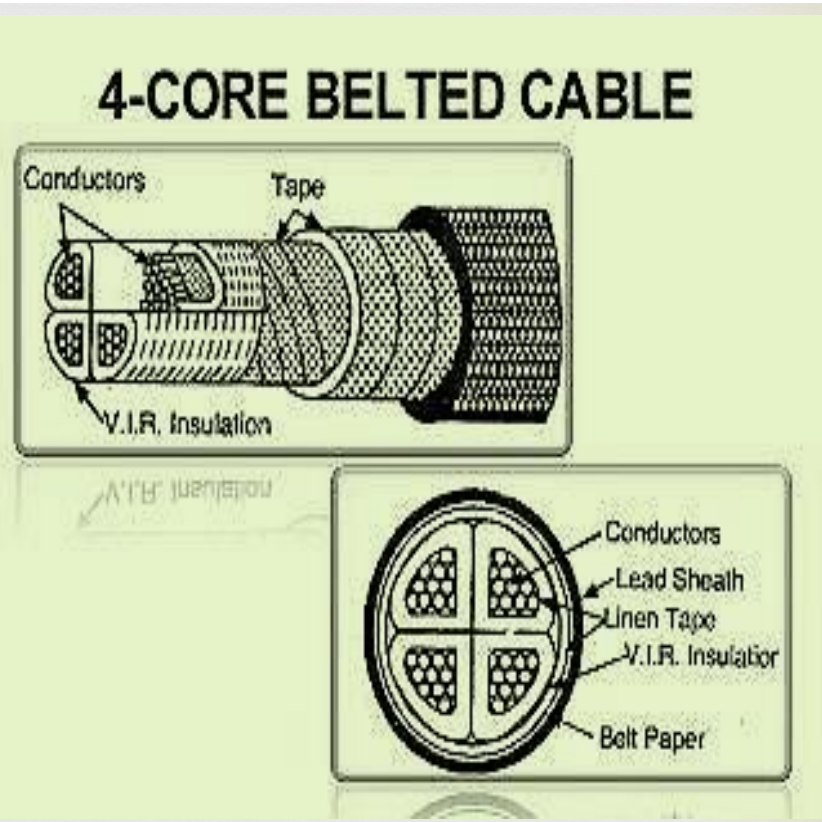
- All cables have one or more number of central cores.
- Depending on number of cores the cable are classified as;
- **i) Single-Core Cable (SCC):**
- It consists only one core of tinned stranded copper (or aluminium) insulated by layers of impregnated paper.
- The advantages of single-core cable are simple in construction and availability of large cross section.








Conductor
Armoured: steel wire
Out sheath:PVC or PE

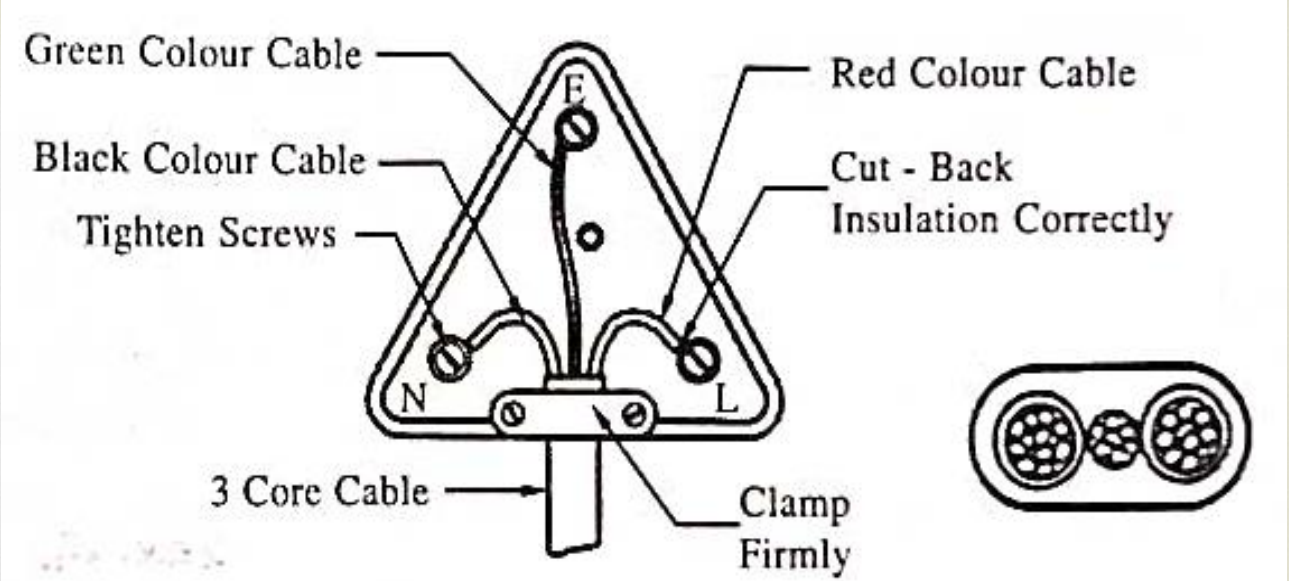

4-CORE BELTED CABLE
Conductors
Tape
V.I.R. Insulation
Conductors
Lead Sheath
Linen Tape
V.I.R. Insulation
Belt Paper

5 Core
4 Core
3 Core
2 Core
1 Core

- **ii) Double-Core Cable or Twin-Core Cable:**
- This cable consists of two copper (or aluminium) cores.
- Each core is insulated separately and there is an overall insulation around the cores.
- This is again provided with different layers to protect from various injuries as shown.
- **iii) Three-Core Cable:**
- It consists of three cores of stranded copper (or aluminium) and each core is insulted from each other by layers of impregnated paper.
- Another layer of impregnated paper tape is wound around three cores.
- The cable may be provided with lead sheath to protect the cable form moisture and mechanical injury.
- This is mainly used for 3- phase service.
- **iv) Four-core Cable:**
- Its construction is similar to three core cable and is used for 3-phase, 4-wire supply system.

3. According to type of insulation:

- The satisfactory operation of a cable depends to a large extent on the characteristics of insulation used.
- Therefore selecting a proper insulating material for a particular job is most important.
- The following are the classification of cables depending upon insulation used.
- **i) Vulcanized Indian Rubber (VIR) Cables:**
- This type of wires/cables is generally used in casing-capping, cleat wiring, conduit wiring and for general electrical wiring etc.
- These are available in two different grades i.e. 250V and 600V.
- It consists of tinned copper conductor (or aluminium) with a layer of Vulcanized Indian Rubber insulation as shown in fig.
- The copper conductor is tinned to provide protection against corrosion due to presence of sulphur, zinc oxide and other mineral ingredients in the VIR.



(b) Connection of Two-core Cable with Earth Continuity Conductor

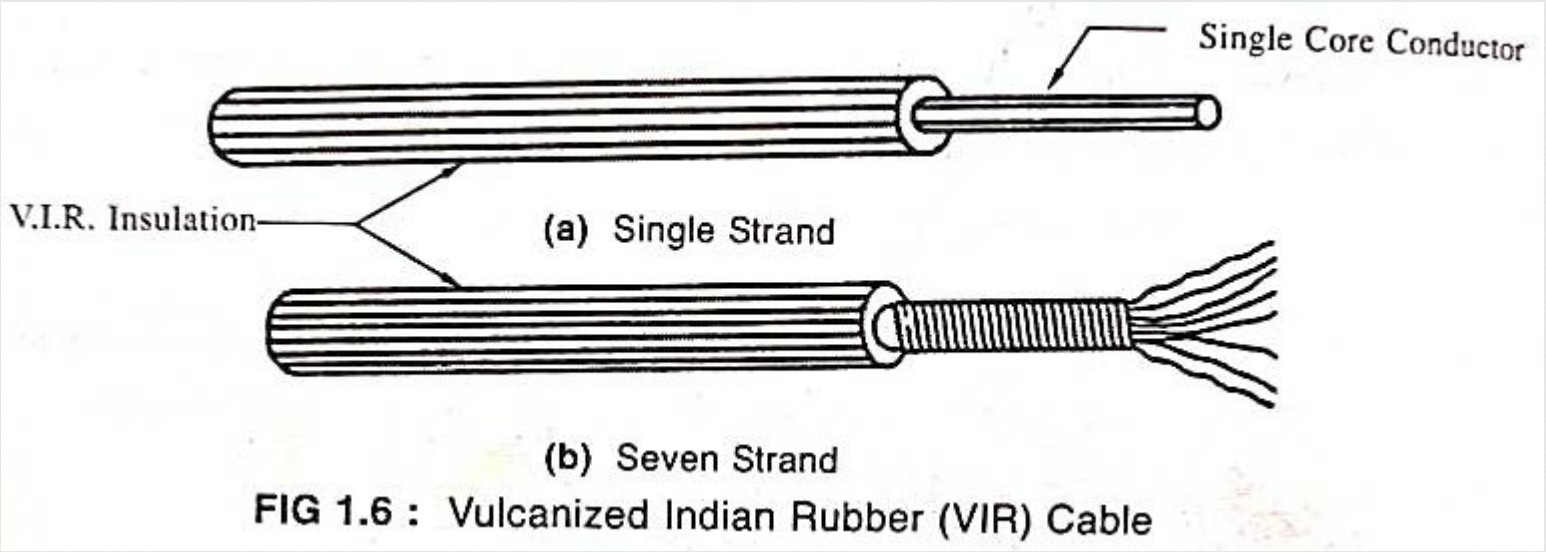
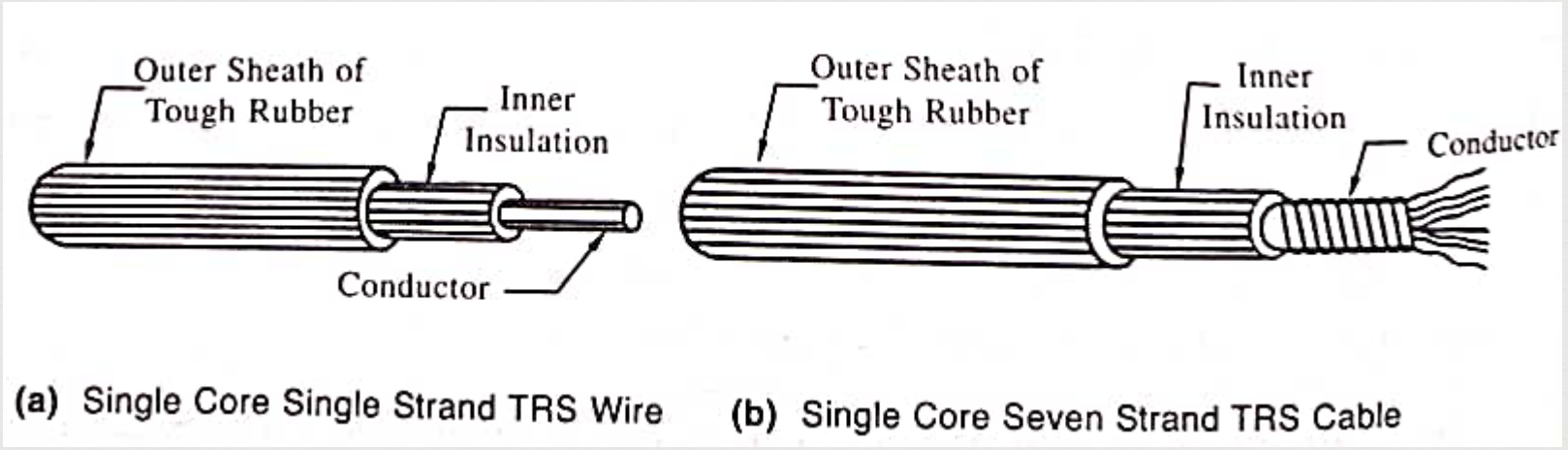
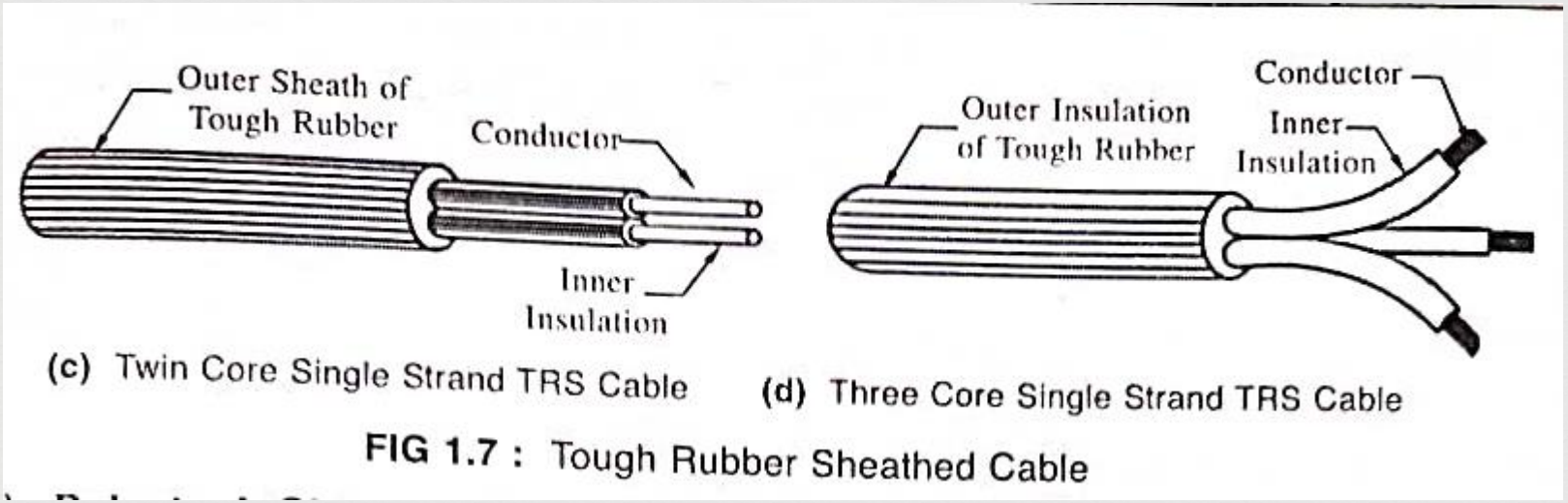


FIG 1.6 : Vulcanized Indian Rubber (VIR) Cable



(a) Single Core Single Strand TRS Wire (b) Single Core Seven Strand TRS Cable



(c) Twin Core Single Strand TRS Cable (d) Three Core Single Strand TRS Cable

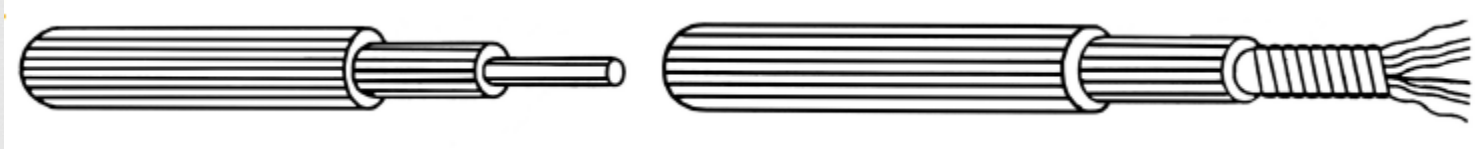
FIG 1.7 : Tough Rubber Sheathed Cable

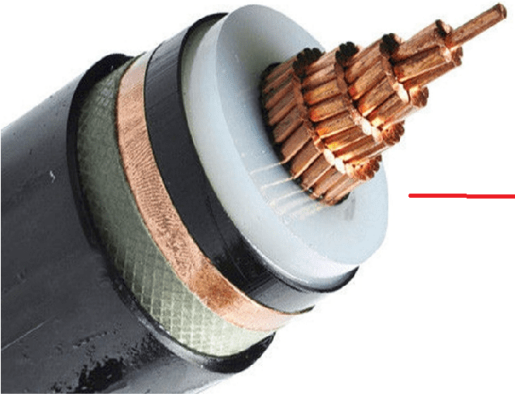
T.R.S electric cables

- Over the rubber insulation cotton tape sheathed covering, with moisture resistant compound is provided.
- Finally it is finished with wax to protect the wires from damages while drawing through the conduit pipe.
- These are available in different sizes as 1/18, 3/20, 3/22, 7/20, 7/22, 7/16, 19/18, 19,16 S.W.G. etc. (numerator represents number of strands and denominator represents gauge number of each strand).
- They are available in different colours such as white, black and brown.
- **ii) Tough Rubber Sheathed (TRS) or Cab Tyre Sheathed (CTS) Cables:**
- These cables are generally used in batten wiring (TRS or CTS wiring).
- These are available in 260/440 volt and 650/1100 volt grades and they may be single core or twin core as shown in fig.
- It has a tinned copper conductor or aluminium conductor covered with Vulcanized Rubber.
- Over the Vulcanized rubber, it is provided with Tough rubber, hence the name Tough Rubber Sheathed cable.
- The Tough Rubber provides protection to the cable against wear and tear.
- These are cheap and light in weight.
- These are available in different sizes such as 1/18, 3/22, 3/20, 7/22 S.W.G. etc.

iii) Polyvinyl chloride (PVC) cables:

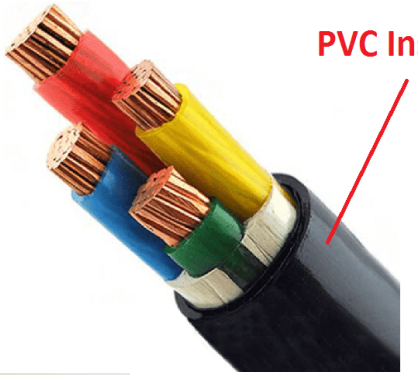
- These cables are used in industrial and domestic wiring such as batten wiring, casing and capping wiring, conduit pipe wiring etc.
- These are available in 250/440 volt and 650/1100 volt grades and may be single core, double core, three core and three and half core for different applications as shown in fig.
- It is consists of a tinned copper conductor or aluminium conductor may be single core or multi strands, covered with P.V.C. As PVC is harder than rubber, PVC cables do not require cotton tape against mechanical and moisture protection.
- The PVC insulation does not create any chemical reaction with the metal of the wire/cable.
- P.V.C. insulation has more life and good appearance.
- These cables are available in different sizes such as 1/18, 3/22, 3/20, 7/22, 7/20 S.W.G. etc. and available in various colours like white, black, red, yellow, blue etc.



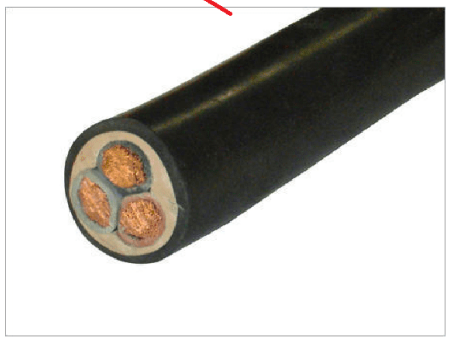


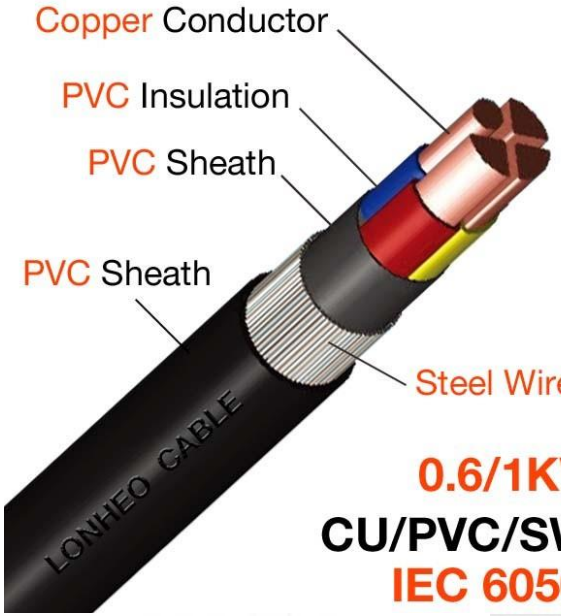
XLPE Cable

VIR Cable



PVC Insulation



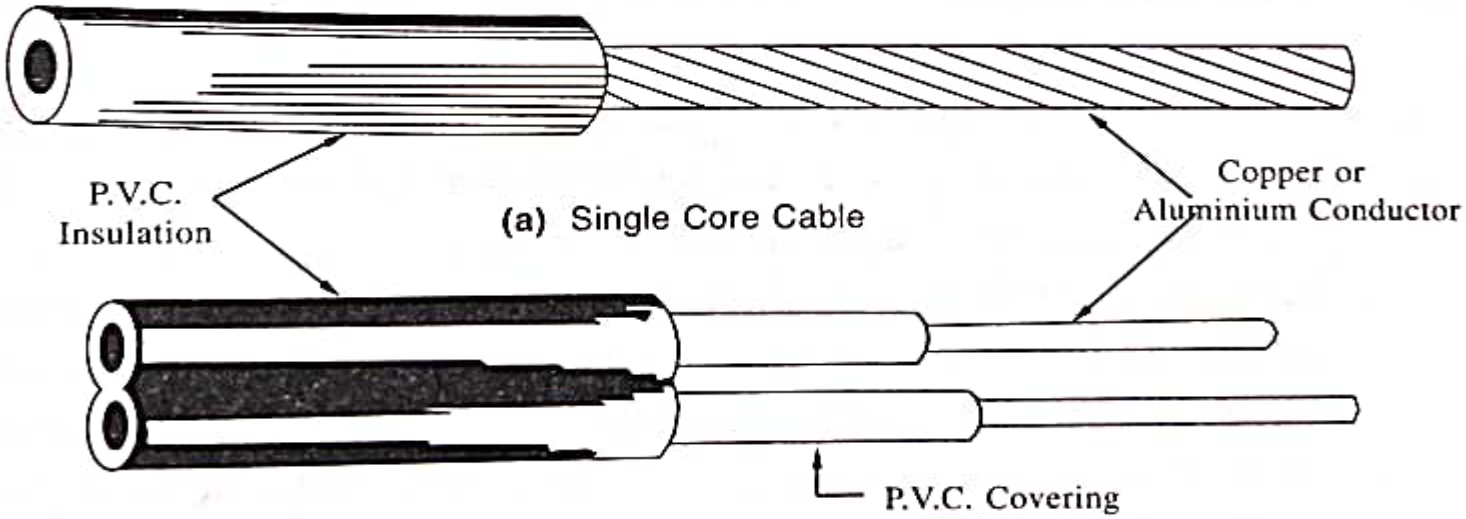


3+1 Core

0.6/1KV

CU/PVC/SWA/PVC

IEC 60502



(b) Two Core Cable

FIG 1.8 : Polyvinyl Chloride Cable (PVC)

iv) Lead sheathed cables:

- These cables are used where the climate condition is wet and has a little bit of moisture.
- These cables consist of a tinned copper conductor or aluminium conductor, covered with rubber insulation, and then covered with a continuous sheath of lead.
- The lead provides protection to the cable against moisture as well as mechanical injury.
- These cables are fire proof and weather proof and not affected by chemical and fumes.
- They are available in different sizes like 1/18, 3/20 S.W.G. and even in single core, double core, two core with earth continuity conductor etc.

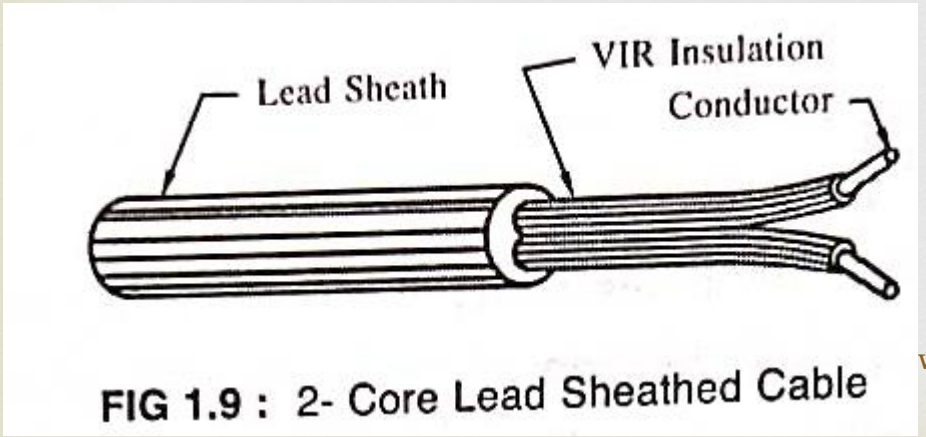


FIG 1.9 : 2- Core Lead Sheathed Cable

v) Weather proof cables:

- These cables are generally used for outdoor applications i.e. where the wires are exposed to sunlight, rain etc.
- It is generally used in service lines and are available in 250 and 600 grades.
- These cables consists of tinned copper or aluminium conductors cover with a layer of VIR or PVC insulation.
- This insulation is covered with cotton tape braided and weather proof compounds as shown in fig.
- They are available indifferent sizes like 1/18, 3/20, 3/22, 7/20 S.W.G. and so on.

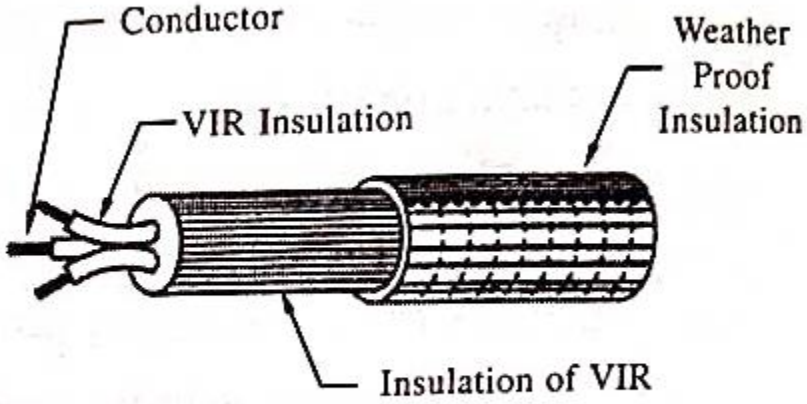


FIG 1.10 : 3 - Core Weather Proof Cable

vi) Flexible cords and cables:

- These are used for connecting wires for such purposes as from ceiling rose to lamp holders, socket outlets to household appliances like electric heater, table lamp, fans, refrigerators, T.V etc.
- These wires are required to be durable and flexible.
- Flexibility is obtained by using conductors with more number of strands.
- If they are not flexible it may crack and break very soon.
- These cables have tinned copper conductors.
- They are available in different sizes like 14/0.9976, 40/0.0076, 162/0.0076, which means that there are 14, 40 or 162 strands of copper wires each having a diameter of 0.0076 inch which is equivalent to 36 S.W.G.

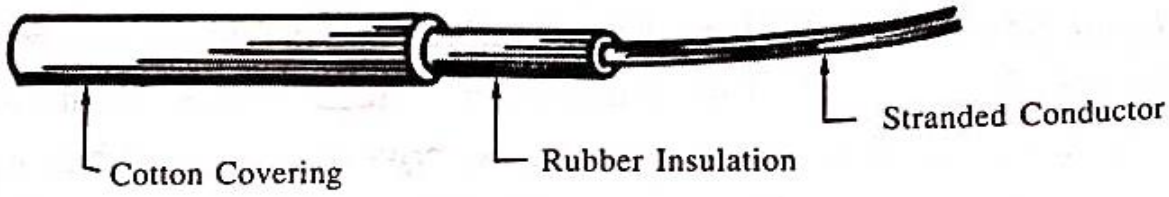
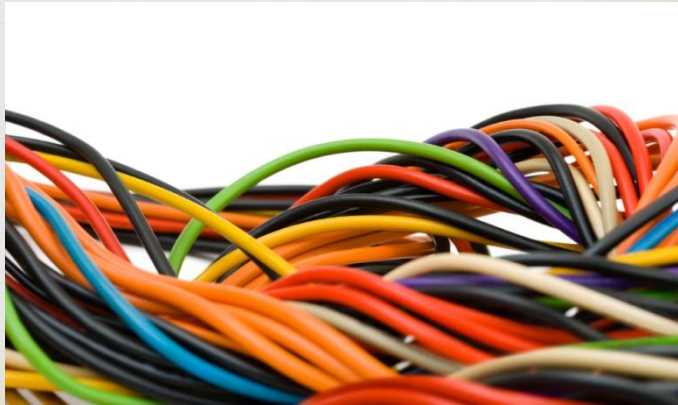


FIG 1.11 : Flexible Cords and Cables

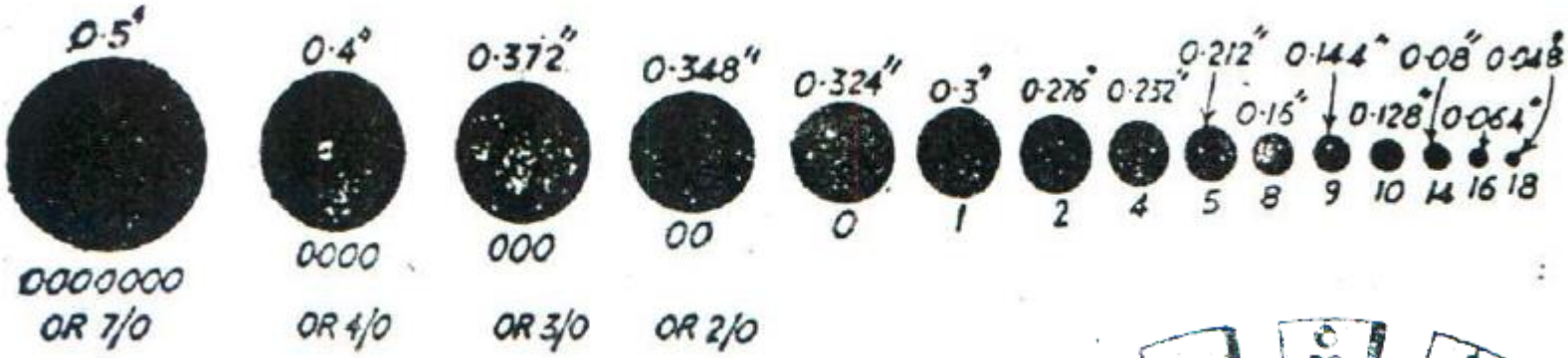


3.Use of Cables

- Electric Power can be transmitted and distributed either by OH conductors or underground cables (LV,HV, EHV)
- UG cables are used where its difficult to erect OH lines and use of impractical.
- Eg:Congested urban areas, thickly populated areas where municipal authorities prohibited OH lines for reasons safety, general appearance or around plants and substances or where maintenance conditions do not permit the use of OH lines.
- The type cable used will be depends on the voltage and service requirements.
- Cables used only for congested urban areas at comparatively low and medium voltages.
- Development in design of cables, distribute the power at high voltages and transmit power for short distances.

4.Standard Wire Gauge

- The Standard Wire Gauge (S.W.G) is a device, which is used for determining the size of a wire in terms of gauge number.
- The wire gauge commonly used in India is the British Standard Wire Gauge.
- It is a thin circular plate of steel, with a number of slots on its circumference as shown in fig.
- The slots are made of different sizes and the numbers are marked on each slot in a systematic way.
- Holes are provided at the end of each slot for removing the wires easily.
- To find the gauge of a wire, insert the wire in each slot and find a particular slot into which a bare wire just slides without being damaged.
- The number marked opposite to the slot is number of the gauge required.
- The largest wire gauge number is00,00,000 (named as seven zero) or simply written as 7/0 having a diameter of 12.70mm, whereas the smallest number of wire is 40 having a diameter of 0.1219mm.
- It can be observed that the higher the number of wire gauge, the smaller is the diameter and vice-versa.
- Table 1.1 gives the diameters and area of cross-section for corresponding gauge numbers of the British Standard Wire Gauge.


0·5"
0·4"
0·372"
0·348"
0·324"
0·3"
0·276"
0·252"
0·212"
0·144"
0·08"
0·15"
0·128"
0·064"
0000000
OR 7/0
0000
OR 4/0
000
OR 3/0
00
OR 2/0
0
1
2
4
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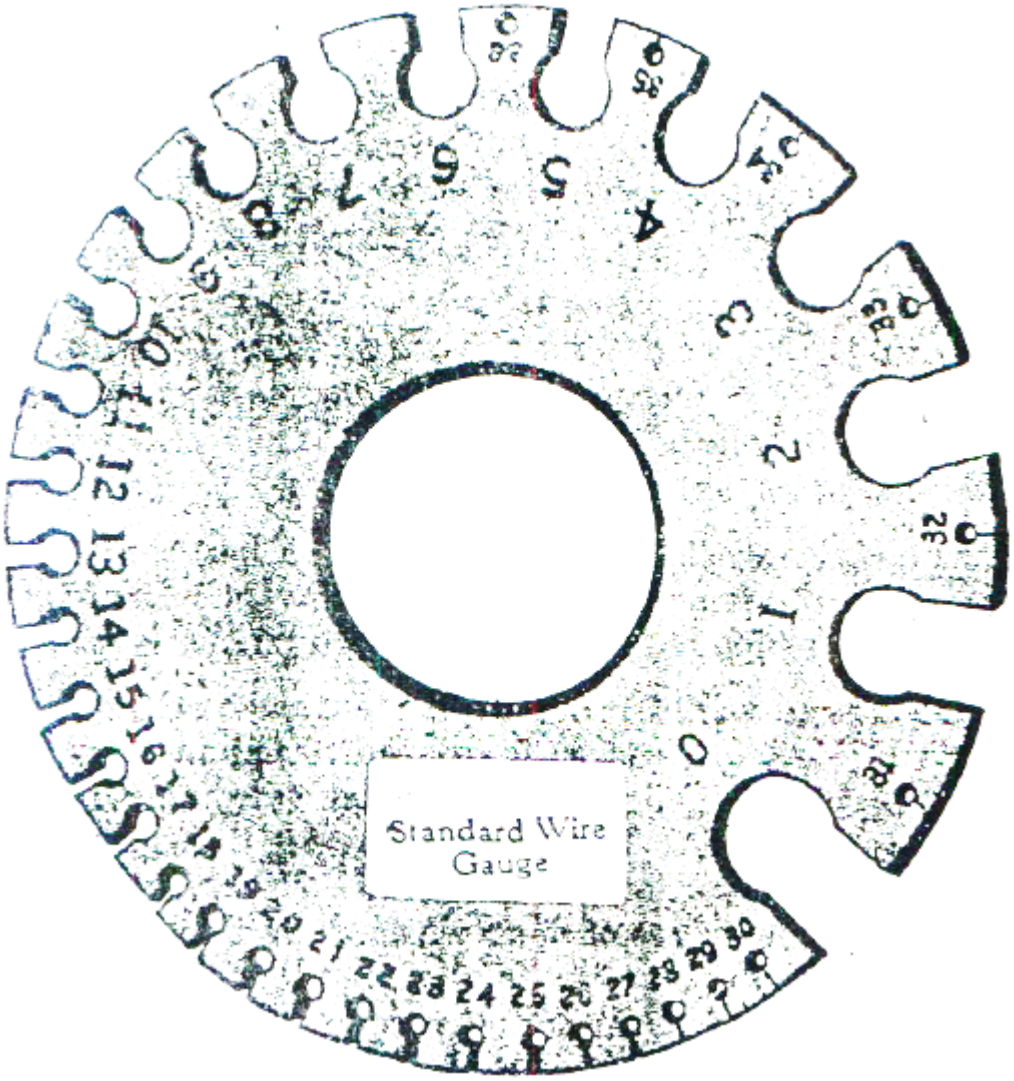
9
10
14
16
18


Standard Wire Gauge

Gauge Number	Diameter in mm	Area in mm^2
7/0	12.7000	126.6769
6/0	11.7856	109.0921
5/0	10.9728	94.5638
4/0	10.1600	81.0732
3/0	9.4488	70.1202
2/0	8.8392	61.3643
0	8.2296	53.1921
1	7.62	45.6037
2	7.0104	38.5990
3	6.4008	32.1780
4	5.5928	24.5668
5	5.3848	22.7735

Gauge Number	Diameter in mm	Area in mm^2
6	4.8768	18.6793
7	4.4704	15.6958
8	4.064	12.9717
9	3.6576	10.5071
10	3.2512	8.3019
11	2.9464	6.8183
12	2.6416	5.4805
13	2.3368	4.2888
14	2.032	3.2429
15	1.8288	2.6268
16	1.6526	2.1450
17	1.4224	1.5890
18	1.2192	1.1675
19	1.016	0.8107
20	0.9144	0.6567

Gauge Number	Diameter in mm	Area in mm^2
21	0.8128	0.5189
22	0.7112	0.3973
23	0.6096	0.2919
24	0.5588	0.2452
25	0.508	0.2027
26	0.4572	0.1642
27	0.4166	0.1363
28	0.3759	0.1110
29	0.3454	0.0937
30	0.315	0.0779

Gauge Number	Diameter in mm	Area in mm^2
31	0.2946	0.0682
32	0.2743	0.0591
33	0.254	0.0507
34	0.2337	0.0429
35	0.2134	0.0358
36	0.193	0.0293
37	0.1727	0.0234
38	0.1524	0.018241
39	0.1321	0.013701
40	0.1219	0.011675

4.1 Specifications of Cables

- The cables are specified in number of ways such as type of conductor material, number of cores that the cable consists, voltage grading etc. Cables may be specified as follows.
- 7/20,VIR, Aluminium conductor, twin core, 650/1100 grade.
  - The numerator '7' indicates number of strands in a cable and denominator 20 represents the gauge number of each strand. The cable has two cores made with Aluminium, with VIR insulation and is used for 650/1100 voltage.
- 19/1.12, Aluminium conductor, 3 1/2 core, 1100V, PVC cable, PVC sheathed.
  - In this case the cable consists of '19' strands, each strand have a diameter of 1.12 mm. The conductor is made with Aluminium, insulation is made with PVC, is covered with PVC sheathing, and is used for 1100 V supply system.

4.2 STRANDED CABLE

- The solid conductor cable consists of only one conductor, whereas stranded conductor cable consists of number of strands of wires of circular cross-section.
- Stranded conductor cable is more flexible than solid conductor cable and becomes easy to handle.
- Stranding is done .by twisting the wires of different layers in opposite direction for successive layers.
- The number of strands in stranded cables are 3, 7, 19, 37, 61, 91 and so on, which can be determined from the formula **1 + 3n (1 + n),** where 'n' is number of the layers.
- In a three-strand cable, two strands are twisted around the third strand. Similarly, in case of seven or more strands the arrangement of the conductors is as below.

a) **7 Strands :** Six strands are twisted around a central strand.

b) **19 Strands** : Seven strands are twisted as above and the remaining 12 strands are twisted in opposite direction to that of previous layer.

c) **37 Strands :** Nineteen strands as above and the remaining 18 strands are twisted in opposite direction to that of previous layer.

5.Size and Current Carrying Capacity of a Wire / Cable

- The size of the wire or cable should be such that, it should carry the maximum circuit current continuously without overheating.
- From Table.1.2 and Table.1.3 the size of wire or cable can be determined for corresponding current carrying capacity.
- In domestic wiring, the wire or cable used must not be of size less than 1/1.l 2 mm (1.0mm^2) Copper or 1/1.4 mm (1.5 mm^2) in Aluminium wire.

TABLE 1.2: Current Carrying Capacity of Copper Conductor, PVC Insulated Cable

Sl.No	Size of the cable			Current rating at 40^0c in ampere	
	Number & diameter of wire in mm	No. & size of equivalent S.W.G	Nominal cross-sectional area in mm^2	2-core cable	3 or 4 cable
1	1/1.12	1/18	1.00	5	5
2	3/0.736	3/22	1.29	10	10
3	3/0.915	3/20	1.93	15	13
4	7/0.736	7/22	2.90	20	15
5	7/0.915	7/20	4.52	28	22
6	7/1.12	7/18	6.45	36	29
7	7/1.32	7/17	9.35	43	34
8	7/1.626	7/16	14.50	53	42
9	19/1.12	19/18	19.35	62	50
10	19/1.32	19/17	25.80	74	59
11	19/1.626	19/14	38.70	97	78

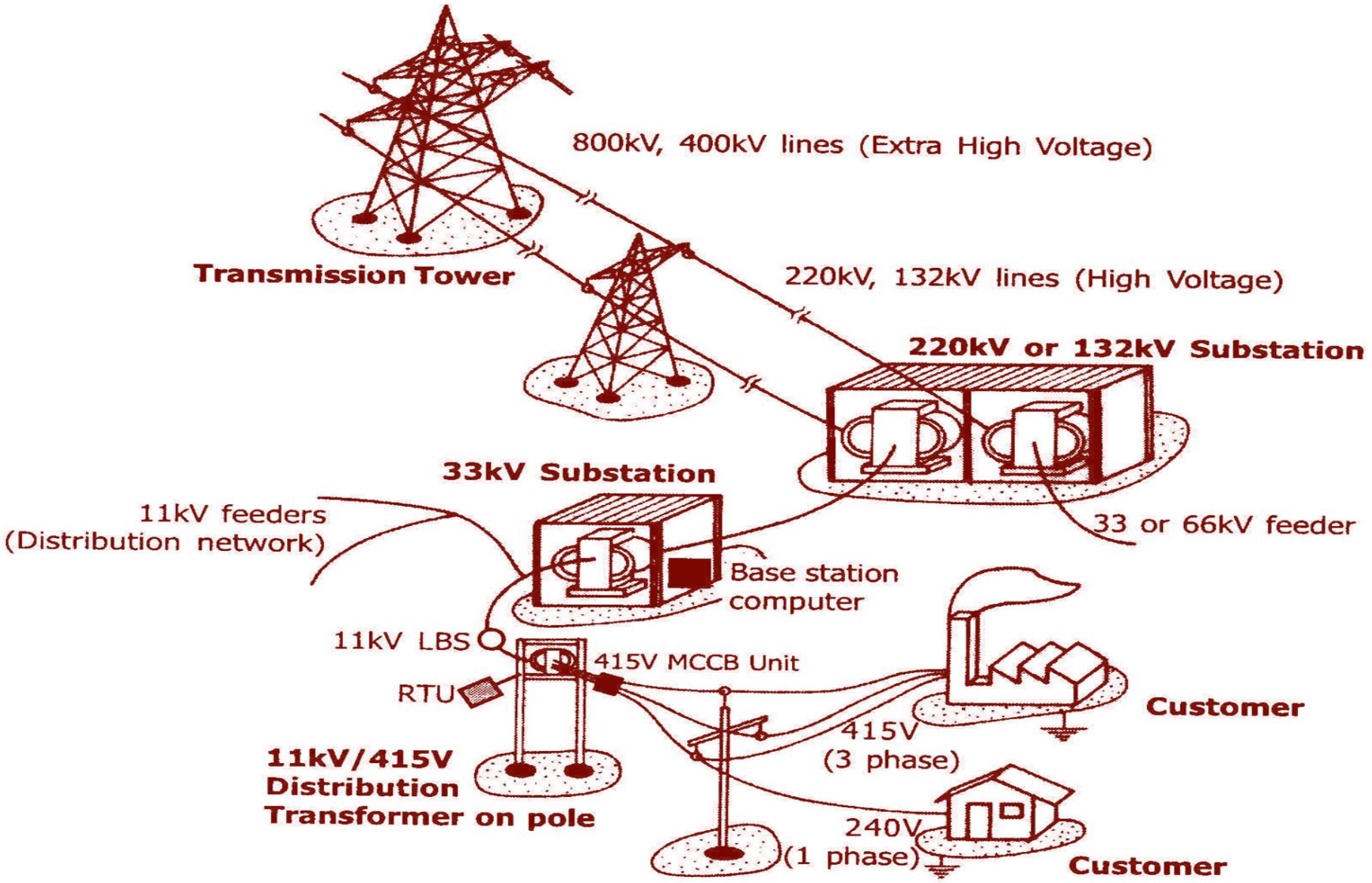
TABLE 1.3: Current Carrying Capacity of Aluminium Conductor, PVC Insulated Cable and PVC sheathed cable.

Sl.No	Size of the cable			Current rating at 40°c in ampere	
	Number & diameter of wire in mm	No. & size of equivalent S.W.G	Nominal cross-sectional area in mm^2	2-core cable	3 or 4 cable
1	1/1.40	3/22	1.5	10	9
2	1/1.80	3/20	2.5	15	11
3	1/2.24	7/22	4.0	20	15
4	1/2.80	7/20	6.0	27	21
5	1/3.55	7/18	10.0	34	27
6	7/1.70	7/17	16.0	43	35
7	7/2.24	19/18	25.0	59	48
8	7/2.50	19/17	35.0	60	55
9	7/3.00	19/16	50.0	91	69

5.1 Wiring Systems

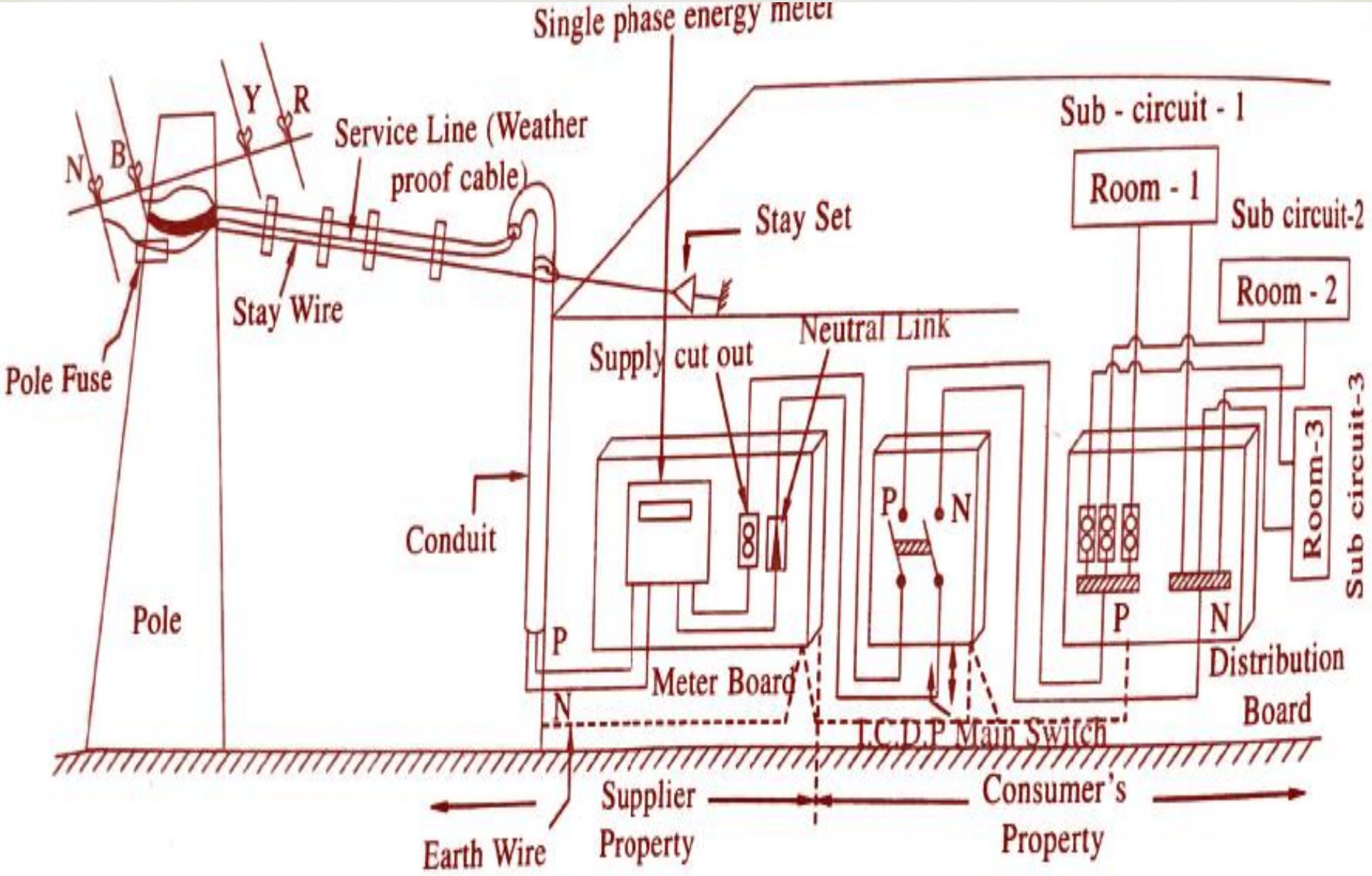
- **A network of wires/ cables connecting various electrical accessories for distribution of electrical energy from the supplier meter board to the number of electrical energy consuming devices such as lamps. Fans, T.V, refrigerator and other domestic appliances through controlling (switches) and safety (fuses, MCB etc.) devices is known as "Wiring System".**
- The supply used in houses for lighting and power purposes is single phase supply (for industries three-phase A.C. supply is employed.
- The single phase circuit is connected across 220/230 volts, across one phase and neutral.

5.2 HOW ELECTRIC SUPPLY COMES TO OUR HOUSE



- Power is carried through a transmission network of high voltage lines.
- Usually, these lines run into hundreds of kilometres and deliver the power into a common power pool called the grid.
- The grid is connected to load centres (cities) through a sub-transmission network of normally 33kV (or sometimes 66kV) lines.
- These lines terminate into a 33kV (or 66kV) substation, where the voltage is stepped-down to 11kV for power distribution to load points through a distribution network of lines at 11kV and lower.
- The power network, which generally concerns the common man, is the distribution network of 11kV lines or feeders downstream of the 33kV substation.
- Each 11kV feeder which emanates from the 33kV substation branches further into several subsidiary 11kV feeders to carry power close to the load points (localities, industrial areas, villages, etc.,).
- At these load points, a transformer further reduces the voltage from 11kV to 415V to provide the last-mile connection through 415V feeders (also called as Low Tension (LT) feeders) to individual customers, either at 240V (as single phase supply) or at 415V (as three-phase supply).
- A feeder could be either an overhead line or an underground cable. In urban areas, owing to the density of customers, the length of an 11kV feeder is generally up to 3 km.
- On the other hand, in rural areas, the feeder length is much larger (up to 20 km). A 415V feeder should normally be restricted to about 0.5-1.0 km.
- Unduly long feeders lead to low voltage at the consumer end.

M.K.Eswaramoorthy


Single phase energy meter
Sub - circuit - 1
Room - 1
Sub circuit-2
Room - 2
Sub circuit-3
Room-3
Service Line (Weather proof cable)
Stay Set
Stay Wire
Pole Fuse
Supply cut out
Neutral Link
Conduit
Pole
Meter Board
Distribution Board
T.C.D.P Main Switch
Supplier Property
Consumer's Property
Earth Wire
N
B
Y
R
P
N

- The supply is taken from the distribution line through service mains either by overhead line or underground cable.
- A pole fuse may be provided to protect the service line against over loading.
- The supply is directly fed to the energy meter and after energy meter a service fuse (Iron clad cutout) is provided for safety purpose.
- Both energy meter and Iron clad cutout are supplied by the supply authority (State Electricity Board), hence both are sealed by supplier.
- The mains (phase and neutral) are taken from the energy meter and are controlled by means of neutral linked Iron Clad Double Pole (I.C.D.P) main switch.
- After passing through the ICDP, the wires go to distribution board.
- From distribution board, the power is distributed to various sub-circuits.
- Separate phase and neutral is taken for each sub-circuit.
- According to Indian Standards the maximum number of points of lights, fans, and 5A socket outlets that can be connected in one sub-circuit is 10 and the maximum load that can be connected in each sub-circuit is 800 watts.
- The earth wire is connected to the all metallic parts of the wiring and appliances except the current carrying conductors.
- Now-a-days instead of fuse, Miniature circuit breakers (MCB's) are used and instead of ICDP automatic isolators are used.

Dr.K.Eswaramoorthy

5.3 CHOICE OF WIRING SYSTEM

- The choice of any wiring system for a particular place depends on many factors. Hence, following points should be considered before selecting the type of wiring system.
- **i) Durability**: The wires used in any wiring must be durable and should be safe from fire and weather conditions etc.
- **ii) Safety:** The wiring selected should not be risky to any human being.
- **iii) Cost:** This is most important factor. The wiring selected should be economical.
- **iv) Appearance:** The wiring must provide good outlook after its installation and it should be according to the construction and design of the building.
- **v) Accessibility:** The selected wiring should be easily accessible and easy to extend.
- **vi) Mechanical protection:** The selected wiring system should provide enough mechanical protection during its use

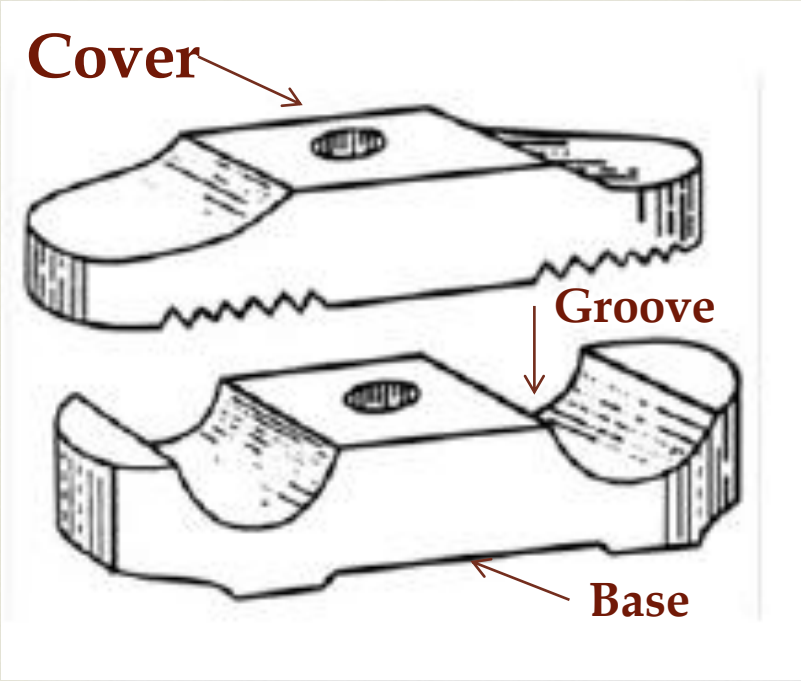
6.SYSTEMS OF WIRING

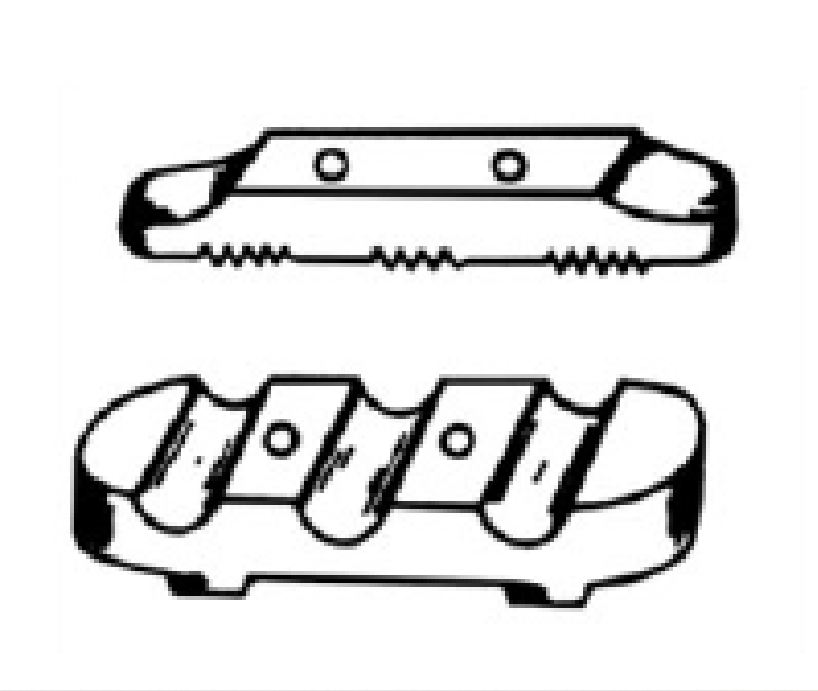
- The various systems of wiring used in our country are:

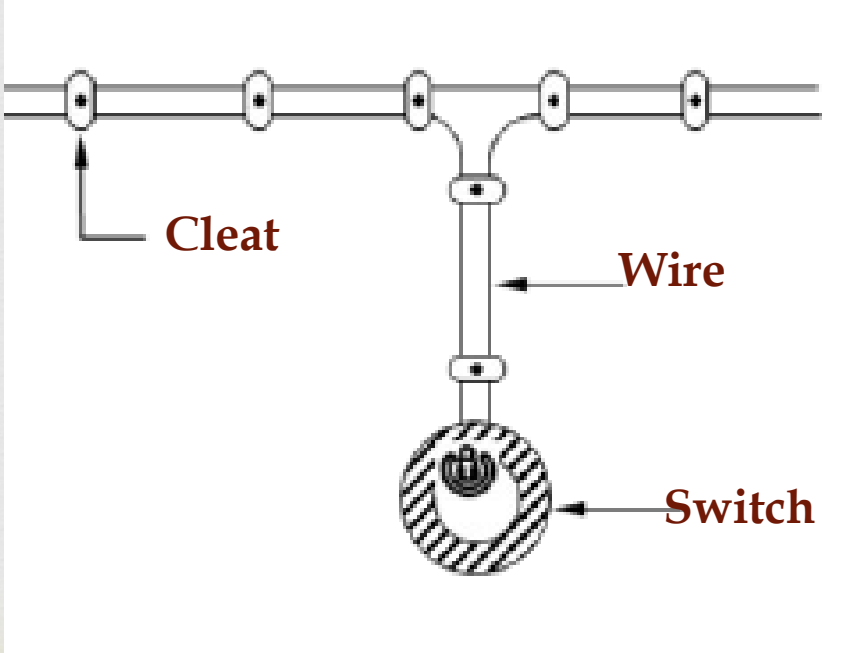
1. Cleat wiring.
2. Wooden casing and capping wiring.
3. C.T.S. or T.R.S. wiring.
4. Lead sheathed or Metal sheathed wiring.
5. Conduit wiring.
   a) Surface or open type
   b) Recessed or concealed type

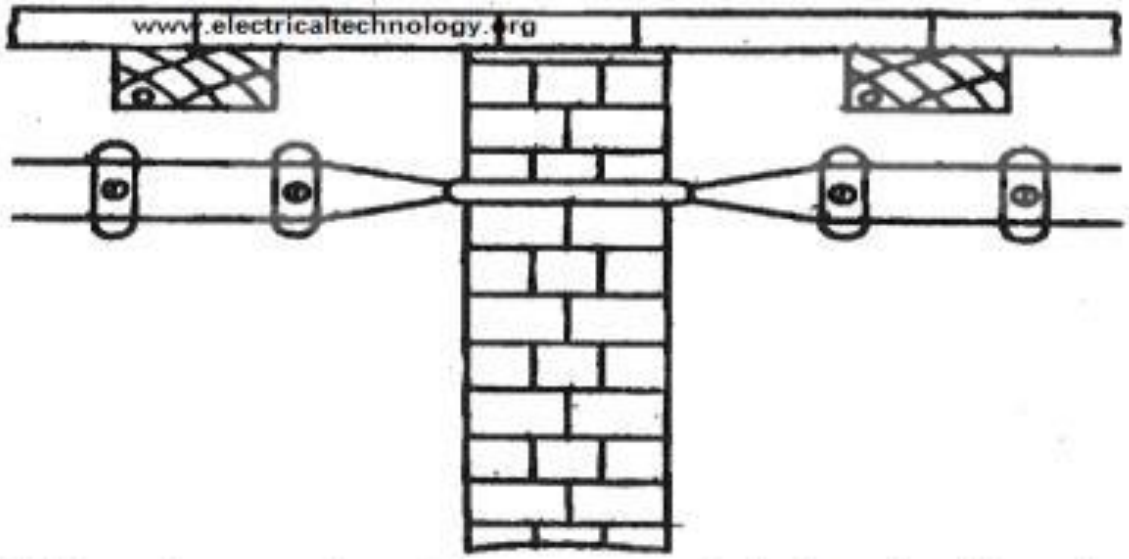
6.1. Cleat Wiring

- The wires/cables used in this system of wiring are either V.I.R. or P.V.C. type.
- The porcelain cleats are used to hold the cables about 6mm above the walls or ceiling.
- The cleats are made in two halves, the base and cover (cap).
- The base has grooves to accommodate the wires and is fixed on the wall and the cover is placed over it and whole of it is then screwed on wooden gutties as shown in fig.
- The wooden gutties are previously fixed and cemented into the wall and ceiling.
- The cleats are of three types having one, two or three grooves to accommodate one, two or three wires respectively.
- The **maximum distance between the cleats** should not be more than **60 cm**, otherwise the wires may in contact with wall or with each other.
- Hence, to **ensure longer life, the safe distance is 30 cm.**
- For a voltage upto **250V, the distance between the cleat grooves should not be less than 2.5cm** for branch circuit and should not be less than 4cm for subcircuits.

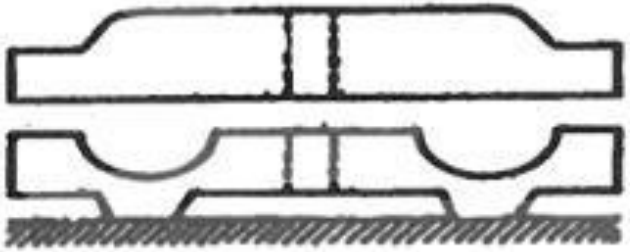

Cover
Groove
Base



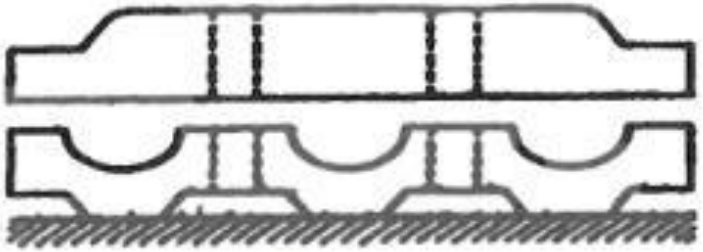

Cleat
Wire
Switch



Use of Wall tube, wires are drawn from one room into the other through partition wall.



i. Cleat with two grooves



ii. Cleat with three grooves

Cleat Wiring

- **Advantages:-**
  - It is cheapest system of wiring.
  - It requires less labour and workman ship.
  - It requires less time for installation and less cost.
  - It can be easily and quickly removed when not required.
  - Extension and fault location is easy.
- **Disadvantages:-**
  - It is quite temporary system of wiring.
  - Less life and less efficiency.
  - Dust and dirt spoil the appearance.
  - The wires are exposed to mechanical injury.
  - The oil, dust and smoke injure the wires.
- **Applications**:
  - It is used for purely temporary purpose like camps etc.
  - It is not suitable in damp places, blacksmith shops etc.
  - It is preferred where appearance is not so important and cost is main consideration.

6.2. **Wooden Casing and Capping Wiring**

- This system was introduced 60 years ago, when it was first considered necessary to provide some protection to cables.
- The cables used in this system are either VIR or PVC insulated cables.
- It consists of **rectangular wooden blocks made from quality seasoned teak wood or any other quality wood called casing.**
- The casing **consists of V shaped grooves** into which the wires are laid.
- The casing is first fixed on the surface of the wall or ceiling by means of wooden gutties and screws.
- The **casing then covered at the top by means of rectangular strip of wood known as capping of same width as that of casing and is screwed to it**.
- The casing and capping are available in different sizes and the length in which these available varies form 2.5 meters to 3 meters.

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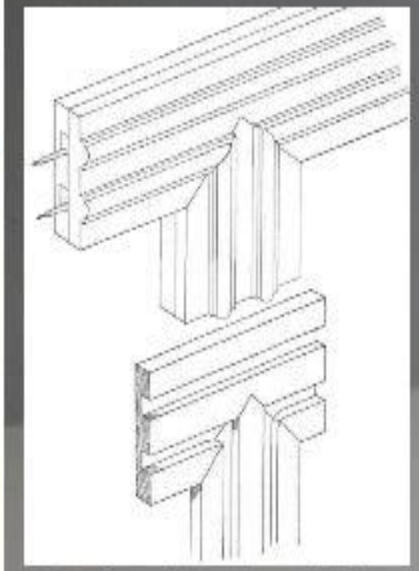
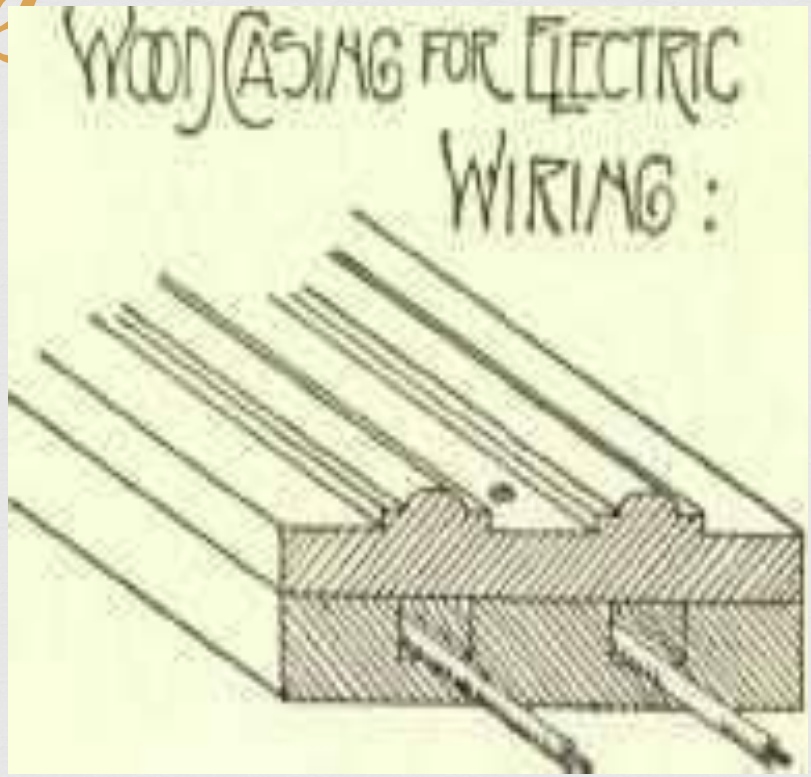


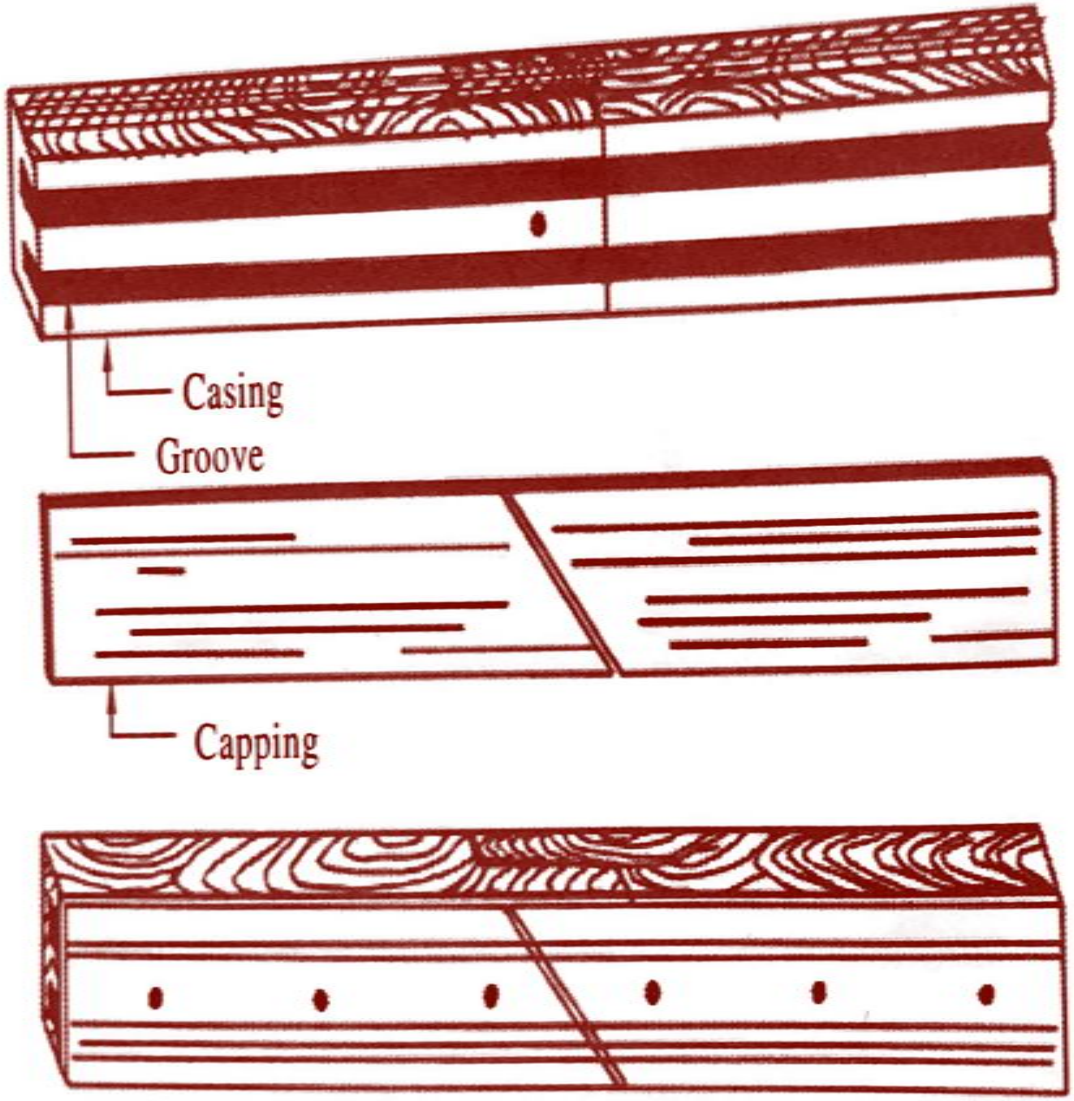
Casing Capping Joints

Casing & Capping Wiring

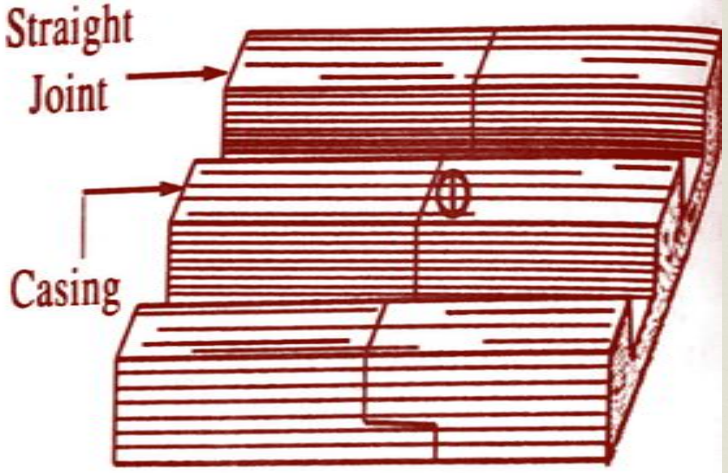
Wooden Casing and Capping Wiring

Wooden Casing and Capping Wiring

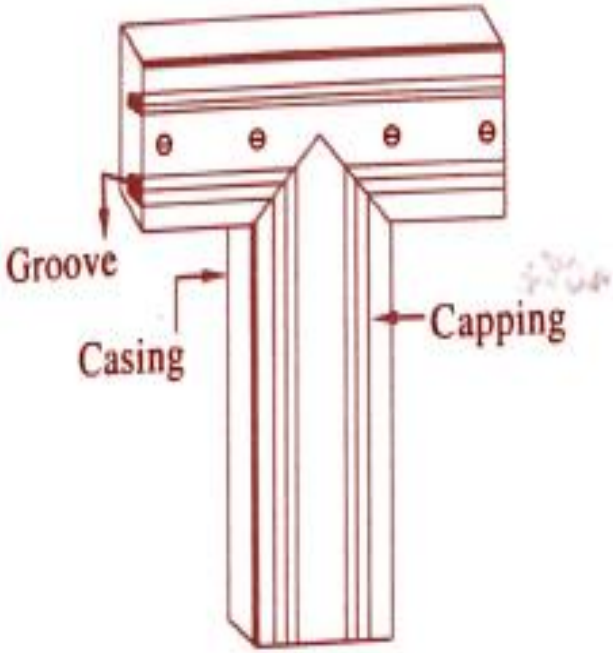




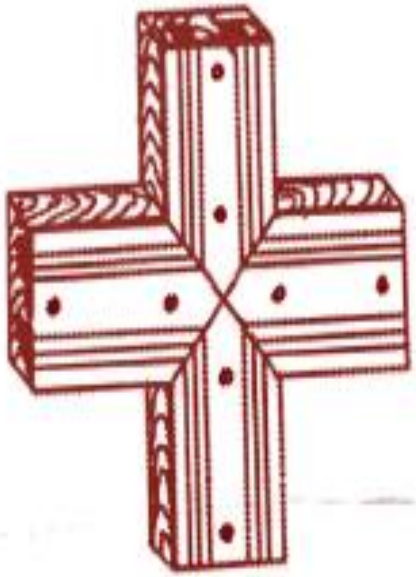
(a) Straight Joint of Wooden Casing - Capping



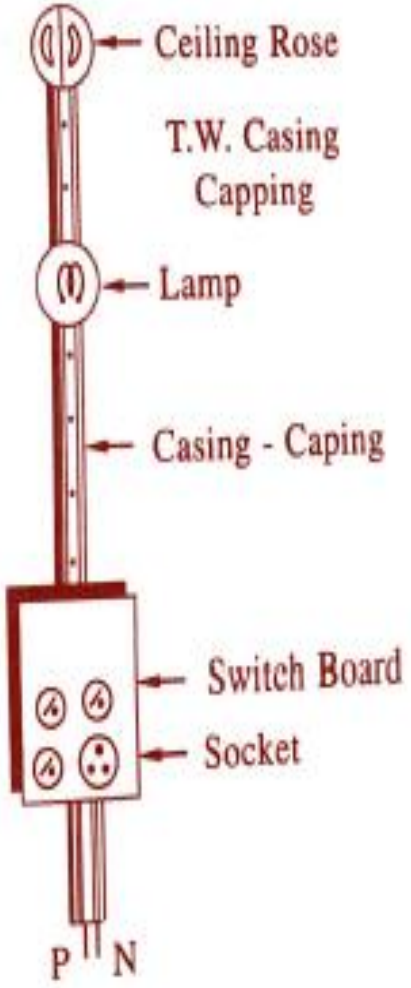
(b) Casing (Top View)



(c) T - Joint of Casing Capping



(d) Cross Joint of Wooden Casing - Capping



(e) Wiring Diagram

Advantages:-

- This wiring has good appearance.
- The life is more compared to cleat wiring.
- Easy for installation and rewire.
- The wires are safe from mechanical damage, rats etc.
- Easy to inspect by opening capping.

Disadvantages:-

- No safety from fire.
- It requires better workman ship, so labour cost is high.
- Can not be used in damp places.
- If not painted and varnished, the vermins may eat the wood, which reduces the life of the system.

Applications: -

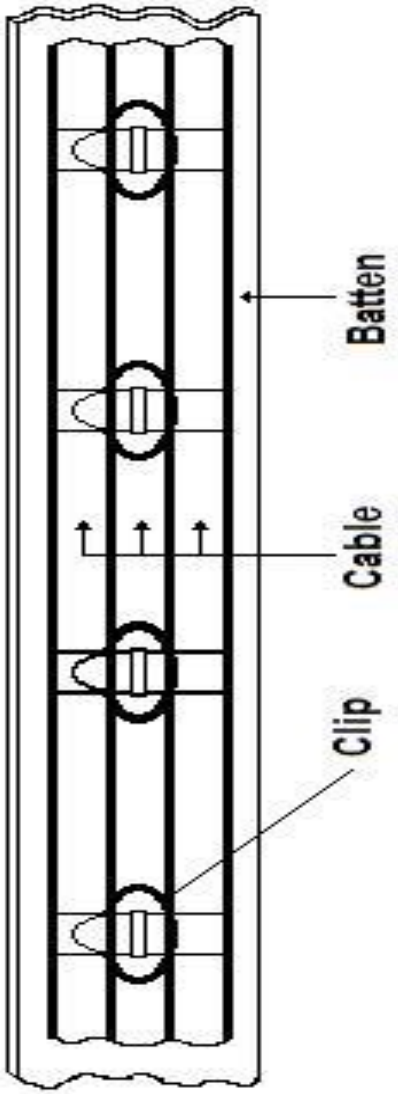
- This system is suitable for low voltage domestic installations in dry places.
- It should never be used where there is a risk of fire such as blacksmith moulding shops etc. and in damp places.

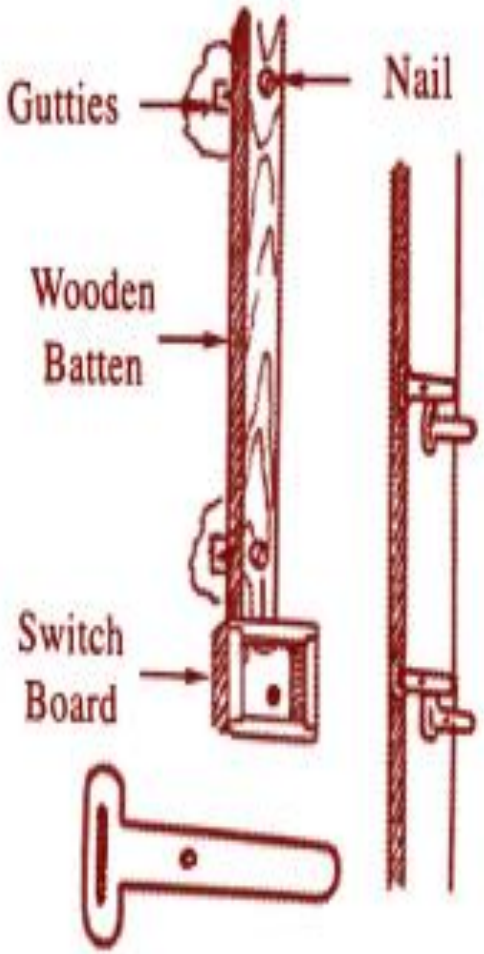
6.3.Tough Rubber Sheathed (T.R.S.) or Cab Tyre Sheathed batten wiring

- **The wires used in this system are T.R.S. or C.T.S. wires, which are available in single core, twin core or three core with a circular or oval shape.**
- These cables are quite flexible and the insulation can resist moisture, chemical, water, steam, but slightly affected by lubricating oils.
- In this system, first wooden battens are secured to the walls or ceiling by means of wooden screws and wooden gutties.
- The wires are fixed on wooden batten with the help of tinned brass link clips already fixed on the batten with brass pins and spaced at an interval of 10 to 15 cm as shown in fig.
- The wooden battens are made with seasoned teak wood and are available in different sizes according to the width and thickness.
- The width are 13, 19, 25, 31, 38, 44, 50,63, 69 and 75 mm, the thickness may be 10mm at least.
- The link clips are available length-wise 16mm, 25mm, 30mm, 40mm, 50mm, 80mm etc.

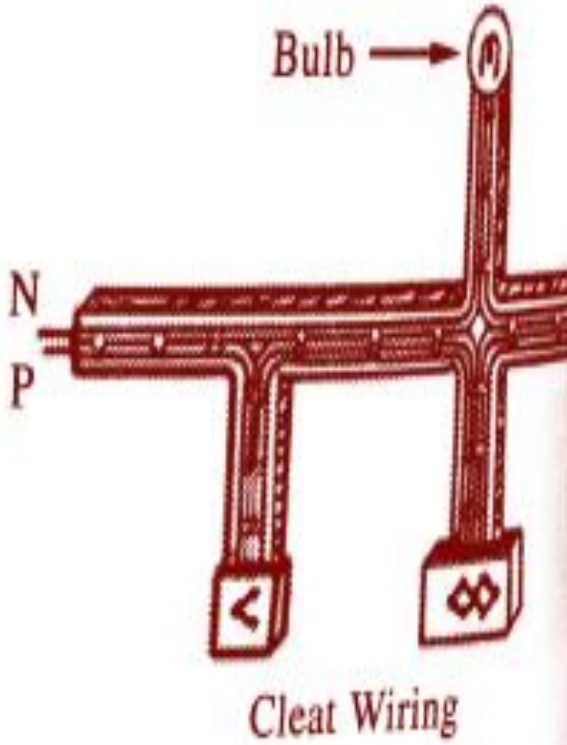
Batten Wiring

Old Wiring System




Gutties
Nail
Wooden
Batten
Switch
Board

Cable
Joint
Clip
Link
Clip
Cleat


Bulb
N
P
Cleat Wiring

Advantages:-

- Its installation is easy, semi-skilled worker can do it, so labour cost is less.
- It is less costly than wooden casing and capping wiring.
- It has good appearance.
- Its life is sufficiently long.
- It can withstand against chemicals such as acids and alkalies.

Disadvantages:-

- There is no safety from fire.
- It is not suitable in places, where it is exposed to sun and rain.

Applications:-

- This wiring is suitable for low voltage installations used for lighting purpose in all places such as domestic, industrial, commercial etc.
- As T.R.S. wire is not affected by moisture, can be used in damp places also.

6.4.Lead Sheathed or Metal Sheathed wiring

- **This type of wiring consists of T.R.S. or P.V.C. insulated wires with an outer covering of lead aluminium alloy containing about 95% of lead.**
- This metal sheath provides protection to the cable against mechanical injury and atmosphere conditions.
- The cables are fixed by means of the link clips on wooden batten.
- The lead sheath must be earthed, at a point of entry to protect against electrolytic action due to leakage current.

Advantages:-

- The wires are safe from fire, moisture and mechanical damages.
- It is easy for installation and looks nice.
- It has long life.
- It can be used in places even which are exposed to sun and rains also.
- It has good appearance.

Disadvantages:-

- It is costlier then T.R.S. wiring because of lead covering.
- It is not suitable for places where chemical corrosion may occur.
- Skilled worker required, so the labour is costly.

Applications:-

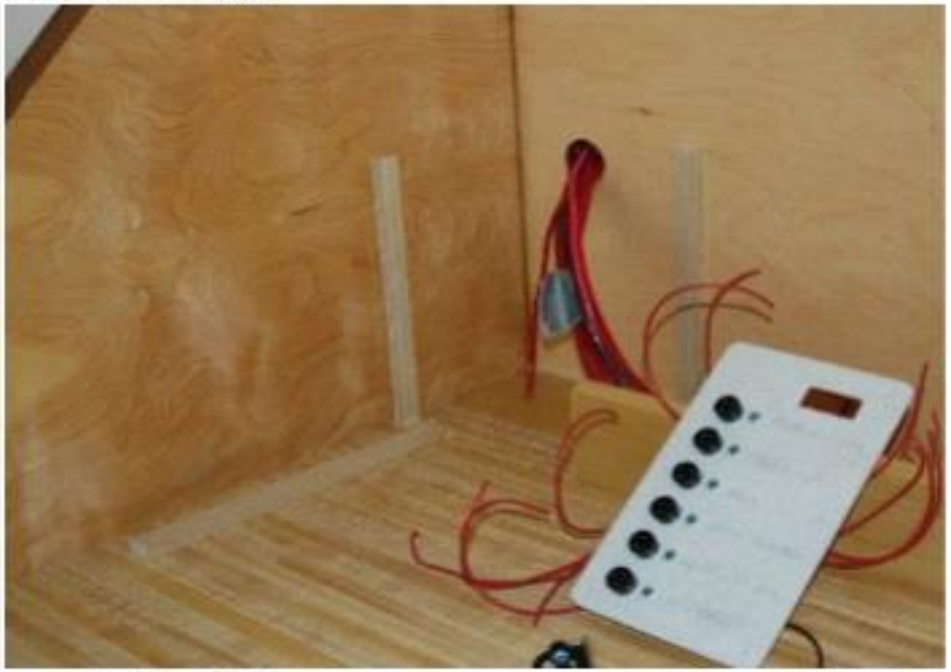
- It is suitable for low voltages (250V) installations. It may be used in places exposed to sun and rain.
- When wooden battens are not available wires can be fixed directly on walls.

6. 5. Conduit wiring

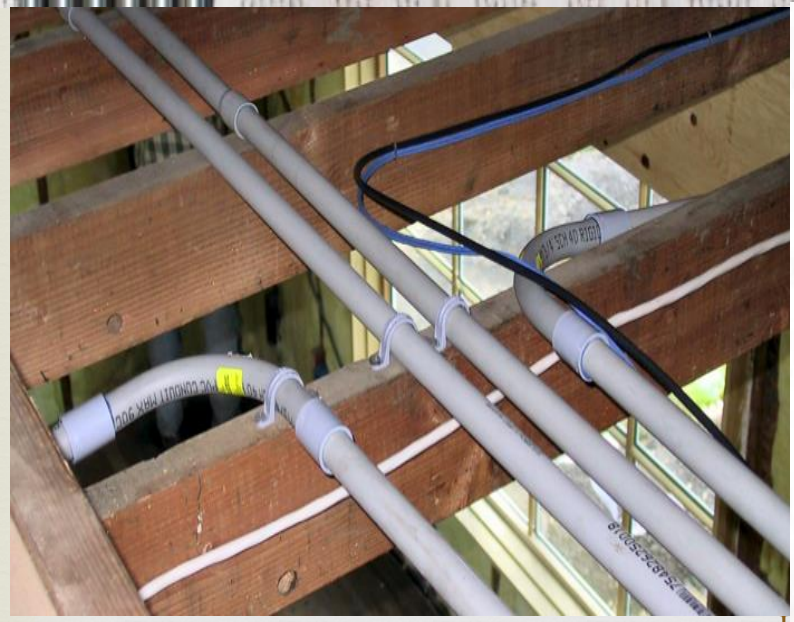
- In general conduit means tube or channel. Tubular conduits are most commonly used in electrical installations.
- When wires/cables are drawn through the conduit and terminated at the outlets (switches, holders, ceiling rose etc.), such a system of wiring is known as conduit wiring.
- **There are four types of conduits, which are commonly used. They are**
  - **1 Rigid steel (metal) conduits.**
  - **2 Flexible steel conduits.**
  - **3 Rigid P.V.C. (non-metallic) conduits.**
  - **4 Flexible P.V.C. conduits.**
- The conduits are electrically and mechanically continuous. The conduits are available in lengths of 3.00 meters and in diameters from 12mm to 65mm.
- The different sizes of conduits are 12mm, 19mm, 25mm, 32mm, 38mm, 50mm and 65mm etc.

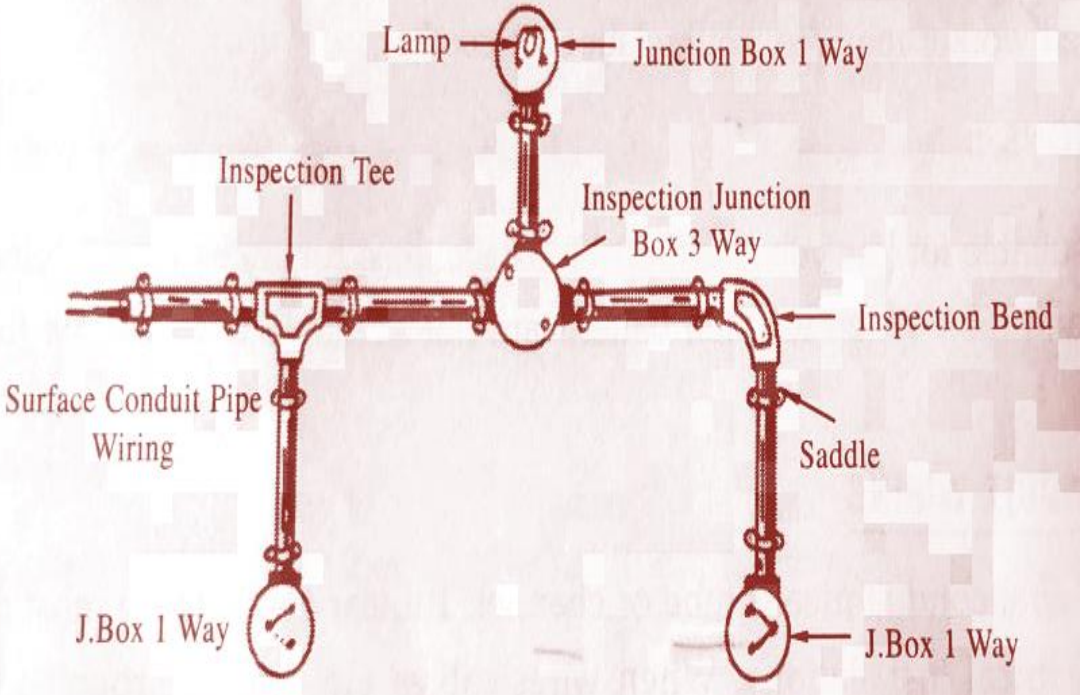
- Conduit wirings are two types.
- **i) Surface conduit wiring:**
- **In this system conduits are fixed on the surface of the walls or ceiling by means of the saddles, secured to wooden gutties with screw at an interval of not more than one meter as shown in fig.**
- The V.I.R or P.V.C. cables are drawn by means of G.I. wire of size of about 18 SWG.
- The earth wire is fixed by means of the earth clips. This system is generally employed in workshops or factories etc.
- If metal conduits are used they are cut with hacksaw and are threaded with die-set for bends, junction boxes etc.

Surface Conduit Wiring



Concealed Conduit wiring




Lamp
Junction Box 1 Way
Inspection Tee
Inspection Junction Box 3 Way
Inspection Bend
Surface Conduit Pipe Wiring
Saddle
J.Box 1 Way
J.Box 1 Way

- **ii).Concealed conduit wiring:**
- In this system the conduit (now-adays P.V.C. is mostly used) is buried under the wall (plaster) or ceiling.
- In this case first the channels are provided in the wall and then the conduits are fixed in the channels by means of clamps and hooks.
- Then the wires are drawn into the conduits by means of G.I wire.
- As the wiring is done under the plastic, so the whole of the system is made water tight to prevent the entering of moisture.
- It is generally used in domestic, offices, commercial etc.
- Now-a-days P.V.C. conduits are extensively used in place of steel conduits.
- There are cheaper in cost and require less time for installation.
- They provide good protection against acid, alkalies, oil and moisture.
- In P.V.C. conduits jointing is done with a special made solution.
- The main drawback of P.V.C. conduit is that it cannot withstand high temperatures, hence does not provide protection against fire.

Advantages:-

- Metal conduit wiring provides protection against mechanical damage, moisture and fire etc.
- The life is sufficiently long.
- The system is water proof, chemical proof.
- Replacement of conductors, fault location and extension is easy.
- The wiring can be done in any place.
- Concealed conduit wiring gives good appearance.
- If metal pipe is earthed properly, this wiring is shock proof.

Disadvantages:-

- This system is costly compared to any other wiring system.
- If the burs are not removed properly, they may damage the cable insulation.
- The installation of conduit wiring requires skilled labour, which increases the cost.
- P.V.C. conduit can not provide protection against fire.

Applications:-

- It is most commonly used system in all places such as textile mills, saw mill, flour mills, work shops, factories etc. as it provides good protection against mechanical damage.
- It can be used in damp places, places where fire hazards are more and places where appearance is quite importance.

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6.6 General Rules Related to wiring

- The wiring installation shall generally be carries out in conformity with the requirements of the Indian Electricity Rules.
- The following are some of the extracts of B.I.S (Bureau of Indian Standards) regulations pertaining to wiring installations and are recommended by the National Electrical Code (NEC).

1) All fittings, accessories and appliances used in wiring installations shall conform to Indian standards (I.S. mark).
2) Height of the main switch and distribution boards should be at a height of 3meters and all switch boards should be at a height of 1.5meters from floor level.
3) All the lighting fittings shall be at a height of not less than 2.25m from the floor level.0
4) A switch and socket-outlets shall be installed at any height 1.3m above the floor level s desired.
5) All plugs and socket-outlets shall be of 3-pin type, the earth pin of the socket should connect permanently to earth.
6) No socket-outlet shall be provided in the bathroom at a height less than 1.3m.
7) Unless otherwise specified, all ceiling fans shall be hung not less than 2.75m above the floor.
8) If the voltage exceeds 250V, all the distribution boards and main switches should be provided with danger board.
9) Total load in the circuit should not exceed more than 800 watt and number of points should not be more than 10.
10) Power devices should have different circuits.

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11) For lighting load the fuse wire should not exceed 5A capacity and for power load it is 10 Amp.
12) The size of a conductor should be such that the voltage drop should not increase more than 3% of the connected voltage when full load current is flowing.
13) The minimum size of the conductor in any sub-circuit should not be less than 1/1.12mm (1.0mm2) in case of Copper wire and 1/1.4mm (1.5mm2) in case of Aluminium wires.
14) All the accessories should be fixed on the round blocks or board with brass screws.
15) All the Iron clad appliance, switches etc. should be earthed.
16) Neutral should be linked.
17) All the switches should be connected though live wire, but not in neutral.
18) All the boards and switches should be fixed on left and side of the entrance.
19) Each apparatus should be controlled from a separate switch.
20) In wiring the live line of the supply should be Red, Yellow or Blue colour, and the colour of neutral and earth wire should be Black and Green respectively.

6.7. Comparisons of all Wiring and Cable Systems

S.No	Particular	Cleat wiring	Wooden casing and capping wiring	Batten wiring		Conduit wiring	
				T.R.S. Wiring	Lead sheathed wiring	Metal conduit wiring	P.V.C. conduit wiring
1.	Material required	Cleats, V.I.R or P.V.C wires, screws, gutties, blocks, boards etc.	Teak wood casing & capping, V.I.R wire, wooden gutties, screws,	Teak-wood batten, T.R.S wires, gutties, screws, nails, link clips, blocks, etc	Wooden batten, lead covered wires, gutties, screws, link clips, boards, blocks, boards etc.	Metal conduits, V.I.R or P.V.C wires, saddles, gutties, screws, bends, blocks etc. boxes, elbows etc.	P.V.C conduits, V.I.R or P.V.C wires, saddles, gutties, P.V.C bends, junction boxes, elbows etc.
2.	Cost	Cheap	Medium	Medium	Costly	Very costly	Medium
3.	Life	Very short	Fairly long	Long	Long	Very long	Very long
4.	Mechanical strength	Nil	Fair	Fair	Good	Very good	Very good

5.	Safety from dampness	Nil	Poor	Good	Good	Fairly good	Fairly good
6.	Appearance	Not good	Fair	Good	Good	Fairly good	Fairly good
7.	Type of labour required	Semi-skilled	Highly skilled	Skilled	Skilled	Highly skilled	Highly skilled
8.	Additions or Alternations	Very easy	Difficult	Easy	Difficult	Not easy	Not easy
9.	Installation time	Short	Fairly long	Short	Fairly long	Very long	Very long
10.	Reliability	Poor	Good	Good	Fairly good	Very good	Very good
12.	Applications	For temporary installations e.g. functions, marriages etc.	For residential, commercial and office buildings etc.	For residential, commercial and office buildings etc.	Only used for service mains.	Work shops, black smiths, godowns etc.	Domestic, offices commercial etc.

7.Electrical Wiring Accessories

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7.Electrical Wiring Accessories

- An electrical accessory Is a basic part used In wiring either for protection and adjustment or for the control of the electrical circuits or for a combination of these functions.
- The Electrical accessories used in wiring installations are classified according to their functions and use as below.
  - 1. Controlling accessories (Switches).
  - 2. Holding accessories (Lamp holders).
  - 3. Outlet accessories (Plugs & sockets, ceiling roses etc.).
  - 4. General accessories.
  - 5. Safety accessories.

7.1 CONTROLLING ACCESSORIES

- The accessories which are used to control the various appliances in electrical wiring (circuit) are known as 'controlling accessories".
- All switches are control devices for various applications.
- **Switch :**
- A Switch is used t o break the electrical circuit.
- It should so, operate that it must make the circuit firmly and break the circuit without forming an arc between the switch blades and contact terminals.
- The arc formed may damage or burns the switch contacts.
- The switch is always connected in series with equipment (light, fan etc) to be controlled.
- A switch essentially consists of two parts namely Base and Cover.
- Base consists of switch blades and contacts.
- The cover provides protection to the contacts against mechanical damage.
- The switch is fixed to the wooden round block by means of screws.

7.1.1 Types of Switches

- The switches can be classified in different ways as below.
- 1. According to their function and place of use
  - (a) Surface switches or Tumbler switches.
  - (b) Flush switches.
  - (c) Pull or Ceiling switches.
  - (d) Grid switches
  - (e) Architrave switches.
  - (f) Rotary switches.
  - (g) Push button switches.
  - (h) Bed switches.
  - (i) Table lamp switches.
  - (j) Iron-clad water tight switches.

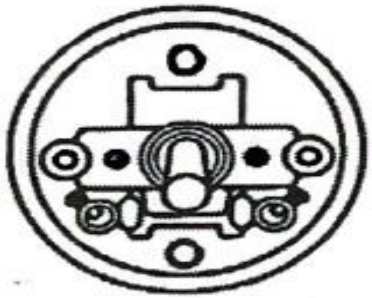
- 2. According to operation required
  - One-way switches.
  - Two-way switches.
  - Two-way centre off switches.
  - Intermediate switches.
- 3. According to number of poles
  - Single-pole switches.
  - Double-pole switches.
  - Triple-pole switches.
- 4. According to type of Base material
  - (a) Porcelain switches.
  - (b) Bakelite switches.
- 5. According to shape of the Base
  - (a) Round switches.
  - (b) Square switches.
  - (c) Oblong (Rectangular) switches.
- 6. According to the colour of the Base
  - (a) White Base switches.
  - (b) Black Base switches.
  - (c) Brown Base switches.

- 7. Main Switches (Iron-clad switches)
  - Double pole Iron clad switches (DPIC).
  - Triple pole Iron clad switches (TPIC).
  - Triple pole Iron clad with neutral link (TPICN).
  - Miniature Circuit Breaker (MCB).
- 8. Knife switches
  - Single Pole Single Throw Switches (SPST).
  - Single Pole Double Throw Switches (SPDT).
  - Double Pole Single Throw Switches (DPST).
  - Double Pole Double Throw Switches (DPDT).
  - Triple Pole Single Throw Switches (TPST).
  - Triple Pole Double Throw Switches (TPDT).

1.According to their function and place of use

(a) Surface or Tumbler Switches :

- These switches are fixed on the mounting block directly fixed on the surface of wall.
- Such switches projected out of the surface of the wall.
- The switches may be one-way or two-way and are available with round and oblong base.
- These are rated as SA, 250 V (lighting switches) and 15A, 250V (power switches) etc.
- The different types of surface switches are shown in Fig.



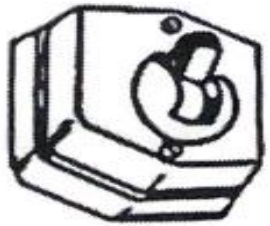
(a) One-Way Switch (5 A) Cover removed

(b) Two-way switch (5 A) cover removed

(c) 5 A or 15 A single pole, 1-way and two-way switch

(d) 5 A, Round base switch

(e) 5A, All black (Reno) 1-way or 2-way round type



(f) 5A, (Pilot) 1-way or 2-way Hexa Base

(g) 5A Oblong Switch

(h) 15 A, 3-Pin Switch Socket Combined

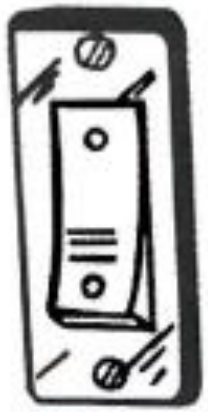
(i) D - P Switch

(j) 5 A, (Reno) Rexa 1-way

(b) Flush Switches :

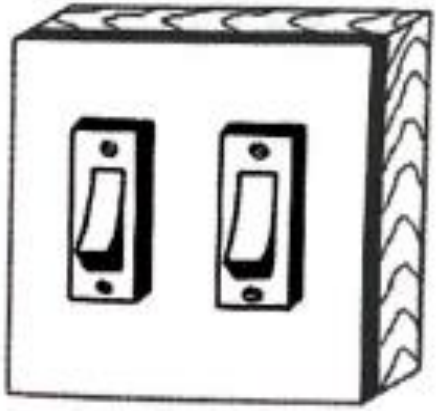
- As the name indicates, these switches are fixed in flush with the wall and they do not project out from the wall.
- These are used, where high quality performance and appearance are desired.
- In these switches, all current carrying parts are mounted on high grade vitreous porcelain base enclosed in an iron/ wood box recessed into the wall.
- These are some times known as piano type switches.
- They are made for 5 A, 250 *V* and 15 A, 250 *V* etc. Now-a-days, these are extensively used for newly constructed houses.
- The various types of flush type switches are shown in Fig.

(a) Piano type one - way



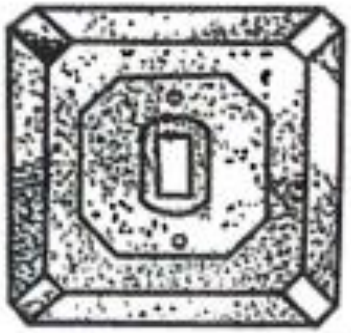
(b) Piano type two-way

(c) Deep Switch

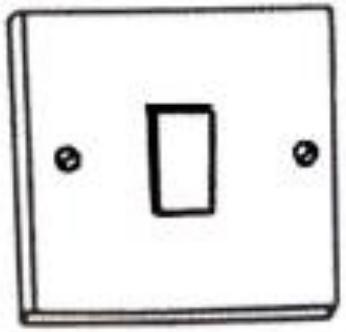


(e) 5A, Double Switch (Royal)

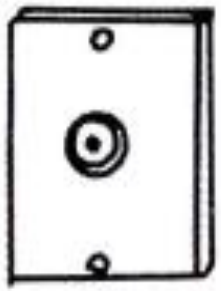
(f) One-way switch, round base



(g) 5 A, Two - way Swtich, square base



(h) 15 A, Plate Type Switch

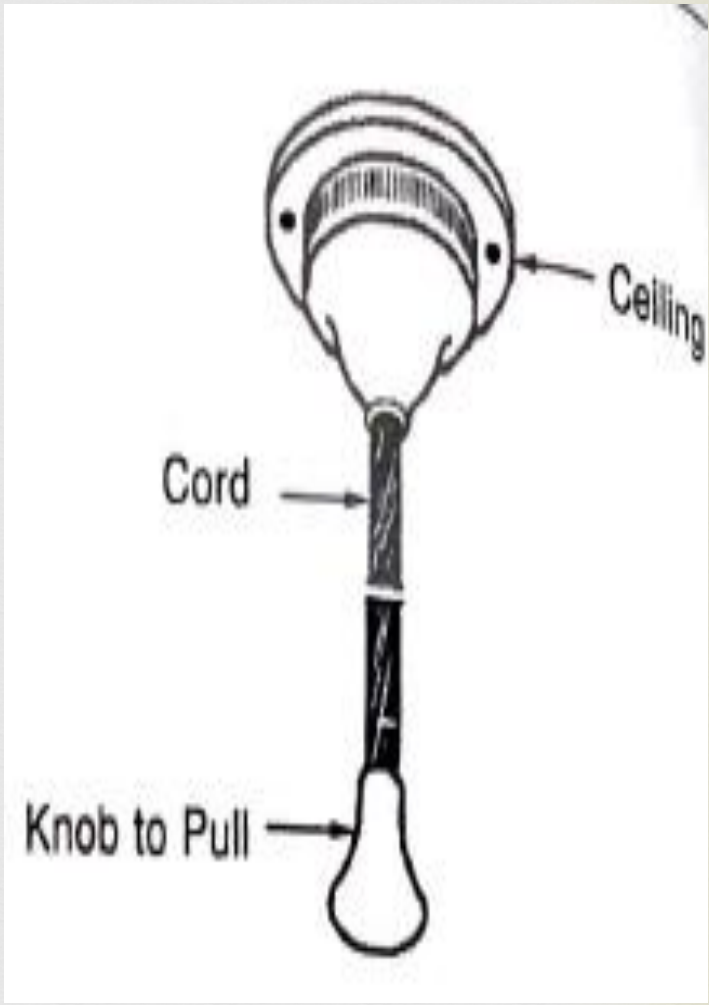


(i) Finger Touch

(j) Mark Switch 1-way or 2-way

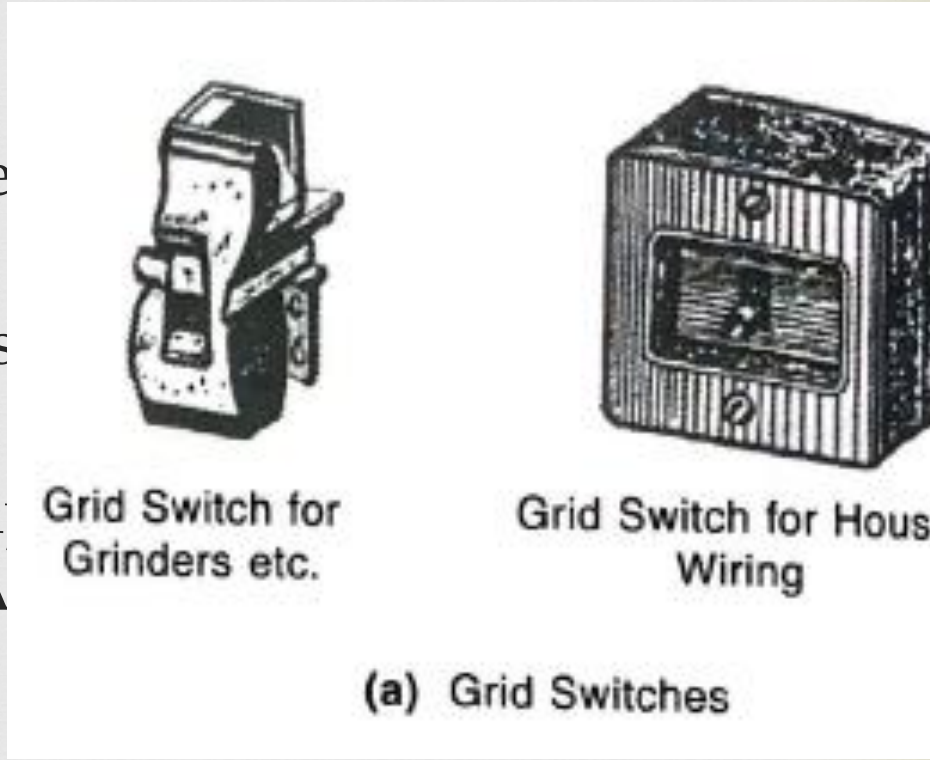
(c) Pull or Ceiling Switches :

- These switches are fixed on the ceiling (roof) and all the live parts are away from the operator.
- It functioning as a one-way switch to make or break a circuit.
- These are operated with a single pull on the cord for the ON and OFF position.
- These are used in bath rooms for operating water heaters, in bed rooms for operating lights or fans and for decoration lights etc.
- The Pull switch with its position is shown in Fig.



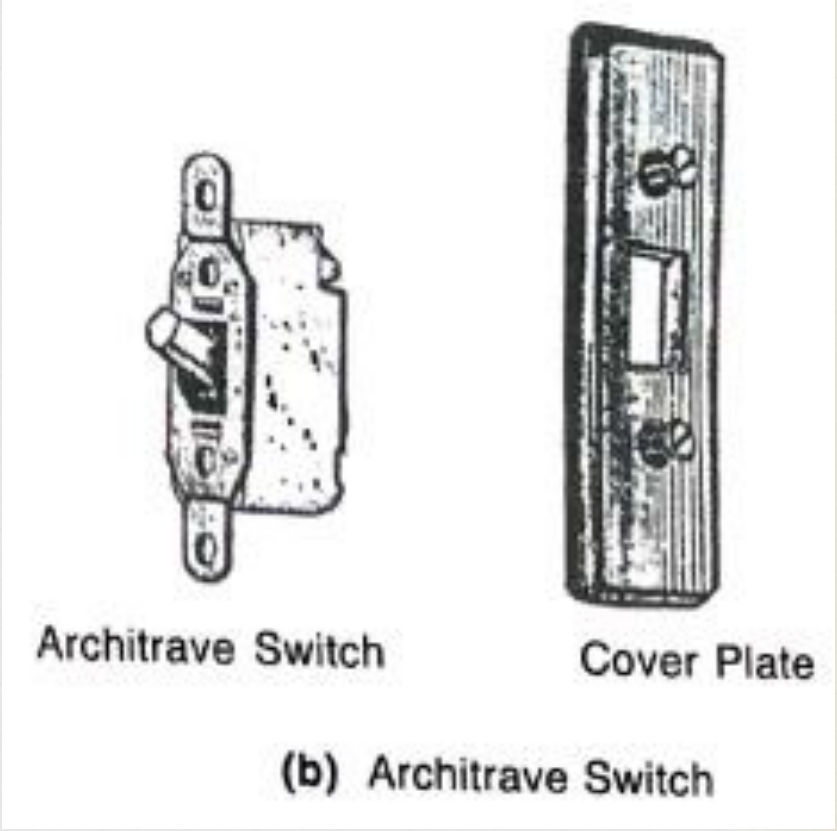
(d) Grid Switches

- These are similar to that of surface switches, but they are light in weight and small in size
- They are used with portable machines such as drill machines portable grinder etc.
- They are made either in one-wa or two-way pattern both for 5 A and 15 A rating.
- These are also called Toggle switches and are shown in Fig.



(e) Architrave Switches

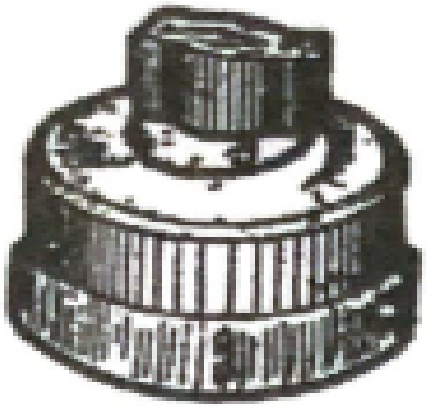
- In this type the switch movement is enclosed in a compact porcelain base as shown in Fig.
- A cover plate shown in Fig. is fixed to this Architrave switch by means of screws.
- These switches cannot operate without cover plate and they are available in one-way and two-way pattern.



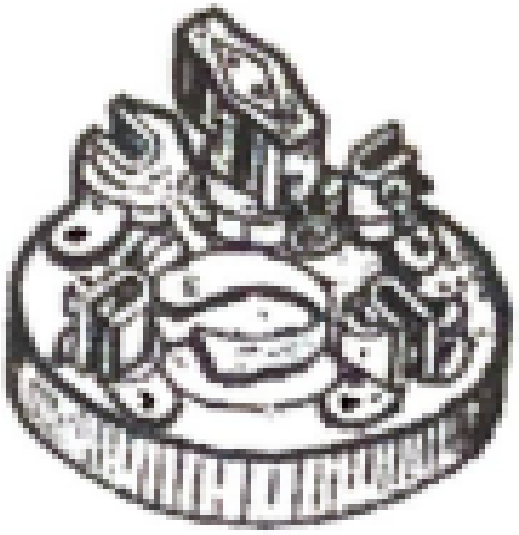
(b) Architrave Switch

Rotary *Switches*

- These switches consist of an insulated handle (knob) to which the blades are fixed.
- So whenever the handle is rotated, the blades move in steps and make in contact with the terminals to which the wires connected.
- The best example of Rotary switch is a fan regulator, when it is in one position fan rotates at a particular speed and if regulator rotates to other position fan rotates at different speed.
- The typical rotating switches are shown in Fig



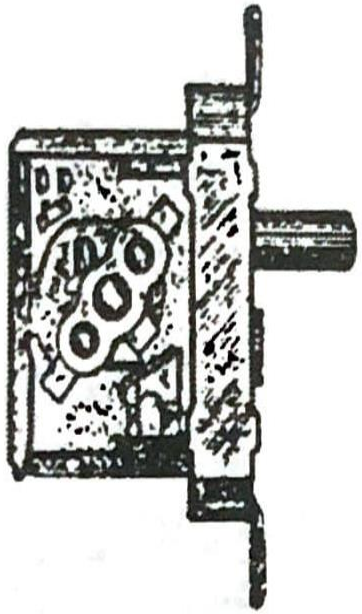
(a)



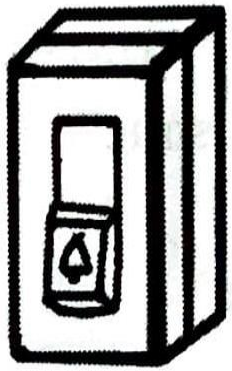
(b)

(g) Push Button Switches

- These switches are mainly used for controlling the electric bells.
- It consists of only one blade. When the knob (button) is pressed, the movement of the blade is controlled by a cam and spring, thus they open or close the circuit.
- These switches are also used for starting motors and controlling the light in refrigerator which lights when the door is opened and goes off when the door is closed.
- Typical push button switches is shown in Fig.

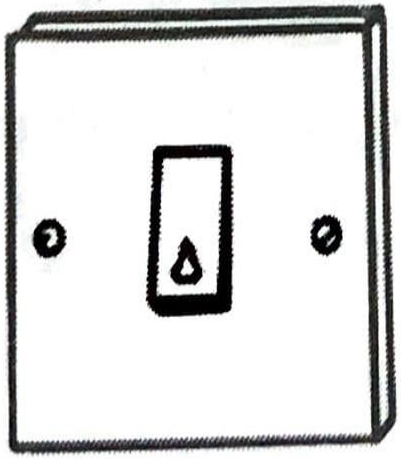


(a) Interior View

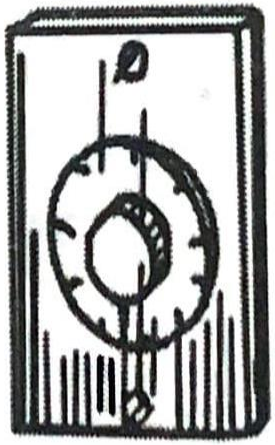


(b) Surface Type

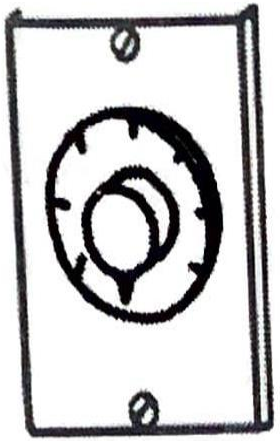
(c) Push Type



(d) 5A, Push Type



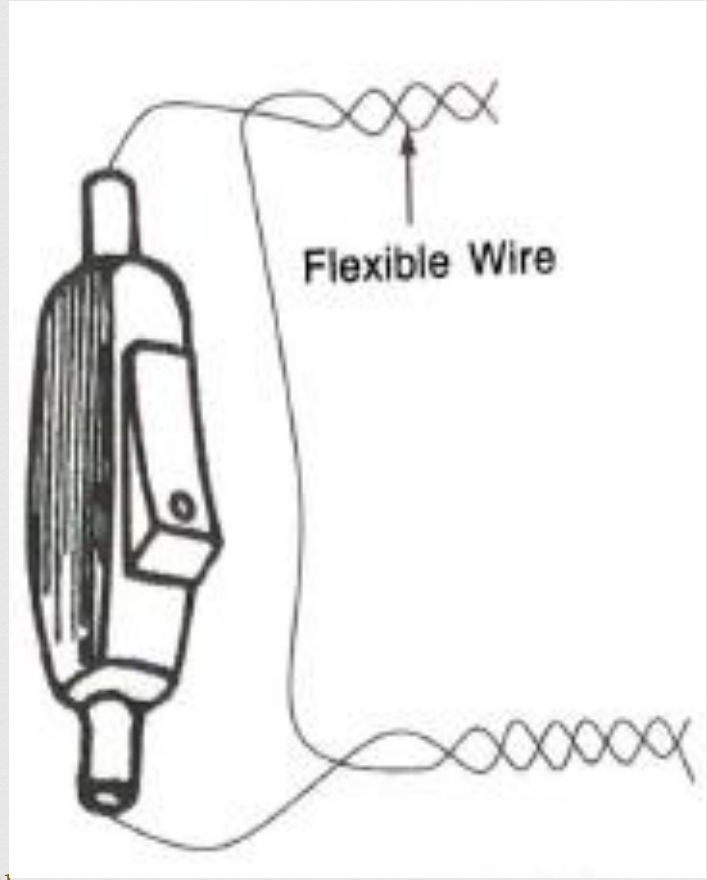
(e) Metal Flush Type



(f) Unbreakable Flush Type

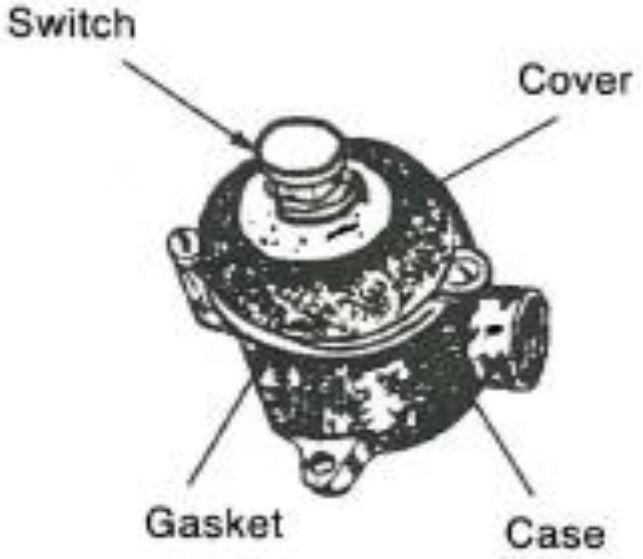
(h) Bed Switches

- These are used to control a light mostly in hanging position.
- Such switches are used for switch OFF the lamp while going to sleep or making the lamp ON while getting up at the night.
- It is connected in series with one of the two flexible wires (commonly in phase wire) as shown in Fig



(j) Iron Clad Water Tight Switches

- These are made with cast iron and are very robust in construction.
- A cork gasket is fitted between the case and the cove1 which makes water-tight.
- These are mostly used for outdoor lamp controls such as street lights.
- The construction is shown in Fig.



(a)

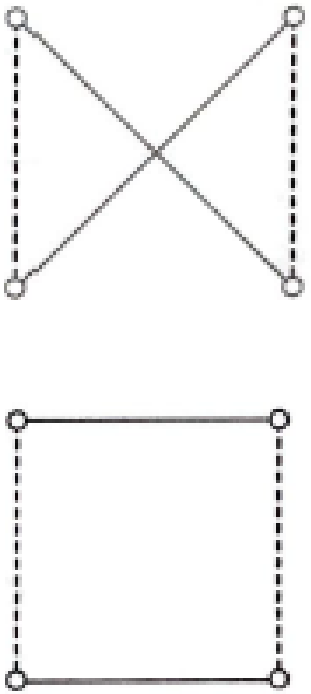
(b) 5/ 15 A

(c) 5A

(d) 15A

2. According to operation required

- **(a) One-way Switch :**
- It has only two terminals whicb can be seen from the back of the switch without opening the cover.
- The base has got a mechanical lever to ON and OFF the switch.
- The terminals and internal strips are designed according to the rated current capacity.
- If the current flowing exceeds the rated capacity, the switch may get damaged due to sparking.
- These switches are fixed on switch boards or wooden blocks by means of screws and the wires are connected carefully.



Possible Connections of Intermediate Switches

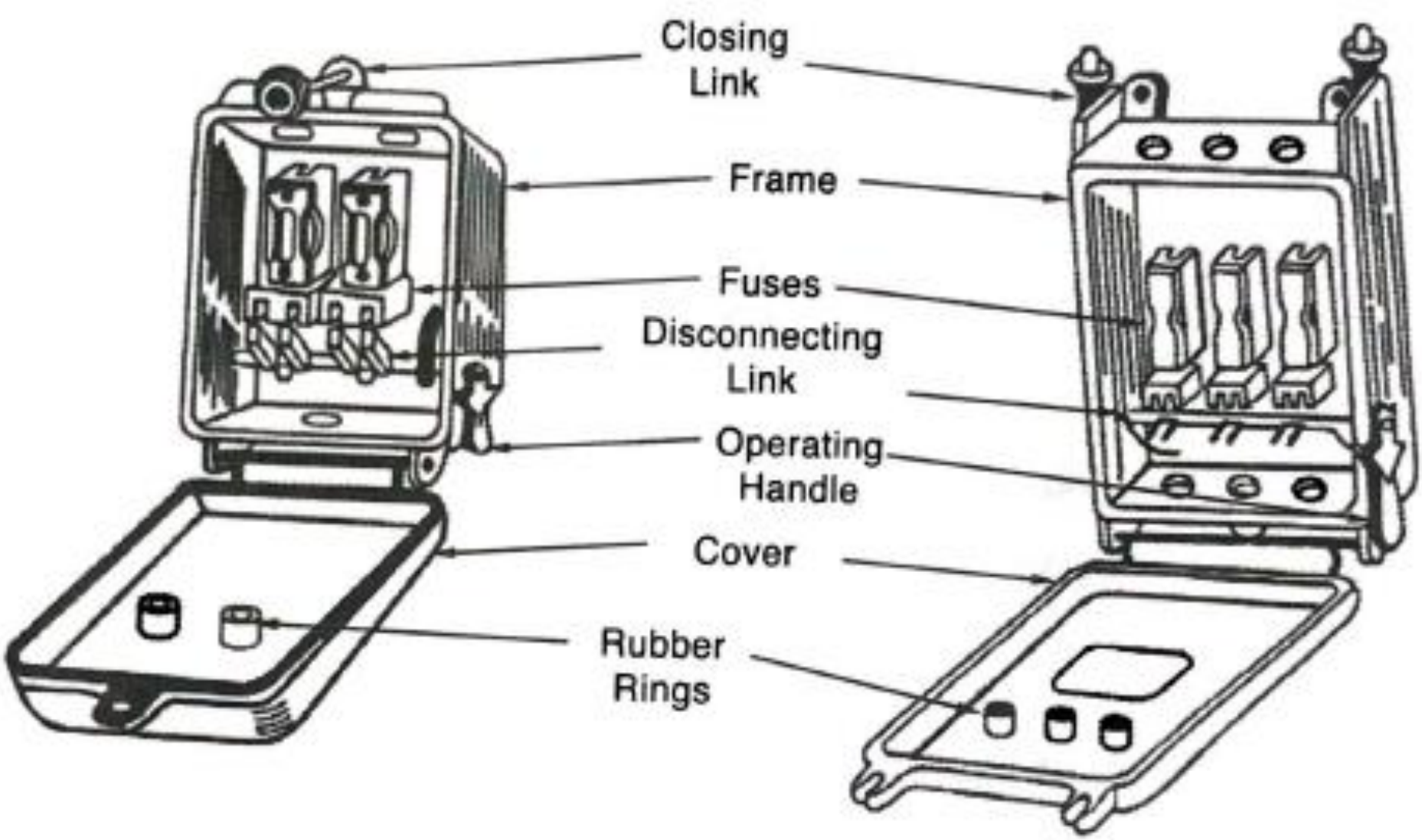
- **(b) Two-way Switch :**
- This switch controls the current in two ways, hence the name two-way switch.
- It has four terminals, out of which two are short circuited inside the switch.
- These are mainly used in stair-case wiring, where one lamp is to be controlled from two different places.
- **(c) Two-way Centre Off Switch :**
- It is similar to two-way switch, but having three operations.
- The switch at one position (down ward) can control one lamp and in another position (up ward) another lamp can be controlled i.e. two lamps can be controlled alternately.
- In the centre position it becomes OFF.
- **(d) Intermediate Switch :**
- It is unique switch and is used where a lamp is to be controlled form more than two places.
- It has four terminals, any two pairs of them being short circuited. These are available with two possible change-over types of connections as shown in Fig

3.MAIN SWITCHES (IRON-CLAD SWITCHES)

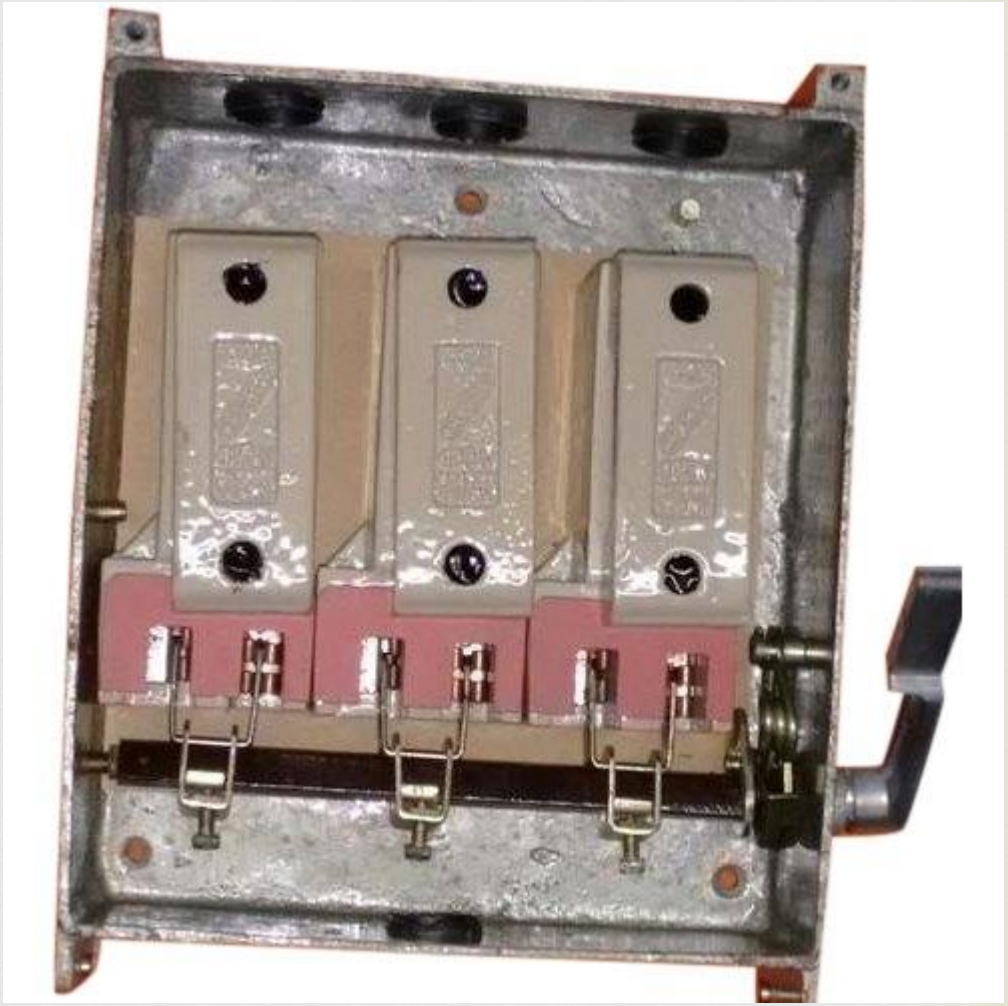
- As per Indian Electricity Rule 50 a suitable linked switch should be provided immediately after the meter board to control the whole supply for a house or office.
- A linked switch is a switch, operating simultaneously on phase and neutral wires.
- As per the rule a suitable cut-out must be provided just after the liked switch to provide protection to the circuit against excessive current.
- The liked main switch and fuse unit may be provided as one unit or as separate unit.
- These main switches are made of Iron, hence the name Iron Clad switches.
- The body of main switch should be earthed properly to safeguard the human being.
- The main switches are different types for controlling single phase and three-phase circuits.

(i) Double-pole Iron-clad Switch (DPIC Switch)

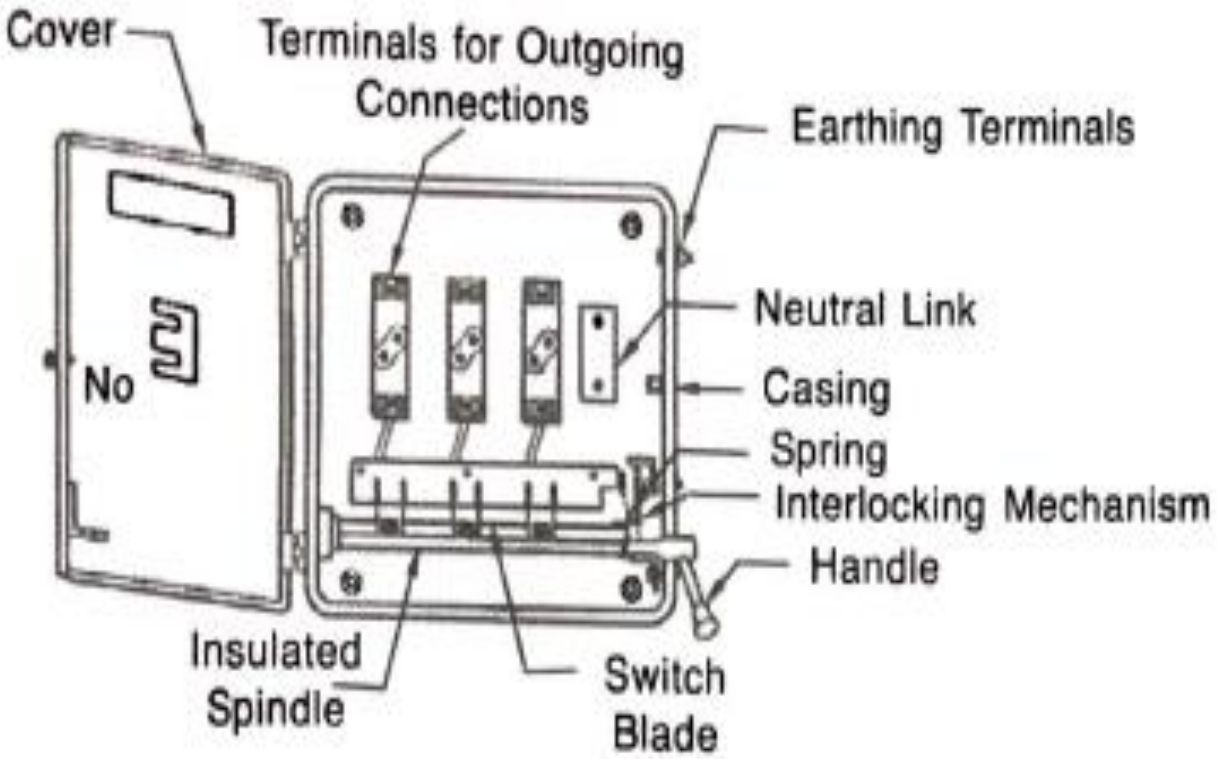
- These are used for single Phase domestic installation, to control the main supply.
- It controls phase and neutral of the supply simultaneously.
- The switch consists of two fuse carriers, one in the phase circuit wired with the fuse and the other in neutral is linked with a brass plate or thick copper wire.
- It has moulded slots for the entry of cables.
- The blade of the double pole switch are made of two links mounted on an insulated bar which is operated by means of handle.
- The movement of the insulated bar controlled by a spring.
- These switches are rated according to the current an voltage ratings like 15 *A* 250 *V*, 30 *A* 250 *V*, 60 *A* 250 *V*, 100 *A* 250 *V* etc.
- The *DPIC* switch is shown in Fig



Double-pose Iron-clad Switch **Triple-pole Iron-clad Switch**



- *(ii) **Triple-pole Iron-clad Switch (TPIC Switch)** :* This is used to control three phase power circuits.
- It has three fuse carriers, one for each phase and the lines are connected to these terminals.
- The switch body is properly earthed to provide protection against electric shock.
- The operation of this switch is similar to D.P.I.C. switch except that it has three blades, each made of two links as shown in Fig.
- These are rated according to the current and voltage ratings as- 15 *A* 440 *V*, 30 *A* 500 *V*, 100 *A* 500 *V* etc.
- **(iii) Triple-pole Iron-clad Switch with Neutral Link (TPICN Switch)**
- If Neutral link is added to Triple-pole Iron-clad switch, then it becomes T.P.I.C.N. switch, which are used for 3-phase 4-wire circuits.
- It has four blades, each made of two links, which are operated by means of handle.
- It is earthed through an earth terminal and is shown in Fig

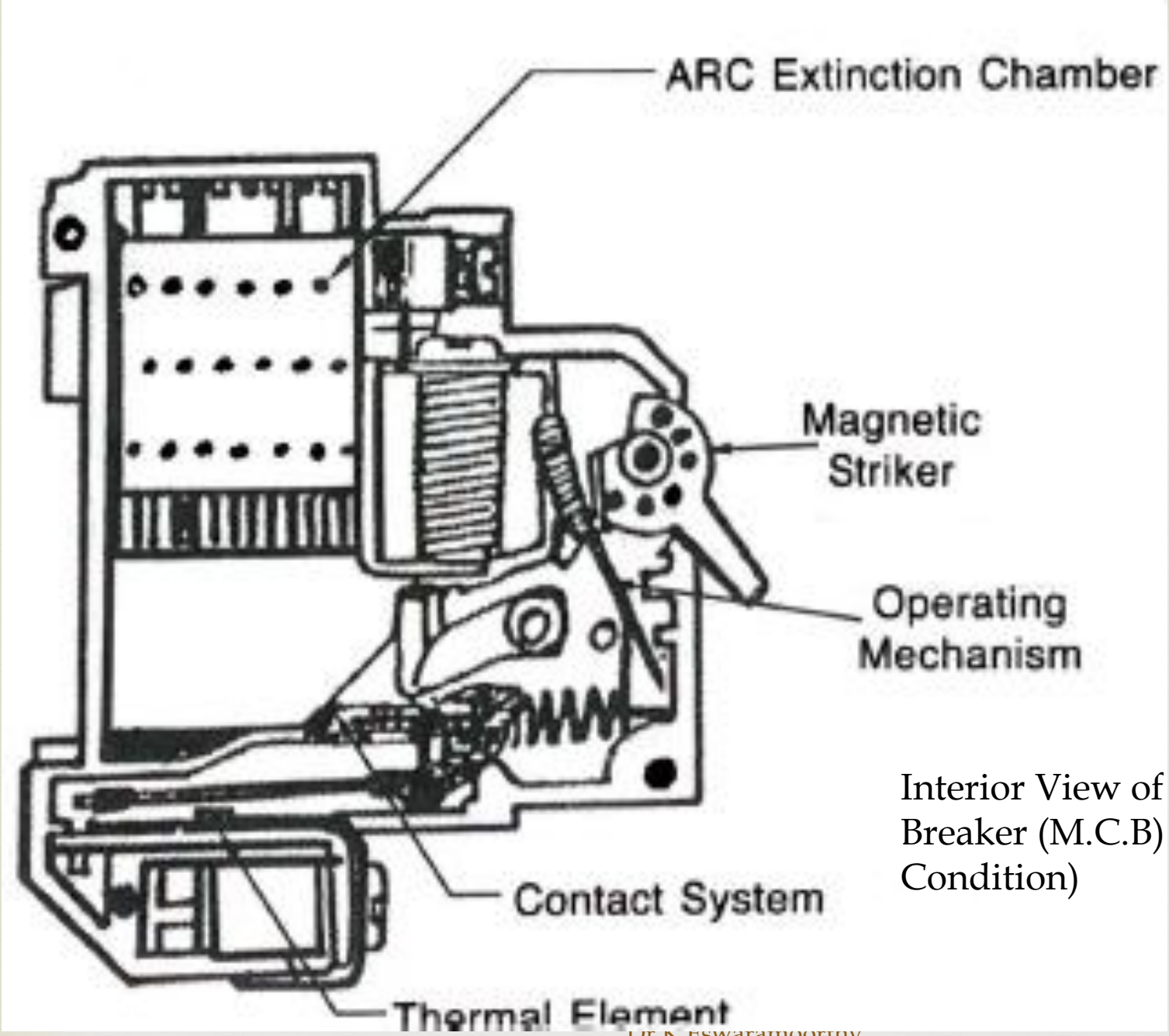


(a) TPICN

(b) D.P. Switch Flush type with fuse carrier indicator and earthing

T.P.I.C. With Neutral Link and D.P. Switch

- **(iv) Miniature Circuit Breaker (MCB) :**
- It is a protective device which provides protection to the wiring installation: and costly equipment against over-currents and short-circuits faults.
- It consists of thermal overload and magnetic short-circuit tripping device.
- Thermal operation is achieved with a bimetallic strip, which deflects when over-currents flowing through it and by some mechanism the contacts are opened.
- The interior view of MCB is shown in Fig..
- Now-a-days the fuses are replaces by MCB 's due the following advantages.
- ADVANTAGES :
- 1. Automatic switch OFF in case of over-load or short-circuit.
- 2. Quick identification of fault circuit at any time (less then 1 m sec).
- 3. Supply restored by switching ON again.
- 4. It has no fuses to replace or rewire.
- MCB's are used for protection of Motors, Air conditioners, Refrigerators, computers!
- Mixers, Heaters, Pumps, Grinders and all Lighting circuits. MCB needs no repairs.
- It does not deteriorate with time. Once it is fixed in the circuit, we can forget about recurring problems.



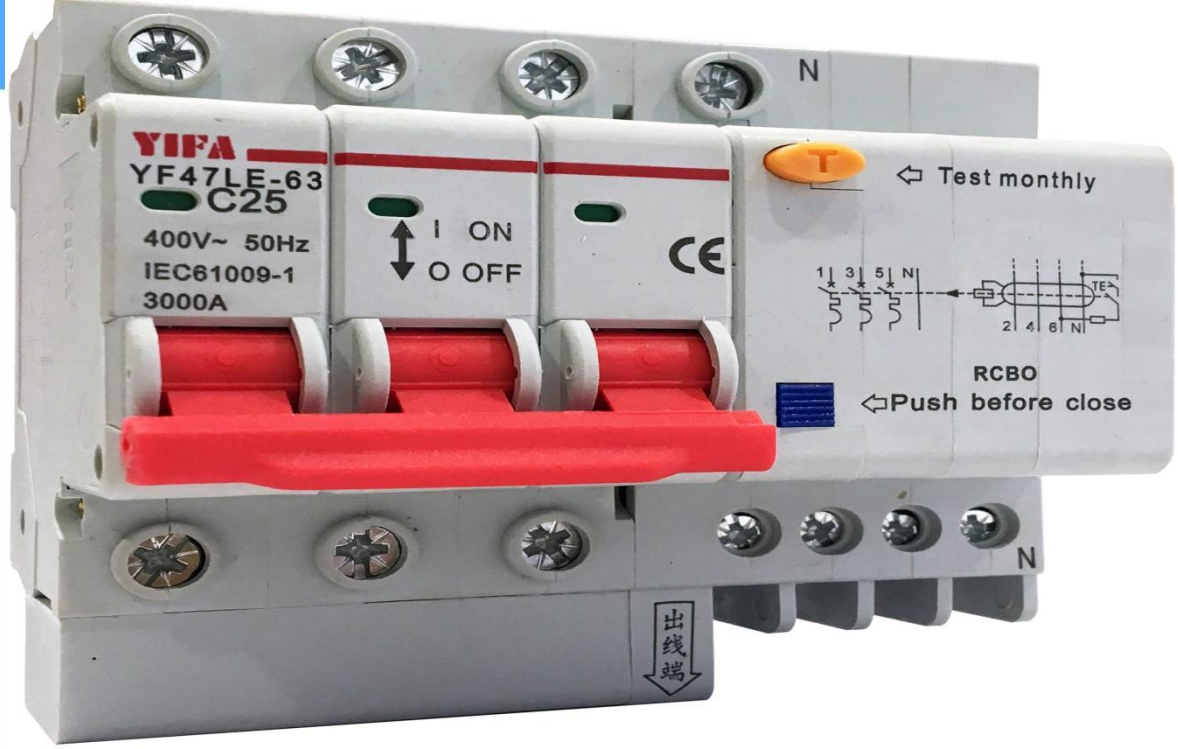
Interior View of Miniature Circuit Breaker (M.C.B) (In Open Condition)

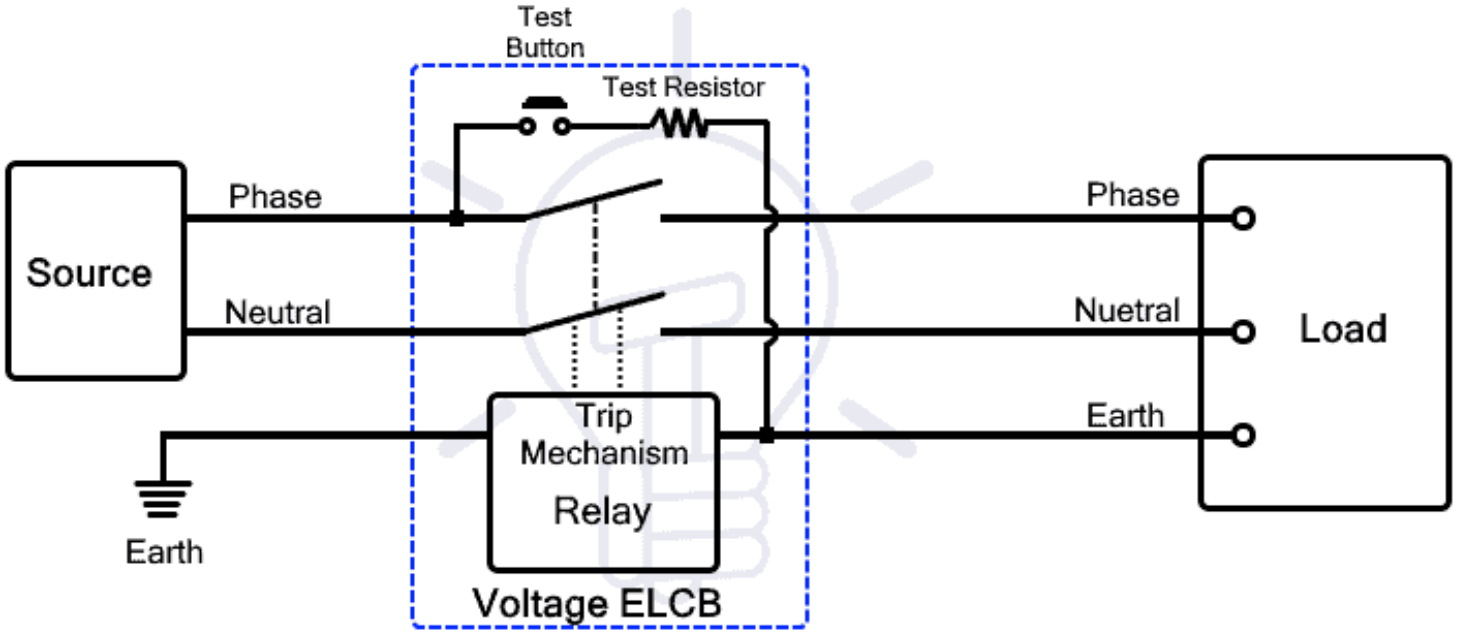
- These are available with current ratings of 0.5, 1, 2, 3, 4, 5, 6, 7.5, 10, 16, 20, 25, 32, 35, 40, 63, 100, 125, 160 A and voltage ratings of 240/415 V A.C. and upto 220 V D.C.
- The operating time is less than 5 millisecond and capable of breaking fault currents upto 9000 Amps.

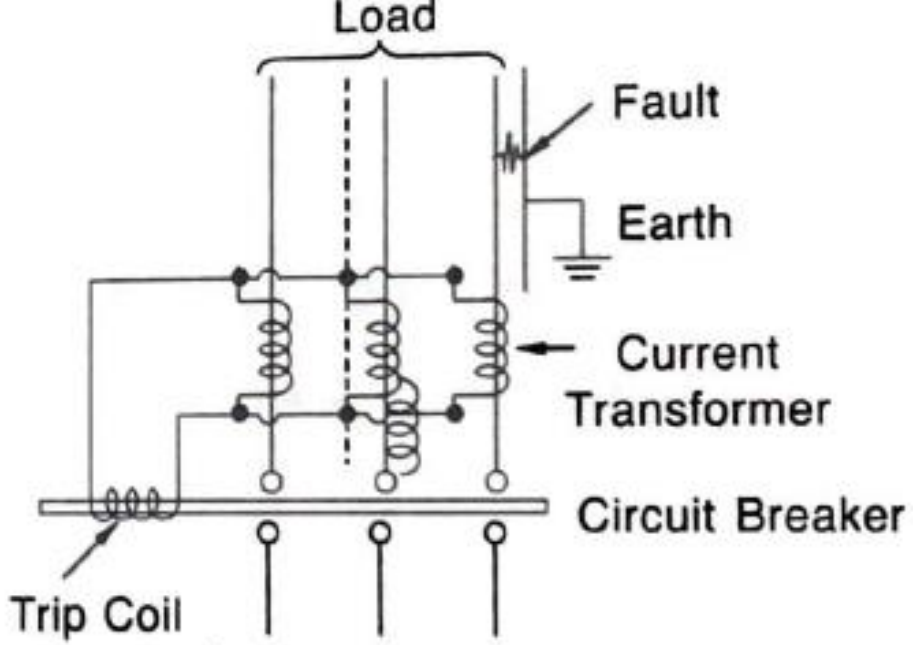
v).Earth Leakage Circuit Breaker (ELCB)

- It is a device which provides protection against Earth leakage.
- These are two types, namely
  - current operated type and
  - voltage operated type.
- Current operated earth leakage circuit breaker is used, when the product *of* the operating current in amperes and the earth-loop impedance in ohms does not exceed 40.
- This is used for 3-phase, 3- circuit as shown in Fig (a).
- During normal operating conditions, the algebraic sum of currents in the three coils of the current transformer is zero and no current flows through the trip coil.
- In case of any earth leakage, the currents are unbalanced and the trip coil is energized and thus the circuit breaker is tripped.
- Voltage operated earth leakage circuit breaker is suitable where the earth-loop impedance exceeds 40 ·
- When the voltage between the earth continuity conductor and earth electrode rises to a sufficient value, the trip coil will operate.
- Such a circuit is shown in Fig. (b).

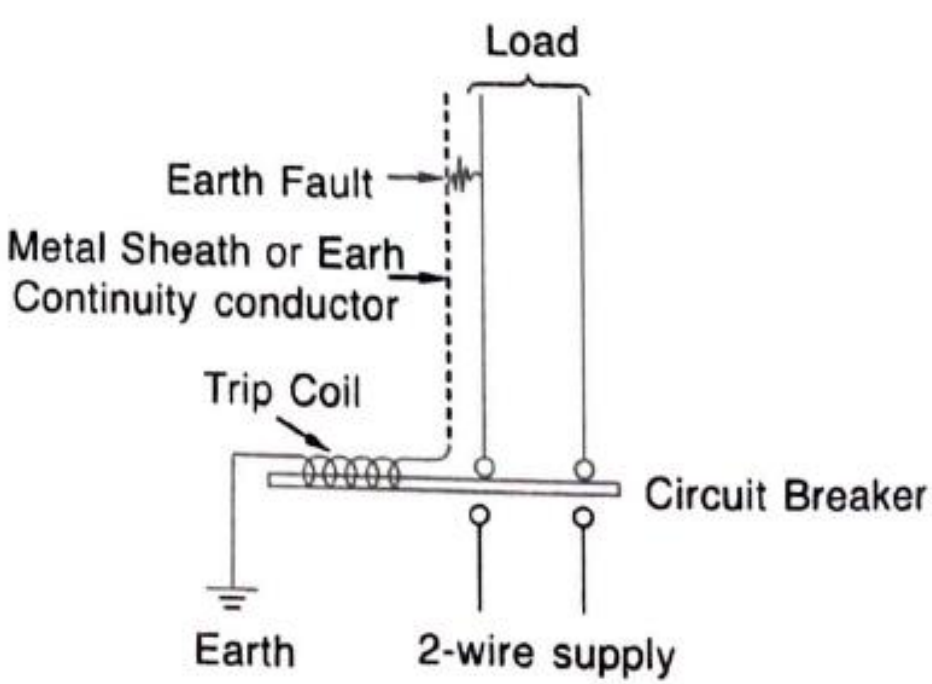
ELCB (Earth Leakage Circuit Breaker)





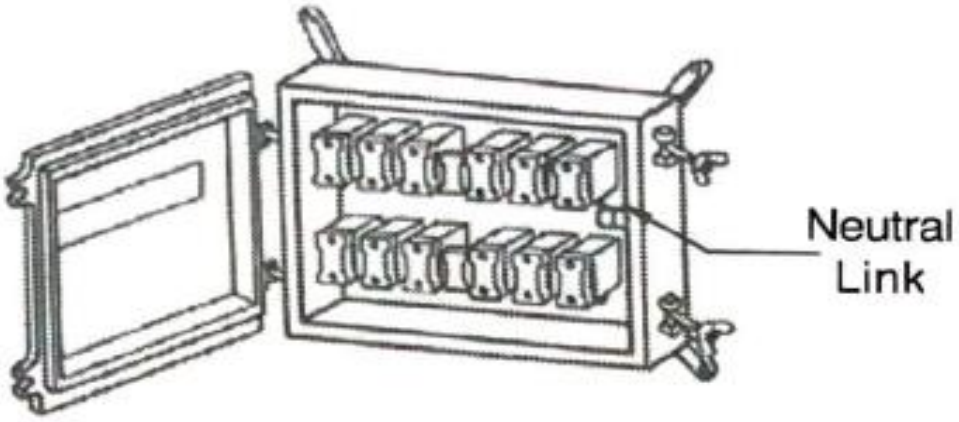


(a) Current Operated Earth Leakage Trip

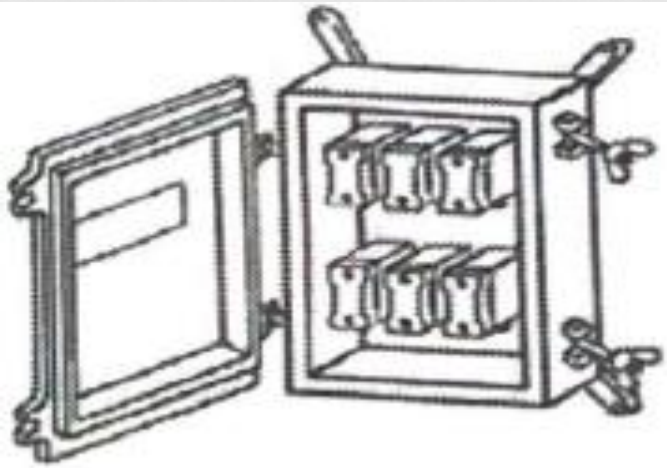


(b) Voltage Operated Earth Leakage Trip

Earth Leakage Circuit – Breaker (Connection Diagrams)



12 - Way Distribution Board



6 - Way Distribution Board

vi). Distribution Boards

- These are used where the total load is more than 800 watts.
- The total load is divided into a number of circuits and the supply is fed to each circuit from distribution boards.
- Each circuit is provided with a separate fuse .
- The number of fuses are equal to number of sub-circuits but the neutral may be common to all circuits.
- All the fuse and neutral link is enclosed in metal box as shown in Fig.

7.4 HOLDING ACCESSORIES

- **The accessories which are used to hold the electric lamps are known as "Holding accessories".**

Holders :

- As the name indicates the function of lamp holder is to support (hold) the lamps and also to connect it electrically.
- Holders are designed for quick removal and replacement of the lamps.
- It consists of either moulded or porcelain interior with a solid or spring control plunger and easily wired terminals.
- Earlier, brass holders were in use, but now-a-days these have been replaced by bakelite with porcelain interior.

Types of Lamp Holders

- The Lamp Holders are classified in different ways as below.
- 1. According to the Size :
  - I. Bayonet Cap (B.C) Lamp Holders : These are further classified into
    - (a) Pendent holders.
    - (b) Batten holders.
    - (c) Bracket holders
    - (d) Water-tight bracket holders
  - *II. **Screw Holders** :* These are further classified into
    - (a) Medium Edison Screw (MES) holders.
    - (b) Goliath Edison Screw (GES) holders

- 2. According to the place of use.
  - (a) Switched Bayonet Cap lamp holders.
  - (b) Angle holders.
  - (c) Miniature screw type lamp holders.
  - (d) Slanting holders.
  - (e) Swivel lamp holders.
  - (f) Fluorescent lamp holders and Starter holders.
  - (g) Lamp holder adopters.
- 3. According the material used.
  - (a) Brass lamp holders.
  - (b) Bakelite lamp holders.

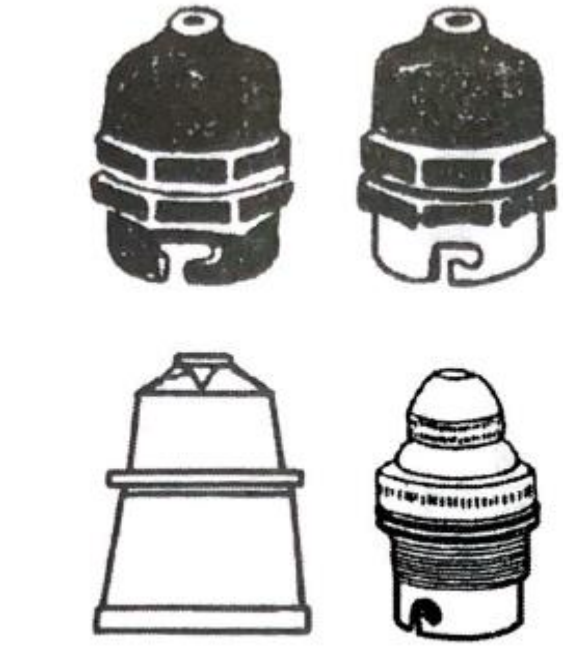
I. According to the Size

- At any place, where the lamp is to be installed, the lamp holder of suitable size and type must be used.
- According to size these are classified as below.

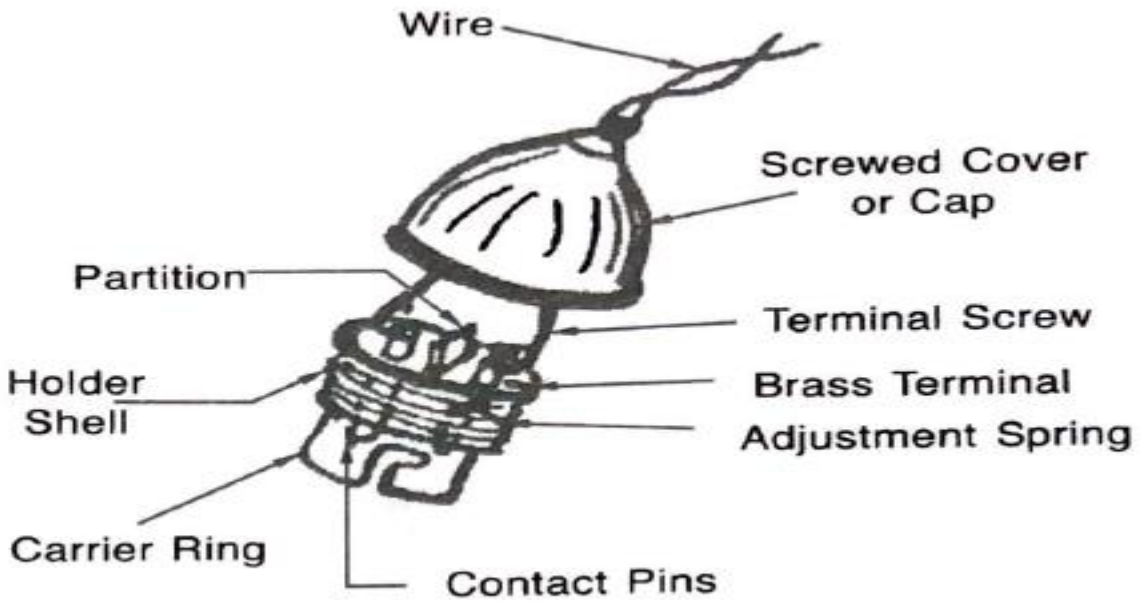
(i) Bayonet Cap (B.C) Lamp Holders :

- In this type, the bulb is inserted into the slot and is held in position by means of two pins in the lamp cap.
- It consists of two solid or hollow spring contact terminals, the cables are connected to these terminals allowing the cable through grooves, provided at the top of the holder.
- In this type of holders the lamp is inserted, forced in, twisted slightly and then left in position.
- These holders are used for ordinary tungsten filament lamp upto 200 watt with bayonet lamp cap.
- These are further classified as discussed below.

- ***(a) Pendent Lamp Holders :***
  - These are used in places where the lamps are required in hanging position.
  - These are made of either brass or bakelite.
  - These are used upto the lamps of 200 watts.
  - These are used along with ceiling roses for suspending the lamps from the ceiling.
  - The various views of pendent holders are shown in Fig.



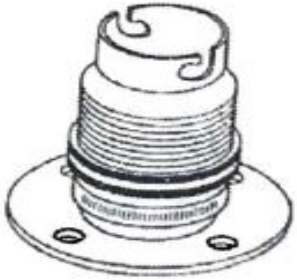
(a) Different types of Pendent Holders



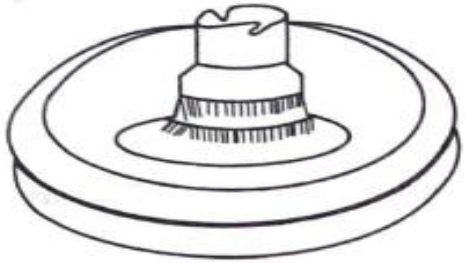
(b) Parts of Bayonet Cap Pendent Lamp Holder

- **(b) Batten Holders :** These are used on the flat surface on the round blocks or wooden boards. These are made of either brass or bakelite.
- These are used for the lamps upto 200 watts, having bayonet cap.
- These are fixed to the round blocks or switch boards by means of screws, inserted into the holes provided on circular construction.
- The lamps are inserted, forced in, turned slightly and then left in position. The Batten Holders are shown in Fig.

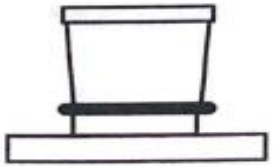
(a) 3 Hole batten holder (standard)

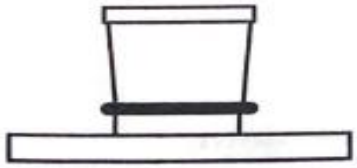


(b) Brass batten holder



(c) Batten holder on round block



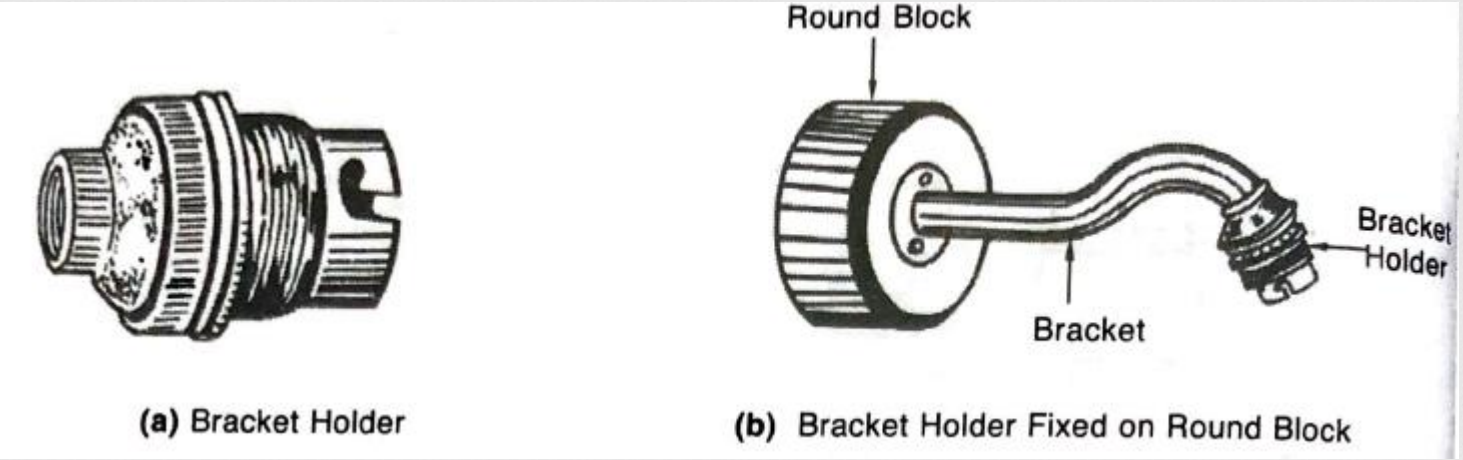


(d) Batten Holder Skirt

(e) Angle Batten Holder

(f) Office Type Batten Holder

- **(c) Bracket Holders :** These are used with a bracket. These are generally made of brass and used upto the lamps of 200 watts.
- These are used to give direct light to a particular place.
- These are fixed to the bracket by the internal threading of the cap as shown in Fig.



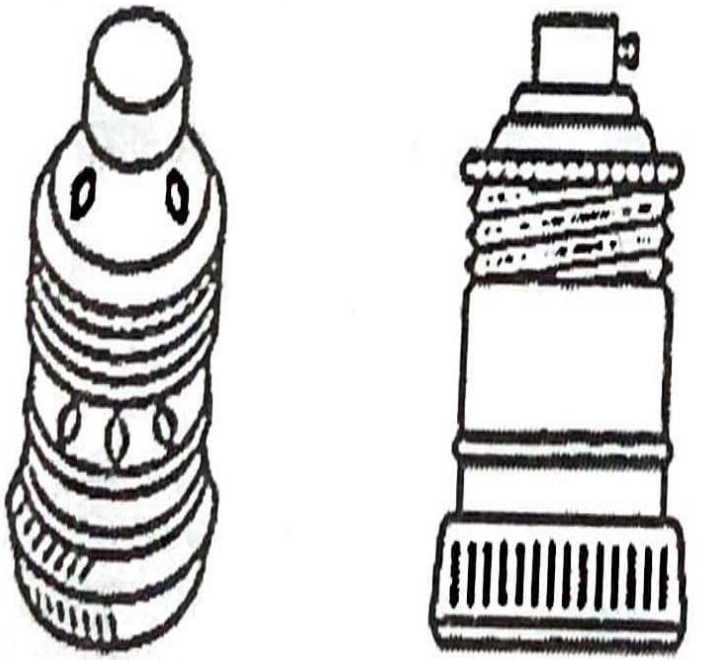
- **(d) Water-Tight Bracket Holders :**
- These holders are similar to that of bracket holder, but provided with tubular glass, fixed with water tight cover.
- The are used outside the house and for street light, where the lamps are require to save from falling of water over it.

Dr.K.Eswaramoorthy

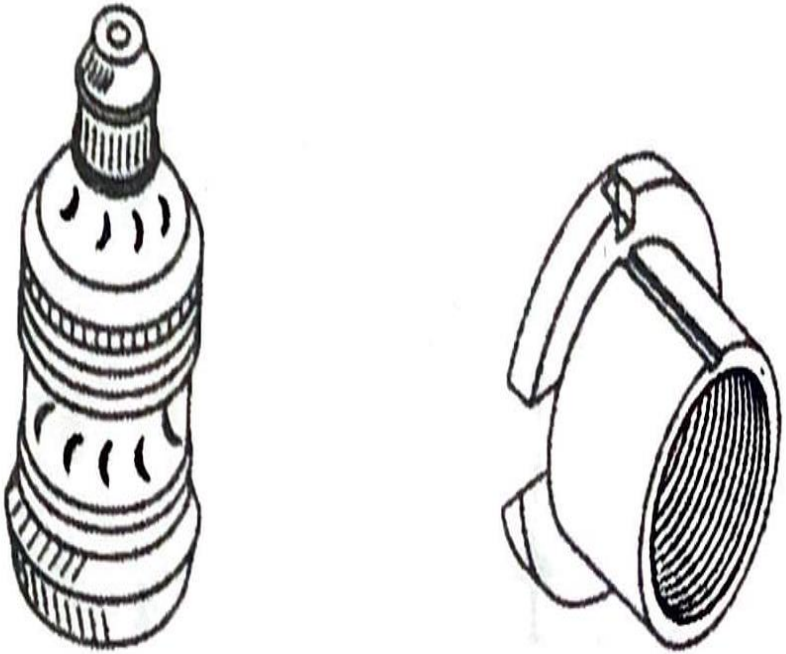
1. Screw Holders

- These holders are used with Screwed type lamps.
- These a again classified into two types namely
  - **(i) Medium Edison Screw (MES) Holders :**
  - These are provided with inner, screw threads and lamps are fitted in it by screwing as shown in Fig. (a)
  - It has a centre contact which is connected to the phase wire and the screwed cap is connected to neutral wire. These are used for lamps upto 300 watts.
  - These are used in studios, head lights, flood lights etc.

- **(b) Goliath Edison Screw (GES) Type Holders :**
- The cover of these typed holders is made of porcelain.
- These are used for lamps having wattage beyond 300 watts.
- These holders are used in studios, flood lights, focusing lights etc. Fig.



(a) Medium Edison Screw Holder

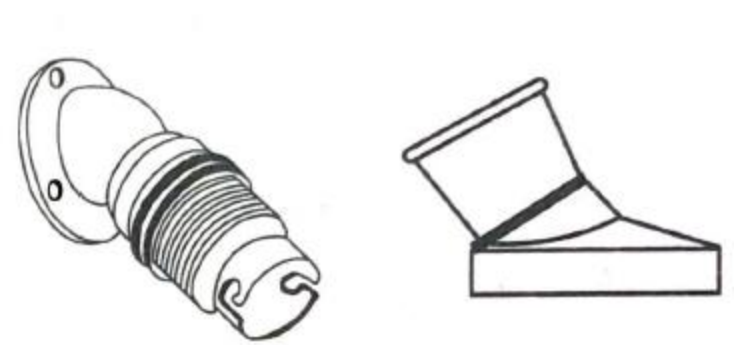


(b) Goliath Edison Screw Holder

2. According to the Place of Use

- These holders are used at various places depending upon the purpose.
- Hence, according to the place of use the holders · are classified as explained below.
- **(a) Switched Bayonet Cap Lamp Holders:**
- These holders have a push-bar and are used to carry a current of not exceeding 2 amps only.
- The push-bars are nondetachable and are shown in Fig. (a) .
- **(b) Angle Holders :**
- These holders are used, when the lamps are to be kept in a particular angle.
- These are sued for advertising boards, kitchens etc.
- These are used upto 200 watts and are rated as 5 A, 250 V. The typical Angle holder are shown in Fig. (b).

(a) Switched Bayonet Cap Lamp Holder



(b) Angle Holders

Dr.K.Eswaramoorthy

(c) Miniature Screw Type Lamp Holders :

- These are used for holding miniature lamps such as night bulbs, decoration bulbs, torch lights bulbs etc.
- Miniature lamps are fitted in these holders just like screws.

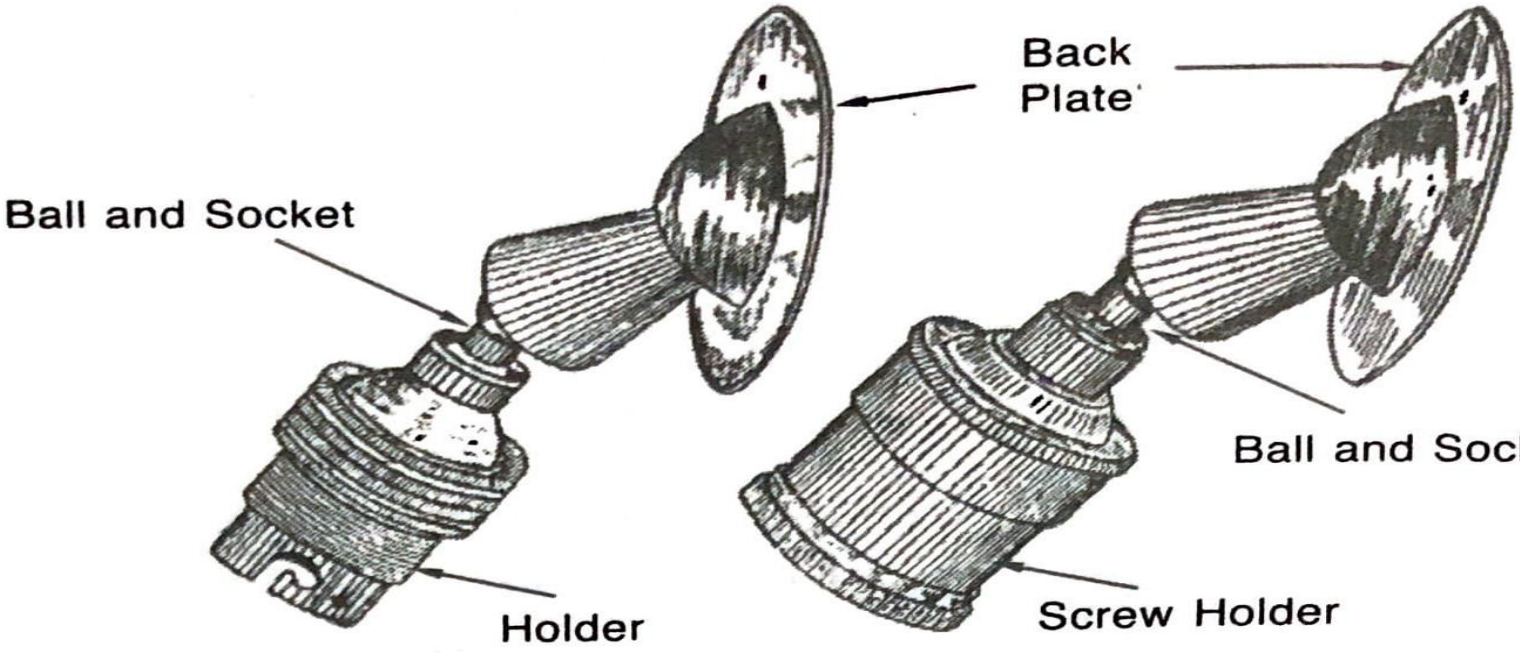
(d) Slanting Holders :

- These are bayonet type and are used for lamps to be fixed on advertising boards, for flood lights in stadiums and for stages.
- These are provided with shades over it, so that total light output will concentrate at a particular place.

(e) Swivel Lamp Holders :

- These holders are designed for wide angle directional lighting.
- It gives light towards a particular object, so that it can be projected.
- These are most commonly used for the lighting of shop windows, showcases etc.
- It consists of a ball and socket joint fitted between a back plate and the lamp-holder as shown in Fig. and these can be fixed to wall or ceiling.

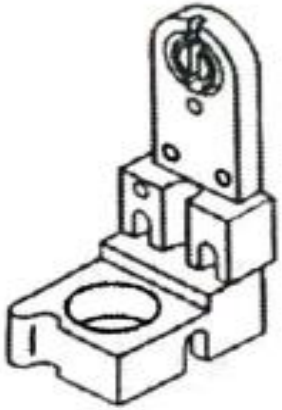
Dr.K.Easwaramoorthy



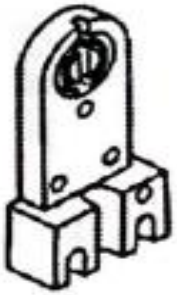
(a) Angle Swivel Lamp Holder

(b) Edison Screw Swivel Holder

Holder for the starter

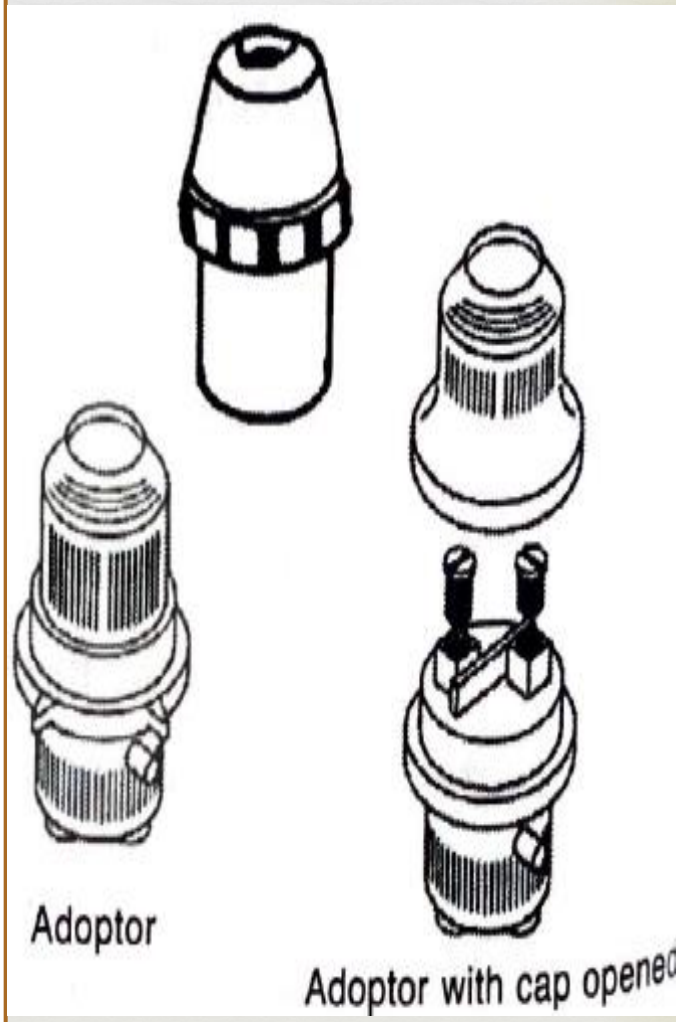


Combined tube and starter holder



Fluorescent Pin tube holder

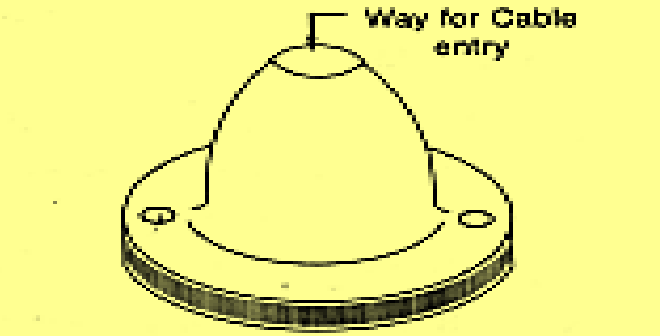
- **(f) Fluorescent Lamp Holders and Starter Holders** :
- These are used for holding Fluorescent tube lights and starters. These are made of plastic or bakelite.
- The consist of two strips inside which actually fed the supply to the tube and start
- These are available separately or in combination and are shown in Fig.
- **(h) Lamp Holder Adopters :**
- These are used for tapping temporary power for small electric appliances from lamp holders.
- Adopters with multiple plugs are also available for taking supply to a number of appliances from a single lamp holder.
- They are rated as 6 A ,250 V. These adopters should not be used in bathrooms or other damp places.
- Fig. shows different lamp holder adopters.



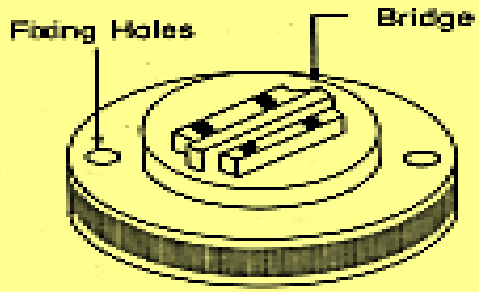
7.5.OUTLET ACCESSORIES

- These. accessories are used to take the supply for portable appliances like fans, T.V, electronic iron etc. The accessories such as
- (a) Ceiling roses,
- (b) Socket outlets (plug sockets) and
- (c) Plugs etc. covered under this type;

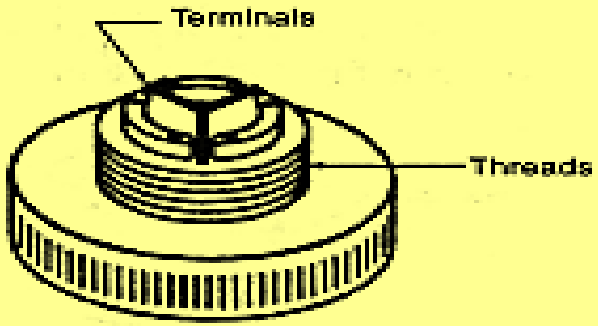
- **1.Ceiling Roses:**
- The ceiling rose is used to take supply for pendent lamps, fans, fluorescent tube etc through 'flexible wire'.
- These may be fixed to wall or ceiling.
- It consists of two parts, the base and cover, both are made of bakelite or porcelain.
- The cover has a hole in the centre for the connecting wires to take out.
- It has threads on internal side, so that it may be fixed or tightened. with the base.
- The base has two or more terminal plates separated from each other by a porcelain or bakelite bridge as shown in Fig..
- The commonly used ceiling roses are two-plate and three.,.plate ceiling roses.
- The two-plate ceiling rose consists of two-terminal plate and three-plate ceiling rose has three terminal plate.
- Each of the terminal plates is provide with a metallic sleeve and a binding screw on one side to connect the circuit wire.
- The base is provided with holes for fixing on round block.
- The insulating bridge is provided with two holes through which flexible wire is passed first before making connections to the terminal plates.
- This is done for taking the weight of the lamp holder, lamp etc.
- These are rated according to the current capacity as 5 A, 250 V.



(a) Top cover looks the same for (b) and (c)

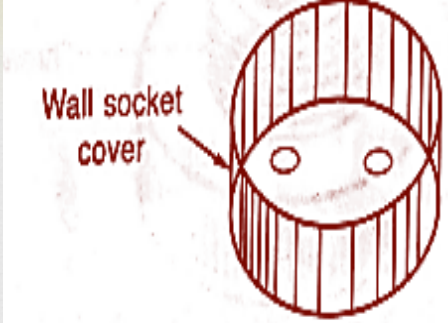


(b) Base of two plate ceiling rose

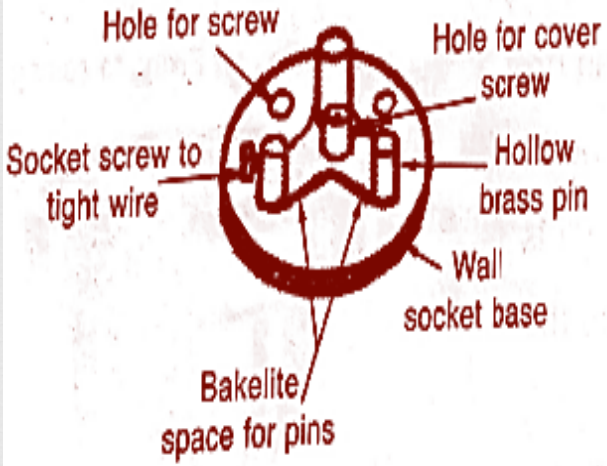


(c) Base of two plate ceiling rose

(d) Ceiling rose with cover



(b) 3 - Pin (Hexa Socket)

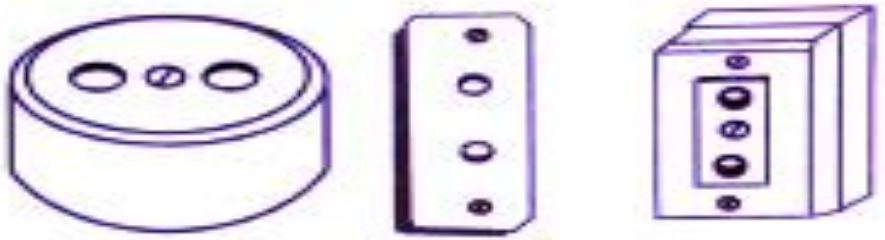


(a) Parts of two - pin socket

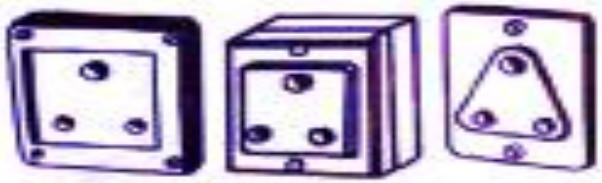
(c) 3 - pin societ on round block

Different Types of Sockets

(d) 3 - pin, 16 A socket flush type



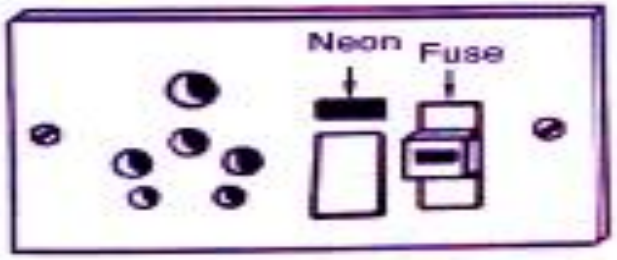
(e) 2 - pin socket (5A)



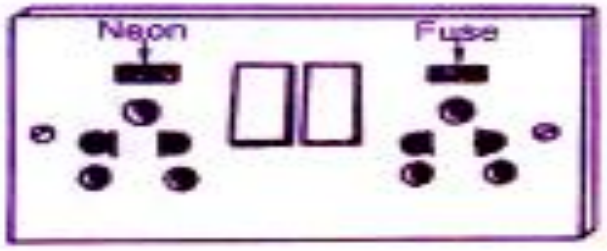
(f) 3 - pin sockets (5A)

(g) 2 - in 1 Socket (5A / 15 A)

(h) 3 Pin Socket with Switch Control (5A)



(i) 5 in 1 with Neon & Fuse (5A / 15A)



(j) Double switch socket with neon

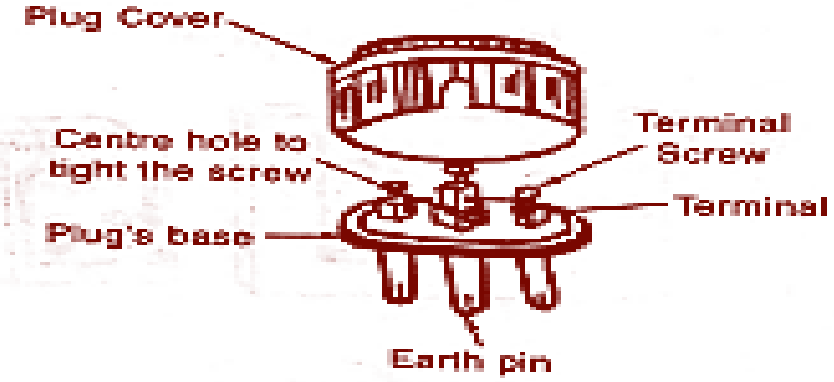
2. Socket-Outlets (Plug Sockets) :

- These are used to take the supply for the electrical appliances such as T.V', radio, table fan, electric iron etc.
- These are made of Bakelite or porcelain.
- According to number of pins and current carrying capacity, sockets are classified into.
- **(i) *Two-pin Socket :***
- These are rated as 5A, 250 *V*. They consists of insulated base having two hollow terminals (pins) as shown in Fig. (a) in which two pin plug can be inserted.
- Both the terminals are of same length and size, to which phase and neutral wires are connected. These are suitable for light circuits.
- **(ii) *Three-pin Socket :***
- These sockets consist of three hollow terminals in which three-pin plug can be inserted.
- Three terminals are marked as Line (L) , Neutral (N), and Earth (E).
- The line (phase) terminal is always on the right hand side neutral terminal on the left hand side, and the top is the earth terminal.
- The earth terminal is bigger and larger than other two terminals. In all cases, the earth win must be connected to the earth (top) terminal of the Socket.

- These sockets are two types 5 *A*, 250 *V* and 15 *A*, 250 *V* sockets. 5 *A*, 250 *V* socket it called *light socket* and is used for lights, radio, T. V etc..
- The 15 *A*, 250 *V* socket is called power sockets and is used for heater, single phase motor, geyser etc.
- Now-a-days multi pin sockets are available, which consists of 5 or 6 holes with fuse and neon lamp a shown in Fig. (i) & (j).

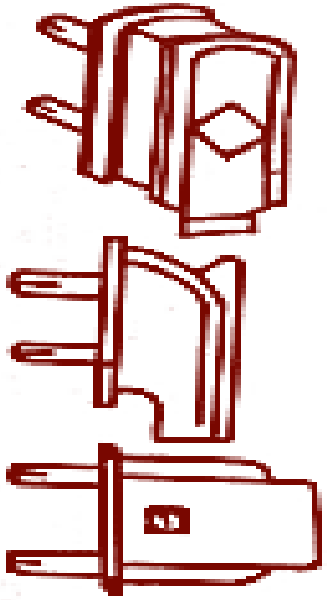
3. Plugs

- Plugs are used to take the supply from the socket-outlets for electrical appliances like lamps, fans , stove, heater. etc.
- These are also of two types bases on number of pins and are made of bakelite or porcelain.
- **(i) Two-pin Plug :**
- It is used to take supply from two-pin socket It consists of two pins made of brass and are of same size and length. They are rated as 5 A 250 V and are shown in Fig. (b).
- **(ii) Three-pin Plug :**
- It is used to take supply from three-pin socket. It consists of three pins, made of brass.
- Two pins are smaller and of same size and third pin is bigger and larger to which earth wire is connected.
- They are rated according to current as 5 A, 250 V and 15 A, 250 V.
- The 5 A, 250 V plug is used for table lamp, fan, radio etc.
- whereas 15 A, 250 V plug is used for power circuits such as heater, geyser, single phase motor etc. Different types of plugs are shown in Fig.

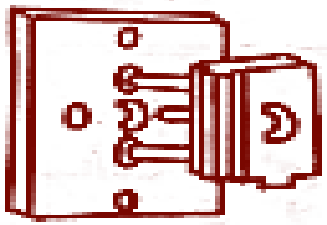


(a) Parts of Plug Top

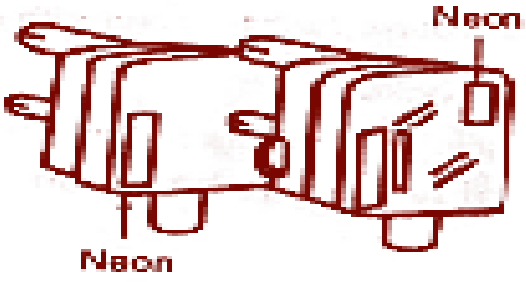
(c) 3 - pin plugs (5A / 15A)



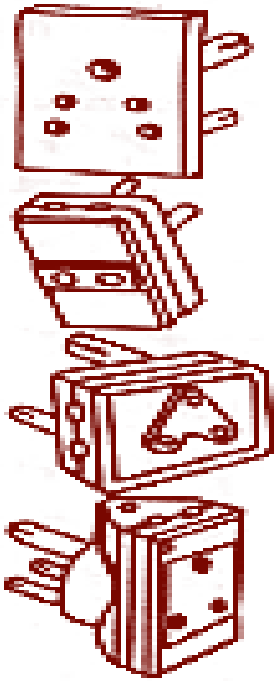
(b) 2 - Pin plugs (5A)



(d) Telephone Socket & Plug



(e) 3-Pin Plug with Neon Indicator



(f) 3-Pin Multi - Plugs (5A / 15A)

7.6 C.T.S. WIRING ACCESSORIES

- For C.T.S wiring system various accessories are required. The following are the various C.T.S wiring accessories
- (a) Wooden batten
- (b) Wire nails.
- (c) Screws.
- (d) Link clips.
- (e) Wooden gutties.
- (f) Round blocks.
- (g) Switch boards.

- **1. Wooden Batten :**
- A well seasoned, perfectly straight and well varnished (on all sides) teak wood batten is used in case of C.T.S wiring.
- The thickness of wooden batten is 10 mm at least.
- These are available in different sizes according to the width as 13, 19, 25, 31, 38, 44, 50, 56, 63, 69 and 75 mm.
- **2. Wire Nails :**
- These are used to fix the link clips on wooden batten.
- These are made of steel and are available in different lengths, as 10 mm, 15 mm etc.
- **3.Screws :**
- The Screws are used for fixing wooden batten, blocks boards and electrical accessories on the wall or ceiling.
- These are available in different sizes such as ½ inch 1 inch, 1 ½ inch, 2 inch etc. '
- **4. Link Clips:**
- These are used to held the wires in position on the wooden batten.
- Link-clips are fixed on the wooden batten at an interval of 10 to 15 cm, then wires are run over it and link-clips are folded to held the wires in tight position.
- These are made of iron or tinned brass.
- These are available in lengths-wise as 16, 25, 30, 40, 50, 80 mm etc.

5. Wooden Gutties :

- The wooden batten, Round blocks, switch boards etc. are fixed to the gutties by means of screws.
- These are fixed in the holes of wall or ceiling and cement has to be applied.
- These are made of teak wood. It is 50 mm sq. on one side and gradually tapered to 30 mm sq. at the other end.
- The size of the gutties depending upon the load it has to carry.

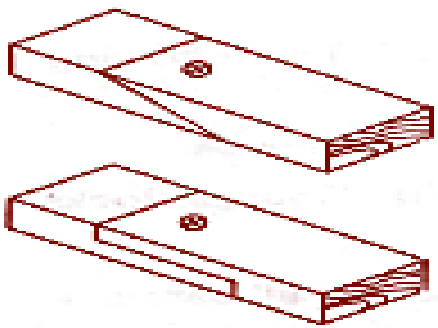
6. Round Block :

- Some of the mounting accessories like lamp holders, surface switches ceiling roses etc. are fixed on round blocks and are made of quality wood.
- For fixing these accessories on round blocks, holes are drilled on round blocks and fixed over it by means of screws.
- These have grooves for the entry of batten/wires, for making connection to the accessories.
- The wooden blocks are fixed to the wooden gutties, already provided in the wall or ceiling with the help of wooden screws.

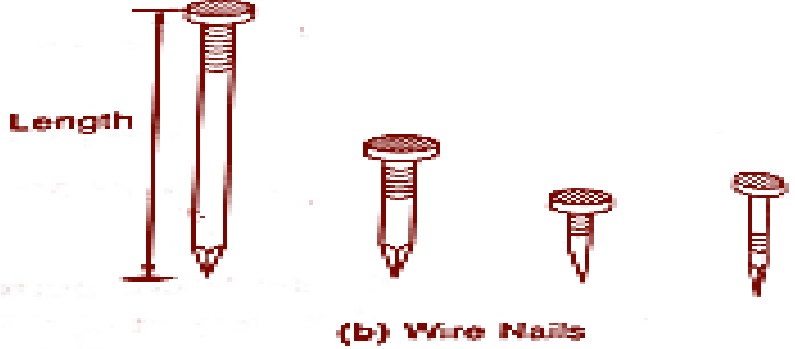
7. Switch Boards :

- Generally, all the switches, sockets, fan regulators, holders for bed lamps etc. are fixed on switch boards.
- These are made of quality wood and are fixed to the.gutties, already provided in the walls by means of screws.
- These are available in different sizes as 10 x 10 cm , 10 x 20 cm ' 20 x 15 cm, 30 x 25 cm etc.
- Now-a-days these are provided with different colours of decolum sheets for attraction purpose.

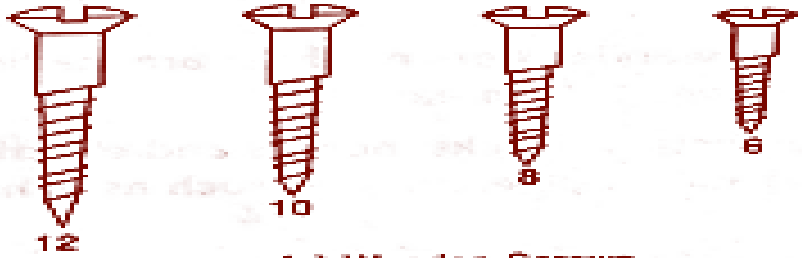
Dr.K.Eswaramoorthy



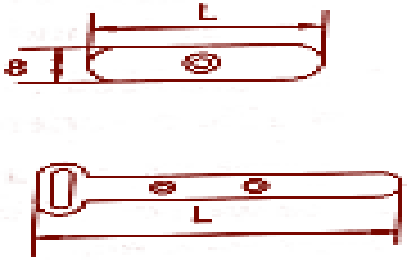
(a) Wooden Batten

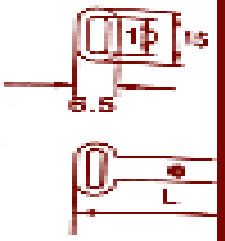


(b) Wire Nails

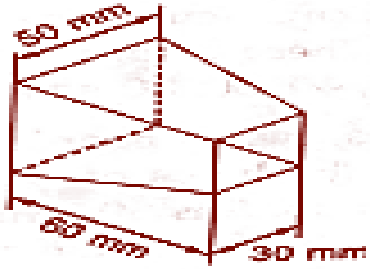


(c) Wooden Screws

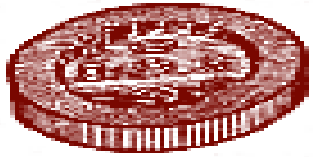




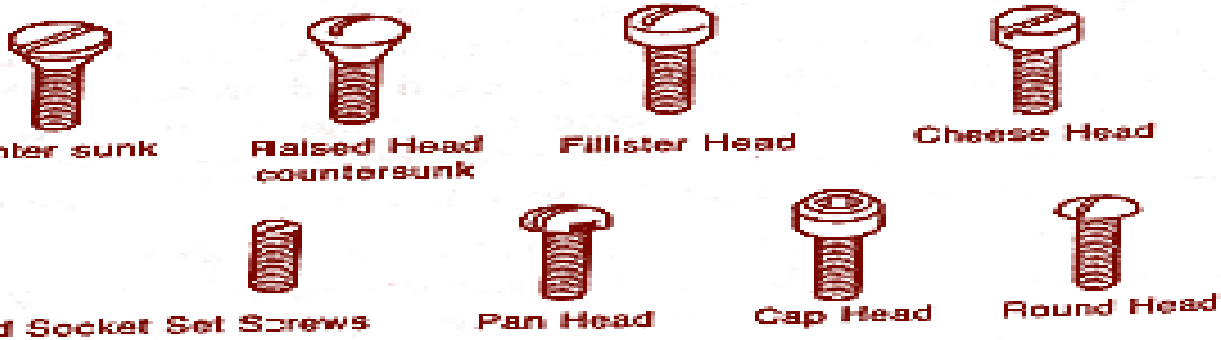
(d) Link-clips



(e) Wooden Gutties



(f) Round blocks



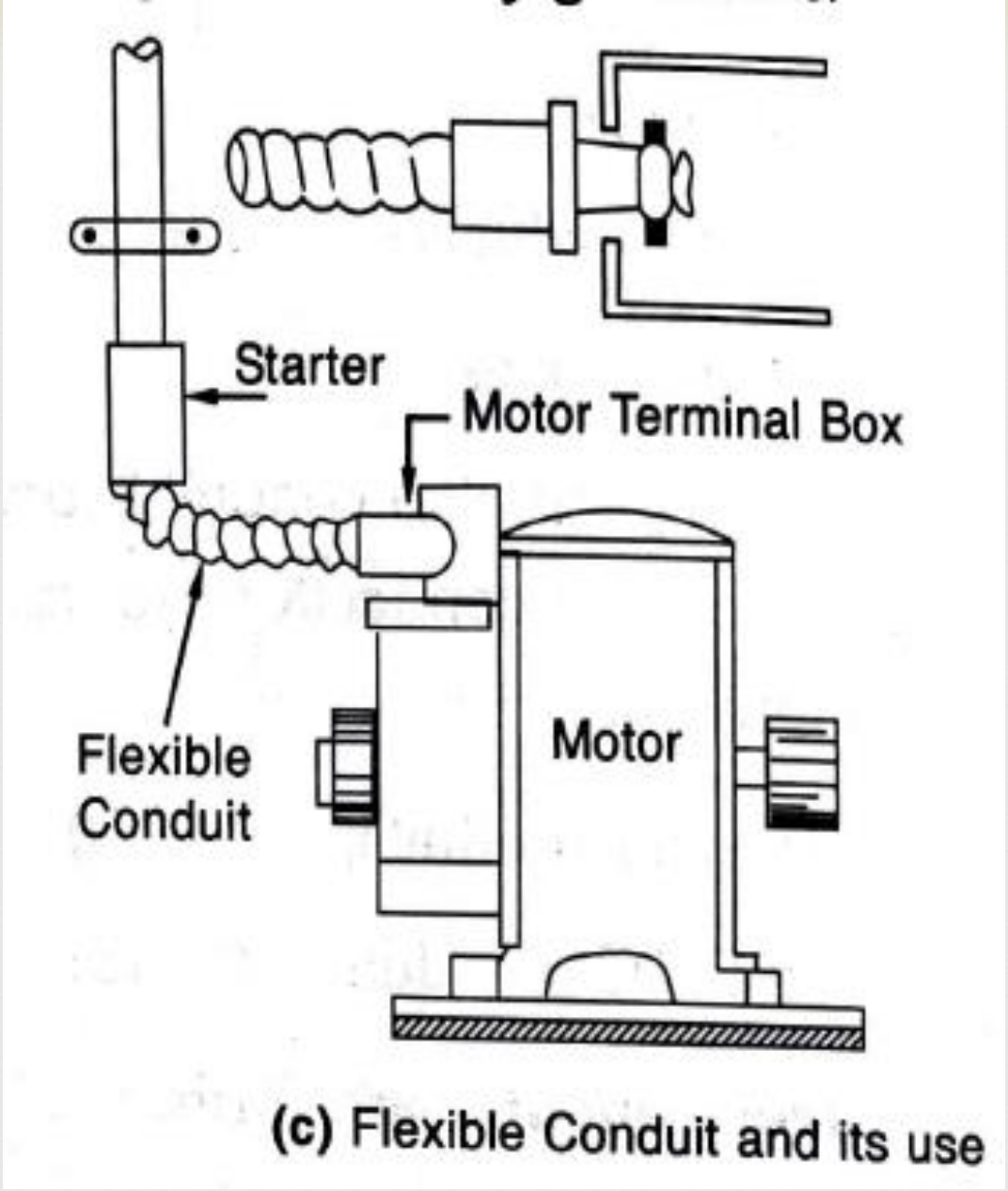
(g) Machine Screws

7.7 CONDUIT WIRING ACCESSORIES

- For installing conduit wiring the following accessories are required.
- (i) Conduits
- (ii) Conduit bends
- (iii) Elbows
- (iv) Tees
- (v) Couplings
- (vi) Conduit bushings
- (vii) Conduit reducers
- (vii) Saddles
- (ix) Conduit boxes

- 1. Conduits : In general, a conduit is defined as a tube or channel in which the wires are drawn for making connections to various electrical accessories. The most commonly used conduits are
- (a) Rigid steel conduits, (b) Flexible steel conduits
- (c) Rigid P.V.C. conduits, (d) Flexible P. V. C. conduits
- **Rigid steel conduits** are further divided into Light gauge conduits and Heavy gauge conduits.
- Light gauge conduits are made of thin sheet steel.
- Threading cannot be done over these pipes, due to less thickness.
- Heavy gauge conduits are either solid-drawn or welded together.
- Threading can be done over these pipes.
- These are available in different sizes with an external diameter of 12, 16, 19, 25, 31, 38 and 50 mm.
- Rigid steel conduits are used for surface conduit wiring

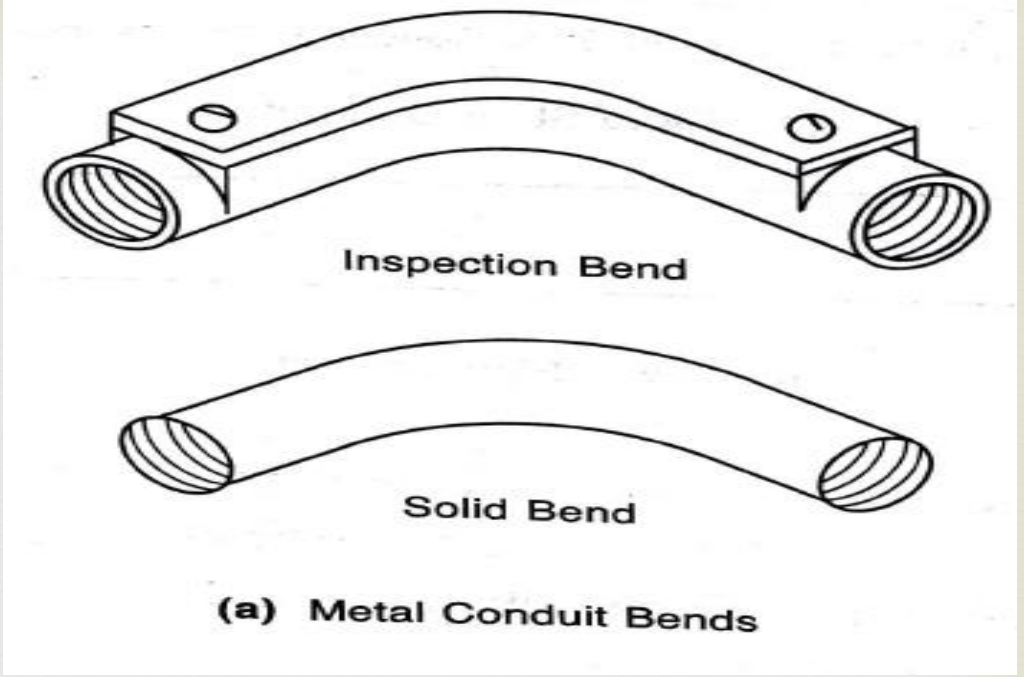
- **Flexible steel conduits** consists of light gauge galvanized steel strip spirally would to form a tube.
- These are used for protecting cable-ends connected to a vibrating machine.
- These are available in different sizes from 19 mm to 50 mm diameter and in lengths of upto 250 meters.
- As it can bend easily, no elbow is required.
- ·Now-a-days P.V.C - . conduits have got wide applications in wiring installations , because these can be moulded to any required shape easily.
- These are light in weight, shock proof, acids alkali and corrosion resistant. These are used for surface or concealed conduit type o f wiring P.V.C conduits are suitable for hm1ted temperature range.
- Beyond 60 deg-c P.V.C conduits starts melting and at very low temperatures they get cracks.
- **Flexible P.V.C. conduits** are used when rigid conduits cannot be used e.g. near the terminal box of motors, generators, transformers etc.
- These are costlier than rigid conduits. P.V.C. conduits (rigid & flexible) are available in lengths upto 250 meters with an external diameter of 19 mm to 50 mm.
- All types of conduits are shown in Fig



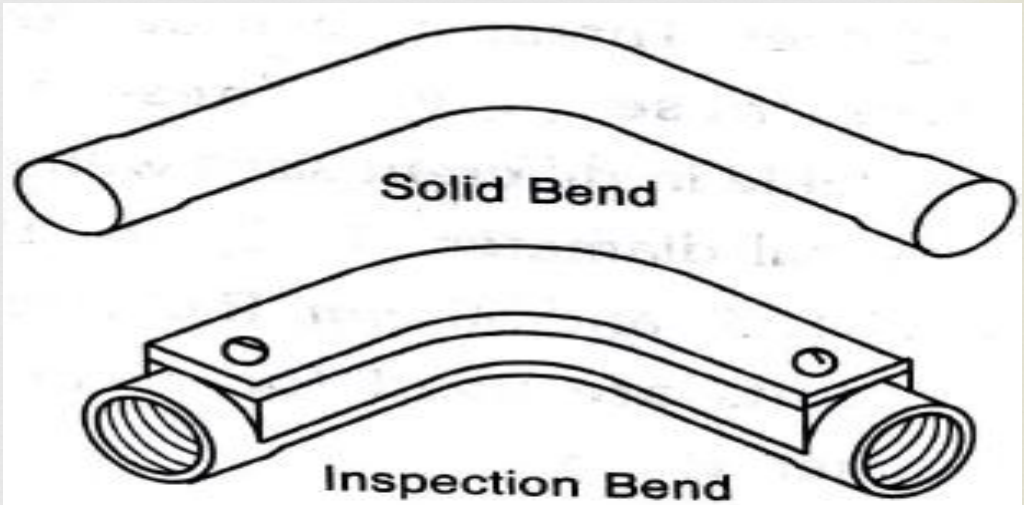
(c) Flexible Conduit and its use

2. Conduit Bends

- These are generally used for change in direction of conduit.
- In practical conduit can.be bent on the job, but for neat and quick work a conduit bend is employed.
- These may be either solid type of inspection type as 'shown in Fig.
- By the use of inspection type, the wires can be drawn and inspected whenever required.
- These are available according to the sizes of the conduits.



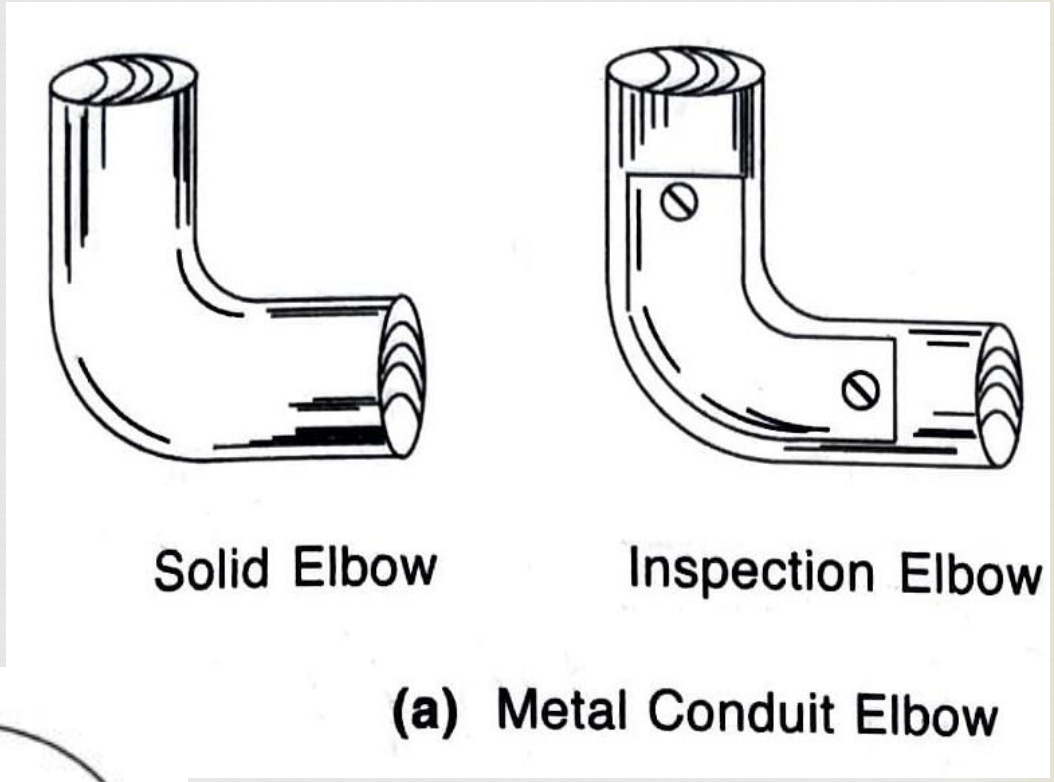
(a) Metal Conduit Bends

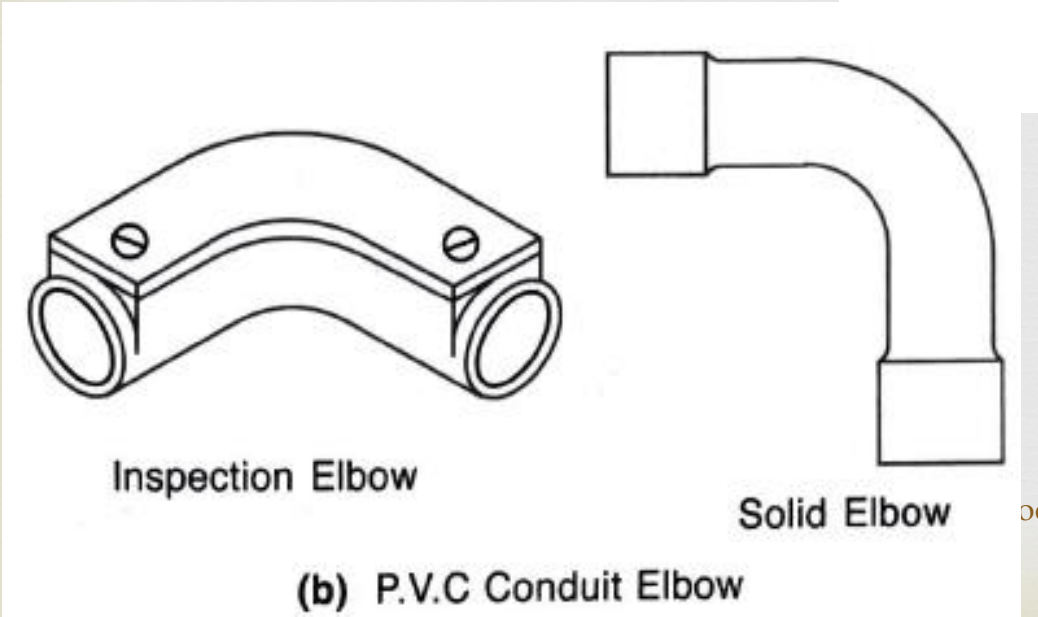


(b) P.V.C. Conduit Bends

3.Elbows

- These are used where sudden turn is required, for example at sharp ends, where the conduit bent at 90° ·
- These may be either solid type or inspection type as shown in Fig.





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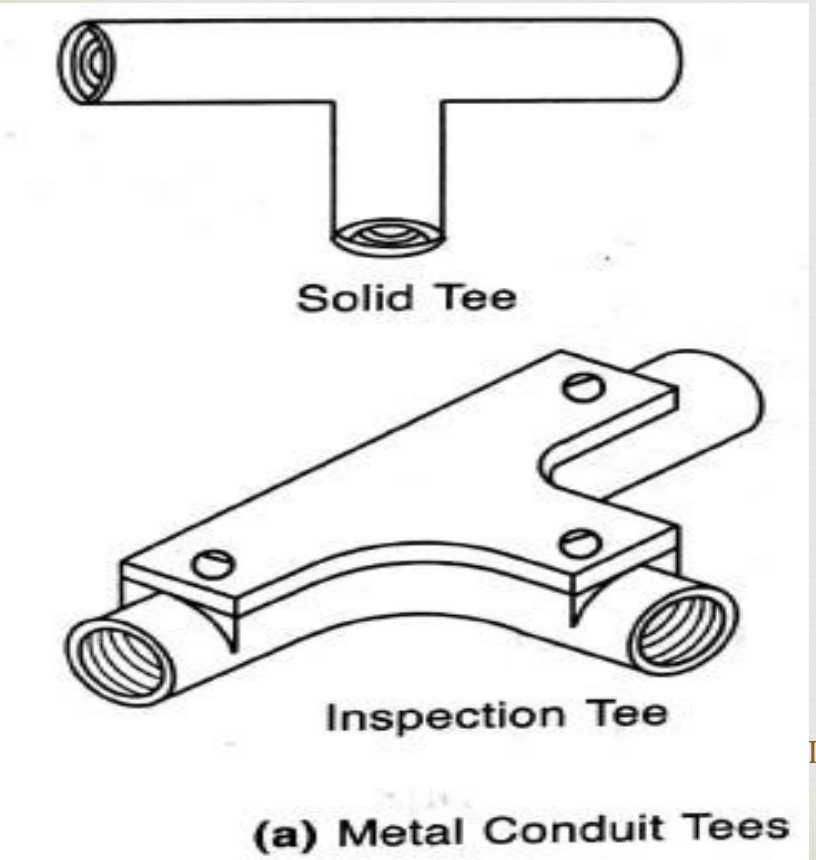
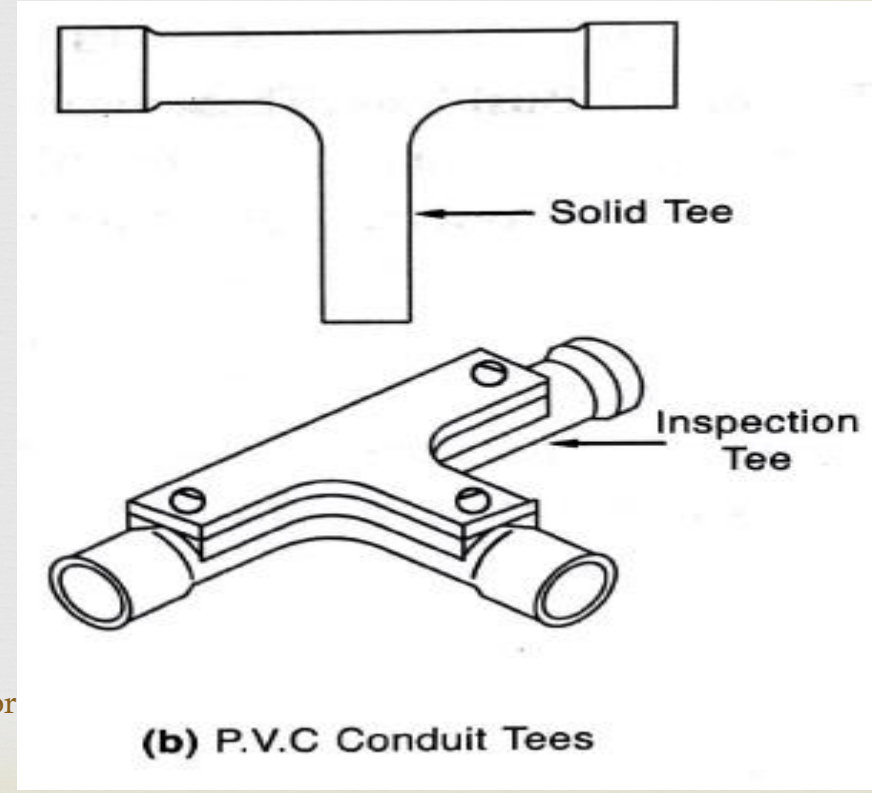
5. Tees

- Tees are used to take diversion form the main line either to drop to switch points or to the light points.
- These are used at the end of the conduit run.
- Inspected type Tees, facilitate, pulling of cable and providing inspection facility whenever needed. These are available according to the diameter of conduits and are shown in Fig.



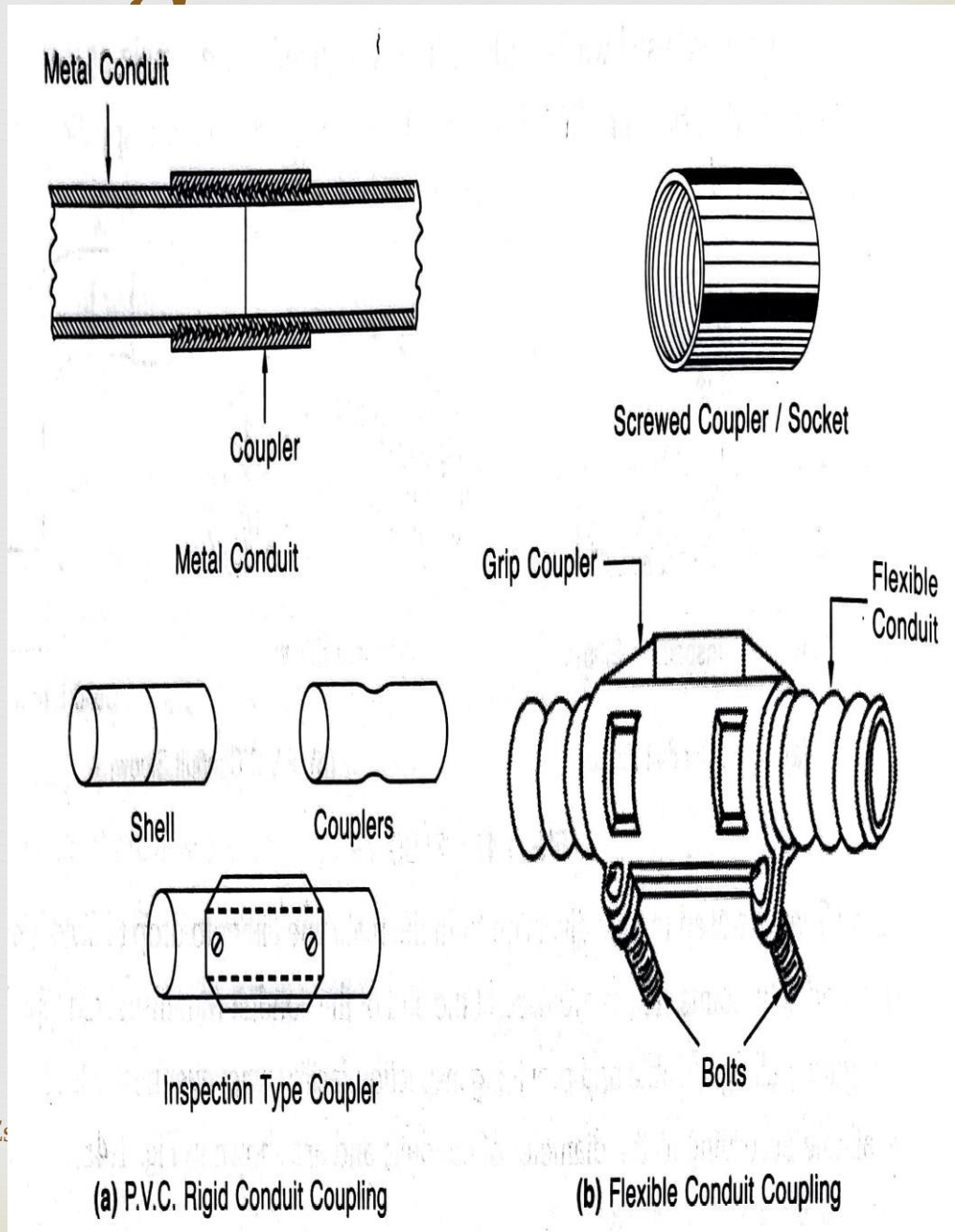
(a) Metal Conduit Tees



(b) P.V.C Conduit Tees

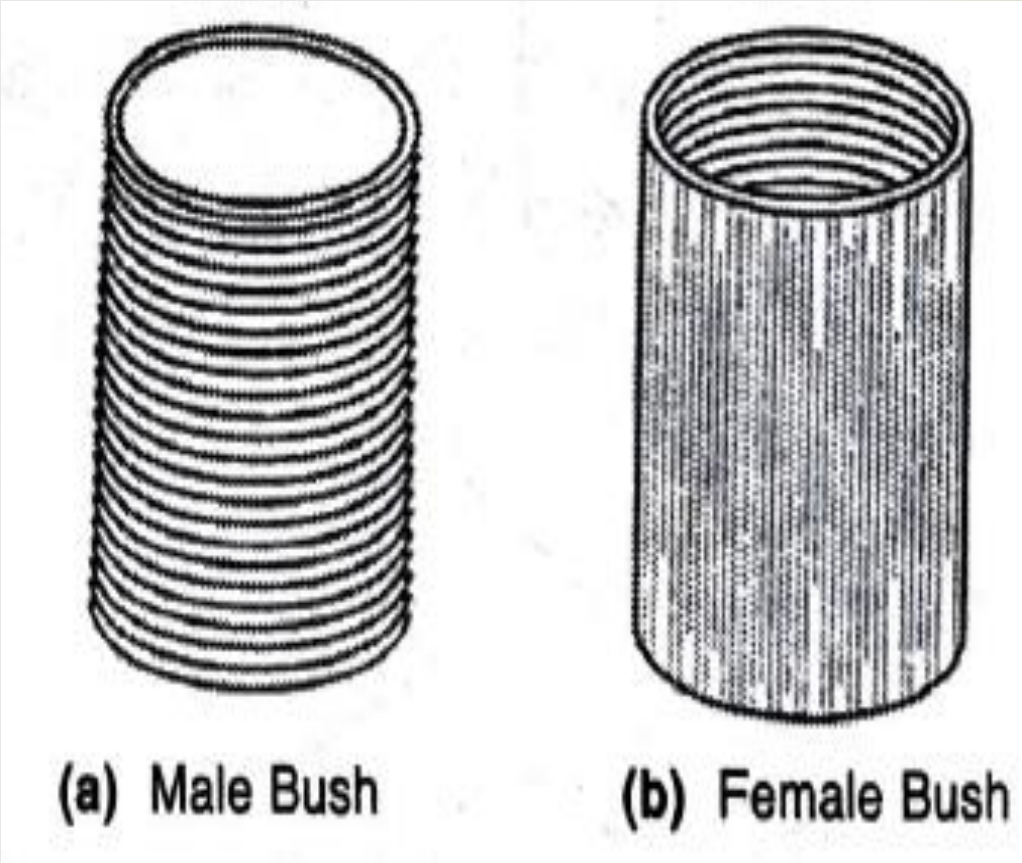
6. Couplings

- These are used to join two lengths of conduits or to couple two pipes together.
- Couplers are threaded on its inner surface to which the conduits are tightened and are shown in Fig. (a).
- The flexible conduits are joined by means of Grip coupler as shown in Fig. (b).
- Normally, P.V.C. conduits are joined by means of push-type coupler.
- The conduit shall be pushed right through to the interior of these couplers.
- These may be either solid or inspection type.



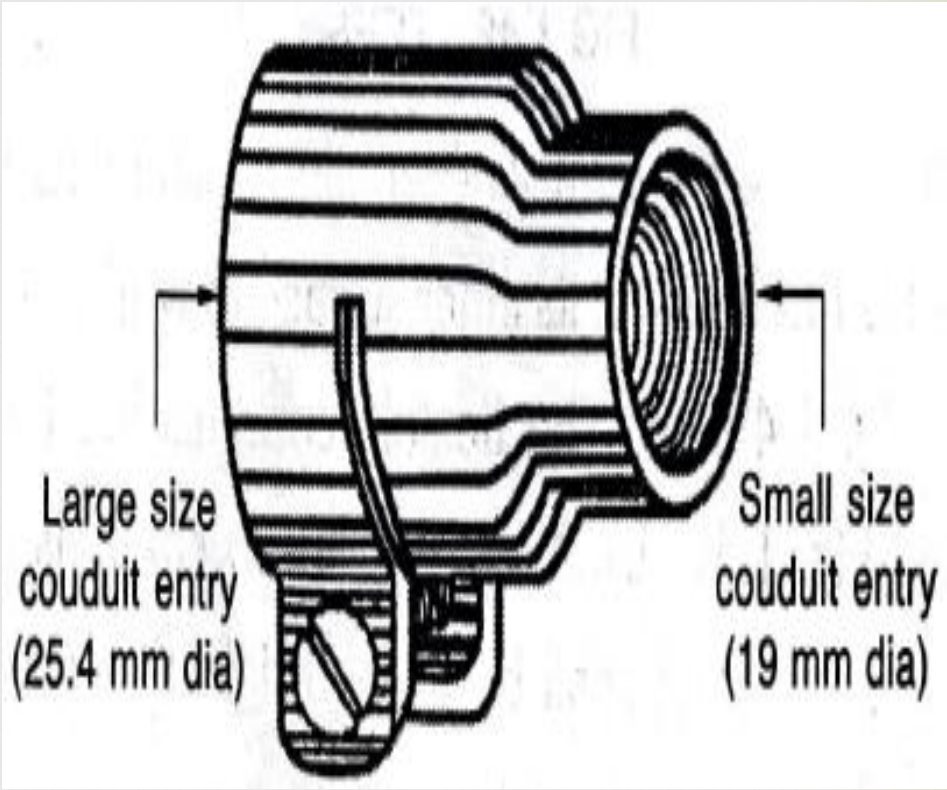
7. Conduit Bushings

- These are used, when the rigid conduit enters the conduit box or when the conduit enters a hole which is not threaded and is made of iron or steel.
- These are two types male and female.
- Male bushings are provided with threads on upper surface and female bushes are provided thread on inn.er side as shown in fig.



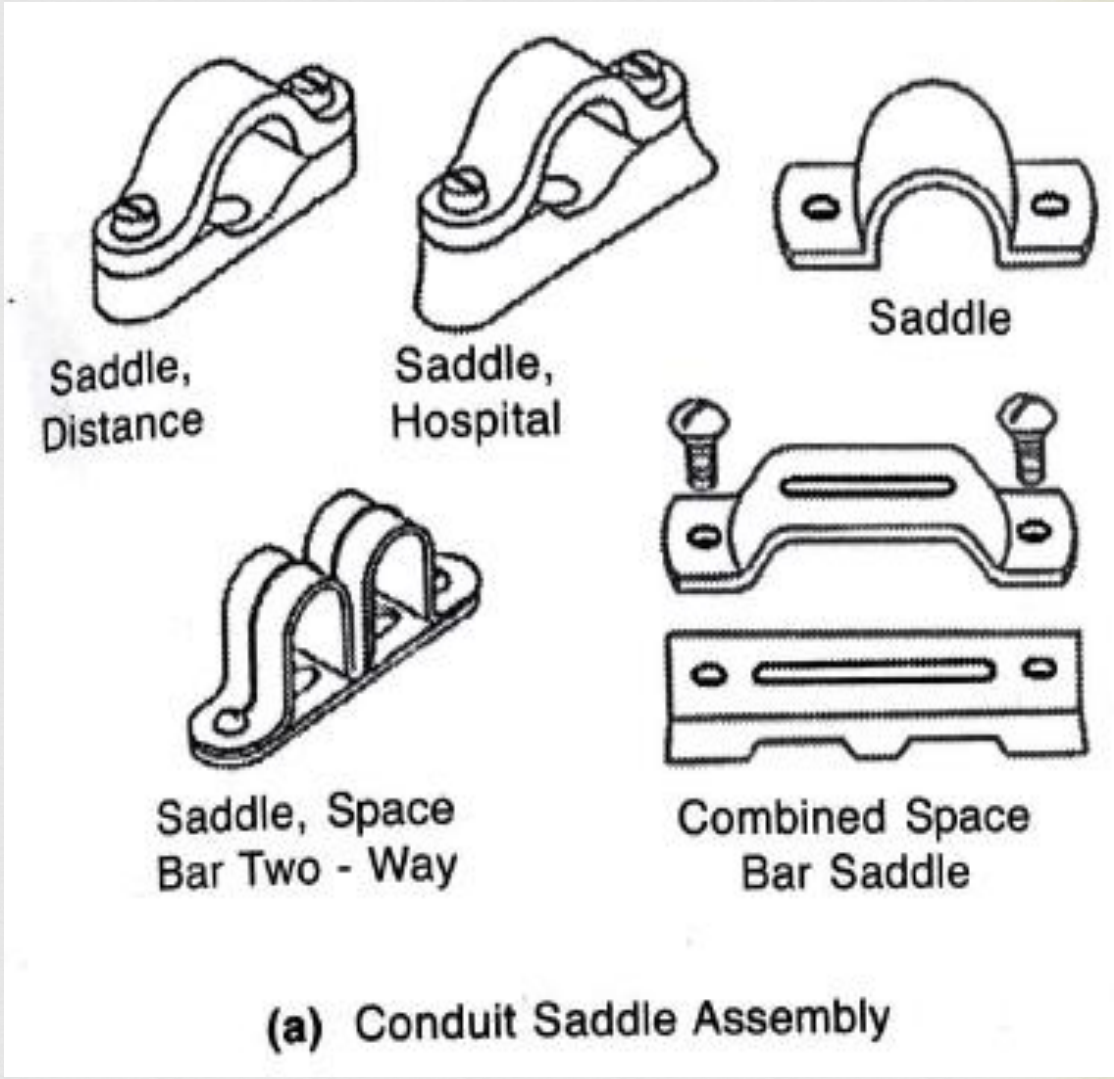
8. Conduit Reducers

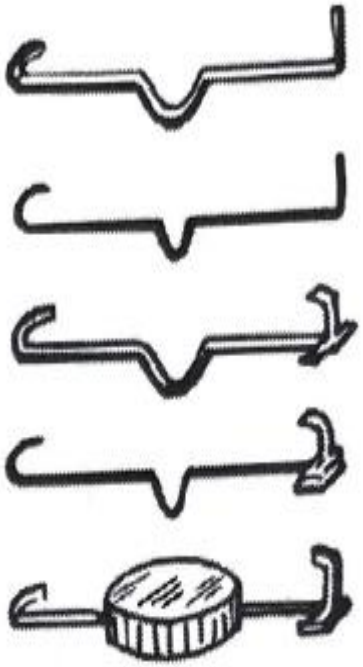
- These are sued to join two different sizes of conduits.
- Fig. shows a conduit reducer which changing 25.4 mm conduit pipe to 19 mm conduit pipe.
- In practice the size of the conduit used in domestic installation is not changed.



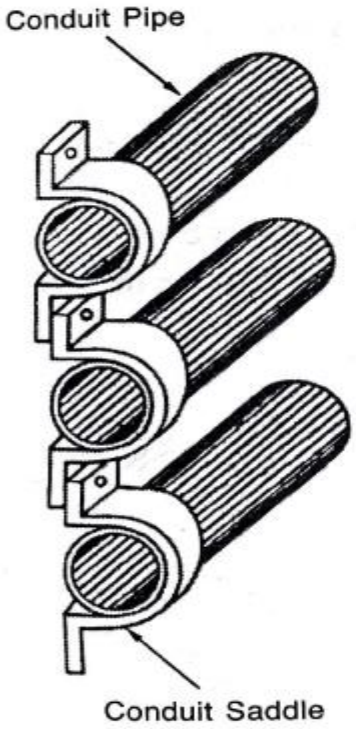
9. Saddles

- These are used to fix conduit pipe on the surface of the wall.
- These are made from sheet steel.
- Saddles have one or two holes through which screws are tightened ·
- These are also called as clamps, conduit straps.
- These are available in different sizes according to the size of the conduits.
- Multiple saddles are used if two or more lengths of conduits run together as shown in Fig.

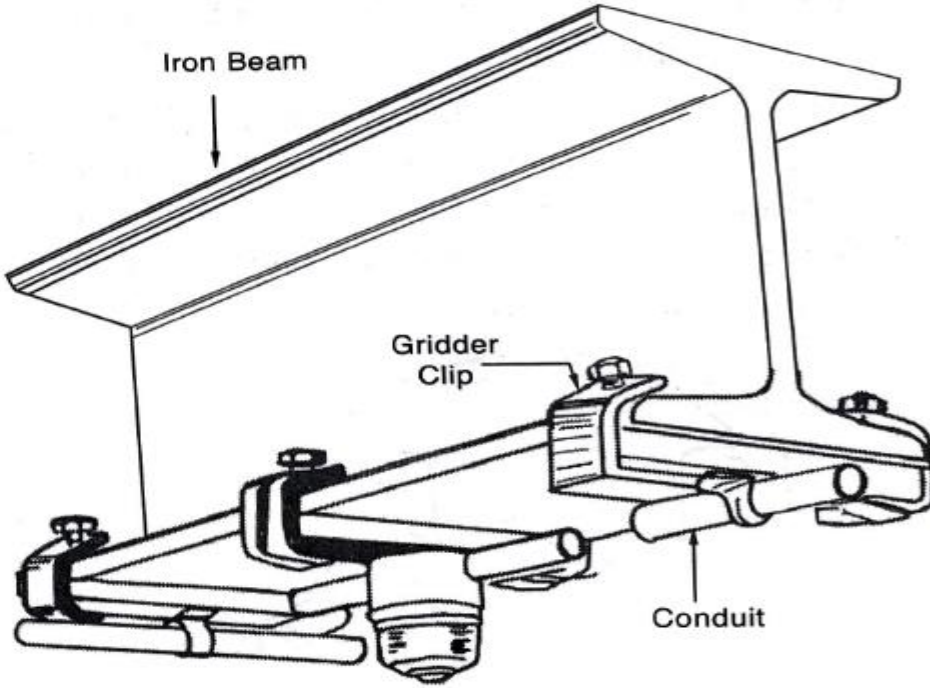




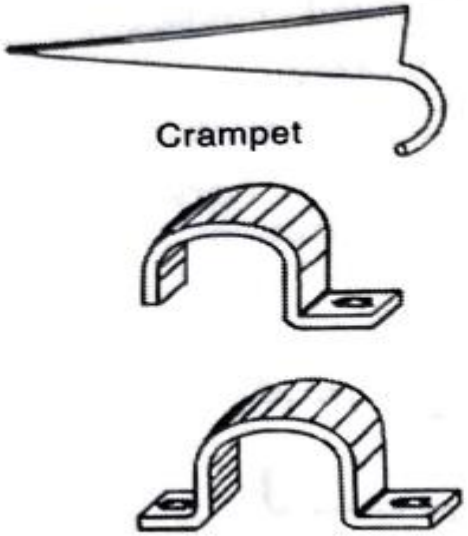
(b) Girder Clips for Conduits



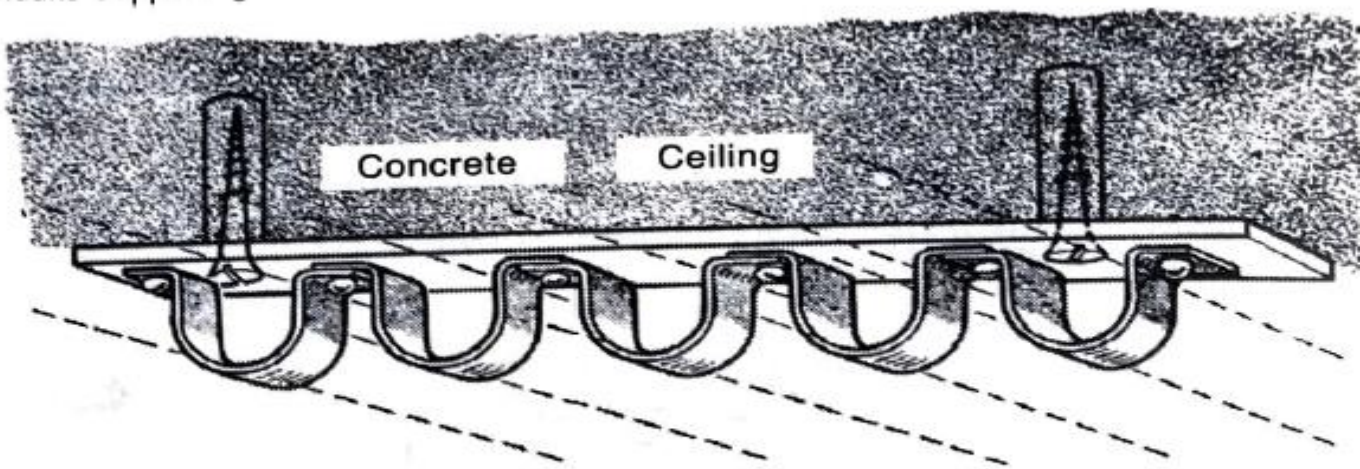
(c) Conduits Supporting With Saddles



(d) Fixing of Conduits with Girder Clamps/Clips



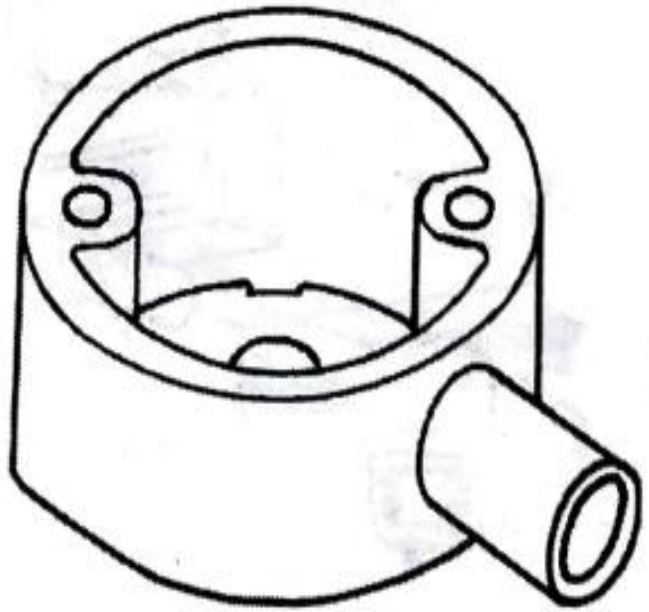
(e) Two Hole & One Hole Saddle



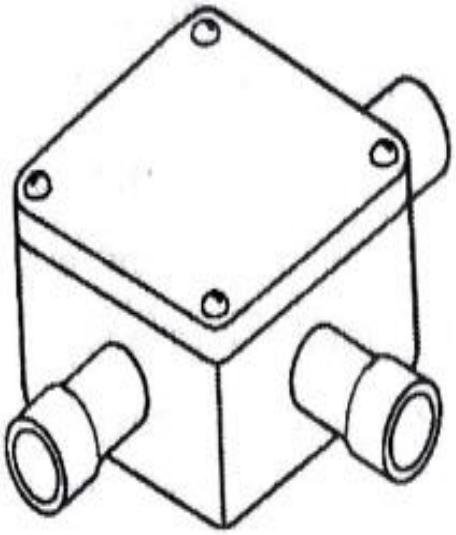
(f) Assembly of Saddles on Ceiling

Conduit Boxes

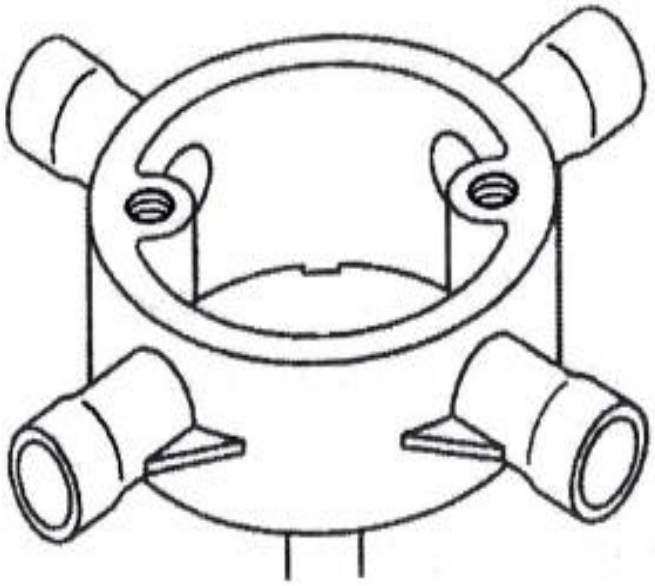
- These are used to join a number of conduit pipes comes from different directions.
- These are used for several purposes.
  - (i) To provide connections for lights, fan, heater etc. The conduit box used for this purpose is called outlet box.
  - (ii) To facilitate the pulling of conductors in the conduits. The box serving this purpose is called Inspection box.
  - (iii) To house the junction of cable joints. The box used for this purpose is called junction box.
- These are provided with a cover held by screw on it, so it can be opened to draw thewires and inspect the joints.
- These are available in different shapes as round, square rectangular, hexagonal etc.
- These may be one-way, two-way, three-way or four-way Some times the switches and other accessories are also be fixed over the conduit box as shown in Fig.



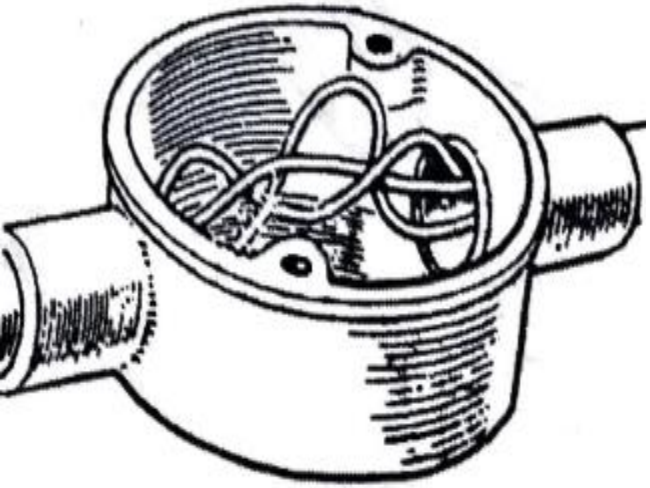
(a) One-way



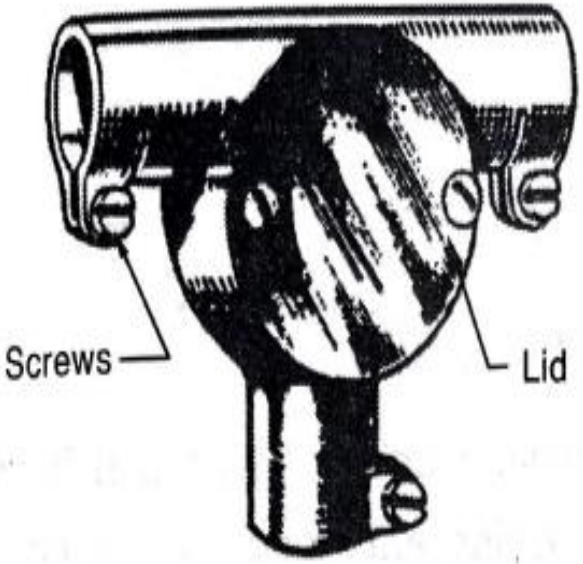
(c) Three-way



(d) Four-way



(b) Two-way



(e) Tee box with grip

(f) Junction box with holder

1.8 SAFETY ACCESSORIES

- The accessories which are used to provide safety to the electric circuit and the electrical appliances are called safety accessories.
- One of such a safety devices is a Fuse.
- The fuse was originally invented by Thomas Alva Edison in 1880 and being considered as the weakest link in the electrical circuits.
- **1.8.1 FUSE**
- A Fuse is a safety device used for the purpose of protecting an electrical circuit against excessive current.
- The fuse is a small piece of metal wire connected between two terminals mounted on an insulted base.
- It is always connected in series with the circuit.
- In the event of excessive current (due to short-circuit or over-load etc.), the fuse element melts and open up the circuit, thereby protecting the circuit or appliance from damage.

1.8.2 - PRINCIPLE OF OPERATION

- The operation of fuse depends upon the heating effect of an electric current.
- Obviously, the heat is produced in a conductor, if it carries current and the heat produced is proportional to the square of the current

$$H \alpha I^2$$

- Hence, the heat produced in fuse element is proportional to the square of current flowing in the circuit.
- Generally, the fuse wire has low melting temperature, which is made of either lead-tin alloy or tinned copper wire.
- In normal operating conditions, the fuse carries the normal current safely without heating.
- But, when t h e current exceeds the normal current, the heat produced will increase.
- If this temperature increases above the melting point of the material of the fuse wire, it melts and breaks the circuit.
- In this way fuse protects a machine or apparatus or any installation from damage due to excessive current.

8.3 FUSE ELEMENT MATERIALS

- **The material used for fuse element should possesses the following characteristics.**
  - (i) Low melting point. Eg : Tin, lead.
  - (ii) High conductivity. Eg : Silver, copper.
  - (iii) Low cost. Eg : Lead, tin, copper.
  - (iv) Free from deterioration due to oxidation. Eg : Silver.
- In general; no material possesses all the desirable characteristics.
- The materials common used for fuse elements are tin, lead, silver, copper, zinc, antimony, aluminum and alloy of lead and tin.
- An alloy of lead and tin (lead 37 % and tin 63 %) is used for small currents i.e. upto 15 A For currents exceeding 15 A copper wire fuses are used.
- The copper is tinned to provide protection against oxidation. Zinc is used, where a considerable time-delay is required.
- **Now-a-days silver is extensively used as fuse, inspite of high cost due to the following advantages.**
  - (i) It does not get oxidized.
  - (ii) The conductivity is very high.
  - (iii) Its operating speed is fast.
  - (iv) There is no deterioration of material when used in dry air and remains bright.
  - (v) The coefficient of expansion is so small, therefore fuse element can carry the rated current continuously for long time.

8.4 TERMS GENERALLY USED

- The following are the definitions of a few terms commonly used in the study of fuses.
- **1. Fuse :** It is a safety device used for the purpose of protecting an equipment against an excessive current.
- **2. Fuse Element or Fuse Wire :** It is that part of the fuse which melts when an excessive current flows in the circuit and isolates the faulty section from healthy section.
- **3. Fuse-Carrier :** It is a removable part for carrying the fuse element.
- **4. Fuse Base :** It is the fixed part of the fuse, provided with terminals, to which incoming and outgoing wires are connected.
- **5. Current Rating or Rated Current :** The maximum current, which the fuse wire can carry continuously without melting is known as current rating or rated current. It is specified by the manufacturer.

- **6. Fusing Current :** The minimum value of current at which fuse element melts is known as fusing current. For round wire the approximate value of fusing current is given by

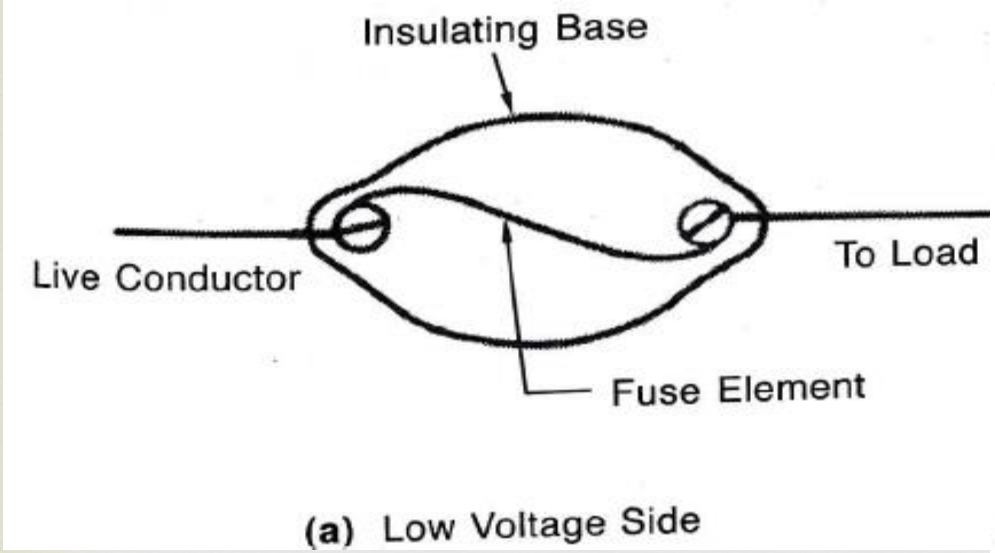
$$I = kd^{3/2},$$

- • Where 'k' is constant, called the fuse constant and 'd' is the diameter of fuse -wire. The fuse constant differs from material to material.
- **7. Fusing Factor :** It is defined as the ratio of minimum fusing current to the current rating of fuse element.

$$\text{Fusing Factor} = \frac{\text{Minimum Fusing current}}{\text{Current rating of fusing element}}$$

8.5 TYPES OF FUSEs

- Fuses can be built in various forms and can be classified into the following types.
- (i) Open type fuse.
- (ii) Semi-enclosed type (Rewirable or Kit-kat fuse).
- (iii} Totally enclosed type (cartridge fuses).
- **1. Open Type Fuse :**
- The fuse which is used in open space is called ***open type fuse.*** In this type of fuse, the fuse element is kept open in the atmosphere.
- Generally, these are used with transmission and distribution overhead lines, on poles for giving supply to the consumers.
- It has two terminals mounted over the insulated base and the fusing element is kept free and open to the atmosphere as shown in Fig. These are connected in series with the load.
- **Disadvantages** : The open-type fuses have the following disadvantages.
- (i) The replacement is not easy,' because one terminal is always. live .
- (ii) The fusing current is not constant, but depends on environment conditions.
- '(iii) In case of fusing, the arc produced may · fall on some articles which may catch fire .



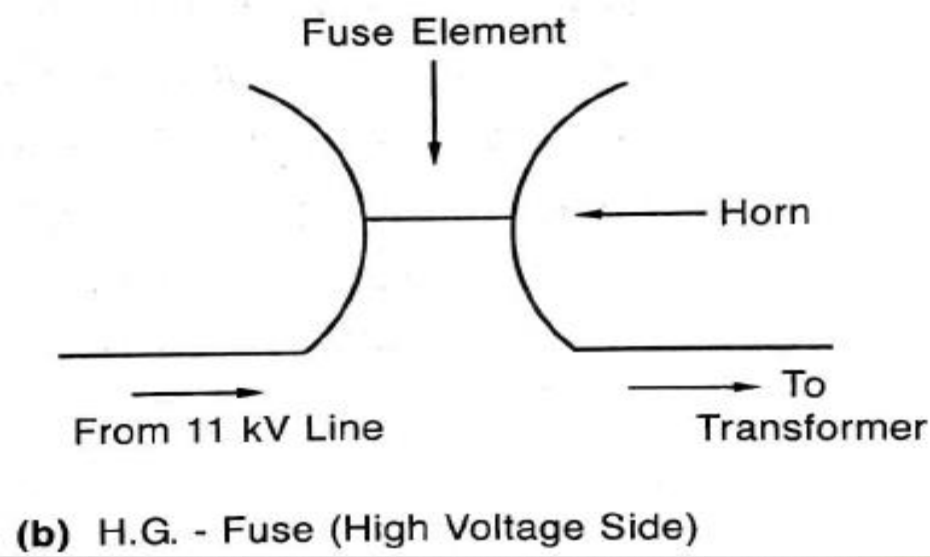


FIG : Open-Type Fuses

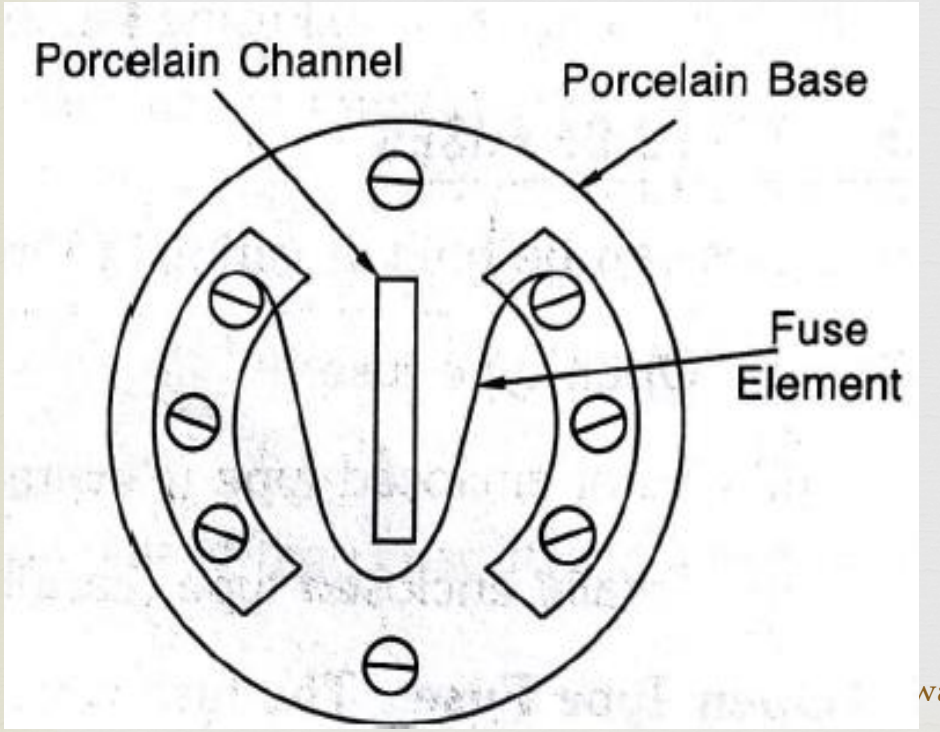


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FIG : Round type Fuse Unit

- **Semi-Enclosed Fuse :** In this type of fuse the fuse element is neither open nor enclosed.
- These are generally used in house wiring Purpose .
- These are of two types namely :
  - (a) Round type fuse unit and
  - (b). Kit-kat or Rewirable fuse .
- **(a) Round Type Fuse Unit :**
- It consists of round pin or bakelite base with two brass connecting plates (terminals).
- The fuse wire is connected between these two -plates through a porcelain channel as shown in Fig.
- This porcelain channel helps in suppression of forming an arc between the two contacts.
- **Disadvantages :** This type of fuse is not in common use due to following disadvantages.
- (i) For replacement of fuse wire , the worker has to touch the live wire or main switch must be opened for such replacement.
- (ii) When the fuse blown off, there is an appreciable arcing will takes place on the screws.
- As, these screws holds the fuse wire, the arc will damage it.
- After two or three arcing the fuse unit will become unstable

- **(b.) Kit-kat or Rewirable Fuse :.** T'his is most commonly used fuse in house wiring.
- It consists of two main parts namely : ·(i) Fuse base and (ii) Fuse carrier.
- **(i) Fuse Base :** It is made of porcelain and is a fixed part of the kit-kat fuse.
- It has two terminals to which incoming and outgoing live or phase wires are connected.
- It consists of one or two holes for fixing it to the wall or wooden boards by means of screws as shown in Fig.
- **(ii) Fuse Carrier :** It is a separate part which holds the fuse element and can be taken out or inserted in the base without risk, even without opening the main switch.
- It consists of two terminals with strips to which fuse element is connected.
- The fuse wire may be lead, tinned copper or alloy of tin-lead.

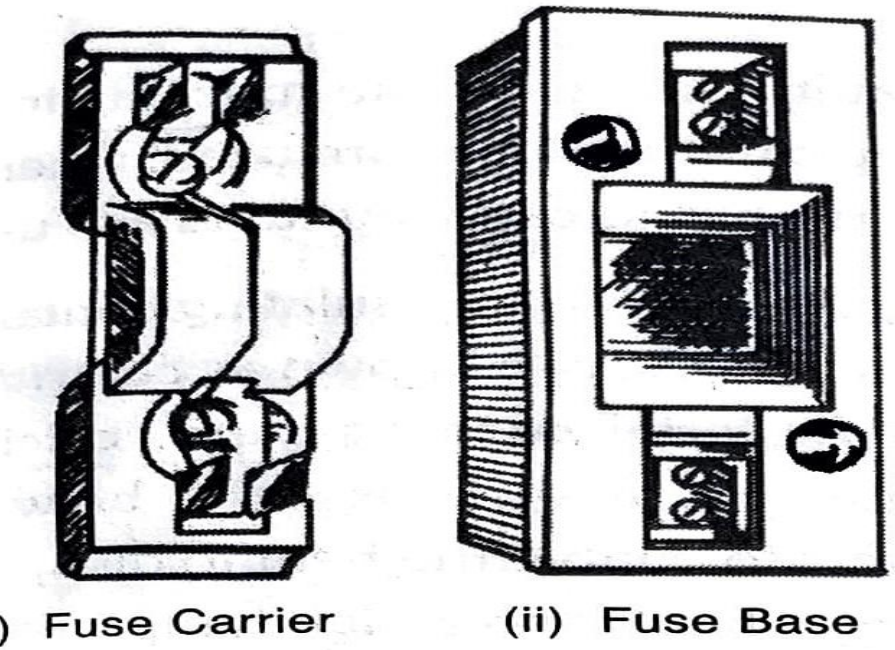

FIG : Kit-kat or Rewirable Fuse

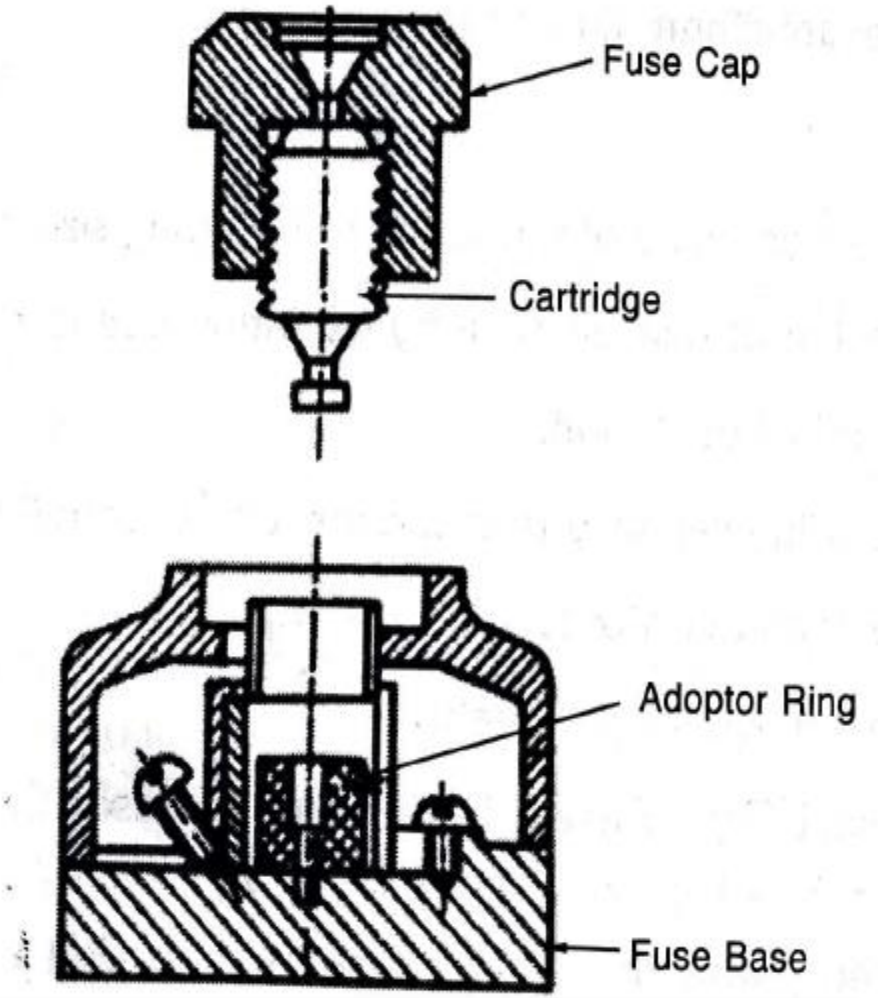

FIG : Diazed or D-Type Cartridge Fuse

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- These are rated according to voltage and current capacity.
- According to voltage these are 250 V and 500 V.
- According to current capacity these are rated as 5 , 15, 32, 63 and 100 A When the fuse element blows off due to excessive current, the fuse carrier is pulled out, the blown out fuse element is replaced by new one.
- The supply is restored by re-inserting the fuse carrier in the base.
- **ADVANTAGES :**
- 1. It is the cheapest form of operation.
- 2. If fuse melts, the · arc does not come out.
- 3. Replacement of fuse element is easy.
- 4. Negligible replacement cost.--
- 5. It requires minimum time to replace.
- **DISADVANTAGES :**
- 1. There is a possibility of replacement of wrong size of fuse element.
- 2 . Deterioration of fuse element by oxidation due to continuous heating.
- 3. Slow speed of operation.
- 4 . Poor rupturing capacity (under short-circuit conditions).
- 5. Accurate calibration of fuse wire is impossible.
- 6. It has no current limiting features.

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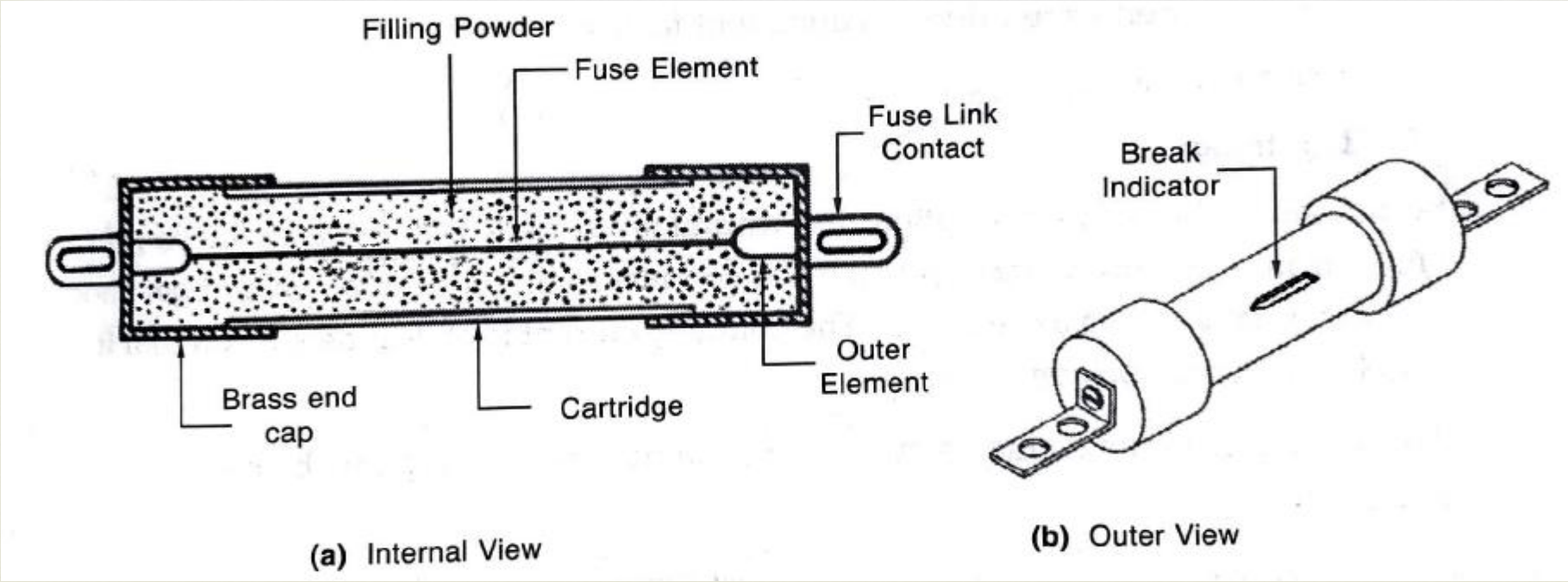
3. Totally Enclosed Type Fuse :

- In this type of fuses the fuse element is completely enclosed in a tube of glass or porcelain or fiber etc.
- As the fusing element does not exposed to atmosphere, the fusing current is controlled and remains constant.
- The best example of this type of fuse is 'cartridge type fuse'.
- **Cartridge Fuses:**
- Cartridge fuses are developed to overcome the disadvantages of the rewirable fuses.
- Cartridge fuses can be classified into two groups.
  - (a) Low Rupturing Capacity fuses. Eg : Diazed or D-type cartridge fuse.
  - (b) High Rupturing Capacity (H.R.C) fuses.
- Rupturing capacity is the ability of a fuse to open the faulty circuit without much arcing or damage to itself.
- For domestic installation, low rupturing capacity fuses are used, whereas for high installations (factory, power station etc.) high rupturing capacity fuses are used .

- **(a) *Diazed* or *D-type Cartridge Fuse* :**
- It essentially consists of an insulating container of bulb or tube shape and sealed at its ends with a metallic cap known as cartridge.
- It has a fuse element and filled with powder material such as sand, calcium carbonate, quartz etc.
- The fusing element generally of silver is fixed between -metallic caps and is made of a number of chambers to enable the heat to dissipate On overloads _or short circuits, the fusible element is heated to a high temperature causing it to vaporize.
- The powder in the fuse cartridge .cools and condenses the vapour and quenches the-arc at the time, of blowing up of fuse.
- When fuse blowing out, it is replaced by a fresh unit as the cartridge cannot be rewired . due to its sealing as shown in Fig.
- There is an index circle which in normal condition is clear or transparent, but becomes blackened in case the fuse blows out, thereby showing the broken circuit. ·
- Some types of cartridges are of rewirable type also .These are fixed in its fuse carrier like the kit-kat fuse .
- These are available with current ratings of 2 to 63 amperes. This type of fuse is commonly used in domestic and industrial electrical installations in many countries.

- **(b) High Rupturing Capacity (H.R.C) Fuses:**
- These are used for clearing extremely heavy fault currents in modern power system.
- **Construction :**
- It is cylindrical in shape and consists of a heat resistant ceramic body having metal end caps.
- Fusible silver current-carrying element is fitted between two caps as shown in Fig..
- The space within the body surrounding the element is filled with a powder.
- The filling material may be chalk, plaster of paris or quartz and acts as arc quenching and cooling medium.
- **Operation :**
- During normal load conditions, fuse element carries normal current, the heat developed is quite bearable and fuse will not blow.
- But, on the occurrence of fault, a heavy current flow through the fuse element and element is thus heated upto 'its melting point. When the melting process is completed, an arc is formed .
- The chemical reaction between silver vapour and filling powder tends to establish high resistance substance which helps in quenching the arc.
- H.R.C. fuses can open a short-circuited circuit within 0.013 second. It has an indicator to show the fuse has blown.
- Their rupturing capacity is as high as 500 MVA and used upto 66 KV and above. They are available from 1 A to 400 A current rating.

- **ADVANTAGES :**
- 1. They are capable of clearing high as well as low fault currents.
- 2. They do not deteriorate with age.
- 3. The operation is quick and reliable.
- 4. They require no maintenance.
- 5. They are cheap as compared with other interrupting devices of equal breaking Capacity
- **DISADVANTAGES :**
- 1. They have to be replaced after each operation, hence costly in operation.
- 2. Heat produced by the arc may affect the associated switches.



9. SAFETY PROCEDURES

- Electricity is used the world over.
- Without electricity , life will become miserable.
- Though the advantages are plenty, there are also dangers while using electricity particularly when not safely handled.
- Many accidents take place while using electricity which is due to several reasons. One of the reason is we are neither able. to see electricity flowing is a wire nor able to hear the same.
- The other reason is familiarity and overconfidence that nothing bad will happen.

1 REASONS FOR FIRE ACCIDENTS IN ELECTRICAL SYSTEM

- The following are some of the reasons due to which human being may be subjected to electric shock.
  - 1. Touching a bare live conductor.
  - 2 . Touching a poorly insulated conductor.
  - 3. Open or short circuit due to equipment failure .
  - 4. Static electricity.
  - 5 . Lightning. . . .
- Some people have misconception that. with high voltage say 66kv or 110kv) if one jumps from the ground and holds the live conductor, the individual will not get shock
- This is a .totally wrong assumption. The charging current itself will be so high that it will result in severe shock and death. .
- The effects of various current strength on human body are given below (current in milliamperes).
- Comparing AC and *DC* from safety point of view, *AC* is more dangerous.
- Even 20 volts *AC* may result in fatal accidents. 3 times *DC* is equal to *AC* in effect.
- Currents through the body in the frequency range of 20 to 100 Hz are very dangerous, since ventricular fibrillation starts.
- *AC* produces ventricular fibrillation every cycle, whereas *DC* produces only once, that is at the time of making contact with the live conductor.

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S.No.	Effect of Electric Shock	Direct Current in milliamperes		A.C. 50 *Hz* to 60 *Hz* in milliamperes	
		Men	Women	Men	Women
1.	Slight sensation on hand	1	0.6	0.4	0.3
2.	Perception threshold	5.2	3.5	1.1	0.7
3.	**Shock :** Not Painful, muscular control not lost	9	6	1.8	1.2
4.	**Shock :** Painful, let-go threshold	76	51	16	10.5
5.	**Shock :** Painful and severe, muscular contractions, breathing difficult.	90	60	23	15
6.	**Shock :** Possible ventricular fibrillation effect from a 3 second shock might result in death.	500	500	100	100

1.REASONS FOR FIRE ACCIDENTS IN ELECTRICAL SYSTEM

- In electrical installations, the fuse is always connected into the live wire (L)- and never into the neutral (N).
- When the fuse is placed in live wire (phase), if the-.current in the circuit exceeds the rated value due to over-load or short-circuit, the fuse automatically melts and breaks (open) the circuit and causes no damage to human being.
- Suppose let the fuse is connected in neutral as 'shown in 'Fig..
- Due to over-loads or short-circuit, even though the fuse blown out, the appliance still getting supply directly from phase wire.
- If a person opens the appliance, he will get a shock.
- Some times due to failure of, insulation the leakage current may pass to the body of the appliance.
- If the appliance is not earthed and as and when the person touches the appliance, the leakage current passes through the person and gets electric shock.
- Hence to avoid above dangerous/damages to human being the fuse is always connected in live wire (phase) but not in neutral.

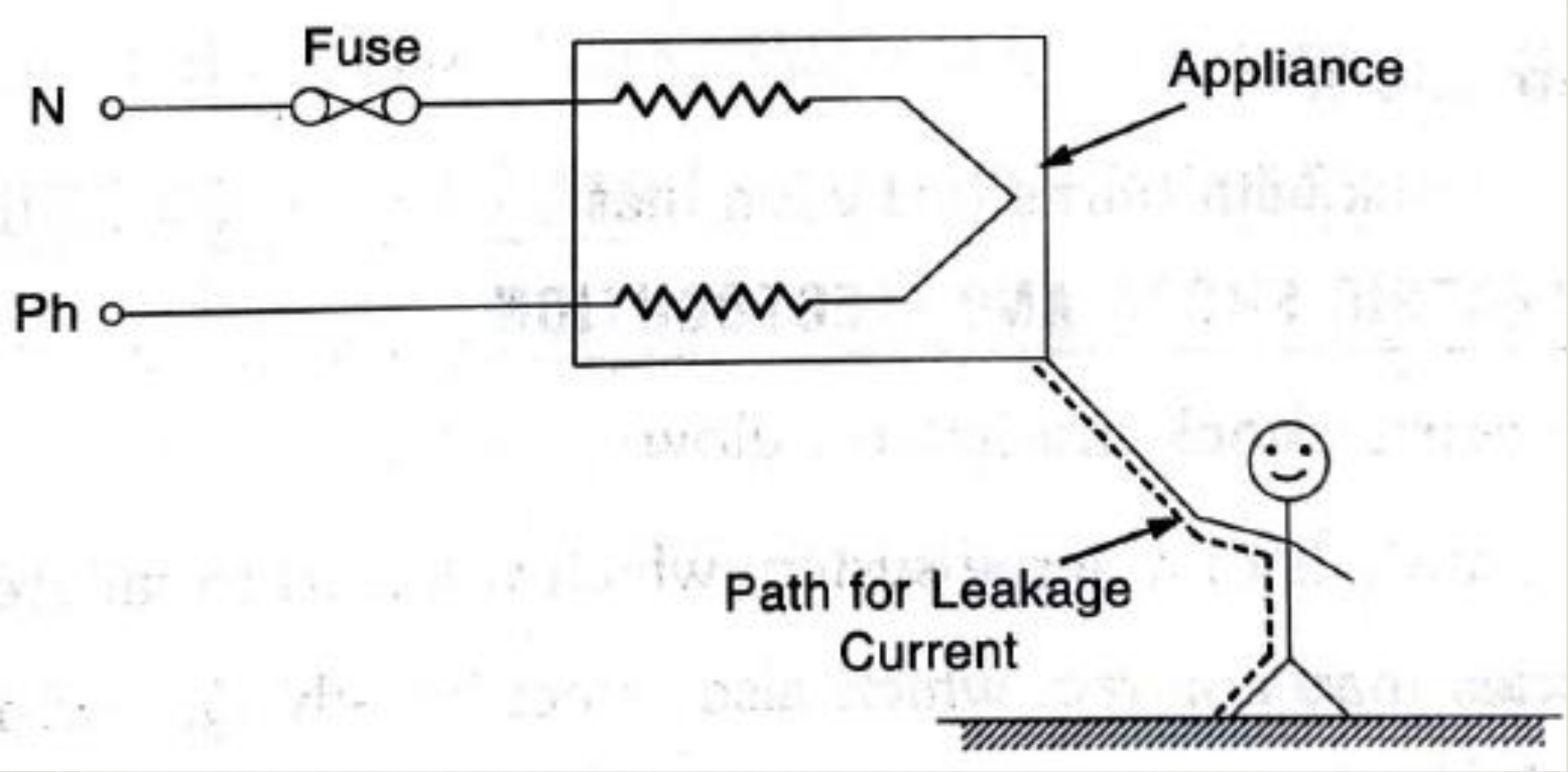

FIG. ,FUSE IN NEUTRAL WIRE

ELECTRIC SHOCK

- Electric shock is a Jarring, shaking sensation resulting from contact with electric circuits or from the effects of lighting.
- Electric shock is sudden (unexpected) and it stimulates the body's nervous system.
- When a shock is experienced by anybody it is because of current passing through the body.
- When a current passes through the body, the effect is involuntary muscular contraction.
- If it is of low intensity, the victim is able to release himself from the source of contact.
- If is high, the victim cannot release himself from the source of contact.
- If the chest becomes the path of the current, the muscles which control breathing will get paralysed.
- The victim may still be in contact with the power supply, and may be in an unconscious state.
- If someone else touches this victim in order to save him, that person will also get a shock or even get electrocuted ..
- Many times multiple deaths have taken place because of a single electrical accidents.
- Electric current passing through the chest may make the heart muscles inactive and pumping action of blood may stop temporarily.
- This is known as ventricular fibrillation, which results death oftenly.

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- While doing work directly with electric supply or machines or appliances using electricity, the person may.
- 1. Get a mild shock ·
- 2. Get a severe shock
- 3. Get a sever shock with burns (or) even dies

1.EFFECTS OF ELECTRIC SHOCK AND ELECTOCUTION

- The effects of electric shock are listed below.
- 1. Temporary paralysis of a nerve system which will lead to failure of breathing.
- 2. Chest muscles may contract which also affect breathing, and if this continuous
- death will result.
- 3 . Normal rhythm of the heart will be, affected, causing ventricular fibrillation. Due to fibrillation of heart, i.e., damaging the heart to small pieces causing the stopping of breathing.
- 4 · Due to stopping of breathing action caused by. blockade in the nervous system respiration.
- 5 . Sometimes breathing has stopped, but heart may continue to beat. This condition cause the . face to appear blue colour.
- 6 . Depending on the strength of the electric current, body may burns either superficial or deep.

- The fibrillation of heart is the most serious cause of death and there is no cure.
- The injury from the shock is less severe if current does not pass through nerve centres and vital organs.
- In many accidents, the victim can be saved if artificial respiration is immediately applied to the victim.
- This artificial respiration should be continued until the victim revives or until a qualified doctor comes to the victim.
- The seriousness of the electric shock is dependent upon the following factors :
  - 1. The contact area of the body with the supply wire or appliance.
  - 2. The contact pressure with the supply wire or appliance.
  - 3. The path of current through the body.
  - 4. Whether it is *AC* or *DC*.
  - 5. Wet or dry condition.
  - 6 . The duration of time in contact with the wire or appliance.
  - 7 . Mental stress at the time of accidents.
- The shock may also result in burns. Sometimes due to a flash over also, the person may be subjected to severe burns. Black skin may completely be turned to white .

PROCEDURE OF FIRST - AID IN CASE OF ELECTRIC SHOCK

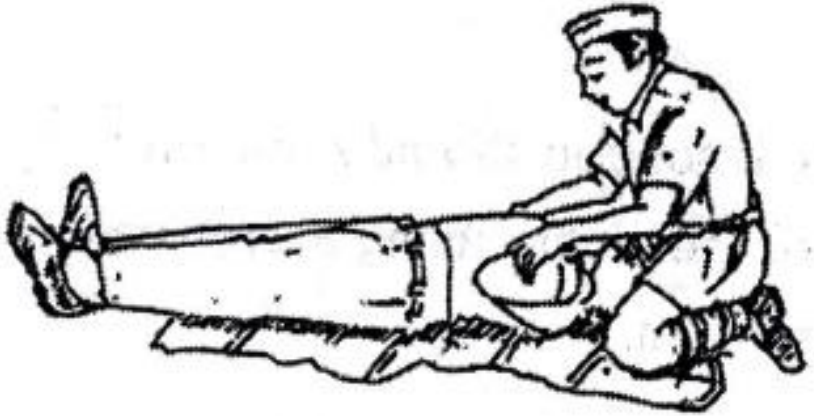
- We do not know when we will come across an electrical accident to some body, may be at home or office or industry.
- It is always better and necessary to know how to give first aid to such victims before arranging to send the victim to the doctor.
- Removal of Victim from Supply :
- The victim if found fallen on the ground or in sitting position in an unconscious state always suspect that the victim is still in contact with the electric supply.
- In an anxious state never touch the victim .
- The event of such a mistake you will also fall into the trap.
- Ascertain whether the victim is still in contact.
- If so, you should stand on a dry wooden plank and remove the victim, otherwise, pull the victim using a dry rope or coconut matting or stick.
- If possible stand on a rubber mat.
- Checking the Victim : Check whether the victim is still breathing send a massage to bring the doctor.
- If apparently the victim is not breathing, give FIRST AID till the doctor arrives to give further treatment.

METHOD - I

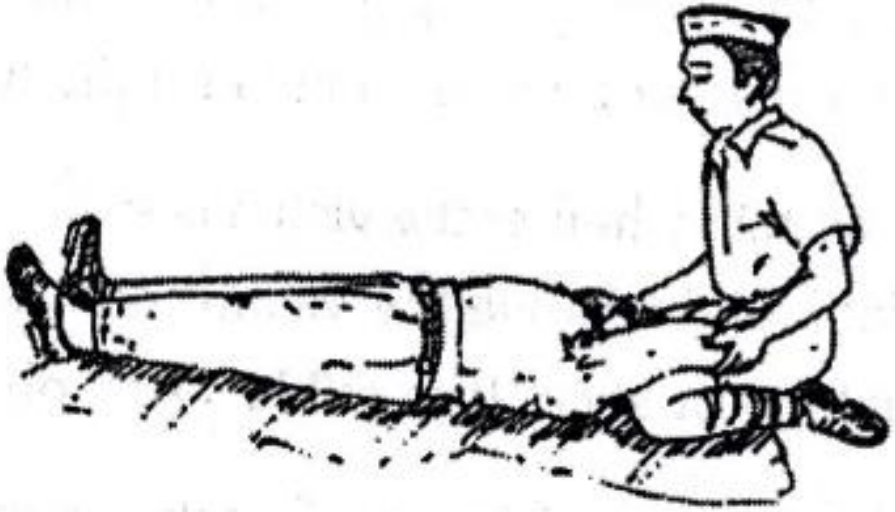
- Keep the victim as shown in Fig. (a) with the face downwards.
- Kneel over the victim 's back placing both the hands on the patient's back near the lowest rib such that the fingers are spread ·outwards while the thumbs of both the hc:1nds almost touch each other and are parallel to the spine.
- Rock yourself gently forward, keeping your arms straight pressing slowly for about seconds as shown in Fig (a).
- Now slowly release the pressure and come to the kneeling position.
- Repeat this process at the rate of about 15 times a minute.
- The purpose is to expand and contract the victims lungs and cause breathing.
- Continue this operation till the natural breathing is re-established. it 'may take a long time i.e. , 31 minutes or even one hour to get the expected result.
- If the victim starts breathing, it is better to synch(once your actions until the victim breaths strongly.
- In some cases it so happens that the victim after a temporary recover of respiration, again stops breathing. It is therefore, very' much necessary to check the, breathing of the victim continuously, and-if natural breathing stops, artificial respirator should be given as explained above.
- Caution : It is important that an unconscious victim should never be given a m drink.

(a)

(b)



(c)



(d)

- **METHOD** – II
- Alternatively, if it is advantageous to place the victim on his back, do so, and loosen his cloths around the chest and stomach. Place a pillow under his shoulders.
- The aim is to make his head fall backwards.
- Draw his tongue forward and proceed as follows .
- You should kneel in a position as shown in Fig. (c).
- Hold the victim just below his elbows and draw his arms over his head until they are horizontal to the ground.
- Keep them there for about 2 seconds. Bring the patients arms down on each side of his chest, pressing inwards up so as to compress his chest.
- Keep the arms in this position atleast for 2 seconds.
- Repeat the above two positions at the same rate. It is always better if we draw out the patients tongue during each lung inflating (inhalted position) stroke (Fig. (c) and release it during each lung deflating stroke (exhaled position as in Fig. (d).

- **METHOD · Ill : (MOUTH TO MOUTH RESUSCITATION)**
- This is very good method and is becoming very popular.
- The procedure is as follows :
- Place the patient, so as to lie on his back. If. there is some foreign matter like tobacco, chacolate etc., in the mouth, remove it, this :will make the air passage clear.
- Step 1 : Open the airway of the patient by lifting his neck with one hand while your other hand tilts his head back and down as far_ as possible such that the chin points upwards (Fig. (a)).
- Step 2 : Pinch the nostrils (nose) to prevent air leakage. Maintain the open airway by keeping the-neck elevated (Fig. (b)).
- Step 3 : Seal your mouth tightly around the victims mouth and blow the air in . The patients chest should rise (Fig.(c)) .
- Step 4 : Remove your mouth. Release the patients nostrils. Listen for air escaping from the patients lungs . Watch for the patients chest to fall.
- Steps 2 , 3 and 4 make one · breathing in - breathing out cycle.
- Repeat this cycle by following steps 2, 3, and 4 at 12 to 15 times a minute.
- Continue until medical help arrives or breathing in the victim is restored.
- For young ones (infants) cover the entire mouth and nose with your mouth.
- Use small puffs of air about 20 times per minute.

(a)

(b)

(c)

(d)

Estimation of Lighting and Power Loads

UNIT – II

UNIT – II
Estimation of Lighting and Power Loads

- Introduction, types of service mains, selection of service main, selection of system wiring, drawing a wire/cable through a conduit, list of electrical materials & their approximate rates, problems on internal wiring scheme, wiring layouts of a office building, work shop, industry,/cement factory/sugar factory, hotel with a 4-storied with lift arrangement, estimation of power load, single line diagram, types of wiring system, size of cable/wire, materials used in power wiring and their rates, estimation of irrigation pump sets, submersible irrigation pump sets, material used in irrigation pump sets.

Introduction

- Estimation means to determine the quantity of various materials required to execute a job and to assess the cost of the execution.
- Before taking the work in hand for execution, it becomes necessary to chalk out a list of quantity of various materials, its cost and labour involved for the completion of the work satisfactorily.
- Thus estimation consists of two parts :
- 1. Preparing list of various materials involved and
- 2. Calculating the cost of materials and labour cost involved for executing the work.

- The quantity and specification of various materials required for installation work written in a tabular form is called schedule of materials.
- Before estimating the quantity of materials and their cost, it is need to prepare building plan on a suitable scale and mark electrical points, switch boards, main board, meter board, distribution board etc. on the plan using specified symbols.
- The path of wiring showing connection to each point is marked by a little thick line.
- An important principle in the selection of symbol is that, as far as possible, they should be self explanatory and easy to draw.
- Sometimes, the conditions which are not specified in the question may be assumed conveniently.
- Ex : Location of main switch board, switch boards, height of building etc.

1.WIRING SYSTEMS

- A network of wires/ cables connecting various electrical accessories for distribution of electrical energy from the supplier meter board to the number of electrical energy consuming devices such as lamps. Fans, T.V, refrigerator and other domestic appliances through controlling (switches) and safety (fuses, MCB etc.) devices is known as “Wiring System”. ,
- The supply used in houses for lighting and power purposes is single phase supply(for industries three-phase A.C. supply is employed).
- The single phase circuit is connected across 220/230 volts, across one phase and neutral.

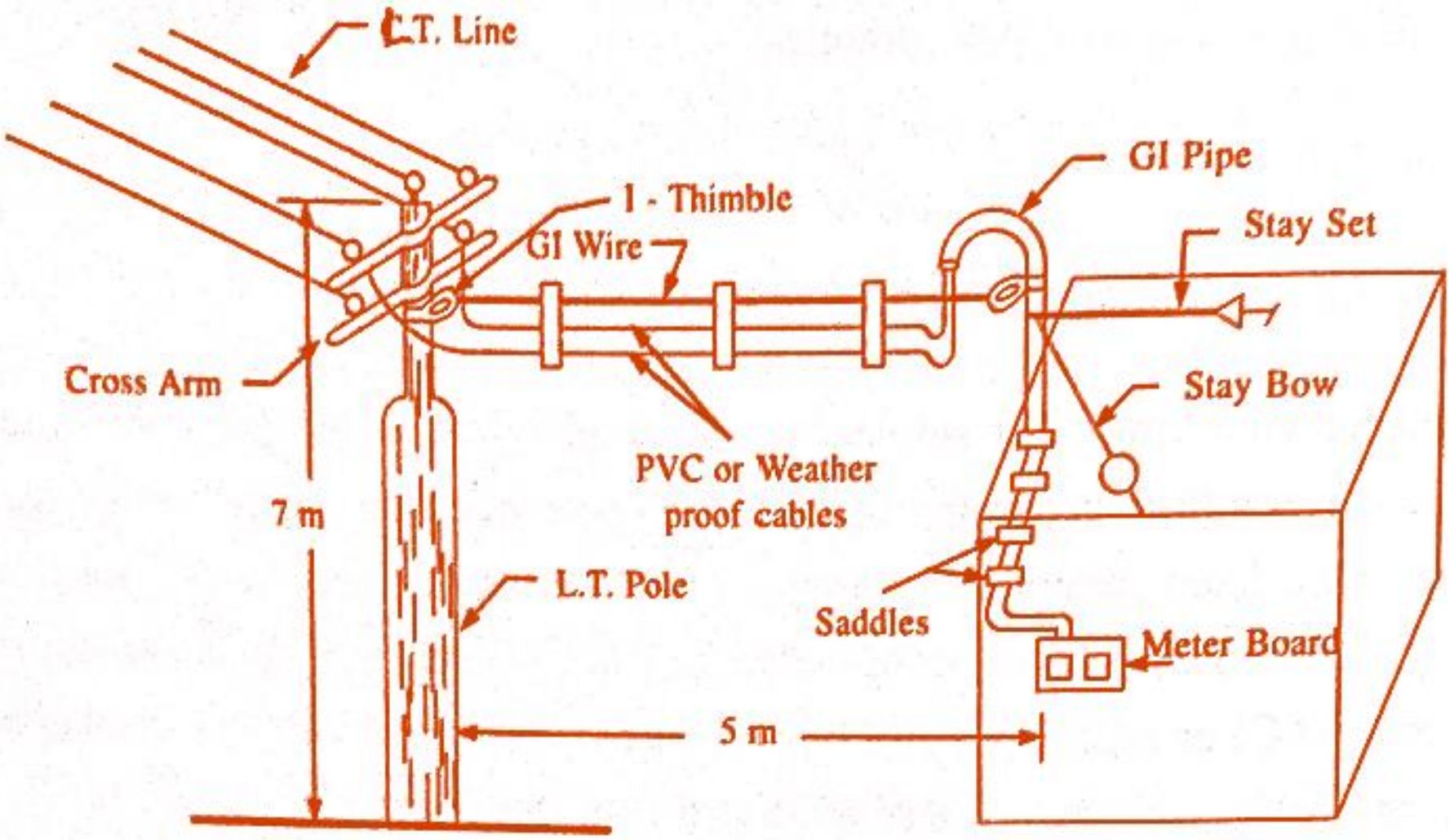
2. TYPES OF SERVICE MAIN (SERVICE LINE)

- The line or cable that brings electric energy from the supplier's distributing lines to the consumer's premises is known as service line or service connection or service main.
- Service lines are of two types namely :
  - (i) Overhead service line.
  - (ii) Underground cable service line.
- **Overhead Service Line :**
- The service line provided above the ground level is known as overhead service line.
- When the service line is provided with the help of an overhead line, it must be fixed minimum clearance above the ground and a definite clearance must be provided from the adjacent buildings.

- For overhead service line All Aluminium Conductor (AAC) or ACSR or Hard drawn copper of different sizes are used according to the load of the consumer.
- These are again sub divided into :
- (a) Weather proof service line and (b) Bare conductor service line.
- **Underground Cable Service Line :**
- The service line provided below the ground level is known as Underground service line.
- This type of connection is used where it is not possible to provide overhead service line and where it is necessary to improve the beauty of the building.
- Low tension 31/2 core cable is used for underground service line.
- It is preferred when the power to be supplied to the consumer is above 25KW.

3. SELECTION OF SERVICE MAIN

- The selection of type of service line depends upon the conditions and given situations.
- Different service lines and the various methods used for installation are discussed below.
- For Overhead Service Line : The various methods for installation of overhead service lines are given below.
- **(a) Weather Proof Cable Method :**
- This method is most commonly used for domestic, commercial, offices etc where the distance between distribution line or L.T pole and consumer premises is less than 40 meter.
- A G.I. wire of 8 SWG is stretched between service pole and G.1 pipe which is raised above the roof.
- The weatherproof (or PVC) cable is then brought to the building by clipping it to the G.I wire as shown in Fig. 2.1 (a) Whether proof cable can withstand against atmospheric conditions like temperature, rain, dust etc.

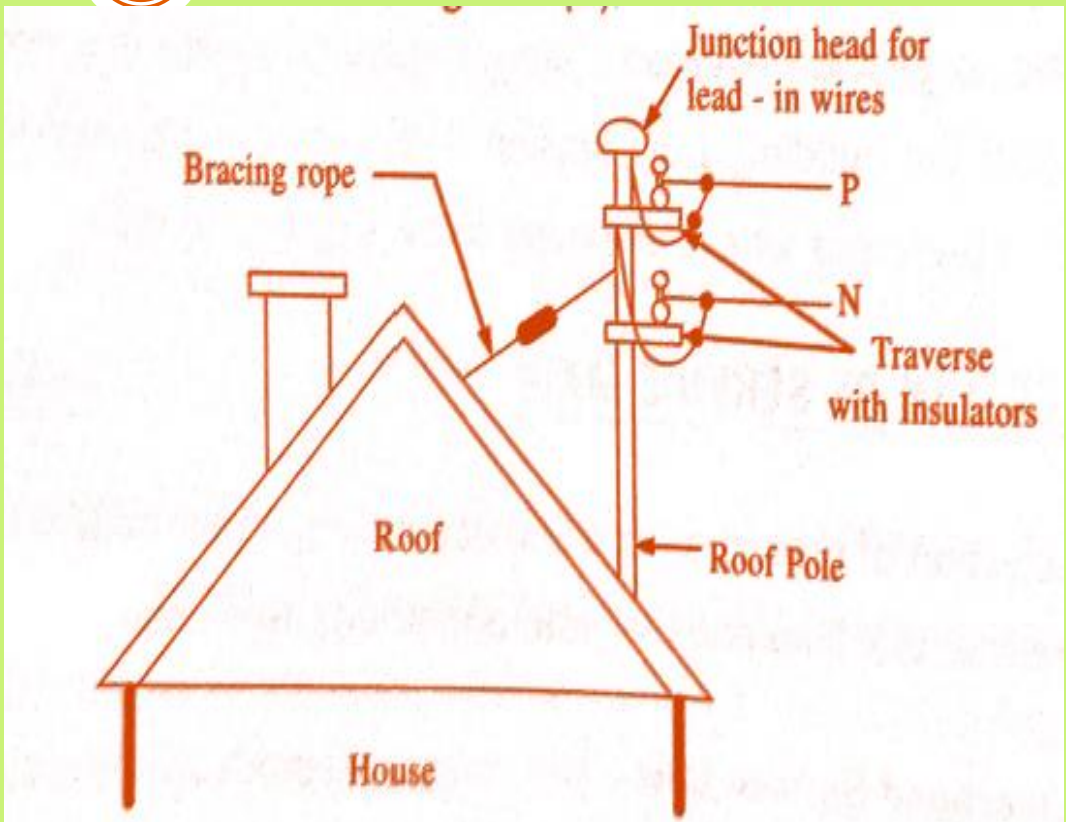


(a) Weather Proof Cable Service Connection

Fig 2.1 :

(b) Roof Pole Connection for Low Roof Buildings

- If the height of the building is very low, service bracket cannot be fixed to the walls of the building.
- In such situations a roof pole is provided with cross arms for fixing insulators to which conductors are fixed as shown in Fig. 2.1 (b).



(b) Roof Pole Connection

Fig 2.1 :

(c) Bracket Pole Connection with Bare Conductor Service Line

- This method is used where it is not possible to use weather proof cables i.e. Where the distance of distribution lines or nearest L.T pole is more than 40 m.
- In this method a bracket is embedded into a wall at a suitable height with pin or shackle type insulators.
- The bare conductors are brought form nearest LT pole and connected to the insulators.
- Now weather proof cable (or PVC cable)are connected to the bare conductor and carried through G.I pipe upto the meter board as shown in Fig. 2.2.

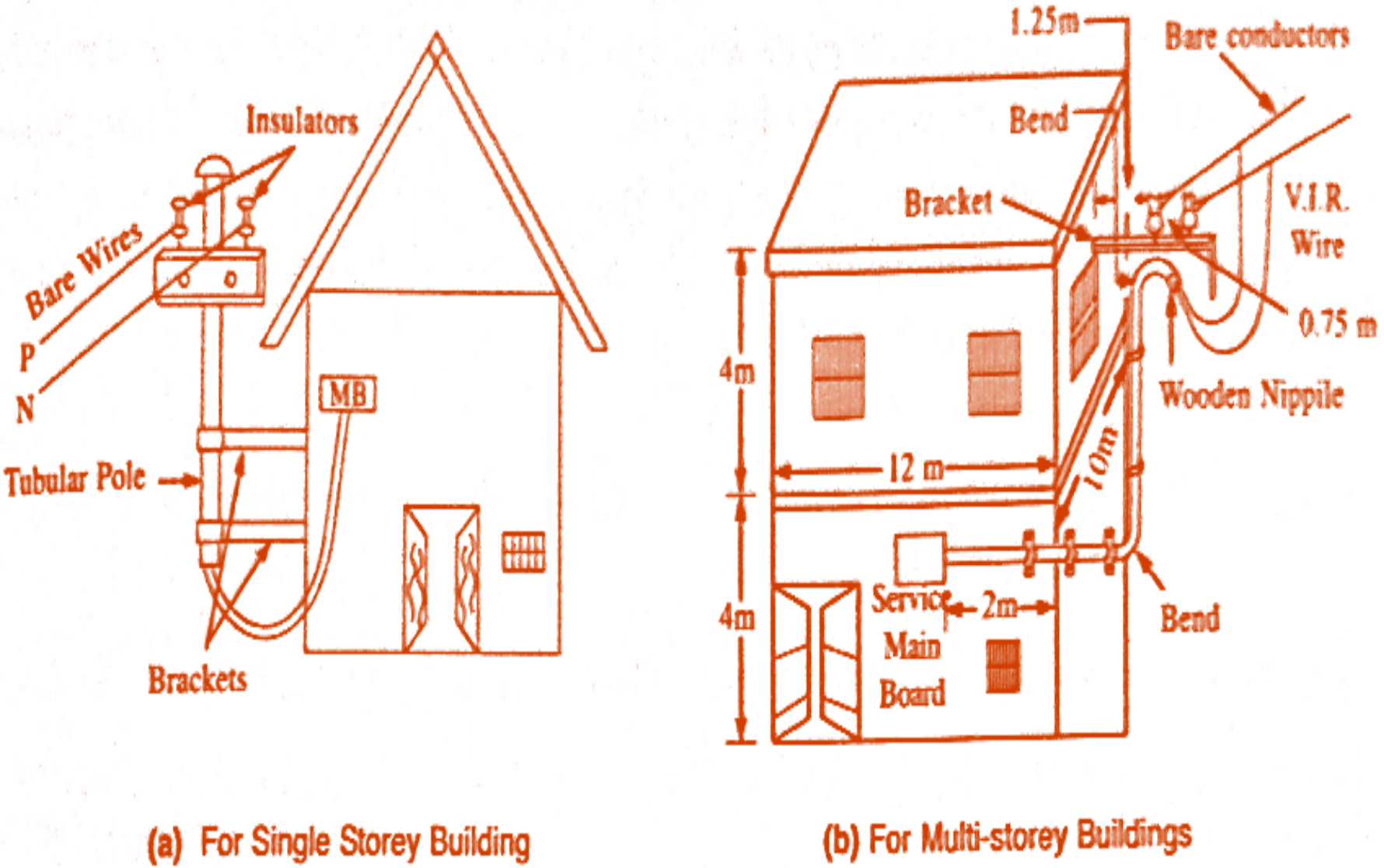


Fig 2.2 : Bare Conductor Service Line

(d) G.I Pipe Service Connection

- In this method G.I pipe is fixed to the wall and raised above the roof to a suitable height.
- The G.I pipe is properly supported by means of stay wire. The shackle insulators are fixed to the G.I pipe and bare conductors are brought from nearest L.T pole and connected to shackle insulators.
- The weather proof cable (or PVC cable) are connected to the bare conductor and carries through the same G.I pipe upto the meter board as shown in Fig. 23.

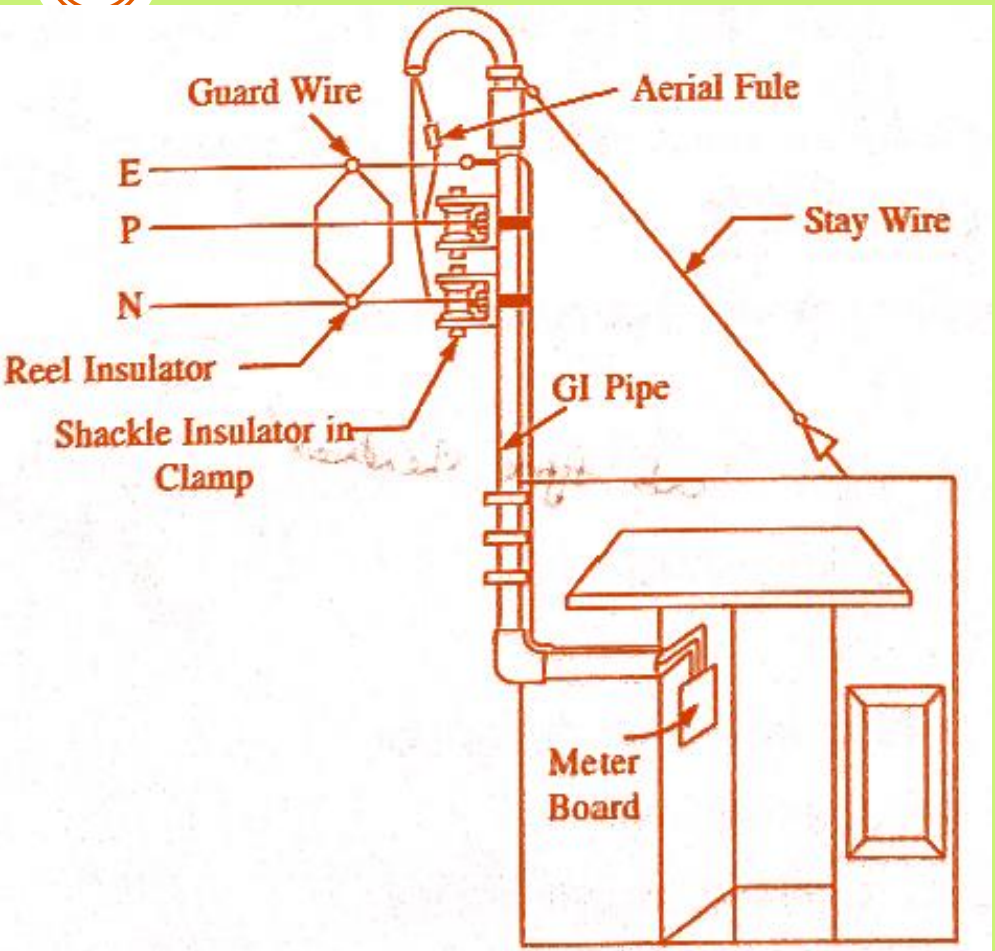


Fig 2.3 : G.I Pipe Service Connection

2. Underground Cable Service Connection

- Underground cable service connection is used when it is not possible to use overhead service line and where there is some restriction to pass overhead service lines.
- In this installation a trench of about 1 meter deep and 0.5 meter wide is made along the road or as required.
- The cable is laid in the trench and cover with sand and bricks.
- Now both ends of the cable are passed through the G.I pipes.
- one end is connected to distribution line and another end of the cable to the energy meter.
- The pipes are properly secured to the L.T pole and wall as shown in Fig 2.4.

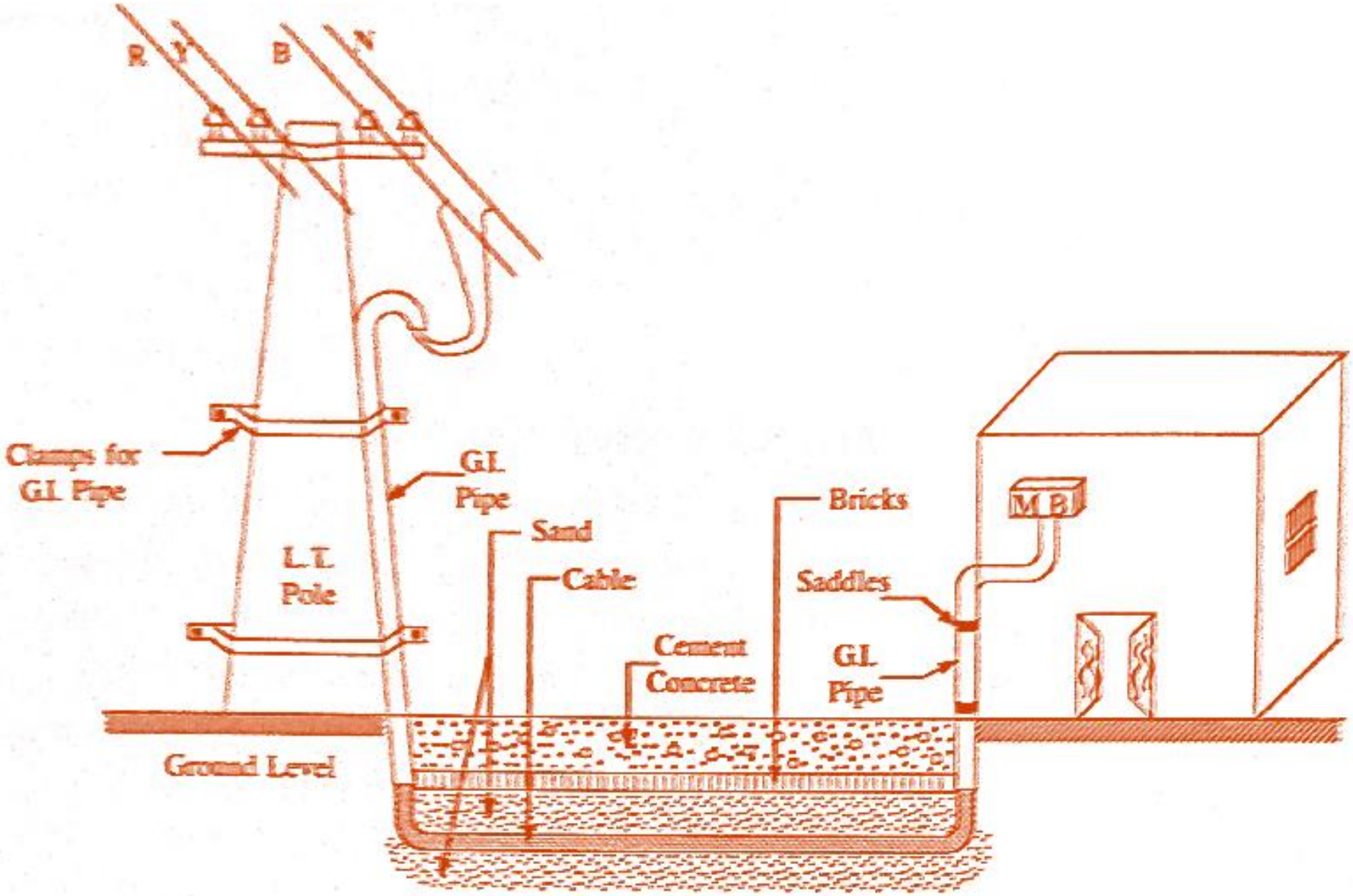


Fig 2.4 : Underground Cable Service Connection

- There are several systems of wiring in common use. They are
- 1. Cleat wiring.
- 2 CTS. (TRS. wiring)
- 3. Wooden casing-capping wiring
- 4 Lead-sheathed wiring.
- 5. Conduit wiring, which are further divided as
  - (a) Surface conduit wiring and
  - (b) Concealed or recessed conduit wiring.
- Each system has its own merits and demerits.

4.SELECTION OF SYSTEM OF WIRING

- Though there are several systems of wirings, no one system is suitable for all installations.
- Great care must be taken in the selection of a particular system of wiring for a particular job.
- The various points to be considered before selecting a particular type of wiring are :
- (i) Durability : The wiring system should withstand wear and tear due to weather.
- (ii) Safety : The wiring system should be no danger of leakage or shock to a person while using.
- (iii) Mechanical Protection : The wiring must be protected from mechanical damages during its use.
- (iv) Appearance : It should give good appearance from architectural point of view.
- (v) Permanency : The wiring must not be affected by the action of weather, fumes, dampness etc.
- (vi) Accessibility : It should be accessible for future extension.
- (vii) Cost : The cost of the system should be economical.

5.DRAWING A WIRE/CABLE THROUGH A CONDUIT

- Cables should not be drawn into a conduit system until the conduit system is completed.
- Usually, a spring or G.I wire is used to draw the cable into conduits. The spring or G.I wire should not be used for drawing directly cables as it may get damaged.
- Hence, the cable ends must be bared for a distance of about 75 mm and threaded though a loop in the draw wire.
- The draw-wire is secured to the spring, and feed the spring into the conduit as shown in Fig. 2.5.

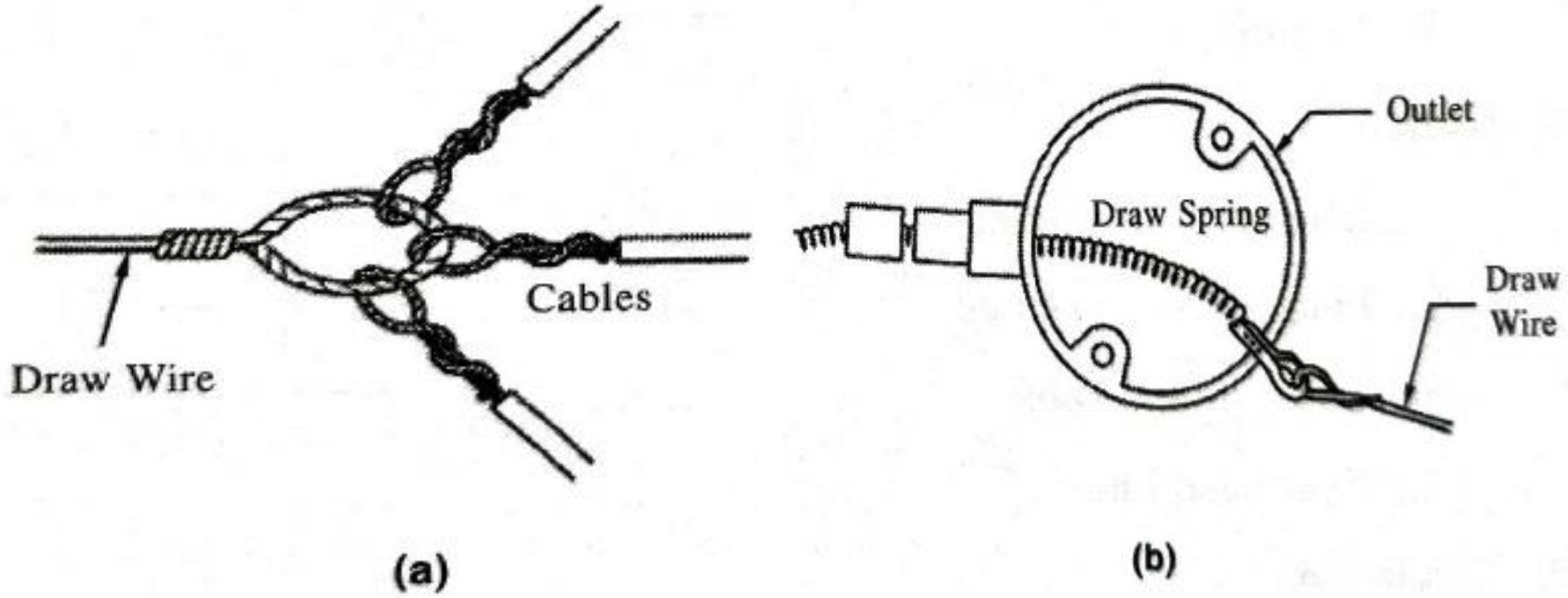


Fig 2.5 : Method of Drawing a Cable in the Conduit

1. ELECTRICAL SYMBOLS

- In engineering symbols are used in layouts and wiring circuits to represent the electrical parts and various accessories.
- Since, the drawing of the actual device at every time is very laborious and difficult to a person.
- In selecting symbols, they should be as far as possible self crests and easy to draw.
- Symbol represents only the function of apart/accessory irrespective of the structure.
- Some of the symbols which are standardized by Bureau of Indian Standards are given below.

(a) Current :

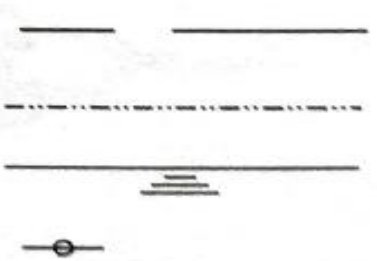
1.	Direct current (D.C.)	+
2.	Alternating current (A.C)	~
3.	Power frequency	~
4.	Either A.C or D.C	≂

(b) Distribution System :

1.	A.C. single phase, 50 *Hz*	1 - 50 *Hz*
2.	A.C. three phase, 50 *Hz*	3 - 50 *Hz*
3.	A.C. three phase, 50 *Hz*, 415 *V*	3 - 50 *Hz*, 415 *V*
4.	A.C. three phase, with neutral, 50 *Hz*.....	3*N* - 50 *Hz*.
5.	D.C. two wire conductor	2 - 110 *V*
6.	Positive	+
7.	Negative	–
8.	Phase	*Ph*
9.	Neutral	*N*

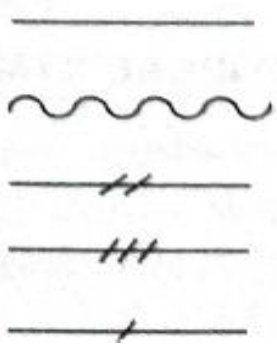
(c) Lines :

1. Line or cable existing .....
2. Line or cable planned .....
3. Underground cable .....
4. Over head Line .....



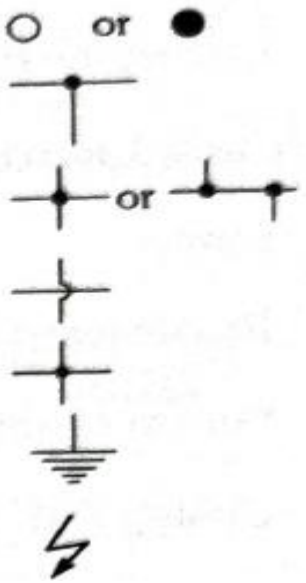
(d) Conductors :

1. Conductors or group of several conductors .....
2. Flexible conductors .....
3. Two conductors .....
4. Three conductors .....
5. n - conductors .....



(e) Terminals and Connection of Conductors :

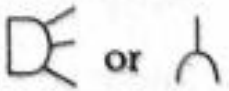
1. Terminal .....
2. Junction of conductors .....
3. Double junction of conductors .....
4. Crossing without electrical connection .....
5. Crossing with electrical connection .....
6. Earth .....
7. Fault .....

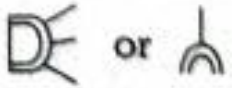


(f) Switch Gear :

1. Switch (general symbol) .....
2. Two - way switch .....
3. Intermediate switch .....
4. Three pole switch .....
5. Three pole switch (Single line representation) .....
6. Isolator .....
7. Circuit breaker .....
8. Neutral link .....
9. Socket .....
10. Plug .....
11. Plug and socket .....
12. Push button or bell switch ..... or

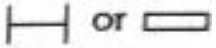
(g) Socket Outlets :

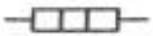
1. Socket outlet, 3 pin, 5A ..... 

2. Socket outlet, 3 pin, 15 A ..... 

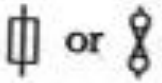
3. Socket outlet, 2 pin, 15 A .....
4. Socket outlet, 3 pin, 15 A with switch combined .
5. Ceiling rose .....

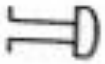
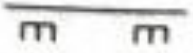
(h) Lamps and Lighting Apparatus :

1. Lamp .....
2. Fluorescent lamp or tube ..... 

3. Group of three 40 W fluorescent lamps.....
4. Ceiling fan .....
5. Bracket fan .....
6. Exhaust fan .....
7. Fan regulator .....
8. Emergency lamp .....
9. Heater ..... 

(i) Miscellaneous Apparatus :

1. Fuse ..... 

2. Signal lamp .....
3. Indicator .....
4. Horn .....
5. Bell ..... 
6. Buzzer .....
7. Siren .....
8. Energy meter .....
9. Distribution board with out switch .....
10. Main fuse board with switch .....
11. Wiring on the surface ..... 
12. Wiring on conduit .....

6.LIST OF ELECTRICAL MATERIALS & THEIR APPROXIMATE RATES (SCHEDULE FOR RATES)

- The various materials used in house wiring and service main are given in the Table. 2.1along with their approximate latest rates.
- The rates of materials are inclusive of all taxes such as sales tax, excise duty, transportation charges etc.
- The rates may not be constant but depends on quality, company and other so many factors.

Table 2.1 :

S.No.	Material with Specification	Rates Rs. Ps.	Remarks
	(A) Electrical Materials/ Accessories :		
1.	I.C.D.P. switch, 15A, 250 V grade with fuse unit	350/each	
2.	1-way Iron Clad Distribution Board 15 A/way, 250 V with fuse unit	200/each	
	2-way Iron Clad Distribution Board 15 A/way, 250 V with fuse unit	250/each	
	3-way Iron Clad Distribution Board 15 A/way, 250 V with fuse unit	300/each	
	4-way Iron Clad Distribution Board 15 A/way, 250 V with fuse unit	325/each	
	5-way Iron Clad Distribution Board 15 A/way, 250 V with fuse unit	350/each	
3.	Miniature Circuit Breaker, 5 A, 250 V	250/each	
	Miniature Circuit Breaker, 15 A, 250 V	275/each	
4.	Double Pole (D.P) flush type switch with neon indicator, 15 A, 250 V	250/each	
5.	I.C. Cut-outs, 15 A, 250 V	100/each	

6.	**Switches**		
	(i) Surface (Tumbler) switches, 5 A		
	(a) One-way	15/each	
	(b) Two-way	25/each	
	(ii) Flush type switches, 5 A		
	(a) One-way	20/each	
	(b) Two-way	25/each	
	(iii) Surface switch, 15 A	30/each	
	(iv) Flush type surface, 15 A	35/each	
	(v) Bed switch, 5 A	15/each	
	(vi) Bell switch (push button), 5 A	20/each	

7.	**Lamp holders**		
	(i) Batten type (Brass)	25/each	
	(ii) Batten type (Bakelite)	20/each	
	(iii) Pendent type (Brass)	20/each	
	(iv) Pendent type (Bakelite)	18/each	
	(v) Bracket type (Brass)	45/each	
	(vi) Bracket type (Bakelite)	40/each	
	(vii) Water tight bracket with holder and shade	60/each	
8.	(i) Socket, 2-pin, 5 A, 250 V surface type	20/each	
	(ii) Socket, 3-pin, 5 A, 250 V surface type	25/each	
	(iii) Socket, 3-pin, 15 A, 250 V surface type	40/each	
	(iv) Socket, 2-pin, 5 A, 250 V flush type	25/each	
	(v) Socket, 3-pin, 5 A, 250 V flush type	30/each	
	(vi) Socket, 3-pin, 15 A, 250 V flush type with neon and switch control	45/each	

9.	(i) Ceiling rose, 2-plate, 5 A (jimbo) (ii) Ceiling rose, 3-place, 5 A	20/each 30/each	
	(B) PVC Insulated Cables :		
1.	1/1.4 mm (1/18) or 1.5 Sq.mm single core, 650 V grade aluminium conductor PVC cable.	10/metre	
2.	1/1.8 mm (1/14) or 2.5 sq.mm single core, 650 V grade aluminium conductor PVC cable	15/m	
2.5	1/1.12 mm (1.0 mm^2) single core, 650 V grade copper conductor PVC cable	15/m	
3.	1/1.4 mm (1/18) or 1.5 Sq.mm single core, 650 V grade copper conductor PVC cable	20/m	
4.	1/1.8 mm (1/14) or 2.5 Sq.mm single core, 650 V grade copper conductor PVC cable	25/m	
5.	1.5 Sq.mm 650 V grade multi-strand flexible PVC cable	16/m	
6.	2.5 Sq.mm 650 V grade multi-strand flexible PVC cable	20/m	
7.	3-core, 3.8 Sq. mm or 3/20, 650 V grade copper PVC cable	15/m	
8.	7-core, 13.85 Sq. mm or 7/16, 650 V grade Aluminium conductor weather proof cable	25/m	for service line

9.	Junction boxes (Round type)		
	1-way	10/each	
	2-way	15/each	
	3-way	20/each	
	4-way	25/each	
10.	Conduit reducers		
	(25.4 × 19) mm	15/each	
	(32 × 25.4) mm	20/each	
	(C) Wooden Materials		
1.	Teak wood batten		
	13×13 mm	25/m	
	19×13 mm	30/m	
	25×13 mm	40/m	
	32×13 mm	45/m	
	38×13 mm	50/m	
	54×13 mm	60/m	

2.	Teak wooden boards with PVC sheet			
		30 cm × 25 m	250/each	
		25 cm × 20 cm	255/each	
		25 cm × 15 cm	200/each	
		20 cm × 15 cm	175/each	
		15 cm × 10 cm	150/each	
		10 cm × 10 cm	125/each	
3.	Round wooden blocks	10 cm × 4 cm	20/each	
4.	Teak wood gutties	2.5 cm^2 × 2.0 cm^2 × 5 cm long	48/doz	doz=dozen
	(D) Earthing Materials			
1.	G.I. plate 60 cm × 60 cm × 6 mm with bolts and nuts		1500/each	
2.	Copper plate 60 cm × 60 cm × 3 mm with bolts and nuts		2500/each	
3.	G.I. pipe 38 mm dia		300/m	
4.	G.I.pipe 19 mm dia		250/m	
5.	G.I. Pipe 12 mm dia		200/m	
6.	Cast Iron cover 30 cm × 30 cm		300/each	

7.	G.I. bolts, nuts check nut with washers	20/each	
8.	G.I.wire (8,12,14,16 SWG)	300/kg	
9.	Earthing thimbles with bolts and nuts	20/each	
10.	Earthing set with G.I pipe complete	1500/each	
11.	Funnel with wire mesh	150/each	
12.	Coal	50/kg	
13.	Salt	25/kg	
14.	Shock treatment chart	75/each	
15.	Caution/danger plate	100/each	

	(E) Hard-Ware Materials :		
1.	Wooden screws		
	51 mm for boards	300/100	
	32 mm for batten/conduit pipe, saddles	250/100	
	19 mm for switches	200/100	
	13 mm for plugs, sockets, and ceiling roses	175/100	
2.	Link clips		
	38 mm size	50/box	1 box =
	50 mm size	75/box	100 no's
3.	Nails		
	13 mm (1/2 inch)	300/kg	
	19 mm (3/4 inch)	300/kg	
	25 mm (1 inch)	300/kg	
	51 mm (2 inch)	300/kg	
4.	Cement, sand, paint, varnish etc.	500/L.S	LS=Lump Sum

S. No.	Item (PVC Materials)	19 mm (3/4")	25.4 mm (1")	32 mm 11/4")	38 mm (11/2")	50 mm (2")
1.	PVC conduit pipe	25/metre	30/metre	35/metre	40/metre	45/metre
2.	Conduit bends (solid)	10/each	15/each	20/each	25/each	30/each
3.	Conduit bends (inspection)	15/each	25/each	30/each	35/each	40/each
4.	Elbows	10/each	15/each	20/each	25/each	30/each
5.	Saddles	60/doz	72/doz	84/doz	96/doz	108/doz
6.	Conduit coupler	20/each	30/each	40/each	50/each	60/each
7.	Conduit Tees (solid)	10/each	15/each	20/each	25/each	30/each
8.	Conduit Tees (inspection)	15/each	25/each	30/each	35/each	40/each

6.1 GENERAL I.E RULES WHILE PREPARING THE INTERNAL WIRING ESTIMATION

- The general rules, which are to be kept in mind in execution of internal wiring are,

1. The meter board, main switch and distribution board are to be kept at a height of 2 m from floor level.
2. The switch board should be kept at a height of 1.5m from floor level.
3. The height at which conduit run on the wall (Horizontal run) may be 3.0 m from ground level.
4. The conductor used is to be of such a size it should carry load current safely. The minimum size of conductor cable used is 1/1.12 mm (1.0 mm2) for copper and1/1.40 mm (1.5 mm2) for Aluminium conductor.

5. Every sub-circuit is to be connected to a distribution fuse board. The load on each sub-circuit is to be restricted to 800 watts. Each sub-circuit is not to have more than a total of 10 points of lights, fans and lighting socket outlets (2 or3-pin, 5 A). The load on each power sub-circuit should not exceed 3000 watts(3-pin, 15 A plug sockets) and should not have more than 2 socket outlets. All the socket outlets should controlled by individual switches. The earth pin of the socket should be connected permanently to the earthing system. It is better to provide a socket at a height of 1.5 m form floor level. Some times it is need to provide a socket below 1.5 m, then it is better to provide inter locked socket-outlet to avoid danger to children, The light or fan wiring and power wiring are to be kept separately.
6. Suitable number of socket-outlets are to be provided at suitable place in all rooms and one or two 3-pin, 15 A socket outlets are to be provided in kitchen.
7. All batten holders from incandescent lamps are provided at a height of 3.0 m from floor level. The clearance between bottom of a ceiling fan and pendent holder and floor should be 2.75 m.
8. All the sub-circuits should have its own continuous earth wire.
9. The distance between ceiling and horizontal run may be taken as 0.25 to 0.5meters, but it depends on the type of the building.
10. Any wiring system has to service at least for 20-25 years, hence high quality materials are to be used. High workmanship must be executed through qualified contractor/engineer. Hence material cost and labour charges may be high.

6.2 STEPS TO ESTIMATE INTERNAL WIRING

- Before proceed to prepare an estimate for internal wiring scheme, it is necessary for the electrical engineer to go through the plan, total points & their location.
- It is a challenging job to estimate different materials comes in wiring scheme and it is very difficult to estimate very accurately, but from the site plans a sufficient accurate estimate can be made.
- The following steps will help in estimate of wiring scheme.
- Step-1 :
- Determination of Number of Sub-circuits :The number of sub-circuits is decided as per the number of points to be wired and total load to be connected to the supply system. The number of points to be wired may be known from the plan and the total load can be known from the wattage of each point. For determining the total load the following wattage may be assumed if not specified.
- 1. Incandescent (Filament) lamp - 60 watt
- 2. Fluorescent tube lamp - 40 wait
- 3. Fan point - 80 wait
- 4 Socket-outlet (lighting), 5 A - 100 watt
- 5. Power socket-outlet, 15 A - 1000 watt

- Step-2 :
- Determination of Size of the Conductor, Main Switch and Distribution Board :The size of the conductor cable depends on the current carrying capacity. The current can be calculated by dividing total load with voltage (current = power/voltage). But the minimum size of the cable is 1/1.12 mm (1.0 Sq.mm) in copper or 1/1.4 mm(1.5 Sq.mm) in aluminium. The size of the main switch depends on the current to be controlled by it. The size and type of distribution board depends on current rating and number of sub-circuits to be connected to it.
- Step-3 :
- Determination of Size and Length of the Conduit/Batten :The size of conduit/batten depends on number of wires passing through it. The length of the conduit/batten can be determined by going through the plan of the building i.e. through horizontal run, vertical up and vertical down. The vertical up is the length of conduit from horizontal run to ceiling and vertical down is the length from horizontal run to switch boards.

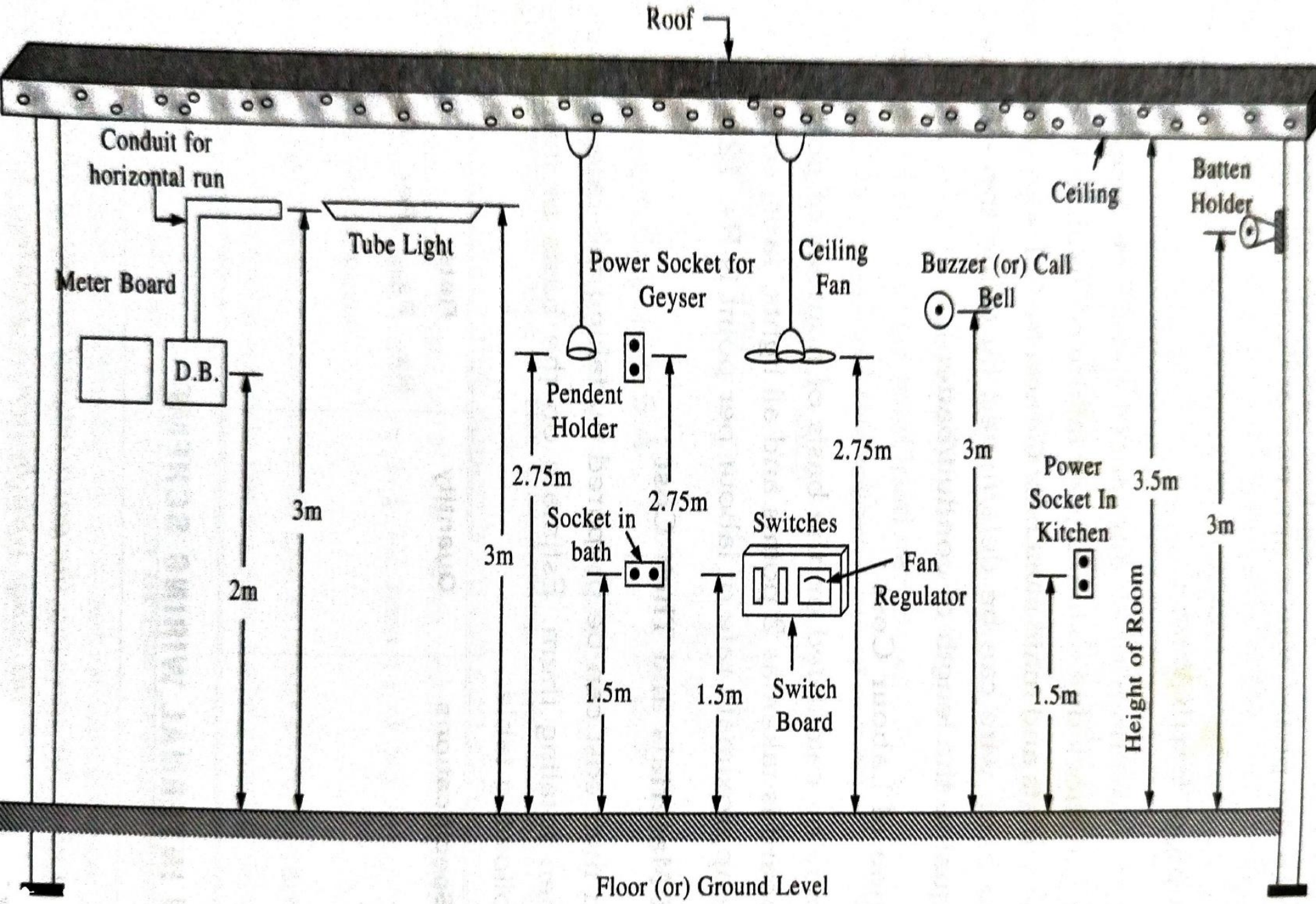
- Step-4 :
- Determination of Length of Conductor Cable :The determination of length of the cable/wire is very laborious process. As a general rule length of the cable is approximately 3 times that of the length of the conduit/batten, out of which the phase wire is approximately double the length of that of the neutral wire.
- Step 5
- Determination of Earth Wire :All metal parts, metal coverings of all appliances should be properly earthed to avoid danger from electrical shock due to leakage or failure of insulation. Hence, earth wire is required for socket outlets and main switches. Generally G.I wire of 14 SWG is sufficient as earth wire. The earth wire can be determined by going though the conduit (earth wire is approx. equal to the length of conduit/batten).
- Step 6
- Determination of Labour Cost :The labour cost may be calculated on the basis of number of points. The main board and distribution board is taken as 2 points and all lights, fans, socket outlets are taken as one point. The approximate rate of labour per point is Rs. 125/-.
- Step 7
- Estimate of Materials and Their Cost :The materials and their cost can be prepared by taking the rate of each item/material separately and then totaling them. Estimate on the basis of item wise rates can be prepared in the following table.

S.No.	Material with Specifications	Quantity	Rate			Cost		Remarks
			Rs.	Ps.	Per	Rs.	Ps.	

PROBLEMS ON INTERNAL WIRING SCHEME

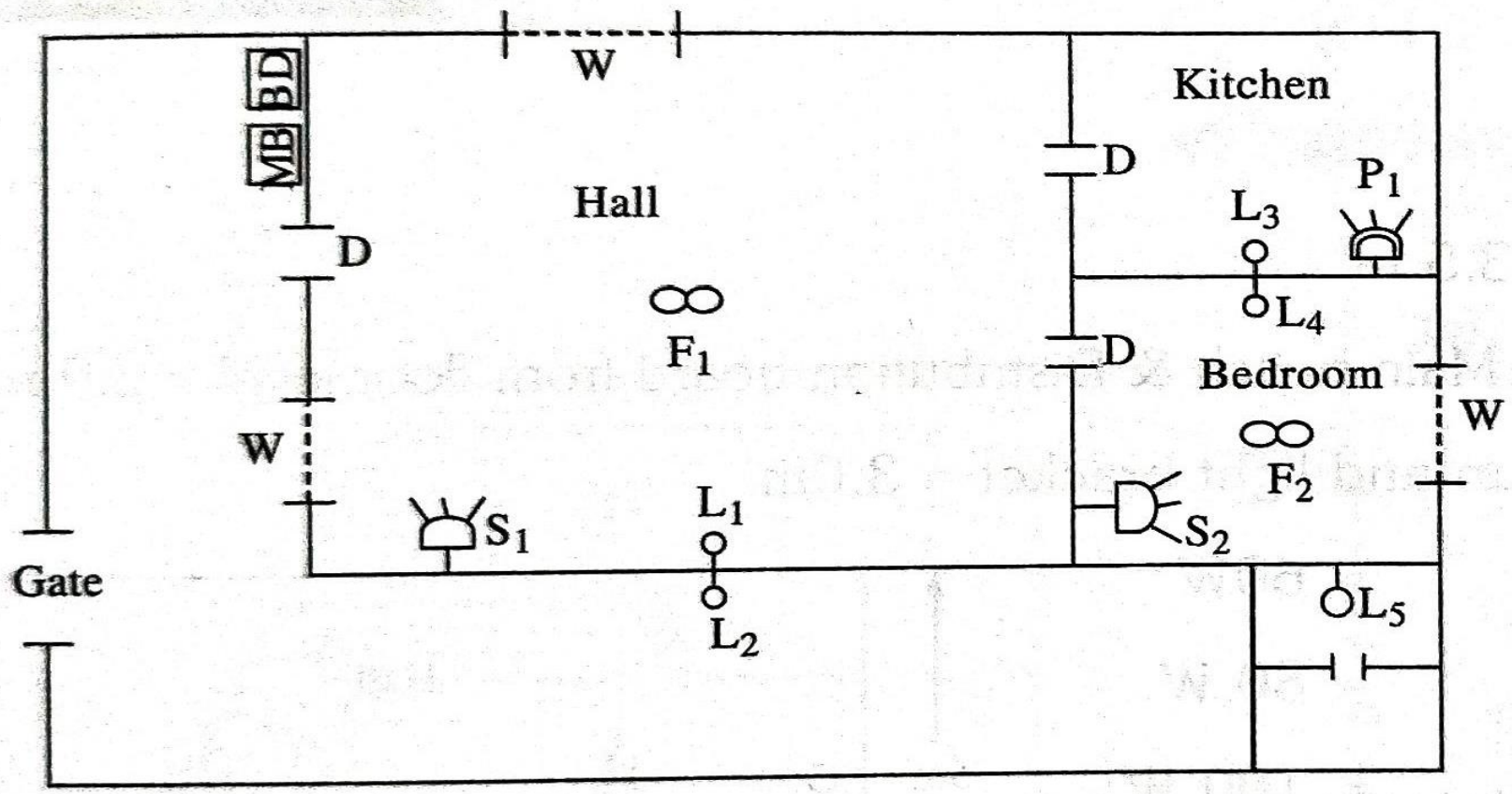
Problem -1

- Draw a neat section view for showing the position and height of Meter board, Main switch,Distribution board, Incandescent lamp with batten & pendent holders, Fluorescent lighton wall, Ceiling fan, Call bell or Buzzer, Switch board and Socket outlets (both light &power sockets).


Roof
Conduit for horizontal run
Meter Board
D.B.
2m
Tube Light
3m
3m
Power Socket for Geyser
Pendent Holder
2.75m
Socket in bath
2.75m
1.5m
Ceiling Fan
2.75m
Switches
Fan Regulator
Switch Board
1.5m
Buzzer (or) Call Bell
3m
Power Socket In Kitchen
1.5m
Ceiling
3.5m
Height of Room
Batten Holder
3m
Floor (or) Ground Level

Problem-2

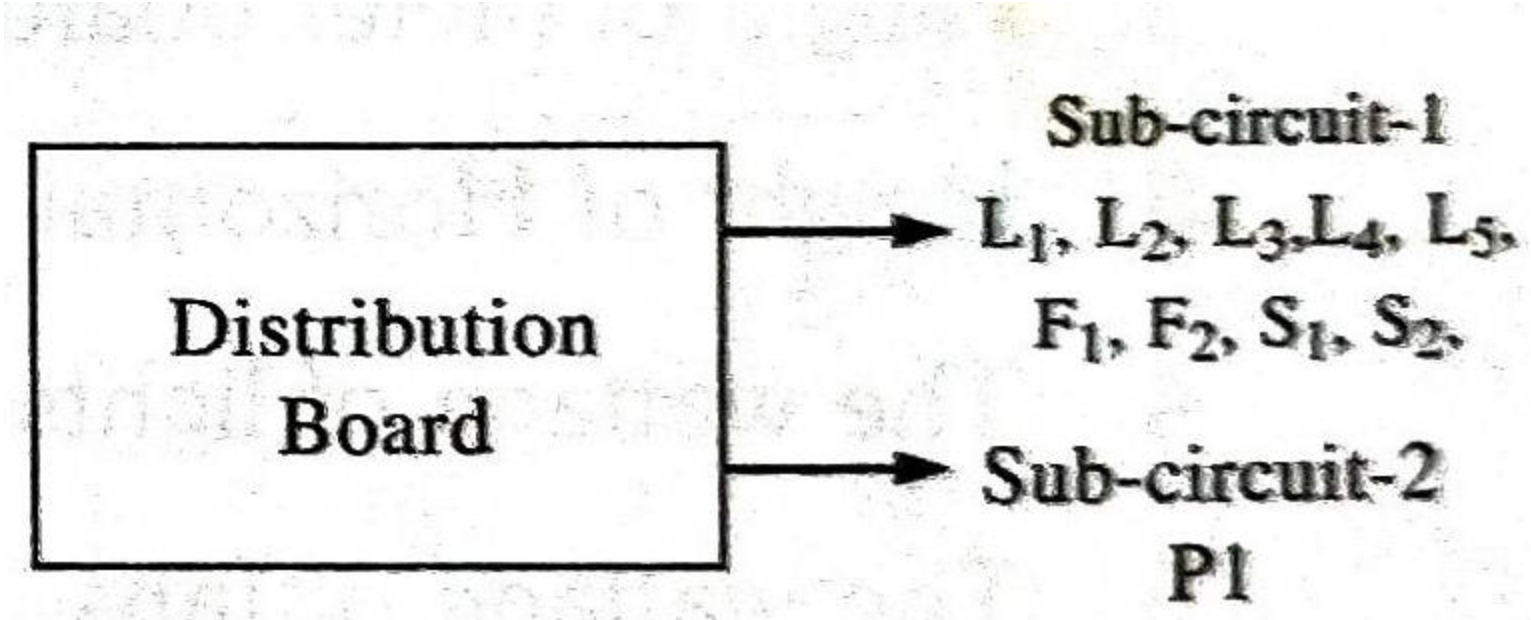
- Estimate the number of sub-circuits and size of the Main switch, Distribution board and the cable required for a residential building which is provided with various electrical installations as shown in the plan.
- Hint : M.B = Meter Board, D.B = Distribution Board, D=Door, W=Window, S1 & S2= Light Sockets ‘1 & 2’ (SA), P1=Power Socket ‘1’.



(a) Plan

Fig 2.7 : Plan

- No. of light points = 5
- No. of fan points = 2
- No. of light sockets = 2
- *1. No. of Sub-Circuits :*
- As per the recommendations of ISI the wattage of each light may be taken as 60 W, fan as 80 W and light socket as 100 W for estimation purpose. Hence,
- Total wattage of lights = 5x 60 = 300W
- Total wattage of fan = 2x 80 = 160W
- Total wattage of light sockets = 2x 100 = 200W
- Total =9 points= 660 W
- Wattage of power socket = 1000 W
- Since number of points to be connected are 9 points (less than 10) and load is 660 W(less than 800W), one sub-circuit is required for light load.
- Separate sub-circuit is required for power load (power socket). Because light and power load should be connected separately.

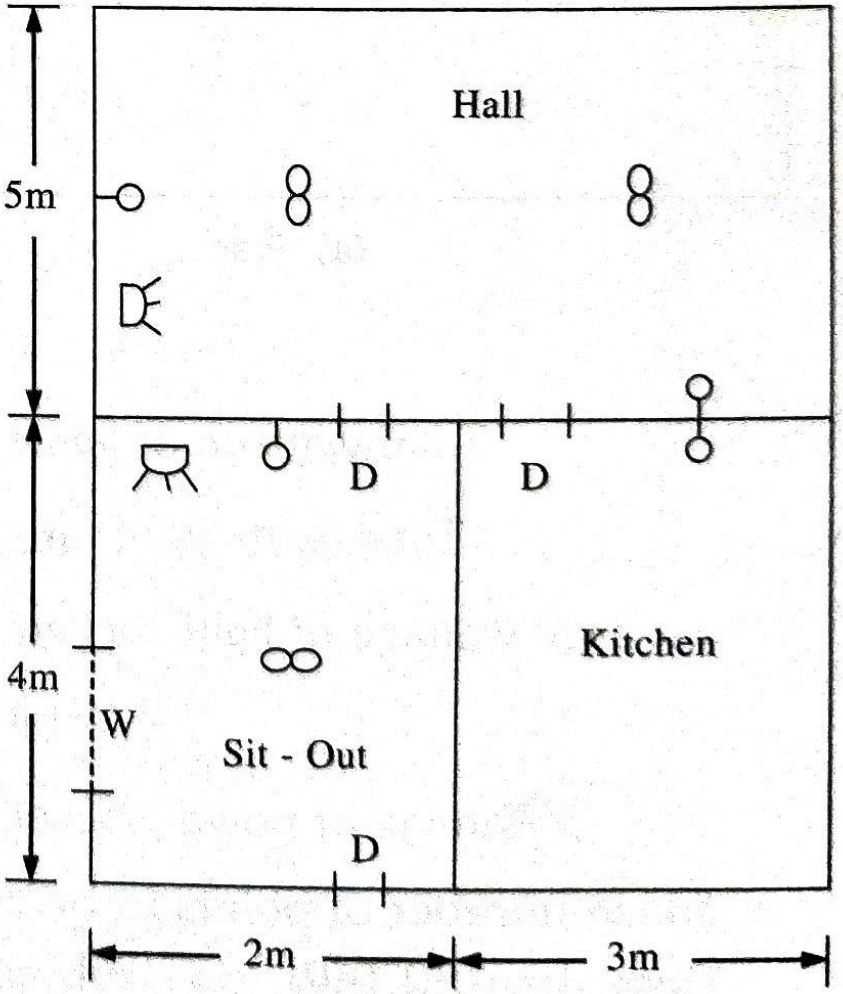


(b) Sub-circuits

- Full load current of sub-circuit-1 = 660/230 = 2.869 A
- Full load current of sub-circuit-2= 1000/230 = 4.347 A
- Hence, 15A, 250V I.C.T.P. Main switch is required to carry a current of 7.216 A(2.869 + 4.347).
- A 2-way Iron Clad Distribution Board, 15 A/way, 250 V with fuse unit is required.
- From Table 1.1 and 1.2 for the above current the size of the cable required for both sub-circuits is 1/1.12 mm (1.0 mm^2) copper or 1/1.4 mm (1.5 mm^2) aluminum conductor single core 650V grade PVC cable for both phase and neutral wires.

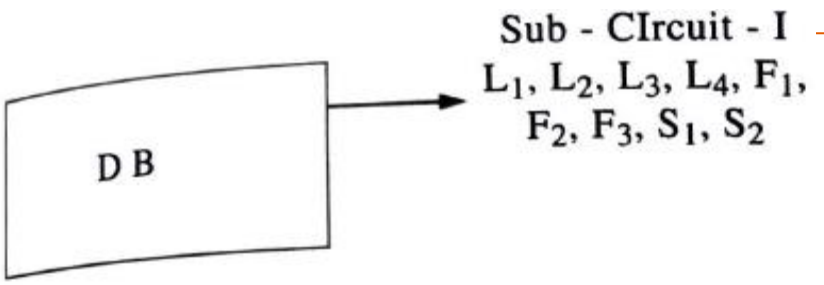
Problem-3

Estimate the quantity of materials required and their cost to make the surface type conduit wiring for a building, the plan of which is shown in Fig. Assume any missing data.

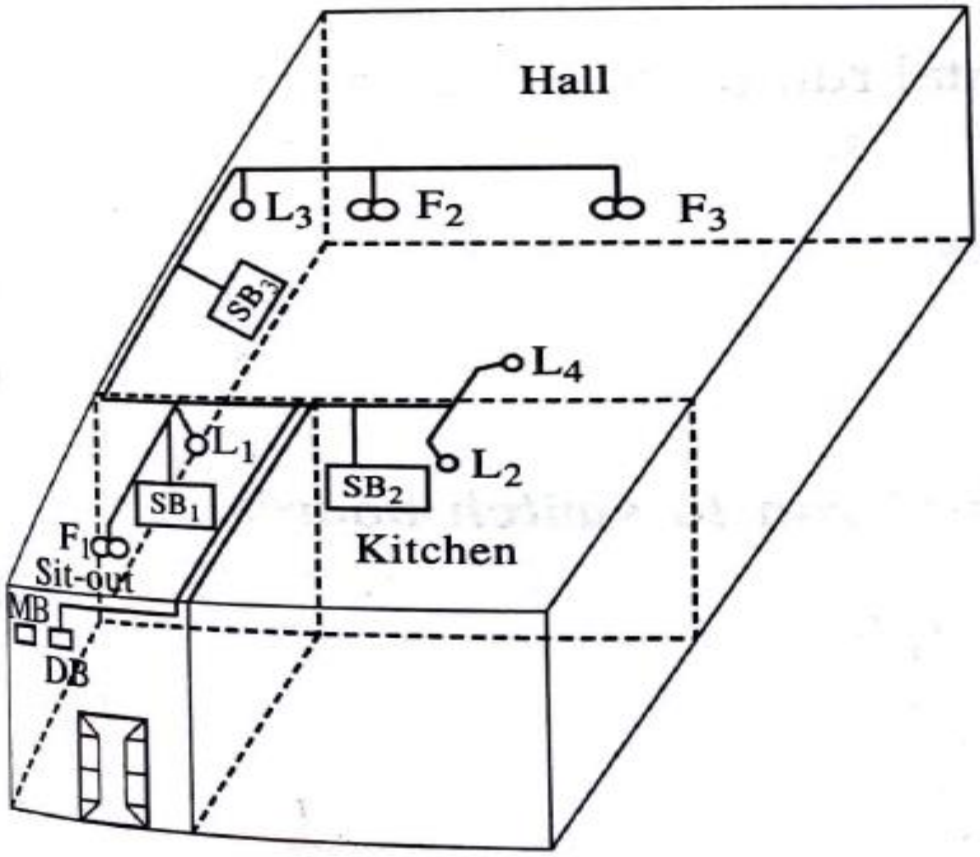


- Assumptions
- 1. The height of room = 3.5 m
- 2. Height of Meter board, Main switch & Distribution board from floor level = 2.0 m
- 3. Height of Horizontal run and light bracket = 3.0m
- 4. The wattage of lights = 60W
- 5. The wattage of fans = 80W
- 6. Wattage of light socket = 100 W
- 7. Wall thickness = 35cm
- 8. Height of switch board = 1.5m

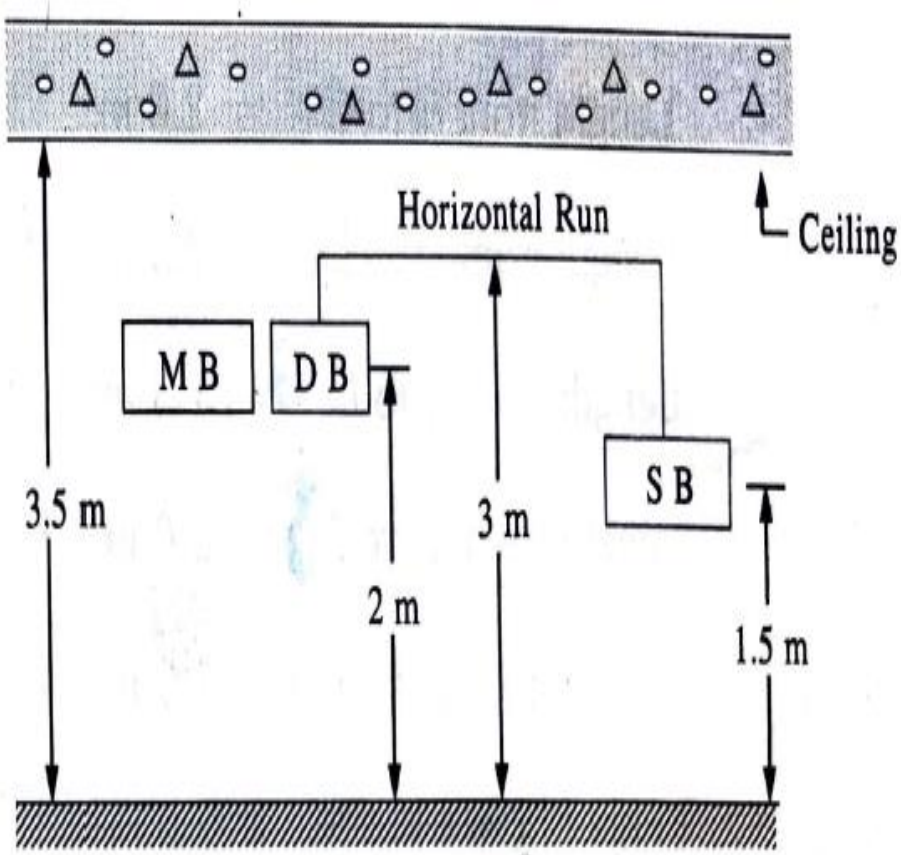
- 1. No. of Sub-Circuits :
- Total wattage of light points = 4x60 = 240 W
- Total wattage of fan points = 3x80 = 240W
- Total wattage of light sockets = 2x 100 = 200 W
- Total = 9 points = 680 W
- Since number of points to be connected are 9 (less than 10) and load is 680 W (less than 800 W), one sub-circuit is sufficient for light load.
- 2.Size of the Cable, Main Switch & Distribution Board:
- Full load current of sub-circuit = 680/230 = 2. 956 *A*
- From the Table 2.2 and 2.3 for the above current the size of the cable required is 1/1.12 mm (1 mm^2) copper conductor or 1/1.4 mm (1.5 mm^2) aluminium conductor, single core, 650V grade, PVC cable for both phase and neutral wires.
- A 15A, 250V grade I. C. D. P. Main switch is required to carry a current of 2. 956 *A*.
- A 1-way Iron Clad Distribution Board, 15 A/way, 250 *V* with fuse unit is required.



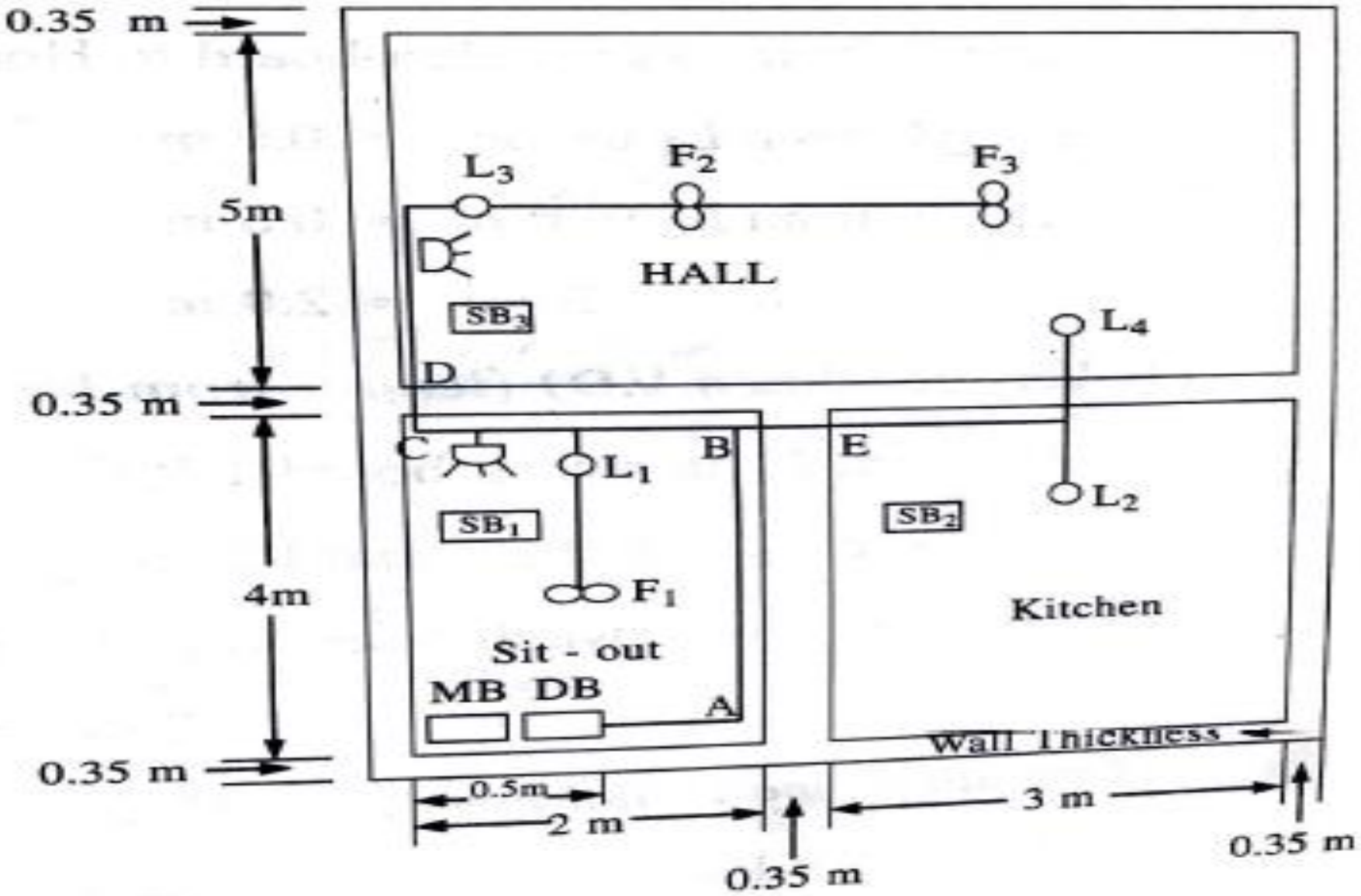
(a) Distribution Board



(c) Layout of Wiring



(b) Heights of D.B, M.B, H.R& S.B



(d) Layout of Conduit

- **3. Size and Length of the PVC Conduit :**
- A PVC conduit of 19mm dia is sufficient to carry the cables.
- The length of conduit can be determined by going through the layout of the plan as shown in Fig. (d).
- (a) Horizontal Run (H.R)
- Length from Meter board to Distribution board (Main board) = 0.2 m
- Length from Distribution board to A = 1.5m
- Length from A to B=4.0m
- Length from B to C=2.0 m
- Length from D to L3=2.5m
- Length from E to L2=1.5m
- Length from L1 to F1=2.0 m
- Length from L3 to F2=1.5 m
- Length from F2 to F3 =2.0 m
- Total =17.2 m
- (b) Vertical up (V.U) (Length From Horizontal Run To Roof) :
- Length from Distribution board to Horizontal run (above D.B) = 1.0 m
- Length from L1 to roof=0.5m
- Length from L3 to roof=0.5m
- Total=2.0 m

- (c) Vertical down V.D) (length from horizontal run to switch boards):
- Length from L1 to switch board-1 (SB1)=1.5m
- Length from L2 to switch board-2 (SB2) =1.5m
- Length from L3 to switch board-3 (SB3) =1.5m
- Total =4.5m
- (d) Conduit in wall thickness at C, B, Lp = 3 x 0.35 = 1.05m
- Total length of PVC conduit run= Horizontal run + Vertical up + Vertical down +conduit in wall thickness
- =17.2+2+4.5+1.05 = 24.75m
- Allow about 10% as wastage = 2.475 m
- Total length of PVC conduit requited = 24.75 + 2.475
  =27.225m = 28 m (say)

- 4. Length of the Cable :
- As a general rule the length of wire/cable is approximately 3 times that of length of the conduit, out of which the phase wire is approximately double the length of the neutral.
- Length of the cable required = 3 x length of PVC conduit
  = 3 x 24.75 = 74.25 m
- Allow about 15 % as wastage and connections= 15 % of 74.25 = 11.137 m
- Hence, total length of cable/wire (1/1.4 mm) required
  = 74.25 + 11.137 = 85.38m = 86 m (say).
- 5.Length of Earth Wire (14 SWG G.I Wire) :
- Earth wire is required for socket outlets and main switch and is drawn along with conduit.
- Length from Meter board to main board (D.B) = 0.2m
- Length from distribution board to switch board-1 (SB)= 1+1.5+4+1+1.5 =9m
- Length oe L, to switch board-3 (SB3)=14+0.35 (in wall at C)+2.54+1.5=5.35m
- Length from L to switch board-2 (SBg)= 1+ 0.35 (in wall at B)+1.5+1.5 =4.35m
- Length from Meter board to Earth pipe= 10 m (say)
- Total length of earth wire = 0.2+1.9+5.35+4.35 +10 = 28.9m
- Allow about 10% as wastage and connections = 2.89 m
- Total length of 14 SWG G.1 earth wire= 28.9+2.89 = 31.79 m= 32 m(say)=1kg (1meter weights 30 grams approx.)

- 6. Labour Cost :
- Labour cost is calculated on the basis of number of points, Meter board and distribution board is taken as 2 points and all light, fan, socket points are taken as one point.
- (i) Meter board = 2 points
- (ii) Distribution board = 2 points
- (iii) Lights, fans & socket points (4 + 3 + 2) = 9 points
- Total = 13 points
- Total Labour cost @ 125/- per point = 13 x 125 = Rs. 1625/-

S.No.	Material with Specifications	Quantity	Rate		Total Cost	Remarks
			Rs. Ps.	Per	Rs. Ps.	
1.	I.C.D.P. Main switch, 15 A, 250 V grade with fuse unit	1 No	350-00	each	350-00	
2.	1-way Iron Clad Distribution Board 15 A, 250 V with fuse unit	1 No	200-00	each	200-00	
3.	Miniature Circuit Breaker (MCB), 15 A, 250 V	1 No	275-00	each	275-00	in D.B
4.	PVC conduit 19mm dia	28 m	25-00	m	700-00	
5.	1/1.12 mm (1.0 mm^2) single core, 650 V grade copper conductor PVC cable	86 m	4-00	m	344-00	
6.	Flush type 1-way switch, 5 A	9 No	20-00	each	180-00	

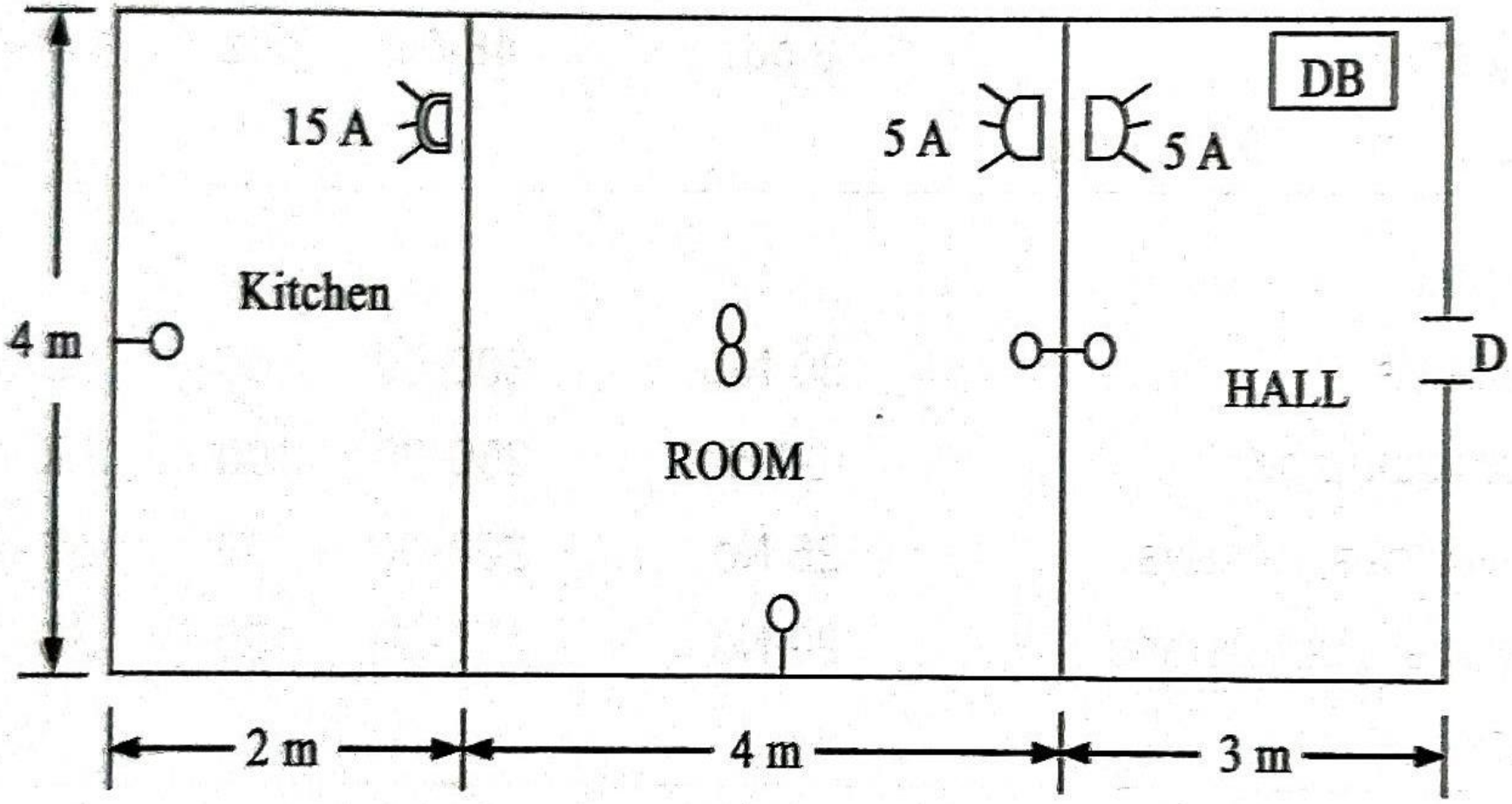
7.	Socket out-let, 3-pin, 5 A, flush type	2 No	30-00	each	60-00	
8.	Ceiling rose 2-plate, PVC type, 5 A (jimbo)	3 No	20-00	each	60-00	
9.	Lamp holders (batten type, brass)	4 No	25-00	each	100-00	
10.	Earth wire 14 SWG G.I wire	1 kg	300-00	kg	300-00	1m = 30 gm
11.	Earth thimbles with bolts & nuts	4 No	20-00	each	80-00	for earthing
12.	Teak wooden boards					
	30 cm × 25 cm	2 No	250-00	each	500-00	for M.B, D.B
	20 cm × 15 cm	3 No	175-00	each	525-00	for S.B's

13.	PVC inspection type junction boxes (Round type)					
	4-way	1 No	25-00	each	25-00	
	3-way	5 No	20-00	each	100-00	
	2-way	4 No	15-00	each	60-00	
14.	PVC bends 19 mm dia (inspection type)	5 No	15-00	each	75-00	
15.	PVC elbows, 19 mm dia	5 No	10-00	each	50-00	
16.	PVC conduit couplers, 19 mm dia	2 No	20-00	each	40-00	
17.	Saddles, 1 9mm dia	3 doz	60-00	doz	180-00	
18.	Round wooden blocks (10cm × 4cm)	4 No	20-00	each	80-00	for fixing lamp holders

19.	Teak wood gutties 2.5 cm^2 × 2.0 cm^2 × 5 cm long	3 doz	48-00	doz	144-00	
20.	Wooden screws 51 mm for boards 32 mm for conduit pipe 19 mm for switches, holders 13 mm for plugs, sockets and ceiling roses	 30 No 100 No 25 No 20 No	 300-00 250-00 200-00 175-00	 100 100 100 100	 90-00 250-00 50-00 35-00	
21.	Nails, 25 mm (1 inch)	½ kg	300-00	kg	150-00	
22.	Earthing set with G.I. pipe complete	1 set	1500-00	set	1500-00	
23.	Cement, Sand, Paint, Varnish etc., for fixing gutties	L.S	—	—	500-00	L.S = Lump Sum
24.	Labour cost		—	—	1625-00	
		Total :			3659-5	
		Contingencies, 10% :			365-95	
		Grand Total :			4025.45	
		Say :			**4026.00**	

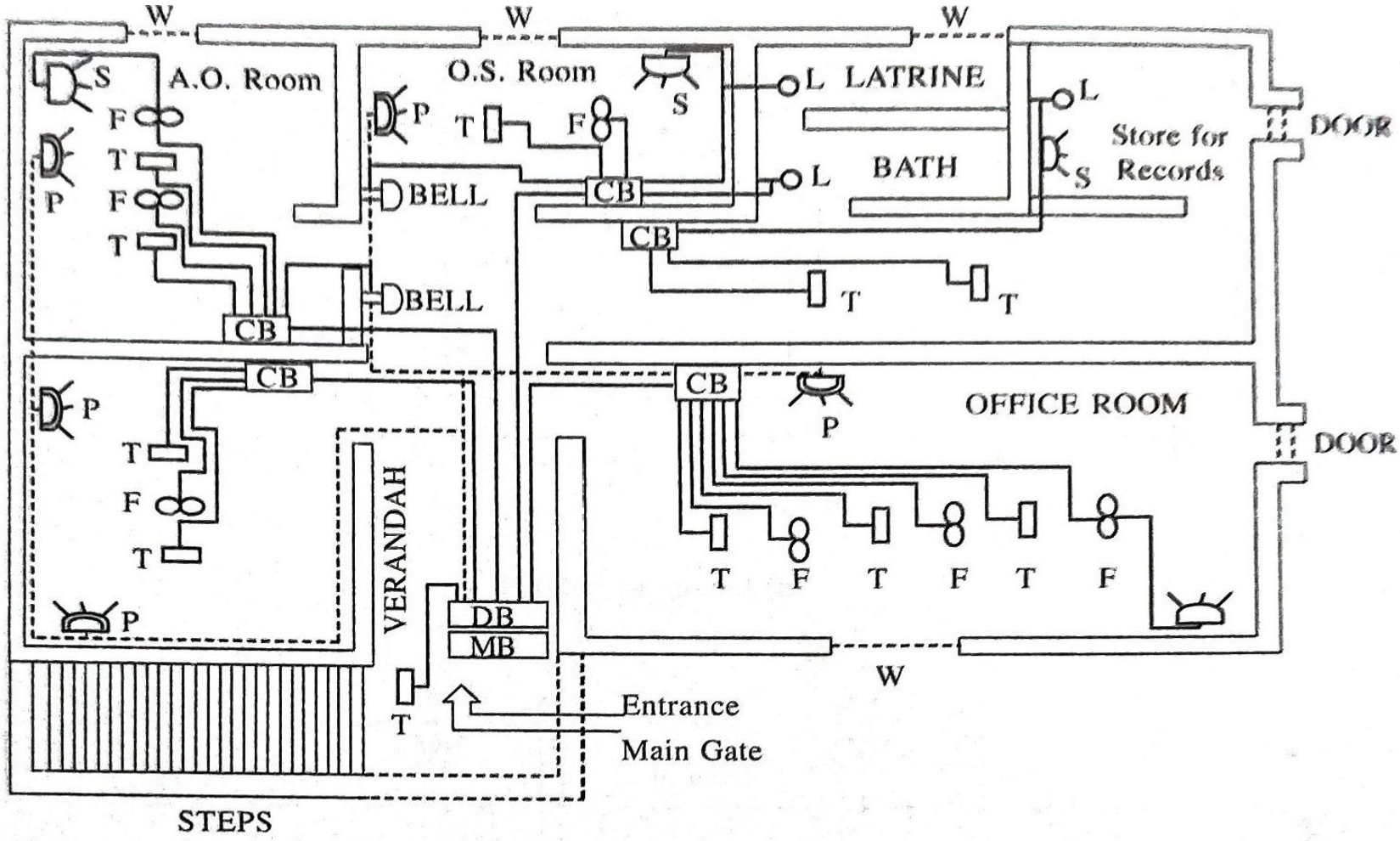
Problem 4

- The plan of a residential building is shown in Fig. 2.10. It is to be provided with CTS system of wiring. Estimate the materials required and its cast. Wattage of Lamps = 60 W.
- Fan = 80 W. 5 A socket = 100 W. 15 A socket = 1000 W. Also draw the wiring diagram. Assume any missing data.


15 A
5 A
5 A
DB
Kitchen
4 m
ROOM
HALL
D
2 m
4 m
3 m

8.WIRING LAYOUT OF A OFFICE BUILDING

- Wiring layout of an office is shown in Fig, Various rooms in office are indicated with sufficient lighting arrangement.
- The bell switches (push button) are provided in office room to call attender.
- Light and power socket outlets are provided in each room to provide connections to coolers, table fans etc.

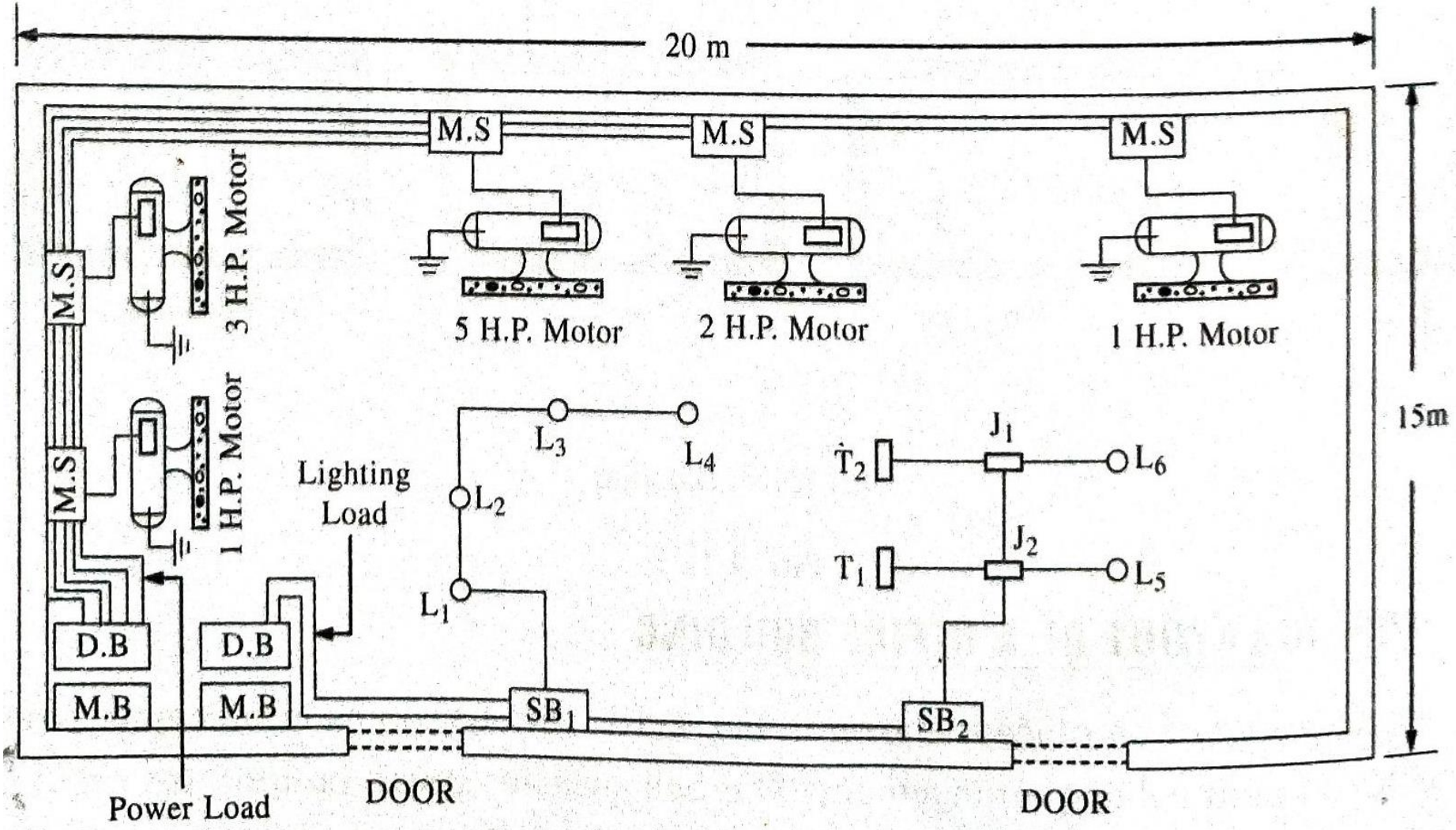


M.B = Meter Board
P = Power Socket
T = Tube Light
A.O = Administrative Officer
DB = Distribution Board
S = Light Socket
F = Fan
O.S = Office Superintendent
C.B = Control Board
W = Window
L = Lamp

Fig 2.18 : Wiring Layout of a Office

9.Wiring Layout of Work Shop/ Electrical Laboratory

- The layout of a Work shop/ Electrical laboratory is shown in Fig.
- The power load and lighting load should be connected separately.
- There are two separate meter boards one for power load and another for lighting load.
- The size of the cable for connecting motors depends on their full load currents of the motors.
- The number of sub-circuits and the size of the cable for lighting load depends on full load current in each sub-circuit.

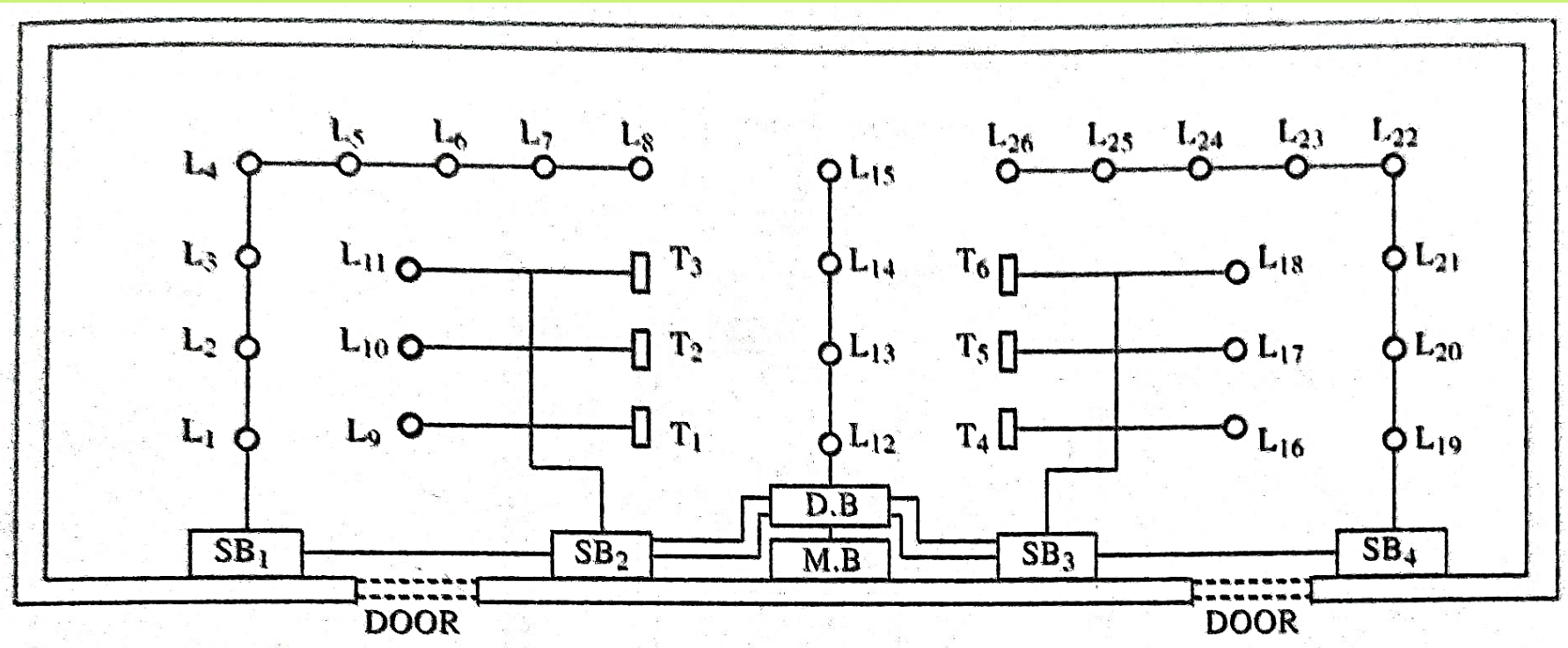


M.B = Meter Board
DB = Distribution Board
M.S = Motor Switch
L = Lamp
T = Tube
J = Junction Box
S.B. = Switch Board

Fig 2.19 : Layout of Work Shop/ Electrical Laboratory

10.WIRING LAYOUT OF A INDUSTRY | MILK DAIRY/CEMENT FACTORY/SUGAR FACTORY

Fig. illustrates the wiring layout for a Factory/Industry. The total load is divided into number of sub-circuits and in any sub-circuit the load does not exceed 800 W and maximum number of points to be connected are below 10.



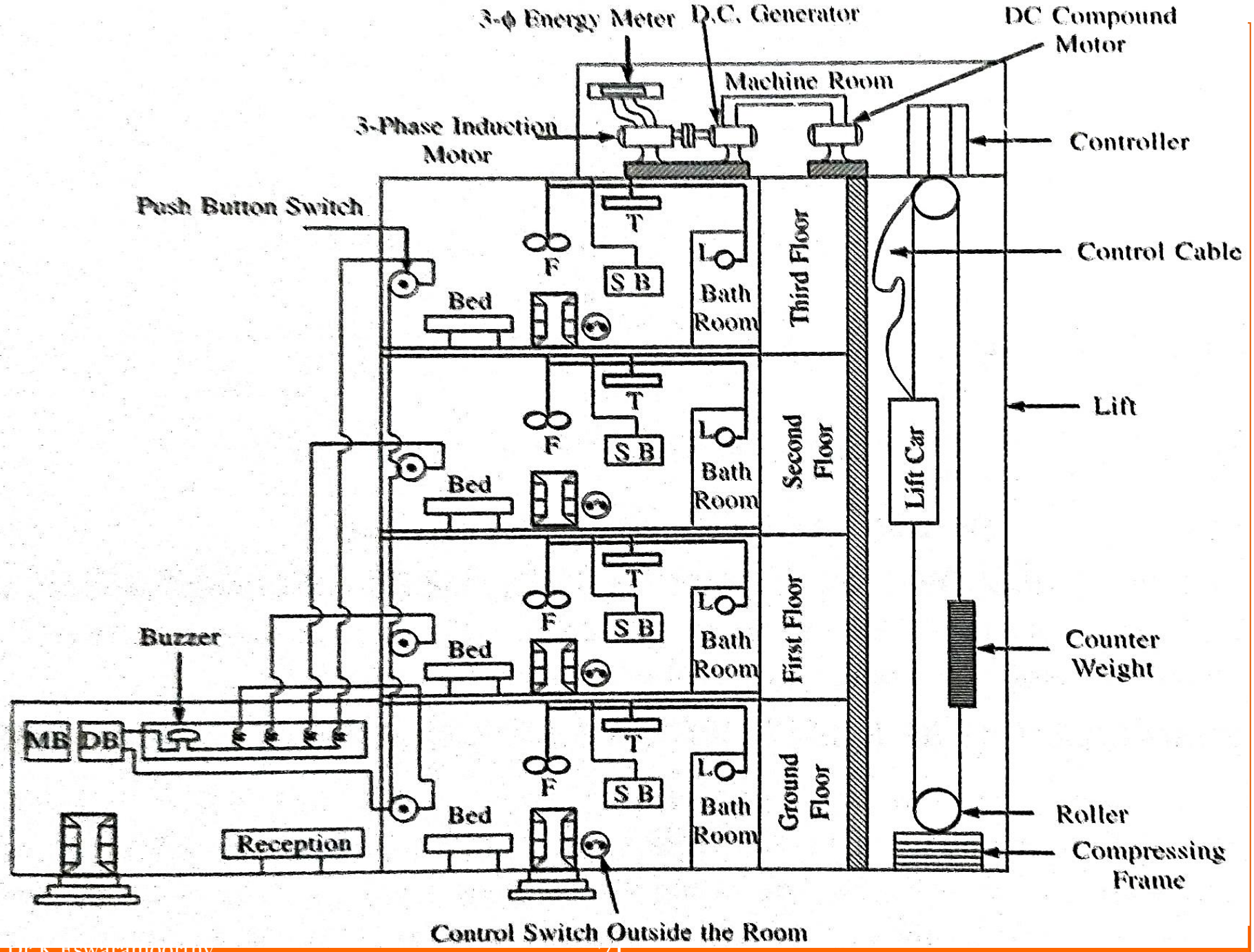
M.B = Meter Board DB = Distribution Board S.B = Switch Board

L = Incandescent Lamp T = Tube

11.WIRING LAYOUT OF A HOTEL WITH A 4-STORIED WITH LIFT ARRANGEMENT

- Fig. shows the wiring layout of a hotel with a 4 story building and with lift arrangement.
- In any hotel, in every room push button is provided to call the attender/boy.
- When customer pushes the button the magnetic circuit works and room number comes on the bell indicator.
- The bell indicator circuit is provided in attender's room or at the reception counter.
- The attender/boy goes to that particular room to attend the work.
- In some hotels stair case wiring is used in the rooms, one 2-way switch is provided in the switch board and another 2-way switch is provided near the bed.

- At the out-side of each room a switch is provided to switch OFF entire circuit in the room as shown in Fig, The lift arrangement is shown in Fig. 2.21.
- Now-a-days, many types of passenger lifts are in use in multi-storyed buildings/hotels/flats.
- The main function of lift is to carry the persons from one floor to another floor.
- A gear-machine consists of a worm gear reduction unit, with a driving sheave on or low speed output shaft and a brake pulley on the high speed input shaft, which is driven either by A.C. induction motor or D.C. compound motor.
- A motor-generator set is used for conversion of a.c to dc supply. A 10 H.P D.C, 220 V compound wound motor is most suitable for 4-storyed building, A 10 kW, 220 V D.C. generator coupled to ac, 3-phase, 400 V, 50 Hz motor will be used to feed the dc compound wound motor.
- A 25 Sq.mm PVC single core, 50V grade is suitable to meet the load. The cables are accommodated in high gauge conduit of size 38 mm dia.

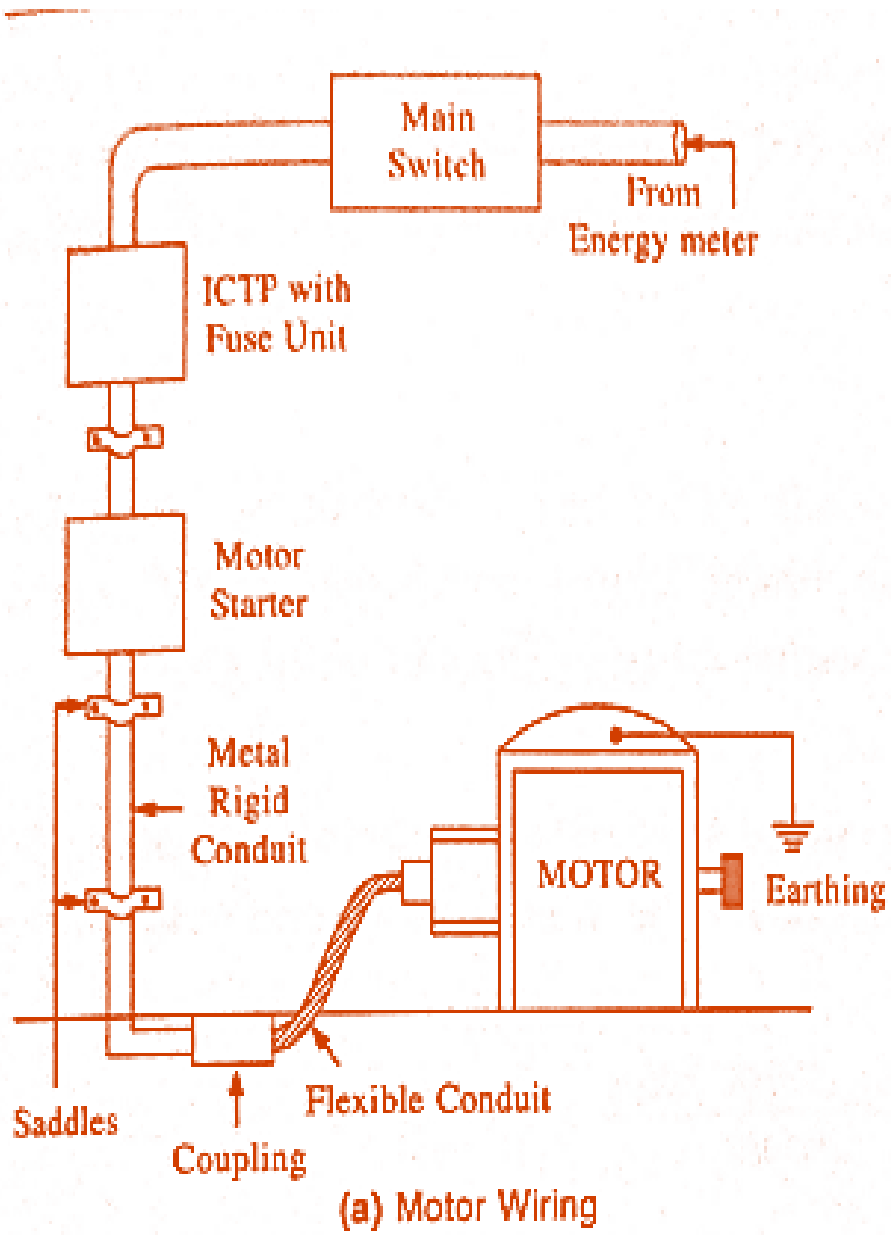

3-ϕ Energy Meter
D.C. Generator
DC Compound Motor
Machine Room
3-Phase Induction Motor
Controller
Push Button Switch
Control Cable
Third Floor
Second Floor
First Floor
Ground Floor
Bath Room
Bed
F
T
S B
Lift
Lift Car
Buzzer
MB
DB
Counter Weight
Reception
Roller
Compressing Frame
Control Switch Outside the Room

12. ESTIMATION OF POWER LOAD

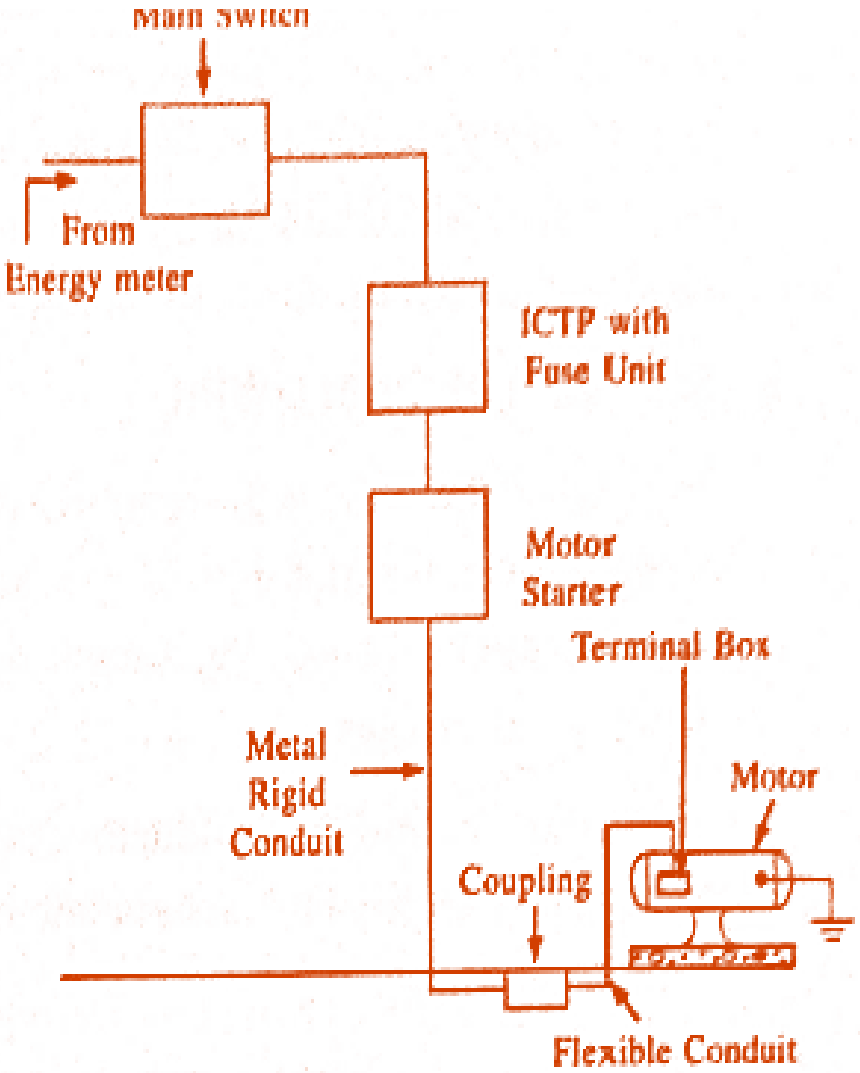
- We are well familiar with estimation of lighting circuits (domestic installation), now we will focus our attention on estimation of power circuits (loads) i.e., installation of motors upto 20 kW load.
- The power circuits can be divided into two groups, namely :
  - **1. Power circuit for heaters, refrigerators, air-conditions and other similar loads**
  - **2. Power circuits for motors, generators and other special purpose large load.**

13. SINGLE LINE DIAGRAM

- Fig.. illustrates the electrical installation for motor.
- The motor has its own Iron Clad Triple Pole switch and Motor starter and are placed at a height of 1.5 m from ground level.
- The main purpose of starter is to limit the starting current to a desirable value. D.O.L, Star/Delta, Auto-transformer starter, Rotor rheostat starter starters are commonly used for starting the motors.
- From the meter board the supply is fed to the Main board (consists of main switch and distribution board). From distribution board the power is fed to the motor through motor switch and motor starter.
- The size of the I.C.T.P switch and starter depends on the rating of the motor. The frame of the motor shall be earthed by using 8 SWG G.I. wire (double earthing is more effective).



(a) Motor Wiring



(b) Single Line Diagram

14. TYPE OF WIRING SYSTEM

- A rigid metallic (heavy gauge) surface conduit is used for power installations, because surface conduit facilitates the additions of number of motors in future and fault finding is easy.
- The rigid heavy gauge conduit is used from Distribution board to Motor base.
- A **flexible metallic conduit** is used to connect the end of the rigid conduit (at motor base) to the motor terminals.
- The rigid conduit and flexible conduit are coupled by means of box connector coupling. Flexible conduit is also used to connect motor switch to motor starter.

- The conduit used must be electrically continuous throughout and connected to the frame of the motor and is properly earthed.
- The conduit should perfectly be laid in covered trench to facilitate safety to the operator and **the trench is about 0.2 m deep.**
- The size of the conduit may be of size **19 mm dia to 51 mm dia depends on number of cables** running through it.
- For lights with in the industry/workshop should provided with separate cable and in separate sub-circuit.
- The lights used may be fluorescent tube lamp, sodium vapour lamp or mercury vapour lamp, because working area needs much illumination.

15. SIZE OF THE CABLE/WIRE

- **The size of the cable/wire required depends on full load current of the motor.**
- But during starting, the motor draws excessive current (2 times the full load current), hence, the cable selected should withstand the starting current. The size of the cable can be calculated as follows.
- For example to find the conductor size required for 5 HP (metric), 415 V, 3-phase, 50Hz induction motor. First assume the efficiency of the motor as 85% and power factor as 0.8 lag.
- Then,

$$\text{Input in watts} = \frac{\text{Output in watts}}{\text{Motor efficiency}} = \frac{\text{Rated BHPX } 735.5}{\text{Efficiency}} = \frac{5 \times 735.5}{0.85}$$

$$= 4326.47 \text{ watt}$$

We know that, Input power $= \sqrt{3}\, V_L\, I_L \cos\theta$, Hence

$$\text{Input full load current} \quad I_L = \frac{\text{Input power}}{\sqrt{3}\, V_L \cos\theta} = \frac{4326.47}{\sqrt{3} \times 415 \times 0.8} = 7.523 \text{ A}$$

Starting current = 2 times the full load current = $2 \times 7.523 = 15$ A

Hence, from Table 1.2 and 1.3, 2.0 mm^2 single core copper conductor having a current carrying capacity of 15 A or 2.5 mm^2 single core aluminium conductor having current carrying capacity of 15 A may be required.

SIZE OF CONDUIT, DISTRIBUTION BOARD, MAIN SWITCH AND STARTER

- The size of conduit always depends upon number of cables and size of the wire/cable to be carried.
- As a general rule, it is better to use 19 mm heavy gauge conduit where 3 wires are to be run and 25.4 mm heavy gauge conduit where 6 wires are to be run.
- Generally for each 3-phase motor 3 cables (2 cables for 1-phase motor) are required from Meter board to Motor starter and 6 cables/wires (2 cables for 1-phase motor)are required from starter to motor terminals.
- The following conduits are needed at different distances for 3-phase and 1-phase motors.

S.No.	Distance	3-Phase Motor	1-Phase Motor
1.	From Meter board to Motor switch	19 mm heavy gauge rigid metal conduit	19 mm heavy gauge rigid metal conduit
2.	From Motor switch to Motor starter	19 mm heavy gauge flexible metal conduit	19 mm heavy gauge flexible metal conduit
3.	From Motor starter to Motor base	25.4 mm heavy gauge rigid metal conduit	19 mm heavy gauge rigid metal conduit
4.	From Motor base to Motor terminals	25.4 mm heavy gauge flexible metal conduit	19 mm heavy gauge flexible metal conduit

- The size and number of ways of Distribution Board depends on number of motors to be installed.
- The size of Main switch Is decided by starting current of the motor, If two or more motors are to be Installed, the main switch should be capable of handling starting current of highest rating motor plus full-load currents of remaining motors.
- The starters used depends on rating and type of the motors to be installed.
- The various types of starters used for a particular motor is as follows.

S.No.	Type of Motor		Type of Starter
1.	Squirrel cage Induction motor		
		(a) Upto 3 H.P	D.O.L. Starter
		(b) From 3 H.P to 15 H.P	Star/Delta Starter
		(c) Beyond 15 H.P	Auto Transformer Starter
2.	Slip-ring Induction motor		Rotor Rheostat Starter
3.	D.C. Series Motor		2-Point Starter
4.	D.C. Shunt Motor		3-Point Starter
5.	D.C. Compound Motor		4-Point Starter

16. MATERIALS USED IN POWER WIRING AND THEIR RATES

- The different materials used in power wiring and their approximate latest rates at given below.
- The rates of materials are not constant, may depend upon the various factors like quality, company, place etc..

A. Material :

S.No.	Material with Specification	Rate		Remarks
		Rs. Ps	Per	
1.	Iron Clad Triple Pole (ICTP) with fuse unit			
	1. 16 A, 415 V	1000-00	each	
	2. 32 A, 415 V	1200-00	each	
	3. 63 A, 415 V	2000-00	each	
	4. 100 A, 415 V	4200-00	each	
2.	Iron Clad Triple Pole with neutral (ICTPN)			
	1. 16 A, 415 V	1200-00	each	
	2. 32 A, 415 V	1400-00	each	
	3. 63 A, 415 V	3200-00	each	
	4. 100 A, 415 V	4400-00	each	
3.	Iron Clad Double Pole (ICDP) with fuse unit, 16 A, 250 V	350-00	each	
4.	2-way,415 V, ICTPN Distribution board with rewirable fuse			
	1. 16 A/way	1500-00	each	
	2. 32 A/way	2000-00	each	
	3. 63 A/way	4500-00	each	

5.	3-way,415 V, ICTPN Distribution board with rewirable fuse		
	1. 16 A/way	1500-00	each
	2. 32 A/way	2000-00	each
	3. 63 A/way	3200-00	each
6.	4-way,415 V, ICTPN Distribution board with rewirable fuse		
	1. 16 A/way	2500-00	each
	2. 32 A/way	3200-00	each
	3. 63 A/way	4800-00	each
7.	Iron Clad (I.C) frames complete		
	1. 50 cm × 60 cm	1500-00	each
	2. 35 cm × 45 cm	1300-00	each
8.	Heavy Gauge Rigid Metal Conduit		
	1. 19 mm dia.	100-00	m
	2. 25.4 mm dia.	150-00	m
	3. 32 mm dia.	225-00	m

9.	Heavy Gauge Flexible Metal Conduit			
	1. 19 mm dia	80-00	m	
	2. 25.4 mm dia	125-00	m	
	3. 32 mm dia	175-00	m	
10.	Conduit bends (metal)			
	1. 19 mm dia	50-00	each	
	2. 25.4 mm dia	60-00	each	
	3. 32 mm dia	75-00	each	
11.	Saddles			
	1. 19 mm dia	5-00	each	
	2. 25.4 mm dia	8-00	each	
	3. 32 mm dia	10-00	each	
12.	Conduit couplers (metal)			
	1. 19 mm dia	75-00	each	
	2. 25.4 mm dia	100-00	each	
	3. 32 mm dia	125-00	each	
13.	Flexible coupling with lock nut			
	1. 19 mm dia	125-00	each	
	2. 25.4 mm dia	150-00	each	
14.	Teak wood gutties			
	2.5 cm^2 × 2.0 cm^2 × 5 cm long	48-00	doz	

15.	Junction boxes (metal) 1. 2-way 2. 3-way 3. 4-way	 50-00 60-00 75-00	 each each each	
16.	Earth wire 8 SWG G.I wire	300-00	kg	
17.	Iron screws	2-00	each	
18.	Earth wire clips	5-00	each	
19.	Caution plate	100-00	each	
20.	Shock treatment chart	75-00	each	
21.	Earthing set	3000-00	Set	
22.	G.I thimble with bolts and nuts	20-00	each	
23.	Labour charges for Civil Engg. work like Digging, Foundation of motors, Cement etc.	2000-00	L.S	
24.	Salt	25-00	kg	
25.	Coal	50-00	kg	
26.	Nails 25.4 mm	300-00	kg	

B. Cost of Conductor Cables per Meter Length :

S.No.	Type of Conductor cable	1.0 mm^2	1.5 mm^2	2.0 mm^2	2.5 mm^2	3.0 mm^2	4.0 mm^2	4.5 mm^2	6.0 mm^2	10.0 mm^2	16.0 mm^2	25.0 mm^2
1.	Single core copper conductor PVC sheathed, 650 V grade	15-00	20-00	25-00	30-00	35-00	40-00	45-00	50-00	—	—	—
2.	Two-core Aluminium conductor PVC sheathed 650V grade cable	—	18-00	—	35-00	—	43-00	—	55-00	—	—	—
3.	3-core copper conductor PVC sheathed cable, 1100 V grade	—	50-00	—	75-00	—	60-00	—	95-00	—	—	—
4.	3-core Aluminium conductor PVC sheathed 1100 V grade cable	—	40-00	—	55-00	—	70-00	—	80-00	105-00	125-00	130-00

1. STEPS TO SOLVE PROBLEMS ON POWER LOAD

- The following steps help in solving problems on power load installation
- Step 1: Determination of Size of The Cable : Calculate the full-load current and starting current of the motor. The size of the cable can be determined from the Table 2.2 and 2.3 for corresponding starting current.
- Srep-2 :
- Determination of Size of The Conduit : Select 19 mm diameter Heavy gauge metal conduit where 2 or 3 wires are to be run and 25.4 mm Heavy gauge metal conduit where 6 wires are to be run.
- Step-3 :
- Determination of Length of The Conduit : Length of the conduit can be calculated by going through the layout of the plan.
- Step-4 :
- Length of The Cable : The length of the cable can be determined by multiplying the conduit by the number of wires passing through it for a particular length.

- Step-5 :
- Determination of Earth Wire : It can be determined by going through the conduit.
- Step-6 :
- Labour Cost : It is based on number of days and number of motors to be installed. The Labour charge can be calculated by multiplying the Electrician rate and helper rate with number of days.
- Step-7 :
- Estimation of Materials and Their Cost : The cost can be calculated by multiplying the quantity of the material with their rates in the table as below.

S.No.	Material with Specifications	Quantity	Rate			Cost		Remarks
			Rs.	Ps.	Per	Rs.	Ps.	

Problem-1

- A 10H.P (metric), 415 V, 3-phase, 50 Hz squirrel-cage Induction motor is to be installed in a floor mill, the plan of which is shown in Fig. 2.23. Show the layout of wiring diagram and estimate the quantity of materials required and their approximate cost. Assume any missing data.

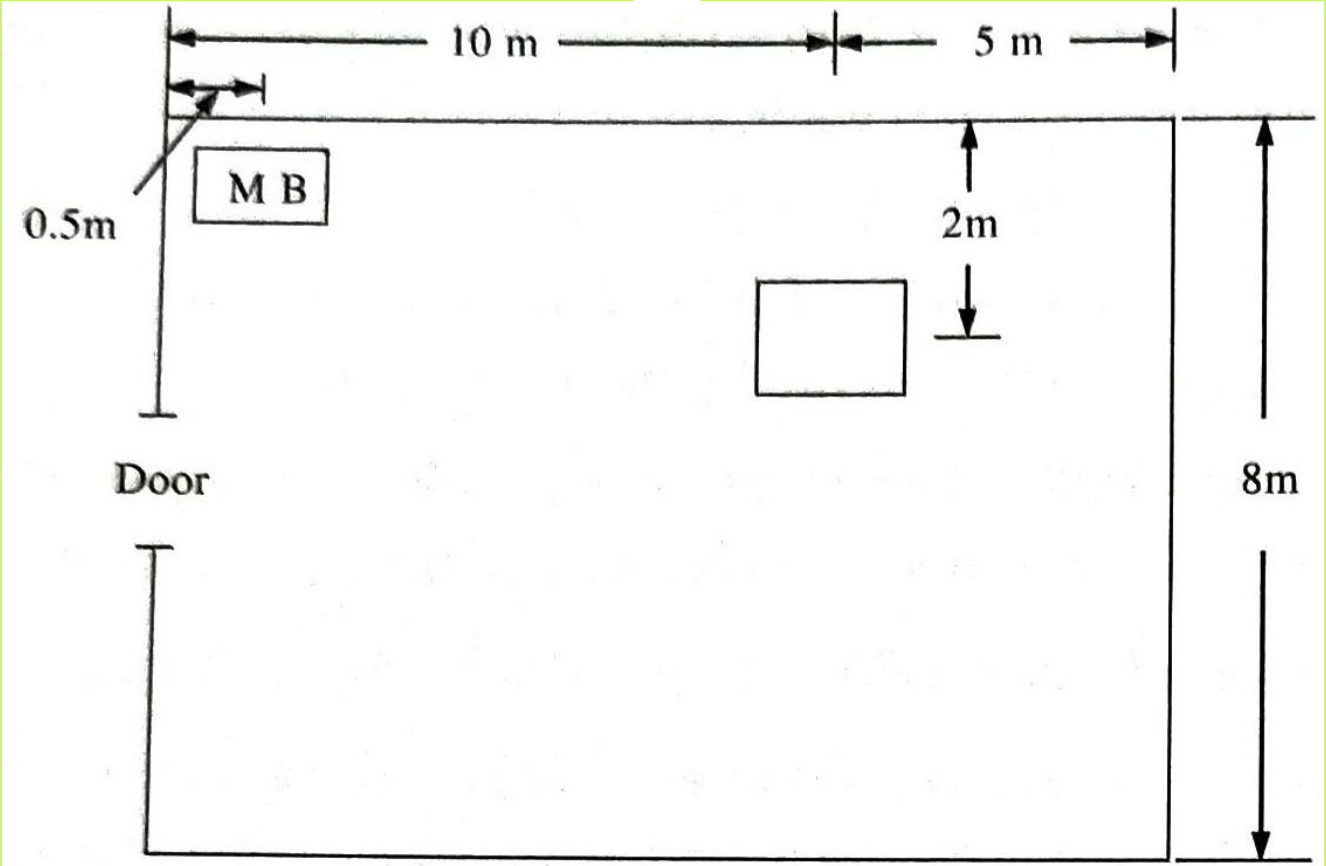


Fig 2.23 : Layout of Floor Mill

- Assumptions :
- 1.The height of Main switch, Motor switch and Motor starter is 1.5 meter from ground level.
- The height of horizontal run will be 3.0 m from floor level.
- The motor shall be installed on a suitable foundation.
- The height of foundation may be 0.5 m above the ground level.
- The cost of the motor and starter may not included in the estimation.
- The efficiency of the motor is 85 % and power factor as 0.8 (lag).

1. Size of the Cable :

$$\text{Input power} = \frac{\text{Rated BHP} \times 735.5}{\text{efficiency}}, \text{ Hence}$$

Full-load current of the motor

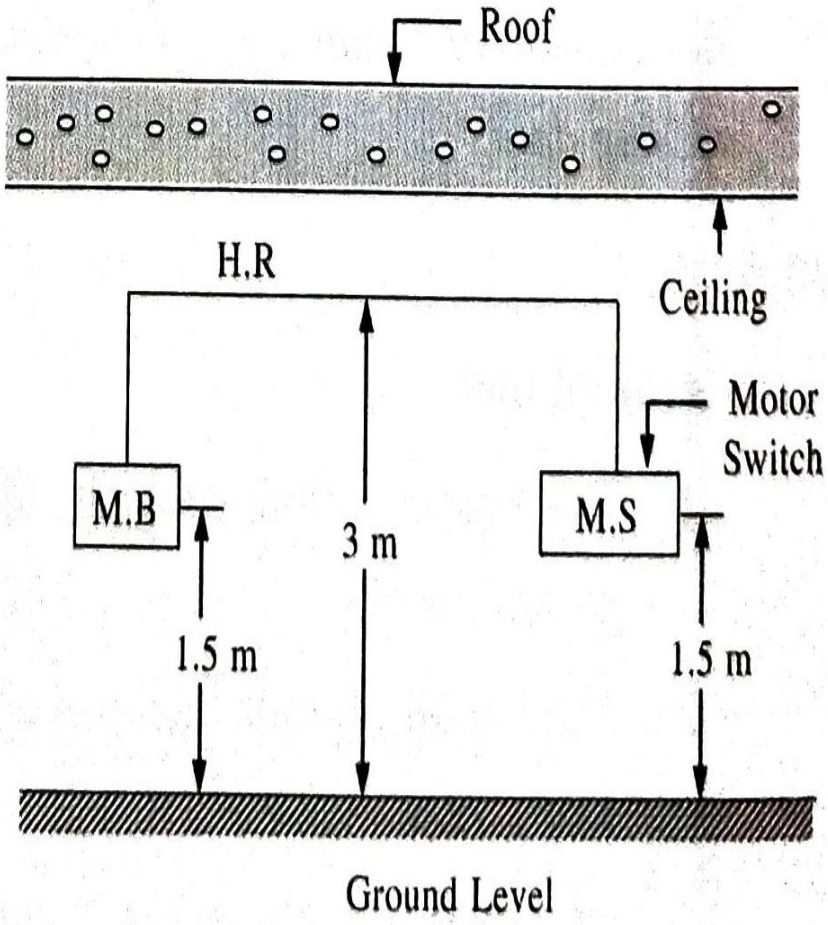
$$I_L = \frac{\text{Rated BHP} \times 735.5}{\sqrt{3} \times V_L \times \eta \times \text{Cos}\theta} = \frac{10 \times 735.5}{\sqrt{3} \times 415 \times 0.85 \times 0.8} = 15.05\ A$$

Starting current = 2 times the full-load η current = $2 \times 15.05 = 31\ A$

Hence, from the Table 1.2 and 1.3 6.0 mm^2 single core copper conductor, PVC cable of current carrying capacity of 36 A or 16.0 mm^2 Three-core aluminium conductor, PVC cable of current carrying capacity of 35 A may be used (cable of higher rating are taken from safety point of view).

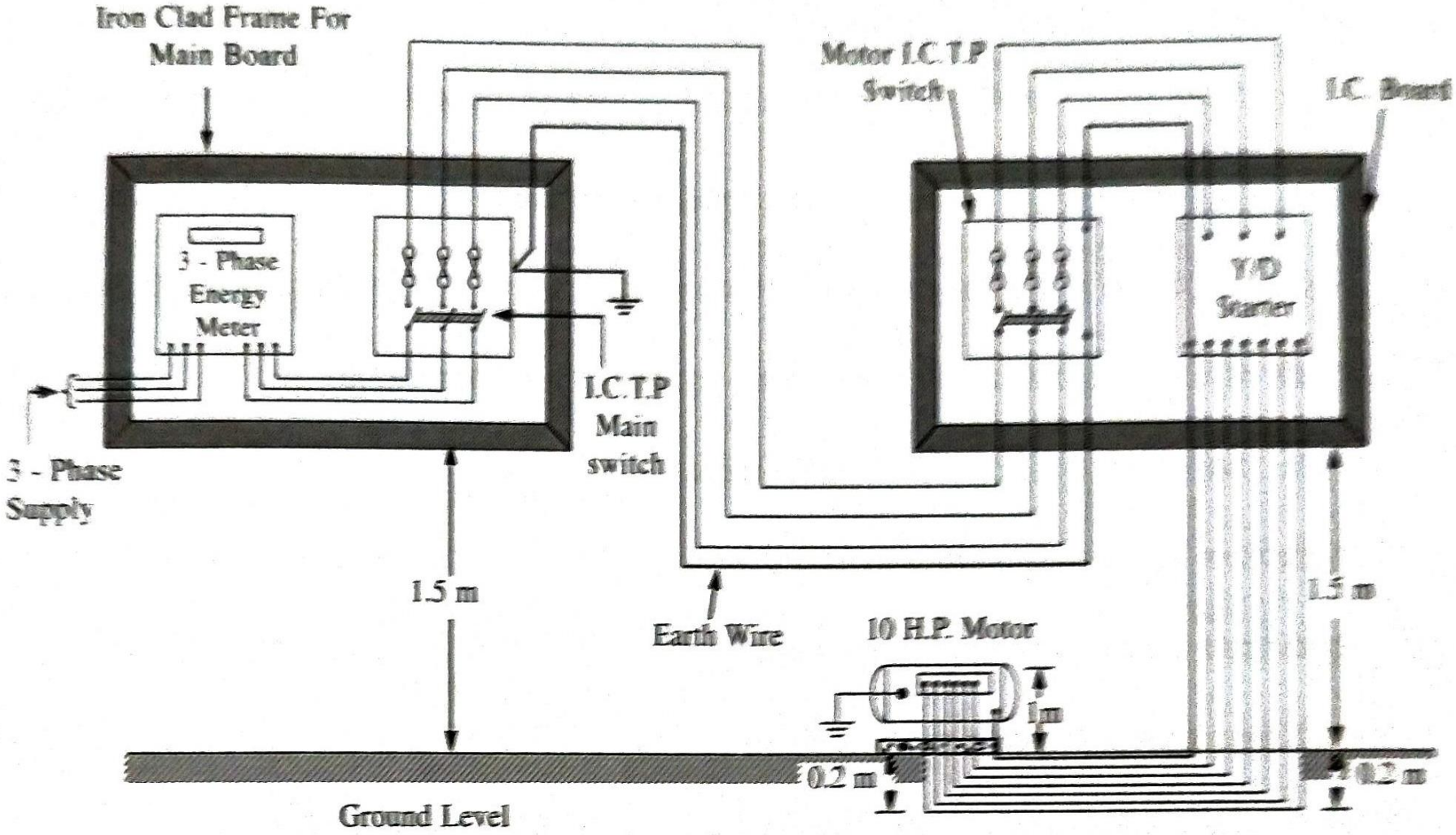
A 32 A, 415 V ICTP switch may be required as Main switch and Motor switch.

2. **Size of the Conduit :** From meter board to motor starter only 3 cables are to be run, hence 19 *mm* dia heavy gauge metal rigid conduit is required from meter board to motor switch and 19*mm* dia flexible metal conduit is required from motor switch to motor starter. From motor starter to motor terminals 6 wires are to be run, hence 25.4 *mm* heavy gauge metal rigid conduit is required from motor starter to motor base, but



(a) Height of M.R, H.R & M.S

25.4 *mm* flexible metal conduit is required from motor base to motor terminals.



(b) Wiring Diagram

Fig 2.24 :

3.Length of the Conduit :

- **<u>19 mm Heavy Gauge Rigid Metal Conduit :</u>**
- Length from Meter Board to ICTP Main switch = 0.5m
- Length from ICTP main switch to Motor switch = 1.5+9.5+1.5-=12.5m
- Total = 13.0m
- Allow 10% as wastage = 1.3m
- Total length of 19mm Heavy Gauge Rigid Metal conduit=13 +1.3 = 14.3m= 15.0 m (sag)
- **<u>25.4 mm Heavy Gauge Rigid Metal Conduit :</u>**
- Length from Motor starter to ground level = 1.5 m
- Length from Motor starter to Motor base =
- Length below the ground + along the ground up to the motor base + below ground level to ground level=0.2+2+0.2 = 2.4m
- Total = 3.9 m
- Allow 10 % as wastage = 0.39 m
- Total length of 25.4 mm Heavy Gauge Rigid Metal conduit= 3.9+ 0.39 = 4.29 m = 5.0 m (say)
- Length of 19 mm Flexible metal conduit from motor switch to motor starter = 0.5 m
- Length of 25.4 mm Flexible metal conduit form motor base to motor terminals = 1.0 m

4.Length of Cable :(6.0 mm^2 single core copper conductor cable)

- Length from meter board to ICTP main switch = 3x0.5 =1.5m
- Length from ICTP main switch to motor switch =(1.5+9.5+1.5) x 3 = 37.5m
- Length from motor switch to motor starter =0.5x 3 = 1.5m
- Length from motor starter to motor base = (1.5+0.2+2+0.2) x 6=23.4m
- Length from motor base to motor terminals = 1.0x 6 = 6.0m
- Total =69.9 m
- Allow 15 % as wastage & connections =10.485 m
- Total length of cable required==69.9 + 10.485 = 80.385 m =81 m (say)

If 3-core aluminium conductor cable is used, then total length of 3-core cable required= 81/3= 27m

Length of Earth Wire :

- According to the rules motor frame, main switch, motor switch, motor starter should be earthed. The earth wire of 8 SWG G.I wire is required for this purpose.
- Length of earth wire = Length of conduit including length of flexible conduit

=15+5+0.5+1 = 21.5 = 22 m (say)

=2.2 kg (approx) (1 kg weight equal to 10 m).

Labour Cost :

Assuming one electrician with one helper will finish the job in two days, Hence

- Labour cost = (Electrician rate + Helper rate) x Number of days

=(2000 + 500) x 2 = Rs. 5000/-

7. Estimation of Materials and their Cost :

S.No.	Material with Specifications	Quantity	Rate		Cost	Remarks
			Rs. Ps.	Per	Rs. Ps.	
1.	Iron Clad Triple Pole switch with fuse unit 32 A, 415 V	2 No	1200-00	each	2400-00	1 for Main Switch 1 for Main Switch
2.	Iron Clad Frame complete with bolts and nuts (50 cm × 60 cm)	2 No	1500-00	each	3000-00	
3.	Heavy Gauge Rigid Metal conduit					
	1. 19 mm dia	15.0 m	100-00	m	1500-00	
	2. 25.4 mm dia	5.0 m	150-00	m	750-00	
4.	Flexible Metal conduit					
	1. 19 mm dia	0.5 m	80-00	m	40-00	
	2. 25.4 mm dia	1.0m	125-00	m	125-00	

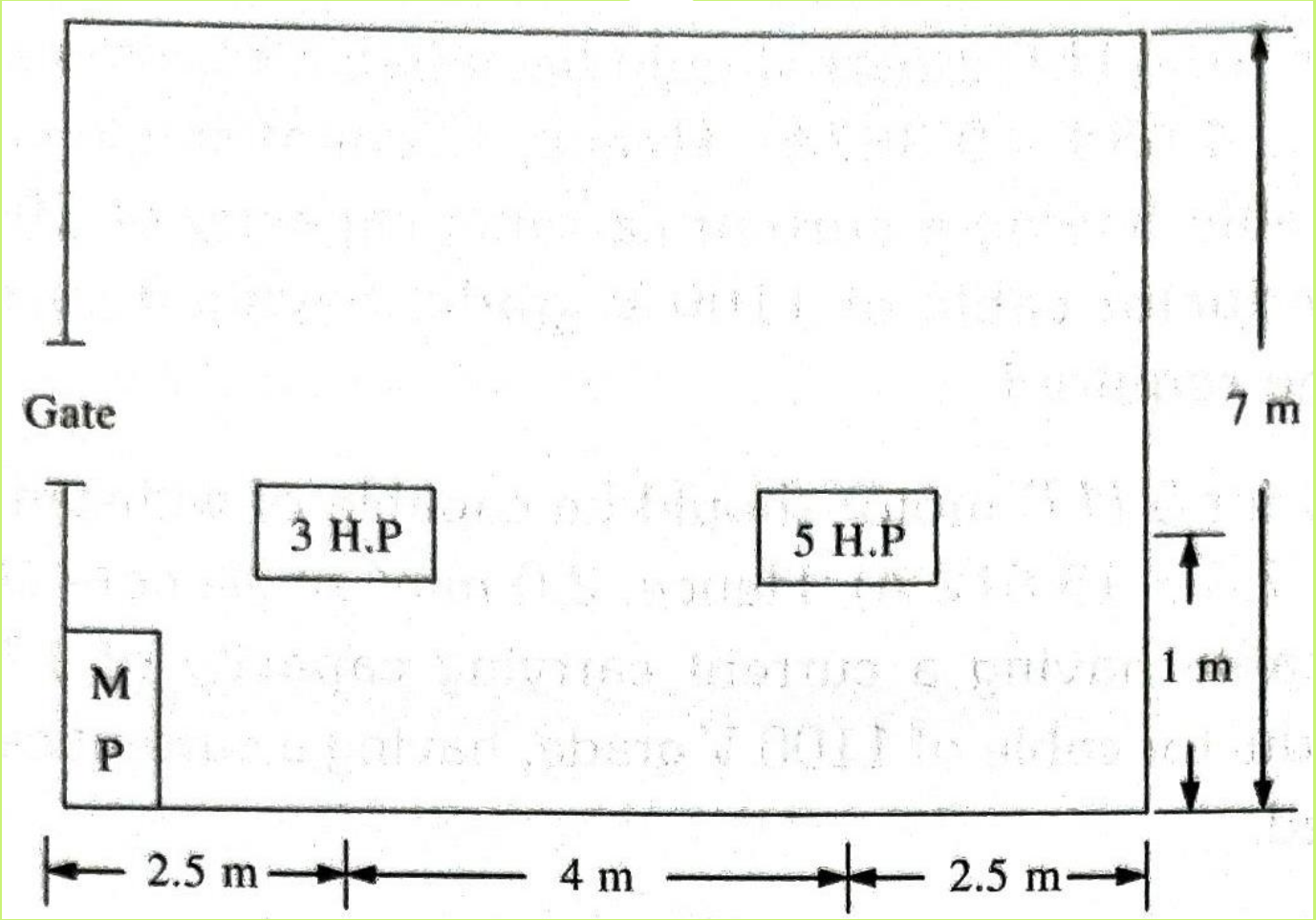
5.	6.0 mm^2 single core copper conductor	81 m	50-00	m	4050-00	
6.	Conduit bends (metal)					
	1. 19 mm dia	4 No	50-00	each	200-00	
	2. 25.4 mm dia	3 No	60-00	each	180-00	
7.	Saddles					
	1. 19 mm dia	15 No	5-00	each	75-00	
	2. 25.4 mm dia	5 No	8-00	each	40-00	
8.	Conduit couplers					
	1. 19 mm dia	2 No	75-00	each	150-00	
	2. 25.4 mm dia	2 No	100-00	each	200-00	
9.	Flexible coupling with lock nut, 25.4 mm dia	1 No	150-00	each	150-00	for coupling rigid & flexible conduits
10.	Teak wood gutties					
	2.5 $cm^2 \times 2.0\ cm^2 \times 5$ cm long	5 doz	48-00	doz	240-00	

11.	Junction box (metal), 2-way inspection type	1 No	50-00	each	50-00	
12.	Earth wire, 8 SWG G.I wire	2.2 kg	300-00	kg	660-00	10 m = 1kg
13.	Iron screws 31 mm	20 No	2-00	each	40-00	
14.	Lugs for connecting wires to motor winding in terminal box	6 No	20-00	each	120-00	
15.	Earthing set complete (earth pipe, Funnel with wire mesh, 30 × 30 cm cover plate, bolts and nuts etc)	1 set	3000-00	set	3000-00	
16.	Coal	25 kg	50-00	kg	1250-00	
17.	Salt	25 kg	25-00	kg	625-00	

18.	Caution plate	1 No	100-00	each	100-00	
19.	Shock treatment chart	1 No	75-00	each	75-00	
20.	Labour charges for civil Engg. work (Digging, foundation of motors covering, cement etc.)	L.S	—	–	2500-00	
21.	Nails 25.4 mm (1 inch)	½ kg	300-00	kg	150-00	
22.	Labour cost	—	—	—	5000-00	
		Total :			**26670-00**	
		Contingencies, 10% :			2667-00	
		Grand Total :			29337-00	
		Say :			**29340-00**	

Problem-2

- Two 3-phase, 400 V Induction motors are installed in a work shop of plan shown in Fig. 2.25. Make a neat single line sketch of power wiring of the machines. Also prepare the list of materials required and their cost for the power wiring installation. Assume missing data, if any.


Gate
7 m
3 H.P
5 H.P
M
P
1 m
2.5 m
4 m
2.5 m

- Assumptions :
- The height of Main switches, Motor switches and Motor starters are 1.5 meter from ground level.
- The height of horizontal run will be 3.0 m from floor level.
- The motors shall be installed on a suitable foundations. The height of foundations may be 0.5 m above ‘the ground level.
- The cost of the motors and starters may not included in the estimation.
- The efficiency of the motors may be 85 % and power factor as 0.8 (lagg).

18.ESTIMATION OF IRRIGATION PUMP SETS

- Irrigation is an artificial application of water to plant roots with the purpose of assisting the growth of agricultural crops. Fertilizer and chemicals can be added to an irrigation system.
- Irrigation starts with sourcing water for the crop from groundwater or surface water from a channel or storage pond.
- The estimation of irrigation pump sets is same as that of power wiring estimation.
- The motor used in irrigation (Agricultural) purpose is Induction motor, which is coupled to a pump that pumps water from a well.
- The motor and pump set are installed in a room called pump-shed.

- All civil construction and foundation work of the pump-shed should be fully completed before the installation of the motor-pump set.
- The pump-shed must have enough space for the installation.
- The pump-shed should be clean, dry and warm, the motor never be installed in dusty and damp room.
- The switch board (panel board) is placed at a height of 1.5 m and the horizontal run may be 2.5 m for ground level.
- A 25.4mm dia heavy gauge metal conduit is provided on the — roof for the entry of service connection from the nearest L.T pole to connect to switchboard.
- A two-core (twin core) weather proof aluminium conductor, 1100 V grade cable is used as service connection.
- The conduit used from switch board to motor base may be 25.4 mm dia heavy gauge rigid metal conduit and is run on the surface.
- The conduit used from motor base to motor terminals is 25.4 mm dia flexible metal conduit.

19.MATERIALS USED IN IRRIGATION PUMP SET INSTALLATION

- The materials used in estimation of irrigation pump set are similar to that of power wiring installation.
- But the switch board is provided with three indicating lamps(OW/25W, 250 V) between each phase and neutral to know whether the power exists in each phase or not.
- One Voltmeter (0-500 V) between any two phases and one Ammeter (0-50 A) in series with any phase are provided in switch board to know voltage and current.
- In addition to these materials a single phasing preventer is provided in switch board to detect the single phasing condition.

1. SINGLE PHASING CONDITION

- The accidental opening of one of the supply lines (due to blowing of fuse or breaking of conductor in only one phase) is known as single phasing condition.
- If the 3-phaseinduction motor continuous to run on single phasing condition,
- **1. Draws more current from remaining two phases (nearly 2 times the earlier current).**
- **2. Torque developed is reduced.**
- **3. There will be severe vibrations and phase windings will get heated.**
- **4. The rotor gets heated due to unbalance currents. This excess heating of rotor and stator will produce noise, heat and smoke.**
- Hence, to avoid above draw backs a single phasing preventer is connected in the supply circuit.
- The single phase preventer consists of phase failure relay which detects the single phasing condition and trips the circuit-breaker or contactor in the motor control circuit.
- The energy meter is not required for agricultural purpose as the tariff is slab system.

20.QUANTITY OF MATERIALS AND THEIR RATES

S.No.	Material with Specifications	Rate Rs. Ps.	Per	Remarks
1.	D.O.L. Starter (automatic) 400 V, 3-phase, 50 Hz with over load & no volt relay etc. Upto 3 H.P motor	2500-00	each	
2.	Star/Delta (automatic) starter with over load & no volt relay etc.			
	1. From 3 H.P to 10 H.P motor	5600-00	each	
	2. From 10 H.P to 15 H.P motor	6400-00	each	
	3. From 15 H.P to 25 H.P motor	7800-00	each	
3.	Single phasing preventer, 45 A range	2500-00	each	
4.	3-core flexible copper conductor PVC sheathed cable			
	1. 2.5 mm^2	65-00	m	For Submersible motors
	2. 4.0 mm^2	85-00	m	
	3. 6.0 mm^2	95-00	m	
	4. 10.0 mm^2	110-00	m	

5.	Cement concrete foundation for pump & motor in 1 : 2 : 4 with bolts and nuts	3000-00	L.S	Lump Sum
6.	Voltmeter A.C, 50 Hz (0-500 V)	800-00	each	
7.	Ammeter A.C, 50 Hz (0-50 A)	700-00	each	
8.	Indicating lamps (0W/25 W, 250 V)	20-00	each	
9.	Twin-core weather proof aluminium conductor with PVC cleats			
	1. 2.5 mm^2	25-00	m	
	2. 4.0 mm^2	40-00	m	
	3. 6.0 mm^2	65-00	m	
	4. 10.0 mm^2	75-00	m	
10.	Pipe clamps		50-00	each
11.	G.I. Thimbles		25-00	each
12.	Stay set	1000-00	each	

21 ESTIMATION FOR ELECTRIFYING THE IRRIGATION PUMP SETS

- The following steps may be followed in estimation of irrigation pump sets.
- Step-1 : Determination of size of the cable and ICTPN main switch.
- Step-2 : Determination of size and length of the conduit.
- Step-3 : Determination of length of the cable.
- Step-4 : Determination of length of Earth wire.
- Step-5 : Determination of Labour cost.
- Step-6 : Determination of Materials and their cost.

Problem

- Prepare the quantity of materials and their cost for an agricultural pump set of 5.5 kW,3-phase, 400 V motor. The distance between the L.T. pole and the pump-set shed(5 X 3 X 3m) is 10 meters. Assume missing data if any.

- Assumptions:
- 1. The height of switch board (panel board) is 1.5 m from ground level.
- 2. The height of horizontal run is 2.5 m from ground level.
- 3. The efficiency of the motor is 85 % and power factor as 0.8 (lagg).
- 4. The cost of the motor is need not to include in the estimation.

1. Size of The Cable and ICTPN Switch :

Full-load current of the motor,

$$I_L = \frac{kW \times 1000}{\sqrt{3} \times V_L \times \eta \times Cos\theta}$$

$$= \frac{5.5 \times 1000}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 11.674\ A$$

Starting current of the motor = 2 × full- load current = 2 × 11.674 = 23.34 9A

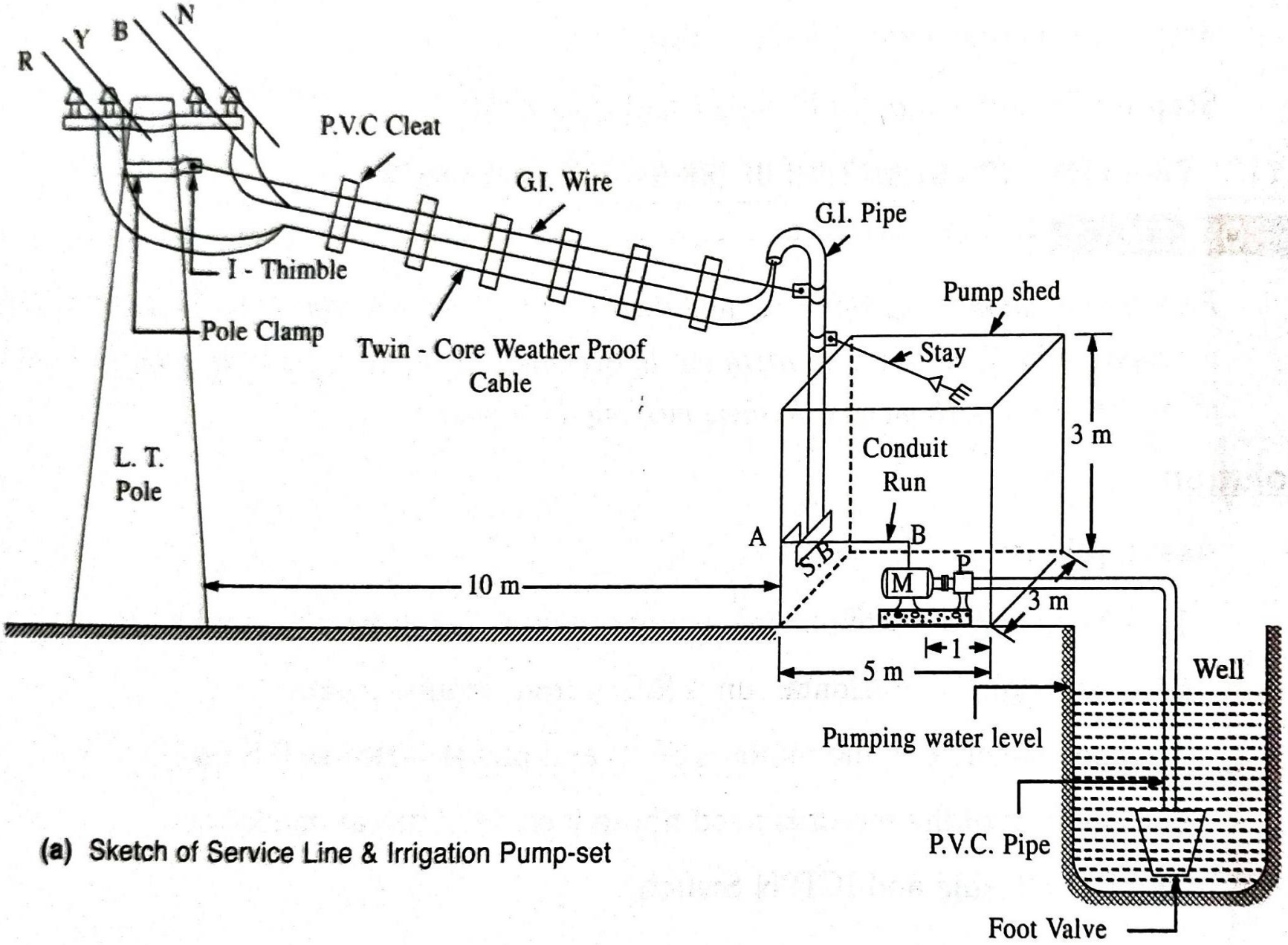
The cable used should be capable of withstanding starting current of 23.349 A. Hence, 4.5 mm^2 single core copper conductor, 650 V grade PVC cable having a current carrying capacity of 28 A or 6.0 mm^2 single core aluminium conductor, 650 V grade, PVC cable having a current carrying capacity of 27 A is required.

A 32 A, 415 V grade, ICTPN switch with fuse unit is required as main switch.

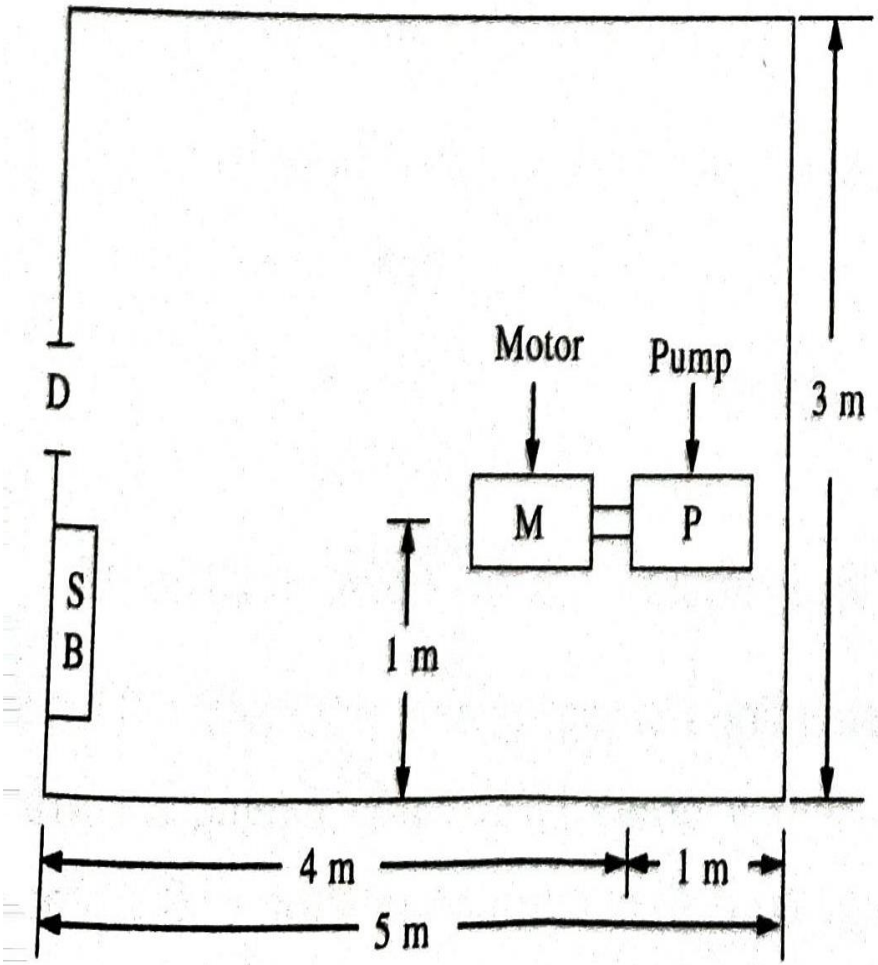
A Star/Delta starter (automatic) with over load &and no volt relay is required.

1.0 mm^2 single core copper conductor cable is required to connect the indicating lamps.

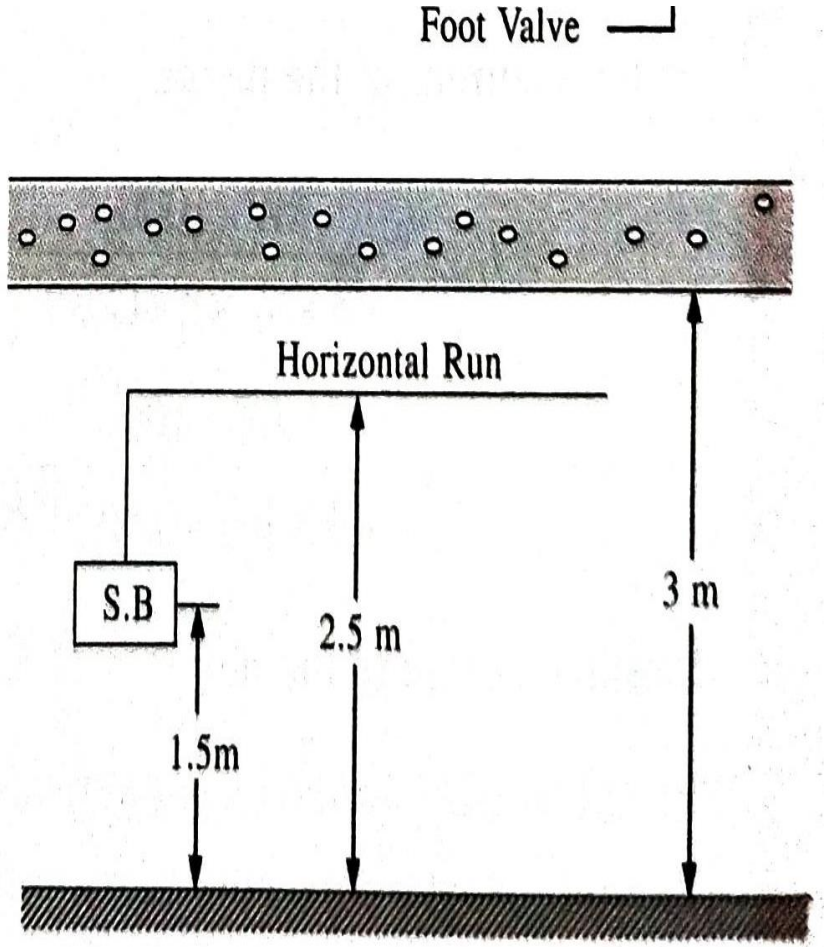
10.0 mm^2, 650 V grade Twin-core weather proof aluminium cable is used as service line.



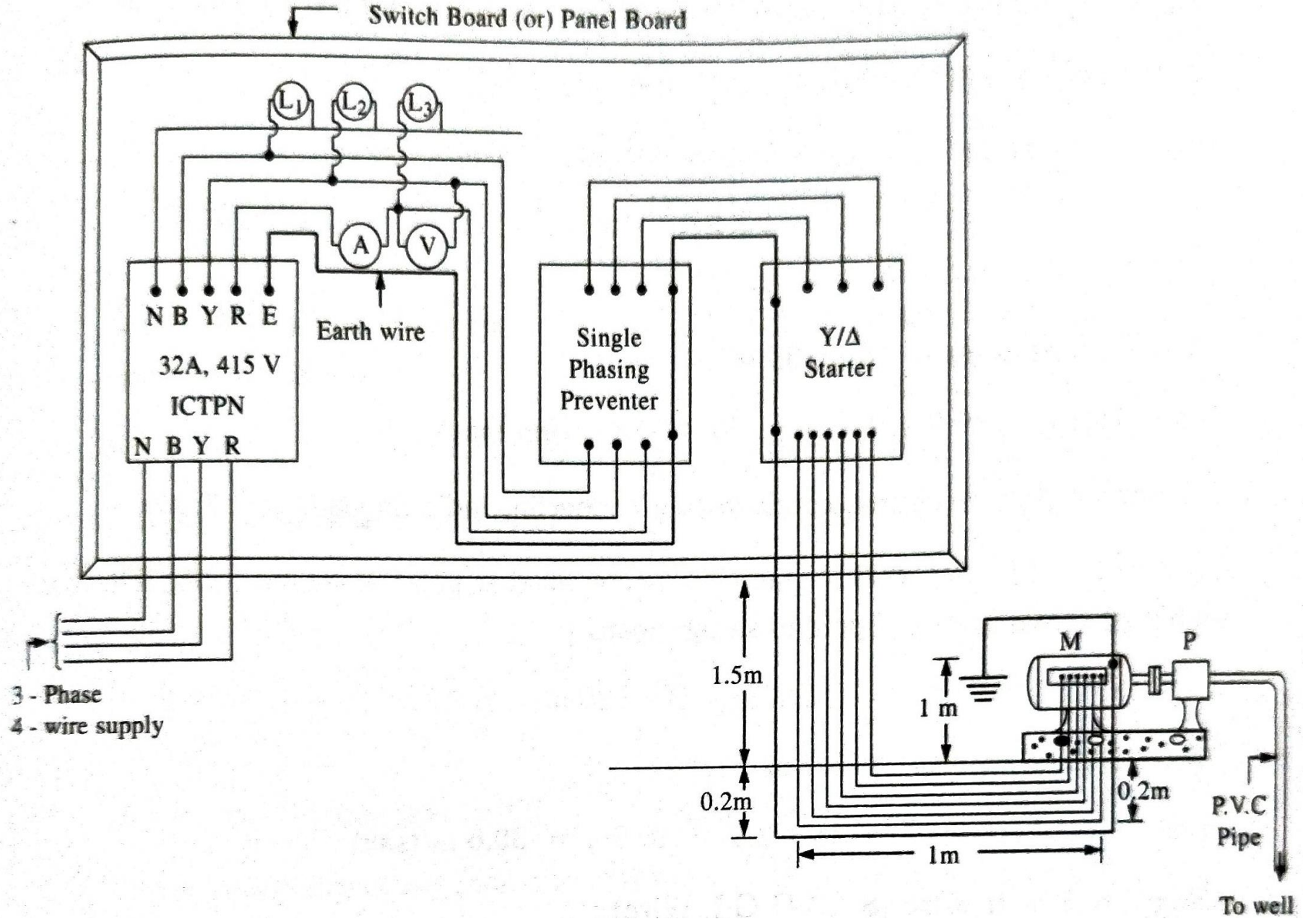
(a) Sketch of Service Line & Irrigation Pump-set



(b) Plan of Pump Shed



(c) Height of SB, HR & Pump Shed


Switch Board (or) Panel Board
L1
L2
L3
A
V
N B Y R E
32A, 415 V
ICTPN
N B Y R
Earth wire
Single
Phasing
Preventer
Y/Δ
Starter
3 - Phase
4 - wire supply
1.5m
0.2m
M
P
1 m
0.2m
1m
P.V.C
Pipe
To well

- **2. Size of The Conduit :** 25.4 mm dia Heavy Gauge metal rigid conduit is required from switch board (starter) to motor base where as 25.4 mm dia flexible metal conduit is required from motor base to motor terminals.
- **3. Length of the Conduit (25.4 mm dia Heavy Gauge Metal Rigid Conduit) :**
- Length from Switch Board to above the roof (for connecting service line) = 3 m
- Length from S .B to horizontal run = 1 m
- Length from A to B =4 m
- Length from B to pump shed floor = 2.5 m
- Length from floor to motor base = 0.2+1+0.2=1.4m
- Total =11.9m
- Allow 10 % as wastage =1.19m
- Total =13.09 m =13.5 m
- Length of 25.4 mm flexible metal conduit from motor base to motor terminals =1.0m

- **4.Length of the Cable (4.5 mm^2 Single Core Copper Conductor Cable) :**
- Length from ICTPN to starter = 0.5 x 3 = 15m
- Length from starter to motor terminals (including flexible conduit)(1+4+2.5+0.2+1+0.2+1)x 6 = 59.4m
- Total =60.9 m
- Allow 15 % as wastage =9.135 m
- Grand Total = 60.9+9.135 = 70.035 m = 70m (say)
- 1.0 mm^2 single core copper conductor for connecting indicating lamps = 2.0 m
- 10 mm^2 (1/3.55 mm), 650 V grade Twin-core weather proof aluminium conductor cable with PVC cleats from L.T pole to switch board

=(10+3) x 2 = 26mAllow 15 % as wastage = 3.9m

- **5.Length of Earth Wire (8 SWG G.I. Wire) :**
- Length from ICTPN to starter = 0.5m
- Length from starter to motor frame
- 1+4+2.5+0.2+1+0.2+1=9.9m
- Length from ICTPN to Earth pipe =5.0 m
- Length from L.T pole to G.I. pipe to support service line = 10.0 m
- Total =25.4 m
- Allow 10 % as wastage =2.54 m
- Grand Totalit25.4 + 2.54 = 27.94 m=28 m (say) = 2.8 kg

- 6.Labour Cost :
- Assuming one electrician with one helper will finish the job in two days.
- Hence, Labour cost =
- (Electrician rate + helper rate) x number of days= (2000 + 500) x 2 = Rs. 5000/-
- 7. Estimation of Materials and Their Cost :

S.No.	Material with Specifications	Quantity	Rate		Cost		Remarks
			Rs. Ps.	Per	Rs.	Ps.	
1.	ICTPN main switch with fuse unit 32 A, 415 V grade	1 No	1400-00	each	1400-00		
2.	Star/Delta starter (automatic) with over load & no volt relay etc.	1 No	5600-00	each	5600-00		
3.	Single phasing preventer (46 A range)	1 No	2500-00	each	2500-00		

4.	Iron Clad Frame complete with bolts and nuts (50 cm × 60 cm)	1 No	1500-00	each	1500-00	
5.	25.4 mm dia Heavy Gauge Rigid Metal conduit	13.5 m	150-00	m	2025-00	
6.	25.4 mm dia Flexible Metal conduit	1.0 m	125-00	m	125-00	
7.	4.5 mm^2 single core copper conductor 650 V grade cable	70.0 m	45-00	m	3150-00	
8.	1.0 mm^2 single core copper conductor 650 V grade cable	2.0 m	15-00	m	30-00	
9.	Conduit bends (metal) 25.4 mm dia	6 No	125-00	each	1125-00	

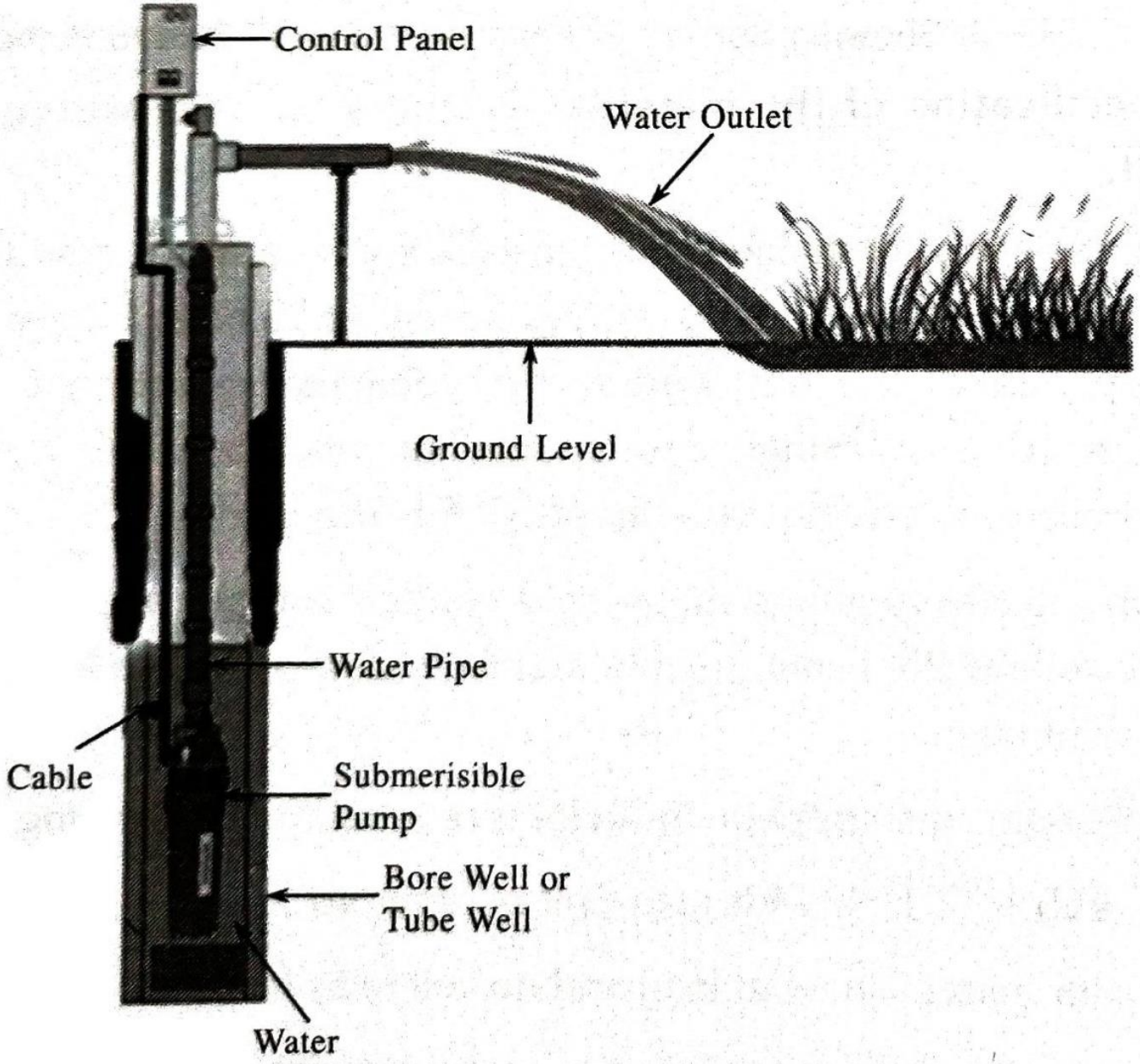
10.	Conduit couplers 25.4 mm dia	1 No	100-00	each	100-00	
11.	Saddles 25.4 mm dia	8 No	8-00	each	64-00	
12.	Flexible coupling with lock nut, 25.4 mm dia	1 No	150-00	each	150-00	for coupling rigid and flexible conduit
13.	Teak wood gutties 2.5 cm^2 × 2.0 cm^2 × 5 cm long	3 doz	48-00	doz	144-00	
14.	Earth wire, 8 SWG G.I wire	2.8 kg	300-00	kg	840-00	10 m = 1 kg
15.	Lugs for connecting wires to motor winding in terminal box	6 No	20-00	each	120-00	

16.	Iron screws 31 mm	20 No	2-00	each	40-00	
17.	Earthing set complete (earth pipe, Funnel with wire mesh, 30 × 30 cm cover plate, bolts and nuts etc)	1 set	3000-00	set	3000-00	
18.	Coal	20 kg	50-00	kg	1000-00	
19.	Salt	20 kg	25-00	kg	500-00	
20.	Stay set	1 No	1000-00	each	1000-00	
21.	Nails 25.4mm	½ kg	300-00	kg	150-00	
22.	Lamp holders, batten type	3 No	25-00	each	75-00	
23.	Indicating lamps (0/25W, 250 V)	3 No	20-00	each	60-00	

24.	Flush type 1-way switch, 5A	3 No	20-00	each	60-00	
25.	Ammeter A.C. 50 Hz,(0-50 A)	1 No	700-00	each	700-00	
26.	Voltmeter A.C, 50 Hz, (0-500 V)	1 No	800-00	each	800-00	
27.	Twin-core 10 mm^2, 650 V grade weather proof aluminium conductor cable with PVC cleats	30 m	75-00	m	2250-00	For service line
28.	Caution plate	1 No	100-00	each	100-00	
29.	Shock treatment chart	1 No	75-00	each	75-00	
30.	Labour charges for civil Engg. work (Digging, foundation of motors covering, cement etc.)	L.S	—	—	2500-00	Lump sum
31.	Labour cost	—	—	—	5000-00	
				Total :	36183-00	
				Contingencies, 10% :	3618-30	
				Grand Total :	39801-30	
				Say :	**39810-00**	

22 SUBMERSIBLE IRRIGATION PUMP SET

- A submersible pump is a unit combining a pump and a motor to an enclosed unit.
- It is a particular type of centrifugal pump designed to function with the pump and the motor. As the name indicates, it works under water.
- The pumps are specially designed to be submerged in a liquid and fitted with completely sealed and waterproof motor.
- The whole assembly is vertically submerged under water in a borehole and driven by electricity to pump the water.
- The power to the motor is fed through one or more flexible watertight cables. It pushes groundwater to the surface for irrigation purpose.
- Most submersible pumps are long cylinders that are about 3 to 5 inches around and2 to 4 feet long.
- Submersible water pumps have a hermetically sealed motor that is close-coupled to the body of the water pump.
- Having a hermetically sealed motor prevents the water from getting inside the pumps motor and causing a short circuit.
- Other components of a submersible water pump are the cable, which is connected to the motor, and a pipe that transports the water to the surface of the well.


Control Panel
Water Outlet
Ground Level
Water Pipe
Cable
Submerisible
Pump
Bore Well or
Tube Well
Water

- When the switch is put on, an electrical current is sent down an electrical wire to the submersible water pump.
- Impellers contained within the body of the pump start turning. The rotation of the impellers sucks water into the body of the pump.
- The impellers then push the water out of the pump and up through the pipe to the surface of earth.
- When the pressure switch cuts off, the current stops operating the submersible water pump, the impellers stop turning. and the pumping of water stops.
- Submersible pumps are also used for supply of fresh water for drinking and various industrial applications such as drainage, sewage pumping, general industrial pumping and slurry pumping.
- Since submersible pumps do not use a motor above ground.
- Floor space can often be better utilized, and the overall cost of the installation may also become reduced.
- These types of pumps also tend to have lower maintenance costs and create less noise than pumps which have the motor mounted above ground.

1 ESTIMATION OF SUBMERSIBLE PUMP SET

- The estimation of submersible pump-set is same as that of irrigation pump-set.
- The panel board (switch board) is installed in a pump-shed at a height of 1.5 m from the ground level and the horizontal run may be 2.5 m from the ground level.
- A 25.4mm dia heavy gauge metal conduit is provided on the roof for the entry of service connection form the nearest L.T pole to connect to panel board.
- A two-core (twin core) weather proof aluminium conductor, 1100 V grade cable is used as service connection.
- A 25.4 mm dia heavy gauge rigid metal conduit is used only from panel board to surface of the tube well and there is no need of metal conduit from surface of tube well to the submersible motor.
- A cable is connected between panel board to submersible motor.
- The materials used in estimation of submersible pump-set are same as that of irrigation pump-set.

UNIT - III

ESTIMATION OF OVERHEAD LINES AND EARTHING

SYLLABUS

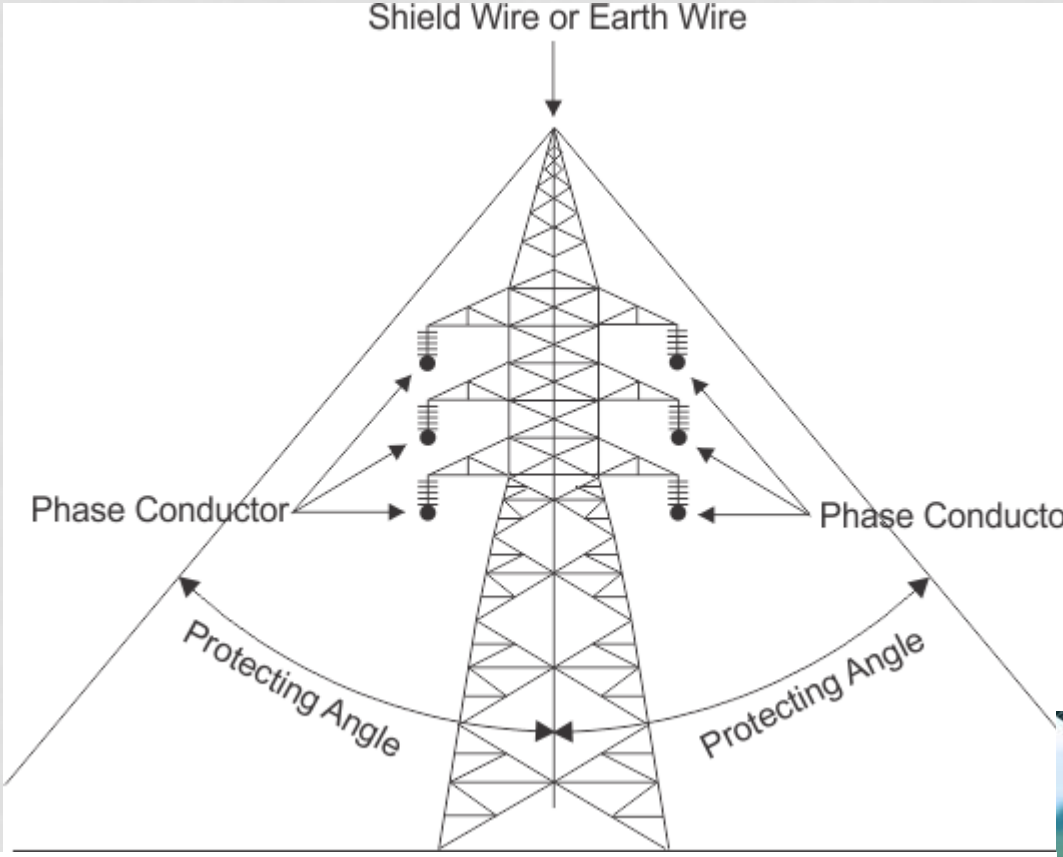
- **Introduction, main components of overhead lines, conductors, insulators, cross-arms and clamps, guys and stays, steps to solve problems on estimation of OH lines, estimation of pole and plinth mounted substations, construction of pole and plinth mounted substations, estimation of materials electrical accessories of pole and plinth mounted transformers, earthing, selection of earthing, earth resistance, methods of reducing earth resistance, estimation of materials for pipe and plate earthing.**

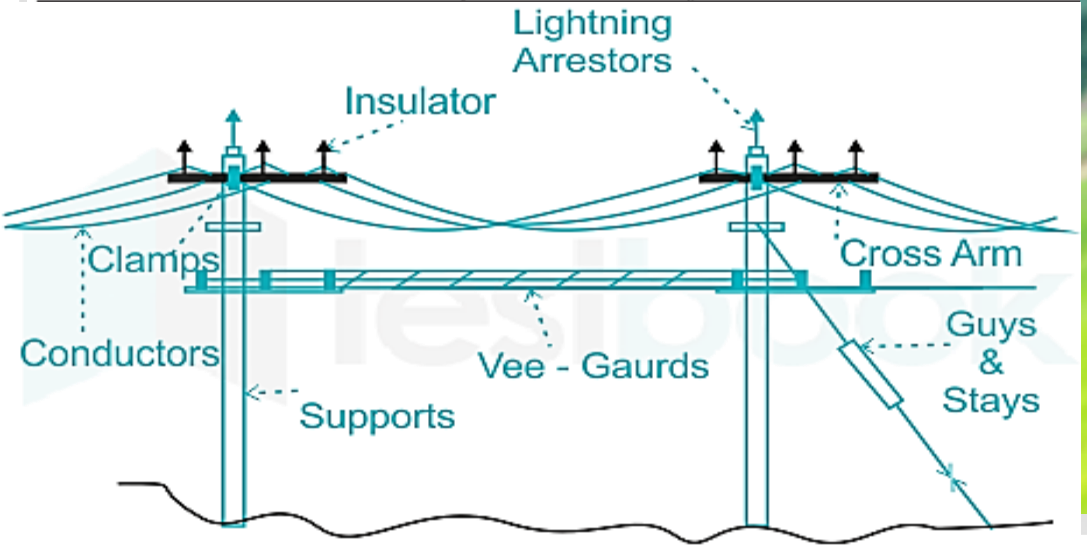
INTRODUCTION

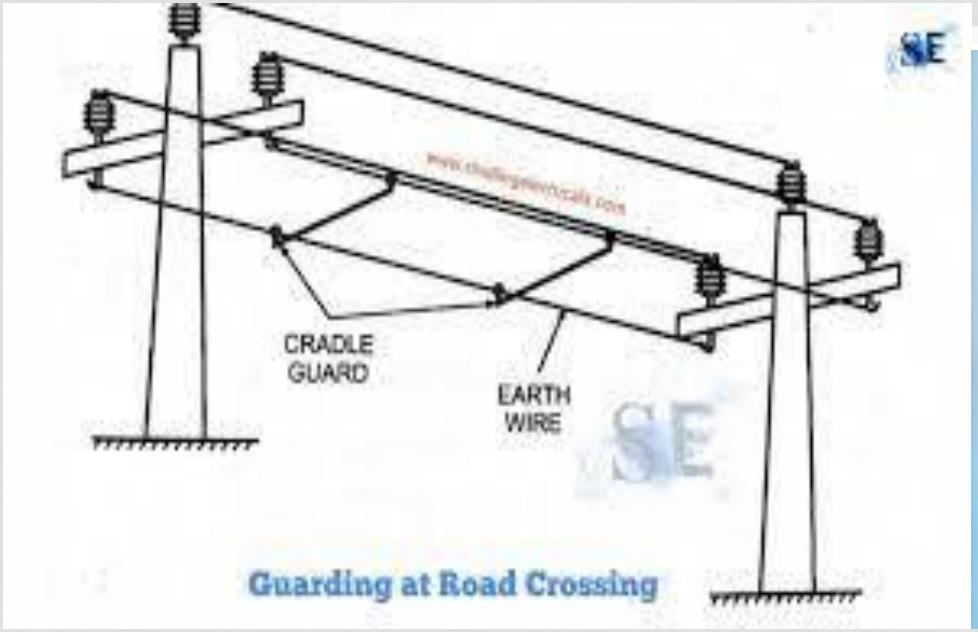
- It is well known that the electrical energy is generated in generating stations at a voltage of 3.3 kV, 6.6 kV or 11 kV.
- The voltage is stepped up to high voltage (such as 220/400 kV) at the generating (sending) end and transmitted over a long distances to the major load centers where it is stepped down to low voltages (such |as 132/66/33 kV).
- This voltage is further stepped down to 11 kV at sub-stations and finally stepped down to 400/230 V.
- This voltage is distributed to various small and big consumers by means of distribution network.
- The overhead lines which convey the electrical energy from generating stations tothe sub-stations are known as overhead (O.H) lines.
- These are also called as Feeders, —In our country 3-phase, 3-wire a.c. system is most commonly adopted for generation and transmission of electrical power, where as 3-phase, 4-wire a.c. system is adopted for distribution system through overhead lines.
- The voltage variations should be within at he prescribed limits which are + 5 % in case of L.T (Low Tension) voltage and + 12.5 % in case of H.T (High Tension) voltage.

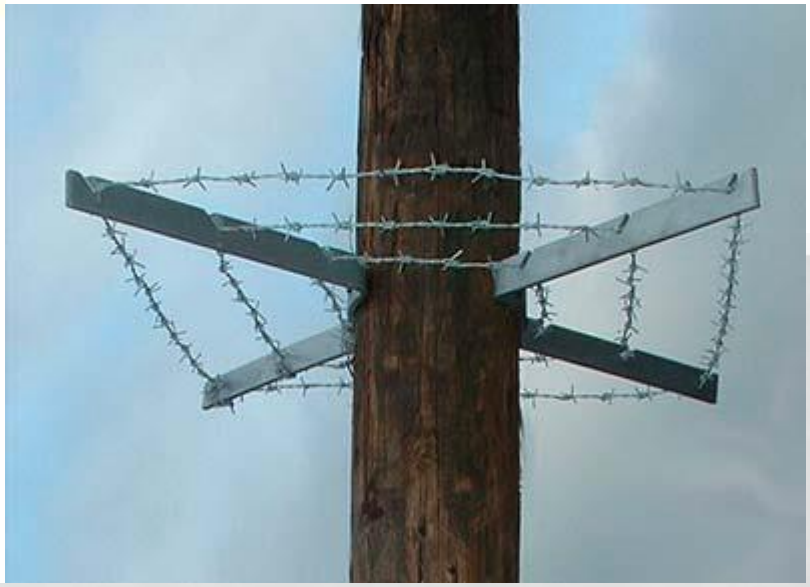
1. MAIN COMPONENTS OF OVERHEAD LINES

- The effective and efficient operation of O.H Transmission lines depends on the |mechanical design of the line. In general the main components of an overhead line are. –
- 1. Conductors : To carry the electrical power form generating end to receiving end.
- 2. Supports : These may be poles or towers depending upon the operating voltage and supports the conductors to keep them at a suitable level above the ground level.
- 3.Insulators : These supports the conductors and insulate them from ground.
- 4. Cross-arms and Clamps : They may be either wood or steel angle section used to provide support to the insulators and conductors along the poles and are fixed tot he supports with the help of clamps.
- 5. Guys and Stays : These are fastened to the poles at the termination or angle points to resist the lateral forces.


Shield Wire or Earth Wire
Phase Conductor
Phase Conductor
Protecting Angle
Protecting Angle


Lightning Arrestors
Insulator
Clamps
Cross Arm
Conductors
Vee - Gaurds
Guys & Stays
Supports


CRADLE
GUARD
EARTH
WIRE
Guarding at Road Crossing



REDMI NOTE 8
AI QUAD CAMERA

- 6. Lighting Arresters : They discharges high voltage induced on O.H lines to the earth due to lightning.
- 7. Fuses and Isolators : They isolates different parts of the O.H. lines.
- 8. Earth Wire : It is run on the top of the tower to provide protection to the O.H. line against lightning strokes,
- 9. Vee Guards : These are provided below the O.H. lines running along or across streets for protection of human being in case of broken of conductors.
- 10. Guard Wires : These are provided above or below the power lines while crossing a communication lines.
- 11. Barbed Wire or Anti-climbing Device : It is provided on each pole at a height of2.5 m from ground level to prevent climbing of unauthorized persons.
- 12. Danger Plates : These are provided at a height of 2.5 m from ground level and indicate working voltage. A word “danger” is written on the danger plate.
- 13. Phase Plate : These indicate the various phases such as R, Y, B or N etc.
- 14.Bird Guards : A wooden or ebonite piece which is fitted on the cross-arm brackets in case of metallic poles to avoid short-circuiting of two phases or one phase and earth due to sitting of bird on the pole. |
- 15. Miscellaneous Items : Jumpers, bolt and nuts etc.

2. CONDUCTORS

- The conductor is one of the most important items in transmission and distribution system of electric power.
- Most of the capital cost is invested on it. Hence, proper choice of material and size of the conductor is utmost importance.
- All conductors used for O.H lines are preferably stranded to increase the flexibility.
- Generally in a stranded conductors, there is one central wire and around this, there is a successive layers of wires containing 6, 12, 18, 24 wires i.e. if there are 'n' layers, the number of individual wires are $3n(n+1)+1$.
- The commonly used materials as O.H. lines are copper, All Aluminium stranded conductors (AAC or AASC), Aluminium conductor Steel Reinforced (ACSR),galvanized steel and cadmium copper.
- But Aluminium Conductor Steel Reinforced conductrs are most commonly used as transmission and distribution lines. ACSR consists of galvanized steel which is surrounded by number of aluminium strands.

- ACSR conductors being of high tensile strength and lighter in weight produces small sag and hence longer spans can be used.
- The size of conductor depends on many factors such as working voltage, length of transmission lines, power to be Stranded Conductor carried, power factor of the load and permissible voltage drop.
- The actual length of conductor = length of the line + 2% for sag + 2% as wastage.

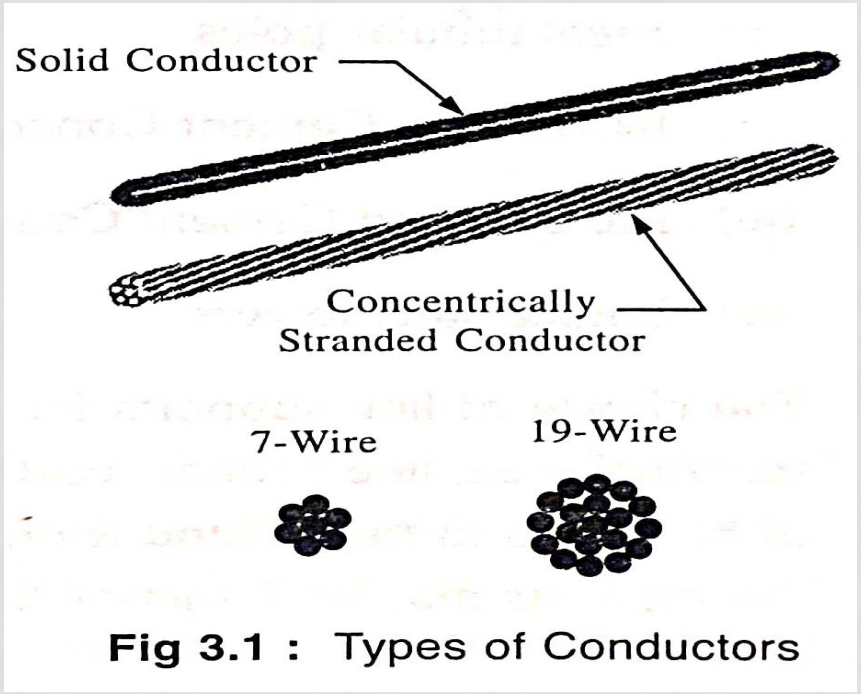


Fig 3.1 : Types of Conductors

The size and current rating for a ACSR conductor for O.H line is as follows,

S.No.	Number and Diameter of wire in mm	Approximate current carrying capacity in Amps. at 45°C
1.	$\frac{6}{1\times2.11}\left(\frac{7}{2.11}\right)$	115
2.	$\frac{6}{1\times2.36}\left(\frac{7}{2.36}\right)$	133
3.	$\frac{6}{1\times2.59}\left(\frac{7}{2.59}\right)$	150
4.	$\frac{6}{1\times3.00}\left(\frac{7}{3.00}\right)$	181
5.	$\frac{6}{1\times3.55}\left(\frac{7}{3.55}\right)$	208

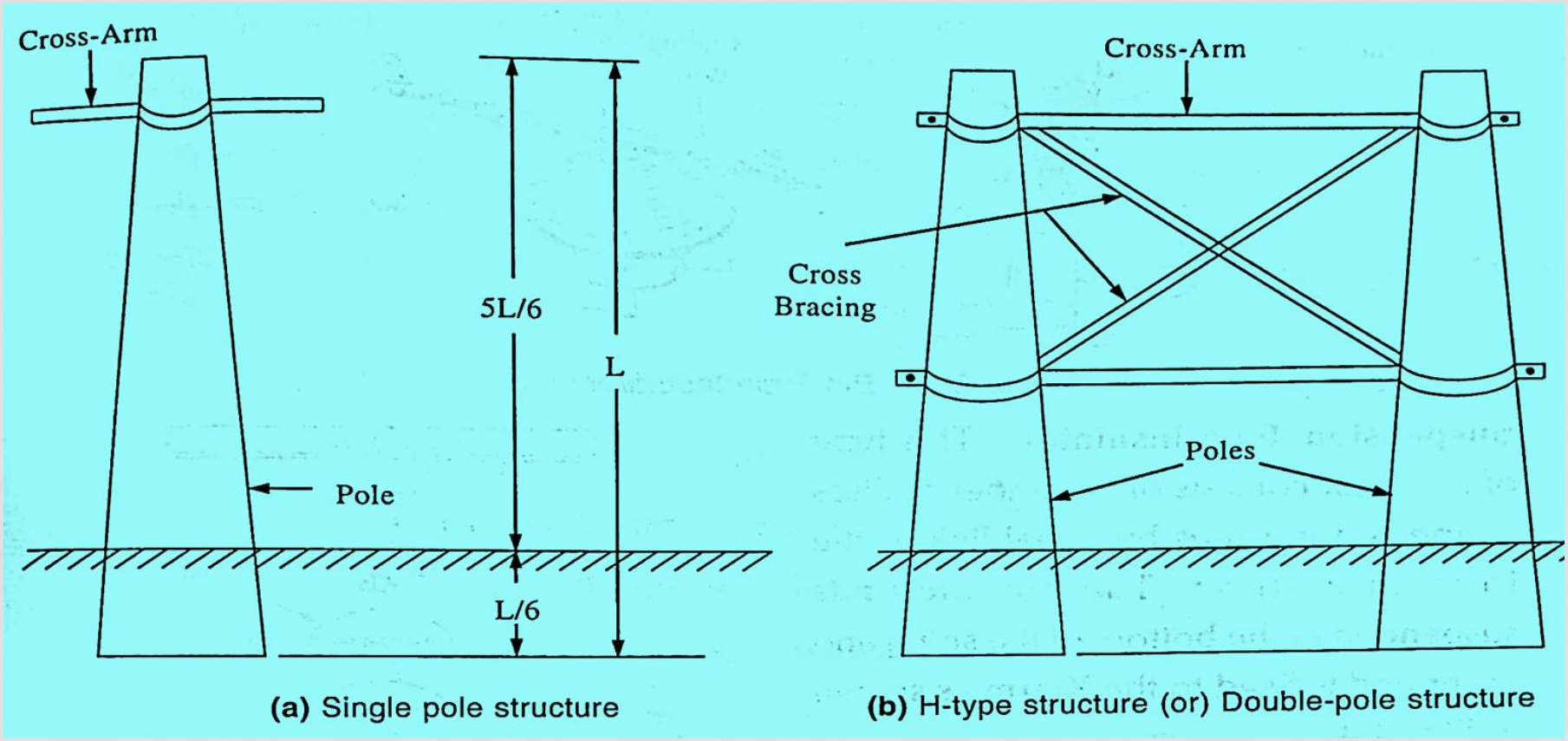
Note : $\frac{6}{1\times2.11}\left(\frac{7}{2.11}\right)$ means '6' aluminium conductors are wound over '1' steel conductor and the size of each wire is 2.11 *mm* in diameter.

2.1 SUPPORTS

- The various types of poles and towers which support the O.H. line conductor are called as supports.
- Line supports must be capable of withstanding the weight of conductor, |wind and ice loads etc.
- The various types of supports used for transmission and distribution of electrical power are :

1. Wooden poles
2. Steel tubular poles
3. Reinforced Cement Concrete (R.C.C) poles
4. Pre Stressed Cement Concrete (P.S.C.C) poles and
5. Lattice steel towers.

- The choice of line supports for a particular case depends upon the line span, cross sectional area, line voltage, cost and local conditions.
- In normal soil the length of pole to be buried in the ground is one-sixth 1/6" of the pole length.
- The normal length of the supports may be 8 meters to 12 meters as shown in Fig. (a).



(a) Single pole structure

(b) H-type structure (or) Double-pole structure

- **H-Type Structure :**
- Generally single poles are used in the straight runs of an O.H. line.
- H-type structure as shown in Fig. (b) is employed in the line at turning points, angle points (90° or any angle), at dead ends.
- Some time in order to achieve line stable, H-type structure is provided after every one kilo-meter in a straight run.

3. INSULATORS

- The function of Insulator is to provide insulation resistance for the leakage current fromO.H. line to support or earth.
- Insulators are mounted on the Cross-arms (also written as X-arms) and the conductors are fixed to the insulators by means of binding wire.
- The various materials used for insulators are porcelain, glass, steatite and special artificial materials.
- The various types of insulators used for O.H. transmission and distribution lines are.
- 1. Pin type insulators.
- 2. Suspension type insulators.
- 3. Strain insulators.
- 4. Shackle insulators.

- **Pin Type Insulator :**
- As the name indicates, this is designed to be mounted on a pin which in turn is secured to the cross-arm of the pole.
- There is a groove at the top of the insulator and conductor passes through this groove and is bound by the aluminium binding wire as shown in Fig. 3.3.
- This type of insulator is used upto 33 kV.

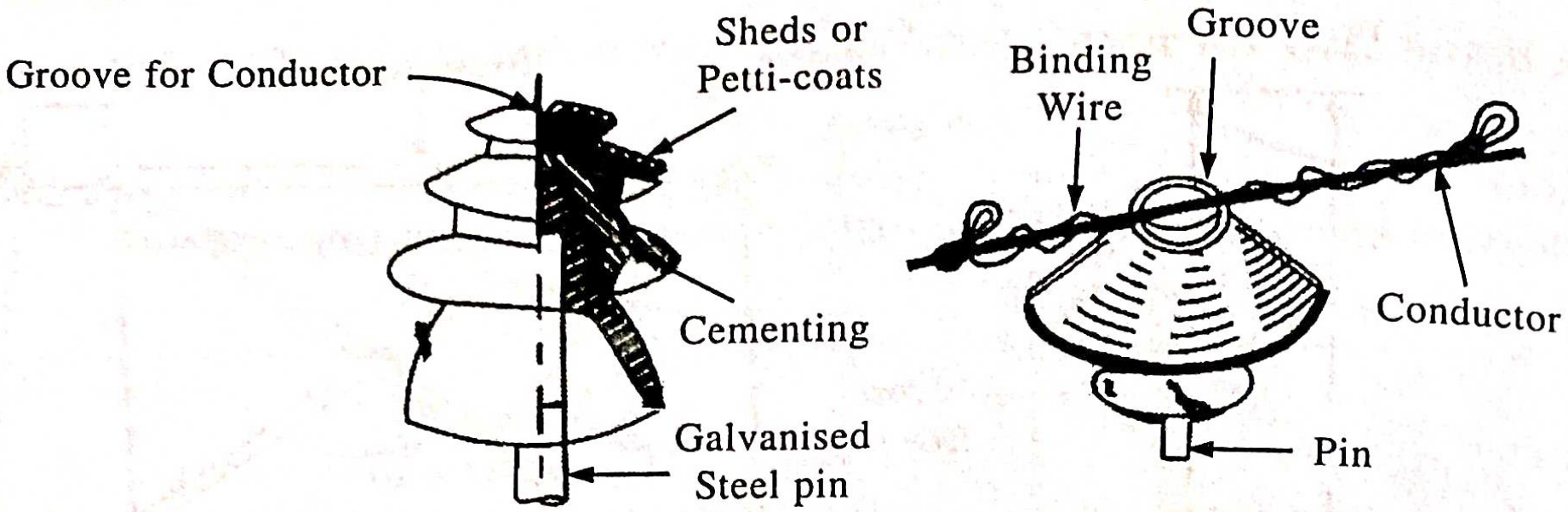


Fig 3.3 : Pin Type Insulator

33 kV Pin
700 CD
33 kV Pin
580 mm CD
22 kV Pin
480 mm CD
11 kV Pin
230 mm CD
22 kV Post
430 mm CD
Lightning Arrestor
L. A. Shell
Solid Core 11 kV
C.T.
Bushing
11 kV Pin Insulator
280 mm CD Type
11 kV Pin Insulator
230 mm CD Type
11 kV Post
320 mm CD
L. A. Shell
D.O
Solid core

- 2. Suspension Type Insulator :
- This type of insulator consists of a number of discs connected in series by metal link in the form of a string.
- The conductor is suspended at the bottom of the string and other end is fixed to the X-arm as shown in Fig. 3.4.

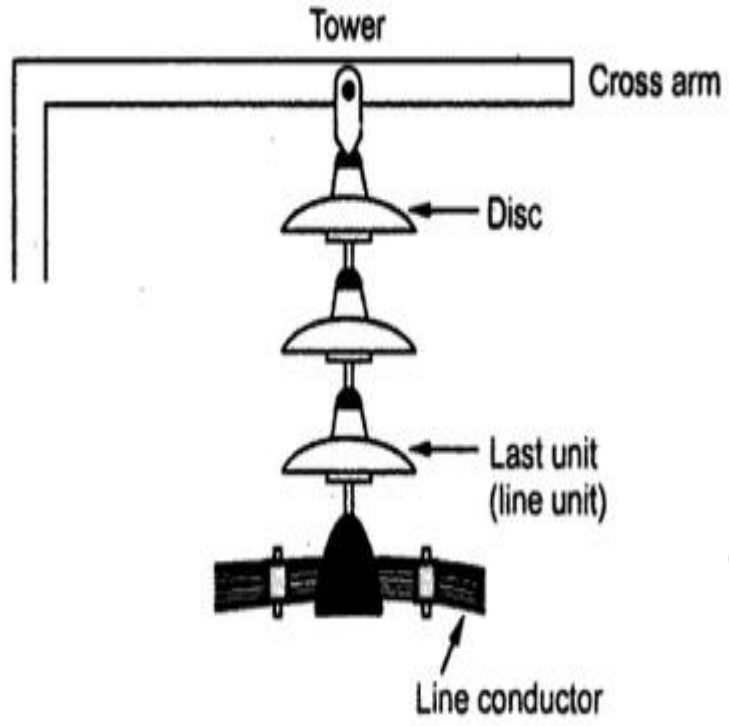
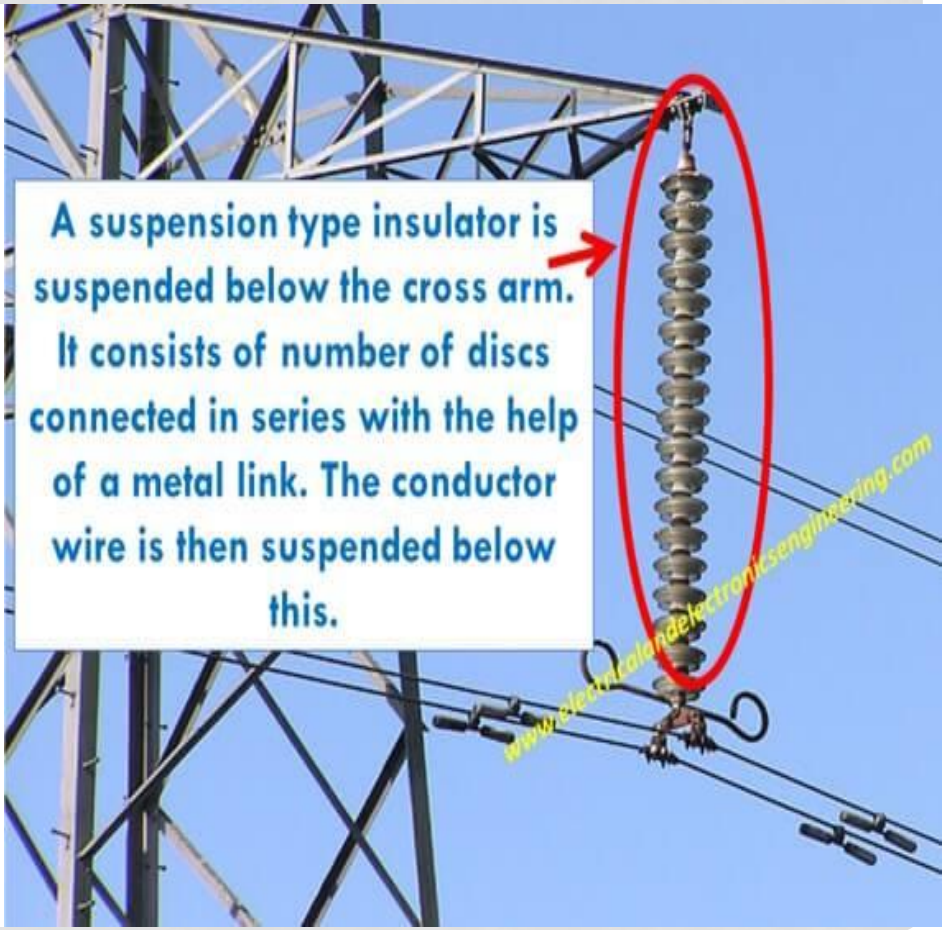
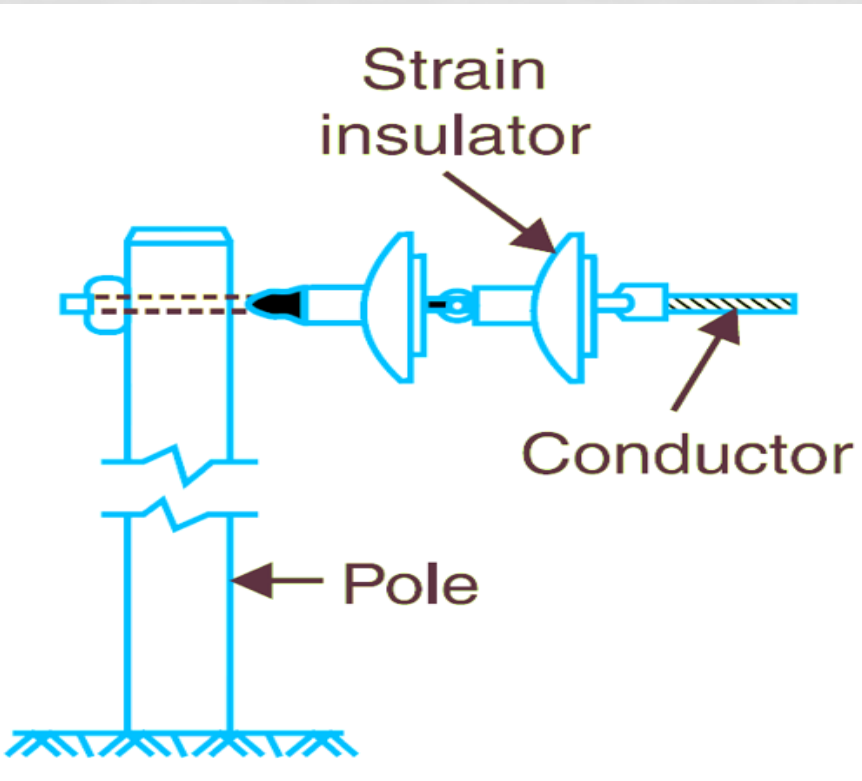


Fig. 2 String of suspension insulator with 3 units

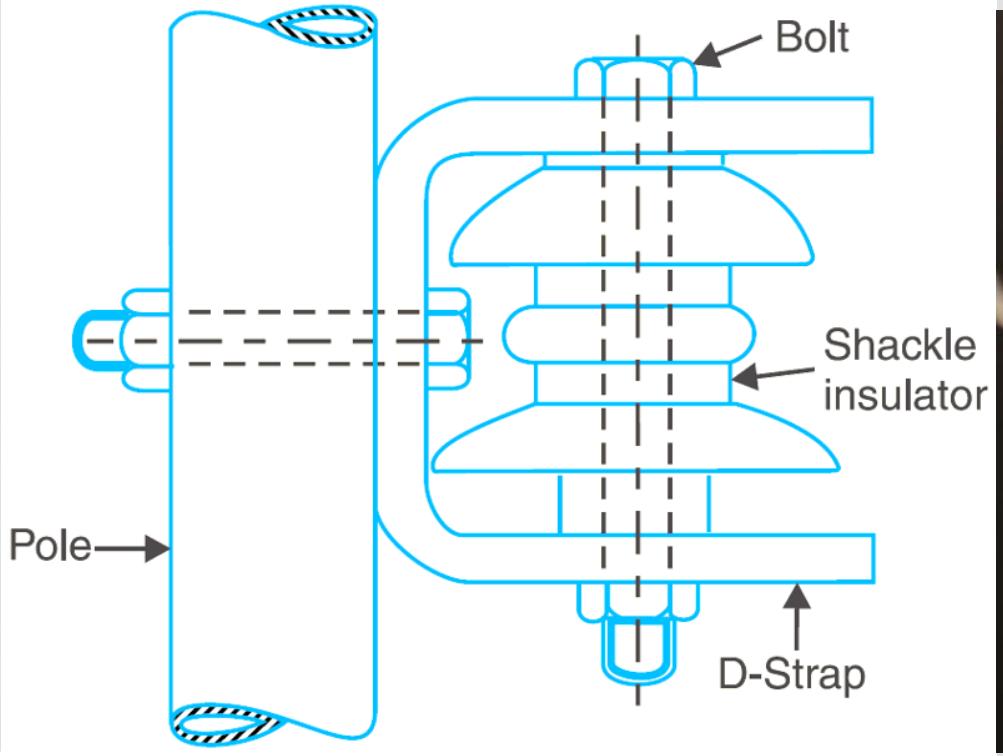


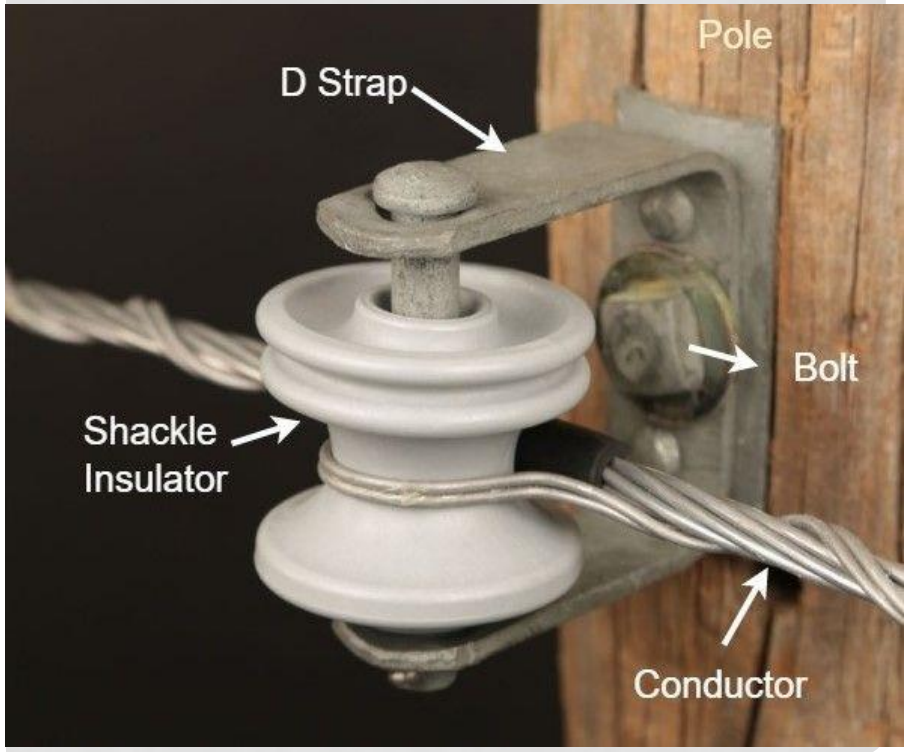
- **3.Strain Insulator :**
- This type of insulator is used where the line is subjected to greater tension like dead end of the line, corner or sharp curve.
- For the voltage below 11 kV shackle insulators are used as strain insulator.
- However, for high voltage transmission lines strain insulator consisting of an assembly of suspension type insulators are used as shown in Fig
- The only difference between suspension type and strain insulator is that in case of suspension type insulator the discs are horizontal where as in case of strain insulator the discs are vertical.



4.SHACKLE INSULATOR :

- Shackle insulator can be used either in a horizontal position or vertical] position.
- These are directly fitted to the pole or cross-arm with a bolt and nut as shown in Fig.3.6.
- The conductor is fixed in grooves by means of soft copper or aluminium -binding wire.



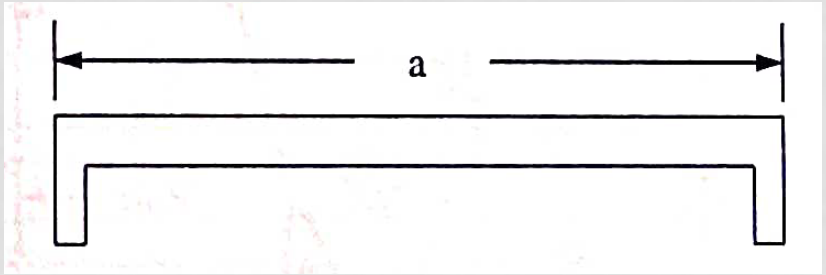


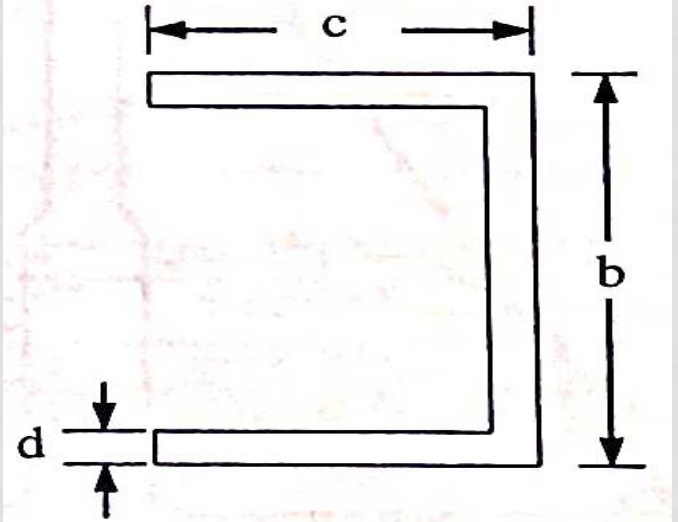
4.CROSS - ARMS AND CLAMPS

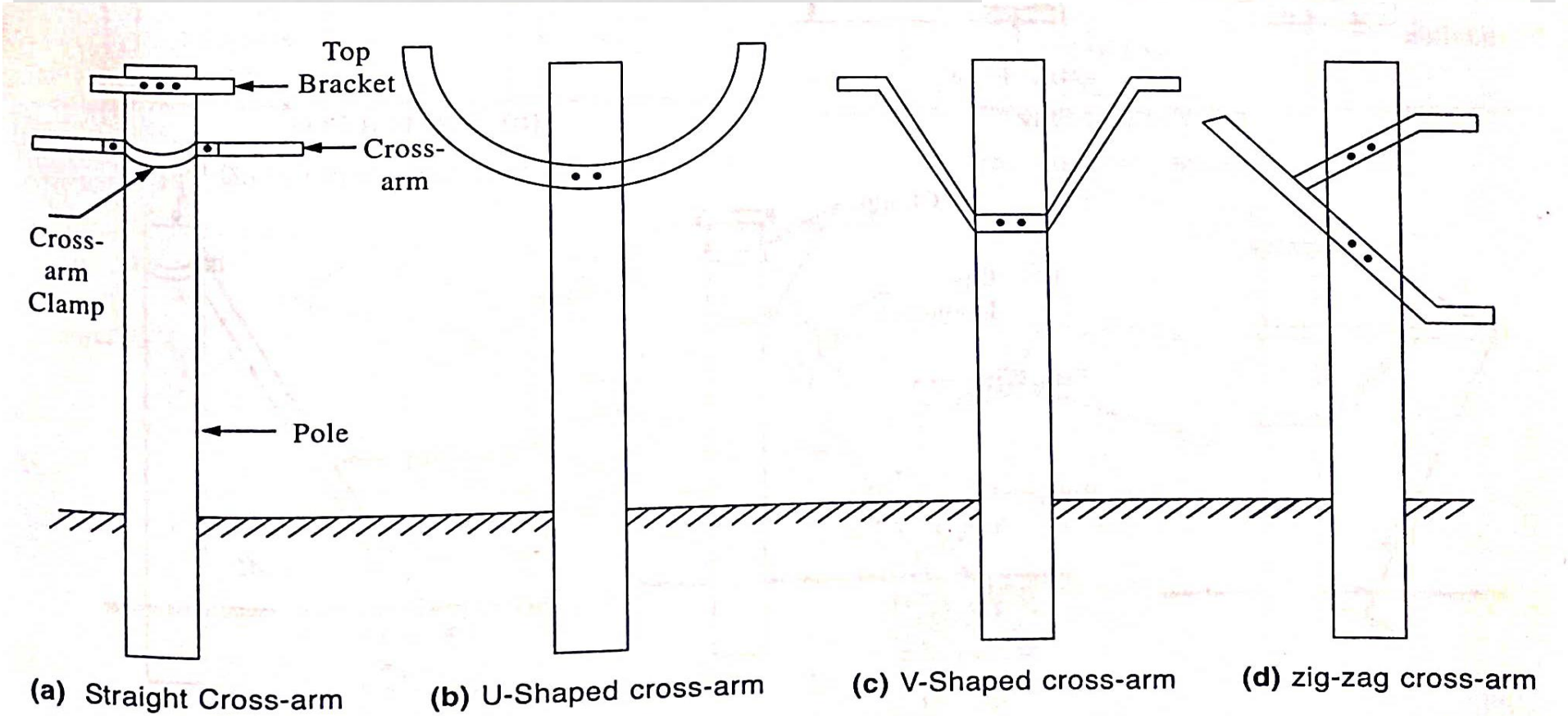
- The function of cross-arm is to support insulators, and to keep the conductors at a safe distance from each other and from the pole.
- These are fitted at the top of the pole by means of clamps.
- The most commonly used cross-arms are Mild Steel (M.S) channel or angle iron and may be of straight, U-shaped, V-shaped or zig-zag shaped as shown in Fig. 3.8.
- The commonly used sizes of Mild Steel channel for different voltages are as follows.

(a) (b) (c) (d)

1. 1.5 *m* × 50 *mm* × 30 *mm* × 3.7 *mm* for 415 *V* (distribution)
2. 1.5 *m* × 76 *mm* × 38 *mm* × 6.4 *mm* for 11 *kV* (Transmission)
3. 2.15 *m* × 100 *mm* × 50 *mm* × 6.4 *mm* for 33 *kV*





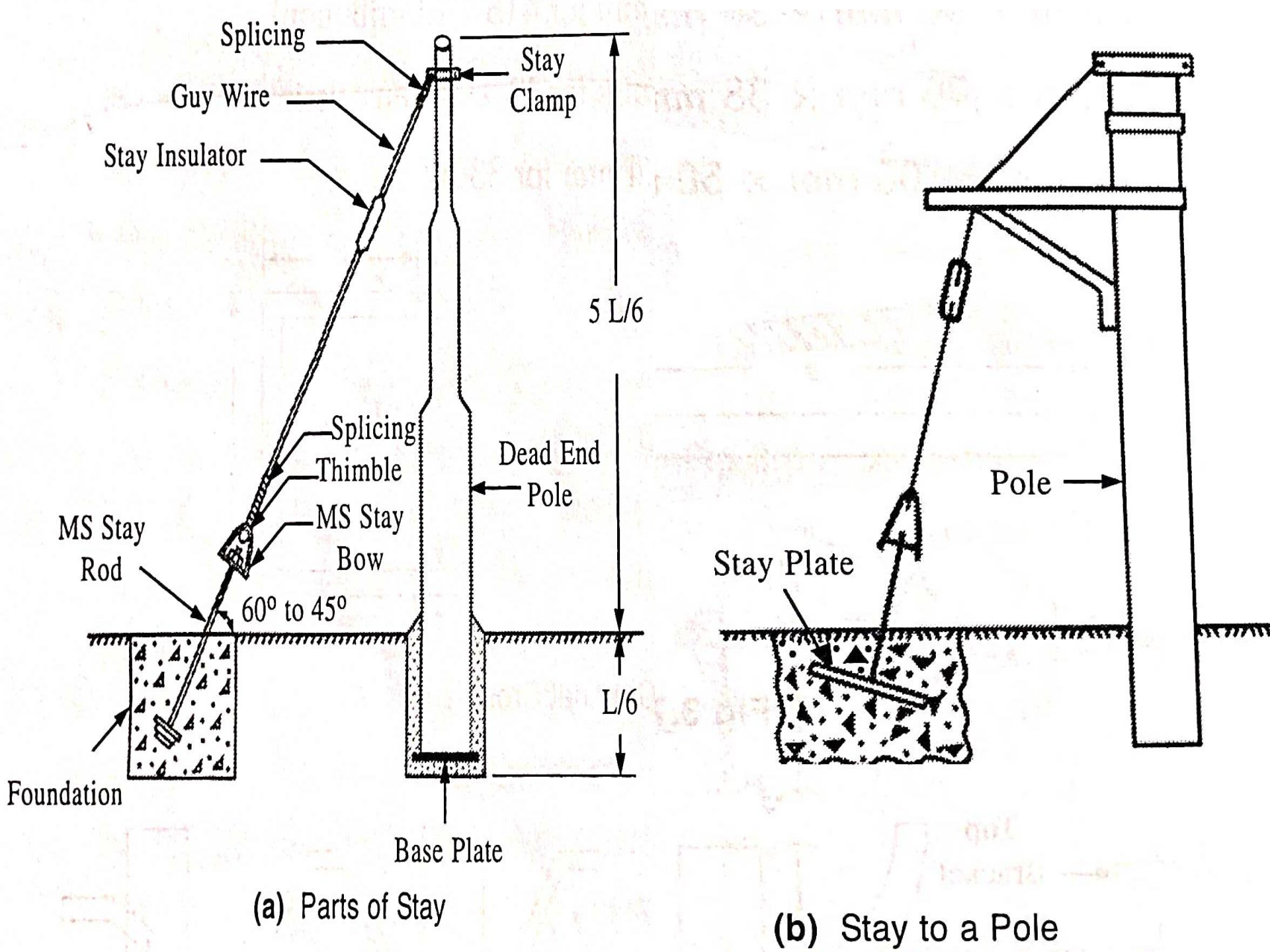


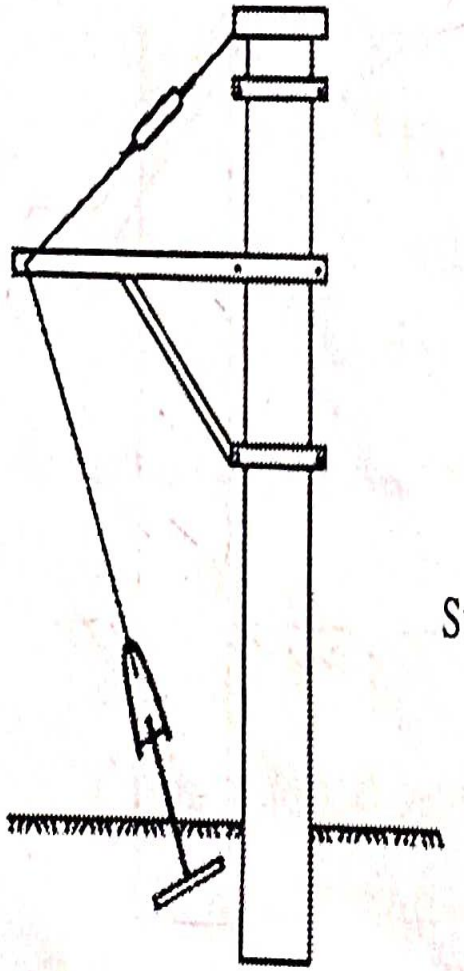
(a) Straight Cross-arm (b) U-Shaped cross-arm (c) V-Shaped cross-arm (d) zig-zag cross-arm

- D-clamps (50 x 6 mm) are made of flat iron and are used for fixing shackle insulators, Cross. arms etc.
- Pole brackets are made of Mild Steel flat of size 60 x 8 mm and are used for fixing pin insulators at the top of the pole when conductors are arranged in delta fashion.

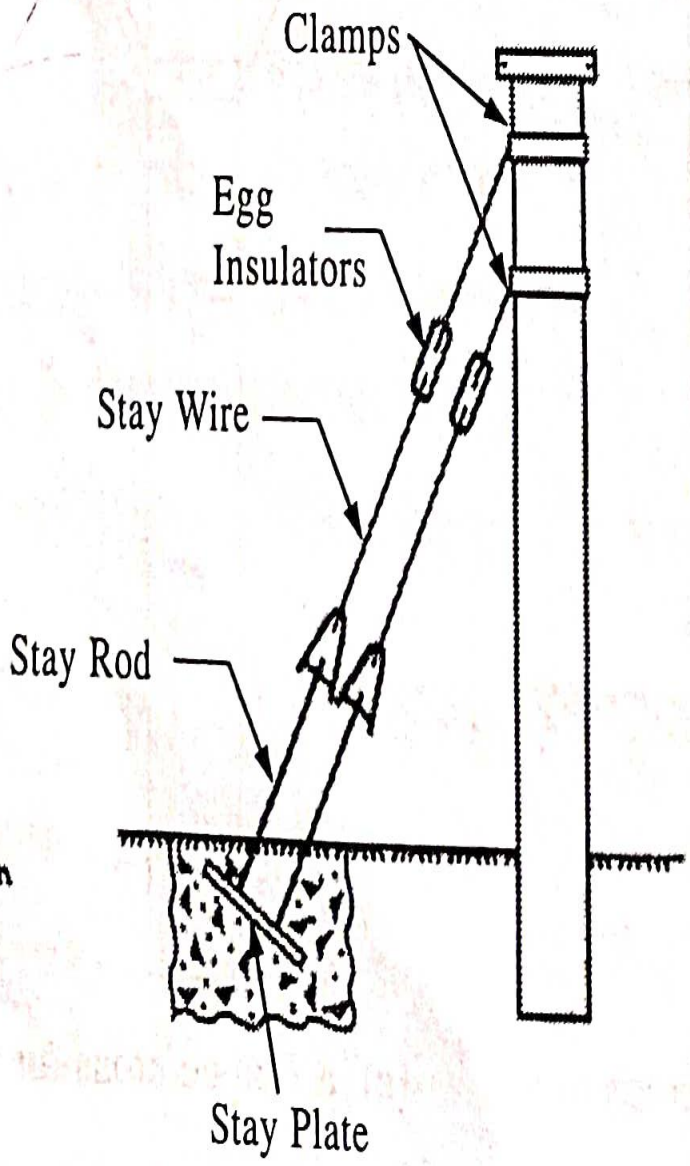
5 GUYS AND STAYS

- It is necessary to support the poles when conductors run at an angle or at terminal points so that pull created by overhead line is balanced. The wire tied between pole and stay tightner is called “Guy wire”.
- The stay rod is well set in ground in concrete foundation before the line conductors are stretched on poles.
- Guy wire is fixed to the pole by means of clamp and then guy wire is tied to stay bow as shown in Fig.,
- The minimum angle between pole and stay is 30°.
- Stay set consists of M.S. rod of 19 mm dia, stay bow, check nut, thimble, stay wire (7/18 or 7/20 S.W.G), Stay clamp and a Cast Iron anchor plate 450 x 450 mm having 4.8 mm hole in the centre.

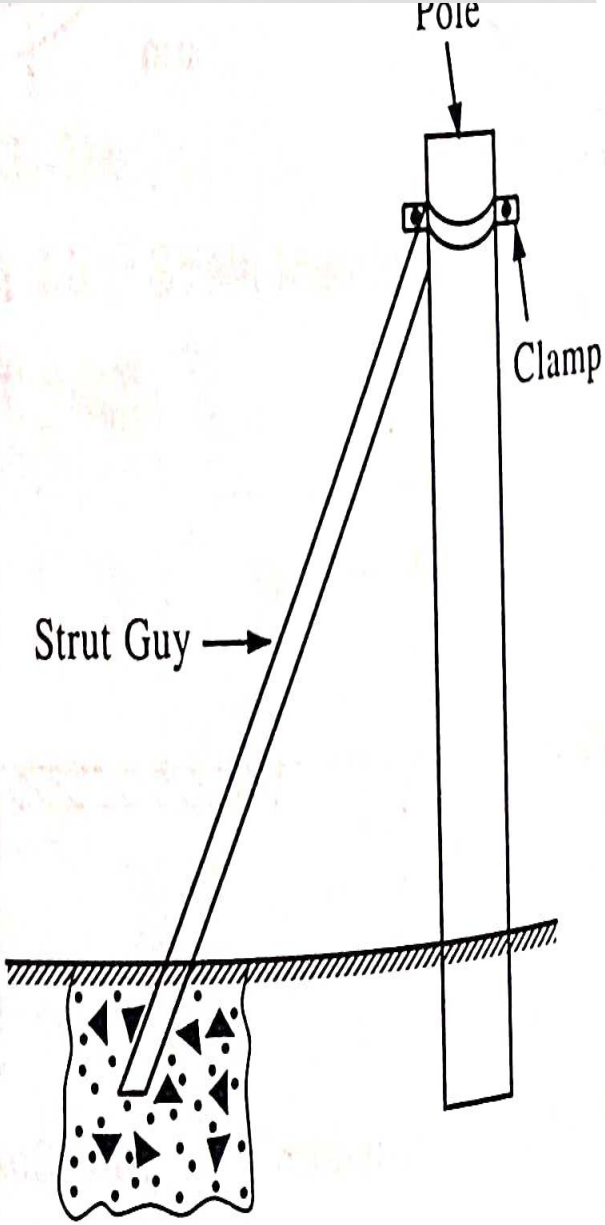

Splicing
Guy Wire
Stay Insulator
Stay Clamp
5 L/6
Splicing Thimble
MS Stay Rod
MS Stay Bow
Dead End Pole
60° to 45°
L/6
Foundation
Base Plate
(a) Parts of Stay
Pole
Stay Plate
(b) Stay to a Pole



(c) Single Stay Arrangement

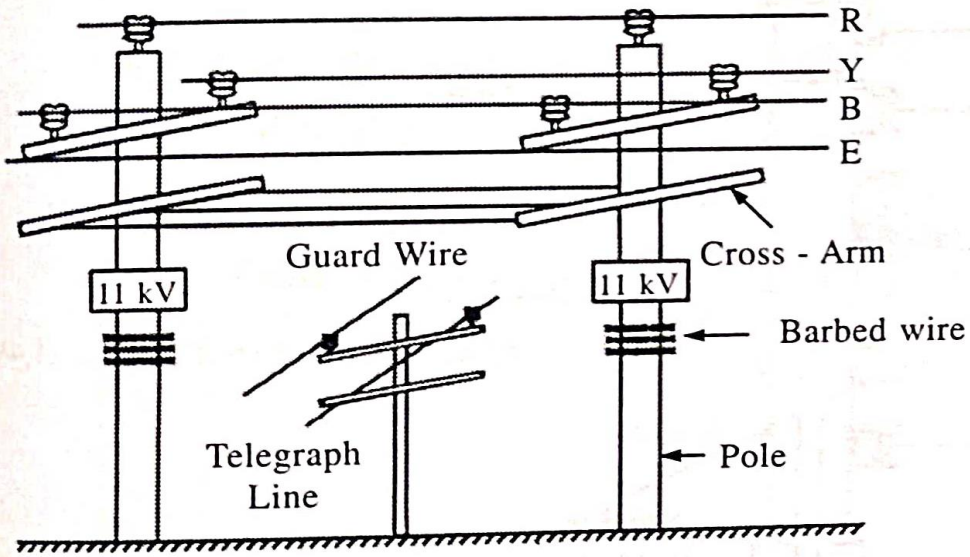


(d) Double Stay Arrangement

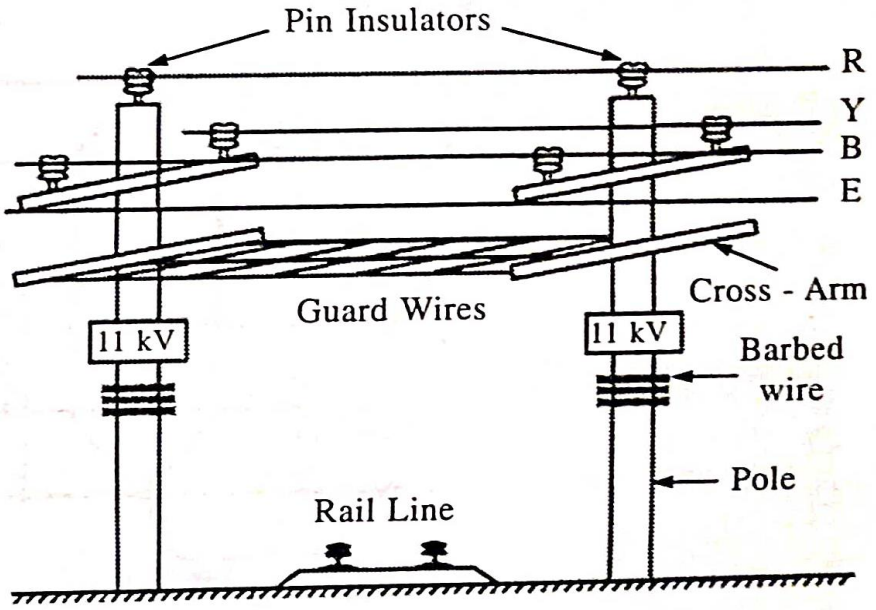


(e) Strut Guy

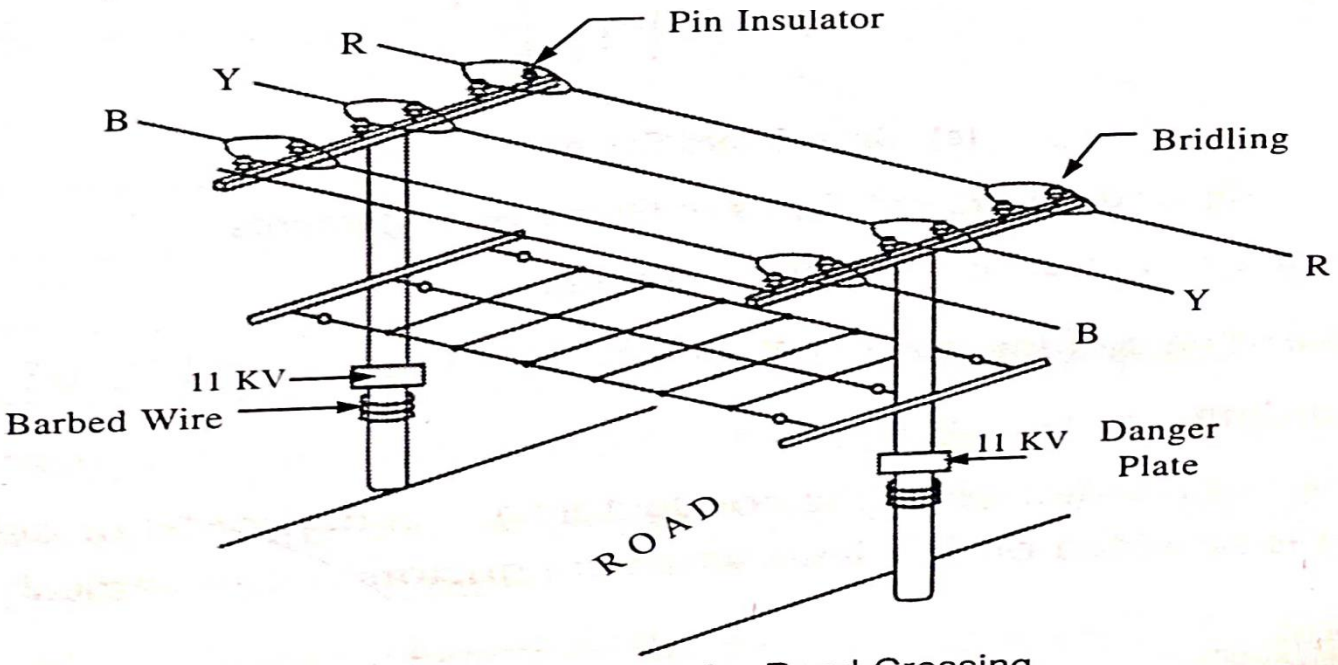
- **5.1 LIGHTNING ARRESTERS**
- The lightning Arrester is a device which provide protection to the electrical equipment against lightning surges.
- When a high voltage occurs, lightning arrester provide low impedance path from phase wire to earth and conducts high voltage surge to ground.
- **5.2 GUARDING OF O.H. LINES**
- A guarding is provided for protection of the life, telecommunication lines, safety of road, railway line etc.
- The guarding is provided at road crossings, river crossings, railway crossings, crossing over L.T line or Telecommunication line etc. LE. rule No. 87 provides that every guard wire shall be connected with earth at each point at which electrical continuity is broken. The various types of guard arrangements are shown in Fig



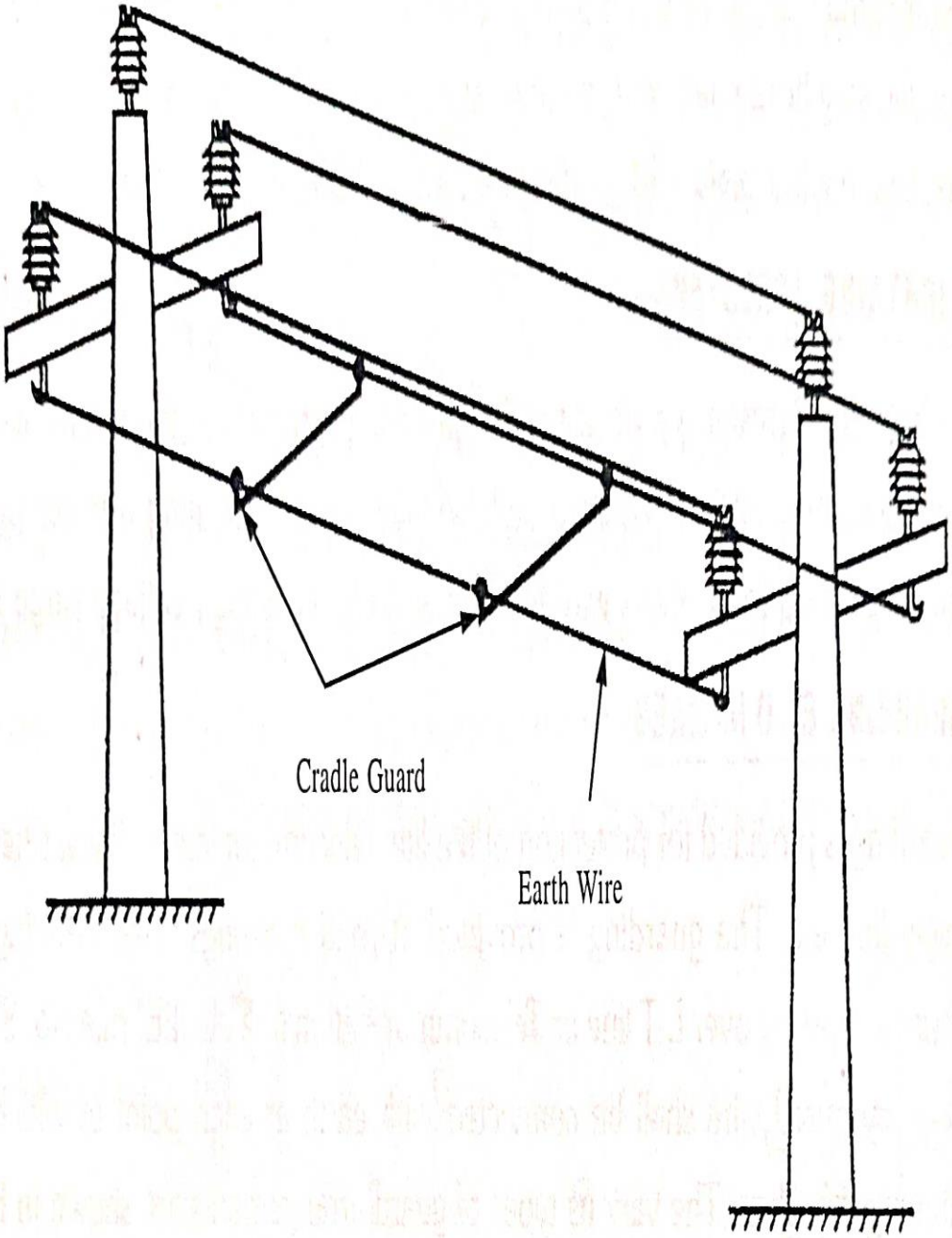
(a) Guarding for Telegraph Line

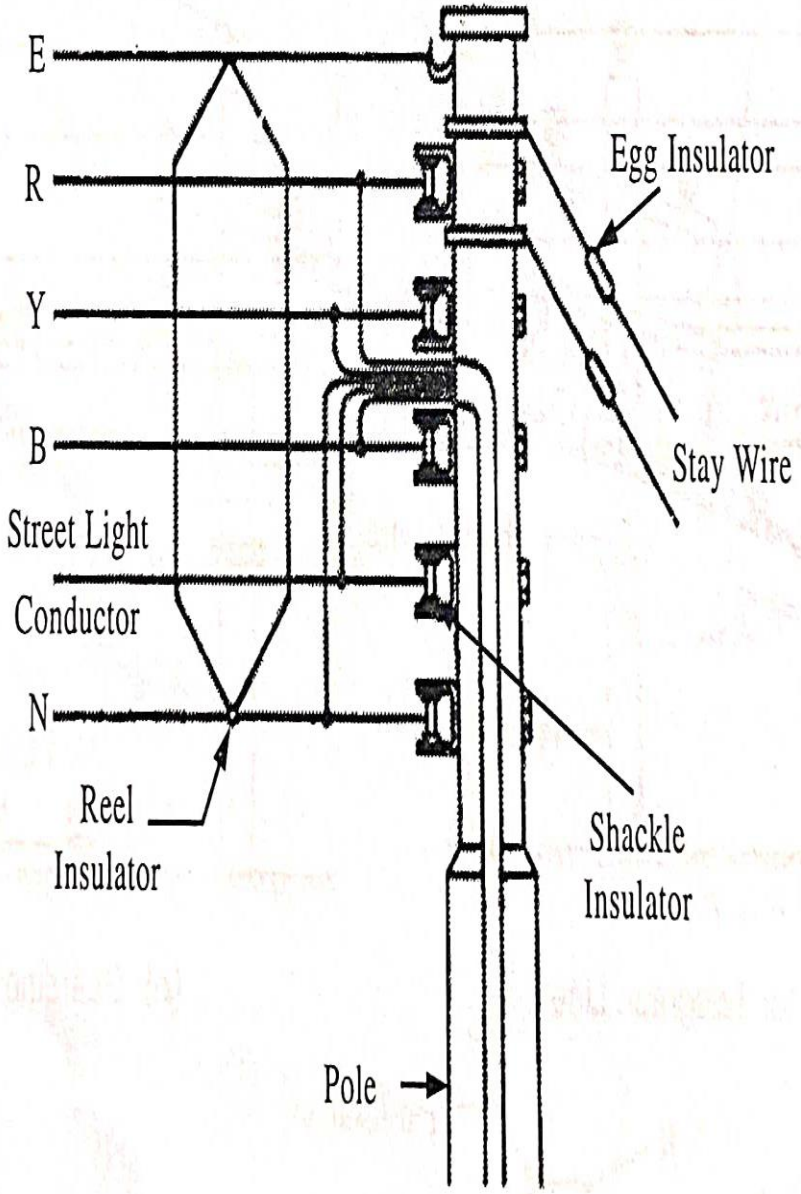


(b) Guarding for Railway Line



(c) Guarding for Road Crossing





(e) Cage Guard System

- There are two types of guarding systems, namely :
- (i) Cradle guarding system and
- (ii) Cage guarding.
- Cradle guarding is provided when the conductors are in horizontal or delta formation.
- Cage guarding is provided on L.T lines when conductors run in vertical formation.

5.3 CLEARANCE OF CONDUCTORS

The minimum clearance of conductors as per LE. rules is given below

S.No	Type of Overhead line	Minimum clearance between conductor and ground in meters.			Clearance from building in meters	
		Across the road	Along the road	At any place	Vertical clearance	Horizontal clearance
1	Low (250 V), Medium (650 V) Voltage	5.8	5.5	4.6	2.5	1.25
2.	High Voltage upto 11 kV	6.1	5.8	5.2	3.66	1.25
3.	High voltage above 11 kV upto 33 kV	6.1	5.8	5.2	3.66	1.83

Note :

(i) For extra high voltage lines, the clearance above the ground shall not be less than5.2 m plus 0.3 m for every 33 kV.

(ii) The minimum clearance along or across any street shall not be less than 6.1 m.

Table 3.2 : Minimum Spacing Between Conductors For Different Voltages

S.No.	Working Voltage	Spacing between Conductors		Spacing between Conductors and Structures
		Vertical Spacing	Horizontal Spacing	
1.	Low voltage	38 cm	46 cm	15 cm
2.	11 kV	76 cm	1.14 m	30 cm
3.	33 kV	1.22 m	1.53 m	61 cm
4.	66 kV	1.98 m	3.23 m	76 cm
5.	110 kV	3.13 m	4.87 m	1.07 m
6.	132 kV	3.66 m	4.96 m	1.3 m

6. STEPS TO SOLVE PROBLEMS ON ESTIMATION OF O.H. LINES

- The following steps will help in solving the problems on O.H. lines.
- **Step-1 ; Determination of No. of Spans : T**he number of spans can be calculated by using the following formula.
- No. of spans= Length of the transmission line/average span
- **Step-2 : Determination of No. of Poles :** Number of poles is always one more than numberof spans. Hence,No. of poles = No. of spans + 1For double pole structure (H-type structure) it requires two poles.
- **Step-3** : **Determination of Length of Conductor :**Length of conductor = length of line x n+ 4 % for sag and wastage.

  Where 'n' = Number of conductors = 2 for 1-phase system
  = 3 for 3-phase system
  = 4 for 3-phase, 4-wire system
  = 5 for 3-phase, 5-wire system

Step-4 : Determination of No. of Insulators : Pin type insulators are required for straight run and shackle/strain insulators are required for the poles at dead end or cut points. Number of insulators depends on type of system and No. of poles. '

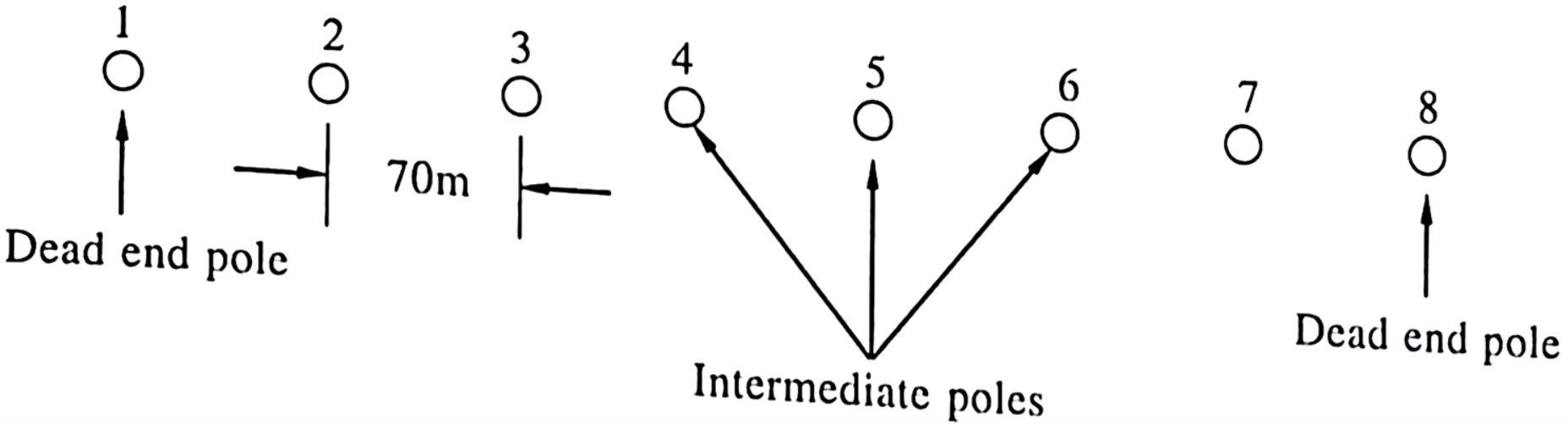
- **Step-5 : Determination of No. of Cross-arms :** Generally each pole is fitted with |one cross-arm. If there is a sudden diversion, two cross-arms may be used for that pole.
- **Step-6 : Determination of G.I. Wire/G.S. (Galvanized Steel) Wire :** 8 S.W.G. G.I/G.S.wire is used for earth wire, guards and for earthing. Total length of earth wire depends on total length of the line, number of earth points to be provided. Earth —wire is passed over the transmission line.
- **Step-7 : Determination of Stay Sets & Earth Sets :** Generally two stay sets are provided for dead end poles and cut-point poles and one for every fifth pole. One earth set is provided for every fifth pole. 1
- **Step-8 : Schedule of Materials :** The quantity of materials required is prepared in the following table.

S.No.	Material with specification	Quantity	Remarks

PROBLEMS ON ESTIMATION OF 11KV AND 400V OVERHEAD LINES

- PROBLEM – 1
- Calculate the no. of various insulators needed for the erection of 490 m, 3-phase, 11kV over head line without any-turnings, by taking a span of 70 m. April/May. 2012

- Length of line = 490 m
- Span = 70m
- **No. of spans= Total length of the line/span**
- =490/70 = 7
- **No. of poles = No. of spans + 1** = 8
- There are 2 dead end poles and 6 intermediate poles
- The insulators used for intermediate poles are 11 kV pin type insulators and for dead end poles 11 kV disc type insulators are used.
- As the given system is 3 phase system, three insulators are required for each pole.



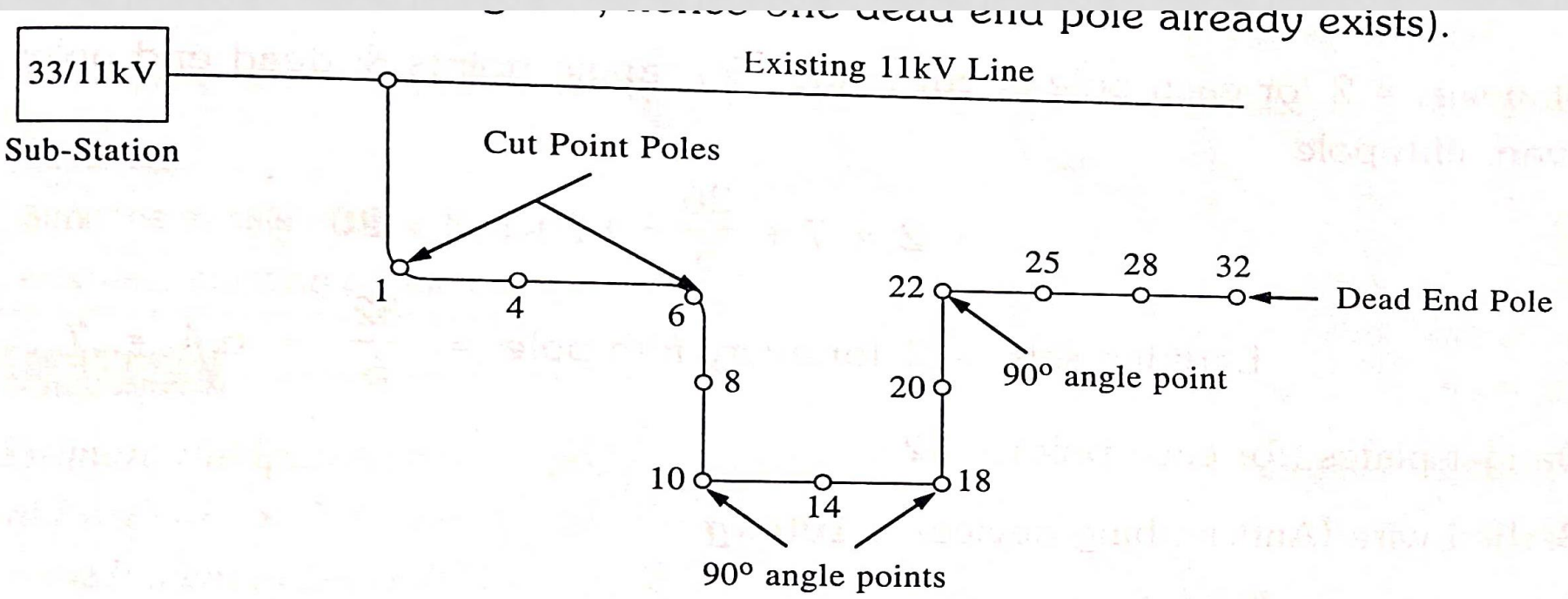
- 1. No. of Insulators :
- Assuming the conductors are arranged in delta fashion with two dead end poles.
- No. of 11 kV pin type insulators = 6 x 3=18
- No. of 11 kV disc type insulators = 2 x 3=6

PROBLEM-2

- A new 2.5km, 11kV line is to be expected and connected to the existing 11kV line. The height of the pole is 10m. ACSR conductor of size 6/1 x 2.11mm is to be used. Estimate the materials required. Atleast two cut points and three 90 deg angle points may be assumed. Assume a span 80m.

- Length of line = 2.5 km = 2500 m
- Span = 80m
- 1. No. of spans = Total length of the line/span = 2500/80 =31.25 = 32

- 2. No. of poles = 32 (31 intermediate poles and 1 dead end poles, because the line is connected to the existing line, hence one dead end pole already exists).



- 3. Length of mm conductor
- =Length of line x n+ 4 % for sag and wastage
- =2500 x 3+ 4% of 7500 = 7800 m = 7.8 km
- 4. No. of insulators :
- Assuming the conductors are arranged in delta fashion.
- No. of 11 kV Pin type insulators= 26x 3 = 78
- No. of 11 kV disc insulators=2x6+3x6+2x3 = 36
- (Each pole at cut point & 90° angle poles consist of two cross-arms, each cross-arm is fitted with 3 disc insulators. Dead end poles Fig Starting Pole consists of only one cross-arm, each cross-arm consists of 3 disc insulators.
- Hence total No. of disc insulators are= 36.

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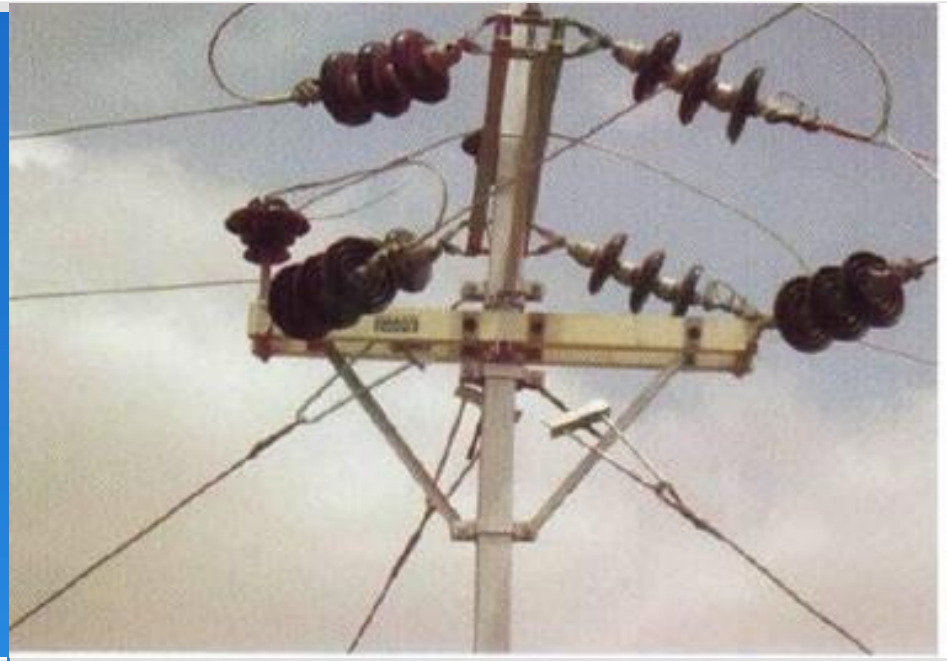
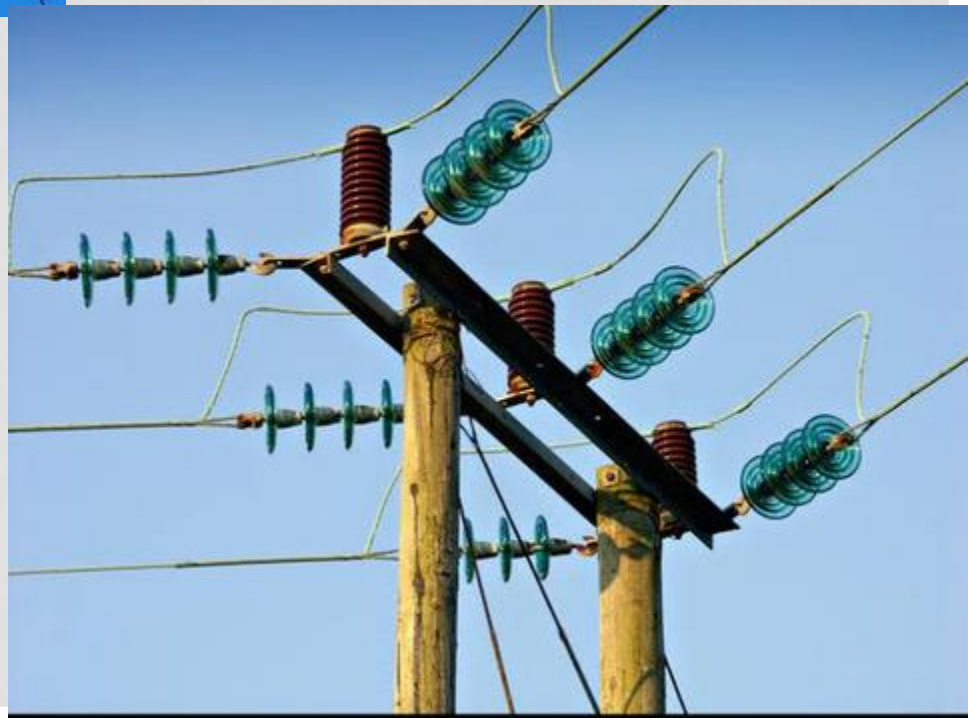




- 5. No. of Cross-arms :
- 1.5m x 76mm x 38mm x 6.4 mm Mild Steel Cross-arms = 38
- (32 for 32 poles + 5 extra for poles at cut points & 90° angle points + 1 for pole in the existing line),

- 60 x 8 mm top insulator brackets for fixing top insulators = 26

- 6. 8S.WG. G.I/G.S.
- Earth wire =Length of line + 4 % for sag and wastage
- =2500 + 4 % of 2500=2600 m = 260 kg (10 m = 1 kg)

- 7. Stay sets = 2 for each pole at cut point, 90° angle points & dead end poles + 1 for every fifth pole
- =2x7+ 26/5 x= 14+5.2 = 20
- Earthing sets = 1 for every fifth pole = 32/5 = 6.4 =7

- Danger plates (for each pole) = 32
- Barbed wire (Anticlimbing device) = 100 kg.
- 8. Schedule of Materials

S.No.	Material with Specification	Quantity	Remarks
1.	PSCC poles, 10 m long	32 No	
2.	M.S. Cross-arm (1.5 m × 76 mm × 38 mm × 6.4 mm)	38 No	2 X-arms for poles at cut points & 90° angle points
3.	M.S. Cross-arm clamps	38 No	For fixing X-arms to poles
4.	Top insulator brackets (60 × 8 mm)	26 No	For fixing top insulators
5.	11 kV Pin insulators with pins	78 No	
6.	11kV disc insulators	36 No	
7.	ACSR conductor (7/2.11 mm)	7.8 km	Km = Kilo meter
8.	G.I/G.S. wire (8 SWG)	260 kg	

9.	Earth wire clamps with eye screw bolt	32 No	To fix earth wire at each pole
10.	Stay sets complete	20 No	
11.	Earthing sets complete	7 No	with anchor rod, base plate etc.
12.	Danger plates with clamps	32 No	
13.	Barbed wire (Anti-climbing device)	100 kg	
14.	Binding wire (Aluminium for fixing conductors over insulators)	L.S	L.S = Lump Sum
15.	11 kV Lightning Arresters	6 No	3 at each dead end pole
16.	Bolts and nuts of different sizes	100 kg	
17.	Cement and Concrete	L.S	For pole foundation.
18.	11 kV gang operating switch with fittings	1 No 11 kV line	For switching ON/OFF the
19.	Sundries to finish the work such as G.I. thimbles	L.S	

7.ESTIMATION OF POLE MOUNTED AND PLINTH MOUNTED SUB - STATIONS

- In the present-day, electrical power is generated, transmitted and distributed in the form of alternating current.
- The electrical energy is generated at low voltage (such as e.6:08 11 kV) but is stepped up to high voltage (such as 220 or 400 kV) for transmission.
- But the consumers do not use high voltage, hence the voltage must be stepped down to low voltage (400/230 V).
- The place where stepping up and stepping down of voltage is done is known as “Sub-Station”.

1.SUB-STATION

- The assembly of apparatus used to change some electrical characteristics (such as voltage, frequency, a.c. to d.c, power factor etc.,) of electrical energy is known as“Sub-Station”.
- The Sub-station may perform any one or two or all of the following operations.
- 1.Switching Operation : To switch ON and OFF the power line.
- 2.Voltage Transformation Operation : To change voltage from high level to lowlevel or vice-versa.
- 3.Power Converting Operation : To change a.c. power into d.c. power andvice-versa.
- 4.Frequency Changing Operation : To change the supply frequency level i.e.from high level to low level or vice-versa.
- 5.Power Factor Correction Operation : To improve the power factor of the system using static capacitors, synchronous condensers or phase advancers.

2. CLASSIFICATIONS OF SUB-STATIONS

- The Sub-stations can be classified in several ways. The two important ways of classifying the sub-stations are as follows.
- 1. According to Service Requirement : In accordance with the service performed, sub-stations are classified as,
  i. Switching sub-stations
  ii. Transformer sub-stations.
  iii. Power factor correction sub-stations.
  iv. Frequency changer sub-stations.
  v. Converting sub-stations.
  vi. Industrial sub-stations.

- According to Design or constructional Features :
- In accordance with design (constructional features) sub-stations are classified as
  1. Indoor sub-stations.
  2. Outdoor sub-stations.

8 MAIN COMPONENTS OF POLE OR PLINTH MOUNTED SUB - STATIONS

- The following are the major components of 11 kV/400 V Pole or Plinth mounted sub-stations,
- **1. Poles :** The poles may be of steel or PSCC type having a length about 8 m to 12 m. In pole mounted sub-stations the transformer is erected on Mild Steel channel of (H-type or 4-pole structure.
- **2. Plinth :** Transformers of capacity more than 250 kVA are placed on a plinth. The plinth is constructed with bricks or stones.
- **3. Transformer :** It is generally called as distribution transformer. It is a 11 kV/400 V step-down transformer.
- **4. Insulators :** Generally this sub-station is located at dead end of 11 kV line, hence11kV disc insulators are used to connect 11 kV line.

2
3

- **5. Cross-arms :** Different sizes of Mild Steel cross-arms are used to erect Disc insulators, Gang Operating Switch, Horn Gap (H.G) fuse etc.
- **6. Fuses :** Horn Gap (H.G) fuses are provided on 11kV (H.T) side, where as open type rewirable fuses are used on 400V (L.T) side.
- **7. Gang Operating Switch (G.O.S) or Air Break (A.B) Switch :** It is used to switch _ON & OFF 11kv line.
- **8. 31/2 Core Cable :** The output of distribution transformer is connected to L.T line -through 31/2 core Aluminium conductor armoured 1100V grade PVC cable.
- **9. Stays :** At least 2 stay sets are provided to support poles.
- **10. Distribution Boxes :** The L.T supply of distribution transformer is fed through distribution box which consists of fuse unit.

- **11. Jumpers :** These are used to connect 11 kV lines. Generally ACSR conductor is used for this purpose .
- **12. Barbed Wire (Anti-climbing Device) :** It is provided on the poles at a height of about 1.5 m to prevent the climbing of unauthorized persons.
- **13. Fencing :** It is provided around the Poles/Plinth to prevent the entry of animals —or children.
- **14. Earthing Sets :** In order to achieve effective earthing this type of sub-station earthed at two or more places.
- **15. Lightning Arresters :** These are provided on 11 kV line to protect the transformer from lightning surges or strokes.
- **16. Danger Plates :** These are provided On each pole and a word ": : Danger" is written on it. This means that the unauthorized Persons are not supposed to enter in sub-station.

9 CONSTRUCTION DETAILS OF POLE AND PLINTH MOUNTED SUB - STATIONS

- In this type of sub-station all the equipment is exposed to atmosphere
- **1. Pole Mounted Sub-station :**
- This type of sub-stations are erected for distribution of power in localities.
- As the name indicates, in this type of sub-station, the transformers upto a capacity of **250 kVA (such as 25, 63, 100, 125, 200, 250etc.,) are placed on H-type structure or 4-pole structure** with a suitable platforms.
- These are cheap, simple and smaller in size. The transformer is of step-down type, which **step-downs 11 kV into 400/230 V.**
- A Gang Operating Switch (also called as Air Break switch) is used for switching ON & OFF of H.T (11 kV) line.

- Horn Gap (H.G) fuse unit is installed for protection of H.T side of transformer against high currents, where as L.T side is protected with L.T fuse unit.
- Lightning Arresters are installed over the H.T line to provide protection of transformer against the surges. The sub-station is earthed at two or more places.
- The oil circuit breaker (O.C.B) installed in the L.T side automatically cuts off the transformer from the consumers in the event of any fault.
- Fig.1 shows the schematic diagram and Fig. 2 shows the layout of Pole-mounted sub-station.

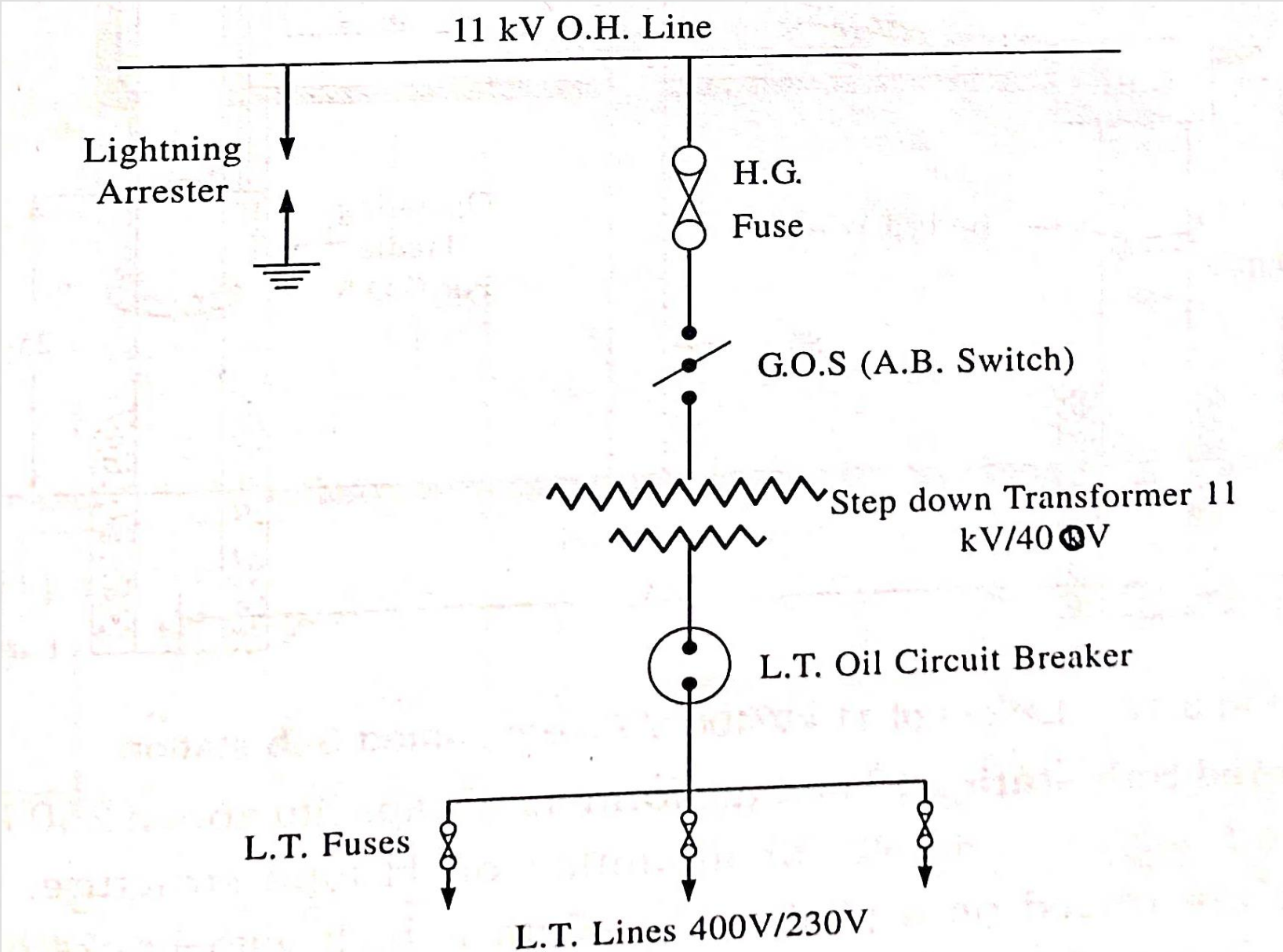
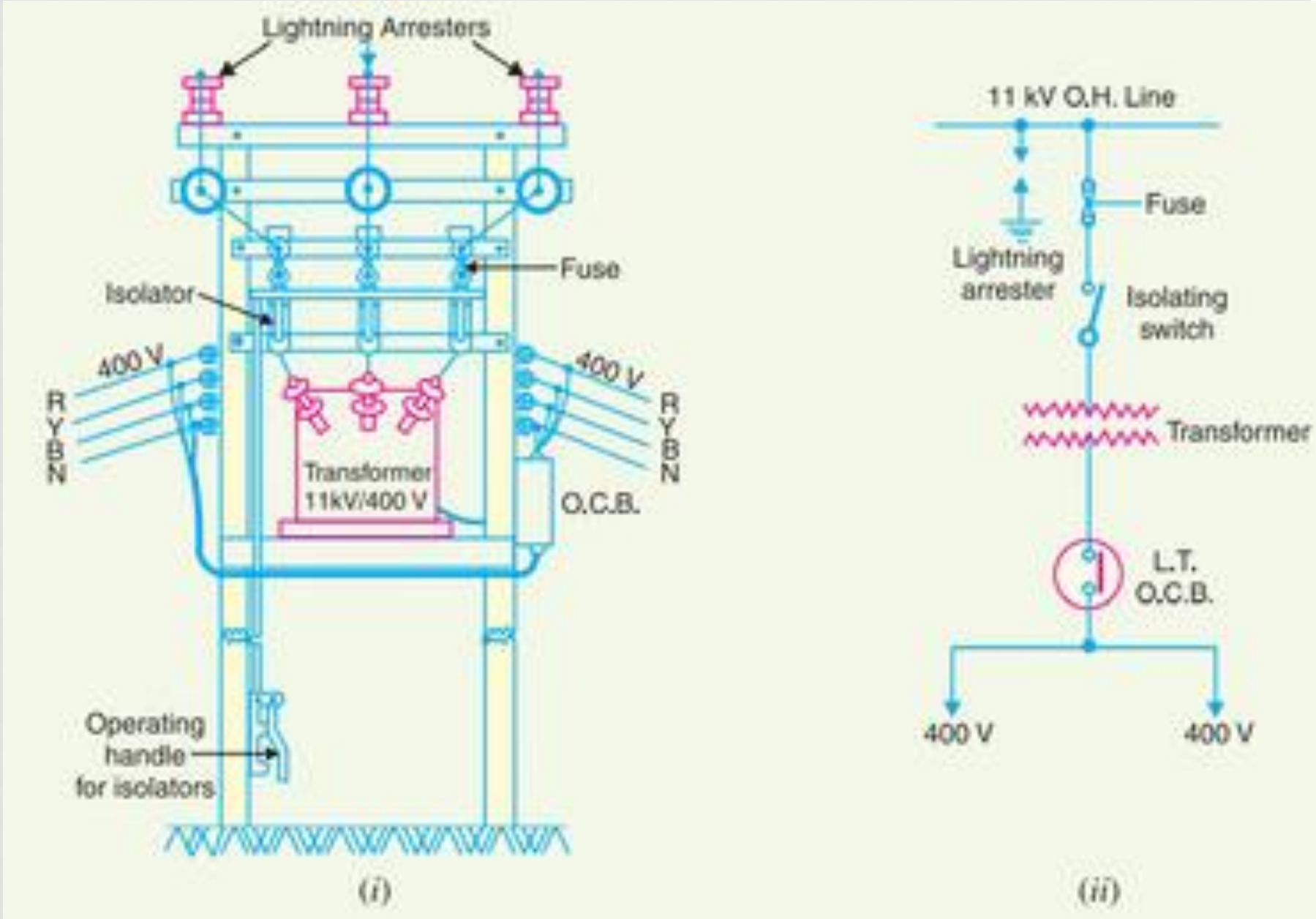
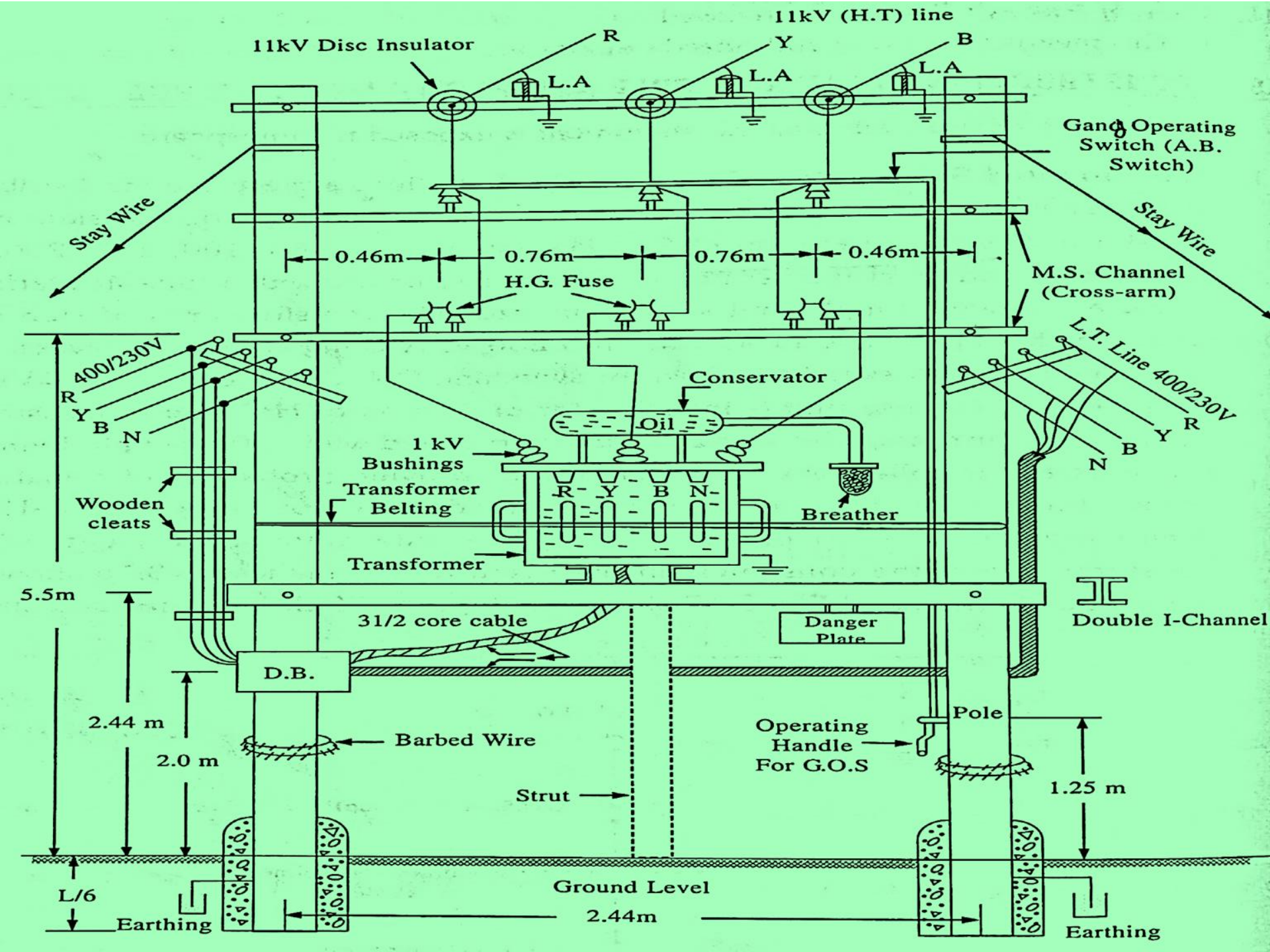


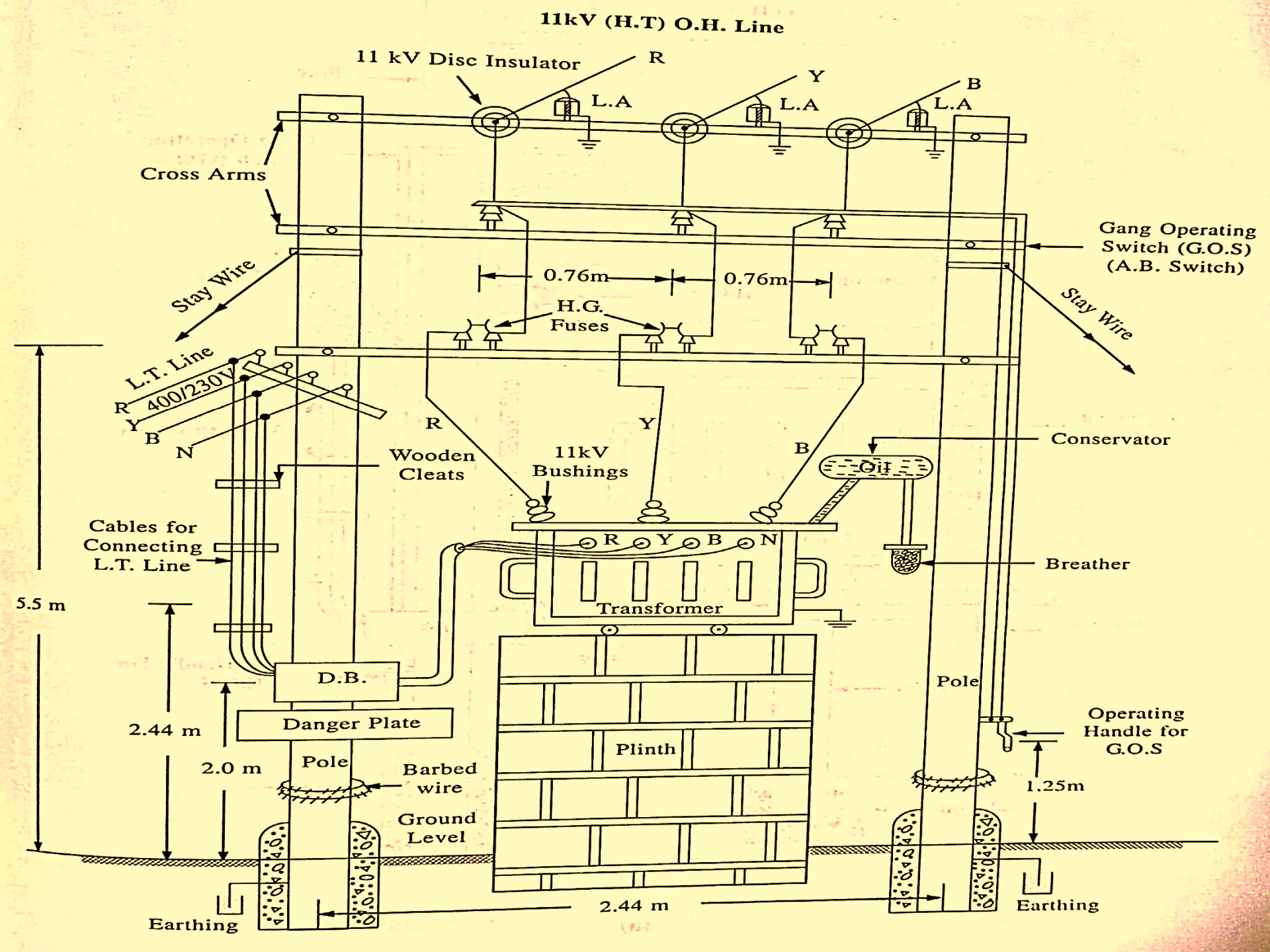
Fig 1 Schematic Diagram of Pole-mounted Sub-station

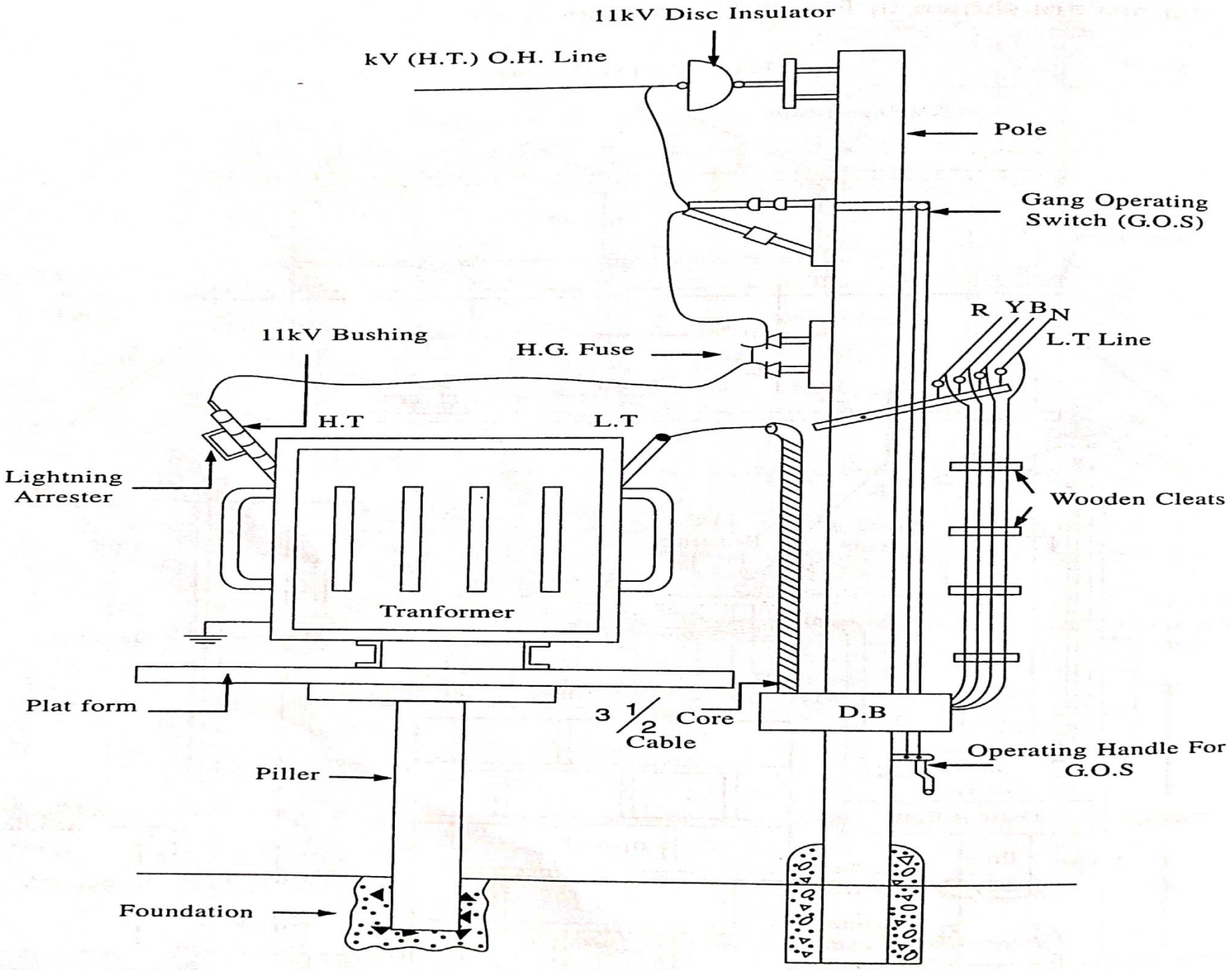

Lightning Arresters
Fuse
Isolator
400 V
R
Y
B
N
400 V
R
Y
B
N
Transformer
11kV/400 V
O.C.B.
Operating
handle
for isolators
(i)
11 kV O.H. Line
Fuse
Lightning
arrester
Isolating
switch
Transformer
L.T.
O.C.B.
400 V
400 V
(ii)

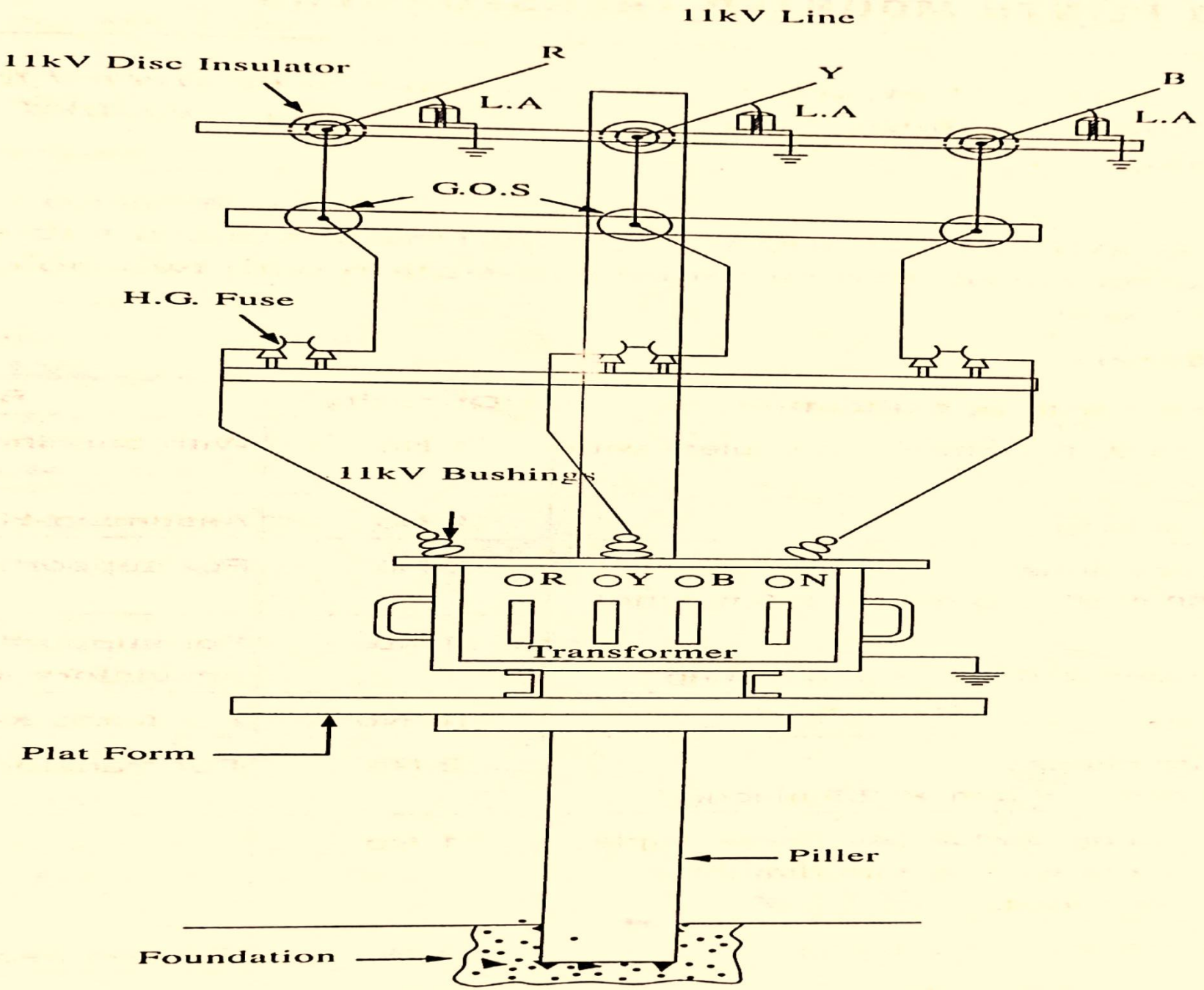

11kV (H.T) line
11kV Disc Insulator
R
Y
B
L.A
L.A
L.A
Gang Operating Switch (A.B. Switch)
Stay Wire
Stay Wire
0.46m
0.76m
0.76m
0.46m
H.G. Fuse
M.S. Channel (Cross-arm)
400/230V
R
Y
B
N
L.T. Line 400/230V
Conservator
Oil
1 kV Bushings
Transformer Belting
Wooden cleats
R Y B N
Breather
Transformer
5.5m
31/2 core cable
Danger Plate
Double I-Channel
D.B.
2.44 m
2.0 m
Barbed Wire
Operating Handle For G.O.S
Pole
Strut
1.25 m
L/6
Earthing
Ground Level
2.44m
Earthing

2. PLINTH MOUNTED SUB-STATION :

- The transformers of capacity above 250 kVA are heavy in weight and will not suitable for mounting on H-type structure.
- Hence, such ;transformers are placed on a plinth. The plinth is built with bricks or stones with cement concrete and transformer is located on a plinth, hence the name Plinth ”mounted sub-station.
- It is also called as Foundation mounted sub-station.
- All the equipments and accessories are arranged on a L.T pole.
- Some times two poles to be used for feeding two L.T lines.. The different views of layouts of Plinth Fig.


11kV (H.T) O.H. Line
11 kV Disc Insulator
R
Y
B
L.A
L.A
L.A
Cross Arms
Gang Operating Switch (G.O.S) (A.B. Switch)
Stay Wire
Stay Wire
0.76m
0.76m
H.G. Fuses
L.T. Line
400/230V
R
Y
B
N
R
Y
B
Wooden Cleats
11kV Bushings
Conservator
Oil
Cables for Connecting L.T. Line
R Y B N
Breather
Transformer
5.5 m
D.B.
Pole
2.44 m
Danger Plate
Plinth
Operating Handle for G.O.S
2.0 m
Pole
Barbed wire
1.25m
Ground Level
Earthing
2.44 m
Earthing


11kV Disc Insulator
kV (H.T.) O.H. Line
Pole
Gang Operating Switch (G.O.S)
R Y B N
L.T Line
11kV Bushing
H.G. Fuse
H.T
L.T
Lightning Arrester
Wooden Cleats
Tranformer
Plat form
3 1/2 Core Cable
D.B
Operating Handle For G.O.S
Piller
Foundation

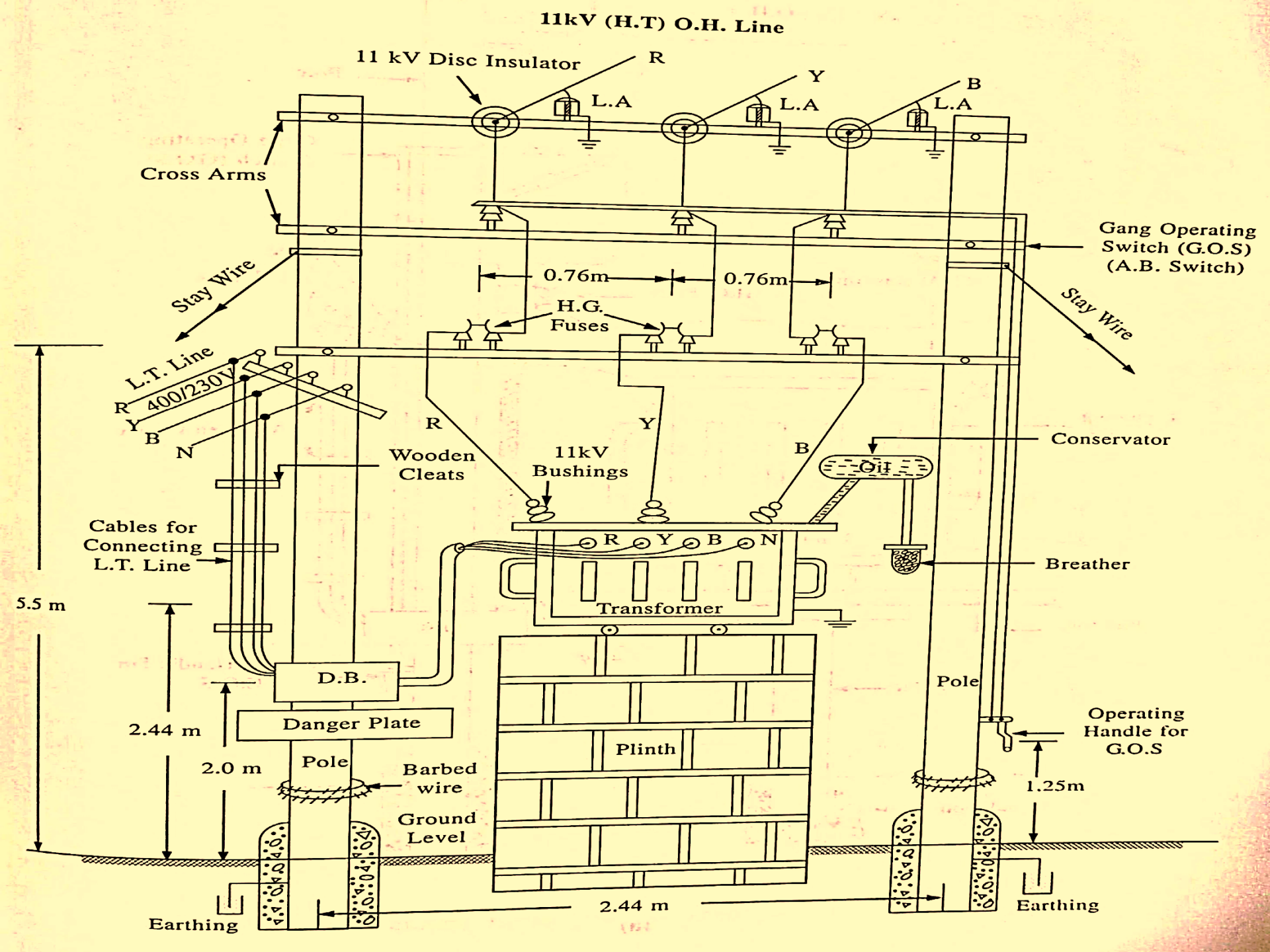

11kV Line
11kV Disc Insulator
R
Y
B
L.A
L.A
L.A
G.O.S
H.G. Fuse
11kV Bushings
OR OY OB ON
Transformer
Plat Form
Piller
Foundation

(b)

10.ESTIMATION OF QUANTITY OF MATERIALS AND ELECTRICAL ACCESSORIESOF POLE AND PLINTH MOUNTED TRANSFORMERS

- PROBLEM
- Draw a neat sketch of 100 kVA, 11 kV/400V, 3-phase pole mounted sub-station and prepare the materials for the erection of the above sub-station. March/April: 2004, 2005, Oct/Nov. 2006

- Solution:
- The sketch of 11 kV/400 V, 3-phase Pole mounted sub-station is shown in Fig. on next.
- The estimate of pole mounted sub-station with two-pole structure and two L.T lines is as follows.


11kV (H.T) O.H. Line
11 kV Disc Insulator
R
Y
B
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L.A
Cross Arms
Gang Operating Switch (G.O.S) (A.B. Switch)
Stay Wire
Stay Wire
0.76m
0.76m
H.G. Fuses
L.T. Line
400/230V
R
Y
B
N
R
Y
B
Wooden Cleats
11kV Bushings
Conservator
Oil
Cables for Connecting L.T. Line
R Y B N
Breather
Transformer
5.5 m
D.B.
Pole
2.44 m
Danger Plate
Plinth
Operating Handle for G.O.S
2.0 m
Pole
Barbed wire
1.25m
Ground Level
Earthing
2.44 m
Earthing

Schedule of materials :

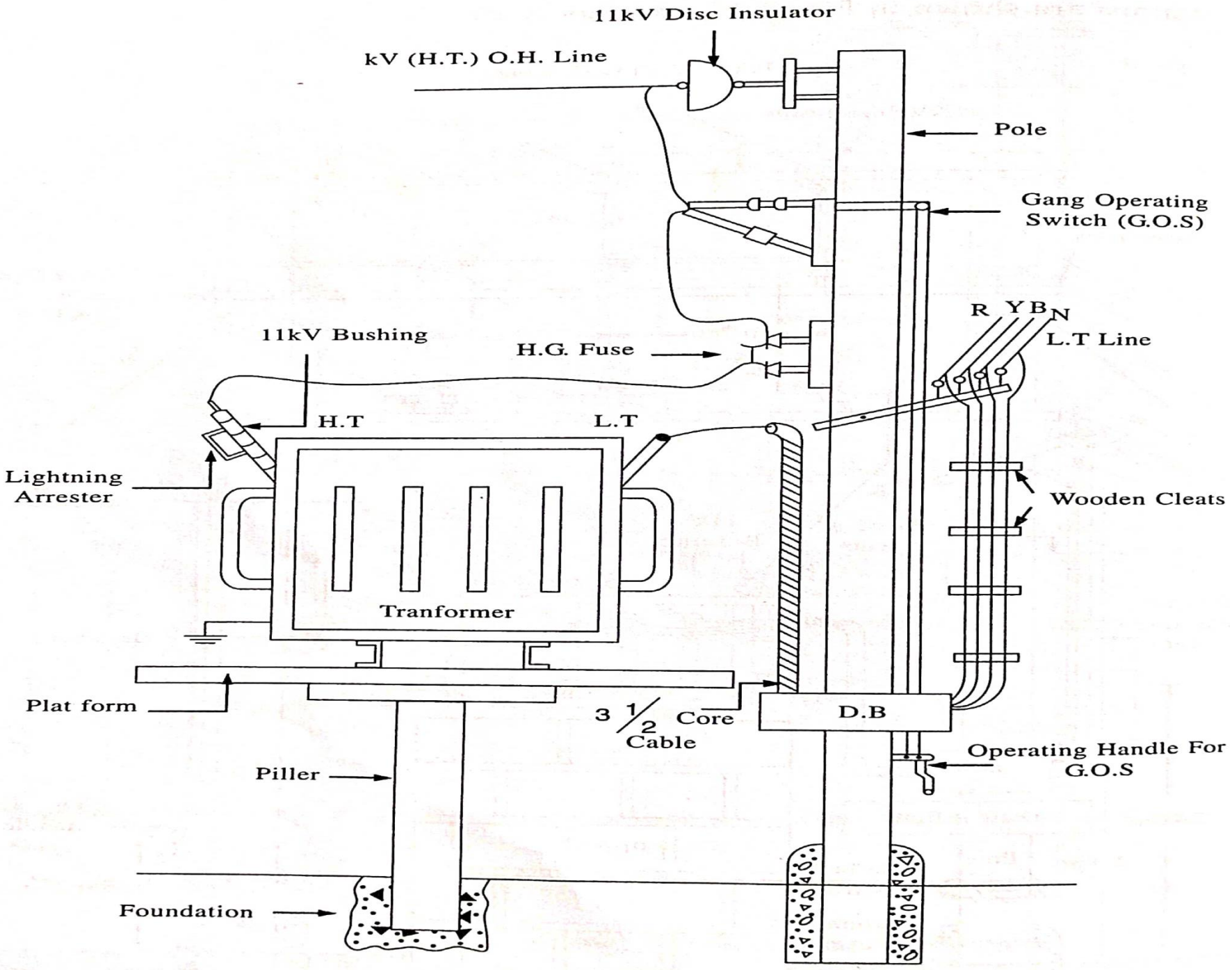
S.No.	Material with specification	Quantity	Remarks
1.	100 kVA, 11 kV/400 V, Transformer complete with all accessories.	1 No	With bushings etc
2.	PSCC poles, 11 m long	2 No	Assuming H-type
3.	M.S.channel (cross-arms) (100 mm × 50 mm × 6mm × 2.5 m long)	2 No	For supporting Transformer
4.	M.S.angles 50 mm × 50 mm × 6 mm × 2.5 m long	3 No	For supporting 11k V disc insulators, G.O.S & H.G fuse
5.	Cross-arm clamps	10 No	For fixing X-arms to poles
6.	M.S. channel with clamps 10 mm × 50 mm × 6 mm × 2.5 m long	2 No	For transformer belting
7.	11 kV Gang Operating Switch (Air Break Triple pole switch) complete with 25 mm diameter operating pipe and handle	1 No	

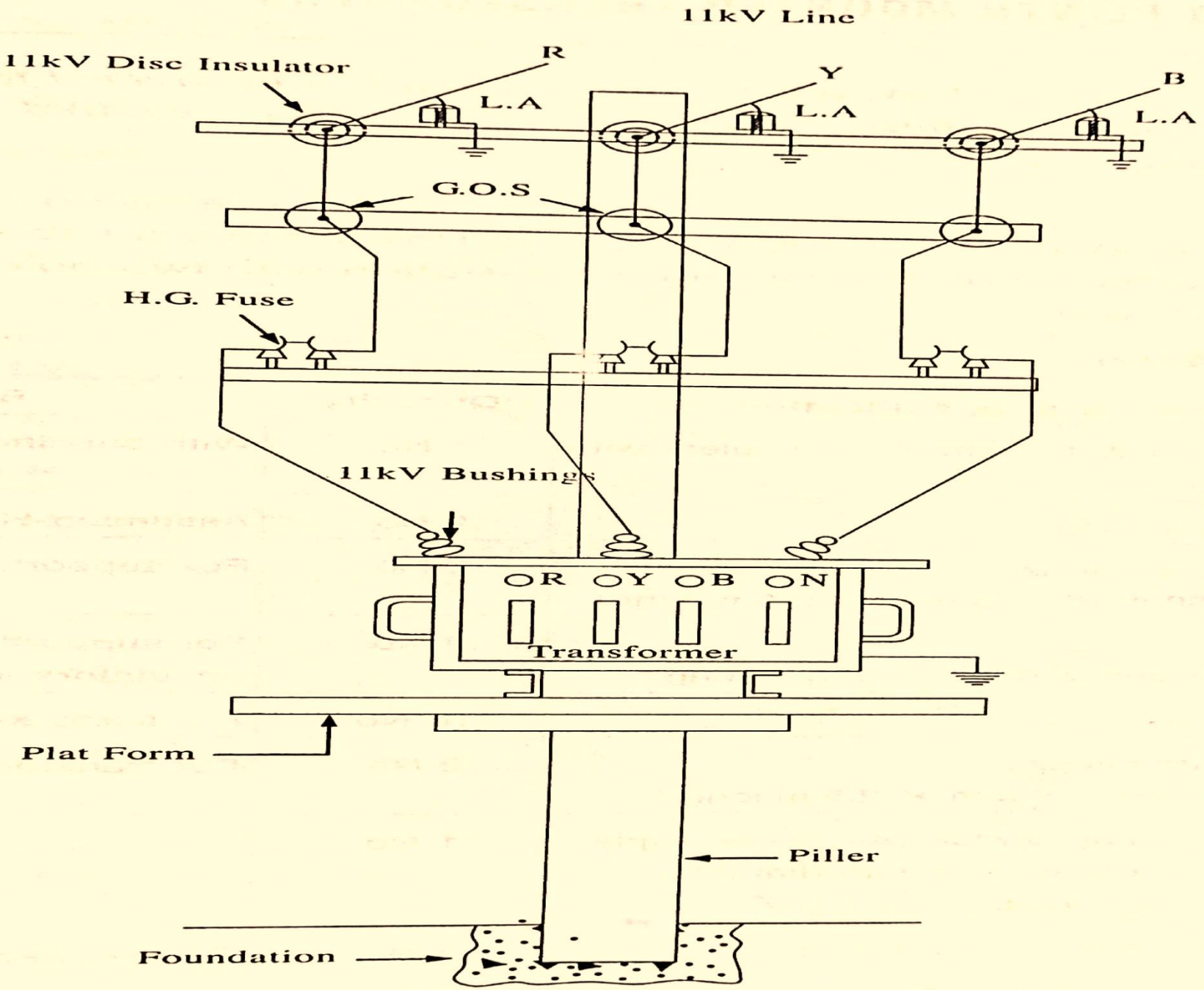
8.	11 kV Lightning Arresters with fittings	3 No	One on each phase
9.	11 kV disc insulators with fittings	3 No	
10.	11 kV Horn Gap (H.G) fuse unit	1 Set	On 11 kV side
11.	ACSR conductor (6/1 × 2.59 mm)	15m	For connecting 11 kV to the transformer
12.	ICTPN switch, 100 A, 500 V with rewirable fuses.	1 No	On L.T. side
13.	Distribution box with locking arrangement	1 No	To fix ICTPN
14.	31/2 core, 120 mm^2, Aluminium conductor armoured, 1100 V grade PVC cable.	11m	5 m from transformer to D.B and 6 m from D.B to L.T line
15.	Stay sets complete	2 No	
16.	Earthing sets complete	2 No	
17.	Earth wire G.I (8 SWG)	10 m	For earthing transformer tank, poles, L.A's, X-arms etc.
18.	100 mm^2, single core aluminium conductor, 600 V grade PVC cable.	20 m	From D.B to one L.T line (For R, Y, B, N)

19.	Barbed wire (Anti-climbing device)	30 kg	
20.	Binding wire (Aluminium)	2 kg	
21.	Nuts & bolts of different sizes	L.S	L.S = Lump Sum
22.	Danger plate with clamps.	1 No	
23.	Concreting 1 : 4 : 8	L.S	For pole foundation
24.	Fencing around sub-station.	L.S	To avoid entry into S.S
25.	Sundries to finish the job (such as aluminium paint, G.I thimbles, Tape etc.)	L.S	

PROBLEM-2

- Draw a neat sketch of 250 kVA, 11kV/415V, 50 Hz Plinth mounted sub-station and estimate the quantity of materials required for the erection of the above sub-station.
- March/April: 2016 [TS]:;-2006


11kV Disc Insulator
kV (H.T.) O.H. Line
Pole
Gang Operating Switch (G.O.S)
R Y B N
L.T Line
11kV Bushing
H.G. Fuse
H.T
L.T
Lightning Arrester
Wooden Cleats
Tranformer
Plat form
3 1/2 Core Cable
D.B
Operating Handle For G.O.S
Piller
Foundation


11kV Line
11kV Disc Insulator
R
Y
B
L.A
L.A
L.A
G.O.S
H.G. Fuse
11kV Bushings
OR OY OB ON
Transformer
Plat Form
Piller
Foundation

(b)

- The sketch of 250 kVA, 11 kV/415 V, 50 Hz Plinth mounted sub-station is shown in Fig..
- The estimate of pole mounted sub-station with two-pole structure and one L.T lines is as follows.
  Schedule of Materials :

S.No.	Material with Specification	Quantity	Remarks
1.	250 kVA, 11 kV/41 5V, 50 Hz Transformer complete with all accessories.	1No	With bushings etc
2.	PSCC poles, 11 m long	2 No	Assuming H-type
3.	Plinth (bricks/stones, cement, sand etc)	1 No	For placing Transformer
4.	M.S.angles 50 mm × 50 mm × 6 mm × 2.5 m long	3 No	For supporting 11 kV disc insulators, G.O.S & H.G fuse
5.	Cross-arm clamps	6 No	For fixing X-arms to poles
6.	11 kV Gang Operating Switch (Air Break Triple pole switch) complete with 25 mm diameter operating pipe and handle	1 No	
7.	11 kV Lightning Arresters with fittings	3 No	One on each phase

8.	11 kV disc insulators with fittings	3 No	On 11kV side
9.	11 kV Horn Gap (H.G) fuse unit	1 Set	
10.	ACSR conductor (6/1 × 2.59 mm)	15 m	For connecting 11 kV to the transformer
11.	ICTPN switch, 100 A, 500 V with rewirable fuses.	1 No	On L.T. side
12.	Distribution box with locking arrangement	1 No	To fix ICTPN
13.	31/2 core, 300 mm^2, Aluminium conductor armoured, 1100V grade PVC cable.	5m	From transformer to D.B
14.	Oil Circuit Breaker 440 V, 600 A with over load tripping and under volt release etc.	1 No	
15.	Stay sets complete	2 No	
16.	Earthing sets complete	2 No	

17.	Earth wire G.I (8 SWG)	10 m	For earthing transformer tank, poles, L.A's, X-arms etc.
18.	150 mm^2, single core aluminium conductor, 600 V grade PVC cable.	20 m	From D.B to one L.T line (For R, Y, B, N)
19.	Barbed wire (Anti-climbing device)	30 kg	
20.	Binding wire (Aluminium)	2 kg	
21.	Nuts & bolts of different sizes	L.S	L.S = Lump Sum
22.	Danger plate with clamps.	1 No	
23.	Concreting 1 : 4 : 8	L.S	For pole foundation
24.	Fencing around sub-station.	L.S	To avoid entry into S.S
25.	Sundries to finish the job (such as aluminium paint, G.I thimbles, Tape etc.)	L.S	

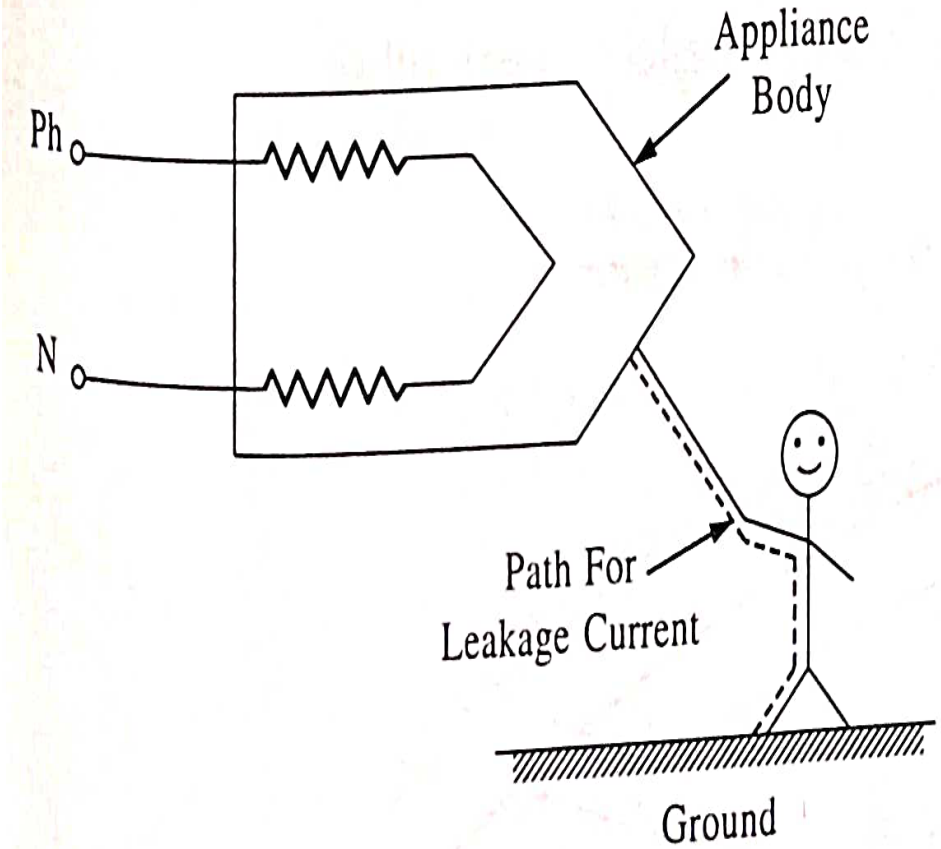
11 EARTHING

- Earthing means the direct connection of the non-current carrying parts of electrical equipments such as metallic frame work, electric motor body, metallic covering of cables, earth terminal of socket outlet, transmission tower etc to earth (ground) is known as "Earthing or (Grounding)".
- The Earthing is done by connecting the body of the appliance to earth by employing some good conductor known as Earth wire.
- The rod, wire, pipe or plate embedded in earth for the purpose of making an effective connection with earth is known as Earth electrode.

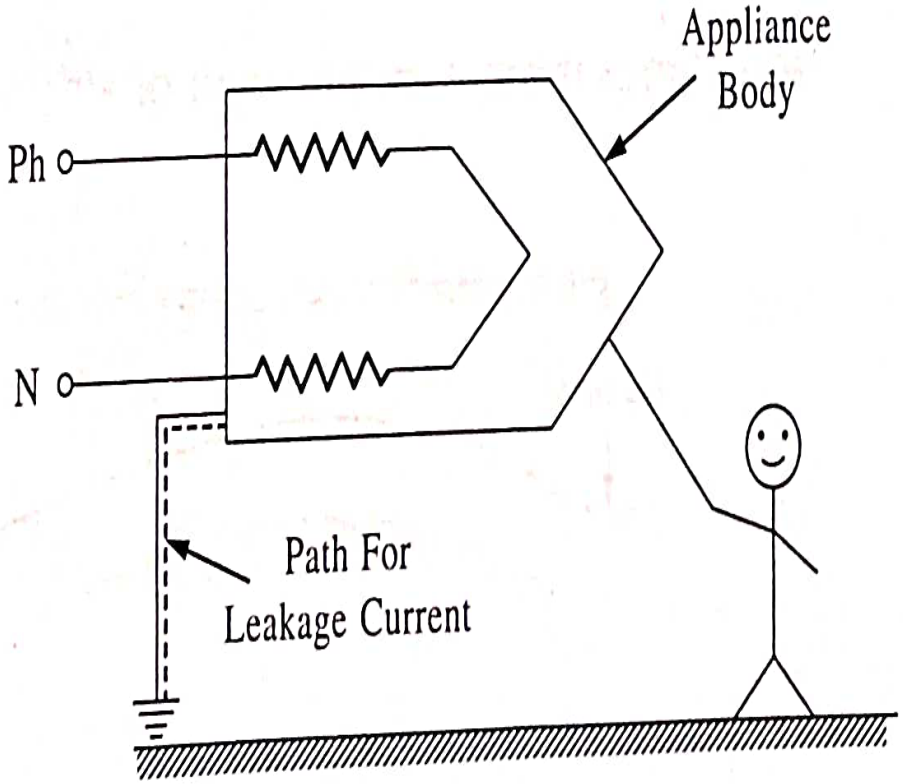
1 PURPOSE/NECESSITY OF EARTHING

- 1. To save human life from electric shock.
- 2. To avoid risk of fire due to earth leakage current through unwanted path.
- 3. To maintain the line voltage constant (since neutral of every alternator, transformer is earthed).
- 4. To ensure that no current carrying conductor rises to a potential with respect to earth than its desired insulation.

- If the appliance is not earthed as shown in Fig. (a).
- Suppose for any reason if the insulation of the cable damages, then the metallic body of the appliance comes indirect contact with the live wire.
- Now, if a person comes in contact with the metallic body the leakage current will pass through the human body and he will get a severe electric shock.
- But if the metallic body of the appliance is earthed as shown in Fig. (b), the leakage current will transformed to the earth through earth wire instead of passing through the human body.
- This is because, the earth wire (having negligible resistance) is in parallel with the human body (having an average resistance of 50 k-ohm)with respect to earth.
- Hence, leakage current always chooses a low resistance path and flow through the earth wire instead of flowing through the human body. In this way earthing of metallic parts of electrical equipment and appliances provide safety to human being.



(a) Appliance body not grounded (earthed)



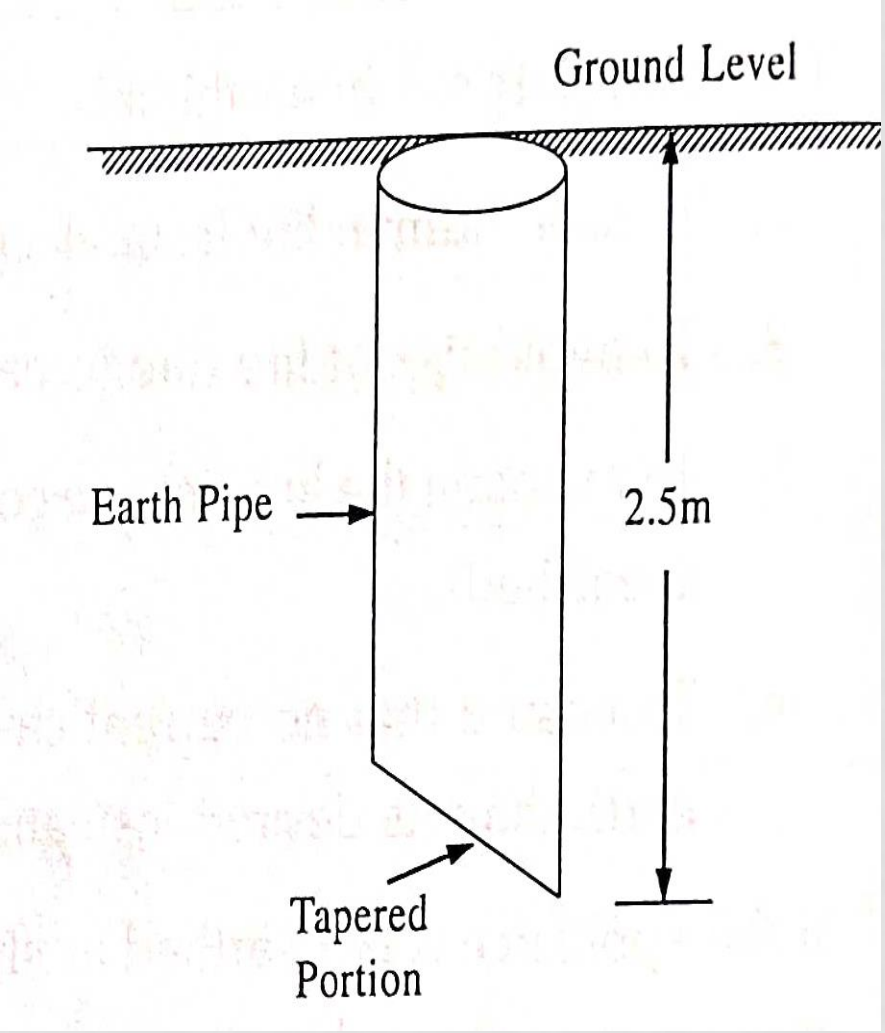
(b) Appliance body is grounded

2 TYPES OF EARTHING

- The various methods of earthing in common use are :
- 1.Rod earthing.
- 2. Strip or Wire earthing.
- 3.Pipe earthing.
- 4, Plate earthing.

1. ROD EARTHING :

- In this system of earthing solid rod of 12.5 mm dia of copper or 16 mm dia of solid G.I or steel rod of length not less than 2.5 metre is driven vertically down wards into the earth either by manually or by hammer.
- Sometimes it is required to drive more than Tapere done rod to reduce the earth resistances to a desired value.
- This system is cheap and is suitable in areas where the soil is loose or sandy.



2. STRIP OR WIRE EARTHING.

- This system is employed in places, where the soil is rocky, :because in rocky areas the soil excavation work is difficult.
- In this system a wire or strip of cross-section 25 mm x 1.6 mm (3.0 mm^2 if round) if of copper or 25 mm x 4mm (6.0 mm^2 if round) of G.1 or steel is buried in the ground in horizontal trenches of minimum depth of ½ meter (11/2 feet) as shown in Fig.
- The length of the wire or strip depends on the requirement of earth resistance, but the length should not be less than 15 meters.
- In order to achieve required resistance, sometimes more than one wire or strip is laid in parallel to each other,

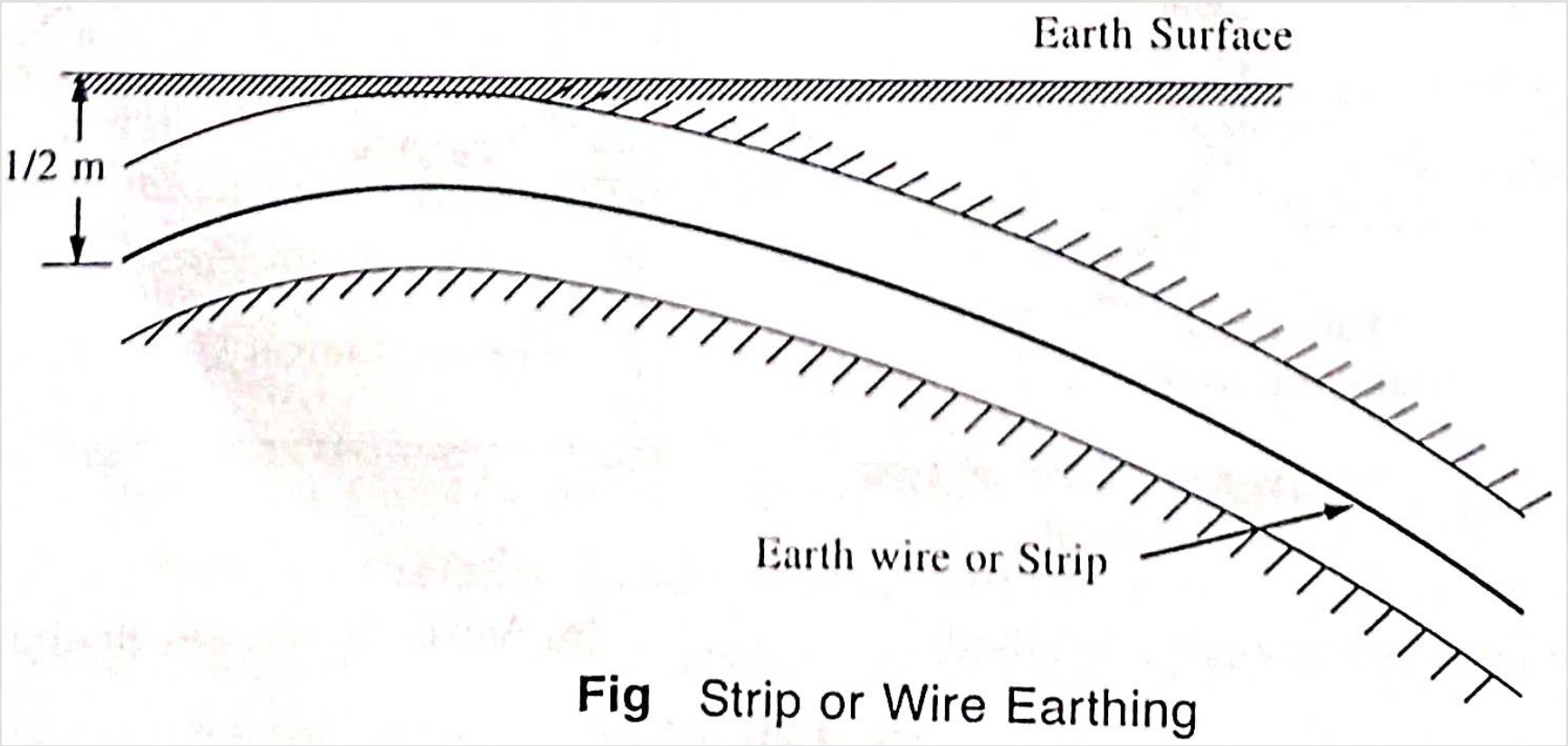
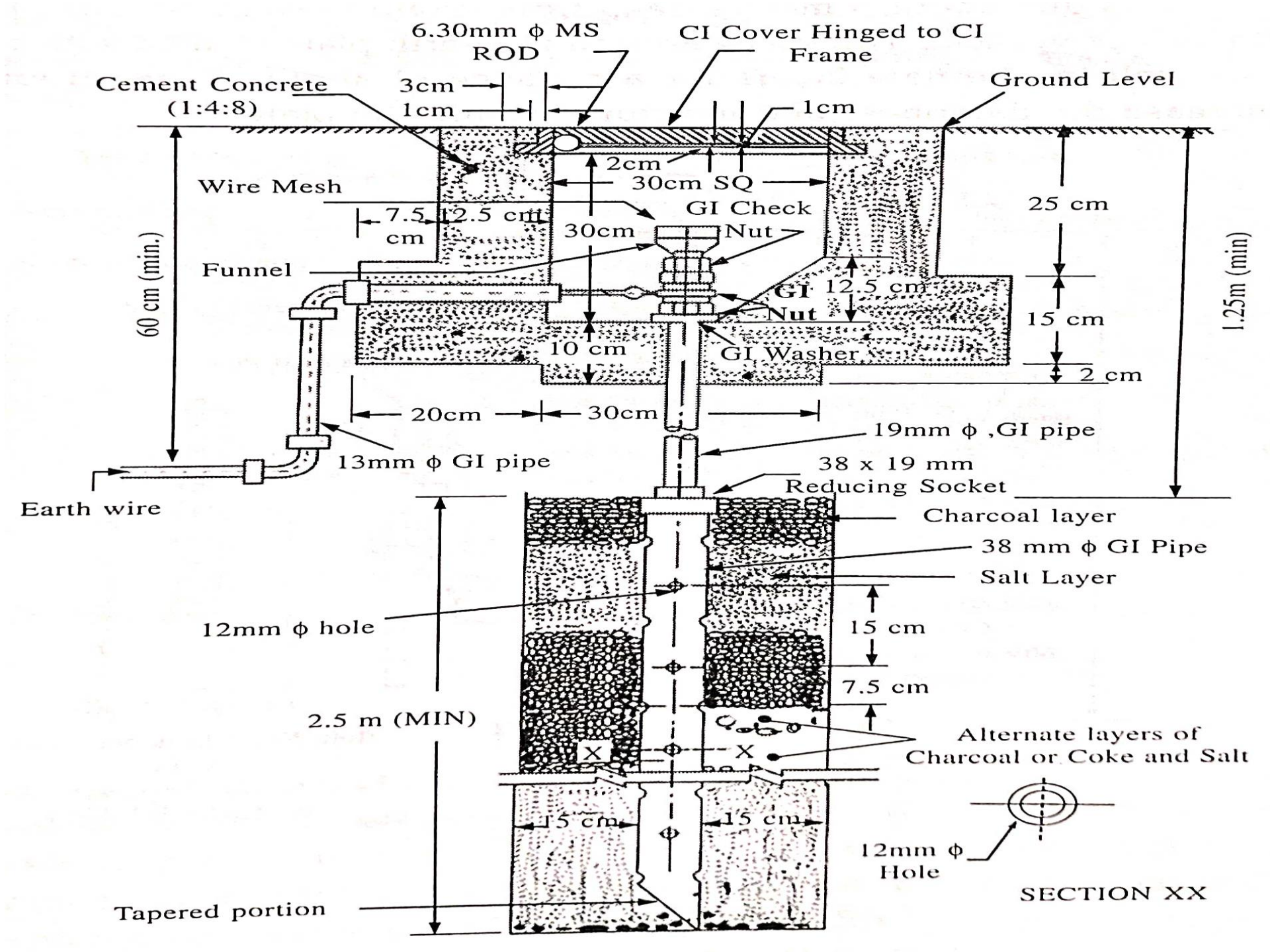


Fig Strip or Wire Earthing

3. PIPE EARTHING :

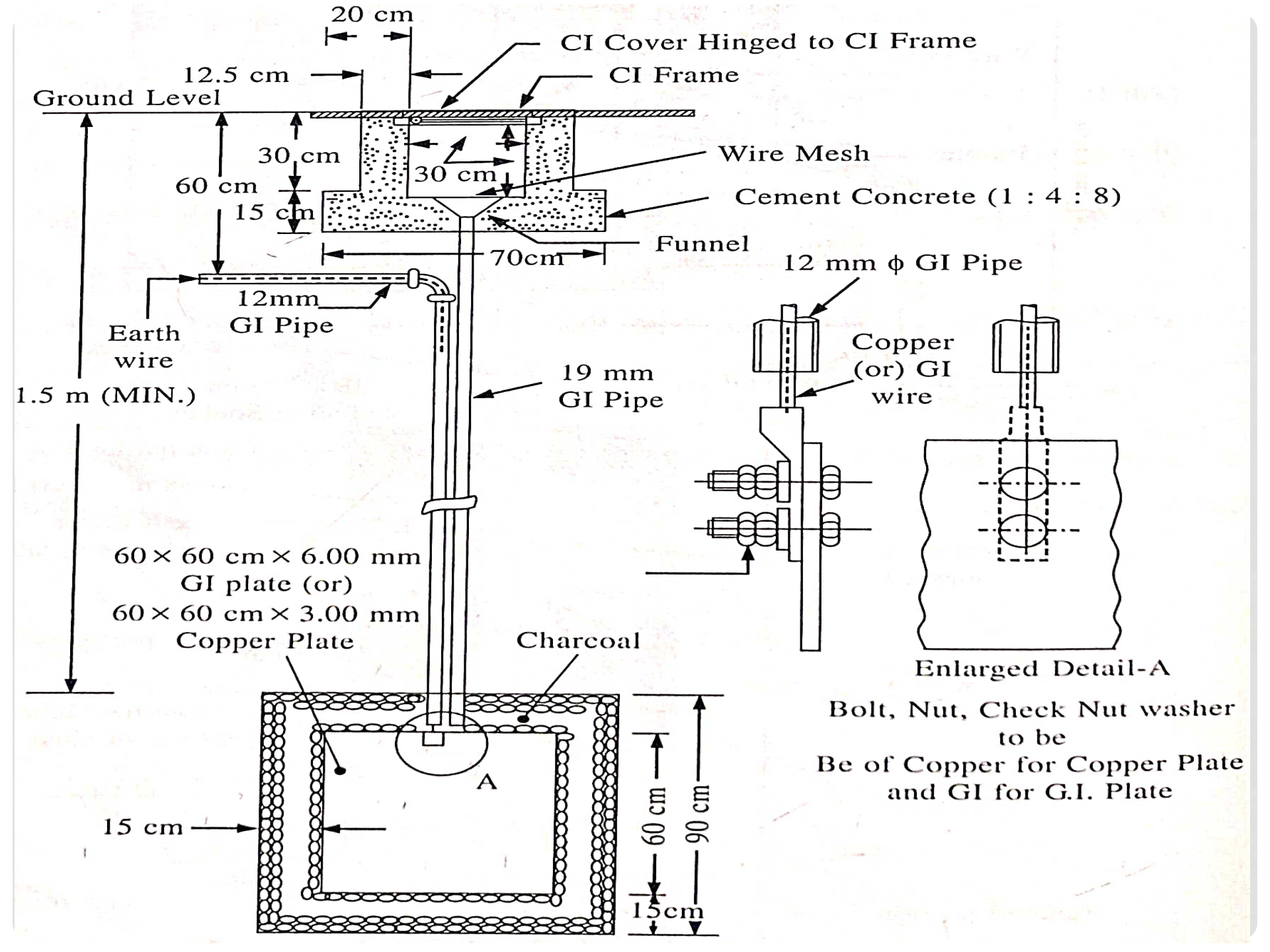
- It is a common system of earthing in which a square pit of sides 40 cm each is dug about 4 to 5 meters deep.
- A G.I. Pipe of 38 mm dia and 2.5 m long is placed vertically in a pit to work as earth electrode.
- The depth at which the pipe is placed depends upon the moisture of the ground, but the pipe is placed at a minimum depth of 3.75 meters.
- The pipe is provided with a tapered casting at the lower end in order to facilitate the driving.
- The pipe in the pit is surrounded by pieces of coke or char coal and salt in alternate layers for a distance of about 15 cm to increase the dampness and moisture around the pipe.
- The pipe has 12 mm dia holes, so that water poured from top is made to spread in the charcoal and salt layers through the holes to decrease earth resistance.


6.30mm ϕ MS ROD
CI Cover Hinged to CI Frame
Cement Concrete (1:4:8)
3cm
1cm
Ground Level
1cm
2cm
30cm SQ
Wire Mesh
GI Check Nut
7.5 cm
12.5 cm
30cm
25 cm
Funnel
GI Nut
12.5 cm
15 cm
60 cm (min.)
1.25m (min)
10 cm
GI Washer
2 cm
20cm
30cm
19mm ϕ ,GI pipe
13mm ϕ GI pipe
38 x 19 mm Reducing Socket
Earth wire
Charcoal layer
38 mm ϕ GI Pipe
Salt Layer
12mm ϕ hole
15 cm
7.5 cm
2.5 m (MIN)
Alternate layers of Charcoal or Coke and Salt
15 cm
15 cm
12mm ϕ Hole
Tapered portion
SECTION XX

- Another pipe of 19 mm dia and minimum length of 1.25 meters is connected to this pipe through a 38 x 19 mm reducing socket.
- At the top, a cement concrete work is made for the protection of pipe from mechanical a damage and is provided with a funnel with wire mesh to pour water.
- The funnel is a connected to 19mm dia pipe by means of bolts and nuts.
- In summer season the moisture in the soil decreases which causes increase in earth resistance, hence 3 or 4 buckets of water are put for every few days.
- Another pipe of 13mm dia is connected to the 19mm pipe near the wire mesh through which earth wire is carried at a depth of 60cm from the surface of the ground.
- The cement concrete work at the top is covered with a iron plate for periodic opening and checking.

4. PLATE EARTHING :

- In this type of earthing a copper plate of dimension 60 cm x 60 —cm x 3mm or a G.I. plate of dimension 60 cm x 60c m x 6 mm is used as earth electrode.
- A pit is dug about 3 meters deep from ground level and earth plate is buried with its face vertical.
- The space around the earth plate is filled with coke or charcoal and salt in alternate layers for a distance of about 15 cm around the plate to increase the dampness and moisture around the plate.


20 cm
CI Cover Hinged to CI Frame
12.5 cm
CI Frame
Ground Level
30 cm
Wire Mesh
30 cm
60 cm
Cement Concrete (1 : 4 : 8)
15 cm
Funnel
70cm
12 mm ϕ GI Pipe
12mm
GI Pipe
Earth
wire
Copper
(or) GI
wire
19 mm
GI Pipe
1.5 m (MIN.)
60 × 60 cm × 6.00 mm
GI plate (or)
60 × 60 cm × 3.00 mm
Copper Plate
Charcoal
A
15 cm
60 cm
90 cm
15cm
Enlarged Detail-A
Bolt, Nut, Check Nut washer
to be
Be of Copper for Copper Plate
and GI for G.I. Plate

- A G.I pipe of 12 mm dia is connected to the plate by means of bolt, nuts and washer for carrying G.I. wire for connections to earth plate.
- The bolt, nut and washer are generally made of same material as that of earth plate.
- Another pipe of 19 mm dia is connected to the plate for carrying water and is connected with funnel with wire mesh to pour water.
- The water is poured for increasing dampness and moisture which in turn reduce the earth resistance.
- At the top a cement concrete work is made to protect the plate from mechanical damage.
- The concrete work is providing with a cast iron cover for carrying periodical opening and inspection.

12.SELECTION OF EARTHING

- The type of earthing to be provided depends on many factors such as type of soil, type of installation etc.
- Double earthing is necessary for certain important installations in view of two reasons, firstly to give minimum resistance to the flow of leakage current and secondly if one earth is out of order, another earthing will do the work. In case of double earthing two earthings are done at a distance of about 5 meters.
- The following table helps in selecting a type of earthing for a particular

S.No	Type of Earthing	Application
1.	Rod earthing	In areas where the soil is loose or sandy.
2.	Strip/Wire earthing	In Rocky areas
3.	Pipe earthing	1. For domestic installations such as heaters, coolers, refrigerators geysers, electric iron etc 2. For 11 kV/400 V distribution transformers. 3. For motors of rating upto 100 H.P Induction motors. 4. For Conduit pipe in a wall, all wall brackets. 5. For distribution poles etc.
4.	Plate earthing	Large installations such as : 1. For transmission towers. 2. All sub-stations. 3. Generating stations.

13 EARTH RESISTANCE

- The earth resistance should be low enough to cause flow of current to earth.
- The following maximum permissible values of earth resistances will give satisfactory results,
- Large power stations = 0.5 ohm
- Major sub-stations = 1.0 ohm
- Small sub-stations = 2.0 ohm
- In all other cases = 5.0 ohm

FACTORS AFFECTING EARTH RESISTANCE

- The resistance of earth depends on the following factors.

1. Condition of soil.
2. Moisture content of soil.
3. Temperature of soil.
4. Depth of electrode at which it is embedded.
5. Size and spacing of earth electrode.
6. Material of earth electrode.
7. Quality and Quantity of coal and salt in the earth pit.

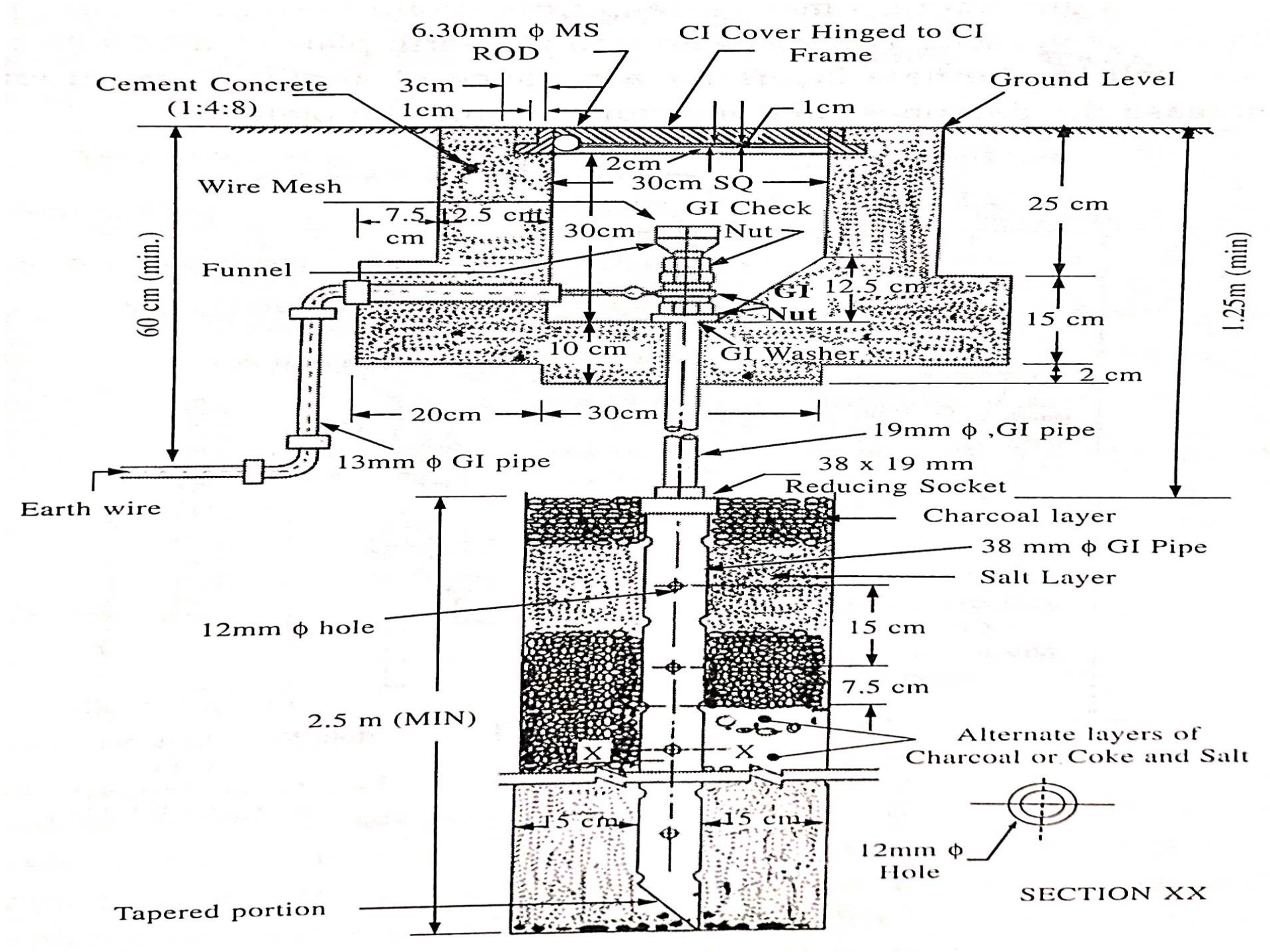
METHODS OF REDUCING EARTH RESISTANCE

- The earth resistance can be reduced from the following methods.
- 1. By Pouring Water : The water increases the dampness and moisture content of earth which causes in reduction of earth resistance.
- 2. Increase in Cross-sectional Area of Earth Electrode : By increasing the area o}earth electrode the earth resistance can be reduced. But the decrease of resistance is not in direct proportional to the area.
- It is found that to reduce the resistance value by one-sixth, the increase in area is 36 times more for the same soil condition and depth of electrode. Hence, this method is not recommended.

- Increase in Depth : The increase in depth below the ground level will reduce resistance of the earth system.
- Electrodes in Parallel ; The earth resistance can be reduced by connecting the number of electrodes in parallel.

PROBLEM 1

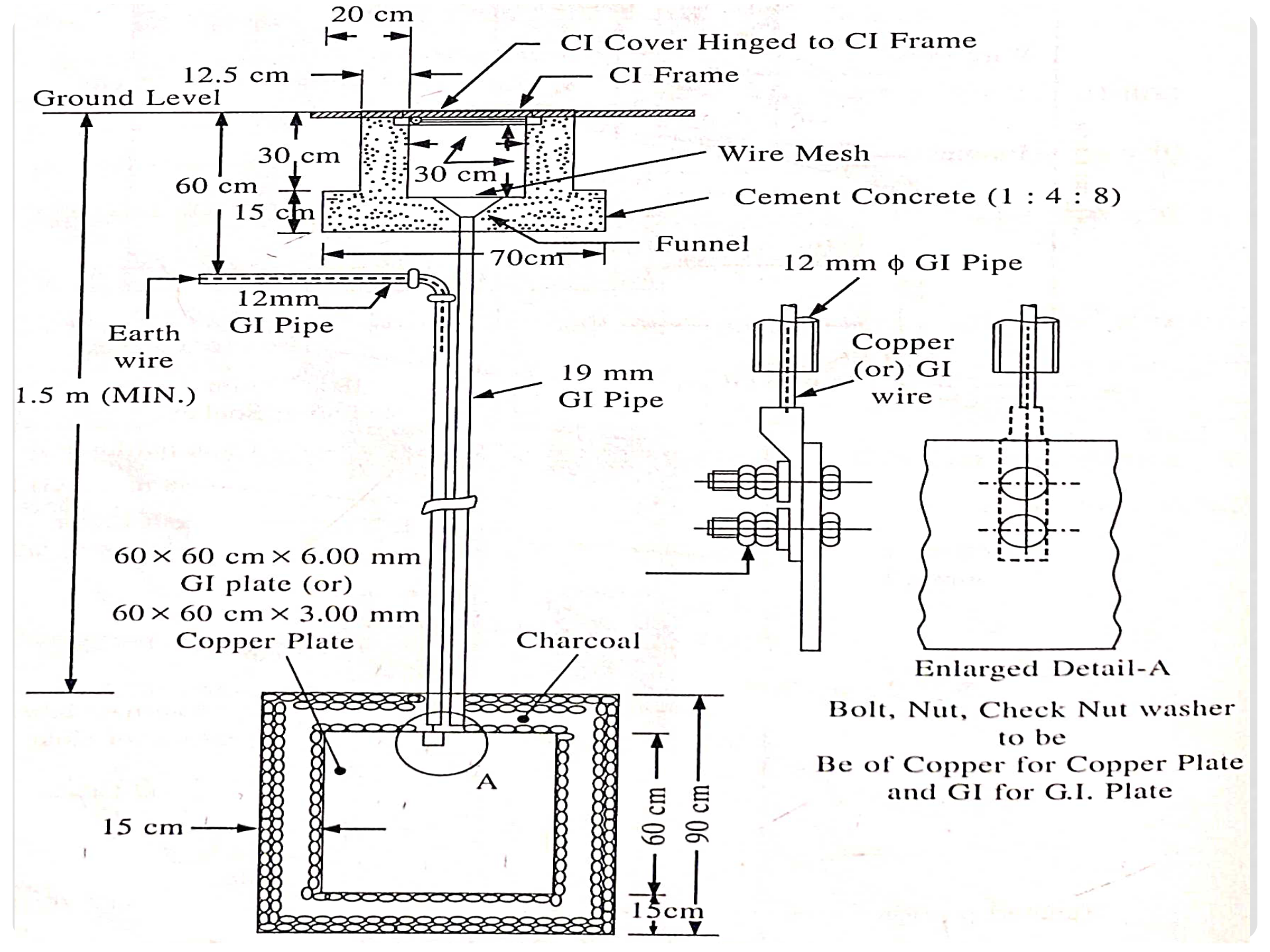
- Draw a neat sketch of pipe of earthing showing dimensions and estimate the materials required. March/April. 2006
- (or)
- Estimate the quantity of material required to provide earthing for 20 kW load small scale industry with a neat sketch.
- (or)
- Draw a neat sketch of suitable earthing with necessary dimensions for a 15 H.P. motor and prepare the quantity estimate of required materials. Oct/Nov. 2006


6.30mm ϕ MS ROD
CI Cover Hinged to CI Frame
Cement Concrete (1:4:8)
3cm
1cm
Ground Level
1cm
2cm
30cm SQ
Wire Mesh
GI Check Nut
7.5 cm
12.5 cm
30cm
25 cm
Funnel
GI Nut
12.5 cm
15 cm
60 cm (min.)
1.25m (min)
10 cm
GI Washer
2 cm
20cm
30cm
19mm ϕ ,GI pipe
13mm ϕ GI pipe
38 x 19 mm Reducing Socket
Earth wire
Charcoal layer
38 mm ϕ GI Pipe
Salt Layer
12mm ϕ hole
15 cm
7.5 cm
2.5 m (MIN)
Alternate layers of Charcoal or Coke and Salt
15 cm
15 cm
12mm ϕ Hole
Tapered portion
SECTION XX

S.No.	Material with Specification	Quantity	Remarks
1.	38 mm dia G.I. Pipe	2.5 m	
2.	19 mm dia G.I. Pipe	1 m	For watering
3.	13 mm dia G.I. Pipe	3 m	To connect earth wire
4.	G.I. Wire 8 S.W.G.	5 m	
5.	G.I. lugs (చెవి)	2 No	For connecting earth wire
6.	G.I. reducing socket (38 × 19 mm)	1 No	For connecting 38 mm pipe to 19 mm pipe
7.	G.I. bolts, nuts and washers for 19 mm dia pipe	2 Sets	
8.	G.I. bends (13 mm dia)	2 No	
9.	30 × 30 cm cast iron frame	1 No	
10.	30 × 30 cm cast iron cover	1 No	
11.	Funnel with wire mesh	1 No	To pour water
12.	Coke or charcoal pieces	15 kg	
13.	Salt	15 kg	
14.	Cement concrete 1:4:8	L.S	L.S = Lump Sum

PROBLEM-2

- Draw a neat sketch of plate earthing and estimate the quantity of materials required. March/April 2005(or)
- Draw a neat sketch of suitable earthing with necessary dimensions for a 132/33 kv sub-station and prepare the list of estimate.


20 cm
CI Cover Hinged to CI Frame
12.5 cm
CI Frame
Ground Level
30 cm
Wire Mesh
30 cm
60 cm
Cement Concrete (1 : 4 : 8)
15 cm
Funnel
70cm
12 mm ϕ GI Pipe
12mm
GI Pipe
Earth
wire
Copper
(or) GI
wire
19 mm
GI Pipe
1.5 m (MIN.)
60 × 60 cm × 6.00 mm
GI plate (or)
60 × 60 cm × 3.00 mm
Copper Plate
Charcoal
A
15 cm
60 cm
90 cm
15cm
Enlarged Detail-A
Bolt, Nut, Check Nut washer
to be
Be of Copper for Copper Plate
and GI for G.I. Plate

The sketch is shown in Fig. 3.2 A. The estimate

S.No.	Material with Specification	Quantity	Remarks
1.	G.I. plate 60 cm × 60 cm × 6.0 mm G.I. plate	1 No	
2.	19 mm dia G.I. Pipe	1 m	For watering
3.	12 mm dia G.I. Pipe	3 m	To connect earth wire
4.	G.I. Wire 8 S.W.G.	5 m	
5.	G.I. lugs	5 No	For connecting earth wire
6.	G.I. bolts, nuts and washers	5 Sets	4 sets for connecting 19 mm and 12 mm dia pipes at A and 1 set for connecting funnel.
7.	G.I. bends (12 mm dia)	2 No	
8.	30 × 30 cm cast iron frame	1 No	
9.	30 × 30 cm cast iron cover	1 No	
10.	Funnel with wire mesh	1 No	To pour water
11.	Coke or charcoal pieces	15 kg	
12.	Salt	15 kg	
13.	Cement concrete 1:4:8	L.S	L.S = Lump Sum

UNIT - IV
Estimating and Costing of Repairs and Maintenance of Electrical Devices and Equipment

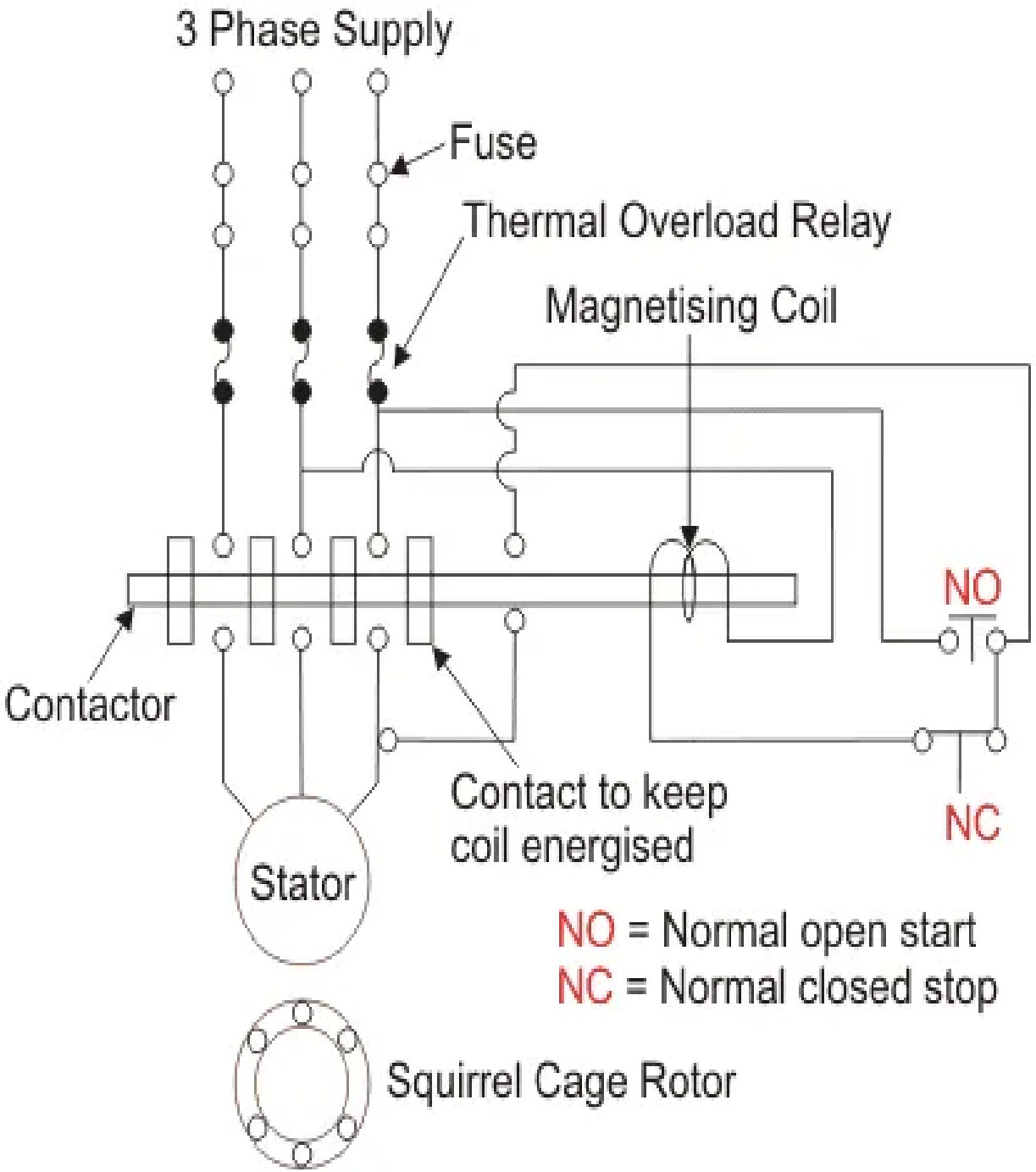
Topics

- D.O.L. starter, small motor, mono block pump, automatic electric iron, table/ceiling fan, ICDP/ICTP Switch, Preparation of detailed drawing work of the product, Preparation of material quantity sheet for the product, Materials and cost required for maintenance work, Estimation of repairing cost and overall cost, Tools used for repairs & maintenance work Preparation of cost schedule for repair and maintenance of electric fan, automatic electric iron, single phase transformer, mixer grinder, D.O.L starter.

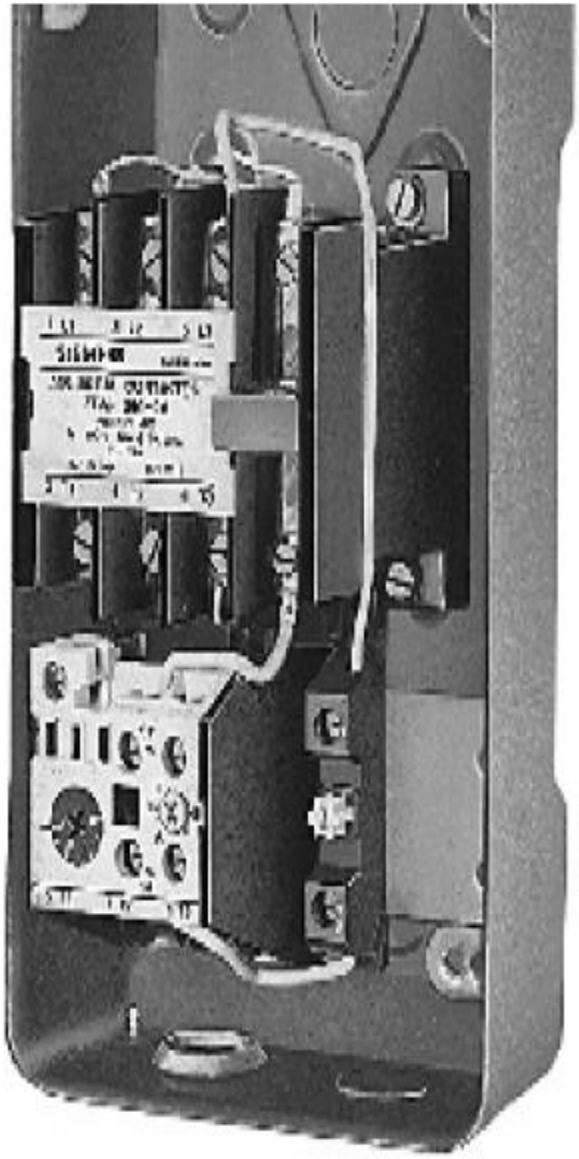
What is DOL Starter?

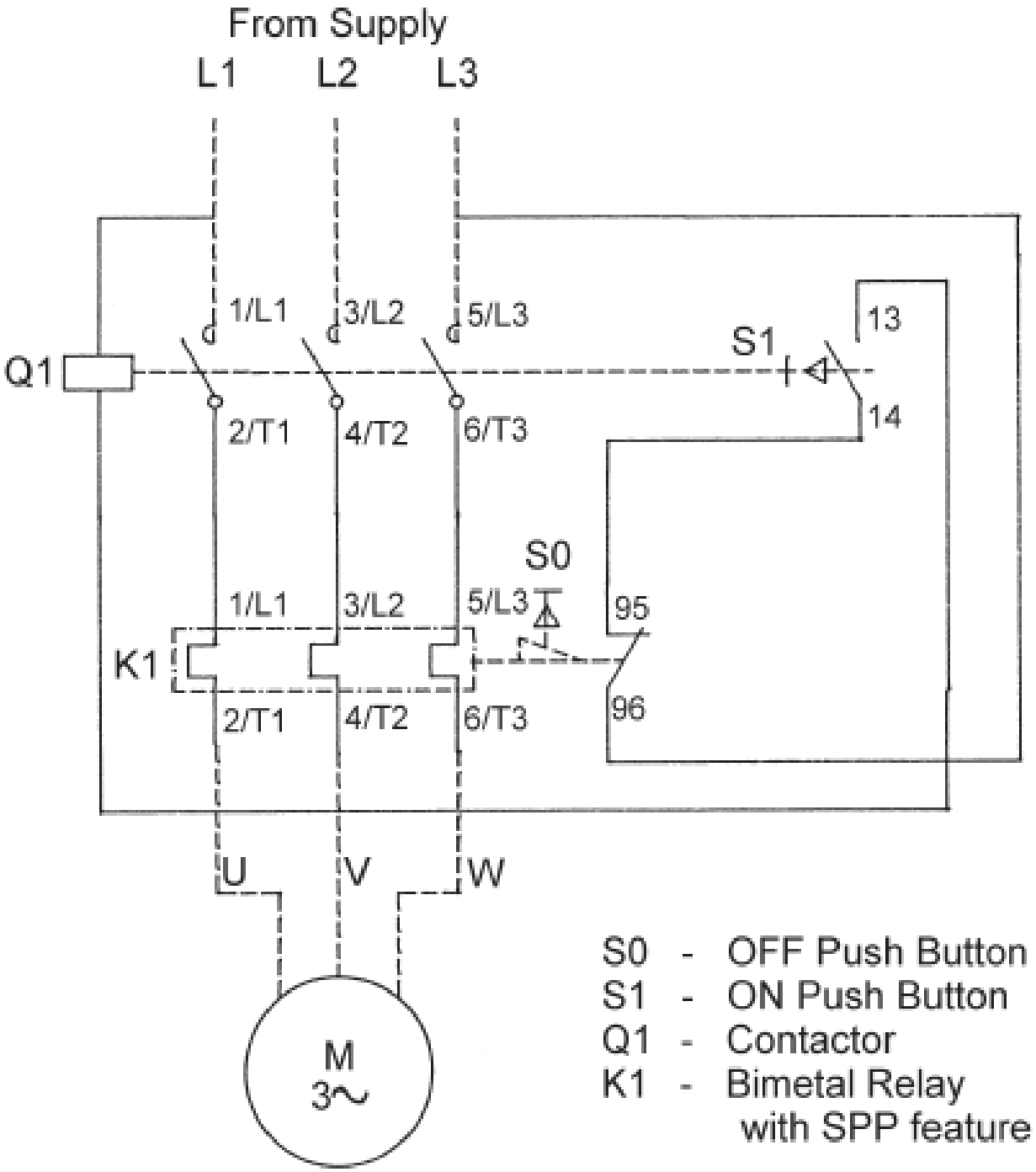
- A **DOL starter** (also known as a **direct on line starter** or **across the line starter**) is a method of starting a 3 phase induction motor.
- In a DOL Starter, an induction motor is connected directly across its 3-phase supply, and the DOL starter applies the full line voltage to the motor terminals.

- Despite this direct connection, no harm is done to the motor.
- A DOL motor starter contains protection devices, and in some cases, condition monitoring. A wiring diagram of a DOL starter is shown below:



SIEMENS
SIEMENS
Direct-On-Line Starter
3TW42 00-1A




From Supply
L1
L2
L3
1/L1
3/L2
5/L3
Q1
S1
13
14
2/T1
4/T2
6/T3
S0
1/L1
3/L2
5/L3
95
K1
96
2/T1
4/T2
6/T3
U
V
W
M
3~
S0 - OFF Push Button
S1 - ON Push Button
Q1 - Contactor
K1 - Bimetal Relay
with SPP feature

- Since the DOL starter connects the motor directly to the main supply line, the motor draws a very high inrush current compared to the full load current of the motor (up to 5-8 times higher).
- The value of this large current decreases as the motor reaches its rated speed.
- A direct on line starter can only be used in circumstances when the high inrush current of the motor does not cause an excessive voltage drop in the supply circuit.
- If a high voltage drop needs to be avoided, a star delta starter should be used instead. Direct on line starters are commonly used to start small motors, especially 3 phase squirrel cage induction motors.
- As we know, the equation for armature current in the motor.

$$I_a = \frac{(V - E)}{R_a}$$

- At starting, the value of E is zero. So starting current is very high.
- In a small rating motor, the rotor has a more considerable axial length and small diameter. So it gets accelerated fastly.
- Hence, speed increases and thus the value of armature current decreases rapidly.
- Therefore, small rating motors smoothly run when it is connected directly to a 3-phase supply.
- If we connect a large motor directly across 3-phase line, it would not run smoothly and will be damaged, because it does not get accelerated as fast as a smaller motor since it has short axial length and larger diameter more massive rotor.
- However, for large-rated motors, we can use an oil-immersed DOL starter.

- The wiring diagram for a DOL stater is shown below. A direct online starter consists of two buttons, a GREEN button for starting and a RED for stopping purpose of the motor.
- The **DOL starter** comprises an MCCB or circuit breaker, contactor and an overload relay for protection.
- These two buttons, i.e. Green and Red or start and stop buttons control the contacts.
- To start the motor, we close the contact by pushing the Green Button, and the full line voltage appears to the motor. A contactor can be of 3 poles or 4-poles. Below given contactor is of 4-pole type.
- It contains three NO (normally open) contacts that connect the motor to supply lines, and the fourth contact is “hold on contact” (auxiliary contact) which energizes the contactor coil after the start button is released.
- If any fault occurs, the auxiliary coil gets de-energized, and hence the starter disconnects the motor from supply mains.

Working principle of a **DOL starter**

- The working principle of a **DOL starter** begins with the connection to the 3-phase main with the motor. The control circuit is connected to any two phases and energized from them only.
- When we press the start button, the current flows through the contactor coil (magnetizing coil) and control circuit also.
- The current energises the contactor coil and leads to close the contacts, and hence 3-phase supply becomes available to the motor.
- If we press the stop button, the current through the contact becomes discontinued, hence supply to the motor will not be available, and the similar thing will happen when the overload relay operates. Since the supply of motor breaks, the machine will come to rest.
- The contactor coil (Magnetizing Coil) gets supply even though we release start button because when we release start button, it will get supply from the primary contacts as illustrated in the diagram of the **Direct Online Starter**.

3 Phase Motor Starter with Overload Protection

- When a motor draws excessive current to meet the load requirements such that this load requirement goes beyond the rated limit, this is known as overload.
- Thermal overload protection is a type of security when the motor draws over current or excessive current and causes overheating of the equipment.
- Overload is also the type of over current. So overload relays are employed to limit the amount of current drawn.
- But that does not mean that protects the short circuit. Fuse or MCB used in the system protects the over current. Overload protection opens a circuit at relatively low currents that are a little higher than the rating of the motor.
- Overload currents are likely to damage if they persist for a long time, i.e. it will not trip if a high value of current flows for a short period such as starting of the motor.
- We often provide overload protection via an overload relay. Overload relays may be solid-state devices with adjustable trip setting also called as the electronic relay or by interacting with related temperature sensors called as a thermal relay or if only operates for excess current flow then called as a magnetic relay.
- For most motors, the maximum rating of the overload protection device is 125% of the full load ampere rating.

Motor Rating at 415 V 3ph, 50Hz		Starter Type	Relay Range	Back-up Fuse Rating (Recommended)		Cu Cable (mm^2) Size
kW	HP			HRC	Rewirable	
0.25	0.33	3TW42 90-1A*64	0.63 - 1	4 A	36 SWG	1
0.55	0.75	3TW42 90-1A*66	1 - 1.6	6 A	34 SWG	1
0.75	1	3TW42 90-1A*68	1.6 - 2.5	6 A	27 SWG	1
1.1	1.5	3TW42 90-1A*69	2 - 3.2	10 A	26 SWG	1
1.5	2	3TW42 90-1A*71	3.2 - 5	16 A	25 SWG	1
2.2	3	3TW42 90-1A*72	4 - 6.3	16 A	24 SWG	1.5
3.7	5	3TW42 90-1A*74	6.3 - 10	25 A	21 SWG	1.5
-	-	3TW42 90-1A*75	8 - 12.5	25 A	19 SWG	1.5
5.5	7.5	3TW42 90-1A*77	10 - 16	32 A	18 SWG	2.5
7.5	10	3TW42 90-1A*78	12.5 - 20	32 A	18 SWG	4

Motor Rating at 415 V 3ph, 50Hz		Starter Type	Relay Range (Recommended)	Recommended Back-up Fuse HRC
kW	HP			
15	20	3TW04 94-2A##	3UA55 (20-32A)	50 A
18.5	25	3TW04 95-2A##	3UA55 (25-36A)	63 A
22	30	3TW04 96-2A##	3UA58Z1 (32-50A)	80 A
30	40	3TW04 97-2A##	3UA58Z1 (40-57A)	100 A
37	50	3TW04 98-2A##	3UA58Z2 (57-70A)	125 A
55	75	3TW05 90-2A##	3UA5830 (85-105A)	160 A

Enter code for coil voltage. ("RO" for 415V, "PO" for 230V)

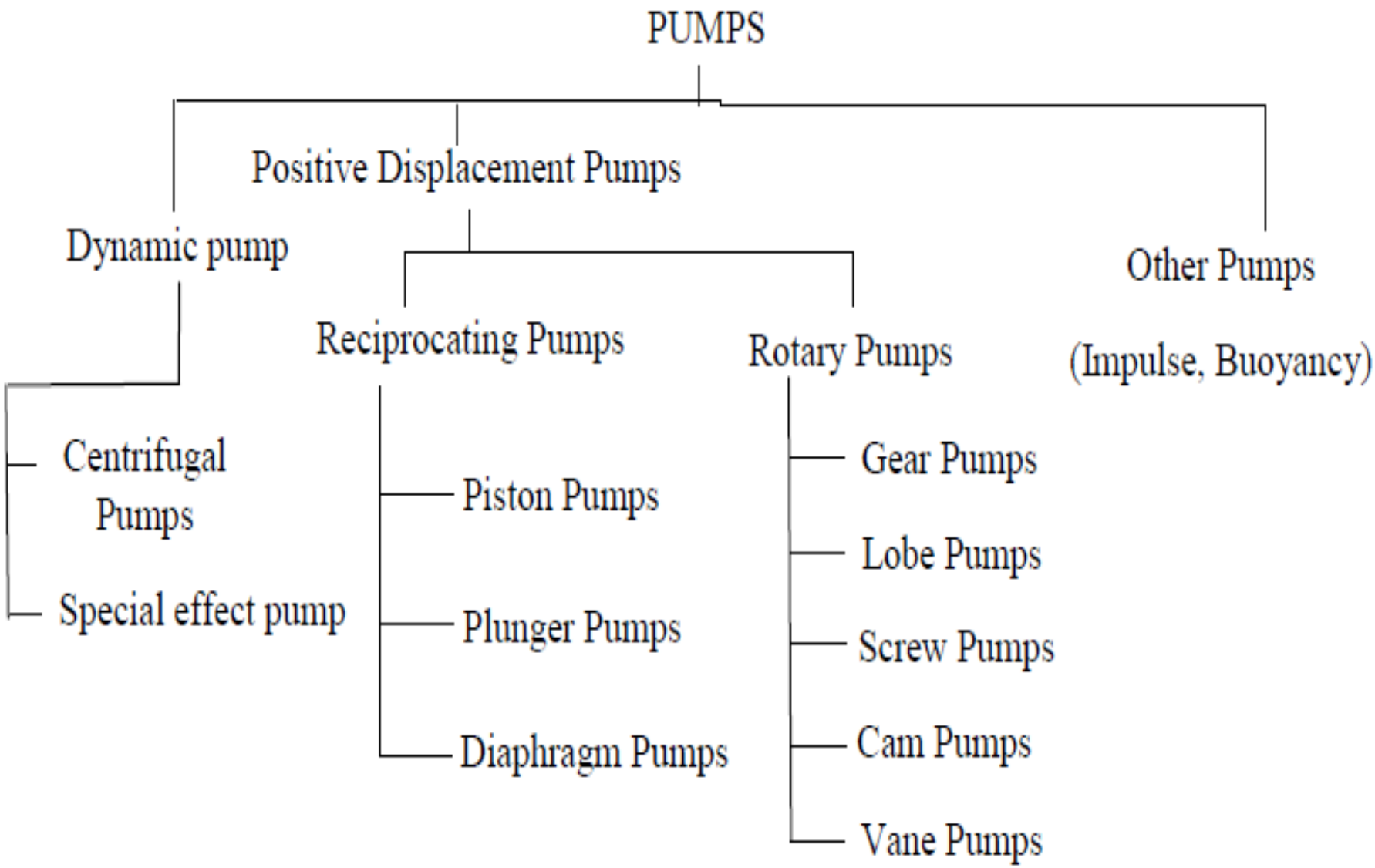
- **Advantages of DOL Starter**
- The advantages of a DOL starter include:
- Simple and most economical starter.
- More comfortable to design, operate and control.
- Provides nearly full starting torque at starting.
- Easy to understand and troubleshoot.
- DOL starter connects the supply to the delta winding of the motor.
- **Disadvantages of DOL Starter**
- The disadvantages of a DOL starter include:
- High starting current (5-8 times of full load current).
- DOL Starter causes a significant dip in voltage, hence suitable only for small motors.
- **DOL Starter** reduces the lifespan of the machine.
- Mechanically tough.
- Unnecessary high starting torque

- **DOL Starter Applications**
- The applications of DOL starters are primarily motors where a high inrush current does not cause excessive voltage drop in the supply circuit (or where this high voltage drop is acceptable).
- Direct on line starters are commonly used to start small water pumps, conveyor belts, fans, and compressors. In the case of an asynchronous motor (such as the 3-phase squirrel-cage motor) the motor will draw a high starting current until it has run up to full speed.

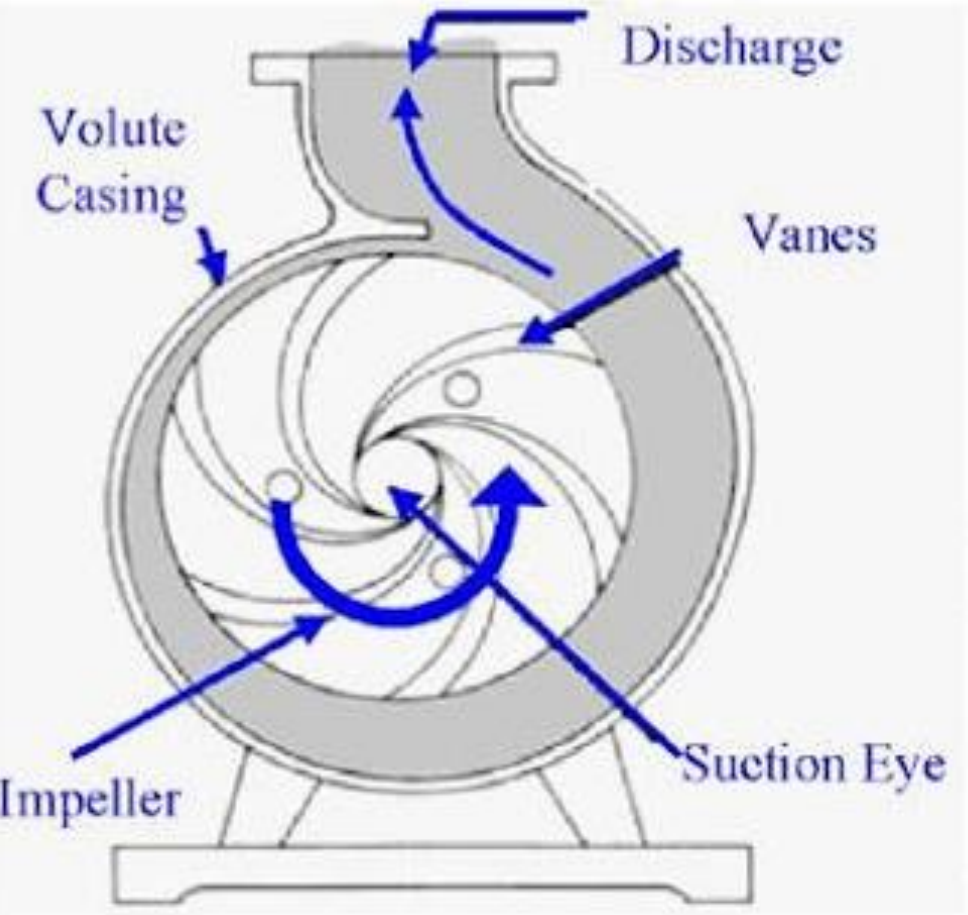
How does a centrifugal pump work?

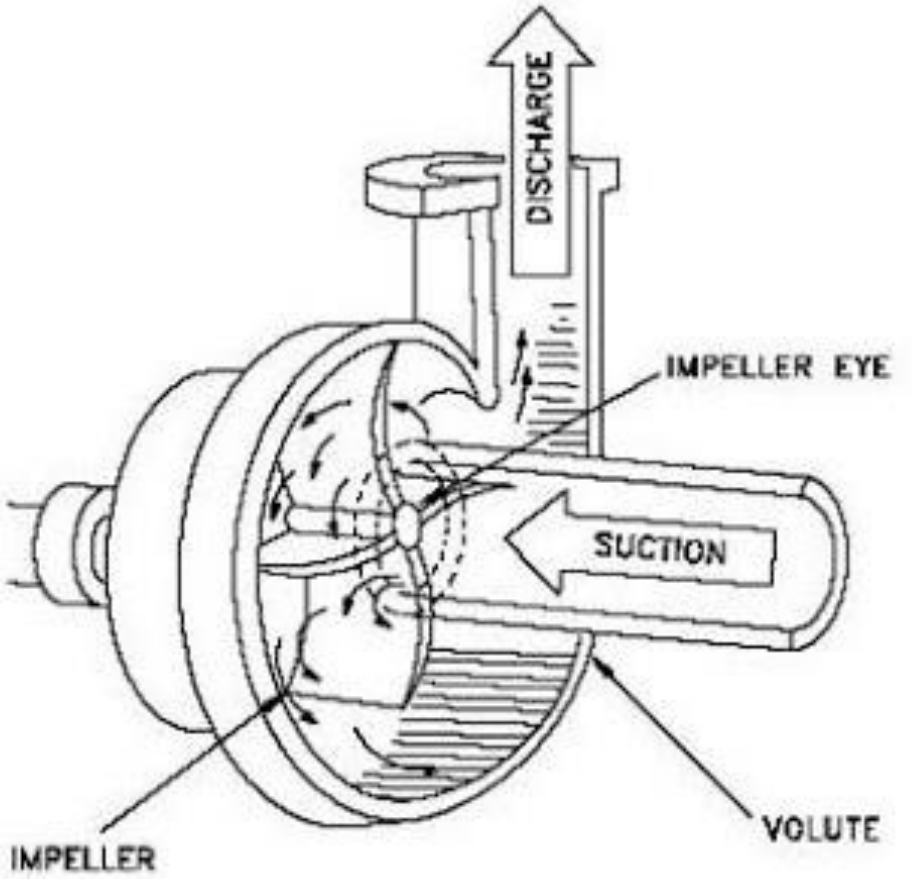
- In its simplest form, a centrifugal pump is made from a housing with an inlet and outlet.
- There is an impeller that is located inside the housing, and a motor or drive that is responsible for rotating the impeller.
- The pumps casing (outer shell) is designed to create a gradually widening channel which is known as the volute.
- When the motor (or drive) rotates the impeller it is creating centrifugal force.

CLASSIFICATION OF PUMPS



This force throws the fluid outward to the volute and causes two things to happen:

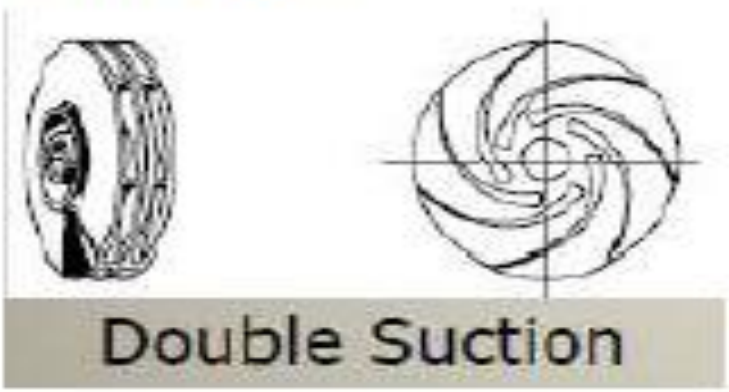




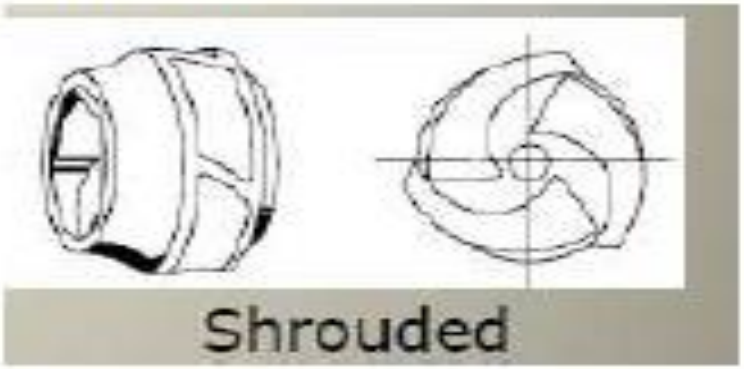
Enclosed Impeller

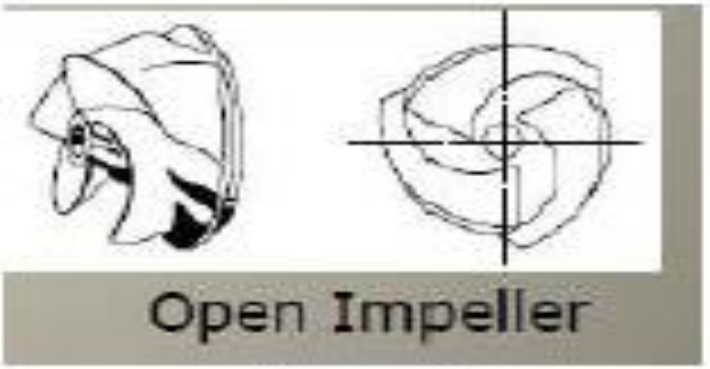
Semi open impeller

1. Radial Flow,

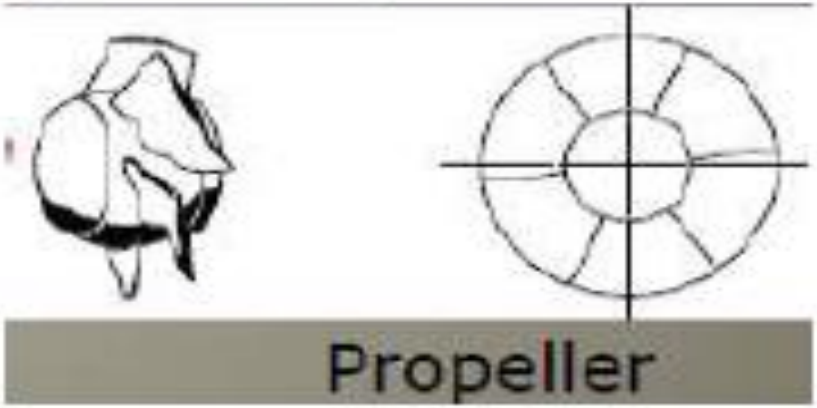


2. Mixed Flow,





3. Axial Flow



- It creates a reduced pressure area at the eye of the impeller, which acts like a vacuum. This provides a flow of liquid to the pump impeller.
- On the other side, the volute causes the fluid to slow down and the pressure inside the pump's housing begins to increase. This increase in pressure forces the liquid out the discharge (outlet) of the pump and then on to the piping systems of the process.

Decide the Type of Pump You Need

- The type of pump you go with depends on where the water supply will be coming from and what kind of output you need. These are the main types of water pumps:
- **Submersible Pumps** – These can be completely submerged in the water of a borewell or an open well.
- **Compressor Pumps** – These are used to move the water where water yield is less and can be used even in loose soil areas.
- **Self-Priming Regenerative Pumps** – Similar to centrifugal pumps, these are also used to lift the water but do not require priming. They can be used for lifting water from a ground tank to an overhead tank.
- **Centrifugal Jet Pumps** – These provide a steady and strong flow of water with the water coming from underground. Depending on the depth, you can get a centrifugal deep well jet or a shallow well jet pump. These pumps can lift water from > 25 Feet depth.
- **Inline Circulation Pumps** – These pumps are used to circulate hot or cold water within the household. They are generally installed with a water heater to deliver hot water to different parts of the house.
- **Booster Pumps** – When a pressurised flow of water is required, for example in lawns or bathrooms, this type of pump is used.

Centrifugal Monoblock Pump

Agriculture Monoblock Water Pumps

Submersible Pump

Booster Pump

Check the Specifications

- Once you have decided the type of pump you want to buy, you will have to look at the specifications. This is an equally important part as your home water pump should be capable of getting a sufficient amount of water with the pressure that you require. Here are some of the specifications you should look at and what they mean:
- **Discharge Rate** – Also known as the flow rate, this is measured in litres per minute (LPM). This will be the amount of water that is pumped within a specific time. The higher it is, the quicker it pumps. A range of 100-200 LPM is usually sufficient for a household.
- **Head Range** – Head here refers to the discharge head – the vertical distance that you will be pumping the water. The head range should fall within this distance for the water pump to pump water effectively. This is measured in meters (m).
- **Power** – This is the amount of electrical power that will be consumed by the pump when in use and it can be measured in kilowatt (kW) and horsepower (HP). This ranges for 0.5-1.5 HP for most pumps with some like inline circulation pump requiring as little as 0.16 HP. This will vary depending on the other specifications of the pump but generally as the amount of water pumped and head range increased, so does the power.

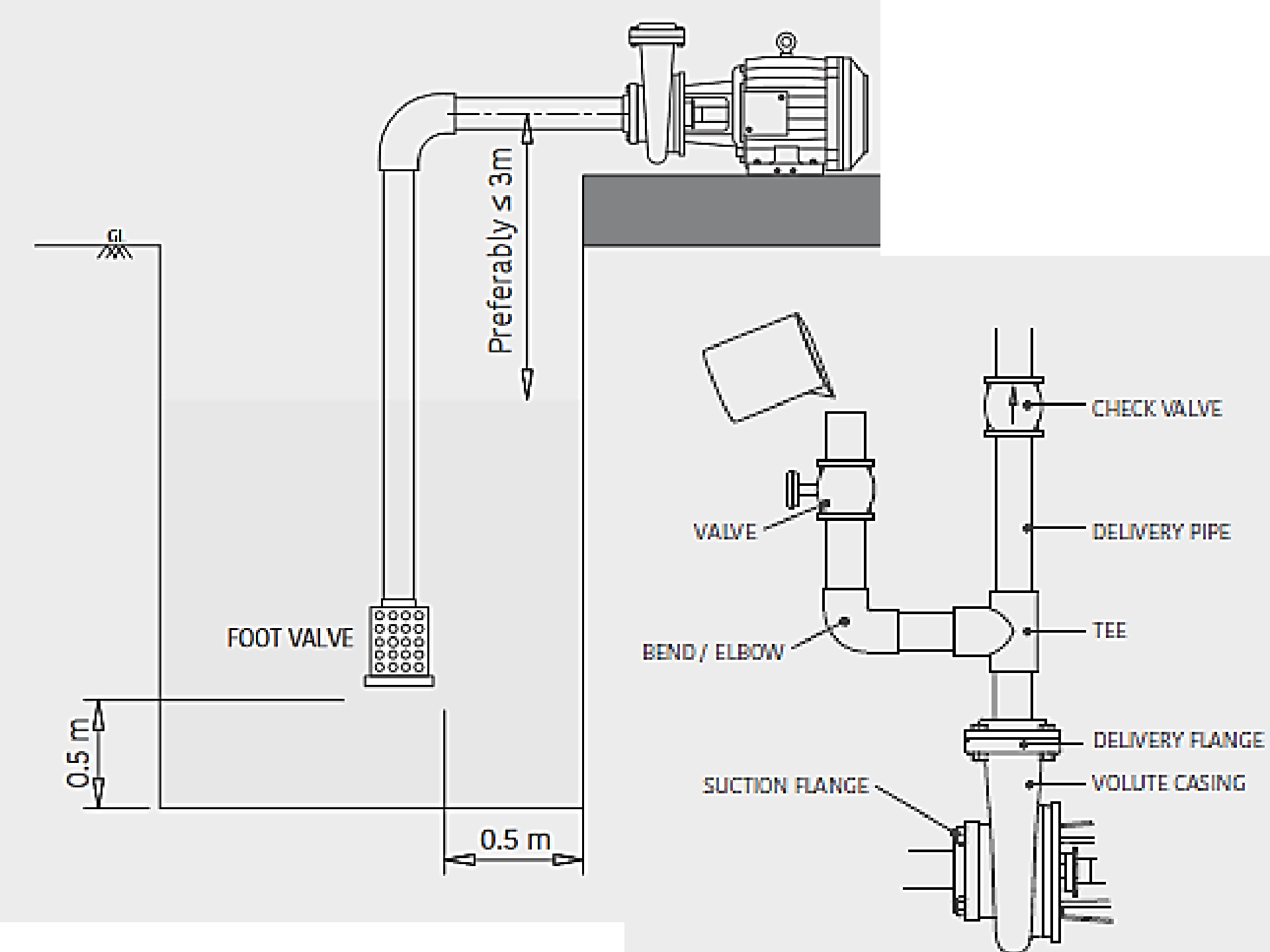
What are the main parts that make up a centrifugal pump?

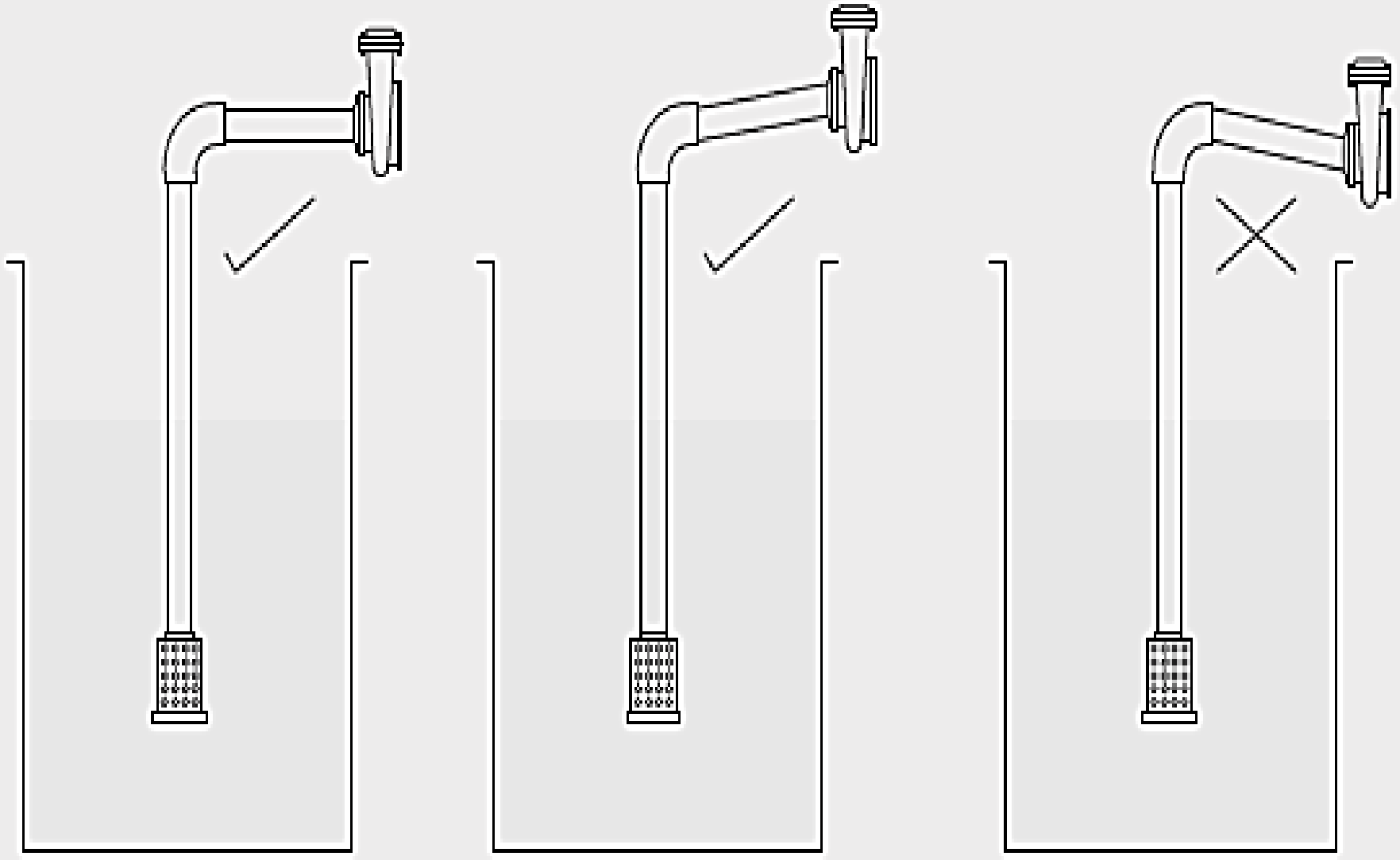
- Now that we have an understanding of how centrifugal pumps operate, we can give an overview of its most common parts:
- **Casing (Volute)** – As we learned earlier, this acts as a pressure containment vessel. It directs the flow of liquid in and out of the centrifugal pump. It slows down the speed of the fluid while increasing the pressure within the casing.
- **Impeller** – This is a rotor that is used to increase the kinetic energy of the flow.
- **Motor (drive)** – Power source of the pump. It is responsible for driving the shaft.
- **Shaft (rotor)** – The impeller is mounted on a shaft. This component uses torque from the motor to transfer energy to the impeller.
- **Shaft Seals** – These are packing rings or mechanical seals which help prevent any leakage of the pumped fluid.
- **Bearings** – work to reduce friction between the rotating shaft and the pump and keep the impeller spinning in place.

- Maintenance Programs for centrifugal pumps can be grouped into three categories:
- routine, quarterly, and annual maintenance.
- Routine maintenance is the process of setting a schedule to inspect, log, and repair components.
- This focuses on components that are leading indicator of potential failure.

Installation

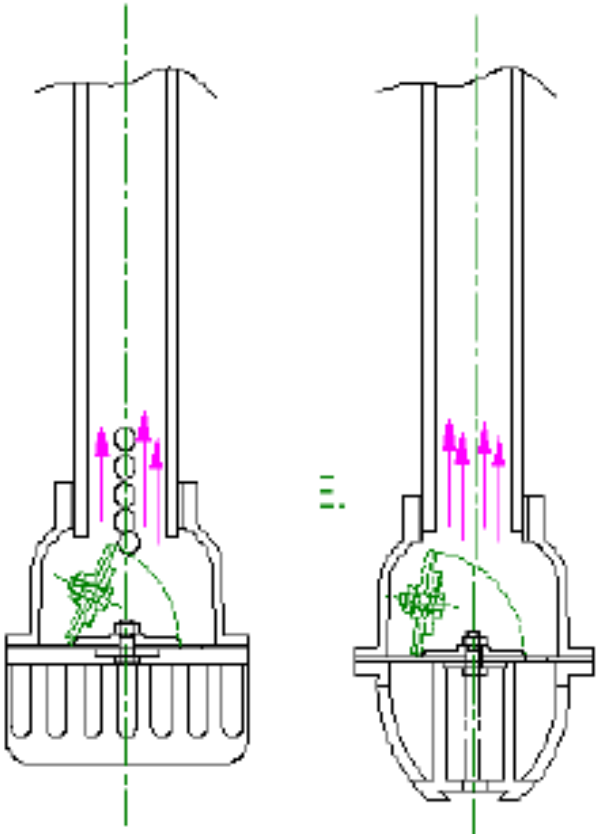
- The following steps are executed prior to installation Installation
- Measure the insulation resistance using a megger of 500 VDC
- Ensure contact points are clean
- Connect the measuring cable to the ground conductor
- Connect the other measuring cable to every core of the motor cable in succession
- Ensure that the insulation resistance, as shown on the megger, is a minimum of 20MΩ
- Prepare a level concrete foundation for mounting the monoblock and tighten the motor base
- using the foundation bolts


GL
Preferably ≤ 3m
FOOT VALVE
0.5 m
0.5 m
CHECK VALVE
VALVE
DELIVERY PIPE
BEND / ELBOW
TEE
DELIVERY FLANGE
SUCTION FLANGE
VOLUTE CASING

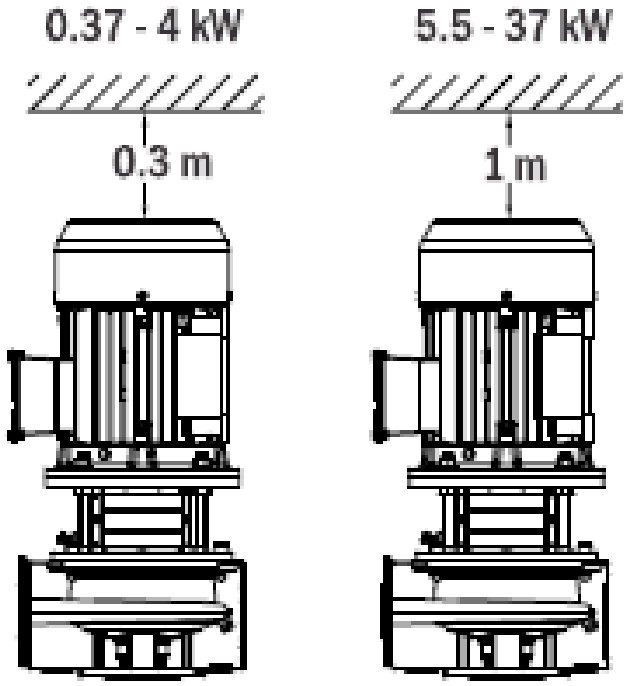

Horizontal suction pipe
Suction pipe inclined up towards pump suction
Suction pipe inclined down towards pump suction

✗ BAD

✓ GOOD

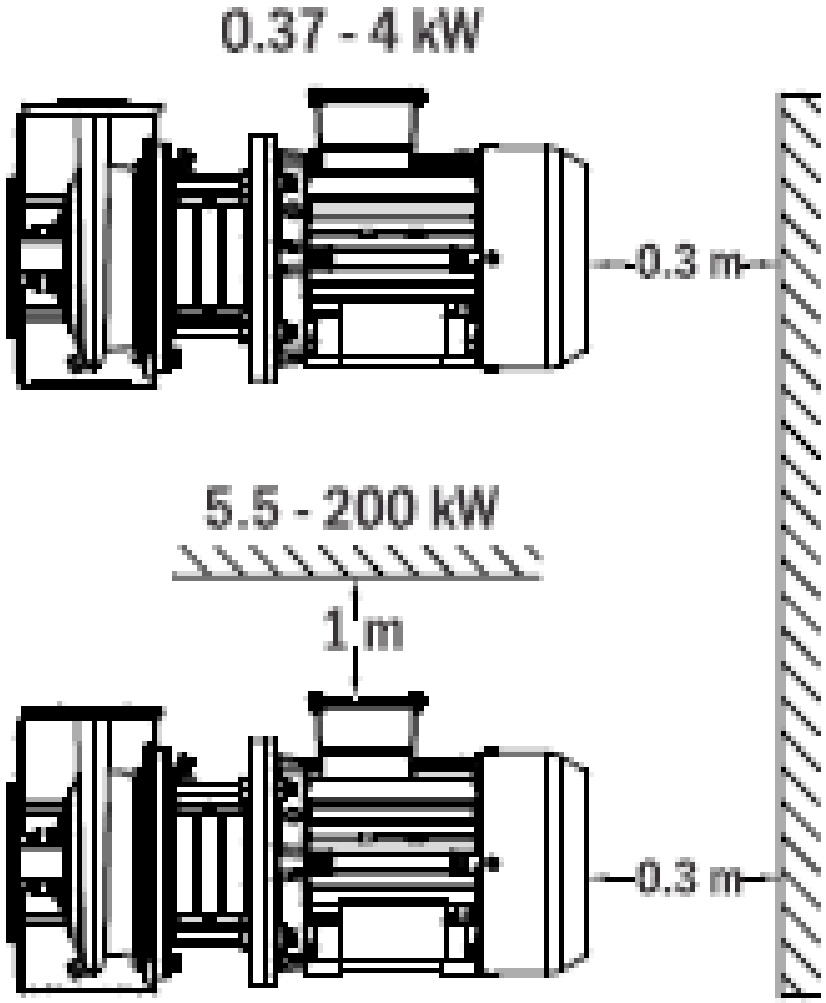


- Vertical installation
- Pumps fitted with motors up to and including 4 kW require a 0.3 m clearance above the motor.
- Pumps fitted with motors of 5.5 kW and up require at least a 1 metre clearance above the motor to allow the use of lifting equipment.

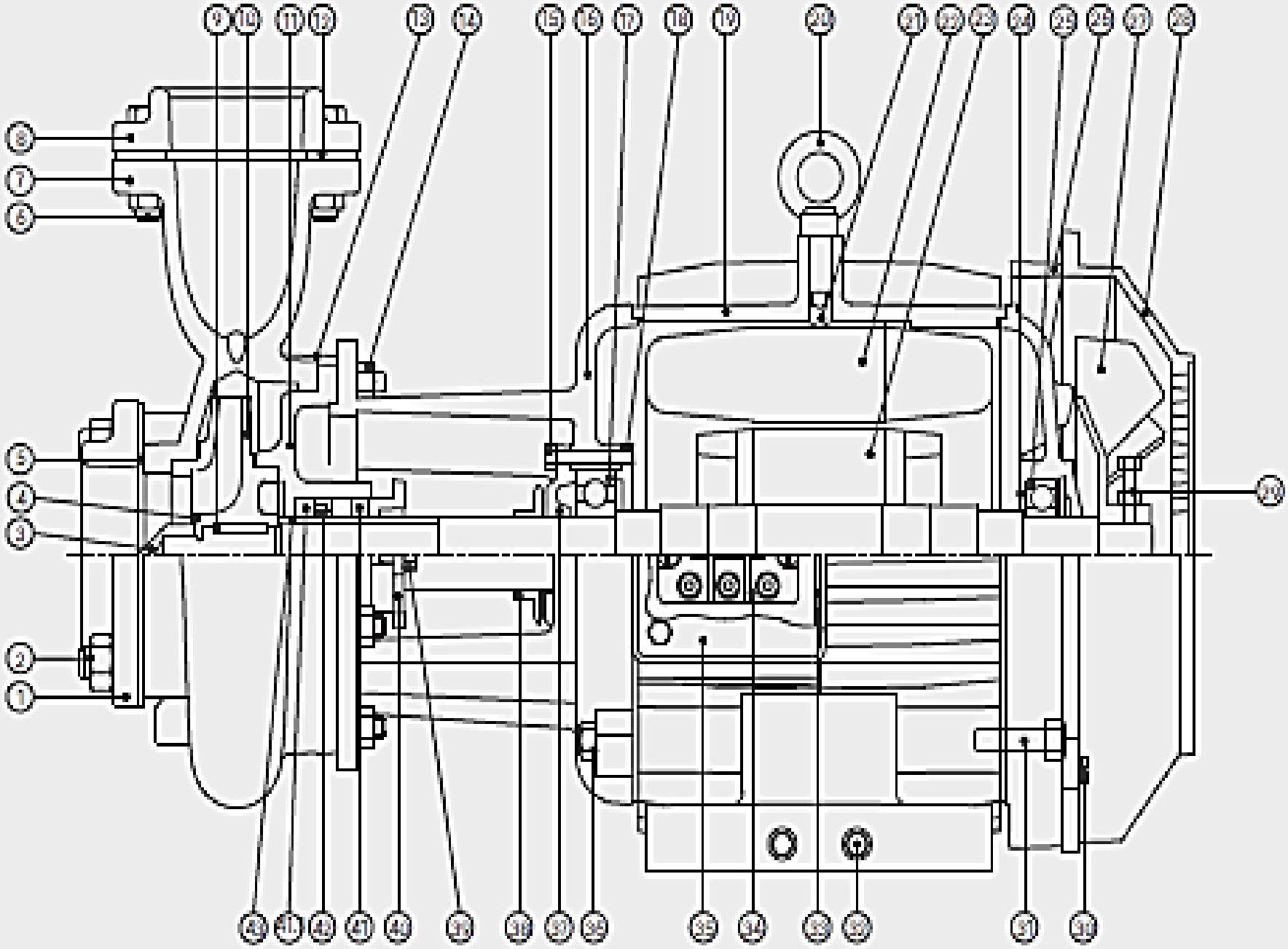


Clearance above the motor

- Horizontal Installation
- Pumps fitted with motors up to and including 4 kW require a 0.3 m clearance behind the motor.
- Pumps fitted with motors of 5.5 kW and up require a 0.3m clearance behind the motor and at least a 1 metre clearance above the motor to allow the use of lifting equipment.
- Mono block pumps with base frame must have the same clearance as pumps with motors from 5.5 kW above.



Clearance behind the motor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No.	PART NAME
1	Flange-square
2	Stud With Hex.nut
3	Impeller Lock Nut
4	Washer
5	Gasket Square
6	Hex. Head Bolt - Nut
7	Casing
8	Flange Square
9	Parallel Key
10	Impeller
11	Yoke
12	Gasket-square
13	Gasket-circular
14	Stud With Hex. Nut
15	Hex. Head Bolt

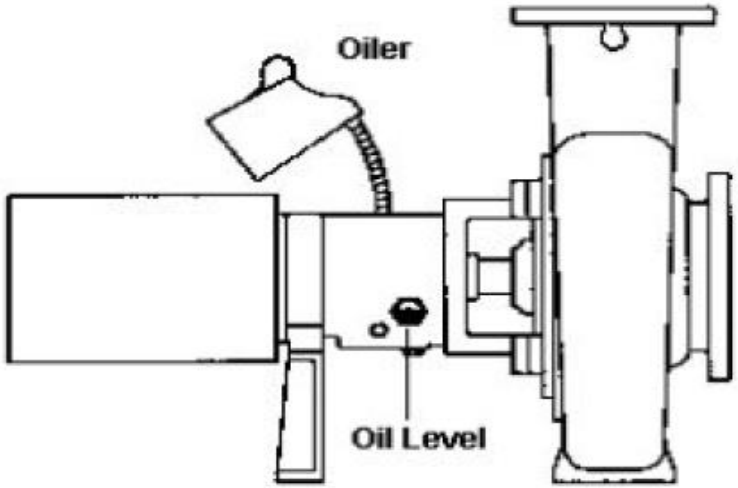
No.	PART NAME
16	Cover Dome
17	Ball Bearing-double Shield
18	Bearing Cap - Front Inner
19	Body
20	Eye Bolt
21	Hex. Socket Screw
22	Stator Stack
23	Rotor With Shaft
24	Shield
25	Ball Bearing-double Shield
26	Rear Cover
27	Fan
28	Fan Shield
29	Hex. Head Bolt & Nut
30	C.h.screw & Spring Washer

No.	PART NAME
31	Hex. Head Bolt
32	Hex. Head Bolt & Washer
33	Terminal Box
34	Terminal Board
35	Terminal Box Cover
36	Hex. Head Bolt
37	Bearing Cap - Front Outer
38	Water Slinger
39	Stud With Hex. Nut
40	Gland
41	Packing Rope
41.1	
42	Oil Seal
43	Sleeve

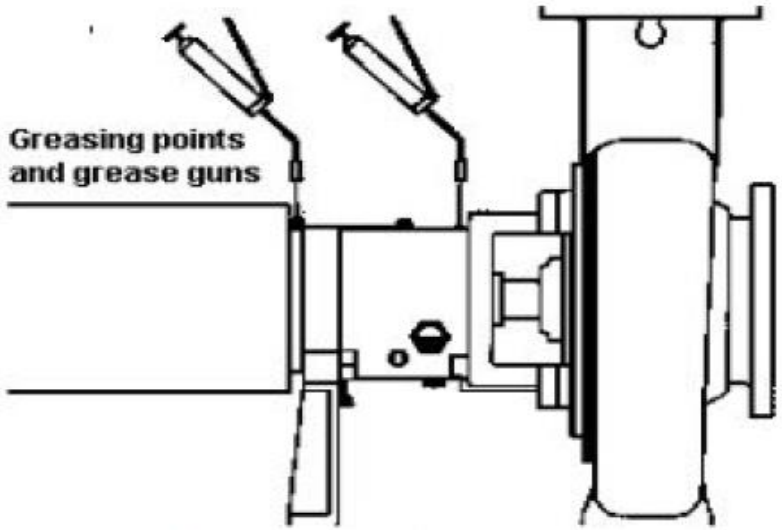
Routine Maintenance

- ● **Bearing And Lubricant Condition**
- ○ Monitor and log bearing temperatures, lubricant level, and vibration. Lubricant should be clear with no signs of bubbling. If bubbling is occurring, this is a good indication to add more lubricant to decrease the temperature of the bearings. If there is an increase in vibration in the bearings, this may be a good indicator of impending bearing failure.
- ● **Shaft Seal Condition**
- ○ Check the mechanical seals. There should be no signs of visible leakage.
- ○ During downtime, inspect the pump's packing to make sure there is adequate lubrication. If the packing looks compressed and dry, replace the packing and add lubricant per the operation manual.
- ● **Overall Pump Vibration**
- ○ Imminent pump failure can be detected by monitoring overall pump vibration. Excessive vibration can result from a change in pump alignment, bearing failures, cavitation, and obstructions in the suction and discharge lines.
- ● **Pump Discharge Pressure**
- ○ The difference in pressure read by the suction and discharge gauges will provide the total developed head pressure of the pump. Confirm this reading is within the pump's designed performance. You can find this on the manufactured website or your operation manuals..

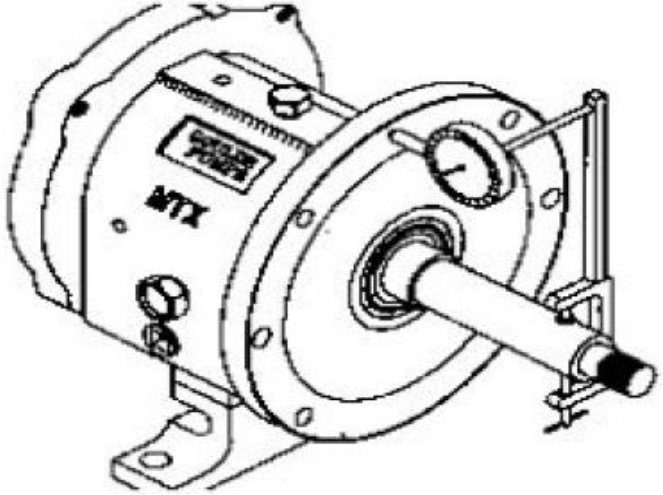
Illustration of Maintenance Checks[1]



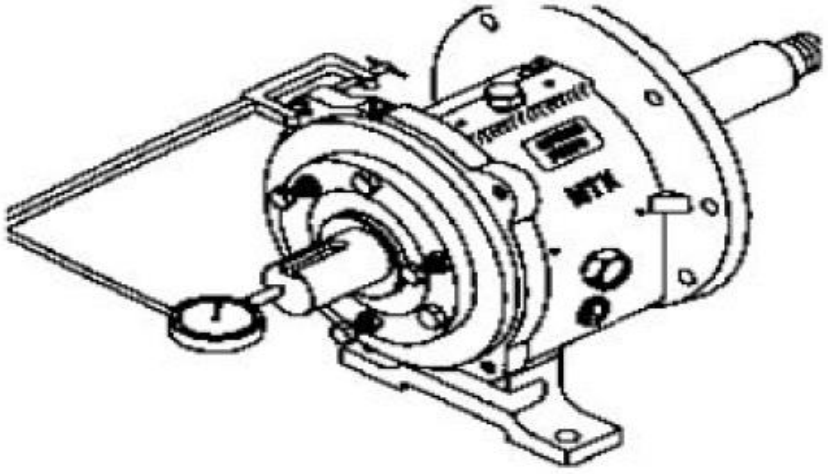
1. Oil level check



2. Re-greasing of bearings



3. Shaft to bearing housing face runout



4. Shaft end play measurement

[1] Pictures courtesy of Goulds Pumps Copyright, Elfer, Inc. 1998, Waterford, New York

Quarterly Maintenance

- Verify the integrity of the pump's foundation and check the hold-down bolts for tightness.
- For oil-lubricated pumps, as a rule of thumb, you should change the oil after the first 200 hours of operation for a new pump.
- Then again after every three months or 2,000 operating hours, whichever comes first. Your operation manual will have specific instructions for oil change intervals and oil grade.
- For grease-lubricated pumps, as a rule of thumb bearings should be greased every three months or 2,000 operating hours, whichever comes first.
- Your operation manual should have specific instructions for grease intervals and grease grade to be used.
- Grease the motor bearings according to the manufacturer's instructions.
- Check the shaft alignment.
- Bearing vibration spectrum on all pump and motor bearings.

Annual Maintenance

- **Bearing Frame And Foot** – inspect for cracks, roughness, rust or scale. Machined surfaces should be free of pitting or erosion.
- **Bearing Frame** – inspect all tapped connections for dirt. Clean and chase threads as necessary. Remove all loose or foreign material. Inspect lubrication passages to be sure that they are not blocked.
- **Shaft And Sleeve** – inspect for grooves or pitting. Check bearing fits and shaft runout, and replace the shaft and sleeve if worn or if the shaft runout is greater than 0.002 inches.
- **Casing** – inspect for signs of wear, corrosion or pitting. If wear exceeds a depth of 1/8-inch, the casing should be replaced. Check gasket surfaces for signs of irregularities.
- **Impeller** – inspect the impeller for wear, erosion or corrosion damage. If the vanes are bent or show wear in excess of 1/8-inch deep, replace the impeller.
- **Frame Adapter** – inspect for cracks, warping or corrosion damage and replace if any of these conditions are present.
- **Bearing Housing** – inspect for signs of wear, corrosion, cracks or pits. Replace housings if worn or out of tolerance.
- **Seal Chamber/Stuffing Box Cover** – check for pitting, cracks, erosion or corrosion. Inspect for any wear, scoring or grooves that might be on the chamber face. Replace if worn more than 1/8-inch deep.
- **Shaft** – check the shaft for any evidence of corrosion or wear and straightness. Noting that the maximum total indicator reading (TIR) at the sleeve journal and coupling journal should not exceed 0.002 inches.

Repairs

Fault	Possible causes	Suggested actions
Pump does not run	No power supply	Check incoming power supply and rectify
	Very low voltage	Operate in the recommended voltage range
	Impeller stuck	Remove the fan cover and rotate fan by hand
	Loose connections	Check the connections
	Fuse blown	Replace fuse
	Pump has been kept for long time	Ensure free rotation of shaft by running the pump idle for a few minutes at least every alternate day
Pump does not discharge water	Faulty foot valve	Check and replace
	Pump not primed	Prime the pump
	Air leakage on the suction side	Check and correct for leakages
	Suction lift too high	Reduce the suction lift
	Foot valve not sufficiently submerged	Lower the foot valve and ensure that the foot valve is submerged at least 1 metre below the free surface of water
	Check valve is jammed	Check and replace
	Motor coil burnt	Rewind the motor
	Low voltage operation	Operate in the recommended voltage range
	The motor starter overload has tripped	Reset the motor starter overload. If it trips again, check the voltage

Fault	Possible causes	Suggested actions
Less discharge from pump	Low voltage operation	Operate in the recommended voltage range
	Wrong direction of rotation	Interchange the supply connections of any two phases
	Static suction lift high	Position the pump within recommended suction lift
	Total head higher than specified head	Ensure delivery head within specified value
	Leakage in pipes	Check the piping system and rectify the faults
	Smaller pipe size used when compared to name plate recommendations	Use recommended size of pipes
	Discharge pipe internally coated with deposits	Clean the pipe
	Foreign bodies lodged in impellers	Check the impellers and remove the foreign bodies
	The valve in the discharge pipe is partly closed / blocked	Check and clean / replace the valves, if necessary
	The Check valve of the pump is partly blocked	Check and clean Check valve. Replace if necessary
	Impeller is worn out	Check and replace
	Leakage in the pipework	Check and repair / replace piping

Current consumption in excess	Single phasing	Check line fuses / availability of three phase supply
	Voltage too low	Check the voltage
	Defective rotor	Change the rotor
	Rotor rubbing against stator ID due to bend	Check and replace the rotor
	Low system head and therefore higher discharge	Throttle the discharge

Fault	Possible causes	Suggested actions
Pump runs rough and noisy	Bearings worn out	Dismantle and replace worn out bearings
	Pump cavitating due to high suction lift	Reduce static suction lift
	Pump not grouted	Grout the pump
	Rotor shaft is bent resulting in rotor rubbing against stator bore	Replace rotor shaft
	Excessive wear and tear	Check impeller. If excessive, replace impeller
Pump leaks excessively	Gland not adequately tightened	Tighten the gland
	Packing rope and oil seal worn out	Replace packing rope and oil seal
	Volute - yoke gasket / delivery flange gasket damaged	Check and replace gaskets
	Pipe line damaged	Check and replace piping

Advantages

- These pumps are mainly designed to provide the best possible efficiency.
- These pumps are compact and simple.
- These pumps are self-supporting.
- They don’t require extra base plates as well as a coupling for fitting.
- The overall size is less and less complexity while installing.
- They are cost effective.

Mono Block Pump Applications

- The uses of monoblock pumps include the following.
- These pumps are used for domestic purposes like gardens, apartments, bungalows, small farms, hospitals, hotels, agriculture, and farm-houses.
- The centrifugal mono block pumps are mainly recommended for freshwater as well as fluids which are not chemically violent toward the components of the pump.
- These pumps are mainly used for agriculture, industrial, civil due to their consistency and strength.
- Thus, this is all about Monoblock pump, types, and applications. There are many factors we have to keep in mind while selecting these pumps like head, size of inlet & outlet, discharge rate, and construction material. From the above information, finally, we can conclude that it is the main mover of the pump like the motor & pump are connected jointly in similar housing. So, there is no requiring of any coupling device among the two shafts because the shafts are attached straight.

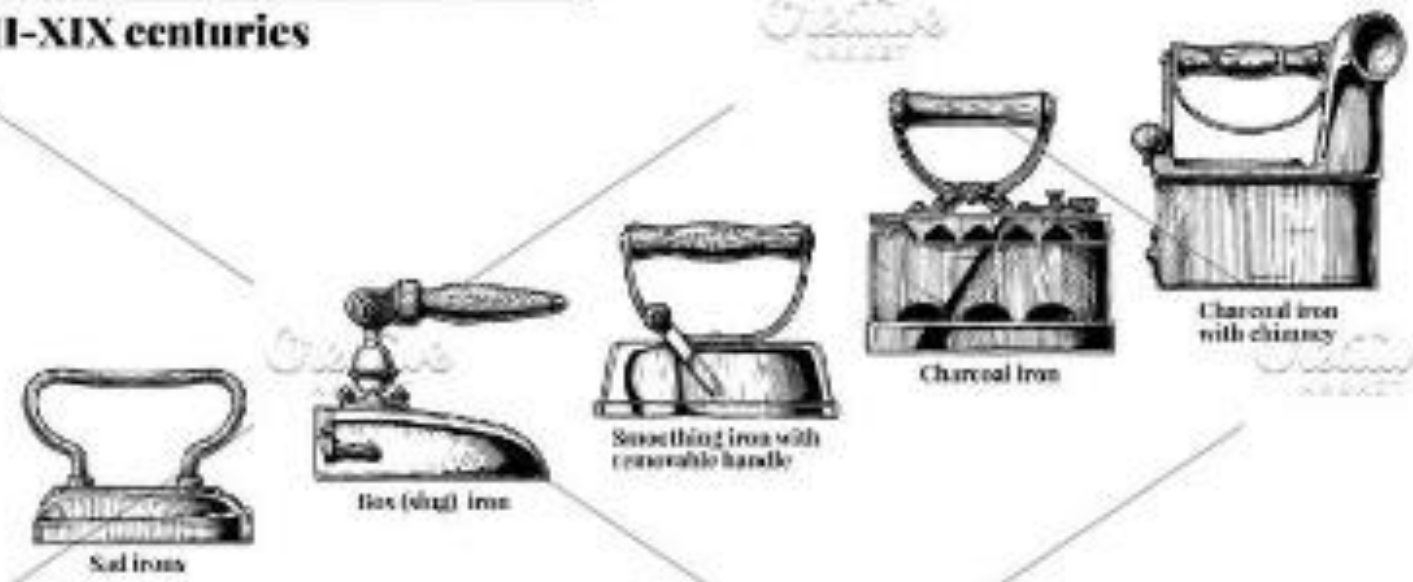
INTRODUCTION

- The electric iron has been a FMCG (fast moving consumer goods) product since the 1880s, but as is the case with many modern inventions, it has its roots in history.
- As early as 400 B.C. just like any technology or device the iron box (the modern-day word used to describe a device that is to use to accomplish one task, it was called by different names and with different designs/variants throughout ages and cultures) has faced many many iterations and many design changes to what we see today.

- Let us consider the evolution and design changes throughout history
- Sad iron
  - Box (slug) iron
  - Smoothing iron with removable handle
  - Charcoal iron
  - Charcoal iron with chimney
  - Gas smoothing
  - Petrol iron
  - 1930s electrical flatiron
  - 1960s clothes iron
  - 1990s Electric steam iron
  - Modern wireless iron

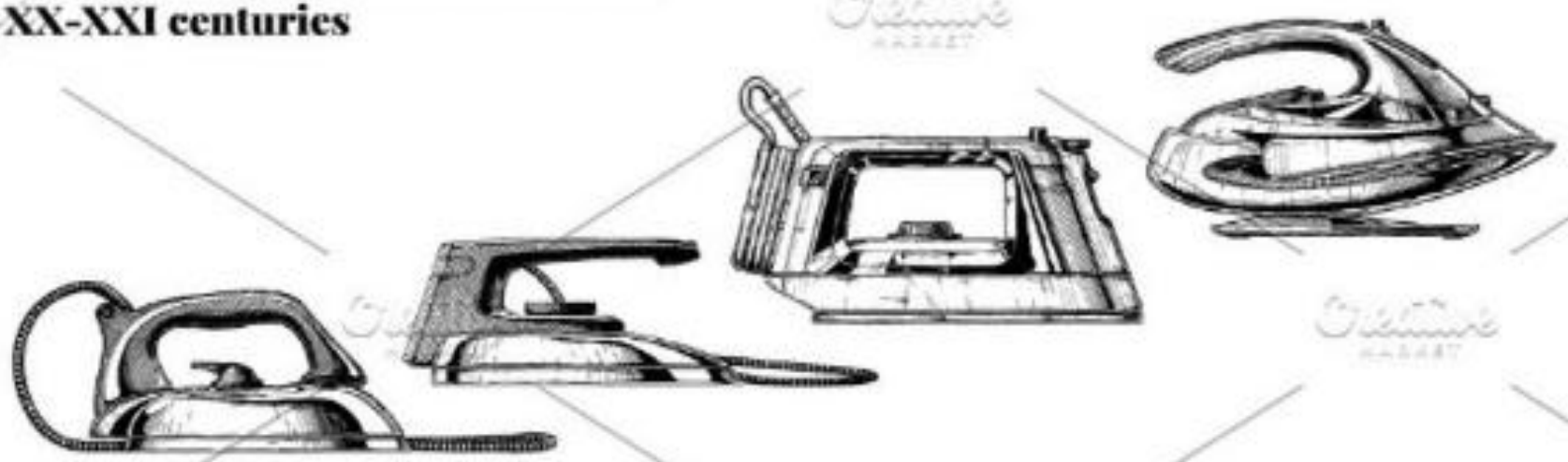
EVOLUTION OF CLOTHES IRON

XVII-XIX centuries



EVOLUTION OF CLOTHES IRON

XX-XXI centuries



Parts of an Electric Iron

- **Sole Plate**
- The sole plate is the thick, triangular-shaped slab of iron that forms the base over which the electric iron is built up.
- The bottom surface and edges are heavily chromium plated, to prevent it from rusting.
- The base plate should hold the iron pressure plate and cover plate in position.
- For this purpose we can see two or sometimes three studs in the base plate. These studs aid in holding the position of cover plate and pressure plate.
- **Pressure Plate**
- This plate is generally called the top plate as it follows the shape of sole plate.
- The pressure plate has some holes through which the studs form the base plate passes through.
- We should tighten the nuts on the studs in such a way that the pressure plate and sole plate are pressed tight against each other.
- In some iron the pressure plate is heavy and made of cast iron while in some other cases, it is a thin sheet of steel, about ¼ cm thick.
- In automatic type of electric iron, the pressure plate has a rectangular or circular hole for locating the thermostat.

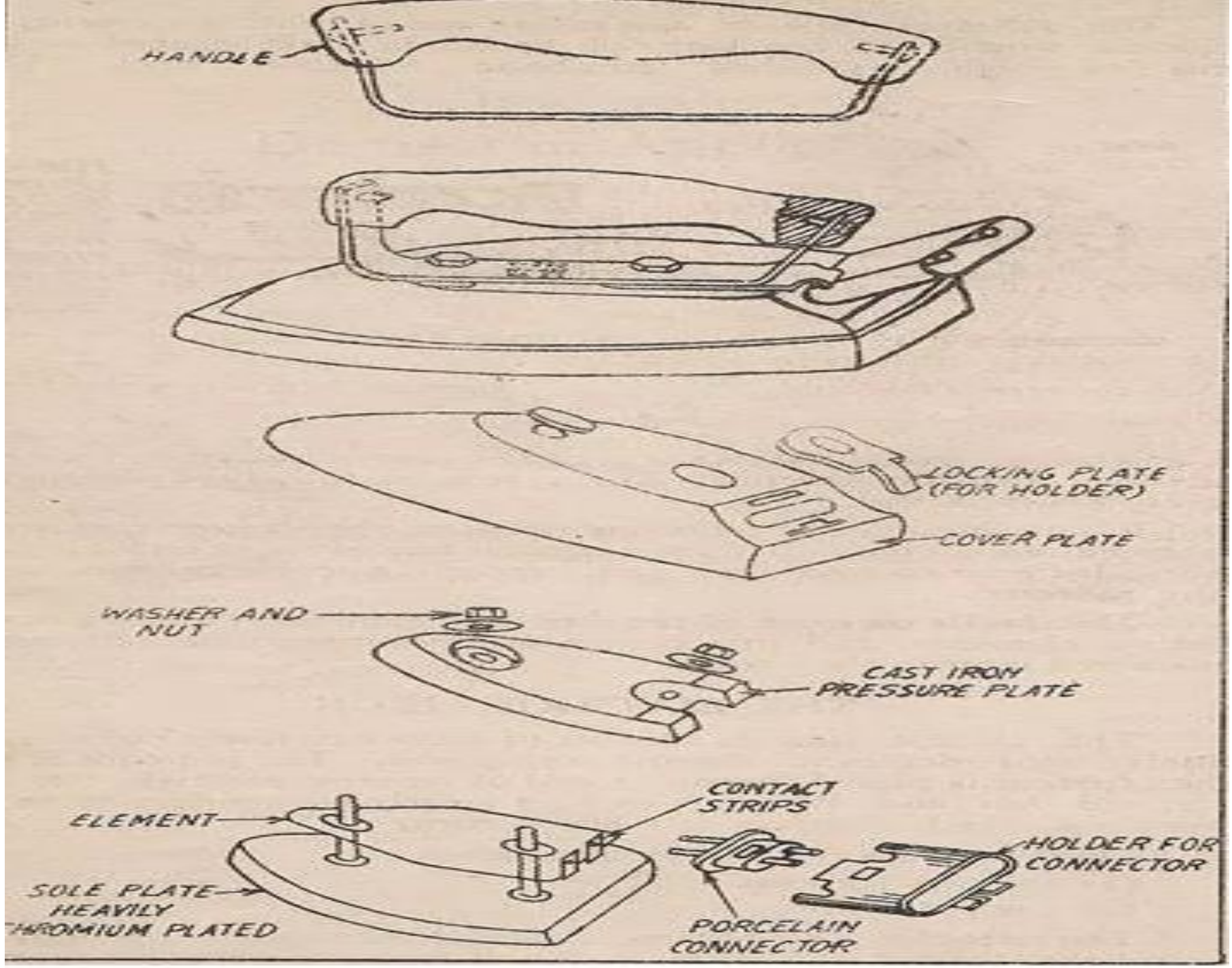
Plastic handle

Sole plate

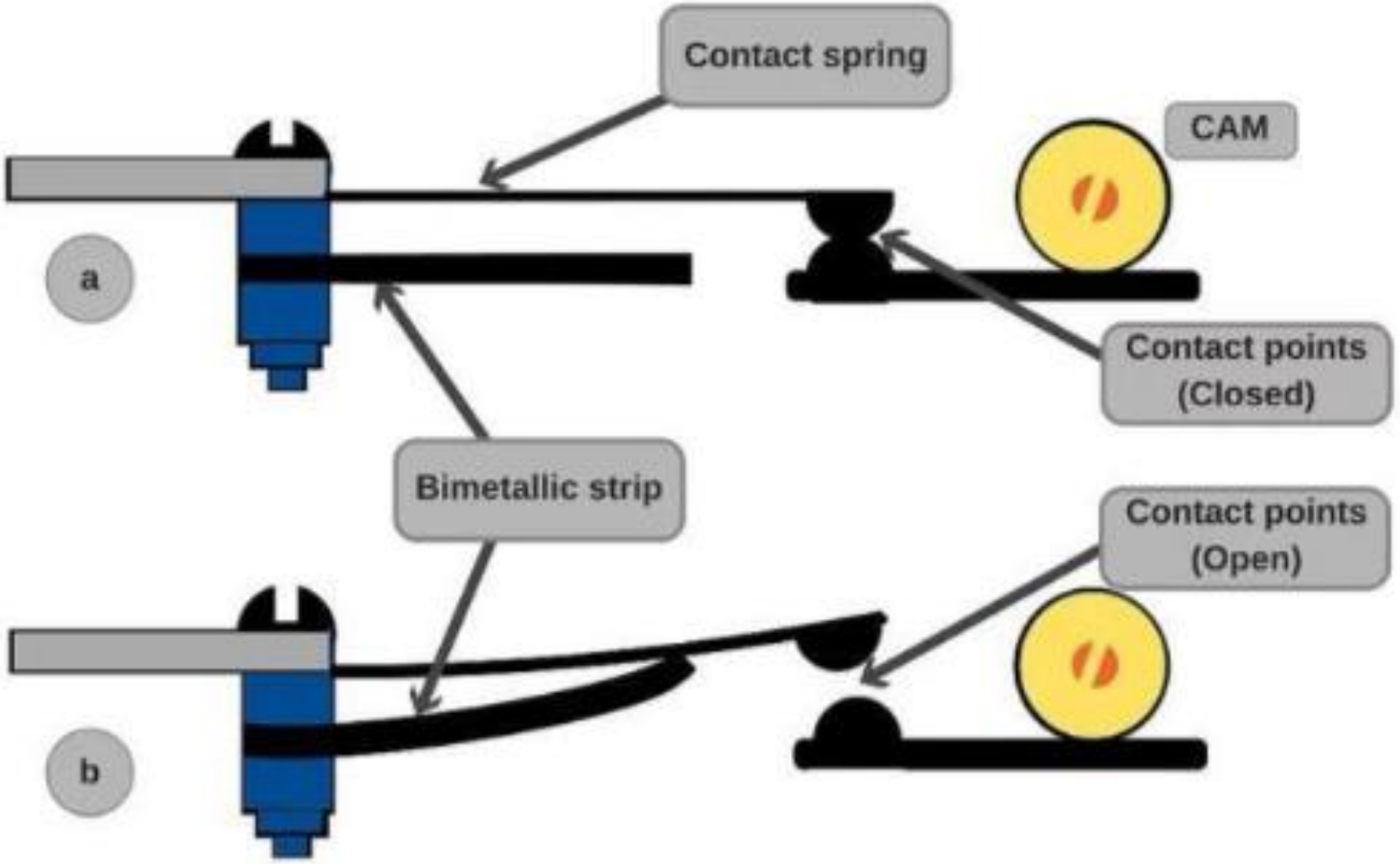
Iron cover

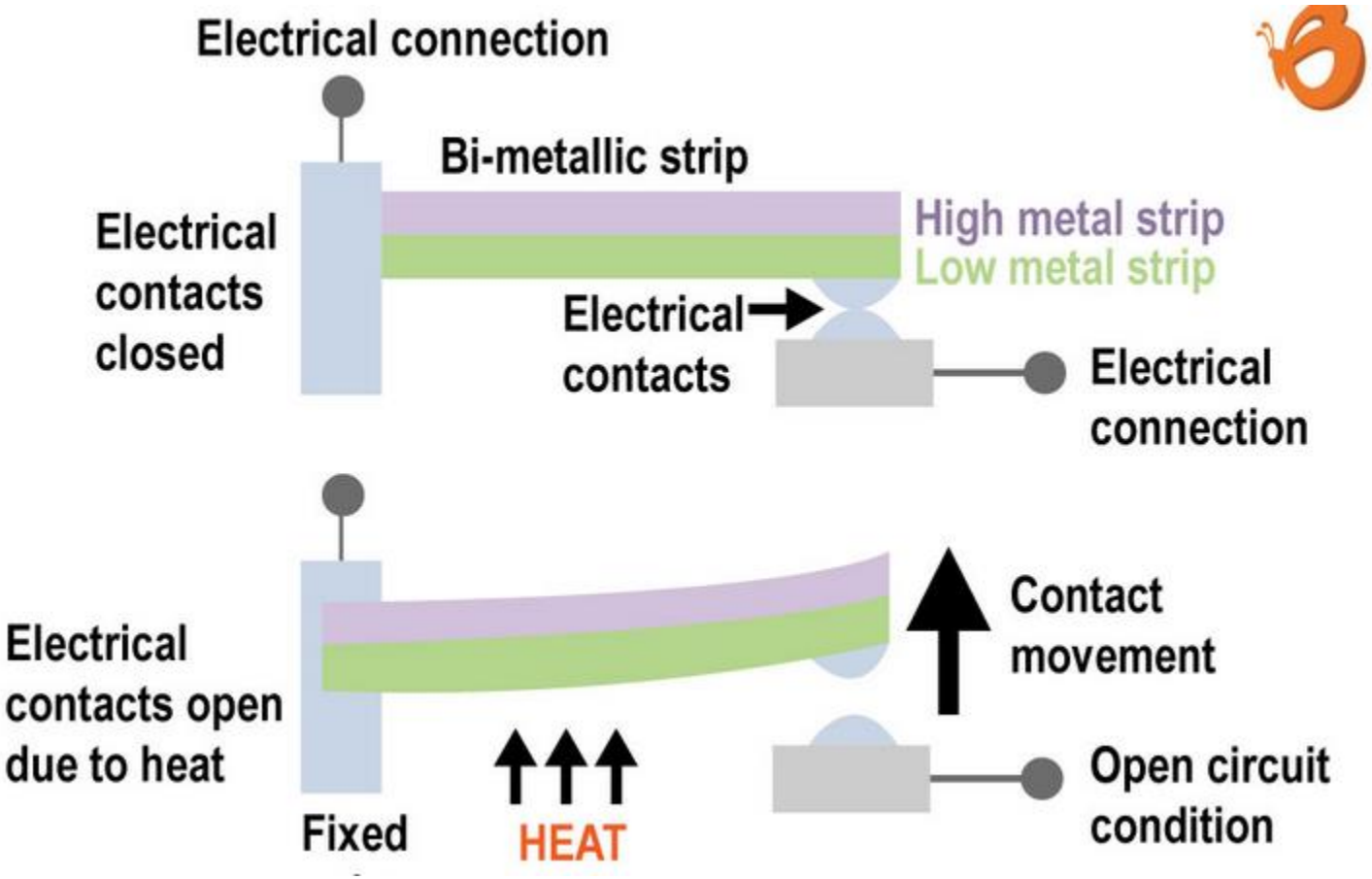
Heating element

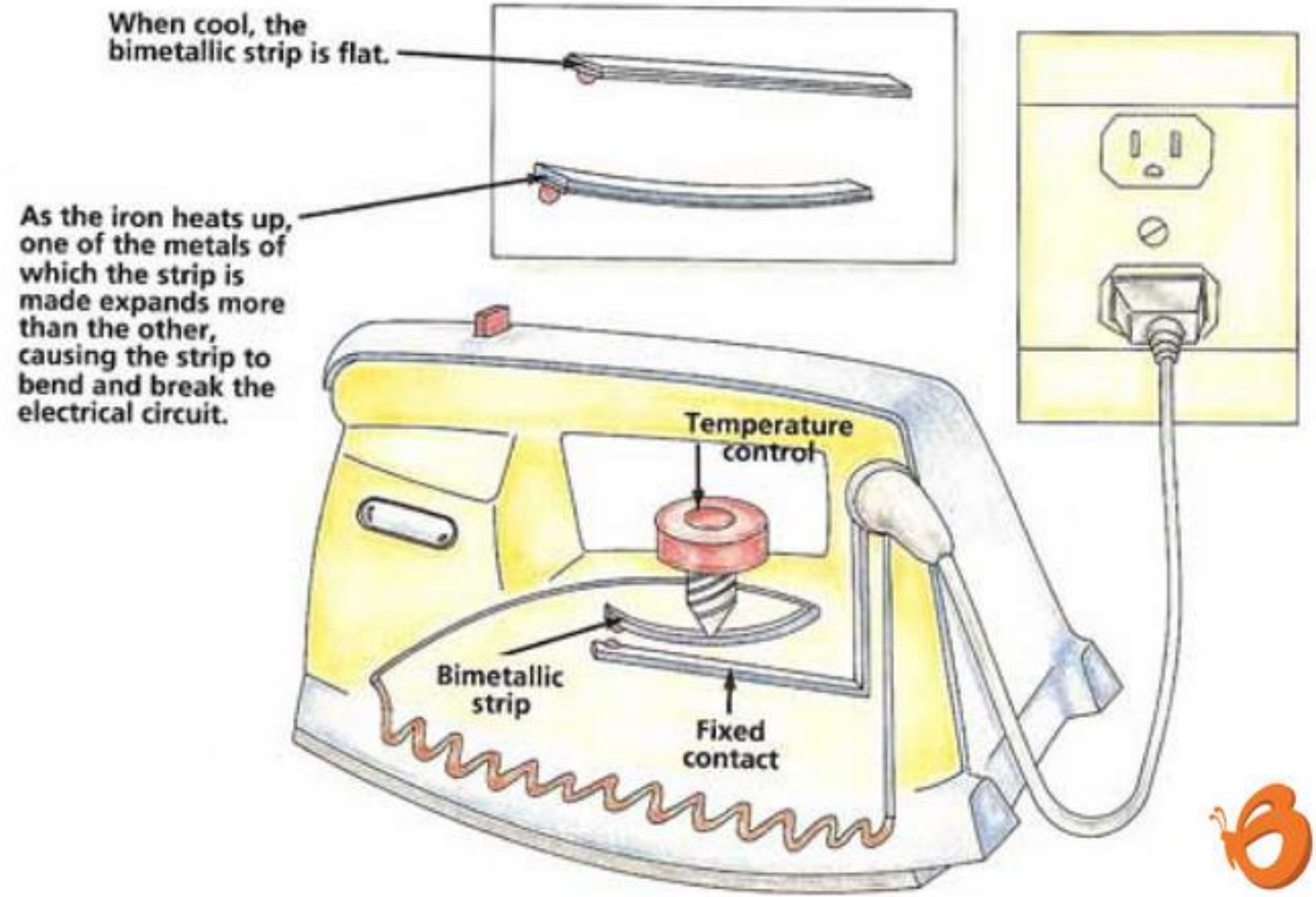
Thermastat

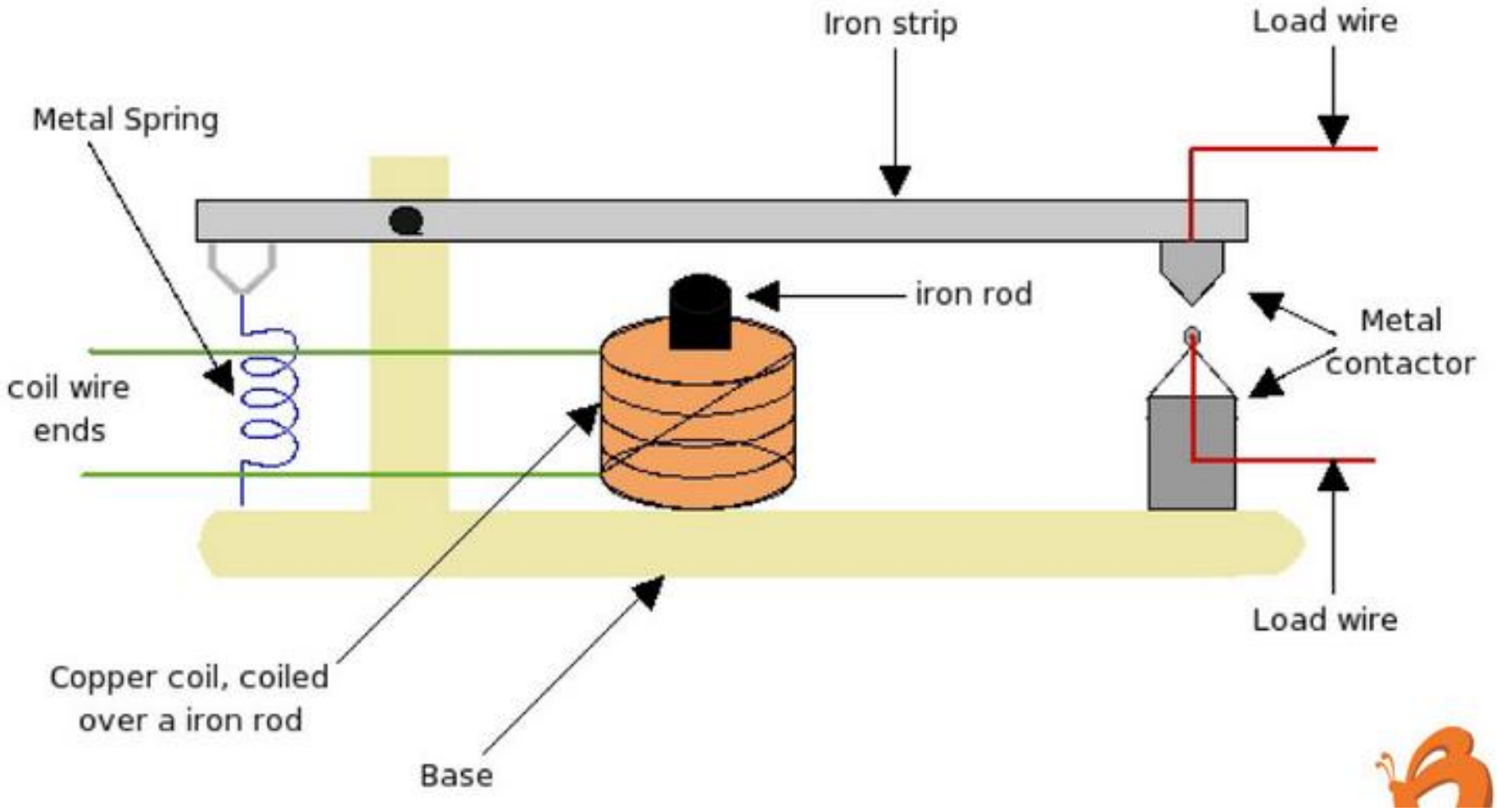

HANDLE
LOCKING PLATE (FOR HOLDER)
COVER PLATE
WASHER AND NUT
CAST IRON PRESSURE PLATE
ELEMENT
CONTACT STRIPS
HOLDER FOR CONNECTOR
SOLE PLATE HEAVILY
HROMIUM PLATED
PORCELAIN CONNECTOR

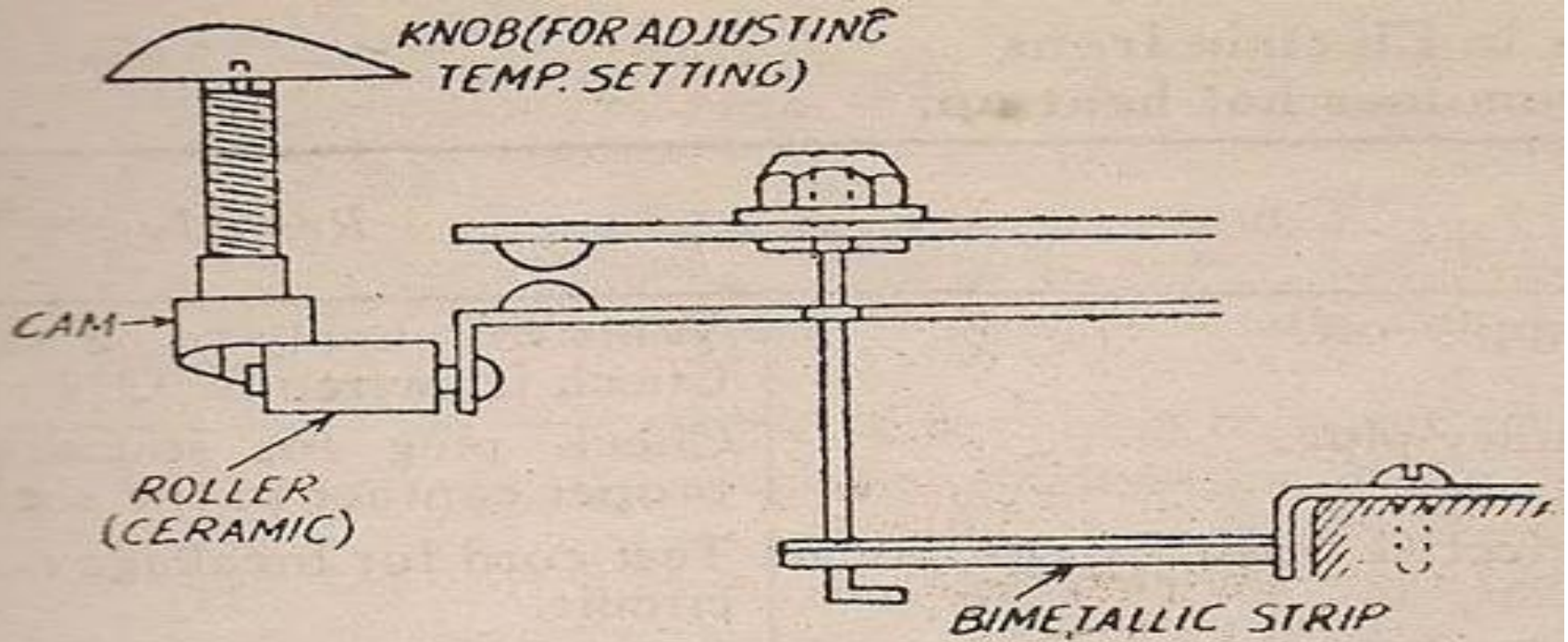
Thermostat

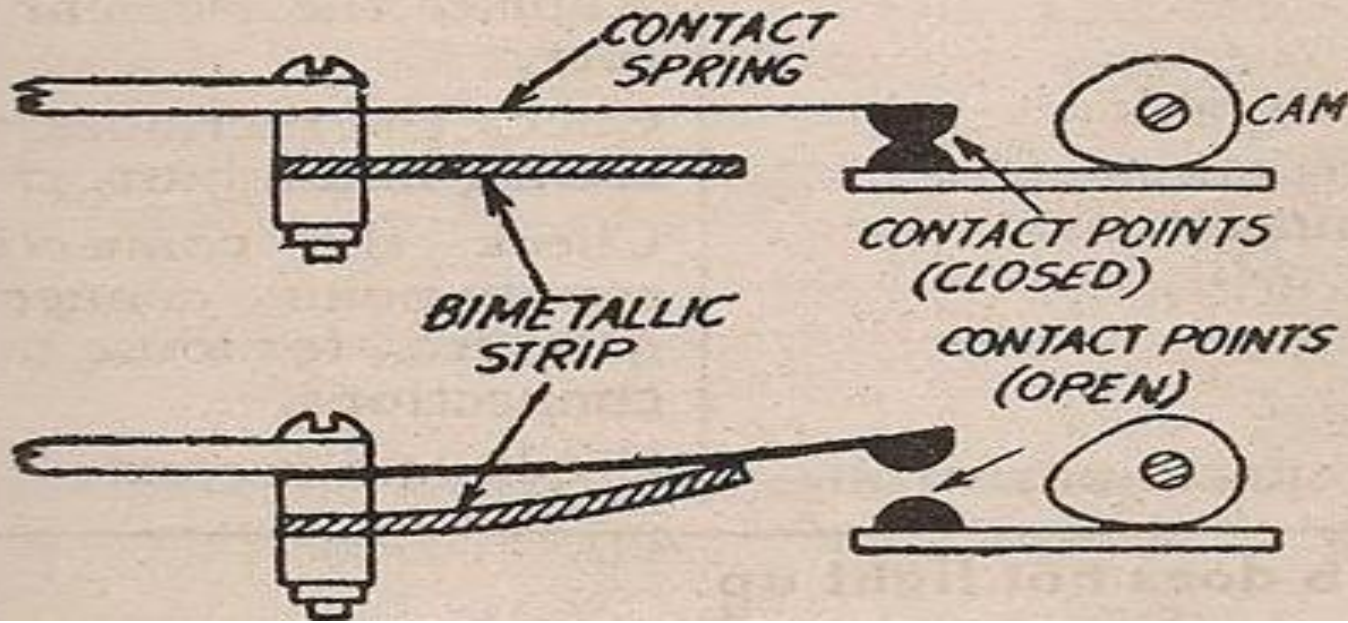

Contact spring
CAM
a
Contact points
(Closed)
Bimetallic strip
Contact points
(Open)
b


Electrical connection
Bi-metallic strip
Electrical contacts closed
High metal strip
Low metal strip
Electrical contacts
Electrical connection
Electrical contacts open due to heat
Contact movement
Fixed
HEAT
Open circuit condition


When cool, the bimetallic strip is flat.
As the iron heats up, one of the metals of which the strip is made expands more than the other, causing the strip to bend and break the electrical circuit.
Temperature control
Bimetallic strip
Fixed contact


Iron strip
Load wire
Metal Spring
iron rod
Metal
contactor
coil wire
ends
Load wire
Copper coil, coiled
over a iron rod
Base


KNOB(FOR ADJUSTING TEMP. SETTING)
CAM
ROLLER (CERAMIC)
BIMETALLIC STRIP


CONTACT SPRING
CAM
CONTACT POINTS (CLOSED)
BIMETALLIC STRIP
CONTACT POINTS (OPEN)

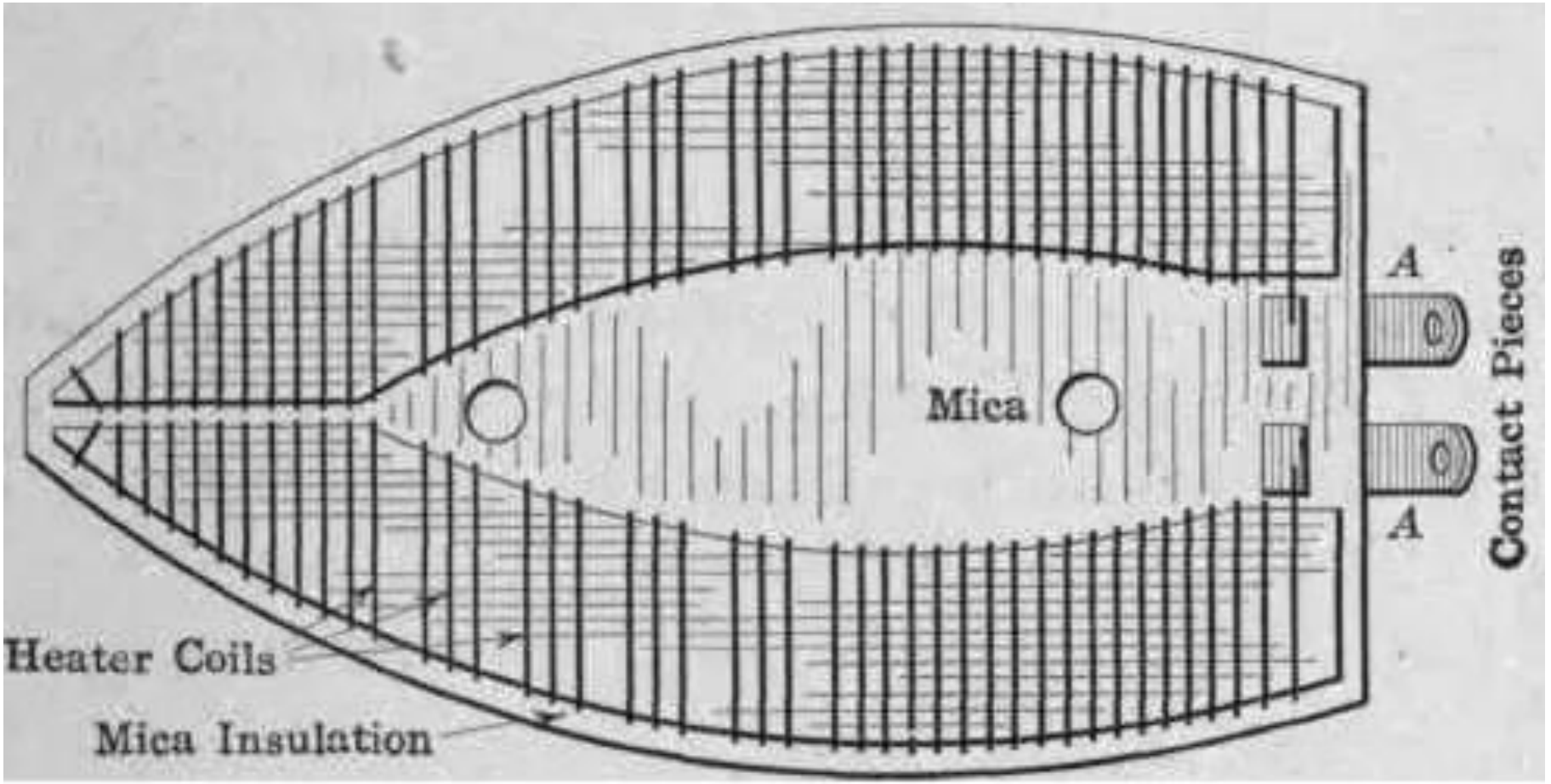
- A thermostat is an important component of an electric iron that regulates its temperature.
- The main function of the thermostat in an electric iron is to make sure that the iron doesn't get too hot if it is left unattended to for a period of time.
- **When an electric current is passed through a coil in an electric iron, the coil becomes very hot.**
- **Through conduction, the heat is transferred to the flat base plate of the electric iron which is used to iron our clothes.**
- However, the heating element continues to get hotter so far there is a continuous drawing of electricity from the power supply.
- This result into a lot of energy wastage and may damage the cloths.
- At this point, thermostat comes in because it is important that the iron doesn't heat up to a temperature that is hazardous.

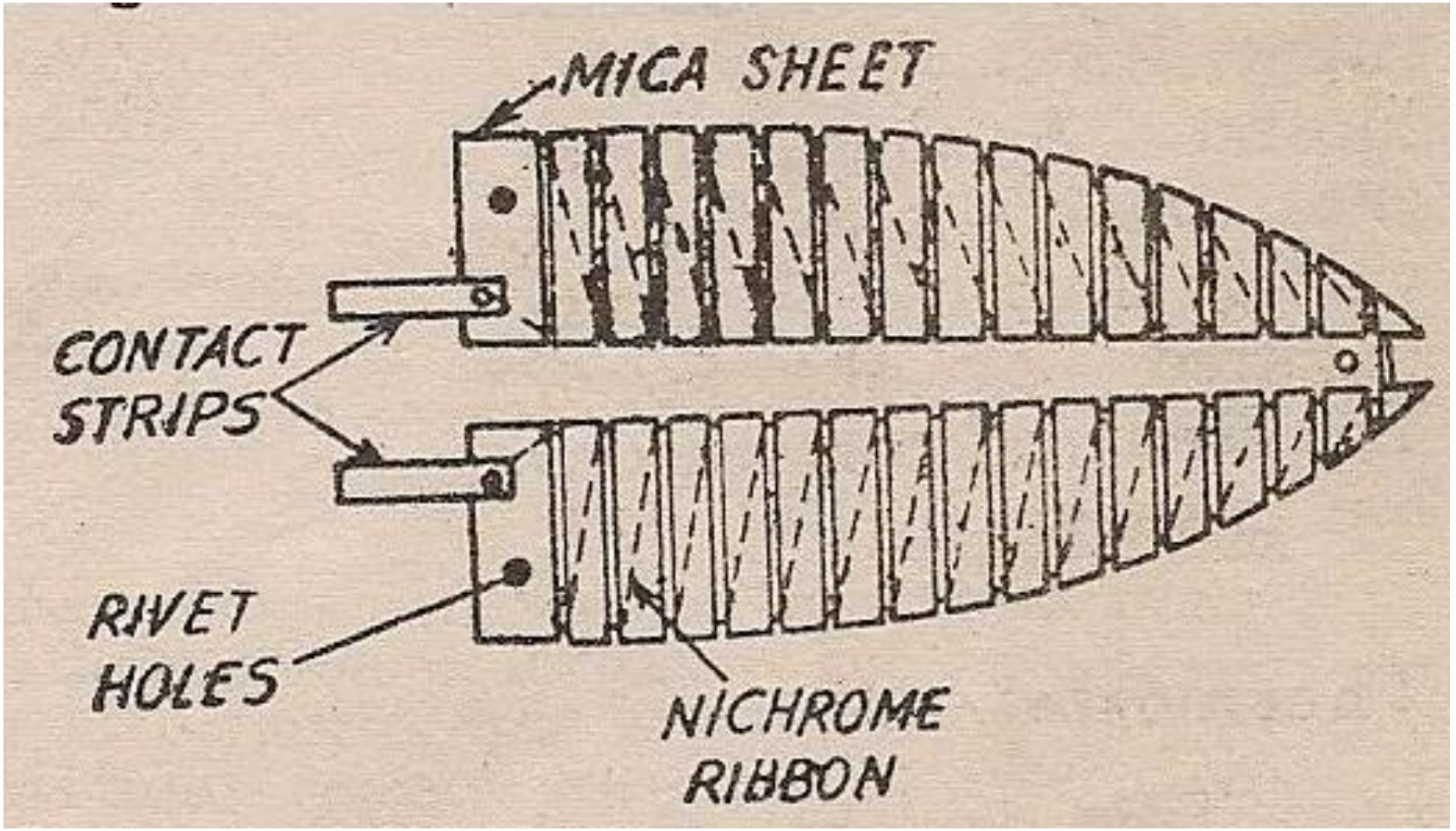
- The thermostat in iron makes use of a bimetallic strip. This bimetallic strip is made up of two different types of metals (brass and iron) with a different coefficient of expansion bonded together.
- Therefore, in the presence of heat, the bimetallic strip expands differently.
- The metallic strip is connected to a contact spring through small pins.
- The bimetallic strip remains in physical contact with a contact point at a moderate temperature.
- However, at a temperature of the iron above a certain limit, the strip tends to bend towards the metal with a lower coefficient of expansion. At this point, the strip stops to be physically connected to the contact point and current stops flowing because of an opening of the circuit.
- Position (a) is when the iron is at normal temperature
- Position (b) is when the iron becomes too hot

- Thermostat utilizes a bimetallic strip to govern the switching that is connected in series with the resistance or heating detail.
- The bimetallic strip is a component which converts a temperature variation into mechanical movement.
- A bimetallic strip includes two extraordinary metals fortified together. The 2 metals possess a different coefficient of expansion.
- If any such strip is heated, it starts to curl in the direction of the metal having the lower coefficient of expansion.
- Upon cooling, it straightens out and comes again to the normal function.
  The principal reason of the bimetallic strip is:
  The bimetallic strip is attached to a contact spring through, minute pins. The contact point between the strip and contact factors stays closed. during a surplus temperature variation, the unfamiliar enlargement causes the strip to twist and the touch among strip and make contact with spring opens.
- Consequently, the delivery to the heating element is momentarily paused (till the temperature goes all the way down to a pre-set value primarily based on the cloth selected).
- A tool stated to as the cam is located close to the contact spring, with which we specify the quantity of curving of bimetallic strip required to separate the touching.
- As a consequence, the use of the bimetallic strip, the temperature is stored steady within sure limits.
- The connecting elements, (that determines the degree of bending and straighten) between the knob and the thermistor is also removed.

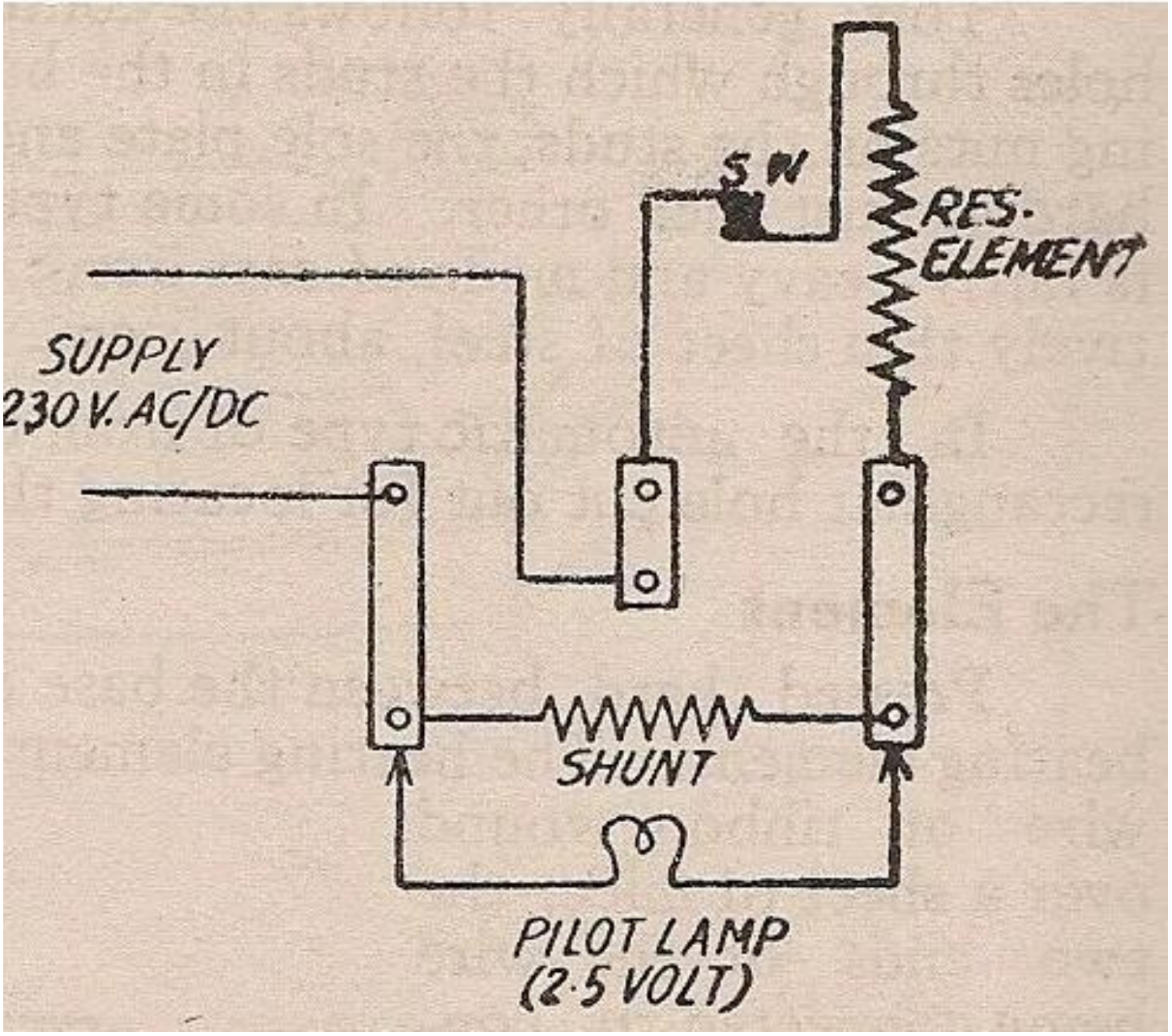
The Heating Element

- The heating element is present between the sole plate and pressure plate. It is pressed hard between the two plates. The heating element consists of nichrome wire wound around a sheet of mica. The two ends of the nichrome wire are connected to the contact strips. The contact strips are connected to the terminals of the iron. There are two reasons for which mica is chosen in the heating material. Mica is a very good insulating material. Besides that mica can also withstand very high temperatures. The entire assembly of mica sheet, nichrome wire and contact strips are riveted together resulting in a mechanically sound and robust construction. There is an asbestos sheet, which separates and thermally insulates the top plate from the heating element.


A
A
Contact Pieces
Mica
Heater Coils
Mica Insulation


MICA SHEET
CONTACT STRIPS
RIVET HOLES
NICHROME RIBBON

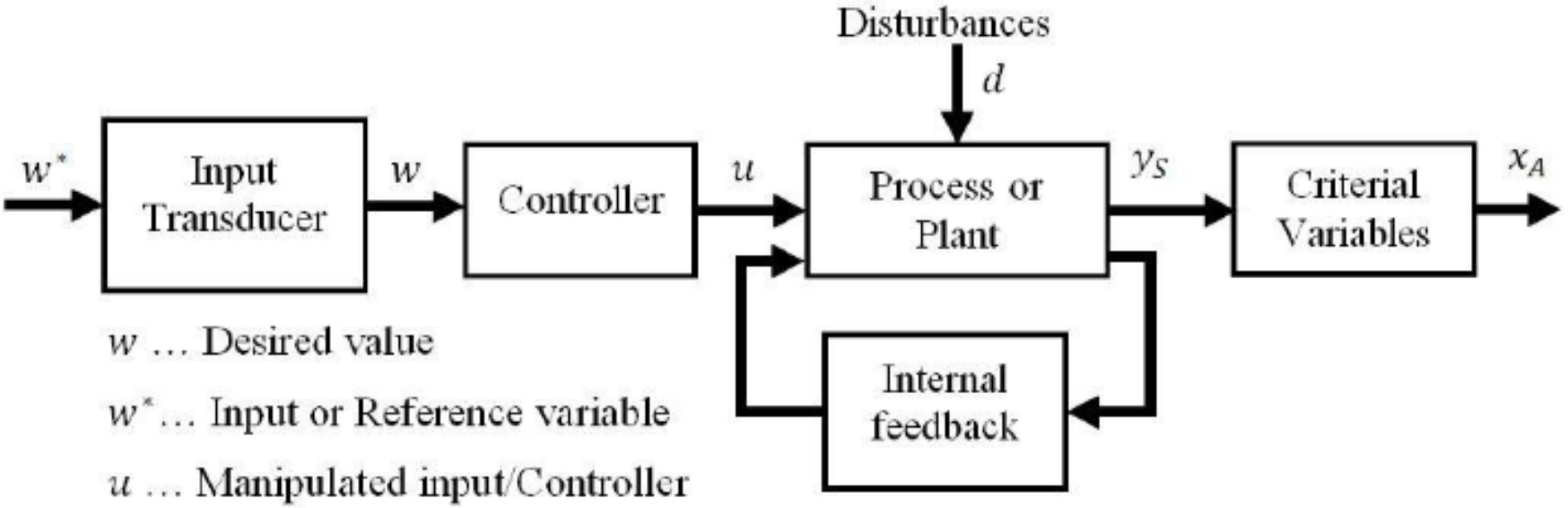
- **The Cover Plate**
- The cover plate is made of thin sheet of iron. It is placed on top of the base plate and it covers all the internal parts of the iron. The handle and connector are only attached to the cover plate.
- **Handle**
- The handle can be made either with wood or with plastic. The handle is attached to the cover plate with the aid of screws. Studs can also be used for this purpose.
- **Pilot Lamp**
- The pilot lamp is housed in the cover plate of the electric iron. One end of the pilot lamp is connected to supply, while the other end is connected to the heating element. A shunt resistance is provided across the pilot lamp which assists in providing a voltage drop. The shunt is designed to provide a voltage drop of 2-5 volts.


S W
RES.
ELEMENT
SUPPLY
230 V. AC/DC
SHUNT
PILOT LAMP
(2·5 VOLT)

selected temperatures for ironing different fabrics in˚ C

Type	Fabric	Temperature
Category 1	Linen	215^0
Category 2	Triacetate	200^0
	Cotton	204^0
Category 3	Viscose/rayon	190^0
Category 4	Wool	148^0
	Polyester	148^0
	Silk	148^0
Category 5	Acetate	135^0
	Acrylic	135^0
	Lycra/Spandex	135^0
	Nylon	135^0

Open-loop Systems



w … Desired value

w^* … Input or Reference variable

u … Manipulated input/Controller

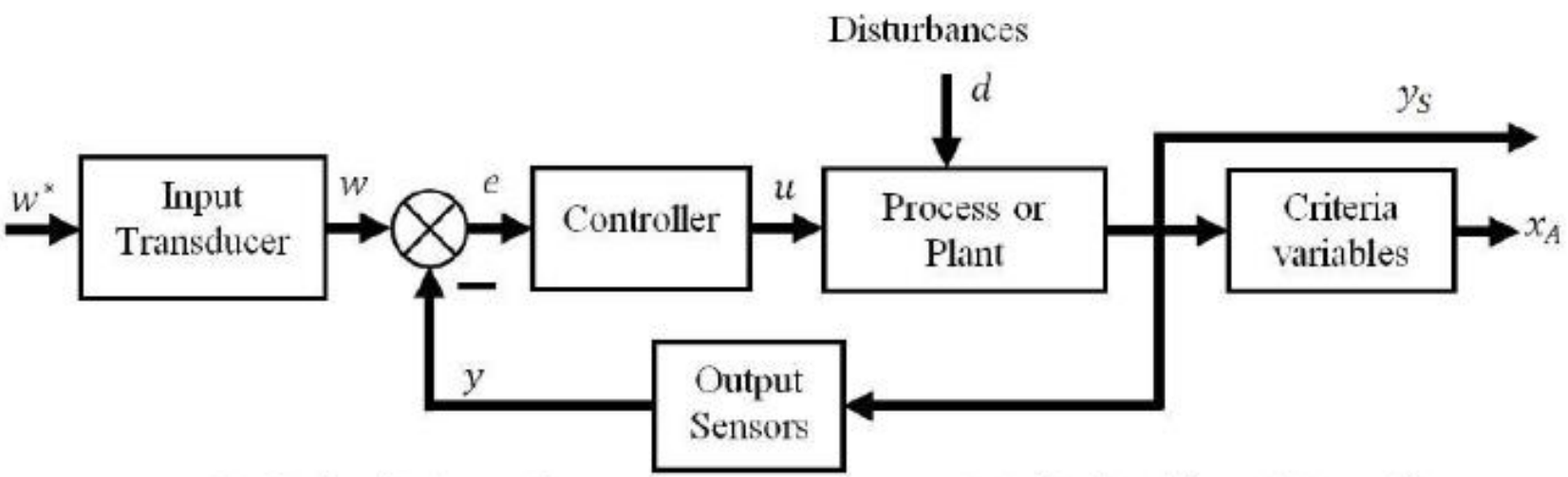
y … Output or Controlled variable

d … Disturbance

y_S … Not measured output

x_A … Criteria variables

closed-loop (Feedback Control) Systems



w … Desired value/set point

w^* … Reference variable

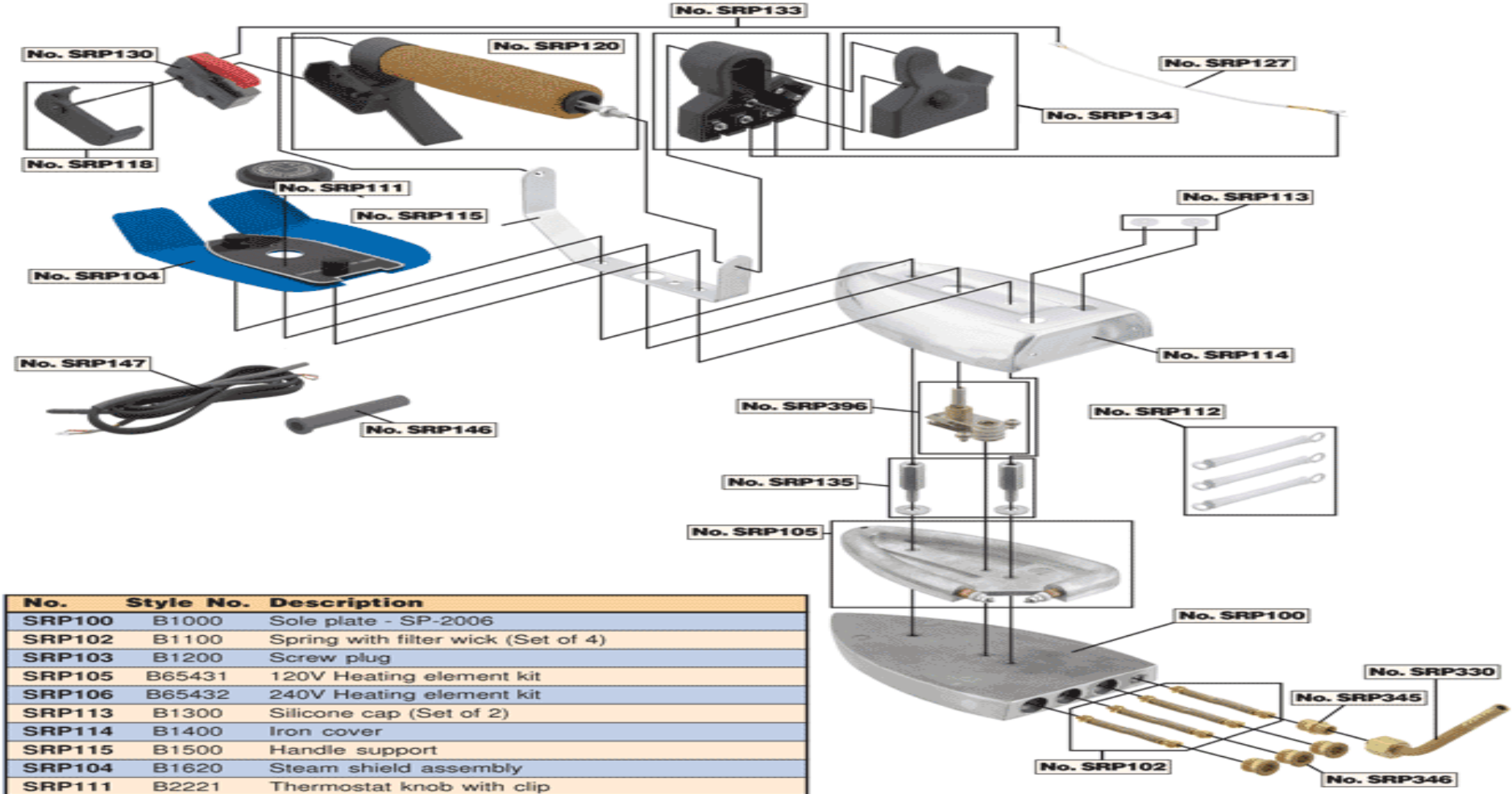
y … Controlled variable

u … Manipulated input/ Controller output

y_S … Not measured output

x_A … Criteria variables

Parts for Sapporo SP2005, SP2006 & SP2007 Steam Electric Irons



No.	Style No.	Description
SRP100	B1000	Sole plate - SP-2006
SRP102	B1100	Spring with filter wick (Set of 4)
SRP103	B1200	Screw plug
SRP105	B65431	120V Heating element kit
SRP106	B65432	240V Heating element kit
SRP113	B1300	Silicone cap (Set of 2)
SRP114	B1400	Iron cover
SRP115	B1500	Handle support
SRP104	B1620	Steam shield assembly
SRP111	B2221	Thermostat knob with clip
SRP112	B2325	Terminal wires (Set of 3)
SRP127	B2600	Thumb switch wires
SRP118	B2827	Thumb switch cover with screw
SRP130	B2900	Thumb switch
SRP120	B3034	Handle set
SRP133	B3541	Rear handle set
SRP134	B4244	Rear cover set
SRP135	B7008	Hex screw with washer (Set of 2)
SRP146	B4500	Rubber sleeve
SRP147	B4600	4-Wire cord
SRP396	485F	Thermostat with 2 screws *
SRP330	X-76	3-Piece steam tube kit *
SRP345	X-74	Renewable inlet plug *
SRP346	X-66	Renewable plug *

* For SP2007 Model irons

Parts for SP2007 Steam Electric Irons

How Can I Identify an Electric Iron Problem?

- As with many small appliances, regular maintenance makes a dramatic difference in how trouble free your electric iron will be. Even so, things can happen.
- If the iron doesn't heat, make sure power is on to the outlet, check the electrical cord, and check the thermostat (see the Appliance Controls Fix-It Guide) and replace if necessary.
- If the iron heats but steams improperly, inspect the soleplate and clean the vents (see below) and flush sediment out of the steam chamber (see below).
- If the iron produces too much or too little heat, test the electrical cord. Also test and, if needed, adjust calibration of the thermostat (see the Appliance Controls Fix-It Guide).
- If the iron does not spray properly, inspect and clean the nozzle (see below).
- If the iron leaks or spits, clean the steam vents, nozzle, and tank.
- If the iron sticks to fabric, clean or repair the soleplate. If the iron stains fabric, clean the soleplate, clean the tank with a commercial cleaner, and use distilled or filtered water.
- Caution!
- Iron carefully around buttons, zippers, and other attachments or decorations that can scratch the soleplate.

What Do I Need for Electric Iron Repair?

- Larger hardware stores may have replacement parts for popular brand electric irons. Also, you can get them from the manufacturer or an aftermarket supplier. Maintenance and repair tools you'll need to fix an electric iron include these:
- Screwdrivers
- Toothpicks or pipe cleaners
- Sewing needle
- Commercial electric iron cleaning solution or vinegar and water
- Commercial soleplate cleaner or baking soda and water
- Steel wool
- Emery cloth
- Metal cooking pot

What Are the Steps to Electric Iron Repair?

- **Clean an electric iron:**
- **Clean an electric iron:**
- Unplug the iron and make sure it is cool before cleaning.
- Use a toothpick or pipe cleaner to remove buildup in the steam vents, making sure the debris doesn’t fall into the vents.
- Use a fine sewing needle to carefully clean the spray nozzle of mineral deposits.
- To flush sediment from a steam iron, pour 1/2 cup water and 1/2 cup vinegar into the water tank. Place the iron on a rack over a broiling pan and set the iron to steam until the tank runs dry. Repeat if necessary. Or follow the instructions for using a commercial iron cleaner.

- **Service an electric iron steam and spray mechanism:**
- Unplug the iron.
- Use a fine sewing needle to unclog the steam valve assembly. Also, check the valve spring and replace it if it is broken or has lost tension.
- If the spray pump is accessible, remove it and check for leaks by placing the spray tube in water and squirting the pump. Clean or replace as needed.

- **Clean an electric iron metal soleplate:**
- Unplug the iron.
- Use a sponge and commercial soleplate cleaner or baking soda and water to remove dirt buildup on the soleplate. Rinse well with water and dry. Don’t use harsh abrasives or immerse an electric iron in water.
- Use very fine steel wool (0000) or an emery cloth to remove scratches and burns on the soleplate, then clean the soleplate.

Introduction to Electric Fans

- Electric Fans are everywhere. We use them in our homes, offices, industries, factories, cars, computers, trains, etc. to circulate air and cool down the room (or an area/surface). Depending on the type of power supply, there are three types of electric fans:
- **AC Fans:** These fans run on AC mains power supply. The majority of electric fans fall under this category (including the main product of this article, the Ceiling Fan).
- **DC Fans:** These fans run on DC supply, either a regulated DC Power Supply or a battery. We use DC Fans in computers and portable fans. They are rarely used as mainstream fans nowadays as AC power supply is available everywhere and AC fans are easy to make and use.
- **AC / DC Fans:** Finally, we have the AC / DC Fans, which can run on both AC as well as DC power supplies. Hence, these fans are sometimes are known as Universal Fans.
- Let us now see the different styles of electric fans that we commonly encounter in our daily lives.
- **Ceiling Fan:** It is the most popular fan that we use in our homes to circulate air and cool the room.
- **Table Fan:** You can put this fan on a table or a stool and also shift it easily from one room to other. It is a compact device where the rotor is fixed in the stator with an air gap and the base of the fan houses the capacitor and the regulator. Table Fans usually include an oscillating mechanism to oscillate the fan within certain fixed angles.

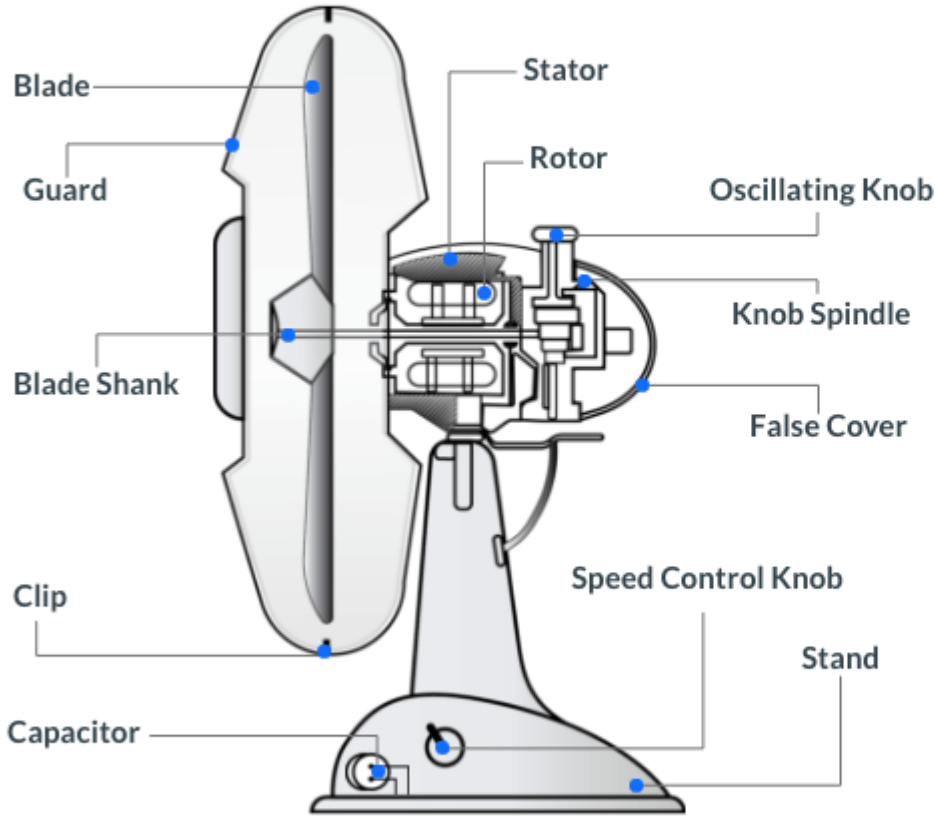
TABLE/CEILING FAN

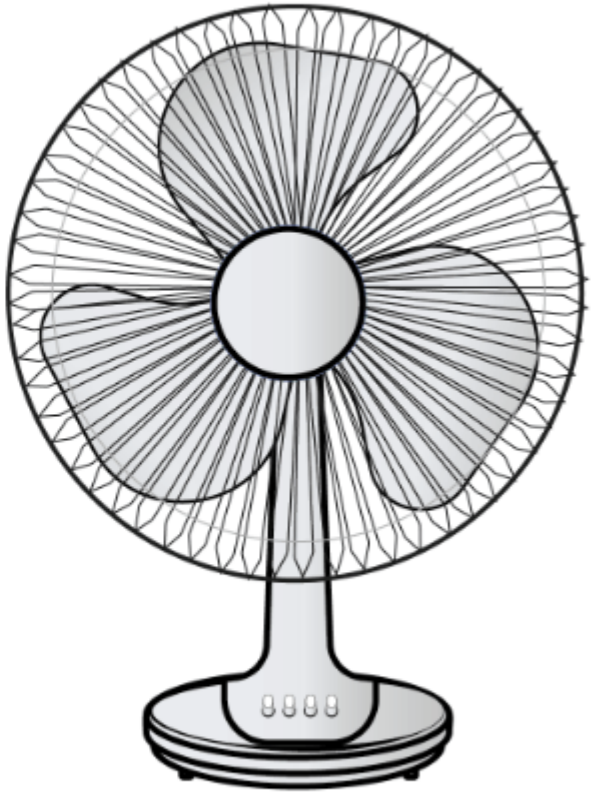
- The fans consists of the following parts
- 1. Rotating part
- 2. Stationary part

- The rotating part consists of
- Rotor (Body)
- Fan blades
- Bearings
- Squirrel cage winding (rotor)

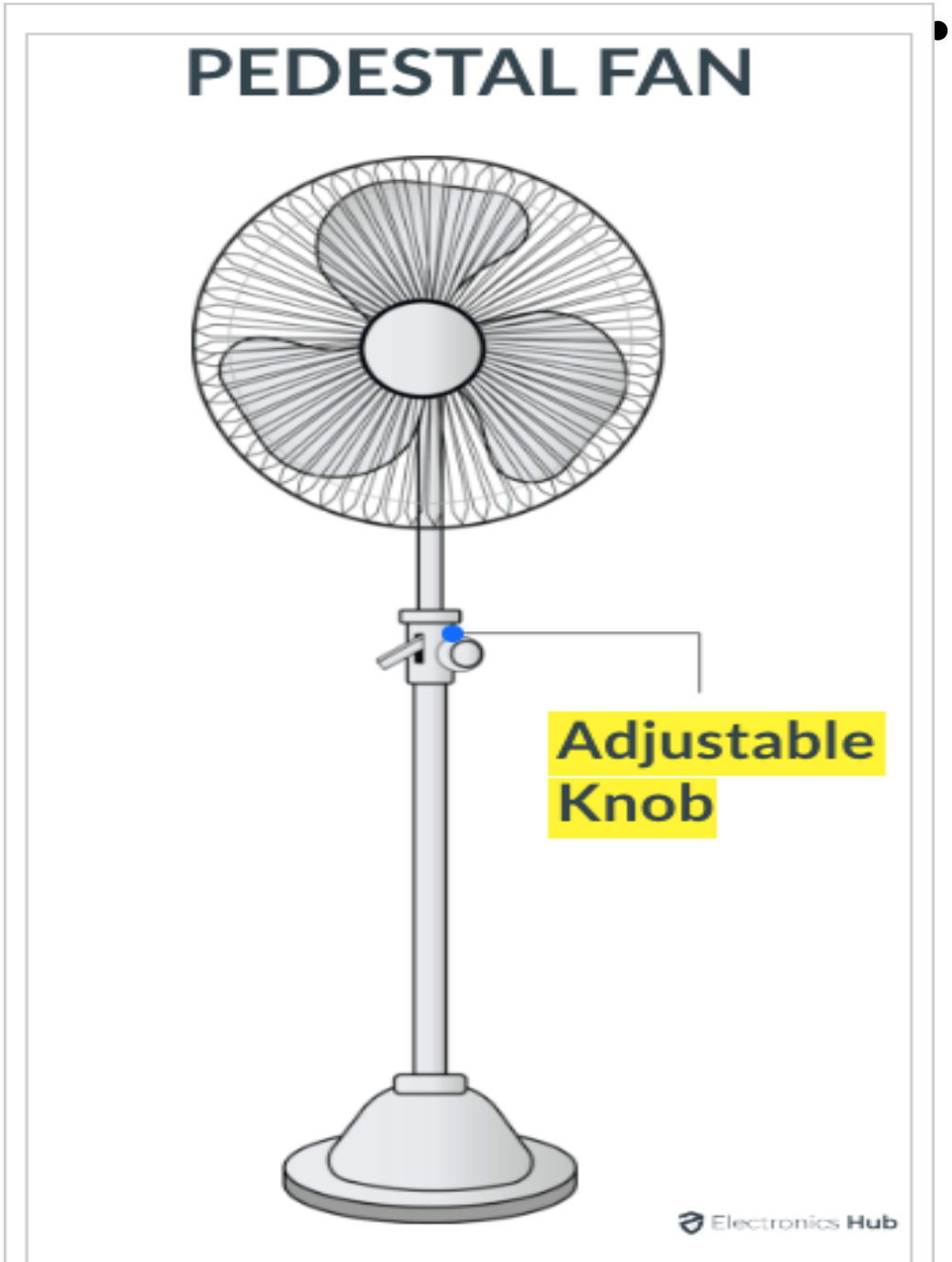
- The stationary parts consists of
- Canopy
- Shackle bolt, nut and split pin
- Suspension rod (Down rod)
- Terminal block
- Capacitor
- Stator winding
- Running winding

PARTS OF A TABLE FAN



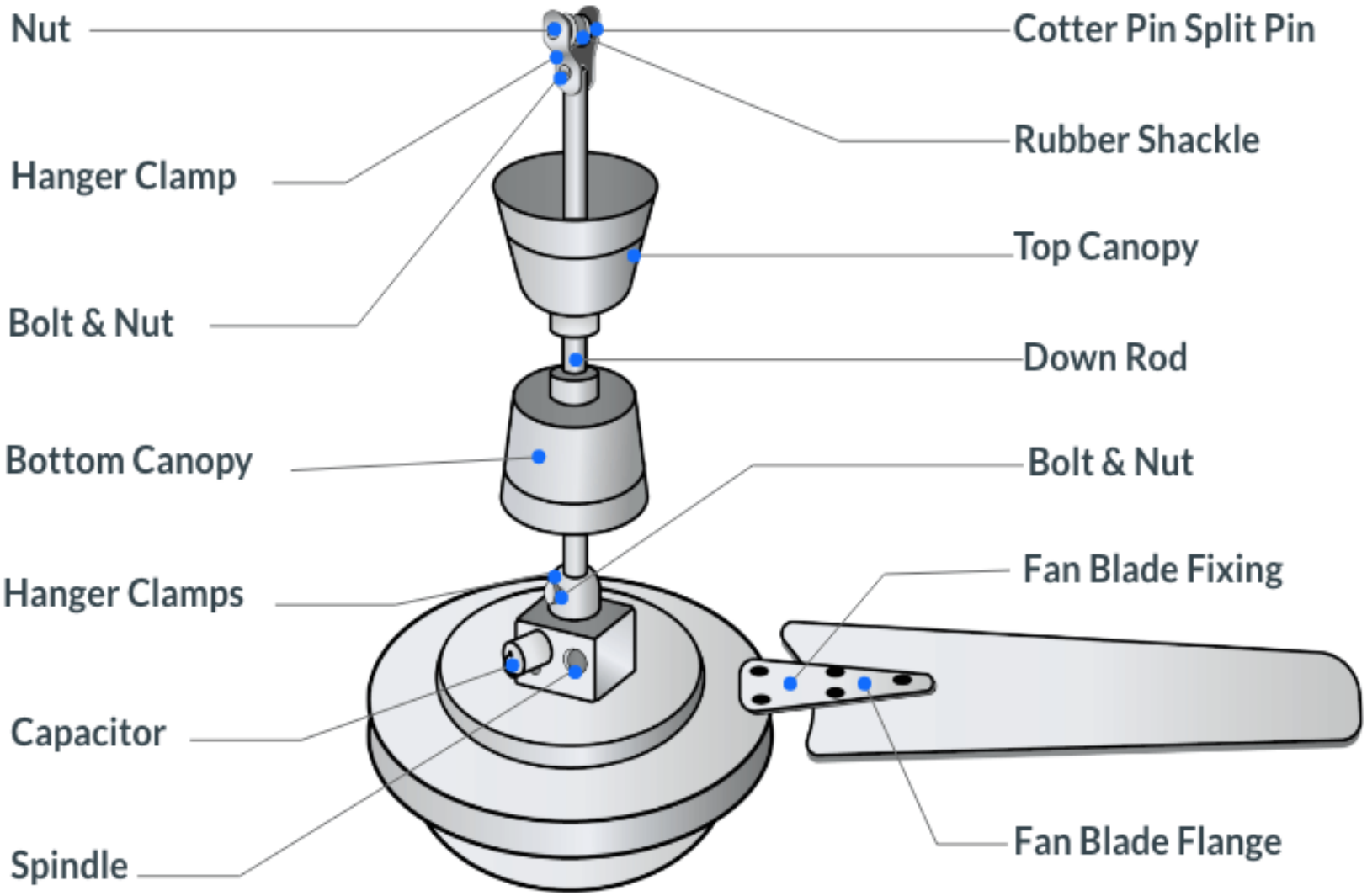


Electronics Hub



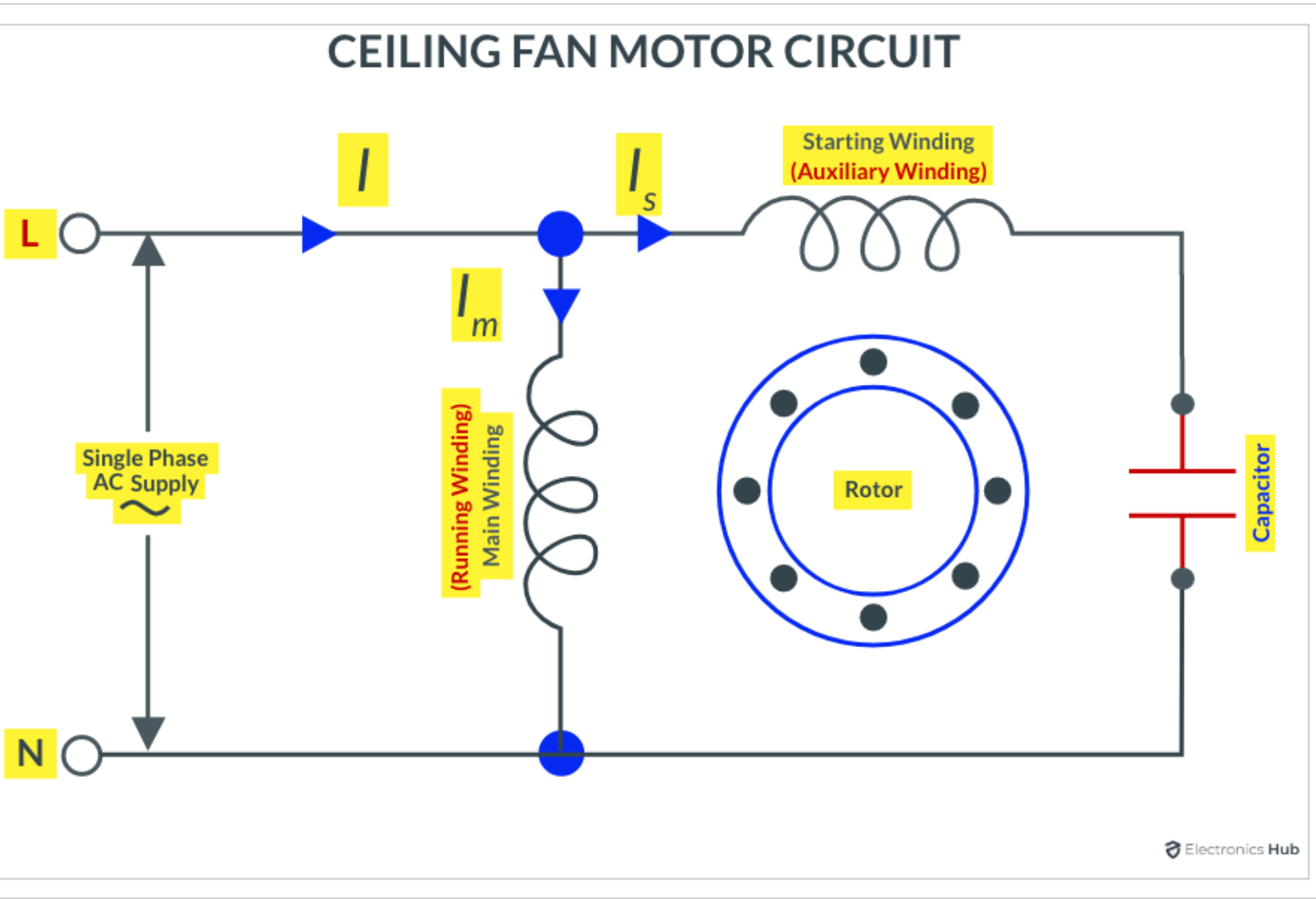
- **Pedestal Fan:** The working of the pedestal fan is very similar to that of a table fan except that the entire fan is mounted on a stand with adjustable height.

PARTS OF A CEILING FAN

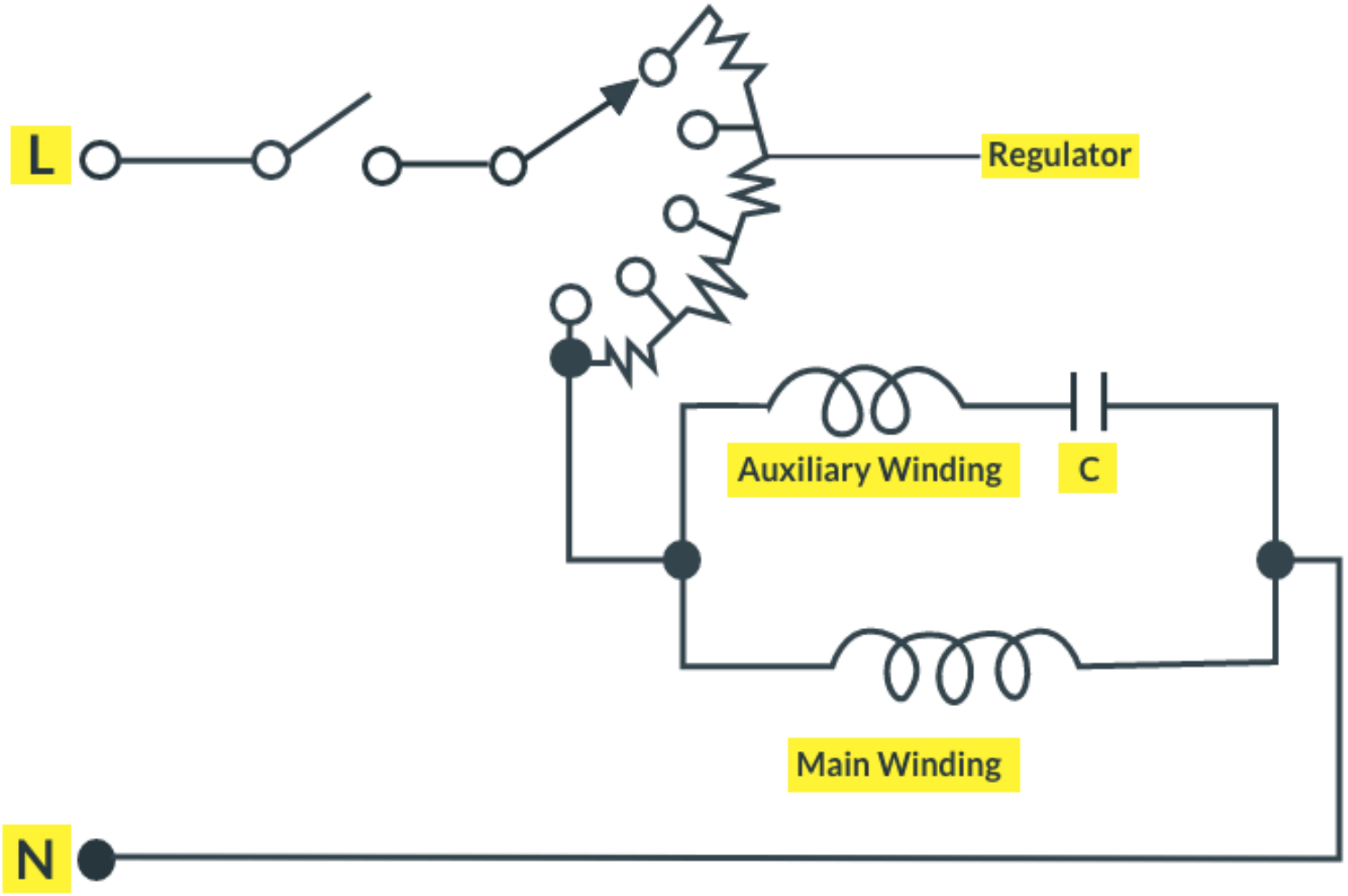


Electronics Hub

- But we are interested in the electrical aspect of the ceiling fan and here are the important electrical parts of a ceiling fan.
- We use ceiling fans in our living rooms, bedrooms, kitchens, etc. by hanging them from the ceiling. They are usually specified by the size of the blade span such as 36” (900mm), 48” (1200mm), and 52” (1300mm) being the popular options.
- **Stator:** The stator, which is the stationary part of the ceiling fan’s motor, consists of two windings: Main Winding and Auxiliary Winding. A shaft or a rod pipe holds the stator.
- **Rotor:** The Rotor is the rotating part of the ceiling fan and we attach the wings/blades to the rotor. In terms of motor, the rotor is similar to a squirrel cage rotor with bars of copper or aluminum (or windings).
- **Capacitor:** As a Ceiling Fan is essentially a Single-Phase Motor, it is not self-starting. To make the motor automatic (self-starting), we use a capacitor in series with the auxiliary winding.
- **Regulator:** We may not want to run the ceiling fan at one speed at all times. This is where a Regulator comes in handy. We can use a regulator to regulate or set the speed of the ceiling fan. Earlier regulators are simply variable resistors in series with the ceiling fan motor. At low fan speeds, the energy is wasted by the resistor as heat and hence, energy is not saved but it is wasted.

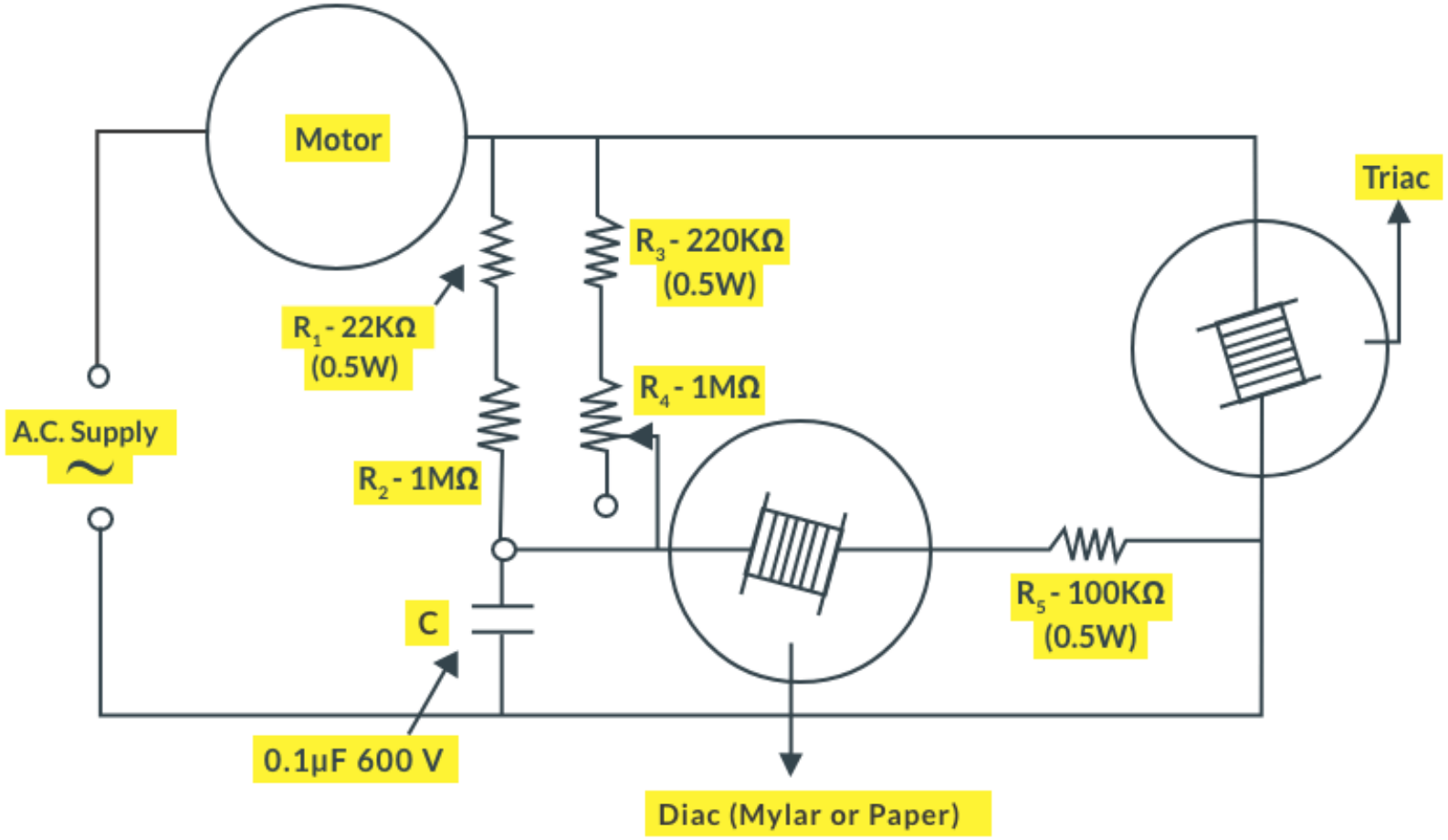

CEILING FAN MOTOR CIRCUIT
I
I_s
Starting Winding
(Auxiliary Winding)
L
I_m
(Running Winding)
Main Winding
Single Phase
AC Supply
Rotor
Capacitor
N
Electronics Hub

VARIABLE RESISTOR REGULATOR



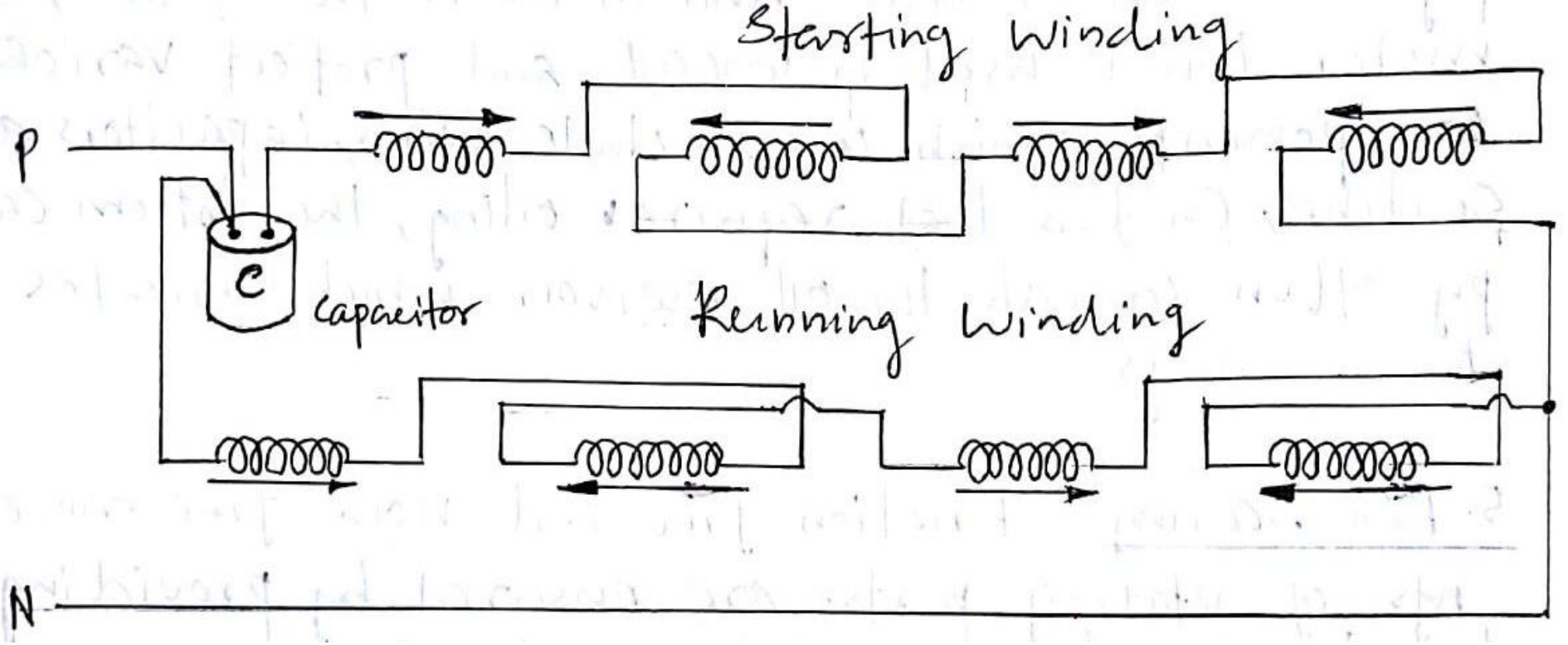
Electronics Hub

ELECTRONIC REGULATOR



Electronics Hub

Coil Connection



Repair and Maintenance

- **REQUIRED**
- Test lamp, bearing puller
- Combination pliers, Tester, Screw driver, Multi meter

POSSIBLE FAULT AND REMEDIES

Fan not working

CAUSES	TEST	REMEDIES
1.Dry bearing. If the bearing with dry bearing (without oil or grease) or brush friction increase heat produced and either rotate at low speed	Check grease and quality of grease after removing	By giving oil or grease this defect can be rectified
2.No supply on wall socket	Test continuity	If it is wiring fault, rewire it
3.Regulator has open circuit	Test the regulator	If it is regulator fault replace it
4.Faulty capacitor	Check the capacitor by supply or multi meter	Replace if necessary
5.Faulty regulator	Check the regulator by series test lamp	Replace if necessary
6.Open or Short circuit on field winding	Check the field winding	Rewind if necessary

- Fan works at low speed

CAUSE	TEST	REMEDY
1.Low voltage	Check the supply voltage	Give correct supply
2.Faulty capacitor	Check capacitor	Replace by new one
3..Winding fault	Check the winding	Rewind if necessary
4.Weak field winding	Check the insulation resistance of field winding	Repair it

Fan gives shock

CAUSE	TEST	REMEDY
1.Winding may be earthed end cover may be touching the open portion of winding	Test for continuity	There must be earthed by an earth wire coming from the wall socket by the third wire in the load

Fan working at low speed and become hot

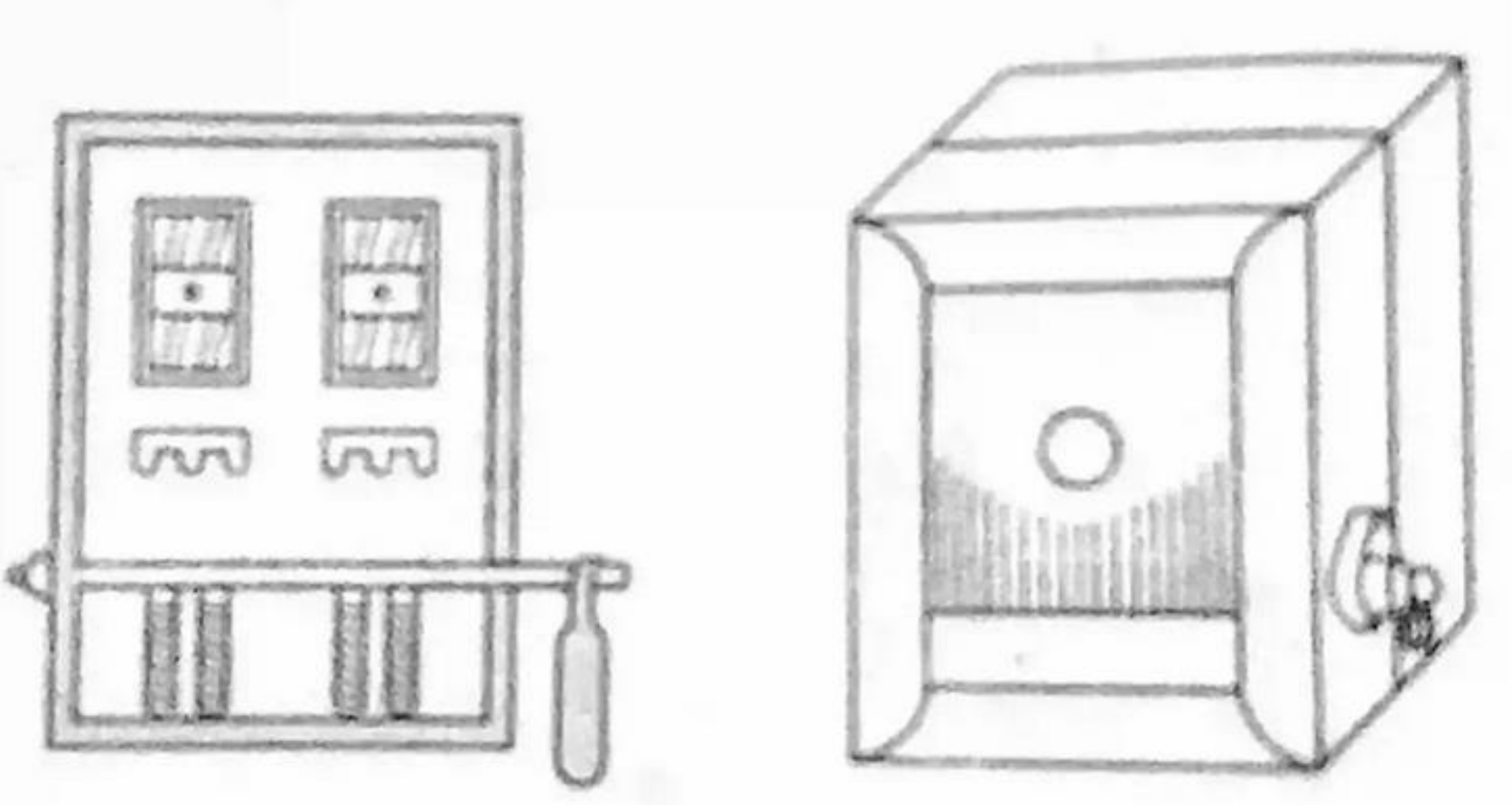
CAUSE	TEST	REMEDY
1.Capacitor is burn out	Capacitor test	Replace it
2.Blade are bended	To set the blade in correct position take them out from the grill, place the blade on the flat and clean floor in such a position so the blades may touch the floor	If bend is occur straighten by pushing or using a mallet
3.Winding shorted	Test using series test lamp	Replace winding
4.Winding earthed	Test for continuity	There must be earthed by an earth wire coming from the wall socket by the third wire in the load

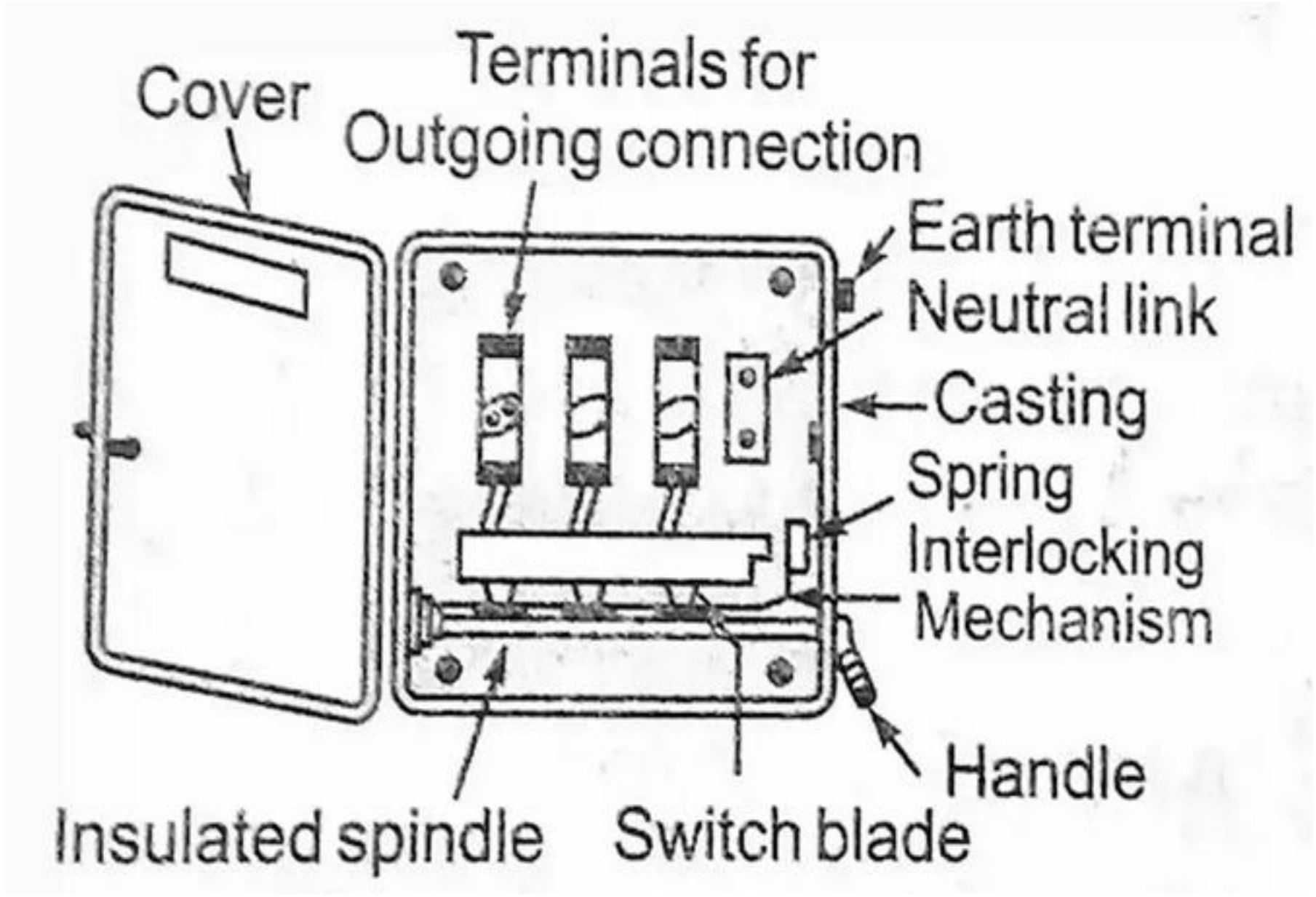
ICDP/ICTP Switch

- ICTP (Iron Clad Triple Pole) Switch
  It is used alongwith the energy meter to isolate the
  supply of electricity automatically or manually

Double pole Iron-clad main switch:

- This switch shown in Fig is also referred to as D.P.I.C switch and is mainly used for single phase domestic installations, to control the main supply.
- It controls phase and neutral of the supply simultaneously.
- This switch consists of two fuse carriers.
- The one in the phase circuit is wired with the fuse and the other in neutral is linked with a brass plate or thick copper wire.
- These switches should be earthed properly to safeguard the user.
- The current rating of the switch varies from 16 amps to 200 amperes.
- Specification of these switches should have
- - current rating
  -voltage rating
  -type of enclosure (sheet steel or cast iron).



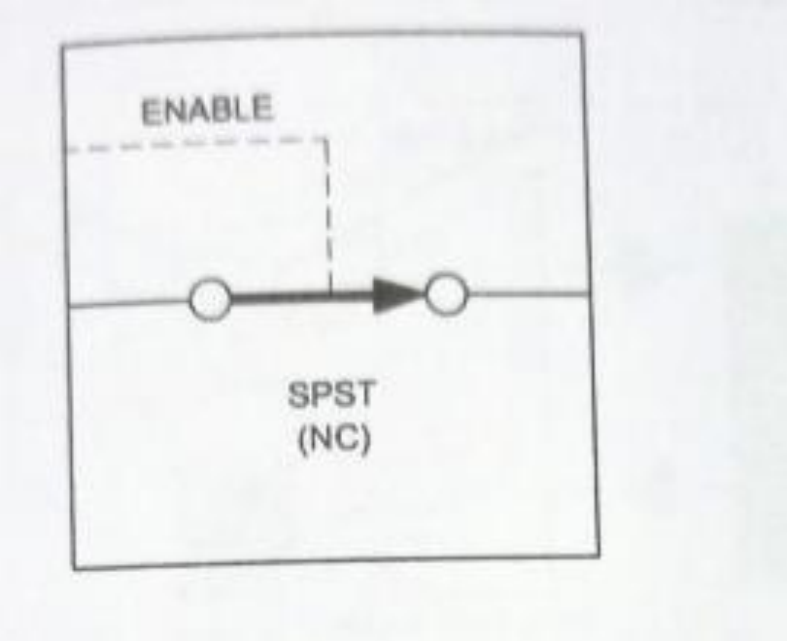

Cover
Terminals for
Outgoing connection
Earth terminal
Neutral link
Casting
Spring
Interlocking
Mechanism
Handle
Insulated spindle
Switch blade

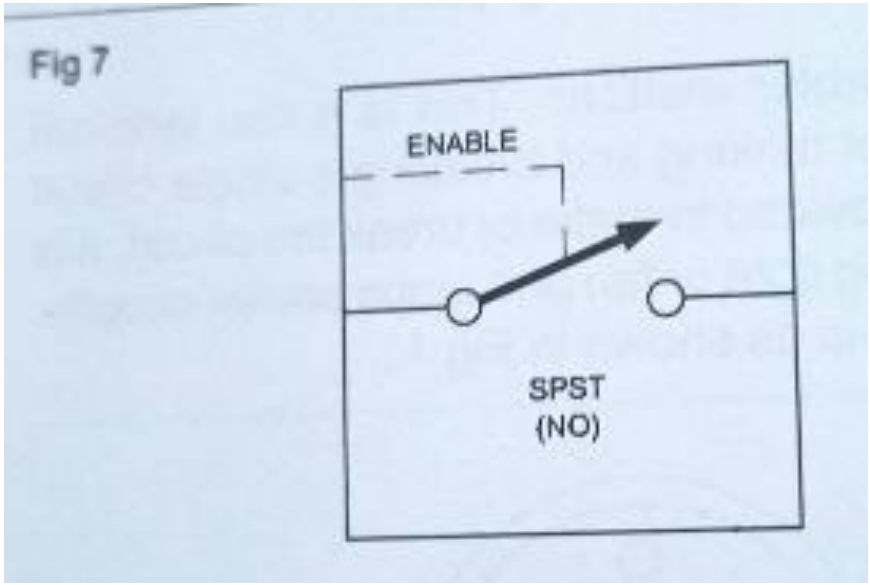
- Triple (three) pole Iron-clad main switch: This is shown in Fig and is also referred to as TPIC switch and is used in large domestic installation and also in 3-phase power circuits, the switch consists of 3 fuse carriers, one for each phase.
- Neutral connection is also possible as
  some switches are provided with a neutral link inside the casing.
  These switches need to be earthed through an earth terminal or screw provided in the outer
  casing
- The current rating of the switch varies from 16 to 400 amps.
- Specification of these switches
  should have
  -current rating
  -voltage rating
  -type of enclosure (sheet steel or cast iron)
  -whether with neutral link or otherwise
  -rewirable type fuse carriers or HRC type fuse carrien.

Switches used in electric industry

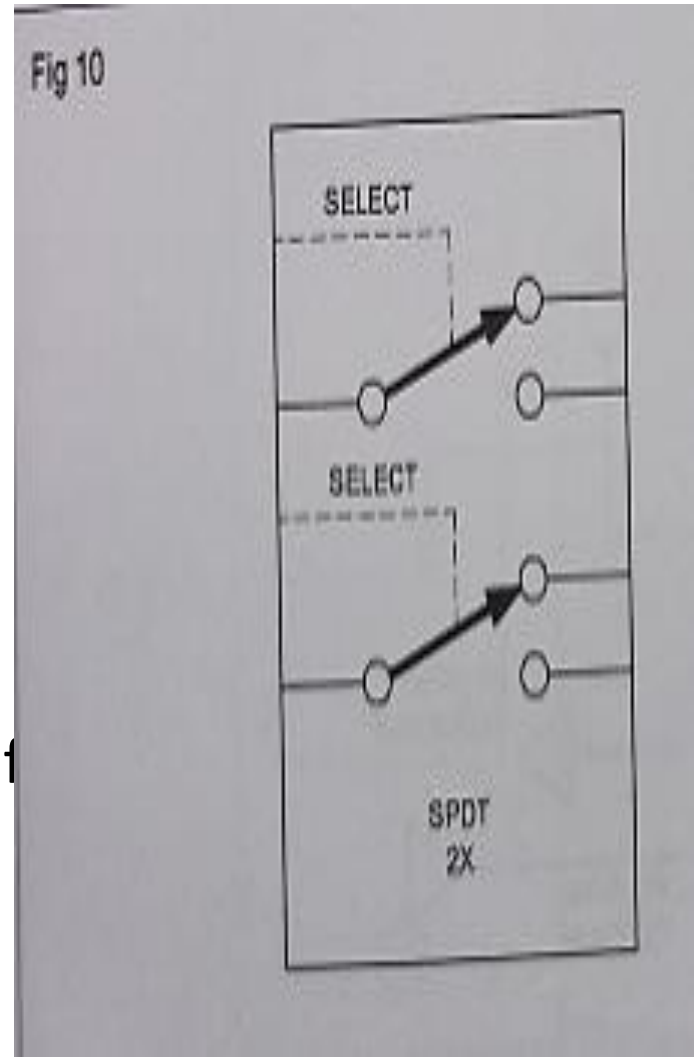
- Switching is the most fundamental function in electronics, and plays a vital role in every system
  Most widely used switch configurations in the industry today are:
  1 Single Pole Single Throw (SPST)
  2 Single Pole Double Throw (SPDT)
  3 Double Pole Double Throw (DPDT)
  Single Pole Single Throw (SPST) is an analog switch used in many industrial instruments and consumer devices to implement test interfaces etc. It consumes very low power with maximum
  current in the range of 690 nA
- Normally open SPST switch can isolate multiple peripherals from source and select the required one.

- Normally closed SPST switch can connect at all times to a peripheral and when not desired the output can be totally stopped by a press of a switch.
- Some SPDT switches have a select pin and other will have a enable pin. The master in the
  design for digital control chooses the required trigger action
- Schmitt trigger action at select and enable control pins results in higher reliability.
- Digital bus switches are widely used multiple peripheral and host selection functions, power and
  clock management, sample and hold circuits, test and debug interfaces etc.





- A dual SPDT switch in (Fig 10) can be used
- 1.to route the audio signal from either base band processor to speaker
  2. to wirelessly route the audio signals between cell phone and an external hands-free device.
  The dual SPDT and dual SPST switches are available either for simultaneous selection or for simultaneous enable.
  Simultaneous select is to connect one of the two signal points or peripherals.
  Simultaneous enable is normally open and upon control by master gets enabled remain enabled till disabled.



- The symbol of dual SPST switch is shown in (Fig 11) A DPDT switch is a dual SPDT switch into a single select pin as shown in (Fig 12)
  A circuit using digital switch is shown in fig (13)
  The application of dual SPDT in the circuit are shown in Fig13 and fig 14

Fig 11

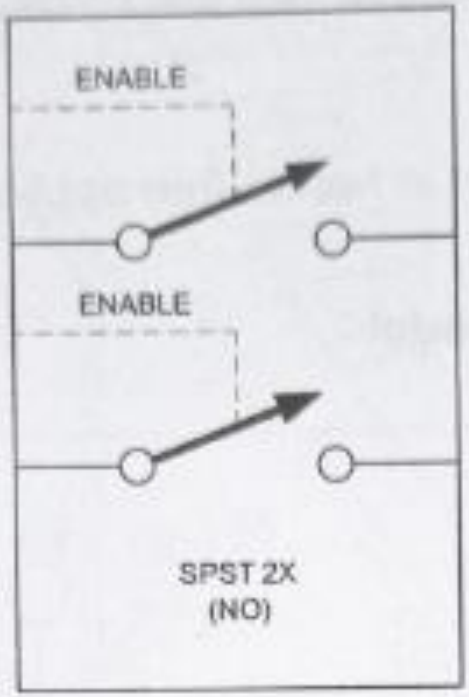
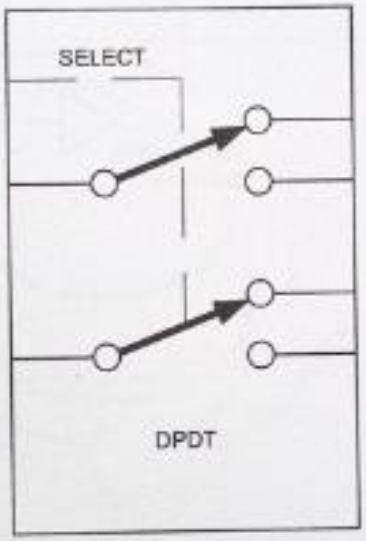


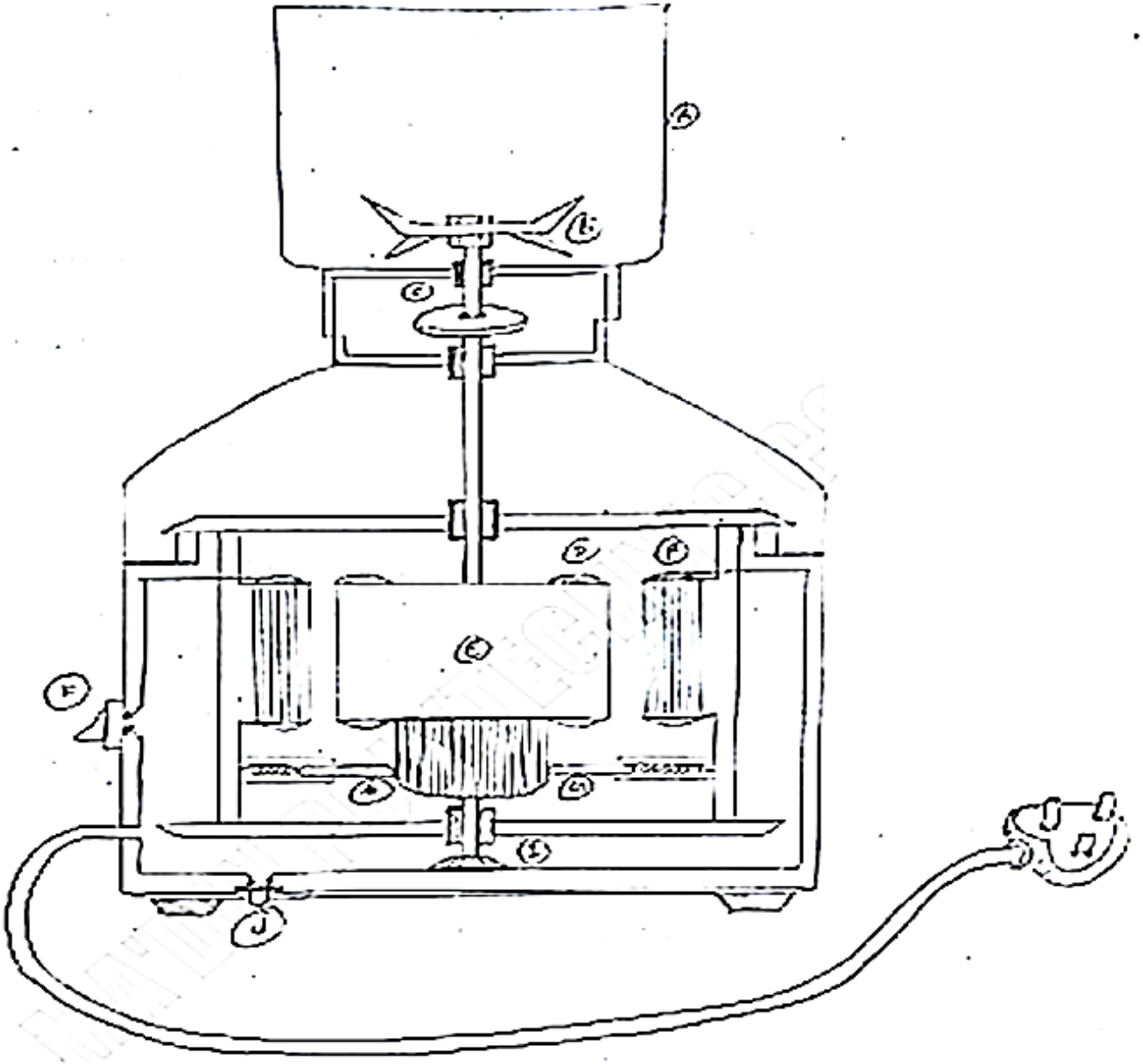
Fig 12



ELECTRIC MIXER

- TOOLS REQUIRED:-
- Screw driver, Combination pliers, Test lamp, Tester, Knife
- PRINCIPLE:-
- It is worked on by using a universal motor. A universal motor may be operated either on DC or Single phase AC supply.
- Approximately same output. Being a series wound motor it has high starting torque and a variable speed characteristics. It runs dangerously high speed on no load.
- That's why such motors are would built into a device driver. I which tapings field method is usually employed for speed control purpose.
- In this method a field plate is tapped various points and speed is controlled by field strength for this purpose either of the following two arrangement may be used.
  - The field pole is wound in various sections with different sizes of taps are brought out from each sections.
  - Nichrome resistance is wound over one field pole and taps are brought out from te wire.

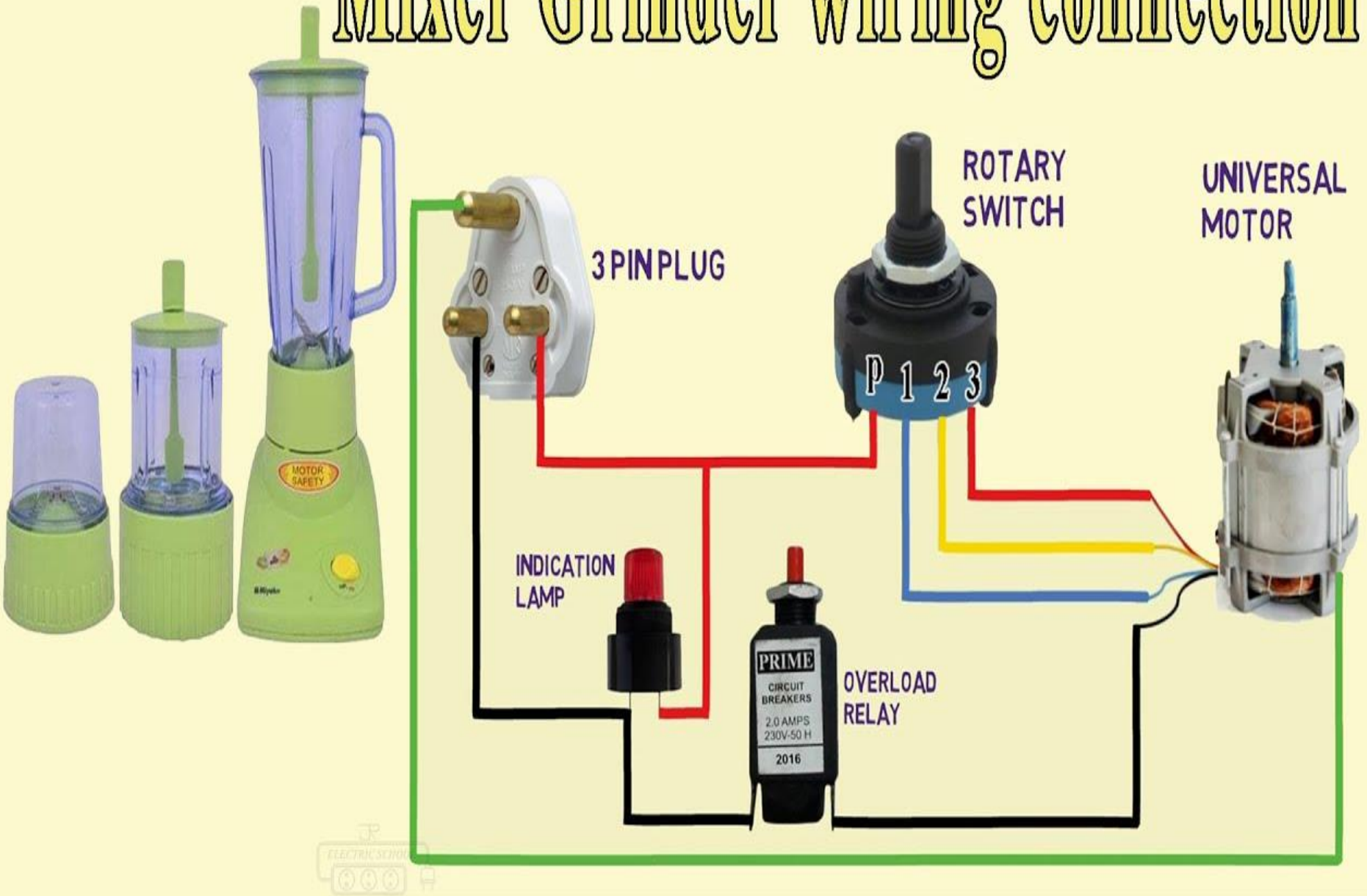
- It’s very useful appliance for grinding. Another use of mixer is prepare fruit juice.
- The speed of mixer is high.
- The mixers are available in small medium and large sizes.
- Large size one is the mostly used for commercial purpose.
- The electric mixer can be divided into three parts from construction point of view.



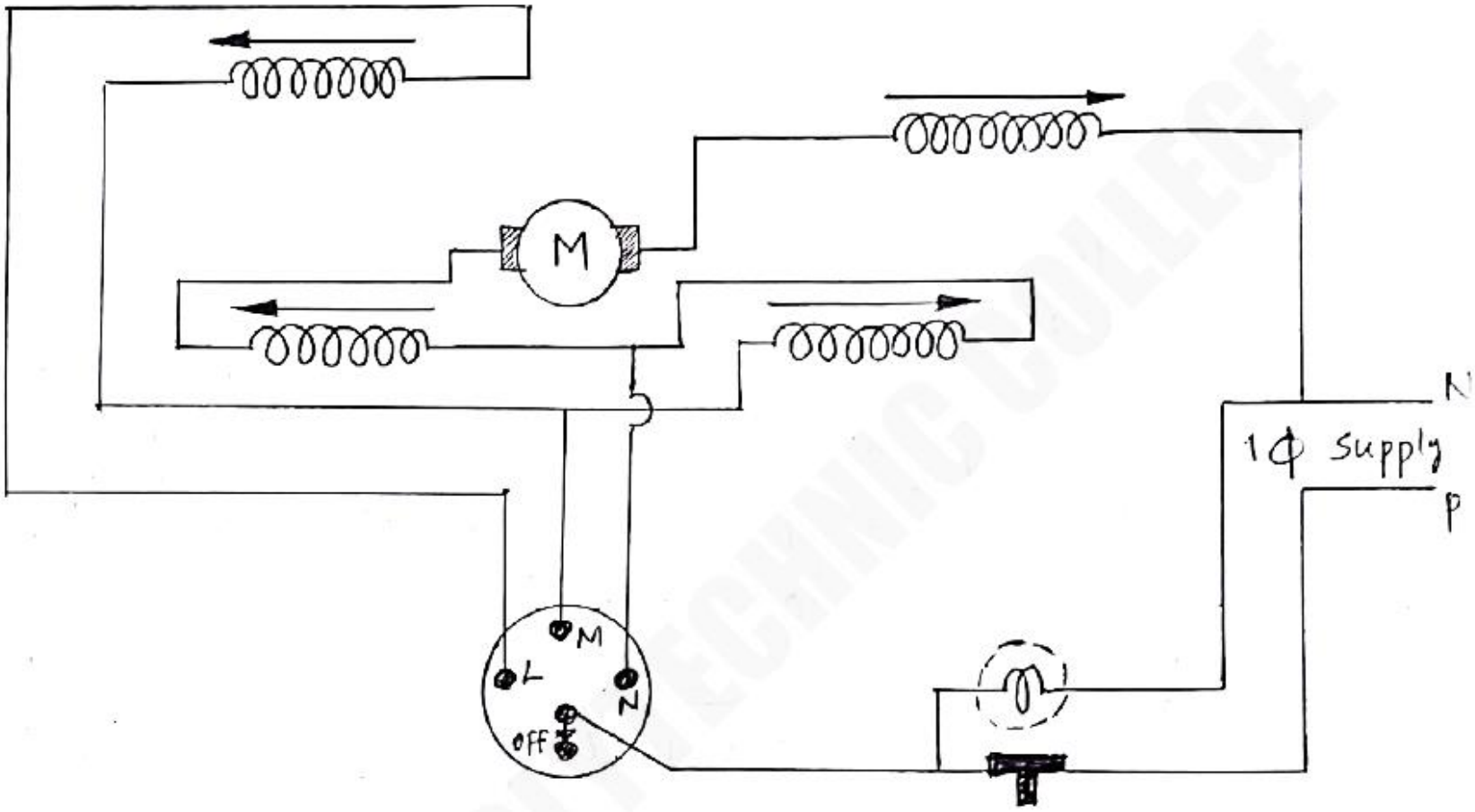
(A) Jar (B) Blade (C) Brush Bearing (D) Rotor winding
(E) Rotor (F) Stator winding (G) Brush (H) Commutator
(I) Cooling fan (J) Over load protector (K) switch

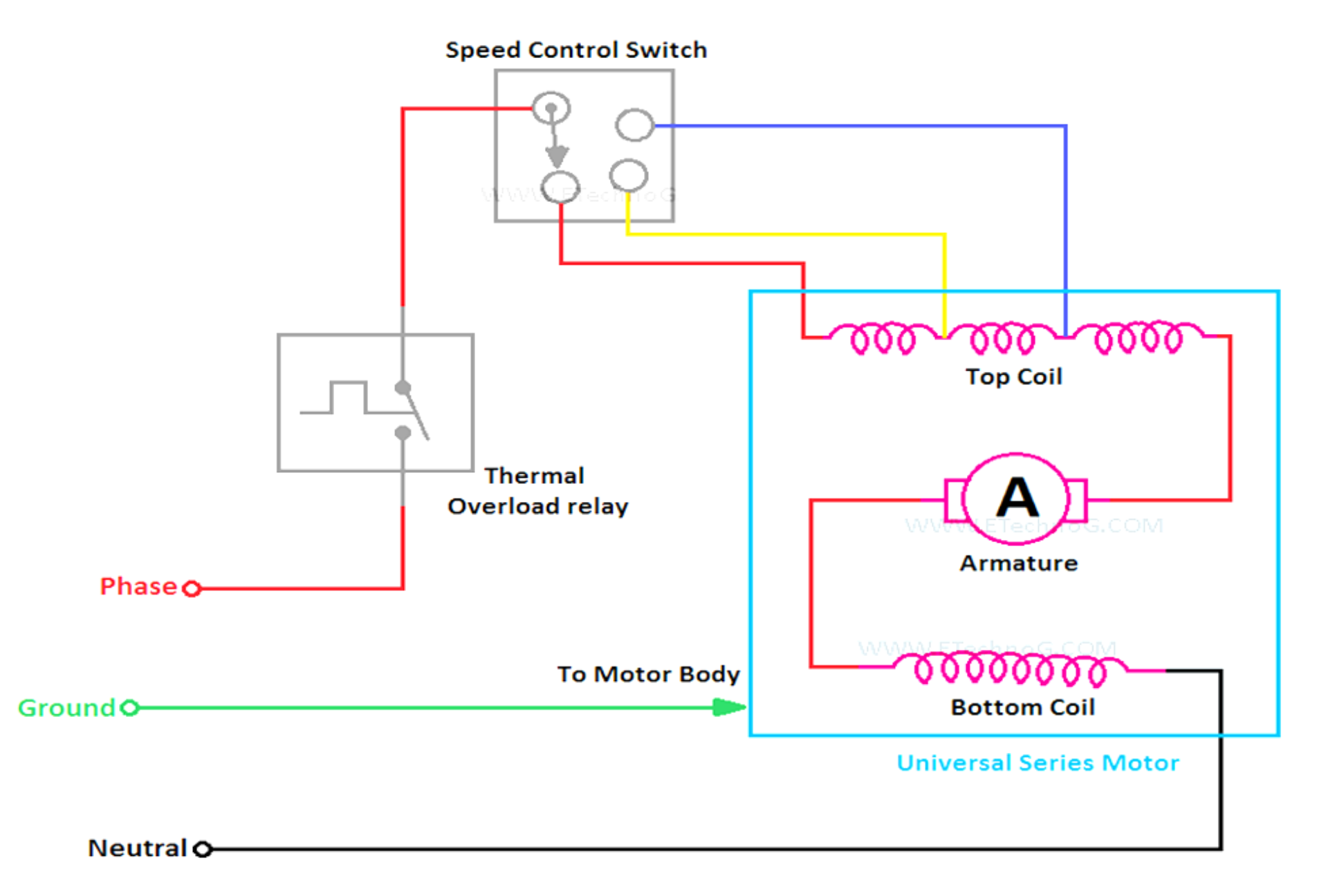
- **Base**
- The base portion houses an electrical universal motor with a ON , OFF switch or a selected switch.
- If it is a multi speed motor.
- **Grinder and Blender**
- Grinder is of two types.
- The one is for fruit juice, vegetable juice, etc... It’s called blender for grinding dry and hard pieces.
- The blades of grinder are small in size and are made of hard stainless steel.
- **Bowl**
- The material to be grinded or mixed is put into the bowl after the preparation of it.
- Ready the bowl along with the grinder is detached from the shaft of the motor. The content are then poured out.
- The bowl grinding blades are coupled to the motor with the help of Dayton coupling.

Mixer Grinder wiring connection



CONNECTION DIAGRAM





Electrical Mixer Grinder Internal Circuit Diagram

POSSIBLE FAULT AND REMODIES:-

- 1. Mixer grinder is heating

CAUSE	TEST	REMEDY
1.Overload	Check the load.	Reduce it.
2. Low or high supply voltage.	Check the supply voltage. .	Give proper supply.
3. Bearing and couple are too tightened.	Check the tightness of bearing and couple.	If it's not normal tight it to appropriate level.

- 2.Mixer does not exist.

CAUSES	TEST	REMEDIES
1. Supply does not exist.	Check for continuity.	Replace if necessary.
2. Couple is mechanically block.	Check rotation.	Dismantle if required and test.
3. Coil are open circuited.	Test the field coil for open circuit (test lamp).	Replace if it necessary.
4. Complaint on over load switch.	Check for switch with test lamp.	Replace if it necessary.
5. Defective the selection switch.	Check rotatory switch.	Replace if it necessary.
6. No adequative pressure on brush holder.		
7. Short circuit on armature.	Check the armature by growler to located effective coil.	Replace the coil if required.

- 3. Mixer makes sound

CAUSE	TEST	REMEDY
1. Bearing problem.	Check the bearing.	Replace it or replace if is necessary.
2. Improve coupling.	Check the joining of couples and jar. .	Make it correct. Give proper supply.

UNIT - V
Departmental Test, REC and Electrical Act 2003

Syllabus

- Introduction, departmental procedure for obtaining a service connection, insulation resistance desirable for electrical installation, earth resistance to be maintained for an electric installation, testing of wiring installation, rural electrification scheme, survey of load in a village, capacity of transformer, location of transformer, estimation of electrification of a village, economic feasibility of the scheme, Indian electricity(I.E) rules, general conditions for supply and use of energy, electric supply lines, systems and apparatus for low and medium voltages.

Introduction

- The Electricity Act, 2003, is intended to consolidate the laws relating to the Generation, transmission, distribution, trading and use of electricity and generally for taking measures to the development of electricity industry promoting competition therein protecting interest of consumers and supply of all areas, rationalization of electricity tariff, ensuring transparent policies, constitution of central Electricity Authority, Regulatory commission and establishment of Appellate Tribunal.
- In this unit, focus our attention on various departmental tests to be conducted for a wiring installation, Design of Rural Electrification Scheme and Indian Electricity Rules.

1.DEPARTMENTAL PROCEDURE FOR OBTAINING A SERVICE CONNECTION

- The State Government may grant service connection on application made by the consumer in the prescribed form and on payment of the prescribed fee (if any) to supply energy in any specified area.
- There is certain procedure to obtain a service connection by a consumer. To obtain a new service connection the following steps should be followed.
- **Step-1 :**
- **Approach Customer Service Centre with Relevant Documents :**
- To get a service connection, first the consumer has to approach customer service centre to get a prescribed application form which can be had at free of cost.
- The consumer has to fill the entire particulars in the application and shall indicate his full name and address for communication.

- **Step 2:**
- **Registration of Application in the Customer Service Centre :**
- The filled-in application is then registered in customer service centre by paying Registration fee in the form of Demand Draft towards “Divisional Electrical Engineer, operation, APCPDCL”.
- The amount for D.D. depends on type of category ie. Rs. 25/- for category-I (domestic) and Rs. 50/- for other L.T. categories (commercial, industrial, agricultural etc) and Rs. 100/- for H.T. service.
- The relevant documents such 4proof of owner ship of the premises, wiring certificate from the licensed ¢ electrical contractor and 2 or 3 pass photo size photographs should be attached with the application.
- Then the consumer will be given an acknowledgement of the application which consists of registration number and date of registration.
- **Step-3:**
- **Line Inspector will Inspect and Examine the Premises :**
- The application from customer service centre is then sent to the concerned Assistant Engineer (A.E)operation.
- After receiving and going through the application the A.E will ask the Line Inspector to inspect the premises.
- The Line Inspector will inspect and examine the premises to fix the point of entry of service line and the position of the service cutout and energy meter in consultation with consumer and/or his licensed electrical contractor.
- After the inspection of the premises a test report with the particulars of load will be prepared and an estimate will be formulated.

- **Step-4 :**
- **Submission of Test Report and Estimation to Assistant Engineer (A.E)/Assistant Divisional Engineer (A.D.E) :**
- The Line Inspector will submit the test report and estimation in a prescribed form to A.E/A.D.E. After studying the report the A.E/A.D.E will ask the section officer to intimate the consumer in the prescribed proforma to pay the deposits and keep ready the service wire etc.
- **Step-5 :**
- **Payment of Service Connection Charges and Security Deposit :** Now the consumer has to pay
- (a) Service Line charges (for extension work),
- (b) Development charges and
- (c) Security deposit in the form of Demand Draft towards “Divisional Electrical Engineer, operation, APCPDCL”.
- The amount of charges depends on number of kW (for domestic) or H.P (for industrial and agricultural). The security deposit will be taken normally for 3 months consumption charges. All the charges and deposits shall be in the form of crossed demand draft and will not accepted in cash. The section officer will issue temporary receipt for all the deposits obtained.

- **Step-6 :**
- **Allotment of Service Number and Energy Meter :**
- After payment of deposits, the service number and energy meter will be allotted with in one month on seniority basis. Then the A.E. of the sub-division will issue the work order for the metering equipment.
- **Step-7 :**
- **Fixing of Energy Meter :**
- The service line and the metering equipment will be laid and erected in the consumer premises.
- The service line will be connected to the mains and service will be released.
- After this, a test report will be collected in the prescribed proforma and sent to Electricity Revenue Office (ERO) for billing.
- The supplier (State Electricity Board) may affix one or two seals to any cut-out and energy meter and no person other than the supplier shall break a such seal.
- The electricity bill should be paid at the bill collection centre monthly/bi-monthly as per the norms of the Electricity Board Tariff.
- **Note:**
- The same service procedure is to be adopted to get the service connection for Industries (H.T) and Agricultural loads. In such cases :required to enable the department to make longer notice which may extend to six months necessary arrangements.

CENTRAL POWER DISTRIBUTION COMPANY OF A.P. LIMITED

CUSTOMER SERVICE CENTRE

APPLICATION FOR SUPPLY OF ELECTRICITY AT LOW TENSION

Registration No. _____

For New Loads/Addl. Loads

To

The Asst.Engineer/Operation

_____

I/We request you to supply electricity at L.T. to my premises as mentioned below:

1. Name of the Customer in whose name connection is required.

_____

2. (a) Location of premises where supply is required :

Street :	Mandal :
Village :	District :
	Pin Code :

(b) Nearest electric pole number

_____

(c) Type of service wiring

1. Over head _____ Under Ground_____
2. Type of entry: Enclosed in PVC conduit : Yes/No G.I. Pipe: Yes/No
3. Is the pipe externally visible : Yes/No

(d) Is wiring in the premises completed : Yes/No

(e) If any other services existing in the same premises: Yes/No

SC No	Category

(f) If any other service existing elsewhere in the same name or in the name of the sister concern if Yes, details thereof : Yes/No

SC No	Category

3. Address for communication with Telephone No.

Address	Telephone No

4. Details of connected load for Industries/Agriculture services/ Domestic/commercial load Street lights/Temporary supply

5. Status of Customer :

Individual	_____	Registered partnership	_____
Unregistered partnership	_____	Public Ltd., company	_____
Private Ltd., company	_____	Any other	_____

6. Social Group : SC/ST/Others

7. Category supply

Category	Type	Tick	Category	Type	Tick
Cat - I	Domestic		Cat - II	Non-Domestic	
Cat - III	Industrial		Cat - IV	Cottage Industry	
Cat - V	Agriculture		Cat - VI	Street Lights	
Cat - VII	General purpose		Cat - VIII	Temporary supply	

8. Connected Load :_____ KW _____ HP

9. Details of Application fee paid

D.D. for Rs.	D.D. No	D.D. Date

10. Tick whichever is applicable :

S.C. or S.T.	Necessary Community Enclosed
Partnership	Location, Head office, names & address of partners & copy of partnership deed enclosed
Company	Name of present Directors & Copy of Memorandum of Articles of Association enclosed.

11. Undertaking

I. I/We undertake and agree to pay the Tariff and miscellaneous charges prescribed by the APCPDCL and abide by the terms and conditions of supply notified by the APCPDCL from time to time. Which shall govern the supply of Electricity to me/us in all respects.

II. I/We shall undertake to execute an agreement in the prescribed form, is so called upon by the APCPDCL whether such an agreement is executed or not, this application itself shall oblige me/us conform to and abide by terms and conditions of supply notified by the APCPDCL from time to time.

Signature of Applicant : _____ **Date :** _____

ACKNOWLEDGEMENT

Section/CSC : _____

Registration No : _____

Date of Registration : _____

Signature of Receiving :_____

Officer with Stamp

2. INSULATION RESISTANCE DESIRABLE FOR ELECTRICAL INSTALLATION

- Before energising any installation system the installation should be inspected and tested to make sure that there is no short circuit fault, earth leakage, discontinuity etc. and the wiring job has been carried out in accordance with requirements of Indian Electricity Rules.
- The chances for breaking of conductor section are :
  - 1. Scrapping of insulation while drawing, laying,
  - 2. Puncturing of insulation while fixing clips,
  - 3. Driving nails, screws etc.
- These are unavoidable and these necessitate the testing of installation work before connecting it with the supply mains i.e. energising it.

- Megger is a portable instrument which is generally used for testing of installation.
- It is a combined unit of an ohm-meter and D.C. hand driven Generator.
- **1. Insulation Resistance of an Installation :**
- The insulation resistance shall be measured by applying a D.C. voltage not exceeding 500V for medium voltage circuits between the earth and the whole system of the conductor.
- The insulation resistance in mega-50 ohms of an installation shall not be less than

$$\frac{50}{\text{No. of points in the circuit (points + switches)}}$$

- The insulation resistance in any case should not be less than 0.5 MQ and need not be more than 1 Mega ohm,
- In case of P-V.C cables insulation resistance is equal to

$$\frac{12.5\text{M}\Omega}{\text{No. of points in the circuit}}$$

- **2. Insulation Resistance of Motors and Other Equipments :**
- The insulation resistance of each phase winding against the frame and between the windings shall be measured.
- A Mega ohm-meter of 500 V (or) 1000 V rating shall be used.
- Minimum acceptable value of insulation resistance in MQ at 25°C $= \frac{20XE}{1000 + 2P}$
- Where E = Rated phase to phase voltage in volts.
- P = Rated power in kW.

3.EARTH RESISTANCE TO BE MAINTAINED FOR AN ELECTRIC INSTALLATION

- The main purpose of Electrical installation (equipment) earthing is to safe guard human being from shock hazards.
- In order to achieve effective operation, the earth electrode resistance should be lower than an acceptable value which could be calculated from circuit details.
- This low resistance will discharge the leakage current to earth and safe guard the human being from risk of electric shock.
- The value of earth resistance in ohms = $\frac{Voltage}{Leakage\ current} = \frac{V}{I}$
- The maximum permissible values of earth resistances below for various electrical installations
- 1. Large Power Stations = 0.5 Q
- 2. Major Sub-Stations = 1.00
- 3. Small Sub-stations = 200
- 4. In all other cases = 5.090

4.NECESSITY OF INSPECTION AND TESTING OF WIRING INSTALLATION

- On completion of the wiring, a general inspection shall be carried out by competent personnel in order to ensure that there is no short circuit, earth leakage or discontinuity etc. moreover the wiring is done according to the Indian Electricity Rules.
- The main objective of this inspection is to check whether all equipment, fittings, accessories, wires/cables used in the installation are of adequate rating and quality to meet the requirements of the load.
- Also the layout, finish, neatness, clearances, tightness of termination, rating of protective devices and their settings must also be inspected and checked.
- After inspection, various tests shall be carried out before an installation or an addition to the existing installation is put into service.

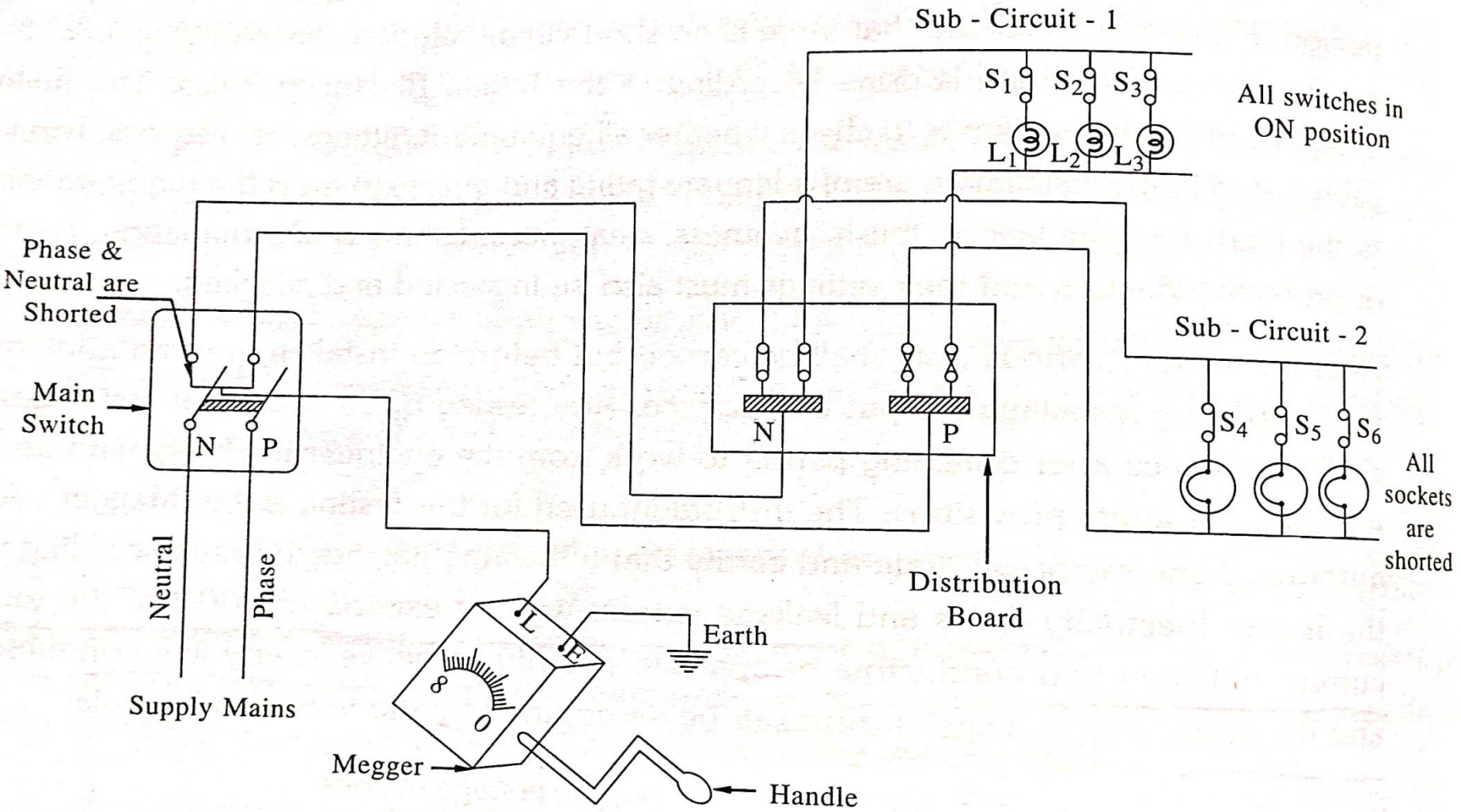
- Any testing of the electrical installation shall commence after obtaining permit to work from the engineer in-charge and after ensuring the safety provisions.
- The instrument used for this testing is the ‘Megger’.
- An authorized contractor will state and certify that the wiring has been done according to the Indian Electricity Rules and leakage current will not exceed 1/5000" of the total current between two conductors of opposite polarity or between any live conductor and the earth.
- The leakage current can be determined by the following formula.
- **Leakage current in Amps =**

  Supply voltage in volts/(Insulation Resistance in mega Ohms)

5.TESTING OF WIRING INSTALLATION

- Before energizing any new installation system or an addition to an existing system following tests shall be carried out to ensure that the wiring installation is satisfactory in all respects.
- 1. Insulation resistance between conductor and earth.
- 2 Insulation resistance between the conductors.
- 3. Polarity of single-pole switch.
- 4. Wiring continuity or open circuit
- 5. Earth continuity test.

1. INSULATION RESISTANCE BETWEEN CONDUCTOR AND EARTH

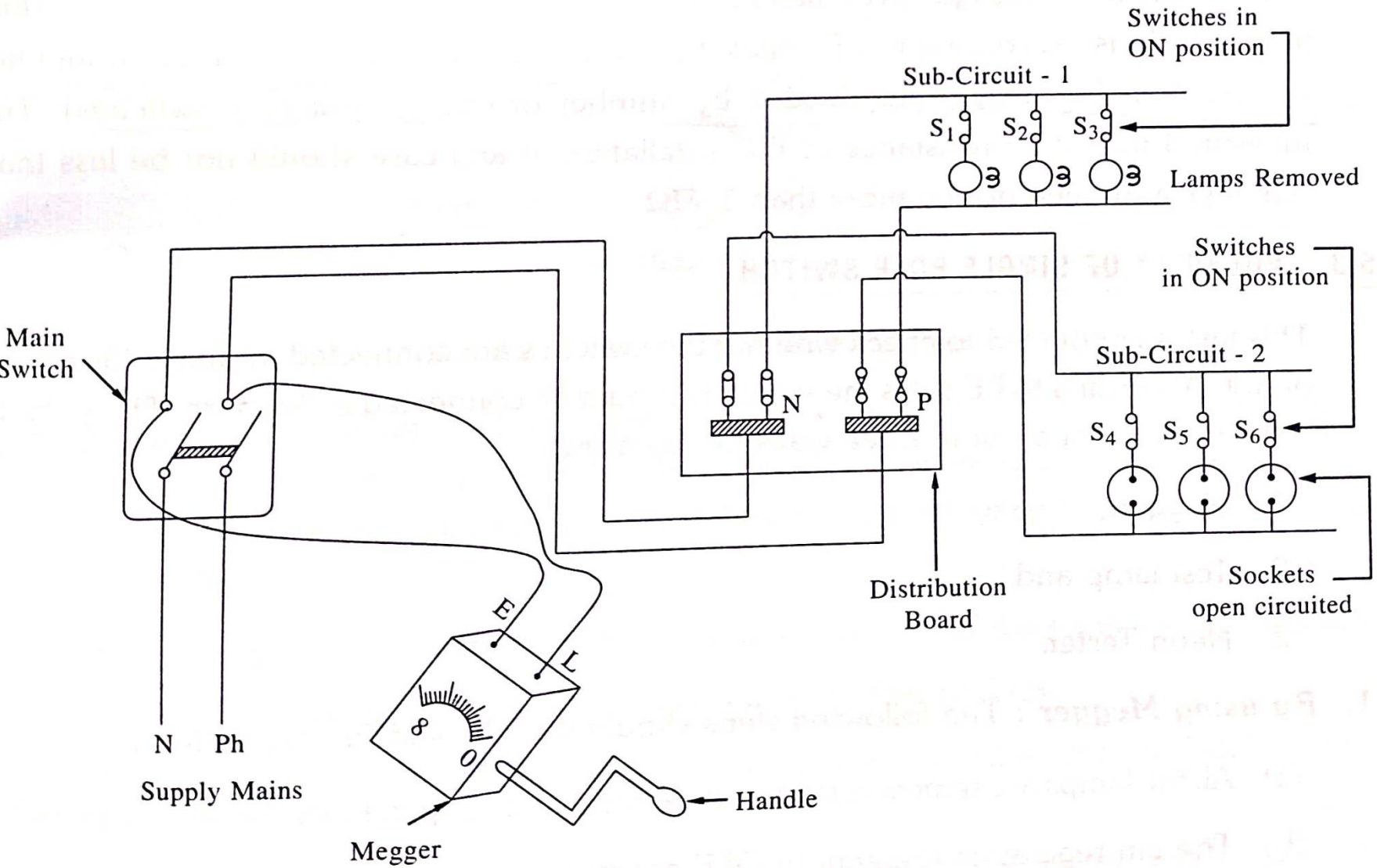


- The objective of this test is to find the insulation resistance between the conductors of opposite polarity (phase and neutral).
- The following steps should be followed for this test.
- (i) Put the main switch in OFF Position and remove the fuse carriers.
- (ii) Keep all the distribution board fuses in position
- (iii) Insert all the lamps in their hoIders and all Switches for fans & lights should be "ON position.
- (iv) Put load in the sockets and keep the Switches in ON position
- (v) Short-circuit phase and neutral terminals on the installation side
- (vi) Connect the Line (L) terminal of the megger phase wire and earth terminal of the megger to neutral in main switch as shown in Fig.

- (vii) Rotate the handle of the megger at its ratcircuit formed between conductors and earth.
- (viii) Note down the reading of the megger shown by its needle deflection.
- The reading of the megger Gives directly the insulation resistance between the conductor and earth in mega-ohms.
- According to IE. rules, the measured insulation resistance should not be less than 50 mega-ohms divided by number of outlets (points + switches).
- The measured insulation resistance of the installation in any case should not be less than 0.5 M-ohm and need not be more than 1 M-ohm.

2 INSULATION RESISTANCE BETWEEN CONDUCTOR

- The object of this test is to find the insulation resistance between the conductors of opposite polarity (phase and neutral).


Switches in
ON position
Sub-Circuit - 1
S1
S2
S3
Lamps Removed
Switches
in ON position
Main
Switch
Sub-Circuit - 2
N
P
S4
S5
S6
Distribution
Board
Sockets
open circuited
E
L
N
Ph
Supply Mains
Handle
Megger

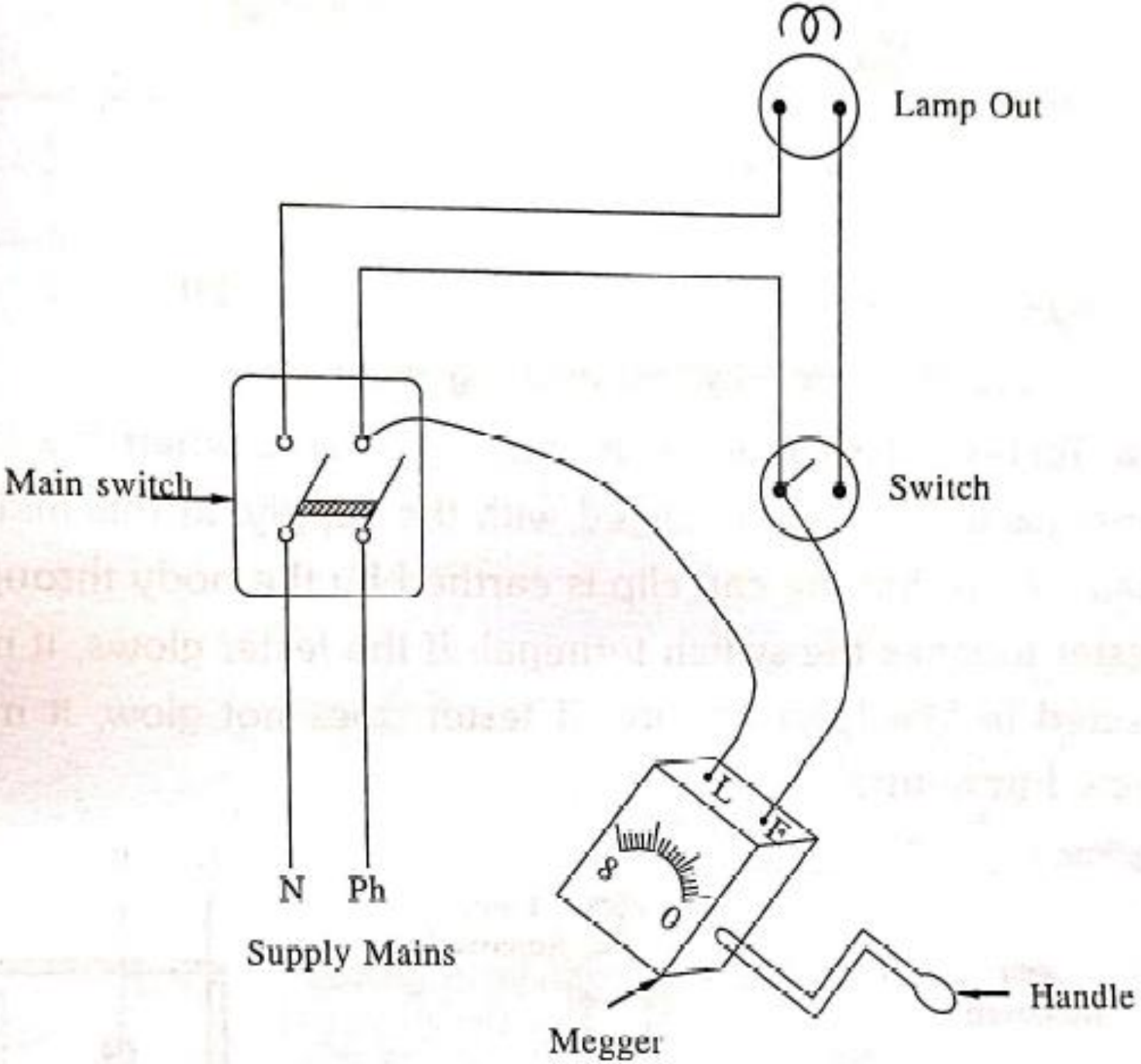
- Procedure :
- The following steps should be followed for this test.
- 1. Put main switch in OFF position and remove the fuse carriers.
- 2. Distribution board fuses should be in position.
- 3. Remove all lamps from their holders and all the switches for lights & fans shouldbe in ON position.
- 4. Disconnect the load in the sockets and keep the switch in ON position.
- 5. Connect the Line (L) terminal of the megger to phase wire and Earth (E) terminalof the megger to neutral in the main switch as shown in Fig.
- 6.Rotate the handle of the megger at its rated speed to send current throughthe circuit.
- 7. Note down the reading of the megger shown by the needle deflection.
- The reading of the megger gives directly the insulation resistance between the conductorsin mega-ohms.
- According to I.E. rules, the measured insulation resistance should notbe less than 50 mega-ohms divided by number of outlets (points + switches).
- The measured insulation resistance of the installation in any case should not be less than0.5 MQ and need not be more than 1 MQ.

3.POLARITY OF SINGLE POLE SWITCH

- This test is conducted to check whether the switches are connected in phase (live) wire or not.
- According to I.E. rules the switches should be connected in live wire. The polarity test can be carried out in three ways i.e. by using,
- 1.Megger
- 2. Test lamp and
- 3. Neon Tester.

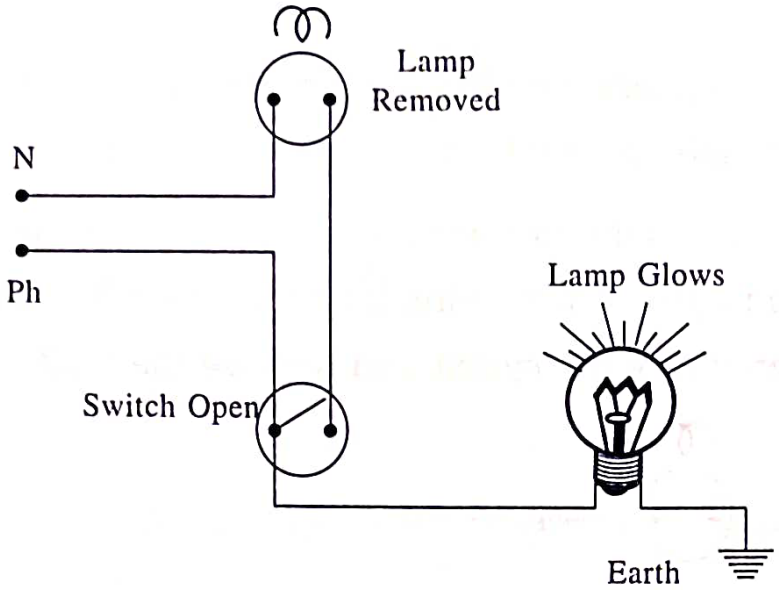
1. By using Megger :

- The following steps should be followed for this method.
- (a) All the lamps are removed from their h
- (b) The fan regulators are kept in OFF position.
- (c) Keep all the fuses in Position
- (d) Remove the covers of all switches,(e) Connect Line (L) terminal of the megger to ph(E) terminal to the individual switch terminal phase wire in the main switch and Earths turn by turn as shown in Fig.

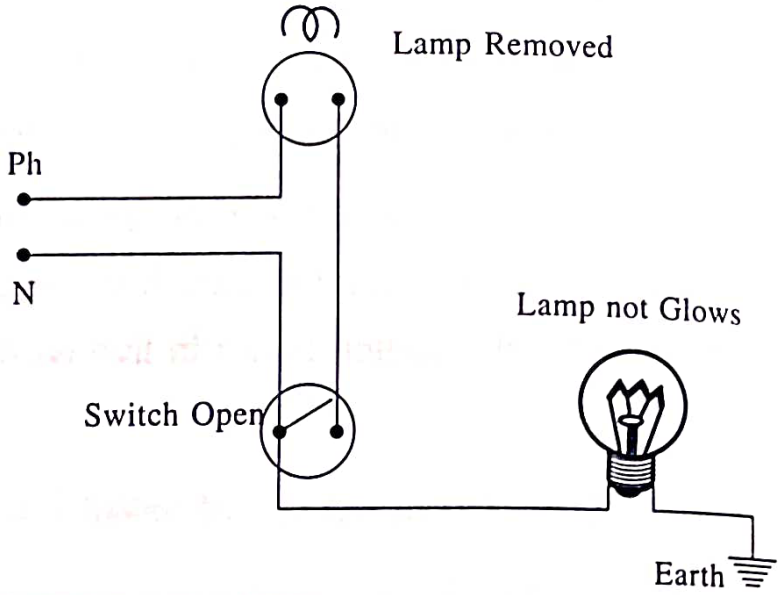

Lamp Out
Main switch
Switch
N
Ph
Supply Mains
L
E
∞
0
Megger
Handle

2. By using Test Lamp

- This system is possible when the installation is already been energized i.e., it is connected with the supply. It is very common appliance and is kept by all wire-men and electricians for quick testing. The following steps should be followed for this method.
- (a) Remove all the lamps from their holders and keep all the switches in OFF position.
- (b) Insert main fuse and put the main switch in ON position.
- (c) Connect one end of the test lamp to earth and another end to switch contact in turn as shown in Fig.
- Now, if the test lamp glows on one of the two contacts of the switch, it indicates that the switch is connected in phase (live) wire, if test lamp does not glow, it indicates that the switch is connected in neutral.


Lamp
Removed
N
Ph
Lamp Glows
Switch Open
Earth

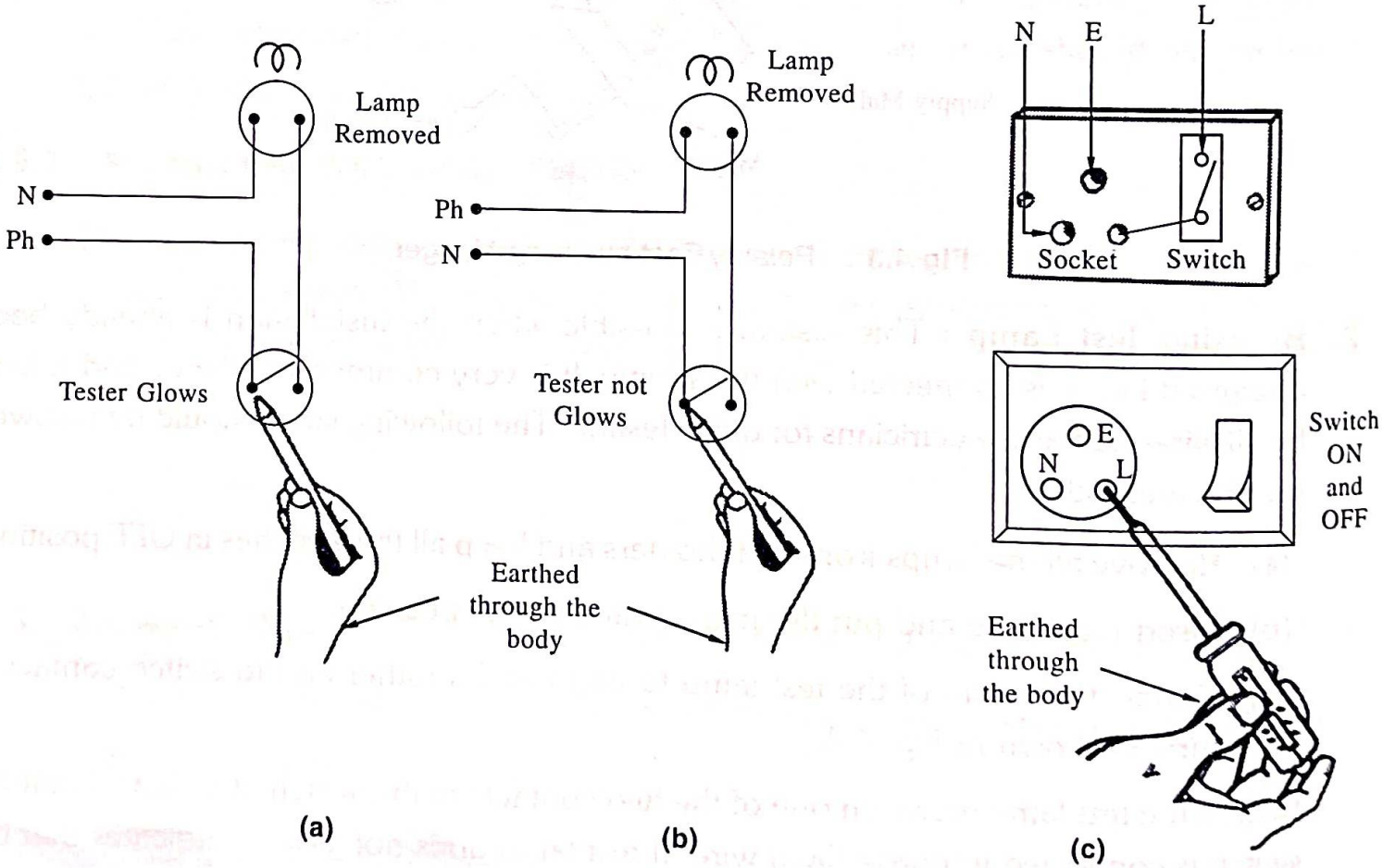
(a)


Lamp Removed
Ph
N
Lamp not Glows
Switch Open
Earth

(b)

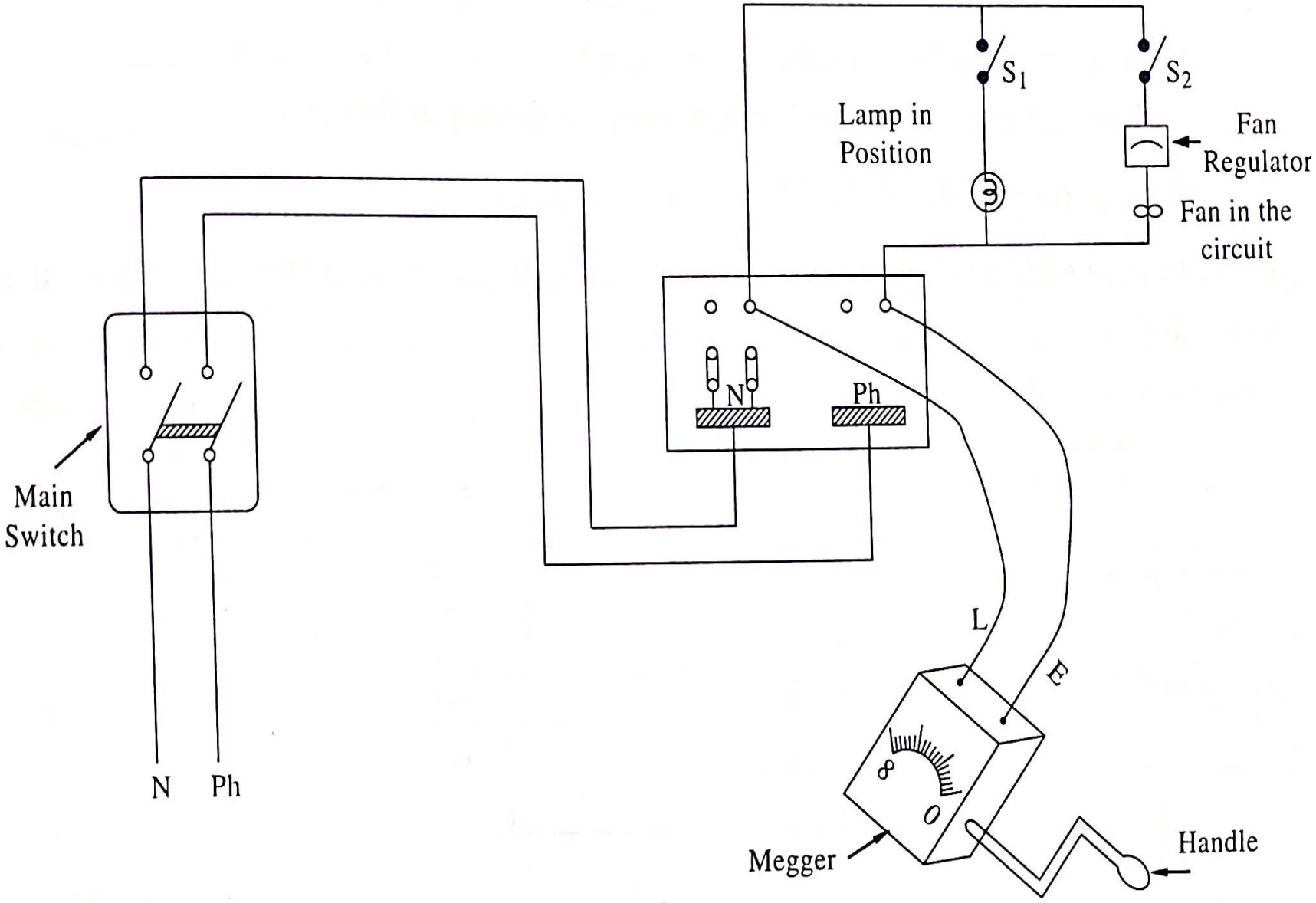
3. By using Neon Tester

- This method is only applicable when the installation has been already energized i.e. it is connected with the supply.
- In this method the tester is held in the hand such that the cap clip is earthed by the body through hand when the tip of the tester touches the switch terminal.
- If the tester glows, it means that the switch is connected in live (phase) wire, if tester does not glow, it means that the switch is connected in neutral.
- Test can also be done on the socket to verify whether, the phase wire isconnected to the right side hole of the socket or not iwire or not as shown in Fig. 4.5 (c). and the switch controls the phase


Lamp
Removed
N
Ph
Tester Glows
Earthed
through the
body
(a)
Lamp
Removed
Ph
N
Tester not
Glows
(b)
N
E
L
Socket
Switch
E
N
L
Switch
ON
and
OFF
Earthed
through
the body
(c)

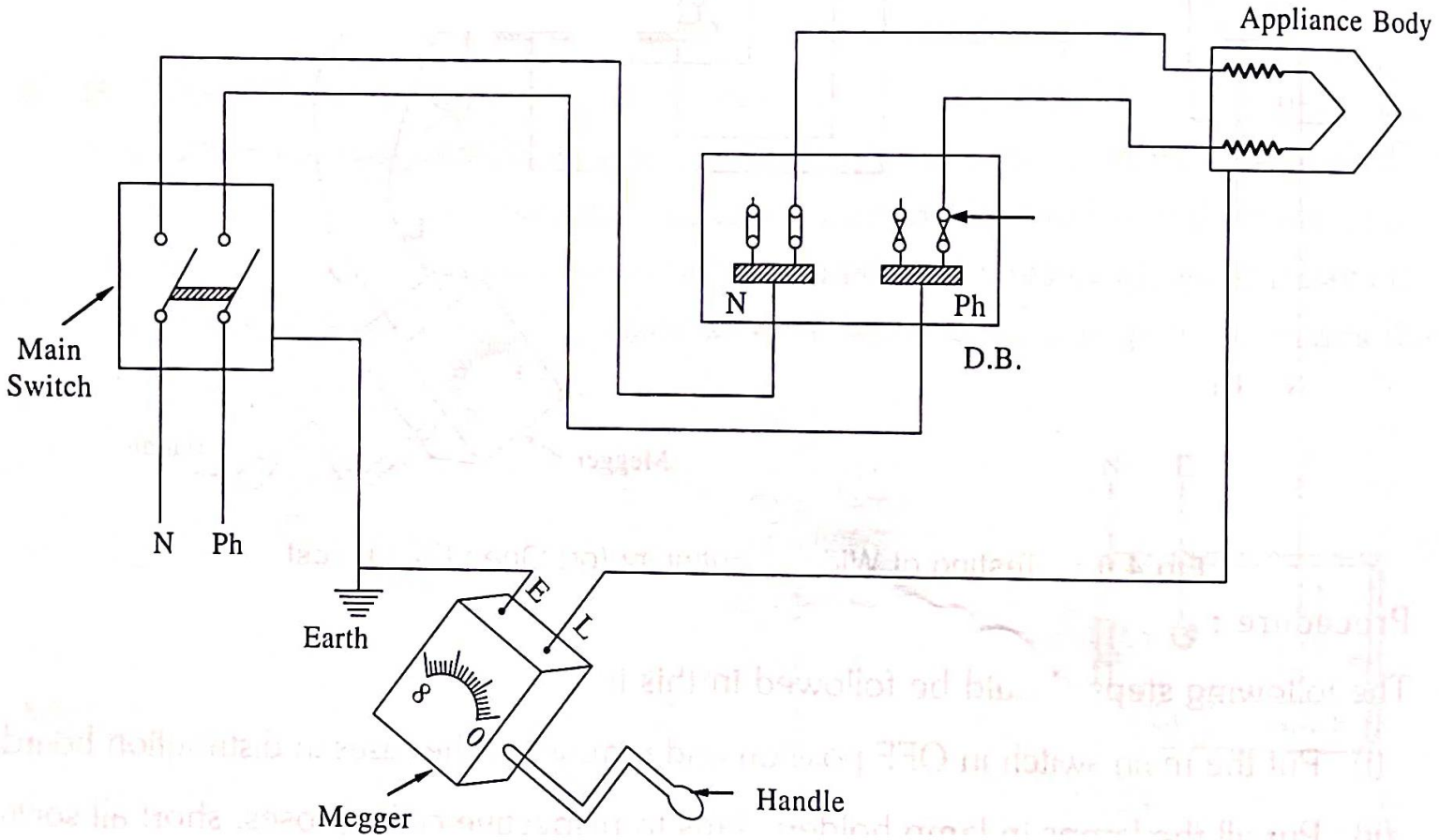
4 WIRING CONTINUITY OR OPEN CIRCUIT TEST

- This test is carried out for checking the continuity of the circuit, sub-circuit and load points.


S1
S2
Lamp in
Position
Fan
Regulator
Fan in the
circuit
N
Ph
Main
Switch
N
Ph
L
E
∞
0
Megger
Handle

- Procedure :
- The following steps should be followed in this test.
- (i) Put the main switch in OFF position and remove all the fuses in distribution board.
- (ii) Put all the outlets.
- (iii) Keep all the switches in OFF position.
- (iv) Connect the megger terminals L and E to the individual circuit phases and neutral lamps in lamp holders, fans to respective ceiling roses, short all socket as shown in Fig.
- (v) Rotate the Megger handle and put the switches ON and

5 EARTH CONTINUITY TEST



- This test is carried out to check the earth continuity of the installation.
- Procedure :The following steps should be followed in this test.
- (i) Put main switch in OFF position and take out the main fuse.
- (ii) Kept all lamps in their lamp holders and kept all the switches in ON Position,
- (iii) Connect Earth (E) terminal of the megger to earth wire at the main switch and Line (L) terminal should be connected to all the metallic parts of the installations and earth terminal of the 3-pin socket as shown in Fig.
- (iv) Rotate the handle of the Megger at its rated speed.
- If the needle of the megger shows zero reading, it means that the circuit is earthed or grounded.
- If megger shows infinity, it means that there is a break in the earth wire, hence check and remove the fault.

6 RURAL ELECTRIFICATION SCHEME

- The Scheme through which Rural Electrification is carried out is known as Rural Electrification Scheme.
- This scheme is organized by Rural Electrification Corporation(R.E.C), whose head office is at Delhi.
- The main functions of Rural Electrification Corporation are:
- (i) Achieving of 100% Electrification of the Colonies, Habitations, Harijanwadas etc.
- (ii) Erection of new sub-stations providing of additional Transformers for reduction of low voltage and providing of intermediate poles to improve the distribution network and to reduce the line losses.
- (iii) Energisation of Agricultural Pump-sets, replacement of meters with high accuracy meters and Providing of Air-Blast (A.B) cables in the theft prone areas to reduce the theft.
- For achieving all targets, the R.E.C is mobilizing funds from various government bodies and from the abroad also.
- The R.E.C may provide 100% or some percentage of subsidies for Rural electrification depending on the type and place of erection work.
- Theses schemes are generally executed 1 year to 3 or 4 year depending on the work.

7.SURVEY OF LOAD PARTICULARS IN A VILLAGE

- Before taking up of the erection of lines both L.T & H.T. in a village, it becomes necessary to survey the load particulars.
- The survey of the load should be carried out accurately.
- In general the various types of loads in a village are as follows.
- (i) Domestic load
- (ii) Industrial load
- (iii) Agricultural load
- (vi) Commercial load
- (v) Street lighting load
- (vi) Temples, Hospitals, Hotels etc.

- Having marked the position of the load on the map, on the basis of the walk over survey, a detailed load survey can be carried out for effective electrification of a village.
- After load survey, a detailed route survey for the lines has to be made and alignment of the lines should be done.
- The proposed route shall be of the shortest practicable distance.
- The first thing to do is, select the route and plot it on a map. The second step is to conduct a walk survey to determine the topography of the area and any obstacles likely to come across.
- The following area should be avoided as far as possible.
- (i) Abrupt changes in the line route.
- (ii) Restricted access for transport vehicles.
- (iii) Difficult crossings.
- (iv) Private land.
- (v) Railway track crossing.
- (vi) Telephone line crossing.
- (vii) Crossing over buildings.
- (viii) River/pondage crossings.

- For the river on which the crossing is to be done, the dates of high flood level of atleast the previous 20 years is to be obtained from the revenue authorities and clearance is to be designed.
- The Railway and Road crossings should be as minimum as possible.
- Proper guarding is necessary at the road, Railway line, Communication line crossings.
- For conducting a survey of distribution lines in a village, a scaled map of the Village taken and following are marked on the map.
- 1. The nearest H.T. lines from which the tapping will be taken for the distribution transformer.
- 2. The location of distribution transformer after taking into consideration the distribution of load.
- 3. The layout of the L.T. lines network with location of angle poles and road crossings.

8.CAPACITY OF TRANSFORMER

- The Transformer located in rural areas is called Distribution Transformer(11 kV/440 V).
- The capacity (rating) of the transformer depends on the total load, Studies have revealed that, the capacity of distribution transformer should much greater than the total load.
- For an existing distribution system the appropriate Capacity of transformer may be taken by considering a suitable Diversity Factor to meet the future increased load demand.
- Generally a diversity factor of 1.5 may be assumed for distribution transformer.
- For example if the total load is 500 kVA, the transformer capacity is 500x1.5= 750 kVA.

1.DETERMINATION OF CAPACITY OF A TRANSFORMER

- PROBLEM --1:
- Determine the capacity of a transformer required in a village for the following load particulars.

a) 100 No's of domestic loads of 500W each.

b) 2 Industries with 5 H.P. motors each,

c) 50 Agricultural pump-sets with 2 H.P. motors each.

d) 1 Hospital with a load of 10 kW load.

- Assuming the efficiency and power factor of Industrial motors and Agricultural pump-sets as 85 % and 0.8 p.f. lag. respectively.
- For domestic and hospital load efficiency as100 % and p.f being unity.

1. Domestic load $= \dfrac{100 \times 500}{1 \times 1 \times 1000} = 50\ kVA$

2. Industrial load $= \dfrac{2 \times 5 \times 735.5}{0.85 \times 0.8 \times 1000} = 10.816\ kVA$

3. Agricultural load $= \dfrac{50 \times 2 \times 735.5}{0.85 \times 0.8 \times 1000} = 108.161\ kVA$

4. Hospital load $= \dfrac{1 \times 10}{1} = 10\ kVA$

Total = 178.977 kVA

- Capacity of a Transformer
- = Total load x diversity factor
- = 178.977 x 1.5 = 268.465 kVA

- The choice of capacity of Transformer is as follows.
- 1. One Transformer of a capacity of 300 kVA (because 268.465 kVA rating transformer is not available).
- 2. One transformer of capacity 200 kVA for supplying agricultural load and another of rating 100 kVA for supplying Domestic, Industrial and Hospital load.

9.LOCATION OF TRANSFORMER

- The distribution transformer is generally placed on H-type poles (called pole-mounted transformer) or on a plinth (called plinth-mounted transformer).
- The transformer should be located at the load centre to keep the voltage drop and losses within permissible limits.
- If the transformer is not located at the load centre, then the farthest consumer obtain an extremely low voltage even though a reasonably good voltage level is maintained at the transformer secondary.
- If a village has limited load including agricultural load, then one transformer is sufficient.
- If a village has more agricultural load, then it is advisable to install two transformers, one for supplying agricultural loads and another for supplying other loads (domestic, industrial, commercial etc.).

9.1 VOLTAGE REGULATION

- Owing to the variations in the current flow through a transmission and distribution line, there is variation in the voltage drop in the line. Thus the receiving end voltage changes with changing load.
- It is necessary under electricity rules to maintain the voltage at the receiving end of lines within permissible limits as given below.
- 1. Voltage upto 33 kV = $\pm 6\%$
- 2. Voltage above 33 kV= $\pm 12.5\%$

- The voltage regulation is usually considered as the percentage drop with reference to the receiving end voltage.
- Percentage regulation = $\frac{Es-Er}{Er} * 100$
- Where Es = Sending end voltage and
- Er = Receiving end voltage.
- The voltage regulation of the line depends on type of conductor, kW-km, voltage drop and power factor.
- The kW-km for 11 kV, 3 lines for 1% voltage drop constants at various power factors are given in Table.
- The Regulation factors for different conductors is as follows.

Table 4.1 : Regulation constants of 11 kV Line

S.No.	Details of the Conductor	kW-km for 1% voltage drop			
		UPF	0.9 p.f	0.8 p.f	0.7 p.f
1.	$\frac{7}{2.11}$ mm (20 mm^2) ACSR (Squirrel)	706	674	640	605
2.	$\frac{7}{2.59}$ mm (30 mm^2) ACSR (Weasel)	1150	970	900	840
2.	$\frac{7}{3.35}$ mm (50 mm^2) ACSR (Rabbit)	1920	1490	1330	1200

Table 4.2 : Regulation Constants of Distribution (415 *V*) Line

S.No.	Details of the Conductor	kW-km for 1% voltage drop			
		UPF	0.9 p.f	0.8 p.f	0.7 p.f
1.	$\frac{7}{2.11}$ mm (20mm^2) ACSR (Squirrel)	1.08	0.98	0.93	0.88
2.	$\frac{7}{2.59}$ mm (30mm^2) ACSR (Weasel)	1.63	1.41	1.31	1.23
3.	$\frac{7}{3.35}$ mm (50mm^2) ACSR (Rabbit)	2.72	2.18	1.96	1.78

The above values are for

- The above values are for a conductor temperature of 60°C.
- For a conductor temperature of 50°C the above values shall be about 3 % higher and for a temperature of 70°C about 3 % lower.
- 11 kV % regulation

$$= \frac{kW - km}{Diversity\ Factor\ (D.F)\ x\ Regulation\ constant}$$

- $$= \frac{kVA - km\ x\ Power\ factor}{Diversity\ Factor\ (D.F)\ x\ Regulation\ constant}$$

- L.T % regulation

$$= \frac{kW - km}{Diversity\ Factor\ (D.F)\ x\ Regulation\ constant}$$

- $$= \frac{kVA - mts\ x\ 0.0007355}{Diversity\ Factor\ (D.F)\ x\ Regulation\ constant}$$

2 CALCULATION OF VOLTAGE REGULATION

- Calculate the voltage regulation of a 11 kV line with 7/2.59 mm ACSR conductor which is emanating from 33/11 kV substation. The connected distribution transformers and distances are shown in Fig.

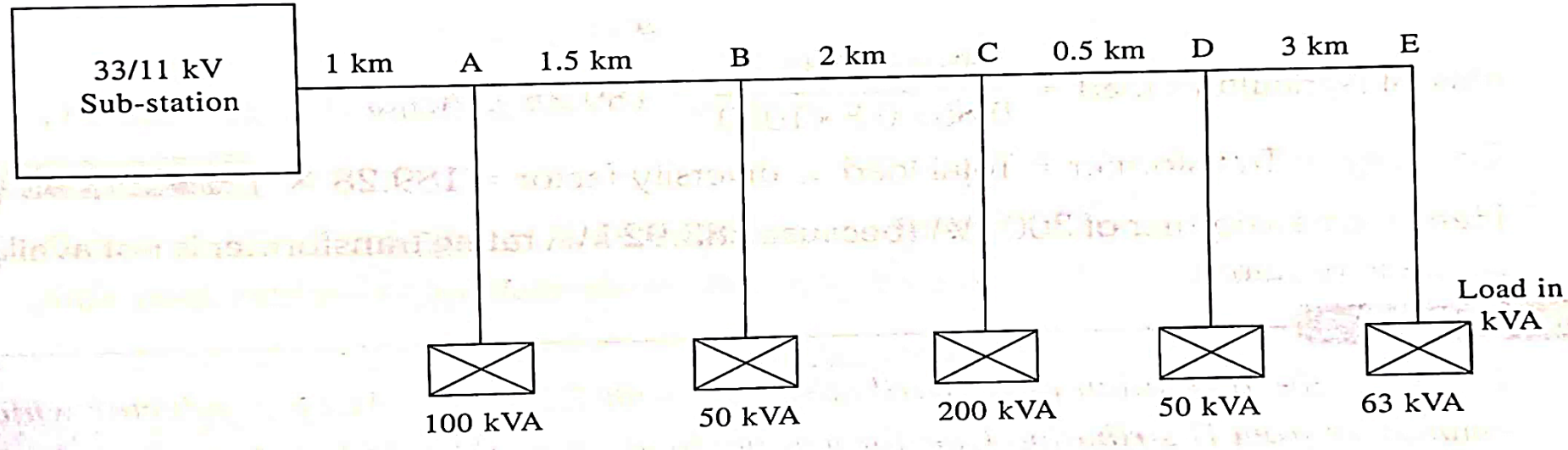


Fig : Load Particulars of 11 kV Line

- For calculating the voltage regulation of the line, it is assumed that the loads are concentrated at the point of tappings and taking moments about the section we have,
- kVA-km = 100 x 1+50x (1+ 1.5) +200 x (1+1.5+2)+50x (1+ 15+9 +0,5) +63 x (1+1.5+2+05 +3)
- = 100 + 125 + 900 + 250 + 504 = 1879 kVA-km

- The kVA-km moments can also be calculated as follows.
- kVA-km = (100 + 50 + 200 + 50 + 63) x 1+ (50 + 200 + 50 + 63) x 1.5 +(200 + 50 + 63) x 2 + (50 + 63) x 0.5+63 x 3 =463 + 544.5 + 626 + 56.5 + 189 = 1879 kVA-km

- Now kVA-km x power factor
- 1879 x 0.8 = 1503.2 kW-km

- Assuming a diversity factor of 1.5, regulation constant for 7/2.59 mm ACSR conductor for 1% drop at 0.8 p.f is 900 (from Table 4.1).
- % regulation

$$= \frac{kW - km}{Diversity\ Factor\ (D.F)\ x\ Regulation\ constant}$$

- % regulation $= \frac{1503.2}{1.5\ x\ 900} = 1.113\%$
- The regulation is within the limits, hence satisfied.

Problem-3

- Calculate the kVA rating of a distribution transformer needed in village situated at 2 km from a33/11 kV Sub-station. The village has 35 No. Agriculture load of 5 H.P. each. (with 85% efficiency and 0.8 log power factor and diversity factor as 1.5).

- kVA of Agriculture load =

$$= \frac{35 \times 5 \times 735.5}{0.85 \times 0.8 \times 1000} = 189.28\ kVA.$$

- kVA.Capacity of Transformer

  = Total load x diversity factor

  = 189.28 x 1.5 = 283.92 kVA

Hence, a transformer of 300 kVA (because 283.92 kVA rating transformer is not available)rating is required.

Workout

- Calculate the regulation of a distribution line with 7/2.11 mm ACSR conductor which is emanating from Distribution transformer, the load particulars with distance are shown inFig.

March/April. 2014

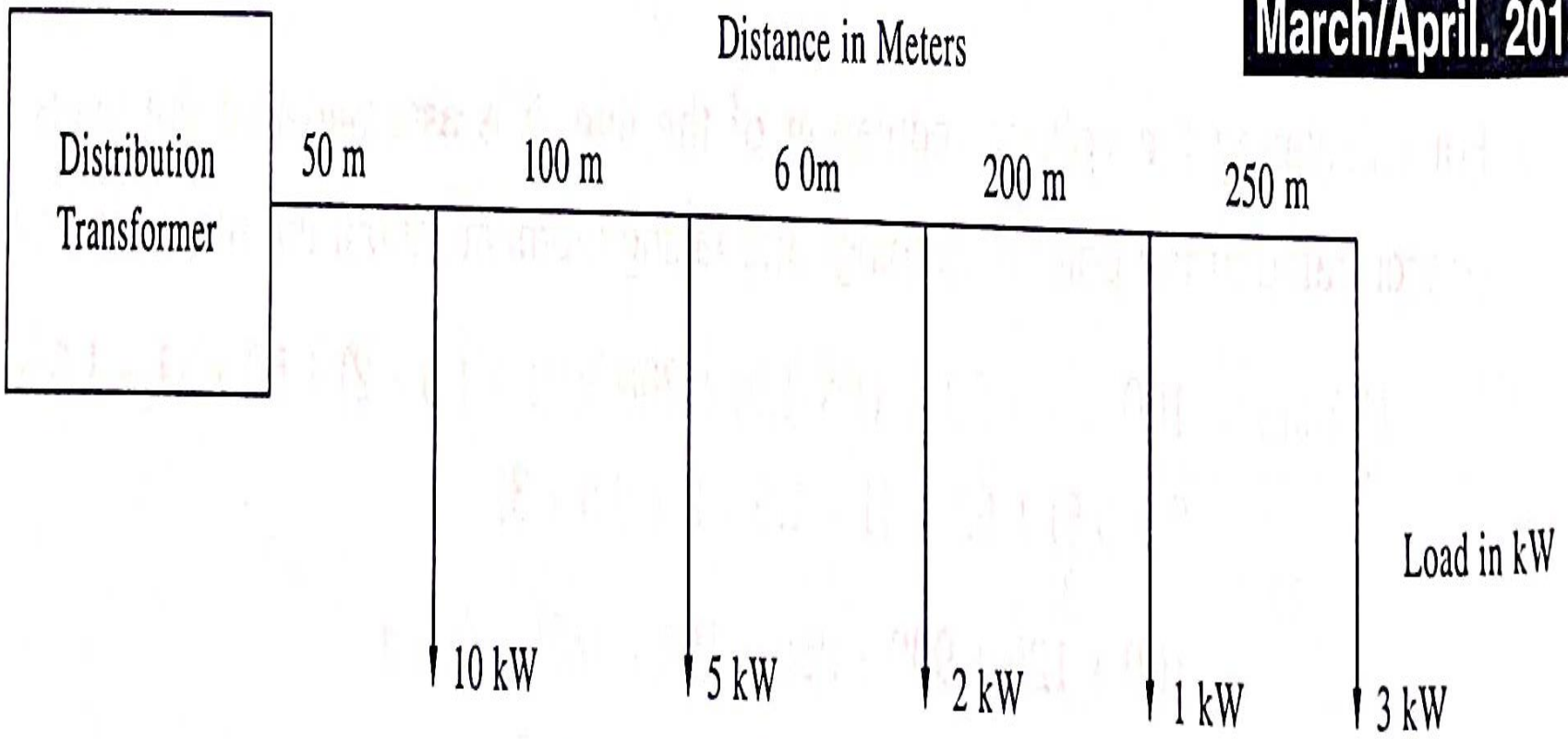


Fig 4.9 : Load Particulars of a Distribution Line

olution :

10 ESTIMATION OF ELECTRIFICATION OF A VILLAGE

- The following example explains the estimate for the quantities and cost of the materials required for electrification of a village.

PROBLEM:-.1

- Prepare an estimate for the quantity of materials required and their cost for a village electrification which has loads of
- (a) 162 No’s domestic loads each 500 W.
- (b) 3 No’s rice mills each of 10 H.P.
- (c) Street lights of 23 No’s each of 40 W.
- (d) 23 No’s agricultural load each of 7.5 H.P.

- Assume any missing data.

- Assumptions :
- A 3-phase, 5-wire system is running in the village for supplying domestic, rice mills, street lights for a length of 2kM.
- A 3-phase, 3-wire system is required for supplying agricultural pump sets for length of 3.5 kM.
- The efficiency and power factor of motors is 85 % and 0.8 lagging. respectively.
- Diversity Factor of the loads is 1.5.
- Average span = 50 m

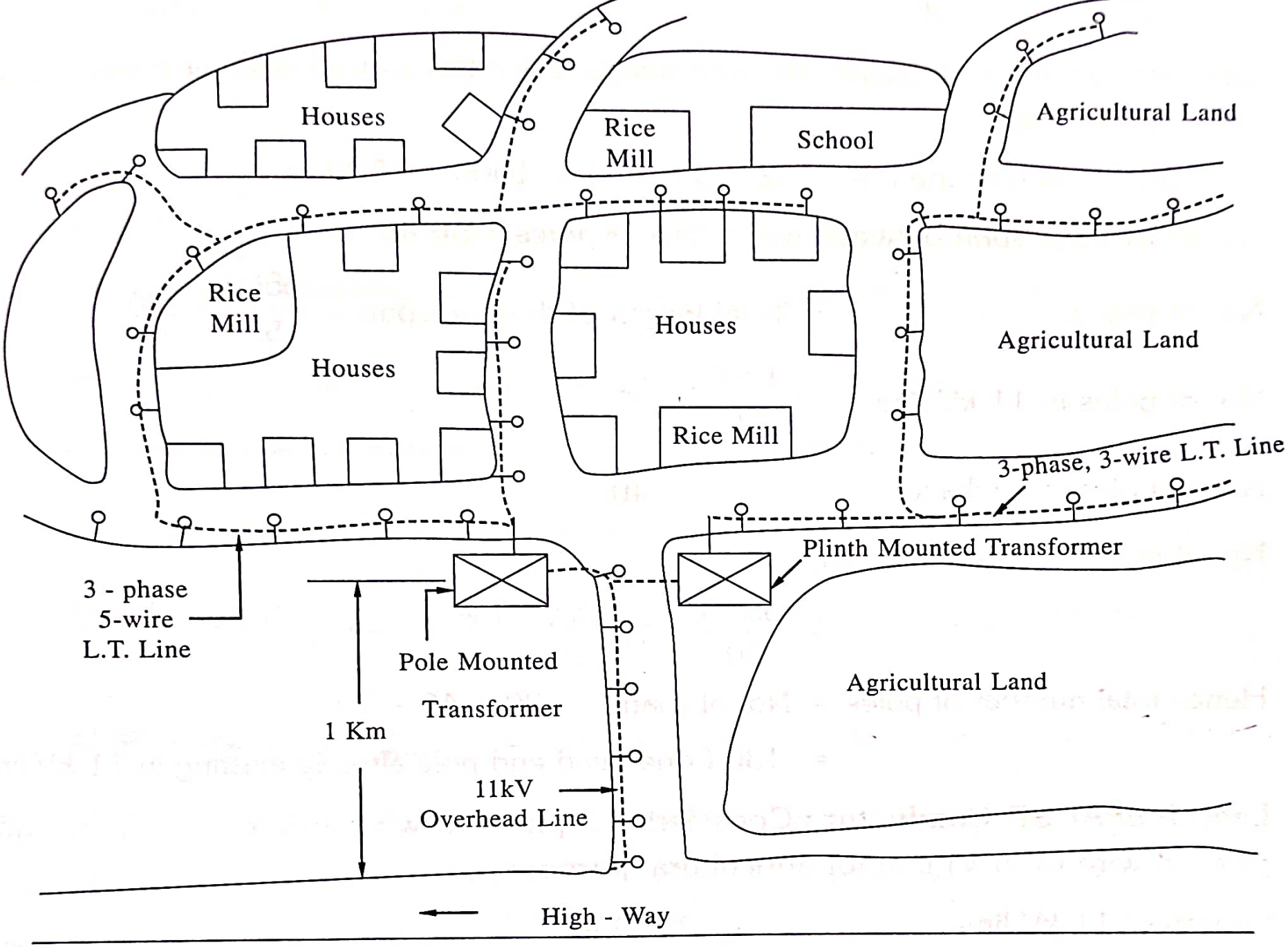


Fig 4.11 : Plan of a Village and Layout of L.T. and H.T. Lines

- 1. Capacity of Transformer :

(i) Domestic load $= \frac{162 \times 500}{1000} = 81\ kVA$

(ii) Rice mill load $= \frac{3 \times 10 \times 735.5}{0.85 \times 0.8 \times 1000} = 32.448\ kVA$

(iii) Street light load $= \frac{23 \times 40}{1000} = 0.92\ kVA$

(iv) Agricultural load $= \frac{23 \times 7.5 \times 735.5}{0.85 \times 0.8 \times 1000} = 186.579\ kVA$

Total = 300.947 *kVA*

Taking diversity factor 1.5 into consideration,

The capacity of transformer to be installed= 300.947 x 1.5 = 451.42 kVA = 500 kVA.

It is proposed to install two transformers of rating 300 kVA and 200 kVA. (The transformers of capacity above 250 kVA- Plinth Mounted Sub-station)

The 300 kVA transformer (plinth mounted) is exclusively for Agricultural load and 200 kVA transformer(pole mounted) is for other loads (domestic, rice mills, street lights etc.)

- **2. No. of Poles required :**
- The input to the distribution transformer is to be fed from 11 kV line which is at a distance of 1 km.
- Total length of the line = (2+3.5+1) x 1000 = 6500 m
- Let an average span between two adjacent poles = 50m
- No. of spans = Total length of the line/span =6500/50 = 130
- No. of poles in 11 kV line = 1000/50= 20
- No. of poles in a village = 2000/50 = 40
- No. of poles for agricultural purpose = 3500/50 = 70
- Hence total number of poles=No. of spans
- = 20 + 40 + 70=130 (one dead end pole already existing in 11 kV line).

- **3. Length of ACSR Conductor :**
- Considering 3-phase, 5-wire system in a village and 3-phse, 3-wire (415 V) line for agricultural purpose.
- Length of 11 kV line = 1000 m
- Length of 3-phase, 5-wire line = 2000m
- Length of 3-phase, 3-wire line = 3500 m
- Total length of ACSR conductor (7/2.59 m)'for 11 kV line= 3 x 1000 = 3000 m
- Total length of ACSR conductor (7/2.11 m) for L.T. line= 5 x 2000 + 3 x 3500 = 20500 m

- **4. No. of Insulators :**
- Considering 5 (five) 90° angle points with in a village and 6 (six)angle points and 1 dead end pole in agricultural line.
- No. of 11kV pin insulators = 20x 3 = 60
- No. of 11 kV Disc insulators = 1x 3 = 3
- No. of L.T. pin insulators = (3 x 63 +4 x 35) = 189 + 140 = 329
- No. of L.T Reel insulators = 40x 1 = 40
- No. of L.T shackle insulators=(5x 4+7x 3) x2 =(20+21)x 2=82

S.No.	Material with Specifications	Quantity	Rate		Total Cost	Remarks
			Rs	Per	Rs. Ps.	
1.	300 kVA, $\frac{11\text{kV}}{400\text{ V}}$, Distribution Transformer complete with all accessories.	1 No	4,10, 1000-00	each	4,10, 000-00	
2.	200 kVA, $\frac{11\text{kV}}{400\text{ V}}$, Distribution Transformer complete with all accessories.	1 No	2,10, 000-00	each	2,10, 000-00	
3.	PSCC poles 8m or 11m	130 No	2,600-00	each	3,38,000-00	
4.	ACSR conductor $\left(\frac{7}{2.59\text{ mm}}\right)$ for 11 kV line	3 km	12-00	m	36,000-00	
5.	ACSR conductor $\left(\frac{7}{2.11\text{mm}}\right)$ for L.T. line	20.5 km	11-00	m	2,25,500-00	

6.	11 kV pin insulators with pins	60 No	150-00	each	9,000-00	
7.	11 kV Disc insulators with fittings	6 No	450-00	each	2,700-00	At T/F
8.	L.T pin insulators with pins	329 No	120-00	each	39,480-00	
9.	L.T Reel insulators	40 No	10-00	each	400-00	
10.	L.T Shackle insulators with D-clamps	82 No	45-00	each	3,690-00	
11.	M.S. Cross-arms for 11 kV (1.5 m × 76 mm × 38 mm × 6.4 mm)	20 No	250-00	each	5,000-00	
12.	M.S. Cross-arms for L.T poles (1.5 m × 50 mm × 30mm × 3.7 mm)	121 No	175-00	each	21,175-00	110 + 11
13.	Top insulator brackets (60 × 8 mm)	118 No	62-00	each	7,316-00	

14.	M.S. Channel with clamps (100 mm × 50 mm × 6 mm × 2.5 m long)	2 No	750-00	each	1,500-00	for supporting T/F
15.	M.S. angles with clamps (50 mm × 50 mm × 6 mm × 2 m long) for G.O.S, H.G.fuse and	6 No	350-00	each	2,100-00	3 for each T/F
16.	M.S. Channel (10 mm × 50 mm × 6 mm × 2.5 m long)	2 No	150-00	each	300-00	for T/F belting
17.	11 kV Gang Operating switch (Air Break Triple Pole) complete with 25 mm dia operating pipe and handle	2 No	4,500-00	each	9,000-00	
18.	11 kV H.G. Fuse unit	2 sets	500-00	set	1,000-00	
19.	ICTPN, 100 A, 500 V with rewirable fuses.	2 No	4,100-00	each	8,200-00	
20.	Stay sets (complete)	50 No	3,200-00	each	1,60,000-00	
21.	Earth sets (complete)	20 No	2,100-00	each	4,200-00	
22.	Earth wire (8 SWG)	50 m	18-00	m	900-00	earthing
23.	11kV Lightning Arresters with fittings	2 sets	3,300-00	set	6,600-00	for 2 T/F

24.	Distribution boards with locking arrangement	2 No	650-00	each	1,300-00	
25.	Barbed wire	50 Kg	40-00	kg	2,000-00	
26.	Binding wire (Aluminium)	5 Kg	50-00	kg	250-00	
27.	31/2 core, 120 mm^2, aluminium conductor, armoured, 1100 V grade, PVC cable.	20m	525-00	m	10,500-00	From T/F to D.B.
28.	120 mm^2, single core aluminium conductor, 600V grade PVC insulation, PVC cable.	50m	150-00	m	7,500-00	From D.B. to L.T. Line
29.	Nuts & Bolts of different sizes	L.S	—	—	1,000-00	
30.	Danger plate with clamps	15 No	10-00	each	150-00	
31.	Cradle guards	1 No	200-00	each	200-00	
32.	Cement	2 bags	190-00	bag	380-00	
33.	Sand	L.S	—	—	150-00	
34.	Plinth (Bricks)	1 No	2,000-00	each	2,000-00	For T/F
35.	Sundries to finish the job (such as aluminium paint, G.I. thimbles, tape et.)	L.S	—	—	5,000-00	
				Total	**15,32,491/-**	
				Storage & transportation 5%	76,624-55	
				Labour charges 10%	1,53,249-10	
				Contingencies 5%	76,624-55	
				Grand Total	18,38,989/-	
				Say	**18,39,000/-**	

ECONOMIC FEASIBILITY OF THE SCHEME

- Its on which required for completion of the scheme most economically, which may consists of the following
- 1. Economical load centre.
- 2, Economical length of the transmission and distribution line
- 3. Economical of the cost of the land
- 4. Economical for easy transportation of the main and auxiliary equipment

INDIAN ELECTRICITY (I.E) RULES

- These rules extract are from the Indian electricity rules.
- Before actually studying Indian Electricity rules (I.E. Rules) and other precautions, we should realise why these rules and regulations have been framed.
- The rules and regulations have been framed by competent authority to:
- 1. Safe guard consumers of electrical energy from shock.
- 2. Minimize risk of fire.
- 3. Ensure satisfactory operation of equipment and apparatus used.

- **Rule-1 : Short Title and Commencement :**
- (i) These rules may be called the Indian Electricity Rules, 1956.
- (ii) They shall come into force at once.
- **Rule-2 : Definitions**
- In these rules, unless the context otherwise requires
- (a) “The Act” means means the Indian Electricity Act, 1910;
- (b) “Accessible” means within physical reach without the use of any appliance or special effort;
- (c) “Ampere” means a unit of electric current and is the unvarying electric current which when passed thoroug a solution nitrate of silver in water, in accordance with the specification set out in Annexure 1 , deposits silver at the rate of 0.001118 of a gramme per second.
- (d) “Annexure” means an annexure to these rules;
- (e) “Apparatus” means electric apparatus and all machines, fittings, accessories and appliance in which conductors are used;

- (f) “Authorised person” means a Person
- (g) “Bare” means not covered with insulating material;
- (h) “Cable” means a length of insulated single conductor (solid or stranded) Or two or more such conductors, each provided with its own insulation, which are laid up together. Such insulated conductors may or may not be Provides with an overall mechanical protective covering;
- (i) “Flexible cable” means a cable consisting of one or more cores each formed of a group of wires, the diameter and the physical properties of the wires and the insulating material being such to afford flexibility;
- (j). “Circuit” means an arrangement of conductor or conductors for the Purpose of conveying energy and forming a system or a branch of a system:
- (k) “Circuit breaker” means a device, capable of making and breaking the circuit under all conditions and unless otherwise specified, so designed as to break the current automatically under abnormal condition;

- (l) “Concentric” means a composite cable comprising an inner conductor which is insulated and one or more outer conductors which are insulated from one another and are disposed over the insulation of and more or less around the inner conductor:
- (m) “Conductor” means any wire, cable, bar, tube, rail or plate used for conducting energy and so arranged as to be electrically connected to a system;
- (n) “Conduit” means rigid or flexible metallic tubing or mechanically strongand fire-resisting non-metallic tubing into which a cable or cables may bedrawn for the purpose of affording it or them mechanical protection;
- (o) “Covered with insulating material” means adequately covered with insulating material of such quality and thickness as to prevent danger;
- (p) “Cut-out” means any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above predetermined amount and shall also include fusible cut-out;

- “Danger” means danger to health or danger to life or any part of body from shock, burn or other injury to persons or Property or from fire or explosion.
- “low” where the voltage does not exceed 250 volts under normal conditions subject, however, to the percentage variation allowed by these rules;
- “medium” where the voltages does not exceed 650 volts under normal conditions subject, however, to the percentage variation allowed by these rules:
- ”high” where the voltage do: s not exceed 33,000 volts under normal conditions subject, however, to the percentage variation allowed by these rules;
- “extra high” where the voltage exceeds 33,000 volts under normal conditions subject, however, to the percentage variation allowed by these rules;
- (v) “electrician” means a person over 21 years of age, who is competent for the purpose of the rule in which the terms is used and who has been appointed in wiring by the owner, agent or manager of installation.

- **Rule-3 :** Authorization owner, agent or manager of a mine, or the agent of analyzed well in an oil-field or a contractor to carry out duties incidental
- A supplier or a consumer, of the oil-field or the owner of a drilled well in an for the time being a under contract with the generation, transformation, transmission, Conversion and distribution.
- **Rule-4 : Qualification of Inspectors**
- No person shall be appointed to be an Inspector unless-
- i) He possesses a degree in electrical engineering or its equivalent university or institution; and
- (ii) he has been regularly engaged or less than two years have

GENERAL SAFETY PRECAUTIONS :

- **Rule-29 : Construction, Installation, Protection, Operation and Maintenance of Electric Supply Lines and Apparatus :**
- All electric supply line and apparatus shall be of sufficient ratings for power, insulation and estimated fault current and of sufficient mechanical strength, or the duty which they may be required to perform under the environmental conditions of installation and shall be constructed, installed, protected, worked and maintained in such a manner as to ensure safety of human being, animals and property.

- **Rule-30 : Service Lines and Apparatus on Consumer's Premises :**
- (i) The supplier shall ensure that all electric supply lines, wires fittings and apparatus belonging to him or under his control, which are on a consumer's premises are in safe conditions and in all respects fit for supplying energy and the supplier shall take due precautions to avoid danger arising on such premises from such supply lines, wires fittings and apparatus.
- (ii) Service lines placed by the supplier on the premises of a consumer which are under ground or which are accessible shall be so insulated and protected by the supplier as to be secured under all ordinary conditions against electrical, mechanical, chemical or other injury to the insulation.
- (iii) The consumer shall, as far as circumstances permit, take precautions for the safe custody of the equipment on his premises belonging to the supplier.
- (iv) The consumer shall also ensure that the installation under his control maintained in a safe conditions.

- **Rule-31 : Cut-out on Consumer's Premises :**
- (i), ‘The supplier shall provide a suitable cut-out in each conductor of every service line other than earthed or earthed neutral conductor or the earthed) conductor of a concentric cable with in a consumer's premises, in position. Such cut-out shall be contained within an adequately enclosed fireproof receptacle.
- Where more than one consumer is supplied through a common service line, each such consumer shall be provided with an independent cut-out at the point of junction to the common service.
- (ii) Every electricity supply line other than the earthed or earthed neutral conductor of any system or the earthed external conductor of a concentric cable shall be protected by a suitable cut-out by its owner.

- **Rule-32 : Identification of Earthed Neutral Conductor and Position of Switches and Cut-out Therein :**
- Where the conductors include an earthed conductor of a two-wire system or an earthed neutral conductor of a multi-wire system or a conductor which is to be connected there to, the following conditions shall be complied with.
- (i) An indication of a permanent nature shall be provided by the owner of the earthed or earthed neutral conductor, or the conductor which is to be connected there to, to enable such conductor to be distinguished from any live conductor.
- Such indication shall be provided :
- (a) Where the earthed or earthed neutral conductor is the property of the supplier, at or near the point of commencement of supply;
- (b) Where a conductor forming part of a consumer's system is to be connected to the supplier’s earthed or earthed neutral conductor, at the point where such connection is to be made;
- (c) In all other cases, at the point corresponding to the point or commencement of supply or at such other point as may be approved by an Inspector.

- **Rule-33 : Earthed Terminal on Consumer's Premises :**
- (i) The supplier shall provide and maintain on the consumer's premises for the consumer's use a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under Rule 58.
- (ii) The consumer shall take all reasonable precautions to prevent mechanical damages to the earthed terminal and its lead belongings to the supplier.
- (iii) The supplier may recover from the consumer the cost of installation on the basis of the schedule of charges notified in advance, and there such schedule of charges is not notified.

- **Rule 34: Accessibility of Bare Conductors :**
- Where bare conductors are used in building, the owner of such conductors shall.

1. Ensure that they are inaccessible;
2. Provide in readily assessable position switches for rendering them dead whenever necessary; and
3. Take such other safety measure as are considered necessary by the Inspector

- **Rule-35 : Danger Notices :**
- owner of every medium, high and extra-high voltage installation shall affix permanently in a conspicuous position a [Danger] notice in Hindi or English and the local language of the district, with a sign of skull and bones [of design as per the relevant ISS No. 2551] on:

1. Every motor, generator, transformer and other electrical plant and equipment together with apparatus used for controlling or regulating the same;
2. All supports of high and extra-high voltage overhead lines which can be easily climbed upon without the aid of ladder or special appliances.

- **Rule-36 : Handling of Electric Supply Lines and Apparatus :**
- Before any conductor or apparatus is handled, adequate precautions shall betaken, by earthing or other suitable means, to discharge electricity such conductor or apparatus and any adjacent conductor or apparatus if there is danger therefrom, and to prevent any conductor of apparatus from being accidentally or inadvertently electrically charged when Persons are working thereon.
- Every person who is working on an electric Supply line or apparatus or both shall be provided with tools and devices such as gloves, rubber shoes, safety belts, ladders, earthing devices, helmets, line testers, hand lines and the like for protecting him from mechanical and electrical injury. Such tools and devices if shall always be maintained in sound and efficient working conditions.
- No person shall work on any live electric supply line or apparatus and no person shall assist such person on such work, unless he is authorized in that behalf and takes the safety measures approved by the Inspector.
- Every telecommunication line on supports carrying a high or extra-high voltage lines shall, for the purpose of working thereon, be deemed to be a high voltage line.

- **Rule-37 : Supply to Vehicles, Cranes, etc., :**
- Every person owning a vehicle, travelling crane or the like to which energy is supplied from an external source shall ensure that it is efficiently controlled by a suitable switch enabling all voltage to be cut-off in one operation and where such vehicle, travelling crane or the like runs on metal rails, the owner shall ensure that the rails are electrically continuous and earthed.

- **Rule-38 :Cables for Portable or Transportable Apparatus :**
- Flexible cables shall not be used for portable or transportable motors, generators, transformers, rectifiers, electric drills, electric sprays, welding sets or any other portable or transportable apparatus unless they are heavily insulated and adequately protected from mechanical injury.
- Where the protection is by means of metallic covering, the covering shall be in metallic connection with the frame of any such apparatus and earth.
- The cables shall be three core type and four core type for portable and transportable apparatus working on single phase and three phase supply respectively and the wire meant to be used for ground connection shall be easily identifiable.

- **Rule-39 :Cables Protected by Bituminous Materials :**
- Where the supplier or the owner has brought into use and electric supply line(other than on over-head line) which is not completely enclosed in a continuous metallic covering connected with earth and is insulated or protected in situ by composition of material of a bituminous character:
- It shall not be permissible for the supplier or the own after the coming into force of these rules, to bring into use any further electric supply line as aforesaid which is insulated or protected in situ by any composition or material known to liable to produce noxious or explosive gases on excessive heating.

- **Rule-40 : Street Boxes :**
- Street boxes shall not contain gas pipes and precautions shall be taken to Prevent as far as reasonably possible, any influx of water or gas.
- Where electric supply lines forming part of different systems pass through the same street box they shall be readily distinguishable from one another and all electric supply lines at high or extra-high voltage in street boxes shall be adequately supported and protected so as to prevent risk of damages or danger from adjacent electric supply lines.
- All street boxes shall be regularly inspected for the purpose of detecting the presence of gas and if any influx or accumulation is discovered, the owner shall give immediate notice to any authority or company who have gas mains in the neighbourhood of the street box and in cases where a street box is large enough to admit the entrance of a person after the electric supply lines or apparatus therein have been placed in position, ample provision shall be made:

- **Rule-41 : Distinction of Different Circuits :**
- The owner of every generating station, sub-station, junction-box or pillar in which there are any circuits or apparatus, [whether intended for operation at different voltages or at the same voltage], shall ensure by means of indication of a permanent nature, that the respective circuits are readily distinguishable from one another.
- **Rule-42 :Accidental Charge :**
- The owner of all circuits and apparatus shall so arrange them that there shall be no danger of any part thereof becoming accidentally charged to any voltage beyond the limits of voltage for which they are intended. Where AC and DC circuits and installed on the same support they shall be so arranged and protected that they shall not come into contact with each other when live.

- **Rule-43 : Provisions Applicable to Protective Equipment :**
- Fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires, in addition to fire extinguisher suitable for dealing with electric fires, shall be conspicuously marked and kept in all generating stations, [enclosed sub-station and switch station] in convenient situations. The fire extinguishers shall be tested for satisfactory operation at least once @year and record of such tests shall be maintained.
- First-aid boxes or cupboards, conspicuously marked and equipped with such contents as the state Government may specify, shall be provided and maintained in every generating station enclosed sub-station and enclosed switch-station so as to be readily accessible during all working hours.

- **Rule-44 :Instructions for Restoration of Persons Suffering from Electric Shock :**
- Instructions, in (English or Hindi and local language of the district, and where Hindi the local language, in English and Hindi) for the restoration of persons suffering from electric shock, shall be affixed by the owner in a conspicuous place in every generating station, enclose switch-station and in every factory as defined in clause (m) of section 2 of the Factories Act, 1948 (LXIII of 1948).
- Copies of the instructions shall be supplied on demand by an officer or officers appointed by the Central or the State Government in this behalf at a price to be fixed by the Central Government.
- The owner of every generating station, enclosed sub-station, enclosed switch-station, and every factory or other premises to which this rule applies, shall ensure that all authorised persons employed by him acquainted with and are competent to apply the instructions.
- In every manned high voltage or extra-voltage generating station, sub-station or switch-station, an artificial respirator shall be provided and kept in goods working condition.

- **Rule-45 :Precautions to be Adopted by Consumers, Owners, (Occupiers), Electrical Contractors, Electrical Workmen and Suppliers :**

- No electrical installation work, including additions, alternations, repairs and adjustments to existing installations, except such replacement of lamps, fans, fuses, switches, low voltage domestic appliances and fittings as in no way alters its capacity or character, shall be carried out upon the premises of or on behalf of any [consumer, supplier, owner of occupier], for the purpose of supply to such consumer, owner, [or occupier] except an electrical contractor licenced in this behalf by the State Government and under direct supervision of a person holding a certificate of competency [and by a person holding a permit] issued or recognized by the State Government.
- No electrical installation work which has been carried out in contravention of sub-rule (i) shall either be energised or connected to the works of any supplier.

- **Rule:46 :Periodical Inspection and Testing of Consumer's Installation :**
- Where an installation is already connected to the supply system of the supplier, every such installation shall be periodically inspected and tested at intervals not exceeding five years either by the Inspector [or any officer appointed to assist the Inspector] or by the supplier as may be directed by the State Government in this behalf or [in the case or installations belonging to, or under the control of the Central Government, and] in the case of installations in mines, oil fields and railways, by the Central Government.
- The fees for such inspection and test shall be determined by the Central or the State Government, as the case may be, in the case of each class of the consumers and shall be payable by the consumer in advance.
- Notwithstanding the provisions of this rules, the consumers shall at all times be solely responsible for the maintenance of his installation in such condition as to be free from danger.

GENERAL CONDITIONS RELATING TO SUPPLY AND USE OF ENERGY

- **Rule-47 :Testing of Consumer's Installation :**
- Upon receipt of an application for a new additional supply of energy and before connecting the supply or reconnecting the same after a period of six months, the supplier shall inspect and test the applicant's installation.
- The supplier shall maintain a record of test results obtained at each supply point to a consumer, in a form to be approved by the Inspector.
- If as a result of such inspection and test, the supplier is satisfied that the installation is likely to constitute danger, he shall serve on the applicant a notice in writing requiring him to make such modifications as are necessary to render the installation safe. The supplier may refuse to connect or reconnect until the required modifications have been completed and he has been notified by the applicant.

- Rule-48 :Precautions Against Leakage Before Connection :

I. The supplier shall not connect with his works the installation or apparatus on the premises of any applicant for supply unless he is reasonably satisfied that the connection will not at the time of making the connection, cause a leakage from the installation or apparatus of a magnitude detrimental to safety. Compliance with the rule shall be checked by measuring the insulation resistance as provided below:

- (a) High voltage equipments/installations :
  - 1. High voltage equipments shall have the IR value as stipulated in the relevant Indian Standard.
  - 2. At the pressure of 1000 V applied between each live conductor and earth for a period of one minute the insulation resistance of HV installations shall be at least 1 mega ohm or as specified by the [Bureau of Indian Standards] from time to time.
- (b) Medium and low voltage installation : at a pressure of 500 V applied between each live conductor and earth for a period of one minute, the insulation resistance of medium and low voltage installation shall be at least 1 mega ohm or as specified by the [Bureau of Indian Standards] from time to time.

II. If the supplier declines to make a connection under the provisions of sub-rule (i),he shall serve upon the applicant a notice in writing stating his reason for so declining.

- **Rule-49 :Leakage on Consumer's Premises :**
- If the Inspector or any officer appointed to assist the Inspector and or the supplier has reason to believe that there is in the system of a consumer leakage which is likely to affect injuriously the use of energy by the supplier or by the other persons, or which is likely to cause danger, he may gives the consumer reasonable notice in writing that he desire inspect and test the consumer's installation.
- If, on such notice being give :
- (a) The consumer does not give all reasonable facilities for inspection and testing of this installation, or
- (b) a leakage exceeding 5000" part of the maximum current supplied to the consumer's installation.

- **Rule-50 :Supply and Use of Energy :**
- The energy shall not be supplied, transformed, converted or used or continued to be supplied, transformed, converted or used unless provisions as set out between are observed:
- (a) The following controls of requisite capacity to carry and break the current [are placed] after the point of commencement of supply as defined in Rule 58, so as to be readily, accessible and capable of being easily operated to completely isolate the supply to the installation, such equipment being in addition to any equipment installed for controlling individual circuit or apparatus:

- 1. A linked switch with fuse (s) or a circuit breaker by low and medium voltage consumers;
- 2. A linked switch fuse (s) or a circuit breaker by HV consumers having aggregate installed transformer/apparatus capacity up to 1000 kv to be supplied at voltage (above 11 kVA and not exceeding 33 kv),
- 3. A circuit breaker by HV consumers having an aggregate installed transformer/apparatus capacity above 1000 kV and supplied at 11 kV and above 2500 kVA supplied at higher voltage (above 11 kVA and not exceeding 33 kV);
- 4. A circuit breaker by EHV consumer;
- Where energy is being supplied, transformed, converted or used, the [consumer, supplier or the owner] of. the concerned installation shall responsible for the continuous observance of the provisions of sub-rule (i) in respect of his installations,
- Every consumer shall use all reasonable means to ensure that where energy is supplied by a supplier no person other than the supplier shall interfere with the service lines and apparatus placed by the supplier on the premises of the consumer.

- **Rule-51 :(A) Additional Provisions for Supply and Use of Energy in Multi-Storeyed Building (More than 15 Metres in Height) :**

i. Before making an application for commencement of supply or recommencement of supply after an installation has been disconnected for a period of six months or more the owner/occupier of a multi-storeyed building shall give not less than30 days notice in writing to Inspector together with particulars. The supply of energy shall not be commenced or recommenced within this period, without the approval or otherwise in writing of the Inspector;

ii. The supplier/owner of the installation shall provide at the point of commencement of supply a suitable insulation device with cut-out or breaker to operate on all phase except neutral in the three phase four circuit and fixed in conspicuous position at not more than 2.75 metres above the ground so as to completely isolate the supply to the building in case of emergency.

- The owner/occupier of a multi-storeyed building shall ensure that electric installations/works inside the building are carried out and maintained in such ; manner as to prevent danger due to shock and fire hazards, and the installation tried out in accordance with the relevant code of practices.
- (iv) No other service pipes shall be taken along the ducts provided for laying power cables All ducts provided for power cables and other services shall be provided with fire - barrier at each floor crossing.

- **Rule:51 Provisions Applicable to Medium, High or Extra-high Voltage Installations :**
- The following provisions shall be observed where energy at medium, high or extra -high voltage is supplied, converted, transformed or used :
- (i) (a) All conductors (other than those of overhead lines) shall be completely enclosed in mechanically strong metal casing or metallic covering which is electrically and mechanically continuous and adequately protected against mechanical damage unless the said conductors are accessible only to an authorized person or are installed and protected to the satisfaction of the inspector so as to prevent danger.
- (b) All metal works, enclosing, supporting or associated with the installation, other than that designed to serve as a conductor shall be connected with an earthing system as per standards laid down in the Indian Standards in this regard.
- (c) In case of installation provided in premises where inflammable materials including gases and / or chemicals are produced, handled or stored, the electrical installations, equipment and apparatus shall comply with the of flame proof, dust tight, totally enclosed or any other suitable requirements as per the type of electrical fittings depending upon the hazardous on relevant Indian Standard Specifications.

- Where an application has been made to a supplier for supply of energy to any installation, he shall not commence the supply or where the supply has been discontinued for a period of one year and above, recommence the supply unless he is satisfied that the consumer has complied with, in all respects.
- Where a supplier proposes to supply or use energy at a medium voltage or to recommence supply after it has been discontinued for a period of six months, he shall, before connecting or reconnecting the supply, give notice in writing such intention to the Inspector, [or any appointed to assist the Inspector].

- **Rule-52 : Appeal to Inspector in Regard to Defects :**
- In any applicant for a supply or a consumer is dissatisfied with the action of the supplier in declining to commence, to continue or to recommence the supply of energy to his premises on the grounds that the installation is defective or is likely to constitute danger, he may appeal to the Inspector to test the installation and the supplier shall not, if the Inspector or, under his orders, any other officer appointed to assist the Inspector is satisfied that the installation is free from the defect or danger complained of, be entitled to refuse supply to the consumer on the grounds aforesaid, and shall, within twenty - four hours after the receipt of such intimation from the Inspector, commence, continue or recommence the supply of energy.
- An test for which application has been made under the provision of sub-rule (i)shall be carried out within seven days after the receipt of such application.
- This rule shall be endorsed on every notice given under provisions of rules 47,48 and 49.

- **Rule-53 : Cost of Inspection and Test of Consumer's Installation :**
- The cost of the first inspection and test of a consumer's installation carried out in pursuance of the provisions of rule 47 shall be borne by the supplier and the cost of every subsequent inspection and test shall be borne by the consumer unless in the appeal under rule 52, the Inspector directs otherwise.
- The cost of any inspection and test made by the Inspector, [or any officer appointed to assist the Inspector], at the request of the consumer or other interested party, shall be borne by the consumer or other interested party, unless the Inspector directs otherwise.
- The cost of each and every such inspection and test by whomsoever borne shall be calculated in accordance with the scale specified by the Central or the State Government as the case may be in this behalf.

- **Rule : 54 Declared Voltage of Supply to Consumer :**
- Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the voltage at the point of commencement of supply as defined under rule 58 to vary from the declared voltage :
- In the case of low or medium voltage, by more than 6 percent; or
- In the case of high voltage, by more than 6% on their higher side or by more than 9% on the lower side; or
- In the case of extra high voltage, by more than 10% on the higher side or by more than 12.5% on the lower side.
- Provided that in the case of high voltage, the voltage variation limit of 12.5 % may continue till the 315 March, 1974.

- **Rule-55 : Declared Frequency of Supply to Consumer :**
- Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the frequency of an alternating current supply to vary from the declared frequency by more than 3 %.
- **Rule-56 : Sealing of Meters and Cut-outs :**
- (i) A supplier may affix one or more seals to any cum maximum demand indicator, or other apparatus premises in accordance with section 26, and no person other than the sup shall break any such seal.
- (ii) The consumer shall use all reasonable means in his power to ensure such seal is broken otherwise than by the supplier.
- (iii) The word “Supplier” shall for the purpose of this rule include a State Government when any meter, maximum demand indicator or other apparatus is placed upon a consumer’s premises by such government.

- **Rule-57: Meters, Maximum Demand Indicators and other Consumer's Premises :**
- Any meter or Demand indicator or other apparatus placed upon a consumer's premises in accordance with section 26 shall be of appropriate capacity and shall be deemed to be correct if its limits of error do not exceed 3 per cent, above or below absolute accuracy at all loads in excess of one tenth of full loads and up to full load :
- (ii) No meter shall register at no load.
- (iii) Every supplier shall provide and maintain in proper condition such suitable apparatus as may be prescribed or approved by the Inspector examination, testing and regulation of meters used or intended to be used in connection with the supply of energy :
- Iv) Every supplier shall examined, test and regulate all meters, maximum demand indicators and other apparatus for ascertaining the amount of energy supplied before their first installation at the consumer's premises and at such other intervals as maybe directed by the State Government in this behalf.

- **Rule-58 : Point of Commencement of Supply :**
- The point of commencement of supply of energy to a consumer shall be deemed to be at the point at the incoming terminal of the cut - outs installed by the consumer under rule 50.

- **Rule-59 :Precautions Against Failure of Supply - Notice of Failures :**
- The layout of the electric supply lines of the supplier for the supply of energy throughout his area of supply shall under normal working conditions be sectionalised and so arranged, and provided with cut-outs or circuit-breakers so located, as to restrict within reasonable limits the extent of the portion of the system affected by any failure of supply.
- The supplier shall take all reasonable precautions to avoid any accidental interruptions of supply, and also to avoid danger to the public or to any employee or authorized person when engaged or any operation during and in connection with the installation extension, replacement, repair and maintenance of any works. The supplier shall send to the Inspector [or any officer of a specified rank and class appointed to assist the Inspector] notice of failure of supply of such kind as the Inspector may from time to time require to be notified to him, and such notice shall be sent by the earliest practicable post after the failure occurs or after the failure becomes known to the supplier and shall be in such form and contain such particulars as the Inspector may from time to time specify.

14. ELECTRIC SUPPLY LINES, SYSTEMS AND APPARATUS FOR LOW ANDMEDIUM VOLTAGES

- **Rule-60 : Test for Resistance of Insulation :**
- Where any electric supply line for use at low or medium voltage has been disconnected from a system for the purpose of addition or alternation or repair, such electric supply line shall not be reconnected to the system until the supplier or the owner has applied the test prescribed under rule 48.
- The provisions of sub-rule (i) shall not apply to overhead lines except, overhead insulated cables unless the Inspector otherwise directs in any particular case.

- **Rule-61 :Connection with Earth :**
- The following provisions shall apply to the connection with earth of systems at low voltage in cases where the voltage normally exceeds 125 volts and of systems at medium voltage :
- (a) Neutral conductor of a 3-phase, 4 wire system and the middle conductor of a2-phase, 3 wire system shall be earthed by not less than two separate and distinct connections with a minimum of two different earth electrodes or such large number as may be necessary to bring the earth resistance to a satisfactory value both at the generating station and at the sub - station. The earth electrodes so provided, may be inter connected to reduce earth resistance. It may also be earthed at one or more points along the distribution system or service line in addition to any connection with earth which may be at the consumer's premises.
- (b) In the case of a system comprising electric supply lines having concentric cables, the external conductor of such cables shall be earthed by two separate and distinct connections with earth.
- (c) The connection with earth may include a link by means of which the connection may be temporarily interrupted for the purpose of testing or for locating a fault.

- (d) No person shall make connection with earth by the aid of, nor shall he keep it in contact with any water main not belonging to him except with the content of the owner thereof and of the Inspector.
- (e) Alternating current systems which are connected with earth as aforesaid may be electrically interconnected :
- Provided that each connection with earth is bonded to the metal sheathing and metallic armouring (if any) of the electric supply lines connected.
- The frame of every generator, stationary motor, portable motor, and the metallic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or controlling energy and all medium voltage energy consuming apparatus shall be earthed by the owner by two separate and distinct connections with earth.
- All metal casings or metallic coverings containing or protecting any electric supply - line or apparatus shall be connected with earth and shall be so joined and connected across all junction boxes and other openings as to make good mechanical and electrical connections throughout their whole length.

- All earthing systems shall :
- (a) Limit earth resistance sufficiently low to permit adequate fault current for the operation of protective devices in time and to reduce neutral shifting;
- (b) Be mechanically strong, withstand corrosion and retain electrical continuity during the life of the installation. All earthing systems Shall be tested to ensure efficient earthing, before the electric supply lines or apparatus are energised.
- (v) All earthing systems belonging to the supplier, shall, in addition, be tested for resistance or on dry day during the dry reason not less than once every two years,
- (vi) A record of every earth test made and the result thereof shall be kept by the supplier for a period of not less than two years after the day of testing and shall be available to the Inspector [or any officer appointed to assist the Inspector and holding gazetted rank] and [authorized under sub - rule (2) of rule 4 A] when required.

- **Rule-62 : System at Medium Voltage :**
- When a medium voltage supply system is employed, the voltage between earth and any conductor forming part of the same system shall not, under normal conditions, exceed low voltage.

ELECTRIC SUPPLY LINES, SYSTEMS AND APPARATUS FOR HIGH AND EXTRA - HIGH VOLTAGES

- **Rule-63 : Approval by Inspector :**
- (i) the owner of any high or extra-high voltage installation shall, before making application to the Inspector for approval of his installation or additions thereto, test every high or extra-high voltage circuit or additions thereto, other than an overhead line, and satisfy himself that they withstand the application of the testing and shall duly record the results of such tests and forward them to the Inspector.
- (ii) The owner of any high or extra - high voltage installation who makes any additionsor alternation to his installation shall not connect to the supply his apparatus oFelectric supply line, comprising the said alternations or additions unless and untilsuch alternations or additions have been approved in writing by the Inspector.

- **Rule-64 : Use of Energy at High and Extra - high Voltage :**
- (i) The Inspector shall not authorise the supplier to commence supply or where the supply has been discontinued for a period of one year and above, to recommence the supply at high or extra - high voltage to any consumer unless :
- (a) all conductors and apparatus situated on the premises of the consumer are so placed as to be inaccessible except to an authorised person and all operations in connection with the said conductors and apparatus are carried out by an authorised person;
- (b) the consumer has provided and agrees to maintain a separate building or a locked weather - proof and fire - proof enclosure of agreed design and location, to which the supplier at all times have access for the purpose of housing his apparatus and metering equipment, or where the provision for a separate building or enclosure is impracticable, the consumer has segregated the aforesaid apparatus of the supplier from any other part of his own apparatus.

- ii) The following provisions shall be observed where energy at high or extra – high voltage is supplied, converted, transformed or used :
- (a) (i) Clearance as per Indian Standard Code shall be provided for electrical apparatus so that sufficient space is available for easy operation and maintenance without any hazard to the operating and maintenance personnel working near the equipment and for ensuring adequate ventilation,
- (ii) The following minimum clearance shall be maintained for bare conductors or live parts or any apparatus in outdoor such stations, excluding overhead lines, of HV and EHV installations :

Voltage Class	Ground Clearance (met.)	Sectional Clearance (met)
Not exceeding 11 kV	2.75	2.6
Not exceeding 33 kV	3.7	2.8
Not exceeding 66 kV	4.0	3.0
Not exceeding 132 kV	4.6	3.5
Not exceeding 220 kV	5.5	4.3
Not exceeding 400 kV	8.0	6.5

- (ii) All EHV apparatus shall be protected against lightning as well as against switching over voltage. The equipment used for protection and switching shall be adequately co-ordinated with the protected apparatus to ensure safe operation as well as to maintain the stability of the inter - connected units of the power system.

- **Rule-65 : Testing, Operation and Maintenance :**
- (i) Before approval is accorded by the Inspector under rule 63 the manufacturer's test certificates shall, if required, be produced for all the routine tests and required, under the relevant Indian Standard.
- (ii) No new HV or EHV apparatus, cable or supply line shall be commissioned unless such apparatus, cable or supply line are subjected to site tests as per relevant Code of Practice of the ‘Bureau of Indian Standards.
- (iii) Not withstanding the provisions of the Inspector may require certain additional tests to be carried out before charging the installation or subsequently.
- (iv) All apparatus, cables and supply lines shall be maintained in healthy conditions and tests shall be carried out periodically as per the relevant Codes of Practice of the [Bureau of Indian Standards].

- **Rule-66 : Metal - Sheathed Electric Supply Lines — Precautions Against Excess Leakage**
- (i) The following provisions shall apply to electric supply lines (other than overhead lines) for use at high or extra - high voltage.
- (a) The conductors shall be enclosed in metal sheathing which shall be electrically continuous and connected with earth and the conductivity of the metal sheathing shall be maintained and reasonable precautions taken where necessary to avoid corrosion of the sheathing :
- (b) The resistance of the earth connection with metallic sheath shall be kept low enough to permit the controlling circuit breaker or cut - out to operate in the event of any failure of insulation between the metallic sheath and the conductor.

- **Rule-67 : Connection with Earth :**
- (i) All non - current carrying metal parts associated with HV/EHV installation shall be effectively earthed to a grounding system or mat which will :
  - (a) limit the touch and step potential to tolerable values;
  - (b) limit the ground potential rise to tolerable values so as to prevent danger due to transfer of potential through ground, earth wires, cable sheath fences, pipe lines, etc.;
  - (c) maintain the resistance of the earth connection to such as a value as to make operation of the protective device effective;
- (ii) Single - phase high or extra-high voltage systems shall be earthed in a manner approved by the Inspector.
- (iii) In the case of a system comprising electric supply - lines having concentric cables, the external conductor shall be the one to be connected with earth

- iv) Where the earthing lead and earth connection are used only in connection with earthing guards erected under high or extra - high voltage overhead lines where they cross a telecommunication line or a railway line, and where such lines are equipped with earth leakage relays of a type and setting approved by the Inspector, the resistance shall not exceed 25 ohms.
- Every earthing system belonging to either the supplier or the consumer shall be tested for its resistance to earth on a dry day during dry season not less than once a year. Records of such tests shall be maintained and shall be produced, if required before the Inspector or any office appointed to assist him.
- V) In so far as the provisions of rule 61 are consistent with the provisions of this rule, all connections with earth shall also comply with the provisions of that rule.

- **Rule 68:General Conditions as to Transformation and Control of Energy :**
- Where energy at high or extra - high voltage is transformed, converted, regulated or otherwise controlled in sub-stations or switch-station (including outdoor sub-stations and outdoor switch-stations) or in street boxes constructed underground, the following provisions shall have effect :
- (a) Sub - stations and switch - stations, shall preferably be erected above ground, but where necessarily constructed underground due provisions for ventilation and drainage shall be made and any space housing switchgear shall not be used for storage of any materials especially inflammable and combustible materials or refuse.
- (b) Outdoor sub-stations except pole type sub-stations and outdoor switch-stations shall (unless the apparatus is completely enclosed in a metal covering connected with earth, the said apparatus also be by armoured cables) be efficiently protected by fencing not less than [1.8 meters] in height or other means so as to prevent access to the electric supply - lines and apparatus therein by an unauthorised person.

- (c) Underground street boxes (other than sub-stations) which contain transformers shall not contain switches or other apparatus, and switches, cut-outs or other apparatus required for controlling or other purposes shall be fixed in separate receptacles above ground whereever practicable.
- (ii) Where energy is transformed, suitable provisions shall be made either by connecting with earth a point of the system at the lower voltage or otherwise to guard against danger by reason of the said system becoming accidentally charged above its normal voltage by leakage from a contact with the system at the higher voltage.

- **Rule-69 : Pole Type Sub-Stations :**
- Where platform type construction is used for a pole type sub-station and sufficient space for a person to stand on the platform is provided, a substantial hand - rail shall be built around the said platform and if the hand rail-is of metal, it shall be connected with earth.
- Provided that in the case of pole type sub-station on wooden support and wooden platform the metal hand - rail shall not be connected with earth.

- **Rule-70 : Condensers :**
- Suitable provisions shall be made for immediate and automatic discharge of every static condenser on disconnection of supply.
- **Rule-71 : Additional Provisions for Supply to High Voltage Luminous Tube Sign Installation :**
- i) Any person who proposes to use or who is using energy for the purpose of operating a luminous tube sign installation, or who proposes to transform or who is transforming energy to a high voltage for any such purpose shall comply with the following conditions :
- (a) All live parts of the installation (including all apparatus and live conductors in the secondary circuit, but excluding the tubes except in the neighbourhood of their terminals) shall be inaccessible to unauthorised persons and such part shall be effectively screened.
- (b) Irrespective of the method of obtaining the voltage of the circuit which feeds the luminous discharge tube sign, no part of any conductor of such circuit shall be in metallic connection (except in respect of its connection with earth)with any conductor of the supply system or with the primary winding of the transformer,

- (ii) The owner or user of any luminous tube sign or similar high voltage installation shall not bring the same into use without giving to the Inspector not less than 14days' notice in writing of his intention so to do.
- **Rule 73: Supply to X-ray and Frequency Installation :**
- Any person who proposes to employ or who is employing energy for the purpose of operating an X-ray or similar high-frequency installation, shall comply with the following conditions:-
- (a) Mechanical barriers shall be provided to prevent too close an approach to any high-voltage parts of the X-ray apparatus, except the X-ray tube and its leads, unless such high-voltage parts have been rendered shock-proof by being shielded by earthed part metal or adequate insulating material.
- (b) Where extra-high voltage generator operating at 300 peak kV or more are used, such generators shall be installed in rooms separate from those containing the other equipment and any step-up transformer employed shall be so installed and protected as to prevent danger.

- (c) X-ray tubes used in theraphy shall be mounted in an earthed metal enclosure.
- (d) Every X-ray machine shall be provided with a milli-ammeter or other suitable measuring instrument, readily visible from the control position and connected, if practicable, in the earthed lead, but guarded if connected in the high-voltage lead.
- (e) All X-ray generators having capacitors shall have suitable means for discharging the capacitors manually.
- (f) Except in the case of self-contained units, all 200 peak kV, or higher, X-ray generators shall have a sphere-gap installed in the high-voltage system adjusted so that it will break down on over-voltage surges.
- II) (a) All non-current-carrying metal parts of tube stands, fluoroscopes and other apparatus shall be properly earthed and insulating floors, mats or platforms shall be provided for operators in proximity to high or extra-high voltage parts unless such parts have been rendered shock-proof.
- (b) Where short-wave therapy machines are used, the treatment tables and examining chairs shall be wholly non-metallic.
- (iii) The owner of X-ray installation or similar high-frequency apparatus shall not bring the same into use without giving to the Inspector not less than 14 days' notice in writing of his intention so to do :