AIR UNIVERSITY

DEPARTMENT OF MECHANICAL & AEROSPACE ENGINEERING

WORKSHOP TECHNOLOGY

ELECTRIC SHOP

COURSE CONTENTS

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WIRING SYSTEM

System of Supply

There are two systems for tapping off Electric supply from the main, namely,

1. Tree system
2. Distribution system

Tree System

System in which sub-circuits are tapped off from the main circuit at some convenient place. Nowadays, this system is out of practice as there are many joints for sub-circuits. Moreover, it is very difficult to find faults. Figure 1 shows the connection of such a system.

Advantages

1 The length of cables required for the installation of the wiring is less and therefore the initial cost is also very less.

2 **Disadvantages**

1. Fuses in the installation are scattered.
2. Location of faults is not easy.
3. The voltage available at different points of load will vary.
4. Appearance of the system is not so good.

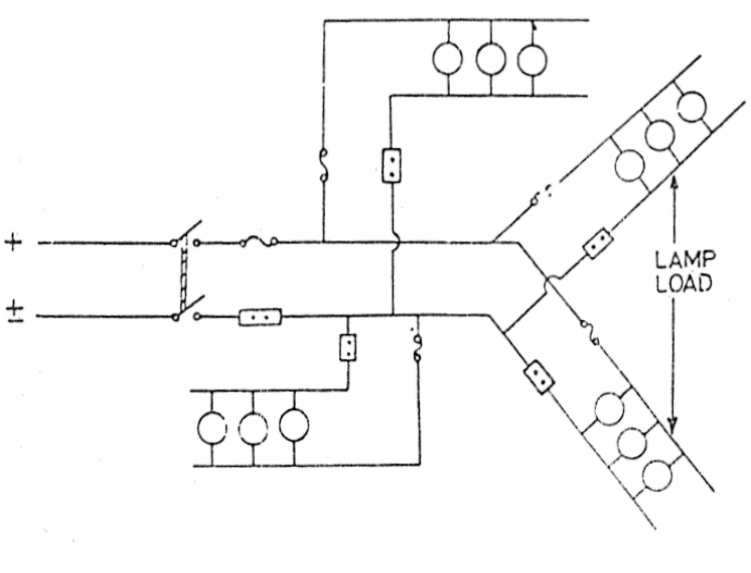


Figure 1: Arrangement of Tree

Distribution System

System is most commonly used nowadays. In this system the main distribution circuits is brought to one or more distribution boxes from where it is further distributed to different branch circuits as shown in figure 2.
This system is tapped off from the distribution box without interfering with the other circuit. Moreover, each circuit is independently tested for finding the faults.

Advantages

1. Fault finding is very easy, as there is protection for every sub-circuit.
2. The voltage available at different points of the circuits will be same.
3. Renewal or extension of the circuits is easy.

Disadvantages

1 In this system more length of cable is required for installation. Therefore, the more initial cost of erection.

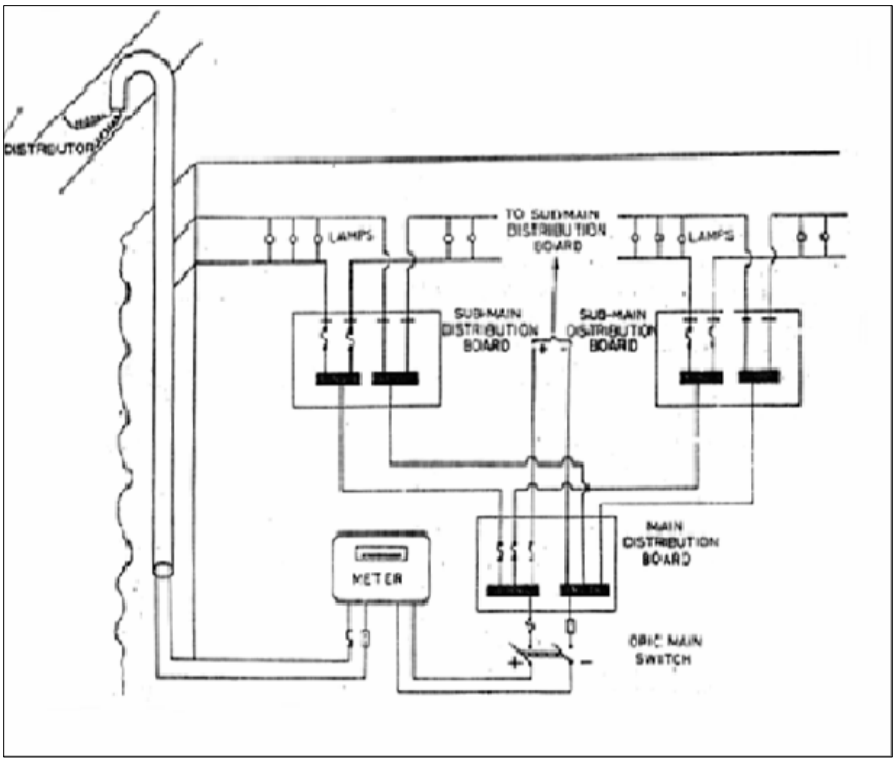


Fig 2: Distribution System

SELECTION OF WIRING

Wiring systems are of many types. The selection of an individual system depends upon number of factors. When selecting a wiring system following factor must be considered.

1. **Initial Cost:** The initial cost of the wiring system adopted must be economical to suit the consumer.
2. **Durability:** The cable used in the installation of the wiring must be sufficiently sound so as to bear the changing atmosphere of the surrounding. It should also be in a position to pass the full-load current of the circuit.
3. **Mechanical Protection:** The system chosen must provide good mechanical protection to the cables used in the installation of the wiring.
4. **Safety from Fire**: This is an important factor and must be considered while selecting an individual system. The system adopted should be free from risk as far as possible.
5. **Appearance after Completion of the Job**: The wiring should appear attractive, from this point of view concealed conduit wiring is best, but its initial cost is very high. However, C.T.S (Closed Tree System) wiring also looks attractive and has low cost of installation.
6. **Accessibility**: It should be easy to extend or repair the wiring.
7. **Life:** The system adopted should have long life.

RULES FOR WIRING

Before the erection of wiring the following general rules should be kept in view.

1. According to Pakistan Electricity rule 1937, the **total lighting load** in a sub-circuit should not be less than 400W. For estimating the load, the following values should be considered for individual points.

Fluorescent tube	— 40W each
Socket outlet, ceiling fan, lamp	— 60W each
Mercury vapor lamp	— 80W each.

2. According to Pakistan Electricity rule 1937, the **maximum power load** in a sub-circuit should, not be more than 2000 W or two Electric points, whichever is less.
3. The **current rating of the main switch** and distribution box should be calculated according to the load on the circuit.
4. The cable used in the installation should be kept free from dampness, fire, chemical fumes and leakage. Therefore, all metal coverings provided for the protection of cables must be earthed, so that there is no damage due to the leakage of the installation.
5. In domestic wiring, wall socket used must have an earth continuity conductor.
6. All the metal (as the cover of the main switches, pipes, brackets, fans, etc. including the earth point of the wall socket) in an installation should be earthed
7. No switch or fuse should be installed in the earth continuity conductor. (Because earthing need easiest path).

8. A live wire (wire of electric supply in which current flows) must be protected by a fuse of current rating depending on the requirement of the load. Further it should be controlled through the switch.
9. The height of the controlling board in an installation should be 1.5m from the ground level and should be installed on the left side of the entrance.
10. The height of the fan and light points should be 2.75m and 2.5m respectively from the ground level. Round blocks should be fixed with two screws on diametrical ends.
11. Every sub-circuit must have a separate distribution fuse board, because it will provide more protection to your equipment.
12. The light and power wiring circuits should be installed independently.
13. The switches and starters of the motor should be easily accessible to the operator.
14. In an ac three-phase, four-wire system the distribution of the load should be indicated by red, yellow and blue color and the neutral with black. In dc distribution, the positive and negative wire should be represented with the red and blue color respectively and the neutral with black.
15. When the installation completed it should be tested, it should be tested with a meager before connecting it to supply. The leakage current in this case should not exceed. $1/5000^{th}$ part of the maximum current of the voltages.
16. If the operating voltage of the circuits exceeds more than 250 V, a **CAUTION** notice should be fixed to motors, generator, transformers, etc. If several apparatus are installed in one enclosure, one notice will serve the purpose.

TYPES OF ELECTRICAL WIRING

There are following types of electrical wiring.

1. Cleat wiring or Temporary wiring
2. Wooden or Batten wiring
3. Casing and Capping
4. Conduit Wiring
5. Trunking Wiring

1 Cleat Wiring or Temporary Wiring

It is a temporary wiring used for function and construction work. Wooden and plastic cleats used for this purpose and distance between the two cleats lies between 4 to 6 feet.

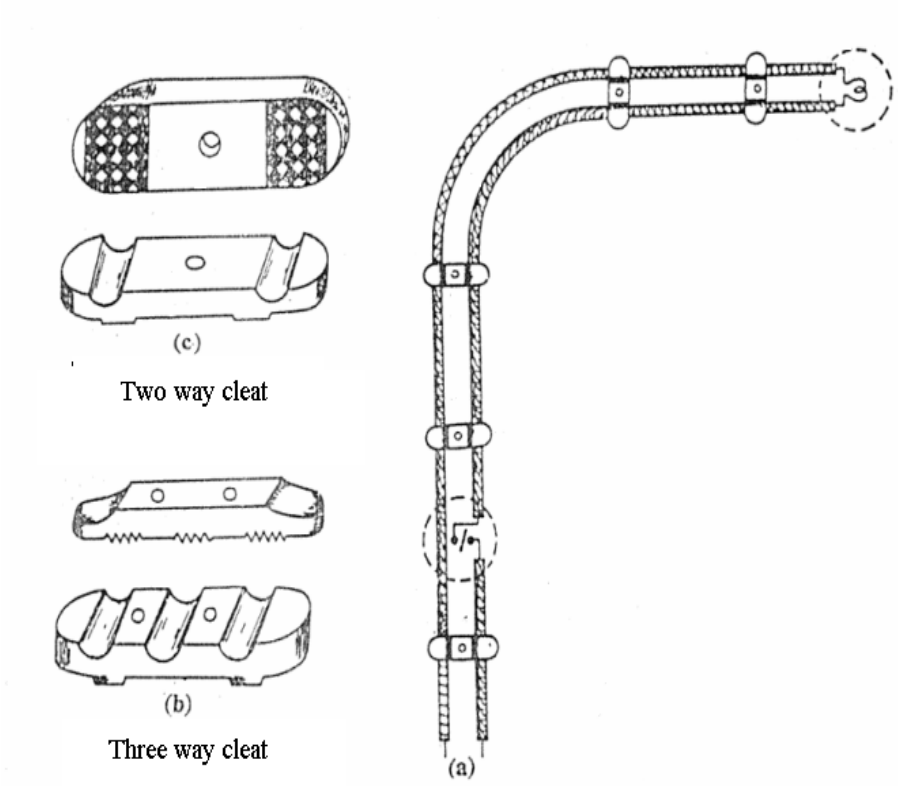


Figure 3: Cleat wiring

2. Wooden or Batten Wiring

Wooden pieces and steel clips are used for this purpose Distance between two clips will be 4 to 6 inches. Steel clips is fixed with the help of nail and then lay out the wire on the wooden piece and then fixed them with steel clips.

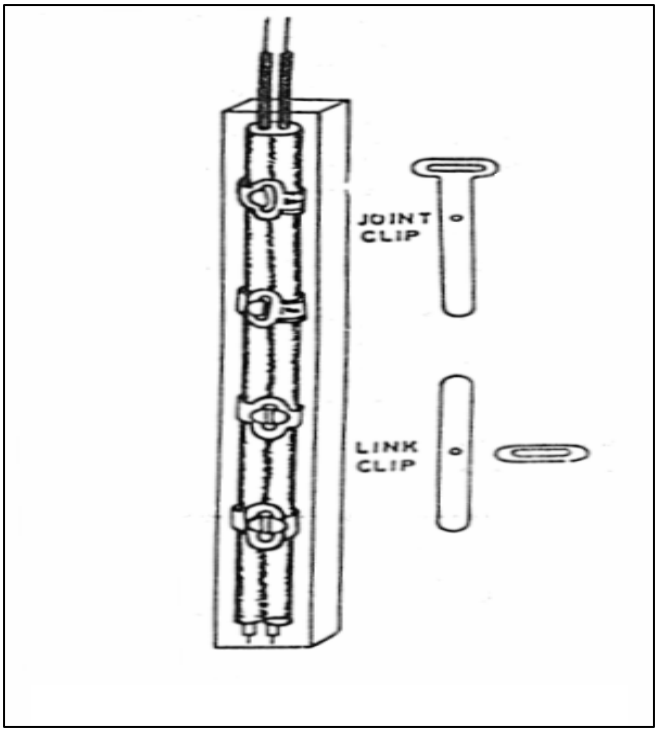


Figure 4: Wooden or Batten Wiring

Advantages

1. Cheap wiring.
2. Installation is easy.
3. Extension is possible.
4. Easy to locate the fault as the wires are open.

Disadvantages

1. In case of short circuit wood can easily catch the fire.
2. Unsafe from mechanical damages
3. Unsafe from water.
4. Life span is short i.e. about 10 to 15 years.

3. Casing and Capping Wiring:

It consists of two parts lower one is called casing and the upper part for covering is known as capping. Casing is fixed with the help of rawal plug. Then lay out the wires and cables in the casing and finally covered with capping.

Sizes of Casing and Capping:

Following size of casing and capping are easily available.

1. 16x16mm
2. 16x25mm
3. 16x38mm
4. 38x40mm

5. 40x40mm
6. 40x60mm
7. 60x80mm
8. 80x80mm

Advantages

a. Installation is easy.
b. Extension is possible.
c. Material can be reused.

Disadvantages

1. Costly wiring.
2. Difficult to locate the fault as the wires or cables are covered.
3. In case of short circuit casing and capping can catch fire as they are made of Plastic.

4. <u>Conduit Wiring:</u>

There are two types of conduit wiring

1. Open or External
2. Internal or Concealed

P.V.C (Poly Vinyl Chloride) pipes are used for this type of wiring in which cable passes from one point to other point for electric supply within P.V.C. pipes. In internal wiring the pipe is fixed concealed in the roof and wall, while in open wiring the pipes are fixed on the wall with clips or saddle.

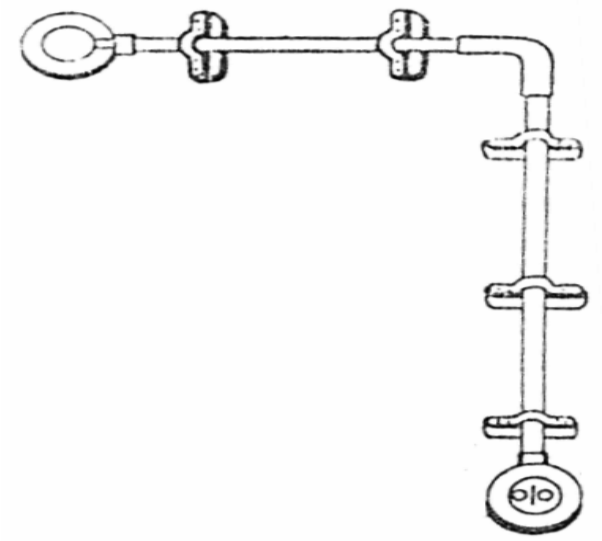


Figure 5: Open Conduit Wiring System

Accessories used in Conduit Wiring

1. L-Bend
2. T-Bend
3. Junction Box
4. Socket
5. Saddle

Advantages

1. Wiring is water proof.
2. Safe from mechanical damages.
3. Look beautiful as it is concealed.
4. Long life (approx 100 years).

Disadvantages

1. Difficult to locate the fault as the wires or cables are covered.
2. Extension is difficult.
3. Installation is difficult.

6. Trunking Wiring

It is used for heavy voltage lines in substation and generation. Iron trunks are used for this wiring. Trunks available in circular or square shape. Couplers are used for jointing different lengths which fixed with screw. Trunking wiring is used mostly in developed cities.

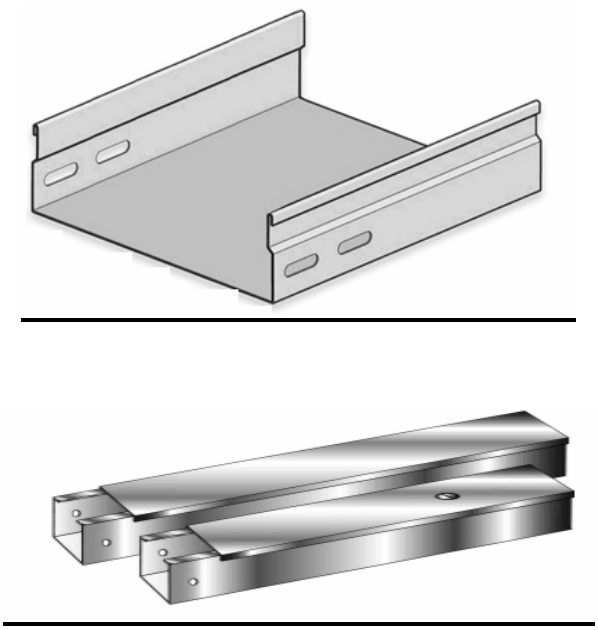


Figure 6: Iron Trunks

TYPES OF JOINTS USED IN ELECTRICAL WIRING AND INSTALLATION

There are following types of joint used in electrical installation.

1. Straight Twist Joint
2. Britannia Joint
3. Married Joint
4. Tee Joint
5. Duplex or Double Tee Joint
6. Pig Tail Joint
7. Scarf Joint

STRAIGHT TWIST JOINT

This type of joint is used to joint two or more than two wires.

Procedure

1. First remove the insulation from ends of both wires and cables up to minimum length of 8cm.
2. Clean the ends of wires with sand paper.
3. Bend the two wires form 2cm at 90 degree and couple them with each other.
4. Take 4-6 turns for bending.

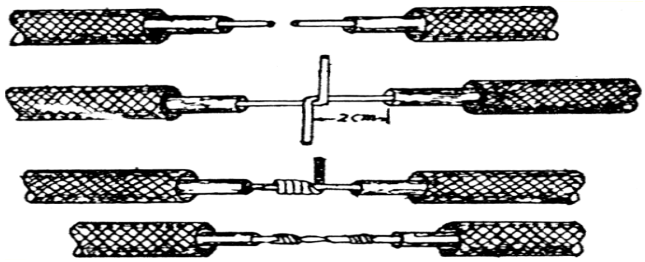


Figure 7: Straight Twist Joint

BRITANNIA JOINT

This type of joint is used to joint earthing wires.

Procedure

1. Take a bend about 45 degree at the ends.
2. Place those at each other distance between the ends of wires must be a minimum length of 8cm.
3. Take another wire for turning and take 6-8 turns for jointing.
4. Sold the joint with soldering wire.

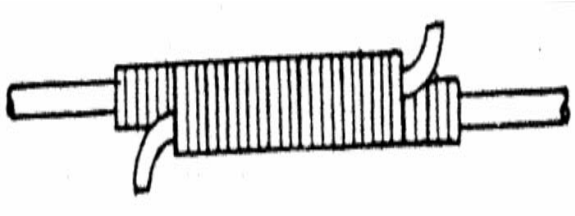


Figure 8: Britannia Joint

MARRIED JOINT

This type of joint is used to joint the stranded wires or cables as shown in the figure 8.

Procedure

1. First remove the insulation from ends of both wires up to 8cm.
2. Twist them from insulation ends up to 2.5cm and spread the remaining part like flower than coupled them with each other.

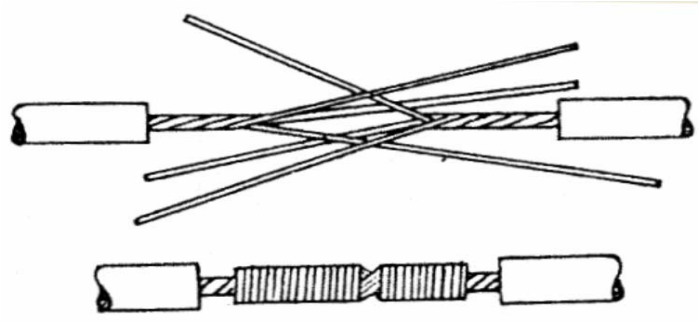


Figure 9: Married joint

TEE JOINT

This type of joint is used to get the connection from horizontal wire

Procedure

1. First remove the insulation from centre of horizontal wire up to 5cm.
2. Remove the insulation from end of second wire or cable up to 8cm.
3. Place the second wire at 90 degree on the horizontal line and take 6-8 turns for jointing.
4. Than sold the joint with soldering wire.

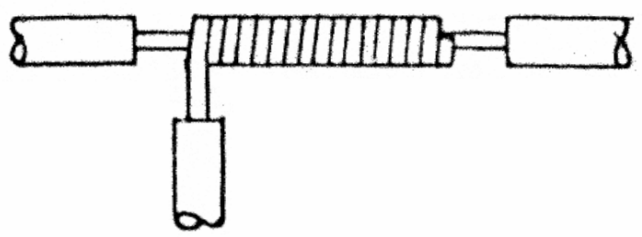


Figure 10: Tee Joint

DUPLEX OR DOUBLE TEE JOINT

This type of joint is used to get connection from centre of two core cable.

Procedure

1. First remove the insulation from centre of 2 core cable up to 12cm.
2. Then remove the insulation from two wire or cable (covered in the core) up to 8cm.
3. Remove the insulation from ends of other two wire up to 8cm and 10 cm respectively.
4. Take 6-8 turns for jointing.

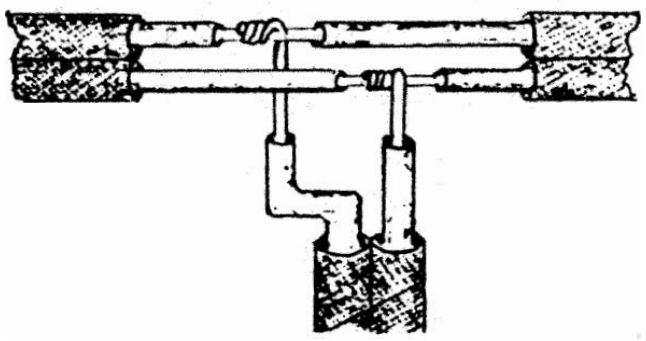


Figure 11: Duplex Joint

PIG TAIL JOINT

It is a simple joint used to joint two parallel cables or wires.

Procedure

1. Remove the insulation from ends of both wire up to 5cm and twist them with each other.

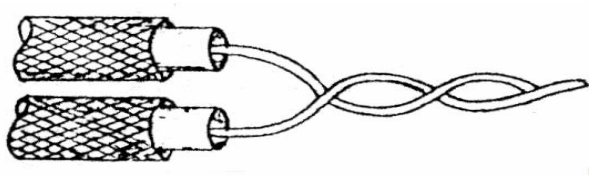


Figure 12: Pig Tail Joint

SCARF JOINT

This type of joint use to joint the solid (single) earthing wire from electric supply pole to ground

Procedure

1. Make the shape of ends of wire as shown in the figure and than overlap them and use another wire for jointing.

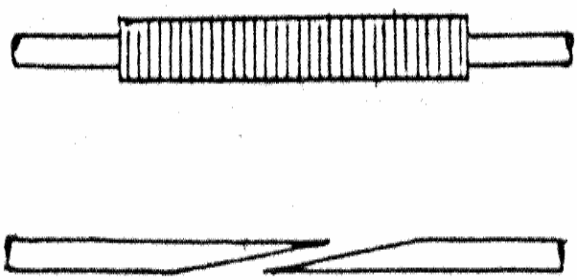


Figure 13: Scarf Joint

TYPES OF INSULATORS

Insulating material can be classified into two groups.

1. Organic
2. Inorganic

In general, organic insulators such as rubber, paper, oil, cotton, thermoplastic materials, and so forth composed of long molecular chains of carbon and hydrogen sometimes linked with other elements (oxygen, chlorine, etc.). Organic insulator deteriorates rapidly when the temperatures exceed about 150 degree centigrade.

Inorganic insulators, such as mica, porcelain, air, etc, can function indefinitely in temperature exceeding 1000^0C.

Insulators can also be classified as,

1 Solid Insulators
2 Liquid Insulators
3 Gaseous Insulators

SOLID INSULATORS

Solid insulators such as wood, rubber, cotton, paper, polymers and some other are used in electric supply for insulation and protection. Natural rubber, resins, varnishes and bakelite are all polymers. one type of chemical reaction called polymerization some simple molecules are linked to form much larger molecules containing thousands of the original molecules. A new substance formed in the way is said t be **polymers** Depending on their composition and molecular structure, polymers can be subdivided into many classes: polyvinyl, polyurethanes, polyesters, polyamides, polyamide, Dacron and Mylar are polyesters and Kapton is a polyimide.

Uses of solid insulator

Such synthetic materials are uses to insulate the wires in the coils of motors, transformers, electromagnets, relays, etc, as well as the heavily-insulated wires and cables which distribute electric power in building. Although we tend to use more and more synthetic materials, natural insulators are still indispensable in many applications. **Cotton** is still widely used in the manufacture of insulating sheets, plates and cables. **Paper** is still one of the best materials to cover high voltage conductors. **Asbestos,** a natural inorganic material, is employed in the sistant control panels. **Mica**, a superb insulators, acts as support for the heating elements in toasters and as a high-temperature, uncrushable insulator in the commutators of direct current machines.

LIQUID INSULATORS

Mineral oil is used in big power transformer as both an insulator and heat-transferring agent. It also prevents oxidation of the insulating materials because it completely surrounds the windings and inhibits the access of air. Oxidation is a particularly important problem in high-voltage transformers because they tend to produce corona discharges. In The presence of air, such HV discharges generate ozone, which is a very strong oxidizing agent. By immersing the winding in oil, we prevent the formation of ozone and, at the same time, heat dissipated by windings is carried away to the surrounding tank. Because oil is a much better insulator than air, we can also reduce the size of transformer.
Oil, however has the disadvantage of being flammable and its ignition temperature is only about 150^0C .Some higher-temperature synthetic liquid insulators get around this problem, but they are more expensive and often cannot be used with other insulators because they tend to attack them chemically

GASEOUS INSULATORS

Air

One of the best insulators known is the air which surrounds us. Its thermal properties are better than those of porcelain; it acts as a cooling agent, and costs absolutely nothing. However at very high temperature, air becomes a good conductor, owing to the phenimen9n of ionization. For example at 2000^0C the resistively of air is still as high as that of porcelain, when its temperature increases to between 5000^0C and 50000^0C its conductivity approaches that of salt water.

Sulfur Hexafluoride

Sulfur Hexafluoride (SF6) is another important insulating gas. Its molecules have the special ability to absorb free electrons, which accounts for its very high dielectric strength (10 times greater than air at a pressure of 400kg) Sulfur hexafluoride is used in high-voltage circuit breakers and enclosed transmission lines where space reduction is particularly important.

Hydrogen

Hydrogen is another important insulating gas sometimes used to cool large rotating machines. Hydrogen has a much lower density and viscosity than air and, consequently, produces less traction at high rotational speeds. Furthermore, for a given temperature rise, it absorbs almost 14 times as much heat as air does, Finally m pure hydrogen prevents any oxidation of the insulating materials and thereby prolongs their life. Hydrogen cooling systems, however, are very complex and require constant maintenance; their use is only justified in very large machines.
Form a safety point of view, hydrogen does not explode or burn, even in the presence of an electric arc, provided that the oxygen content is kept is low 10 percent.

CLASS	ILLSTRATIVE EXAMPLES
105 ^{0}C	
A	Materials or combinations of materials such as cotton silk and paper when suitably impregnated or coated or when immersed in a dielectric liquid Such as oil. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to have Thermal life at 105^{0}C.
130 ^{0}C	
B	Materials or combination of materials such as mica, asbestos, etc, with Bonding substances. Other materials or combinations of materials may be Included in this class if by experience or accepted tests they can be shown to have comparable thermal life at 130^{0}C.
155 ^{0}C	
F	Materials or combination of materials such as mica, glass fiber, asbestos, Etc, with suitable bonding substances. Other materials or combination of Materials may be included in this class if by experience or accepted tests they can be shown to have comparable life at 155^{0}C.
180 ^{0}C	
H	Materials or combination of materials such as silicone elastomer, mica, glass fiber asbestos, etc, with suitable bonding substances such as appropriate silicone resins. Other materials or combination of materials may be included in this class if by experience or accepted tests they can be shown to have comparable life at 180^{0}C
200 ^{0}C **N**	Material or combination of materials which by experience or accepted test can be shown to have the required thermal life at 200^{0}C.
220 ^{0}C **R**	Material or combination of materials which by experience or accepted test can be shown to have the required thermal life at 220^{0}C.
240 ^{0}C **S**	Material or combination of materials which by experience or accepted test can be shown to have the required thermal life at 240^{0}C.
Above 240 ^{0}C	Material consisting entirely of mica, porcelain, glass, quartz, and similar inorganic materials. Other material or combinations of material may be Included in this class if by experience or accepted tests they can be shown

To have the required thermal life at temperature above 240^0C.

INSULATORS USED IN TRANSMISSION AND DISTRIBUTION OF ELECTRICAL SYSTEM

Following materials used in transmission and distribution system for insulator

1. Porcelain
2. Glass
3. Rubber
4. Mica

Following type of insulators are commonly used in transmission and distribution line This is made up of porcelain or glass.

1. D-shackle
2. Pin type
3. Disk type

D-shackle

For low voltage (220,440-600 V)

Figure 14: D-Shackle

Pin type

For medium voltage line (11-33kV)

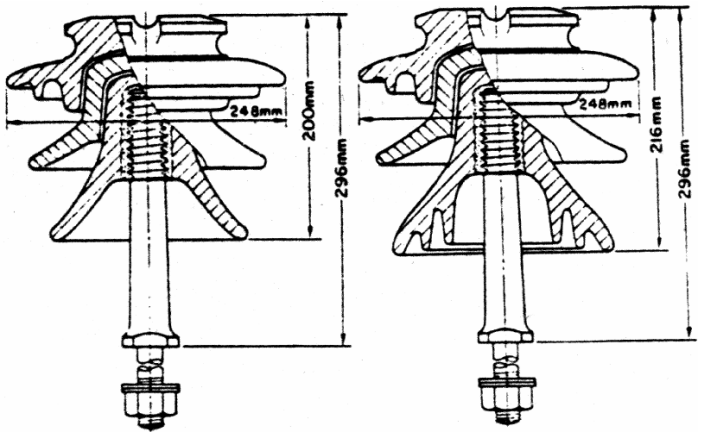


Figure 15: Pin type Insulator

Disk type for high and extra high voltage line {33, 66,132,220, kV (high)} and 500kv to 1500kv (extra high)

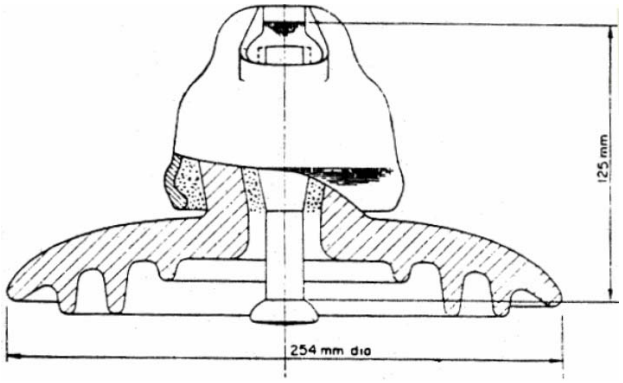


Figure 16: Disk type Insulator

EXPERIMENT # 1

TO CONTROL "ONE LAMP WITH ONE SWITCH"

APPARATUS

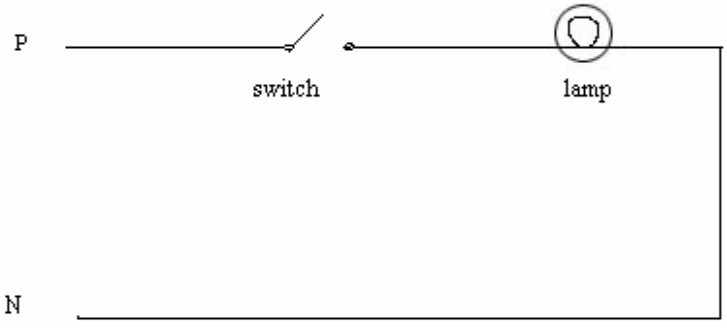
Lamp, lamp holder, one way switch, cable($1.5mm^2$),wire cutter, screw driver, electric tester and pliers.

PROCEDURE

Connect one terminal of the lamp with one end of the switch. The other terminal of the lamp holder and switch is connected with the power source, in such a way that cable connected with the lamp holder connect with the Neutral Terminal of the power source and the cable connected with the switch connected with the Phase Terminal of the Power Source. When the Switch is closed the connection made circuit completed and the Lamp lights up, and when the Switch is opened, connection in switch breaks and the lamp turned off.

SAFETY PRECATIONS

1. Connection should be tight.
2. Do not touch naked or bear wires.



CIRCUIT DIAGRAM

EXPERIMENT # 2

TO CONROL "TWO LAMPS IN SERIES WITH ONE SWITCH"

APPARATUS

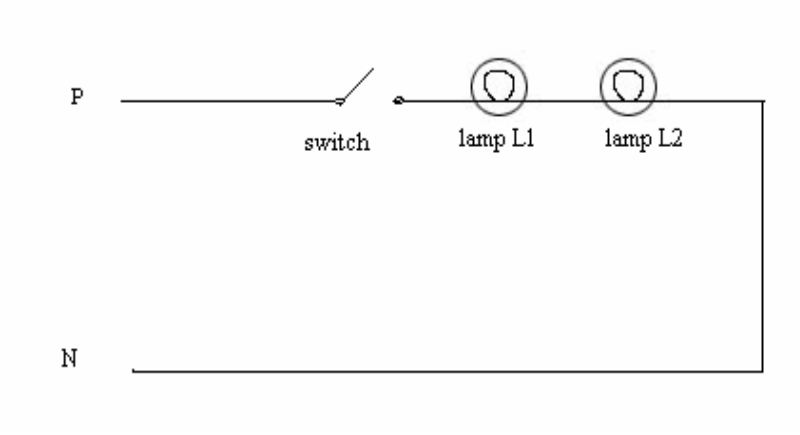
Lamp, lamp holder, one way switch, cable($1.5mm^2$),wire cutter, screw driver, electric tester and pliers.

PROCEDURE

Connect one terminal of the lamp L1 with one end of the switch. The other terminal of the lamp holder connects with terminal of the second lamp holder (in series connection). Connect the second terminal of the lamp L2 with switch S. The other terminal of the lamp L1 and switch is connected with the power source in such a way that cable connected with the lamp holder connects with the Neutral terminal N of the power source and the cable connected with the switch connected with the Phase terminal P of the power source. When the switch S is closed, the connection makes circuit complete and the lamp lights up, and when the Switch is open, connection breaks and the lamp turns off.

SAFETY PRECATIONS

1. Connection should be tight.
2. Do not touch naked or bear wires.



CIRCUIT DIAGRAM

EXPERIMENT # 3

TO CONTROL "TWO LAMPS AND TWO SOCKETS WITH SEPARATE SWITCHES".

APPARATUS

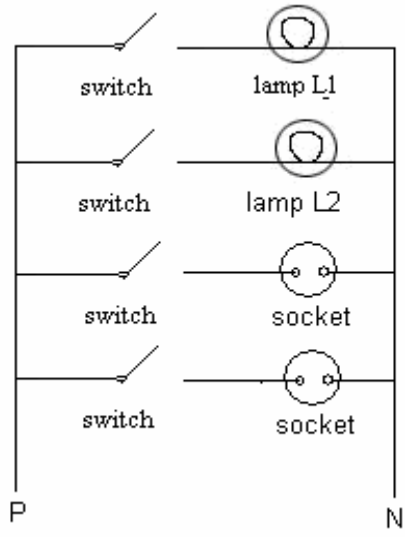
Lamp, Lamp holders (2 No), sockets (2 No), one-way switches (4 no), cable ($1.5mm^2$), wire cutter, screw driver, electric tester and pliers.

PROCEDURE

Connect One Cable with one terminal of 4 Switches in series and one cable with one end of two lamps holder and Sockets in series .Connect second end of lamps holder and socket with switches. Connect the common cable of Switches and lamps and socket with Power Source in such a way that Cable Connected with switches should connect with Phase and the Cable connected with lamps and socket connect with Neutral side of Power source. When the Switch is closed the connection made circuit completed and the Lamp lights up, and when the Switch is opened, connection in switch breaks and the lamp turned off.

SAFETY PRECATIONS

1. Connection should be tight.
2. Do not touch naked or bear wires.



CIRCUIT DIAGRAM