CHAPTER-2

Residential and Commercial Electrical Systems

Electrical Wiring

- A process of connecting various accessories for distribution of electrical energy from supplier's meter board to home appliances such as lamps, fans and other domestic appliances is known as Electrical Wiring.
- The wiring system selected will depend to a large extent on the types of service required.

Factors Affecting the Selection of Wiring

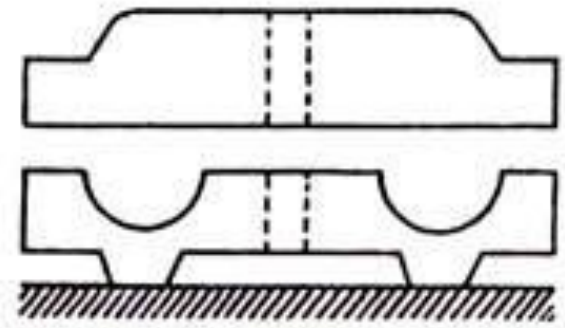
1. Durability
2. Safety
3. Appearance
4. Cost
5. Accessibility
6. Maintenance Cost

Types of Internal Wiring

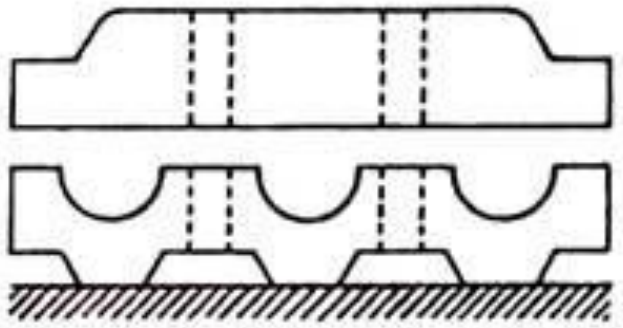
- Cleat wiring
- Casing and capping wiring
- Batten wiring
    a) CTS or TRS or PVC sheath wiring
    b) Lead sheathed or metal sheathed wiring
- Conduit wiring
    a) Surface or open Conduit type
    b) Concealed or underground type Conduit

Cleat Wiring

- In this system of wiring, cables are supported and gripped between porcelain cleats and 6mm. above the wall or roof.
- The main part is base, which is grooved to accommodate the cables, the other part is the cap which is put over the base



(i) Cleat with two grooves



(ii) Cleat with three grooves


CLEAT WIRING

- Cleats are placed above the wall or roof at an interval of 30 to 60 cm.
- The cables recommended for this type of wiring are VIR or PVC cables and any other approved insulated cables.

Advantages

1. It is the cheapest system.
2. Installation and dismantling is easy.
3. Less skilled persons are required.
4. Inspection is easy.
5. Alterations and additions are easy.

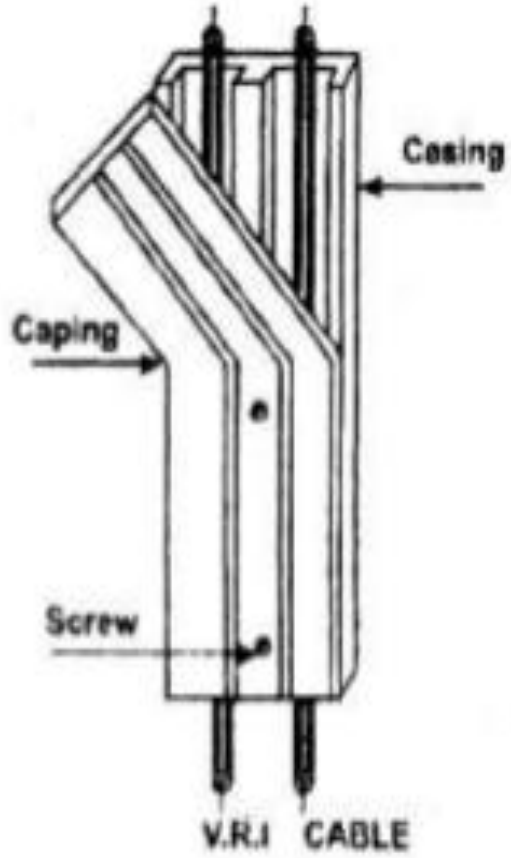
Disadvantages

1. It is purely temporary wiring system.
2. Appearance is not good.
3. Cables are exposed to atmosphere and there is a possibility of mechanical injury.
4. This system should not be used in damp places other wise insulation gets damaged.

Casing and Capping Wiring

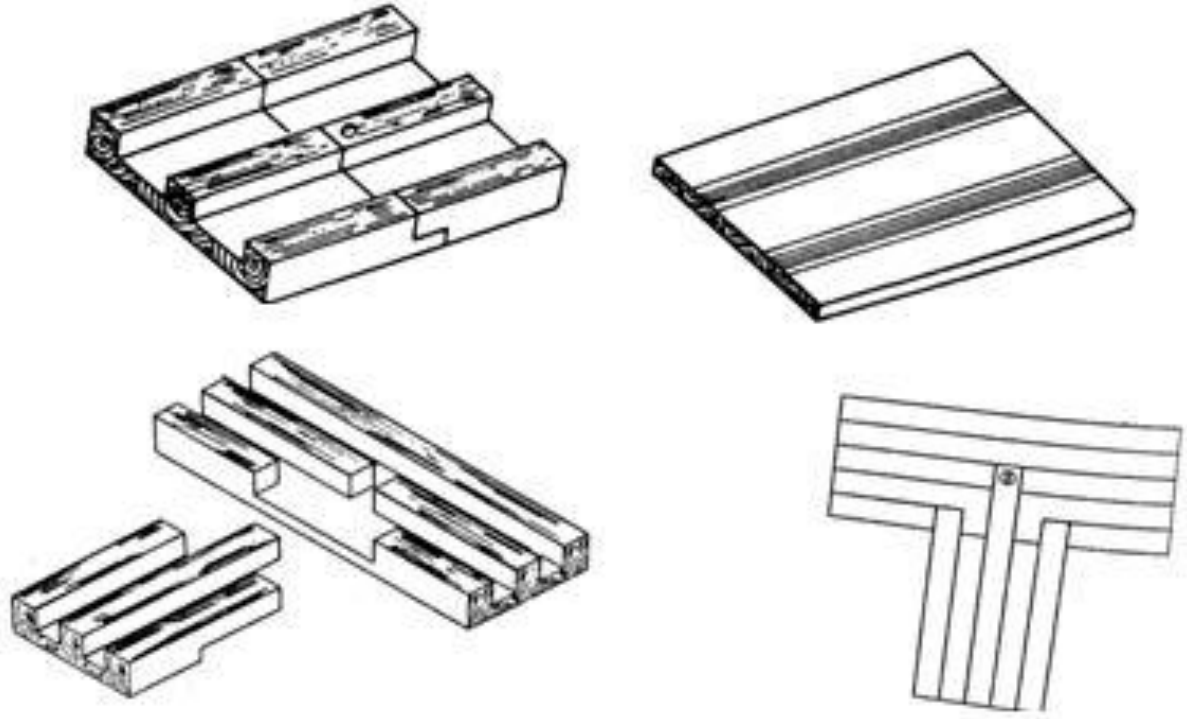
- It consists of rectangular blocks made from seasoned and knots free wood (preferably teak-wood).
- The casing has usually two (or three) 'U' shaped grooves, into which the VIR or PVC cables are laid in such a way that the opposite polarity cables are laid in different grooves.
- The casing is covered by means of a rectangular strip of the same width as that of casing known as capping and is screwed to it.
- This system of wiring is suitable for low voltage installations.





Wooden Casing & Capping Wiring System





Advantages

1. It provides good insulation as conductors are apart.
2. It provides good mechanical strength.
3. Easy to inspect by opening the capping.

Disadvantages

1. It is costly system now – a – days because it needs seasoned, knot free wood.
2. There is every risk of fire.
3. The labor cost is more because it requires skilled carpenters.
4. This system can not be used in damp places.

CTS or TRS or PVC Sheath Wiring

- CTS cables are available in single-core, twin-core or three-core with a circular or oval in shape.
- CTS cables are sufficiently chemical proof, water proof, steam proof.
- The cables are run or carried on well seasoned, perfectly straight and well varnished (on all four sides) teak wood batten of thickness 10 mm. at least.
- The width of the batten depends upon the number and size of cables to be carried by it. Battens are fixed to the walls or ceilings by means of gutties or wooden plugs.
- The cables are held on the wooden batten by means of tinned brass link clips spaced at an interval of 10 cm.
- .This system is suitable for low voltage installations..


CTS OR TRS
WIRING

Advantages

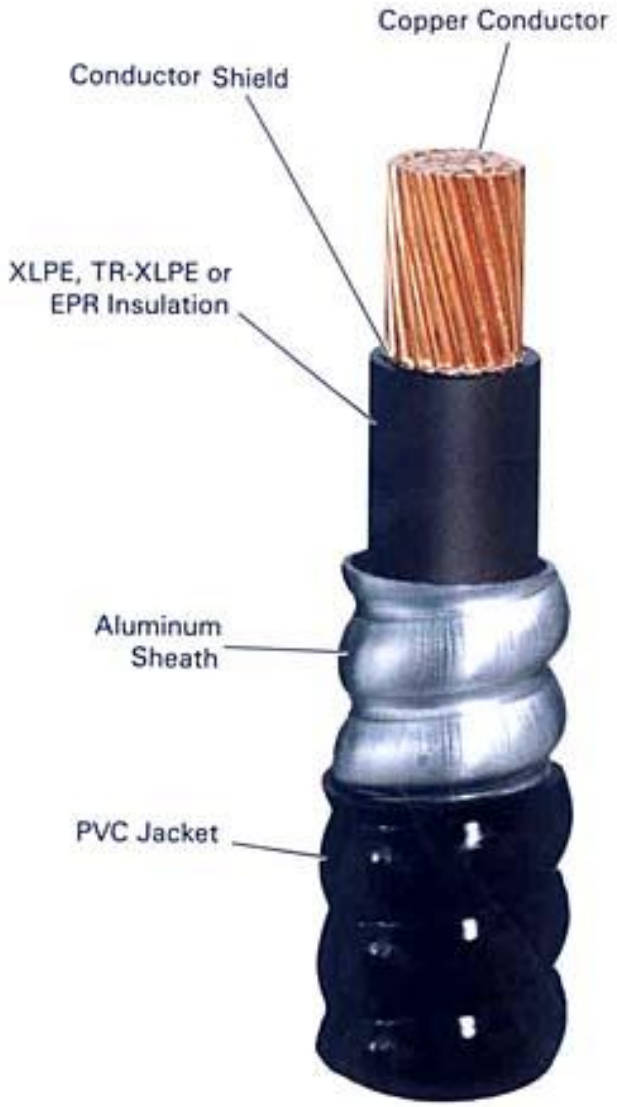
1. It's appearance is good, if carried properly.
2. It's life is sufficiently long.
3. It can withstand the action of most chemicals such as acids and alkalies.
4. It's installation is easy and quick compared to casing-capping.
5. It is cheap compared to casing – capping, metal conduit and lead sheathed wiring.

Disadvantages

1. This system of wiring is not recommended in situations exposed to sun and rain, unless preventive steps are taken.
2. It can not be used in damp places.
3. Good work man ship is required to make a sound job.
4. Only suitable below then 250V.

Metal Sheathed Wiring

- In lead sheathed or metal sheathed wiring the cables used are insulated wires, TRS or PVC, with metal outer covering of about 1 mm. thick. The metal covering is known as sheathing and is made of lead – aluminium alloy containing about 95% of lead. The metal sheathed cables are run on wooden batten and are fixed to it by link – clips. The whole metal sheathing efficiently earthed as per IS:732-1983

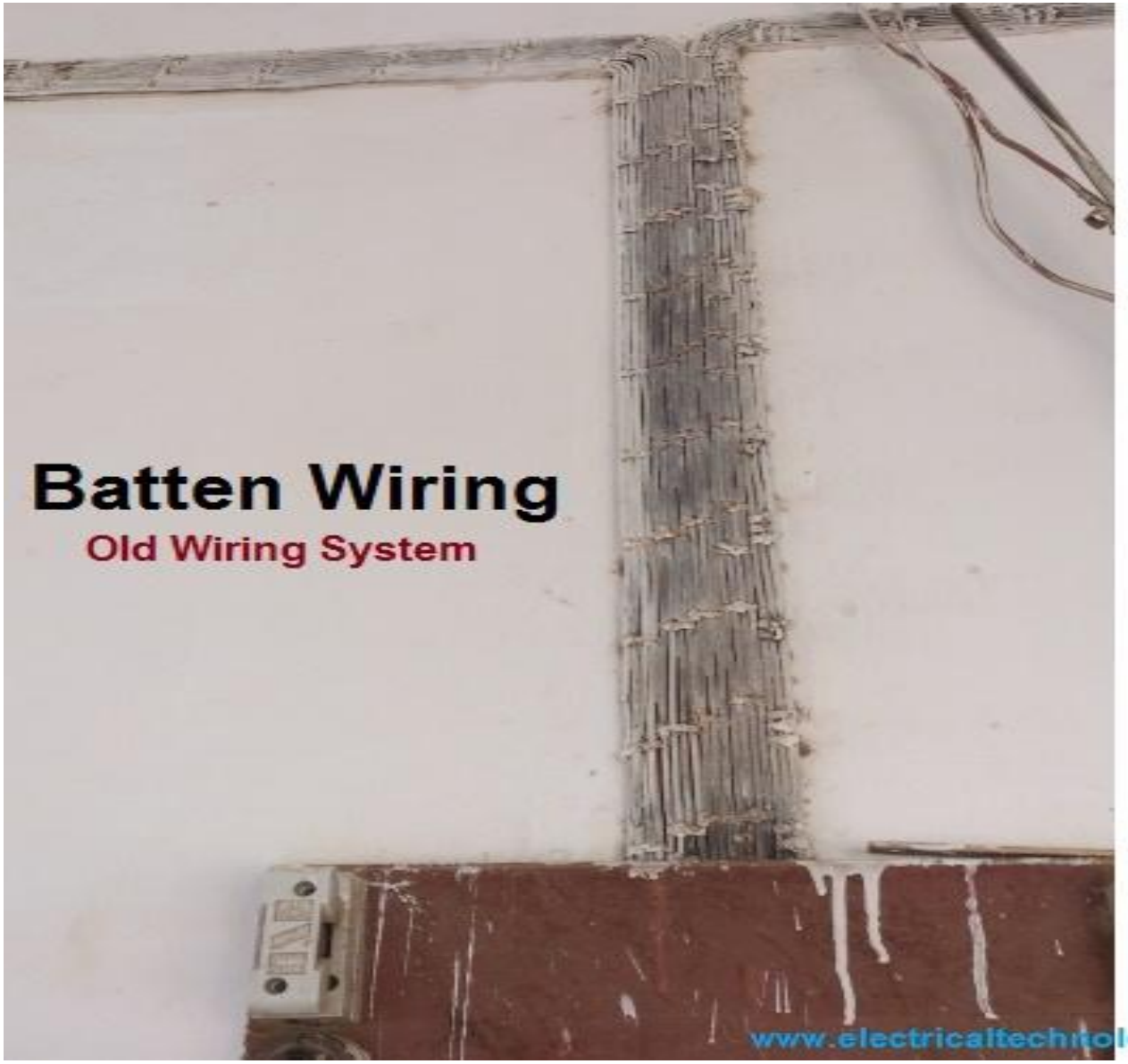

Copper Conductor
Conductor Shield
XLPE, TR-XLPE or
EPR Insulation
Aluminum
Sheath
PVC Jacket

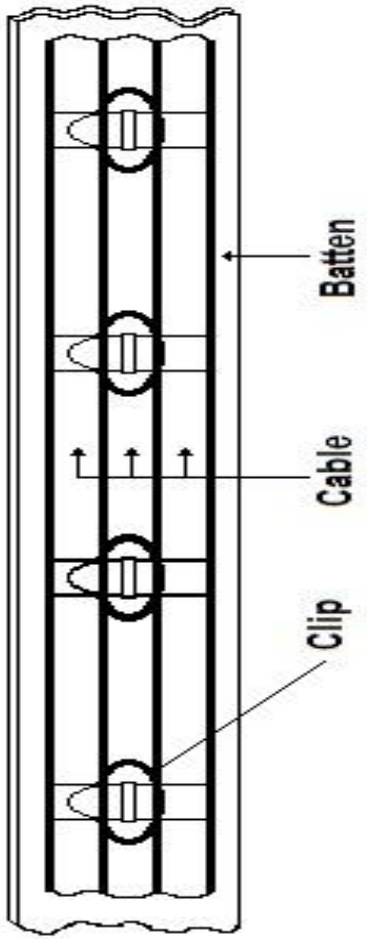
Advantages

1. It provides protection against mechanical injury.
2. It can be used in damp situations.
3. It can be used in situations exposed to-sun, and rain provided no joint is exposed.
4. It has longer life.

Disadvantages

1. It is costly system of wiring.
2. It is not suitable where chemical (acids and alkalies) corrosion may occur.
3. In case of insulation damage, the metal sheath become alive and gives shock.


Batten Wiring
Old Wiring System
www.electricaltechnology.org


Batten
Cable
Clip

Conduit Wiring System

Conduit wiring system consists of either VIR or PVC cables taken through tubes or pipes and terminated at the outlets or switches / sockets. The tube or pipe is known as “conduit”. Conduit wiring may run over the surface of the walls and ceiling or may be concealed under masonary work.

Types of Conduits

1. Rigid steel / metal conduit.
2. Rigid PVC / non-metallic conduit.
3. Flexible steel conduit.
4. Flexible PVC / non-metallic conduit.



MS Conduit Pipes







Surface Conduit Wiring

All steel conduits should be coated or finished with galvanized or enameled surface. Conduit accessories must be of threaded type. No steel conduit less than 12.7 mm. in diameter should be used.

The conduit should be laid over the wooden gutties, and should be fixed to the wall by means of saddles at an interval of not more than 1.2 m.

Concealed Conduit Wiring

The conduits (metal or PVC) are embedded along walls or ceiling in plaster at the time of building construction. The conduits are fixed by means of saddles not more than 60 cm. apart. The VIR or PVC cables are drawn into the concealed by means of GI wire of size 18 SWG.

PVC conduits are increasingly being used in place of steel conduits. PVC conduits are less expensive and the labour time saved may be as much as 25% to 50% compared to the time taken when installing steel conduits. PVC conduits are resistant to acids alkalies, oil and moisture.





Surface Conduit Wiring





Concealed Conduit wiring

Advantages

1. It provides protection against mechanical damage.
2. Metal conduits provides protection against fire due to short circuit etc.
3. The whole system is water proof.
4. It's life is long.
5. Replacement of defective wiring is easy.
6. It is shock proof if earthing is done properly.
7. PVC conduit wiring (particularly concealed) is cheap.
8. PVC conduit wiring requires less time.
9. Concealed conduit wiring appearance is very good.

Disadvantages

1. PVC conduit does not provide protection against fire.
2. Metal conduit wiring is very costly.
3. Metal conduit wiring requires more time.
4. Metal conduit wiring needs skilled labour.
5. Very hard to find the defects in the wiring.
6. Very complicated to manage additional connection in the future.

General Rules for Wiring

The following general rules should be kept in mind while executing the electrical wiring work:

1. The current rating of the cable / conductor should be slightly greater (at least 1.5 times) than the load current.
2. Every live wire / line should be protected by a fuse of suitable rating as per load requirements.
3. Every sub-circuit should be connected with the fuse distribution board.
4. All metal coverings used for the protection of earth must be connected to earth.
5. No switch or fuse is used in earth or neutral conductor.
6. Every apparatus should be provided with a separate switch.

7. No additional load should be connected to the existing installation until it has been satisfied that the installation can safely carry the additional load.
8. All the switches and starters should be accessible to the operator.
9. A caution notice (danger plate) should be fixed on very equipment.
10. In any building light wiring and power wiring should be kept separately.
11. When the installation has been completed it should be tested before giving the supply and the leakage in the wiring should not exceed 1/5000 of the maximum current of the load.
12. In 3-phase, 4 – wire installation the load should be distributed almost equally on all the phases.
13. In case of 3-phse, 4-wire system, at the main board, indication should be done in Red, Yellow and Blue. Neutral should be indicated in black.

Electrical Energy Distribution Systems

- As per the recommendations of ISI the maximum number of points of lights, fans and socket outlets cannot be exceed beyond 10 and the maximum load that can be connected in such a circuit is 800 watt. Hence in case of more load or more points to be connected to the supply system, then it is to be done by having more than one circuit through

(a) Distribution board system

(b) Tree system

(c) Joint box system

(d) loop – in – system.

General Requirements of Electrical Installation

a) Layout wiring
b) Conductors
c) Rating of lamp, fan and socket outlet point
d) Joint box and looping in system
e) Reception and distribution of main supply
f) Arrangement of apparatus on switchboards
g) Single phase supply
h) Three phase, four wire supply
i) Sub distribution board
j) Sub circuits
k) Diversity
l) Diversity factor for sub circuit

Layout Wiring

Power and heating sub-circuits should be kept separate and distinct from lighting and fan sub-circuits in conformity with IS: 732-1983. All types of wiring, whether concealed or unconcealed, should be capable of easy inspection. The unconcealed wiring when run along the walls should be as near the ceiling as possible. In all types of wiring due consideration should be given for neatness and good appearance.

In 3-phase installations, care should be exercised to ensure balancing of loads on the three phase circuit.

Conductors

All conductors should be of copper or aluminium. The conductor for final sub-circuit wiring should have a nominal cross sectional area not less than 1.00 mm^2 if copper is used and 1.50 mm^2 if aluminium is used. The cross-sectional area of conductor for power wiring should not be less than 1.50 mm^2 for copper and 2.50 mm^2 for aluminium.

Flexible cables and flexible cords should not be used in places where they are liable to be subjected to mechanical damage unless these cables and cords are protected by flexible conduits or tough rubber or PVC sheath.

Rating of lamp, fan and socket outlet point

For purpose of estimating the current to be carried by any conductor, ratings as indicated in the table below are assumed:

Appliance or point	*Power rating assumed*
Incandescent lamps	60 watts
Ceiling and table fans	100 watts
Ordinary socket outlet points	100 watts
Fluorescent lamps	60 watts
Power socket outlet points	1000 watts (Unless actual value specified).

Joint box and looping in system

Where looping-in system of wiring is specified, wiring should be done without any junction or connection boxes. When joint box system is specified, all joints are made by means of approved mechanical connectors in suitable and approved joint boxes. Looping-in system is generally preferred.

Reception and distribution of main supply

- At the entry level there should be a circuit breaker or linked switch on live conductor.
- No break in the neutral wire in the form of switch or fuse throughout the installation
- All main switches should be either metal clad enclosed or of any insulated enclosed pattern and should be fixed at close proximity to the point of entry of supply.

Reception and distribution of main supply

IS: 732-1983 stipulates that:

(i) Open type switch boards shall be placed only in dry situations and in ventilated rooms and they shall not be placed in the vicinity of storage batteries or exposed to chemical fumes;

(ii) In a damp situation or where inflammable or explosive dust, vapour or gas is likely to be present, the switch board shall be totally enclosed or made flame proof as may be necessitated by the particular circumstances;

(iii) Switch boards shall not be erected above gas stoves or sinks, or within 2.5 m of any washing unit in the washing rooms of laundries, or in bathrooms, lavatories or toilets, or kitchens;

(iv) In case of switch boards unavoidably fixed in places with abnormal moist atmosphere, the outer casing shall be weatherproof and shall be provided with glands and bushings or adopted to recieve screwed conduit, according to the manner in which the cables are run.

Reception and distribution of main supply

Metal clad switchgear should preferably be mounted on any one of the following type of boards

- Hinged type metal boards
- Fixed type metal boards
- Teak wood boards

Arrangement of Apparatus on Switchboards

(i) Equipment should be so mounted on the switch board that there is no possibility of an inadvertent contact with live parts whenever a person is performing operations like changing fuses, manipulating switches etc.

(ii) No apparatus should project beyond any edge of the board. No fuse body should be mounted within 2.5 cm of any edge of the board and no hole, other than the holes by means of which the panel is fixed, should be drilled closer than 1.3 cm from any edge of the board.

(iii) No live parts, unless they are effectively screwed by substantial barriers of non-hygroscopic, non-inflammable insulating materials, should be so spaced as to cause an arc to be struck between live parts and earth.

Arrangement of Apparatus on Switchboards

(iv) The arrangement of all the accessories shall be such that these connections shall be easily accessible and traceable.

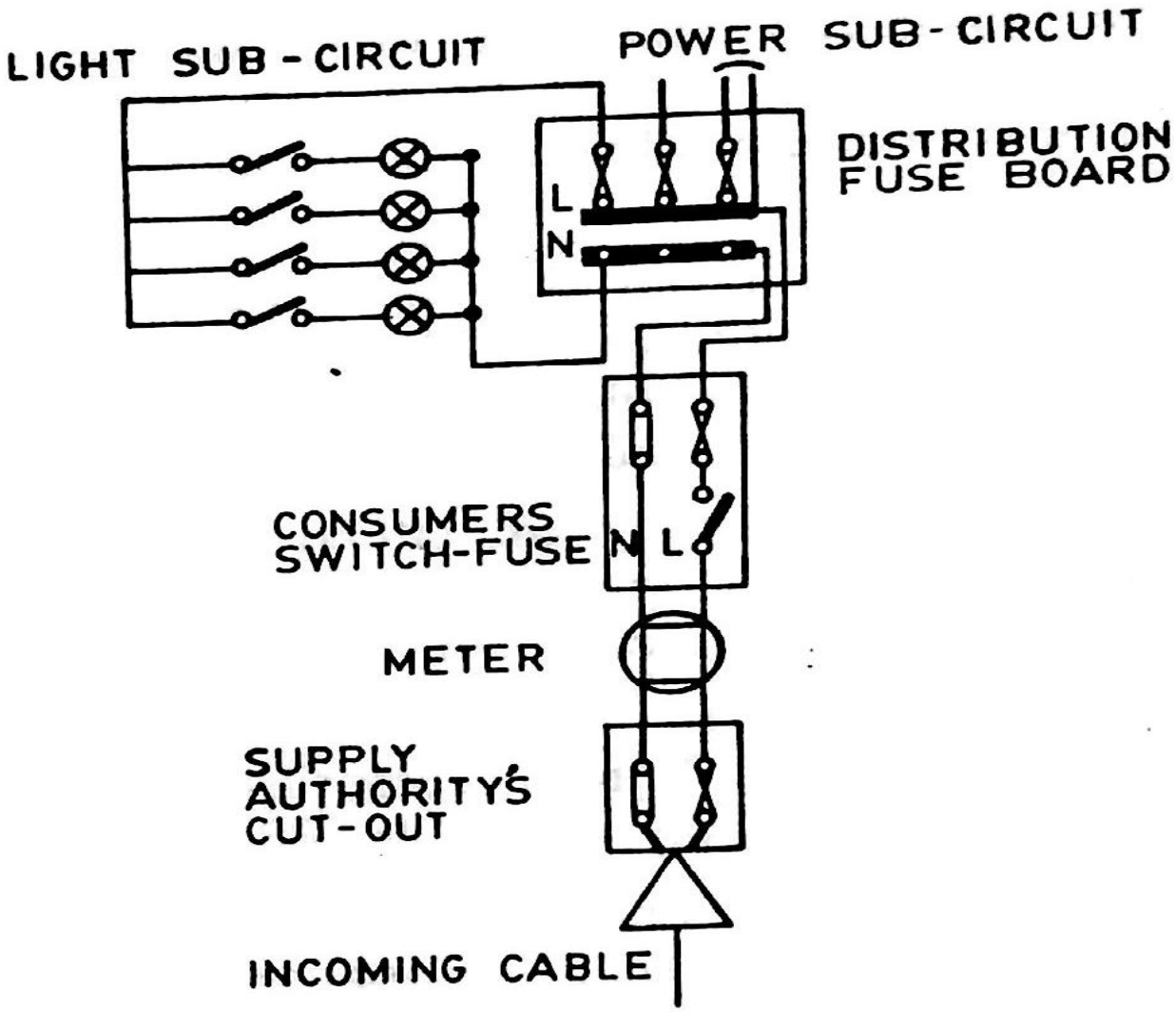
(v) Whenever switches and fuses are fitted on the same pole, these fuses should be arranged such that they are not alive when their respective switches are in the 'off' position.

Single Phase Supply

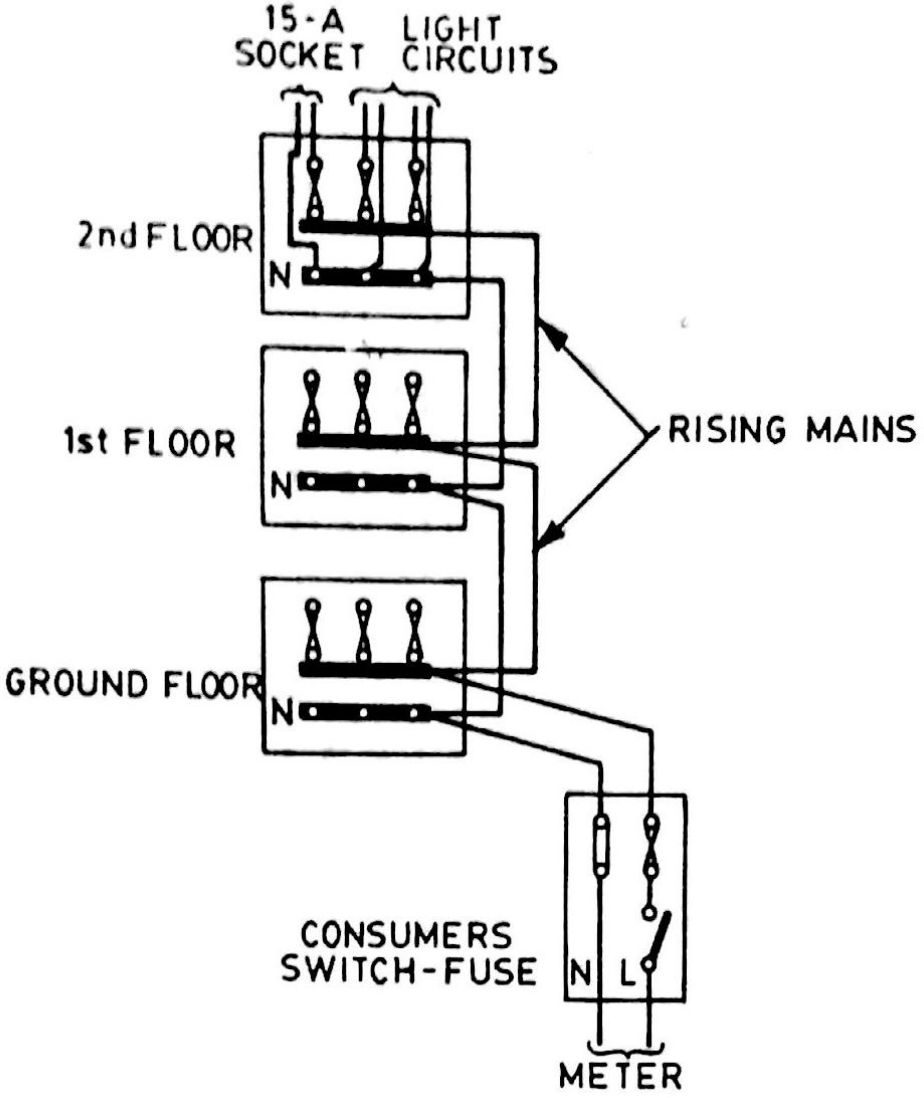
All loads in a single phase installation are connected in parallel and supplied at the same voltage. The feeder cables and the installation wiring should be designed such that switching on or off any load in the system does not affect any other load in the system.

The consumer's main switch fuse is connected after the meter and feed a distribution fuse board. It is important to note that fuses should be connected only in live wire and never in the neutral wire. Similarly all switches installed on live wire only and never on the neutral wire.

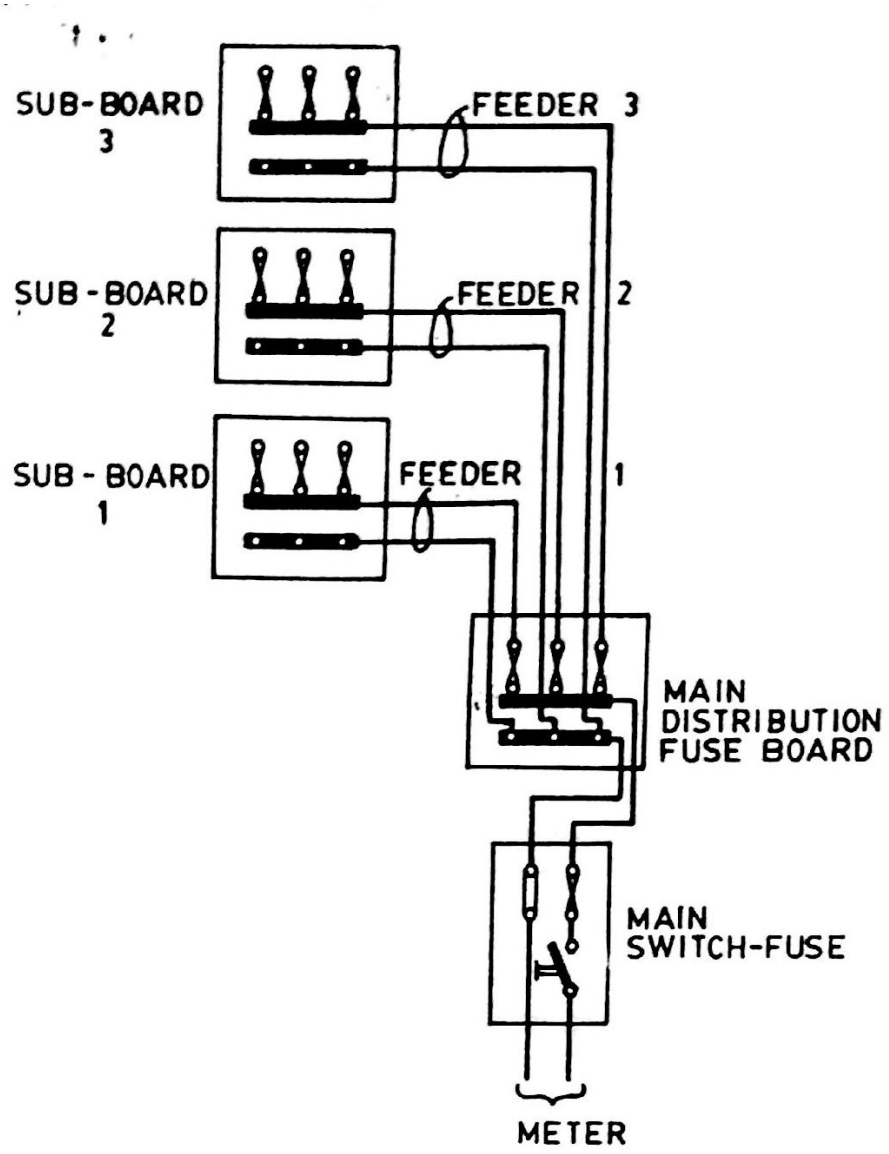
Simple diagram of Single Phase Installation



Single Phase Installation with a number of sub-distribution boards having a common main switch fuse



Single Phase Installation with a number of sub-distribution boards each connected to the mains through a separate fuse



Service Connection

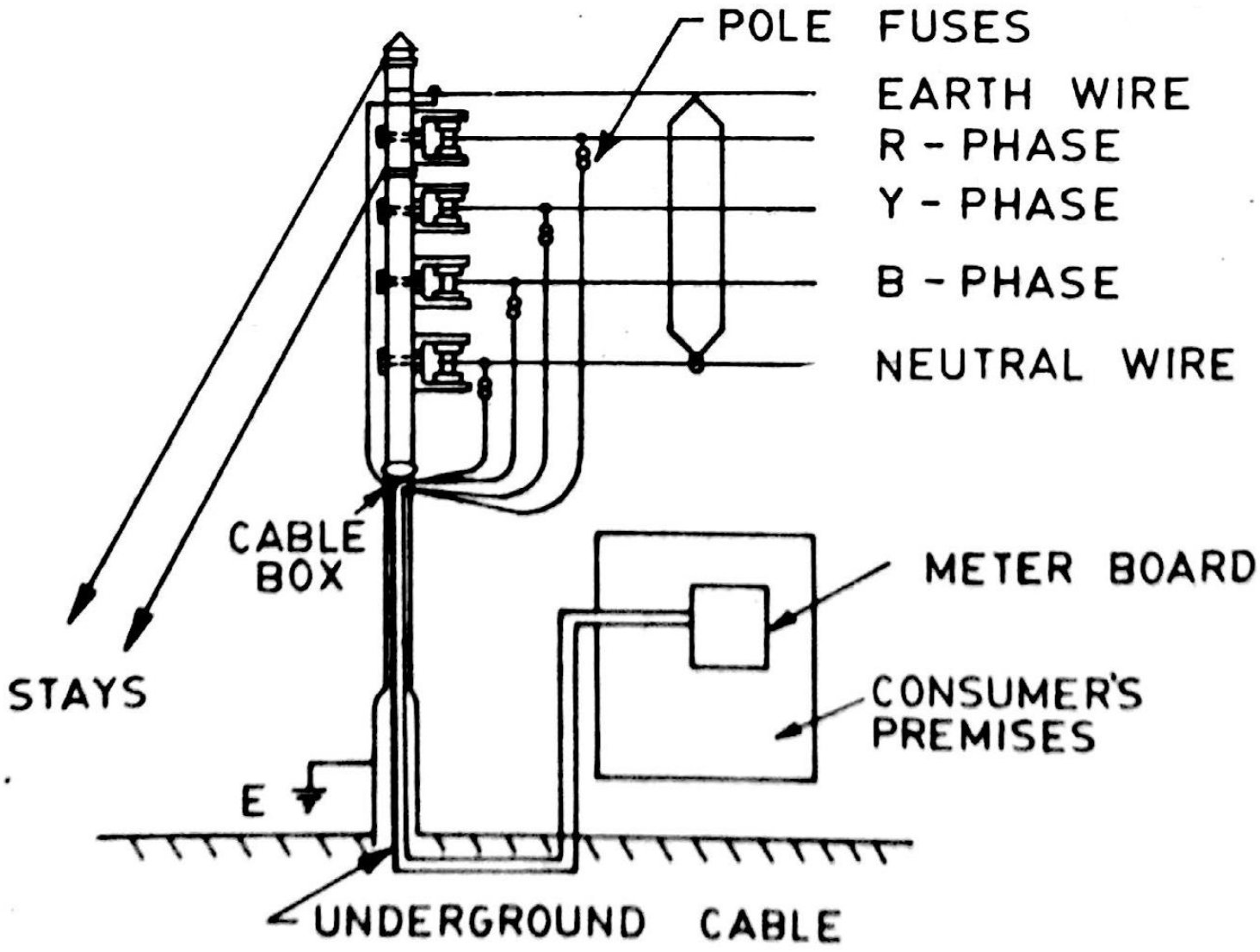
The line bringing electric power from supplier's low voltage distribution up to the energy meter installed at the consumer's premises is called the service connection.

The electric supply authority supplies power to the consumers through a low voltage three phase four wire distribution system called the secondary distribution system.

Large consumers supplied at higher voltages through three-wire high voltage distribution system called the primary distribution system (6.6, 11, 33 kV)

Service connection may be by mean of underground cables or by mean of overhead conductors or cables.

Underground Service Connection



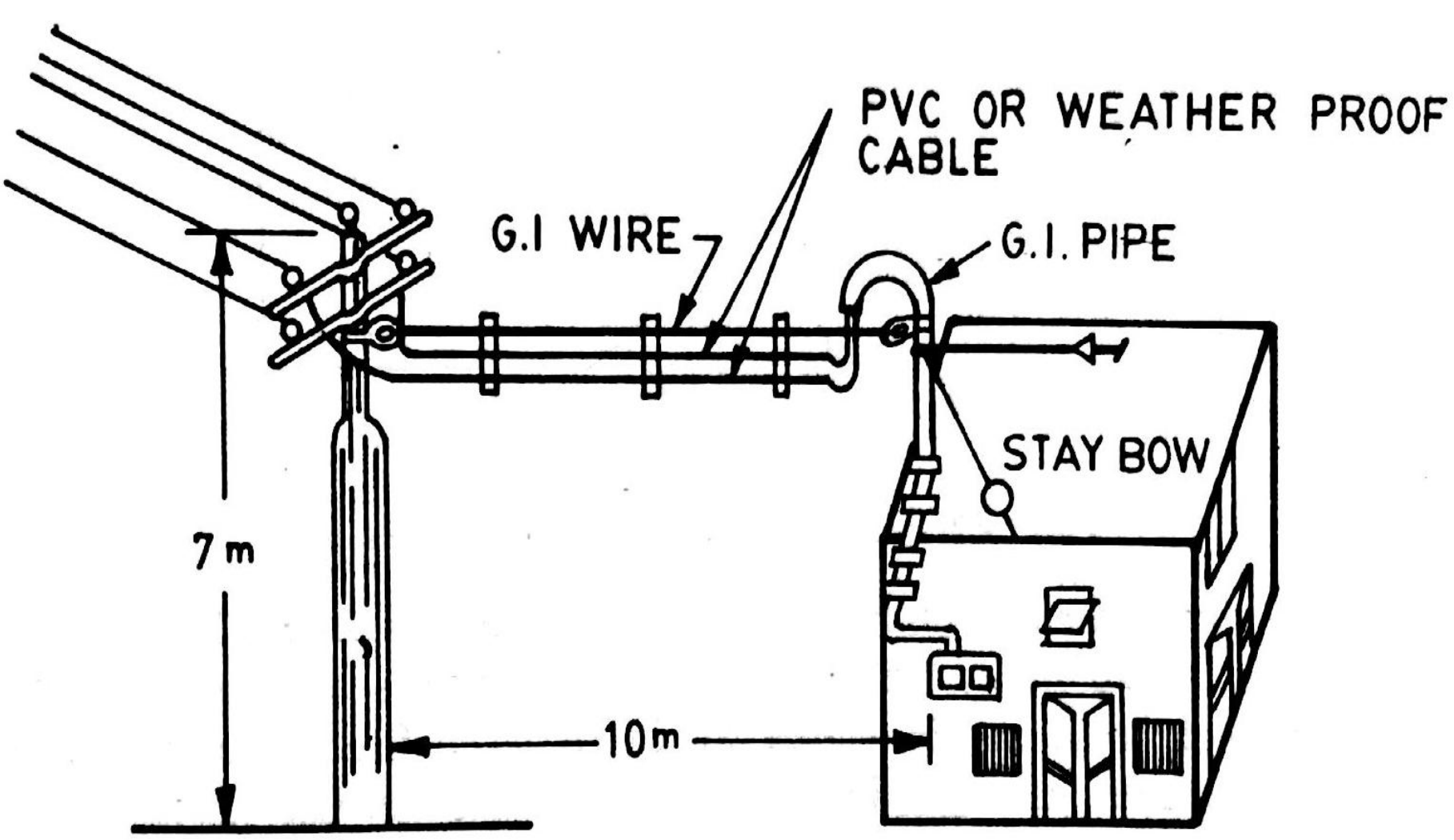
Overhead Service Connection

This system is used when the consumer's premises are more than 45 meter away from the supplier's distribution pole.

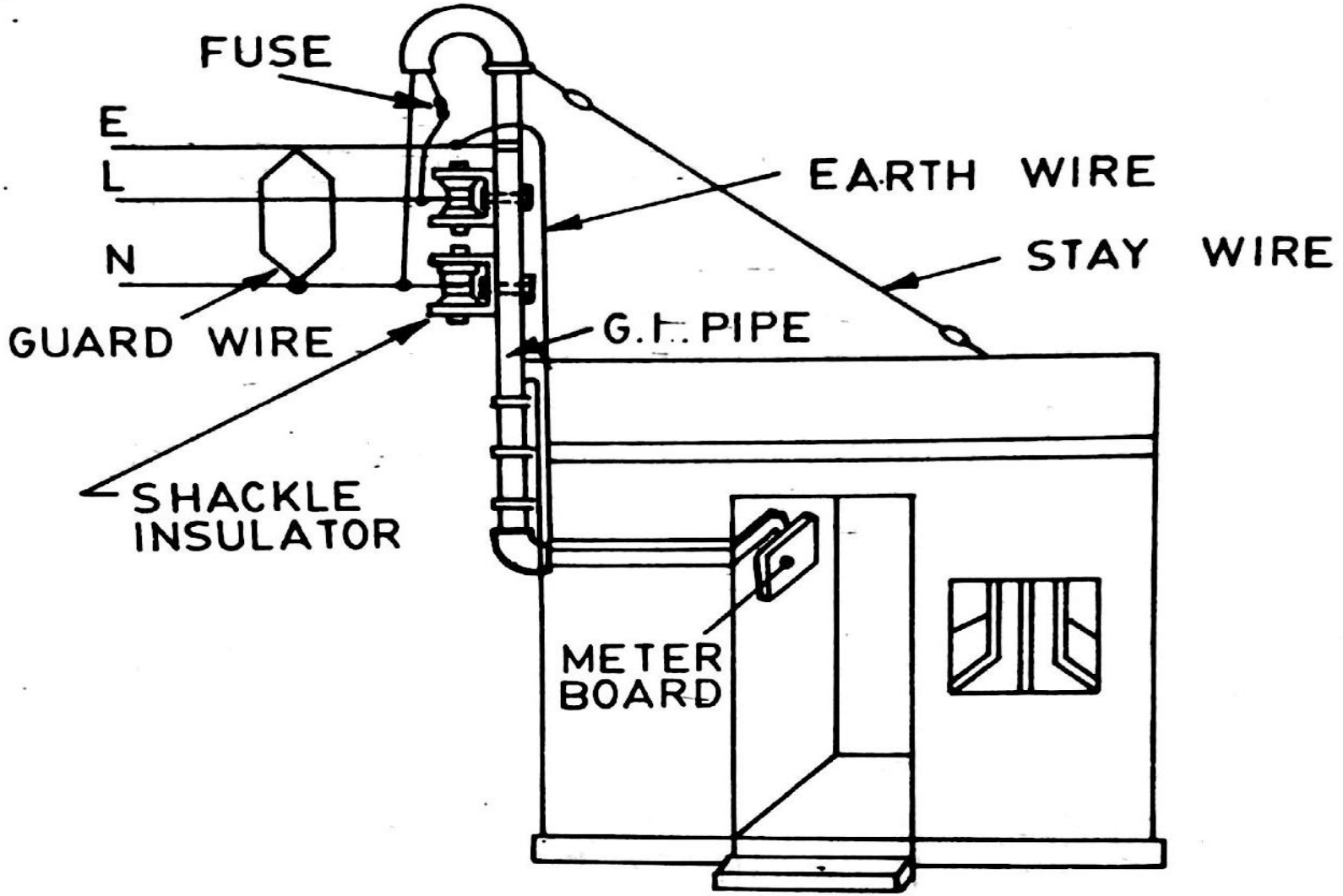
a) PVC or weather proof cable service line

b) Bare conductor service line

PVC or weather proof cable service line

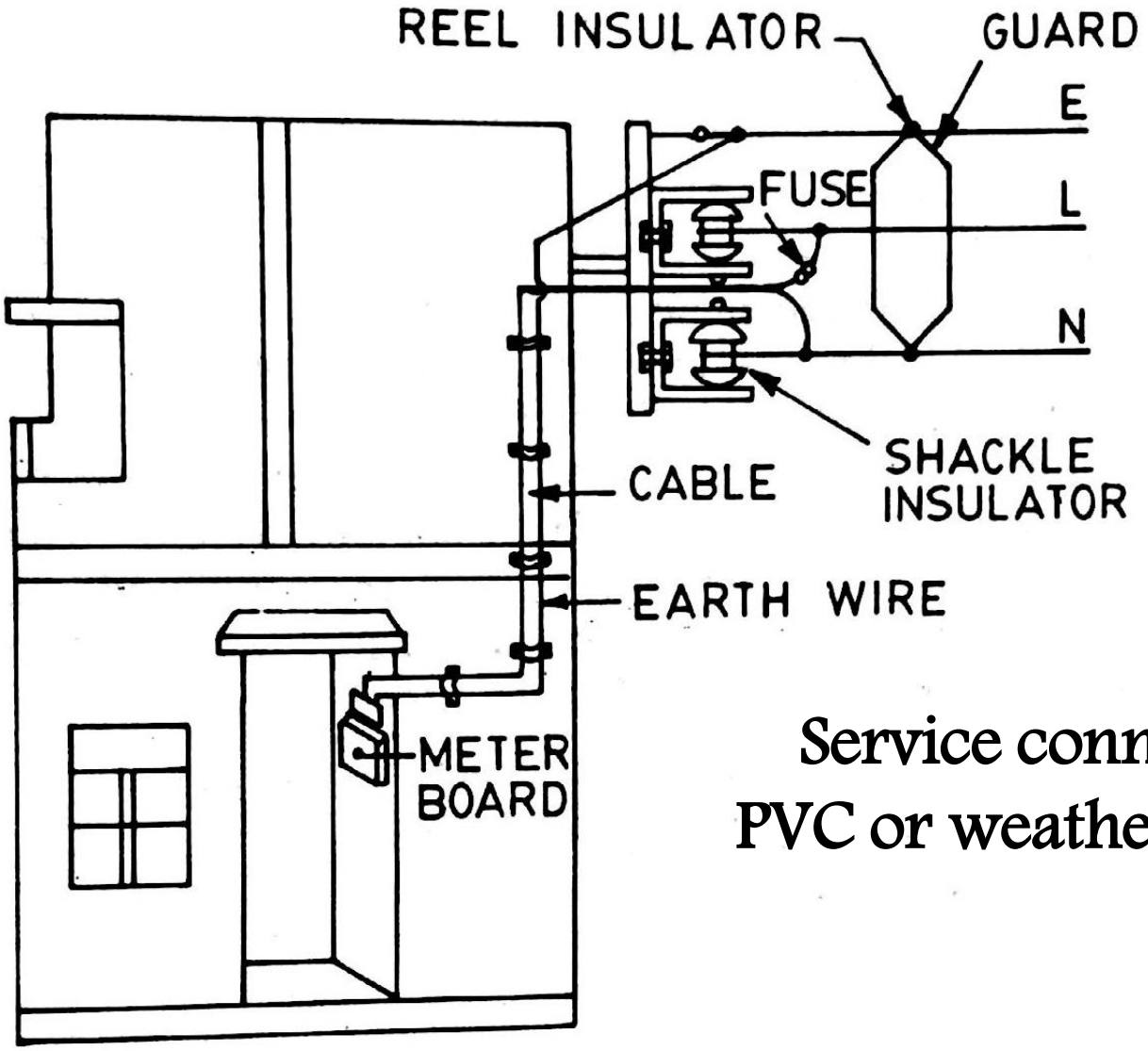


Bare conductor service line



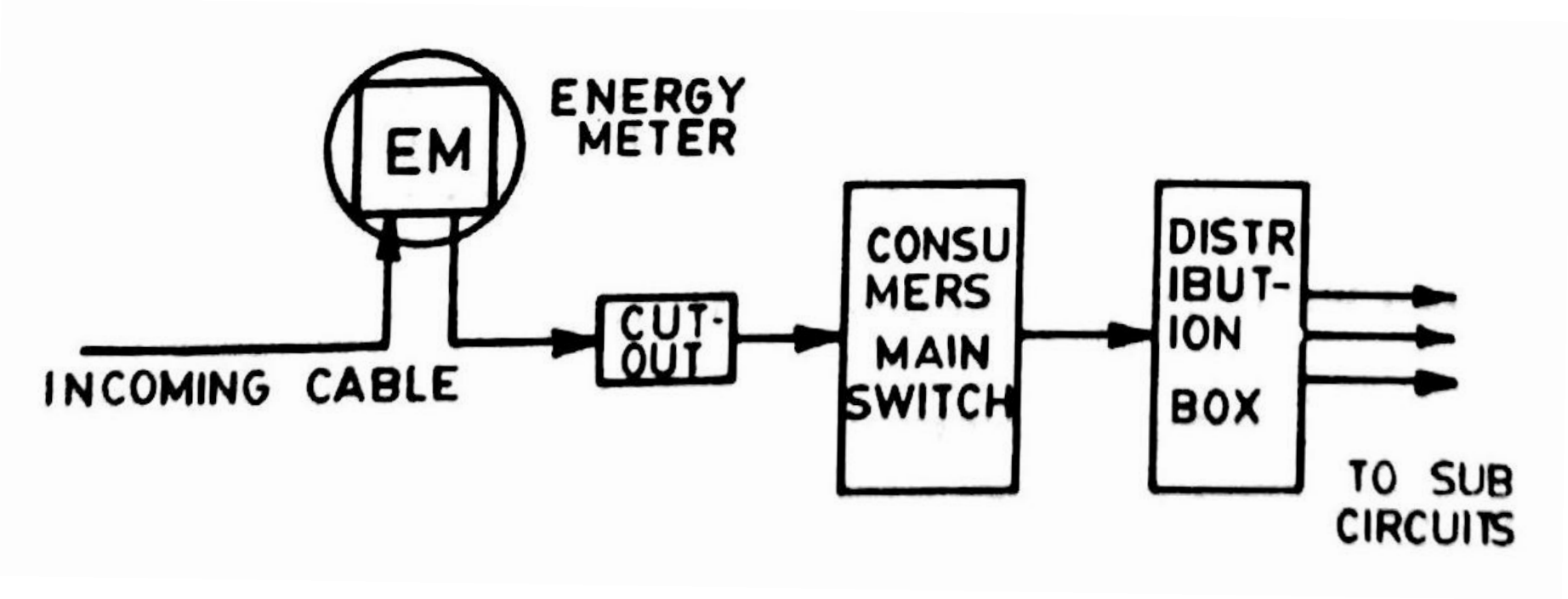
Service connection through GI Pipe

Bare conductor service line



Service connection with
PVC or weather proof cables

Service Mains



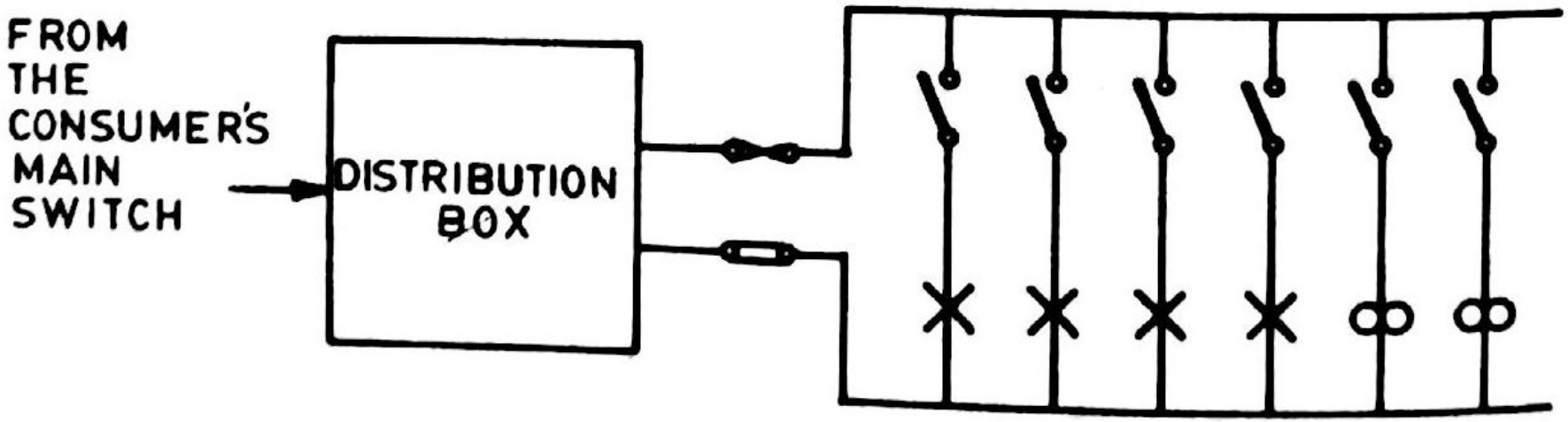
Block diagram of the meter distribution board.

Sub Circuits

-After the main switch the supply is taken to the various load points.

-In the given circuit same circuit contains light, fan and power circuit which has various drawbacks.

-Dividing the wiring into a number of smaller circuit is called sub-circuit.

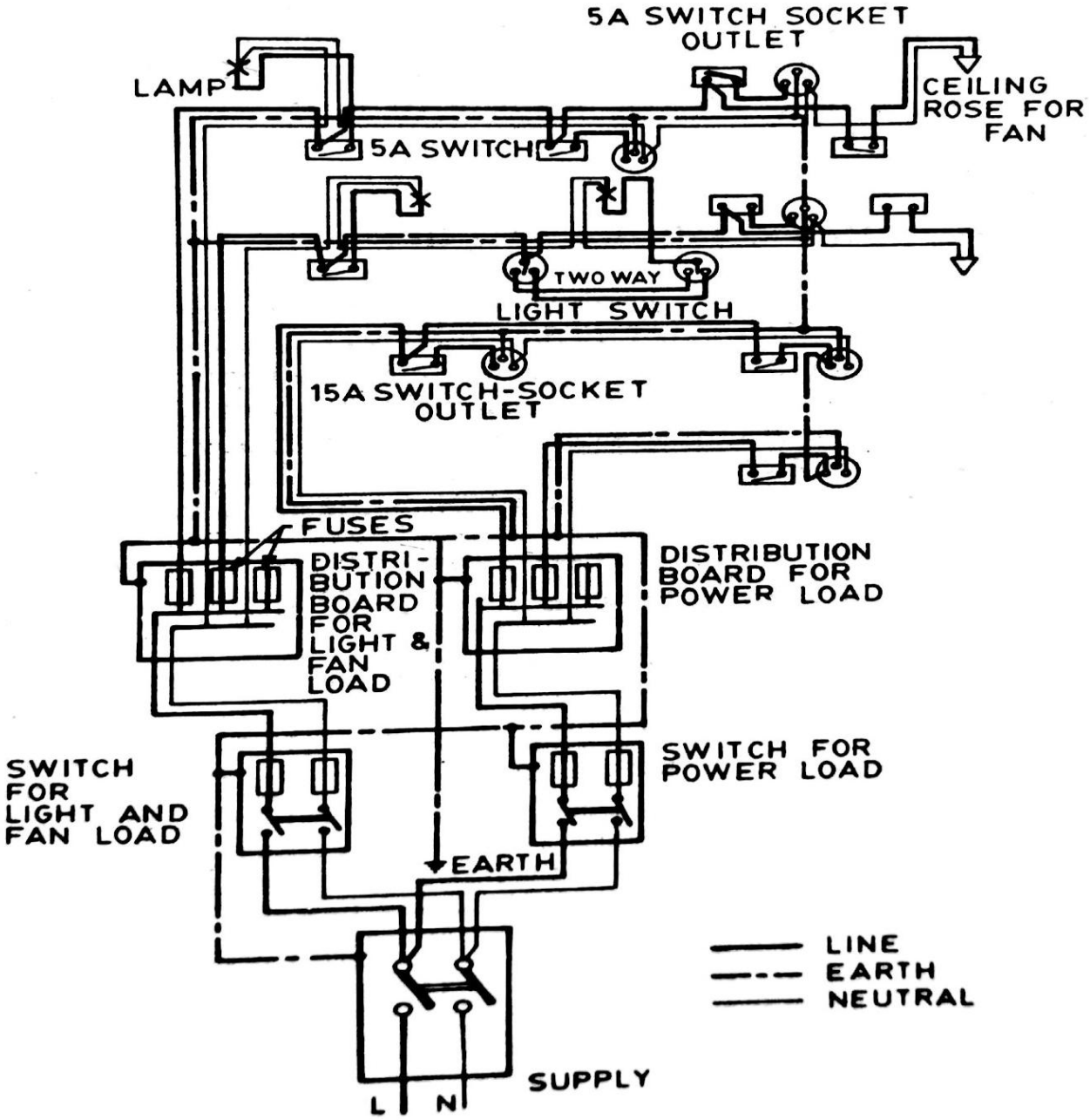


Sub Circuits

Sub-circuit divided into two parts:

a) Light and fan sub-circuit

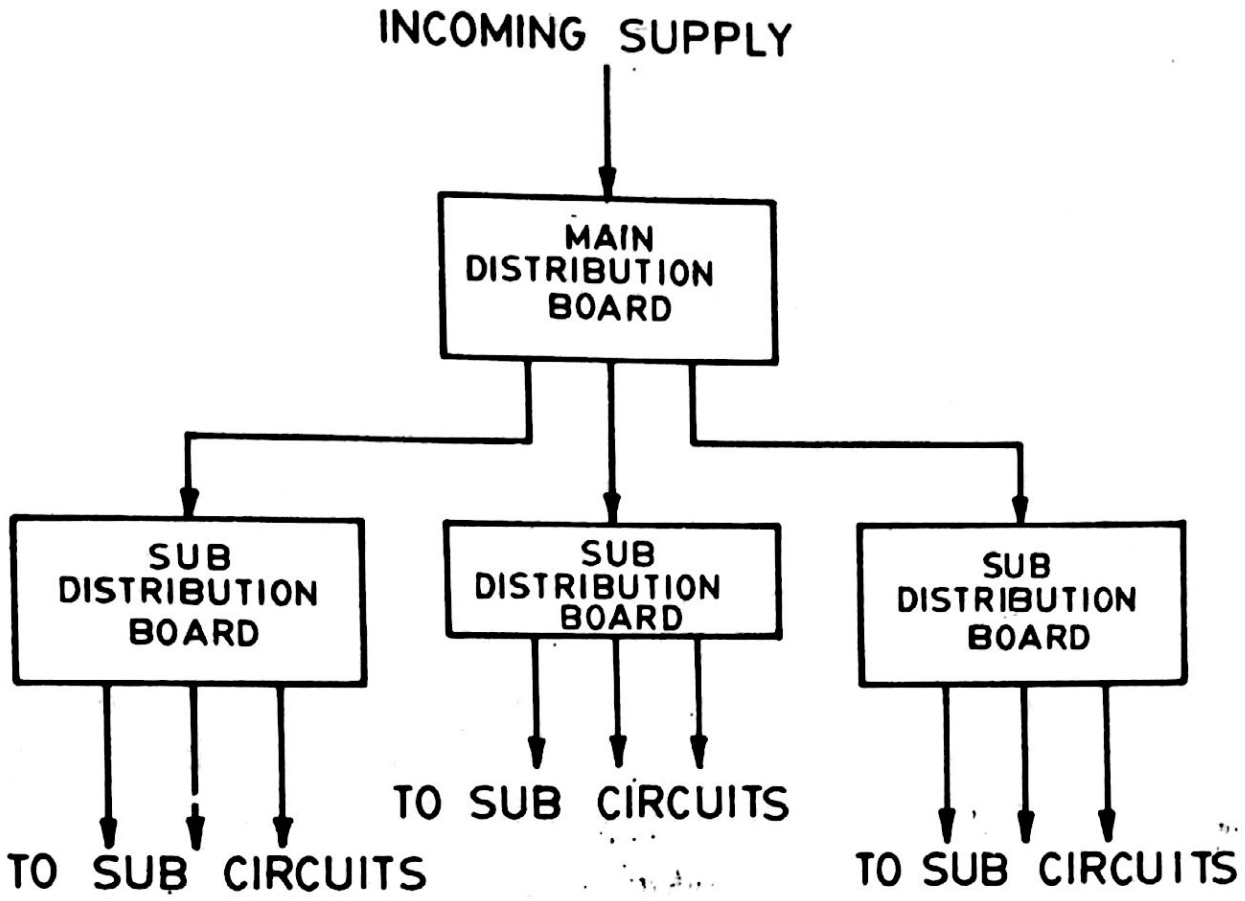
b) Power Sub-circuit


5A SWITCH SOCKET OUTLET
LAMP
CEILING ROSE FOR FAN
5A SWITCH
TWO WAY
LIGHT SWITCH
15A SWITCH-SOCKET OUTLET
FUSES
DISTRI-BUTION BOARD FOR LIGHT & FAN LOAD
DISTRIBUTION BOARD FOR POWER LOAD
SWITCH FOR LIGHT AND FAN LOAD
SWITCH FOR POWER LOAD
EARTH
LINE
EARTH
NEUTRAL
L
N
SUPPLY

Location of Outlets.

Location of Control Switches

Location of Main Board and Distribution Board



Guidelines for Installation of Fittings

- Switches, socket outlets and light points
- Fans
- Fuses and switches
- Earthing installation

Load Assessment

For assessing the total load of a building the following guidelines may be adopted after deciding the number and type of outlets.

Incadescent light point	60 watts.
Fluorecent tubes	60 watts.
Ceiling fans	100 watts.
Light sockets (5 A socket)	100 watts.
Power sockets (15 A socket)	1000 watts.

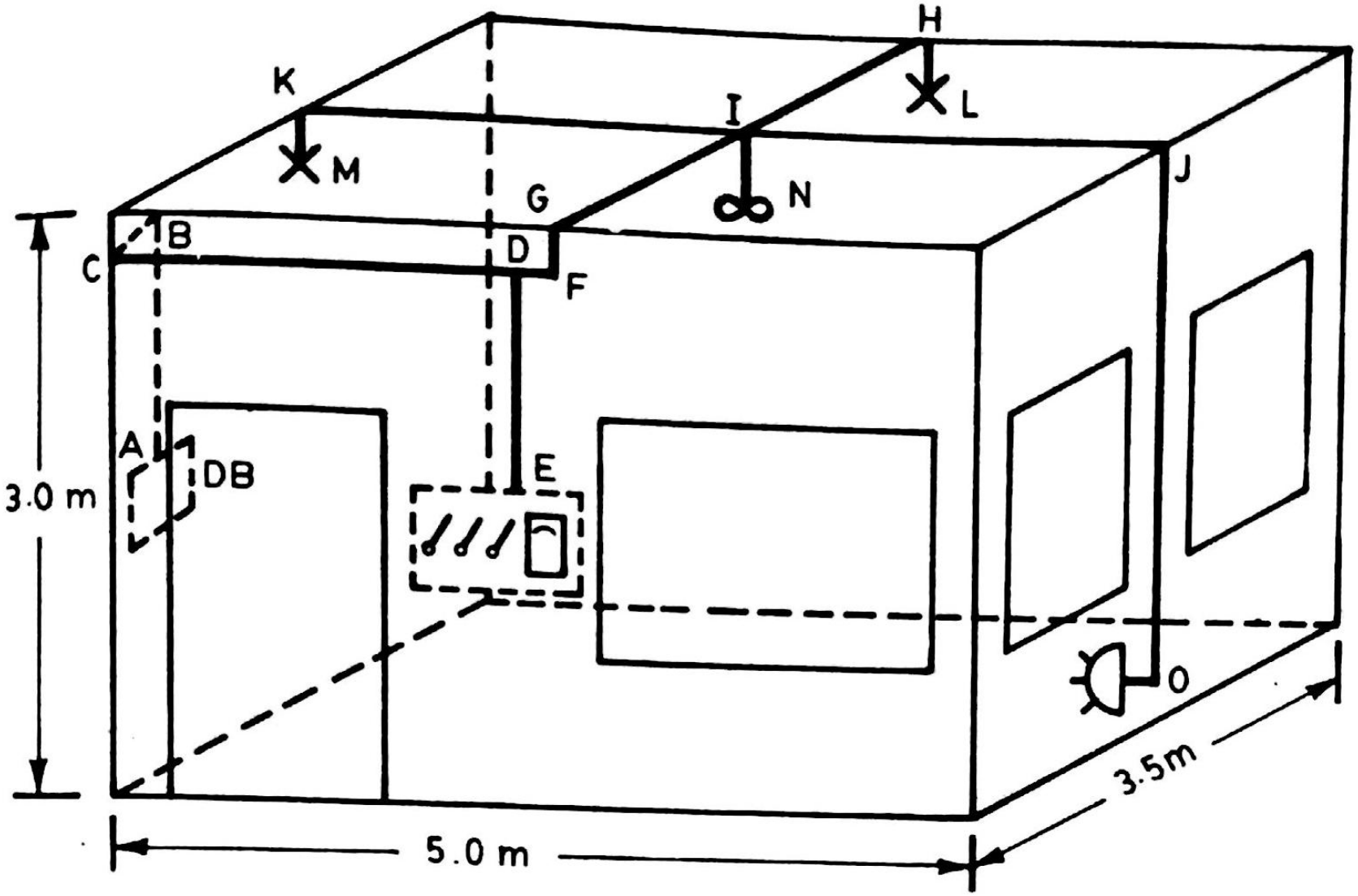
Estimating and Costing of Electrical Installation

- Quantity and specification of material
- Price list
- Labour charges
- Overhead charges
- Contingencies
- Profit purchase system

Electrical Installations for Residential building: Estimating and Costing of Material

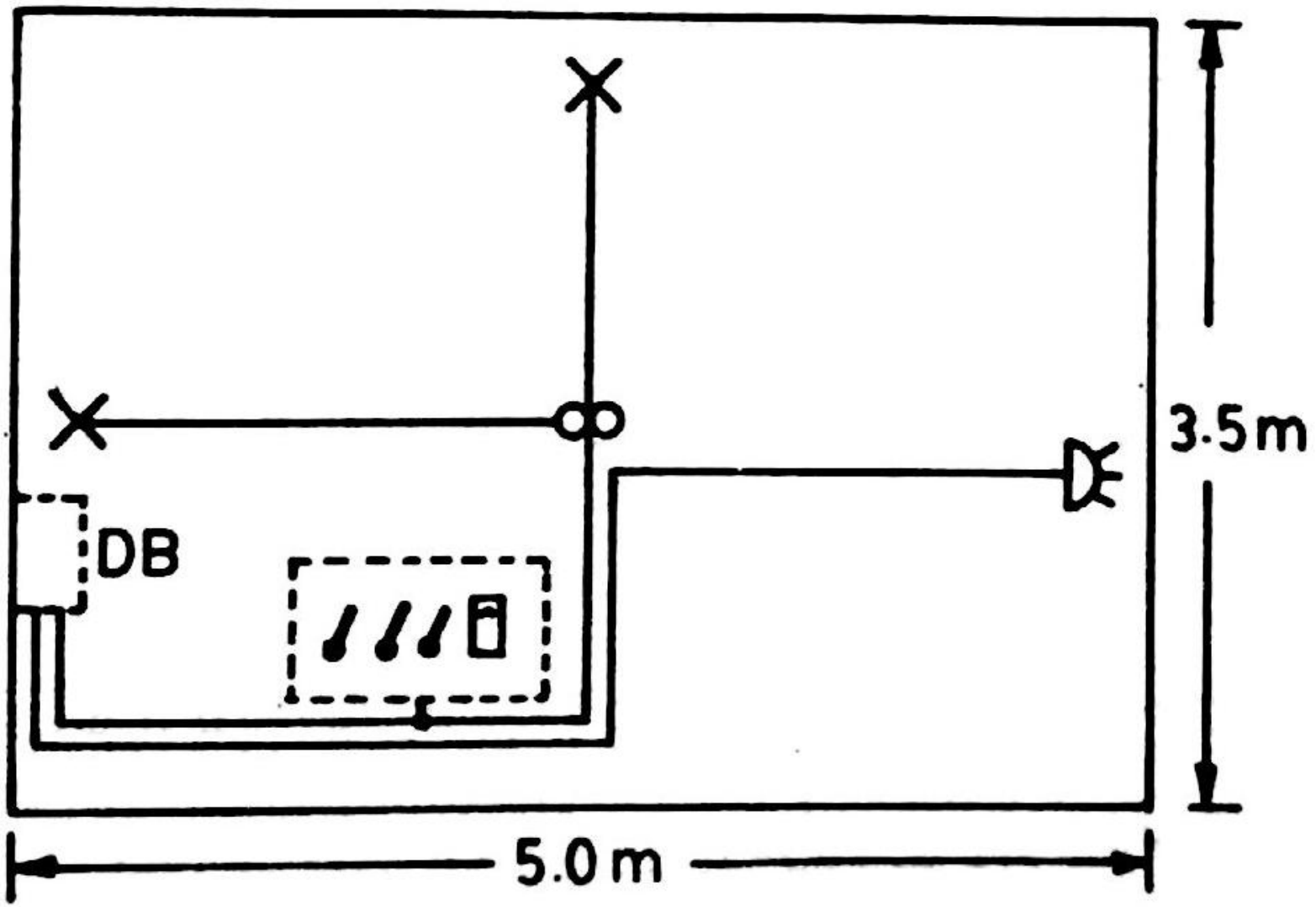
- Choice of particular type of wiring depending upon a particular use, financial implication and personal preferences.
- Installation work should be as per Indian Electricity Rules 1956.
- The planning and designing of electrical wiring should be done before civil work start.
- Layout of electrical wiring prepare in advance and handed over the civil engineer to make necessary provisions in the building for electric work.

Example of Estimating and Costing of materials

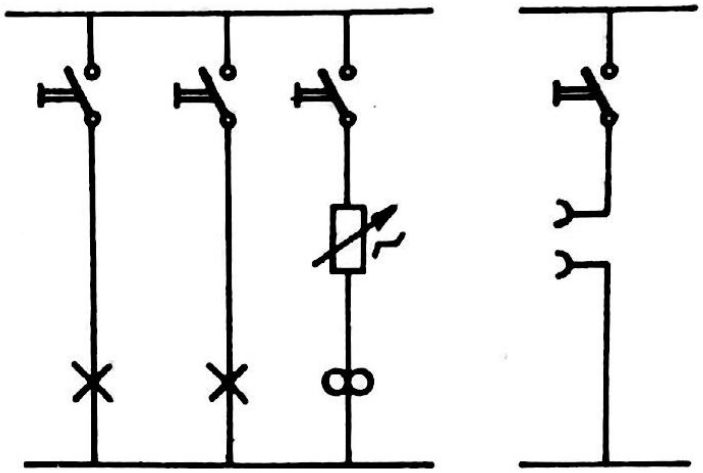


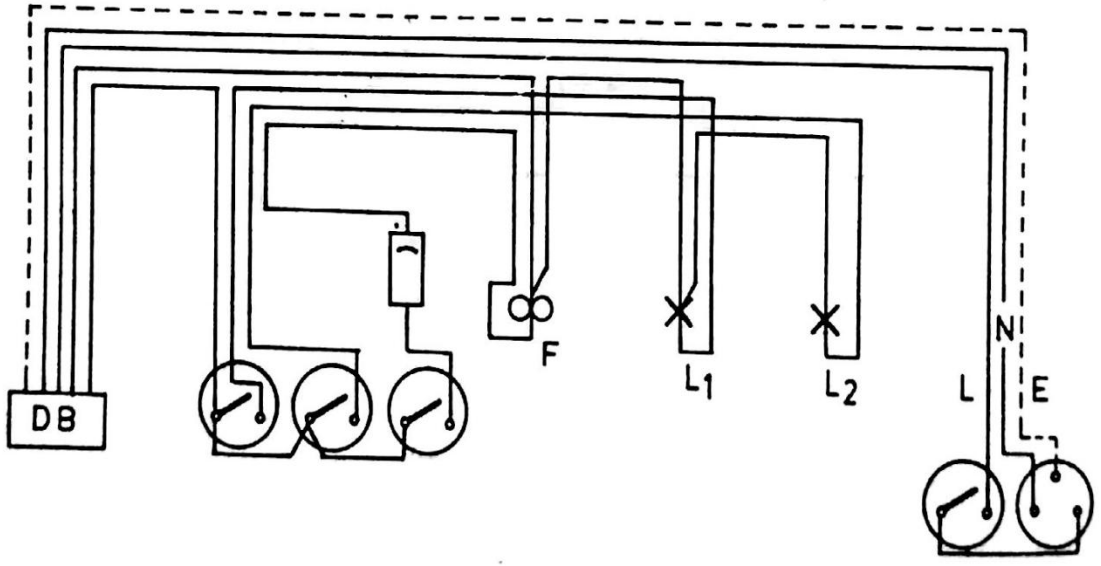
Wiring installation in a room – an isometric view.

Installation Plan



Schematic and Wiring Diagram





Electrical Installations for Commercial Building

Electric service and supply

- Supply authority supplies power to the consumer through low voltage i.e. 415V/240V three phase four wire distribution
- Large consumers are supplied at higher voltage: 6.6, 11, 33 kV three wire high voltage feeder

Internal Distribution

- Small residential installation
- Medium Large Installation
- Large Installation

Large Installation

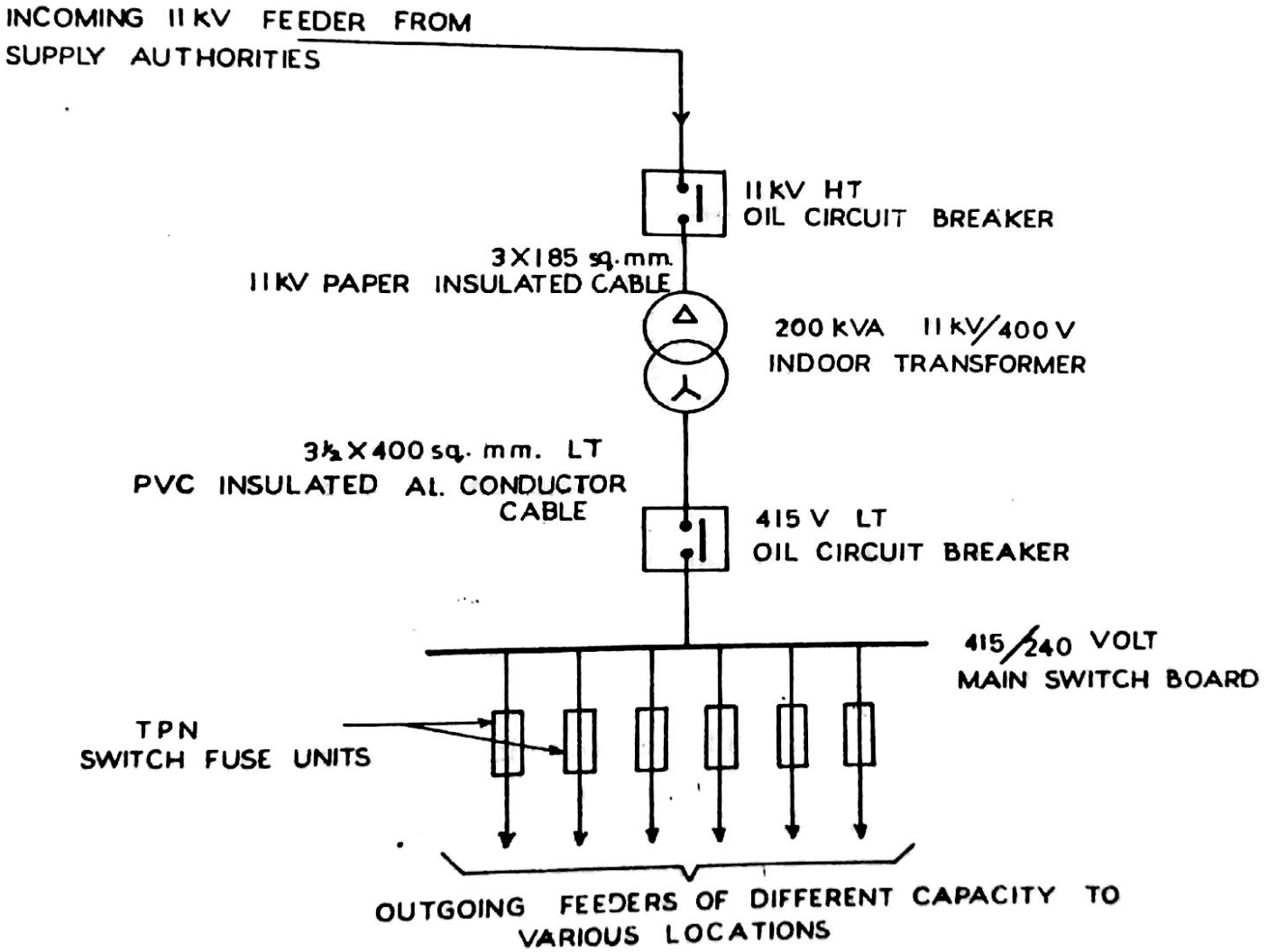


Figure 5.16: Schematic layout of a substation and low voltage switchboard.

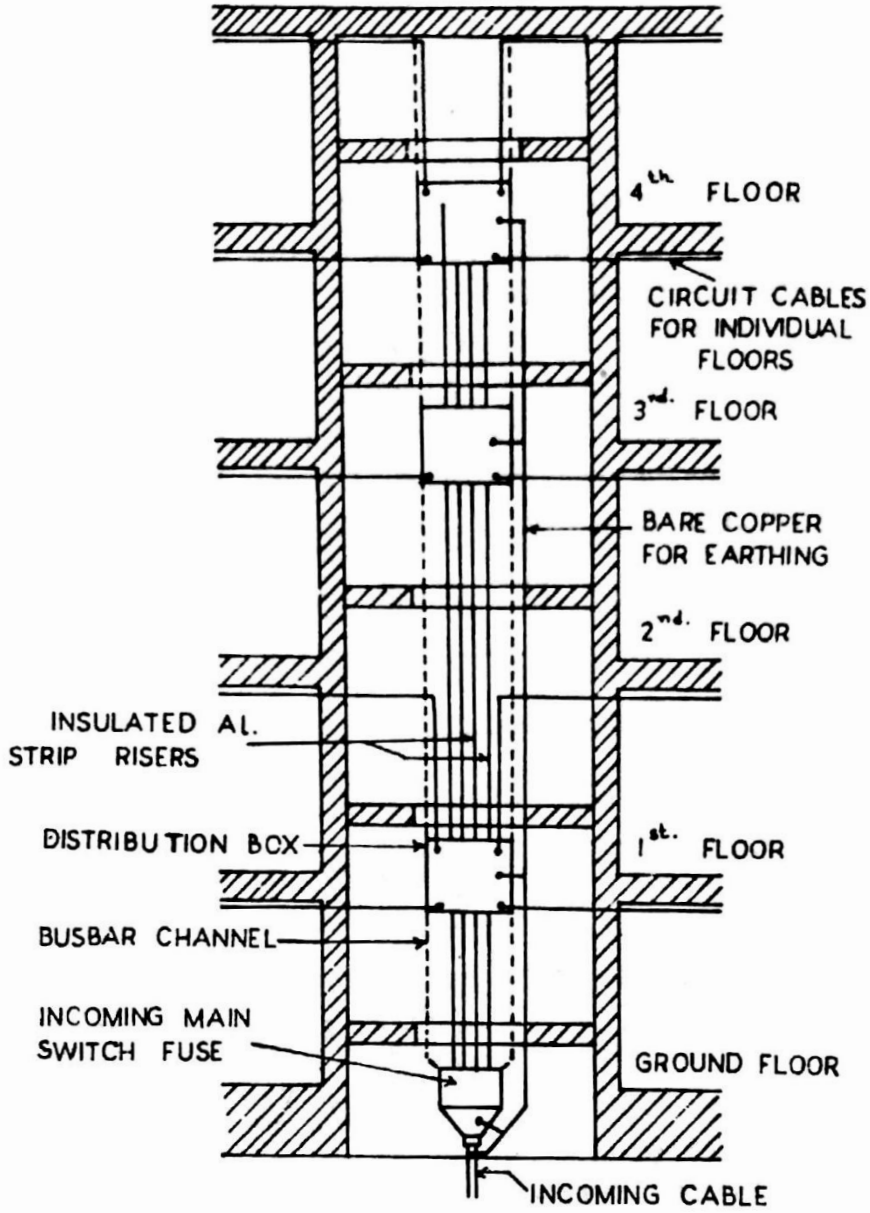


Figure 5.17: Arrangement of a rising main channel for a five storey building.