Chapter 6
Installation of Transmission Lines

6.1 Steps before Installing Transmission Lines

It is usually necessary to resurvey the transmission route and plan for difficult features and obstructions such as landslide zones, gulley crossings, trees, ground clearance, and cultivated land.

- Choose a short straight route.
- Calculate the number of poles required for the given length and use pegs to mark the location of the pole pits.
- If wooden poles are proposed in the design then select straight hardwood poles.
- The poles should be buried about one metre deep in the ground. Bitumen paint should be applied to the portion to be buried to prevent rotting.
- The specifications for the poles for different types of transmission are shown in Table 6.1.

Table 6.1: Specifications for Wooden Poles

Type of Transmission/ Pole Specifications	Single Phase 220V	Three Phase	11 kV
Height of poles	6m	7m	8m
Diameter of poles	125 mm	150 mm	175 mm
Ground clearance	4.5m	5m	6.3m
Spacing of poles			
- For transmission	30 – 35m	30 – 35m	50m
- For distribution	25m	25m	

6.2 Installation Procedure

- Clear the path of the transmission route.
- Dig holes in the ground for the poles and fix accessories (e.g., D-iron clamps and insulators) on the poles. The spacing between the insulators is shown in Figure 6.1.
- Insert the pole base in the pit (Figure 6.2) ensuring that after erection the pole will be in line with the other poles and vertical; check verticality with a plumb bob
- Fill the pit with earth and stones and compact well.

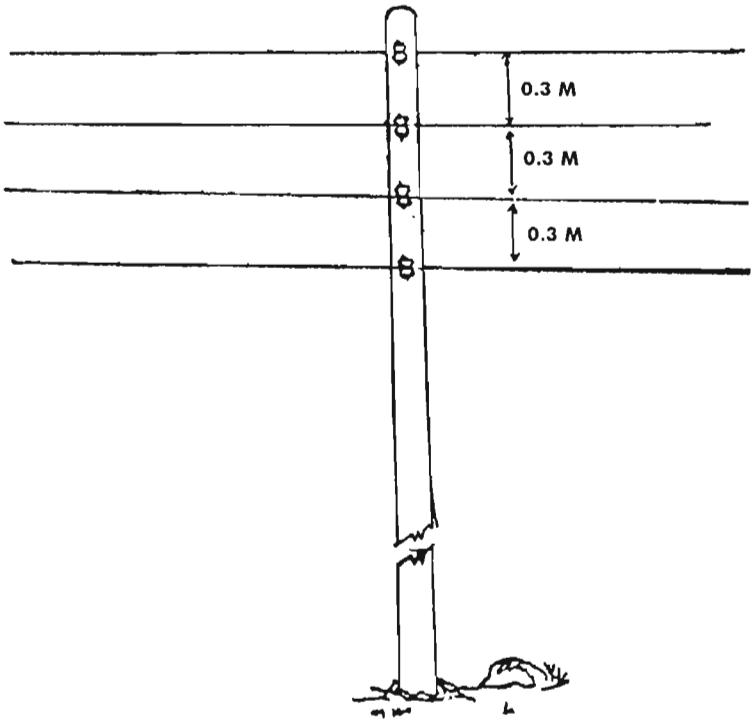

Figure 6.1: Spacing of Conductors at the Pole

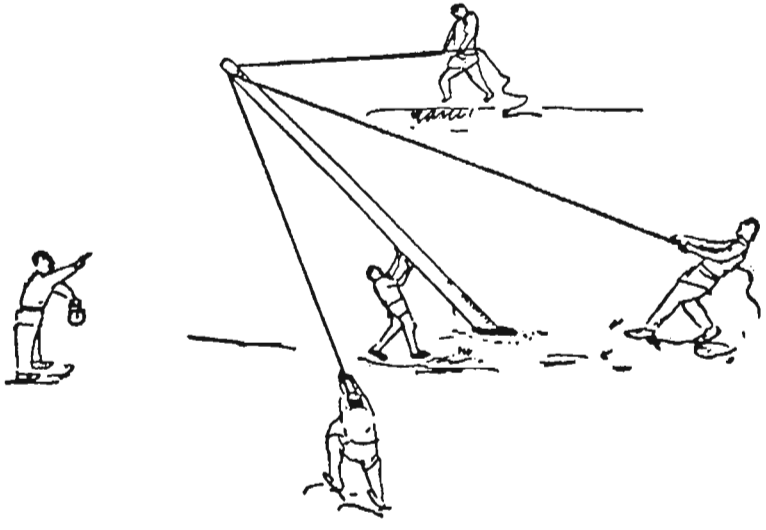

Figure 6.2: Erection of Poles

- Install stay wires on the poles at every bend, on the first and last pole, and on poles with a jumper (Figure 6.3).

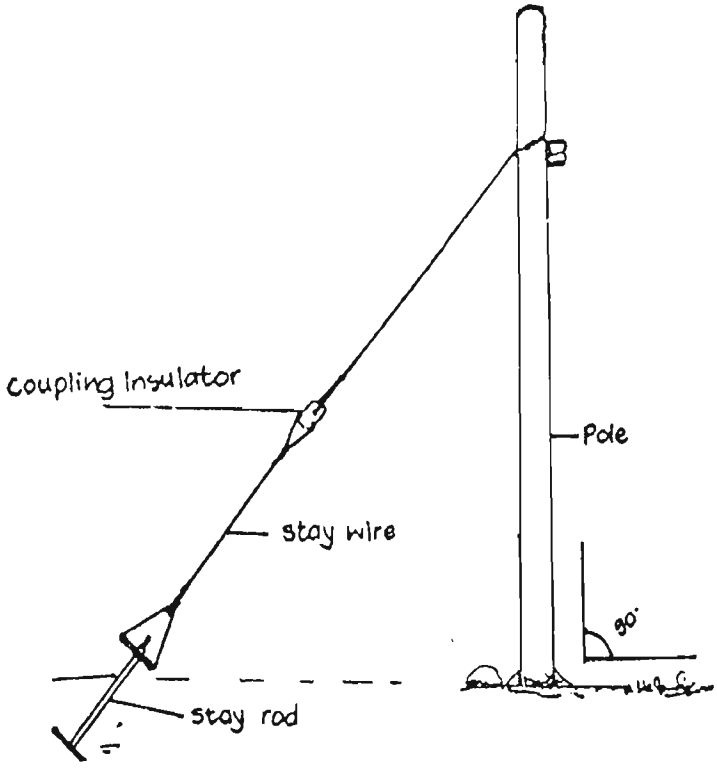

Figure 6.3: Erection of Stay Wires

After all poles have been erected, commence installing the wires. Start to unroll the wire and lift the end up to the pole carefully; the wire should not be overlapped during pulling (Figure 6.4). Generally, pulling of the wire can be started from the powerhouse; but if this is in a valley and the route is uphill (vertical slope), then pulling may be started from uphill and the wire run down towards the powerhouse.

- Lines are generally pulled using portable manual wire puller machines with a capacity of two tonnes.
- When pulling wires, make them tight enough so that they do not sag heavily or swing and touch another wire. The spacing between the wires should be uniform. Normally, the spacing should be about 0.5m per 50m pole spacing.
- The wire sag should be observed visually from some distance (about 50 metres); the extent of sag should be the same between all poles (Figure 6.5). The sag in the cable can be measured using a level but this will not be possible in all cases.

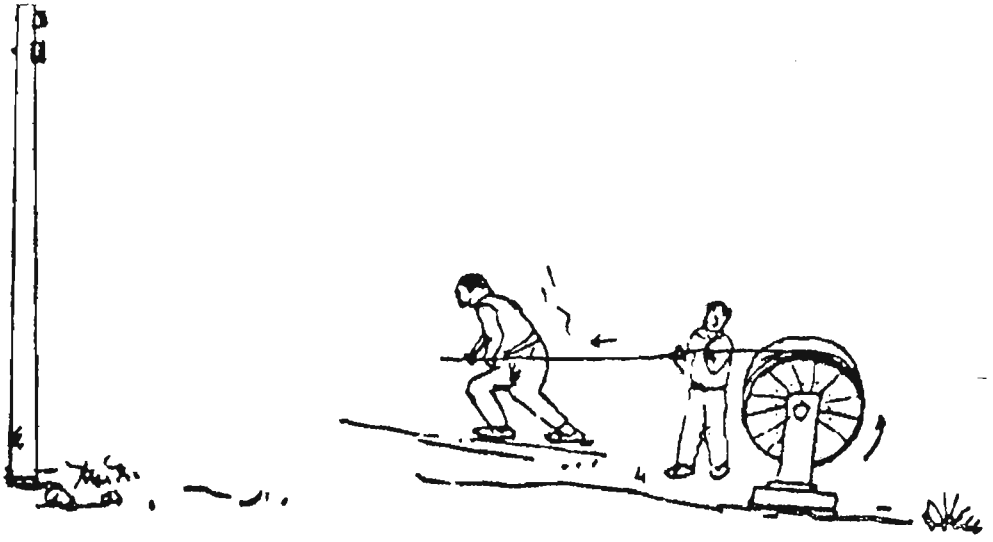

Figure 6.4: Unrolling Wire

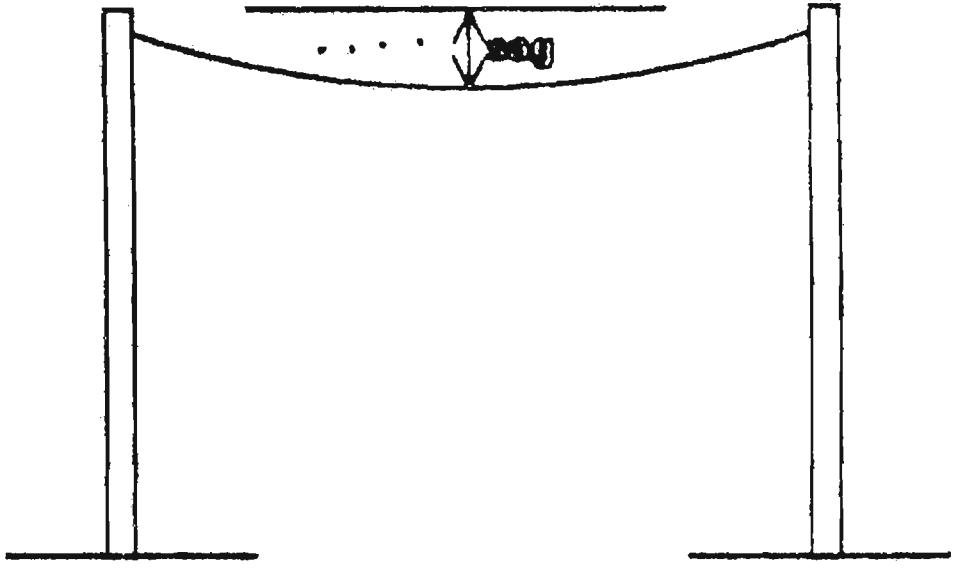

Figure 6.5: Spacing of Sag

- Excessive tension on the conductor should be avoided as it could cause it to break.
- During installation of transmission lines, the ends of two wires can be connected using the following procedure (see also Figure 6.6).

  - Open all strands of both ends of the conductors.
  - Bring the two ends together, overlapping by at least 300mm, and twist each strand together with one from the opposing conductor.
  - Wrap the twisted strand lengths around the joint and pass the last strand underneath another strand to give the joint a smooth, tight, and unbreakable finish.

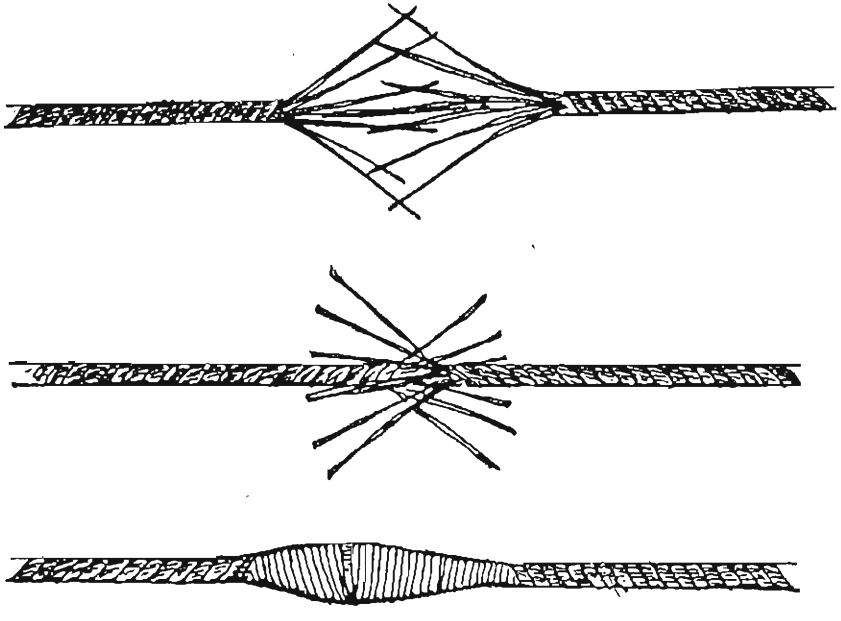

Figure 6.6: Method of Joining Wire Ends

- Safety belts should be used during the installation of transmission lines, and the installers should be informed about the safety aspects.
- After the transmission lines have been erected, all the routes should be checked for such things as ground clearance, road clearance, compaction of pole pits, and position of stay wires.
- Anti-climbing devices and 'Danger' boards should be installed on each pole.

6.3 Installation of Distribution and Service Lines

Distribution lines bring power from the transmission line to the service wires supplying the consumers. The installation procedure for distribution lines is similar to that for transmission lines. If the lines pass through a village, it is necessary to make sure that there is appropriate ground clearance and that the lines are a sufficient distance from the houses. Stay wires should be installed wherever necessary.

The service line brings electrical power from the distribution line to the premises of individual consumers. This wire can be pulled by hand from the pole to each house. Normally flat, twin-sheathed solid aluminium conductors are used, so excessive tension in the wire should be avoided. The wire should be fixed to the pole and connected to the distribution line by wrapping it around it three or four times. It may also be tied to the pole to avoid excessive stress at the joint.

6.4 Earthing

Earthing is the process of providing a path to earth for excessive electricity and voltage caused by short circuits or lightning, and thus preventing damage to equipment and people. There are two basic systems for earthing.

- System earthing means connecting the neutral points of generators and transformers to the mass of the earth.
- Equipment earthing means connecting the outer casing or supporting structure of live electrical equipment to the general mass of the earth.

Earth connections should be provided at the following points.

- The neutral of all the power systems such as the generators and transformers
- The earth terminals of each lightning arrester
- The frames of such components as the generator, motor, ELC, ballast, transformer, and control/instrument panel
- All metal casings or coverings containing or protecting any electric supply or apparatus
- The armouring of underground cables
- The metallic poles and towers of overhead lines

System and equipment earthing should be separated by a minimum distance of ten metres.

A good earth should have very low resistance and should thus be made in an area where the ground is normally moist, for example, near a canal. Salt and coal can be used to further reduce earth resistance.

6.4.1 Earth Electrodes

The earth electrode is a plate or pipe of copper or GI driven into the ground and connected to an electrical system or piece of electrical equipment. The number and type of earth electrodes required per installation depend upon factors such as the type of soil, the type and capacity of the installation or equipment, and the value of the required earth resistance. Plate electrodes should be used only when the current carrying capacity is the main consideration, as, for example, for the powerhouse earth. The approximate sizes of earth electrodes recommended for MHP installations are given in Table 6.2. The different ways of preparing and connecting earth electrodes are described below.

The earth should be connected with eight SWG wire (4.06mm diameter); copper wire for copper electrodes and GI wire for GI electrodes

Table 6.2: Recommended Sizes of Earth Electrodes

Conductor Type (to be buried vertically)	Size (mm)
Copper plate	600 long x 600 wide x 3.15 thick
GI plate	900 long x 900 wide x 3.15 thick
GI pipe	38 diameter x 2,500 long

6.4.2 Pipe Electrodes

The general arrangement for pipe earth electrodes is shown in Figure 6.7. Pipe electrodes should have an internal diameter of at least 38mm if made of galvanised iron and 10mm if made of cast iron and a length of at least 2.50m. They should be driven fully into the ground. Where rock is encountered at a depth of less than 2.50m, the electrodes may be buried inclined to the vertical but the inclination should be not more than 30 degrees off vertical.

Pipes or rods should normally be a single piece. If it is necessary to reduce the depth of burial of an electrode, this must be done without increasing the resistance. This is achieved by using a number of rods or pipes and connecting them together in parallel. The distance between two electrodes in such cases should preferably be not less than twice the length of the electrode.

The copper earth wire should be joined to a hole drilled in the top of the pipe and held tight with a brass nut and bolt. Before attaching, the earth wire should be scraped to ensure good contact between the wire and the pipe.

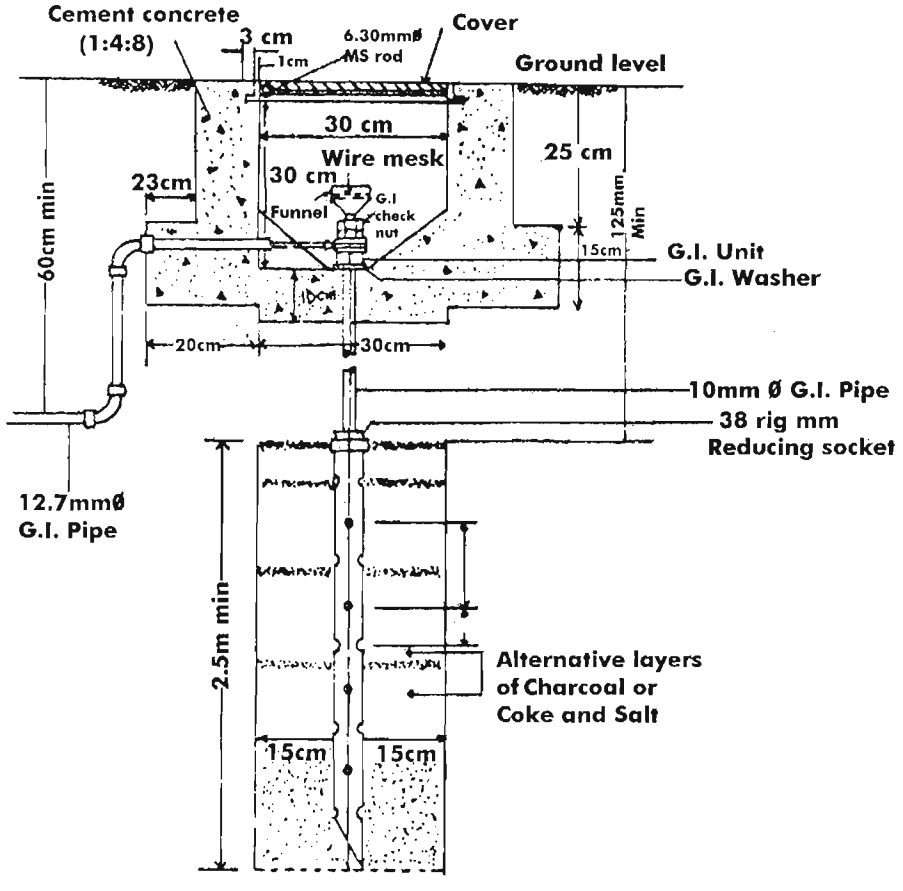

Figure 6.7: Typical Pipe Earth Electrode

6.4.3 Plate Electrodes

A typical arrangement for a plate earth electrode is shown in Figure 6.8. Plate electrodes can be made of copper or galvanised iron. The minimum recommended sizes are shown in Table 6.2. Plate electrodes should preferably be buried vertically so that the top edge is not less than 1.50m below the surface of the ground. The copper earth wire should be joined to a hole drilled in the top of the plate and held tight with a brass nut and bolt. Before attaching, the earth wire should be scraped to ensure good contact between the wire and the pipe.

If the resistance of a single plate electrode is higher than the required value, two or more plates should be used in parallel, the two plates being separated by not less than eight metres.

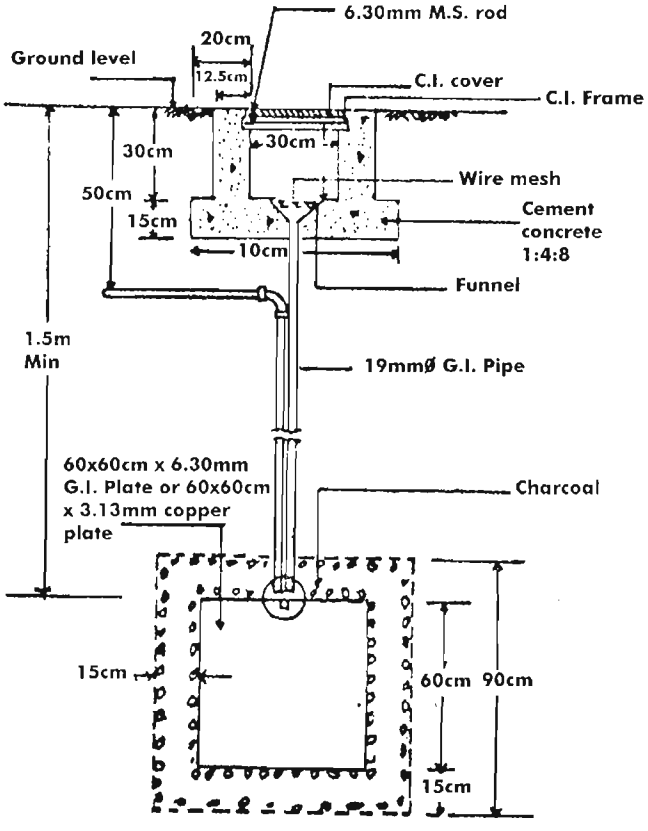

Figure 6.8: A Typical Plate Earth Electrode

6.5 Lightning Arresters

During storms, high voltage from lightning can come into contact with the transmission and distribution lines. If not prevented, this voltage will transmit across the coils of the generator and its body, causing a short circuit and damage. Therefore, it is necessary to provide earthing for this high voltage to discharge before it reaches the generator. This earthing is provided by a lightning arrester connected between phase and earth. In the case of three-phase transmission, a separate arrester is needed for each phase and the earth as shown in Figure 6.9. A 0.5kV lightning arrester will be sufficient for low-tension transmission, but a higher voltage rating is required for high-tension transmission.

The lightning arrester should be installed as close to the generator as possible, usually at the first pole outside the powerhouse. If the transmission line is more than a kilometre long, one lightning arrester should be installed for every kilometre.

6.5.1 Installation Procedure

- Check whether the lightning arrester is as per the specification.
- Mount a frame on the pole and fix the lightning arrester to it (Figure 6.9). If more than one lightning arrester is to be used, the distance between two arresters should be at least 100mm.
- There are two plates on the lightning arrester. Connect a wire from the plate marked 'earth' and bring it to neutral and to the ground and earth it. For the earthing procedure see Section 6.4. Connect a wire from the other plate and join it to the live part of the transmission/distribution system, i.e., the R, Y, and B phases.
- The last arrester on the transmission line should be within 1,000m of the farthest consumer.

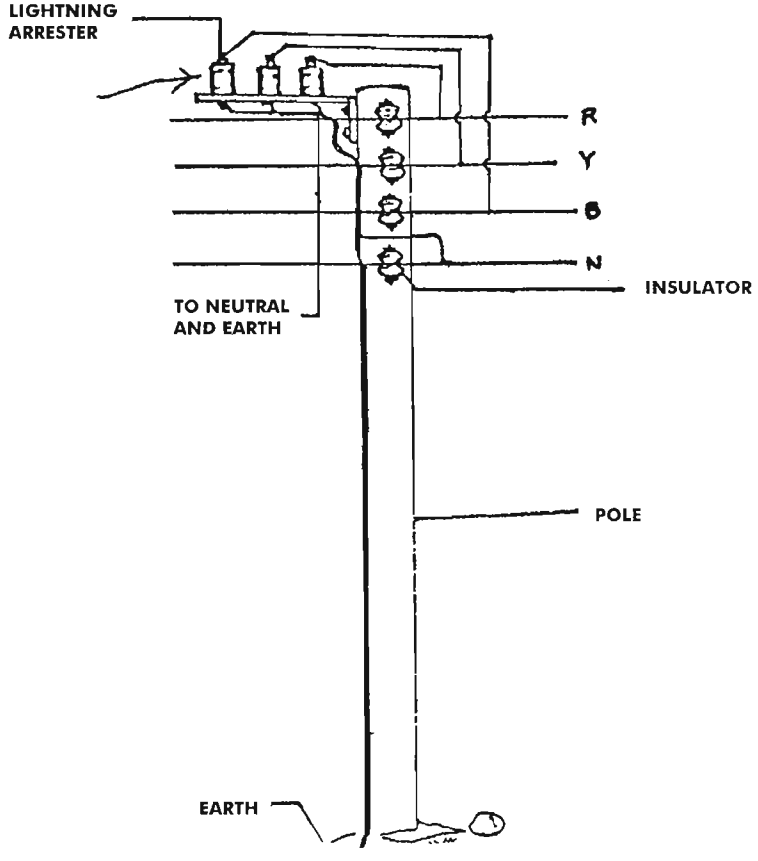

Figure 6.9: Installation of Lightning Arresters