4 GENERATION AND DISTRIBUTION OF ELECTRIC POWER

What we have already learnt

- An emf is induced in a conductor when it cuts the magnetic lines of force or when the magnetic flux linked with the conductor changes.
- DC is the electric current flowing in the same direction always.
- An electric current which changes its direction at regular intervals is called AC.
- An AC Generator is a device used to generate AC.
- In an AC generator, the induced current flowing in one direction produced during the first half of revolution of the armature coil and the induced current flowing in the opposite direction produced during the next half of revolution together constitute one cycle. The number of cycles per second is called frequency.
- A transformer is a device used for changing the voltage of an AC.
- Ohm's Law. At a constant temperature, the current flowing through a conductor is directly proportional to the potential difference between the ends of the conductor.

  Ohm's law is $\frac{V}{I} = R$
- According to Joule's law, the heat produced in a current carrying conductor is $H = I^2Rt$

The source of electric power required for the working of devices like torch, calculator etc. is known to you. But have you ever thought of the places where the electric power we get in our houses is generated? Do you know how this electric power is brought to your houses? This chapter deals with certain important points, pertaining to the generation and transmission of electric power and various problems related to transmission.

4.01 Powerhouses or power generating stations

Try to find out more devices which work on AC and DC and expand the following list.

Those working on AC

- Mixie
- Electric iron
- Grinder
- Washing machine
-

Those working on DC

- Calculator
- Mobile phone
- Quartz watches
- Radio (Radios appear to work on AC. But actually the AC is converted into DC and then used for its working.)
-

In table 4.1 certain centres generating electric power in our country and the states in which they are situated are given.

Power Station	State
Moolamattom	Kerala
Pallivasal	Kerala
Kuttiadi	Kerala
Kayamkulam	Kerala
Brahmapuram	Kerala
Sabarigiri	Kerala
Ramagundam	AndhraPradesh
Neyveli	TamilNadu
Kalpakkam	TamilNadu
Tharapur	Maharashtra
Kotta	Rajasthan

Table 4.1

What are the differences between the generators installed in the places mentioned in the above table and those used in houses and shops?

- The electricity generated in the generators mentioned above is transmitted to distant places.
- The electricity produced in the generators used in houses and shops is not distributed on a large scale.
-

The centres where electric power is generated for large scale distribution are called power houses or power stations.

4.02 Different power stations

What differences do you notice in the method of production of electricity in the power stations mentioned in table 4.1? Find out the answer through discussions and record them in the science diary.

In power stations at Moolamattom and Pallivasal the energy of water falling from great heights is used for rotating the turbines of the generator (fig 4.1). This type of power stations is called hydro electric power stations.

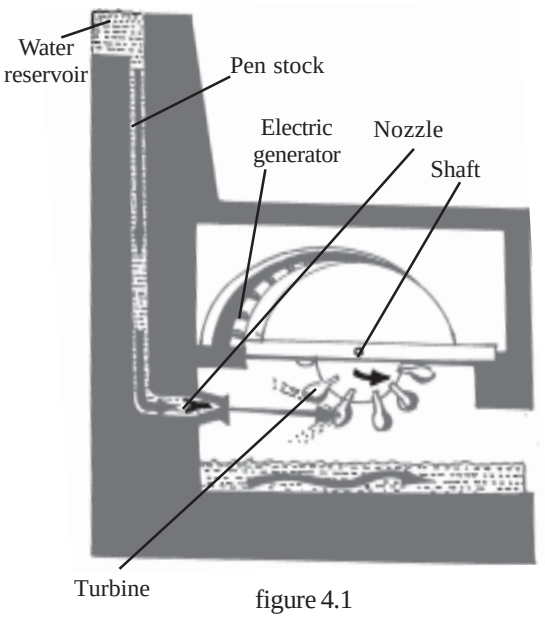

figure 4.1

In the power stations located at Kayamkulam, Ramagundam and Neyveli the fuels used are naphtha, coal and lignite respectively. The heat energy released during the burning of these fuels is used for heating water and producing steam at high pressure. The steam thus produced is used for rotating turbines and thereby to generate electricity. Power stations of this type are called thermal power stations. Here heat energy is converted into electrical energy.

But, in the power stations at Tharapur, Kalpakkam and Kotta steam at high pressure is produced by boiling water using the heat energy liberated during nuclear fission. This steam is used to rotate turbines and generate electricity. This type of power stations is called nuclear power stations.

Now it is evident that different power stations make use of different sources of energy. Energy changes taking place in the different types of power stations are shown in table 4.2. Complete the table

Power station	**Energy change**
Hydro electric power station	Mechanical energy ⟶ electrical energy
Thermal power station	Heat energy ⟶ electrical energy
Nuclear power station	Nuclear energy ⟶ ⟶ electrical energy

Table 4.2

4.03 Power generator

In our country, electricity is generated and transmitted in the form of AC for domestic and industrial purposes. A large AC generator consists mainly of the same parts as those of an ordinary generator. Write down the important parts of an AC generator.

- Field magnet
-

Large AC generators require very strong field magnets. Can a permanent magnet be used as field magnet?

Electromagnets are used as field magnets in large generators. Shouldn't we provide the required DC for this purpose?

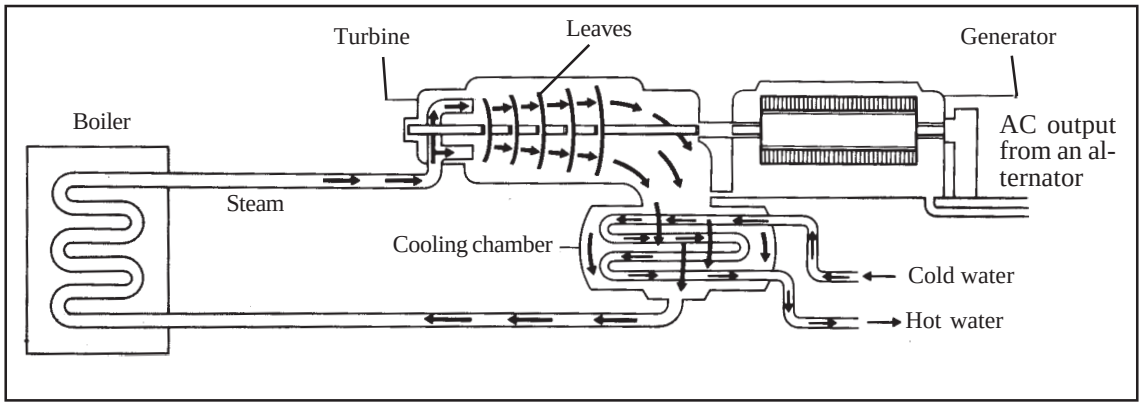

figure 4.2
Thermal power plant

The auxiliary generators meant for providing DC to electromagnets are called excitors.

The most important parts of a generator are armature and field magnet. In order to cut the magnetic lines of force one of them is to be rotated and the other is kept stationary. The part of the generator which rotates is called the rotor and the other part which is at rest is called stator.

In large generators, armature functions as the stator and field magnet as rotor.

4.04 Single phase generator and Three phase generator

Normally electricity is brought to our houses using two wires. But, you might have also noticed four or five wires in the distribution lines. Now, let us try to understand the meaning of the terms single phase AC, three phase AC, neutral etc, which we usually speak of, while dealing with AC.

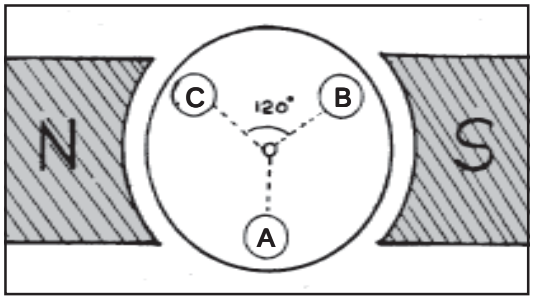

figure 4.3

In order to increase the efficiency of an ordinary generator, instead of using a single pair of magnetic poles, a few pairs of magnetic poles and the same number of armature coils are used. By properly connecting these coils of the generator we get an electric current of

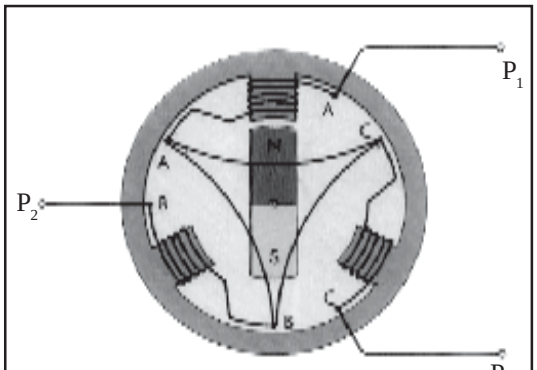

figure 4.4 (a)
Three phase generator

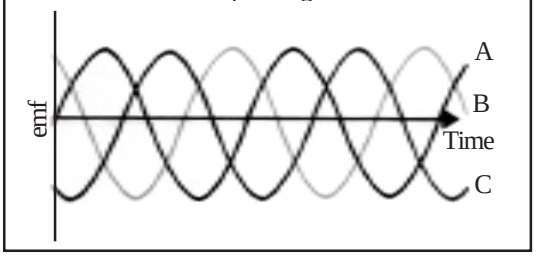

figure 4.4 (b)

one particular nature. This type of generator is called a single phase generator. The generators used in houses and shops are of this type.

In large power generators, for every pair of magnetic poles there are three identical armature coils arranged at an angle of 120° around the field magnet [fig 4.4(a)]. When the field magnet rotates, AC is produced in the three armature coils. But the maximum and minimum emf produced in three armature coils are at three different instances. The electric current from these three coils is treated as three different phases. Thus three distinct AC are produced in the three coils simultaneously.

Now, discuss the following statements and choose the correct ones and record them.

- In a three phase generator each field magnet has only one armature coil
- In a three phase generator each field magnet has three sets of armature coils.
- The number of turns in each armature coil is the same
- The number of turns in each coil is different
- The three armature coils in a three phase generator, generate three distinct AC.
- The maximum and the minimum emf induced will be the same for every coil in a three phase generator.
- The frequency of the AC will be the same in each armature coil.
- In the three armature coils AC of three different phases are produced at the same time.

If each end of the three armature coils is made to meet at a common point, the voltage at that point will be zero. This point is called the neutral point. This point is earthed. The transmission lines are connected to the free ends P_1, P_2 and P_3 of the armature coils. These are called phase lines.

In our country electricity is generated at a frequency of 50 Hz and at a voltage of 11kV or 11000volt.

4.05 Star connection

The three phase lines from the transformer of the last stage of the distribution network are shown in figure (fig 4.5). If the phase lines are connected as shown in the figure it is called star connection.

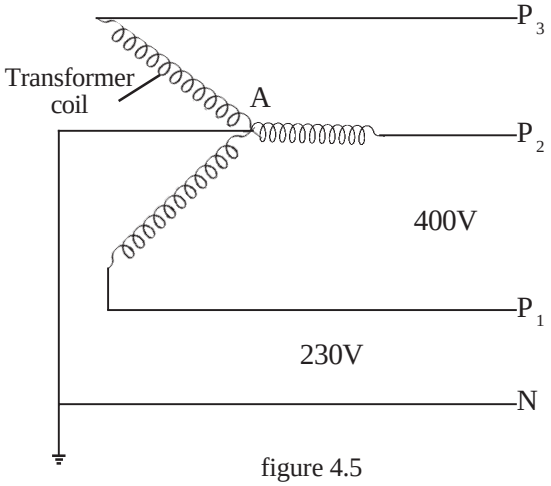

figure 4.5
A star connection

The voltage at the point A is zero. Therefore, this point is called neutral and it is earthed.

- The potential difference between P_1 and neutral is 230V.

- The potential difference between P_1 and P_2 is 400V
- Then, what will be the potential difference between P_1 and P_3 and that between P_2 and P_3?
- What will be the potential difference between P_2 and neutral and that between P_3 and neutral?

Thus you have understood the meaning of the terms neutral lines and phase lines in a star connection. Try to find out the correct statements from the following and record them in the science diary.

- The potential difference between the neutral line and the earth is zero.
- The neutral and the earth are at different potentials.
- If a person standing on the earth touches the neutral he does not get electric shock.
- If a person standing on the earth touches the neutral line he will get electric shock.
- If a person touches the phase line alone, without touching the ground or the neutral line he will not get electric shock.
- If a person standing on the ground touches the phase line he will not get electric shock.

From your answers you can reach the conclusion that the neutral line is at zero potential. Try to verify the correctness of your conclusion using a tester, in the presence of your science teacher.

Discuss the reason for the intermittant earthing of the neutral lines and try to reach your own conclusion. Note the same in your science diary.

4.06 Distribution of electric power

We know that the electricity produced at the power stations is brought to our homes through wires. The process of taking electricity from the generating stations to places where it is utilised is called power transmission.

What are the problems related to the transmission of electricity to distant places? By Joule's Law, $H = I^2 Rt$, the conducting wires used for power transmission get heated, causing loss of energy.

How can the loss of energy during transmission be minimised? According to the relation $H = I^2 Rt$, there are two ways.

- Reduce the strength of electric current (I)
- Reduce resistance (R)

In order to reduce resistance we have to make use of thick wires of comparatively low resistivity. Practically, it is quite difficult to make use of conducting wires having thickness greater than a certain limit. Therefore the effective method of reducing the loss of energy is to reduce electric current (I) to a minimum value. As current I is reduced the electric power is also reduced accordingly. How can the electric current be reduced, without changing the electric power? According to the relation $P = VI$, it is enough to raise the voltage (V) in accordance with the decrease in the value of electric current (I). We can make use of step-up transformer for this purpose.

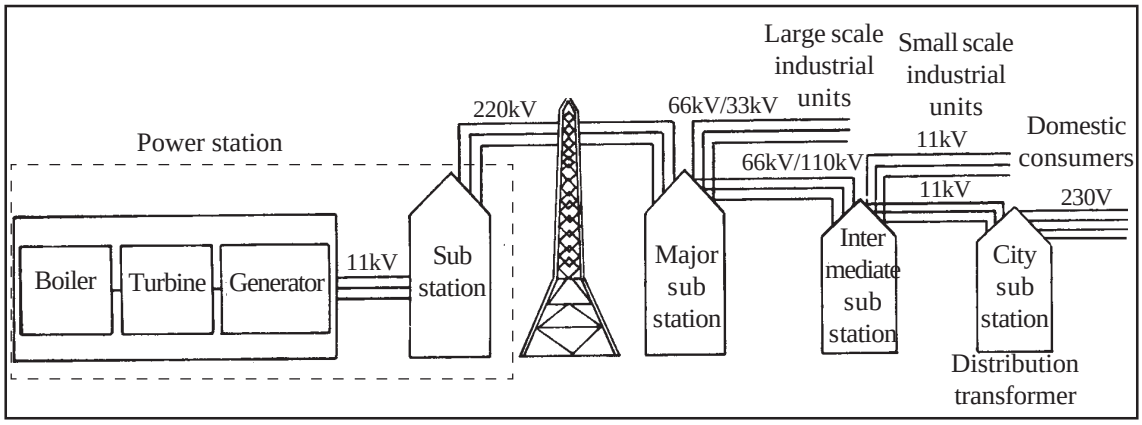

figure 4.6

The figure showing the different stages of the distribution of power

In fig 4.6 different stages of the generation and distribution of electrical power are depicted. Try to find out the answers to the following questions related to this and record the same in the science diary.

- What is the voltage at which electric power is generated at the power station?
- At what stage of the distribution network is the step up transformer used?
- What are the stages at which step-down transformers are used?
- What type of transformer is used for the distribution of electrical power for household uses? What are the output voltages from these transformers?

4.07 Power grid

We know that power stations are located at different places in our country. The electricity produced at these stations is brought to certain selected centres for distribution to other regions. Is there any advantage in linking together the different power stations? Discuss and reach your own conclusions. Record them in the science diary.

Grid is a national network for bringing together the electrical energy generated at different states and to effectively distribute the same.

Presently, ACSR (Aluminium Conductor Steel Reinforce) cables are used for power transmission.

4.08 Household electrification

Do you know how electrification is done in houses and shops? As shown in fig 4.7 make two electrical circuits-one in series pattern and the other in parallel pattern. Examine the working of each.

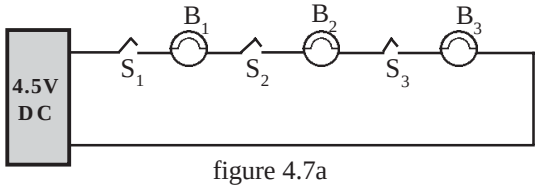

figure 4.7a

Series connections

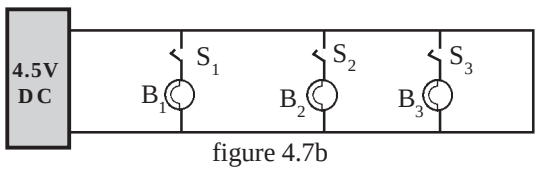

figure 4.7b

Parallel connections

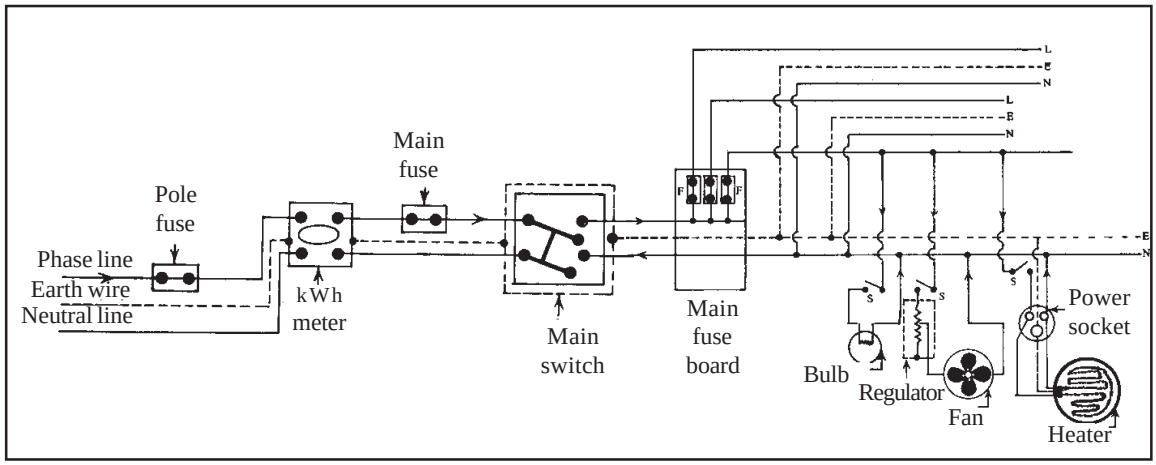

figure 4.8
Domestic electric circuit

What do you understand from the above experiment? In which circuit do the bulbs burn more brightly? Don't you see that bulbs connected in the parallel pattern are brighter? What is the need for connecting electrical devices in parallel in household electrical circuits? Discuss.

Fig 4.8 shows a house hold electrical circuit. Make a close observation of the figure and note down the important points you have observed.

- The main line consists of phase and neutral lines.
- All fuses are connected to the phase line.
- Connections to the main switch are made from the watt hour meter.
-

Circuit breaker

Presently circuit breakers are used instead of fuses. A solenoid and a switch are connected in series with the phase line. A thick soft iron core is placed partially inside the solenoid.

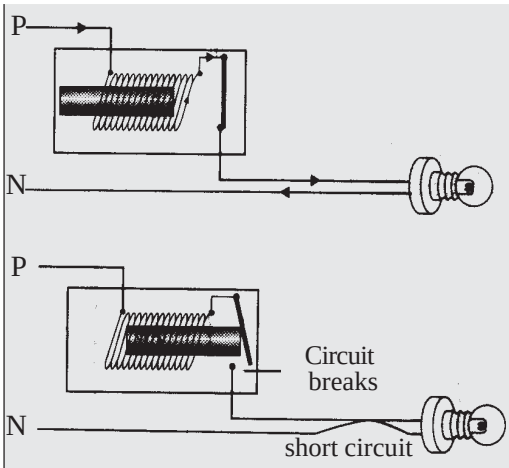

figure 4.9

When the strength of the current increases beyond a certain limit the core is pulled into the solenoid. During this process the core strikes the switch and the circuit is broken, thereby stopping the current in the circuit . After rectifying the defects in the circuit, it can be brought back to the initial condition.

Now-a-days, MCB (Miniature Circuit Breaker) is used. Similarly ELCB (Electric Leakage Circuit Breaker) is used between distribution box and main switch.

4.09 Three pin plug and earthing

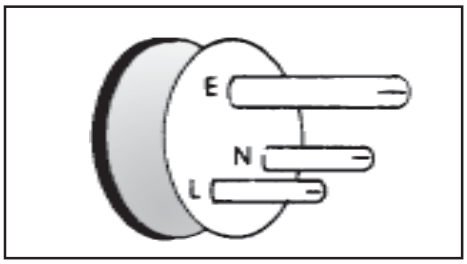

figure 4.10(a)
Three pin plug

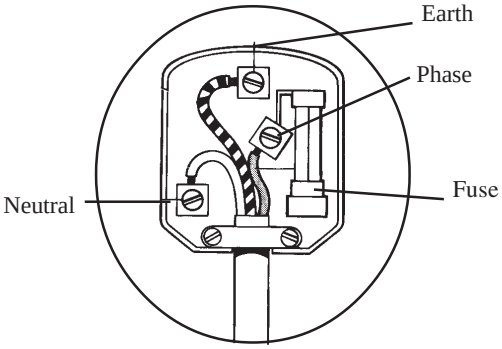

figure 4.10(b)
Three pin socket

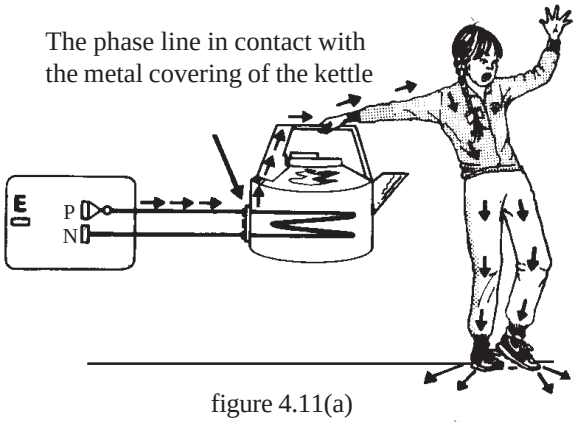

figure 4.11(a)

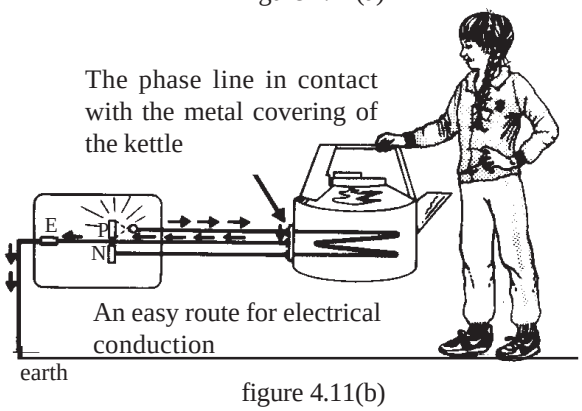

figure 4.11(b)

Haven't you seen three pin sockets in the switch boards used in household electrical circuits? Three pin plugs should necessarily be used while handling electrical equipments of high voltage. What is the reason for this? Observe the figure 4.11(a).

In the figure 4.11(b), the person using the electric kettle is safer than the person in fig 4.11(a).

Discuss the following points

- The larger pin of the three pin plug is connected to the earth (E).
- When the phase line comes in contact with the metalic covering, the fuse wire melts and thus the circuit is broken.
- The earth pin of the three pin plug is longer and thicker.
- The pins in the three pin plug are split upto the middle.
- The cable used for joining the earth pin, the body of the equipment and the earth terminal in the socket are thicker.

In house hold electrical circuits the red coloured cable is used as phase line, light blue or black cable as neutral and green cable as earth.

Red wire is used as phase line as red indicates danger.

The wire used for earthing must have a resistance less than that of human body.

Have you ever thought of the proper way of earthing electric circuits? Try to arrange an

interview with a senior officer of the KSEB office in your neighbourhood and collect sufficient information. It may be recorded in the science diary.

Earthing is done in electric circuits in houses by digging pits and filling them with salt and charcoal of coconut shells. In summer season these regions are kept wet by pouring sufficient water. This is meant for reducing resistance.

Chart of electric shock

State of the body	Electrical resistance of the body	100V		500V	
		Current	Effect	Current	Effect
Completely wet	1000Ω	0.1A	Slight burn, death certain	0.5A	Severe burn, chance of death
Neither wet nor dry	5000Ω	0.02A	No burn, painful shock	0.1A	chance of death, slight burn
Dry	100000Ω	0.001A	Mild shock, no burn	0.005A	mild shock, no burn

Summary

- **Power station** - The centre where electricity is generated for distribution.
- **Rotor and stator** - Rotor is that part of the generator which rotates and stator is the part remaining stationary.
- **Excitor** - Provides DC to the electromagnets working as field magnets in large generators.
- **Neutral line** - The line starting from the common point at which the three phase lines meet. The voltage of this line is zero.
- **Household electrification** - Devices are connected in parallel in household electrification. Fuses and switches are connected to phase lines.
- **Earthing** - Connecting an electrical equipment to the earth so as to allow the easy flow of electrical charges.
- **Grid** - The network connecting generating stations and distribution centres.
- Voltage drop and power loss are serious problems associated with power transmission.
- Three pin plugs are safer than two pin plugs.

More activities for you

1. AC is used for the distribution of electrical power. Discuss the reason for this.
2. What is the adverse effect of using a thick copper wire, when the fuse wire in your school or house is broken?
3. Find out the similarities and differences between hydro electric , nuclear and thermal power stations.
4. Point out the mistakes in the household electrical circuits shown below.

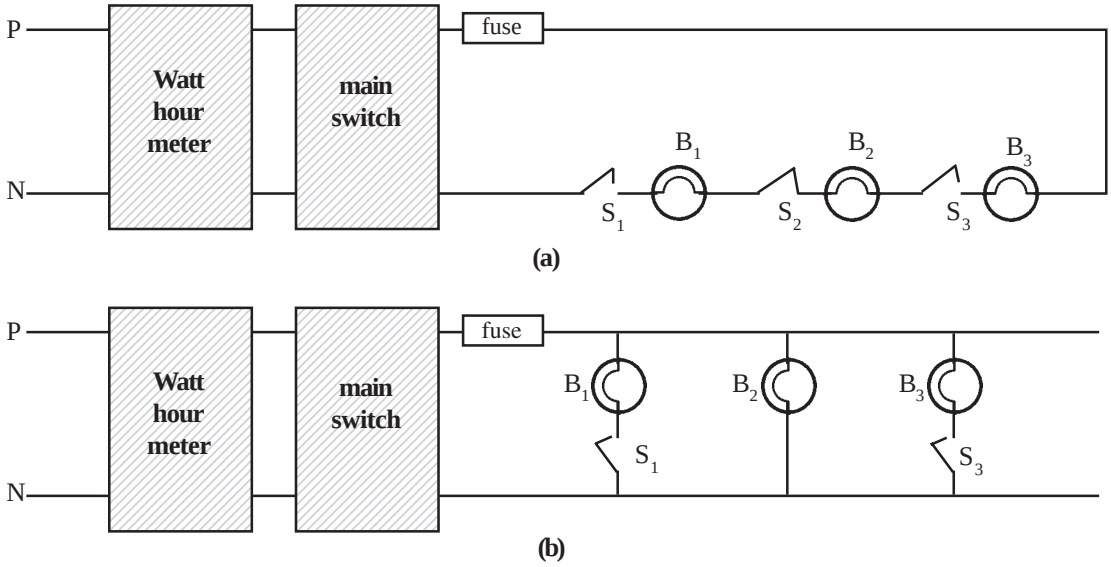

figure 4.12

5. Suppose you intend to construct an additional room in your house. Draw the circuit diagram for connecting two lamps, a fan and a plug.
6. Make a study of the measures taken for saving electrical energy in your house and the houses in your neighbourhood.
7. Find out the advantages of using of MCB and ELCB in electrical circuits.
8. The following picture shows a three pin plug (fig 4.13)
   a. What is the use of terminal E?
   b. To which part of the equipment is E to be connected?
   c. To which terminals are the fuse and the switch connected - N or L?

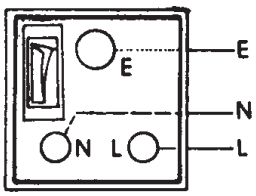

figure 4.13

9. Electrical equipments should not be handled with wet hands. Why?

10 Earthing is effective only if fuse is connected to live wire (phase wire). Give reasons.

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