7 Electricity

The world has seen enormous changes over the last hundred years. The harnessing of electricity has been the single most important factor behind these changes. You can easily think of the large number of ways in which electricity plays a role in our lives today. In this chapter, we will discuss the basics of electricity.

WHAT IS ELECTRICITY?

Streaks of lightning across the sky are caused by electricity produced in the clouds. Cells produce electricity when they are connected to watches, cameras, torches, and so on. The electricity in our homes is carried by wires from giant power stations. To understand how these seemingly different things are related, we need to know about a quantity called charge.

Charge

Charge is a fundamental part of matter. You could say that mass and charge are two things that characterise matter. The tiniest particles that matter is made up of have mass and carry charge. The SI unit of charge is the coulomb, which has the symbol C.

Fig. 7.1 Lightning is caused by static electricity.

Charge exists in two forms—positive and negative. 'Positive' and 'negative' are just names we have given to the two types of charge. The charges are not positive and negative in the mathematical sense. Many things around us happen because of charges. All these things are together called electricity.

Normally matter contains an equal amount of positive and negative charges. Sometimes, however, there is an imbalance of charges, and a body gets a net negative or a net positive charge. We then say that the body is electrically charged. You already know that electrically charged bodies, such as a comb rubbed against hair or nylon, exert a force that is called electrostatic force. This and other effects produced by charges that accumulate or build up in bodies are studied under electrostatics. The term static electricity is used to describe this kind of electricity that is caused by charges that are at rest. Lightning, as you will learn later, is a result of static electricity.

Electric Current

Under certain conditions, charges can flow. When charges flow, they give rise to what is called an electric current. An electric current is defined as the charge flowing past a point per unit time. Thus, when Q coulombs of charge flows past a point in t seconds, the current I at that point is

$$I = \frac{Q}{t} \text{ coulomb/second}$$

The unit coulomb/second is called the ampere, with the symbol A. This is the SI unit of current.

Most of the electrical gadgets we use in our homes work only when an electric current flows through them. In other words, they work because of the effects produced when an electric current flows through them. The effects produced by an electric current (or a flow of charges) are studied under a branch of physics called current electricity, or simply electricity.

Electric Potential

Just as water flows from a higher level to a lower level, charge also flows from a higher to a lower 'level'. The level of charge is described by a quantity called electric potential. Thus, an electric current flows only when there is a difference in potential. The SI unit of potential and of potential difference (p.d.) is the volt, whose symbol is V.

There is a very close relation between the potential difference across two points and the current that flows between them. The higher the potential difference (commonly called voltage), the greater is the current.

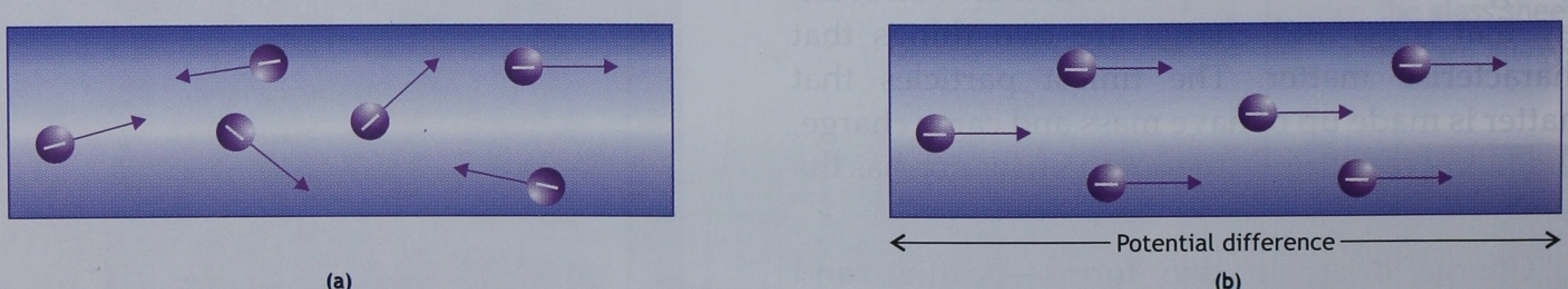


Fig. 7.2 (a) Irregular (or random) motion of charges does not give rise to an electric current. (b) The regular (or uniform) flow of charges gives rise to an electric current. Charges flow in this manner only when there is a potential difference.

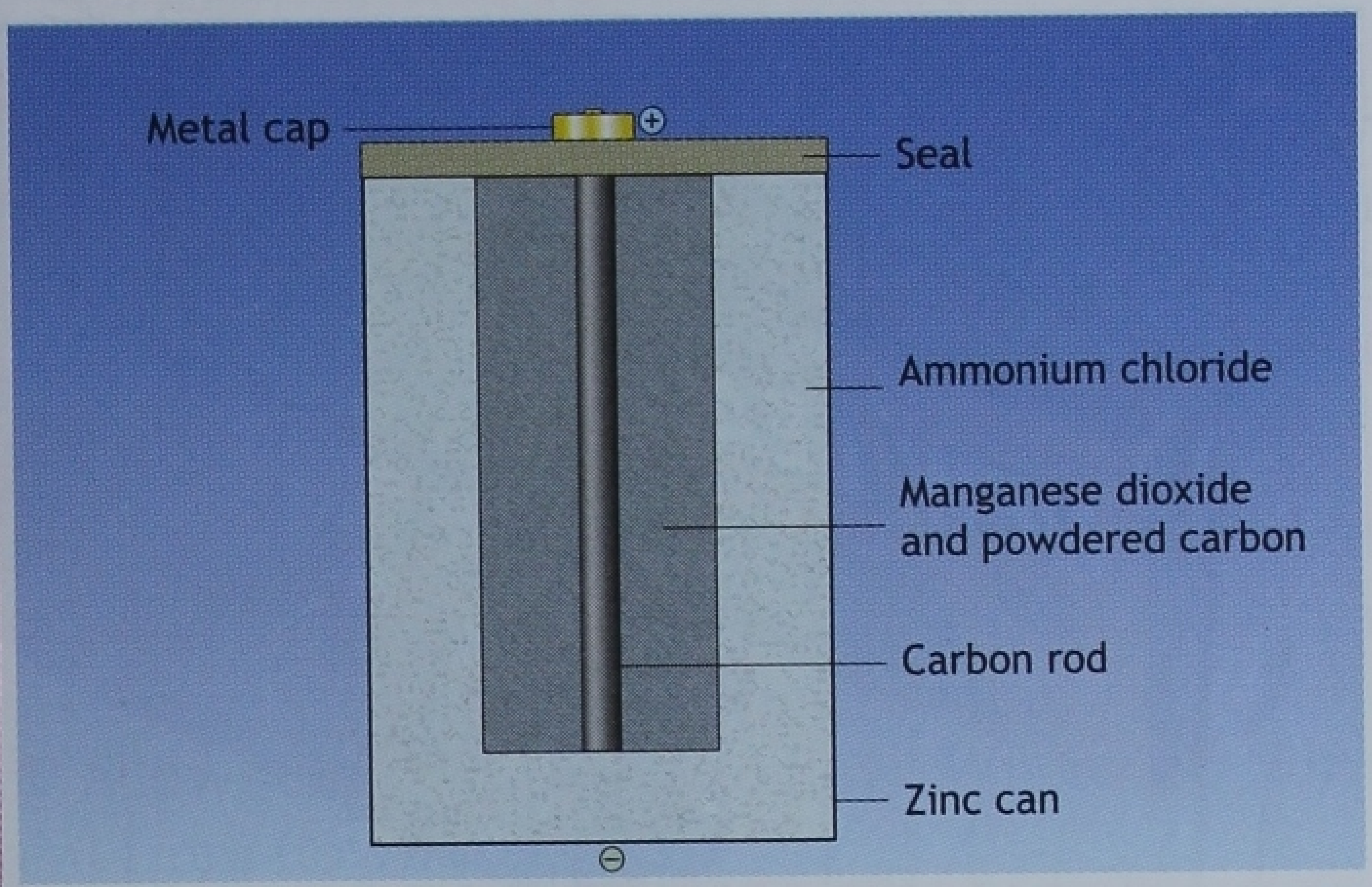
SOURCES OF ELECTRICITY

We can obtain electricity or electric current from different sources. Any source of electricity creates a difference in potential within itself. The common sources of electricity are cells, batteries and the mains.

Electric Cells

Cells come in differrent shapes and sizes. Common pencil and torch cells usually have a potential difference or voltage of 1.5 V. Button cells (Figure 7.4), used in watches, cameras, and so on, create potential differences of 1.5 V to 3 V. All cells produce electrical energy from reactions between the chemicals stored in them. The cells we are discussing are called dry cells because the chemicals in them are not in the form of a liquid.

(a)



(b)

Fig. 7.3 (a) Common cells (b) Inside a cell

Figure 7.3(b) shows the inside of a common cell. Such cells have an outer casing or shell made of zinc and a rod made of carbon at the centre. The space inside is separated into two chambers by porous cloth or paper. A mixture of powdered carbon and manganese dioxide is packed around the carbon rod in the inner chamber. And a paste of ammonium chloride and other chemicals is filled in the outer chamber.

You may have noticed that there is a '+' sign and a '–' sign at the two ends of a cell. These denote the positive and negative terminals of the cell. When we use a cell we connect these terminals to the gadget we want it to run. Electric current enters and leaves the cell through these terminals. In the type of cell we are discussing, the carbon rod acts as the positive terminal, while the zinc casing acts as the negative terminal. The carbon rod has a metal cap for better contact, and the top of the cell is sealed to prevent leakage.

Fig. 7.4 Button cells

When the cell is connected, a chemical reaction between the zinc casing and the chemicals inside produces electricity. When the chemicals are used up, the cell becomes 'dead', or it cannot be used any more. Such cells, which get used up, are called primary cells.

Batteries

The word 'battery' is used in more than one sense. The correct meaning is an arrangement of a number of cells, for example, the 9-V battery shown in Figure 7.5(a). Quite often, however, the common cell is also referred to as a battery.

In this section, we will discuss what is called a storage battery. Unlike the cells we have discussed in the previous section, storage batteries can be recharged. That means when the chemical energy of the battery decreases, it can absorb electrical energy and store it again as chemical energy. In other words, when the chemicals in the battery get used up, they can be restored by a kind of reverse chemical process. This way, storage batteries can be used many times over.

Fig. 7.5 (a) 9-V battery made of 6 cells (b) Lead-acid battery

Storage batteries can be of two types. The first type is the lead-acid battery or accumulator used in motor vehicles and in inverters (which provide electricity during power cuts). Such batteries consist of several storage cells connected together. Each cell has a plate of lead and another of lead oxide dipped in acid (hence the name lead-acid cell). Lead-acid batteries create or provide a potential difference of 6 V to 12 V.

The dry batteries used in mobile phones, electronic cameras and other portable devices are also storage batteries. As you must know already, they can be recharged. So can some pencil cells available in the market these days. Storage cells are also called secondary cells, as opposed to primary cells, which cannot be recharged.

Mains

The most important source of electricity is what is commonly called the 'mains', or the electric supply to our homes, offices, factories, and so on. This electricity is generated on a large scale in power stations, either by burning fuels (thermal power) or from water stored in reservoirs (hydel power). Electricity is also generated from nuclear energy, wind energy, solar energy and other sources of energy. However, these sources meet only a tiny fraction of our total requirement of electrical energy.

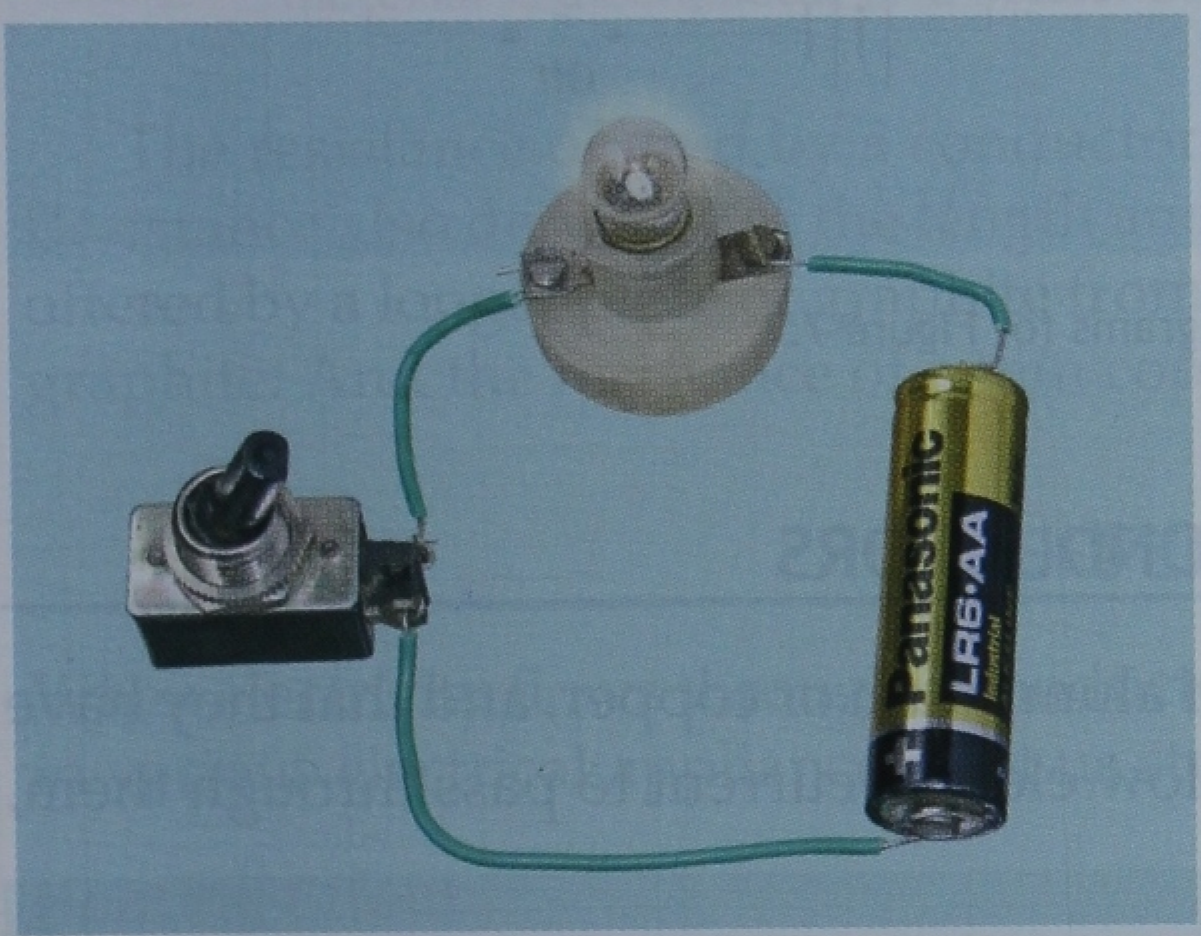
The mains provide or have a potential difference of 220 V. This is a high voltage, so you must never use the mains for any of the activities given here or in any other book.

Fig. 7.6 Some dry batteries and cells can be recharged.

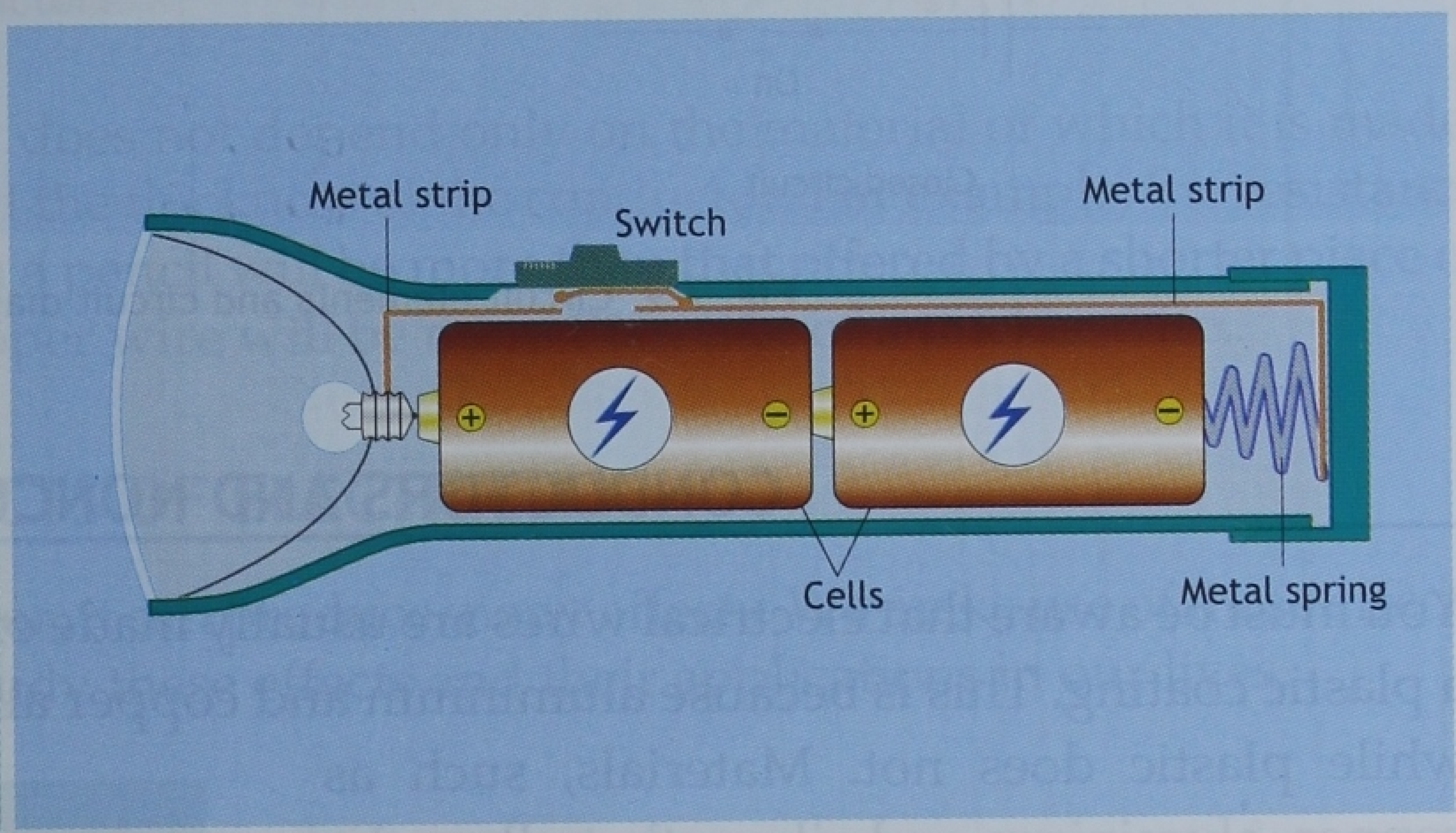
ELECTRICAL CIRCUITS

We have already discussed one condition for the flow of electricity. Electricity can flow only when there is a potential difference, which is provided by the sources of electricity that we use. The other condition is a closed path. An electric current can flow only along a closed path. An arrangement of devices through which electric current can flow is called an electric circuit.

Figure 7.7(a) shows a very simple electric circuit. It has a cell, which is the source of electricity, and a bulb, which is a device that makes use of electricity. These two are connected by wires through a switch. A switch is a device used for opening (breaking) or closing (completing) an electric circuit. When you 'turn on' a switch, it closes the circuit and allows electric current to flow. When you 'turn off' a switch it breaks the circuit and stops the current from flowing.



(a)



(b)

Fig. 7.7 (a) This circuit is essentially the same as that of (b) a torch.

Figure 7.7(b) shows a torch, which is essentially the same kind of circuit as that shown in Figure 7.7(a). Here, the cells and bulb are connected by a spring and two metal strips. And the circuit is closed or broken by the sliding switch.

All electrical circuits are made up of the elements shown in Figure 7.7—(a) a source of electricity, (b) a switch and (c) one or more electrical devices. These components are connected together by wires. It is difficult to actually draw the components of an electrical circuit. Hence, symbols are used to denote them in a circuit diagram, which shows the arrangement of an electric circuit. Figure 7.9 shows the symbols for the components used in Figure 7.7. You will notice that the circuit diagrams for Figures 7.7(a) and (b) are almost the same. The lines in the diagram stand for the connecting wires, while the arrow shows the direction in which current flows. Notice that current flows from the positive to the negative terminal of the cell (or cells).

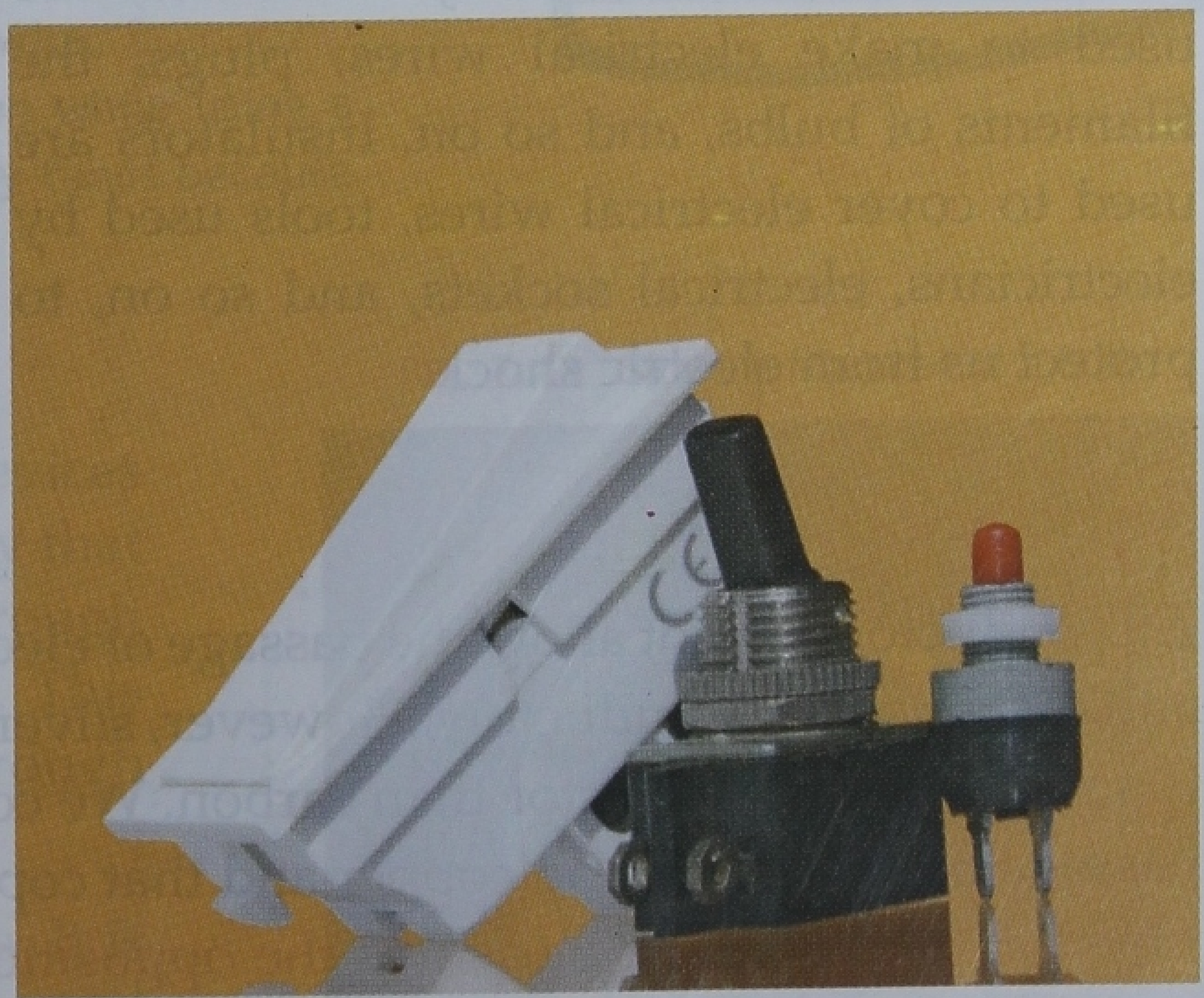


Fig. 7.8 Switches

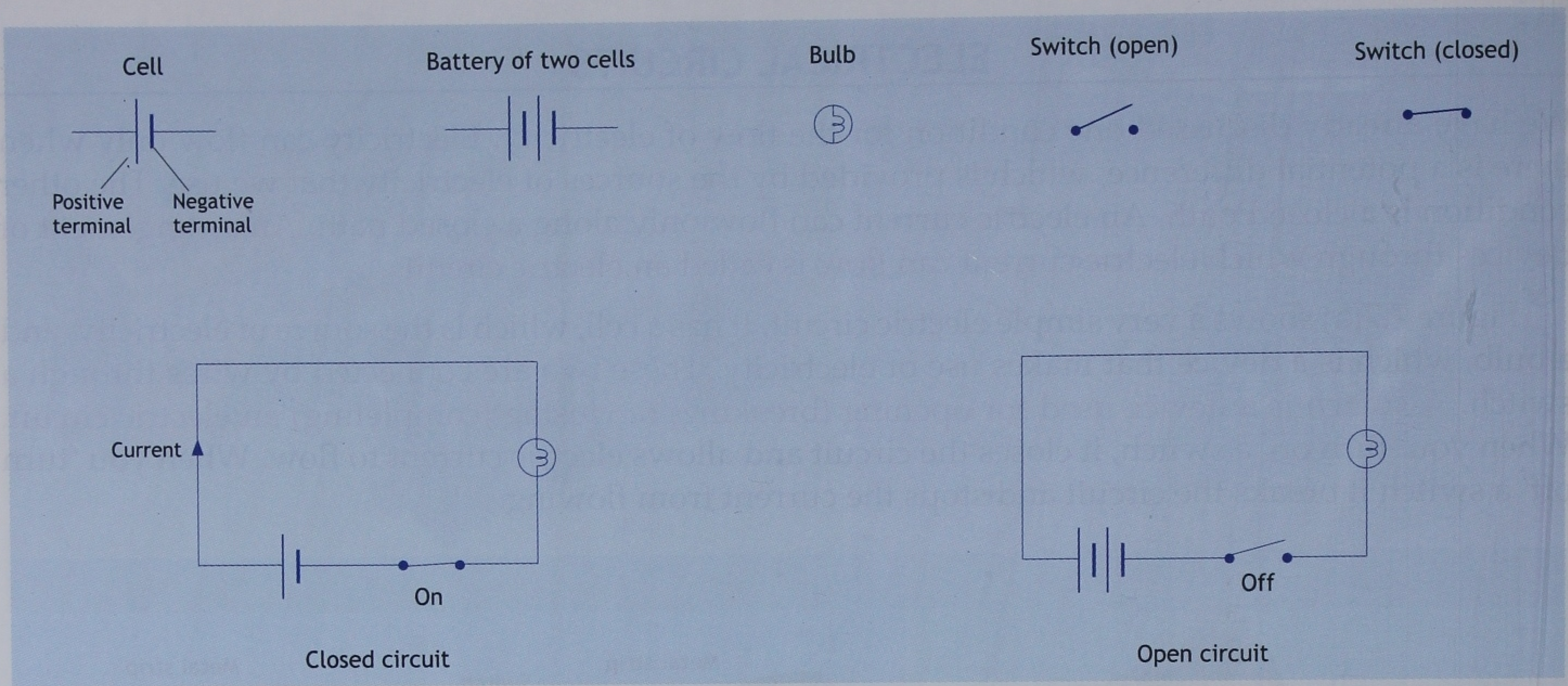


Fig. 7.9 Circuit elements and circuit diagrams for Figure 7.7

CONDUCTORS AND NONCONDUCTORS

You must be aware that electrical wires are usually made of aluminium or copper, and that they have a plastic coating. This is because aluminium and copper allow electric current to pass through them, while plastic does not. Materials, such as copper, aluminium and silver, that allow the passage of electricity are called conductors. Materials, such as plastic, wood and rubber, that do not allow the passage of electricity are called nonconductors or insulators.

Fig. 7.10 Uses of insulators

It should be obvious why conductors are used to make electrical wires, plugs, the filaments of bulbs, and so on. Insulators are used to cover electrical wires, tools used by electricians, electrical sockets, and so on, to protect us from electric shock.

Resistance

All conductors do not allow the passage of electricity with the same ease. For example, silver, copper and carbon are all conductors. However, silver is a slightly better conductor than copper and copper is a much better conductor than carbon. We could also say that carbon offers more resistance to the flow of electricity than copper and that copper has a higher resistance than silver. Resistance is a physical quantity that measures the opposition offered to the flow of current by a conductor. The higher the resistance, the lower is the current under similar conditions.

ACTIVITY This simple activity will help you get an idea of the resistance offered by different materials to the flow of electricity. You will get a better result if you use a battery holder to connect two cells. Buy one or make one as shown at the end of the chapter.

Sharpen both ends of a short pencil and connect the ends to a bulb and battery, as shown in Figure 7.11. The bulb will glow weakly. If you replace the pencil with a length of copper wire, it will glow more brightly. This shows that copper has a lower resistance than graphite.

You could also use this circuit to test whether a material is a conductor or a nonconductor.

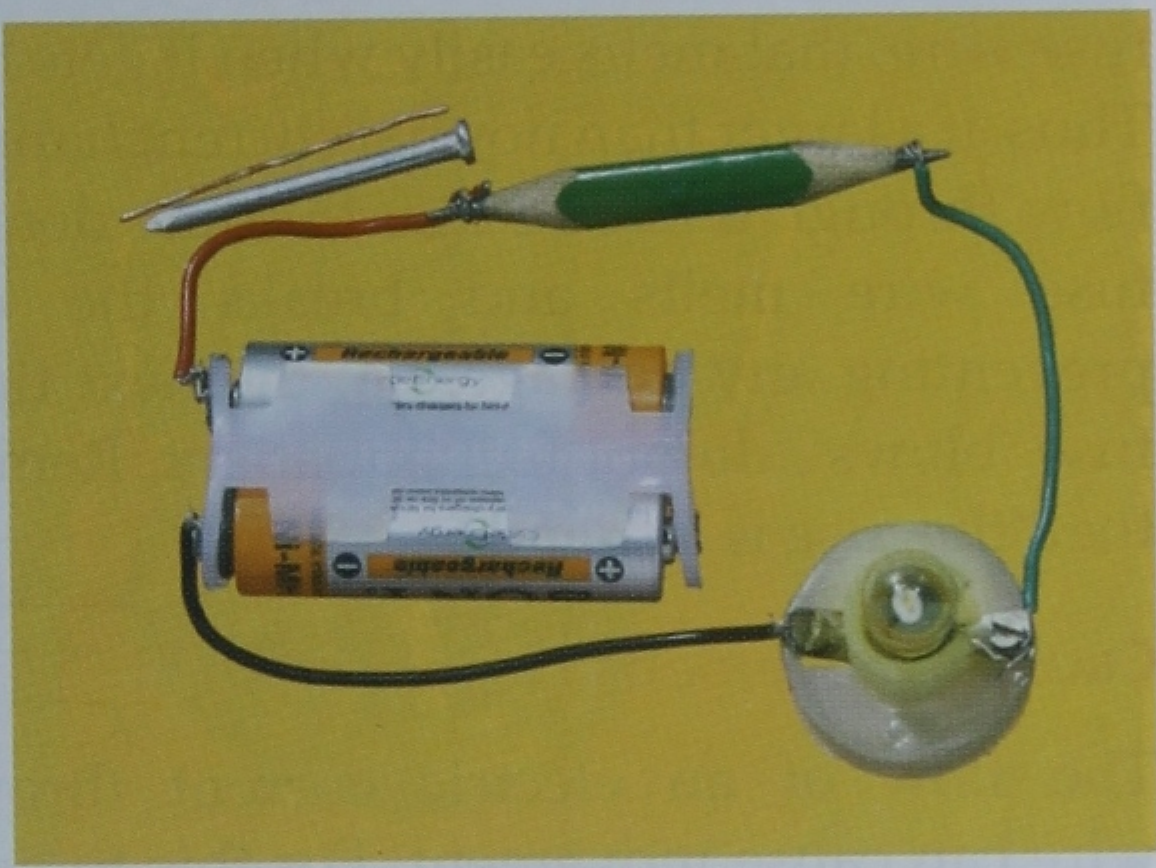


Fig. 7.11

The resistance offered by a conductor does not depend only on the material of which it is made. Resistance also depends on the length and the thickness of the conductor. For example, the resistance offered by a longer piece of graphite from a pencil will be more than that offered by a shorter piece of graphite. And the resistance of a thin copper wire will be more than that of a thicker wire.

EFFECTS OF ELECTRICITY

When electricity flows through a conductor, it can produce many effects. We make use of these effects in various electrical appliances. Let us study these effects and their applications in our lives.

Heating Effect

When an electric current flows through a conductor, heat is produced. The larger the current, the more is the heat produced. And how large the current is depends on the voltage of the source and the resistance of the conductor.

ACTIVITY Make the ends of a thin wire touch the terminals of a cell for a short while. The wire will get hot at once since its resistance is low, and this allows a large current to flow through it. In fact, if the source has a higher voltage, the heat produced will melt the wire. Do not try this, however. Be careful not to hurt yourself even while using a 1.5-V cell. Also, do not repeat the activity too many times because the cell will get used up fast.

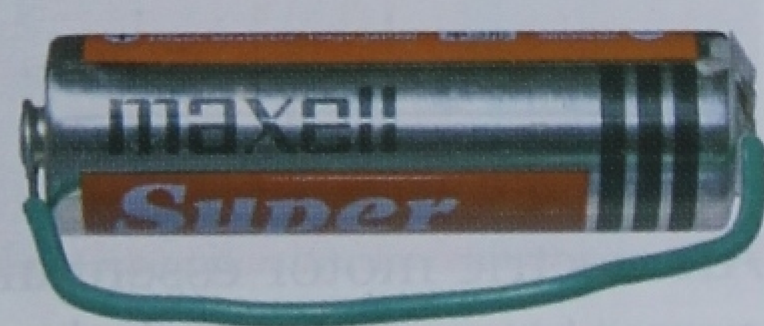


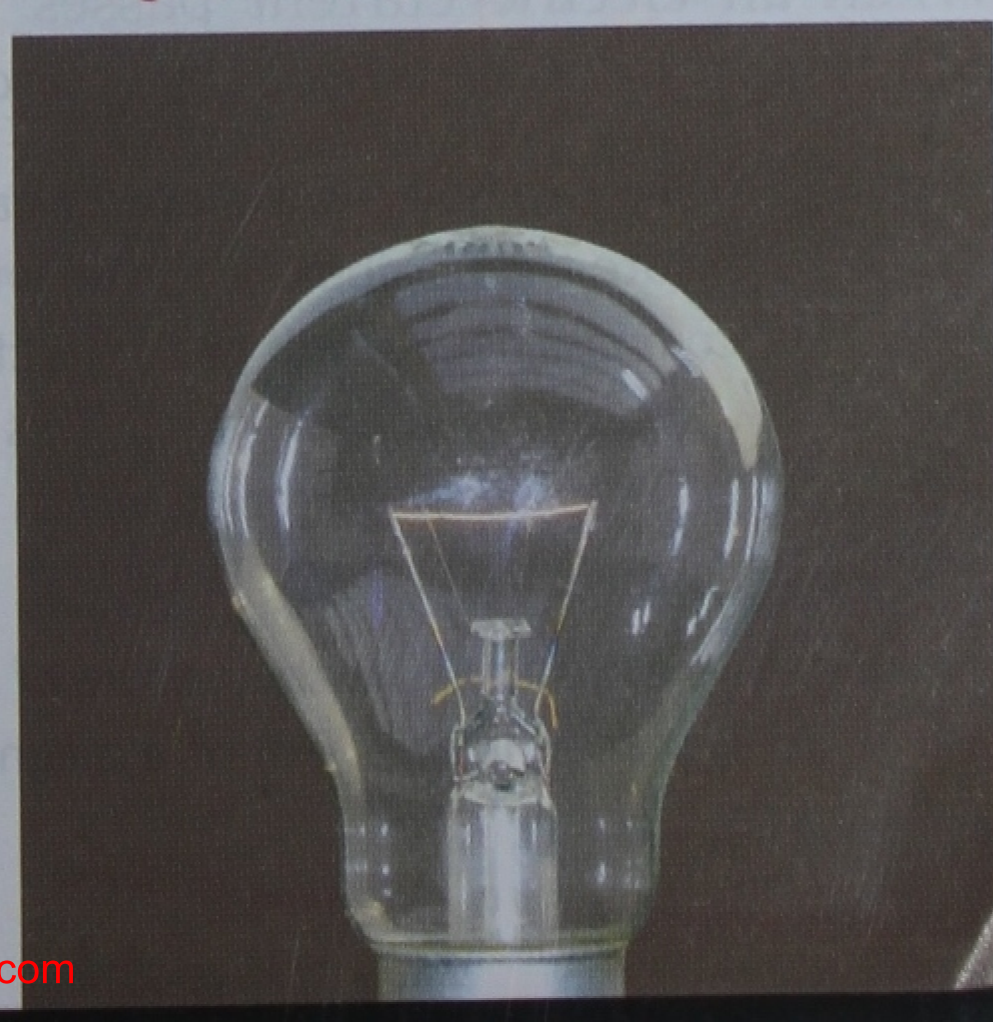
Fig. 7.12

Applicatons

Heaters, irons, geysers, toasters, and other heating devices have a heating element. This is made of a special alloy that becomes very hot when an electric current passes through it. Electric bulbs have a filament made of tungsten. This filament gets so hot when an electric current flows through it that it glows white.

A fuse is a safety device used in electrical circuits. It is used to prevent electrical fires and protect electrical devices from damage. It has a special kind of wire, called

Fig. 7.13 Glowing filament of a bulb



fuse wire, that melts easily when it gets heated. Thus, if a larger than normal current happens to flow through a circuit due to some defect, the fuse wire melts and breaks the circuit, preventing any damage. So, the next time the fuse 'blows', do not feel impatient. Remember that 'the fuse is a friend'.

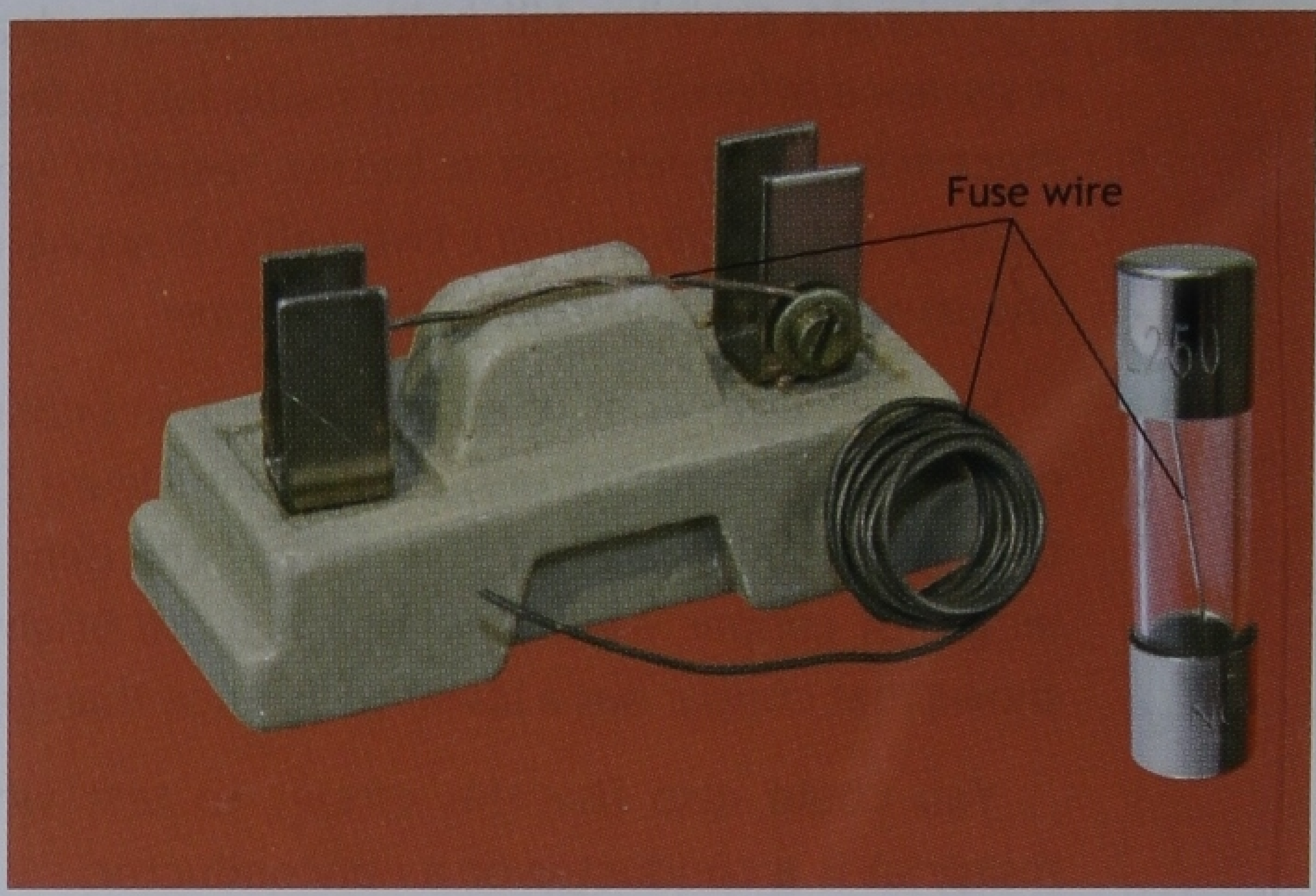


Fig. 7.14 Fuse

Causing Movement

The flow of an electric current through a wire can cause movement. For this to happen, the wire has to be placed in a magnetic field (the region around a magnet where its effects can be felt). The current-carrying wire then experiences a force that makes it move.

ACTIVITY You will need a cell, a magnet and an electric wire about 10 cm long. Tape the wire to the table in such a way that it is free to move. Place a magnet near it, as shown. Connect one end of the wire to one of the terminals of a cell. Then make the other end of the wire touch the other terminal of the cell. The wire will move every time it makes contact with the terminal.

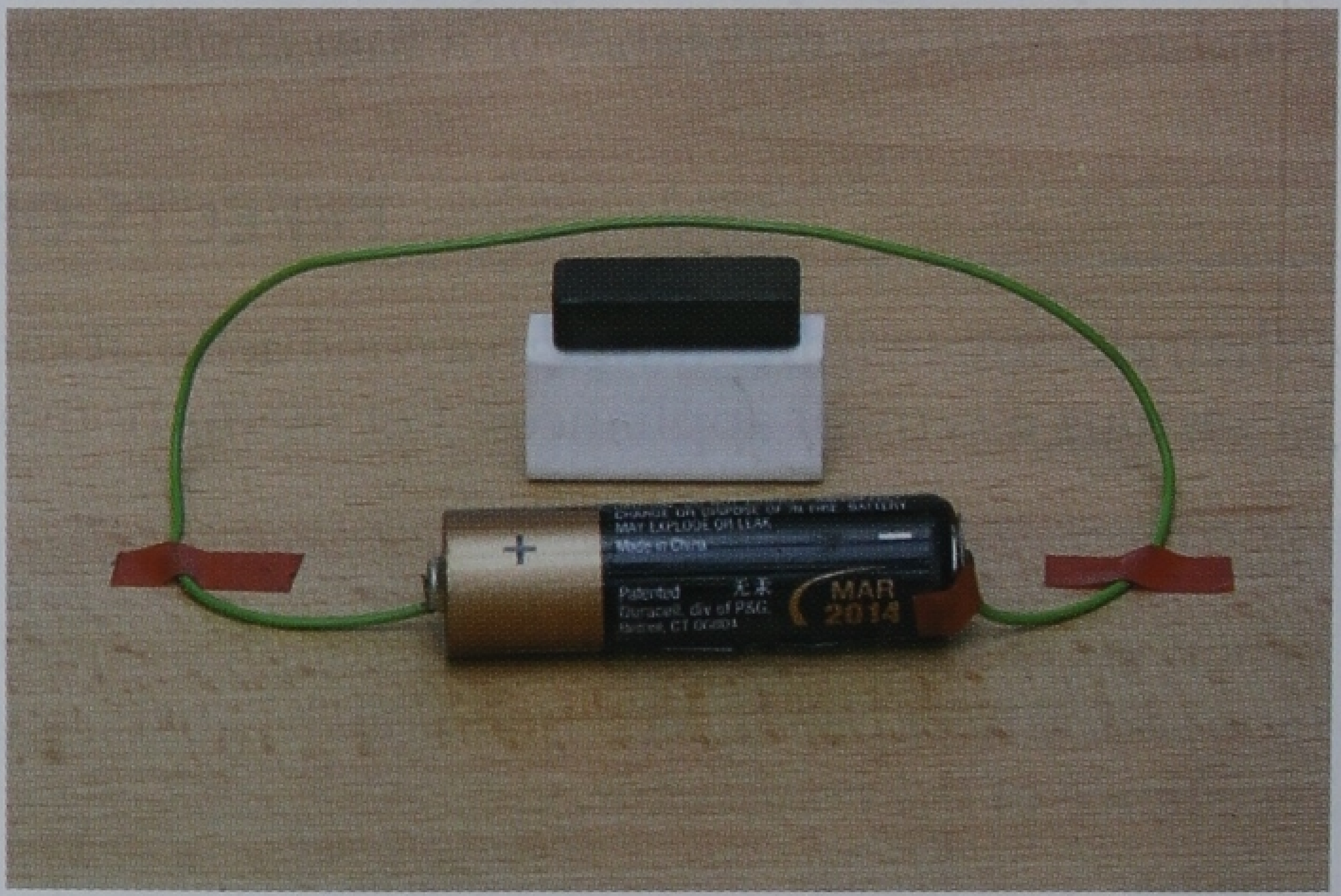


Fig. 7.15

Applications

An electric motor essentially consists of a coil of wire placed in a magnetic field. When an electric current passes through the coil, the coil rotates. Electric motors are used to drive many of the gadgets we use at home, such as fans, washing machines, food processors and pumps.

Magnetic Effect

When an electric current passes through a conductor, a magnetic field is created around the conductor. In other words, the conductor behaves as a magnet.

ACTIVITY Make two holes in a piece of cardboard and pass a wire through them. Place a compass under the wire and rotate the cardboard till the wire is parallel to the needle. Connect the free ends of the wire to a cell. The compass needle will get deflected in one direction. Reverse the connections to the cell (this will change the direction of the current). This time the needle will get deflected in the opposite direction. You can also change the direction in which the needle is deflected by placing the compass above and below the wire carrying current.

You know that the needle of a compass ordinarily points in the N-S direction. It can get deflected only if it is placed in the field of a magnet. Thus, the current-carrying wire behaves as a magnet.

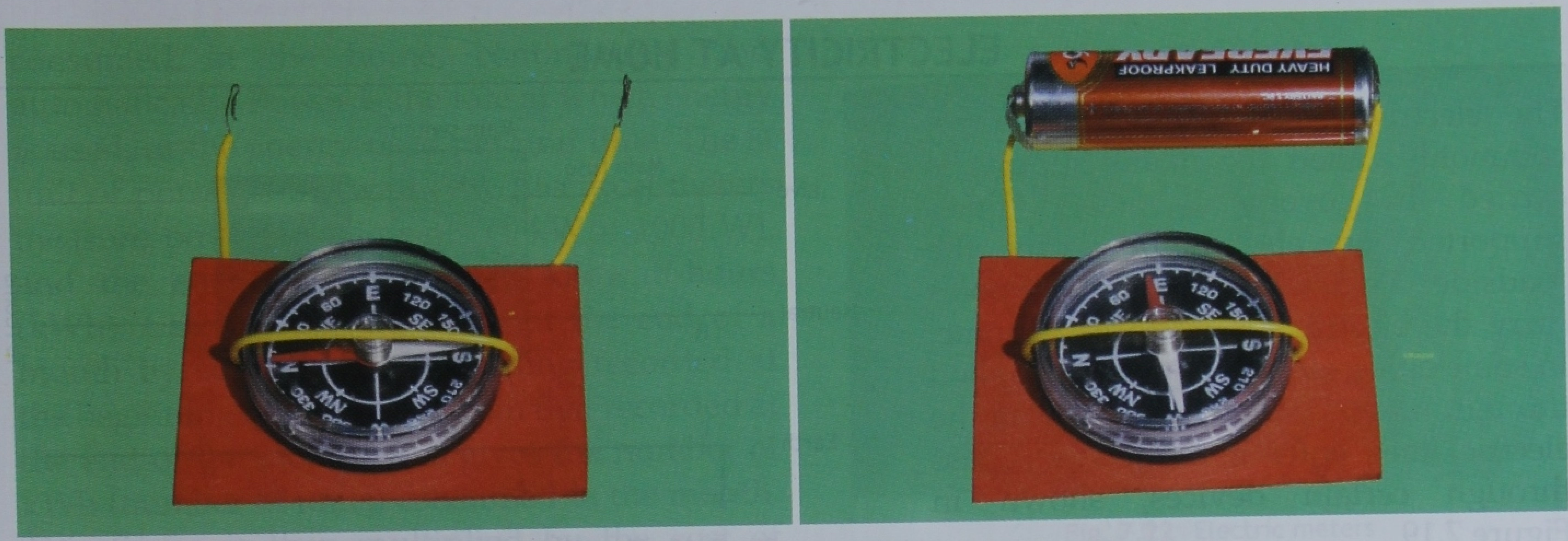


Fig. 7.16 A current-carrying conductor behaves as a magnet.

Electromagnet

In your previous class, you have learnt that a current-carrying coil behaves as a magnet. Such magnets, called electromagnets, lose their magnetic properties as soon as current stops flowing through them. Electromagnets are used in door bells.

Chemical Effect

Some liquids allow electricity to pass through them. You will learn more about such liquids, called electrolytes, in your chemistry lessons. A solution of common salt acts as an electrolyte. Even water acts as an electrolyte, provided it is not absolutely pure. This is the reason why you should never touch an electrical gadget with wet hands.

Add a pinch of salt to some water in a plastic or glass vessel. Dip two wires into the solution and connect the wires to a battery. You will soon see bubbles of gas near the wires. When electricity passes through water, water breaks up into hydrogen and oxygen.

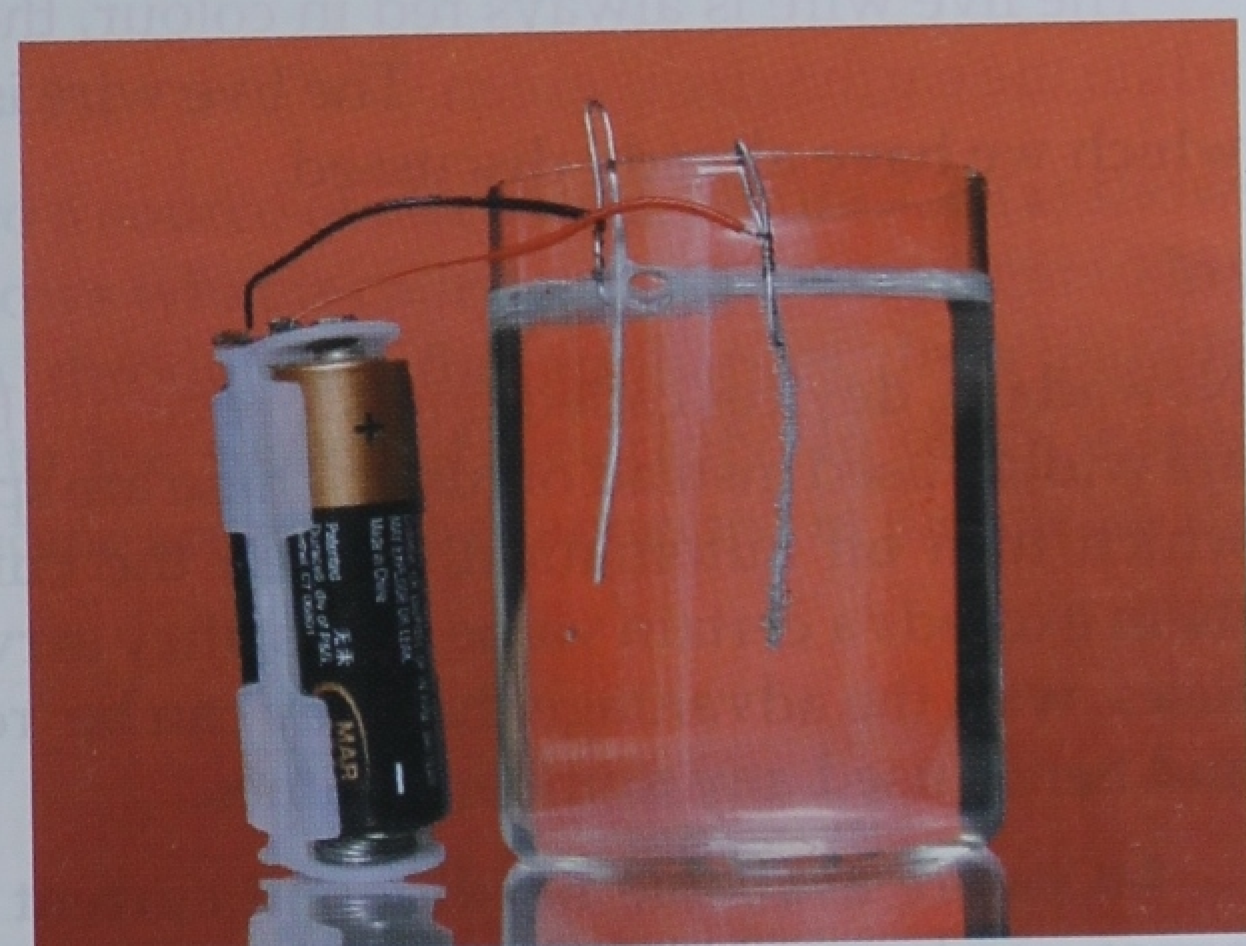


Fig. 7.17 Water breaks up into oxygen and hydrogen.

The decomposition of an electrolyte on the passage of electricity through it is called electrolysis. This is used in a process called electroplating, in which an inexpensive metal is coated with chromium, nickel, silver, and so on, to protect it from rusting or to make it more attractive. For example, suppose an iron spoon has to be coated with silver. The spoon is dipped in a solution containing a salt of silver. A silver rod is also suspended in the solution. The spoon and the rod are connected to a source of electricity. The passage of electricity through the solution decomposes the silver salt, and silver is deposited on the spoon.

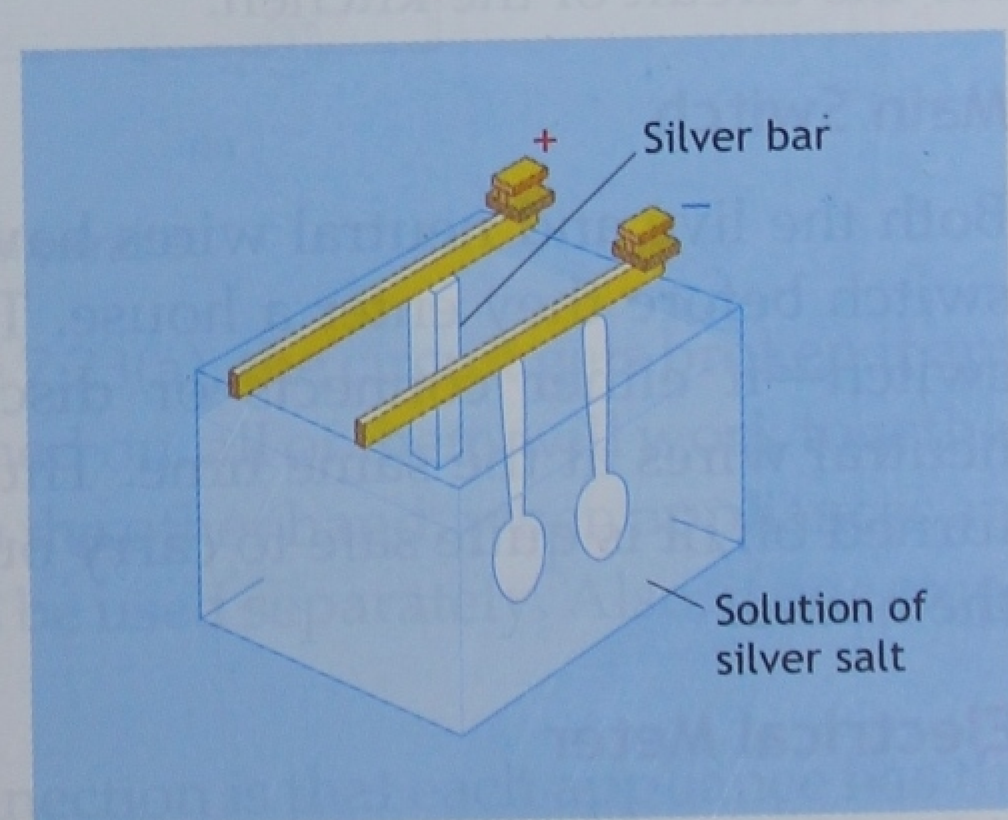


Fig. 7.18 How metal spoons are electroplated with silver

ELECTRICITY AT HOME

The electricity that we use at home, commonly called the mains supply, is carried by overhead power lines, supported on electric poles by the roadside. Two wires from these poles carry the electric supply to each home. In some cities, electric power is supplied through underground cables. Before the electric lines enter a house, they pass through certain devices, shown in Figure 7.19.

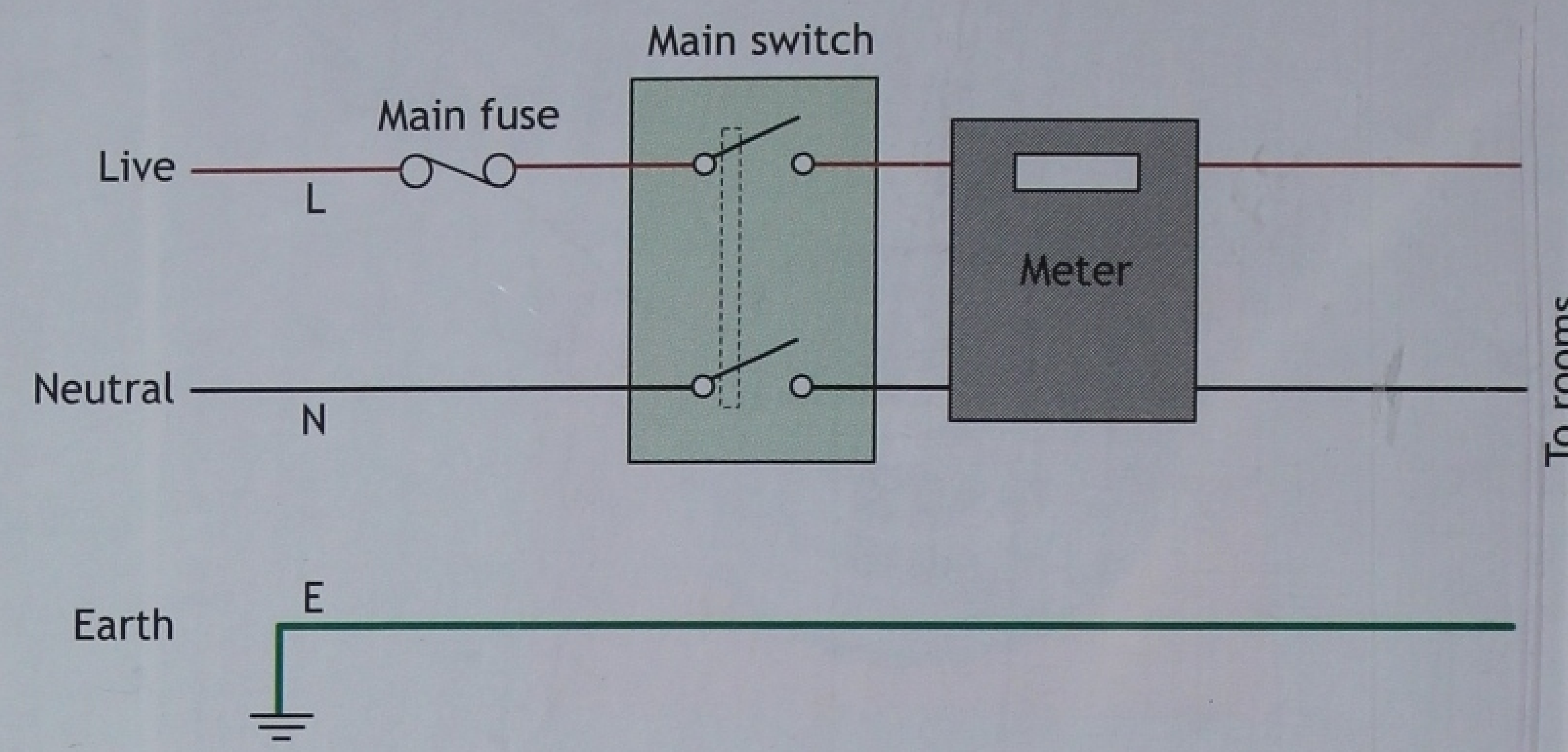


Fig. 7.19 The electric supply lines as they enter a home

The wires marked L and N are called the live wire and the neutral wire respectively. These two supply electrical power to the home. The potential difference between them is 220 V. The third wire, called the earth wire, is connected to a copper plate buried near the house. It is a safety device, and does not supply any power. It ensures that even if the body of some device happens to come in contact with the live wire, we do not get a shock.

The live wire is always red in colour, the neutral wire is black, while the earth wire is green. The live wire is connected to the fuse, which we have already discussed.

MCB

Nowadays, devices called miniature circuit breakers (MCB in short) are widely used instead of fuses. These are specially made switches, which turn off automatically when the current flowing through them exceeds a certain value. Thus, they serve the same purpose as fuses, with the advantage that they can be 'reset', just like a switch, and hence used any number of times.

Fig. 7.20 Miniature circuit breaker

MCBs are available for different current values (amperes) and hence, can be used in different sections of the circuit in a home. For example, there may be one for the circuit of a bedroom and another for the circuit of the kitchen.

Main Switch

Both the live and neutral wires have to pass through the main switch before they enter a house. The main switch is a double switch—it either connects or disconnects both the live and neutral wires at the same time. Thus, when the main switch is turned off, it is quite safe to carry out any electrical work inside the house.

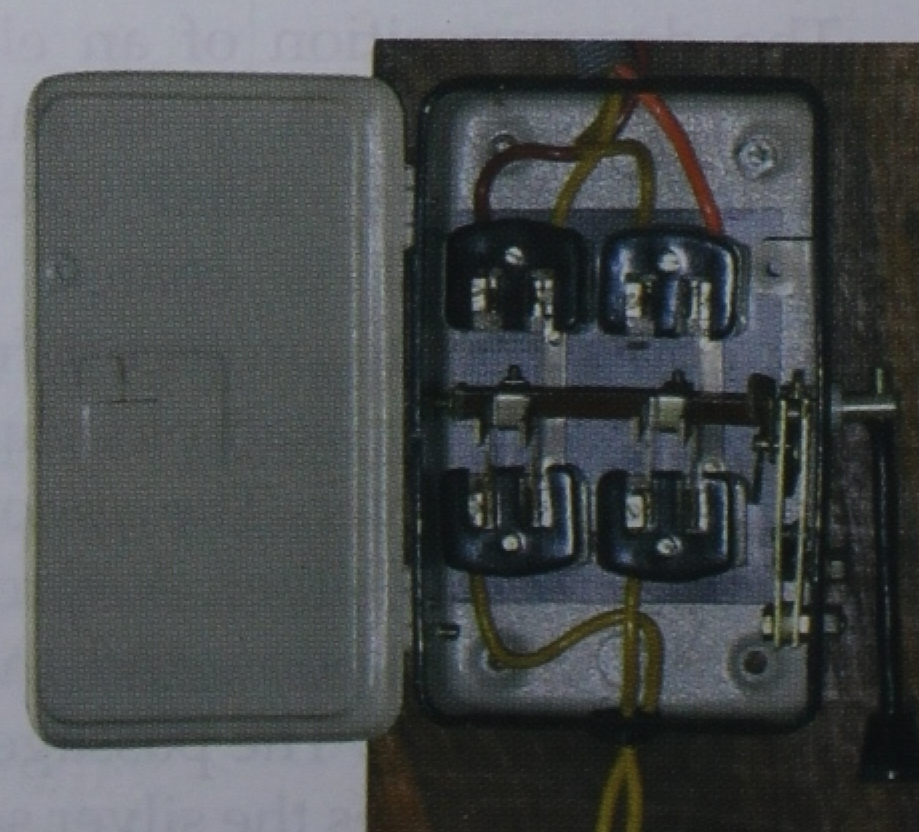


Fig. 7.21 Main switch

Electrical Meter

After the main switch, the electrical supply lines pass through the meter. This records the amount of electrical power consumed in the home, continuously and automatically. Power is the rate at which energy is used, or the energy used per unit time. The SI unit of power is the watt (W). Electrical meters measure power in kilowatts (1 kW = 1000 W), and the energy consumed in kilowatt-hours (kWh). Calculations are made at the end of a month by subtracting the reading recorded at the beginning of the month from that recorded at the end of the month. This gives the number of kWh (number of units) consumed in the month. This figure is then multiplied by the cost of 1 unit of energy.

Fig. 7.22 Electric meters

Suppose the reading at the end of a month = x kWh,

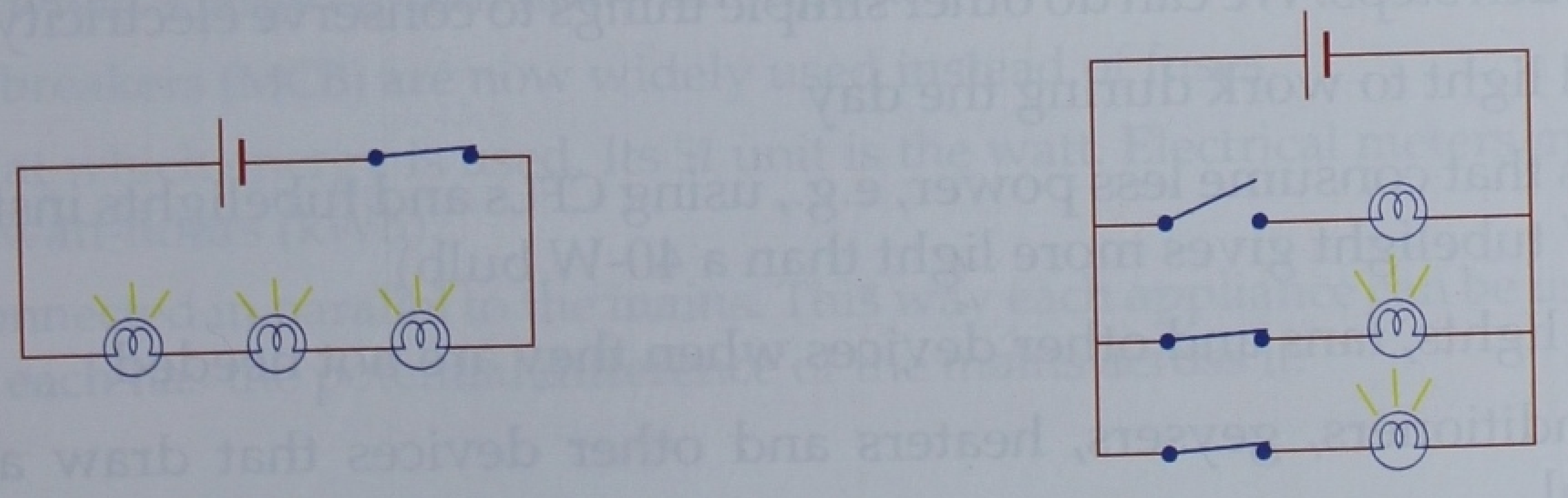
and the reading at the beginning of the month = y kWh.

Then energy consumed in the month = $(x - y)$ kWh,

and cost of energy = Rs $(x - y) \times$ cost of 1 unit of energy.

How Circuits are Connected

There are two ways of connecting electrical appliances to a source of electricity. Figure 7.23(a) shows what is called a series connection, and Figure 7.23(b) shows what is called a parallel connection. In a series connection, current flows along a single path through all the appliances. In a parallel connection, each appliance is connected individually to the source of electricity. In other words, current can flow through several paths. Appliances at home are always connnected in parallel to the mains. This has two advantages.



(a) (b)

Fig. 7.23 Bulbs connected (a) in series (b) in parallel

1. If appliances are connected in series, as the bulbs in Figure 7.23(a), the circuit gets broken if any of them stops functioning. Besides, when the switch is turned on, all of them will work together and there will be no option of using them one at a time. On the other hand, when appliances are connected in parallel, as in Figure 7.23(b), each of them can be used separately. Also, if one stops functioning, it does not affect the other circuits.
2. The other and more important advantage of a parallel connection is that each appliance has the same voltage (potential difference) applied across it.

Safe Use of Electricity

Electricity is a great convenience and absolutely essential in our lives. However, it also carries the danger of electrical shock and electrical fires. Fortunately, these dangers can be avoided almost totally by following a few rules for electrical safety. Some of these are:

1. All electrical wires must be properly secured and insulated. Loose or exposed wires are the most common causes of electrical mishaps.
2. Fuses must always be in place. They should never be replaced by copper wires.
3. Electrical outlets, such as plug points, should never be overloaded. It is common practice to use adapters to draw power for several devices from a single socket. This can lead to overheating.
4. Household gadgets which draw large amounts of power, such as heaters, should be connected to proper power outlets (sockets). Such outlets are somewhat larger, and marked 15 A (ampere), while low power outlets are marked 5 A.
5. All wiring and gadgets must be properly earthed.
6. Wires without insulation must never be used in any electrical circuit, except for earthing.
7. Children should not handle electrical devices or try to repair electrical sockets, switch boards, and so on.

CONSERVATION OF ELECTRICITY

Most of the electricity we use is generated by burning fossil fuels. Fossil fuels, as you know, are nonrenewable. That is why it is sensible to conserve electricity. Besides, the generation of electricity leads to pollution. Conservation of electricity makes sense from the point of view of reducing pollution as well.

Using renewable sources of energy, such as solar panels and wind farms, to generate electricity is one way of conserving fossil fuels and reducing pollution. However, it may not be possible for individuals to take such steps. We can do other simple things to conserve electricity. Some of these are:

1. Using natural light to work during the day
2. Using devices that consume less power, e.g., using CFLs and tubelights instead of incandescent bulbs (a 40-W tubelight gives more light than a 40-W bulb)
3. Switching off lights, fans and other devices when they are not needed
4. Using air conditioners, geysers, heaters and other devices that draw a lot of power only when essential

POINTS TO REMEMBER

- Charge is a fundamental part of matter. It exists in two forms—positive and negative. The SI unit of charge is the coulomb, with the symbol C.
- When there is an imbalance of charges in a body, it is said to be electrically charged. A charged body applies electrostatic force on other bodies.
- An electric current is defined as the charge flowing past a point per unit time. The SI unit of electric current is the ampere (A) = coulombs/second.

- An electric current flows only when there is a difference in potential. Potential difference is measured in volts (V). The higher the potential difference, the greater is the current.
- Any source of electricity creates a difference in potential. The p.d. of common cells is 1.5 V and of the mains is 220 V.
- Chemical energy is converted into electrical energy in cells and batteries.
- Storage batteries can be 'recharged' and used many times over, so they are known as secondary cells or batteries. Lead-acid batteries (accumulators) are used in motor vehicles and inverters, while dry batteries are used in mobile phones, electronic cameras and similar devices. Primary cells cannot be recharged.
- An arrangement of devices through which electricity can flow is called an electrical circuit. A circuit diagram is a representation of a circuit using symbols for electrical components.
- A switch is a device for opening and closing a circuit.
- Materials that allow the passage of electricity are called conductors. Materials that do not allow the passage of electricity are called nonconductors or insulators.
- Resistance is a physical quantity that measures the opposition offered to the flow of current. The resistance of a conductor depends on its thickness, length and the material it is made of. The higher the resistance, the lower is the current under similar conditions.
- When electricity passes through a conductor, it produces heat. This is used in bulbs, geysers, and so on.
- When a wire carrying a current is placed in a magnetic field, a force acts on it. This is used in electric motors, which drive fans, washing machines, air conditioners and food processors.
- A wire or coil carrying a current has a magnetic field around it, or behaves as a magnet.
- Liquids that allow the passage of electricity are called electrolytes.
- The decomposition of an electrolyte on the passage of electricity is called electrolysis. Inexpensive metals are coated with more expensive metals with the help of electrolysis. This is called electroplating.
- The three wires of the mains supply are the live (red), neutral (black) and earth (green). The earth wire is a safety device. It is connected to a copper plate buried near the house.
- A fuse is a safety device that prevents electrical fires and damage to appliances. The fuse wire melts and breaks the circuit when a large current flows through it.
- Miniature circuit breakers (MCB) are now widely used instead of fuses.
- Power is the rate at which energy is used. Its SI unit is the watt. Electrical meters measure the energy consumed in kilowatt-hours (kWh).
- Appliances are connected in parallel to the mains. This way each appliance can be used independently of the others and each has the potential difference of the mains across it.

EXERCISE

Short-Answer Questions

1. Distinguish between electric charge and electric current. What are their SI units?
2. When is a body said to be electrically charged? What causes lightning?
3. What is resistance?
4. Name three sources of electricity along with their voltages.
5. Distinguish between primary and secondary cells.
6. What is the meaning of the term 'battery'?
7. What is an electrical circuit?
8. What are the advantages of having electrical appliances connected in parallel?

Long-Answer Questions

1. Explain electric current and electric potential. What are their SI units? What is the relation between them?

2. What are the principal parts of an electric circuit? Draw a neat circuit diagram using the symbols of these parts.
3. What are the effects of electricity? Describe each of these effects and mention their uses in everyday life.
4. Mention five precautions needed for the safe use of electricity.
5. What can we do to conserve electricity?

Objective Questions

Choose the correct option.

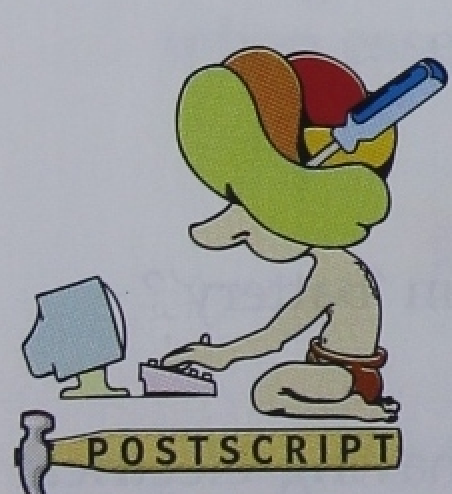
1. Which of the following statements is not correct?
   (a) Conductors have more charge than insulators.
   (b) Conductors allow charge to flow through them more easily than insulators.
   (c) Common metals are good conductors.
   (d) Electrical wires are usually covered by insulators.
2. Which of the following is not a source of electric current?
   (a) Battery (b) Conductor
   (c) Cell (d) Accumulator
3. Which of the following cannot be recharged?
   (a) Accumulators (b) Dry batteries
   (c) Storage batteries (d) Primary cells
4. The purpose of a fuse used in household wiring is
   (a) to prevent electric shock
   (b) to distribute electricity in the different parts of the household
   (c) to disconnect an electrical appliance when it is not in use
   (d) to prevent electrical fires
5. In domestic wiring, the neutral wire has which of the following colours?
   (a) Black (b) White
   (c) Green (d) Red
6. Electric meters measure the consumption of energy in
   (a) watts (b) kilowatts
   (c) kilowatt-hours (d) joules

Fill in the blanks.

1. Electric current flows when there is some difference in ....
2. The earth wire is connected to a ...... buried near the house.
3. A metal surface can be protected from corrosion by ....
4. A current-carrying coil behaves as a ....
5. A force acts on a wire carrying current when it is placed in a ...... field.
6. The SI unit of potential difference is the ....

Write true or false.

1. Insulators do not carry electric current because they do not have charge.
2. An MCB can be used instead of a fuse in an electrical circuit.
3. The insulation on a wire prevents it from getting hot when carrying current.
4. Electrical devices such as lamps and fans offer resistance to the flow of current.
5. The potential difference in a circuit is shown by an arrow.
6. An electric motor makes use of the magnetic effect of a current.



Making a Bulb Holder

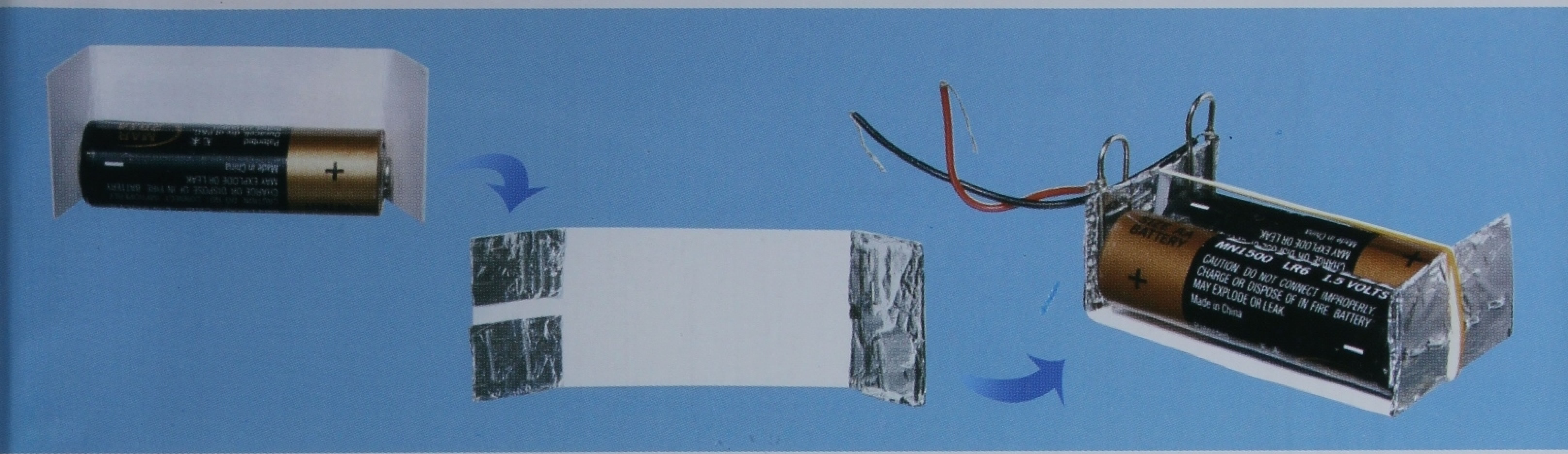
Use a piece of rubber or wood as the base. Push in a drawing pin attached to a wire.

Twist some wire around a bulb and fix it to the base with tape or glue.

Connect the wires to a battery.

Making a Battery Holder

Fold a strip of cardboard and staple three pieces of aluminium foil as shown. Take care to position the staples in such a way that they make contact with the terminals of the cells. Connect wires with the help of paper clips. Use a rubber band to hold the device together.



Making a Galvanoscope

A galvanoscope is a device used to detect current. You can make one using a coil and a magnetised needle.

Buy about 10 feet of 28-gauge enamelled copper wire. Wind the wire around a glass to make a coil. Tape the coil to a base (a piece of cardboard, plastic or wood) to make it stand. Scrape off the enamel from the free ends of the wire. Magnetise a needle and hang it from the top of the coil. The needle will point N-S. Turn the base to align the coil and needle. Then connect a cell to the free ends of the coil. The needle will get deflected as current flows through the coil. If the cell is dead, the needle will not get deflected. The galvanoscope will detect even very weak currents.

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