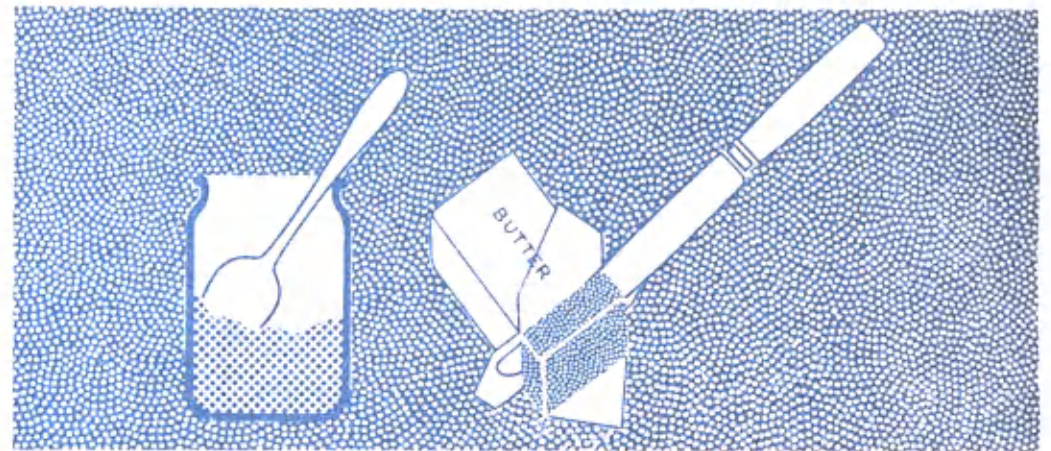
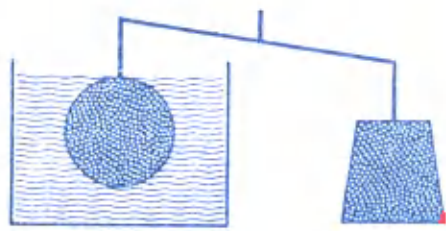
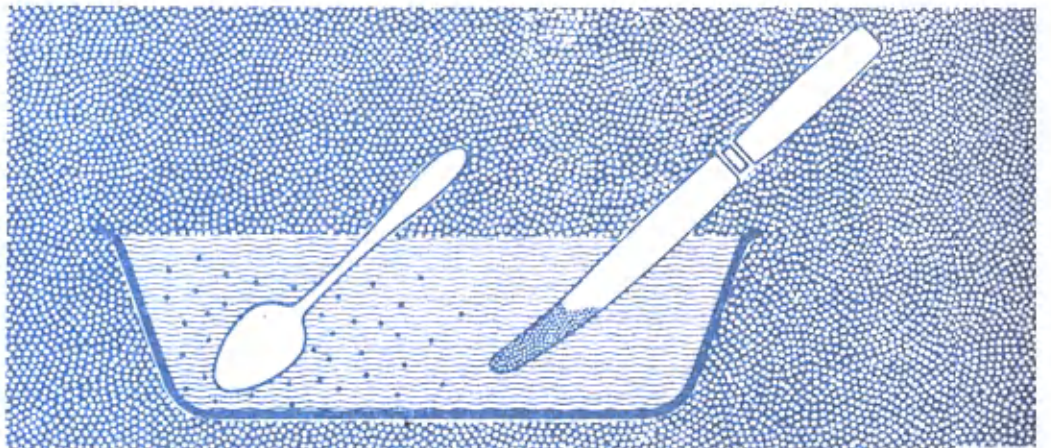
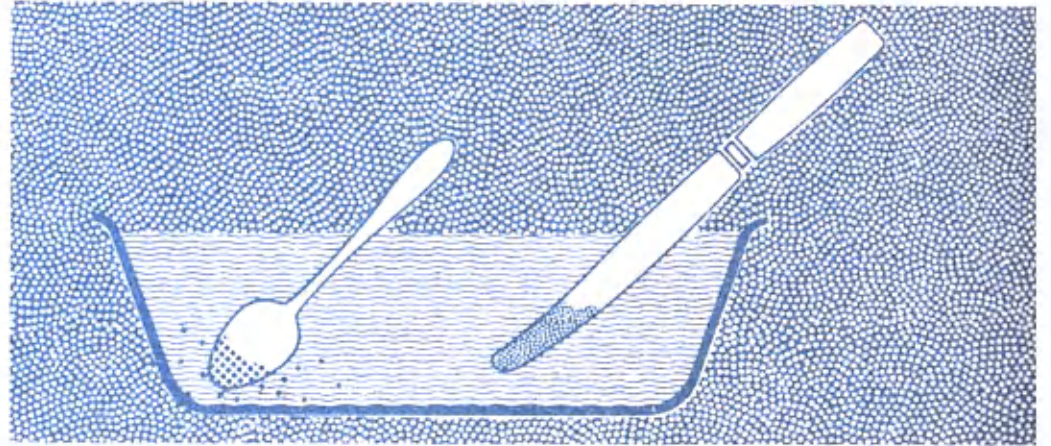




Science in the Home



VISUAL SCIENCE

1 *FIRST BOOK*

Living things: how young animals begin life; where plants store food; life-cycles of plants and animals. Water: its role in nature; ice, water, steam; floating and sinking. Earth and sun: seasons, climates, day and night. Sound: how it is caused and how it travels; loud and soft sounds; high notes and low.

2 *SECOND BOOK*

Air: its weight and power; burning and breathing. Heat: its sources; how heat travels through air, through liquids, through solids; using and keeping heat. Light: how it travels; brightness and colour; reflection. Weight and work: falling and gliding; levers; arms and legs.

3 *SCIENCE IN THE HOME*

Water: how it comes to our homes; hard and soft water; water and rust. Food: the role of cooking; digestion and nutrition; why food must be kept clean. Glass: how it is made; its properties; its value in the home. Electricity: heating and lighting; the electric bell; the fuse.

4 *SCIENCE IN THE COUNTRY*

The life-histories of plants and animals in more detail; introduction to the chemistry of the soil; how seeds form and germinate; the nitrogen cycle; the carbon cycle; first lessons in animal and human physiology; further aspects of the behaviour of liquids; how water rises in plants; introduction to study of weather.

5 *MOVING ABOUT*

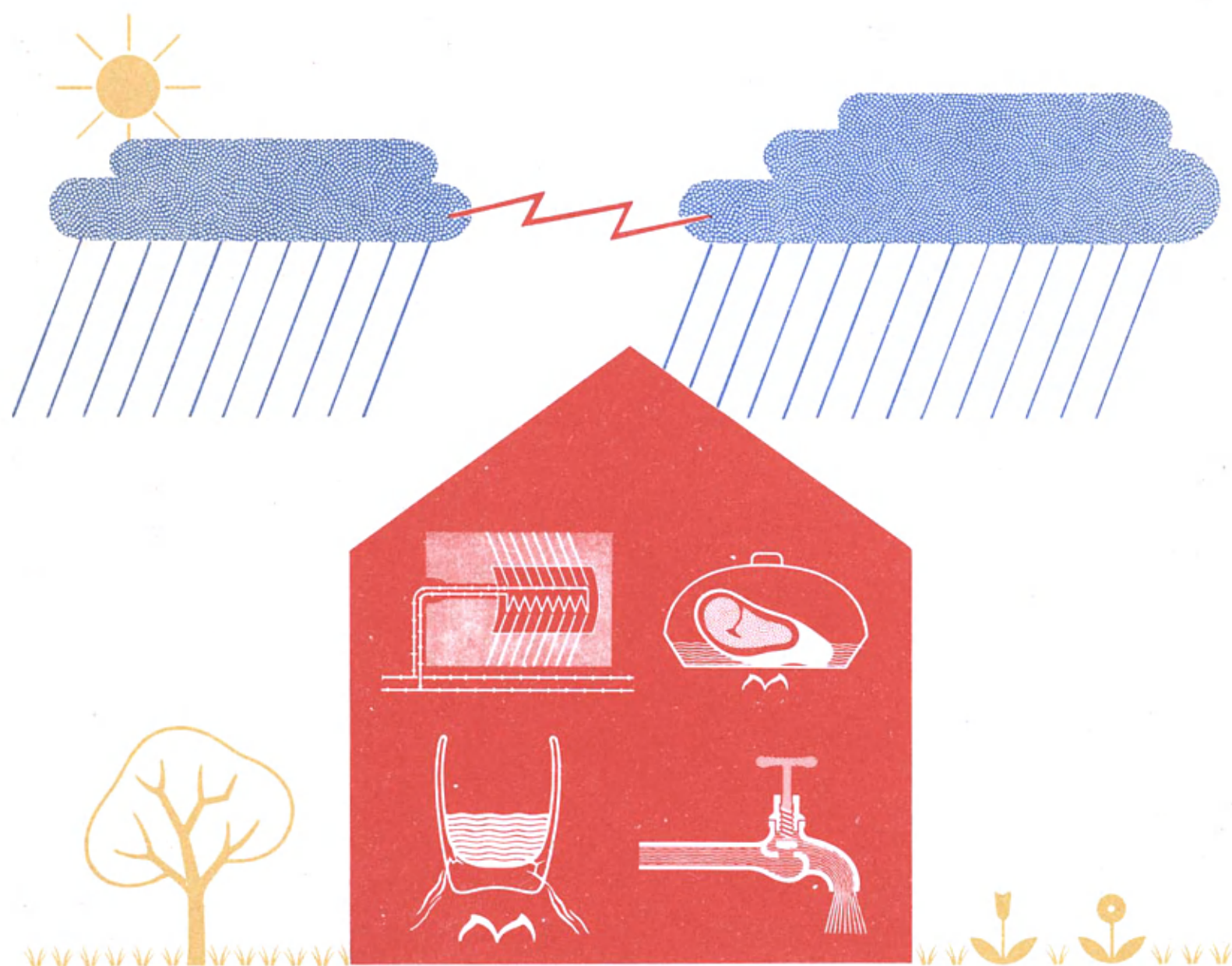
Devices which assist movement: the wheel, the screw, the propeller, the jet, the oar. Stopping, starting and turning (acceleration and inertia). Movement of animals in water, in the air, on land, underground; limbs, muscles, nerves. Pressure in air and in liquids. The magnet.

6 *MACHINES WHICH WORK FOR MAN*

The sun as a source of power: from coal to steam and steam engines, to the turbine and electricity, to coal gas; watermills and windmills. Simple chemical changes as sources of power. Electrolysis and electro-magnetism. Gravity and work. Sources of power compared.

VISUAL SCIENCE

SCIENCE IN THE HOME



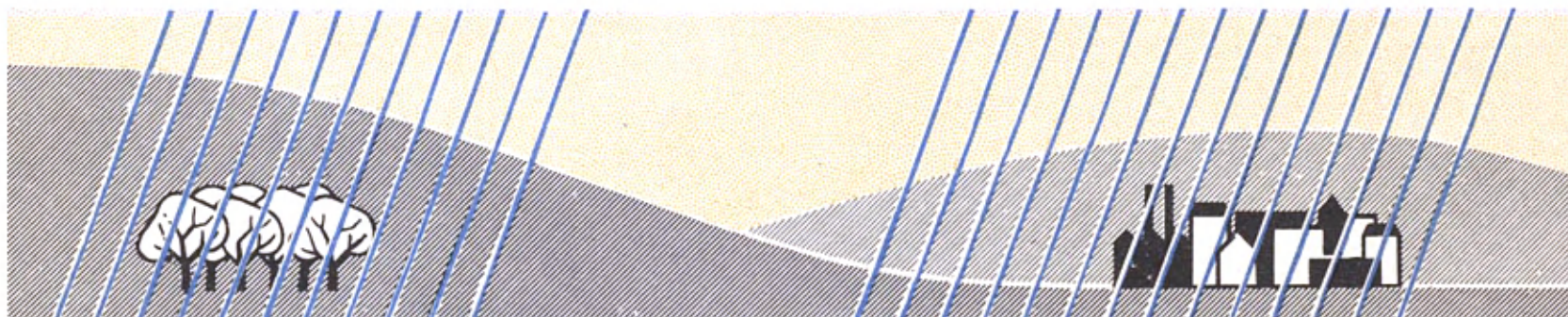
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LIST OF CONTENTS

How to Use this Book	<i>Page</i> 5
The Water from the Tap	6
The Power of Water	8
How Different Things Mix with Water	10
How Soap Cleans when Water Won't	12
Water and Rust	14
How Iron is Made from its Ore	15
What We Have Learned about Water	16
A Fire Burns, a Man Breathes	18
Cooking in Water and Cooking in Fat	20
The Food We Eat	22
The Story of a Loaf of Bread	24
Why We Must Protect Food	26
What We Have Learned about Food	28
Windows, Warmth and Light	30
Making and Shaping Glass	32
Some Qualities of Glass	34
What We Have Learned about Glass	36
How Electricity is Carried to Our Homes	38
Light and Heat from Electricity	40
Getting Just the Heat We Need	42
How Electricity Rings the Doorbell	44
Dangers from Electricity	46
What We Have Learned about Electricity	48
Some Books to Read	49

HOW TO USE THIS BOOK

Science is not simply a "subject" which you learn in the classroom, in the laboratory or by reading books. It is a way of observing, of understanding, of doing things. In your own home, among the things you see and handle every day, there are many opportunities to observe, to understand and to do things in a scientific way. The purpose of this book is to help you to make use of these opportunities, not only so that you will learn something about science, but also so that you will find more enjoyment in seeing everyday things and doing everyday jobs.

The pictures are not intended to show you how things look, but to give you scientific information about them. Every line and every patch of colour has something to tell you, just as in a good map. In the charts about food, for instance, carbon is always shown in black, oxygen in red, hydrogen in blue. Certain simple drawings, called "Isotype symbols" are used over and over again, always with the same meaning, so that you will recognise and understand them quickly and easily every time you see them.

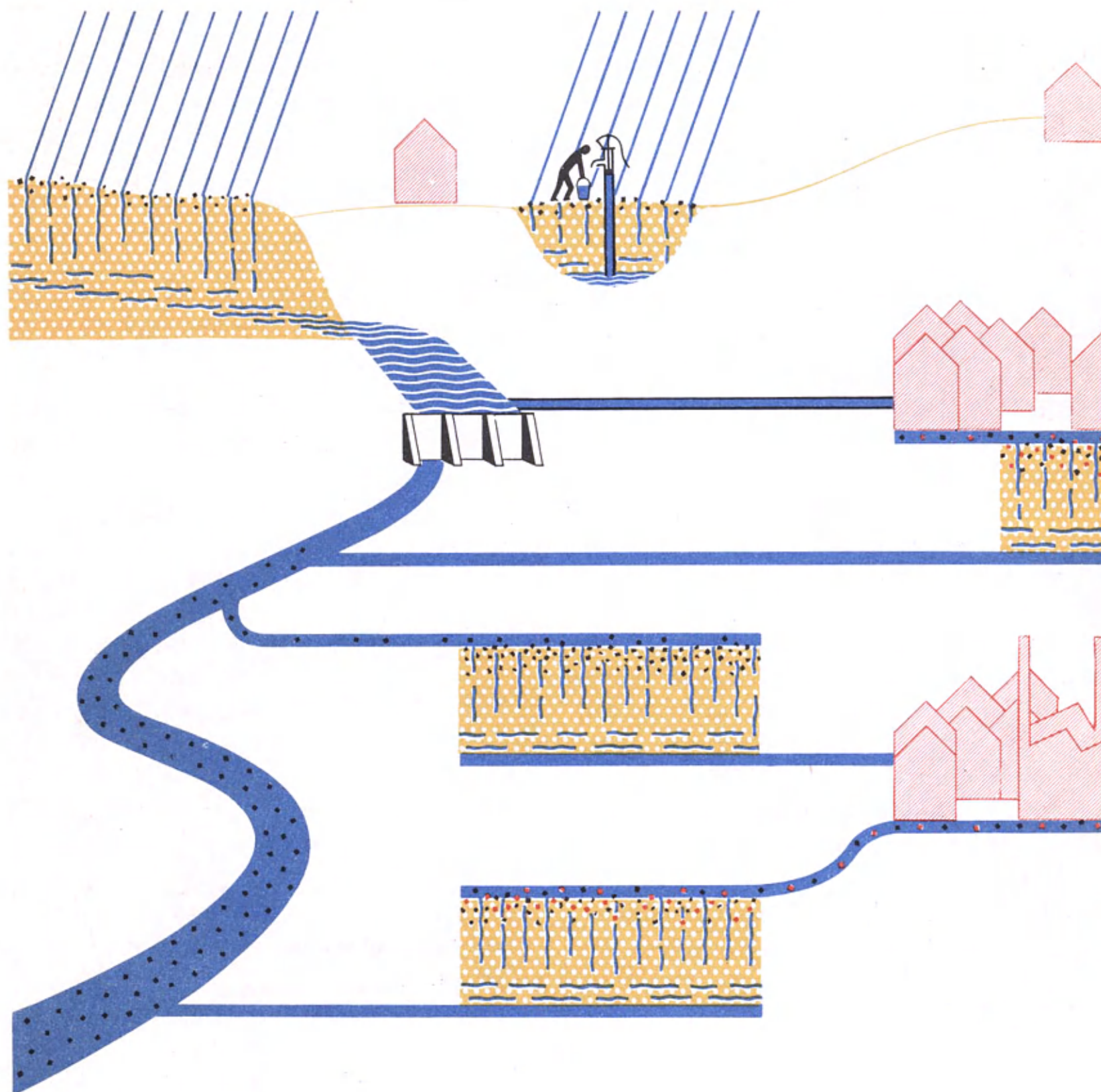
It is easy to imagine that because this book contains many pictures and few words it can be

read and understood in a short time, but this is quite wrong. Isotype pictures, like engineers' blueprints or navigators' charts, are packed with interesting information, and the more carefully you examine them the more you will learn from them. On some pages we have asked a number of questions. You will not be able to answer all of them after a quick glance at the pictures, but you *will* after you have examined the pictures thoroughly. On other pages we have used text to add to the information given in the pictures.

We hope that you will enjoy studying this book and that you will want to read some of the others we have listed on page 49. But you will find that the best ways of increasing your knowledge of science are by observing and studying real things and by conducting simple experiments. See for yourself how things behave under different conditions and test for yourself whether the same things always behave in the same way under the same conditions. When you have done that, you will find that this book helps to make your knowledge more orderly and useful, by showing you how the results of your observations and experiments all fit in with certain laws of nature.

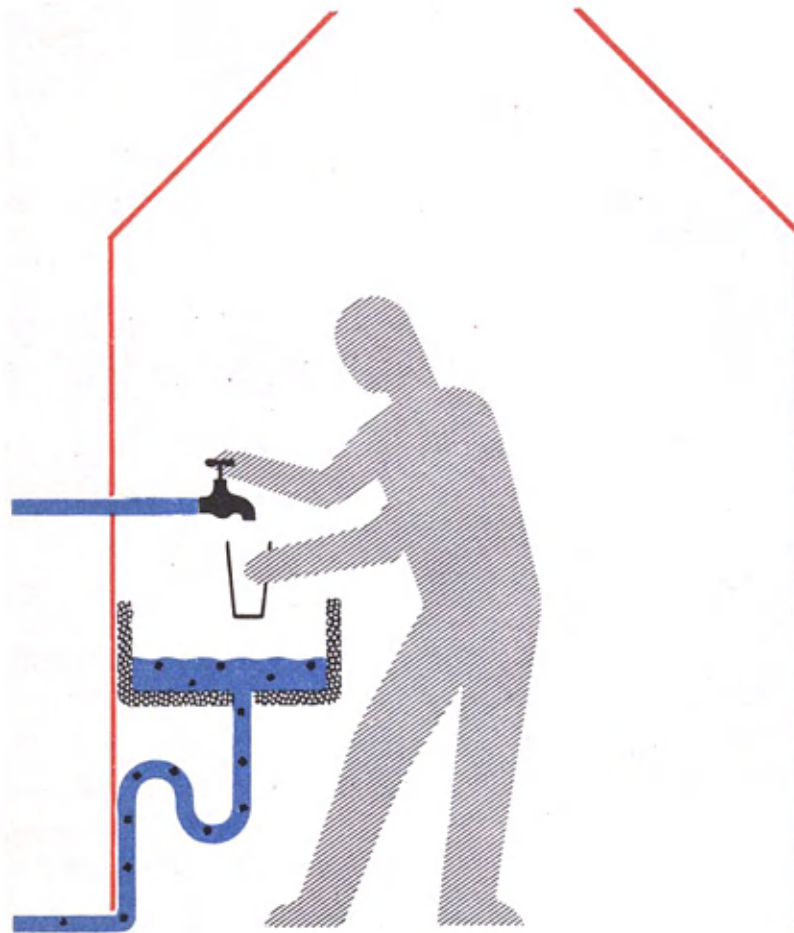
The Editors

The Water from the Tap



Look at the picture on the left

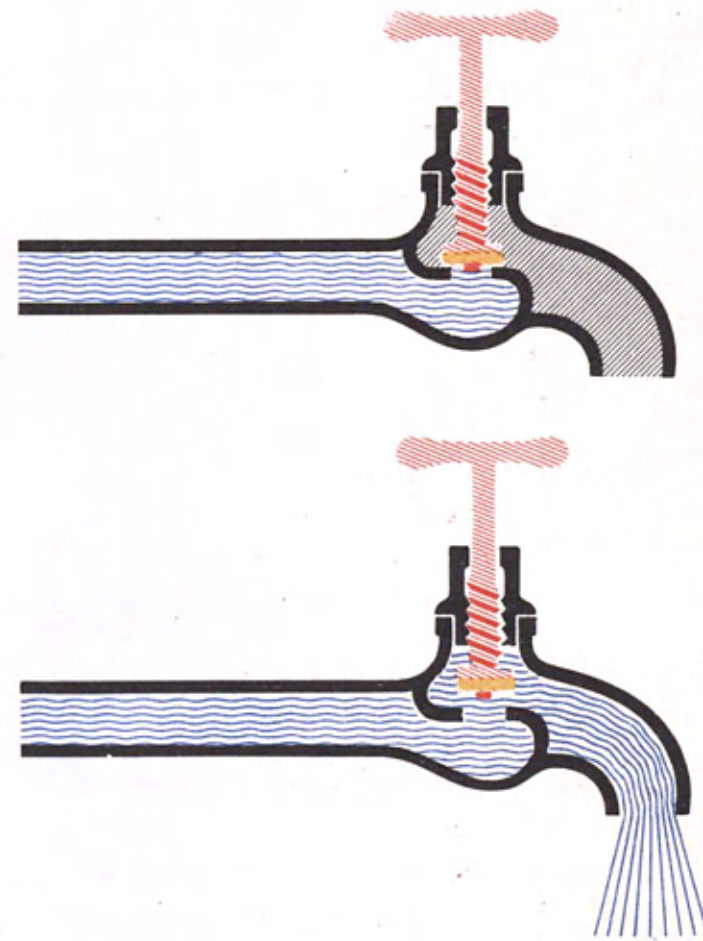
- 1 What do the yellow patches stand for? What do the blue lines on the yellow patches stand for?
- 2 What happens to the rain when it falls on the earth?
- 3 How does the water get into the well below the pump? To the reservoir above the dam?
- 4 How is dirty water shown? Is the water clean or dirty when it reaches the houses in the first town?
- 5 How are dangerous impurities from sewage shown? Point out the filters which remove them.



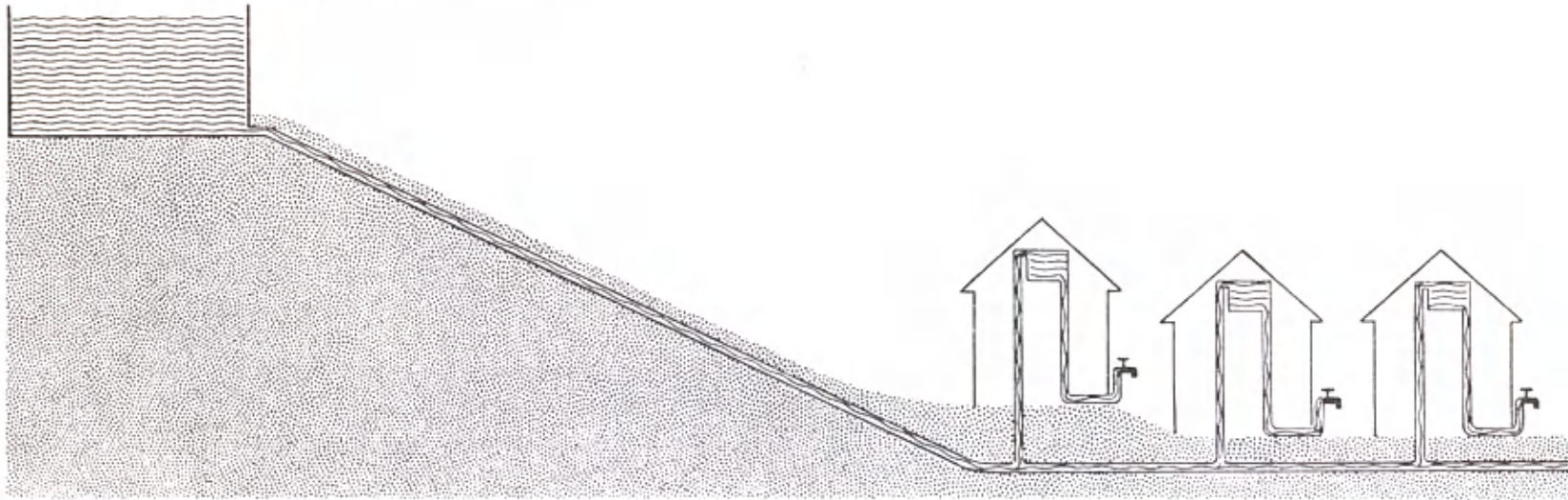
- 6 Has the water to be cleaned again before it reaches the second town? How did the dirt get into the water?
- 7 Has the water to be cleaned after it leaves the second town?

Look at the pictures below

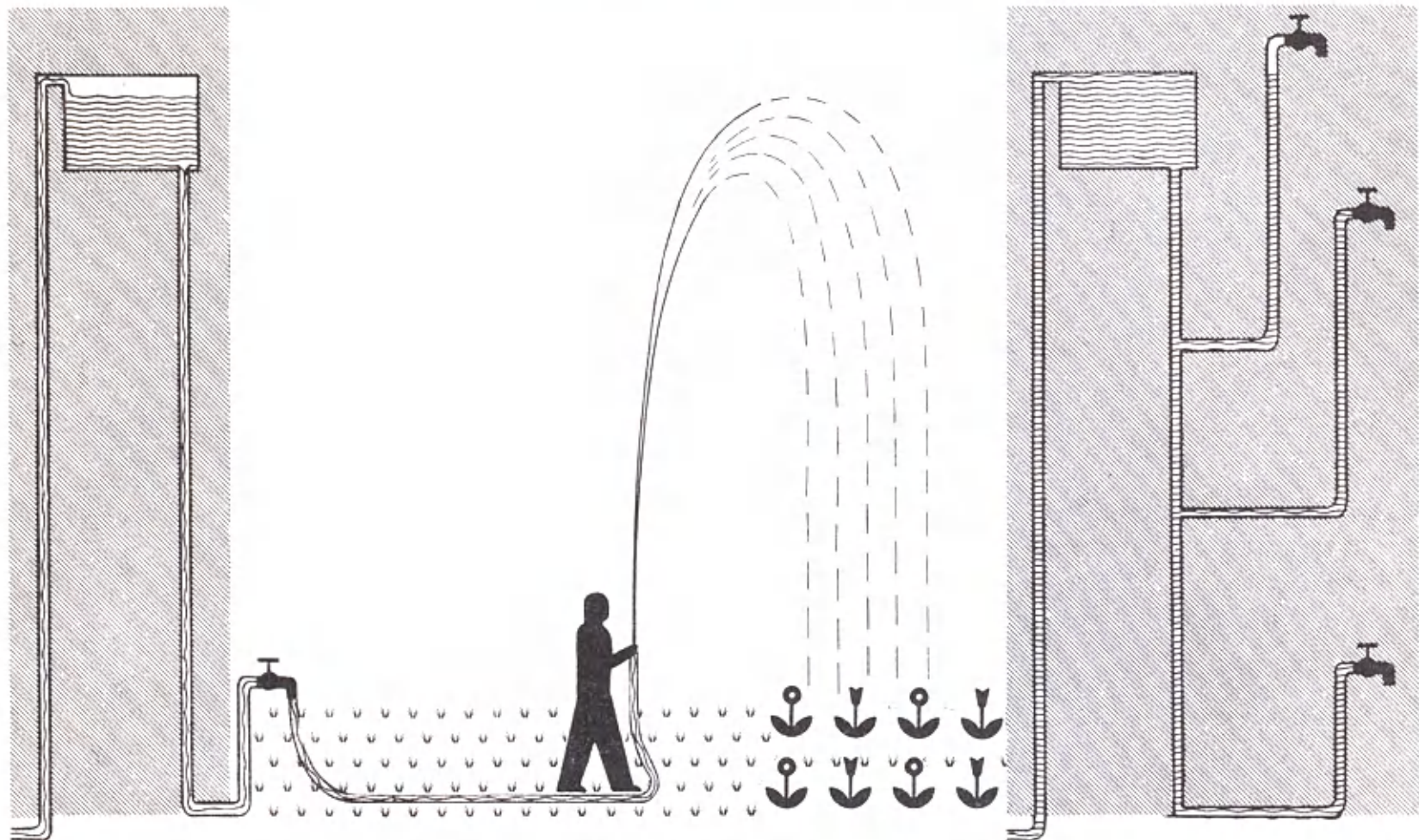
- 8 When the boy turns on the tap, where does the clean water come from? What do you think happens to the dirty water from the kitchen sink?
- 9 Which colour shows the washer in the tap? What happens to the washer when the tap is turned on?



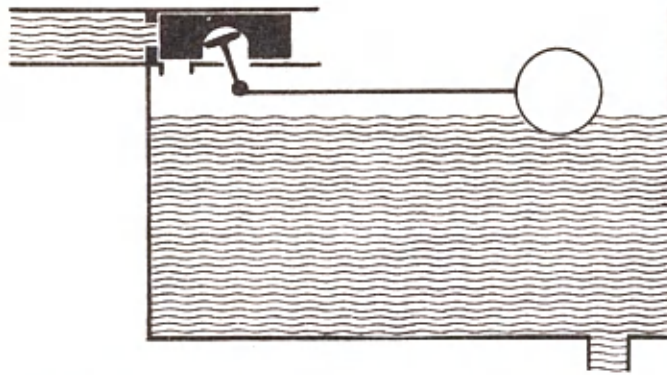
The Power of Water



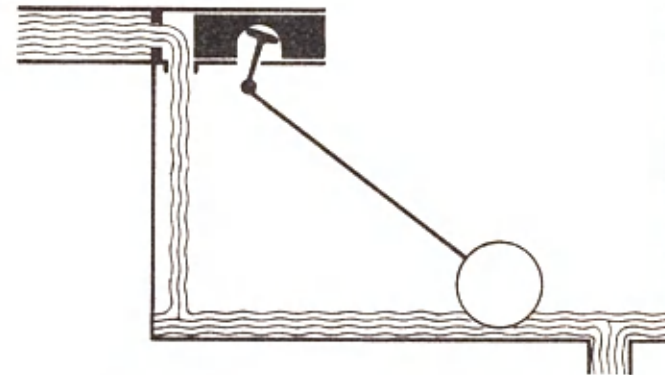
To keep the tanks in houses full, the level of water in the reservoir must be higher than in the tanks.



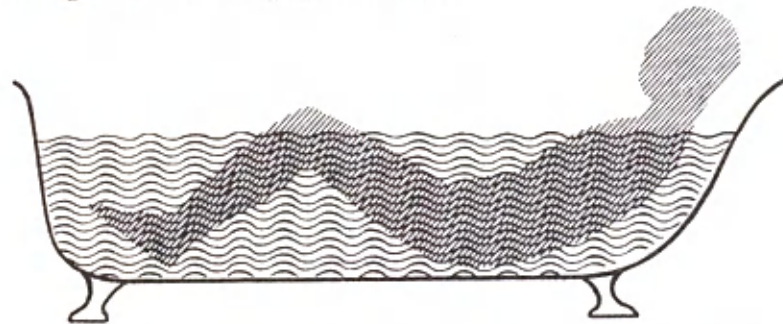
Water will not rise higher than the water level in the tank it is drawn from. What happens when the jet from the hose reaches that height? Can water be drawn from the highest tap on the right?



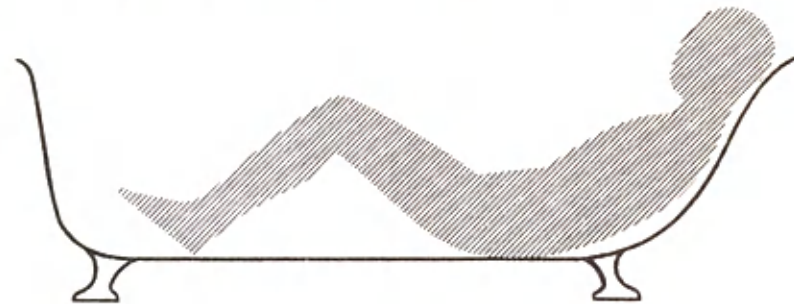
When this tank is almost full, the water holds up a hollow ball fixed to a rod. Attached to the rod is a lever which keeps the inlet pipe closed.



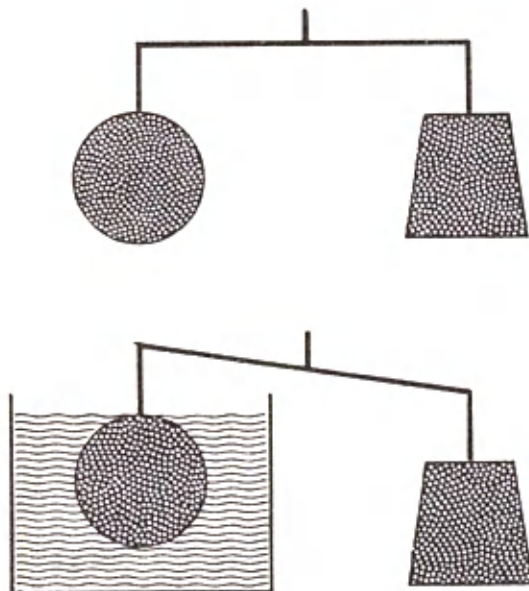
As the tank empties the ball falls to the bottom and moves the rod. The lever turns and opens the inlet pipe. Water pours in to fill up the tank.



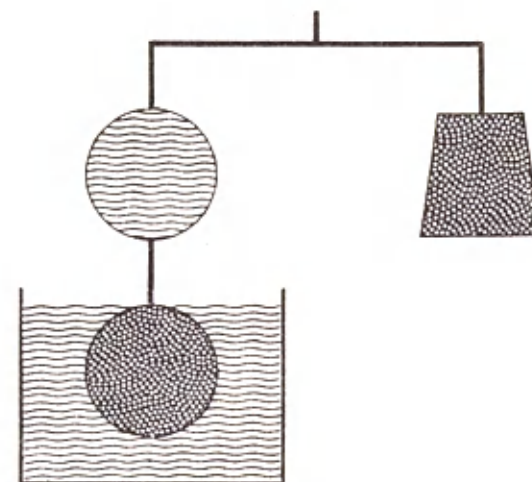
The water in the bath supports part of this man's weight; his body feels slightly lighter.



If there is no water, the whole of his weight rests firmly on the bottom of the bath.

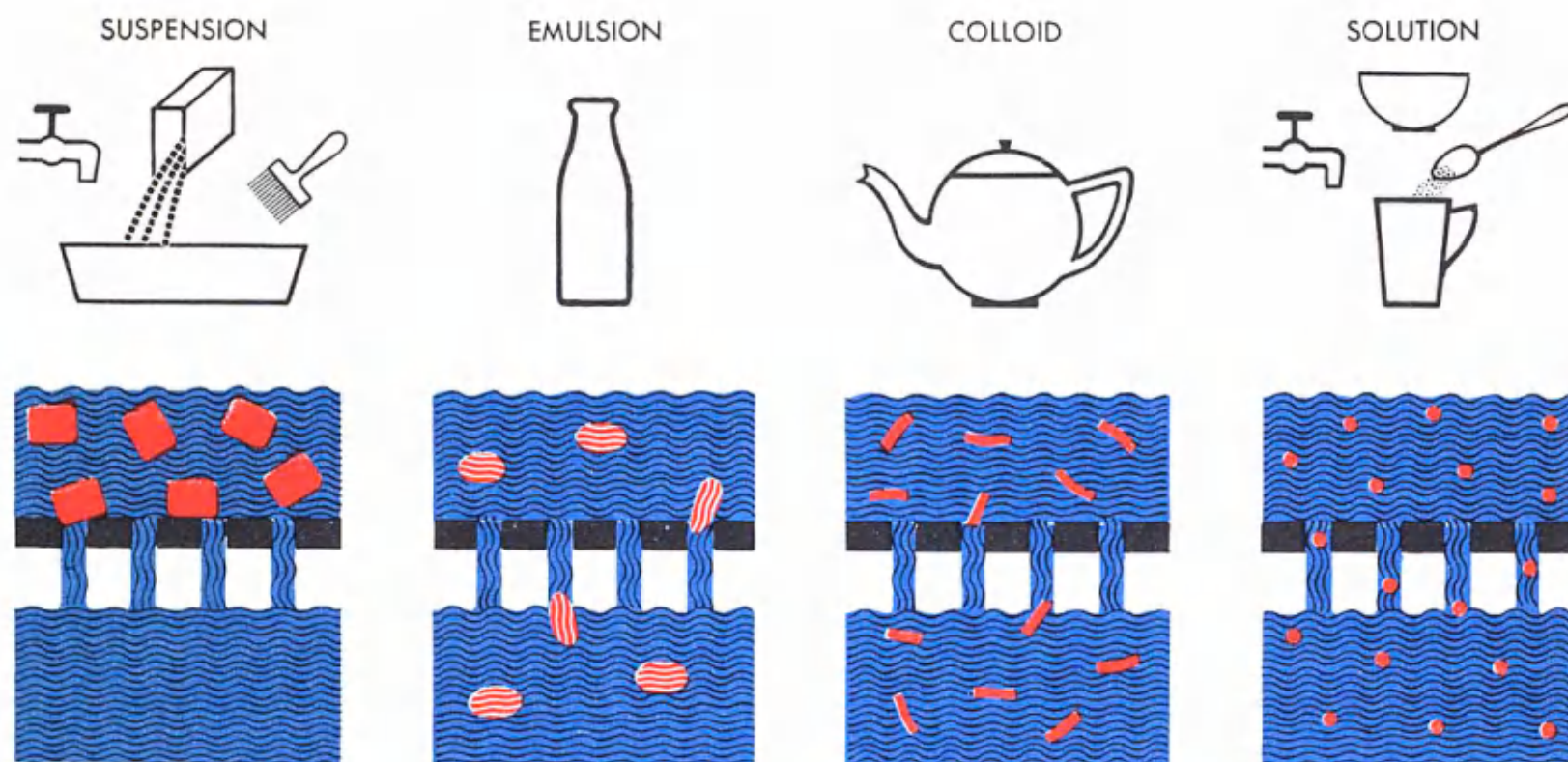


In air the ball weighs as much as the block. In water it weighs less than the block.



The ball pushes aside a volume of water as large as its own. The weight it loses is equal to the weight of the water pushed aside.

How Different Things Mix with Water



The blue oblongs stand for water; the red patches show various things mixed with water; the broken black lines show filters.

What do we mean when we say something "mixes" with water? These pictures show four things which mix with water in different ways.

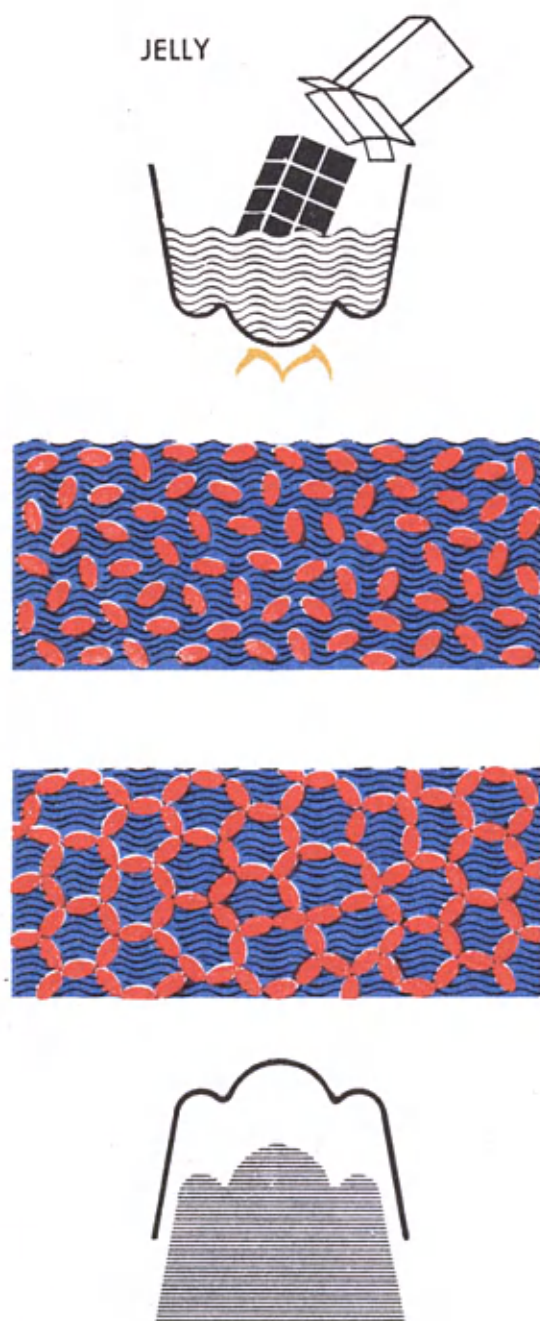
Chalk mixes with water, but most of it can easily be separated again. Strain some of the mixture through a filter-paper. Water trickles through and chalk remains on the paper. The solid particles of chalk are too big to pass through the pores of the paper. They were simply floating about in the water. They were, as we say, "in suspension".

In milk, globules of fat are suspended in water, but you cannot separate them from the water by means of a filter-paper. The globules

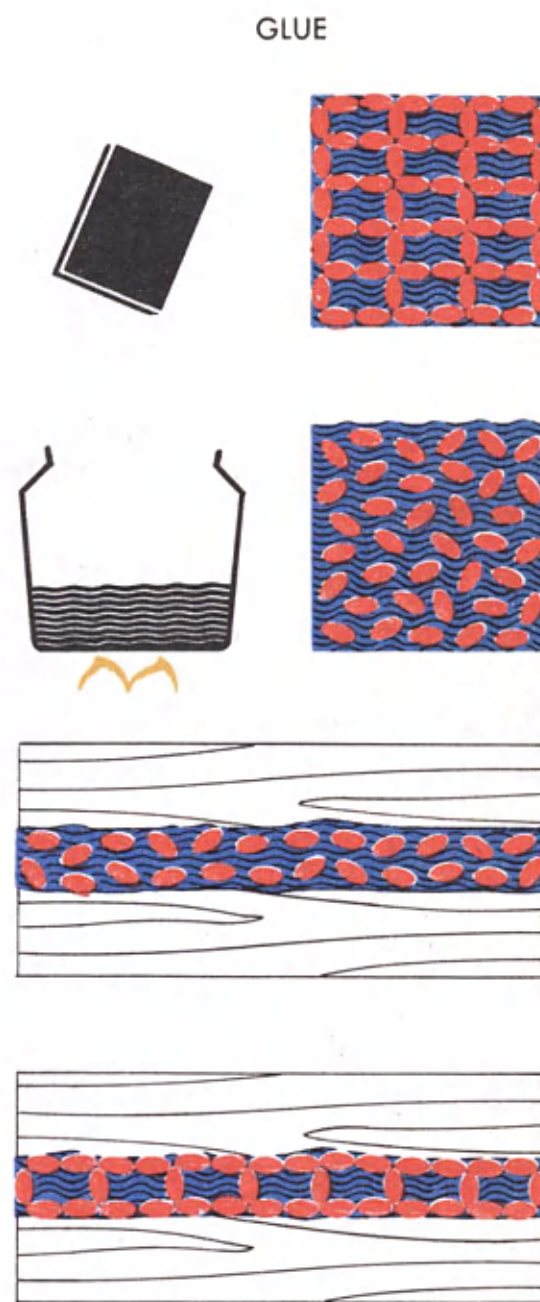
of fat are not solid. They will squeeze through the pores of the paper. A mixture of water and drops of another fluid is called an emulsion.

When tea is mixed with boiling water some of it breaks into very small particles which colour the water. These particles are too small to be separated from the water by any filter. This kind of mixture is called a colloid.

In water, sugar breaks up into the smallest particles possible—into what are called molecules. These tiny particles cannot be separated by filtering, but only by boiling the mixture until all the water is driven off. A mixture of this kind is called a solution.

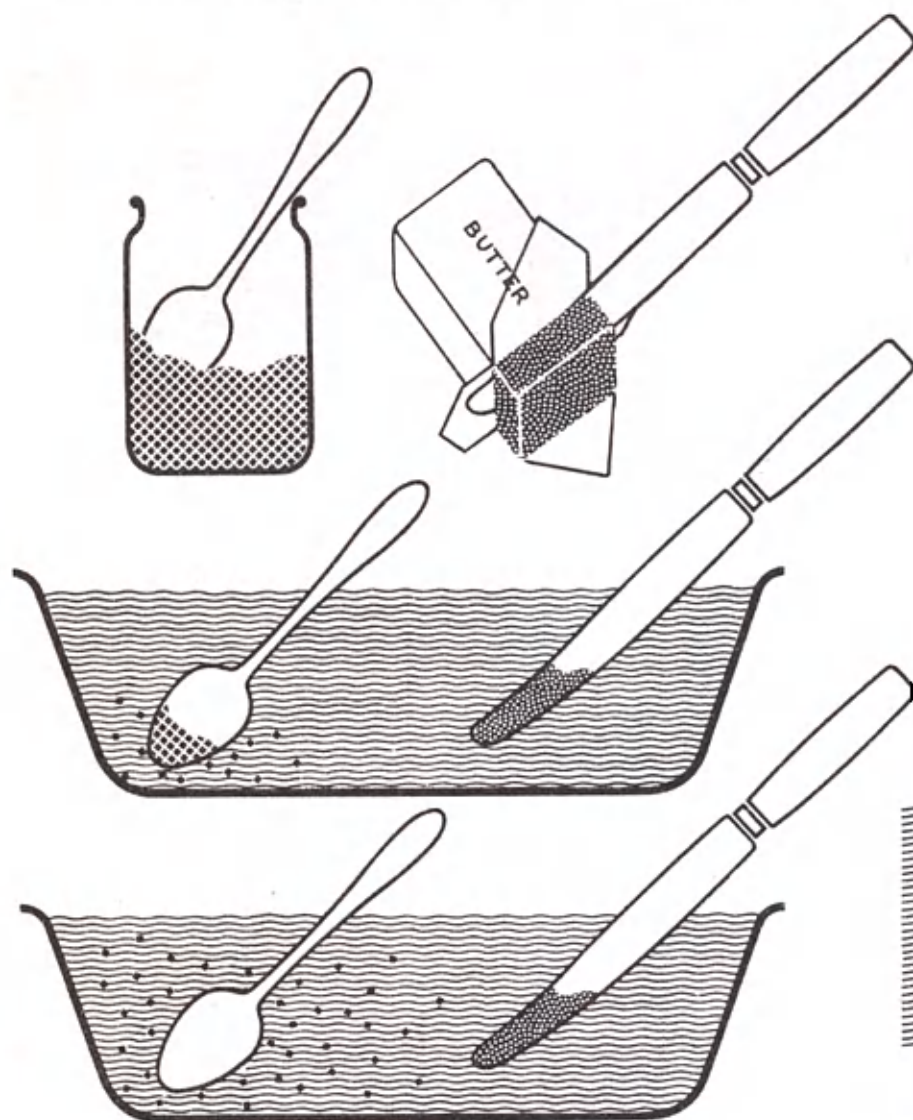


One form of colloid which is often used in the home is table jelly. When the jelly cubes are placed in hot water, separate particles of jelly float about in the water. As the water cools these particles join together to form little cells, each containing some of the water.



When glue is boiled in water and allowed to cool, something very similar happens. But the cells formed by the glue are smaller and much firmer than those formed by the jelly. When glue cools it is hard enough and strong enough to hold two pieces of wood together.

How Soap Cleans when Water Won't



First look at the pictures above.

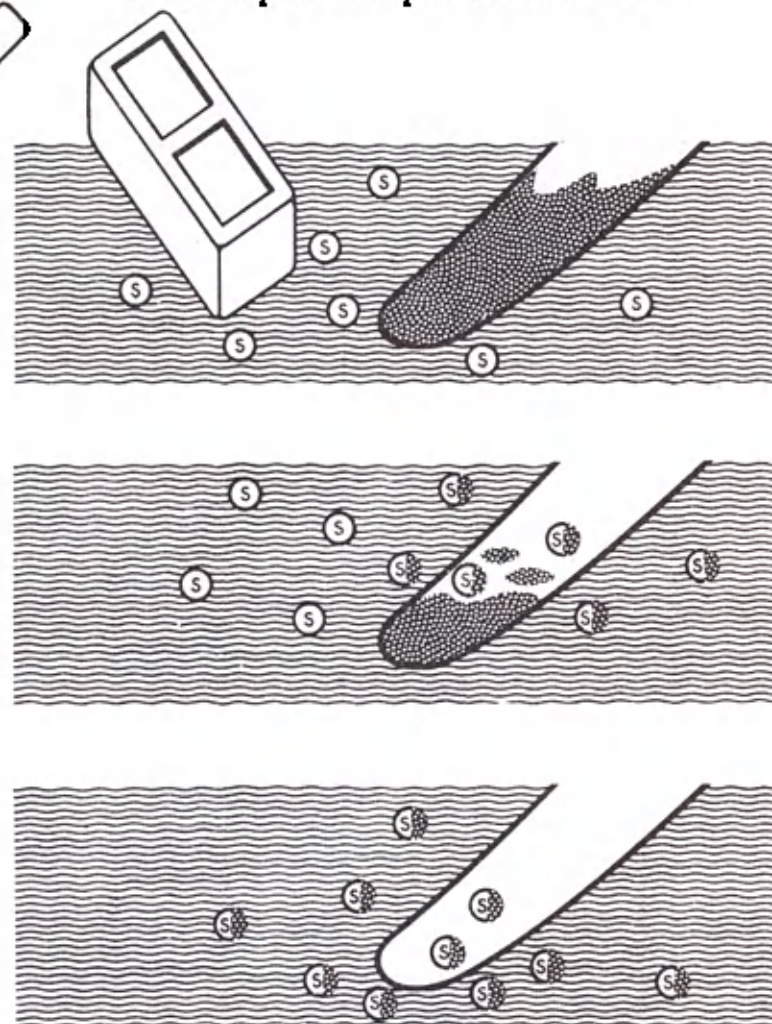
Why do we use soap? Can we not clean things just as well with cold water only?

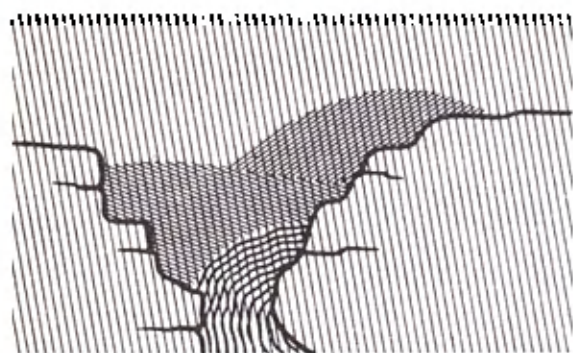
Some things *can* be cleaned with clear cold water, but not all. Take a spoon smeared with treacle and leave it in water. The water gradually dissolves the treacle, and the spoon is left quite clean. Now leave a dirty butter-knife in cold water. The butter still clings to it. Butter will not mix with or dissolve in cold water.

Next look at the pictures below.

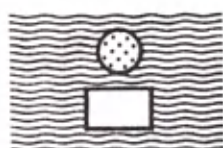
If you add soap to the water the particles of soap will mix with particles of butter and form an emulsion. The emulsion washes off in the water.

There is always a certain amount of oily substance on our bodies to which the dirt clings. Clear water alone will not wash off the oil and dirt. We must use soap to keep ourselves clean.

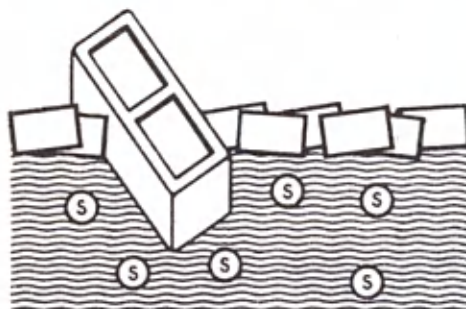
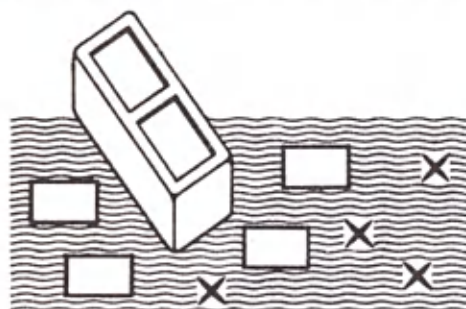
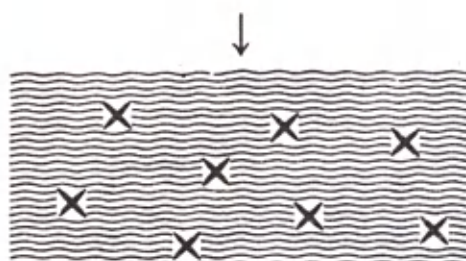




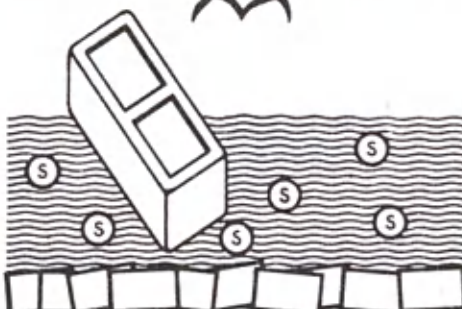
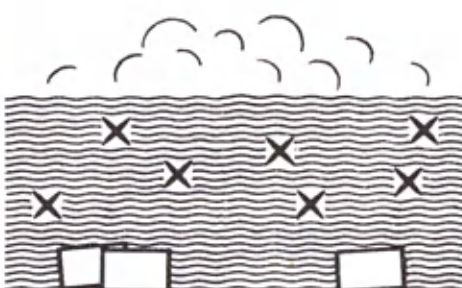
Carbon dioxide from the air dissolves in this stream. It becomes slightly acid and dissolves chalk particles, making the water hard.



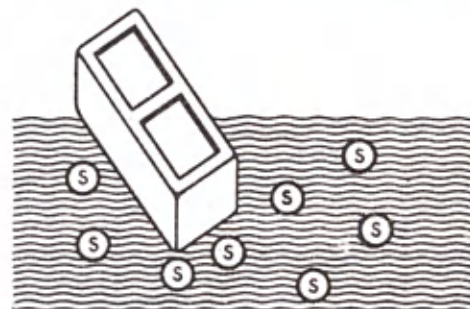
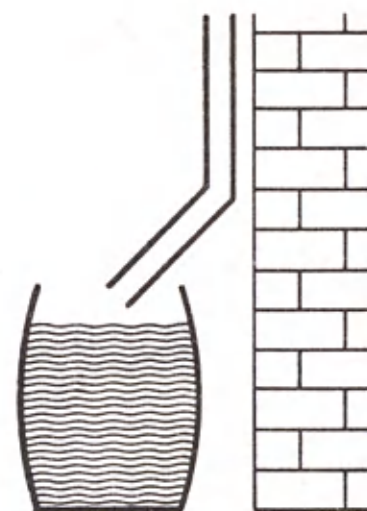
- — carbon dioxide
- — chalk
- × — "hardness" in water



Soap causes a chemical change which throws the dissolved chalk out of solution. It forms a scum on top of the water.

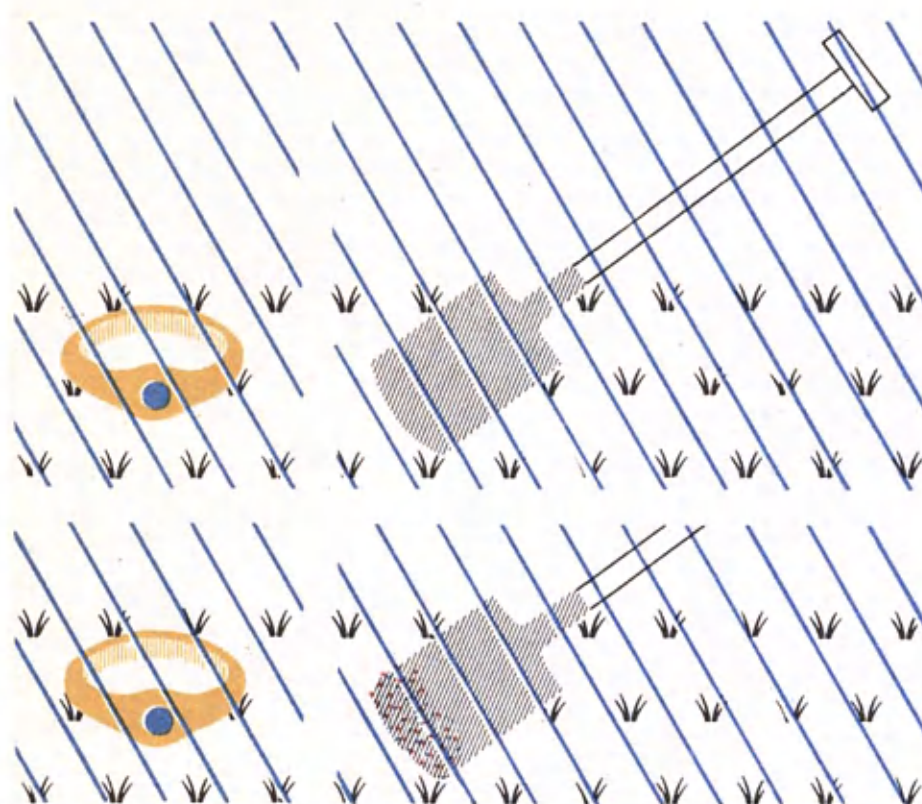


If hard water is boiled the chalk will separate and form a "fur" inside the vessel. The water becomes soft. Soap lathers well in it.



Rain water is always soft. If it is left to stand in a water butt, it may dissolve carbon dioxide from the air, but so long as there is no chalk in it, it does not become hard. Soap does not have the job of softening such water. It can form a lather at once.

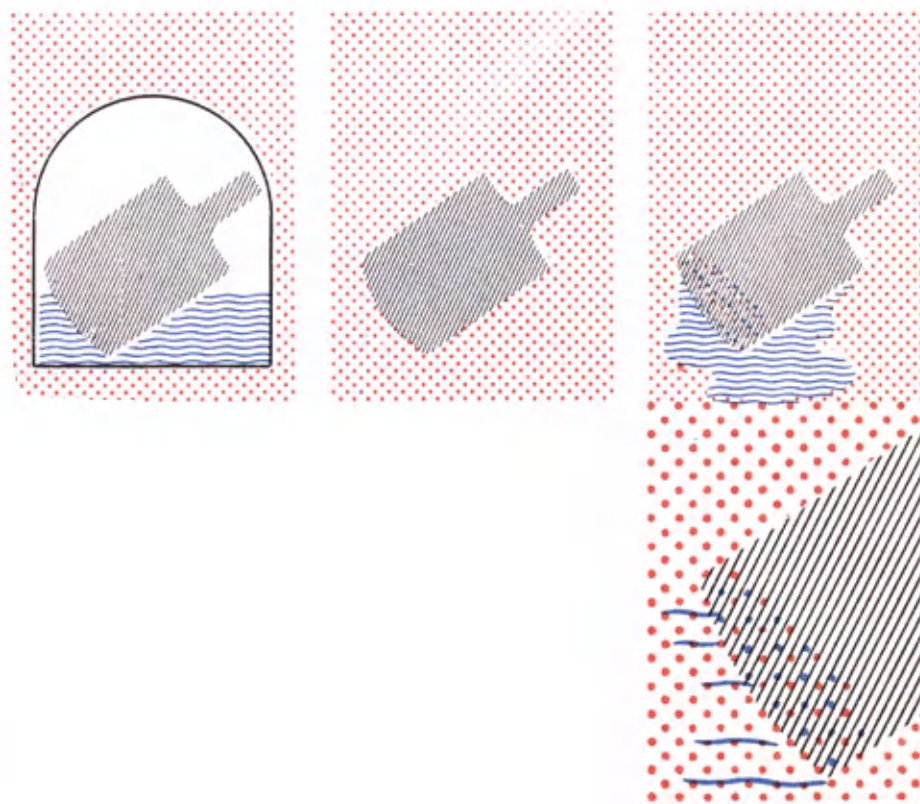
Water and Rust



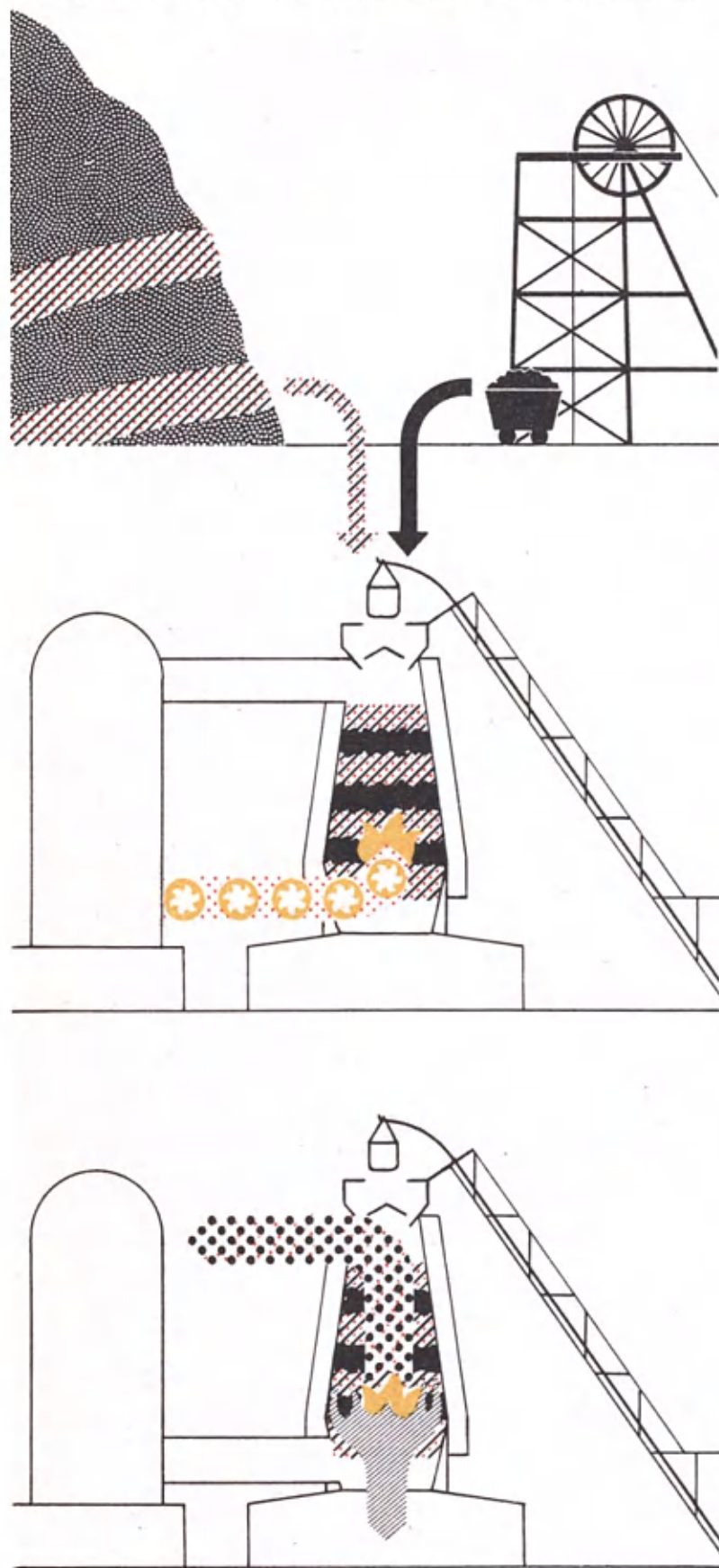
- 1 What metal do you think the ring is made of? What metal do you think the blade of the spade is made of?
- 2 Is the ring clean when the rain first falls on it? Is the spade?
- 3 Does the ring change in any way when it is left out in the rain? Does the spade?
- 4 What colours are used to show rust on the spade? Do you think the water helped to make the spade rusty?

Red dots show air, blue lines water.

- 5 Look at the first picture. Does any water touch the spade? Any air?
- 6 Look at the second picture. Does air touch the spade? Does water?
- 7 Look at the last two pictures. Does air touch the spade? Does water? What happens to the iron?
- 8 Look at the colours of the dots which are used to show rust in the last picture. What two things do you think are necessary before rust can form on iron?



How Iron is Made from its Ore



You do not find iron metal in the earth. You find a rocky mineral called "ore". Most iron ores contain iron chemically joined to oxygen.

To get the iron from the compound oxide, layers of iron ore are placed in a blast furnace with layers of coke. The coke and iron ore are heated strongly in the furnace and the heat causes chemical changes in both of them.

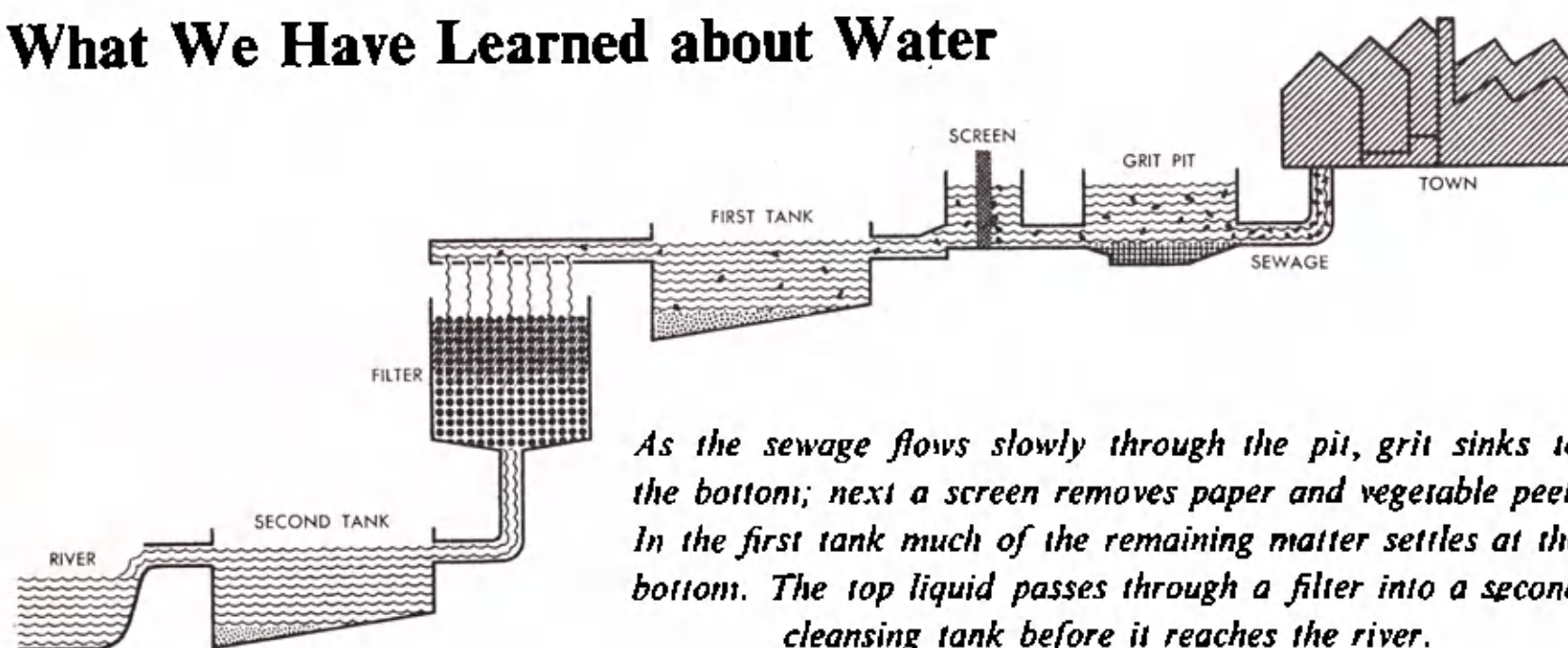
Coke contains a high proportion of carbon, and carbon will very readily join itself to oxygen.

In the blast furnace there is plenty of oxygen—oxygen combined with iron in the iron oxide. As the heat passes up through the furnace the carbon in the coke combines with the oxygen from the iron ore to form a colourless gas called carbon monoxide. When the oxygen is taken away from the iron oxide pure iron remains.



The diagram above shows you what happens. The bottom strip shows iron combined with oxygen. Oxygen is taken away and pure iron remains. The top strip shows carbon. Oxygen combines with carbon and produces carbon monoxide.

What We Have Learned about Water



1. If we live in a town, the water we use for washing and drinking has probably had to soak through the soil and flow along the bed of some stream or river. It has gathered dirt and impurities which must be removed before it comes to our homes. This is usually done by making the water pass through filter-beds at the water-works. It is sometimes also necessary to add chemicals to the water to help purify it.

If a town lies near the source of a stream or river, its water will collect fewer impurities. There will be less need to take so much trouble to get it clean.

When waste water leaves our homes some of it may once more soak through the earth and find its way into a river. Therefore water is cleaned not only before it reaches our homes, but also after it leaves them.

2. No matter how many twists and bends and joints in the pipes, the water in our homes will not rise higher than the level of water in the

reservoir it comes from. Therefore the water level in the reservoir must be higher than the highest water tank in the houses it supplies.

In the water-pipes in our homes, the water is always pushing up towards the same level as the water in the reservoir. If we allowed it to reach that level, the water-storage tanks would overflow.

To prevent this, we make use of the power of water to support weight. When the tank is almost full, the water lifts a ball. This ball moves a lever which closes the inlet water-pipe.

3. Different things mix with water in different ways. Chalk (or sand or sawdust) can be *held in suspension* in water. The solid particles can be separated from the water by filtering.

In milk (or in broth) globules of fat mix with water to form an *emulsion*. The globules cannot be separated by filtering; since they are soft they usually squeeze through the pores of the filter.

Table jelly, and glue form *colloids* when mixed with water. Particles form themselves into small cells, each containing a little water.

4. Greasy things cannot be cleaned properly in clear cold water. If we use soap, particles of soap mix with particles of grease to form an emulsion in the water. Because there is always a certain amount of oily substance on our skins, we must use soap as well as water to keep our bodies clean.

Carbon dioxide from the air dissolves in water and makes it slightly acid. It then dissolves particles of chalk which make it hard. Before soap can form a lather in hard water it must

first cause chemical changes which produce a chalky scum on the surface of the water.

5. Neither air alone nor water alone will cause rust to form on iron. Both air and water must be present. In nature both air and water usually *are* present. Unless iron is protected it combines with oxygen and water to form rust.

Iron ore usually contains iron oxide, a compound of iron and oxygen. In the blast furnace, layers of ore and layers of coke are strongly heated. The carbon in the coke takes the oxygen from the iron oxide and combines with it to form carbon monoxide gas. Pure iron remains in the furnace.

THINGS TO DO

1. Put some washing soda crystals in an old iron spoon. Heat slowly over a gas flame. Describe carefully what happens and try to explain it. Take the white powder which remains and dissolve it in a little water; pour into a saucer and leave for a few days.

Repeat this experiment with some crystals of blue copper sulphate, which you can get from a chemist if you show him a note from your teacher. (Remember that copper sulphate is poisonous.)

2. Place a heavy stone in a bucketful of water. Lift the stone from the bottom of the bucket right out of the water. What do you notice about its weight when it leaves the water?

3. Take a U-shaped glass tube, and half fill it with water. What do you notice about the level of water in each arm of the tube? Now insert a

funnel into one side of the tube, and try to fill the funnel to the brim. What happens?

4. Many houses in the country collect rain water in a water butt. This water is used for washing but not usually for drinking. Try to explain this.

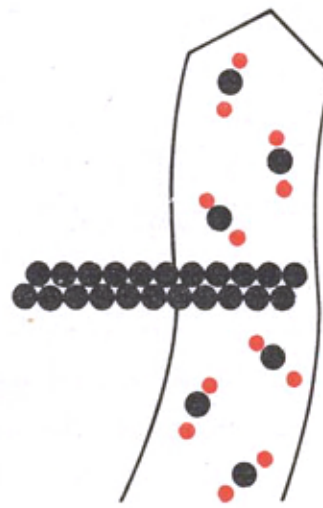
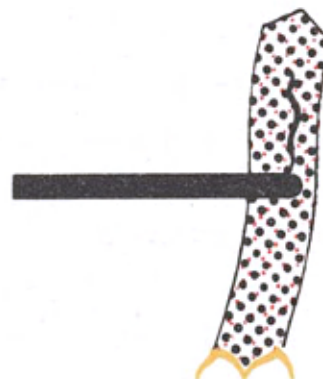
5. Sea water cannot be used either for washing or for drinking because of the amount of salt dissolved in it. How can pure water be obtained from sea water?

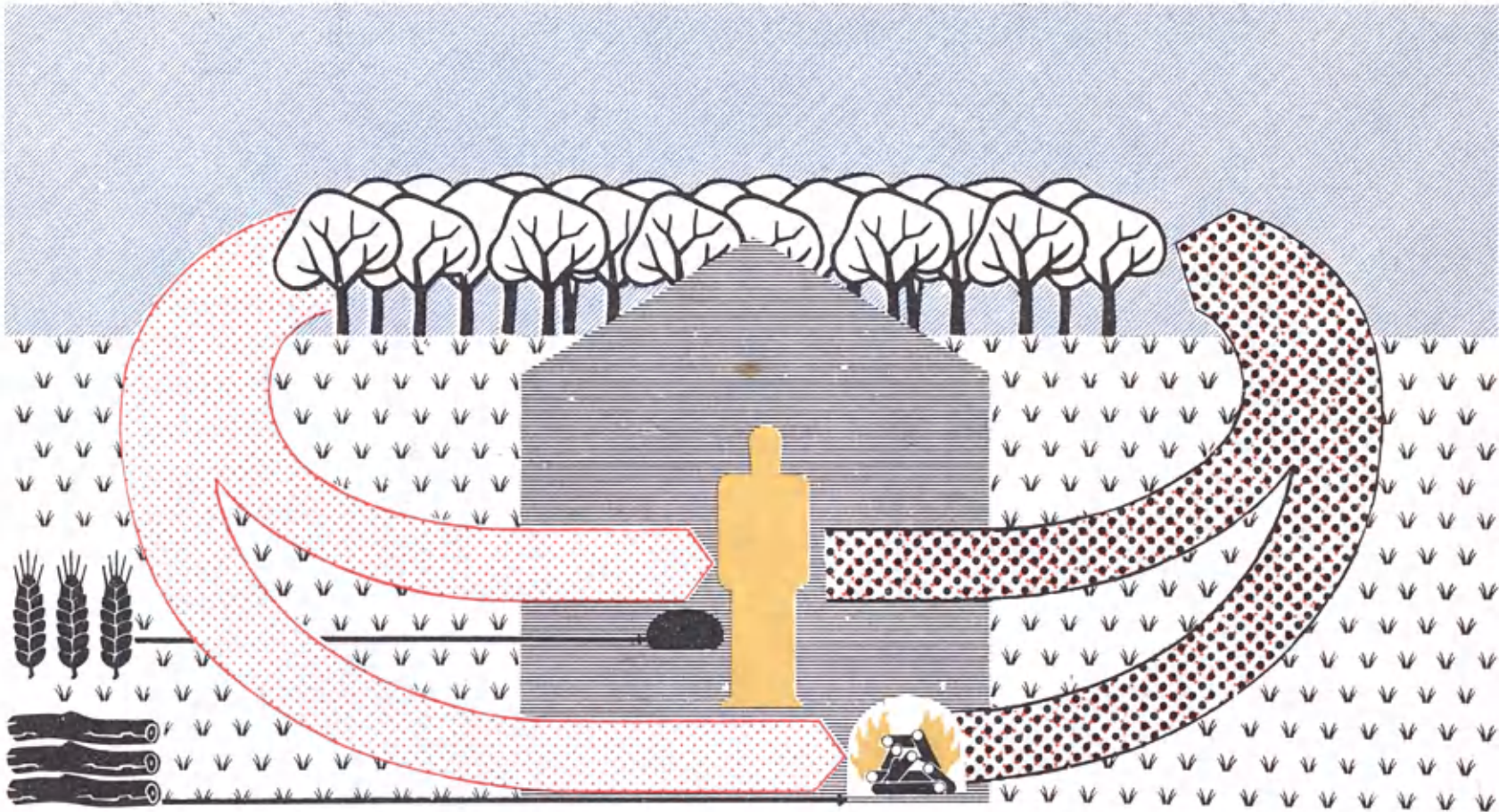
6. Get a bottle of some fluid used for cleaning greasy clothes. Invent a way of finding out whether it will dissolve rust, butter, margarine, mutton fat, ink, the green colouring matter of plants. Try out your method. Now explain what kinds of stain could be removed from clothes by using this fluid.

A Fire Burns, a Man Breathes



The stick of carbon burns in the open air. Hold it above a fire and it goes out. Why? To burn, the carbon must be able to get oxygen from the air and combine with it to form an invisible gas called carbon dioxide. The air above the fire contains a large amount of carbon dioxide from the burning coal, and only a little oxygen. Without enough oxygen the carbon cannot burn.





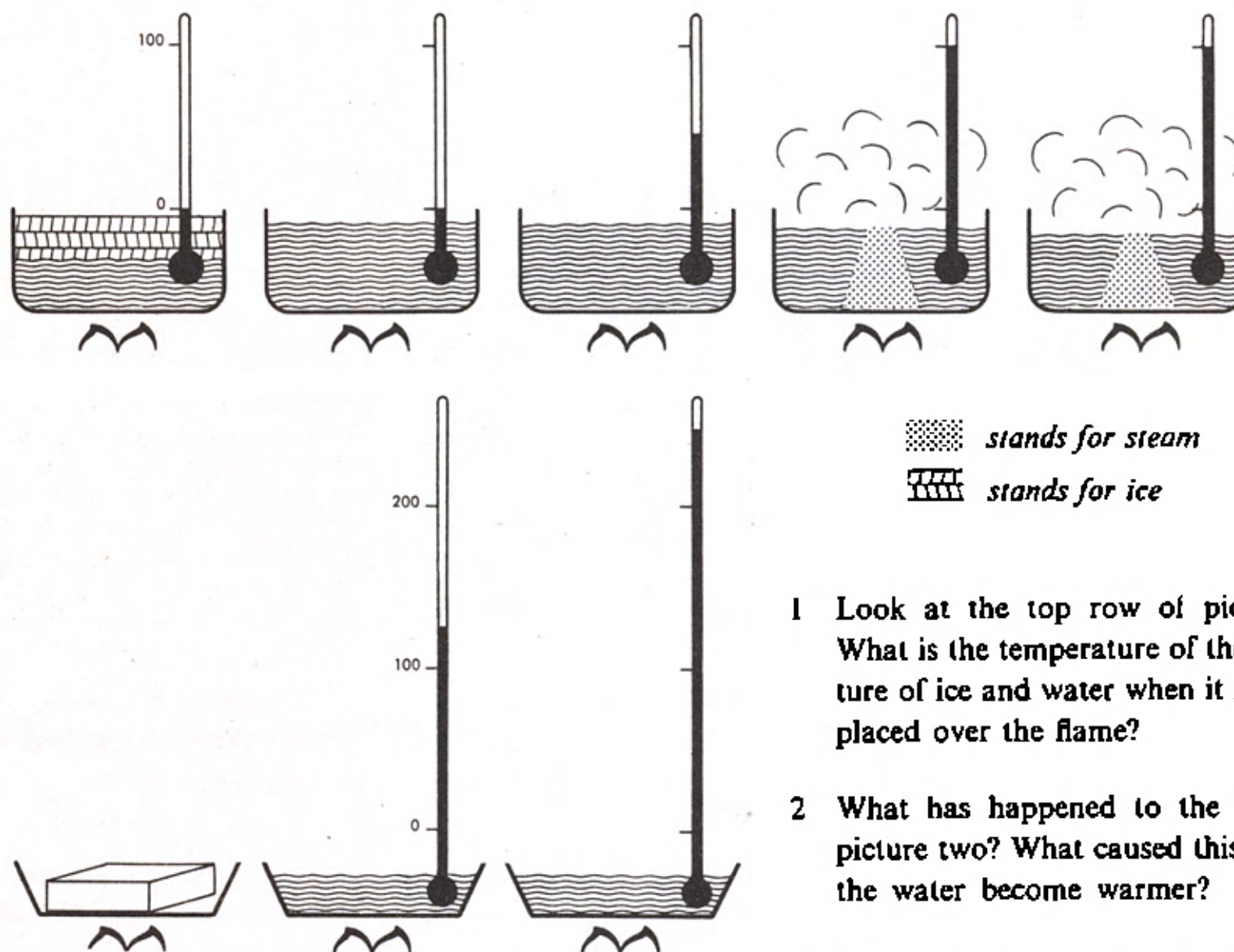
- 1 Do the logs contain carbon? What is taken from the air as the fire burns?
- 2 What gas is produced as the fire burns? Where does it go to?
- 3 Does the wheat contain carbon? Does the loaf of bread?
- 4 In our bodies carbon combines with oxygen and produces carbon dioxide. Where do our bodies get this oxygen? How does it enter our bodies?
- 5 What would happen to the supply of free oxygen in the air if nature produced no more? What would happen to the supply of carbon dioxide?

- 6 If there were no free oxygen left in the air, would fires still burn? What would happen to human beings and animals?

Every time a fire burns, every time an animal or a human being breathes, free oxygen is taken from the air and carbon dioxide added to the air. But all the time plants are taking in carbon dioxide and giving out free oxygen.

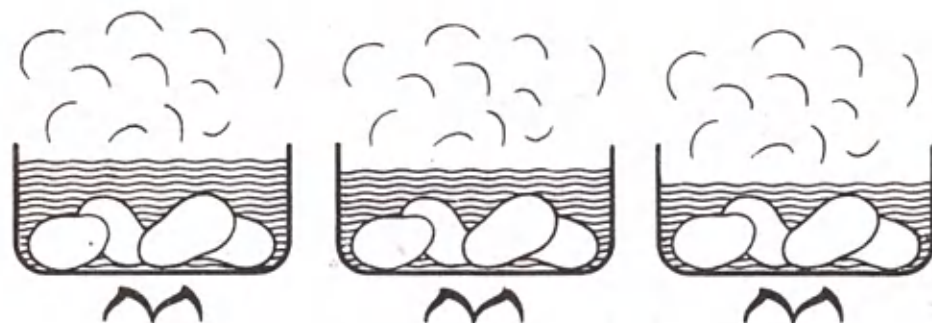
Plants cannot get the carbon they need from the soil. Instead, every green leaf absorbs carbon dioxide from the air. During daylight carbon dioxide acts with water inside the leaf to produce starch and free oxygen. The starch contains carbon in a form which the plant can use, and the oxygen returns to the air.

Cooking in Water and Cooking in Fat



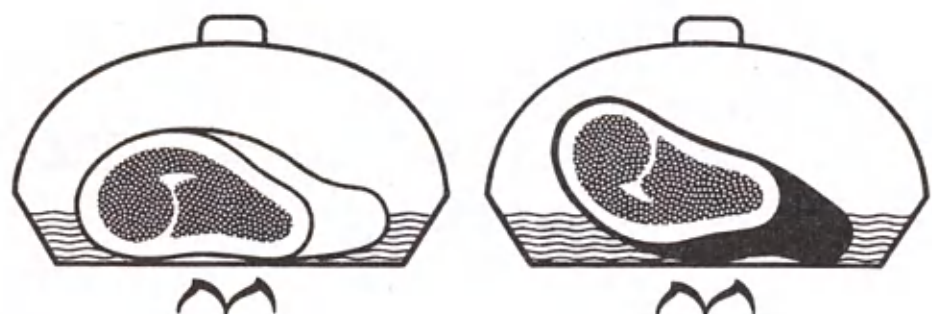
- 6 The second row of pictures shows fat instead of water. Which reaches a temperature of 100° more quickly, the fat or the water? Which do you think needs less heat to melt it, solid fat or ice?
- 7 Will the temperature of water rise above 100° if it is heated for a long time? Will the temperature of fat?

- 1 Look at the top row of pictures. What is the temperature of the mixture of ice and water when it is first placed over the flame?
- 2 What has happened to the ice in picture two? What caused this? Has the water become warmer?
- 3 Is the water warmer in picture three? Has any other change taken place?
- 4 Is the water hotter still in picture four? What other change is taking place?
- 5 The water is still being heated in picture five. Does its temperature go on rising? What happens instead?

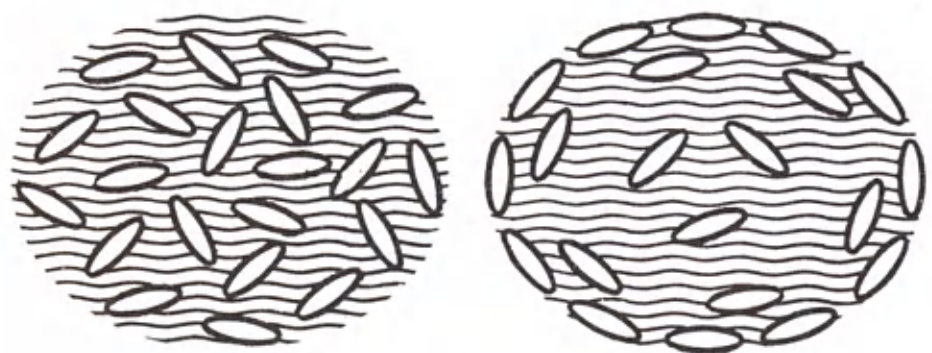


When potatoes are boiled, changes take place in them which we cannot see. A raw potato contains many particles of starch which are valuable as food. But it also contains a hard substance called cellulose which makes the potato difficult to digest.

These three pictures show what happens when the potatoes boil. At first each particle of starch is completely surrounded by a thin, hard shell of cellulose. After a time the shell softens and breaks. As boiling goes on, the starch particles break up into smaller pieces which can easily be digested.



When meat is cooked in fat we can see the changes which take place. A thin crust forms around it. This crust keeps the juice and flavour inside the meat. (Do you think this will happen if we put it in cold water and then boil it?)



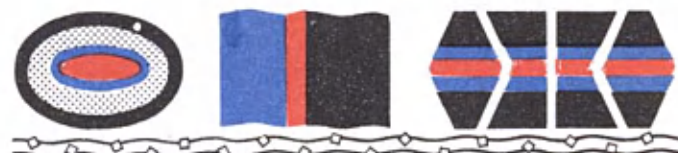
Part of the meat which is valuable as food is a substance called "protein". When meat is roasted, some of the protein particles join together to form the crust. Our bodies can digest the protein in *raw* meat, but cooking makes meat tender by breaking down stringy parts. It also destroys many impurities.

The Food We Eat



The row of drawings at the top of this column shows some of our main sources of food. The next row shows what some of our food is made of. Solid black stands for carbon, red for oxygen, blue for hydrogen. (Pure hydrogen is an invisible gas. When combined with oxygen it forms water.)

The first drawing shows protein from animal foods, the second fat, and the third starch from vegetable foods. Each contains carbon, oxygen and hydrogen in different proportions; the protein also contains a substance called nitrogen. The shaded patch shows salts.

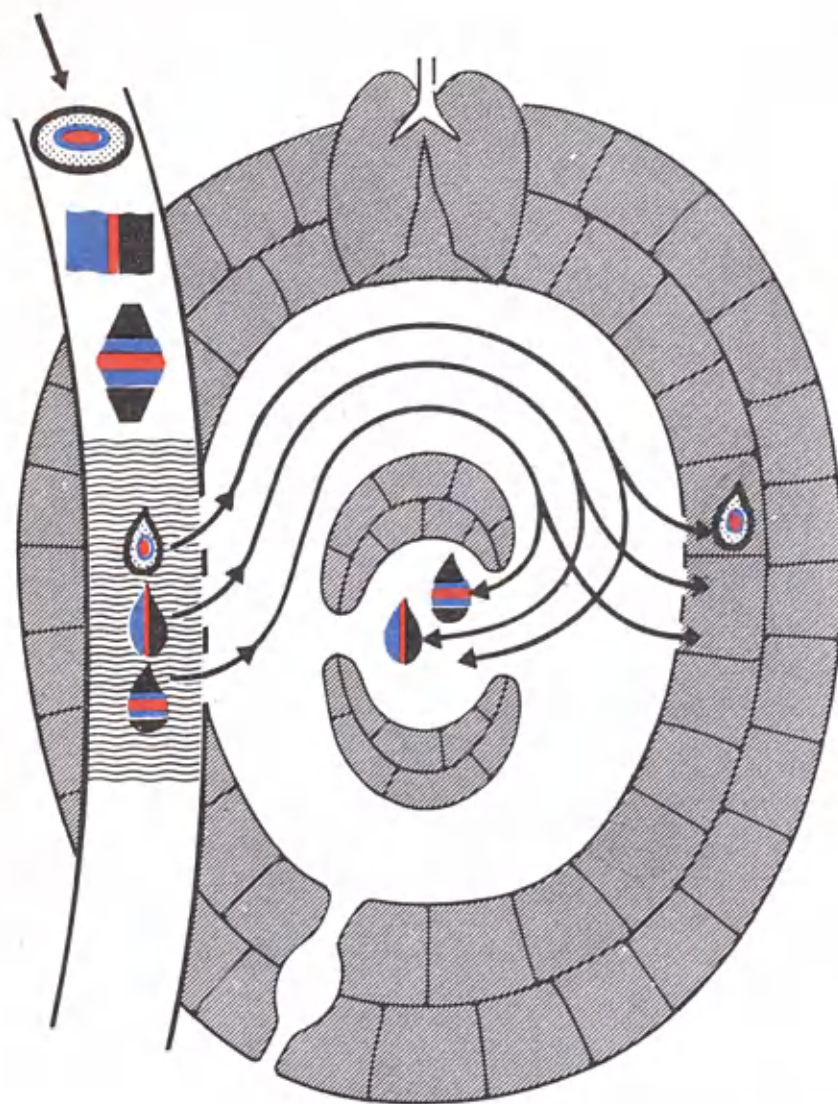


Protein particles are not changed much by cooking, but they join together in new ways. Protein helps to make an egg hard when it is boiled, and to form a crust round roasting meat.

Fat, which is hard to digest when it is raw and solid, changes to liquid when it is cooked and forms an emulsion with other liquids. The emulsion is easier to digest. Starch particles are broken up by cooking into smaller pieces, but each piece still contains carbon, oxygen and hydrogen.

In cooking, the salts in our food mix with water to form a solution.



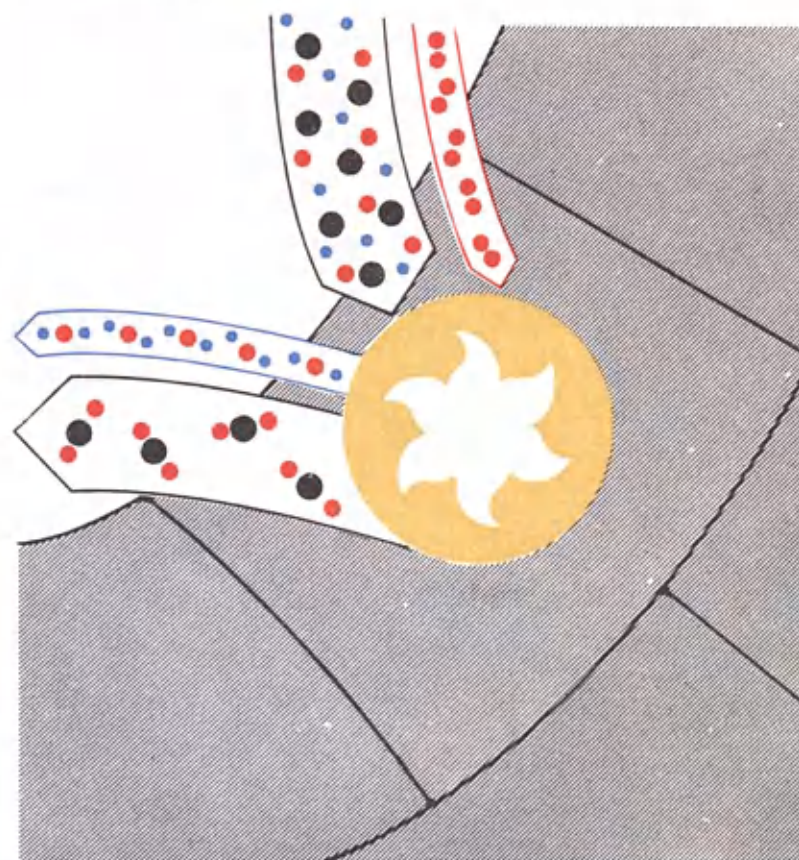


When we sit still we need little energy. We breathe rather slowly and the chemical changes in our body cells take place rather slowly. When we walk fast or run about we need more energy. We breathe faster and the chemical changes in our body cells go on faster. More warmth and energy is produced.

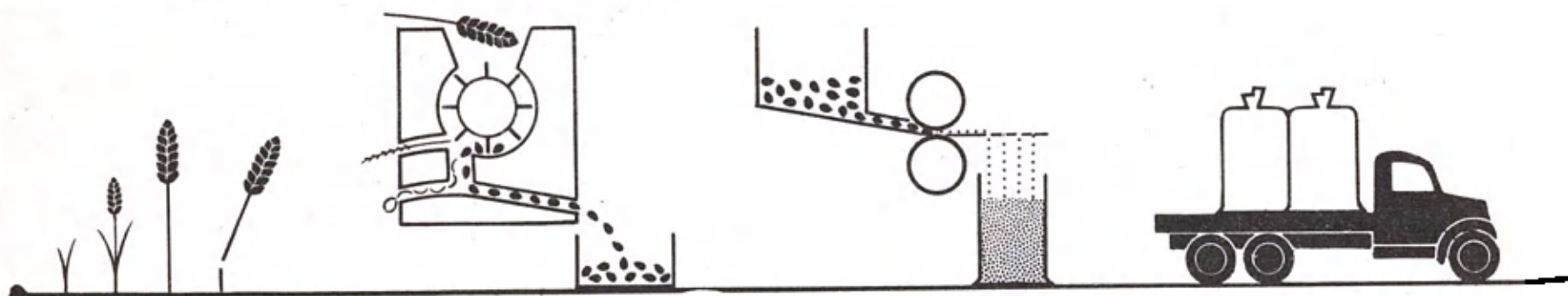
In our insides, food is acted upon and dissolves in digestive juices. The solution passes through the walls of the intestine to other parts of the body. Protein goes mainly direct to the cells of our bodies, where it helps to build and repair tissues. Fat and starch go partly to the liver to be stored, partly direct to body cells.

The food which enters the cells contains carbon, hydrogen and oxygen. Free oxygen from the air we breathe also enters the cells. It combines with the carbon to form carbon dioxide. Hydrogen and oxygen remain and combine to form water.

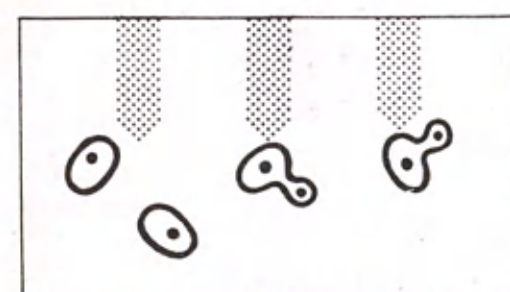
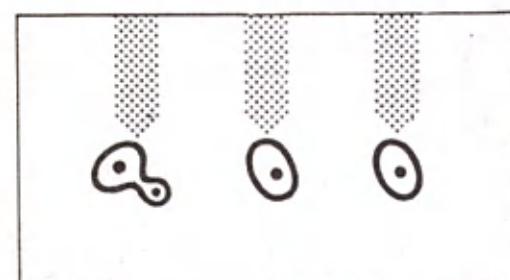
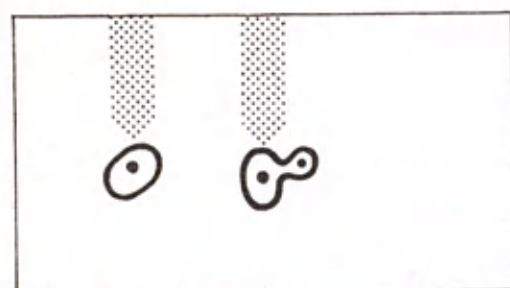
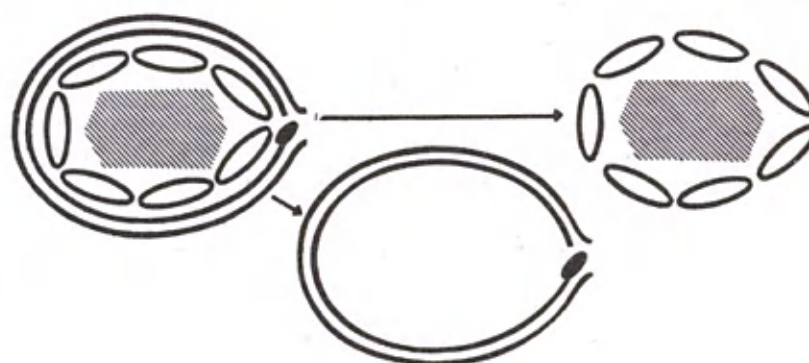
When carbon combines with oxygen in the air it produces fire and warmth. In the same way, the chemical changes which take place in our body cells provide our bodies with warmth and energy.



The Story of a Loaf of Bread



The pictures below show how yeast grows. Every ounce of yeast is made up of millions of tiny living cells. When oxygen and food are present, each cell quickly bulges out to form a "bud". The bud rapidly grows, breaks off from the old cell and forms a separate new one.

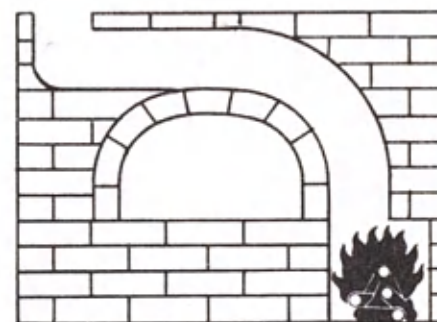
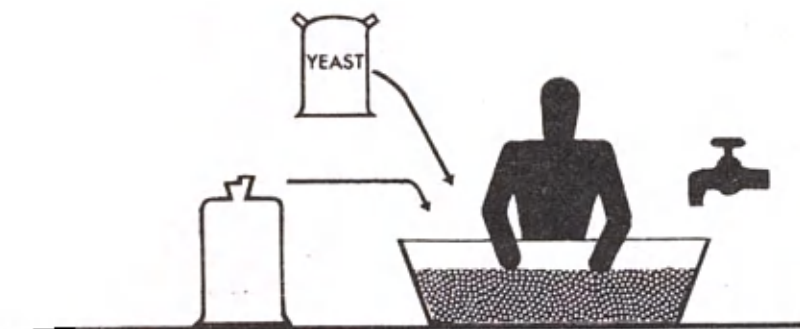


The pictures above the line show how bread is made. First the stalks and husks of the wheat are separated from the kernels; then the kernels are ground into flour. The flour goes to the bakery where it is mixed with yeast and water to make dough. The dough is left to "work" for a time to allow it to rise. Then it is shaped into loaves and baked.

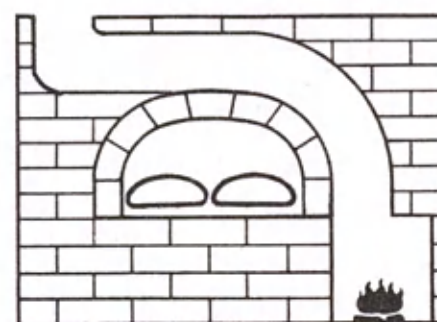
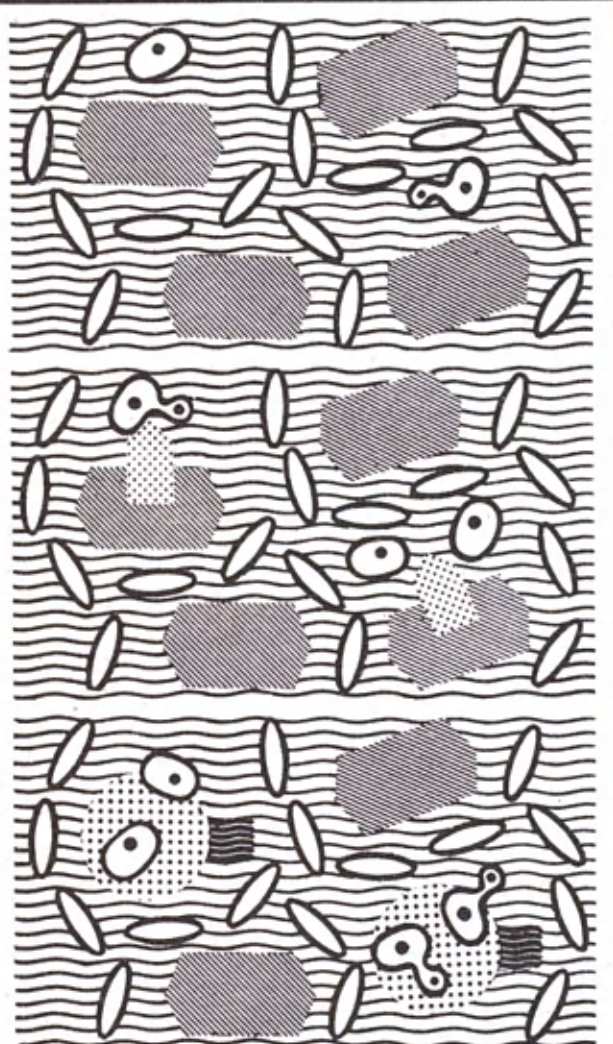
Now look at the pictures below the line. When the husk is removed from the wheat, the kernel that remains contains starch and protein.

Dough, then, contains protein, starch, yeast and water. The protein forms a colloid which makes the dough stodgy and "heavy". To enable them to grow, the yeast cells take oxygen from some of the particles of starch. This causes chemical changes which produce carbon dioxide and alcohol. The carbon dioxide makes the dough rise.

In the oven, heat kills the yeast cells and so stops the chemical changes. The carbon dioxide makes the bread light; the alcohol evaporates; the protein helps to form the crust.

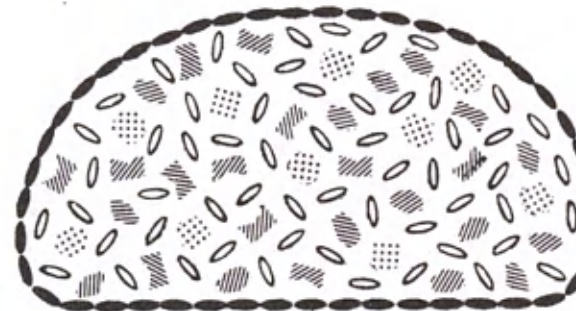


The baker's oven must be hot before the dough goes into it.

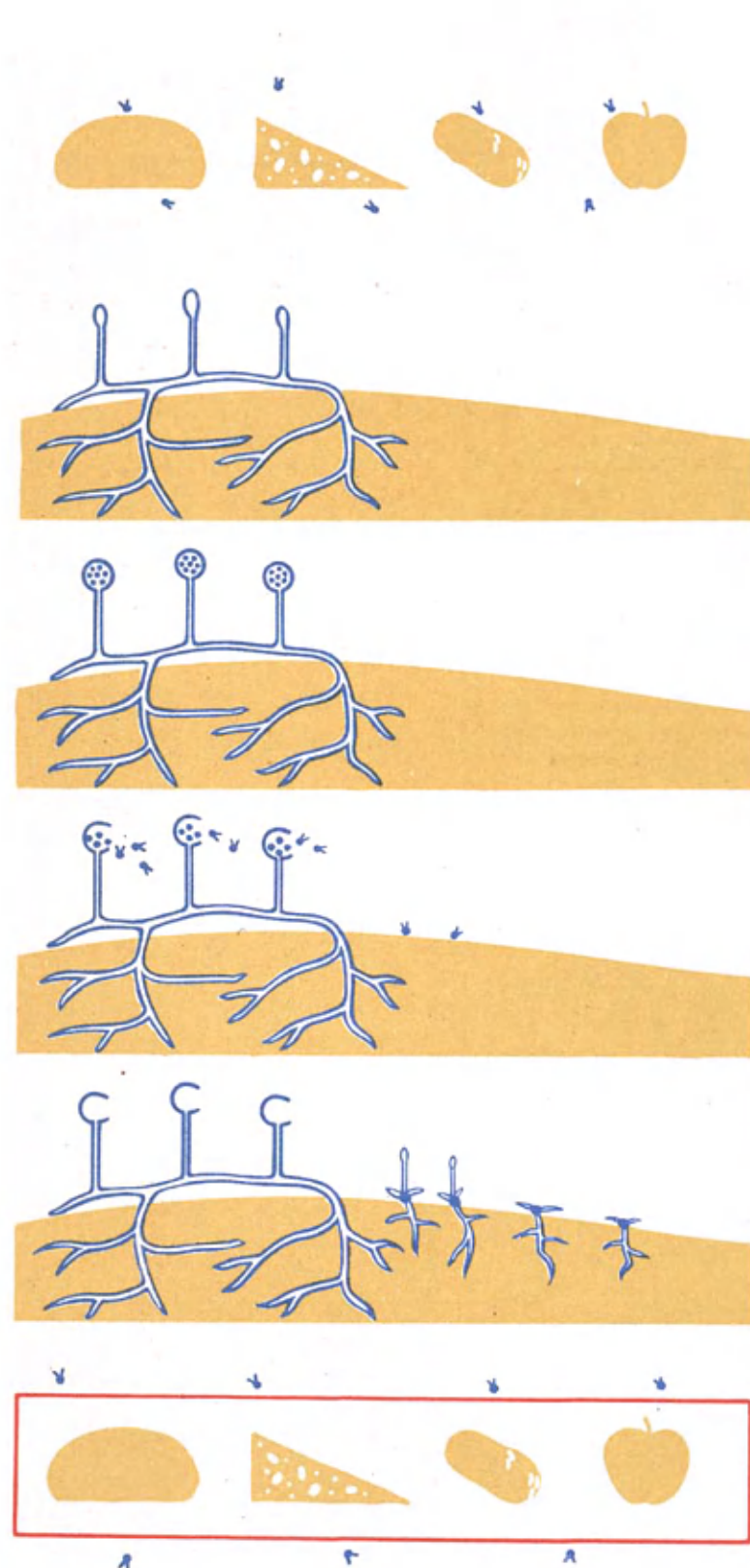


When the bread is baking the heat must not be too fierce.

-  — protein
-  — starch
-  — oxygen
-  — carbon dioxide
-  — alcohol

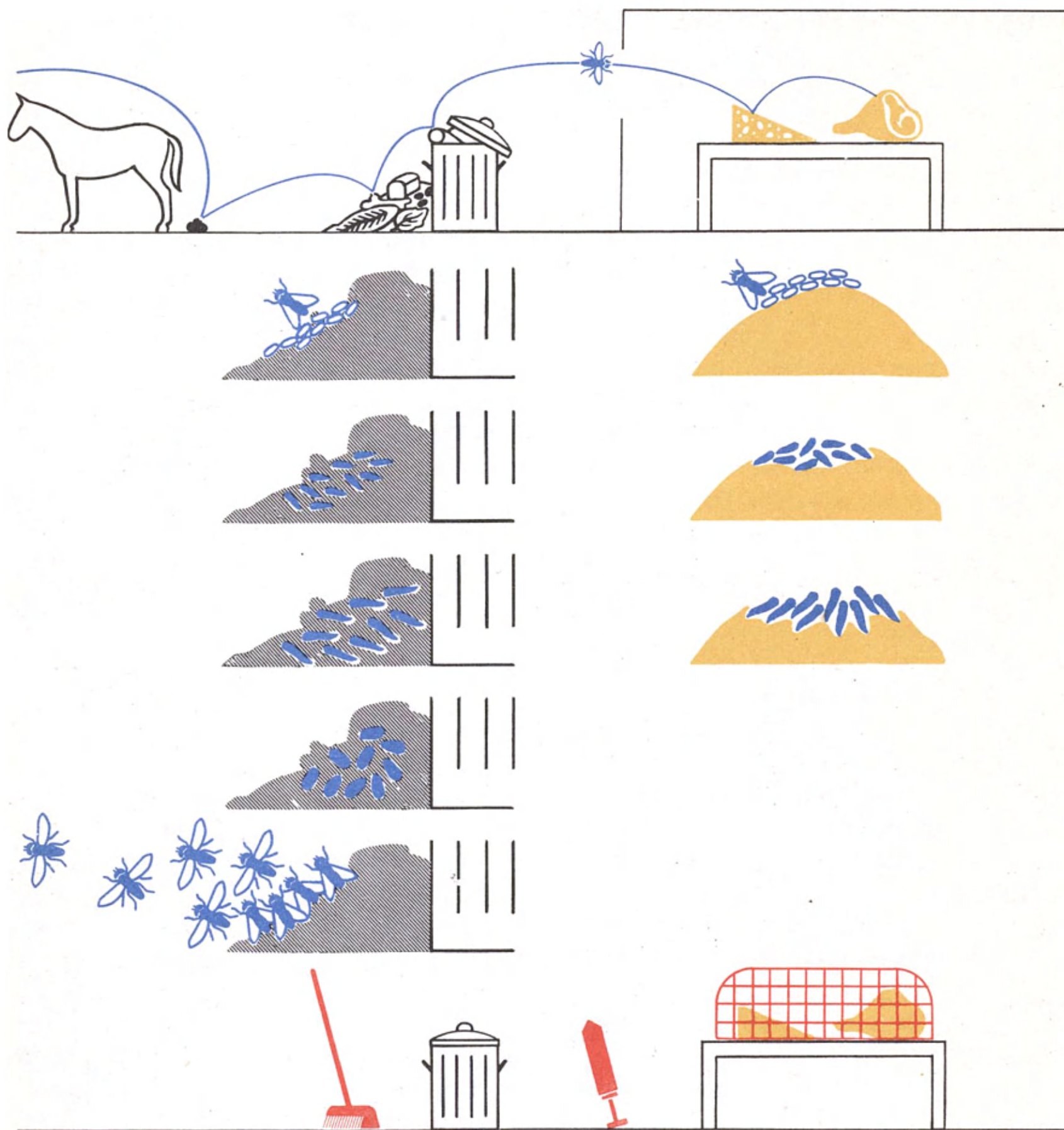


Why We Must Protect Food



In the four centre pictures on the left, pin-mould is growing on moist food.

- 1 Look at the first of these four pictures. What do you notice about the threads of mould in the air?
- 2 What change has taken place in the second picture? What do you think the blue dots stand for?
- 3 What happens when the seed-pods break? Does the amount of mould on the food increase?
- 4 In the top picture you see these seeds falling on food. Look at the bottom picture and say how we can prevent this.
- 5 Look at the pictures on the right. Name some of the things flies may visit before they alight on food.
- 6 What creatures hatch from the eggs the fly lays in the garbage? When the maggots have gone through all stages of growth, what do they turn into?
- 7 Do flies also lay eggs on food? Do maggots hatch out?
- 8 How can we stop flies laying eggs around dustbins? On food? Name a modern way of killing flies.



What We Have Learned about Food

1. Nearly all fuels and all foodstuffs contain carbon. In fires and in the cells of our bodies carbon combines with oxygen from the air and produces carbon dioxide. Every day burning and breathing take more and more oxygen from the air and put more and more carbon dioxide into it. If all the free oxygen in the air were used up, no fire could burn and no animal or human being could live.

The oxygen in the air is replaced by growing green leaves. During daylight, carbon dioxide taken from the air acts with water inside the leaf and produces starch and oxygen. The starch feeds the plant and the oxygen goes into the air.

2. Fat gets hot more quickly than water, and reaches a much higher temperature before it boils. When meat is cooked in fat the protein particles help to form a crust round it which keeps in the juice and flavour.

Many vegetables contain particles of starch surrounded by tiny hard walls of cellulose. Boiling first breaks the cellulose walls and then splits the starch into smaller pieces and changes some of it chemically. This makes the vegetables easier to digest.

3. The fats, starch and protein in our food all contain carbon, hydrogen and oxygen combined with one another. Protein particles are not changed very much by cooking. We can digest them quite well uncooked.

Cooking makes fat easier to digest by changing it into liquid which forms an emulsion with

other liquids; it also makes particles of starch smaller and easier to digest.

Here is a little sum which reminds you what happens when free oxygen from the air we breathe acts on the food particles in the cells of our body:

(carbon + hydrogen + oxygen) + oxygen
makes (carbon + oxygen) + (hydrogen + oxygen)
This chemical change produces the warmth and energy our bodies need.

4. The dough from which our bread is made contains protein and starch from ground wheat-kernels, plus yeast and water.

The yeast cells take oxygen from some of the starch particles to enable them to grow and multiply. This causes chemical changes which produce carbon dioxide and alcohol. Baking kills the yeast cells and so stops the chemical changes. The alcohol evaporates; the carbon dioxide bubbles make the bread light; the protein helps to form the crust.

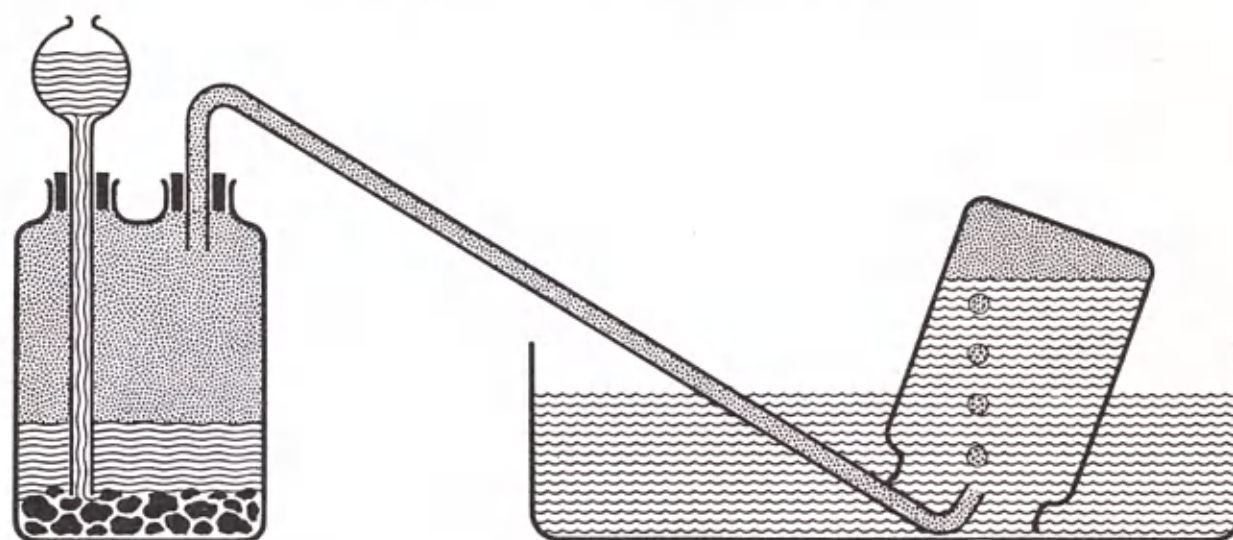
5. On certain moist foods pin-mould grows and produces pods full of tiny seeds called spores. When the pods break the spores may float quite a long way in the air, fall on other food and begin to grow there. We can protect moist food from these airborne spores by keeping it covered.

Houseflies visit all kinds of filthy places. They may be carrying disease germs when they alight on our food.

Flies lay eggs in heaps of garbage and some-

times in meat. Maggots from the eggs turn first into chrysalises then into flies. Meat can be protected from flies by keeping it in a

meat safe or under a wire-gauze cover. We can help to stop the number of flies from increasing by keeping all rubbish in a closed dustbin.



THINGS TO DO

1. Mix a little starch into a paste with cold water and pour the paste slowly into a cupful of boiling water. Allow to cool. Pour into this *one* drop of iodine solution. Note what happens. This test allows you to find out whether or not various foods contain starch: i.e. add a spot of iodine and see whether you get a colour change and what kind of change.

2. Test for the presence of starch in (1) bread (spot with iodine solution); (2) potato (boil in water first); (3) roots of carrot and turnip.

3. Leave a piece of moist bread in a saucer for a while. At the same time, leave another piece on which you have sprinkled a little bleaching powder. Also leave a piece of moist bread under a saucer. At the end of a week, compare the three pieces and explain what has happened in each case.

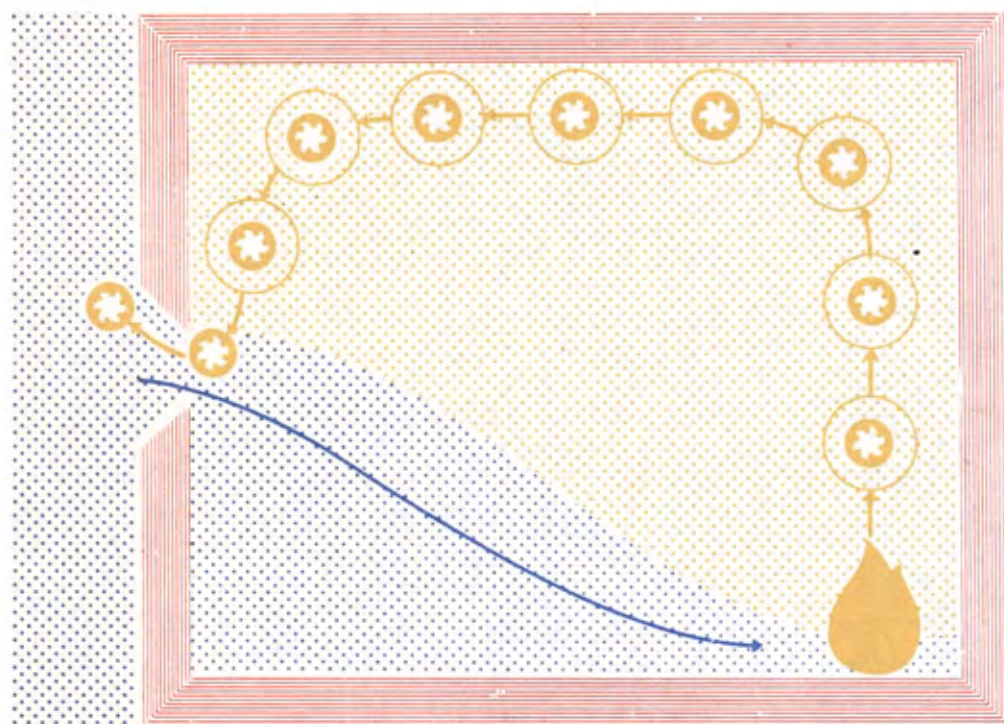
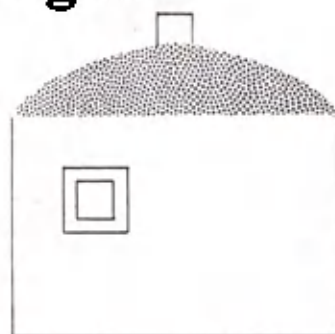
4. Put a few lumps of chalk in a two-necked jar, fitted with a thistle funnel in one neck and a length of glass tubing in the other, placing the lower end of the glass tubing under water, as shown in the diagram. Fill a jam jar with water and hold its neck under water, just above the tubing. Now pour a little dilute hydrochloric acid down the funnel. The acid acts on the chalk and produces carbon dioxide which bubbles into the jar. When the jam jar is full of carbon dioxide, place a lighted taper at its mouth. What happens? Why is this?

5. Fill a second jar with carbon dioxide; without letting any gas escape, place a few green leaves in it and stopper it up firmly. Leave it in bright light for a few hours, then place a lighted taper at its mouth. Does the taper go out? Explain what happened in the jar.

Windows, Warmth and Light

HOUSE WITHOUT GLASS

In all the pictures on these two pages yellow stands for warm air, blue for cold air, black shading for shadow; stands for heat.

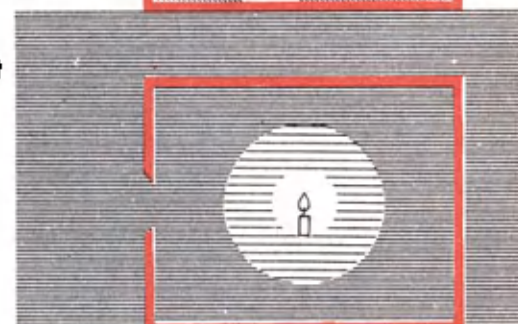


Many years ago houses had no glass in the windows. This picture shows how such a house was warmed on a winter day.

day



night



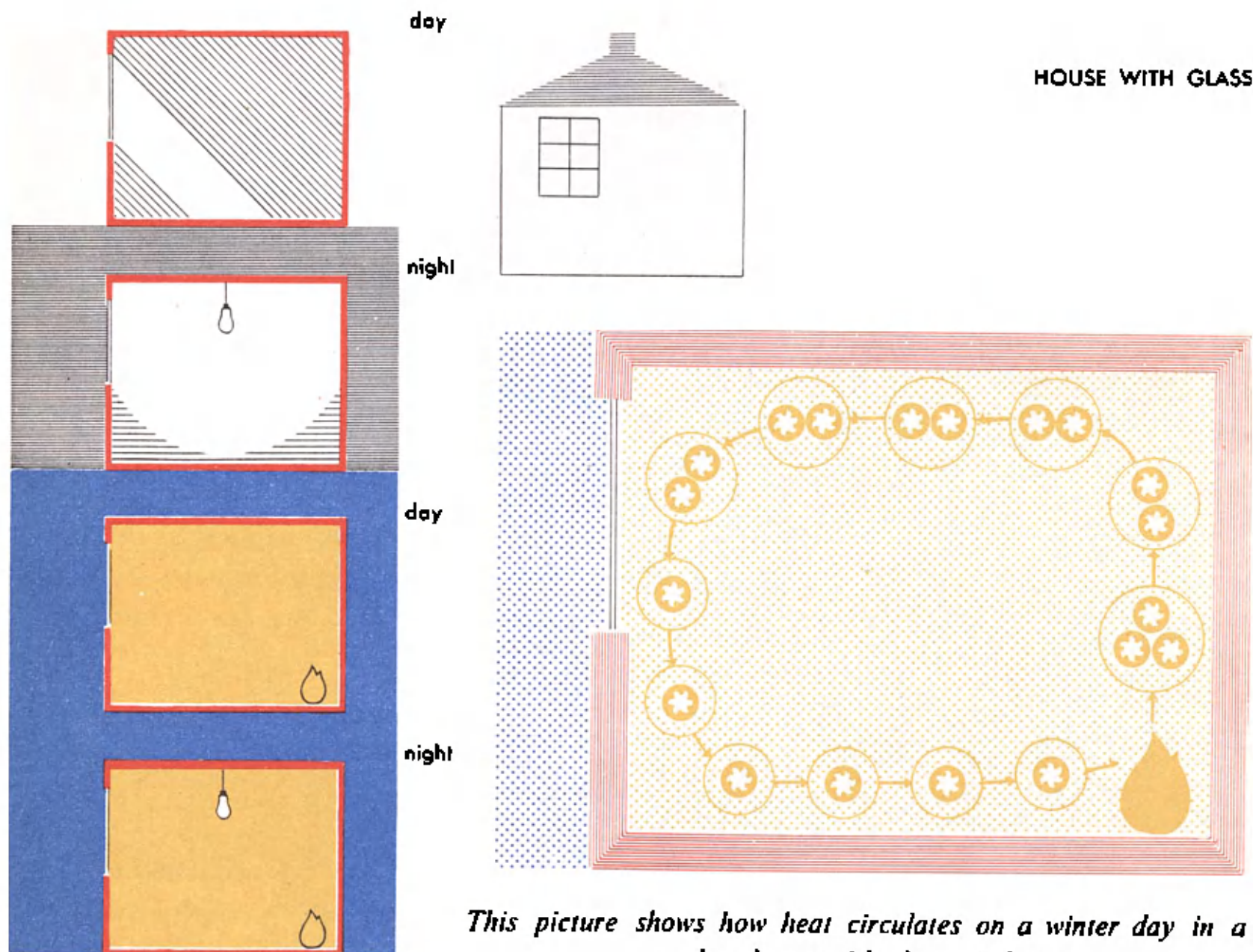
day



night

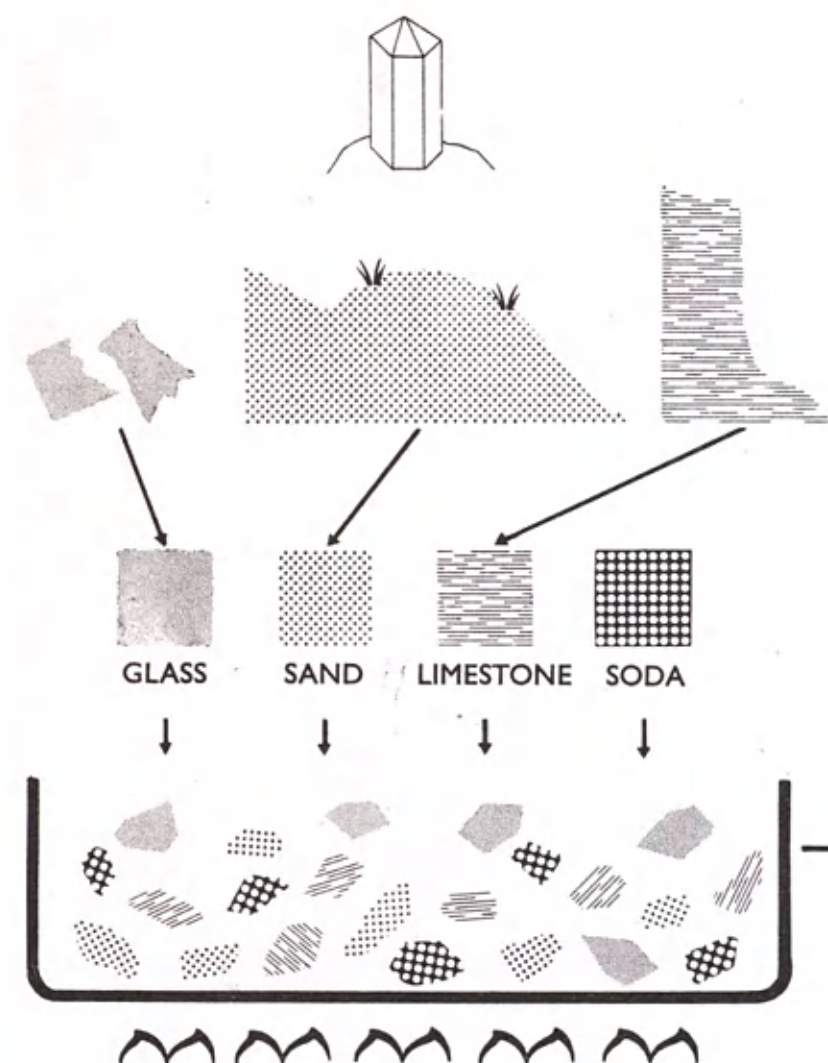


- 1 Look at the two columns of small pictures. Which has the larger window, the house with glass or the house without?
- 2 Which is colder by day? Why is this? Why is its window small?
- 3 Which house gets more direct light during the daytime?
- 4 In which house are the shadows darker? What do you think is the reason?
- 5 How was the old house lighted at night? How is the modern one lighted?
- 6 Why were shutters placed over the window of the old house on a cold night? Why were they not used during the day?



- 7 Look at the large picture on the left. How does cold air enter the room?
- 8 Why is the air warm at the top of the room? How does heat escape?
- 9 Look at the large picture above. Is there any cold air in the room? What happens to hot air rising up from the fire?
- 10 For simplicity, no chimneys are shown on these pictures. What difference do you think a chimney makes to the movement of the warm air?
- 11 When some of the warm air passes up a chimney, how do you think fresh air comes into the room to replace it?

Making and Shaping Glass



Delicate vessels are made by *blowing* glass. First the glass is left to cool until it becomes plastic, like soft modelling clay. (Even then it is still white-hot!) A blob of glass is placed over one end of a blow-pipe and the glass blower blows through the other end until the blob is roughly the size and shape he wants. He finishes shaping it with tools and then breaks it off from the pipe.

Glass is useful in our homes mainly because it is transparent. Certain transparent substances called crystals are found in nature, but few of them are as transparent as glass, and none can be shaped so easily or used in so many ways.

Nowadays, partly in order not to waste it, broken glass forms an ingredient of glass-making. The second ingredient is sand, which contains many semi-transparent crystals; the third is usually limestone, a form of hard chalk, and the fourth soda.

To make lenses and heavy glass ornaments, lead oxide is used instead of limestone; to make glass for ovenware, less soda is used and a substance called boron oxide is added.

The mixture is heated strongly in a large tank until it melts into a thick liquid.



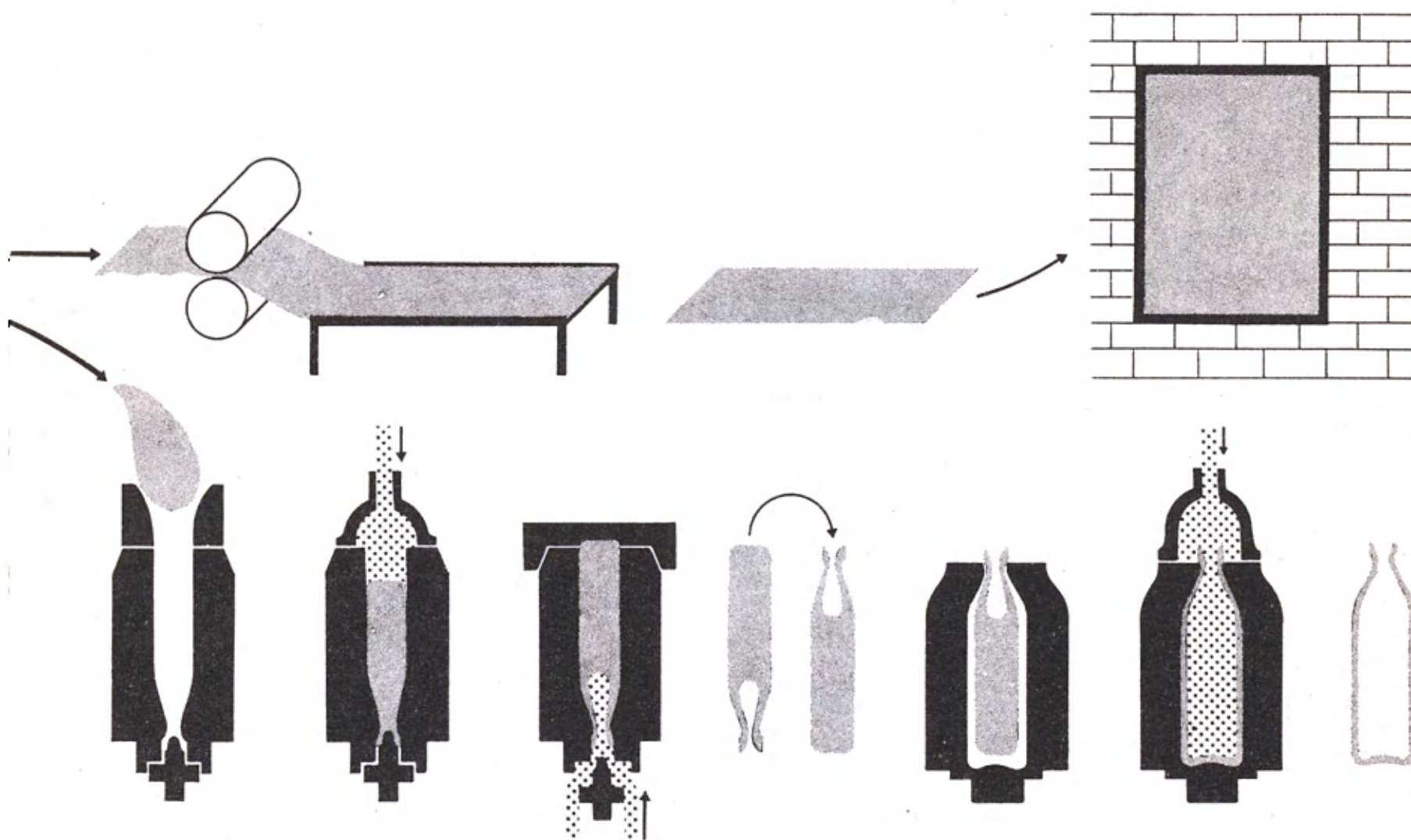
The first row of pictures below shows you in a simple way how plate glass for large windows is often made.

Molten glass from the furnace is passed between a pair of cast-iron rollers which are cooled by water. The rollers cool the glass enough to make it plastic, and press it into a long, flat strip which slides on to a table. The strip is cut into lengths, then ground and polished ready for use.

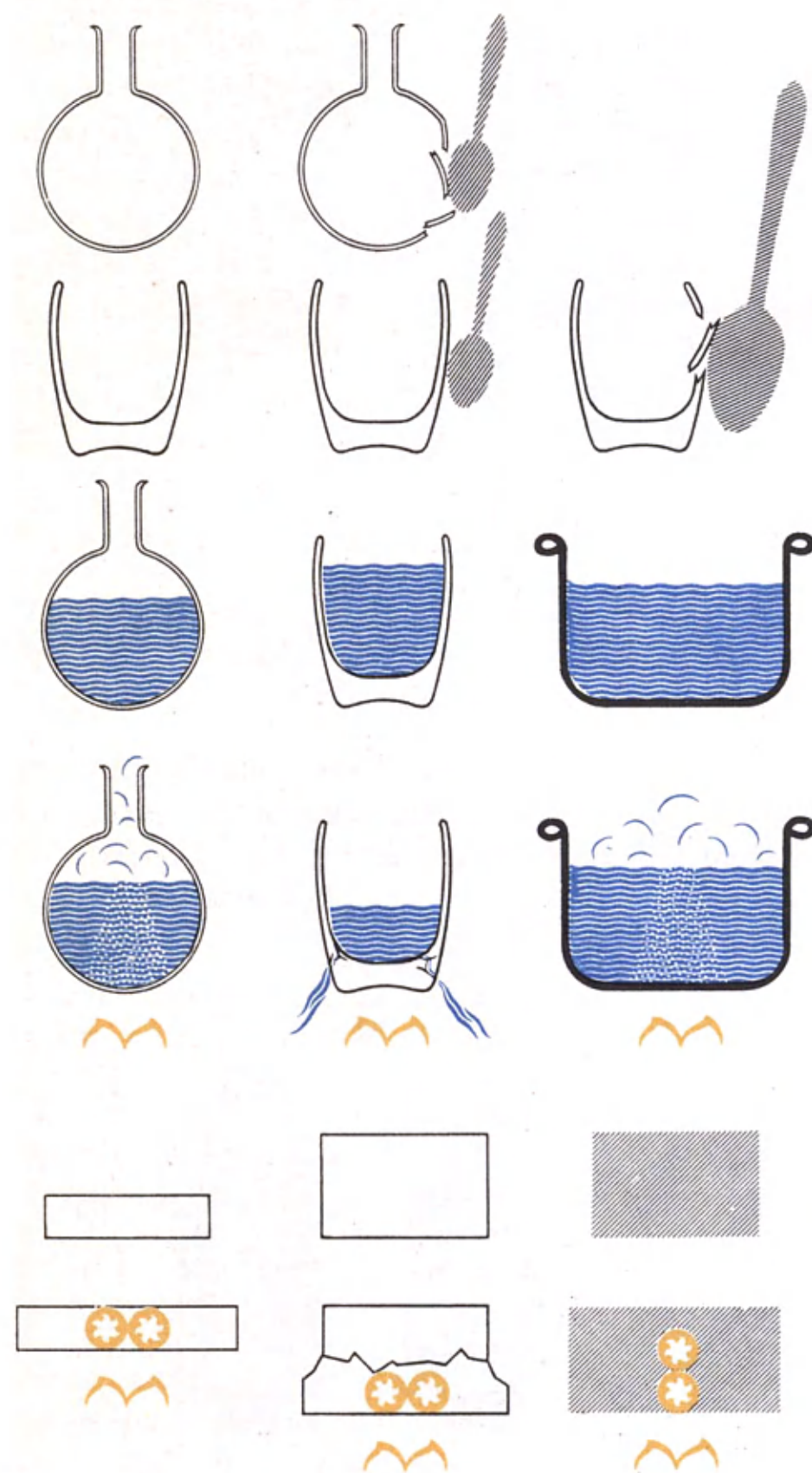
The bottom row of pictures shows you one of the modern ways of making bottles. It is called the "blowing-and-blowing" method.

A mould shaped like a thin bottle is sealed at the neck end and held upside-down while a blob of hot glass is dropped into it. Air is blown into the open end of the mould and the glass is pushed down to form the shape of the neck. More air is now blown into the neck end to shape the bottom of the bottle. But the glass is not yet hollow except just inside the neck.

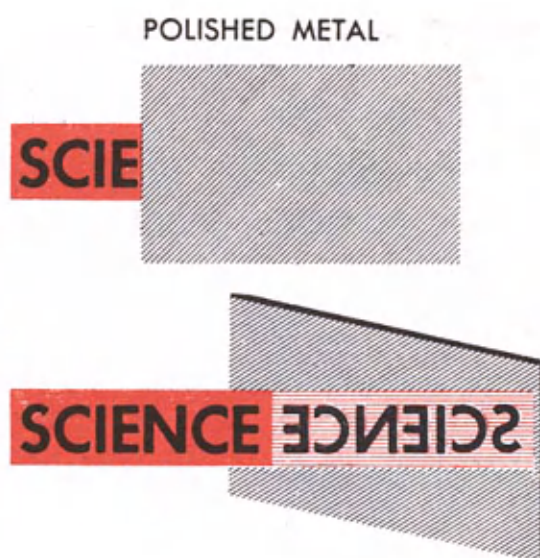
While the glass is still hot it is placed in a larger mould. More air blows it up like a balloon until it fits the mould. When the second mould is opened the bottle has only to be cooled before it is ready for use.



Some Qualities of Glass



- 1 Which is made of thinner glass, the flask or the tumbler? Which will break when it is tapped lightly? Which needs a harder knock to break it?
- 2 The flask, the tumbler and the metal pot are filled with cold water. Can you boil the water in the flask? In the tumbler? In the metal pot?
- 3 What happens to the tumbler of cold water when it is placed over a flame? Do you think heat would break a pot made of thick metal?
- 4 Look at the pictures at the bottom. The first two show thin glass, the second two thick glass, the last two thick metal. Does the thin glass expand when it is heated? Does thick glass? Does thick metal?
- 5 Does heat travel through the whole thickness of the metal? Of the thin glass? Of the thick glass?
- 6 Why does only a part of the thick glass expand? What happens as a result of this?
- 7 Can you think of a way of keeping very hot water in a thick glass tumbler?



- 8 Is polished metal transparent, like glass? Is polished wood?
- 9 What are most mirrors made of? Is it possible to make a mirror of polished wood? Of polished metal? Is any light reflected from polished wood?
- 10 Look at the letters seen through the magnifying glass. What do you notice about them? Do you think the last letter of the word is really as far to the right as it appears to be?
- 11 Is the lens of a magnifying glass of even thickness?
- 12 Behind the first wedge-shaped piece of glass is a strip of red paper. When you look through the side of the glass what appears to happen to the strip?
- 13 Behind the second wedge of glass is a beam of white light. If you look at it through the glass what do you see?
- 14 From white light, lights of different colours can be obtained. Can you think how the glass breaks up the white light into the separate colours?
- 15 What do we see in the sky when rain-drops split the light from the sun into separate colours?

What We Have Learned about Glass

1. At the very dawn of history men already knew how to make glass. Almost six thousand years ago glass was used in Egypt and Mesopotamia for coating beads made of stone, and more than three thousand years ago the ancient Egyptians knew how to mould vases from glass. Glass-blowing began, probably near Syria, just before the time of Christ. But it was not until about eight hundred years ago that clear glass windows were first made, and even after that several hundred years passed by before the houses of ordinary people had them.

The window of a house during the middle ages was simply a hole in the wall through which light and air could pass. On a winter day, however big the fire might be, warm air was always escaping from the window, and cold air blowing in through it. Therefore people did not want their windows to be too large, and the result was that little sunlight came into the rooms.

In a modern house with large glass windows, we can enjoy plenty of daylight, even on the coldest days, without suffering from cold draughts. The warm air from our fire does not escape through the window; it rises towards the top of the room and, as it cools a little, comes down again and is then again warmed by the fire.

2. The main ingredients which go into the melting tanks at the glassworks are sand and broken glass. Other ingredients are usually limestone and soda, but these may be replaced

by different substances to produce different qualities of glass.

The glass-blower uses a blow-pipe to blow a blob of hot glass into a bubble roughly the size and shape of the vessel he wants to make. He uses tools to finish the shaping.

When many jars or bottles all of the same shape and size are to be made, the glass is blown inside a mould by machinery.

Plate glass for large windows is made by passing molten glass between water-cooled rollers and rolling it into long strips which are then cut into lengths, ground and polished.

3. Lemonade bottles, jam jars, milk bottles, tumblers are not always handled very gently. They are made of thick glass, since thick glass does not break so easily as thin glass when it is knocked. Electric light bulbs, test-tubes, retorts all have to withstand heat. They are made of thin glass, because heat will not crack thin glass as easily as it will thick glass.

Glass is not a good conductor of heat. If we place thick glass over a flame, the side nearest the flame will become hot and expand while the other side remains cool and does not expand. The result is that the glass cracks. When very thin glass is placed over a flame the heat can travel the short distance from one side to the other much more rapidly, and the glass is less likely to break.

4. When rays of light pass through a lens (except through its centre) they are bent. Look

at something through a sloping lens; its position will seem to have shifted. This also happens when the rays pass through a wedge of glass.

When white light passes through a wedge of

glass, it is split up into the separate colours from which it is made. This is because in passing through the glass, each colour is bent by a different amount.

THINGS TO DO

1. When you are in a very warm room on a cold day open the window slightly at top and bottom. Hold a strip of thin paper near the top of the window then near the bottom. What do you notice? Where does cold air come in more quickly?

2. Half fill a glass jar with water. Place a long straight stick in the jar. What do you notice? How would you explain this?

3. Take two beads of exactly the same size (or two pen nibs). Thread one on a piece of cotton and suspend it in a round glass flask full of water. Hold the other bead near the flask. Do they still look the same size? Try to explain what has happened.

4. Obtain some glass tubing from the chemist and by heating it over a gas flame (1) bend it (2) close the end (3) blow a bubble at the closed end. Take care not to burn yourself with the hot glass.

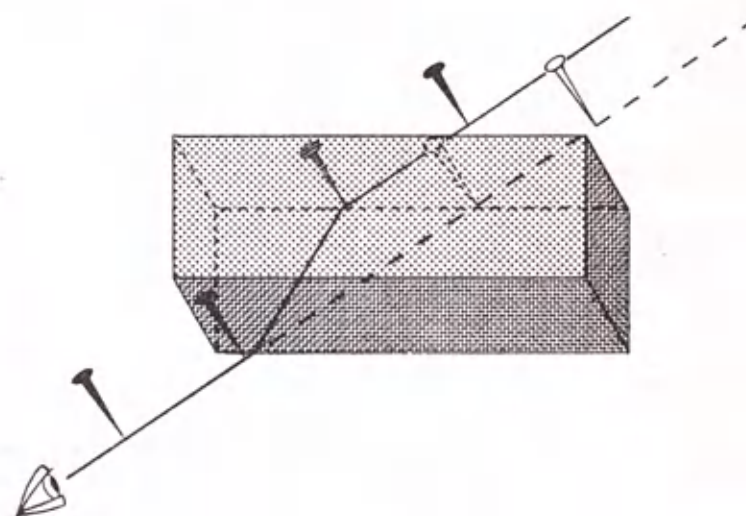
5. Make a list of all the uses of glass which you might come across during a walk between home and school.

6. Obtain two rolls of cardboard of such sizes that one slides easily inside the other. Make slits near one end of each so that con-

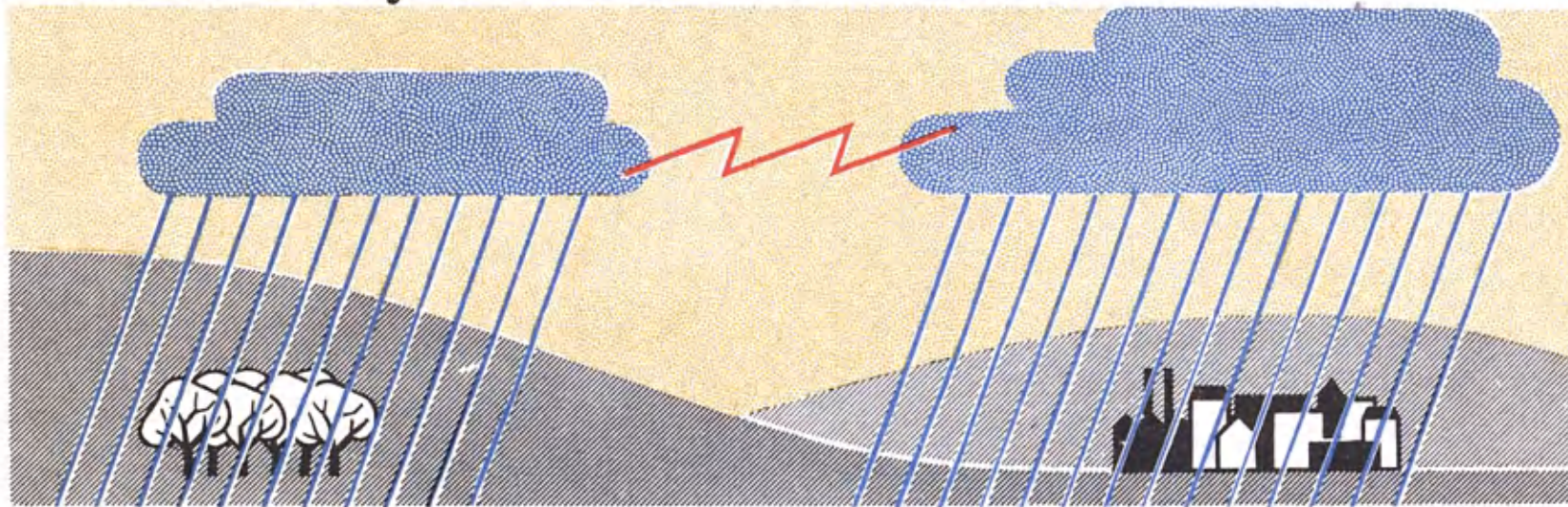
vex lenses (thin at the edges, thick in the centre) may be slipped into them. Hold the cardboard together with sticky tape. Now slide one tube into the other. Point one lens towards a distant object. Look through the other lens. You have made a model telescope.

7. Replace the lens nearer to the eye with a concave lens (that is, thicker at the sides than in the middle). This time you will have made a model of what is called a "Galilean" telescope.

8. If you can get a thick block of glass, you can trace the path of a ray of light through the block by using pins. The picture will explain the method. To the eye all four pins appear to be in one straight line.

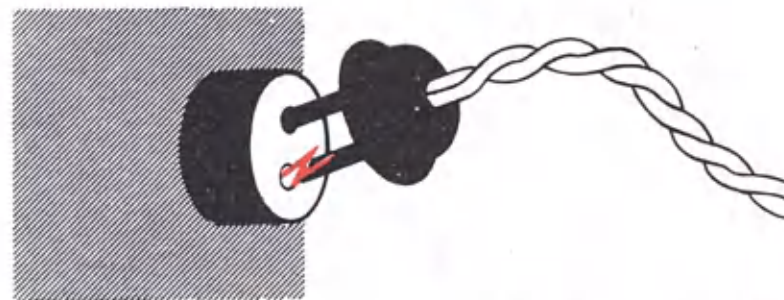


How Electricity is Carried to Our Homes

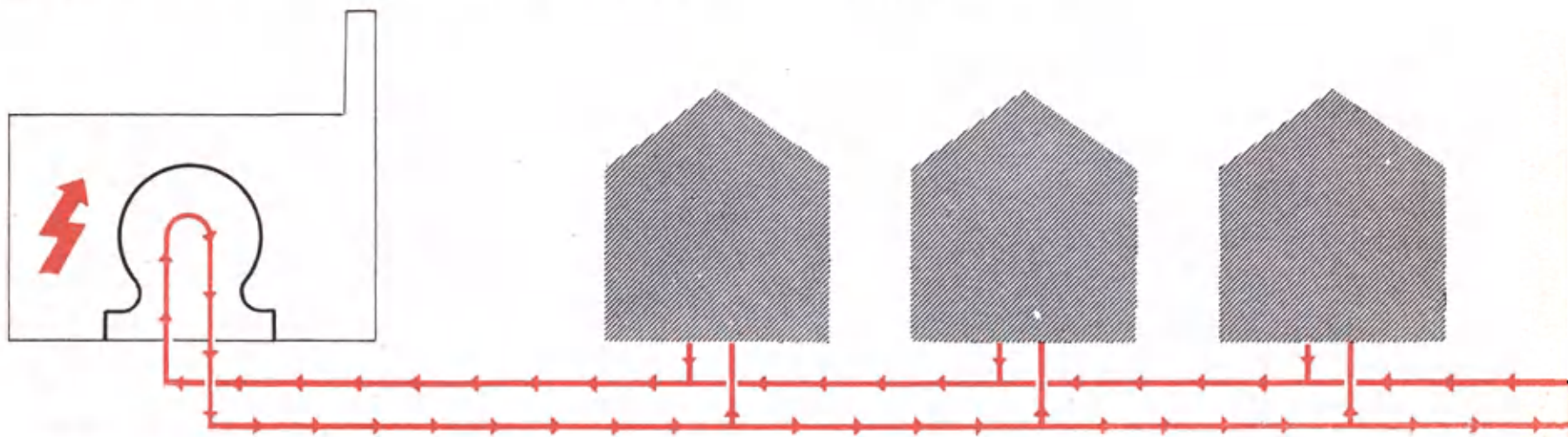


Red stands for electricity, yellow for heat.

- 1 What do we call the flashes we sometimes see in the sky on a hot, stormy day? Do we ever see smaller flashes rather like these in our homes?
- 2 Do you think electricity existed before men learned how to produce it?
- 3 How many wires must be used to carry electricity from the power station to our homes? How many wires lead to the electric socket in the wall? To the electric light bulb?



- 4 Does electricity flow along the wires behind the socket when the plug of the electric fire is pulled out? When it is pushed in?
- 5 Does electricity flow along the wires leading to the bulb when the light switch is off? When it is on?

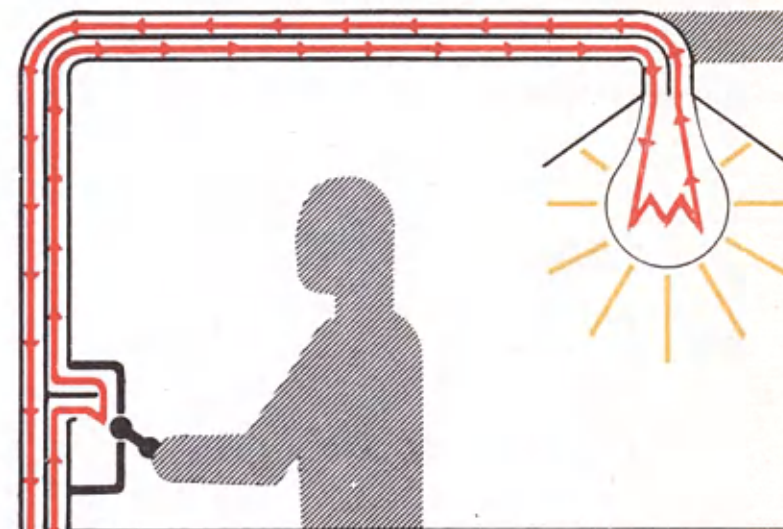
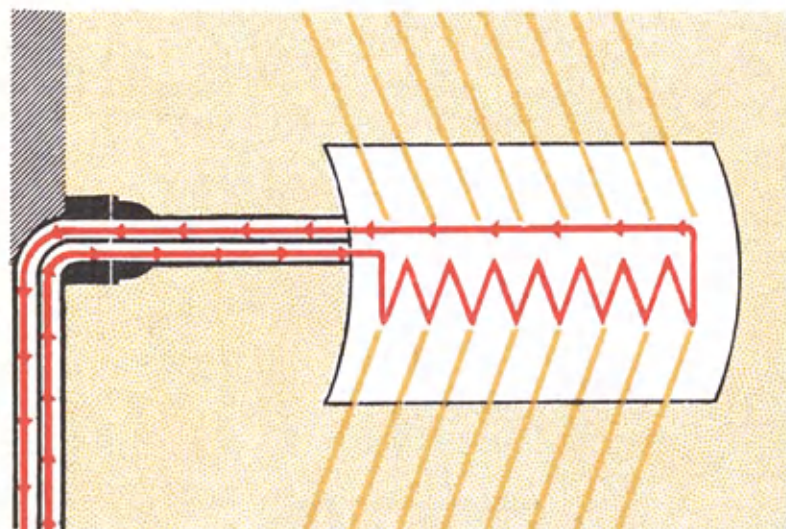
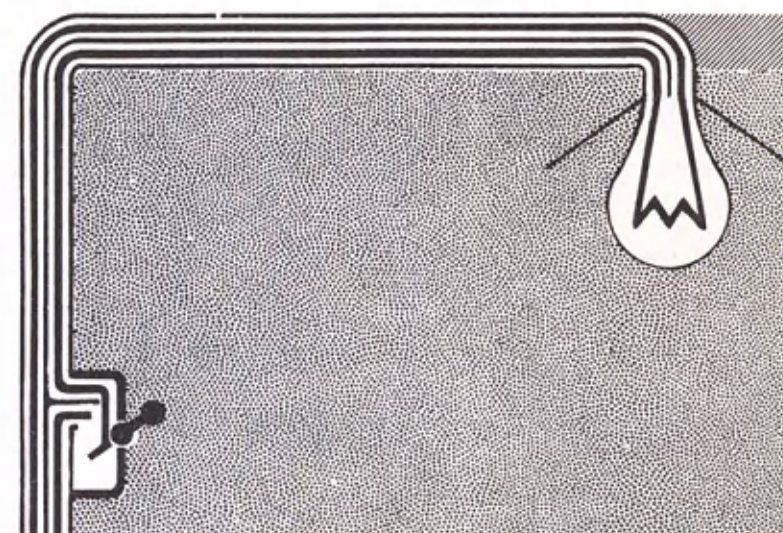
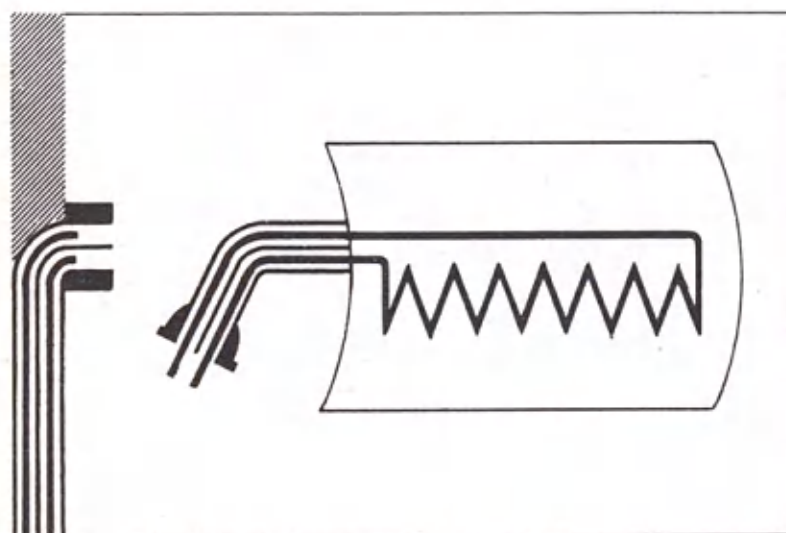


6 In the first two pictures below, trace (a) the lines showing the wires leading to the socket, and (b) those showing the wires leading to the bulb. Can you, in either case, get from one wire to the other without lifting your pencil from the paper?

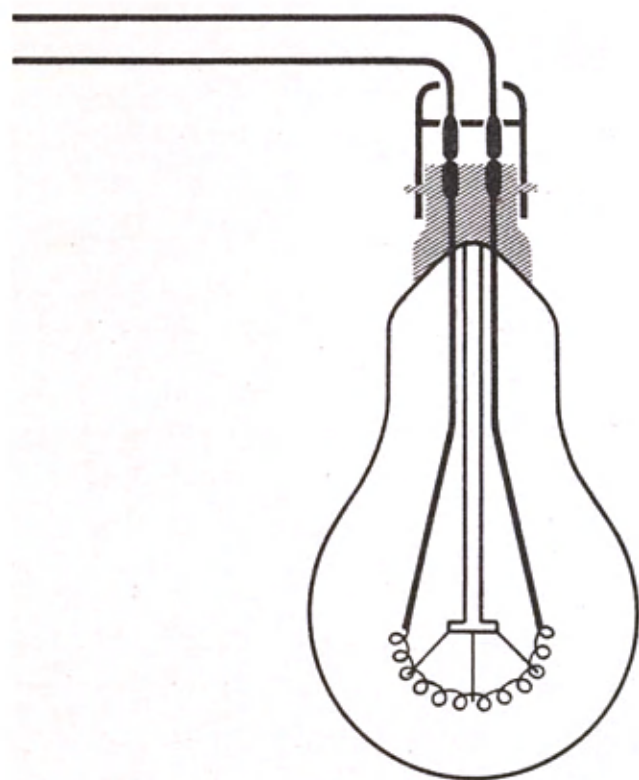
7 Does electricity flow when there is no connection between the two wires?

8 Now trace the red lines leading from the power station (a) to the fire and (b) to the bulb in the bottom pictures. Is it possible now, in either case, to get from one wire to the other without lifting your pencil from the paper?

9 Say what must happen before electricity can flow along wires.

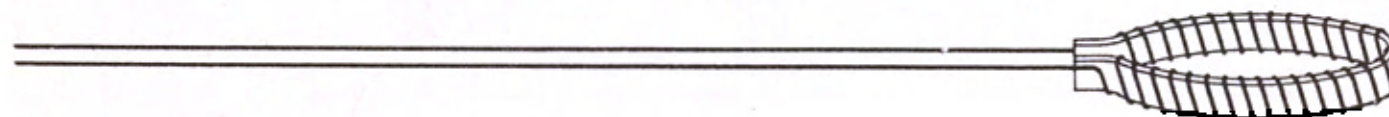
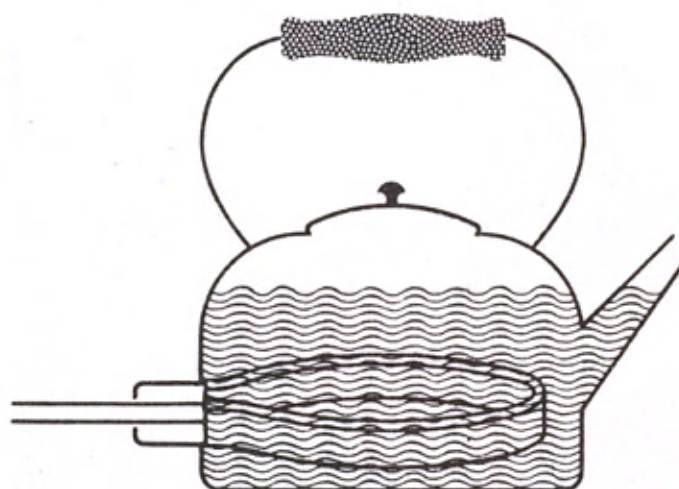
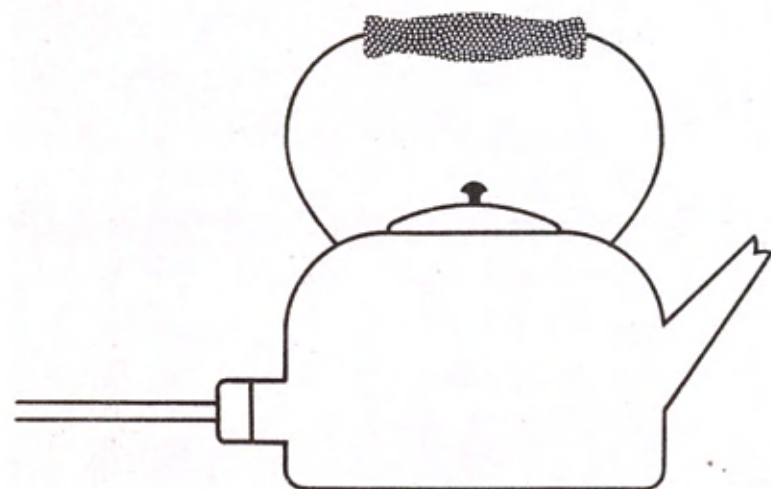


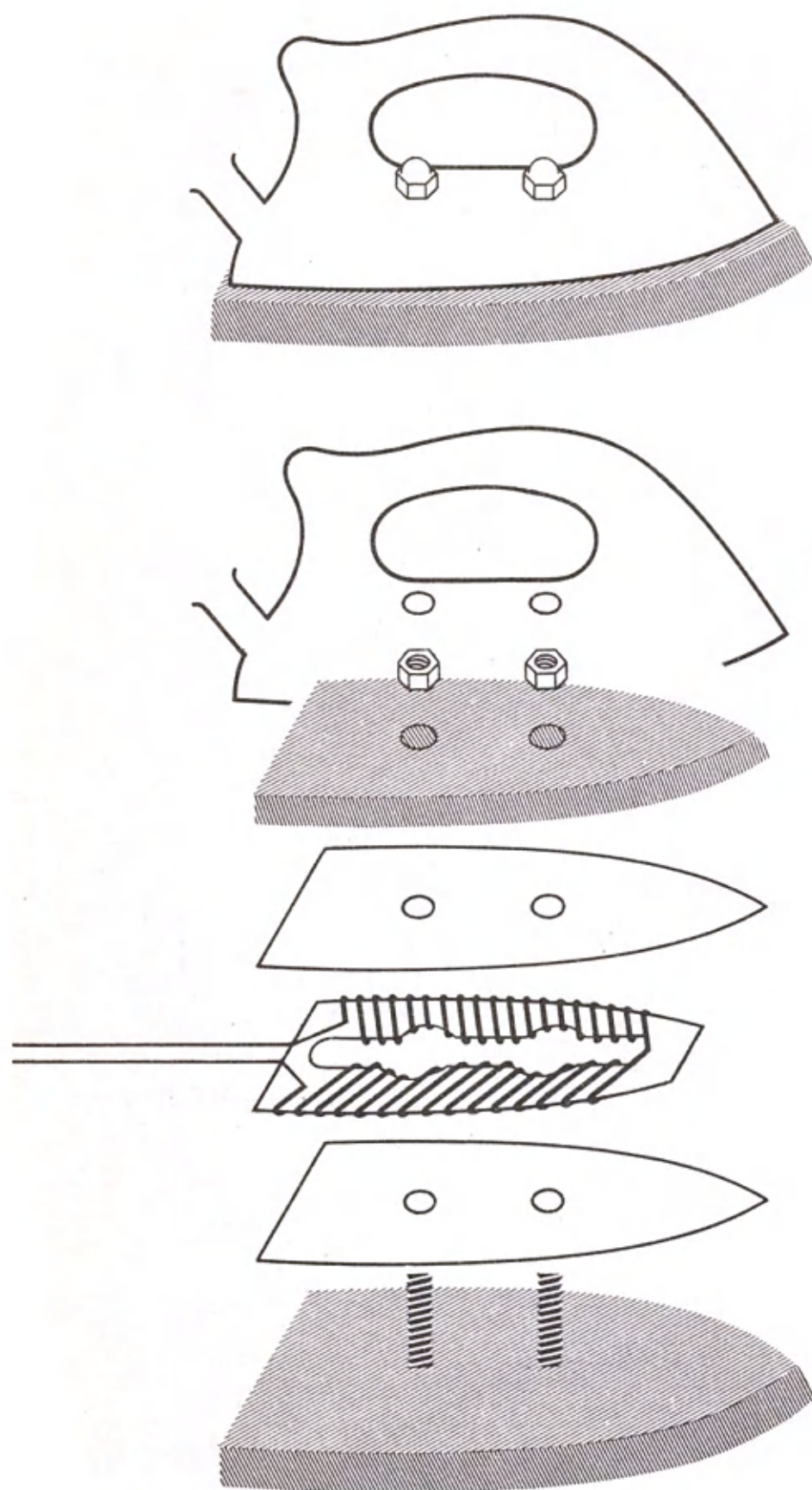
Light and Heat from Electricity



Inside an electric light bulb is a thin wire, made of a metal called tungsten. When the light is switched on, electricity flows along the tungsten wire and makes it white-hot, so that it gives out a bright light. There is no oxygen inside the bulb, so the wire cannot burn.

A long, thin wire is also used to heat the water in an electric kettle. If this wire touched the metal part of the kettle or the water inside the kettle, electricity would flow through the metal or the water instead of travelling all the way along the wire. To prevent this, the wire is coiled round a ring made of some material which will not carry electricity, and covered with an outer ring of similar material.





If you were to take an electric flat-iron to pieces, you would find that the bottom part of it is made up of five separate layers, bolted together. The centre layer is a flat frame with a long, thin wire wound round it, and on each side of this frame is a thin, flat plate. The two outer layers are the thick steel plates which give the flat-iron the weight which is needed for ironing.

When the electric iron is plugged in, the wire quickly becomes red-hot. Heat passes through the two thin plates and makes the heavy steel plates hot enough to make the linen quite smooth.

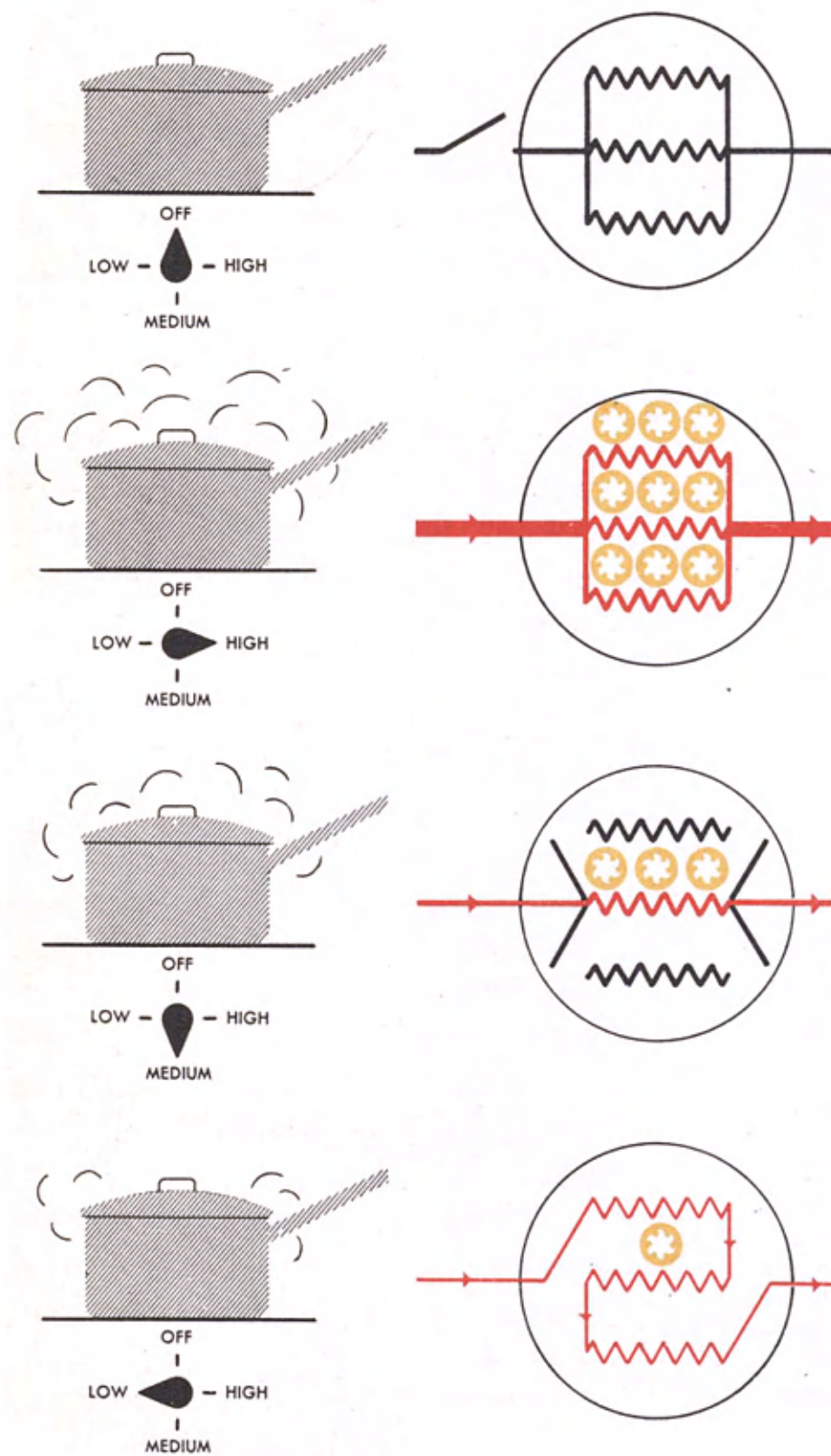
But although heat can pass through the two thin plates, electricity cannot. They are made of material which will not carry electricity. Materials of this kind are called "non-conductors" of electricity. When a wire which carries electricity is surrounded by a non-conductor we say it is "insulated".

Electricity can travel more easily through thick metal than it can through thin wire.

If the wire in the electric iron were not insulated, the electricity would travel through the steel plates instead of through the wire.

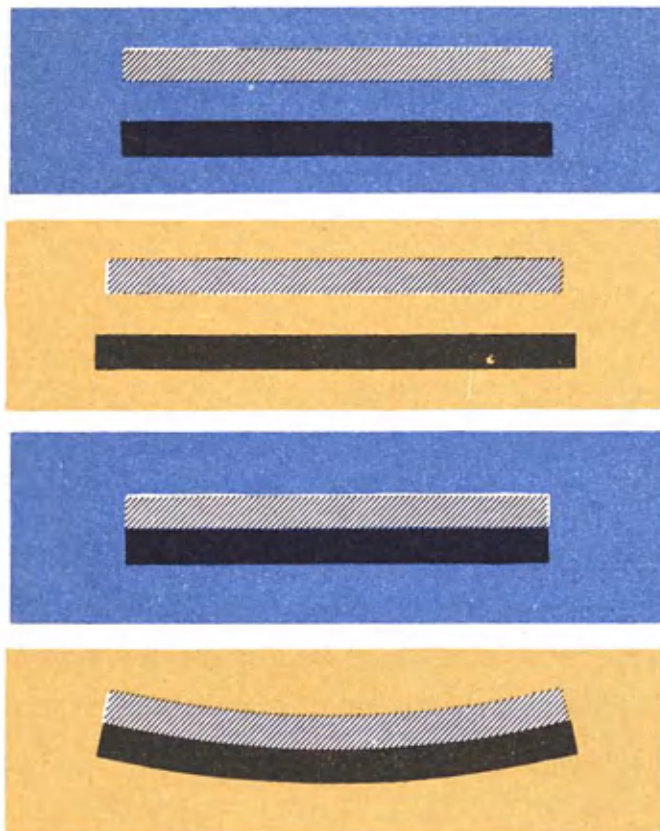
The current would then be much too large and the fuses would melt.

Getting Just the Heat We Need



The round diagrams show the wires which heat a hot-plate. The thicker the red lines, the more electricity is flowing along the wires.

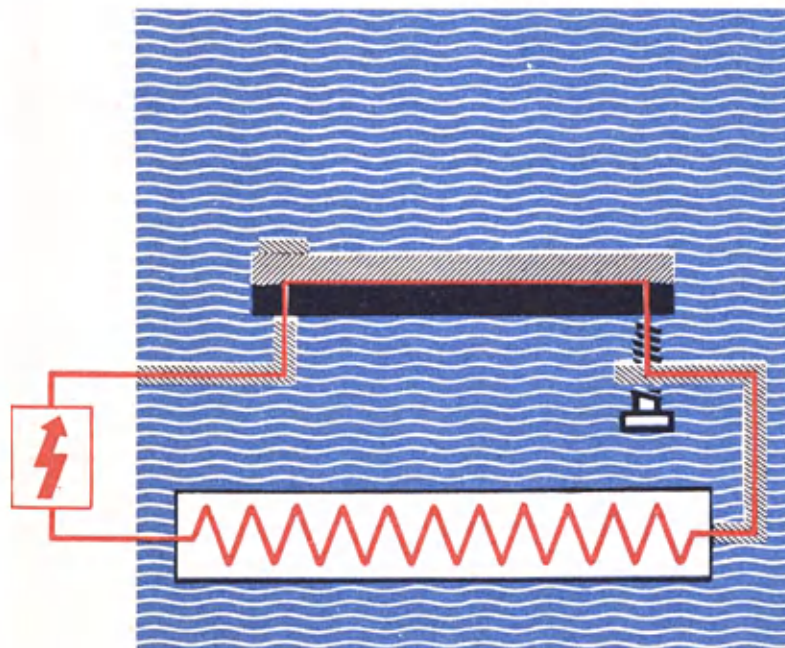
- 1 How many heating wires are there under the plate? Does electricity flow along any of them when the switch is off? Why is this?
- 2 When does the plate produce most heat? When does it produce moderate heat? When does it produce little heat?
- 3 In which position is the total flow of electricity greatest? In which least?
- 4 How many heating wires carry electricity when the switch is at "high"? At "medium"? At "low"?
- 5 When the switch is at "low" does electricity flow along the heating wires in the same way as it does when the switch is at "high"?
- 6 Does more electricity flow along one short wire or along three short wires side by side? Does more flow through a long wire than through a short one?



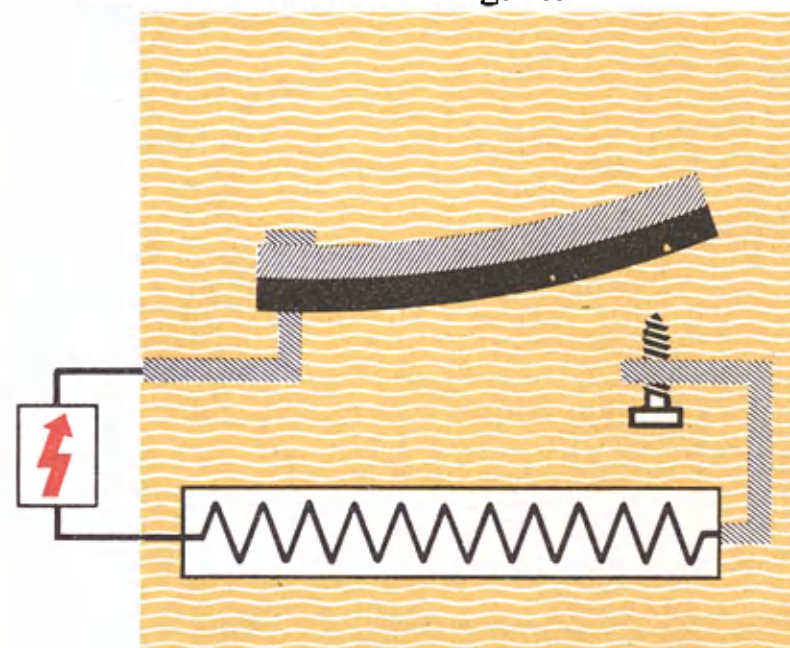
Blue stands for cold, yellow for heat

▨ stands for steel

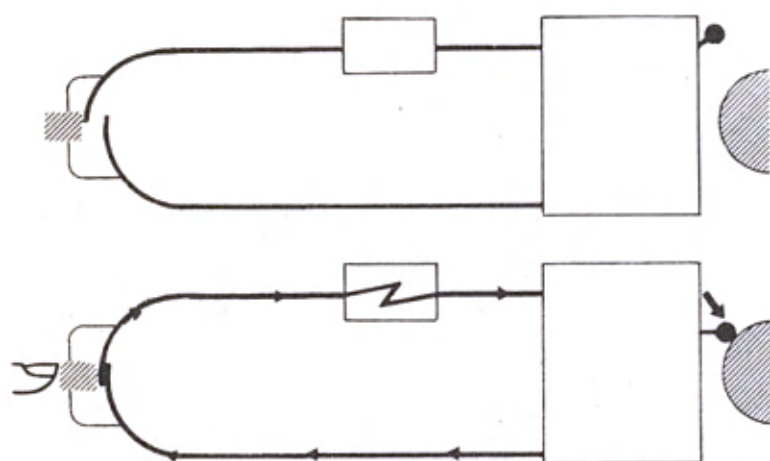
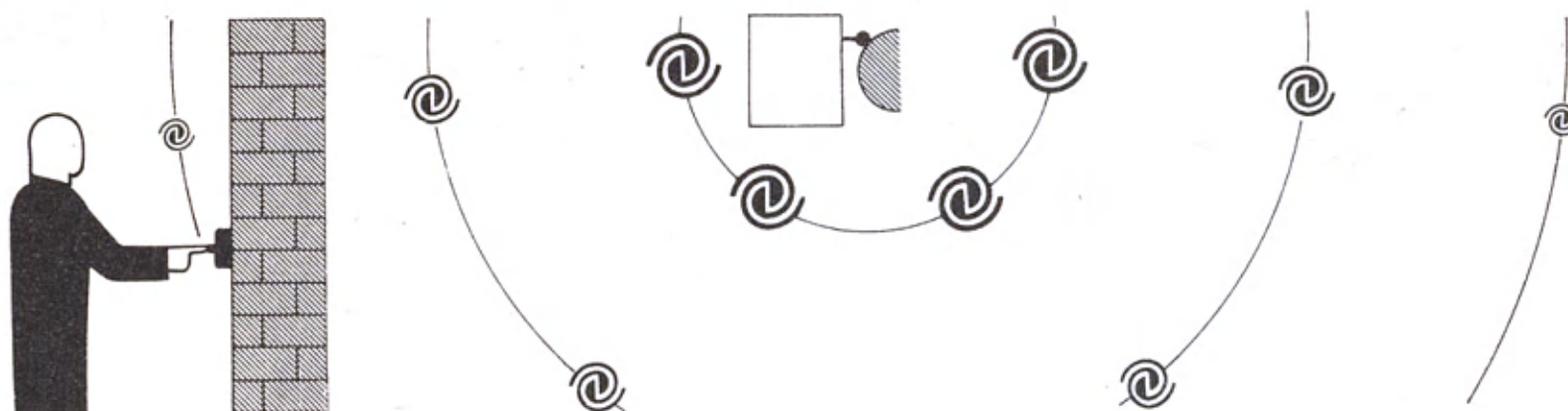
■ stands for brass



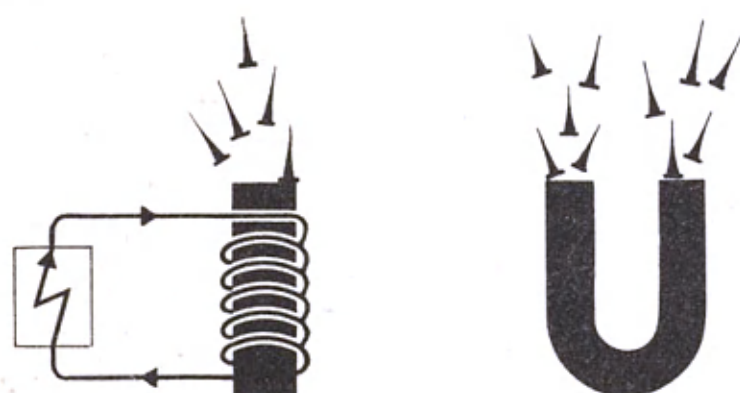
- 7 Look at the first two pictures. Are the two strips of metal equal in length when they are cold? What happens when both of them become hot?
- 8 Look at the next two pictures. A length of brass is firmly joined to a similar length of steel. Is the whole strip straight while it is cold?
- 9 What happens when it becomes hot?
- 10 Now look at the pictures below. While the water in the boiler is cold, electricity for the heater flows through the brass-and-steel strip. What happens to the strip when the water becomes hot?
- 11 What happens to the electric current when the strip bends away from the screw?
- 12 What do you think will happen when the water becomes cool again?



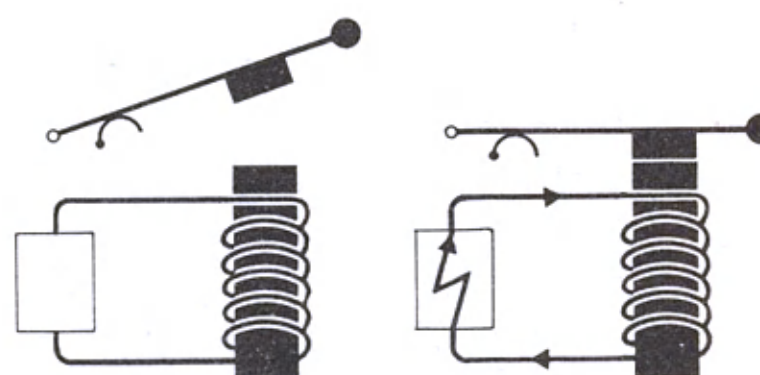
How Electricity Rings the Doorbell



Why does the electric bell ring when the button at the door is pressed? Wires behind the bell-push lead to a box near the gong. In the circuit is a battery which supplies electricity. When nobody touches the button, there is a gap between the wires and no electricity can flow along them. Press the button and the gap closes; the current flows and the bell rings.



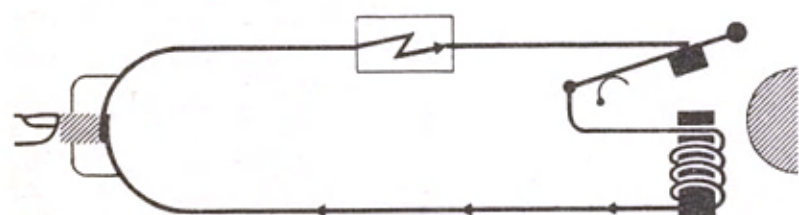
When electricity flows along a coil of wire wound round an iron rod, the rod becomes a magnet. It attracts steel or iron just as a horseshoe magnet does. Inside the box near the gong there is just such a magnet.



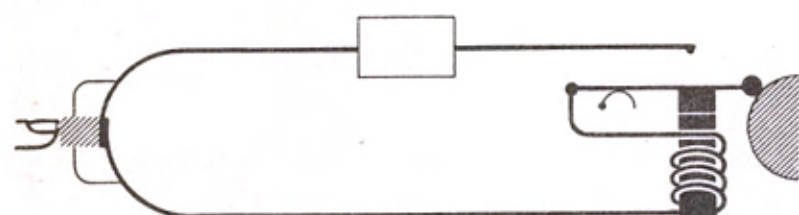
Above the rod is an iron striker held up by a weak spring. When the current flows along the coil, the magnetism in the rod overcomes the weak upward push of the spring and pulls the striker down so that it hits the gong.



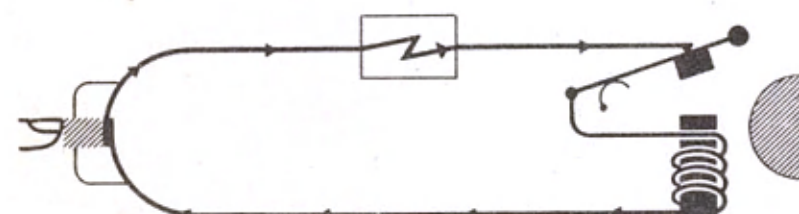
But while the bell is pressed, the striker hits the gong not once but many times. Look carefully at the pictures below and you will see how this comes about.



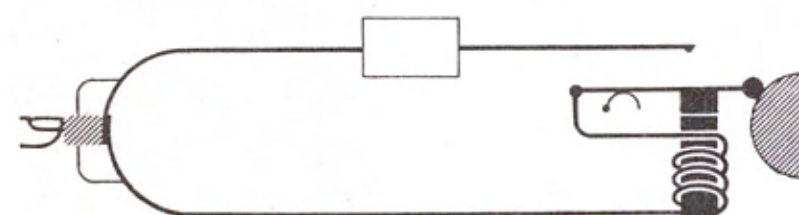
At the first instant the button is pressed, electricity flows right round the wire *and through the striker itself*.



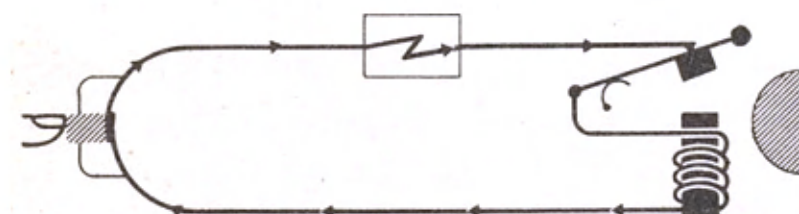
The rod becomes a magnet and pulls the striker down so that the bell rings. This causes a gap between the wires. *No current flows and the rod is no longer a magnet.*



The spring pushes the striker up, and again the current begins to flow.

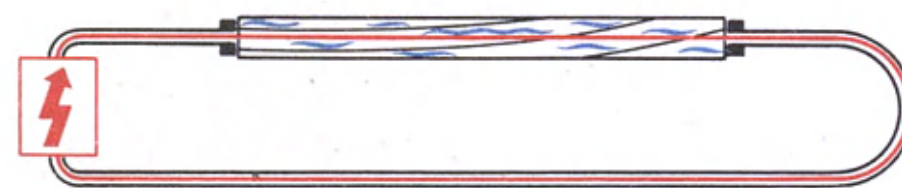
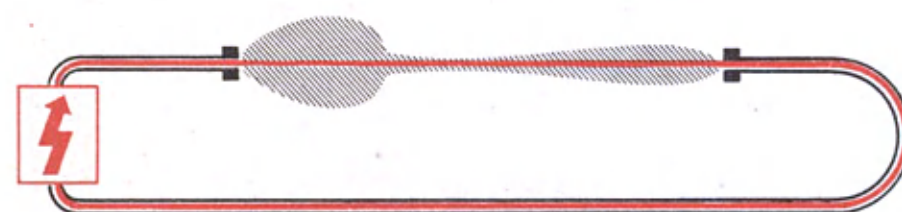
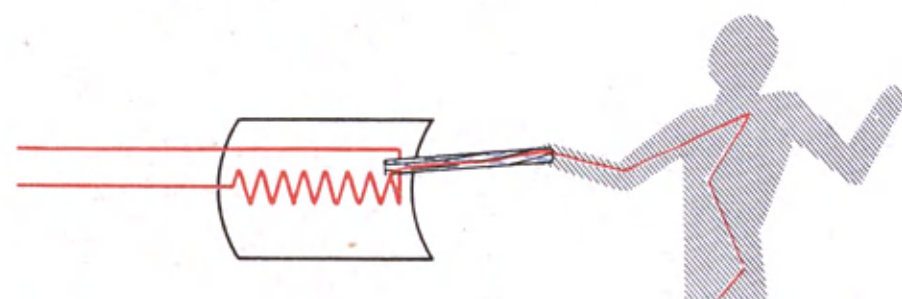
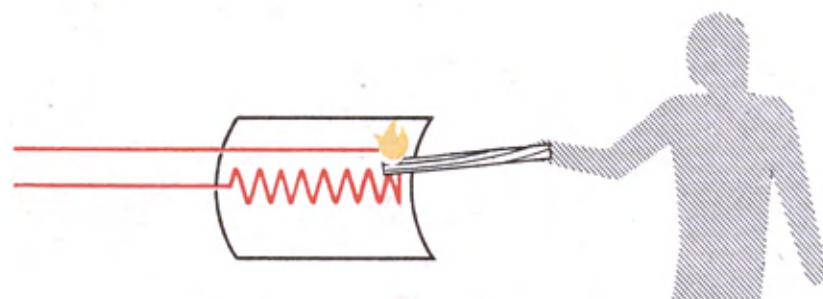
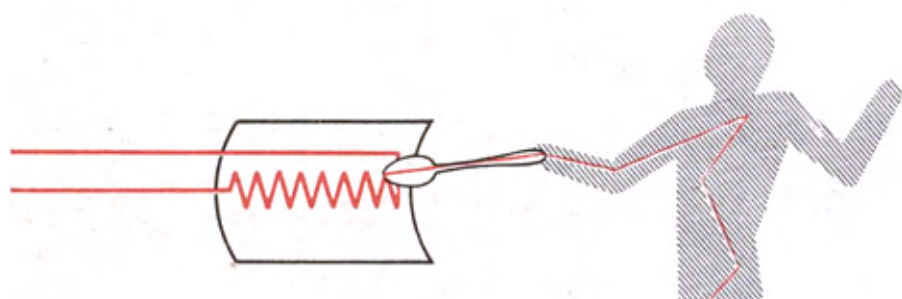


Once more the rod becomes a magnet and pulls the striker down, breaking the current.



The spring again pushes the striker up. The current flows, the rod becomes a magnet, and so the ringing goes on.

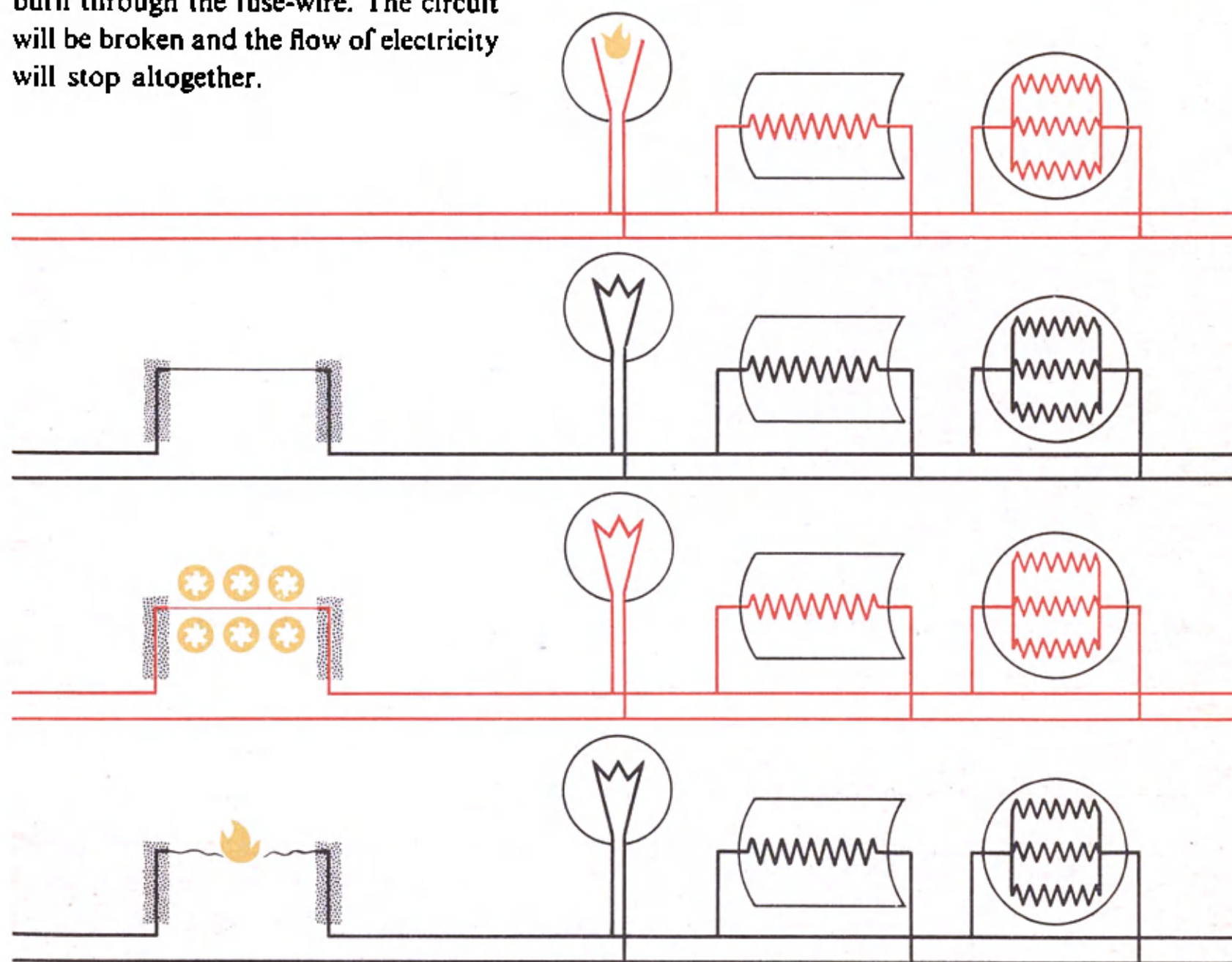
Dangers From Electricity



- 1 Are the hot wires of an electric fire insulated? Why is this?
- 2 Look at the pictures on the left. What may happen if you touch the wires with a metal spoon? With a piece of dry wood? With a piece of wet wood?
- 3 If a gap in an electric circuit is filled with a metal spoon can the current flow? Can it flow if the gap is filled with dry wood?
- 4 What happens if the gap is filled with wet wood?
- 5 Look at the top three pictures on the right. What do you notice about the insulation between the two wires in the first picture?
- 6 In the second picture that insulation has broken. What happens to the electric current? To the wood near the wires?
- 7 What happens to the wood in the third picture?
- 8 How can you avoid getting a shock from an electric fire? What would you do if you noticed badly worn insulation round a wire in an electric circuit?

If, for any reason, there is a sudden increase in the flow of electricity through a circuit, wires may be burnt and destroyed. Bulbs or electric fires may be put out of order.

We avoid this by putting a short piece of soft, thin "fuse-wire" into the circuit. If there is an increase in the flow of electricity now, the heat will quickly burn through the fuse-wire. The circuit will be broken and the flow of electricity will stop altogether.



What We Have Learned about Electricity

1. Electricity will only flow where there is a closed circuit. That is, it must be able to flow from wherever it is produced to wherever it is needed and back again without any break in the wires. If we make a break—by turning off a switch or pulling a plug out of a socket—no electricity will flow.

2. Electricity gives us heat and light by making thin wires very hot. Heating wires must not touch anything else which will carry electricity; if they did, the electricity would take a short cut through that substance instead of travelling right along the wires.

3. Under a hot-plate are three heating wires. When the switch is off there is a break in the circuit, and no electricity flows along any of them. When it is at "high" electricity flows through all three at once; at "medium" it flows along only one; at "low" it flows through all three, *one after the other*. In the last position

the electricity has a long way to travel through thin wire; the current is weak and the wire does not become so hot.

4. Some metals expand more than others when heated. Make a strip by joining equal, parallel lengths of two different metals, and when it becomes hot it will bend. Electricians use such strips to make devices for automatically switching off the current when the water in an electric boiler becomes hot.

5. When electricity flows along wire coiled round a piece of iron, the iron becomes a magnet. When the current stops flowing the iron loses its magnetism.

6. To prevent damage to wires in expensive electrical apparatus, we use a short length of thin fuse-wire in the circuit. If there is a sudden increase in the flow of electricity, the extra heat quickly destroys the fuse-wire. The circuit is broken and the current stops.

THINGS TO DO

1. Attach two copper wires to a 2-volt accumulator and to one of these join about 3 or 4 inches of very fine iron wire. Make a little hook at the end of this iron wire. At the end of the copper wire make a small loop. Now drop the hook into the loop and pull fairly tight. (1) What do you observe and how do you explain it? (2) Repeat the experiment, but use about 2 yards of the iron wire. How do you account for the difference in the result?

2. Get an old electric bell, take off the cover and trace how the current flows (1) when the striker touches the bell (2) when the two are apart. Take the bell to pieces, and if it is not broken, clean the metal parts with sandpaper and replace them. Connect a dry-cell battery to the terminals and try to make the bell ring.

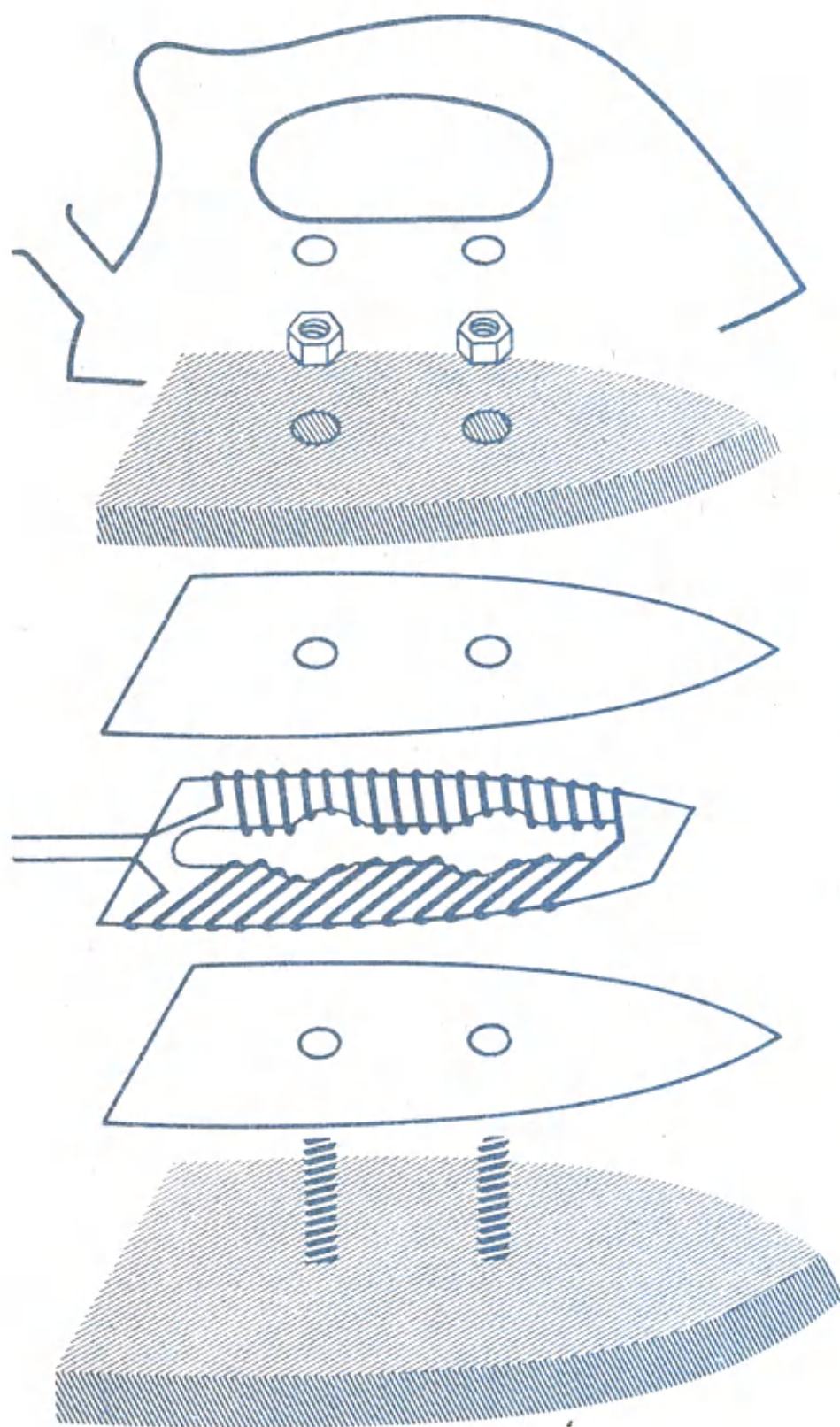
3. Ask your father or older brother to explain to you how to replace the fuses in your home.

SOME BOOKS TO READ

As you have studied this book you have probably felt that you would like to read more about some of the subjects dealt with. From the list of books given below you will be able to pick out quite a number that will interest and help you. The easier ones are marked*, but don't be afraid to look at some of the others as well. They are all interesting, and many of them contain pictures which will help you to understand more about science.

Another enjoyable way of building up your knowledge of science is by visiting museums. If you live near London, or if ever you go there, you would especially enjoy a visit to the Science Museum at South Kensington.

Everyday Knowledge in Pictures	<i>Odhams</i>	7/6	HOLMES, B. and M. The Water We Use	<i>Pilot Press</i>	2/6
The Wonder Book of Science	<i>Ward Lock</i>	12/6	HONEY, W. B. English Glass	<i>Collins</i>	5/-
ALEXANDER, I. The Story of Plant Life	<i>Penguin</i>	1/6	*JARVIS, A. The Things We See: Indoors and Out	<i>Penguin</i>	3/6
*COLES, M. J. About Your Home	<i>Blackie</i>	2/6	*LAUWERYS, J. A., and GLOVER, A. H. T. Making Light	<i>Nelson</i>	3/-
*CROSSLAND, J. R. (ed.) The Book of Wonders	<i>Collins</i>	2/3	*LAUWERYS, J. A., and GLOVER, A. H. T. The Thirst of Cities	<i>Nelson</i>	3/-
CULLIS, W. Your Body and the Way it Works	<i>Allen & Unwin</i>	2/6	*LITTLE, W. B. Science in the City	<i>Pitman</i>	4/6
*FAWCETT, R. Bread	<i>Gawthorn</i>	3/6	MCDUGALL, A. T. Nature's Giant Forces	<i>Pitman</i>	3/-
*FAWCETT, R. Glass	<i>Gawthorn</i>	3/6	*MORGAN, A. P., and SIMS, J. W. The Boy Electrician	<i>Harrap</i>	9/-
*FAWCETT, R. Soap	<i>Gawthorn</i>	3/6	O'DEA, W. T. Electric Illumination	<i>Cassell</i>	9d.
FORTUNE, J. B., and MANN, P. B. The Story of Iron	<i>Penguin</i>	1/6	PEARSON, F. J. Our Food	<i>Cassell</i>	3/6
*FREEMAN, M. and I. Fun With Chemistry	<i>Pilot Press</i>	7/6	*PETERSHAM, M. and N. The Story Book of Wheat	<i>Wells, Gardner, Darton & Co.</i>	3/6
GERARD, G. The Story of Power	<i>Nelson</i>	4/-	*TAYLOR, F. S. The Young Chemist	<i>Nelson</i>	5/-
HASTINGS, A. B. The Biology of Water Supply	<i>H.M. Stationery Office</i>	1/6	THORNHILL, P. The Air We Breathe	<i>Pilot Press</i>	2/6
HILL, F. J. Electricity	<i>Collins</i>	2/-	WAY, R. B. and GREEN, N. D. Electricity	<i>Wells, Gardner, Darton & Co.</i>	5/-
*HOLLOWOOD, B. The Things We See: Pottery and Glass	<i>Penguin</i>	2/6			
HOLMES, B. and M. Keeping Warm	<i>Pilot Press</i>	2/6			



A GRADED COURSE IN GENERAL SCIENCE

Visual Science aims to give a basic course in General Science during the years from 9 to 15; to focus activities by encouraging observation and fostering a taste for experiment. It makes a radically new approach to the problem of science teaching in its early stages.

The first two books, a two-year course, are directed broadly at the ages 9–11. They contain much “Nature Study” therefore, but the clarity of the Isotype method of visual exposition has made it possible to introduce other aspects of science which closely touch the child’s daily life.

The next four books, which cover the ages 11–15, are of particular value to Secondary Modern Schools and as a background course to frame the more specialised studies of the Grammar School or the Junior Technical School. Each deals with many topics stemming from one general theme, and illustrates them by reference to everyday phenomena. The emphasis throughout is on knowledge which will be of direct practical use in later life. At the same time, exercise is given in simple scientific reasoning, all the main branches of organised science are represented, and the principles of elementary science clearly emerge.

Visual Science reflects the most progressive tendencies in science teaching. The contents rest firmly on the suggestions contained in recent reports on the teaching of science prepared by the Science Masters’ Association, the Association of Women Science Teachers, and the Ministry of Education.