EASY EXPERIMENTS IN ELEMENTARY SCIENCE

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by

Herbert McKay

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PREFACE

This book is a first book in science, intended for pupils of any age, but the younger the better.

Easy experiments without the use of formal apparatus can be repeated at home.

Any child of eight can do most of the experiments in this book. Some of them were devised by my own boy before he was eight. He derived more amusement from them than ordinary toys.

Pupils will be able to devise new easy experiments for themselves. They will begin to question nature. A more difficult series of experiments would not develop this attitude of mind. Such experiments have a tendency to keep science strictly to the science lesson.

Easy experiments help children to understand the science of everyday life. The direction of smoke in the air, a cap blown off by the wind, sugar dissolving in hot tea, are examples of everyday phenomena which may be developed by easy reasoning into sound science training.

PREFACE

Easy experiments and easy reasoning based on them form an ideal educational subject for little children. So far from being abstruse, as it is often wrongly supposed to be, easy science is practical and straightforward. The results of experiments are obvious to the senses. The reasoning is no more than a little common sense.

A glance at the summaries will show that pupils who do the easy experiments are acquiring a considerable amount of scientific knowledge and training.

H. McKay

CONTENTS

HINTS ON HOME-MADE APPARATUS

i. Nearly all the apparatus used in the easy experiments in this book is either familiar household things or can be easily made.

ii. Experiments have been chosen which can be carried out either at school or at home.

iii. A simple and useful laboratory may be made at home with little or no expense. Tin cans and jam jars are very useful. A large basin can always be borrowed from the kitchen.

iv. Spring balances are a cheap form of weighing machine. It is well to have two—one weighing up to a pound, and the other to a stone or half a stone.

v. At home heating can be done over a small gas-ring. At school it is well to have a Bunsen burner.

vi. The following are useful: a six-inch square of fine wire gauze; pieces of looking-glass, especially oblong pieces; small sheets of coloured glass; triangular glass prisms (these are made for a sort of ornament. They serve a much higher purpose when used for experiments on light); a lamp chimney; a magnifying glass; some lengths of glass tubing.

vii. **A measuring jar**. Get a tall glass jar—a gas jar or a preserved fruit jar. Gum a strip of paper on the outside from top to bottom. (Figure 1.)

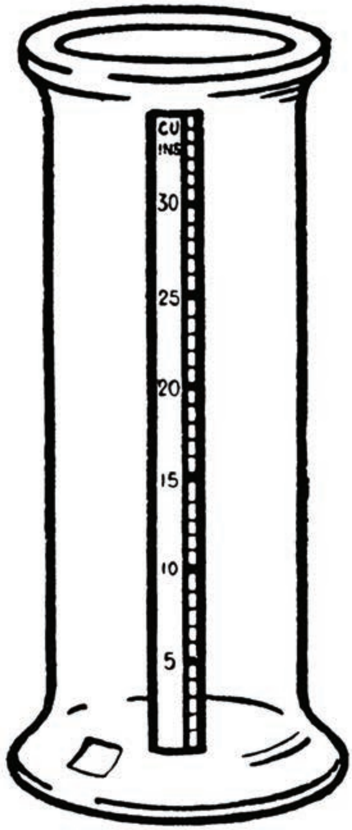


Fig 1

Cut a piece of wood as accurately as you can one inch square, and longer than the jar. Mark the wood accurately in inches, so that each part is a cubic inch.

Hold the wood upright in the jar touching the bottom, and pour in water till it reaches the highest inch mark that is inside the jar. Mark the level of the water on the strip of paper.

Withdraw, say, five cubic inches and mark the level again. Then withdraw five cubic inches again and mark the level.

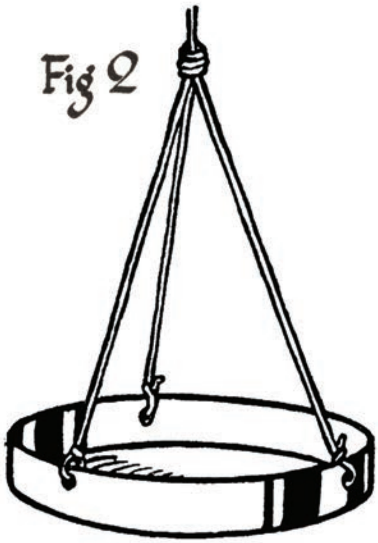
Hold the wood again upright and touching the bottom. Fill the jar with water up to the lowest mark. Withdraw five cubic inches again. In this way carrying the markings as low as possible.

The marking may be completed by measurement. It is well never to use the lowest part of the jar.

viii. **A scale-pan**. Scale-pans are often needed.

Get a tin lid and make three nail-holes equally spaced round the brim. Tie pieces of thin string in these holes and knot them together above. (Figure 2.)

Fig 2



CHAPTER I

LESSONS ON THE AIR

1. How we know there is air

Experiment 1. Swing 'round your arm with the palm flat. The air can be felt. You feel it also when it blows against you, and when you run through it.

Experiment 2. Take a deep breath and blow some scraps of paper on the table. You can see the air moving the papers.

Experiment 3. If there is a small room with a door opening outward, close the windows and any other openings. Then open the door and try to close it quickly. The cushioning effect of the air can be felt.

Repeat this experiment with a window open. The cushioning effect is lost because air escapes through the window. This can be shown by holding smouldering brown paper near the open window while some one else shuts the door quickly.

Experiment 4. Drop a sheet of thin paper and notice that it seems to be supported.

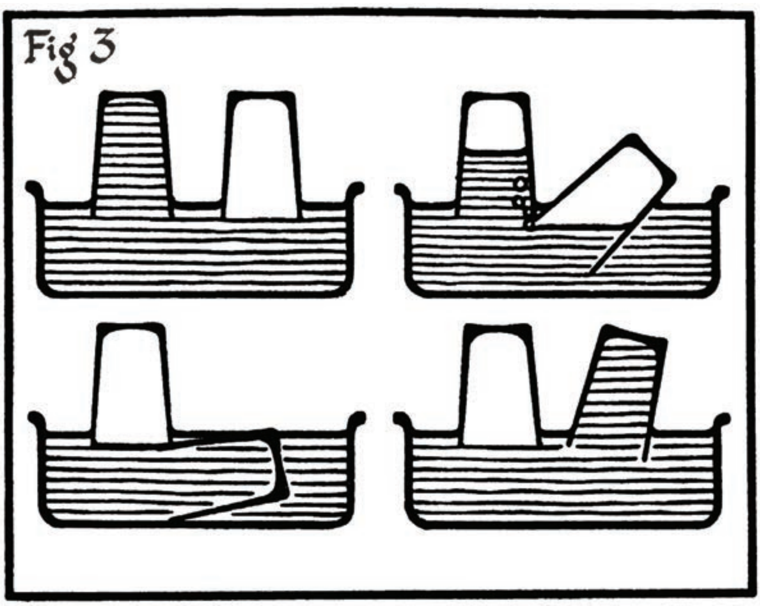
Experiment 5. Hold an "empty" bottle mouth downward in a basin of water. You will see that the water does not rush into the bottle. It is kept out by the air in the bottle.

Gradually tilt the bottle. Bubbles of air are seen escaping. As they escape water runs into the bottle.

Experiment 6. Hold a finger tightly over the end of a piece of glass tubing. Then hold the tubing upright in water. It will be seen that water does not enter the tube.

Take the finger from the end of the tube. Air can be felt escaping, and water rises in the tube.

Experiment 7. Fill a glass tumbler with water and upend it in a basin of water. In doing this keep the open end down and slowly raise the closed end. (Figure 3.)



Hold a second tumbler beside the first, but without water in it.

Now tilt the second tumbler slightly with its rim under the rim of the first tumbler. Bubbles of air can be seen rising into the first tumbler.

With care the whole of the air can be poured into the first tumbler, and the second tumbler is then seen to be full of water.

Experiment 8. Hold a sheet of cardboard in the hand and swing it through the air edge on. You will find that the air offers very little resistance to the movement.

Now swing the cardboard round held upright. You will find that the resistance of the air is much greater.

Experiment 9. Repeat the last experiment, using sheets of cardboard of different sizes from six inches square up to two feet square (or the largest piece you can get).

You will find that the larger the sheet is, the greater is the resistance of the air.

Experiment 10. Hold a sheet of paper flat on the hand. Run along, gradually turning the hand over till the sheet of paper is being held up against the hand by the air pressing on it.

As soon as you stop, the paper drops.

Experiment 11. When you are flying a kite draw it rapidly against the air. You will see that the kite is pushed up by the air.

If there is no wind you will find that the kite begins to fall as soon as you stop pulling it against the air.

Try to fly a kite by pulling it in the same direction as the wind. Then notice the difference when you pull against the wind so as to get the full pressure of the moving air.

2. Air presses on things

It is rather difficult to detect the pressure of the air because usually air pressure in one direction is balanced by an equal air pressure in the opposite direction.

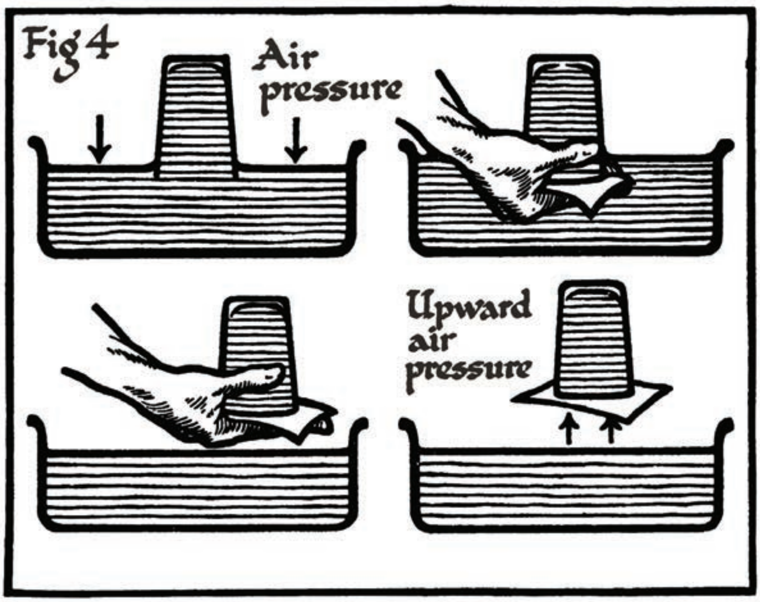
The pressure on one side of a door, for example, is usually balanced by the pressure on the other side. We do not notice the pressure at all.

But in coal mines, where air is driven down for ventilation, the air pressure is sometimes greater on one side of a door than on the other. It is then difficult to open the door against the pressure. Such doors usually have a hole in them with a slide over it. Before opening the door, the hole is opened. Air rushes through and equalizes the pressure on the two sides of the door. The door then opens easily.

In the following experiments it will be seen that air pressure on one side of a thing is reduced to show the effect of the air pressure on the other side.

Experiment 1. Fill a glass tumbler with water and upend it in a basin of water. Slip a piece of paper (a little larger than the mouth of the tumbler) over the tumbler. Hold it there on the flat hand. (Figure 4.)

Raise the tumbler out of the water. Take care that the paper is still flat over the mouth. Remove the hand



holding the paper up. It will be found that the paper and the water in the tumbler are held up by the air pressing up on the paper.

The upward pressure of the air is greater than the downward pressure of the water in the tumbler.

Experiment 2. Make a nail-hole in the bottom of a tin can, and another in the side.

Fill the tin with water and fit the lid on tightly. Hold the tin over a basin of water. Cover the hole in the side with a finger. You will find that the water does not run out. It is kept in by the air pressing up.

Open the hole in the side. The water begins to run out at once because the upward pressure of the air is balanced by the downward pressure of air which gets into the tin through the hole in the side.

Open and close the hole in the side several times, and note how the flow of water starts and stops.

Experiment 3. Cut out a round piece of leather. Make a nail-hole in the middle. Pass a piece of strong string through the hole and knot it below.

Leave the leather to soak in water for at least a day.

Put the sucker on a flat piece of stone or wood. Press it down tightly to squeeze out the air from underneath it. The stone or wood may then be raised by the string. The sucker is held down by the pressure of air above it which is not balanced by air pressure below it.

Slip a knife under the sucker. It comes away instantly because air gets in below it.

Press the sucker to a smooth wall and pull at the string to show the sideways pressure of air. The sucker may also be pressed to flat surfaces leaning in any direction.

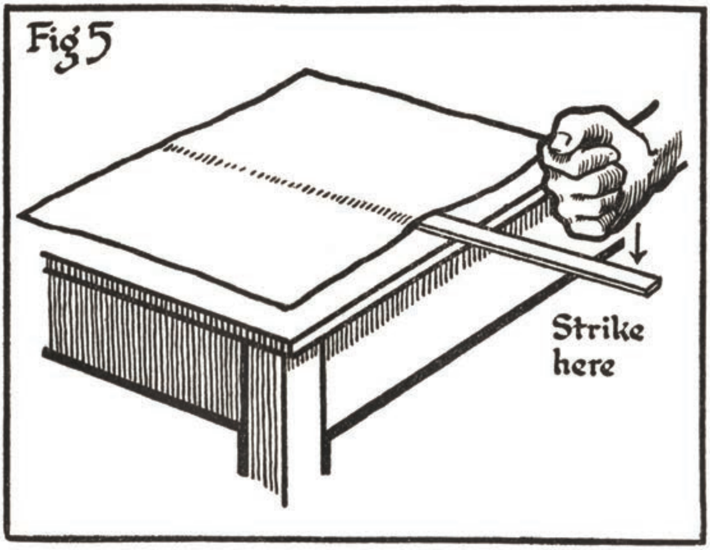
Experiment 4. Place a plate or a flat piece of tin on the table. Cut a potato in two and press a cut surface of the potato tightly on the plate. When the air has been squeezed out from under the potato the plate may be raised by means of the potato.

Experiment 5. Place a thin strip of wood sticking half its length over the edge of the table. Spread a newspaper flat over the part of the wood on the table.

Press the end of the wood gently. The newspaper is raised.

Now give the end of the wood a sharp blow. If you

Fig 5



strike sharply enough the strip of wood may break. (Figure 5.)

When you press gently, the air has time to get in under the paper to balance the air pressure above. When you strike sharply the pressure above is not balanced for a moment by air pressure below, and the wood is held down long enough for it to be broken.

Experiment 6. (*Note:* For this experiment use narrow tubing or wider tubing drawn out narrow at the end.) Hold a straight piece of glass tubing upright in water. Put a finger over the upper end and raise the tubing out of the water.

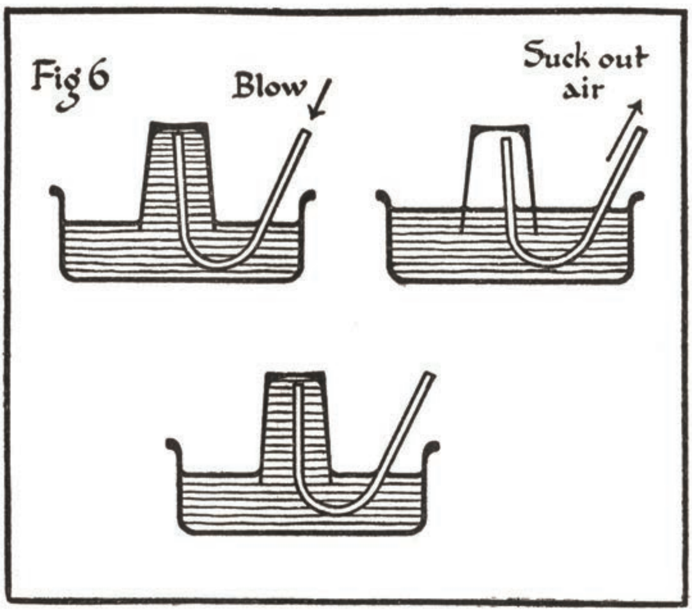
So long as the finger is kept in its place the water does not run out. It is kept in by the upward pressure of the air below. Remove the finger and the water runs out. The air pressure below is now balanced by the air pressure above.

A tube may be used in this way to carry small amounts of water from one jar to another.

3. *Air pressure*

Experiment 1. Fill a tumbler with water and upend it in a basin of water. Notice how the water is held up in the tumbler. The air pressing down on the flat surface of the water presses it up into the tumbler.

Experiment 2. Fill a tumbler with water and upend it in a basin of water. Pass a piece of tubing (rubber tubing or bent glass tubing) under the water and up to the top of the tumbler. (Figure 6.)



Blow down the tube. As soon as air reaches the top of the tumbler the water drops to the level of the water outside. The air pressure inside is now equal to that outside.

Increase the air pressure in the tumbler by blowing down the tube. The water begins to fall in the tumbler.

Reduce the air pressure in the tumbler by sucking air out of the tube. The water begins to rise in the tumbler. You may notice that if you leave the tube open before the water has risen to the end of it, the water at once sinks to the level of the water outside.

Experiment 3. Use a syringe to raise water out of a basin. Notice how the air pressure in the syringe is reduced by raising the plunger.

Experiment 4. Use a fountain-pen filler to raise ink. The air pressure is reduced by squeezing the rubber and then allowing it to expand.

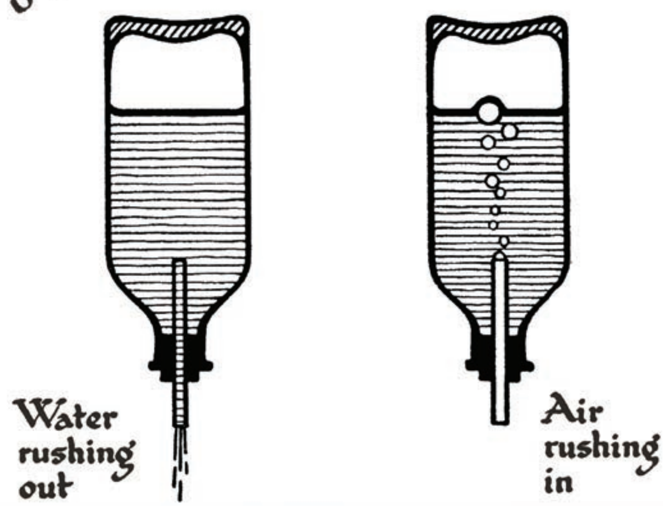
Experiment 5. Get a cork that will fit a soda-water bottle. Make a hole in the cork and push a piece of glass tubing through it. (If you have no other way of making a hole in the cork, use a large nail.)

Nearly fill the bottle with water, push the cork in, and see that the end of the tube is about two inches above the cork. (Figure 7.)

Hold the bottle cork down over a basin of water and notice exactly what happens. A little water runs out. This reduces the pressure above and air rushes in from below. This increases the pressure above and more water runs out. The process goes on till the bottle is empty.

Experiment 6. Fill a narrow-necked bottle with

Fig 7



water, upend it over a basin, and watch how the water runs out. You should be able to see that the process is the same as when a narrow tube was used. It may, however, be a little more irregular.

Experiment 7. Rubber tubing or a piece of bent glass tubing may be used as a siphon.

Place a jar of water in a raised position (for example, on a wooden box placed on the table). Place another jar below to catch the water that comes over.

Fill the tube with water by placing it in a basin of water or by sucking water into it. Close each end of the tube with a finger. Put one end of the tube into the jar of water and lower the other end over the jar below.

Open the ends of the tube. Water will be seen to run out so long as the ends of the tube are below the level of the water surface.

Let the water go on running till it stops. Find out why it stops.

You might also try to raise water to a higher level by siphoning. You will soon find that you cannot.

If there were no air pressure the water in the bent tube would simply run out on either side. The air pressures at the ends of the tube balance, but in the longer limb there is a greater length of water pressing down, so the water runs down at that side.

Experiment 8. If you have a bottle of preserved fruit you will find that the lid is tightly fixed on. Make a small hole in the lid and it comes off at once.

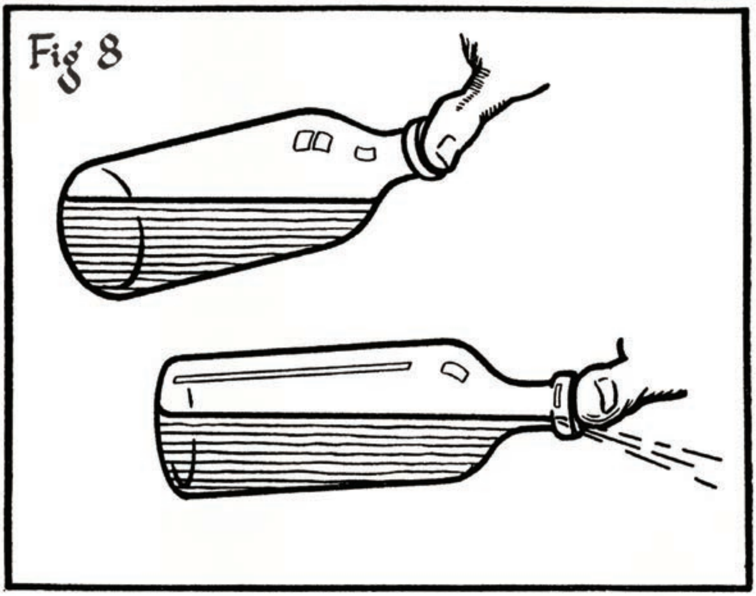
The lid is placed in position when the top of the bottle is full of steam. When the bottle cools the lid is held down by the pressure of the air.

Experiment 9. Blow into a football bladder or a toy balloon. Notice that it fills out evenly, showing that the pressure of the air is the same in all directions.

The same even effect may be noted when air is pumped into a bicycle tyre.

4. Air is elastic

Experiment 1. Fill a narrow-necked bottle one-quarter full of water. Blow hard into the bottle and at once close it with your thumb. Tilt the bottle till the mouth is under water. Then open the mouth slightly. Water will be sent squirting out. After a little practice you will find that you can squirt it some distance. (Figure 8.)



When you blow into the bottle the air in the bottle is compressed. As soon as you remove your thumb it springs back to its former size and so drives out the water.

The pressure of compressed air is used to drive machines, especially in coal-mines where steam or oil would be dangerous.

Experiment 2. Wet an india-rubber ball and throw it on the floor. You will find a round wet mark where it hits the floor. This shows that the ball was squeezed up or compressed when it hit the floor. To see the amount of squeezing, put the ball on the mark and press it down till it just fits on the mark.

The ball jumps back because the compressed air at once springs back to its former size. To show that this is so drop two balls together, one with a hole and the other without. If the hole is at all big the ball bounces very feebly.

Experiment 3. Close the end of a garden syringe. (This can be done with clay or plasticine.) Then ram the plunger down hard and let go.

You will feel the cushioning effect of the air. When you let go the plunger it will be driven back by the spring of the compressed air.

Experiment 4. Blow out a toy balloon and close the opening. Press the balloon gently with the fingers. It gives way but recovers its shape when the pressure is removed.

The same effect may be noted with an india-rubber ball.

Experiment 5. If any kind of pop-gun is available use it and find out how it works. You will find that air is compressed and then suddenly released. It quickly recovers its former size and drives before it the cork or whatever was put in its way.

Experiment 6. Get a bottle with a long straight neck and a cork to fit it.

Fill the bottle nearly full of water. Try to push in the cork. You will find that the air pushes it back.

Experiment 7. If there is a small room with a door opening outward close all the openings and repeat the experiment of trying to close the door quickly.

You will feel the cushioning effect of the air. This effect is used in air-cushions of various kinds. Pneumatic tyres are a kind of air-cushion. Watch a bicycle moving slowly. You will see that the tyres give slightly where they touch the ground and at once recover their shape.

Experiment 8. On a calm day close all the openings in a room except one window. Pin some thin strips of paper so that they hang across the opening.

Jerk the door open five or six inches. The shock is carried through the air and the streamers are pushed out almost instantly. Jerk the door back and the streamers are pushed in by the air outside.

Note that the pressure of the door on the air is carried to every part of the room. The effect is seen at the windows because the streamers show it there.

5. Things need air to burn

Experiment 1. Light a candle, place it on the table, and put a large glass jar over it. Notice that the candle soon goes out.

Repeat the experiment. Just as the candle is going out raise the jar to admit more air. The candle will burn up again.

Experiment 2. Try other methods of cutting off the supply of air.

Set fire to a piece of sulphur on a tin lid. Then cover the burning sulphur with sand.

Set fire to another piece of sulphur and cover it with a piece of wood or tin for a short time.

Experiment 3. Try to set fire to the pages of an old magazine. You will find it difficult because the pages are so close together that there is little air between them.

Now raise the pages one by one to admit air, and they burn readily. Or crumple the pages.

Experiment 4. Set fire to a sheet of paper. Try to put it out by waving it about. It burns better because it is continually being brought to fresh air.

Now lay a sheet of burning paper flat on the table or the floor. The paper burns badly or goes out because very little air can get to it.

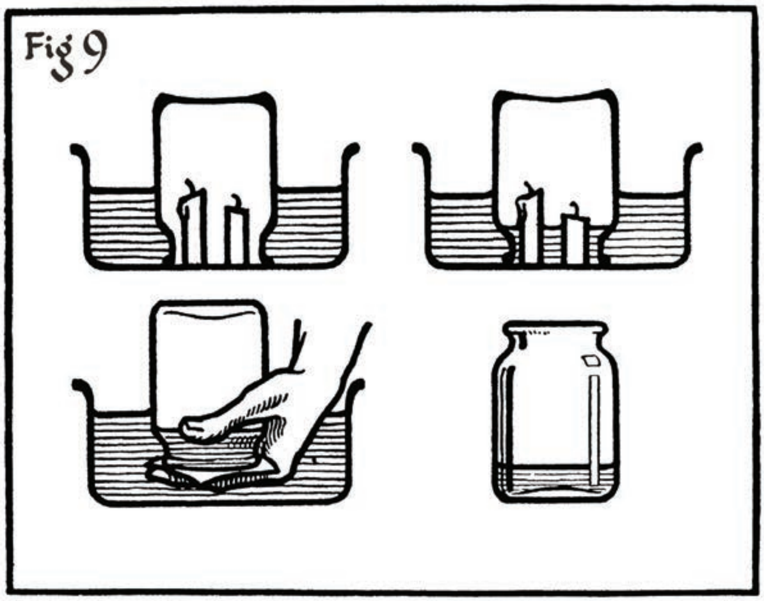
Experiment 5. Make a small fire of crumpled paper on the ground. Cut off the supply of air by putting an old rug or mat over it.

This is the method to use if your clothes should catch fire. Do not feed the fire by rushing into fresh air, but smother it by cutting off the supply of air.

Experiment 6. Fix two candles upright on the bottom of a basin of water. (One candle should be longer than the other.) (Figure 9.)

Light the candles and place a jar over them. The candles soon go out. Leave the jar to cool. When the jar is cold you will see that water has risen into it showing that some of the air has been used up.

Slip a piece of cardboard over the mouth of the jar, raise it out of the water, and turn it mouth up and



still covered. Light a taper or a paper spill, remove the cardboard cover, and put the taper into the jar. The taper goes out at once. It will not burn in the gas left.

The part of the air which makes things burn is called oxygen. The remainder (in which a taper does not burn) is chiefly nitrogen.

Experiment 7. Rinse a glass jar (a jam jar) with water. Sprinkle the inside with iron filings. Upend the jar in a basin of water and place a weight on it to keep it steady. Treat other jars in the same way.

Watch the jars day by day. You will see that water gradually rises in them and then ceases to rise.

Take one jar out of the water and plunge a lighted taper or spill into it. The taper goes out at once.

Measure the amount of water that has risen into one of the jars. (Either use a measuring jar or weigh the water.) Measure also the amount of water the jar holds when it is full. You will find that it is about five times as much.

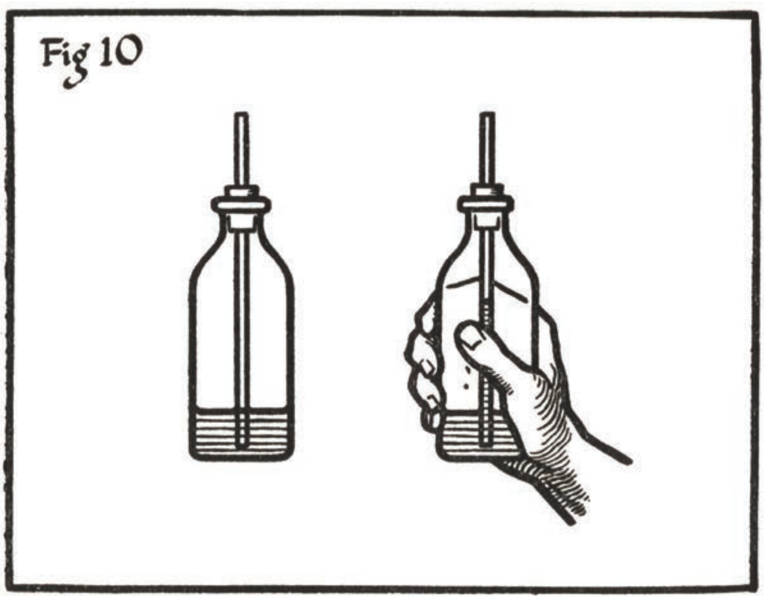
One-fifth of the air is oxygen and four-fifths nitrogen.

6. *When air is heated*

The difficulty of showing the effect of heat on air is that air is invisible. A drop of coloured water may, however, be used to show how far air extends in a tube.

Experiment 1. Cork a bottle tightly with a cork having a piece of glass tubing through it. Before pushing in the cork dip the end of the tube in coloured water. When the cork is in place the drop of water should be just clear of the cork.

Fig 10



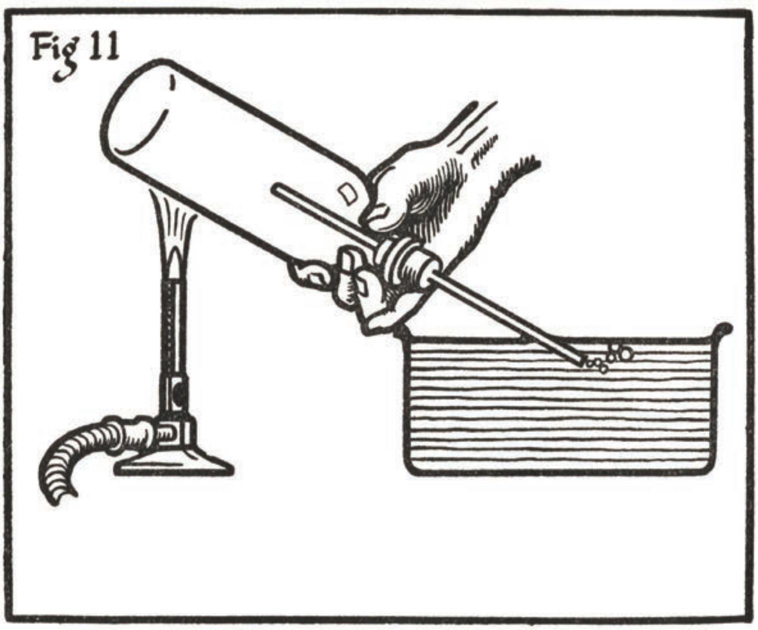
Place the bottle on its side and heat it gently by holding it in the hands. It will be seen that the water moves out, showing that the air in the bottle has expanded.

Experiment 2. This is a warm air toy. (Figure 10.)

Get a small bottle which can be held comfortably in the hand. Put some red ink in it and cork it with a cork through which passes a piece of narrow glass tubing. The tubing should reach to the bottom of the bottle. The cork may be waxed to keep it airtight.

Hold the bottle in the hand. The expanding air drives the red ink up the tube. The point is to see how far you can raise it.

Experiment 3. Use the same bottle as in Experiment 1. (Figure 11.)



Fix the bottle upright with the end of the tube passing under water in a basin. (The bottle may be held in a retort stand, or tied to a rod across two piles of books, or simply held in the hand.)

Heat the bottle gently by allowing a small gas flame to flicker about it. The expanding air will be seen bubbling through the water.

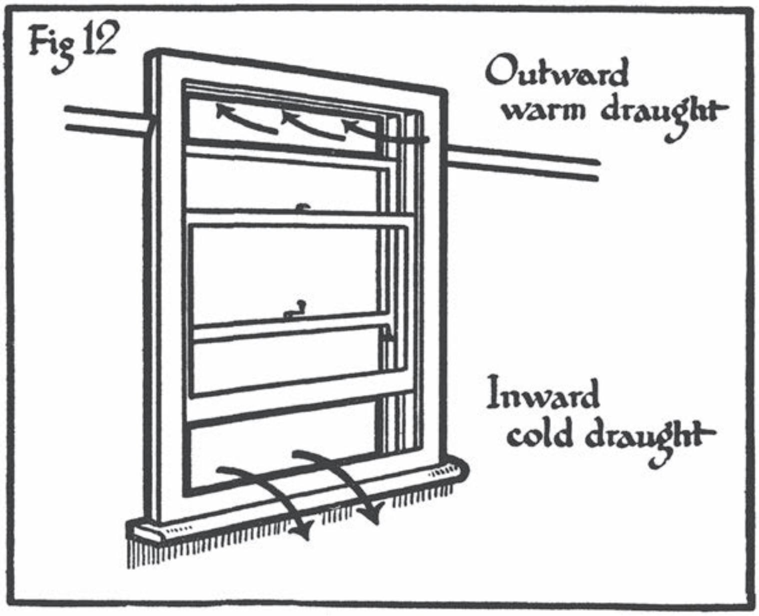
Leave the bottle to cool. The pressure of the air outside being now greater than that inside, will force water up the tube into the bottle.

Notes: i. If you have any difficulty in seeing that hot air is lighter than cold air, think of a bottle of air. When the air is heated it expands and some pours out. There is the same volume of air as before (the bottleful), but there is less weight because some of the air poured out.

ii. It is sometimes said that "hot air rises". This is only true in the sense that any heavy thing rises—when it is pushed up. Hot air is often pushed up by heavier cold air.

Experiment 4. Close the door and windows of the room. Hang a thermometer near the ceiling for ten minutes and note the temperature. Find the temperature also near the floor. Usually the temperature is higher near the ceiling. The light warm air is above the heavier cold air.

Experiment 5. On a calm day close all the openings in the room except one window. Leave this window open an inch or two at top and bottom. (Figure 12.)



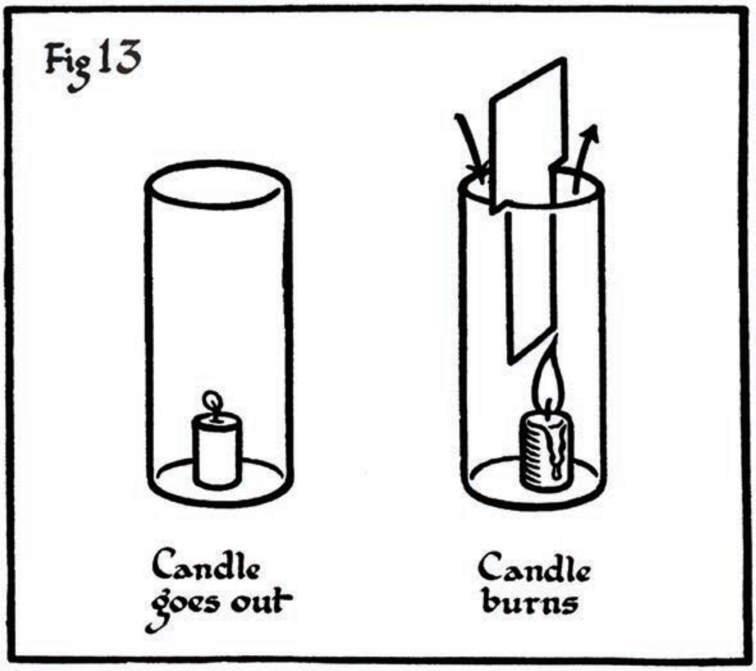
Hold a piece of smouldering paper near each opening in turn. The smoke will show an inward current below and an outward current above.

Windows should be left open above and below for ventilation. The inward current of cool fresh air will drive out the warm stale air above.

Experiment 6. Light a candle, place it on the table, and put a lamp chimney over it. If the chimney fits down flat the candle will soon go out.

Light the candle again and put the lamp chimney over it. Just as the candle is going out raise the chimney slightly. The rush of cold air from below drives out the hot used up air and the candle burns up again.

Experiment 7. Cut a strip of paper or thin card that will just go into the lamp chimney. (Figure 13.)



Light a candle and put the chimney over it. Just as the candle is going out push the paper down into the chimney a little to one side of the candle. The candle will burn up at once.

Hold a piece of smouldering paper above the chimney, first at one side of the paper and then at the other side. The smoke will show that there is a downward current on the side away from the candle, and an upward current above the candle.

(At first all the air above the candle was heated and there was no cold air to drive it up. This is a case where hot air does not rise—because it is not pushed up.)

Summary: Science of the Air

How we know there is air

Although we cannot see air we know it is all about us because of its effects. For example, water does not enter a bottle unless the air in it is allowed to escape.

Air resists the movement of things through it. The greater the moving surface the greater is the resistance of the air.

Air pressure

Air pressure on one side of a thing is usually balanced by an equal pressure on the other side, so that the effects are not observed. When the air pressure is not balanced it is seen to be very great. (The pressure of air is about fifteen pounds on every square inch of surface.)

Water is raised in a syringe by decreasing the air pressure inside the syringe whilst the pressure outside remains unchanged.

Water may be moved from one vessel to another at a lower level by siphoning. The air pressures at the ends of the siphon tube balance, but in the longer limb there is a greater length of water pressing down.

Air pressure at any point is the same in all directions.

Air is elastic.

Things need air to burn

Things do not burn unless there is a constant supply of air.

In burning, part of the air is used up. This part is called oxygen and forms about one-fifth of the air. The remaining four-fifths is chiefly a gas called nitrogen, in which things do not burn.

Heated air

When air is heated it expands. A result of this is that warm air is lighter than cold air.

Rooms are best ventilated by leaving windows open both top and bottom. An inward stream of heavier cold air below drives out the lighter warm air above.

There is a strong draught up chimneys because the hot air in the chimney is forced up by the heavier cold air outside.