pressure in the two tubes, and the atmospheric pressure on the water in the tumblers lifts the water into the tubes.

Experiment 63. Unequal columns.

Put a large handful of salt into a tumbler partly filled with water and stir until the salt is dissolved. Now pour fresh water into another tumbler until it is at the same height as the salt water. Make the arms of equal length, put one arm in the salt water and the other in the fresh water, then suck a little air out of the top coupling and close it with a plug. Do you find that the column of salt water is shorter than the column of fresh water (1, Fig. 83)? It is shorter because salt water is heavier than fresh water.

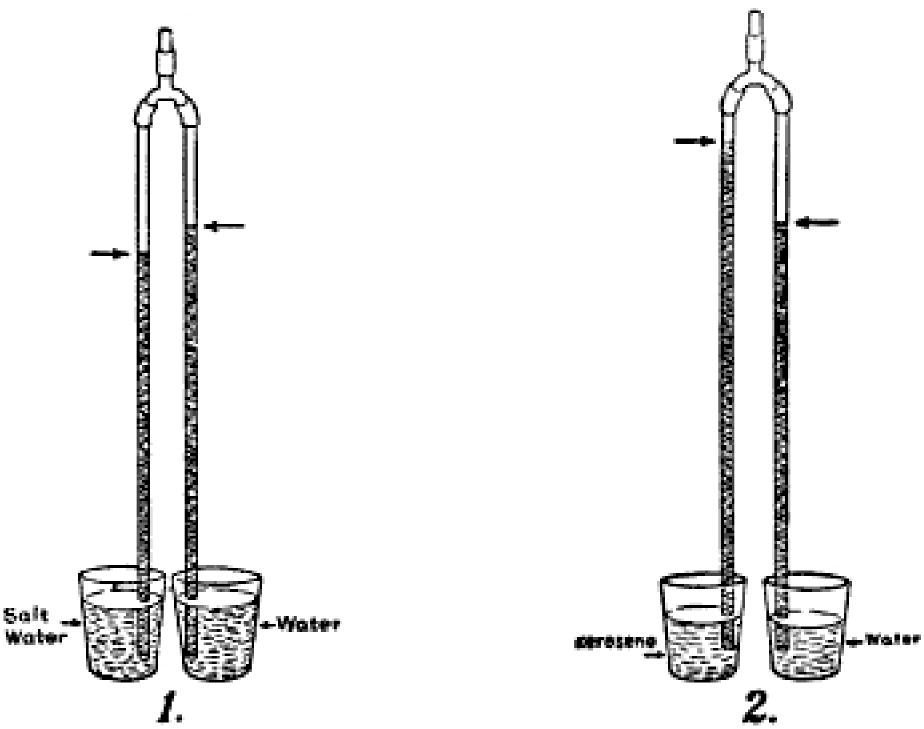

FIG. 83

UNEQUAL COLUMNS

If you have gasoline or kerosene convenient till one tumbler half full of either, and the other tumbler half full of water, then repeat the experiment. Do you find that the column of gasoline or kerosene is longer than the column of water (2, Fig. 83)? It is longer because gasoline and kerosene are lighter than water.

Experiment 64. To fuse wire into glass.

Find a piece of thin iron or copper wire about 4 inches long, heat the end of a piece of No. 2 tubing until it is nearly closed, insert the iron or copper wire into the small hole, and heat the glass around the wire until it shrinks and grips the wire firmly (Fig. 84). The glass then serves as a handle for the wire.

FIG. 84

WIRE FUSED INTO GLASS

It is difficult to make a secure joint between iron or copper wire and glass because they both expand and contract more than glass when heated and cooled. It is easy to make a secure joint between platinum wire and glass because platinum and glass expand and contract at practically the same rate when heated and cooled. Platinum, however, is too expensive to be used for ordinary experiments.

Experiment 65. To cut window glass.

The common glass cutter is a small very hard steel wheel

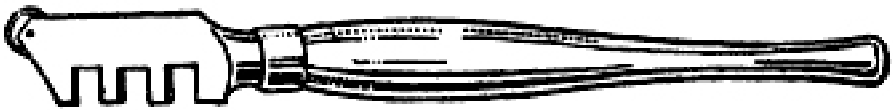

FIG. 85

A GLASS CUTTER

mounted on a handle (Fig. 85). Practice with one on a pane of glass: place a ruler on the glass, draw the wheel along the ruler (Fig. 86) with sufficient pressure to scratch the glass, place the under side of the scratch exactly over the edge of the table, and press down on both sides.

Experiment 66. To bore a hole in glass.

Place a piece of window glass flat on the table, pour a little kerosene on the spot to be bored, clasp the file near the end, press the end down hard on the spot and turn it back and forth with a gouging motion (Fig. 87). You twist the file just as you would twist an awl to force it into hard wood.

You will soon penetrate the surface; use plenty of kerosene and continue the boring until you are nearly through; then turn the plate over and start a hole on the other side to meet the one you have made.

FIG. 86

CUTTING A PANE OF GLASS

Do not rush things; it will take you ten or fifteen minutes to bore through ordinary window glass.

Bore a hole in a bottle in the same way, except that the boring is all from the outside.

If the end of the file becomes dull, break off a small piece, with a pair of pliers, to expose a fresh surface.

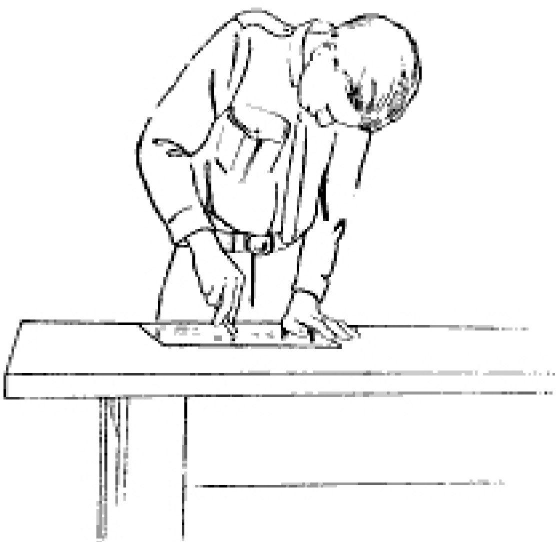

FIG. 87

BORING A HOLE IN GLASS

Experiment 67. To cut a bottle in two.

Wind a strip of blotting paper or wrapping paper 2 inches wide around the bottle at one side of the line along which you wish to cut. Make three or more thicknesses and then tie the paper with cord within ½ inch of the edge to be cut. Wrap another similar piece on the opposite side of the place to be cut and 3/16 inch from the first piece (Fig. 88).

FIG. 88

BOTTLE READY TO BE CUT IN TWO

Now stand the bottle in a pail of water until the paper is thoroughly wet (about five minutes), take it out, rotate it in a horizontal position and direct the blowpipe flame against the glass between the papers (Fig. 89).

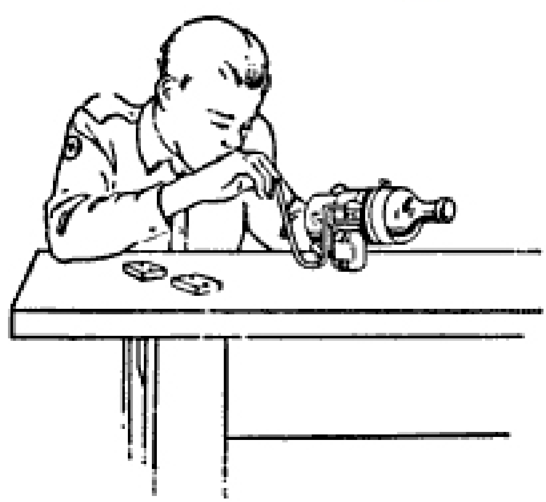

FIG. 89

HEATING THE BOTTLE

Continue this for four or five minutes, then if the bottle has not dropped apart, plunge it vertically into the pail of water.

The bottle will break into two parts along the line between the two papers (Fig. 90). If it does not do so, repeat the operation until it does. Smooth the rough edges outside and inside with the file. You cannot do this with the flame because the glass is too brittle.

Experiment 68. To grind glass.

Rough edges of glass can be ground smooth by means of emery paper. For example, to smooth the edges of the glass bottle you have just cut in two, use the file for the rough work, then lay a piece of emery paper on a plate of glass, emery side up, pour a little kerosene on it and rub the rough surface on the emery with a rotary motion (Fig. 91).

FIG. 90

THE BOTTLE CUT IN TWO

Finish with fine emery paper, and smooth the edges inside and out with the fine paper.

FIG. 91

SMOOTHING THE EDGES

Experiment 69. To cement glass.

There are two important points to remember in cementing glass: first, to get the glass clean, and second, to press the surfaces together after applying the cement, to squeeze out as much of the cement as possible, and to keep them pressed together until the cement in hard. To clean the glass wash it thoroughly with soap and water, rinse, and dry with a clean cloth.

There are many excellent glass cements on the market. Some of these are solid and used only on hot glass; others are liquid and are used on cold or hot glass.

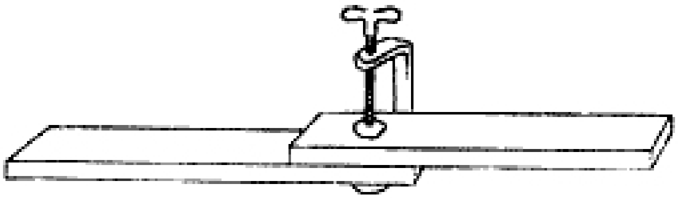

FIG. 92

CEMENTING GLASS

Cement two strips of glass together (Fig. 92) with sealing wax or solid shellac or some other solid cement as follows: Clean the glass thoroughly, place in the oven or on the stove, heat gradually until the glass just melts the cement, rub the cement over both surfaces, bring them together when the cement is fluid, press them together to squeeze out as much cement as possible, and keep them pressed together until the cement is hard.

Cement a strip of wood to a strip of glass in the same way.

Cement a strip of wood to a strip of glass with liquid glue, both wood and glass being cold. Keep them pressed together until the glue is dry, perhaps a day or two.

MAGICAL EXPERIMENTS

Boys, you can perform many magical experiments with apparatus made out of the glass tubes, rubber stoppers, and rubber unions supplied with "Experimental Glass Blowing." We outline a number in the following pages. You can invent many more for yourselves.

MAGIC WITH FLAMES

Experiment 70. Magic lighting.

Light your alcohol lamp, blow it out, and bring a lighted match down toward the wick from above (Fig. 93). Does the lamp light in a most magical manner **before the match touches the wick**?

Repeat this with a kerosene lamp and with a candle. Do they light in the same magical manner?

FIG. 93

MAGIC

The "why" of it

When the lamp is lighted, the alcohol or kerosene turns to gas, and it is the gas which burns; when the candle is lighted, the wax turns to an oil, the oil turns to a gas, and it is the gas which burns.

The gas rises from the wick for a short time after the flame is blown out, and it is this gas which lights when you bring the match down toward the wick.

Experiment 71. Air used by flames.

Drop melted candle wax on a tin can cover and attach the bottoms of two candles to the cover (Fig. 94); use one candle about

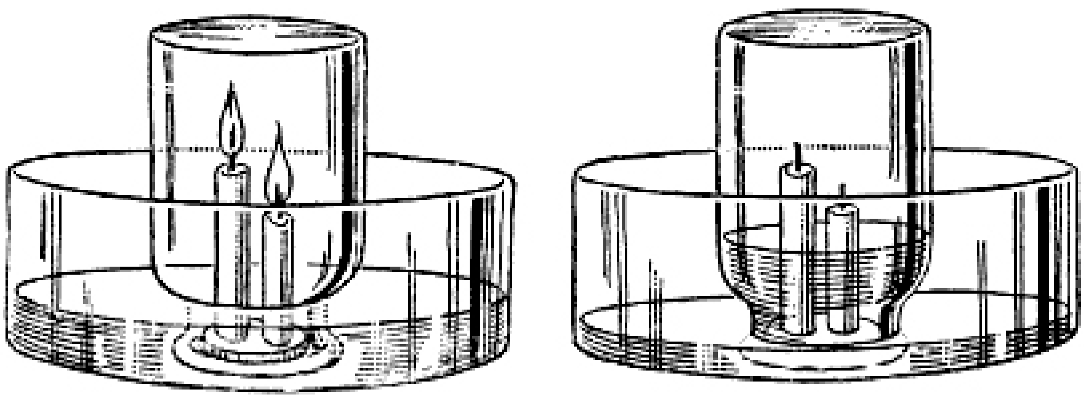

FIG. 94

THE CANDLES GO OUT AND THE WATER RISES

4 inches long and another about 3 inches, stand them upright in a pan of water, light them, and invert a wide-mouthed bottle over them. Does some air escape at first due to expansion, do both candles go out, the taller one first, and does the water rise until the bottle is abut one-fifth full?

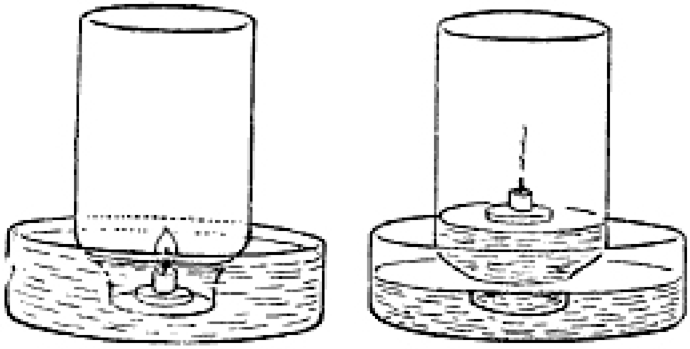

FIG. 95
THE CORK RISES

Cut a piece of candle ½ inch long, float it on a flat cork or can cover in the pan of water, light it, and invert a fresh empty bottle over it (Fig. 95). Is the result similar?

The "why" of it

The water rises in the bottle because 1/5 of the air is used up by the burning candle. Air is 1/5 oxygen and 4/5 nitrogen. The oxygen unites with the burning gas of the candle and produces water vapor (H_2O) and carbon dioxide (CO_2); the nitrogen takes no part in the burning.

The water vapor (H_2O) condenses to water on cooling and takes up very little space. The carbon dioxide remains a gas and occupies space, but this is offset by the volume of the air which escaped at first. The result is that the volume of gas at the end is about 1/5 less, and the atmospheric pressure on the water in the pan lifts water into the bottle.

The candle goes out because it must have oxygen to burn and the oxygen is used up.

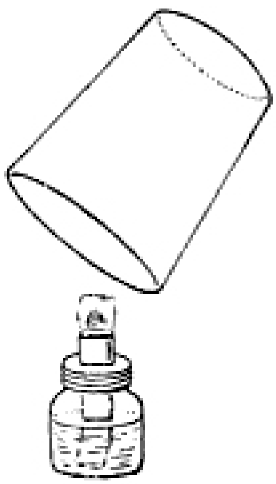

FIG. 96
WATER FROM
FLAME

Experiment 72. Water produced by fire.

It is certainly magic to produce water from fire, but you can do it easily as follows:

Hold a clean, dry, cold tumbler over your alcohol lamp flame (Fig. 96). Does water deposit in the form of mist on the inside of the tumbler?

Repeat with fresh tumblers with the flame of a kerosene lamp and of a candle. Are the results similar?

Direct the blowpipe flame into the end of a piece of No. 2 or No. 4 tubing. Does water deposit in drops inside the tube about 1 inch above the end?

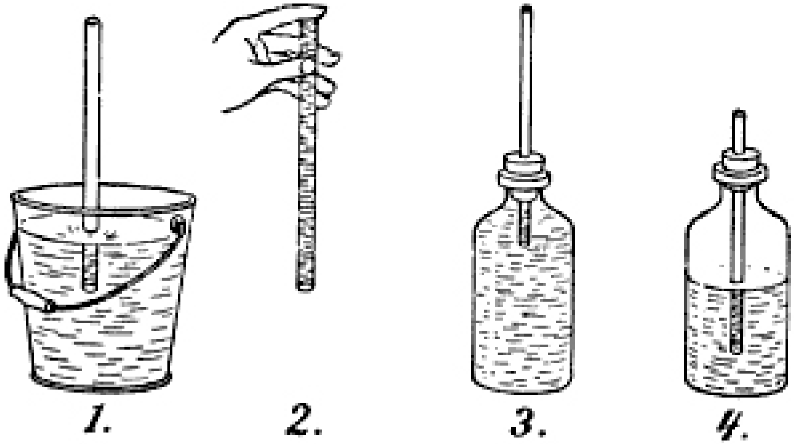

FIG. 97

ATMOSPHERIC PRESSURE

The "why" of it

One of the chief constituents of alcohol, kerosene, and candle wax is hydrogen (H), and when this burns in the oxygen (O) of the air, it produces water (H_2O). It is this water which condenses on the cold glass.

MAGIC WITH AIR

Experiment 73. Atmospheric pressure.

Arrange a No. 6 tube as in 1, Fig. 97, and suck air out at the top. Does the water run uphill into your mouth?

Hold your finger over the top and lift the tube out of the pail (2). Does the water remain in the tube? Fill a bottle with water to overflowing, insert a No. 2 tube into your one-hole stopper, insert the stopper into the mouth of the bottle (3) without admitting air below the stopper, and try to suck water out of the bottle. Do you find that you cannot do so?

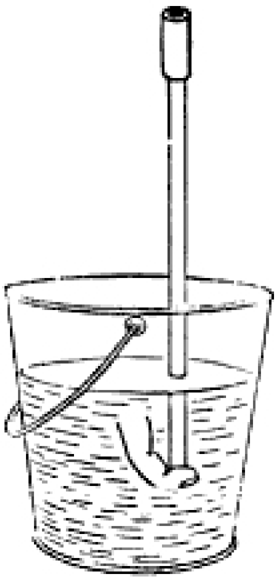

FIG. 98
WATER DRIVEN UP TUBE BY ATMOSPHERE

Repeat (3) with the bottle half full of air (4). Do you find that you can now suck part of the water out of the bottle, and all of it if you admit air?

The "why" of it

The atmosphere which surrounds the earth exerts a pressure of 15 pounds per square inch at the earth's surface. It exerts this pressure equally downward, sidewise, and upward.

It is this atmospheric pressure on the water in the pail (1) which lifts the water into the tube when you decrease the pressure on the water in the tube by sucking out air and then water.

It is this pressure upward that supports the water in 2.

The water does not rise in 3 because the atmosphere cannot exert pressure downward on the water in the bottle.

The rise of the water in 4 is due to another fact, namely, that any gas expands when the pressure on it is decreased. When you suck air out of the tube you decrease the pressure on the water in the tube and thereby on the air in the bottle; the air then expands and lifts the water into your mouth.

Experiment 74. Great pressure of air.

With the apparatus Fig. 98

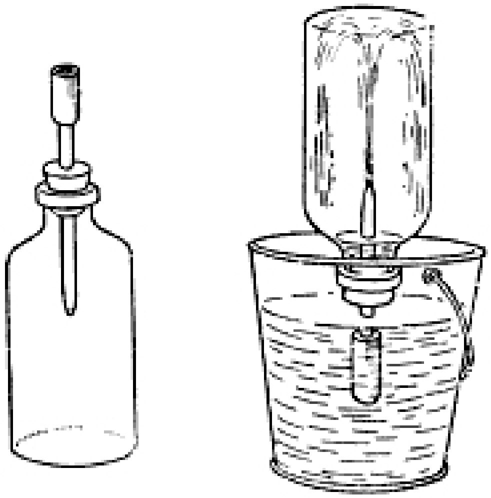

FIG. 99
A FOUNTAIN