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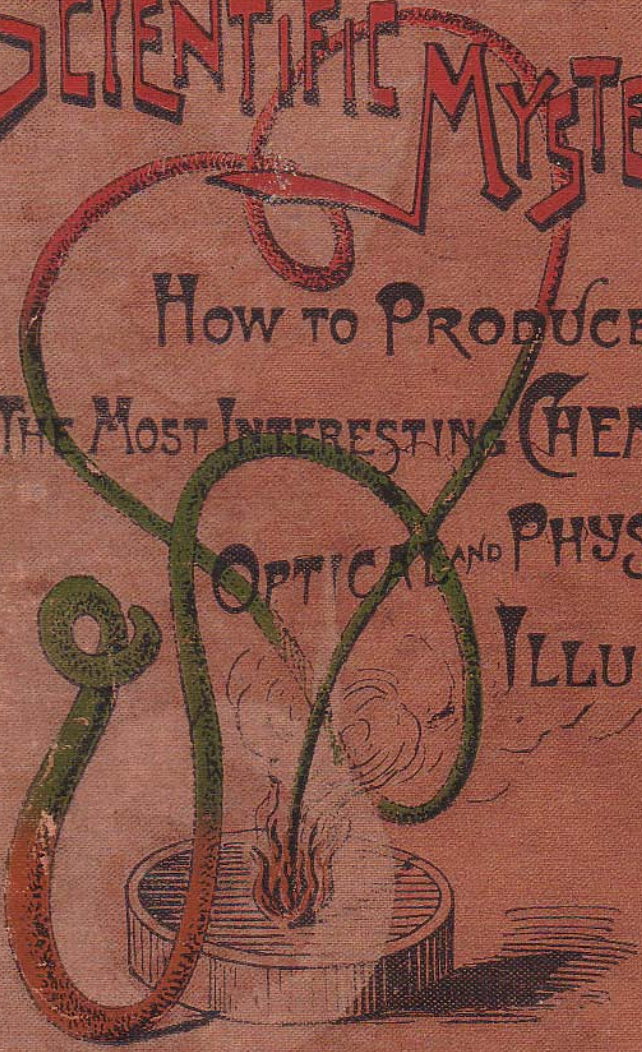

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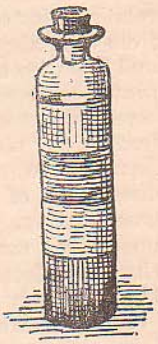
CONTENTS

SCIENTIFIC MYSTERIES.

ANCIENT AND MODERN CHEMISTRY.

'THE FOUR ELEMENTS.'

The evolution of chaos into earth, air, fire, and water can be represented in the following manner:—In a narrow phial or glass tube pour mercury to the height of one-fourth of its capacity; for the next fourth, add a saturated solution of subcarbonate of potash; next fourth, methylated or pure spirit of wine, tinted blue; and, lastly, turpentine tinted red. On shaking this mixture together you will have a representation of chaos; but soon, on resting, the elements will separate themselves, and the mercury will represent earth, the blue spirit air, the red turpentine fire, and the colourless potash solution water.



THE FOUR ELEMENTS.

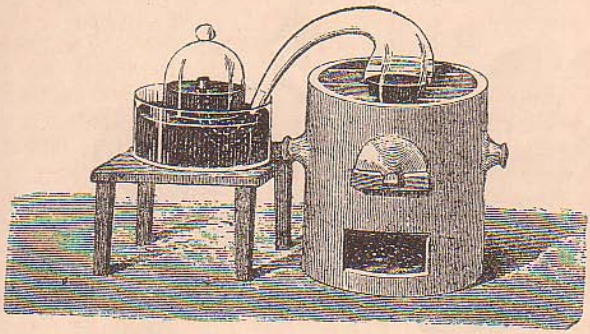
There is nothing very wonderful in the mixture described above, but it will serve the chemical lecturer as an introduction to a short sketch of the evolution of ideas concerning elements and chemical compounds. Aristotle himself, to whom the theory of 'the four elements' is credited, was too clear-sighted to use the expression in just the sense that it would be understood now. But, in a general way, earth, air, fire, and water were regarded as the elementary constituents of

creation until about the middle of the seventeenth century, when the famous Robert Boyle dealt with the idea critically in his ' Sceptical Chymist.' The progress of scientific knowledge was satisfactory in the latter half of the seventeenth century, but just as the eighteenth century opened, a German chemist named Stahl introduced the extraordinary phlogiston theory, which checked advancement and confused the great chemists of Europe for nearly the next hundred years. His proposition was that phlogiston was a constituent of all inflammable bodies, and that when a substance burned it was parting with its phlogiston, and that part of matter which could be no further consumed he called ' dephlogisticated.' When it was objected that when metals were burned or calcined they became heavier (actually, as we now recognise, because they have combined with oxygen obtained from the atmosphere), the answer of the Stahlian theorists was that in parting with their phlogiston they had parted with the principle of levity. The absurdity of this attempted explanation did not dispose of the theory as it should have done.

In the second half of the eighteenth century Scheele in Sweden and Priestley in England both separated oxygen gas from the atmosphere, and would have discovered the wonderful relationships of the gases if they could have freed their minds from the phlogiston delusion. Scheele called oxygen fire-air, and Priestley called it dephlogisticated air. Cavendish, who proved the compound character of water about the same time, regarded the inflammable gas hydrogen, which he separated from it, as ' phlogisticated water.' It was the French chemist Lavoisier, who, about 1780, gathered together the chemical discoveries of his contemporaries, and first revealed their true bearing. From his day onward the truth has been understood that nothing in nature is ever lost ; and that the changes effected by fire, decay, or chemical action of any kind, are only redistributions of elements.

The drawing on page 3 exhibits the apparatus which Lavoisier constructed to prove that in chemical changes matter is only transferred, not destroyed. It must be understood that Priestley and Scheele had led the way in examination of the atmosphere. Lavoisier was at this time concerned to prove the truth of the theory which he had asserted, that ' Nothing is created, nothing is lost, in nature.' Distilling mercury into a vessel in the upper part of which was a gradu-

ated enclosed space containing air, he found that in the superheated condition a red pellicule of oxide of mercury was formed on the surface of the metal. As this formed the volume of air diminished. When the volume of air was reduced by about one-sixth, it remained constant, and no more oxide of mercury was formed. The air which remained in the glass bell was what we now call nitrogen. From the fact that it was incapable of supporting life, Lavoisier named it *azote* (from the Greek *a*, privative, and *zoe*, life). Scheele had called it *aër mephiticus*. Lavoisier proved that his mercury had increased in weight by just so much as the air had lost, and he also, by the action of heat, extracted the gas from the



LAVOISIER'S APPARATUS.

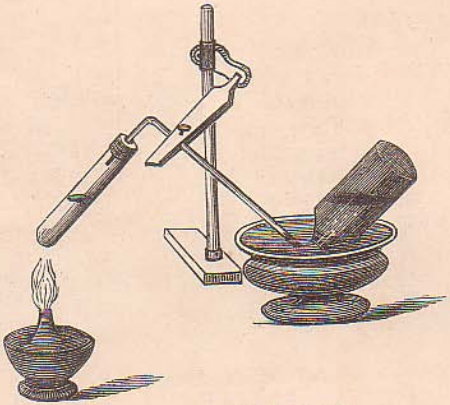
red oxide, leaving behind the mercury. The gas he at first called 'vital air,' but afterwards named it oxygen, from Greek words signifying that it generated acids. It may be here stated that the gases oxygen and nitrogen, which form the atmosphere, are not in that combination chemically united. They form simply a mixture, the nitrogen serving merely to dilute the too active oxygen. These gases are at present reckoned among the elements.

At present about sixty-six bodies are recognised as elements. These, as far as is known, constitute the whole of the created universe, mostly in combination. It is probable that some of these bodies will be found to be themselves compound, and it is pretty certain that other elements will yet be discovered.

In the experiments given in the following pages we shall show certain of the characteristics of some of the most interesting of these bodies which are known to chemists.

COLLECTING GASES.

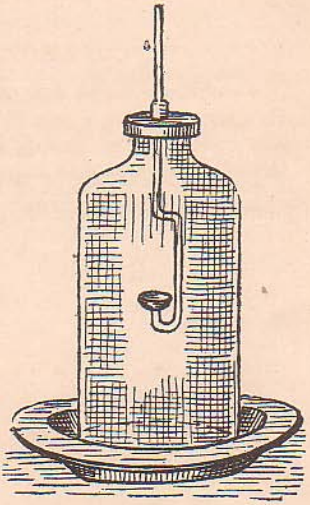
Before describing a few of the experiments which may be performed with the gases it is necessary to explain the very simple process of collecting them. If a bottle full of water be inverted into a tub or basin of water, and unstopped under the surface of the water, the liquid will remain in the bottle.

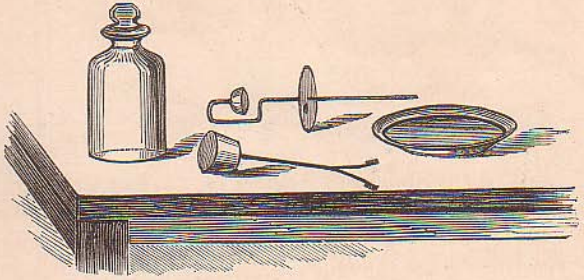


COLLECTING A GAS OVER WATER.

If now the delivery-tube of a retort or flask in which a gas is being produced be brought into the basin of water the gas will ascend from it in bubbles. By directing these bubbles into the bottle as it is still held inverted in the water, the gas will rise into the bottle, displacing the liquid as it ascends. When the bottle is filled with the gas, it can be tightly stoppered under the water, and can then be set aside. The figure above shows the collection of gases in a narrow-mouthed bottle. In a well-arranged laboratory a pneumatic trough is used. This is shown in the drawing under Oxygen (page 6). It is simply a small cistern provided with a ledge on which the

bottles in which the gas is to be collected can stand; but for a pneumatic trough any tub or basin can be substituted, into which, when partially filled with water, the vessel to be filled with the gas is when full of water inverted, as shown in the first drawing. For the collection of some gases it is convenient to use a vessel called a deflagrating-jar. This is used chiefly for experiments with oxygen. It is tightly stoppered, but has no bottom. To be filled with gas, the jar is first filled with water, a tray or plate being placed over the bottom until the jar is brought into position in the pneumatic trough. When filled with gas the tray is again placed under the jar, while still beneath the surface of the water, and it is thus





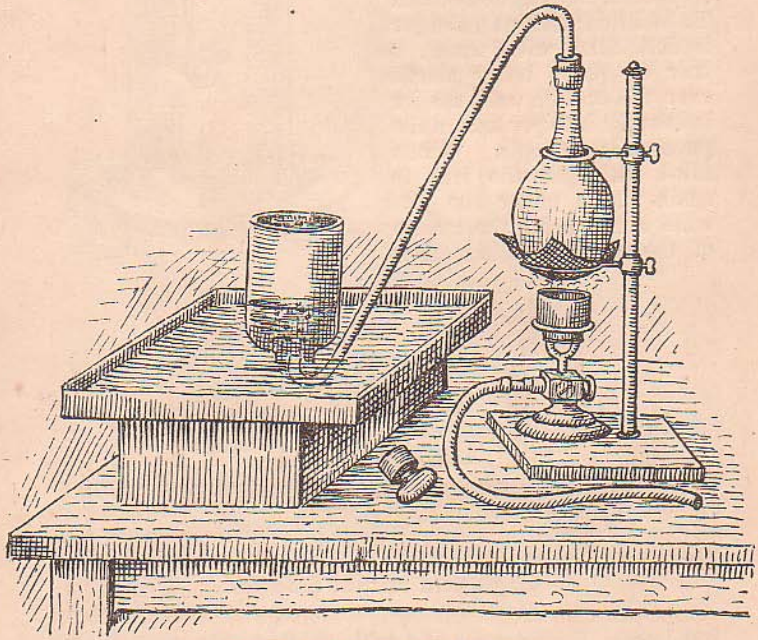
GAS-JAR WITH DEFLAGRATING-SPOON.

lifted out. For experiments with sulphur, phosphorus, &c., in oxygen, the stopper is removed and the chemical inserted in the gas in the deflagrating-spoon shown in the engraving.

EXPERIMENTS WITH THE GASES.

OXYGEN.

Place in a small retort or a hard glass flask 1½ oz. chlorate of potass and ¼ oz. black oxide of manganese, both dried and

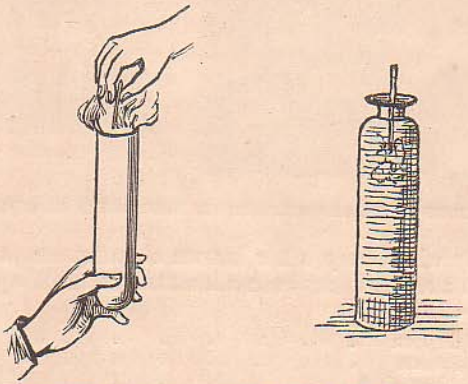


COLLECTING OXYGEN IN PNEUMATIC TROUGH.

finely powdered. Fit a delivery-tube to the apparatus to collect over water. Heat at first cautiously, and as soon as

the flask is thoroughly warmed through heat strongly. In a few moments the gas will be seen bubbling through the water at the end of the delivery-tube. Obtain four or five bottles, and fill them with the gas in the method described in the previous section, or by the aid of a pneumatic trough as illustrated on the opposite page. Set aside the bottles filled with gas for the experiments figured below.

Light a match and then blow it out, leaving the end glowing, and plunge it into one jar: it will be rekindled with a brilliant flame. Bring to red heat the end of a spiral of steel watch-spring wire, and plunge it into a second: the iron will burn, giving off a series of beautiful sparks.



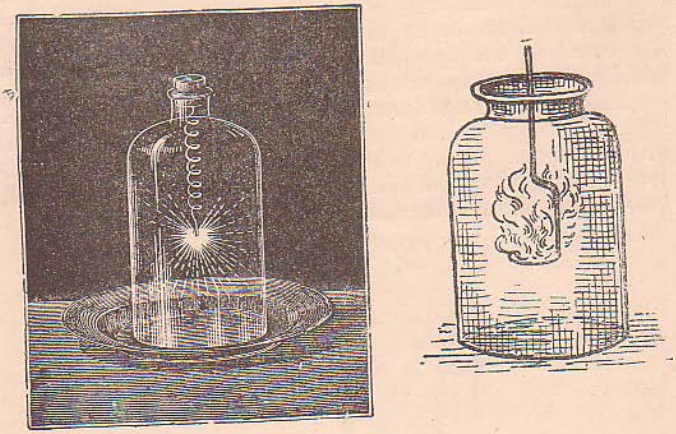
BURNING MATCH AND RELIGHTING BRAND IN OXYGEN.

In the other bottles lighted phosphorus and sulphur may be introduced by means of the deflagrating-spoon already figured. Sulphur, which gives scarcely any light when burnt in the air, burns in the gas with a bright blue flame, and phosphorus burns with a dazzling white light.

Oxygen gas is the active principle of the air we breathe. About one-fifth of the atmosphere consists of oxygen. Without oxygen nothing would burn. It has a great affinity for most metals and other substances, with which it readily combines, producing the beautiful effects of light and heat seen in the foregoing experiments.

Oxygen forms one-fifth of the atmosphere, eight-ninths of

water, about one-half of the earth's crust, four-fifths of all vegetables, and three-fourths of all animals. It combines



BURNING STEEL AND SULPHUR OR PHOSPHORUS IN OXYGEN.

chemically with every other known element except fluorine. The earth's crust, it has been calculated, is made up about as follows:—

Oxygen	50
Silicon	25
Aluminium	10
Calcium	4·5
Magnesium	3·5
Sodium	2
Potassium	1·6
Carbon, iron, sulphur, chlorine	2·4
All other substances	1

The substances from which the oxygen was obtained in the experiment described—chlorate of potassium and peroxide of manganese—are compounds of that element with others which are found to be the most convenient for experimental purposes. The peroxide of manganese employed is not decomposed in the experiment. It can be used again and again. But it has this peculiar property—viz., that in its presence the chlorate of potassium is decomposed at a much lower temperature than

would otherwise be necessary. Chlorate of potassium consists of potassium 39 parts, chlorine $35\frac{1}{2}$ parts, and oxygen 48 parts. In chemical works it is thus expressed—$KClO_3$. That is to say, it is a compound of one equivalent of potassium (K representing the old name Kalium), one of chlorine, and three of oxygen. At the end of this book will be found a table of the elements, with their symbols (that is, the letters employed to represent them) and their equivalent weights. Whenever potassium unites chemically with another element or compound it does so in the proportion of 39 or multiples of that weight; chlorine in the proportion of $35\frac{1}{2}$, and oxygen in the proportion of 16 or multiples of those weights. If no little figure is attached to the symbol a single equivalent only is understood.

When in the above experiments the oxygen combined with the sulphur, sulphurous ~~acid~~ anhydride (SO_2) was formed; when it combined with phosphorus, phosphorus peroxide (P_2O_5) was formed; with the steel wire an oxide of iron (FeO) was formed. But it should be stated that the brilliant glow was due not to the iron itself combining with the oxygen, but to the carbon present in the steel. Pure iron wire would only burn with a steady glow. The union of carbon and oxygen in this experiment, and in that with the match-end, results in the formation of carbonic acid gas (CO_2). This will be referred to in a subsequent section.

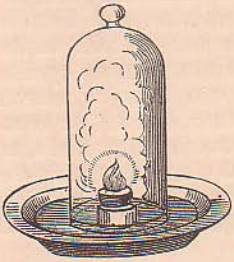
The name 'oxygen' was given to the element originally by Lavoisier, as we have already stated, from a belief that it always generated acids in its compounds. This, however, is not the case. If a small piece of the element sodium or potassium be attached to a wire and suspended in a bottle of oxygen, it will combine with it and become converted into soda or potash, either of which is a typical alkali, the exact opposite of an acid.

NITROGEN.

Take a soup-plate full of water, and float in this a small saucer supported on a large cork; place in the saucer a small piece of phosphorus, ignite it by touching with the heated end of an iron wire, and place over the whole a bell-jar. The phosphorus burns with the production of a large quantity of white vapour, and the water will be seen to rise. On standing

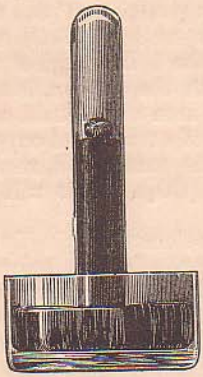
some minutes the vapour will disappear. The gas that remains is nitrogen.

Explanation.—The oxygen, which is the active part of the atmosphere, combines with the phosphorus to form phosphoric acid, which dissolves in the water, leaving the inactive nitrogen behind. The latter is neither combustible nor supports combustion. It may be decanted as shown in the figure, page 17; if a lighted taper is plunged in it, the flame will be extinguished. So, too, an animal left in it will die—not that it is poisonous, but because oxygen is necessary to support life.



SEPARATING NITROGEN.

Pour a few drops of blue-litmus solution into the water in the soup-plate, and it will be turned red, showing the presence of an acid (phosphoric).



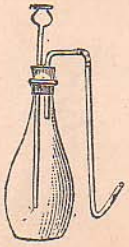
SEPARATING OXYGEN FROM NITROGEN IN THE AIR.

In a small glass vessel pour quicksilver to the depth of one and a half to two inches. Make a pellet of tow and soak it in a solution of pyrogallate of potassium. Cover the pellet with a test-tube. The pyrogallate will absorb the whole of the oxygen of the atmosphere enclosed in the test-tube, and the mercury will rise in its place. The gas remaining will be nearly pure nitrogen.

HYDROGEN.

Hydrogen gas is easily made, but much caution must be observed, as will be explained. The annexed figure shows a useful form of flask when it is desired to collect the gas. Put $\frac{1}{4}$ oz. of wrought-iron filings into the flask and pour over them $2\frac{1}{2}$ oz. of water. Add $\frac{1}{2}$ oz. of sulphuric acid gradually through

the long tube, keeping the flask in motion while the acid is being added. Action will at once ensue, the water being decomposed, its oxygen uniting with the iron, and its hydrogen escaping. The latter can be collected in a pneumatic trough, as already explained; but during the first five or six minutes after ebullition has commenced the gas is mixed with air, and this is a violently explosive mixture. When the hydrogen is coming through the delivery tube pure, a light applied will cause it to take fire with a slight pop, and it will continue to burn with a pale-blue flame. But before a light is applied the purity of the gas should be proved by holding an empty test-tube for a few seconds over the mouth of the delivery tube of the flask. If on holding a lighted match to the still inverted test-tube the gas ignites quietly, it may be assumed that all the air has been expelled from the flask. This precaution is essential, as it is a dangerous moment when the light is applied. If this be done too soon, the gas will explode and the apparatus will be shattered. Every precaution should be taken when the light is applied, by the flask being covered with a cloth, and nothing should be on the table or floor which could be injured by the acid liquid.



HYDROGEN FLASK.

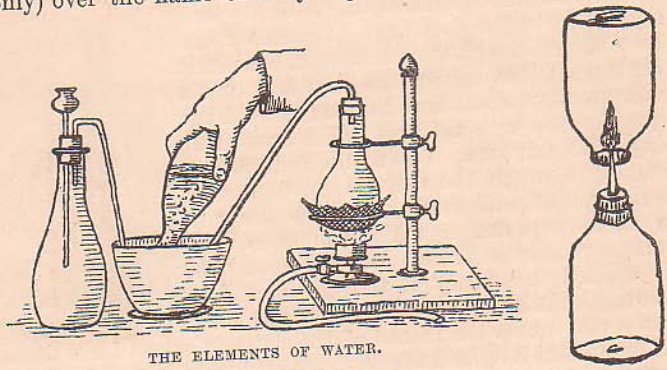
EXPERIMENTS WITH HYDROGEN.

COMPOSITION OF WATER.

Water is composed of two volumes of hydrogen and one of oxygen. Collect these two gases in about that proportion (it is not necessary to be exact) in a sound soda-water bottle in the method already described for the collection of gases. Cork the bottle under the water and set aside. If the cork be removed and the mouth of the bottle brought to the flame of a candle or gas, the oxygen and hydrogen mixture will explode with a loud report. In making this experiment the soda-water bottle should always be enveloped with several folds of a cloth or towel, as, if there should be an unseen flaw in the bottle, the explosion will shatter it to fragments.

To show that water is really formed during the combustion

of oxygen and hydrogen, invert a dry bottle (containing air only) over the flame of a hydrogen flask. The glass of the



THE ELEMENTS OF WATER.

bottle soon becomes clouded with moisture which condenses on the cold glass.

MAKING GAS FROM A BOTTLE.

Into an ordinary half-pint stone ginger-beer bottle put ½ oz. of methylated ether, about 2 oz. sulphuric acid, and 4 oz. water; about ½ oz. slips of zinc, and a cork with a hole through it, with a gas-burner in it, should also be supplied.

When you wish to make the gas, put into the bottle the pieces of zinc, and replace the cork with the one which has the gas-burner through it; allow the bottle to stand for five minutes, then put a light to the burner (taking the precautions already suggested), and it will burn with a good light like any ordinary gas-jet.

The ether and the hydrogen give a vapour which has a great illuminating power. Hydrogen alone has no illuminating power. It burns with a very pale-blue flame. The presence of some carbon is necessary to give it whiteness. In an ordinary gas or candle flame carbon is present in an incandescent solid condition.

A MODEL GAS MANUFACTORY.

Take a large-bowled clay pipe and fill it with finely powdered coal, close the top with common clay or putty.

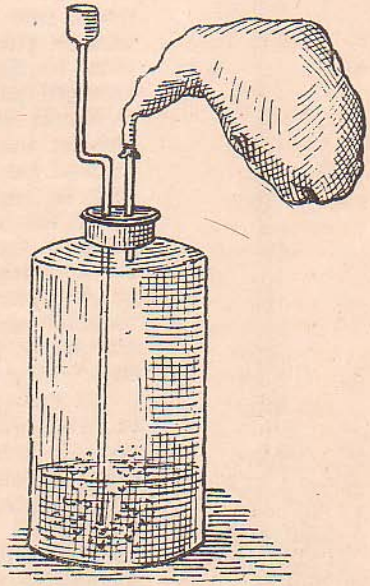
When heat is applied, as, for instance, by putting the bowl of the pipe into a fire, gas will issue from the stem, and in a few moments may be ignited, burning with a luminous flame.

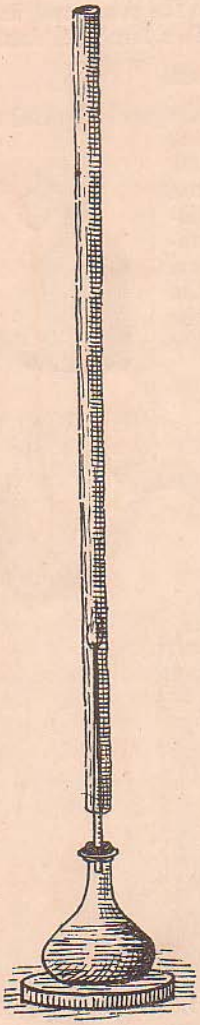
INEXTINGUISHABLE FLAME.

If a narrow-mouthed bottle full of hydrogen be ignited at the mouth, the gas will burn as it escapes. The gas being very light will ascend and will soon all escape. The flame will not descend into the bottle because the inflammability of hydrogen is only due to its combination with the oxygen of the atmosphere. If now water be poured into the bottle the flame will not be extinguished, but will be rather rendered more vigorous, as the water will the more rapidly force the gas out of the bottle.

GAS BALLOONS.

These may be filled in the following way :— Take a bottle fitted with a cork carrying a safety tube and an upright delivery tube. Place in the bottle some granulated zinc, replace the cork and pour down the safety tube a mixture of 1 part hydrochloric acid with 4 parts water, sufficient to cover the zinc. After a few moments have elapsed, tie over the delivery tube the mouth of the balloon; as soon as it is filled, detach and firmly close by means of a cotton or silk thread. The balloon is now filled with hydrogen, which is the lightest of all known substances. When set





free the balloon will mount in the air. If it be allowed to ascend at night with a piece of lighted magnesium wire attached, it will form a very effective meteor.

MUSICAL FLAME.

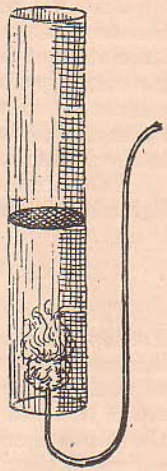
This is produced from a hydrogen flame as follows :—

Take a quart bottle, as shown in the drawing, and fit it with a good cork. Put in the bottle 2 or 3 oz. of zinc cuttings and rather more than half fill the bottle with water. Through the cork a hole must be bored with a round iron skewer, and a stem of a tobacco pipe about eight inches long must be fitted into it. When all is arranged pour about 1 fluid ounce of sulphuric acid on the water and zinc, and let the ebullition which results proceed for a few minutes before the cork is inserted. Having corked the bottle, the hydrogen gas which is then escaping through the pipe stem may be cautiously lighted by a long taper; but the precautions already indicated should be observed or a violent explosion may occur, shattering the bottle and endangering the experimenter.

To make the flame musical, a glass or metal tube, 16 or 18 inches long and $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter, is brought over the jet, the flame being 4 or 5 inches above the lower aperture. When the correct height is reached, which varies according to the size of the tube, a beautiful organ-like note is produced, the tone of which depends on the diameter of the tube.

MUSICAL TUBES.

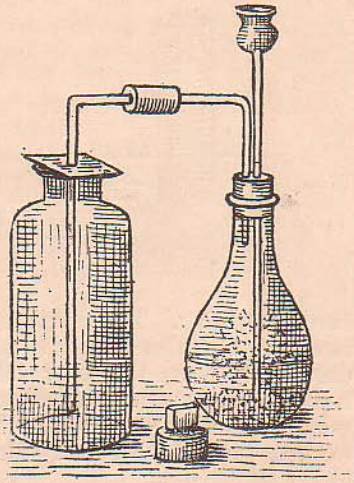
Pure hydrogen is not essential for producing flame music. The following method may be adopted. The materials required are a thin glass tube about a foot and a half long and an inch and a half in diameter, a small piece of wire gauze, about two feet of stout wire, a small sponge and methylated spirit.



Cut a circle of wire gauze slightly larger than the inner diameter of the tube and force it half way up the glass cylinder. Then bend the wire according to the accompanying figure, place the sponge moistened with the spirit in the turned-up end, light and introduce into the tube from below. As soon as the gauze becomes red-hot remove the flame, and the tube on cooling will emit musical sounds.

CARBONIC ACID GAS.

Requirements.—A bottle fitted with a safety tube and bent delivery tube similar to that used for producing hydrogen, some pieces of marble, and dilute hydrochloric acid, 1 part acid to 10 parts water. The marble is placed in the bottle and the acid poured down the safety tube, and the gas collected as shown in the figure. Carbonic acid is a very heavy gas, and is the same as that which is produced by explosions in coal mines (after-damp). It will displace the air in the bottle, and the bottle



PRODUCING CARBONIC ACID GAS.

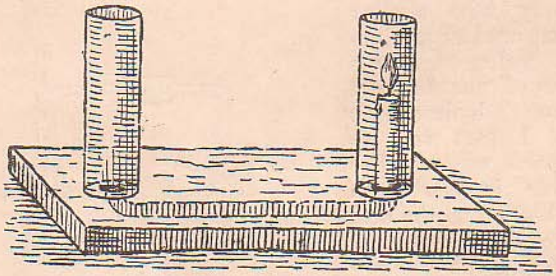
is full of it when a lighted taper introduced a little way down is extinguished. The bottle should then be slowly lowered and stopped with a tight-fitting greased stopper.

Carbonic acid gas can be poured into another bottle or test-tube like a liquid. The following experiments will illustrate some of its qualities. Take a test-tube filled with the gas carefully closed with the thumb, and another test-tube one-quarter filled with lime-water, now pour the gas into the latter and shake—the clear solution will instantly cloud owing to the formation of common chalk (carbonate of calcium).

Take another test-tube filled with the gas and plunge a lighted match into it—the flame will be instantly extinguished.

CARBONIC ACID GAS FROM THE LUNGS.

The apparatus shown in the next sketch was devised by Faraday to illustrate the fact which he was explaining in his lectures on a candle, that the process of breathing is analogous to that of combustion. He had shown that the candle went out if enclosed in a bell after it had converted the oxygen of the atmosphere into carbonic acid gas. The arrangement shown is simply a board with a groove in it connecting the



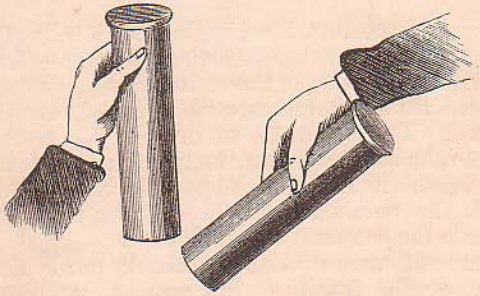
two glass tubes. The groove is covered by a fitting lid, and in one of the tubes a taper is burned. It burns well enough, drawing air from the other tube through the groove. If, however, the experimenter covers the supplying tube with his mouth, and simply allows the breath from his lungs to be expired in it, without any blowing, the candle will soon flicker and go out.

COMBUSTION AND RESPIRATION.

The processes of combustion and respiration both consist of the combination of carbon and oxygen and both result in the formation of carbonic acid gas. And just as the candle cannot burn without a supply of uncombined oxygen, so is it with human life. The presence of carbonic acid gas vitiates the atmosphere, and when it exists in too great proportion renders it dangerously poisonous. The carbon for combustion is provided in coal, in gas, in petroleum, in candles; the carbon for respiration is provided in food. Food is therefore the fuel of the body. Obviously by the processes referred to vast quantities of this poisonous gas are being emitted into the atmosphere every minute. The air, however, is kept pure by the provision that this carbonic acid gas furnishes a large part of the food of plants, which are endowed with the power of separating and assimilating the carbon and again setting free the life-giving oxygen.

DECANTATION OF GASES.

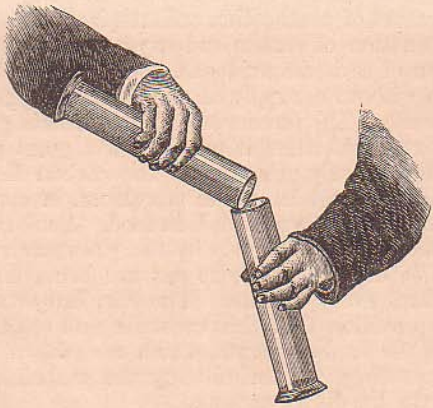
In the case of light gas such as hydrogen, the vessel in which it is kept must be either covered with a glass plate or



DECANTING HYDROGEN.

in some such way, or retained in an inverted position. If the receiver, held mouth downward, be gradually turned

upright, the hydrogen will pour from it in an upward stream, as is illustrated in the first engraving. A heavy gas like



DECANTING CARBONIC ACID GAS.

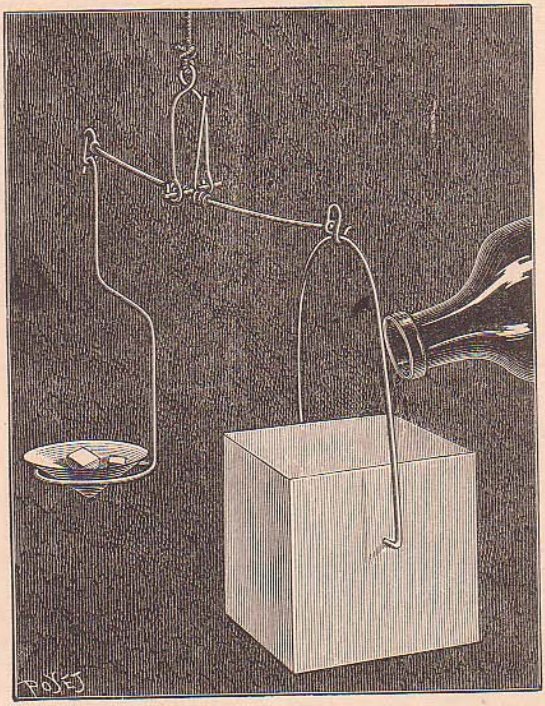
carbonic acid can be poured from one vessel to another as if it were water, in the manner shown in the second drawing.

WEIGHING CARBONIC ACID GAS.

Interesting experiments exhibiting the density of carbonic acid gas can be made in the following manner :—Construct a rough balance with wire as shown in the engraving and adapt a cardboard scale pan and a card box to the two arms as represented. From a bottle of the gas sufficient can be poured into the box, displacing the lighter air, to counterpoise a given weight in the scale pan. The effect produced is curious to the uninitiated, as the operator appears to pour nothing into the box from an empty bottle.

Another still more striking experiment can be shown also dependent on the density of this gas. A cardboard disc of octagonal shape is suspended on a wire axis, supported by two wire uprights and held in place by a couple of corks. Sugar-loaf paper bags made from writing-paper of form similar to those in which grocers weigh sugar are attached to

the edges of the disc between each angle, and an arrangement as represented on page 20 is obtained. Now from a jug con-

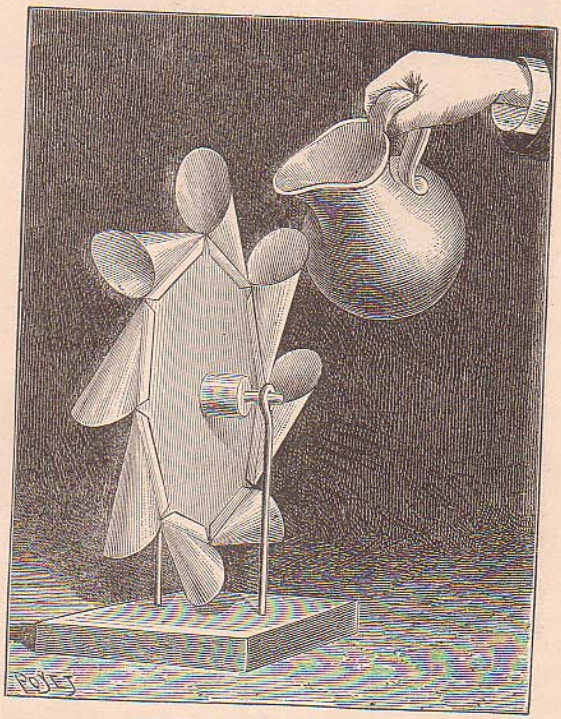


taining carbonic acid gas pour the invisible fluid into the cups one at a time, so as to set the disc revolving, and the motion can be kept up as long as any gas remains in the jug to fill the vessel with.

CHLORINE GAS.

Take an ordinary stone ginger-beer bottle or glass flask, pour into it 1 oz. black oxide of manganese and 3 oz. of

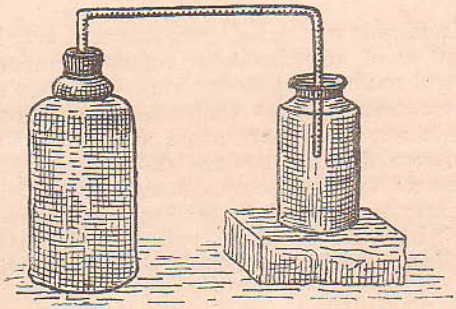
strong hydrochloric acid. Fix into the neck a cork previously fitted with a bent glass tube as seen in the accompanying figure, and carefully warm by plunging into hot water. After a few moments have elapsed place a wide-mouthed glass jar or bottle under the delivery tube. This jar will then be seen to



fill with a heavy, yellow, badly-smelling gas called 'chlorine.' Great care must be taken not to inhale this gas, which is very injurious.

Fasten some Dutch metal to a piece of wire (do not crush up the Dutch metal), carefully lower it into the gas, when it will take fire spontaneously.

Collect another bottleful in the same way, and shake some

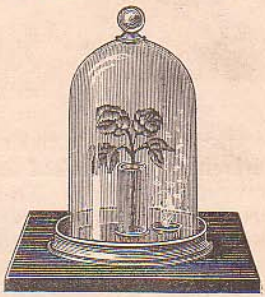


COLLECTING CHLORINE.

powdered antimony into it; the antimony will catch fire, emitting beautiful sparks.

CHLORINE WATER.

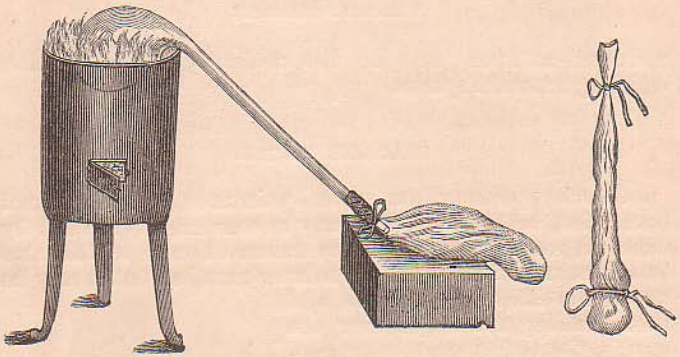
Chlorine gas is suffocating and poisonous, and should not be inhaled, but its properties may be conveniently studied by dissolving some in water. One measure of water will dissolve two measures of chlorine. A narrow-mouthed bottle may be two-thirds filled with the gas, and then, holding the finger over the mouth, the bottle, containing one-third water and two-thirds chlorine, may be shaken. Suction is exerted on the finger, and the yellowish gas disappears. This solution is chlorine water. It is a most powerful bleaching agent. A little poured into ink or wine destroys the colour. It will also destroy putrefactive odours in such substances as manures, rotten eggs, &c. It acts by combining with hydrogen, for which it has a strong affinity, removing it from any compound with which it comes into contact.



BLEACHING A FLOWER.

LAUGHING GAS.

This is nitrous oxide N_2O and it is used very largely for the production of anæsthesia for simple operations. This section would not be complete without some mention of this gas; but we strongly advise students, for many reasons, not to indulge in any such experiments as inhaling this or any other gas, even though there are books which tell them this can be done with perfect safety. A small quantity of nitrous oxide gas may be prepared by heating two ounces of nitrate of ammonia in a glass retort, and collecting the gas evolved in an ox bladder. The bladder should be first wetted and then



COLLECTING LAUGHING GAS.

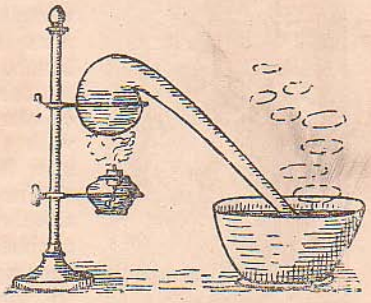
squeezed up to remove all the air. In this state the neck is attached to the beak of the retort after the latter has been placed over a spirit-lamp. To inhale the laughing gas it is desirable to use a pipe with a tap; a tube of elder with the pith pushed out will answer quite well. This is pushed into the neck of the bladder, which is held by the left hand with the thumb over the tube. With the right hand the nostrils should be closed. Then having emptied the lungs by a long expiration, the gas is inspired through the tube. In one or two minutes, if the experiment be successful, the sensation follows.

EXPERIMENTS WITH PHOSPHORUS.

Experiments with phosphorus need great care, as the substance is capable of causing great injury. It should never be touched by the fingers, and should be kept, and when necessary cut, under water, and pieces of it picked up with a pair of metal pincers.

PHOSPHORESCENT RINGS.

A pretty experiment is to put into a small retort about an ounce of solution of potash with about half a drachm of phosphorus. The retort should be placed on a stand over a spirit-lamp with the beak dipping about half an inch in water contained in a saucer or shallow basin. A very gentle heat must be applied until the liquid boils. The retort will soon be filled with a white cloud, a gas will pass through the water in the saucer and will emerge in luminous rings, which have a very pretty appearance in a dark room.



FIRE UNDER WATER.

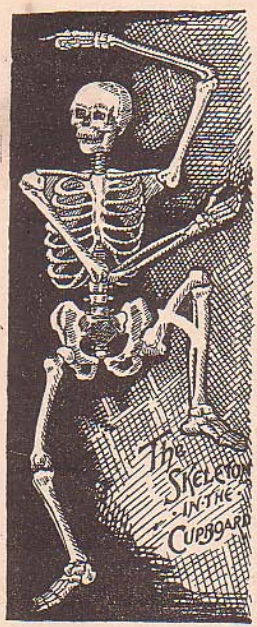
Into a glass of water put a few small pieces of zinc and a small piece of phosphorus; then plunge a glass tube into sulphuric acid, and place the thumb over the upper orifice;

withdraw the tube, which must be instantly immersed in the glass, and remove the thumb. Phosphuretted hydrogen will presently be disengaged, which will inflame on rising to the surface of the water.

THE WILL-O'-THE-WISP.

Make some phosphorised ether by dissolving phosphorus in ether. Keep in closely-corked or stoppered bottles.

Pour a few drops on a piece of lump sugar, and drop it into a glass of warm water. The surface of the water will become luminous; move gently by blowing, and beautiful and brilliant undulations of the surface will be produced.



THE SKELETON IN THE CUPBOARD.

Requirements.—The bottle of phosphorised oil described in the next experiment, and a small brush.

Directions.—Get a large sheet of blue or brown paper, and then, with the aid of the brush dipped into the oil, roughly sketch the outline of the human skeleton; attach it to the wall in an empty cupboard, in a dark room. On opening the cupboard the design will appear in phosphorescent lines. The gruesomeness of the spectacle will depend considerably on the skill of the artist. Other devices may be adopted at the will of the operator.

LUMINOUS BOTTLE OR WATCH LIGHT.

Place a piece of phosphorus the size of a pea in a long glass phial, and pour warm oil carefully over it till the phial

is one-third filled. The phial must be carefully corked, and when used should be unstopped a moment to admit the external air, and closed again. The empty space of the phial will then appear luminous, and give as much light as a dull ordinary lamp, and just sufficient to see the face of a watch. Each time that the light disappears, on removing the stopper it will instantly reappear. In cold weather the bottle should be warmed in the hands before the stopper is removed. A phial thus prepared may be used every night for six months.

THE WELL OF FIRE.

The phosphuret of lime required for this experiment may be kept in a wide-mouthed bottle, corked.

Take a tumbler three parts full of water and drop in the phosphuret of lime. Phosphuretted hydrogen gas will be produced, will rise in bubbles through the water, and take fire when they burst through the surface, ending in beautiful ringlets of smoke.

TO CAUSE A BRILLIANT EXPLOSION UNDER WATER.

Drop a piece of phosphorus the size of a pea into a tumbler of hot water, and, from a bladder furnished with a stopcock, force a stream of oxygen directly upon it. This will cause a most brilliant explosion under water.

MINIATURE FIREWORKS.

Put half a drachm of solid phosphorus into a pint Florence flask, holding the flask slanting while dropping in the solid, so that the phosphorus may not break the flask. Pour upon it about 8 oz. of water, and heat the whole over a spirit-lamp. As soon as the water is heated streams of fire will issue from the water by starts, resembling sky-rockets; some particles will adhere to the sides of the flask, resembling stars, and will frequently display brilliant rays. These appearances will continue at times until the water begins to simmer, when immediately a curious aurora borealis begins, and gradually ascends, till it collects to a pointed flame; when it has continued half a minute, remove

the lamp, and the point that has formed will rush down forming illuminated clouds of fire, rolling over each other for some time, which, disappearing, a splendid hemisphere of stars presents itself; after waiting a minute or two, heat again, and nearly the same display will recur. Let the repetition of removing and replacing the lamp be made for three or four times at least, that the stars may be increased. After the third or fourth time of removing the heat, in a few minutes after the upper surface of the flask is dry, many of the stars will shoot with great splendour from side to side, and some of them will fire off with brilliant rays, continuing to do so for several minutes. The flask and its contents may be kept in a cool secure place, and used several times over.

EXPERIMENTS WITH METALS.

LEAD AND COPPER.

Take a crystal or two of the nitrate of copper, bruise them, then moisten with water, and roll them up quickly in a piece of lead-foil, and in half-a-minute or a little more the lead-foil will begin to smoke, and soon after take fire and explode with a slight noise. Unless the crystals of the nitrate of copper are moistened, no heat will be produced.

TO ENGRAVE ON STEEL.

Dissolve some powdered sulphate of copper in a small quantity of water; rub the surface of the steel over with a piece of wetted soap, so as to cover it with a thin coating; then dip the point of a pencil into the solution, and with it write or draw the required design on the steel. After a few minutes, wash, and the steel will be found to be beautifully and permanently engraved.

TO MELT SILVER IN A WALNUT-SHELL.

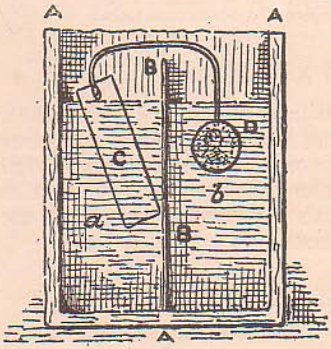
Mix together in a mortar 3 parts of nitre, 1 of sulphur, and 1 of sawdust. Fill a walnut-shell tightly with this, and insert in the mixture a threepenny piece. Light the mixture, and the silver will melt, while the shell will be only charred.

SOLUBLE SPOONS.

These can be made by fusing in a crucible 15 parts of bismuth, 9 of lead, and 6 of tin, and making spoons of the compound metal. This metal will fuse and disappear in a cup of tea.

TO GET AN EXACT COPY OF ANY COIN OR MEDAL; AND TO MAKE A SEAL OR ANY DEVICE IN COPPER.

Materials.—A fully-saturated solution of sulphate of copper (about 6 or 8 oz.), and about 6 or 8 oz. of sulphuric acid (1 part) and water (3 parts) for the other side. A wooden box lined with pitch, with a thin cardboard fastened in the middle. A piece of zinc about 2 in. by 1½ in., a piece of copper wire soldered on and bent over the partition to hold the impression in the solution of sulphate of copper. A piece of wax (preferably a thin sheet). A camel's-hair pencil, and some powdered blacklead.



AAA Pitch-lined box
BB Cardboard division
C Zinc strip
D Wax medal to be copied
a Colourless solution
b Blue solution

Directions.—First take the impression of the medal to be copied by softening the wax before the fire, and carefully pressing it on the coin; when it is cold, remove it cautiously, and cover it thinly, but completely, with a covering of blacklead. Pour the solution into the bath (one solution on each side); put the zinc plate into the colourless liquid, and attach to the other end of the copper wire the wax impression which you wish to copy, and allow it to dip into the solution of sulphate of copper, taking care that the wire is in contact with the blacklead. In the same way you can cut any device, initials, &c., into the wax, and coat with copper.

Explanation.—This experiment is really depositing copper on the impression by electricity, the electricity being produced between the two solutions through the porous division. Care must be taken to have a good connection between the copper and the blacklead on the impression, the blacklead being a conductor of electricity and the wax not. The slower the copper is deposited, the firmer and harder will be the resulting deposit.

TO COAT STEEL WITH COPPER.

Into a 1-oz. bottle of acidulated solution of copper sulphate, dip the bright steel blade of a knife (or any piece of bright steel). In a few minutes it will be coated with copper.

TO COAT COPPER WITH SILVER, IRON WITH COPPER, AND TIN WITH IRON, FROM ONE SOLUTION.

Make a solution of 20 grains of nitrate of silver in 1 oz. of distilled water, put it into a 1-oz. phial, labelling it 'Poison.' Pour half the solution from the bottle into a wineglass, and put into it a piece of copper wire; it will in a few minutes become coated with a thin layer of silver; if it be allowed to remain in the solution until the previously colourless solution becomes green, and the copper then taken out, a piece of iron wire put into the solution will become coated with copper in about twenty minutes; a piece of zinc put in when the iron is taken out will become covered with a thin coat of iron.

Explanation.—The first solution is one of nitrate of silver; when copper is put into it, it is attacked by the nitric radical (nitric acid) and forms a solution of nitrate of copper, throwing out the silver which previously was held in solution by the nitric acid. Iron put into the solution of copper is in turn attacked by the nitric acid, and leaves a solution of nitrate of iron, throwing out the copper. Zinc put into this solution is attacked, and leaves a solution of nitrate of zinc, throwing out the iron.

TO MELT IRON IN A MOMENT.

Heat a piece of iron (a poker will do) to white heat, then apply to it a roll of sulphur. The iron will immediately melt and run into drops. This experiment is best performed over a wash-basin of water, allowing the melted iron (really sulphide of iron) to drop into the water.

MELTING LEAD ON A CARD.

Turn up the sides of an ordinary playing card so as to make a tray and place a piece of lead in the centre.

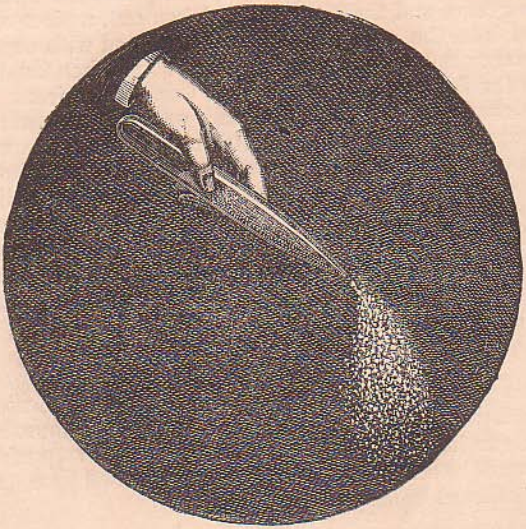
On holding this over a lamp the lead will melt before the card catches fire.

SILVER FIRE.

Provide a piece of burning charcoal, and sprinkle upon it a pinch of nitrate of silver. Most lustrous sparks will be immediately thrown out, and the surface of the charcoal will be coated with silver.

CHEMICAL FIREWORKS.

In a tube of green glass blown into the shape shown in the sketch, place some oxalate of iron, powdered and quite dry; heat it to redness, and pass a current of hydrogen through the compound. The iron will be reduced to a metallic state under the combined influence of the heat and of the hydrogen, and



if the tube be then closed by means of a blow-pipe flame, and thus protected from the action of the air, it can be kept indefinitely. On breaking off the end of the tube by means of a steel nipper, and shaking out some of the powder in the dark, a beautiful rain of fire can be produced, the instantaneous oxidation of the reduced iron yielding this effect.

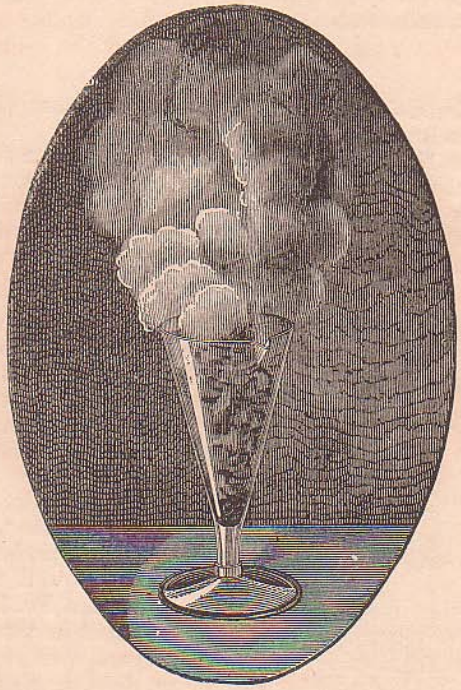
THE MAGNESIUM LIGHT.

To show this hold the end of a piece of magnesium ribbon by a pair of pliers, and introduce the other end into a flame, when it will at once take fire and burn brilliantly.

The resulting ash will be a small dose of calcined magnesia.

VAPOUR OF NAILS.

If it is desired to exhibit effectively certain characteristics of chemical combination, this can be done by pouring a little



nitric acid on a few iron nails in a wineglass. The conscientious expounder will make it clear that the orange-

coloured fumes are not, as might be assumed, the nails converted into vapour, and that these actually remain in solution.

PYROPHORUS.

This is a powder which on being shaken into the air takes fire. The preparation of it is as follows:—A small quantity of tartrate of lead (prepared by precipitating lead acetate with tartaric acid) is placed in a small bottle in a crucible, which must be subjected to a clear heat till all vapour ceases to come off, when a cork must be securely fitted to the bottle, the contents of which are now pyrophorus.

A small quantity shaken into the air will ignite with beautiful scintillations.

SILVER TREE.

Ingredients.—(1) Nitrate of silver, 2 drachms; (2) quicksilver, 1 drachm.

Dissolve No. 1 in ¼ pint of distilled water, and set the glass vessel containing the solution on the chimney-piece, where it is not likely to be disturbed. Now pour in No. 2; in a short time the silver will be precipitated in the most beautiful arborescent form, resembling real vegetation.

TIN TREE.

Ingredients.—(1) Muriate of tin, 3 drachms; (2) nitric acid, 10 drops; (3) piece of zinc attached to copper wire. The zinc may be roughly cut into the form of a flower.

Directions.—Put No. 1 into a 4-oz. white glass bottle with sufficient water to three parts fill, then add No. 2; shake well until dissolved. Now place No. 3 through a cork and insert in the solution, so that no part shall touch top, bottom, or side of glass vessel. Let the whole rest quietly for a short time. The tree will grow, and have a very lustrous appearance.

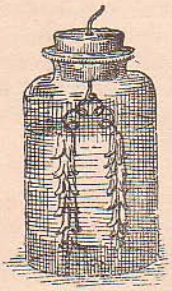
CHEMICAL VEGETATION.

More striking than either of the other trees is the effect of crystallisation in a solution of silicate of soda. Silicate of soda is sometimes called 'water glass,' and it can be bought cheaply in the condition of a thick solution. It is actually glass in a liquid state, and can be diluted with water. In its thick condition it may be used as a cement for china and glass. To produce the chemical vegetation shown in the drawing, let a bottle be filled with one-third of the silicate solution and two-thirds water. Much shaking and stirring will be

necessary to get a homogeneous fluid. Then put sand into the bottle until you have a layer a quarter or half an inch thick. This can be best added through a wide tube. A few crystals of alum, of sulphate of iron, and of sulphate of copper, each about the size of a pea, should be dropped into the solution, and then with a glass rod firmly embedded in the sand, but not covered by it. The bottle must then be set aside in a quiet place and not disturbed. In a few hours

crystals will begin to sprout in filaments and in stalactites of varying colours. Sulphates of chromium, cobalt, nickel, and other salts may be employed. Those we have named are the most common.

LEAD TREE.



Ingredients.—Sugar of lead, $\frac{1}{4}$ oz.; zinc fastened to a wire (copper or brass) twisted in the form of a spiral spring. The effect is heightened if from the centre is suspended a small porcelain doll with wire twisted round it.

Place the lead acetate in a bottle of distilled water, shake well, then thrust zinc and appendages into it, and cork securely. In a few days the tree will begin to grow, and produce a most beautiful effect.

DEVELOPMENTS OF COLOURS.

INVISIBLE CORRESPONDENCE.

Magic Ink, No. 1.

Materials.—Bottle labelled A : A solution of copper sulphate (1 oz.). Contents of B : A solution of ammonium hydrate (1 oz.)

Take a clean quill pen, dip into the ink in the bottle labelled A. Write the desired sentences, and allow to dry. The writing will be invisible. To make it visible, sponge over with the solution in bottle labelled B, when the writing will appear in BLUE characters.

Magic Ink, No. 2.

Contents of A : Solution of iron sulphate. Contents of B : Solution of pyrogallic, tannic, or gallic acid. Each bottle to contain 1 oz.

Take a clean quill pen, dip into the ink in bottle labelled A. Write the desired sentences, and allow to dry. The writing will be invisible. To render it visible, sponge over with the solution in bottle B, when the writing will appear in BLACK characters.

Magic Ink, No. 3.

Write with very dilute sulphuric acid, using a clean quill pen. Dry by exposing to the atmosphere. To render the writing visible, hold before a hot fire until the letters appear in BLACK.

Magic Ink, No. 4.

Solution of cobalt chloride. Any writing or picture done with this fluid is invisible until heated strongly for a few seconds, when the written characters or pictures appear of a

blue colour. By simply breathing upon the paper, they again disappear from vision, to reappear if again heated.

MAGIC DYE.

Dissolve indigo in dilute sulphuric acid, and add to it an equal quantity of solution of carbonate of potash. A piece of white cloth dipped in this mixture will become blue; a piece of yellow cloth will become green; a piece of red cloth, violet; while a vegetable-dyed cloth will turn red.

TO WRITE WITH A BRUSH.

Distribute among your company a lot of apparently blank visiting cards. On these you have, however, previously written with invisible inks, mottoes, names, &c. You now need simply to dab the card with the end of a feather or camel's-hair brush damped with the developing solution to bring out the writing distinctly. To carry out this performance you will require the following chemicals:—(1) A strong solution of sulphate of iron for blue ink, or (2) a strong solution of sulphate of copper for brown ink; and (3) for the developer a strong solution of yellow prussiate of potash. With a clean quill pen write with the solution of either No. 1 or No. 2, and allow to dry. The writing will remain invisible. Dip a feather or small brush into No. 3 or the 'Developer,' the writing will then appear distinctly written—in blue if No. 1 ink has been used, or in brown if No. 2 was used. This performance carried out on a rather large scale, on sheets of paper affixed to the wall, can be made effective by a little previous arrangement.

THE BLUSHING PICTURE.

Requirements.—No. 1 solution, 4 drachms of diluted methylated spirit in which a few grains of phenolphthalein have been dissolved. No. 2, half an ounce of strong ammonia solution; a camel's-hair pencil.

Directions.—Take any print of a well-known character, carefully paint in the hands and face with No. 1 solution, and allow to dry.

Then pour a few drops of No. 2 solution on a dry sponge and pass it within an inch of the painted parts, which will

instantly become crimson. On removal of the sponge the colours will fade and the features will resume their original colour.

The blushing will be greatly intensified if the picture be previously slightly damped, which can be best accomplished by holding it a few seconds over a basin of boiling water and allowing it to cool.

CHAMELEON PICTURES.

Put into separate 2-drachm bottles, some bromide of copper, muriate of cobalt, and acetate of cobalt in solution. Label distinctly.

Directions.—Draw a scene on paper with bromide of copper. The trees stretching across the sky, and the snow-covered ground may be changed to vernal beauty by heat. This is done by painting in the grass, foliage, &c., in muriate of cobalt, and the blues—of the sky and water—in acetate of cobalt. These tints will be invisible until held before the fire.

Of course you will save a great deal of time, and add to the mystery, by preparing your sketches beforehand. A skilful artist can make these pictures represent in a wonderful manner 'the return of spring.'

CHAMELEON MINERAL.

To prepare it, take 1 part of manganese dioxide, and 3 parts of nitrate of potash. Powder finely, mix, and place in a small crucible, which must be kept at a red heat, in a common fire, for twenty minutes; then let them cool.

Directions.—Place as much as will cover a sixpenny-piece of this substance in each of two glasses; pour cold water into one, and the liquid will become first green, then, in a few moments, purple, then red. Fill the second with moderately hot water, and you will obtain a beautiful violet, which changes into crimson. The colours will be of greater or lesser intensity in proportion to the quantity of powder used; and, in the course of the changing of colours, the various intermediate shades will be observed. The compound should be kept in a small wide-mouthed bottle.

TO RESTORE COLOUR BY WATER.

If sulphate of copper be heated, it loses its blue colour; but if, when cold, a drop of water be added, it immediately regains it, and gives off steam with a slight hissing sound.

RED TO BLUE.

Copper shavings, which are of a reddish colour, will dissolve in a solution of ammonia (commonly called spirit of hartshorn), forming a blue liquid if in contact with the air.

BLUE TO RED.

Tincture of litmus, and solution of sulphate of indigo, of each about ½ oz. in separate bottles.

Directions.—Pour a little of each into separate wine-glasses and dilute. Mix these two blue fluids together, and to the astonishment of everybody the result will be a beautiful red.

BLUE DESTROYER AND BLUE PRODUCER.

In one glass tint water with a little indigo solution; in another have a thin solution of starch to which has been added a few drops of solution of iodide of potassium. Then add to each a little chlorine water. This will convert the first into a colourless solution, but will develop a blue in the second.

CHEMICAL COLOUR TRANSMUTATIONS.

Take five test-tubes, and into them pour severally small quantities of the five liquids described below. Pour the contents of No. 1 into No. 2 and a scarlet colour is produced; pour this into No. 3 and the liquid becomes clear again; this poured into No. 4 becomes milky; and this, in turn, poured into No. 5, becomes jet black.

Materials.—No. 1 bottle: two drachms dilute solution iodide of potassium. No. 2 bottle: two drachms dilute solution mercury bichloride, labelled 'Poison.' No. 3 bottle: two drachms strong solution iodide of potassium. No. 4 bottle: two

drachms strong solution of iodide of potassium and oxalate of ammonium. No. 5 bottle: two drachms sulphide of ammonium.

THE TRIPLE COLOURS.

Pour a small quantity of the solutions labelled Nos. 1, 2, and 3 (see below) into three separate test-tubes. Add to each in turn a small quantity of liquid No. 4. No. 1 will turn to blue; No. 2 to yellow; and No. 3 to red-brown.

Materials.—No. 1: ½ oz. solution of ferrous sulphate. No. 2: ½ oz. solution of bismuth nitrate. No. 3: ½ oz. solution of copper sulphate. No. 4: 2 oz. solution of prussiate of potash.

IMPROVING ON NATURE.

By keeping the stem of a cut white rose in a solution of yellow prussiate of potash for 4 or 5 hours and then transferring it to a solution of sulphate of iron, the colour of the petals is changed to a delicate primrose but the odour is not affected. Pink candy tuft may be changed to an emerald green by the fumes of tobacco. The fumes of burning sulphur will tip a purple dahlia with a white edge, or a scarlet one with yellow.

THE CONJURER'S WINE-BOTTLE.

The methods by which variously tinted fluids can be poured out of the same bottle are sometimes based on the chemical colour changes such as are described in this chapter. In a clear glass wine-bottle or decanter nearly filled with water dissolve about 20 grains of ferrocyanide of potassium. Then range four empty wineglasses on a table. No. 1 is clean; No. 2 has been rinsed out with a solution of perchloride of iron; No. 3 with a solution of sulphate of copper; and No. 4 with a solution of sulphate of zinc, leaving a few drops of the solution in each glass. When the solution is poured from the decanter into these glasses it will appear like water in No. 1, of a rich blue in No. 2, like sherry in No. 3, and like milk in No. 4.

TO PRODUCE A YELLOW FROM TWO COLOURLESS FLUIDS.

Dissolve 20 grains of sugar of lead in a test tube in ½ oz. of distilled water, adding a few drops of acetic acid to clear it. Separately dissolve 20 grains of iodide of potassium in a

teaspoonful of distilled water. Both solutions are colourless. A few drops of the latter poured into a little of the former will at once cause a yellow precipitate of iodide of lead, the two metals changing their associates.

TO PRODUCE A RED IN A SIMILAR WAY.

Dissolve 5 grains of perchloride of mercury ('poison') in an ounce of water, and 10 grains of iodide of potassium in another ounce. Put the first solution in a wineglass, and add the iodide solution to it. The mixture quickly becomes red, like blood, but if enough iodide is added it becomes clear again. Quacks use this experiment as a means of showing how their medicines purify the blood.

SILVER PRECIPITATES.

Have a row of five wineglasses half filled with water. Dissolve a little salt in one; iodide of potassium in the next; chromate of potassium in the next; phosphate of soda in the next; and common washing-soda in the fifth. These will give a clear solution in every case. Then add a few drops of a strong solution of nitrate of silver into each glass. In the first a milky white will be produced, the second will be yellow, the third red, the fourth orange, and the fifth brown.

TRANSFORMATION LIQUID.

Solution of caustic potash 1 oz.; powdered nitrate of cobalt 1 drachm.

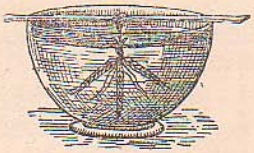
Directions.—Mix the nitrate of cobalt with the caustic potash, when decomposition of the salt and precipitation of blue oxide of cobalt will take place. Cork the bottle and the liquid will assume a blue colour, from which it will pass to a lilac, afterwards to a peach tint, and finally to a light red.

CRYSTALLISATION EFFECTS.

The beautiful forms into which many minerals and salts crystallise, offer means of obtaining objects of great beauty. The usual method of obtaining crystals of salts is by evaporating a solution of such salts. Crystals of certain volatile bodies like camphor can be obtained by sublimation.

THE BEAUTY OF CRYSTALLISATION.

Dissolve 18 oz. of alum in 2 pints of soft water by boiling it gently over a moderate fire, keeping it stirred with a wooden spatula until the solution is completed. When the liquor is *almost* cold, suspend a small basket, ears of corn, moss rose, hyacinth, or almost any vegetable specimen, by means of a small thread or twine from a stick placed horizontally across the aperture of a deep glass or earthenware jar, into which the solution is poured. The articles should remain in the solution for twenty-four hours; when taken out they are to be carefully suspended in the shade until quite dry. The whole process of crystallisation is best conducted in a cool place. When the objects to be crystallised are put into the solution while it is quite cold, the crystals are apt to be formed too large. On the other hand, should it be too hot, the crystals will be small in proportion. The best temperature is about 95° F.



Other salts besides alum may be used, such as sulphate of iron (green-coloured crystals); sulphate of copper (blue); bichromate of potash (red); and nitrate of potash, and common salt (white).

THE HOAR-FROST SHRUB.

To produce this, place a sprig of rosemary, or any other garden herb, in a glass jar, so that when it is inverted the stem may be downwards, and the sprig supported by the sides of the jar; put some crystals of benzoic acid on a piece of hot iron, such as a fire-shovel, invert the jar over the iron, and leave the whole untouched until the sprig becomes, by the deposited vapour, like hoar-frost. The plant should be first moistened with water.

TO MAKE CRYSTAL ROOM-ORNAMENT.

Ingredients.—Common alum; sulphate of copper; sulphate of soda; sulphate of potash; sulphate of iron; sulphate of zinc; sulphate of magnesia; get ½ oz. of each in separate chip boxes.

Directions.—Dissolve each of the salts in warm water in a separate tumbler. When dissolved pour altogether into an evaporating-dish, and mix well with a glass rod. Place the dish in a warm place where it cannot be affected by dust, and where it is not liable to be agitated. When evaporation has taken place the whole will begin to shoot out into crystals. Their colour and peculiar form of crystallisation will distinguish each crystal separately, and the whole together will display a very curious and pleasing appearance. Preserve carefully from dust.

Sprigs of plants, roses, ferns, beetles, &c., if suspended in this solution, will become coated with a lustrous or crystalline coat.

HOW NATURE SEPARATES OUT THINGS WHICH ARE DIFFERENT

Take ½ oz. powdered alum and ½ oz. sulphate of copper; dissolve in 1 oz. of boiling water; put into a glass tube or phial, and on cooling you will see colourless crystals of alum formed side by side with blue crystals of sulphate of copper.

GROWTH WITHOUT LIFE.

Materials required.—A small bottle containing about 1 drachm of chloride of copper in crystals, and a 4-oz. bottle filled with *strong* solution of ferrocyanide of potassium.

Directions.—Take a tumblerful of water and put into it a dessert-spoonful of the solution. Mix by stirring, and then carefully drop in a crystal or two out of the small bottle and let the glass stand quite still for a few minutes, when a beautiful structure resembling brown seaweed will grow up and soon fill the glass. A tall narrow jar is best to use, and the exact quantities can be best judged by practice.

TO MAKE A SOLUTION CRYSTALLISE AT THE WORD OF COMMAND

may be thus effected. Prepare a solution of sulphate of soda, ¾ oz. in hot water 2 oz. Tie over tightly with a piece of split-skin. Allow to cool; it will not crystallise if well tied over. At the word of command, the skin must be secretly, or apparently accidentally, punctured; the solution will commence to crystallise at once and proceed with great rapidity.

CHEMICAL LANDSCAPES.

These are produced by the immersion of some lump muriate of ammonia in a 25 per cent. solution of nitrate of lead strongly acidified with nitric acid. Suitable proportions are 2 oz. of nitrate of lead, 6 oz. of distilled water, ½ oz. of nitric acid, and from 2 to 3 drachms of muriate of ammonia. The chemical action may be explained as follows:—The nitric acid decomposes the hydrochlorate, forming ammonia nitrate and setting free chlorine gas, which the moment the outer circumference of each minute bubble comes in contact with the lead solution forms insoluble lead chloride. This is piled up in the most fantastic shapes, hollow stems reaching to the surface of the solution. After a few hours splendid crystals of ammonia nitrate begin to form. The effect is very beautiful. With a little imagination, perfect winter landscapes, ruins, trees, palms, &c., may be made out. The vessel containing the solution should be placed on a mantelshelf, or some place where it is not likely to get shaken. This is a *sine quâ non*. If undisturbed, it will last for days.

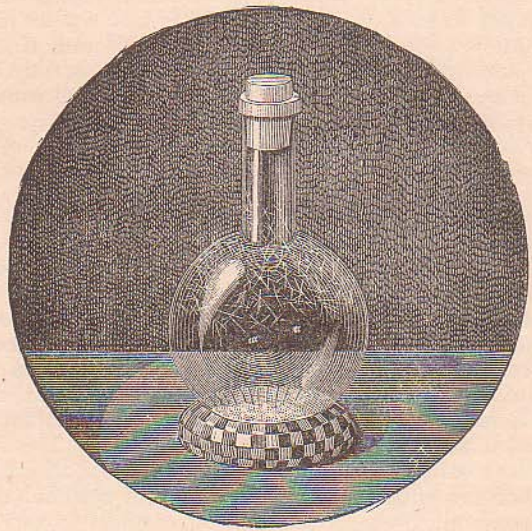
FROSTED GLASS.

Make a solution of alum or Epsom salts in hot water, containing as much of the salt as the water will take up. Add

to the solution while still hot a little glue and then brush it over the glass to be frosted. By stirring a little whiting into the solution before brushing it on the glass a more opaque frosting will be obtained.

FROST IN SUMMER.

Very beautiful silky white transparent crystals can be deposited on the surface of a glass vase by confining in it a combination of 2 parts by weight of iodine with 1 part of



cyanide of mercury. On rubbing these substances in a mortar the powder, at first of a brownish colour, assumes a brilliant red tint, and must then be transferred to the vase, which must be securely corked and sealed. The crystals readily form themselves in great abundance.

PARLOUR CHEMICAL MAGIC.

A COMPANY OF GHOSTS.

A suitable *début* may be made by imparting a ghastly appearance to the company.

Prepare a mixture of saturated solution of salt one part, and methylated spirit (coloured with saffron) three parts.

Directions.—Dip a small piece of tow into the mixture, and having extinguished all the other lights in the room ignite the tow. This will give a most ghastly appearance to all the company. Nitrate of strontium instead of salt will produce a brilliant red flame; nitrate of barium or boric acid a green one.

THE MAGIC BOTTLE.

Into a wine-bottle put some water and enough logwood powder to bring it to the tint of claret. Prepare four wine-glasses as follows:—(1) Cleaned with pure water; (2) containing a few drops of acetic acid; (3) containing a few drops of solution of potash; and (4) containing a small piece of alum. On pouring from the bottle into these glasses you will have liquids resembling, respectively, claret, sherry, gin, and port.

ANOTHER WONDERFUL BOTTLE

From which may be procured, in succession, port wine, sherry, claret, water, champagne, or ink, at the will of the operator.

Materials.—A. 1-oz. bottle, containing tincture of perchloride of iron 6 drachms, hydrochloric acid 2 drachms. B. A 1-drachm bottle of saturated solution of ammonium sulphocyanide (labelled 'Poison'). C. A 1-drachm bottle of

strong solution of perchloride of iron. D. A 1-drachm bottle of dilute solution of ammonium sulphocyanide (labelled 'Poison'). E. A 1-drachm bottle of solution of lead acetate (concentrated). F. A 1-drachm bottle of solution of ammonium sulphide or pyrogallic acid. G. A 2-drachm pill-box of bicarbonate of potash.

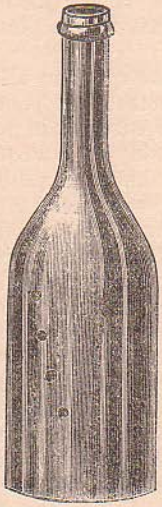
Directions.—Procure a dark-coloured pint wine-bottle; into it pour two teaspoonfuls of solution A. This small quantity of liquid will not be observed by the audience. Next procure seven wineglasses of different patterns. Into No. 1 wineglass pour one or two drops of solution B; into No. 2 glass one or two drops of C solution. Into No. 3 glass one or two drops of D solution. Leave No. 4 glass empty. Into No. 5 glass pour a few drops of E solution. Into No. 6 glass place a few grains of powder G. Into No. 7 glass pour a little of F solution. Care must of course be taken to remember into which glasses the several solutions are placed. When before the audience request some one to bring you a jug of cold (hard) water, and to guarantee to the company that it is pure. Show that your wine-bottle is (practically) empty. Fill it up from the jug, and having asked the audience whether you shall produce wine or water, milk or ink, &c., you may obtain either by pouring a little of the water from the bottle into the prepared glass, thus:—No. 1 glass gives a port-wine colour. No. 2 glass gives a sherry colour. No. 3 glass gives a claret colour. No. 4 left empty to prove that the solution in the bottle is colourless. No. 5 produces milk. No. 6 effervescing champagne. No. 7 ink. Don't let any of the company test any of the fluids by drinking them.

BLOOD-WRITING.

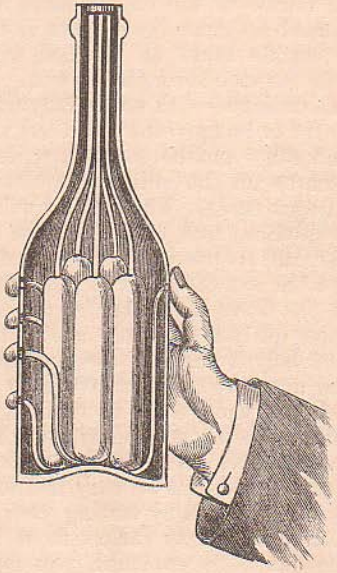
Ask anybody for a wooden match, and on a piece of blank paper (previously prepared) write your name in bold, blood-red characters. This is accomplished by having first rubbed over the surface of a sheet of note-paper some red iodide of mercury with a piece of cork. Take the paper so prepared and hold it over the flame of a candle or lamp, slowly moving it to prevent burning. The red colour will quickly disappear. Anything now written or drawn on the paper with a pointed piece of wood will appear as if written in blood.

INEXHAUSTIBLE BOTTLE.

The true conjurer's bottle, from which various wines are actually poured, is a mechanical contrivance, the design of which is represented in the annexed sketch. It will be seen that five earthenware or tin cylinders are packed inside an



INEXHAUSTIBLE BOTTLE.



SECTION OF INEXHAUSTIBLE BOTTLE.

apparently ordinary wine-bottle, and each of these has a vent-pipe connecting it with an air-hole in the bottle. These holes are so placed as to be conveniently stopped by the conjurer's fingers. He opens either at his pleasure, and thus can pour out any of five beverages.

BLOOD-RED WRITING ON THE ARM.

This truly astonishing trick is a purely chemical experiment, and was introduced by the late Robert Heller, and was considered one of his best illusions.

Materials.—Six plain cards, on which any lady's name is written—say Jane, Mary, Ann, or such like ; the six cards must have each the same name written thereon. Half-ounce indiarubber ball enema, camel-hair pencil, 2-oz. flat bottle filled with a solution composed of tincture of perchloride of iron, and water, of each 1 oz.; 2-oz. flat bottle filled with a solution of sulphocyanide of potassium, 1 in 10 water. The bone nozzle of the enema must be cut so short that when it is placed between the fingers it may not be seen projecting. The nozzle must be plugged with beeswax, and a pin or needle inserted through the wax.

Directions.—Ask some lady friend on the quiet to allow her arm to be operated on; then with the camel-hair pencil, which must not be too wet, write with the solution of iron the name on the lady's arm which has already been written on the six cards. The writing will soon dry and be invisible. The lady may now be led into the room and seated on a chair as far back as possible; she may now be blindfolded. Having taken the six cards out of your pocket, shuffle them, and say that you have a number of cards in your hand on which a number of ladies' names are written. Then ask the blindfolded lady if she can see the cards; of course she cannot. Allow any person in the room to select one of your tickets, which tell the person to retain. Now place the little ball enema in the right hand with the nozzle between the fingers; and, as it has been charged with the solution of potassium sulphocyanide, it is an easy matter to direct the spray to fall on the lady's arm by waving your own hand at a distance of eighteen or twenty inches from her arm. When the full name has been produced, you may now turn to the person who drew the card, and ask if this was the name written on the card, which it is most likely to be. The materials for the above are not expensive.

N.B.—One object of blindfolding the lady is to prevent the spray from going into her eyes.

FIRE-EATER.

Prepare a piece of thick string about 9 inches long, by soaking it in a saturated solution of nitre, and drying it. Wrap the string in a piece of tow and ignite it. Hold it in the left hand; with the right hand put some tow into the

mouth, chew it and appear to swallow it. Now take the handful in which is the string and put into the mouth, taking out at the same time, unobserved, the piece already chewed. Take a breath *through the nostrils* and breathe it out through the mouth. Repeat a few times and smoke will issue forth, and on opening wide the mouth it will be lighted up with a glow. When the mouth is shut and the tow pressed together the fire goes out.

WATER AND INK CHANGE PLACES.

Materials.—Three 1-drachm pill-boxes of pyrogallic acid. Three 1-drachm bottles of strong solution of perchloride of iron.

Directions.—Procure two 3-oz. or 4-oz. wide-mouth bottles of same shape, each having a loosely-fitting cork. Fill both with water. Dissolve in one of them the contents of one of the pill-boxes. Into the other fix a piece of black silk, to the upper edge of which a black pin, bent so as to form a hook, is to be attached. Place the silk in one of the bottles, and press it against the sides (the water will keep it in place). Suspend it by means of the bent pin to the rim of the bottle. The bottle will appear to the audience as though full of ink. Into the cork of the other bottle bore a hole sufficiently large to hold lightly one of the small phials provided. Uncork the phial (now inserted in the cork), and place the cork beside the bottle containing the powder. These preparations must be made previous to showing the trick. When the performer is before the audience he draws attention to the fact that the black liquid is on his left and the colourless liquid on his right. He then covers each bottle with different-coloured handkerchiefs. Then, as though he had forgotten to place the corks into the bottles, he makes some applicable remark, raises slightly each handkerchief in turn, and inserts the corks quickly, taking care not to let the audience see the bottles. By this means the contents of the phial is shot into the bottle containing the dissolved powder unobserved. Having relaid the handkerchiefs he asks the audience on which side was the black and on which the colourless liquids, passes his wand, repeats magical words, lifts up the left handkerchief (and with it the pin and silk

attached) and lo! the liquid is colourless. Taking off the handkerchief from the bottle on the right he discovers to the audience a bottle full of ink.

ANOTHER INK AND WATER TRICK.

For this performance get the following:—Three packets labelled respectively Nos. 1, 2, and 3. No. 1 contains about ½ oz. of granulated sulphate of iron; No. 2, about 1 drachm of tannin; and No. 3, about ½ oz. of powdered oxalic acid.

Directions.—Take two decanters (preferably different shapes, so as to avoid suspicion of changing), and fill them both with water. Introduce into one of them a *small* portion of No. 1 powder and the same of No. 2. This will form a black compound resembling ink. Into the other put another portion of No. 1 only, and shake till dissolved. This liquid will be clear like water. Now wrap up a pinch of No. 3 and the same of No. 2, each in a small piece of blotting-paper (different colours so as to prevent mistake), and conceal these in the palm of your hand. You are now ready for the trick. Step among the audience and explain that you have two bottles, one containing ink and the other water. This they may see for themselves. Now place the ink bottle at one end of the room, cover with a borrowed handkerchief, and, while doing so, contrive to slip in the blotting-paper containing No. 3. Shake well, and let it stand covered. Go to the other end of the room and do the same with the 'water' bottle, slipping in No. 2 packet. On removing the covers chemical action will have occurred in the bottles, and the two liquids will appear to have changed places, the ink bottle containing water and the water one ink. It is well to practise this trick, as well as some others, in private before showing it to an audience.

SHEETS OF FLAME.

This is a simple and very harmless trick, but all the preparations for it should be made beforehand. Get a supply of thin Chinese or Japanese white tissue paper; if you cannot get it use ordinary tissue paper. Obtain ½ oz. of nitrate of strontia and dissolve it in a soup-plateful of hot water. Cut your paper into strips the width of this page, draw over the

contents of the soup-plate, and hang the strips on a string to dry. When dry cut the paper into pieces about three inches square. Now you are ready for your audience. Light a vesuvian surreptitiously, and when the glow is over conceal it behind your hand. Fold up one of the papers as best you can with your fingers, and while drawing it through the middle fingers of the hand in which you have the vesuvian allow the corner to touch the head of the vesuvian. Immediately the paper bursts into an intense crimson flame, and if you let it go it flies a few feet into the air and disappears. Of course you must make your spectators believe that the flame was produced by drawing the paper through your fingers. Nitrate of barium will give a green flame.

THE HUMOROUS EGG.

In a quill place a small quantity of quicksilver, and, having fastened it well in, insert the quill through the end of a newly boiled egg. The egg being placed on the table will dance about until cold.

THE MYSTERIOUS EGG.

An egg can be shown in a bottle with a mouth too narrow for it to have passed through. How did it get there?

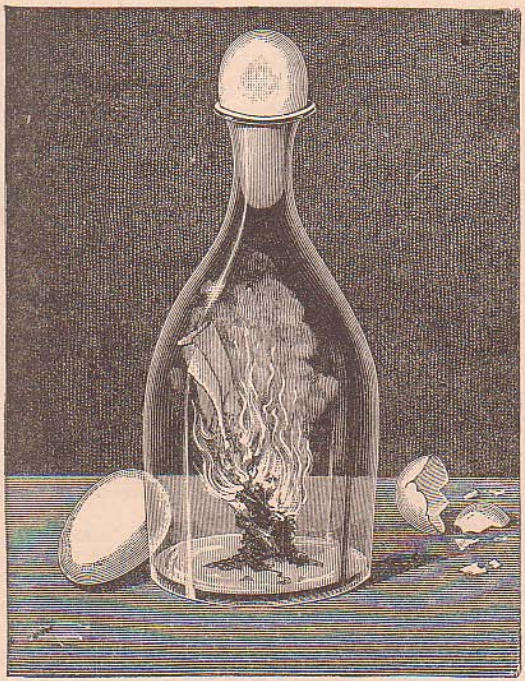
How to do it.—When an egg is soaked in equal parts of strong acetic acid and water it becomes softened, and may be pressed into any form. Water will again harden it.

You might remark that you had at first thought of exhibiting the hen in that bottle, but left that trick for another occasion.

PUSHING ITS WAY.

An interesting experiment, showing the effect of the pressure of the atmosphere, is to take an ordinary water-bottle with a neck too small to pass an egg through it. A sheet of paper is lighted and dropped into the bottle, and at once a hard-boiled egg, freed from its shell, is pressed into the mouth of the bottle so as to hermetically seal it. The combustion of the peper inside the bottle produces a partial vacuum, and the outside pressure of the atmosphere at once

begins to act on the egg, pressing it through the neck. It elongates itself gradually, and shortly drops suddenly into



the bottle with a detonation similar to that which boys make when they burst a blown-out paper bag.

TWO LIQUIDS FORM A SOLID.

Requirements.—A saturated solution of sulphate of magnesia and a like solution of caustic potash. To be kept in separate bottles.

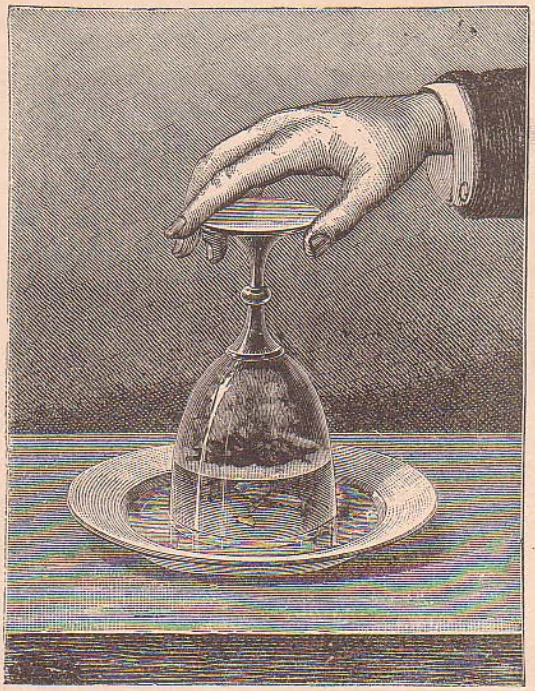
Directions.—Mix the two liquids together in a wine-glass, and the mixture will immediately become almost solid.

Add a saturated solution of chloride of calcium to a satu-

rated solution of carbonate of potash. The two transparent liquids will combine to form an opaque and almost solid substance.

THE RISING FLOOD.

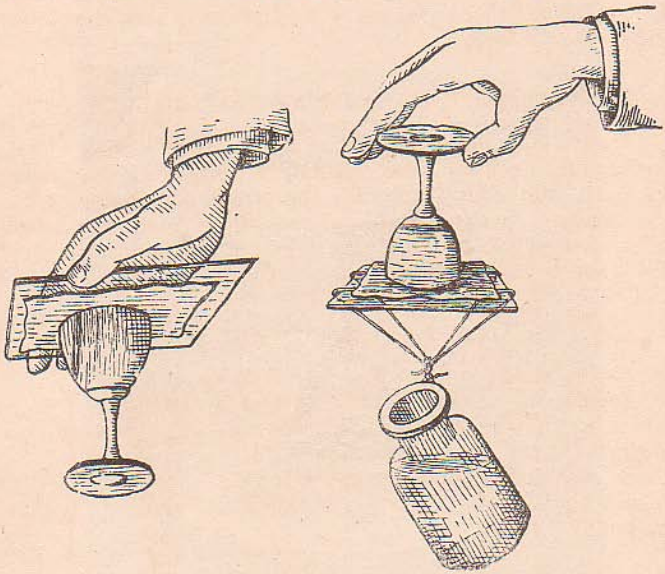
The experiment shown by the next engraving is another simple means of exhibiting the effect of creating a partial vacuum. A piece of paper fixed to a cork floating on the



surface of water in a plate is lighted and covered with a tumbler. To the extent of the vacuum created the water will rise in the glass, in consequence of the pressure outside.

THE MARVELLOUS WINE-GLASS.

A striking experiment can be performed with a wine-glass, a small plate of glass, and some blotting-paper. The wine-glass is three-quarters filled with water, a piece of thick blotting-paper is laid over its mouth, and over the blotting-paper the glass plate is placed. It is essential that the mouth of the wine-glass should be even and that the glass plate should be flat. Now, holding the whole arrangement with



both hands, turn all over so that the water shall come in contact with the blotting-paper. This will absorb some of the water and create a partial vacuum in the wine-glass. The wine-glass now adheres firmly to the blotting-paper and to the glass plate, and may be held in either of the positions shown. In the second drawing, as will be noticed, the wine-glass not only holds the glass plate, but a bottle is attached by wire, and into it a considerable weight of water may be

poured. Of course a point arrives when the force of the adhesion will be overcome, so that it is desirable when performing the experiment to have beneath cloths or some other receivers which will prevent a smash.

A LIQUID PRODUCED BY TWO SOLIDS.

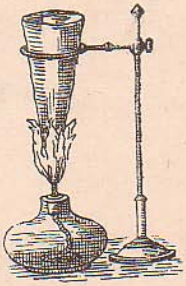
Rub together in a dry mortar equal portions of carbonate of ammonia powdered, and blue vitriol powdered; these will yield a blue liquid. A colourless semi-liquid may be obtained by rubbing together equal parts of sulphate of soda powdered, and acetate of lead.

CONTRACTION ON MIXING LIQUIDS.

Take a long narrow test-tube and half fill it with water, then carefully pour in strong alcohol till quite full. On closing the open end of the tube with the thumb and shaking for a few moments, so as to get the two thoroughly mixed, the liquid will no longer fill the tube, showing that the liquids occupy less space when mixed than when separate.

A PAPER BOILER.

In a neatly made and carefully cemented cone made of writing-paper, water may be boiled over a spirit-lamp as shown in the engraving. The explanation of the fact that the paper is not inflamed is that the heat is too rapidly conducted through it.



VORTEX SMOKE-RINGS.

All the apparatus required to produce this effect is an empty cigar-box, one of the ends of which, being removed, is replaced by canvas tightly nailed round it. A circular hole 1 inch in diameter is bored in the opposite end; inside the box is a saucer half filled with carbonate of ammonia, upon which sufficient hydrochloric acid is poured till a dense vapour of ammonium chloride fills the box, which upon slight rapid

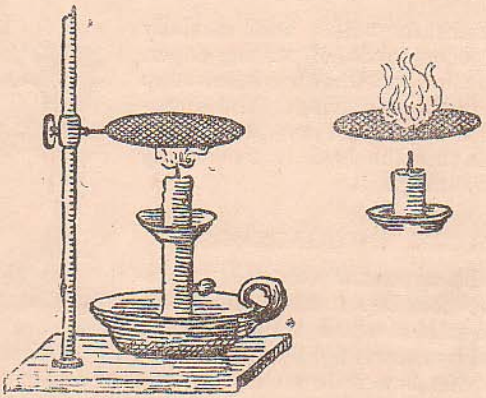
pressure upon the canvas end of the box is ejected from the hole, and assumes beautiful circles of white smoke, which ascend and retain their shape till dissipated.

THE PENETRATING SMOKE.

Take two dinner tumblers, and into one drop about twenty drops of strong solution of ammonia, into the other about twenty drops of hydrochloric acid. Hold a handkerchief before the glasses and request a gentleman to blow some smoke (from pipe or cigar) towards the table. As he does so pretend to catch the smoke in one of the glasses, which you must then invert over the other, and immediately cover with the handkerchief, and in a few seconds uncover again. The glasses will be found to be full of smoke.

TO CUT A FLAME IN HALF.

Take a piece of fine iron wire gauze and lower it gradually over an ordinary gas flame (or candle). As the gauze descends



the flame will be cut off, the lower part however keeping the same shape as before. If you now turn out the gas and re-

light above the gauze, the flame will appear on the upper surface only.

On this principle the Davy Safety Lamp is constructed.

TO PRODUCE FIRE FROM TWO LIQUIDS.

Ingredients.—(1) Glauber's spirit of nitre; (2) spirit of turpentine (or oil of cloves or caraway); in two phials.

Directions.—Take a drachm of each solution, put No. 2 into a glass vessel and add No. 1—both solutions in themselves being perfectly cold. A great flame will arise and destroy them both, leaving only a little resinous matter at the bottom.

Or,

Take 1 oz. of turpentine and ½ oz. of nitric acid, with a few drops of sulphuric acid in the nitric acid.

Directions.—Pour the turpentine into a saucer, then add carefully the nitric acid. It will immediately burst into flame.

THE LIQUID ISLAND.

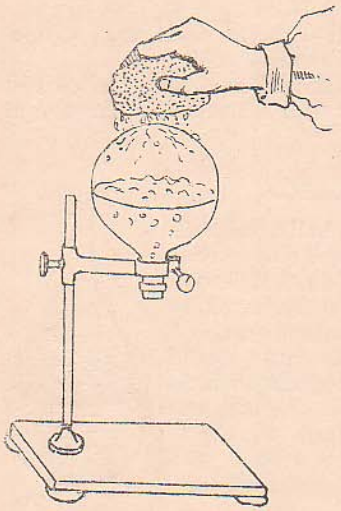
A half-pint flask should be half filled with a saturated solution of sulphate of zinc; about a drachm of bisulphide of carbon, tinted with a trace of iodine, should then be carefully poured on the surface of the zinc solution, and the flask filled up with water; the latter should be carefully poured in so as to mix as little as possible with the zinc. The carbon will assume the shape of a perfect amethyst-coloured sphere floating between the two fluids, and if undisturbed will last for weeks.

TO PROVE THAT SUGAR CONSISTS LARGELY OF CHARCOAL.

Put some sugar into a glass dish, and dissolve it in the smallest possible quantity of boiling water. Pour on the mixture a quantity of strong sulphuric acid, about half the volume of the sugar solution, stirring together with a glass

rod. The dish should be large enough to contain six times the quantity of sugar solution experimented with. The success of the experiment depends on not using too much water, and in rapidly pouring in the acid. The explanation of this experiment is that sugar consists of carbon with the elements of water. Oil of vitriol (sulphuric acid) has a strong affinity for water, and snatches it from its chemical combinations. In the case of sugar it leaves a porous mass of charcoal (carbon) behind.

TO MAKE WATER BOIL BY THE APPLICATION OF COLD.



In a glass flask water is boiled for some time, until all the air has been expelled and its place taken by steam. The flask is then quickly corked and inverted, and cold water is applied by means of a sponge to the bottom of a flask. This condenses the steam above the surface of the water, a partial vacuum is formed, and the water begins to boil. This is an experiment similar to, but simpler and more striking than, the one often shown by placing a glass of water under the bell-jar of an air-pump, and exhausting the air in the jar. When a vacuum is nearly produced the water in the jar begins to boil.

FIRE AT COMMAND.

The simplest test of a true magician's wand is that it will produce fire when this agent is called for. A glass rod can be proved publicly for this quality in the following manner.

First powder a little chlorate of potash. Then take finely powdered sugar and mix equal parts of sugar and chlorate of potash very carefully by means of a bone spatula on a piece of writing-paper. You must not rub the two together violently or a dangerous explosion may result, and in powdering chlorate of potash it is important to note that no dust or other foreign body is present or an explosion (resulting from the sudden separation of the oxygen gas in the chlorate) may occur. Half a teaspoonful of the mixed white powder will be sufficient for the experiment. Put this in the middle of a saucer or plate and do not hold your face over it. Then take a glass rod wet at the tip with a drop of sulphuric acid. The powder will instantly burst into flame.

This experiment may be varied, and any legend adopted which the ingenuity of the magician may suggest. Thus it may be described as

CALLING FORTH THE FIRE FROM MOUNT ETNA.

Dip the glass rod into oil of vitriol and hold the moistened end to the top of a cone described below, which in a few seconds will burst into flame.

The cones are composed of 3 parts powdered chlorate of potash, 1 part powdered white sugar, made into a paste with mucilage of acacia and carefully dried.

Professor Frikell employed another method of producing a similar effect. He would in the following manner

LIGHT A CANDLE BY THE WORD OF COMMAND.

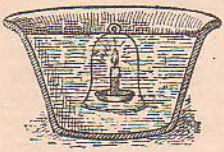
Materials required.—A candle, a few pieces of potassium, a phial of mineral naphtha, and a small piece of wet sponge.

Directions.—Place a pellet of potassium in the wick of

the candle, making it fast by running a needle and white thread through the potassium, and securing it to the wick. Now dip wick and potassium into the naphtha. It is then ready for use.

Hold the candlestick in the left hand, quickly press the wet sponge, lifting the extended arm. Cry, 'I command you to be lighted!' Touch the candle with the wet finger and the candle will burst into flame.

TO BURN A CANDLE UNDER WATER.



Place a small lighted candle on a cork or on a small saucer and float it on water contained in a deep pan. Then cover the whole with a bell-jar and force the jar gradually and steadily under the water till the top of the jar is level with the surface of the water. The candle will then continue to quietly burn till the air contained in the jar is exhausted.

ARITHMETIC AND CHEMISTRY.

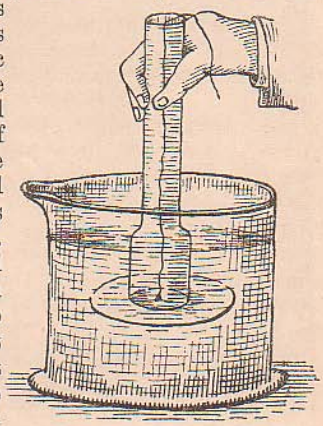
Get any solution which will leave a stain on the skin without injuring it, such as a solution of permanganate of potash, or a solution of pyrogallic acid, say $\frac{1}{2}$ drachm to 1 ounce of distilled water. The latter is more effective if a little ammonia is applied after the application of the solution. Entrust the solution to one of the company, with a request that during your momentary absence he will touch with the wet stopper in the bottle a finger or thumb of any person in the room, and on your return you will undertake by means of calculation, not only to discover the person who shall be thus marked (for in a few minutes the solution, though colourless, will leave a blue spot on the skin), but also to state without going near anyone the hand, the finger, and the particular joint of the finger on which the mark is to be found. To accomplish this your company must be arranged in a definite order, and one person must be willing to carry out your instructions. He must first know himself, but must not tell you, the number of the person (in the order of arrangement). Tell him to double that number,

to add 5, to multiply the result by 5, to add 10, to add 1 if the right hand or 2 if the left hand was touched, multiply again by 10, add to the total the number of the finger (say 1 for the thumb, 2 for the index, and so on), and again multiply by 10. Add again the number of the joint (1, 2, or 3), and lastly add the number 35. He must then tell you the total arrived at. From this you quickly deduct 3535, and you will have four figures which will indicate in proper order the person selected, the right or left hand, the finger and the joint where the little black spot is to be found. For example, suppose the sixth person of the series should be selected, the left hand, the middle finger, and the second joint; the calculation will run as follows:—

$6 \times 2 = 12 + 5 = 17 \times 5 = 85 + 10 = 95 + 2$ (for the left hand) $= 97 \times 10 = 970 + 3$ (for the third finger) $= 973 \times 10 = 9730 + 2$ (for the second joint) $+ 35 = 9767 - 3535 = 6232$; i.e. the sixth person, the left hand, the third finger, and the middle joint.

PRESSURE FROM BELOW.

The following is an easy experiment to prove that the pressure exercised by fluids is as great from below upwards as from above downwards. A disc of mica is held against the bottom of an ordinary cylindrical glass lamp-chimney by means of a piece of string attached to the mica disc. The chimney, closed at the bottom by the mica, is plunged into a vessel of water. The disc of mica will be retained in position by the pressure from below. On pouring water into the lamp it will be found that the loose mica support will not relax until the water in the lamp-glass has attained the exterior level.



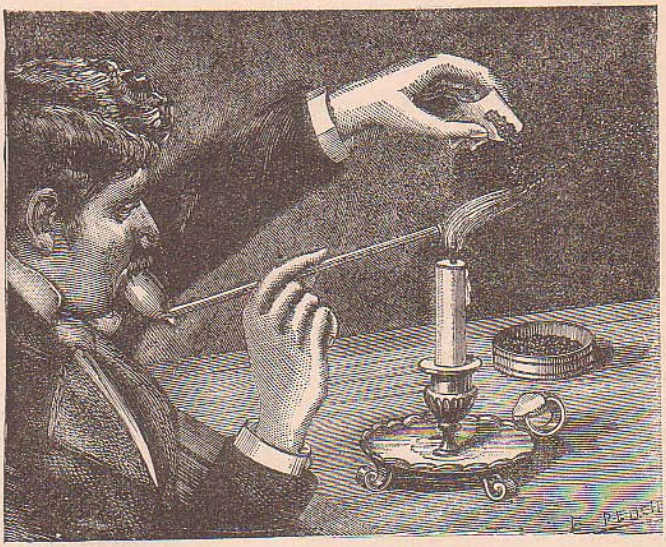
ARTIFICIAL RAIN AND HAIL.

In amateur theatricals the representation of a hailstorm is sometimes desirable. A fair imitation of one can be produced as follows :—

Make a hollow cylinder of wood, let it be very thin at the sides, about eight or ten inches wide, and two or three feet in length. Divide its inside into five equal parts by boards of five or six inches wide, and let there be, between them and the wooden circle, a space of about one-sixth of an inch. These boards are to be placed obliquely. In the cylinder put four or five pounds of shot; when turned upside down the noise of the shot going through the various partitions will resemble rain. Larger shot will produce the sound of hail.

ARTIFICIAL LIGHTNING

may be produced by putting a small quantity of lycopodium



into a quill or glass tube and blowing through a flame. We show the performance of this experiment in the subjoined

illustration. Of course the room should be rather dark to obtain a good effect.

Lycopodium is a very fine powder, and consists of the spores of a club moss. These club mosses were in distant ages vast growths, and it is to them we owe our finest anthracite, bituminous, and cannel coal. They are now mostly extinct. The spores are contained in cases and correspond to the seeds in flowering plants. The fineness and smoothness of this powder is such that in a bottle half filled with it it seems almost of a liquid nature. By agitating it waves or ripples can be produced on its surface. It is partly to its fineness, and partly to its resinous character, that lycopodium owes its property of instantaneous inflammation. It also provides another curious phenomenon. If a thin layer of lycopodium be sprinkled on the surface of a glass of water, the finger may be thrust into the vessel, and the lycopodium thus pushed into the fluid will, so to speak, separate the molecules of the water and keep them from coming into contact with the finger. The sensation of coldness of the water will be distinctly appreciable, but the finger will not become wet. On this characteristic of lycopodium is based the experiment of

TAKING A COIN OUT OF WATER WITHOUT WETTING THE HAND.

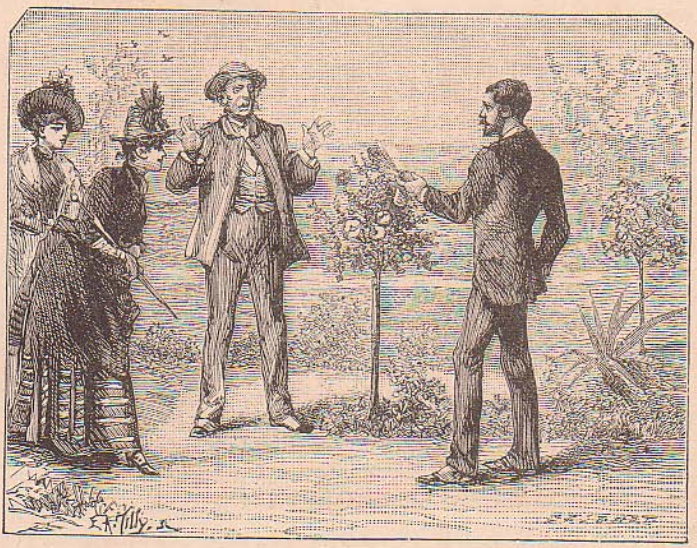
With some lycopodium powder well sprinkle the surface of the water in which the coin is placed, or the hand may be rubbed over with the powder. In either case the hand may be dipped into the water without becoming wet, and thus the coin may be removed. After performing the feat a shake of the hand will dislodge the adhering powder.

THE FLOATING BEACON.

Directions.—Take a small pyramid-shaped piece of camphor, place it on the surface of some *clean* water in a basin, ignite the point with a match. The flaming beacon will then commence darting about on the surface of the water, and will continue doing so till burnt out.

TO CHANGE WHITE ROSES INTO RED ONES.

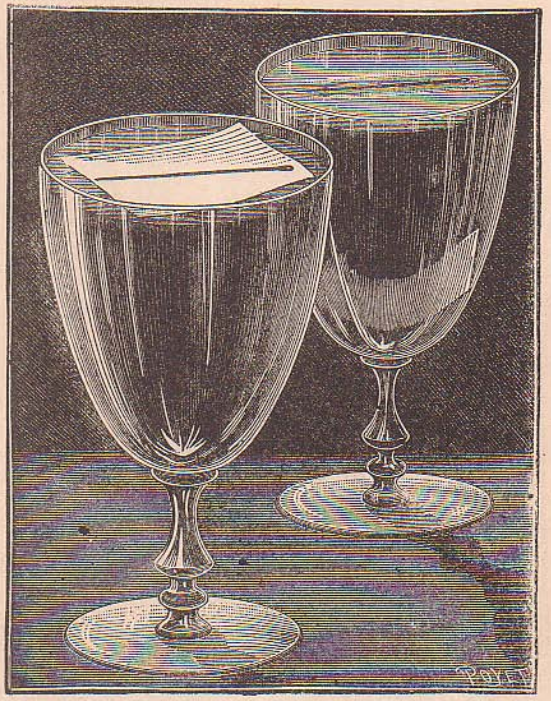
This is a performance suitable for the garden or the parlour. The dry petals of a white rose must be first delicately, and as far as possible uniformly, sprinkled with aniline



crystals. The rose should be shaken so as to leave as little as possible visible; what there is will be only trifling specks. By bringing to play on it a spray of eau-de-Cologne or other spirit from a vaporiser—those connected with a finger ring enable the performance to be most mysteriously accomplished—the delicate white petals can be promptly suffused with a rich crimson blush.

THE FLOATING NEEDLE.

Take a steel needle and pass the fingers over it to slightly grease it. Lay it very carefully on a piece of cigarette-paper on the surface of a glass of water. The paper will soon sink,



but if the experiment be carefully performed, the needle will remain floating. The slightly greased surface serves to form a meniscus round the needle, actually preserving it from contact with the water.

THE INCOMBUSTIBLE HANDKERCHIEF.

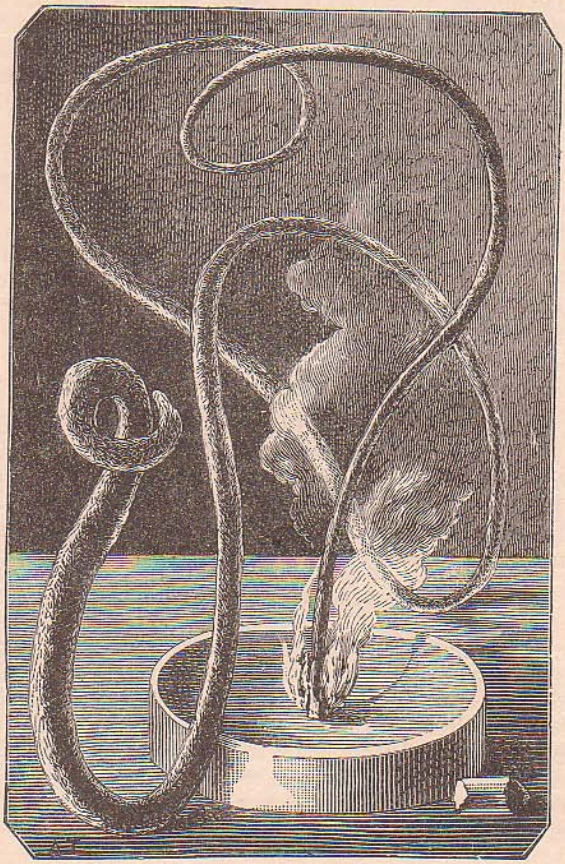
Get a brass or copper or other metal ball about three inches in diameter. The large knob of a door or of the stair

banisters will do. Fit very tightly round it a fine linen handkerchief; you had better practise with an old one of your own before you venture to borrow one from your fair cousin. Then with a pair of tongs take a red-hot coal from the fire, blow on it to make it glow, and let it rest on the top of the

handkerchief. The coal will continue to burn, but the handkerchief will not be injured. The explanation of this effect is that the metal being a so much better conductor of heat than the handkerchief, the heat passes from the coal to the metal direct, and the handkerchief has not time to become even scorched.

PHARAOH'S SERPENTS.

These well-known chemical toys are little cones or cylinders formed of sulphocyanide of mercury made into a paste with a



little mucilage of tragacanth, with the addition of about 5 per cent. of nitrate of potash. The sulphocyanide of mercury is made by adding sulphocyanide of potassium to a weak solution

of acid nitrate of mercury, and collecting, washing, and drying at 212° the light white precipitate thrown down. The 'egg' made from the sulphocyanide of mercury thus obtained must be carefully dried on a water-bath. To exhibit it, a lighted match is applied to the end of the egg, on which the 'serpent' unrolls itself to an enormous length. It must be remembered that the product is very poisonous, and should be burned as soon as the exhibition is finished. The vapours given out by the serpent are also highly poisonous, and care should be taken not to inhale them.

More harmless, but less effective serpents may be made from bichromate of potash, 2 parts; nitrate of potash, 1 part; powdered white sugar, 3 parts.

Powder the ingredients separately; then mix thoroughly. Make small paper cones about the size of fumigating pastilles, and press the mixture into them. Place one of the cones on a plate and light the point. A serpent will gradually and gracefully uncoil itself.

HEAT AND COLD.

A small piece of fresh lime; nitric acid and sulphuric acid, of each 1 oz. separately in bottles. Label both 'Poison.'

Directions.—Dissolve a little of the lime in nitric acid; then pour some of the liquid into a glass and add a few drops of sulphuric acid; the whole will become a nearly solid mass, and at the same time give out a strong heat.

THE MYSTERIOUS BOTTLE

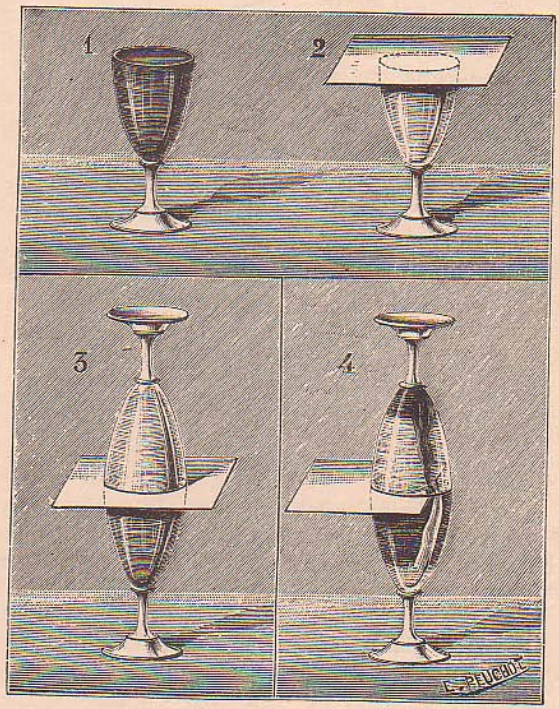
will make many wonder 'how it's done.' The bottle (2 oz. or 4 oz.) is fitted with a perforated cork and bent glass tube, reaching to the bottom. Half an ounce of ether is put in and the bottle is filled up with water. If the bottle is put into hot water it will immediately begin to empty itself; if it is then put into cold water it will begin to fill again.

Note.—Care must be taken with the experiments with *ether, as its vapour is very inflammable.*

GRAVITATION OF LIQUIDS.

Take two glasses of exactly similar shape and of equal size. Fill one (1) quite full with wine, and the other (2) with

water. Cover glass 2 with a sheet of writing-paper, invert it, and place on the top of glass 1, as shown in fig. 3. Now very carefully draw the paper partly away, leaving about an

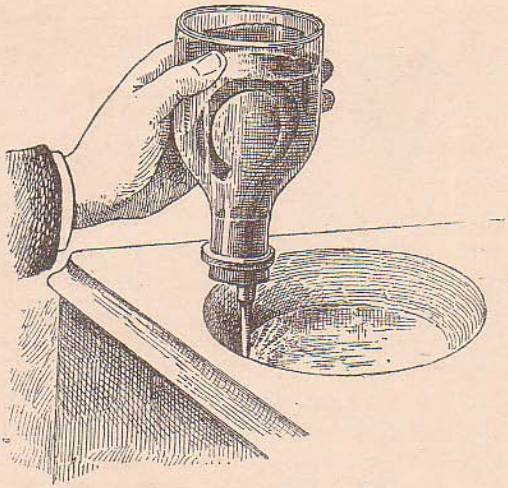


inch where the two liquids come into contact. Gradually a stream of wine will ascend into the upper glass, while a corresponding stream of water will pass into the lower vessel.

THE CUP OF TANTALUS.

A bottle without a bottom, but tightly corked, is fitted with a glass tube such as is shown in the drawing. On pouring

water into this vessel nothing occurs until the liquid covers the bend of the syphon thus formed. It then all runs off down



to the mouth of the tube in the bottle. When the apparatus is sold as a toy, a figure of Tantalus is attached to the tube with his mouth ready to drink just above the level to which the water can reach.

CHEMICAL FERNERY.

Fold into a triangular form six pieces of cap or other paper, about 4 or 5 inches long, and 1½ broad, previously steeped in a concentrated solution of bichromate of potash. Place them on edge on a plate, and light along the top edge. As they smoulder, fern-fronds will curl out in a most wonderful manner.

WHAT HOLDS IT UP?

Materials.—A small tumbler or ale glass, a bit of sponge, and methylated spirit.

Directions.—See that the hand is large enough to well

cover the mouth of the glass, moisten the bit of sponge with spirit, light it, and drop it into the glass, which at once cover with the naked hand. The flame will be immediately extinguished, but the glass will remain suspended to the hand, without any visible support. Unless the glass is jerked it will require a strong, steady pull to free it from the hand.

This experiment may be varied in the following manner. Fill the glass to the brim with water, and slide over the mouth a piece of paper, being careful to exclude any air bubbles. The glass may then be turned over, and the water will not run out. The effect is made more striking if a disc of transparent mica be substituted for the piece of paper.

SOAP BUBBLES.

The best soap solution to use for the production of bubbles that can be blown to a great size and do not burst readily is the following:—Castile soap shavings, 1½ parts; glycerine, 10 to 15 parts; water, 20 parts. A large bubble blown with this solution has kept unbroken for 48 hours under a shade. Blow a bubble and let it fall in a glass dish, in which previously a little vinegar and common soda have been placed. It will remain suspended in the dish, apparently supported upon nothing. Fill other bubbles with carburetted hydrogen from a gas jet—which can be easily done by connecting a piece of indiarubber tubing with the pipe-stem. Fill others with carbonic anhydride (prepared by the action of hydrochloric acid on common chalk); others, again, may be filled with phosphuretted hydrogen (safely prepared from hypophosphite of calcium heated in small retort or test-tube). The bubbles come over slowly and give time for getting the pipe-bowl under the solution before another bubble comes. The phosphuretted hydrogen bubble, on coming into contact with the air, ignites. This is a very pretty experiment.

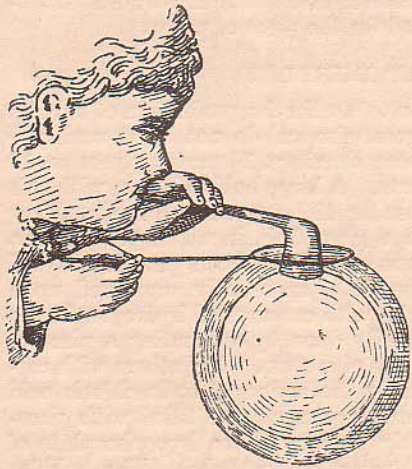
ROSIN BUBBLES.

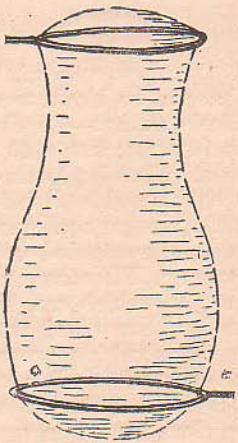
Soap bubbles are the emblem of evanescence. Bubbles blown of rosin are much more permanent, and exhibit a

peculiar metallic lustre. They are blown like soap bubbles from a pipe, but from rosin just sufficiently heated to liquefy it. Do not melt rosin over an open fire, or it may inflame. A better rosin mixture may be made from rosin 46 parts and Canada balsam 53 parts. Melt together, and add a few drops of turpentine. Before using, heat the mixture.

DOUBLE BUBBLES.

To blow a double bubble—that is, one bubble within the other—it is necessary to have a wire ring about 2 inches in diameter; it should be a perfectly finished ring, the wire being of about the thickness of a hair-pin, and it should be provided with a stem. To this a bubble from a pipe-bowl can be with care transferred. The operator then again takes his pipe provided

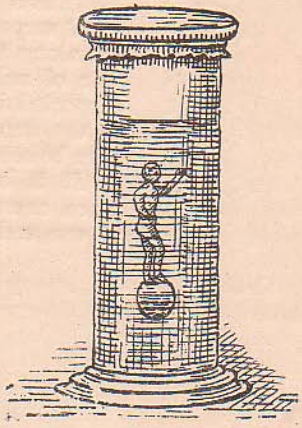




with some soap solution, passes it through the ring, and blows his second bubble. The outer bubble will be seen to expand and keep out of the way of the inner one. Sometimes a very beautiful effect of colours is produced in these double bubbles.

With two rings such as we have described, it is possible to elongate a bubble into a vase-shaped figure as shown in the drawing.

THE DIVING IMP.



This is an interesting toy showing the effect of air pressure. It consists of a glass cylinder nearly full of water, in which floats a small glass figure to which is attached a glass ball pierced at its lowest extremity. Over the top of the cylinder a piece of sheet indiarubber is tightly tied; in pressing this with the hand the air in the vessel is compressed and forces the water into the glass ball, which causes the imp to sink.

On taking away the hand the pressure is relieved, the water flows out of the ball, and the diver rises again to the surface.

CURIOUS FIRES.

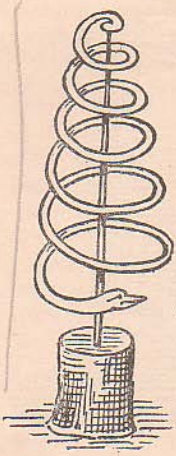
1. Ignite a chlorate of potash lozenge on a plate; it burns freely, and leaves an ash similar to the Pharaoh's serpents. 2. To imitate green tea.—Heat the crystals of bichromate of ammonia in a saucer over a gas-flame; the residue closely resembles green tea.

THE SEA ON FIRE.

Materials required.—A soup plate, some potassium and naphtha, and a few paper ships.

How to proceed.—Fill the plate with water, pour a little naphtha on the water, then place the ships in position. Now make such a remark as, 'I am now about to burn the fleet of King Tim Buck Too, the King of the Cannibal Islands.' Throw a piece of potassium into the plate, and you will have a fleet on fire. Potassium and sodium are light, soft metals which have so strong an attraction for oxygen that they will separate this element from its combination in water, and unite with it so violently as to burst into flame. The conflagration may be extinguished by covering with a second plate.

THE REVOLVING SERPENT.



Take a piece of cardboard and draw a spiral serpent on it as shown in the figure, cut along the lines with a sharp knife or pair of scissors, and mount on a needle supported in a cork in the manner shown in the annexed sketch. The serpent will then be seen to revolve of its own accord.

If it be placed on a stove or warm place, or mounted on a bent wire pointed at one end and held over a lamp flame, the motion will be greatly accelerated.

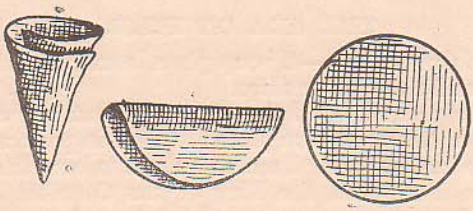
PARLOUR FIRE-WORKS.

Small circular filter-papers, saturated with strong solutions of boracic acid, lithium chloride, sodium chloride (common salt), &c., and a bottle of methylated spirit.

Instructions.—Fold paper into cones, pour on a few drops of the spirit, and set on fire.

Or,

Ten-inch circular or square filter-papers, soaked in strong



solutions of the undermentioned chemicals and dried, give very effective results when lighted in a dark room, or thrown, on ignition, in the air against a dark background :—Red, solution of nitrate of strontia ; violet, solution of chlorate of potassium ; yellow, solution of carbonate of soda ; green, solution

of nitrate of barium. For facility the powders may be kept in a box wrapped in different coloured paper. In this latter, as in the former, the addition of a little spirit to the prepared paper will assist the display.

THE RAINBOW FIRE-CLOUD.

Required.—(1) A strong globe of iron or brass capable of holding half a pint, in which are two apertures—the one for putting the liquids through, the other should have a small tap fixed into it. This represents a steam-boiler—the man-hole to put the water in, the jet to blow the steam off when the water boils. (2) Methylated spirit of wine ½ oz., nitrate of copper, nitrate of strontia, nitrate of barium, and chloride of copper, 1 drachm of each. These salts colour the flame green, red, yellow, and blue.

Directions.—Mix the powders with the liquid and put into the boiler, and screw the entrance up perfectly vapour-proof. The boiler should now be set upon a retort-stand and a spirit-lamp placed underneath it. By means of the jet-tap it is easy to find when the liquid boils. As soon as this takes place, the steam is shut off, and the heat continued for about five minutes. The jet-tap being now turned on, the whole of the liquid blows out with considerable force and assumes the shape of a cloud. Now light it, and you will be amply repaid for your trouble when you see the cloud on fire in different colours.

FIRE-BALLOONS.

These show well when set off from a window on dark evenings, and are easily manufactured, all sizes, out of parti-coloured tissue-paper, and are made to ascend by the air inside the balloon being made hot by a sponge saturated with spirit and lighted.

THE DANCING FIRE-BALL.

Directions.—Procure a stout and tolerably wide test-tube. Place into it a teaspoonful of powdered chlorate of potash, and heat over a spirit-lamp. When it is liquefied and begins to boil, drop into it a piece of charcoal about the size of a pea. It will immediately begin to glow, and will dance about on the surface of the liquid as if alive.

OPTICAL DELUSIONS.

THE MAGIC MIRRORS.

Make two holes in the wainscot of a room, each a foot high and ten inches wide, and about a foot distant from each other. Let these apertures be about the height of a man's head, and in each of them place a transparent glass in a frame, like a common mirror.

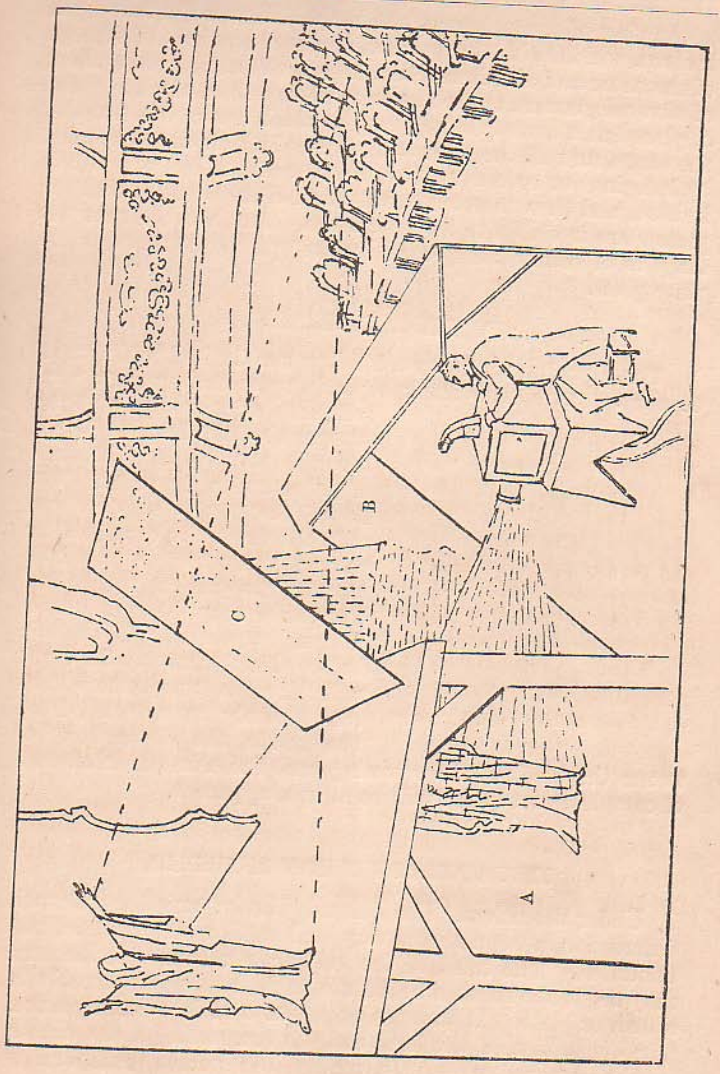
Behind the partition, and directly facing each aperture, place two mirrors, enclosed in the wainscot, at an angle of 45°. These mirrors are each to be eighteen inches square; and all the space between them must be enclosed with pasteboard painted black, and well closed that no light can enter. Let there be also two curtains to cover them, which you may draw aside at pleasure.

When a person looks into one of these fictitious mirrors, instead of seeing his own face, he will see the object which is in face of the other; thus if two persons stand at the same time before these mirrors, instead of each seeing himself they will reciprocally see each other. Expecting to see Hyperion you face a satyr, or *vice versâ*.

There should be a sconce with a lighted candle placed on each side of the two glasses in the wainscot, to enlighten the faces of the persons who look in them, or the experiment will not have so remarkable an effect.

STAGE GHOSTS.

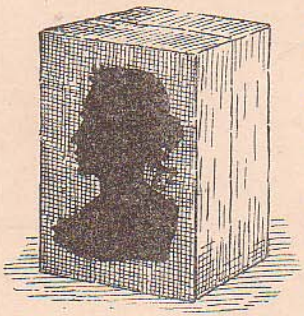
The accompanying drawing will give an idea of the mechanism necessary for the production of a stage ghost. An actor, A, dressed in a white sheet, stands under the stage, out


B
C
A

of the view of the audience, but in the full rays of a lime-light lantern, which, with its operator, is also concealed. The image of the actor and all his movements are reflected from a sheet of silvered glass, B, under the stage on to a sheet of plate glass, C, placed at a corresponding angle, which covers the front of the stage, and all the sides and edges of which are concealed by hangings or scenery. The stage must be but very dimly lighted, and then the cloudy reflection of the actor behind the plate glass is visible to the spectators. Another actor on the stage is of course easily seen by the spectators through the plate glass.

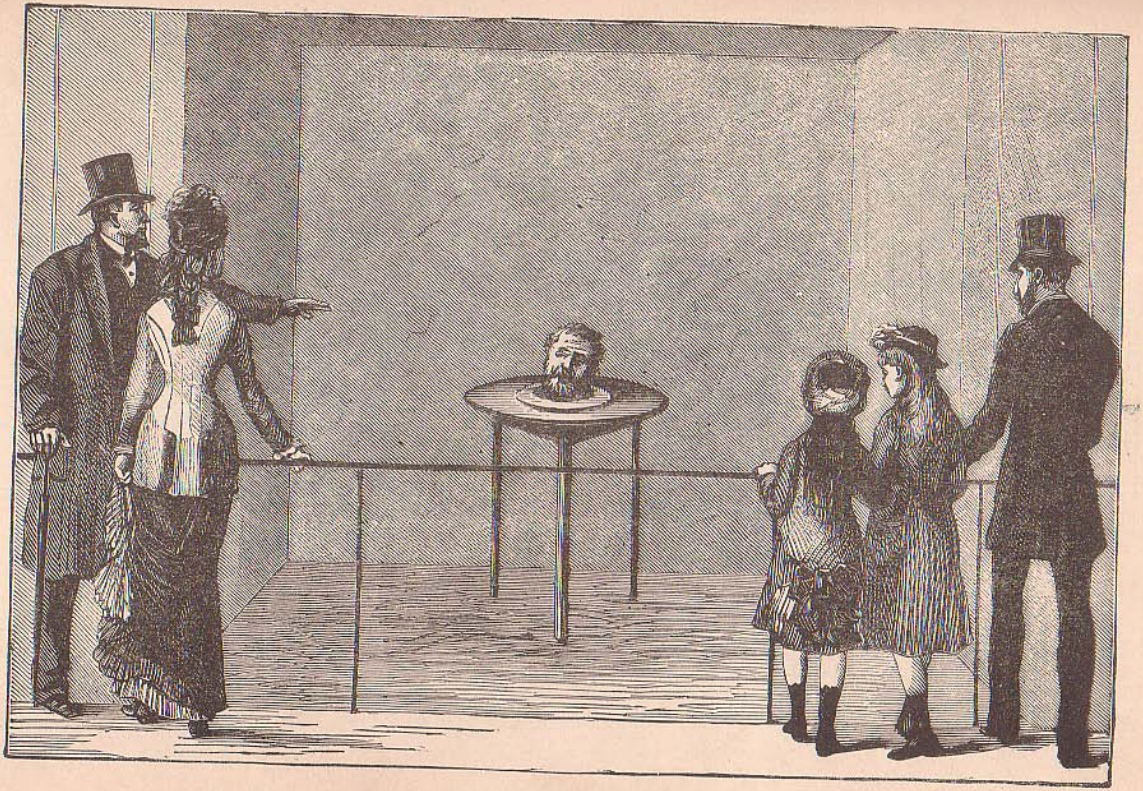
A BLACK BLACK.

The experiment illustrated below was devised by Chevreul to show that a true black depends upon the absolute non-reflection of any rays of light. A pasteboard box is lined throughout with the blackest of velvet, silk, or paint. The lid of the box is also covered with the same black material or colour. Then in the lid a hole is cut; the smaller the better. The hole may be cut into a design if preferred. If the box be so placed that a side light will fall upon it so that no light can possibly be reflected from the inside, the distinction between the black of the covering and the absolute blackness of complete absorption will be at once apparent.



DECAPITATION NO MURDER.

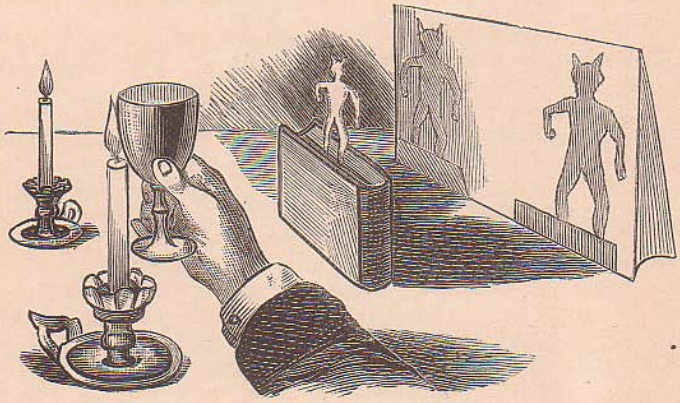
Under the title of 'The Beheaded Lady,' or with some such description, a popular and very striking illusion is sometimes exhibited. The head of the lady or gentleman, as the case may be, is shown on a neat little table, resting apparently in a dish or plate. It answers questions and is evidently alive. The disposition of the head and the surroundings are shown in the annexed plate. In reality the person exhibited is



seated, and the table and plate are mechanically fixed round his or her neck. The body and legs are concealed by squares of mirrored glass, framed by the legs of the table. These squares must be fixed at angles of 45° with the walls of the room, and the walls, sides, and back must be of a homogeneous and dull colour. A half-light aids the illusion.

COMPLEMENTARY COLOURS.

A good experiment, illustrating the effect of coloured shadows, can be performed with two candles, an opaque figure, and a white screen placed as shown in the drawing.



By interposing between one of the candles and the shadow a red coloured glass, or a glass of red wine, the shadow opposite will appear red, while the other shadow will at first be lost, but on looking intently will appear faintly with a green tint. A glass of beer held in front of a candle will cause one shadow to appear yellow and the complementary one violet; a pale blue solution will bring out an orange second shadow, and so on.

MISCELLANEOUS SCIENTIFIC APPLICATIONS.

TO ENGRAVE NAMES ON GLASS.

Materials required.—1 oz. of sulphuric acid, a few crystals of fluorspar, a lead vessel, a spirit-lamp or candle, a piece of glass, bees' wax, and a sharpened piece of wood.

Directions.—Put the sulphuric acid and fluorspar into the lead cup. Melt the wax and finely coat the glass with it, and by means of the sharpened wood (or a pin would do) trace the name on one side of the glass. Lay the glass, waxed and traced side down, on the lead vessel, and heat the latter by means of the lamp or candle. The design will shortly be found to be fixed in the glass; when the wax is scraped off, the etching is left beautifully distinct on the glass. Or the above process may be simplified by simply painting over the waxed glass some hydrofluoric acid (kept in a gutta-percha bottle) and allowing it to stand for a few minutes.

Hydrofluoric acid, which is formed when sulphuric acid acts on fluorspar, has a violent action on glass. It cannot, therefore, be kept in glass bottles. Hence the use of the lead cup and of the gutta-percha bottle mentioned in the above experiments.

ARTIFICIAL CORAL FOR GROTTOES.

Materials required.—Vermilion, 2 drachms; pale resin, 1 oz.; melt the resin and stir in the vermilion. Have ready branches of twigs peeled and dried; paint them over with the mixture while hot. The blackthorn is the best branch for the purpose. Hold these over a gentle fire, turning them round till they are perfectly covered and smooth.

RELIEF DESIGNS ON EGG-SHELLS.

Get an egg with a thick shell and paint or draw your design on it, using melted fat as the medium for the sketch. Then suspend the egg in strong acetic acid, which will dissolve away the surface of the shell not protected by the fat or grease.

TO POLISH SHELLS.

Boil the shells for two or three hours in water with a few lumps of quicklime. When the water has cooled transfer the shells to a vessel containing dilute hydrochloric acid (1 to 3). This will loosen the epidermis, which must then be peeled off. The shells should then be polished with rottenstone and oil applied with chamois leather. Finally they may be rubbed with a little olive oil simply.

TO TAKE PRINTS OF LEAVES &c.

Very accurate and beautiful prints of leaves may be obtained in the following manner:—First get a sheet of fine writing-paper, and oil it well with olive oil until the paper has pretty well absorbed the oil. Hang the paper in the air to dry until there are no longer any globules of oil upon it. Then move the oiled side of the paper horizontally over the flame of a lamp or candle until you have a smooth black surface. Now lay your leaf carefully and smoothly on this blackened paper, and, laying another piece of paper over it, rub it carefully and firmly with your finger for about half a minute. Next take the leaf, and lay it on the page or sheet of paper on which you want to get your impression, cover it with blotting-paper, and apply gentle pressure as before. If you are careful you will be able to obtain several beautiful impressions from the same leaf.

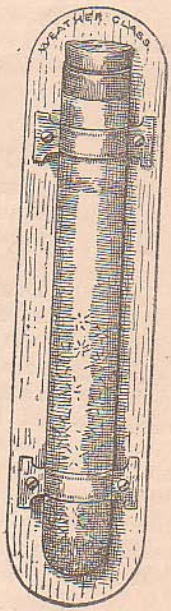
SUN PRINTING: FOR TAKING TRUE COPIES OF TRACINGS, LEAVES, PATTERNS OF LACE, &c.

Requirements.—Ammonio-citrate of iron, 2 drachms; solution of ferrocyanide of potassium, 2 drachms; distilled water to 2 oz. Mix and label: 'The prepared solution. To be kept in the dark.' A camel-hair brush.

Directions.—By candle-light take a sheet of writing-paper and brush one side of it over with the solution; hang it up to dry in a dark room or cupboard. When dry, place the object to be copied next the prepared surface, in a printing-frame; then expose to direct sunlight for a few minutes till the prepared paper has turned grey; take it out and wash the paper in clean water; the printing will then become permanently fixed. Instead of a printing-frame, the object and paper may be enclosed between a piece of glass and a piece of flat wood tightly bound together.

THE CHEMICAL WEATHER-GLASS.

Requirements.—A narrow glass phial or tube 8 or 10 inches in length and $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter (one of the old-fashioned long eau-de-Cologne bottles is sometimes used), 2 oz. of proof spirit, 2 drachms of camphor, 25 grains of crystallised nitre, and 25 grains of muriate of ammonia.



Directions.—Powder and dissolve the last three in the proof spirit, pour the solution into the bottle, and close with a cork which has been perforated by a red-hot needle. This is then suspended in an upright position. The indications for this weather-glass are as follows:—Fine, the liquid part will remain transparent, and the solids will collect at the bottom of the phial. Rain, the solids will gradually rise, and small, star-shaped crystals will form and move about in the clear liquid. Twenty-four hours in advance a storm or high wind will be indicated by the liquid becoming turbid, the solid portion rising to the surface. During the hot summer months, in fine weather the solid portion remains at the bottom; in winter, during frost or snow the solid particles keep in constant motion.

TO BLEACH FLOWERS.

Light a piece of sulphur or some flowers of sulphur in a deflagrating-spoon (see page 5), and lower into a large, wide-mouthed bottle.

When the sulphur ceases to burn, lower any coloured flowers, such as red roses, into the bottle; the colour will be discharged and the flowers rendered nearly white.

WINDOW-PANE BAROMETERS.

Paint a window-pane with one or other of the following solutions:—

1. Chloride of cobalt, 1; gelatine, 10; water, 100 parts.
2. Chloride of copper, 1; gelatine, 10; water, 100 parts.
3. Chloride of cobalt, 1; gelatine, 20; water, 200 parts; nickel oxide, $\frac{3}{4}$; chloride of copper, $\frac{1}{4}$ part.

The variations of colour will indicate probable weather. In damp states of the atmosphere the glass will be almost colourless, but in dry weather No. 1 will assume a blue, No. 2 a yellow, and No. 3 a green tint.

A FAIRY FOUNTAIN.

The 'Fairy Fountain' consists of a dome-shaped tin vessel of sufficient capacity to hold 10 or 12 oz., with a small hole at the top of the dome to admit of chemicals and water. This opening is covered with a screw-on cap with a pin-hole in the centre, through which aerated water is forced in a beautiful spray to a height of 15 or 20 feet as soon as the chemicals generate sufficient gas. To set the fountain in operation unscrew the brass cap from the nozzle, fill two-thirds full of water, add $\frac{1}{2}$-oz. each of tartaric acid in crystals, and bicarbonate of soda, and a little aniline colour, screw on the cap, and set in a large basin. The effect is very pretty when the water is tinted with any aniline colour and the fountain placed before a light; or its utility may be illustrated by adding some strong perfume to the water before charging, when a very pretty and effective perfume-spray is the result.

THE FOUNTAIN.

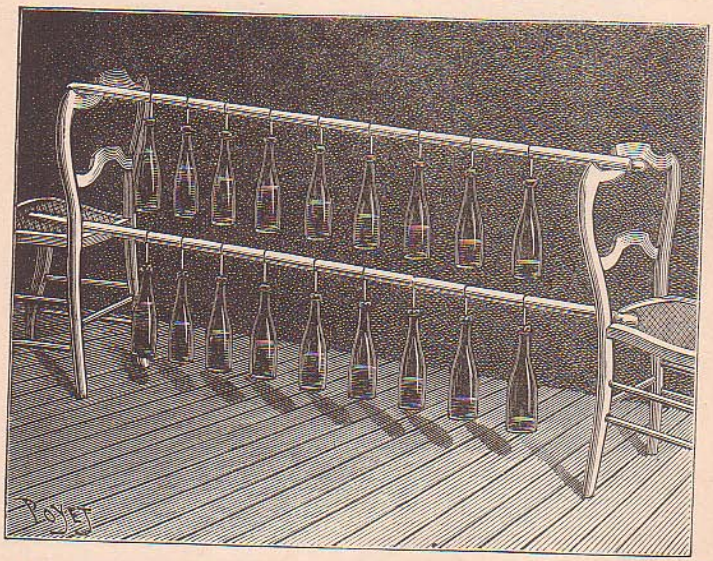
Any tinman will supply vessels the requisite shape for about 6*d*.

COBALT WEATHER-PROPHETS.

Tiny figures dressed in fabrics dyed with a solution of nitrate of cobalt, or pictures drawn with the same solution, are sometimes sold. Cobalt salts have the property of changing from blue to pink as they absorb moisture, so that in dry weather the dress or the picture is of a blue tint, but as the atmosphere becomes damp the fabric or the drawing acquires a pink colour.

THE BOTTLE HARMONICA.

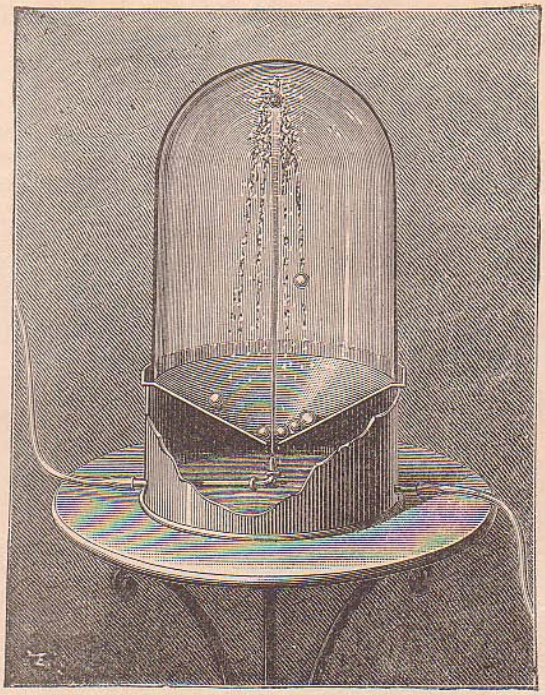
By the arrangement indicated below a very good musical instrument can be produced by an experimenter who has patience and a correct ear. A couple of broom-handles are



balanced on two chair-frames, and from these pint champagne bottles containing water in gradually varying quantities are suspended by threads. To play on the bottles the drumsticks sold with children's toy drums answer perfectly.

THE DANCING CORKS.

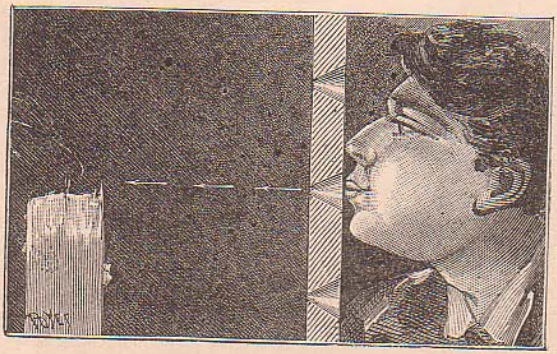
The design annexed shows the arrangement of a water-jet with cork pellets kept continually dancing in the column of water under a glass bell. This combination is an attraction in several of the filter-shops in London. A small pipe is

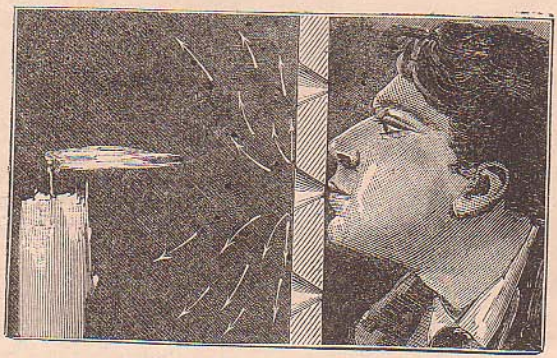


adapted from the water-supply, and is fitted as shown in a vessel somewhat of the shape of a spittoon. The cork balls as they fall on the sloping floor of the vessel necessarily find their way to the jet, and are at once carried up again by the current. Another pipe has to be provided to carry away the waste water.

TO BLOW A FLAME TOWARDS YOU.

A curious illustration of the effects of different draughts can be shown by the simple experiment depicted below. If a funnel-shaped orifice be cut through a screen, and a candle flame be situated some 4 or 6 inches in a direct line from

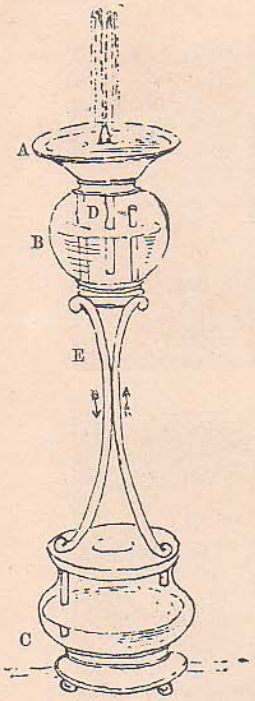




the narrow aperture and on that side of the screen, a steady blow will drive the flame in a direction away from the blower. But if the operator and the candle change sides, the draught occasioned by blowing will so disperse the pressure of the atmosphere as to cause the flame to be directed towards the blower.

HERO'S FOUNTAIN.

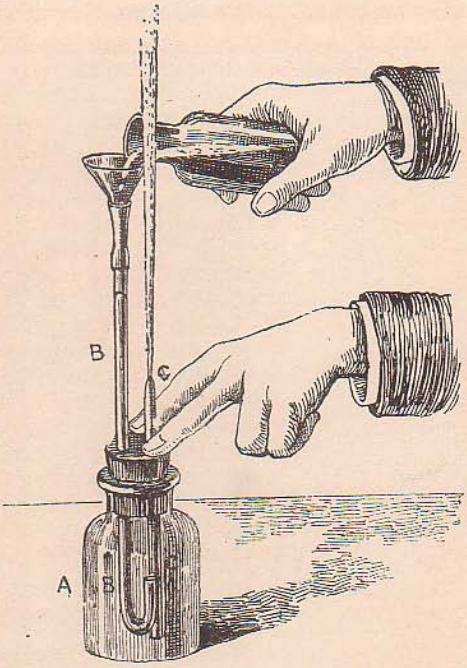
By the arrangement shown in the diagram, which was devised by Hero of Alexandria, 120 B.C., a fountain may be constructed which will play for some time. The apparatus consists of a brass dish, A, and two glass globes, B and C. The jet in the brass dish is supplied by a tube, D, which reaches nearly to the bottom of the globe B. The globe B must first be partly filled with water or other liquid, by pouring it into the brass dish so as to partly fill C, then inverting the apparatus for a time. The apparatus is then fixed into its original position. Water is then poured into the dish and is conducted by tube E to the glass globe C. This forces the air up tube F, and causes a pressure on the liquid in the globe B sufficient to force some up the tube D and make the fountain play.



MERCURY FOUNTAIN.

Mercury, being thirteen times heavier than water, will, under proper arrangements, force a jet of water to a great height. The height would be thirteen times that of the column of mercury if it were not for the counteracting influence of gravitation. This can be illustrated by an apparatus such as is shown in the illustration (page 89), A being a bottle filled with water, and through its cork pass two tubes, B being the one into which mercury is poured, and C (which is drawn to a narrow point with a small orifice) that from which the jet of water is ejected. The finger is held over the orifice of C while the mercury is being

poured into B. On removing the finger the water is at once ejected. A 6-inch column of mercury will force the jet some

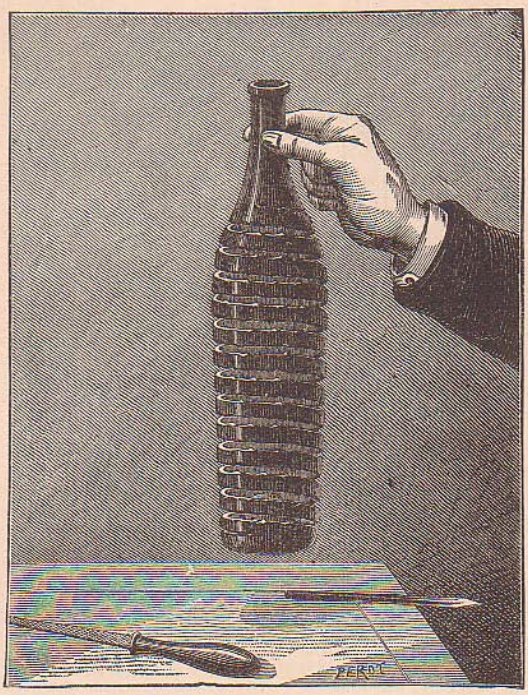


4 or 5 feet high. The cork must be held firmly or it may be forced out.

A SPIRAL BOTTLE.

A carbon pencil invented by Berzelius provides the means of cutting glass vessels in any form or shape desired. This pencil is made of a compound of lampblack, 5 oz.; gum arabic, 2 oz.; gum tragacanth, $\frac{3}{4}$ oz.; gum benzoin, 2 oz. Powder and mix all, and make into a paste with water. To use this for cutting glass it is formed into the shape of a pencil, made red-hot, and applied to the vessel to be cut. The part to be cut is first traced with a diamond. A tumbler can be cut off

at any desired point by putting oil into it to the level of the point to be cut, and plunging into the oil a red-hot iron. In a little while the part of the tumbler above the level of the oil can be readily broken off. By a little practice with the pencil



and a glazier's diamond, it is quite easy to cut a champagne-bottle into the curious form represented in the engraving. A parchment lining carefully fitted to the inside of the bottle, with some announcement written or printed upon it, makes a striking advertisement.

THE PERFUMED STAR.

A pretty and useful perfume-lamp may be made thus:— A clean, star-shaped piece of platinum foil is suspended from

a brass wire twisted into the shape of an M with the two ends sunk into a circular cork float (fire-proofed), sufficient in diameter to float easily in a small drinking-goblet, which is one-third filled with eau-de-Cologne, lavender-water, or any spirituous perfume. The float with suspended star is placed upon the surface. The spirit is lighted, and flaming up causes the star to become red-hot. To the top of the goblet is fitted a brass cap, perforated with ventilating holes on each side. When the platinum star has become red-hot, as it will do in a few seconds, the flames are extinguished by putting on the cap. The star continues to glow, and if the apparatus be placed in a dark room appears very brilliant, while a delightful perfume is diffused around by the slow evaporation of the spirit. This experiment is a modification of the 'Instantaneous Lamp,' in which spongy platinum and hydrogen are used, instead of the foil and spirit, to produce a flame.

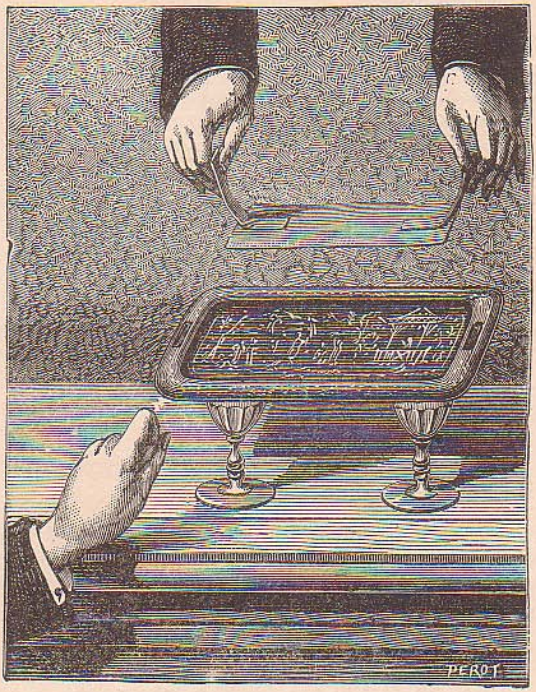
TO MAKE DRESSES FIREPROOF.

Tungstate of soda mixed in the starch with which muslin or other fabrics are prepared, in the proportion of 4 oz. to a pint, with ½ oz. of phosphate of soda, will render it very uninflammable. If a light be applied to a piece of muslin so starched, the material will smoulder and char, but will not blaze.

A SIMPLE ELECTROPHORUS.

Place a tea-tray on two tumblers as shown in the engraving. Cut a sheet of thick brown paper to a size to fit the flat part of the tray. Attach bands to the paper by sealing-wax in order to provide handles for it. The arrangement is now complete. To make it work, the sheet of paper should be first well warmed repeatedly, so as to get it perfectly dry. At last, when the paper has been thoroughly dried, and while it is still warm, lay it on a wooden table, and brush it vigorously with a hard and quite dry clothes-brush. Then, by means of the handle, lay the paper on the

tray, touching the tray with the finger at the time; and at the moment of lifting the paper off, let another person bring

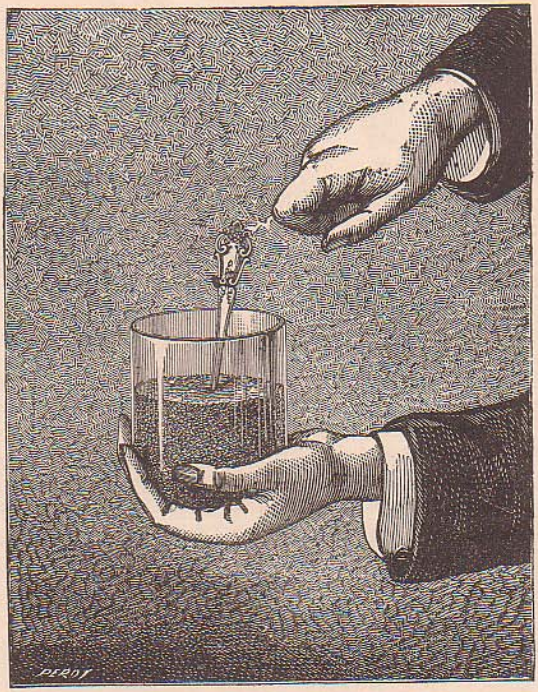


his knuckle to the tray, as shown. A visible spark will be produced, and the experiment may be repeated seven or eight times. From this electrophorus a simple

LEYDEN JAR

can be charged as follows:—Fill a glass goblet half full of shot and thrust a teaspoon into the shot. Everything must be perfectly dry. The jar can be charged by bringing the handle of the spoon into contact with the tray as described in

the last experiment, the spoon-handle being substituted for the knuckle. By taking several charges in this way, a spark



can be given out from the Leyden jar to the tray, or to another conductor.

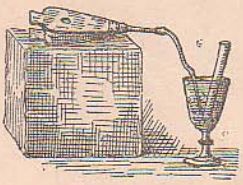
ARTIFICIAL ICE.

Requirements.—A wine-glass, a small thin test-tube, an ounce of sulphuric ether, and a pair of bellows fitted with an indiarubber tube with a pointed glass nozzle.

Directions.—Place about half an ounce of water in a test-tube and plunge it into the ether which is contained in the wine-glass. The glass nozzle of the bellows is then placed in the ether, and a regular stream of air blown through the

liquid. In a few moments the water in the test-tube will congeal.

Note.—It is advisable to perform this experiment during the day, or at some distance from a fire or light, as the vapour of ether is very inflammable.



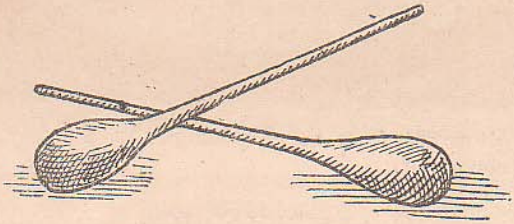
ARTIFICIAL ICE (2).

Nearly fill a jam-pot with crushed sulphate of soda. Pour on it sufficient hydrochloric acid to render it semi-fluid, and into the mass push a test-tube partly filled with the coldest water procurable. The water should be frozen in about ten minutes.

NIHILIST BOMBS.

Introduce a few drops of water into some small glass bubbles, having a neck about an inch long, and afterwards close the end of the neck. This neck being put through the wick of a burning candle, the flame boils the water into steam, and the glass is broken with a loud explosion.

The force of the expansion of water by heat may also be shown in the following way. Get a tube made by a tinsmith,

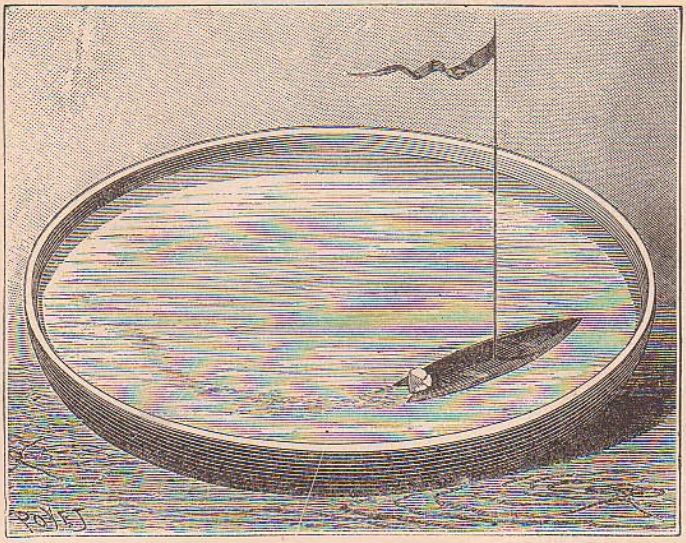


half an inch in diameter and closed at one end. Put a piece of ice the size of a cherry (the ice may be obtained by the process described above), or half a teaspoonful of water, into the tube and cork the open end tightly. Suspend this over a flame, so that the ice melts and is converted into steam. The cork will be forced out with a loud explosion. Water will produce 1,700 times its volume of steam.

CAMPHOR ON WATER.

The revulsive effects of certain spirituous and oily bodies when brought into contact with water are very curious, and have been studied by many scientists. The most remarkable of these effects is produced by camphor.

Fill a small basin with hot water, and throw upon its surface a few fragments of camphor. They will instantly

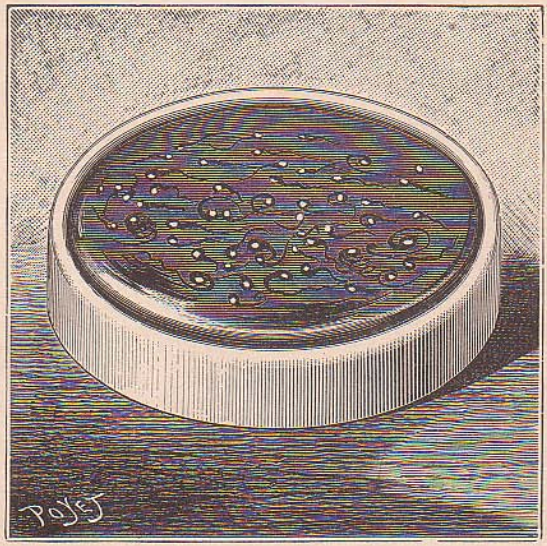


acquire a rotary and progressive motion, which will continue for some minutes. Before the motion ceases drop on to the surface a little oil of turpentine. The floating particles will quickly dart away as if by magic, and will become almost stationary.

From a very thin sheet of tin, cut out and shape a little boat such as is shown in the engraving. The mast may be made from a splinter from a wooden match. From the stem of the boat a triangular piece must be cut so that a fragment of camphor can be placed on the two terminal points, allowing

contact of the camphor with the water. This will be sufficient to give motive power to the boat

The motions of tiny fragments of camphor on a surface of mercury are very singular, but this is an experiment which



often fails. For success, the surface of the mercury must be perfectly free from dust. Sometimes it is redistilled, but this is not necessary if the fluid metal be carefully syphoned into a perfectly clean saucer.

COLOURED FIRES.

We may as well mention that the manufacture of these and other pyrotechnic chemicals, except on specially licensed premises, is an offence under the Explosives Act. The preparation of small quantities for experimental purposes would hardly be objected to. Such compounds should be ignited in small pill-boxes resting on a tile or old plate. All the ingredients must be dried and *powdered separately* and then lightly

mixed on a sheet of paper. It is to be always borne in mind that sulphur and chlorate of potassium explode violently when rubbed together.

Red Fire.—Nitrate of strontium 1½ oz., flowers of sulphur 3 drachms, chlorate of potassium 3 scruples, sulphuret of antimony 2 drachms, powdered charcoal 1 scruple. Dry and grind separately and mix.

Green Fire.—Nitrate of barium 77 parts, sulphur 13 parts, charcoal 3 parts, chlorate of potassium 5 parts by weight.

White Fire.—Gunpowder 15 parts, sulphur 22 parts, nitre 64 parts.

Yellow Fire.—Sulphur 16 parts, dried carbonate of soda 23 parts, chlorate of potassium 61 parts.

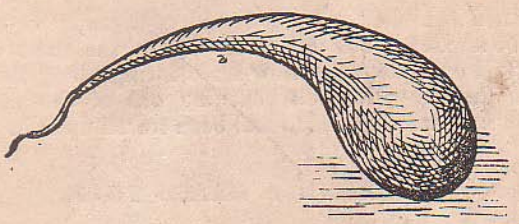
Blue Fire.—Ter sulphuret of antimony 1 part, sulphur 2 parts, nitre 6 parts.

Orange-Red.—Sulphur 14 parts, chalk 34 parts, chlorate of potassium 61 parts.

All these compounds are the better for the addition of 20 per cent. of powdered shellac, which makes them burn better.

PRINCE RUPERT'S DROPS.

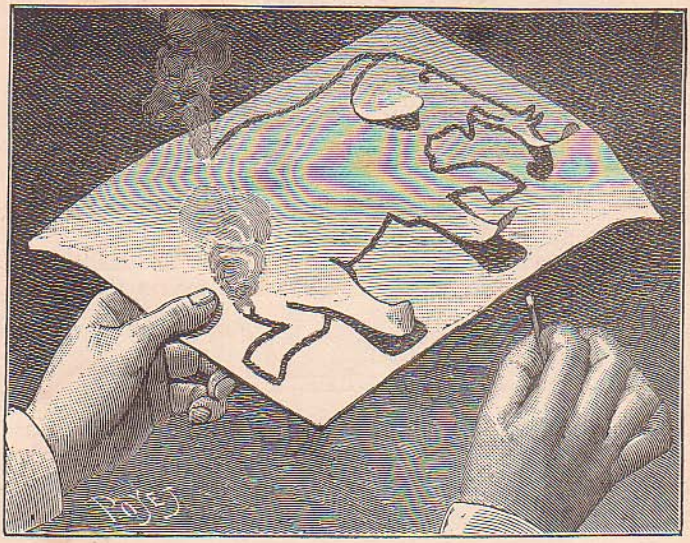
Prince Rupert's drops is the name given to tears of glass which have been suddenly cooled by dropping into water. On nipping off the end they fly into impalpable powder, and if held firmly in the hand during the operation produce a most curious sensation. Place one of these drops into a



tumbler of water and nip off the smaller end—the explosion that follows is so energetic as to even break the glass vessel.

FIRE DESIGNS.

Make first a saturated solution of nitrate of potash in water, then with a wooden style or goose quill trace with this solution any writing or design you may wish to produce on a sheet of unglazed paper. The paper must be allowed to dry,

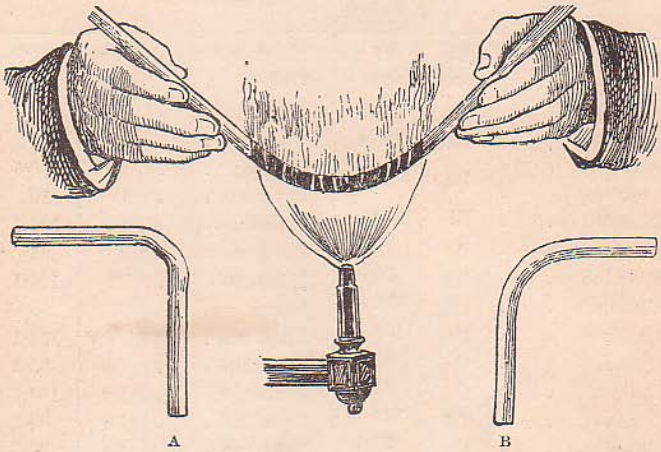


and when exhibited a red-hot end of a match or cigarette must be applied to one end of the design, the sheet of paper being laid on a plate. A slow smouldering along the course of the design will result, burning out of the paper the signature or drawing which had been traced upon it.

TO BEND A GLASS TUBE.

Hold the tube in an ordinary gas flame near the upper part and parallel with the long axis of the flame. The tube must be continually rotated while it is being held in the gas. It will become black, and in a few minutes will be softened. While in this state it can be bent, but some practice is

necessary to bend the tube in a workmanlike manner. The bend A will show the way in which the tube is likely to go;



A B

B is how it should be done. The operation must be performed in the flame, all sides of the tube being exposed in turn to the hottest part.

TABLE OF ELEMENTARY SUBSTANCES.

Elements	Symbol	Atomic Weight	Elements	Symbol	Atomic Weight
Aluminium	Al	27	Molybdenum	Mo	95·5
Antimony	Sb	120	Nickel	Ni	58
Arsenic	As	74·9	Niobium	Nb	94
Barium	Ba	136·8	Nitrogen	N	14
Beryllium (Glucinum)	Be	9	Osmium	Os	198·5
			Oxygen	O	16
Bismuth	Bi	210	Palladium	Pd	105·7
Boron	B	11	Phosphorus	P	31
Bromine	Br	79·8	Platinum	Pt	194·4
Cadmium	Cd	111·8	Potassium	K	39
Caesium	Cs	132·6	Rhodium	Rh	104·1
Calcium	Ca	40	Rubidium	Rb	85·3
Carbon	C	12	Ruthenium	Ru	104·2
Cerium	Ce	141	Scandium	Sc	44
Chlorine	Cl	35·4	Selenium	Se	78·8
Chromium	Cr	52·4	Silicon	Si	28
Cobalt	Co	58·9	Silver	Ag	107·7
Copper	Cu	63·2	Sodium	Na	23
Didymium	Di	144·6	Strontium	Sr	87·4
Erbium	E	165·9	Sulphur	S	32
Fluorine	Fl	19	Tantalum	Ta	182
Gallium	G	68·8	Tellurium	Te	128
Gold	Au	196·2	Thallium	Tl	203·7
Hydrogen	H	1	Thorium	Th	233
Indium	In	113·4	Tin	Sn	117·7
Iodine	I	126·6	Titanium	Ti	48
Iridium	Ir	192·7	Tungsten	W	183·6
Iron	Fe	55·9	Uranium	U	238·5
Lanthanum	La	138·5	Vanadium	V	51·3
Lead	Pb	206·5	Ytterbium	Yb	172·7
Lithium	Li	7	Yttrium	Y	89·8
Magnesium	Mg	24	Zinc	Zn	64·9
Manganese	Mn	54	Zirconium	Zr	90
Mercury	Hg	199·7			