as shown in Fig. 46, and close up the mouth of the tube with a bit of wax to keep the gas from escaping. This done, put a few pieces of *red phosphorus* (*P*), each about the size of a buckshot, in a small beaker and set this in a porcelain bowl, or other deep vessel; now fill both of them full of boiling water (H_2O) and remove the wax from the mouth of the tube and place the tube in the beaker, as shown in

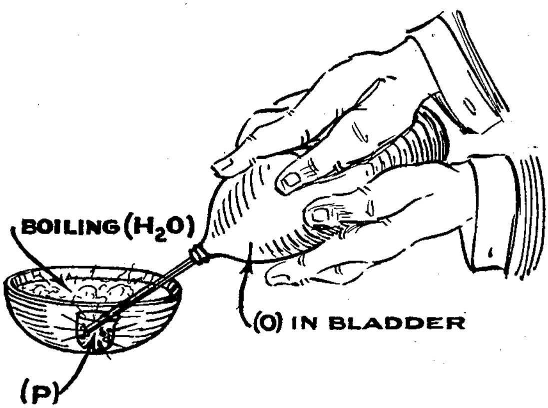

FIG. 47.—Directing a Stream of Oxygen on Phosphorus.

Fig. 47. The phosphorus (*P*) will ignite and burn with exceeding brilliancy under the water (H_2O).

How the Experiment Works. The phosphorus (*P*) combines with the oxygen (*O*) that is directed upon it, and the reason it will burn under water (H_2O) is by virtue of the fact that while the hot water (H_2O) melts it, it will not dissolve it, and coupled to this it has an extraordinary affinity for oxygen (*O*).

NOTE.— In making this experiment, be sure to use red phosphorus instead of *yellow* or *white phosphorus*, as it is not poisonous like the two latter kinds. Also it is a good plan to place a sheet of wire gauze over the bowl while the experiment is in progress.

How to Make an Oxy-Calcium Light. This is a very dazzling light which is also called a *lime-light*, because a piece of lime is used in its production, and a *Drummond light*, after the man who invented it. You can make one on a small scale easily enough, for all you have to do is to drill a 1/16-inch hole in a board and set the end of a stiff wire into it, the height of which is the same as that of your

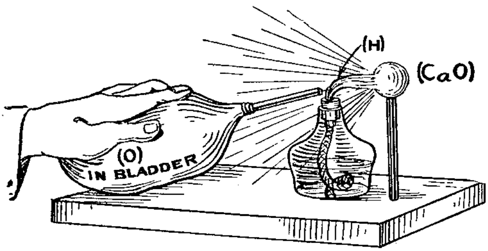

FIG. 48.—How to Make an Oxy-Calcium Light.

alcohol lamp. Now take a piece of quicklime, that is, calcium oxide (*CaO*), and set it on the free end of the wire support so that it will be in a line with the flame.

The next step is to make enough oxygen (*O*) to fill the toy balloon or bladder with, then press down on the latter and direct the stream of gas on the flame so that they will both strike the piece of lime as shown in Fig. 48. The flame thus produced will be very hot and it will heat the lime to incandescence at the point where it strikes it, and the result is a light of dazzling brightness.

How the Oxy-Calcium Light Works. The chief element in alcohol (C_2H_5OH) that burns is hydrogen (H). Now when oxygen (O) and hydrogen (H) are mixed together at ordinary temperatures no chemical action takes place; if you seal the mixed gases in a tube and keep this tube heated to 300 degrees for several days, a small amount of the gases will combine to form water (H_2O). At 500 degrees they will combine, though still very slowly; but if you raise the temperature to 700 degrees they will combine instantly and develop an intense heat. Since the alcohol flame is hotter than 700 degrees, the oxygen (O) and the hydrogen (H) combine easily.

How Sulphur Burns in Oxygen. Take a bit of sulphur (S) the size of a pea, wrap one end of an iron wire around it, light it, and hold it in a beaker of oxygen (O). The sulphur (S) burns with a wonderful scintillating flame that is violet-colored; the result of the combustion is that sulphurous acid (H_2SO_3), nitrogen (N) and potassium sulphate (K_2SO_4) are set free and the beaker is filled with the fumes of these substances.

EXPERIMENTS WITH NITROGEN.

There are several ways to obtain nitrogen (N), and among these are to burn phosphorus (P) in air, to pass air over finely divided copper (Cu), and by the evaporation of liquid air. In the first two processes the oxygen (O) of the air is taken up by the phosphorus (P) and the copper (Cu), and this leaves the nitrogen (N) behind. For the production of large amounts of nitrogen (N), liquid air is allowed to evaporate. The oxygen (O) passes off first because it is the lighter gas and the nitrogen (N) is left behind.

A Simple Way to Make Nitrogen. Fill a soup-plate half full of water (H_2O), then light a piece of paper and place it in a beaker, or a tumbler, which you invert and set in the water (H_2O), as shown in Fig. 49. You will soon see that

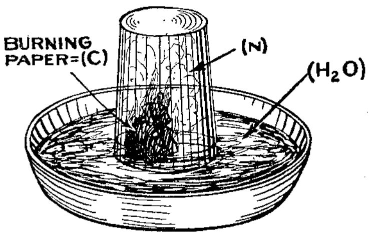

FIG. 49.—A Simple way to Make Nitrogen.

the flame of the burning paper grows more and more feeble, and that the water (H_2O) rises higher and higher in the beaker or tumbler, until it is considerably above the level of that in the soup plate. When the paper will no longer burn, you will have considerable nitrogen (N) in the glass.

How the Experiment Works. When the paper burns, it consumes the oxygen (O) in the beaker or tumbler, and this produces a partial vacuum in it. The pressure of the outside air on the water (H_2O) in the soup-plate is now greater than that of the air in the beaker, or tumbler, and consequently it forces the water (H_2O) up and into the latter.

The oxygen (O) in the beaker, or tumbler, combines with the carbon (C) in the paper and forms carbon dioxide (CO_2); this gas is heavier than the air and so falls on the surface of the water, which absorbs it; hence the gas that remains in the tumbler is nitrogen (N).

Another Easy Way to Make Nitrogen. Pour a tablespoonful of alcohol (C_2H_5OH) into a little tin pill-box, or an iron or porcelain dish, having a diameter of 1½ or 2 inches, and set this in a wine-glass. This done, stand the wine-glass in a soup-plate filled with water (H_2O). Now light the alcohol (C_2H_5OH), and then set a beaker, or a tumbler or a small fruit-jar over them, as shown in Fig. 50.

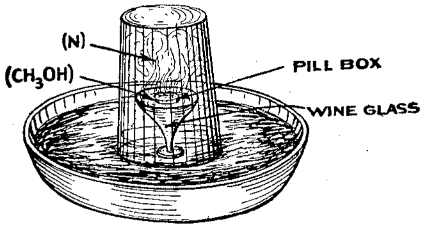

FIG. 50.—A Better Way to Make a Little Nitrogen.

How the Experiment Works. As soon as the alcohol (C_2H_5OH) is ignited, the oxygen (O) of the air in the beaker, or other vessel, combines with the carbon (C) of it just as it did with the carbon (C) of the paper in the foregoing experiment and forms carbon dioxide (CO_2). The phenomenon of the water (H_2O) rising in the beaker, or other vessel, is due to the same causes as described in the experiment above.

How to Make a Larger Amount of Nitrogen. For experimental purposes you will need considerably more nitrogen (N) than either of the preceding processes will give you. To make a larger amount, place a very little dry *red* phosphorus (P) in a small porcelain dish and set it on top of a wine glass; now stand this in a soup-plate filled with water (H_2O) and ignite the phosphorus (P) with the end of a wire which you have heated a bright red in the flame of your lamp or burner. Having done this, set a glass jar—a pint fruit-jar will do—over the burning phosphorus (P), as shown in Fig. 51. When the phosphorus (P) has burned out, the jar will then contain only nitrogen (N).

How the Experiment Works. As soon as the phosphorus

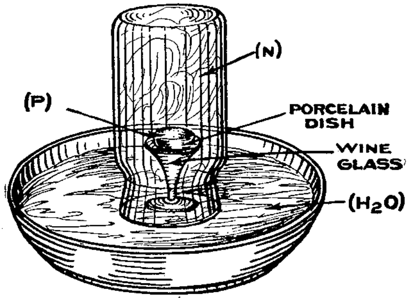

FIG. 51.—How to Make Nitrogen for Experimental Purposes.

(P) begins to burn, the air in the jar expands because of the heat that it develops, but very soon the air contracts, for the oxygen (O) unites with the phosphorus (P) and forms a white smoke which is phosphorus trioxide (P_2O_5); this compound falls to the surface of the water (H_2O), combines with it and so disappears, thus leaving only the nitrogen (N), which is in a tolerably pure state.

The Self-Extinguishing Match. This is the complementary experiment to the one explained under the caption of "A Self-Lighting Match." Twist a copper wire around a match, as shown in Fig. 43, lift the jar of nitrogen (N) up from the soup-plate, then light the match and let it get to burning well. When this is done, put it up into the jar, and you will see how quickly the flame will be extinguished. This experiment shows that nitrogen (N) will not support combustion.

What Else the Experiment Shows. The fact that the match will not burn in nitrogen (N) does not at all show that it is a poison. While nitrogen (N) will not support combustion, we take into our lungs a little more than three times as much of it as we do oxygen (O) and with no harmful effect. But carbon dioxide (CO_2), cyanogen (C_2N_2), and several other gases will kill, not only because they cannot support combustion, but because they are poisonous.

EXPERIMENTS WITH CARBON DIOXIDE.

Carbon dioxide (CO_2) is a wonder gas, and many strange and striking effects can be produced with it which are worthy of a place on a magician's program. In this respect it is quite unlike nitrogen (N), which is sluggish and, in consequence, permits but very few experiments to be performed directly with it. Carbon dioxide (CO_2) is a colorless and odorless gas and it is considerably heavier than the air, and for this reason when you perform experiments with it you can handle it just as though it were a liquid like water (H_2O), that is, the vessels need not be corked up, nor covered over, nor inverted, to keep it in them.

How to Show there is Carbon Dioxide in the Air. Fill a clean saucer or a small flat, porcelain dish with clear *lime-water*, which is calcium hydroxide ($Ca(OH)_2$), and this you can make by pouring some water on *quicklime*, which is calcium oxide (CaO). Then set the dish of lime-water in the open air, and it will soon be covered with a film of calcium carbonate ($CaCO_3$) the common name of which is *carbonate of lime.* If you will now break the film, it will fall to the bottom of the dish and the operation can be repeated until all the quicklime (CaO) in the solution is changed into calcium carbonate ($CaCO_3$).

How the Experiment Works. That carbon dioxide (CO_2) is present in the air is evident, since this gas must combine with the calcium hydroxide ($Ca(OH)_2$) to form calcium carbonate ($CaCO_3$). Chalk, limestone, marble, egg-shells, oyster shells, coral and pearls, and calcite and Iceland spar are all formed of calcium carbonate ($CaCO_3$).

To Show that You Inhale Oxygen and Exhale Carbon Dioxide. You can easily show that after you inhale oxygen (O) you exhale carbon dioxide (CO_2) by means of this very simple experiment. Fill a tumbler about three-fourths full of lime-water, that is, calcium hydroxide ($Ca(OH)_2$); then take a good deep breath (oxygen (O)) and blow through a straw into the lime-water, as shown in Fig. 52. The clean lime-water will be made murky by the formation of calcium carbonate ($CaCO_3$) in it, and for the same reason as explained under the foregoing caption of "How the Experiment Works."

A better way to make the experiment is to take a wide-mouth bottle and fit it with a cork and two bent glass tubes, as shown in Fig. 53. Pour in enough lime-water, that is, calcium hydroxide ($Ca(OH)_2$), to half fill the bottle, then put the short tube in your mouth and draw in. The outside air will then pass through the long tube and up through the lime-water ($Ca(OH)_2$), which will remain clear. Now repeat the operation, but this time blow through the long tube and the lime-water ($Ca(OH)_2$) will get murky,

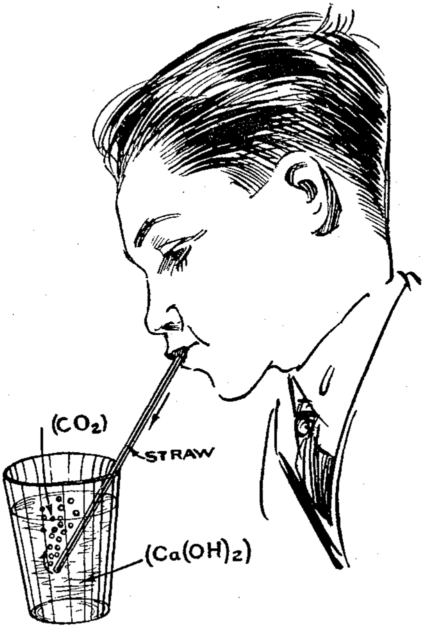

FIG. 52.—A Simple Way to Show Carbon Dioxide.

just as it did in the previous experiment, and for the same reason.

How to Make Carbon Dioxide. In the experiments above, it has been shown that chalk, limestone, and marble are all forms of calcium carbonate ($CaCO_3$) and hence these substances contain carbon dioxide (CO_2). Now all you have to do to make a little of this gas is to put some powdered chalk, limestone, or marble into a test tube half full of water (H_2O), and then add a few drops of hydrochloric acid (HCl) to it, as shown in Fig. 54. Instantly there will be a commotion of the liquid set up by the production of numerous small bubbles of gas which rise to the

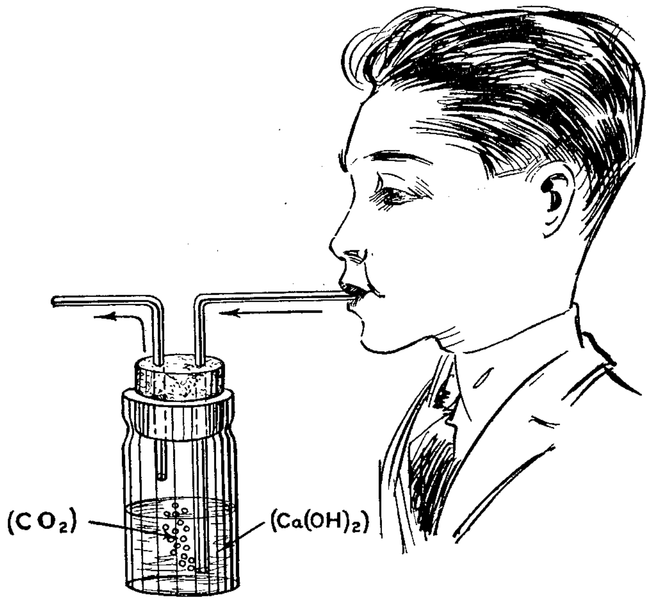

FIG. 53.—A Better Way to Show Carbon Dioxide.

surface and then break, and these are formed of carbon dioxide (CO_2).

How the Experiment Works. While carbon dioxide (CO_2) is given off in the above reaction, calcium chloride ($CaCl_2$) and water (H_2O) are left behind.

NOTE.— Do not use blackboard crayon for the experiment, as this is usually made of gypsum, that is calcium