contained by the bulb, causing the air to occupy less space and increasing the weight of the bulb in proportion to the amount of water forced in. As the weight of the bulb increases the diver descends, and when the finger is removed from the elastic cover of the tube, the air by its own elasticity regains its normal volume, and the bulb, becoming lighter, rises to the top of the jar.

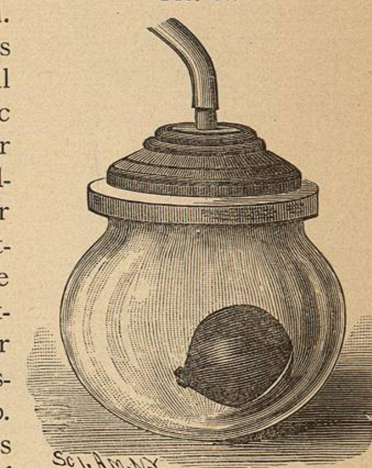
CHAPTER VII.

GASES.

Gases are elastic fluids in which the molecular force of repulsion is superior to the force of attraction. Expansion, the most characteristic property of gases, is due to this force. The limit of the expansive force of a gas is unknown. If there were no opposing causes, it would appear that the particles of a gas might separate indefinitely.

The expansive force of the atmosphere is opposed by the earth's attraction; the air is thus in a state of equilibrium.

FIG. 80.



Dilatation of Balloon in a Vacuum.

The expansibility of air is shown by inclosing a small quantity of it at atmospheric pressure in an elastic rubber balloon,* and placing the balloon in the receiver of an air pump, then removing the atmospheric pressure from the exterior of the balloon by exhausting the receiver. The air in the balloon will expand, distending it as shown in Fig. 80.

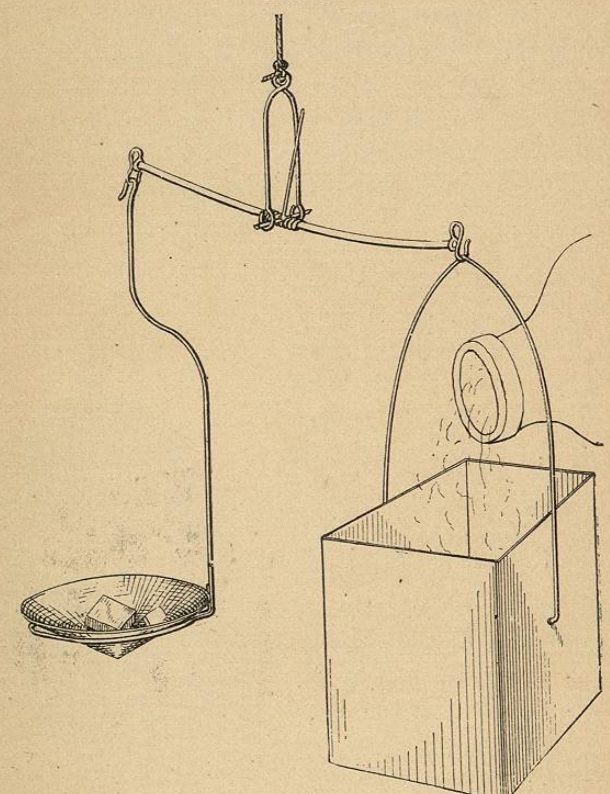
In former experiments illustrating the diffusion of gases, it was shown that carbonic acid gas was very much heavier than air, by pouring the gas from one vessel to another, thus to a great extent displacing the air in the receiving vessel, in the same manner as it would be displaced by the pouring in of a liquid. In the case of pure hydrogen or illuminating gas, the order

*The small inflatable balloons applied to the toy squawkers, and which may be bought in any toy store for three cents, answer perfectly for this experiment.

of things was reversed; *i. e.*, to fill the vessel it was necessary to invert it, so that the air might be displaced by the rising of the gas, which is so much lighter than air.

To show visibly that one gas is heavier than air and the other lighter, a pair of balances may be pressed into service. If the balances are not at hand, a pair may readily

Fig. 81.

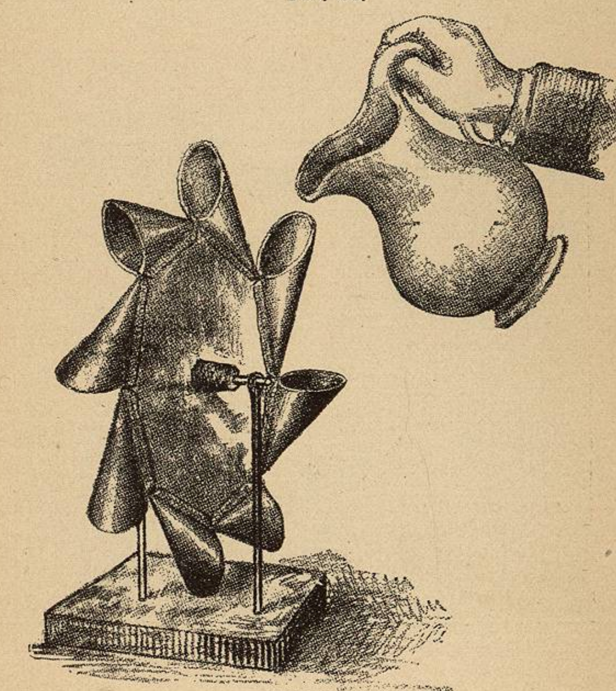


Weighing Gases.

be made of wire, as shown in the engraving. All the pivots should be made V-shaped, to reduce the friction to a minimum. The pivot of the beam should be a little higher than the bearing surface of the hooks at the ends of the beam. The conical scale pan may be made of paper, by radially slitting a disk, overlapping the edges, and sticking them to-

gether. The paper box for receiving the gas is five inches in each of its dimensions, and is suspended from the scale beam by a wire stirrup, so that it may be reversed. After bringing the scale to equilibrium in air by placing some small weights in the pan, the air contained by the box may be displaced by pouring in carbonic acid gas. The box will immediately descend, showing that carbonic acid gas is

Fig. 82.

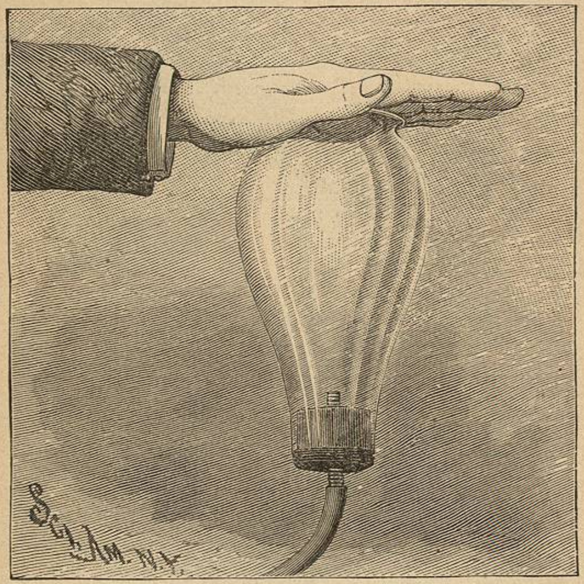


Gas Wheel.

heavier than air. Allowing the weights in the pan to remain the same, the paper box is inverted, when the carbonic acid falls out, and air takes its place. The balance beam again becomes horizontal. Now, by opening a jar of hydrogen under the box, the air is again displaced, this time, however, by the rising of the inflowing gas. When the greater portion of the air is replaced by hydrogen, the box rises, showing by its buoyancy that its contents are lighter than air. If the balance is allowed to remain for a time, the gas will be diffused, and the balance beam will return again to the horizontal position.

To determine the weight of air, a globe provided with a stop cock is completely exhausted and weighed. Air is then admitted and the globe is again weighed, when its weight will be greater than before. The difference between the

FIG. 83.



Hand Glass.

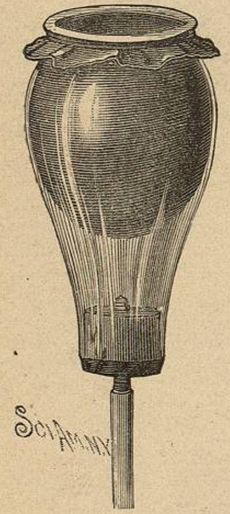
weight in the first and second cases will be the weight of the air contained by the globe.

One hundred cubic inches of dry air under an atmospheric pressure of 30 inches, and at the temperature of 60° Fahrenheit, weigh 31 grains. The same volume of carbonic acid under the same conditions weighs 47·23 grains, 100 cubic inches of hydrogen weigh 2·14 grains.

Air at the same pressure and at a temperature of 32° is about $\frac{1}{773}$ as heavy as water.

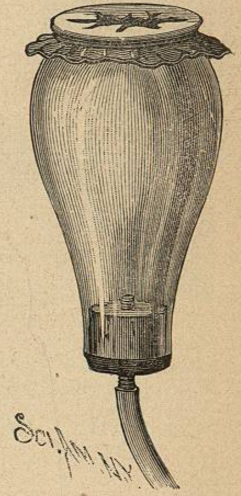
In Fig. 82 is shown a very simple wheel, to be operated by gases. The wheel consists of a disk of light but stiff card board, mounted between two corks on a straight knitting needle, and provided around its periphery with buckets formed of squares of writing paper, attached to the periphery of the disk by two adjoining edges so as to form hollow cones, as shown. The knitting needle is journaled in wire or wooden standards, and lubricated so that it may turn freely. Carbonic acid gas may be generated in a

FIG. 84.



Rubber Forced Inward by Air Pressure.

FIG. 85.



Crushing Force of the Atmosphere.

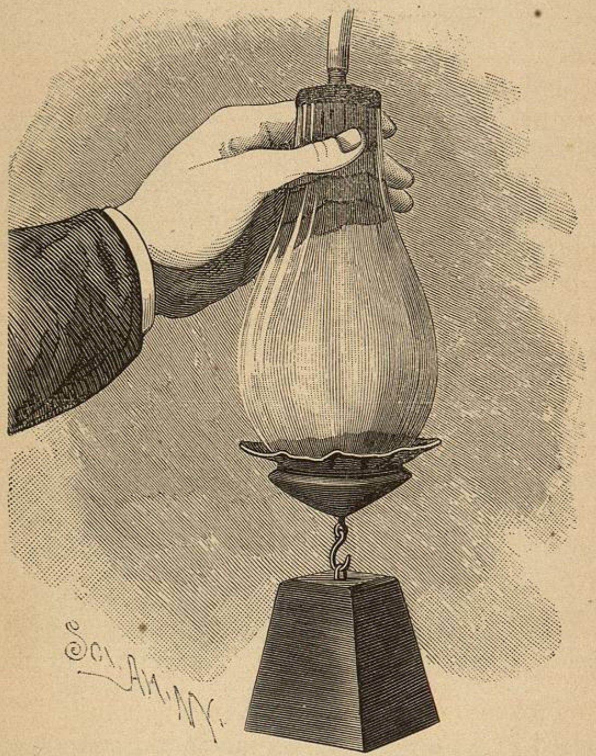
pitcher and poured upon the wheel in the manner illustrated. By making the wheel large enough and carefully balancing it, it may be turned by liberating hydrogen gas under the mouths of the buckets.

To exhibit some of the effects of atmospheric pressure, all that is required besides an air pump, or aspirator, is a large and heavy lamp chimney.

The lamp chimney needs no other preparation for use than the insertion of a five-sixteenths inch tube in the center of the cork and the thorough sealing of the cork with its tube in the smaller end of the chimney.

A very striking and instructive experiment consists in exhausting the air from the chimney by applying the suction tube of the pump to the tube at the closed end of the chimney, while the palm of the hand is applied to the large open

Fig. 86.



Weight Lifted by Air Pressure.

end of the chimney. As the air is exhausted from beneath the hand, the pressure of the atmosphere exerted on the hand drives the palm down into the chimney, as shown in Fig. 83, and as the exhaustion proceeds, the pressure becomes painful and difficult to endure.

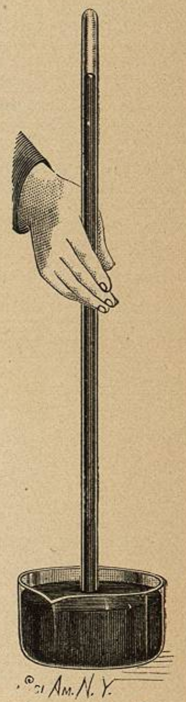
It is easy under such circumstances to realize that the

atmosphere has a very appreciable weight. The same fact may be illustrated by tying over the open end of the chimney a thin piece of elastic rubber, then exhausting the air from the chimney, allowing the external air to press the rubber down into the chimney, as shown in Fig. 84.

The disruptive power of atmospheric pressure is illustrated by the rupturing of a thin piece of bladder tied over the open end of the chimney, as shown in Fig. 85. When the air is exhausted from the chimney, the bladder, if thin enough, will burst with a loud report. If the bladder will not readily burst, the rupture may be started by puncturing it with the point of a knife.

In Fig. 86 is illustrated a similar experiment, in which the inwardly pressed diaphragm is made to raise a weight. A piece of rubber cloth is tied over the open end of the chimney, and a hook is fastened to its center by sewing. The cloth is heavily coated with rubber cement around the sewing of the hook. A weight is placed on the hook, and the air is exhausted as before. The upward pressure of the atmosphere raises the weight. This experiment illustrates the action of a form of vacuum brake now extensively in use; the weight representing the brake.

Fig. 87.



Mercurial Column Supported by Atmospheric Pressure.

THE BAROMETER.

The pressure of the atmosphere is plainly exhibited in the mercurial barometer, the simplest form of which is shown in Fig. 87. It consists of a glass tube about 36 inches in length, closed at one end and completely filled with mercury, the open end being plunged into a vessel of mercury. The column will stand at a height of about 30 inches above the level of the mercury in the vessel, showing that the pressure of the atmosphere under ordinary circumstances is equal to that of a column of mercury of about the height