

The fact that water boils at a temperature below  $212^{\circ}$  when the atmospheric pressure is removed, is exhibited by placing a tumbler of hot, but not boiling, water in the receiver, as shown in Fig. 95, then exhausting the air from the receiver.

The bell suspended in the receiver by a light elastic rubber band stretched across a wire fork, whose shank is inserted in the tube of the receiver cover, as shown in Fig. 96, may be distinctly heard when rung in the receiver before exhaustion, but after exhausting the receiver, the bell will

FIG. 97.



Destruction of Life by Removal of Air.

be heard feebly, if at all, thus showing that the air when rarefied is a poor sound conductor.

The inability of rarefied air to support life is shown by the experiment illustrated by Fig. 97. A mouse in the receiver soon dies when the air is exhausted.

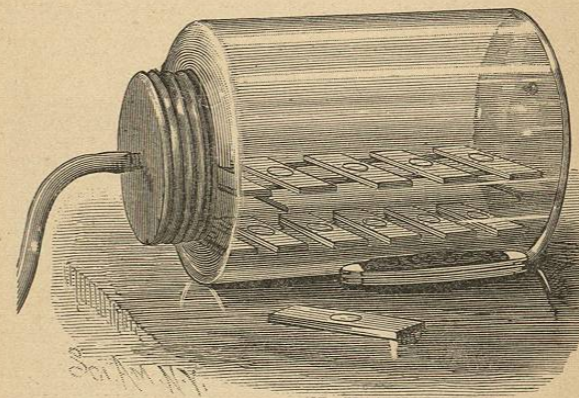
A device for use in connection with the simple air pump for desiccating and for removing air from microscope mounts is shown in Fig. 98. It consists of an ordinary fruit jar having soldered in its cover a short tube, which is adapted to receive the suction tube of the air pump. The objects to be treated are placed in the jar, the cover put on and made tight, and the suction pipe of the pump is applied.

These are mostly well-known vacuum experiments, adapted to the simplified apparatus. There are, of course, many others that may be performed with equal facility by means of this air pump.

With the pump arranged for compression, a large number of experiments of a different character may be performed. A reservoir will be needed, like that shown in Fig. 99. It

consists of a piece of ordinary leader, such as may be procured from any tinman. It should be 3 or 4 in. in diameter and 3 or 4 feet long. Heads are soldered on the ends, and all the seams are made air tight by soldering. A five-sixteenths inch tube is inserted in one end, and another in the

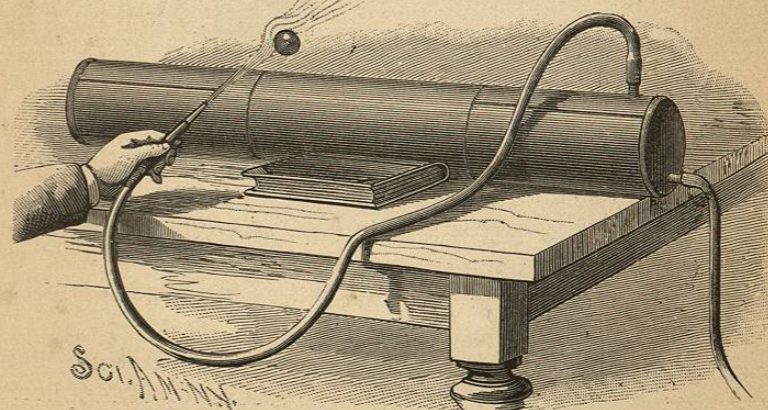
FIG. 98.



Withdrawing Air from Microscope Slides.

side. The discharge end of the pump is connected with one of the tubes of the reservoir, and a rubber tube, having at one end a one-sixteenth inch nozzle of metal or glass, is connected with the other tube of the reservoir. The air

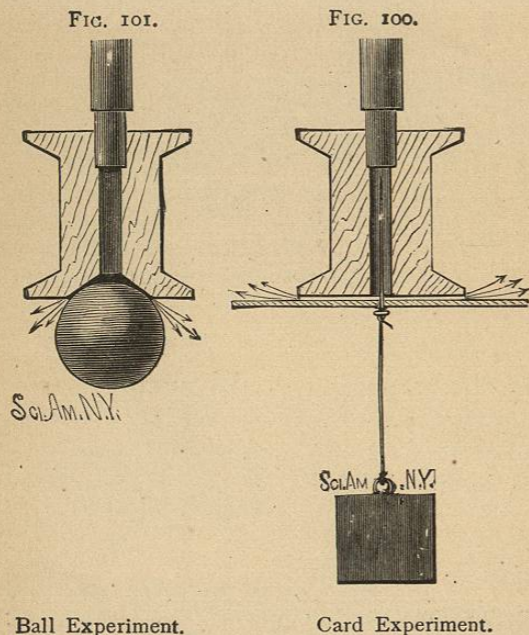
FIG. 99.



Compressed Air Reservoir and Ball Experiment.

may be confined in the reservoir by doubling the discharge tube or applying to it an ordinary pinch cock. A light ball of cork may be supported in the air jet while the nozzle is held in an inclined position, as shown in Fig. 99.

By connecting the discharge pipe of the reservoir with a spool, in the manner shown in Fig. 100, the familiar experiment of sustaining a card, together with an attached weight, by blowing down on the card may be performed.



A pin passing through the card into the central aperture of the spool prevents the card from slipping.

Fig. 101 shows a simple way of exhibiting the ball experiment. The ball is held in the concavity of the spool by blowing forcibly outward against it.

In these cases the air issues in a thin sheet, which adheres to and carries away the air adjoining the upper surface of the object supported, thereby producing a partial vacuum into which the object is forced by atmospheric pressure.

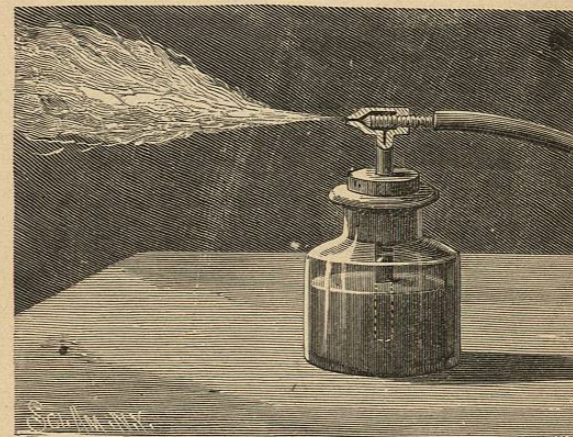
**Dr. A. Carrillo.**

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MONTERREY, N. L. MEX.

In Fig. 102 is shown an atomizer which may be used in connection with the reservoir and air compressor for atomizing liquids for various purposes. In the present case it is represented as an atomizing petroleum burner. A burner of this kind yields a very intense heat, and produces a flame 2 or 3 ft. long. The oil in the vertical tube adheres to the air forced through the horizontal tube and is carried

FIG. 102.



Atomizing Petroleum Burner.

forward with the air in the form of fine spray, which readily burns as it is ejected from the nozzle. The vacuum formed in the vertical tube is supplied by oil forced up by atmospheric pressure.

#### ASPIRATORS FOR LABORATORY USE.

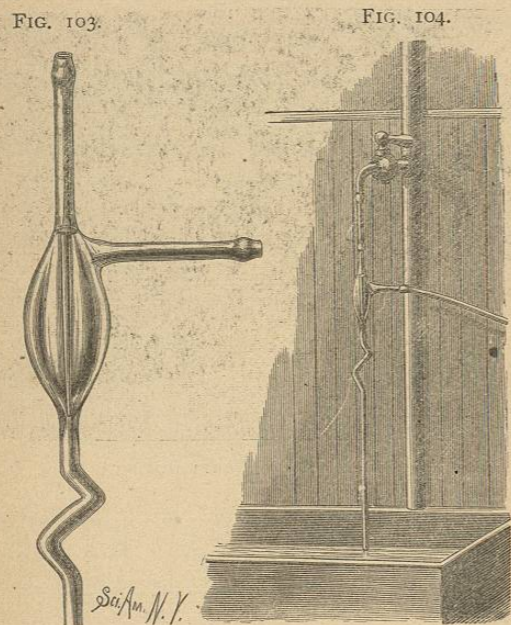
Wherever a head of water of ten feet or more is available, an aspirator is by far the most convenient instrument for producing a vacuum for filtration and fractional distillation. It is also adapted to a wide range of physical experiments.

Besides the advantage of convenience and compactness, the aspirator has the further advantage over piston air pumps in the matter of cost. It may be had at prices varying from \$1.50 to \$4 or \$5.

Two kinds are in general use—one of glass, known as Bunsen's filter pump, and shown in Figs. 103 and 104; the other of brass, shown in Figs. 105, 106, and 107.

The glass aspirator can be purchased of almost any dealer in druggists' sundries or chemical glassware. Any expert glass blower can make it in a short time.

This instrument consists of an elongated bulb terminating in a crooked tube at the bottom and having a tapering nozzle



Bunsen Filter Pump.

inserted in the top and welded. The lower end of the nozzle is located directly opposite and near the crooked discharge tube. A side tube is connected with the bulb at a point near the junction of the nozzle and bulb.

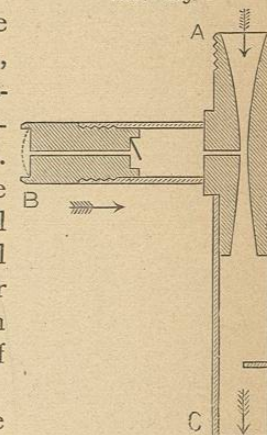
This aspirator is used in the manner indicated in Fig. 104, *i. e.*, the upward extension of the nozzle is connected with a tap by a short piece of rubber tubing, and the side tube is connected by a piece of rubber tubing with the vessel to be exhausted. When the water is allowed to flow through the

aspirator, it leaps across the space between the nozzle and discharge tube and carries with it by adhesion the air from the bulb, which is continually replaced by air from the vessel being exhausted.

It is necessary to securely fasten the ends of the rubber tube connected with the tap, or the water pressure may force it off, thus causing the breaking of the instrument. To secure the best effects with this pump, it is necessary to connect a vertical tube 25 to 30 feet long with the discharge end of the pump.

The metallic aspirator shown in Figs. 105, 106, and 107 is of course free from all danger of being broken in use, and it has other qualities which render it superior to the glass instrument, one of which is a much higher efficiency, another is its ability to retain the vacuum should the flow of water be accidentally or purposely discontinued. It can be screwed directly on the water tap, and needs no additional pipe to cause it to work up to its full capacity; and where a head of water is not available, it may be inserted in a siphon having a vertical height of ten feet or more.

FIG. 105.



Chapman's Aspirator.

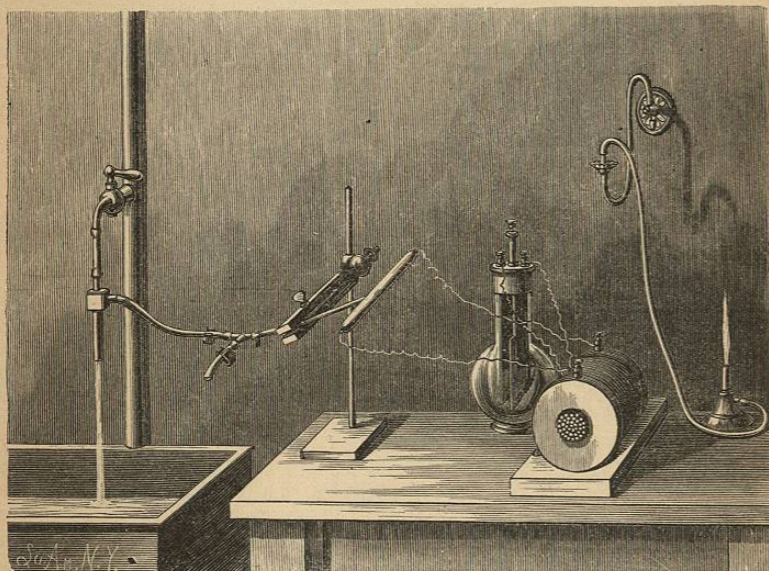
This instrument is known as the Chapman aspirator. Like all instruments of its class, it is based on the principle of the Giffard injector. The construction of the aspirator is shown in section in Fig. 105. The water enters at A, as indicated by the arrow. The air enters at B, and both air and water are discharged at C. The water in going through the contracted passage forms a vacuum at the narrower part into which the air enters. The starting of the instrument is facilitated by a diaphragm which half closes the discharge tube. The water is prevented from entering the air pipe by a small check valve shown in the interior of the lateral tube. Much of the efficiency of this instrument is due to the accuracy with which the contracted passage is formed. A

slight change in the shape of this passage seriously affects the results.

The vacuum produced by this aspirator is equal to that of the mercurial barometer, less the tension of aqueous vapor. That is to say, when the barometer is at 30 inches, the vacuum produced by the aspirator will be about  $29\frac{1}{2}$  inches. Such a vacuum can be produced by water under a pressure of five and one-half pounds.

In Fig. 106 is shown the aspirator applied to a Geissler

FIG. 106.



Exhausting Geissler Tube.

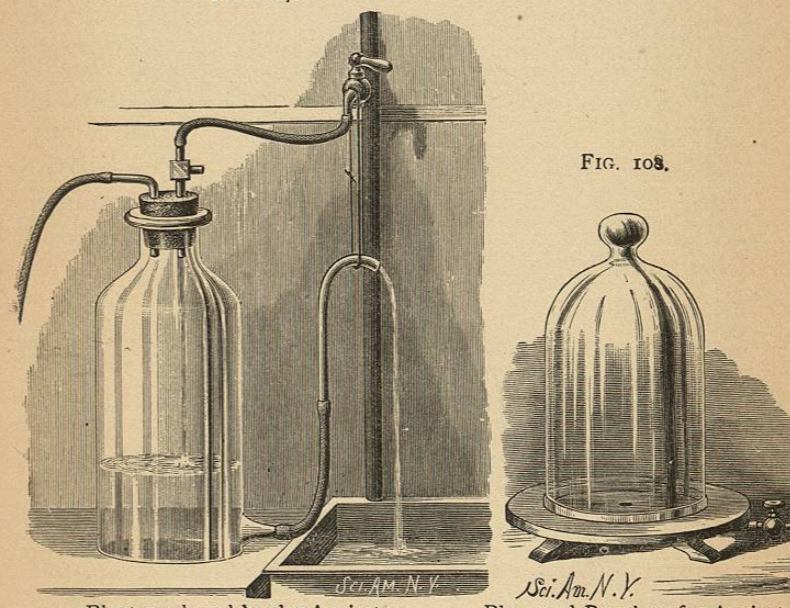
tube. It quickly exhausts an 8 inch tube, so that the discharge of an induction coil will readily pass through. By placing a tee in the connecting pipe, the Geissler tube can be filled with different gases. Each will exhibit its peculiar color as the spark passes. The vacuum is not high enough for a perfected Geissler tube, but it is sufficient for the greater part of vacuum experiments. The aspirator can be arranged to produce a continuous blast sufficient for the

operation of a blowpipe, and for other uses requiring a moderate amount of air or gas under pressure.

The method of accomplishing this is illustrated in Fig. 107. The instrument is arranged to discharge into a bottle or other vessel having an overflow, and the air for the blast is taken out through the angled tube inserted in the stopper of the bottle. The amount of air pressure is regulated by the water pressure and the height of the overflow pipe.

For many vacuum experiments a plate provided with a

FIG. 107.



Blast produced by the Aspirator.

Plate and Receiver for Aspirator.

central aperture, and having a tube extending from the aperture to the edge of the plate, will be found useful. The tube is provided with a suitable valve, which closes communication with the aspirator, and which also serves to admit air, when required, to the receiver fitted to the plate. This plate and various accessories are like the plate and accessories of a piston air pump. Communication is established between the tube of the plate and the aspirator by means of a pure rubber tube, which is practically air tight.