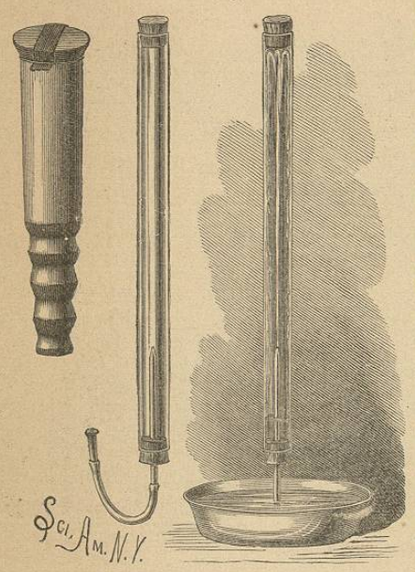
MOUTH VACUUM APPARATUS.

Although the vacuum apparatus already described is very simple, it is quite practicable to perform many experiments of this class by using the mouth as an air pump, thus dispensing almost entirely with mechanism. The operation of producing a partial vacuum is facilitated by employing a valve such as is shown in the left hand figure of Fig. 109. This valve consists of a thick tube of hard wood, having a bore of about $\frac{1}{16}$ inch. One end of the tube is corrugated to receive a rubber pipe, and over the other end is tied a valve of elastic rubber. By connecting this valve with a stopped glass tube by means of a flexible rubber pipe and a jet tube in the manner shown, and then sucking the air through the valve, a partial vacuum may be quickly formed in the tube. The vacuum will be retained by the valve, so that when the valve is disconnected from the jet tube, while the latter is immersed in water, the pressure of the external air will cause the water to enter the glass tube through the jet in the form of a fountain. It is obvious that many of the foregoing experiments may be tried in a similar way.

FIG. 109.



Mouth Vacuum Apparatus.

ANCIENT INVENTIONS OPERATED BY AIR PRESSURE.

More than two thousand years ago, Hero (or Heron), a philosopher and mathematician of Alexandria, invented the fountain shown in the annexed engraving. This device,

FIG. 110.

Hero's Fountain.

because of its antiquity, as well as its simplicity and completeness, is very interesting and instructive.

As represented in the engraving, it may be classed with toys, or at most regarded as only an apparatus for illustrating a scientific principle; but it is more than this. It is the progenitor of a number of modern inventions for raising water and producing air pressure.

The curious feature of the apparatus is that it apparently causes the water to rise above its own level by its own pressure, but such is not the case. Its action is due to the transference of the pressure of one column of water to another column of water at a higher level, through the medium of a column of confined air. It is as truly a case of the application of external power as it would be if a steam air compressor were applied.

The water to be elevated is contained by the upper bulb, which communicates at its lower side with the fountain nozzle, and at its upper side with the downwardly curved tube connecting with the top of the lower bulb. A tube connecting with the lower side of the lower bulb extends upward to the level of the upper bulb, and terminates in a flaring cup.

The upper bulb having been filled with water and the lower bulb with air, the fountain is started by pouring a small quantity of water into the cup, which by flowing downward through the tube connected with the cup exerts a pressure on the air contained by the lower bulb. This pressure is equal to the weight of the column of water in the tube. The air pressure thus created is transferred to the top of the upper bulb by the air column rising from the lower bulb through the tube connecting the two bulbs, so that the pressure of the water column descending from the cup, less a very small allowance for friction, is effective in forcing the water out of the upper bulb through the fountain nozzle.

The proper inclination of the apparatus directs the water jet so that the water falls into the cup and replaces the water used in creating the air pressure in the lower bulb.

When the lower bulb is filled with water, and the water has been entirely discharged from the upper bulb, the action

of the apparatus ceases; but it may be again started by inverting the fountain, allowing the water in the air bulb to run into the upper or water bulb, then righting it and again pouring a little water into the cup.

This device was employed during the last century for elevating water in the mines of Hungary.

In Fig. 111 is shown an interesting modification of Hero's fountain. The apparatus is made of glass, to illustrate the principle on which it operates. It consists of a volute coil of tubing connected at its center with a hollow shaft that communicates with a hollow journal box, from which a standpipe rises. When this coil is turned in the direction indicated by the arrow, water and air assume in the coiled tube positions relative to each other as shown in the engraving; the water being arranged in a series of curved columns on one side of the center of the wheel, the air being correspondingly disposed on the opposite side of the center. The height to which the water will be raised by this machine is equal to the sum of the heights above their upwardly curved lower ends of all the curved columns of water contained by the coil. It will be noticed that the pressure of one curved column of water in the coil is communicated to the next through the intervening air, which weighs practically nothing.

This machine was invented by Wirtz, of Zurich, in 1746.

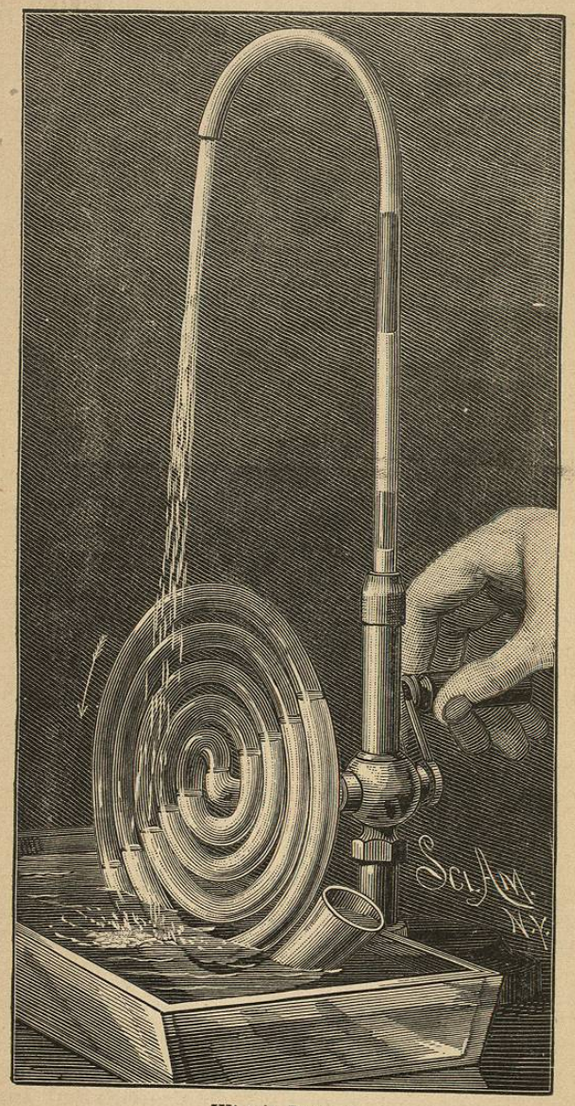
"In 1784 a machine of this kind was made at Archangelsky that raised a hogshead of water in a minute to an elevation of 74 feet, and through a pipe 760 feet long."

INERTIA OF AIR.

Although air is a light and extremely mobile fluid, it has sufficient inertia to permit of the flight of birds, the operation of windmills, and the propulsion of sailing vessels. The aerial top shown in Fig. 112 is dependent upon the inertia of the air. This top is simply a metallic screw wheel, adapted to be revolved by means of a string in the same manner as an ordinary top.

With the application of a sufficient amount of force, this top will rise to a height of 150 to 200 feet. It can hardly be

FIG. 111.

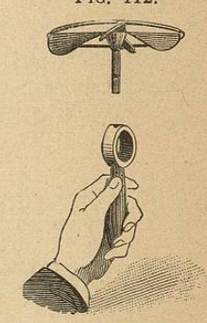


Wirtz's Pump.

called a flying machine, as it does not carry its own motive power. In the next illustration, however, is shown a flying machine which in one sense carries its own power, that is, stored power.

It consists of a light frame furnished at one end with a slender rattan bow inclosed in a little bag of tissue paper, which forms a sort of rudder when the fly-fly ascends, and opens like an umbrella when it descends, forming a parachute, which greatly retards the fall. In the crosspiece of the opposite end is journaled a little shaft formed of a wire having on its inner end a loop receiving a number of rubber bands, which are fastened to the opposite end of the frame. To the outer end of the little shaft is secured a piece of cork, in which are inserted two feathers inclined at an angle with the plane of the shaft's rotation, and oppositely arranged with respect to each other.

FIG. 112.



Aerial Top.

By turning the propeller wheel thus formed, the rubber bands are twisted, and sufficient power is stored in them to turn the propeller wheel in the direction opposite to that required for winding, and thus propel the device through the air.

FIG. 113.

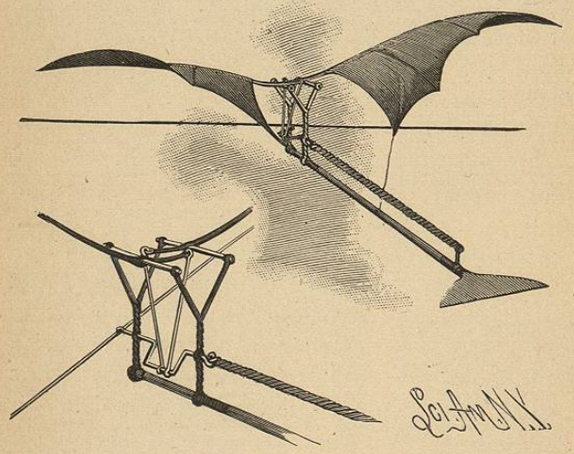
The Fly-Fly.

Another device still more nearly approaching the ideal flying machine is shown in the annexed cut, Fig. 114 being a perspective view of the entire bird, and Fig. 114*a* an enlarged perspective view of the working parts. It is known as Penaud's mechanical bird.

It is a pretty toy, imitating the flight of a bird very well indeed. It soars for a few seconds, and then requires rewinding. Two Y-shaped standards secured to the rod forming the backbone of the apparatus support at their upper ends two wires, upon which are pivoted two wings formed of light silk. The wings are provided with light

stays, and are connected at their inner corners with the backbone by threads. In the Y-shaped standards is journaled a wire crank shaft carrying at its forward end a transverse wire forming a sort of balance, and serving also as a key for winding. The inner end of the crank shaft is provided with a loop to which are attached rubber bands which are also secured to a post near the rear end of the apparatus. Two connecting rods placed on the crank are pivotally connected with the shorter arms of the levers of the wings. The rear end of the backbone is provided with a rudder.

FIGS. 114 AND 114*a*.



Mechanical Bird.

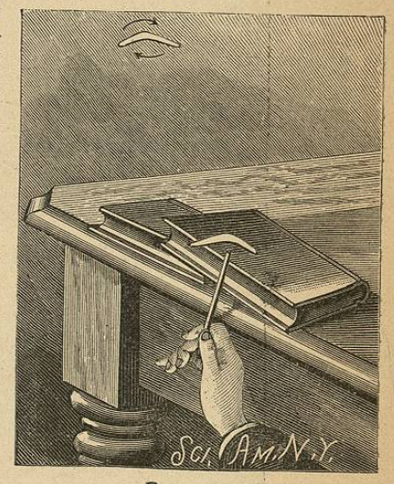
The rubber bands are twisted by turning the shaft by means of the cross wire. When the shaft is released, it is turned by the rubber bands in a reverse direction, causing the crank to oscillate the wings, which beat the air in a natural manner, and propel the device forward. The principle of the inclined plane is involved here, but the plane, instead of being rotated, as in all the cases mentioned above, is reciprocated.

The toy boomerang, which is, in some respects, similar to the regular article, cannot perform all the feats with

which the more pretentious implement is credited; but it can be projected, and made to return over nearly the same path.

The toy boomerang is made of a piece of tough cardboard cut on a parabolic curve as shown in the engraving, one arm of the boomerang being a little longer than the other. When laid on an inclined surface, as shown in the engraving, and snapped by a pencil held firmly in one hand and drawn back and released by the fingers of the other hand, the boomerang is set in rapid rotation by the blow, and is at the same time projected, the first part of the trajectory being practically in the continuation of the plane in which the boomerang is started; but when the momentum which carries it forward is exhausted, the boomerang still revolves, and maintains its plane of rotation, so that when it begins to fall, instead of describing the same trajectory as ordinary projectiles, it makes a circuit to one side and comes back toward the point of starting. The flatness or curvature of the boomerang and the form of its edges, as well as the position in which it is placed for starting, and the speed and manner of starting, all have an effect in determining the outward as well as the return course of the projectile.

FIG. 115.



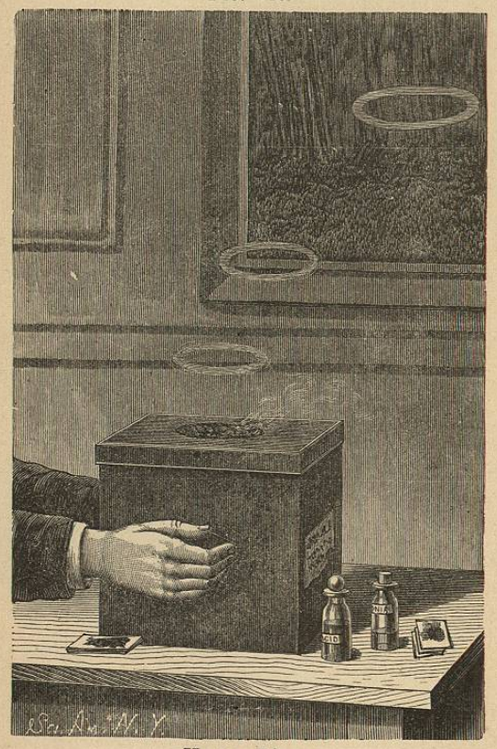
Boomerang.

VORTEX MOTION.

Every one has noticed the symmetrical wreaths of smoke and steam occasionally projected high into the air on a still day by a locomotive; similar rings may often be noticed after the firing of a gun. It is not uncommon to see a

smoker forming such wreaths with his mouth. These rings are simply whirling masses of air revolving upon axes curved in annular form, the smoke serving to mark the projected and whirling body of air, thus distinguishing it from the surrounding atmosphere. The whirls would exist without the smoke, but they would, of course, be invisible.

FIG. 116.



Vortex Rings.

All the apparatus needed for producing vortex rings at will is an ordinary pasteboard hat box, having a circular hole of 4 or 5 inches diameter in the cover. Two pads of blotting paper are prepared, each consisting of six or eight pieces. Upon one pad is poured a small quantity of muriatic acid and upon the other a similar quantity of strong aqua

ammonia. These pads are placed in the box and immediately a white cloud is formed, which consists of particles of chloride of ammonium so minute as to float in the air.

By smartly tapping opposite sides of the box, a puff of air is sent through the circular opening of the cover, carrying with it some of the chloride of ammonium. The friction of the air against the edges of the cover retards the outer portion of the projected air column, while the inner portion passes freely through, thus imparting a rotary motion to the body of air adjoining the edge of the cover, the axis of revolution being annular. After the ring is detached, the central portion of the air column continues to pass through it, thus maintaining the rotary motion.

When two rings are projected in succession in such a manner as to cause one to collide with the other, they behave much like elastic solid bodies. By making the aperture in the box cover elliptical, the rings will acquire a vibratory motion.

By fastening the box cover loosely at the corners, the box may be turned upon its side and rings may be projected horizontally.

It is obvious that smoke may be used in this experiment in lieu of the chloride of ammonium.