the external atmosphere, a quantity of water rises in the pipe, to restore the equilibrium. The water continues to rise till its weight, increased by the tension of the air in the pump, is just equal to the tension of the external air. When the equilibrium is restored, the sleeping valve closes by its own weight.

Now, if the piston be depressed, the air in the barrel is condensed, forces open the piston valve, and a portion escapes into the external atmosphere. If the piston be raised again, an additional quantity of water will be forced into the pump, and after one or two strokes of the piston, it will begin to flow into the barrel, as shown in Fig. 96.

When the water rises above the lowest limit of the play of the piston, the latter in its descent will act to compress the water in the barrel. This pressure forces open the piston valve, and a portion of the water passes above the piston, as shown in Fig. 97. By continuing to elevate and depress the piston, the water will be raised higher and higher in the pump, till at length it will flow from the spout, as shown in Fig. 98.

As the water is raised in the pump by atmospheric pressure, it is necessary that the lowest limit of the play of the piston should not be more than 34 feet above the surface of the water in the reservoir, even at the level of the sea. To provide against barometric fluctuations and other contingencies, it is usual to make this distance considerably less than 34 feet.

The Forcing Pump.

136. In the FORCING PUMP, the sucking pipe may be dispensed with, and the barrel plunged directly into the reservoir, as shown in Figs. 99 and 100, or a sucking pipe may be employed, as will be explained hereafter. We

What is the lowest limit of the play of the piston? (**136.**) What two forms may be given to the Forcing Pump?

shall first consider the case in which the sucking pipe is omitted.

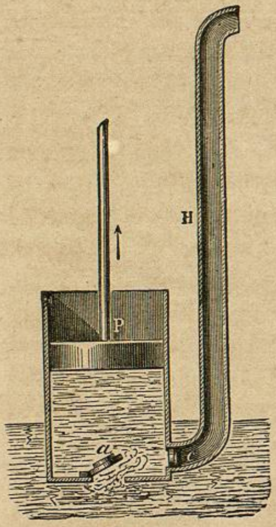

Fig. 99.

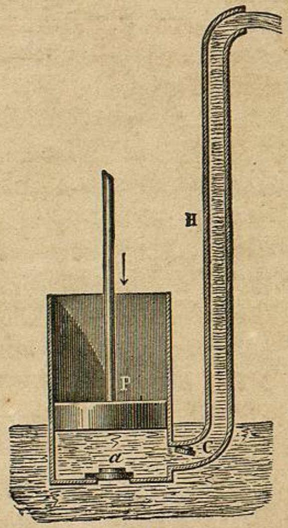

Fig. 100.

In this case the piston is solid, and a lateral pipe, *H*, called the *delivery pipe*, is introduced below the level of the lowest position of the piston. There are two valves, both fixed, the sleeping valve *a*, as in the sucking pump, and a valve *c*, opening into the delivery pipe.

When the piston is raised to its highest position, as shown in Fig. 99, the pressure of the atmosphere on the water in the reservoir forces open the sleeping valve, and the barrel is filled with water up to the bottom of the piston, when the sleeping valve closes by its own weight. On depressing the piston, the valve *c*, is forced open, and a portion of the water in the barrel is forced into the delivery pipe. When

Describe the piston. The delivery pipe. Explain the action of the forcing pump in detail.

the piston reaches its lowest position, the weight of the water in the delivery pipe closes the valve *c*, and prevents the water in the delivery pipe from returning into the barrel.

By continually raising and depressing the piston, additional quantities of water are forced into the delivery pipe, which finally escape from the spout at the top of the delivery pipe, as shown in Fig. 100.

To regulate the flow of the water through the delivery pipe, and to facilitate the working of the pump, an air-vessel is generally introduced, as will be explained in the next article. Sometimes the working is rendered uniform by combining two forcing pumps in such a manner, that the piston of the one ascends, whilst that of the other descends. This combination is also explained in the next article.

The oil in a carcel-lamp is forced up into the wick by a double forcing pump, moved by clock-work.

The Fire Engine.

137. A Fire Engine is a double forcing pump, having its delivery pipe composed of leather or other flexible material. It is used, as its name implies, for extinguishing fires.

Fig. 101 shows a section of the essential parts of a fire engine. In this figure, PQ is the lever to which are attached the piston rods, that move the pistons m and n; R is an air-vessel with two valves, one admitting water from each barrel; Z is the entrance to the hose or delivery pipe; M and N are rods sustaining the framework of the machine.

The two barrels are plunged into a reservoir which is kept supplied with water. This water flows into a space

How is the flow regulated? How is the working rendered uniform? How is the oil raised in a carcel-lamp? (**137.**) What is a Fire Engine? Describe it in detail.

beneath the barrels through holes represented on the right and left of the figure, and from thence is forced into the air-vessel in a manner entirely similar to that explained in

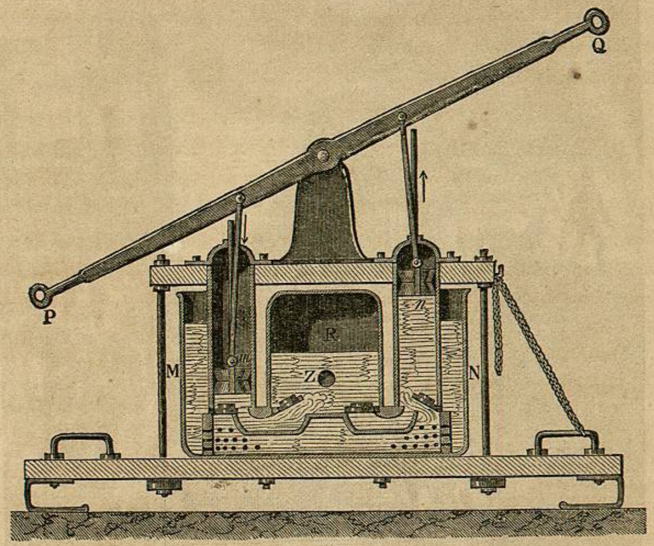

Fig. 101.

the last article. When the water is forced into the air-vessel R, the air is at first compressed, after which it acts by its tension to force a continuous current through the hose.

The lever is provided with long handles at right angles to its length, so that it may be worked by several men acting together. The general method of using a fire engine is shown in Fig. 102.

Within a few years many improvements have been introduced into the fire engine, one of the most important being the application of steam as a motor.

How is it supplied with water? *How is it maneuvered?*

Fig. 102.

The Sucking and Forcing Pump.

138. This pump differs from the forcing pump, described in Art. 136, in having a sucking pipe, which terminates at the sleeping valve. The length of the sucking pipe ought not to exceed 30 feet, but that of the delivery pipe may be of any length compatible with the strength of the pump.

(**138**.) Describe the Sucking and Forcing Pump. How high may water be raised with it?

The Siphon.

139. The SIPHON is a bent tube, by means of which a liquid may be transferred from one reservoir to another, over an intermediate elevation. The siphon may be used with advantage when it is required to draw off the upper portion of a liquid without disturbing the lower portion. This operation is called *decanting*.

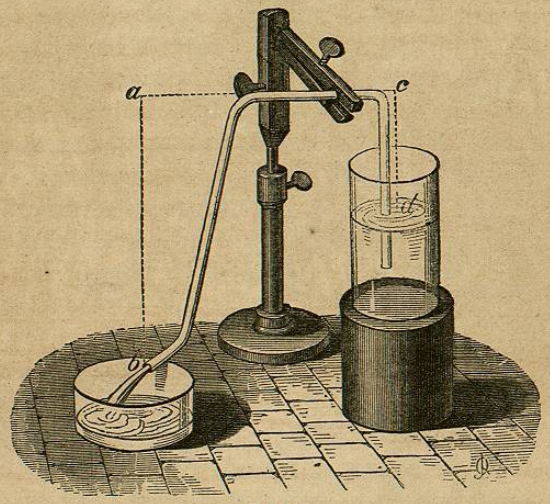

Fig. 103.

The siphon consists of two branches of unequal lengths, as shown in Fig. 103. The shorter one is plunged into the liquid to be decanted, and the flow takes place from the longer one.

To use the siphon, it must first be filled with the liquid. This operation may be effected by applying the mouth to the outer end of

(**139**.) What is a Siphon? When may it be used with advantage? What is decanting? Explain the operation. *How is the siphon prepared for use?*

the siphon, and exhausting the air by suction, or it may be inverted and filled by pouring in the liquid, and stopping both ends, after which it is again inverted, care being taken to open both ends at the same instant. Sometimes a sucking pipe is employed to exhaust the air and fill the siphon.

When the flow commences, it will continue until the liquid in the first reservoir falls below the level of the end of the siphon.

To understand the action of the siphon, we must consider the forces called into play. The water is urged from *d* towards *b*, by the pressure of the atmosphere on the fluid in the reservoir, together with the weight of the water in the outer branch of the siphon; that is, by the weight of a column of water whose height is *ab*. This motion is retarded by the pressure of the atmosphere at *b*, together with the weight of the fluid in the inner branch; that is, by the weight of a column whose height is *cd*. The difference of these forces is the weight of a column of the liquid whose height is the excess of *ab* over *cd*, and it is by the action of this force that the flow is kept up. The greater this difference the more rapid will be the flow, and the less this difference the slower the liquid will escape. When this difference becomes zero, the flow ceases altogether.

The siphon is used for conveying water over hills, but for this purpose the highest point of the tube should not be more than thirty feet above the level of the water in the reservoir, this being about the height at which the atmospheric pressure will sustain a column of water.

If a siphon be mounted on a piece of cork, so as to sink as the level of the fluid falls, the flow will be constant. Such a siphon is called a *siphon of constant flow*.

How long will the flow continue? Explain the principle and action of the siphon in detail. *How high can water be raised by a siphon? Describe a siphon of constant flow.*

IV.—APPLICATION TO BALLOONING.

Buoyant Effort of the Atmosphere.

140. It has been shown that a body plunged into a liquid is buoyed up by a force equal to the weight of the displaced liquid. That a similar effect is produced upon a body in the atmosphere, may be shown by means of an instrument called a *baroscope*, which is represented in Fig. 104.

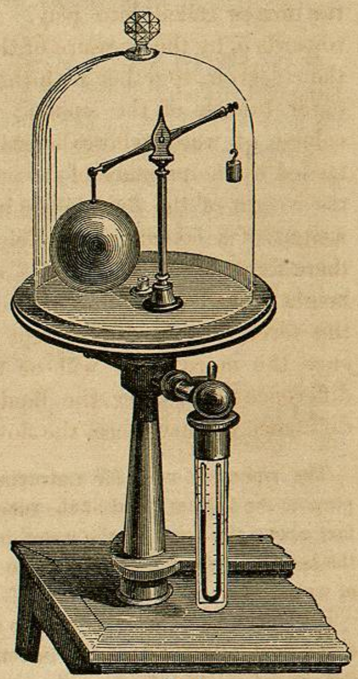

Fig. 104.

The BAROSCOPE consists of a beam like that of a balance, from one extremity of which is suspended a hollow sphere of copper, and from the other extremity a solid sphere of lead. These are made to balance each other in the atmosphere.

If the instrument be placed under the receiver of an air-pump and the air exhausted, the copper sphere will descend. This shows that in the air it was buoyed up by a force greater than that exerted upon the leaden sphere. If, now, the leaden sphere be increased by a weight equal to that of a volume of air equal to the bulk of the copper

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(**140**) What instrument is used to show the buoyant effort of the air? Describe the Baroscope. Explain its use.

sphere diminished by that of the leaden sphere, it will be found, after the air is exhausted, that the balance is in equilibrium. This shows that the buoyant effort is equal to the weight of air displaced. Hence we have the following principle, entirely analogous to the principle of ARCHIMEDES:

When a body is plunged into a gas, it is buoyed up by a force equal to the weight of the displaced gas.

If the buoyant effort is greater than the weight of the body, the latter will rise; if it is less, the body will fall; if the two are equal, the body will float in the atmosphere without either rising or falling.

Smoke, for example, rises, because it is lighter than the air which it displaces. It continues to rise until it reaches a stratum of air where its weight is just equal to that of the displaced air, when it will come to rest and remain suspended. A soap-bubble filled with warm air floats for a considerable time in the atmosphere, being nearly of the same weight as the displaced air.

The Balloon.

141. A BALLOON is a spherical envelope filled with some gas lighter than the air.

Balloons are of very different sizes, and are filled with gases of very different specific gravities, and consequently capable of raising very different weights in ascending to the upper regions of the atmosphere.

The first balloon was constructed by STEPHEN and JOSEPH MONTGOLFIER, two brothers, in 1783. It was made of linen, lined with paper. It was about forty feet in diameter, and weighed 560 lbs. It was filled with heated air and smoke, furnished by burning wet straw, paper, and the like, under the balloon, the lower part of which was left open to receive it. The balloon rose to a height of more than a mile, but it soon became cooled in the upper regions of the air and fell to the earth.

Give the law of buoyancy. *When will a body rise in the atmosphere? When fall? When remain neutral? Examples.* (**141.**) What is a Balloon? *Give an account of the early history of ballooning.*

In the following August, two brothers, named ROBERT, constructed a balloon of silk saturated with india-rubber, and filled it with hydrogen gas. The ascensional power of this balloon was very great, and being set loose in Paris, it rose with great rapidity, and at the end of four minutes had reached a height of nearly a thousand yards, when it was lost sight of by entering a cloud. It descended fifteen miles from Paris, to the astonishment of the people who saw it.

Manner of filling a Balloon and making an ascent.

142. Balloons may be filled either with hydrogen or with illuminating gas, which is a compound of carbon and hydrogen. On account of the readiness with which the latter gas can be obtained, together with its cheapness, it is generally employed. The envelope is made of silk, rendered air-tight by some kind of varnish, and is strengthened by a network of cords. This network also serves to sustain a wicker basket, or car, in which the aeronaut is seated.

Fig. 105 represents the method of filling a balloon, and preparing it for an ascension. Two masts are erected at a suitable distance from each other, at the tops of which are pulleys. A rope passing through a loop at the top of the balloon, also passes over the pulleys, and serves to raise the balloon during the process of filling.

When the process of filling commences, the balloon is raised till it is three or four feet above the ground, when the gas is introduced by means of a pipe or hose which connects with a gasometer. As the balloon fills with gas it is held down by ropes, and when completely filled, the opening is closed, and the car attached. Care should be taken not to fill the balloon completely, as the gas expands in rising, and unless an allowance is made for this increase of volume, the balloon might be ruptured.

To regulate the ascensional power, the car is ballasted by sand, contained in small bags. Everything being ready, the ropes are attached, and the balloon ascends with greater or less velocity, according to the ascensional force, that is, the excess of the buoyant effort over the weight of the entire balloon and its cargo.

When the aeronaut finds that he does not ascend fast enough, he increases the ascensional force by emptying one or more of the sand

(**142.**) *With what are balloons filled? Explain the method of filling a balloon. How is the ascensional power regulated?*

bags. In like manner, in descending, if the velocity is too great, or if the balloon tends to fall in a dangerous place, the weight of the balloon is diminished by emptying some of the sand bags.

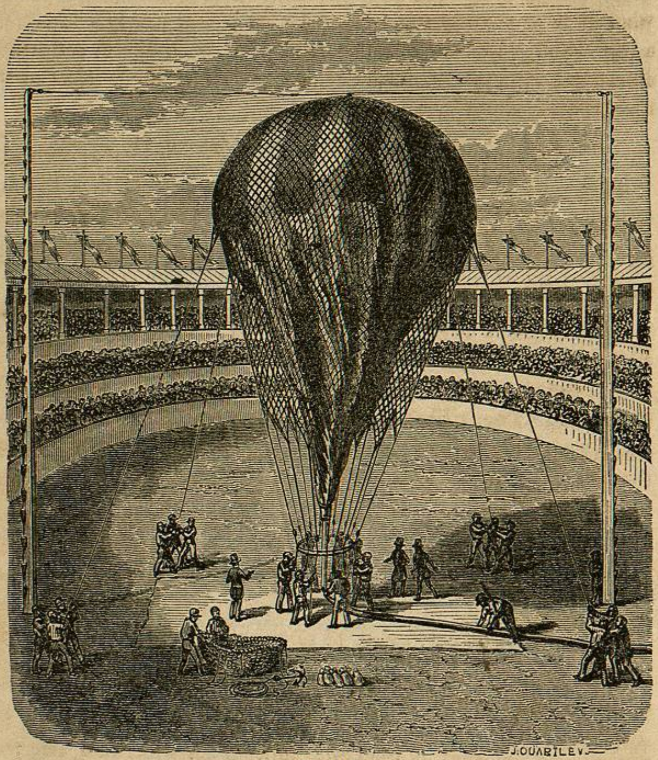

Fig. 105.

To render the descent less difficult, the aeronaut is provided with an anchor or grapple, suspended from a cord, by means of which he can seize upon some terrestrial object when he comes near the earth. When the anchor is made fast, the aeronaut draws down the balloon by pulling upon the cord. The anchor, the sand bags, and the wicker car, are represented on the ground in Fig. 105.

How does the aeronaut make fast to the earth in descending?

At the top of the balloon is a valve kept closed by a spring; it can be opened by means of a string descending through the balloon to the car of the aeronaut. When he wishes to descend, he opens the valve, and allows a portion of the gas to escape. To ascertain whether he is ascending or descending, the aeronaut is provided with a barometer; when ascending, the barometric column falls, and when descending, it rises. By means of the barometer the height at any time may be determined.

The Parachute.

143. A PARACHUTE is an apparatus by means of which an aeronaut may abandon his balloon, and descend slowly to the earth.

The form and construction of a parachute is shown in Fig. 106. It consists of circular piece of cloth, 15 or 16 feet in diameter, presenting, when spread, the form of a huge umbrella. The ribs are made of cords, which, being continued, are attached to a wicker car, as shown in the figure.

When the aeronaut wishes to descend in the parachute, he enters the car and detaches the parachute from the balloon. At first he descends with immense rapidity, but the air soon spreads the cloth, and then acting by its resistance, the velocity is diminished, and the aeronaut reaches the earth without injury. A hole is made at the centre of the parachute, which, by allowing a part of the compressed air to escape, directs the descent and prevents violent oscillations that might prove dangerous.

The parachute was first tried by BLANCHARD, who placed a dog in the car, and detached it from the balloon. A whirlwind arrested its descent and carried it up above the clouds, where BLANCHARD soon after fell in with it, to the great joy of the poor animal. A current again separated the two voyageurs, but both reached the earth in safety, the dog being the last to descend.

J. GARNERIN was the first man who ventured to descend in a parachute, which he did by detaching himself from a balloon at the

What is the use of the valve at the top? What is the use of the barometer? (**143.**) What is a Parachute? Describe it. *Explain its use and action.*

Fig. 106.

height of a thousand yards above the surface of the earth. He descended in safety.

Remarkable Balloon Ascensions.

144. The first ascension was made in October, 1783, by DE ROZIER. His balloon was filled with heated air, and was confined by a rope, so that he only rose to a height of about a hundred feet. In the following year DE ROZIER and D'ARLANDES ascended in a fire balloon from the Bois de Boulogne, and after a voyage of twenty-five minutes they descended on the other side of Paris. In a subsequent ascent DE ROZIER lost his life in consequence of his balloon taking fire. In 1785, BLANCHARD and JEFFRIES crossed the English Channel from Dover to Calais. During the voyage they had to throw overboard all of their ballast, then their instruments, and finally their clothing, to lighten the balloon. In 1804, GAY LUSSAC ascended to the height of 23,000 feet above the level of the sea. At this height the barometric column fell to 12.6 inches, and the thermometer, which at the surface of the earth was 31°, fell to 9½° below 0.

At such heights, substances which absorb moisture, like paper and parchment, become dry and crisp as if heated in an oven, respiration becomes difficult, and the circulation is quickened on account of the rarefaction of the air. GAY LUSSAC relates, that his pulse rose from 66 to 120. The sky becomes almost black, and the silence that prevails is frightful. After a voyage of six hours, GAY LUSSAC descended, having travelled about ninety miles.

On the 1st of July, 1859, Messrs. WISE, LA MOUNTAIN, GAGER, and HYDE, ascended from St. Louis, Mo., and descended at Henderson, Jefferson Co., N. Y., having travelled 1150 miles in a little less than twenty hours, or about fifty-seven miles per hour. This is the most celebrated voyage on record.

Balloons have been used with some success in military operations. As means of travelling, they have thus far proved of no value, on account of the difficulty of directing their course.

(**144.**) *Describe some of the most remarkable Balloon Ascensions. That of* ROZIER. *Of* BLANCHARD *and* JEFFRIES. *Of* GAY LUSSAC. *What effect has the atmosphere at great elevations? Describe the great American voyage. Uses of balloons.*