On the contrary, if it possesses the least weight, this weight is a force which would cause it to fall, unless it were buoyed up by something else. If it is sufficiently light, however, its tendency to descend is counteracted by the buoyant force of the air, and it ascends. Placed in a vacuum, it would immediately fall. Some illustrations may be introduced. to render this point plain. Suppose that a cubic foot of some substance, weighing in the air 400 pounds, is wholly immersed in water, which weighs 62 pounds per cubic foot. By the immersion, a cubic foot of water is displaced to make way for the substance, and, by its effort to return, presses upward against the substance, with a force of 62 pounds; so that the body, if weighed during immersion, will be found to have its original weight diminished by 62 pounds, and will balance the scale at 338 pounds, instead of the 400 required when weighed in the air. Now if, in place of this heavy body, we immerse a cubic foot of some other substance, which weighs only 40 pounds, the water, as before, will press up with a force of 62 pounds; and as the body only exerts a downward pressure of 40 pounds, it will rise, under the influence of the unbalanced upward pressure of 22 pounds. The action of the air on all bodies immersed in it is precisely similar to that of the water, except that most bodies are so much heavier than equal bulks of air that the effects are not ordinarily noticed. For instance, a cubic foot of air of ordinary pressure and temperature weighs about $\frac{163}{2000}$ of a pound; so that a substance, one cubic foot in capacity, which weighs 400 pounds in the air, will weigh $399\frac{1837}{2000}$, or practically the same, in a vacuum. It is obvious, however, that there is some difference in the weights as estimated in the air and in a vacuum; and since the weight of the air varies somewhat at different times, the absolute weight of a body is its weight in vacuum. Of course, the weight of a body in the air is ordinarily sufficiently accurate, and it is only in delicate scientific researches that the method of weighing in vacuum is employed.

From the foregoing considerations, we are led to conclude:

1st. If a body is wholly immersed in any fluid, it will be pressed upward by a force equal to the weight of a volume of the fluid equal to the volume of the body.

2nd. If the upward pressure is less than the weight of the body, the latter will have a tendency to fall, under the action of a force equal to the difference between the body's weight and the weight of an equal volume of the fluid.

3d. If the upward pressure is equal to the weight of the body, the body will have no tendency either to fall or rise.

4th. If the upward pressure is greater than the body's weight, the body will have a tendency to rise, due to a force equal to the difference between the weight of a volume of fluid, equal to the volume of the body, and the weight of the body. These principles are a concise statement of the theory of a balloon's action. If we have a body whose weight per cubic foot is less than the weight of, a cubic foot of air, the body will rise with a force equal to the difference between the body's weight and the weight of an equal volume of air. For instance, if a balloon is filled with hydrogen, the air will exert a lifting force of about $\frac{7}{100}$ of a pound for each cubic foot in the volume of the balloon, so that, if the weight of the balloon and car is less than this lifting force, the balloon will ascend. If common illuminating gas is used in the balloon, the lifting force will be about $\frac{1}{25}$ of a pound for each cubic foot of the balloon's volume. The weight of the material in a balloon varies greatly, of course, according to the construction, some balloons only weighing, with the net work, about $\frac{1}{25}$ of a pound per square foot of surface, or even less, and others weighing as much as $\frac{1}{8}$ of a pound per square foot of surface. The ordinary shape of a balloon approximates closely to that of a sphere, which it is commonly assumed to be in making calculations. An example is appended to illustrate the application of the preceding statements:

A balloon has a diameter of 40 feet, the weight of the material and netting is $\frac{1}{8}$ of a pound per square foot of surface, the weight of the car and contents is 600 pounds, and the gas which distends the balloon is subject to an upward pressure of $\frac{1}{25}$ of a pound per cubic foot.

The volume of the balloon is 33,510 cubic feet, so that the upward pressure due to the air is about 1,340 pounds. The surface of the balloon is 5,026·5 pounds, so that the weight of material and netting is about 628 pounds, to which must be added the weight of the car, making a downward pressure of 1,228 pounds; hence the unbalanced upward pressure, which causes the balloon to ascend, is about 112 pounds. It will now be evident, we think, that the lifting force of a balloon is entirely due to the air, and is impeded, instead of being assisted, by the gas; so that it would be better, if it were practicable, to make a balloon with a vacuum in the interior.

It must be remembered that, as a balloon ascends above the earth's surface, the air in which it is immersed grows continually less dense, so that the lifting force becomes less and less, unless the volume of the balloon is increased. Thus at about 18,000 feet elevation, the air is only about half as dense as at the sea level; at 36,000 feet elevation, $\frac{1}{4}$ as dense, and so on. Hence balloons are rarely filled at the surface, as we have explained in former descriptive articles. We have also detailed the methods of manufacture, varnishes employed, etc., so that it only remains to explain the manner of calculating the size of a balloon required to fulfil given conditions.

In making the estimate for a balloon, one can generally ascertain the weight of the car and contents, the difference of weight of a cubic foot of air and of the gas to be employed (which may be called the buoyant effort), and the weight of the balloon with its ropes and network per square foot of surface. It is then required to find the diameter of a balloon which will have a tendency to rise with a given force. The calculation by which this is determined is somewhat complex, but it will be found explained at length below, an example being added for the purpose of further illustration. The following quantities must first be ascertained:

1. The buoyant effort, or difference between the weight of a cubic foot of air and of gas.

2. The weight, which includes the weight of everything except the material of the balloon and the netting, together with the lifting force.

3. The superficial weight, or weight of the material and netting, per square foot of the balloon's surface.

The operations for finding the required diameter are as follows

(*a*). Divide twice the superficial weight by the buoyant effort.

(*b*). Divide 8 times the cube of the superficial weight by the cube of the buoyant effort.

(*c*). Divide 0·95493 times the weight by the buoyant effort.

(*d*). Multiply 15·27888 times the cube of the superficial weight by the weight, and divide the product by the fourth power of the buoyant effort.

(*e*). Divide 0·91188 times the square of the weight by the buoyant effort.

(*f*). Add together the quantities obtained by rules (*d*) and (*e*), and take the square root of the sum.

(*g*). Add together the quantities obtained by rules (*b*), (*c*), and (*f*), and take the cube root of the sum.

(*h*). Add together the quantities obtained by rules (*b*) and (*c*), subtract the quantity obtained by rule (*f*), and take the cube root of the difference.

(*i*). Add together the quantities obtained by rules (*a*), (*g*), and (*h*). The sum will be the diameter required.

Example: It is required to find the necessary diameter of a balloon, the following data being given:

The weight of the car and contents is 475 pounds, of the valve 25 pounds, and the air is to exert a lifting force of 100 pounds. The gas in the balloon is to be such that the difference between its weight and that of a cubic foot of air shall be 0·04 pound. The weight of the material and netting is to be 0·12 pound per square foot of balloon surface.

Pursuing the same steps as indicated in the preceding rules, we find:

1. The buoyant effort = 0·04 pound.
2. The weight = 475 + 25 + 100 = 600 pounds.
3. The superficial weight = 0·12 pound.

(*a*). $2 \times 0{\cdot}12 \div 0{\cdot}04 = 6$.

(*b*). $8 \times 0{\cdot}001728 \div 0{\cdot}000064 = 216$.

(*c*). $0{\cdot}95493 \times 600 \div 0{\cdot}04 = 14{,}324$.

(*d*). $15{\cdot}27888 \times 0{\cdot}001728 \div 0{\cdot}00000256 = 6{,}187{,}946$

(*e*). $0{\cdot}91188 \times 360{,}000 \div 0{\cdot}0016 = 205{,}173{,}000$.

(*f*). $\sqrt{(205{,}173{,}000 + 6{,}187{,}946)} = 14{,}538$

(*g*). $\sqrt[3]{(216 + 14{,}324 + 14{,}538)} = 30{\cdot}75$.

(*h*). $\sqrt[3]{(216 + 14{,}324 - 14{,}538)} = 1{\cdot}26$.

(*i*). $6 + 30{\cdot}75 + 1{\cdot}26 = 38{\cdot}01$ feet, required diameter.

This explanation will doubtless render the method plain to all who are sufficiently interested to devote a little attention to the matter; and such readers would do well to work out other examples from assumed data.

As there are many who like to know the reasons for a result, we have added the method by which the rules are obtained, which can readily be verified by those who are familiar with algebra. Let

b = buoyant effort, W = weight, and a = superficial weight.

The balloon is to have sufficient volume that the upward pressure of the air, which is the volume of the balloon multiplied by the buoyant effort, shall be equal to the weight, increased by the product of the superficial weight and the surface of the balloon. Assuming that the balloon is in the form of a sphere, this condition is expressed by the following equation, calling x the diameter of the balloon:

$$0{\cdot}5236 \times b \times x^3 = W + 3{\cdot}1416 \times a \times x^2$$

From which we deduce:

$$x = \frac{2a}{b} + \left[\frac{8a^3}{b^3} + \frac{0{\cdot}95493\,W}{b} + \left(\frac{15{\cdot}27888\,a^3 W}{b^4} + \frac{0{\cdot}91188\,W^2}{b^2}\right)^{\frac{1}{2}}\right]^{\frac{1}{3}} + \left[\frac{8a^3}{b^3} + \frac{0{\cdot}95493\,W}{b} - \left(\frac{15{\cdot}27888\,a^3 W}{b^4} + \frac{0{\cdot}91188\,W^2}{b^2}\right)^{\frac{1}{2}}\right]^{\frac{1}{3}}$$

the same value as was given in the foregoing rules.

It will be evident, by inspecting the equation of condition, that the same method can be applied to any form of balloon whose volume and surface can be expressed algebraically.

SENATE CONFIRMATIONS.

We are informed that the nominations of Captain J. M. Thacher as Commissioner of Patents, and General Ellis Spear as Assistant Commissioner, have been confirmed by the Senate, and also that of Major Marcus S. Hopkins as a member of the Appeal Board

It is gratifying to be able to say that they are all gentlemen of the highest personal character, possessed of ability and experience. The duties committed to their charge are of great importance, and will, we trust, be discharged with unswerving fidelity. They have before them a splendid opportunity, by an honest and liberal-minded administration of the Patent Laws, to secure the public confidence, and win for themselves individually, an honorable and widely extended fame.

WE are requested to state that the case of the rotary blower, illustrated and described in our last issue, is formed of cast iron, bored out true, and bolted firmly to the heads of the machine. The mention of "light boiler iron, formed up very truly and inserted into the heads of the machine," is an error.

SCIENTIFIC AND PRACTICAL INFORMATION.

A NEW VARNISH FOR METAL WORK.

A late Italian patent contains the following recipe for a varnish for protecting metal work: A paste is made of finely pulverized quartz, carbonate of potash, or oxide of lead and water according to the color required. A thin coat of this is applied with a brush to the object, which is then placed in a muffle, and heated to 1,495° Fah. The articles emerge covered with a sort of polished glass, which resists blows and which does not split nor scale off, while it serves perfectly to protect the metal against oxidation.

RUSSIAN RAILWAYS IN PERSIA.

Since the revoking of the concessions obtained by Baron Reuter from the Shah of Persia, for the construction of the railways in that country, Russia has been negotiating for the privilege, and the success of her diplomacy is now announced.

Russian capitalists will furnish the funds, and the line to be built will connect the Caspian and Black seas through Tiflis and the port of Peti. The Shah guarantees 6 per cent of the cost of such portions of the road as enter his dominions.

ELECTROPLATING ON CHINA.

M. Hansen has recently patented in France the following process for electroplating on a non-conducting material: Sulphur is dissolved in the oil of *Lavendula spica* to a sirupy consistence. Sesquichloride of gold or sesquichloride of platinum is then dissolved in sulphuric ether, and the two solutions are mingled under a gentle heat. The compound is next evaporated until of the thickness of ordinary paint, when it is applied with the brush to such portions of the china, glass, etc., as are desired to be covered with the electro-metallic deposit. The objects are baked in the usual way before immersion in the bath.

IMITATION GOLD.

An alloy having a very fine and malleable grain, susceptible to a high polish and impervious to rust (which, while closely resembling gold, may advantageously replace that metal in a variety of cases), is made of 100 parts pure copper, 17 parts tin, 6 parts magnesia, 3·6 parts sal ammoniac, 1·8 parts quick lime, and 9 parts bitratrate of potassa. The copper is melted first, and the magnesia, ammonia, lime, and tartrate are successively added in small quantities. The tin in small pieces is then placed in the crucible, and the whole brought to fusion for 35 minutes, after which the alloy is allowed to cool.

EFFECT OF FLAME ON AN ELECTRIC SPARK.

Mr. S. J. Mixter notices a curious effect of a gas flame on the current of a Holtz machine. The jet consisted of a glass tube drawn out to a point, and the flame had a length of about an inch and a diameter of only an eighth of an inch. Inserting this between the two terminals of the machine, the length of spark obtainable was at once increased from less than ten inches to over twelve, the full distance to which the balls could be separated. The same increase was not obtained on simply inserting a conductor between the two terminals, a ball an inch in diameter only lengthening the spark about an inch.

A NEW GALVANIC BATTERY.

A new battery is manufactured by Messrs. C. & F. Fein, of Stuttgart, which is said to be remarkably cheap and to have a constant current, with high electromotive power. It consists of a three-necked jar, similar to a Woolff bottle. In one of the side orifices is inserted a charcoal plate, and in the other a strip of amalgamated zinc, the last covered with cotton. By means of the center tube, pieces of coke and peroxide of manganese are inserted until the bottle is about two thirds full. The remaining space receives a concentrated solution of sal ammoniac. The center tube terminates above in an inverted flask, the neck of which is extended down to the level of the liquid. The flask is also filled with the sal ammoniac solution, and, by affording a continual supply, provides against loss by evaporation. The contact between the charcoal and the copper conducting wire is made by platinum plates. The battery remains constant for a year, and is said to be easily cleaned and renewed.

HIPPOPHAGY IN FRANCE.

During the fall of 1874, Paris ate 1,555 horses, asses, and mules. A horse, which, for his skin, hoofs, etc., alone, is worth but about five dollars, brings as food, in the markets of the French capital, five times that sum.

Gas from Crude Petroleum.

In a reply recently given to one of our correspondents in respect to this subject, he was informed that many attempts had been made to employ crude petroleum for the manufacture of illuminating gas, some of which are in progress, and that, as yet, the various inventors have not succeeded in perfectly overcoming the practical difficulties.

The Ashtabula *News*, Ohio, objects to this reply, because, it says, Ashtabula is now and has been for more than a year lighted by gas made from crude petroleum by a process invented by Dr. Wren of Brooklyn; that the process is entirely successful and very economical; and that among other places which are now using this gas we may name Shelbyville, Indiana, and San José, California.

We are glad to record these evidences of successful progress in the use of crude petroleum, and we hope that gas engineers in all parts of the country will send us reports of what they are doing in that line. Crude petroleum is a very cheap, abundant, and valuable natural product. Its successful, economical use for gas illumination will be of great advantage to the country.