all of you are), you will find a great deal of philosophy in this [holding up a cork and a pointed, thin stick, about a foot long]. Do not refer to your toy-books, and say you have seen that before. Answer me, rather, if I ask you, have you *understood* it before? It is an experiment which appeared very wonderful to me when I was a boy. I used to take a piece of cork (and I remember I thought at first that it was very important that it should be cut out in the shape of a man; but, by degrees, I got rid of that idea), and the problem was to balance it on the point of a stick. Now, you will see that I have only to place two sharp-pointed sticks, one on each side, and give it wings, thus, and you will find this beautiful condition fulfilled.

We come now to another point. All bodies, whether heavy or light, fall to the earth by this force which we call gravity. By observation, moreover, we see that bodies do not occupy the same time in falling; I think you will be able to see that this piece of paper and that ivory ball fall with different velocities to the table [dropping them]; and if, again, I take a feather and an ivory ball, and let them fall, you see they reach the table or earth at different times; that is to say, the ball falls faster than the feather. Now that should not be so; for all bodies do fall equally fast to the earth. There are one or two beautiful points included in that statement. First of all, it is manifest that an ounce, or a pound, or a tun, or a thousand tuns, all fall equally fast, no one faster than another: here are two balls of lead, a very light one and a very heavy one, and you perceive they both fall to the earth in the same time. Now, if I were to put into a little bag a number of these balls, sufficient to make up a bulk equal to the large one, they would also fall in the same time; for if an avalanche fall from the mountain, the rocks, snow and ice, together falling toward the earth, fall with the same velocity, whatever be their size.

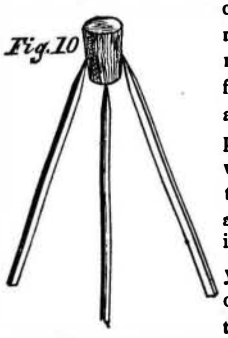


Fig. 10

I cannot take a better illustration of this than that of gold leaf, because it brings before us the reason of this apparent difference in the time of the fall. Here is a piece of gold leaf. Now, if I take a lump of gold and this gold leaf, and let them fall through the air together, you see that the lump of gold—the sovereign or coin—will fall much faster than the gold leaf. But why? They are both gold, whether soverign or gold leaf. Why should they not fall to the earth with the same quickness? They would do so, but that the air around our globe interferes very much where we have the piece of gold so extended and enlarged as to offer much obstruction on falling through it. I will, however, show you that gold leaf *does* fall as fast when the resistance of the air is excluded; for if I take a piece of gold leaf and hang it in the center of a bottle, so that the gold and the bottle and the air within shall all have an equal chance of falling, then the gold leaf will fall as fast as anything else. And if I suspend the bottle containing the gold leaf to a string, and set it oscillating like a pendulum, I may make it vibrate as hard as I please, and the gold leaf will not be disturbed, but will swing as steadily as a piece of iron would do; and I might even swing it round my head with any degree of force, and it would remain undisturbed. Or I can try another kind of experiment: if I raise the gold leaf in this way [pulling the bottle up to the ceiling of the theater, by means of a cord and pulley, and then suddenly letting it to fall within a few inches of the lecture table], and allow it then to fall from the ceiling downward (I will put something beneath to catch it, supposing I should be *maladroit*), you will perceive that the gold leaf is not in the least disturbed. The resistance of the air having been avoided, the glass bottle and gold leaf all fall exactly in the same time.

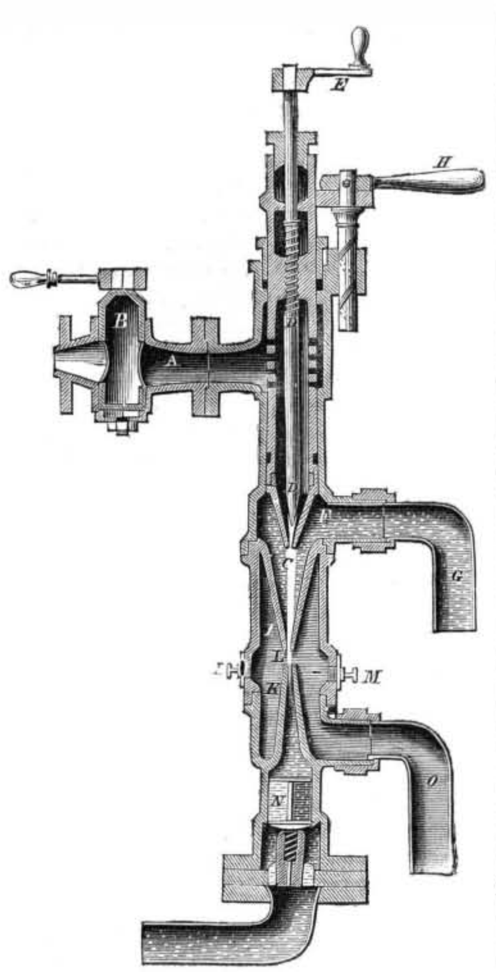
Here is another illustration: I have hung a piece of gold leaf in the upper part of this long glass vessel, and I have the means, by a little arrangement at the top, of letting the gold leaf loose. Before we let it loose, we will remove the air by means of an air-pump, and, while that is being done, let me show you another experiment of the same kind. Take a penny-piece, or a half-crown, and a round piece of paper a trifle smaller in diameter than the coin, and try them side by side to see whether they fall at the same time [dropping them]. You see they do not—the penny-piece goes down first. But now place this paper flat on the top of the coin, so that it shall not meet with any resistance from the air, and upon *then* dropping them, you see they *do* both fall in the same time [exhibiting the effect]. I dare say, if I were to put this gold leaf, instead of the paper, on the coin, it would do as well. It is very difficult to lay the gold leaf so flat that the air shall not get under it and lift it up in falling, and I am rather doubtful as to the success of this, because the gold leaf is puckery, but will risk the experiment. There they go together [letting them fall], and you see at once that they both reach the table at the same moment.

We have now pumped the air out of the vessel, and you will perceive that the gold leaf will fall as quickly in this vacuum as the coin does in the air. I am now going to let it loose, and you must watch to see how rapidly it falls. There [letting the gold loose]; there it is, falling as gold should fall.

I am sorry to see our time for parting is drawing so near. As we proceed, I intend to write upon the board behind me certain words, so as to recall to your minds what we have already examined, and I put the word FORCES as a heading, and I will then add beneath the names of the special forces, according to the order in which we consider them; and, although I fear that I have not sufficiently pointed out to you the more important circumstances connected with the force of GRAVITATION, especially the law which governs its attraction (for which, I think, I must take up a little time at our next meeting); still, I will put that word on the board, and hope you will now remember that we have, in some degree, considered the force of gravitation—that force which causes all bodies to attract each other when they are at sensible distances apart, and tends to draw them together.

GIFFARD'S INJECTOR.

Let no man hereafter conclude, by mere reasoning, that anything cannot be done. That a pipe coming out of the top of a steam boiler should be able, by the mere force of the steam rushing out of it, to blow water



through another pipe right back into the same boiler, without the intervention of any machinery, and thus keep up the supply of water in the boiler, would, most assuredly, have been pronounced impossible by all the philosophers in the world. And yet there are large numbers of steam engines running at this time, the boilers of which are supplied by this process. We gave a description of the apparatus on page 162 of the current volume; but it is so very novel and peculiar that, finding an engraving of it in its most improved form, in the London *Mechanics' Magazine*, we have decided to reproduce it for the benefit of our readers.

The steam from the boiler is admitted through the pipe, A, furnished with a cock, B, and passes down through the perforated cylinder or tube, C, which is made conical at the bottom; the area of the aperture being regulated by the conical rod, D, adjusted by the screw and handle, E. The jet of steam issuing from the orifice of the tube, C, encounters the feed-water in the chamber, F, which enters either from a head of water, or by the aspiration of the apparatus itself, from a tank placed near; from the feed-pipe, G, the supply of feed-water is regulated by raising or lowering the tube, C, by means of the handle, H, and screw of quick pitch. The stream of feed-water propelled by the steam jet issues from the upper orifice, I, and passes into the mouth of the lower pipe, K, leading into the boiler; the intervening space, L, being open to the atmosphere, so that the stream of water can be seen through the sight-holes, M, at this part of the passage. While the injector is at work, a check valve is inserted at N, to prevent the return of water from the boiler when the injector is not working. The overflow pipe carries off any overflow occasioned in starting the injector to work, and the sight-holes, M, are covered by a circular slide.

In starting the injector to work, the handle, H, is first turned into the position suited to the pressure of steam in the boiler; this permits the access of water to the instrument, and regulates its admission. The steam cock, B, is then opened, and the handle, E, turned slightly, so as to elevate the screwed rod, D, which admits a small quantity of steam to the conical opening, I; a partial vacuum is thus produced in the chamber, F, by the rush of steam through the opening, I, and the water flows into it. As soon as this happens, which can be seen by the issue of water from O, the screwed rod, D, is gradually raised until the overflow ceases; thus giving full liberty to the steam to act upon the water at L, and drive it into the boiler through the pipe, K, and the valve, N.

There has been much discussion as to the theory of the action of this wonderful apparatus. Our own explanation is simply this: as the steam in the pipe comes in contact with the cold water, it is condensed, forming a vacuum, into which the steam, under high pressure in the boiler, rushes with tremendous velocity, acquiring sufficient momentum not only to carry itself back into the boiler, but also to carry along with it any particles of water with which it may come in contact on its way.

THE SUBTLETY OF POISONS.—At a recent discussion before the Society of Arts in London on the detection of arsenical poisoning, Dr. Letheby traced the progress of toxicological research from the trial of Donald, in 1815, up to the present time. A little while before that period, *ten grains* of arsenic were required to make a metallic test satisfactory in a court of law. Afterwards, Dr. Black improved the process till he could detect the poison if he had *one grain* to operate upon. It was then thought a marvel of toxicological skill when Dr. Christison said he only required the sixteenth of a grain; but now we can trace the presence of the 250,000,000th of a grain of arsenic! It is to be feared that the detection of this particular poison has reached an almost dangerous degree of delicacy, and extreme caution is necessary in examination for its criminal administration. We live surrounded by means of unconsciously absorbing traces of arsenic; we breathe arsenicated dust from the green wall papers of our rooms; the confectioners supply it wholesale in their cake ornaments and sweetmeats; the very drugs prescribed for our relief are tainted with arsenic; nay, more, even our vegetable food, as Professor Davy has lately pointed out, may be contaminated with arsenic; and there is probably no drinking water containing iron without a trace of arsenic as well. The poison may thus be stored up in the system till, in the course of years, the amount becomes appreciable.