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THE HYDROSTATIC PARADOX.

Such has been the term applied to the enunciation of the truth, that any column of water, however small, may be made to raise any weight, however large, experimentally shown in the familiar piece of apparatus known as the water bellows. This proposition is theoretically correct, although there are practical limits to its application. Why it should be considered paradoxical,however,any more than the action of a lever, has always been a puzzle to us. Theoretically, it is just as true of the lever, that any weight, however small, may be made by its means to raise any weight, however large, as of the water bellows, or the hydrostatic press.

In either case, on the principle of "virtual velocities," the weight of the body which raises, multiplied into the distance it moves, will always equal the weight of the body raised multiplied into the distance it moves, friction being supposed to be nothing. And, practically,in all cases,the weight which raises must be enough heavier than would be found by this equation, to overcome the friction of the apparatus, whether bellows or lever.

Some of our correspondents are puzzling their heads over the theory of hydrostatic pressure as applied to the press of Brahma, and we are in receipt of not less than a dozen inquiries in regard to this subject. We will endeavor to answer these inquiries definitely in this article. The subject only becomes obscure, when we attempt to get back of nature's laws, to find out *why* things are as they are. We shall confine ourselves to the simple question of *how* they are. The equilibrium of fluids was ascribed by Pascal to the principle of virtual velocities above mentioned. This principle or law of nature has been thus enunciated: "Forces in equilibrium must be to each other as their velocities." It may be added, that when any two forces are so related to each other that the motion which each tends to produce is in an opposite direction to that of the other, and so that the distances through which each would move, if an additional force were made to aid either, would be inversely as the forces themselves, then unless an additional force be made to aid one or the other of the two forces thus related, neither will produce motion.

An example of two forces thus related would be two springs, one having a strength equal to the support of two pounds, the other a strength equal to the support of four pounds, attached to fixed supports,and acting upon the ends of a lever six feet long, resting upon a fulcrum placed two feet from one end and four feet from the other—the two-pound spring acting upon the longer arm, and the four-pound spring upon the shorter. In this case, no motion would take place unless one of the springs were assisted by an additional force. The two forces would be in equilibrium.

Now, when a small column of water supports a larger column, their weights are two forces, exactly so related. Neither column can descend without the other ascends,*i.e.*, moves in an opposite direction, and the distances through which the columns would move would be inversely, as their weights. That either may move, an additional force must be applied to at least one of them, which will cause a motion in both. But an infinitesimal additional force applied to one column would be sufficient to destroy the equilibrium,unless some resistance or counteracting force should immediately impede the motion of the other column. Moreover, the properties of fluids are such,that the weights of any two columns of fluids, connected at their bases by a fluid medium, invariably sustain the relation we have described, unless some other force acts upon one or both columns.

It is unnecessary for our present purpose to complicate the question by a consideration of columns of unequal diameters in different parts, the columns here spoken of being those of uniform diameter throughout.

Further, although this law of virtual velocities has been the subject of many explanatory efforts, we know no more about it to-day than we do about the nature of gravity. All we can do is to recognize its existence as we do that of gravity, all else must be merely fruitless speculation.

The hydrostatic press of Brahma,applies an additional force to one of two fluid columns in equilibrium, to not only destroy the equilibrium, but, also, to overcome a counteracting force or resistance opposed to the motion of the opposite column. We have said the two forces in two such columns when no additional force is applied,are the weights of the columns; but as the weights of the columns are to each other as their sectional areas,these areas may be used as the representatives of the two forces, and it will be more convenient to so consider them. But as these areas, when geometrically similar, are to each other as the squares of their diameters, we may operate still more conveniently by making these the representatives of the two forces.

Let the small column of a hydrostatic press be one inch in diameter, and the large column be two inches in diameter. When these columns are in equilibrium, the weights will be to each other as their sectional areas, which are to each other as the squares of their diameters, or as one is to four. Here we have a force of one balancing a force of four, simply because they are so related, that if motion should take place by the action of an additional force on either column, one must move in an opposite direction four times as far as the other. It follows that, as the motion produced by this force must be transmitted through the fluid medium connecting the two columns at their bases, and as this medium is the condition which establishes the peculiar relation between the two forces, the ratio between the force applied and the resistance it will overcome must be exactly the same as existed at first between the two columns, so that if a force of six pounds be applied through a piston resting on the top of the smaller column, it will balance a weight of twenty-four pounds applied through a piston resting on the top of the larger column; and any less force than twenty-four pounds, applied through a piston, to the top of the larger column, would be raised one inch for every four inches the smaller piston descends.

It also follows, that the quantity of fluid displaced from under the smaller piston is exactly equal to that injected into the larger cylinder,and that the stroke of the small piston must always be through a greater distance than the movement of larger piston in the same time, the distances being inversely as the forces. The principle which underlies the action of this machine, namely, the principle of virtual velocities, is as immutable and as inscrutable as the existence of matter and force.

We have here, also, a reason why great hydrostatic power, generated by a small column of water in such a press cannot be made to generate a motion any more rapid than could be produced by the motion of the small column itself, and as a further and final deduction,the greater the difference between the diameters of the pistons, and the greater the consequent power of the press,the slower will be the motion of the larger piston.

All of these facts have been proved by experiment, and we have shown that the law of virtual velocities is sufficient to account for them.

THE WANDERING OF PHOSPHORUS IN PLANTS.

Phosphorus, long known as a chemical rarity costlier than gold, but at present one of the most extensively used of chemicals, is prepared from bones. However, bones can only be regarded as organs of collection, as originally it is derived from the earth. Phosphorus is not found in a native or uncombined state, since its affinity for oxygen is very great. United with this latter element it mostly forms phosphoric acid, which again is met with in union with such bases as soda, lime, magnesia, etc.

These compounds are termed phosphates, and are widely distributed over the globe, although they rarely occur in large masses on one spot. They occur in the soil—in most limestones, and in many clays and marls—which fact accounts for their value as fertilizers. Nearly all iron ores contain traces of phosphates; these are reduced in the process of smelting, phosphorus being set free; hence its presence in cast iron, wrought iron, and steel. The excellent Russian iron from the furnaces of Prince Demidoff, near Nischnetagilsk, according to Schafhäutl, owes its qualities to a trace of phosphorus. Still, this admixture is not always desirable, since, if exceeding certain limits, it makes the iron cold-short.

Phosphorus is also a component part of our own body; it exists there not only as phosphoric acid, but also in a de-oxidized condition united with organic substances; as, for instance,in the fatty matters of the brain, whence the well-known sentence of Moleschott, "No thought without phosphorus!" —a sentence, it may be stated, that has been the subject of considerable abuse. However, it is not only in the brain that phosphorus is met with, for, according to Ronalds, a part of the phosphorus of the urine, from which this element had first been separated, occurs also united with an organic compound.

How does the phosphorus pass into the human body? Through plants especially. To them the part has been assigned to withdraw it from the soil and to prepare it for the food of man. Before phosphorus was known to exist in the animal kingdom, its presence in plants had been considered as an acknowledged fact; indeed, phosphorus was found in them before it had been ascertained in the urine of man. The number of vegetables greatly increased in which the element in question was met with; it remained unknown for a long time that it had to be ranked among their constituent parts, and even when this could no longer be doubted, its origin remained an enigma. Although Fownes had already stated that many volcanic minerals contained phosphorus, this assertion was not regarded as true. To modern times it was reserved to throw light upon this subject. In the molybdate of ammonia, chemistry now possesses an exceedingly sensitive reagent for phosphoric acid, which is so very important for the growth of plants. It has been ascertained by Forchhammer that a soil in which phosphoric acid can scarcely be detected, contains of this material not less than 790 pounds per acre, to a depth of one foot. Is it therefore surprising that phosphates occur so frequently in mineral springs and rivers? It seems that the phosphates in plants serve especially for the formation of the albuminous bodies, that are so all-important for the building up of the human framework. With regard to the wandering of phosphorus in plants, we present the following interesting facts of Corenwinder:

Young plants always yield ashes rich in phosphorus. However, after the maturity of the seeds or fruits (for which phosphoric acid is especially needed), the stems and leaves are found to contain only traces of this acid; and when all the seeds have reached perfect maturity, the stems, leaves, and roots are generally devoid of phosphorus. This element appears to occur in an intimate combination with the albuminous principles of vegetables. Indeed, if these are dissolved with water or other liquid, the phosphates pass also into solution, while they become insoluble, when the albuminates are coagulated by boiling water. The vegetable organs which lack phosphorus, seem also to be free of albuminous substances, at least not a trace of phosphates could be met with in the woody pericarp of certain fruits, as in the almonds and hazelnuts, the ashes of which yield principally silica and lime.

The exudates of plants generally contain no phosphoric acid; at least such is the case with manna and gum-arabic. It is known that in exhausting the pulp of young roots with water, fibrin is obtained, which contains pectose and the incrusting substances. It follows, therefore, that the skeleton of vegetables owes its solidity not to the phosphates,as is the case with that of the animals. The leaves that remain in the forests during winter yield ashes rich in iron, silica, and lime, but free of phosphorus. It is also worthy of note that, although analysis has as yet failed to discover phosphates in the sea, the maritime plants contain considerable quantities of this substance.

Corenwinder, at least, has searched in vain for phosphoric acid in the water of the North Sea, as well as in the boiler sediments of vessels crossing the ocean. The pollards of flowers and the spores of cryptogams are rich in acid of phosphorus; this being especially the case with the pollards of *Lilium candidum.* It is remarkable that the ashes of pollards and those of the semen of animals are nearly alike in their component parts, they being both rich in phosphoric acid!

From all we know, it is certain that the presence of phosphates in plants is necessary to the formation of the organic substances in question. For agriculture it would be highly important to know whether there exists a relation between the quantities of the phosphates and those of the albumenoids, but unfortunately very little is known about this subject, and it will demand manifold and extensive researches before satisfactory information will be obtained. But such researches are very desirable, for it should be the duty of agriculturists to look rather to the production of highly albuminous matters, than to endeavor to bring certain organs of plants to a high state of development without regard to their nutritive value.

THE EXHIBITION OF THE AMERICAN INSTITUTE.

A writer in the New York *Tribune* has given expression to singular views in regard to the character of American inventors. He says that "with some notable exceptions, they have exhibited their powers of invention with reference to secondary rather to general principles; more by using the discoveries of other people than their own." "Of course," he continues, "we shall be told that there are but few general principles, while the details may be considered as infinite, and we shall be reminded, too, that upon Dr. Franklin's discoveries in electricity almost a whole science has been founded— that steamboat navigation, the use of ether in surgery, the mowing machine, are ours, and the power-printing press, the telegraph, and the sewing machine, were all conceived beneath the skies of this new world. We grant that these, and others which could be named, are proud achievements, and their application to so many of the wants of daily life gives them especial prominence; still, we ought to consider that, in compass, acuteness, and perseverance, the English mind is unexcelled, for to it we owe the discovery of the use of steam, the invention of the steam engine, of the power loom, of the spinning jenny, and of the locomotive and railway, all of which required the application of grand principles, and they are of such immense utility that they have an influence upon almost every being on the face of the globe. However, the art of printing from movable types clearly was a necessary preliminary, and it would seem that the German nation was not to be deprived of some share in the great work of modern progress."

The writer of this paragraph has evidently not comprehended the distinction between invention and discovery. Invention is the application of general principles to the construction of new machinery or the development of new processes. Discovery has nothing in common with it. The former either discards experiment, or uses it only to verify the truth of previous conceptions arrived at by a process of pure reasoning. The latter progresses only through experiment— theory only pointing out probable paths of discovery in which to conduct experimental research.

The inventions alluded to by this writer were all, in this