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## FORCE ANALYZED.

We have repeatedly taken occasion to point out the exceedingly loose apprehension which prevails regarding the meaning of the word "force." We doubt if there be another word in the language which is more constantly wrongly used, or which is dragged in to express a greater variety of more wholly different and entirely indefensible significations. We are told of "accelerating force," "moving force," "centrifugal force," "living force," "projectile force," "centripetal force," in mechanics; imaginative biologists wander into such expressions as "psychic force," "odic force," and "vital force." We say a force "may be generated," and that a moving body has such a "force;" and in brief so generally used is the word, anywhere and everywhere, that we carry its wrong meaning into idioms and colloquialisms, and talk of the "force of habit," "force of circumstances," etc.

It will be observed that all these erroneous notions of the term are based on the conception that force is a thing, something tangible and existent; whereas it is nothing of the sort, as a brief consideration will show. The various arguments on this topic are admirably summed up in Professor Tait's latest addition to his excellent work on "Recent Advances in Physical Science;" and we can do no better than to follow the same course of reasoning and adopt the very clear and concise definition of the term "force," to which his views of the subject lead him.

At the outset, we may recall the fact that absolutely nothing can be learned as to the physical world save by observation or experiment, or by mathematical deductions from data so obtained. The exercise of reason is an unavoidable necessity, for it shows us that our senses are merely subjective, that what we call a sensation of color is but an influence upon the eye due to the extent, form, and rapidity of the vibrations of the luminiferous medium; that our classification of sounds, as to loudness, pitch, and quality, is merely the subjective correlative of what in the air particles is objectively the amount of compression, the rapidity of its alternations, and the greater or less complexity of the alternating motion. And thus we may know that light and sound no more exist outside ourselves than does the pain, which a swiftly moving stick is capable of producing on our bodies, reside in the stick itself. Heat, though not material, has objective existence in as complete a sense as matter has. It is merely a form of energy, which, in all its constant mutations, satisfies the test which we adopt as conclusive of the reality of matter, that we cannot in the slightest degree alter its quantity. This test fails altogether when applied to force.

In his endeavor to reach an idea of the meaning of force, Professor Tait first brings forward Newton's laws of motion. Of these the first is: Every body continues in its state of rest or of uniform motion in a straight line, except in so far as it is compelled by forces to change that state. That is, any change whatever in the direction or the rate of motion of a body is attributed to force. This carries with it the upsetting of the old notion that, in bodies moving in a circle, a centripetal force was necessary to balance a so-called centrifugal force, it being imagined that a body moving in a circle had a tendency to fly outward from the center. "If," says our author, "a body is to be made to move in a curved line instead of its natural straight path, you must apply force to compel it to do so; certainly not to prevent it from flying outwards from the center about which it is for the moment revolving. In fact, just as you must apply force *in* the direction of motion to change the *rate* of motion, so must you apply force *perpendicular* to the direction of motion to change that *direction*."

Newton's second law is: Change of motion is proportional to the moving force and takes place in the direction of the straight line in which the force acts. Motion is here used as a technical scientific term for what we now call momentum, the product of the moving mass into the velocity with which it moves. "Change of motion," therefore, is change of momentum, or the product of the mass of the moving body into its change of velocity. "Of course," says Professor Tait, "the longer a given force acts, the greater will be the change of momentum which it produces; so that, to compare forces, which is the essence of the process of measuring them, we must give them equal times to act, or we must measure a force by the rate at which it produces change of momentum. * * * Thus the measure of a force is the product of the mass of the body moved into the acceleration which the force produces on it." Unit force is, therefore, that force which, whatever be its source, produces unit momentum in unit of time. The earth's attraction for a body in our latitudes produces in that body, if let fall, in one second a velocity of about 32.2 feet per second. Hence, if we take 1 lb. as the standard of mass, the weight of a pound of matter is rather more than 32.2 units. of force, so that the unit of force is rather less than half an ounce.

Unit momentum is that of 1 lb. of matter moving with a velocity of 1 foot per second. Unit force is that force which, acting for one second, produces in unit of mass a velocity of 1 foot per second. Momentum, then, is obviously not force. We may substitute ton for pound, or mile for foot, and the relative values will remain unaltered; but if we take minute instead of second, then the time unit increases sixty fold the nominal value of the momentum considered; while that representing the force is increased three thousand six hundred fold. Hence the two cannot possibly be equated. Now as we have shown that there is no such thing as centrifugal force, and as from the above it follows that the so-called accelerating force is not a physical idea at all, we have yet to deal with the term "living force."

And here we pass to Newton's third law, namely: To every action, there is always an equal and contrary reaction; or, the mutual actions of any two bodies are always equal and oppositely directed. And Newton proceeds further to point out—and here is that grand stumbling block of the perpetual motionist, no matter what form his mania may assume—that if the action of an agent be measured by the product of its force into its velocity, and if, similarly, the reaction of the resistance be measured by the velocities of its several parts into their several forces, whether these arise from friction, cohesion, weight, or acceleration, action and reaction, in all combinations of machines, will be equal and opposite. But actions and reactions here dealt with are no longer simple forces, but the products of forces into velocities; they are rates of work, the time rate of increase, or the increase per second, of a very tangible and real something, for the measurement of which Watt devised the practical unit of a "horse power." Now with a moderate exertion a man may raise a hundredweight, which in its descent might be employed to do work, but he is by any exertion unable to lift a ton; and after all his labor to do so, the weight will not do any work by descending again. Hence it appears that force is a mere name, and that the product of a force into the displacement of its point of application has an objective existence. And a simple mathematical operation shows us that it is precisely the same thing to say: the horse power or amount of work done by an agent in each second is the product of the force into the average velocity of the agent, and to say: *force is the rate at which an agent does work per unit of length.*

## THE ENCOURAGEMENT OF INSANITY.

A good many honest but misguided people have expressed the belief that the SCIENTIFIC AMERICAN has been too severe in its remarks about spiritualistic frauds, delusions, and the like. Particularly disagreeable to such people has been our characterization of spiritualism as a mixture of self-deception, knavery, and craze. We are pleased therefore to find our diagnosis sustained by so excellent a medical authority as the London *Lancet*, which goes even further than we have presumed to, and raises a warning voice against those who are in any way party to such spurious manifestations of the psychological instinct. The *Lancet* does not hesitate to say that the practice of gathering neurotic people, at what are politely called *séances*, for the purpose of holding converse with denizens of the spirit world, is so debilitating to the mind and so debauching to the moral sense that it needs to be stigmatized in terms at once trenchant and decisive. "To speak plainly, while strong-brained beings may indulge in this form of dissipation without more serious consequences than perhaps a trifling weakness of memory, minds of less robust mould may suffer severely. Anything more perilous than the custom of permitting young persons of either sex to participate in this abuse of mind power it would be difficult to conceive."

Particularly blamable, the *Lancet* thinks, is the President of the "Psychological Society" and other patrons and leaders of "the last new craze." They ought to know better than to give their countenance and support to a pursuit in which weaker heads are in danger of being turned, to their permanent injury. Already mischief, perhaps irreparable mischief, has been wrought. "Minds that have hitherto done wonderfully well in the world are showing signs of weakness. The worry of trying to be quite sure whether there is a force outside the material world, which will bridge over the gulf between the present and the past—those who now tread the earth, and those who have passed out of normal sight and hearing—is beginning to tell on the mental strength of some who have been lured into the toils of a psychology, which is no longer a science, because it has cast adrift the principles of Nature and elects to run riot in vain imaginings and idle conceits."

These are hard words, but they certainly are neither unjust nor unnecessary. As symptoms of mental degradation, the recent actions and utterances of several once straightforward and sensible English scholars are surely painful enough to warrant any protest, however forcible, against the encouragement of such unsanitary pursuits and speculations.

## MEDICAL PROGRESS OF THE PAST YEAR.

In accordance with its custom, the *Lancet* begins the new year with an extended review of the notable events of the past twelvemonth in the world of medicine and its allied sciences. From the thirty-six columns devoted to this valuable summary of progress, the following items are especially worthy of remembrance.

In the department of anatomy and physiology, several important advances may be noted. M. Malasses has continued his researches in connection with the blood, and has introduced the new term *blood-corpuscle capacity*, to designate the quotient obtained on dividing the number of blood corpuscles in an animal by the weight of the animal in grammes. Thus a rabbit, weighing 2,450 grammes and having 919,450 millions of blood corpuscles, has a blood corpuscle capacity of 375 millions. It is worthy of notice that the blood corpuscle capacity of carnivora, in consonance with their more active metamorphosis of tissue and manifestations of life, is much greater than that of herbivora. Heretofore the pressure of the blood has always been estimated by manometers introduced into the larger blood vessels. Dr. Kries has ingeniously shown that the pressure in the capillaries may