which is found in the lengths of various muscles that act together; as by that means organs of velocity are joined with those of power.

The Bakerian *Lecture on the Force of Percussion. By* William Hyde Wollaston, *M.D. Sec. R.S.* Read November 14, 1805. [*Phil. Trans.* 1806, *p.* 13.]

The force of percussion is a subject, respecting the estimation of which a controversy has subsisted for more than a century past between different classes of philosophers. For although it is agreed that when unequal bodies move with the same velocity, the forces are as their quantities of matter; yet when equal bodies move with unequal velocities, there are two methods of estimating the comparative forces of such bodies. Leibnitz and his followers conceive the forces to vary as the squares of the velocities; while their opponents maintain that the forces are in the simple ratio of the velocities of the bodies respectively. The latter have been considered as Newtonians; but Dr. Wollaston endeavours to show that they can derive no support from any expressions of Newton.

In order to explain the grounds for each opinion, the author proposes the following experiment.

He supposes a ball of clay to be suspended at rest, having two similar and equal pegs slightly inserted into its opposite sides; and he supposes two other bodies, A and B, which are to each other in the proportion of 2 to 1, to strike at the same instant against the opposite pegs, with velocities which are in the proportion of 1 to 2. In this case, the ball of clay would not be moved from its place to either side; nevertheless, the peg impelled by the smaller body B, which has the double velocity, would be found to have penetrated twice as far into the clay as the peg impelled by the larger body A.

It is, Dr. Wollaston says, unnecessary to make the above experiment precisely as it is here stated, because the results are admitted as facts by both parties; but upon these facts they reason differently. One party, observing that the ball of clay remains unmoved, considers the proof indisputable, that the action of the body A is equal to that of the body B, as they would be led to expect, because their *momenta* are equal. Their opponents think it equally proved, by the unequal depths to which the pegs have penetrated, that the causes of these effects are unequal, as they would have expected, from considering the forces as proportional to the squares of the velocities.

The former party observe, in this experiment, that equal *momenta* can resist equal pressures during the same *time;* the other party attend to the *spaces* through which the same moving force is exerted, and finding them to be in the proportion of 2 to 1, observe that the *vis viva* of a body in motion is justly estimated by the magnitude and the square of the velocity jointly,—a multiple to which Dr. Wollaston has thought it convenient to give the name of Impetus.

This latter conception, of a quantity of force as a *vis motrix* extended through space, rather than continued for a certain time, is an

idea which, the author observes, arises naturally from the daily occupations of men, since any quantity of work performed is always estimated by the extent of effect resulting from their exertions. Thus it is well known that the raising of any great weight 40 feet would require four times as much labour as would be requisite to raise an equal weight 10 feet. And if weights so raised were suffered to fall freely, the squares of the velocities acquired would be in proportion to the quantity of labour, that is, as 4 to 1; and if their forces were employed in driving piles, the effects produced would be in that same ratio.

This species of force has, by Smeaton, been aptly denominated mechanic force; and when by force of percussion is meant the quantity of mechanic force which a body in motion can exert, the author apprehends it cannot be controverted that the said force is in proportion to the magnitude of the body, and the square of its velocity jointly.

But of this force Newton nowhere treats, and consequently gives no definition of it; on the contrary, in the preface to the Principia, he expressly says, that he writes "de potentiis non manualibus, sed naturalibus;" and again, in the Scholium to the laws of motion, he says, "Cæterum mechanicam tractare, non est hujus instituti."

It is also evident, that in the third law of motion, when Newton asserts that action is equal to reaction, he means only that the moving forces, or pressures opposed to each other, are necessarily equal. Other persons, however, have interpreted the third law differently, and conceive also a species of accumulated force, which is capable of resisting a given pressure, during a time that is proportional to the *momentum*, or *quantitas motûs*.

If it be of any real utility to give the name of force to such a complex idea of *vis motrix* continued for any certain time, the author recommends that it should be always distinguished by some such appellation as *momentous* force, as he apprehends that, for want of this distinction, both writers and readers of disquisitions upon this subject have confounded and compared together *vis motrix, momentum,* and *vis mechanica;* quantities that are all of them totally dissimilar, and bear no more comparison to each other than lines to surfaces, or surfaces to solids.

In practical mechanics, however, it is at least very rarely that that *momentum* of bodies is an object of consideration; since the extent and value of any effect to be produced depends upon the *quantitas mechanica* of the force applied, or in other words, the space through which any moving force is exerted.

Dr. Wollaston, in the next place, compares the forces of the different bodies by means which he is inclined to think have not been taken notice of by any writer on this question; and he shows, that when the whole energy of a body A is employed without loss, in giving velocity to a second body B, the impetus which B receives is, in all cases, equal to that of A, the squares of their velocities being in the reciprocal ratio of the bodies.

As a simple case of entire transfer of force from A to B, it is evident that if A were allowed to ascend to the height due to its velocity, and if by any mechanical contrivance, of lever or otherwise, the body B were to be raised by the descent of A, their heights of ascent would be reciprocally as the bodies; consequently, that the *square* of the velocity to be acquired by the free descent of B, would be, to that of A, in the above-mentioned ratio, and the quantity of mechanic force so estimated would be preserved unaltered.

But, on the contrary, the *momentum*, which is in the simple reciprocal ratio of the bodies, would be increased by such means in the subduplicate ratio of the bodies that might be employed; and if *momentum* were really a force efficient in proportion to its estimated magnitude, it should not only be capable of reproducing the original quantity, but the additional force, thus acquired, might be employed for counteracting the usual resistances, and perpetual motion would be easily produced. But since the impetus, or mechanic force, remains unaltered, it is evident that the utmost that B could effect, in return, would be the reproduction of A's velocity, and restitution of its former force, neither increased nor diminished, excepting by the necessary imperfection of machinery.

The possibility of perpetual motion is consequently inconsistent with those principles which measure the quantity of force by the quantity of its extended effects, or by the square of the velocity which it can produce.

Since we can, at pleasure, by means of any mechanic force, consisting of a *vis motrix* extended through a given space, give motion to a body for the purpose of employing its impetus in the production of any sudden effect, or can, on the contrary, occasion a moving body to ascend, and thus resolve its impetus into a moving force ready to exert itself through a determinate space of descent, capable of producing precisely the same quantity of mechanic effect; the force depending on impetus may justly be said to be a force of the same kind as any other mechanic force, and may be strictly compared with them as to quantity.

In this manner, the author says, we may even compare the force of a body in motion, with the same kind of force contained in a given quantity of gunpowder, and may say that we have the same quantity of mechanic force at command, whether we have one pound of gunpowder, or the weight which it would raise to the height of 30 feet, actually raised to that height, and ready to be let down gradually; or the same weight possessing its original velocity of ascent, to be employed in any sudden exertion.

By employing the same measure, we have a distinct expression for the quantity of mechanic force given to a steam-engine by a peck or by a bushel of coals; and are enabled to compare its effect with the quantity of work which one or more horses may have performed in a day. In short, whether we are considering the sources of extended exertion, or of accumulated energy,—whether we compare the accumulated forces themselves by their gradual or their sudden effects,

the idea of mechanic force, in practice, is always the same, and is proportional to the *space* through which any *moving force* is exerted, or to the *square* of the velocity of a body in which such force is accumulated.

Mémoire sur les Quantités imaginaires. Par M. Buée. *Communicated by* William Morgan, *Esq. F.R.S.* Read June 20, 1805. [*Phil. Trans.* 1806, *p.* 23.]

Chemical Experiments on Guaiacum. By Mr. William Brande. *Communicated by* Charles Hatchett, *Esq. F.R.S.* Read December 19, 1805. [*Phil. Trans.* 1806, *p.* 89.]

No one of the resins, Mr. Brande observes, possesses so many curious properties as that called Guaiacum; and he thinks it remarkable, that although many of the alterations it undergoes, when heated with different solvents, have been mentioned by various authors, it has not excited a more particular attention.

After noticing its more obvious properties, of which we shall only repeat, that when pulverized, it is of a gray colour, but gradually becomes greenish by exposure to the air, he proceeds to examine the action of various solvents upon it.

The first solvent tried by Mr. Brande was water; about 9 per cent. of extractive matter was taken up, and the solution appeared also to contain a small portion of lime. Alcohol, which was next tried, dissolved nearly the whole of the guaiacum, leaving only about 5 per cent. of extraneous matter. The effects of water, of various acids, and of alkalies, upon this solution, are then noticed. Water forms a milky fluid, which passes the filter. Muriatic acid throws down an ash-coloured precipitate. Liquid oxymuriatic acid forms a precipitate of a pale blue colour. Sulphuric acid forms one of a pale green. Acetic acid does not form any precipitate; nor does nitric acid until after the expiration of some hours, unless water be added, in which case a precipitate may be sooner obtained. This precipitate is of a green or a blue colour; whereas that which forms spontaneously is brown. Alkalies do not form any precipitate when added to the solution of guaiacum in alcohol.

Guaiacum is less soluble in sulphuric ether than in alcohol, but the properties of the two solutions are nearly similar.

Muriatic acid dissolves only a small portion of guaiacum. Sulphuric acid forms with that substance a deep red liquid, which, when fresh prepared, deposits a lilac-coloured precipitate on the addition of water. The effects of nitric acid on guaiacum are minutely examined, of which we shall only mention, that this acid, when its specific gravity was 1·39, completely dissolved guaiacum, which solution, after standing some hours, deposited a quantity of crystallized oxalic acid; but when the nitric acid was diluted, a slight effervescence took place, and a part only of the resin was dissolved, the remainder being converted into a brown substance, which was similar