THE SEARCH AFTER PERPETUAL MOTION.

BY PROFESSOR W. STEADMAN ALDIS, M.A., COLLEGE OF SCIENCE, NEWCASTLE-ON-TYNE.

THERE is something fascinating in motion. Half the pleasure of a healthy existence is derived from or connected with motion. The exhilarating rush of the skater through the frosty air down the long canal, or the gentle gliding with which he describes elegant curves on his carefully-swept corner, the delight of a child in a swing, and of the youth in his bicycle, are all illustrations of this fact. To many persons a gallop on horseback is the best way of restoring the tone of the bodily system; and even the plunging of a yacht in the teeth of a north-easter is capable of becoming a source of pleasure. The worst of it is that the pleasure is for the most part short-lived, and that the exertion of keeping up the motion presently produces a weariness and pain which more than counterbalance the enjoyment. All the work of the world, too, as well as the play, is done by motion; but here the same rule comes in even more rapidly—the agent soon becomes weary of the work. Cannot we, perhaps, get perpetual motion without fatigue or exertion, and if not, why not? The question is analogous to another question popular among children, even among children of a larger growth—Cannot we eat our cake and have it?—but yet for many ages it exercised the world with weary disputations and attempts to answer it in the affirmative. "Yes, we can, we shall—when I have added one more link to my machine," was the answer time after time from some solitary student of occult laws of nature in the Dark Ages. But the missing link never was added, the perpetual motion never came, and to-day we know—at least, all trained and scientific mechanicians know—that it never will come.

The search after perpetual motion has not been in all ages a fruitless one for mankind. The early attempts to effect a transmutation of baser metals into gold, while they failed of their main object, helped to lay the foundations of the science of chemistry. Unsuccessful efforts to square the circle, as it is popularly termed, or more correctly to discover by geometrical means a square whose area is exactly equal to that of a given circle, led mathematicians to many valuable geometrical facts. Similarly, the labours of mechanicians after a machine able to move for ever without external interference, were not without results capable of being applied in the invention and construction of the spinning-jennies and power-looms of more modern times. The day for all these problems is long gone by; no one need now flatter himself that his energies can be usefully employed on their solution; but we must not therefore forget that we owe a debt of gratitude to the men who, in their blind devotion to an impossible idea, helped unconsciously to marshal the forces of science for the conquest of the world.

A student taking up a modern treatise on mechanics, will find it stated as a first law of motion that a moving particle will continue in motion with uniform velocity for ever, unless its motion be checked by some external force. He will see in this law an apparent contradiction to our statement that perpetual motion is an impossibility. The contradiction is, however, merely on the surface, and disappears when we come to examine what was really sought by the mechanicians of the Middle Ages.

If we set a wheel to rotate round a horizontal axis whose ends rest on well-oiled supports, the wheel will go on turning for a long time. If the same wheel be made to turn in the exhausted receiver of an air-pump, it will continue to move for a much longer time. If we could quite get rid of the friction of the axis and of the resistance of the air, the wheel, as far as we can tell, would go on for ever. This is in accordance with the law of motion quoted above. Suppose, however, we fasten a string to the axle of the wheel, so that, as the wheel turns, the string coils round it. Let us also put a small weight at the end of the string, and set the wheel in motion. As it revolves, the string coils round the axis, the weight ascends, and we shall see the speed of the wheel gradually diminish until presently it stops, and the next instant begins to turn in the opposite way, and continues to do so until it gets back to its first position. However well oiled the bearings may be, the motion is no longer perpetual, the reason being that the weight hanging to the string exerts a force which tends to diminish the velocity of the wheel. We have, in fact, not been contented with letting the wheel move itself, which, if hindrances were removed, it might go on to do for ever, but have tried also to make it move something else, and that we find it refuses to do unless the force which started it be repeated at intervals. This latter is the kind of motion which was meant by the words "perpetual motion." What was wanted was not a luxurious ornament to go on ticking or rolling without affecting anything else, but a useful drudge which should do work without help and yet never stop, a kind of machine which we now know to be impossible.

The reason of this impossibility will appear from a few simple considerations of experience and theory.

If our student of mechanics goes on to read the treatise we have supposed in his hands, he will come across two more laws of motion. The first of these is, that the amount of motion produced in a body by a force is always greater or less in exact proportion to the force. If one player strike a cricket-ball with twice the force exerted by another player, the ball will start off in the first case with double the velocity which it has in the latter. The second law is, that

when two bodies act on one another, the first must act on the second with an equal and opposite force to that with which the second acts on the first. Thus, if a cart is drawn along a road by a horse, the horse is pulled backwards by the cart with exactly the same force as the cart is pulled forwards by the horse. When a man jumps upwards he kicks the earth downwards with the same force as the earth, so to speak, kicks him upwards. The man moves a good way up, and the earth does not perceptibly move at all, because the earth is so much larger than the man. The amount of motion which, spread over the body of the man, gives a sensible velocity to each particle, is quite imperceptible when diffused through the whole mass of the earth.

One effect of these laws is, that if any body in motion be employed to impart motion to another, it can only do so by giving up some of its own motion. For the first body must pull the second with a certain force, in order to move it; the second must pull the first backwards with the same force, and must, therefore, diminish the motion of the first by the exact amount by which its own is increased. Perpetual motion without a perpetual supply of force from some external source is as impossible in the case of a body employed as a motor, as it is to keep a purse well filled while continually spending and never putting in a fresh supply of money.

The principle on which the old machines for giving perpetual motion were mostly intended to act was that one train of wheels should set a second in motion, and that this second should either immediately, or through the intervention of some other machinery, repay the compliment to the first. For the reasons which we have seen, this process can never be permanently effected. However smooth the bearings may be, some of the energy or motion of the first train of wheels will be gradually lost in overcoming the friction of sockets and the resistance of the air. The motion communicated to the second system will thus be less than that originally given to the first, and the amount finally coming back to the first will be less still, for a similar reason. Thus, in time all the motion will be lost, to say nothing of the fact that such a machine will do no useful work on any external body.

Modern experimental science has given us many new methods of producing motion. The heat of a fire operating on water compels the piston of a steam-engine to move with the regularity of clockwork, and with more than the strength of a giant. The action of an acid on a metal has been made to produce both heat and light, and motion. Even the mysterious something which gives the loadstone its attractive power, and directs the mariner's needle to the pole, has been made to yield the same. Electricity, magnetism, heat, motion, chemical action, have been shown by many experiments to be each deducible the one from the other. We might imagine that possibly the secret of perpetual motion is in our hands from some interchange of these forces. But, alas for our hopes! experiment has shown that a given quantity of any one of these forms of what is called "energy" will never yield more than a given quantity of any other; and that by whatever cycle we pass from the first form back to the same again, the final result is less than that from which we started—part of the original energy having always spent itself in wearing out the parts of the machinery, or heating the surrounding air.

If a machine, then, be employed to do work, as for instance to set in motion a body not moving to begin with, some part of the energy of the machine must be continually spent, and apparently lost. The steam-engine, as it lifts stroke by stroke its load of water from the mine, uses up for each stroke the heat in a certain quantity of coals. The maintenance for each minute of the brilliant electric light requires the destruction of a definite amount of fuel, or the consumption of a given quantity of metal by an acid. Nothing for nothing is nature's motto in all these matters. By our machinery we can turn energy or motion of one kind into energy of any other; but we cannot create it out of nothing. Even the pleasant motions to which we referred at the beginning of this paper are cases in point, for the human body is a machine which rapidly loses its energy if unfed. Man cannot work, or even play, unless he be supplied with internal heat by means of the food he consumes—heat which has originally come from the sun, and lodged itself in the plants which serve as food for beasts and men. It is to the stores of energy thus imparted to the earth by the sun acting on the growing trees in the ages when our coal-measures were formed, or acting on the earth to-day and forming the herbs which feed us now, that we must look for the possibility of getting *practically* perpetual motion. As long as our coal-beds remain unexhausted, we need never fear but that we shall be able to draw out the heat from that great storehouse, and turn it into motion as we will. What shall happen to the inhabitants of the earth when the collier shall no longer be able to win coal is a problem "beyond the range of practical politics." In the meanwhile it is well to remember that every journey made by an express train, every voyage of a Cunard steamer, nay, every fire we burn in our household grates, involves a dissipation and practical diminution of that great store of energy which the universe contains, the entire extinction of which would, as far as we can tell, be equivalent to the loss of all possibilities of physical activity, or even life.