they will discharge the water, will increase in the propor­tion of the diameter of the wheel. Now, that we shall lose more by this than we gain by the more direct application of the weight, is plain, without any further reasoning, by taking the extreme case, and supposing our wheel enlarged to such a size that the useless part below is equal to the whole fall. In this case the water will be spilled from the buckets as soon as it is delivered into them. All interme­diate cases therefore partake of the imperfection of this.

When the fall is exceedingly great, a wheel of an equal diameter becomes enormously large and expensive, and is of itself an unmanageable load. We have however seen wheels of fifty-eight feet diameter, which worked extremely well; but they are of very difficult construction, and extremely apt to warp and go out of shape by their weight. In cases like this, where we are unwilling to lose any part of the force of a small stream, the best form of a bucket-wheel is an inverted chain-pump. Instead of employing a chain­pump of the best construction, ABCDEA (fig. 9), to raise water through the upright pipe CB, by means of a force applied to the upper wheel A, let the water be delivered from a spout F, into the upper part of a pipe BC, and it will press down the plugs in the lower and nar­rower bored part of it with the full weight of the column, and escape at the dead level of C. This weight will urge round the wheel A without any defalcation; and this is the most powerful manner in which any fall of water whatever can be applied, and it exceeds the most perfect overshot wheel. But though it excels all chains of buckets in economy and in effect, it has all the other imperfections of this kind of machinery. Though the chain of plugs be of great strength, it has so much motion in its joints that it needs frequent repairs ; and when it breaks, it is generally in the neighbourhood of A, on the loaded side, and all comes down with a great crash. There is also a loss of power by the immersion of so many plugs and chains in the water ; for there can be no doubt but that if the plugs were large enough and light enough, they would buoy and even draw up the plug in the narrow part at C. They must therefore diminish, in all other cases, the force with which this plug is pressed down.

The velocity of an overshot wheel is a matter of very great nicety ; and authors, both speculative and practical, have entertained different, nay opposite, opinions on the subject. Μ. Belidor, whom the engineers of Europe have long been accustomed to regard as sacred authority, main­tains that there is a certain velocity related to that obtain­able by the whole fall, which will procure to an overshot wheel the greatest performance. Desaguliers, Smeaton, Lambert, De Parcieux, and others, maintain that there is no such relation, and that the performance of an overshot wheel will be the greater, as it moves more slowly by an increase of its load of work. Belidor maintains that the active power of water lying in a bucket-wheel of any dia­meter is equal to that of the impulse of the same water on the floats of an undershot wheel when the water issues from a sluice in the bottom of the dam. The other writers whom we have named assert that the energy of an undershot wheel is but one half of that of an overshot, actuated by the same quantity of water falling from the same height.

To a manufacturing country like ours, that derives as­tonishing superiority, by which it more than compensates for the impediments of heavy taxes and luxurious living, chiefly from its machinery, in which it leaves all Europe far behind, the decision of this question, in such a manner as shall leave no doubt or misconception in the mind even of an unlettered artist, must be considered as a material service, and we think that this is easily attainable.

When any machme moves uniformly, the accelerating force or pressure actually exerted on the impelled point of the machine is in equilibrio with all the resistances which are exerted at the working point, with those arising from friction, and those that are excited in different parts of the machine by their mutual actions. This is an incontestable truth, and though little attended to by the mechanicians, is the foundation of all practical knowledge of machines. Therefore, when an overshot wheel moves uniformly, with *any velocity whatever,* the water is acting with its whole weight, for gravity would accelerate its descent, if not com­pletely balanced by some re-action ; and in this balance gra­vity and the re-acting part of the machine exert equal and opposite pressures, and thus produce the uniform motion of the machine. We are thus particular on this point, because we observe mechanicians of the first name employing a mode of reasoning on the question now before us which is specious, and appears to prove the conclusion which they draw, but is nevertheless contrary to true mechanical principles. They assert that the slower a heavy body is de­scending (suppose in a scale suspended from an axis *in peritrochea),* the more does it press on the scale, and the more does it urge the machine round ; and therefore the slower an overshot wheel turns, the greater is the force with which the water urges it round, and the more work will be done. It is very true that the machine is more forcibly impelled, and that more work is done ; but this is not be­cause a pound of water presses more strongly, but because there is more water pressing on the wheel, for the spout supplies at the same rate, and each bucket receives more water as it passes by it.

Let us therefore examine this point by the unquestion­able principles of mechanics.

Let the overshot wheel A*f*H (fig. 5) receive the water from a spout at the very top of the wheel ; and in order that the wheel may not be retarded by dragging into mo­tion the water simply laid into the uppermost bucket at A, let it be received at B, with the velocity (directed in a tangent to the wheel) acquired by the head of water AP. This velocity therefore must be equal to that of the rim of the wheel. Let this be *υ,* or let the wheel and the water move over *v* inches in a second. Let the buckets be of such dimensions, that all the water which each receives as it passes the spout is retained till it comes to the position R, where it is discharged at once. It is plain that, in place of the separate quantities of water lying in each bucket, we may substitute a continued ring of water, equal to their sum, and uniformly distributed in the space BER *gfβ*. This constitutes a ring of uniform thickness. Let the area of its cross section *β*B and F*f* called *a*. We have al­ready demonstrated, that the mechanical energy with which this water on the circumference of the wheel urges it round, is the same with what would be exerted by the pillar *brrb* pressing on F*f,* or acting by the lever CF. The weight of this pillar may be expressed by *a* × *br*, or *a* × PS ; and if we call the radius CF of the wheel R, the momentum or mechanical energy of this weight will be represented by *a* × PS × R.

Now, let us suppose that this wheel is employed to raise a weight W, which is suspended by a rope wound round the axis of the wheel. Let *r* be the radius of this axle. Then W × *r* is the momentum of the work. Let the weight rise with the velocity *u* when the rim of the wheel turns with the velocity *v,* that is, let it rise *u* inches in a second. Since a perfect equilibrium obtains between the power and the work when the motion is uniform, we must have W × *r* = *a* × PS X R. But it is evident that R : *r = v : u.* Therefore W × *u = a × v* × PS.

Now the performance of the machine is undoubtedly measured by the weight and the height to which it is raised in a second, or by W × *u*. Therefore the machine is in its