WATER-WORKS.

UNDER this name may be comprehended almost every hydraulic structure or contrivance ; such as canals, con­duits, locks, mills, water-engines, &c. But they may be conveniently classed under two general heads, 1st, works which have for their object the conducting, raising, or other­wise managing, of water ; and, 2dly, works which derive their efficacy from the impulse or other action of water. The *first* class comprehends the methods of simply conducting water in aqueducts or in pipes for the supply of domestic consumption or the working of machinery. It compre­hends the methods of procuring the supplies necessary for these purposes, by means of pumps, water or fire en­gines. It also comprehends the subsequent management of the water thus conducted, whether in order to make the proper distribution of it according to the demand, or to employ it for the purpose of navigation, by lockage, or other contrivances. And in the prosecution of these things many subordinate problems will occur, in which practice will derive great advantages from a scientific acquaintance with the subject The *second* class of water-works is of much greater variety, comprehending almost every kind of hydraulic machine ; and would of itself fill volumes. Many of these have already occurred in various articles of this work, particularly in Hydrodynamics, part iii.— *On Hy­draulic Machinery.* In describing or treating them, we have tacitly referred the discussion of their general princi­ples, in which they all resemble each other, to some article where they could be taken in a connected body, suscepti­ble of general scientific discussion, independent of the cir­cumstances which of necessity introduced the particular modifications required by the uses to which thc structures were to be applied. That part of the present article, therefore, which embraces these common principles, will chiefly relate to the theory of water-mills, or rather of water-wheels ; because, when the necessary motion is given to the axis of the water-wheel, this may be set to the per­formance of any task whatever.

CLASS I.

*Of the conducting of Water.*

This is undoubtedly a business of great importance, and forms a principal part of the practice of the civil engineer : it is also a business so imperfectly understood, that we be­lieve that very few engineers can venture to say, with tolerable precision, what will be the quantity of water which his work will convey, or what plan and dimensions of conduit will convey the quantity which may be proposed.

In the article RIver we have given a sort of history of the progress of our knowledge in hydraulics, a branch of me­chanical philosophy which seems to have been entirely un­known to the ancients. Even Archimedes, the author of almost all we know in hydrostatics, seems to have been en­tirely ignorant of any principle by which he could deter­mine the motion of water. The mechanical science of the ancients seems to have reached no farther than the doc­trine of equilibrium among bodies at rest. Guglielmini first ventured to consider the motion of water in open canals and in rivers. Its motion in pipes had been partially consi­dered in detached portions by others, but not so as to make a body of doctrine. Sir Isaac Newton first endeavoured to render hydraulics susceptible of mathematical demonstra­tion : but his fundamental proposition has not yet been freed from very serious objections ; nor have the attempts of his successors, such as the Bernoullis, Euler, D’Alembert, and others, been much more successful : so that hydraulics may still be considered as very imperfect, and the general conclusions which we are accustomed to receive as funda­mental propositions are not much better than matters of observation, little supported by principle, and therefore re­quiring the most scrupulous caution in the application of them to any hitherto untried case. When experiments are multiplied so as to include as great a variety of cases as possible, and when these are cleared of extraneous cir­cumstances, and properly arranged, we must receive the conclusions drawn from them as the general laws of hy­draulics. The experiments of the Abbé Bossut, narrated in his *Hydrodynamique,* are of the greatest value, having been made in the cases of most general frequency, and with great care. The greatest service, however, has been done by the Chevalier du Buat, who saw the folly of at­tempting to deduce an accurate theory from any principles that we have as yet learned, and the necessity of ad­hering to such a theory as could be deduced from experi­ment alone, independent of any more general principles. Such a theory must be a just one, if the experiments are really general, unaffected by the particular circum­stances of the case, and if the classes of experiment are sufficiently comprehensive to include all the cases which occur in the most important practical questions. Some principle was however necessary for connecting these experiments. The sufficiency of this principle was not easily ascertained. Du Buat’s way of establishing it was judicious. If the principle is ill-founded, the re­sults of its combination in cases of actual experiments must be irregular ; but if experiments, seemingly very unlike, and in a vast variety of dissimilar cases, give a train of re­sults which is extremely regular and consistent, we may presume that the principle, which in this manner harmo­nizes and reconciles things so unlike, is founded on the nature of things ; and if this principle be such as is agree­able to our clearest notions of the internal mechanism of the motions of fluids, our presumption approaches to con­viction.

Proceeding in this way, the Chevalier du Buat has col­lected a prodigious number of facts, comprehending almost every case of the motion of fluids. He first classed them according to their resemblance in some one particular, and observed the differences which accompanied their differ­ences in other circumstances ; and by considering what could produce these differences, he obtained general rules, deduced from fact, by which these differences could be made to fall into a regular series. He then arranged all the experiments under some other circumstances of resemblance, and pursued the same method ; and by following this out, he has produced a general proposi­tion, which applies to the whole of this numerous list of experiments with a precision far exceeding our utmost hopes.

We must however observe, that of this list of experi­ments there is a very large class which is not direct, but requires a good deal of reflection to enable us to draw a confident conclusion ; and this is in cases which are very frequent and important, viz. where the declivity is exceed­ingly small, as in open canals and rivers. The experiments were of the following forms. Two large cisterns were