It may be observed that the height assumed for deter­mining the slope in these two questions, will seldom differ more than an inch or two from the whole height of the reser­voir above the place of delivery ; for in conduits of a few hundred feet long, the velocity seldom exceeds four feet per second, which requires only a head of three inches.

As no inconvenience worth minding results from making the pipes a tenth of an inch or so wider than is barely suf­ficient, and as this generally is more than the error arising from even a very erroneous assumption of *h,* the answer first obtained may be augmented by one or two tenths of an inch, and then we may be confident that our conduit will draw off the intended quantity of water.

We presume that every person who assumes the name of engineer knows how to reduce the quantity of water mea­sured in gallons, pints, or other denominations, to cubic inches, and can calculate the gallons, &c. furnished by a pipe of known diameter, moving with a velocity that is measured in inches per second. We further suppose that all care is taken in the construction of the conduit, to avoid obstructions occasioned by lumps of solder hanging in the inside of the pipes ; and particularly that all the cocks and plugs by the way have waterways equal to the section of the pipe. Undertakers are most tempted to fail here, by making the cocks too small, because large cocks are very costly ; but the employer should be scrupulously attentive to this, because a simple contraction of this kind may be the throwing away of many hundred pounds in a wide pipe, which yields no more water than can pass through the small cock.

The chief obstructions arise from the deposition of sand or mud in the lower parts of pipes, or the collection of air in the upper parts of their bendings. The velocity being always very moderate, such depositions of heavy matters are unavoidable. The utmost care should therefore be taken to have the water freed from all such things at its entry by proper filtration ; and there ought to be cleansing plugs at the lower parts of the bendings, or rather a very little way beyond them. When these are opened, the water issues with greater velocity, and carries the deposi­tions with it.

It is much more difficult to get rid of the air which chokes the pipes by lodging in their upper parts. The air is sometimes taken in along with the water at the reservoir, when the entry of the pipe is too near the surface. This should be carefully avoided, and it costs no trouble to do so. If the entry of the pipe is two feet under the surface, no air can ever get in. Floats should be placed above the entries, having lids hanging from them, which will shut the pipe before the water runs too low.

But air is also disengaged from spring-water by merely passing along the pipe. When pipes are supplied by an engine, air is very often drawn in by the pumps in a dis­engaged state. It is also disengaged from its state of che­mical union when the pumps have a suction-pipe of ten or twelve feet, which is very common. In whatever way it is introduced, it collects in all the upper parts of bendings, and chokes the passage, so that sometimes not a drop of water is delivered. Our cocks should be placed there, which should be opened frequently by persons who have this in charge. Desaguliers describes a contrivance to be placed on all such eminences, which does this of itself. It is a pipe with a cock, terminating in a small cistern. The key of the cock has a hollow ball of copper at the end of a lever. When there is no air in the main pipe, water comes out by this discharger, fills the cistern, raises the ball, and thus shuts the cock. But when the bend of the main contains air, it rises into the cistern, and occupies the upper part of it. Thus the floating ball falls down, the cock opens and lets out the air, and the cistern again filling with water, the ball rises, and the cock is again shut.

A very neat contrivance for this purpose was invented by the late Professor Russell of Edinburgh. The cylindri­cal pipe BCDE (fig. 3), at the upper end of a bending of the main, is screwed on, the upper end of which is a flat plate perforated with a small hole F. This pipe contains a hollow copper cylinder G, to the upper part of which is fasten­ed a piece of soft leather H. When there is air in the pipe, it comes out by the hole A, and occupies the discharger, and then escapes through the hole F. The water follows, and, rising in the discharger, lifts up the hollow cylinder G, causing the leather H to apply itself to the plate CD, and shut the hole. Thus the air is discharged without the smallest loss of water.

It is of the most material consequence that there be no contraction in any part of a conduit. This is evident ; but it is also prudent to avoid all unnecessary enlargements. For when the conduit is full of water moving along it, the velocity in every section is inversely proportional to the area of the section : it is therefore diminished wherever the pipe is enlarged; but it must again be increased where the pipe contracts. This cannot be without expending force in the acceleration, which consumes part of the impelling power, whether this be a head of water, or the force of an engine. See what is said on this subject in the article Pump. Nothing is gained by any enlargement ; and every contraction, by requiring an augmentation of velocity, em­ploys a part of the impelling force precisely equal to the weight of a column of water whose base is the contracted passage, and whose height is the fall which would produce a velocity equal to this augmentation. This point seems to have been quite overlooked by engineers of the first eminence, and has in many instances greatly diminished the performance of their best works. It is no less detri­mental in open canals, because at every contraction a small fall is required for restoring the velocity lost in the enlargement of the canal, by which the general slope and velocity are diminished. Another point which must be at­tended to in the conducting of water is, that the motion should not be subsultory, but continuous. When the water is to be driven along a main by the strokes of a recipro­cating engine, it should be forced into an air-box, the spring of which may preserve it in motion along the whole subsequent main. If the water is brought to rest at every successive stroke of the piston, the whole mass must again be put in motion through the whole length of the main. This requires the same useless expenditure of power as to communicate this motion to as much dead matter ; and this is over and above the force which may be necessary for raising the water to a certain height, which is the only circumstance that enters into the calculation of the power of the pump-engine.

An air-box removes this imperfection, because it keeps up the motion during the returning stroke of the piston. The compression of the air by the active stroke of the pis­ton must be such as to continue the impulse in opposition to the contrary pressure of the water (if it is to be raised to some height), and in opposition to the friction or other resistances which arise from the motion that the water really acquires. Indeed a very considerable force is also employed here in changing the motion of the water, which is forced out of the capacious air-box into the narrow pipe; and when this change of motion is not judiciously managed, the expenditure of power may be as great as if all were brought to rest and again put in motion. It may even be greater, by causing the water to move in the opposite di­rection to its former motion. Of such consequence is it to have all these circumstances scientifically considered. It