form of an undulated curve CDE, and then the surface ac­quires an uniform slope EF, in the lower part of the canal, where the water is in train. If this is a drain, the dis­charge is much less than might be produced by the same bed if this sudden slope could be avoided. If it is to be navigated, having only a very gentle slope in its whole length, this sudden slope is a very great imperfection, both by diminishing the depth of water which might otherwise be obtained along the canal, and by rendering the passage of boats into the basin very difficult, and the coming out very hazardous.

All this may be avoided, and the velocity at the entry may be kept equal to that which forms the train of the ca­nal, by the simple process of enlarging the entry. Suppose that the water could accelerate along the slopes of the ca­nal, as a heavy body would do on a finely polished plane. If we now make the width of the entry in its different parts inversely proportional to the fictitious velocities in those parts, it is plain that the slope of the surface will be made parallel to that of the canal which is in train. This will re­quire a form somewhat like a bell or speaking trumpet, as may easily be shown by a mathematical discussion. It would however be so much evasated at the basin as to oc­cupy much room, and it would be very expensive to make such an excavation ; but we may, at a very moderate ex­pense of money and room, make the increase of velocity at the entry almost insensible. This should always be done, and it is not all expense ; for if it be not done, the water will undermine the banks on each side, because it is mov­ing very swiftly, and will make an excavation for itself, leaving all the mud in the canal below. We may observe this enlargement at the entry of all natural derivations from a basin or lake. It is a very instructive experiment to fill up this enlargement, continuing the parallel sides of the drain quite to the side of the lake. We shall immedi­ately observe the water grow shallower in the drain, and its performance will diminish. Supposing the ditch carried on with parallel sides quite to the side of the basin, if we build two walls or dikes from the extremities of those sides, bend­ing outwards with a proper curvature (and this will often be less costly than widening the drain), the discharge will be greatly increased. We have seen instances where it was nearly doubled.

The enlargement at the mouths of rivers is generally owing to the same cause. The tide of flood up the river produces a superficial slope opposite to that of the river, and this widens the mouth. This is most remarkable when the tides are high, and the river has little slope.

After this great fall at the entry of the canal, in which all the filaments are much accelerated, and the inferior ones most of all, things take a contrary turn. The water, by rubbing on the bottom and the sides, is retarded ; and there­fore the section must, from being shallow, become a little deeper, and the surface will be convex for some distance, till all comes into train. When this is established, the fila­ments nearest the bottom and side are moving slowest, and the surface, in the middle especially, retains the greatest velocity, gliding over the rest. The velocity in the canal, and the depth of the section, adjust themselves in such a manner that the difference between the surface of the basin and the surface of the uniform section of the canal corre­sponds exactly to the velocity. Thus, if this be observed to be two feet in a second, the difference of height will be 3/16ths of an inch.

All the practical questions that are of considerable import­ance respecting the motion of water in aqueducts, may be easily, though not elegantly, solved by means of the tables.

But it is to be remembered, that these tables relate only

to uniform motion, that is, to water that is in train, and where the velocity suffers no change by lengthening the conduit, provided the slope remain the same. It is much more difficult to determine what will be the velocity, *&c.* in a canal of which nothing is given but the form, and slope, and depth of the entry, without saying how deep the water runs in it. And it is here that the common doctrines of hydraulics are most in fault, and unable to teach us how deep the water will run in a canal, though the depth of the basin at the entry be perfectly known. Between the part of the canal which is in train and the basin, there is an in­terval where the water is in a state of acceleration, and is afterwards retarded.

The determination of the motions in this interval is ex­ceedingly difficult, even in a rectangular canal. It was one great aim of Du Buat’s experiments to ascertain this by measuring accurately the depth of the water. But he found that when the slope was but a very few inches in the whole length of his canal, it was not in train for want of greater length ; and when the slope was still less, the small fractions of an inch, by which he was to judge of the variations of depth, could not be measured with sufficient accuracy. It would be a most desirable point to determine the length of a canal, whose slope and other dimensions are given, which will bring it into train ; and what is the ratio which will then obtain between the depth at the entry, and the depth which will be maintained. Till this be done, the engineer cannot ascertain by a direct process what quantity of water will be drawn off from a reservoir by a given canal. But as yet this is out of our reach. Experiments however are in view which will promote the investigation.

But this and similar questions are of such importance that we cannot be said to have improved hydraulics unless we can give a tolerably precise answer. This we can do by a sort of retrograde process, proceeding on the principles of uniform motion established by the Chevalier du Buat. We may suppose a train maintained in the canal, and then examine whether this train *can* be produced by any fall that is possible at the entry. If it can, we may be certain that it is so produced, and our problem is solved.

We shall now point out the methods of answering some chief questions of this kind.

*Quest.* 1. Given the slope *s* and the breadth *w* of a canal, and the height H of the surface of the water in the basin above the bottom of the entry ; to find the depth *h* and ve­locity V of the stream, and the quantity of water Q which is discharged.

The chief difficulty is to find the depth of the stream where it is in train. For this end, we may simplify the hydraulic theorem of uniform motion in the article River; making V = √N*gd*/√S, where *g* is the velocity (in inches)

√b

acquired in a second by falling, *d* is the hydraulic mean depth, and √S stands for √*s -* L √*s*+1∙6. N is a number to be fixed by experiment (see River), depending on the contraction or obstruction sustained at the entry of the canal, and it may in most common cases be taken = 244 ; so that √N *g* may be somewhat less than 307. To find it, we may begin by taking for our depth of stream a quantity A, somewhat smaller than H the height of the surface of the basin above the bottom of the canal. With this depth, and the known width *w* of the canal, we can find the hydraulic depth *d* (see River, p. 265). Then with √*d* and the slope find V by the table : make this V = √N*gd*/√S. This gives √N*g =* √V*s*/√*d*. This value of N *g* is sufficiently exact ; for a small error of depth hardly affects the hydraulic mean depth.

After this preparation, the expression of the mean velo-