excavation lies, and also the law by which it diminishes and afterwards increases. Then draw a line, on which set off from one end the lengths of the canals. At each length erect an ordinate representing the excavation, and draw a regular curve through the extremities of the ordinates. From that point of the curve which is nearest to the base line, draw another ordinate to the base. This will point out the best length of the canal with sufficient accuracy. The length will determine the slope, and this will give the width, by means of the general theorem. These draining canals must always come off from the basin with evasated entries. This will prevent the loss of much fall at the entry.

Two canals may sometimes be necessary. In this case expense may frequently be saved, by making one canal flow into the other. This however must be at such a dis­tance from the basin, that the swell produced in the other by this addition may not reach back to the immediate neighbourhood of the basin, otherwise it would impede the performance of both. For this purpose, recourse must be had to Problem III. p. 283, of the article River. We must here observe, that in this respect canals differ ex­ceedingly from rivers : rivers enlarge their beds, so as al­ways to convey every increase of waters ; but a canal may be gorged through its whole length, and will then greatly diminish its discharge. In order that the lower extremity of a canal may convey the waters of an equal canal admit­ted into it, their junction must be so far from the basin that the swell occasioned by raising its waters nearly ½ more (viz. in the subduplicate ratio of I to 2) may not reach back to the basin.

This observation points out another method of economy. Instead of one wide canal, we may make a narrower one of the whole length, and another narrow one reaching part of the way, and communicating with the long canal at a pro­per distance from the basin. But the lower extremity will now be too shallow to convey the waters of both, therefore raise its banks by using the earth taken from its bed, which must at any rate be disposed of. Thus the waters will be conveyed, and the expense, even of the lower part of the long canal, will scarcely be increased.

These observations must suffice for an account of the management of open canals; and we proceed to the consi­deration of the conduct of water in pipes.

This is much more simple and regular, and the general theorem requires very trifling modifications for adapting it to the cases or questions that occur in the practice of the civil engineer. Pipes are always made round, and there­fore *d* is always ¼th of the diameter. The velocity of water

\*\*\*\*....... . v 307 (√J-0-1)

in a pipe which is in tram, is V ≡ i ■ ■

√s-L√s + l∙6

— 0∙3(√d-0∙l), or = (√d-0∙l) ( 307

∖ ∖⅛∕i — L√s4-l∙6

— 0∙3).

The chief questions are the following.

*Quest.* 1. Given the height H of the reservoir above the place of delivery, and the diameter and length of the pipe, to find the quantity of water discharged in a second.

Let L be the length, and Λ the fall which would produce the velocity with which the water enters the pipe, and actually flows in it, after overcoming all obstructions.

\*\*\*Vi

This may be expressed in terms of the velocity bv -77, G 2G

denoting the acceleration of gravity corresponding to the manner of entry. When no methods are adopted for faci­litating the entry of the water, by a bell-shaped funnel or otherwise, 2G may be assumed as = 500 inches, or 42 feet, according as we measure the velocity in inches or

\*\*\*V^

feet. The slope '8 ~ = ^~γ~~, which must be put into the general formula. This would make it very complicated. We may simplify it by the consideration that the velocity is very small in comparison of that arising from the height H ; consequently *k* is very small. Also, in the same pipe, the resistances are nearly in the duplicate ratio of the ve­locities when these are small, and when they differ little among themselves. Therefore make *s* = —taking A by guess, *a* very little less than H. Then compute the mean velocity *v* corresponding to these data, or take it from the table. If \*\*\* A -∣- ~ be = H, we have found the mean ve­locity V = *v.* If not, make the following proportion.

v°- V2 V’

A : = II — — : s-=r, which is the same with this,

2G 2G 2G

λ + 2G : r = 11 : v ’ and v ,s = 7~V^-2gT+P λ÷2G —2G~

\_ es ∙ 2GH

*“ υa* + 2GA’

If the pipe has any bendings, they must be calculated for in the manner mentioned in the article River ; and the head of water necessary for overcoming this additional re- \*\*\*V“

sistance being called —, the last proportion must be chan­ged for

\*\*\*+∙,⅛+⅞)'∙'=h∙v∙∙

*Quest.* 2. Given the height of the reservoir, the length of the pipe, and the quantity of water which is to be drawn off in a second, to find the diameter of the pipe which will draw it off.

Let *d* be considered as = ¼th of the diameter, and let 1 : c represent the ratio of the diameter of a circle to its circumference. The section of the pipe is 4*cd*2. Let the quantity of water per second be Q ; then \*\*\*-⅛- is the mean 4cαz

velocity. Divide the length of the pipe by the height of the reservoir above the place of delivery, diminished by a very small quantity, and call the quotient *s.* Consider this as the slope of the conduit ; the general formula now be­comes

\*\*\*\*Q 307 (√rf-0∙l)

4ÖF = √s-L√i + 1∙6 - °"3 ~ 04>> °r

⅛ = ≈⅞-<h)-O.3(^-0.,). We may neglect the last term in every case of civil practice, and also the small quantity 0∙l. This gives the very simple for­mula

\*\*\*Q 307√rf

*4cdi~* √S ’

from which we readily deduce

*rt-* Q√s ⅛-Q√s⅜

4c X 3071 3858

This process gives the diameter somewhat too small. But we easily rectify this error by computing the quantity delivered by the pipe, which will differ a little from the quantity proposed. Then observing, by this equation, that two pipes having the same length and the same slope give quantities of water, of which the squares are nearly as the fifth powers of the diameter, we form a new diameter in this proportion, which will be almost perfectly exact.