PRACTICAL HYDRAULIC FORMULÆ FOR THE DISTRIBUTION OF WATER THROUGH LONG PIPES

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Practical Hydraulic Formulæ for the Distribution of Water Through Long Pipes by E. Sherman Gould

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E. SHERMAN GOULD

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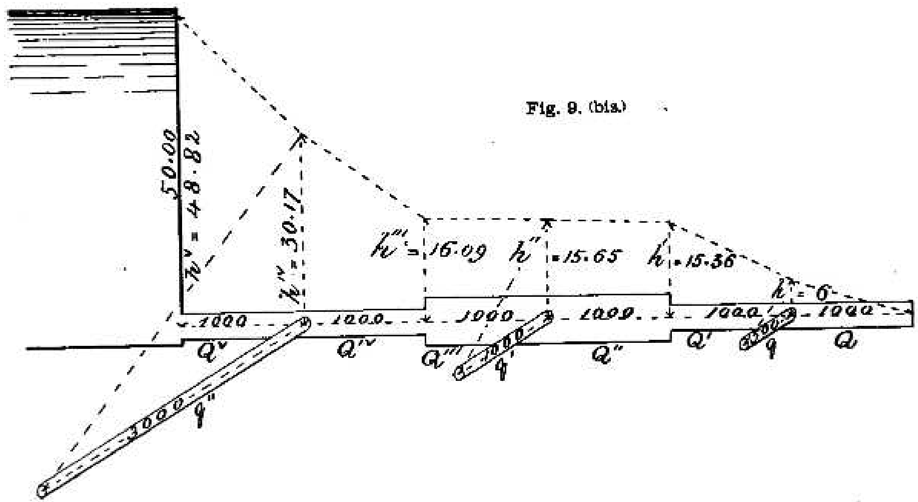
Fig. 9. (bis.)



50.00
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h^iv = 30.17
h''' = 16.09
h'' = 15.65
h = 15.36
h' = 6
1000
1000
1000
1000
1000
1000
Q^v
Q^iv
Q'''
Q''
Q'
Q
q
q'
q''
3000

PRACTICAL

HYDRAULIC FORMULÆ

FOR THE

Distribution of Water Through Long Pipes.

BY

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INTRODUCTION.

The following pages first appeared as a series of articles in the columns of ENGINEERING NEWS. They are now republished with a few corrections and additions.

In virtue of the law of gravitation, water tends naturally to pass from a higher to a lower level, and without a difference of level there can be no natural flow.

It can be said in all seriousness—although the statement may seem to invite the unjust accusation of an ill-timed attempt at pleasantry—that the whole science of hydraulics is founded upon the three following homely and unassailable axioms:

First. That water always seeks its own lowest level.

Second. That, therefore, it always tends to run down hill, and

Third, that other things being equal, the steeper the hill, the faster it runs.

In the case of water flowing through long pipes, the hill down which it tends to run is the HYDRAULIC GRADE LINE. If the pipe be of uniform diameter and character, the hydraulic grade line is a straight line joining the water surfaces at its two extremities, provided that the pipe lies wholly below such straight line, and its declivity is measured—like that of all hills—by the ratio of its height to its length.

But if there be any changes whatever in the pipe, either of diameter or in the nature of its inside surface; or if there be increase or diminution of the volume of water entering it at its upper extremity by reason of branches leading to or from the main pipe, then the hydraulic grade line becomes broken and distorted to a greater or less extent, so that its declivity is not uniform from end to end, but consists of a series of varying grades some steeper than others though all sloping in the same direction.

As regards the third axiom, the proviso—"other things being equal"—must not be overlooked. For we shall find that a pipe of greater diameter but less hydraulic declivity than another, may give a greater velocity to the water passing through it. Also, of two pipes of the same hydraulic slope and diameter, the one having the smoother inside surface affords the greater velocity.

The vertical distance from any point in a pipe to the hydraulic grade line, constitutes the *Piezometric height*, and measures the hydraulic pressure at that point. It will be seen that the solution of problems relating to the flow of water through pipes, lies in the knowing or ascertaining of the piezometric height at any desired point. In general, it is necessary to establish the piezometric height for every point of change of any kind which occurs throughout the entire length of the conduit. The joining of the upper extremities of these heights gives the complete hydraulic grade line.

The object of the following papers is to establish systematic methods for tracing the hydraulic grade line under the different circumstances likely to occur in practice, and generally, to furnish solutions for a large number of practical problems, commencing with the simplest cases and extending to some rather intricate ones, not usually embraced in our hydraulic manuals.

E. S. C.

SCRANTON, PA., MAY, 1889.

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Let us suppose a reservoir of large relative area and capacity to be tapped near its bottom by a horizontal cylindrical pipe, of which the length is equal to about three times its diameter.

If there were no physical resistance to the flow, the velocity of the water issuing from the pipe would be given by the formula for the velocity of falling bodies:

$$V = \sqrt{2gH} = 8.02\ \sqrt{H}$$

in which V = velocity in feet per second, g = the acceleration due to gravity = 32.2 ft., and H = the height, expressed in feet, of the surface of the water in the reservoir above the center of the pipe.

Observation shows, however, that in the case cited the velocity of discharge is equal only to that theoretically due to a height of about two-thirds of H, that is:

$$V = \sqrt{\frac{4gH}{3}} = 6.55\ \sqrt{H}.$$