PRACTICAL HYDRAULICS

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BY

P. M. RANDALL,

AUTHOR OF

"QUARTZ OPERATORS' HAND-BOOK."

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PREFACE.

The present work is designed as a true exposition o. the principles and application of those branches of hydraulics, of which it treats.

The necessity of such a work at this time will be obvious to those who shall have compared the results deduced from the formulas of nearly all our most noted authors on hydraulics, with the results of observation. Thus, the formulas of DuBuat, Eytelwein, Girard, Prony, D'Aubuisson, Neville, Leslie, Pole, Beardmore and Hagen, enjoying the reputation of standard authors, give as by the data at hand, with respect to the flow of water in open streams of medium size, results varying from fifteen to one hundred and twenty-five per cent in excess of the observed results, and in large streams, results varying from thirty to sixty-seven per cent below those observed. These errors are radical. The defectiveness of these and other works heretofore regarded standard on this highly important branch of hydraulics, is well portrayed by the following extracts from an article in an English periodical, "Engineering" of Dec. 31, 1875, entitled "Hydraulic Experiments," viz :

" The tabulated velocities (in Neville's work, based upon DuBuat) " though expressed in hundredths of an inch, are in reality but the " wildest guesses at the actual velocities in irrigation canals of " ordinary dimensions. Colonel Cautley relied upon DuBuat when " he laid out the Ganges Canal, and found him but a rotten reed, " for the water in every instance tore along at an unexpected velo- " city, and the erosion of the bed and destruction of the works " followed in its wake. Du Buat then must be put upon the top " shelf of the book-case, and it will be just as well when the steps "are there to carry up every English work, in which the names of "Brauning, Girard, Bossut, Prony, Eytelwein, or D'Aubuisson are "continually recurring as authorities against whom no action can "be taken. In this general clearance Beardmore, Downing, Box, "and *almost every other hydraulic text book* compiled by English- "men, will with more or less hesitation have been shelved."

Again, "in 1880," says L. D. A. Jackson, in his Hydraulic Manual "the extensive experiments of Captain Allan Cunningham on "the Ganges Canal, have substantiated the truth of Kutter's laws "when applied to very large canals, and dealt the final blow to the "velocity formulas of all the older hydraulicians."

In the main text of the present work it is stated that D'Arcy in 1835, and Bazin, in 1865, published formulas better adapted than any preceding for finding the flow of water in open streams and pipes of medium size; that Humphreys and Abbot published in 1861, formulas suited to the determination of flow of large streams, but not to the flow of small streams, and that the wide gap between the formulas of D'Arcy and Bazin, and those of Humphreys and Abbot were effectually closed up in 1870 by the introduction of Kutter's formula. We will now add, that this achievement with respect to hydraulic science seems to us the masterpiece of the nineteenth century. The Kutter formula applies equally well to small, medium-sized and large streams. Farther experiments may perchance require it to be somewhat modified; but so far as known at present, of all the formulas deduced for like purposes, it seems the nearest approximate to perfection.

The principal tables computed by Herr Kutter, from his formula under consideration, give the coefficients of velocity in terms of *metrical measures*, thereby rendering their application a laborious task in the determination of the velocities themselves in terms of *feet measures*.

To obviate this task, Table 27 in the present work has been computed from the same formula (Kutter's) giving in terms of *feet measures*, the velocities of flow in open streams, differing in regime and in slope, and varying from the size of a small ditch to that of the Mississippi River. The table is nominally for open streams, but is equally well adapted for determining the flow of water in pipes. Table 17 computed for the flow in pipes only, will, for this purpose, be found, however, still more convenient. For this table we are indebted in part to J. T. Fanning's very admirable treatise on "Water Supply Engineering," which indebtedness we hereby respectfully acknowledge. It will be noted however that we have not only considerably enlarged the original table of Mr. Fanning, but, among other things, conferred upon it a new and valuable feature—that of giving the quantity of flow in addition to the velocity. Each result set down in Tables 17 and 27, represents essentially a mean of numerous observed results: hence must necessarily coincide in practice with other results obtained under like conditions. With respect to accuracy, scope of application and ease of reference, these tables seem to meet more fully the requirements of all concerned in this branch of hydraulic engineering, than any others designed for similar purposes.

Tables 28 and 29 will be found very important auxiliaries to Table 27, in the ready determination of the flow of water in beds of different forms.

Tables, two relating to the flow of water in rectangular weirs, four to quadrant weirs, seven to the flow through rectangular orifices, and eight to the different values of the so-called "miner's inch," will also be found of no little value in practice. The simplicity of the *quadrant weir*, its cheapness and the assurances by Prof. Thompson of its superiority over those of different forms, induced the author of the work in hand to compute Table 4.

This form seems peculiarly well adapted to the measurement of the flow of small quantities of water; for example, from two to 20 miner's inches. This table, however, greatly exceeds those limits. The discussion of the subjects of "*maximum work* effected by water on issuing under pressure from pipes," and of "*minimum weight* and consequent *minimum cost* of an inverted siphon," is, so far as the author is informed, new. By the application of the principles here demonstrated, the *greatest economy*, the only proper limit or standard of the *truly practical*, is attained.

The simple plan, pursued in the preparation of the present work consists :—

1st. In demonstrating concisely the principle, or principles, involved in the subject matter, yet in a manner sufficiently ample and clear to be readily followed by the student, or by the practitioner desiring to refresh his mind, or to assure himself of the correctness of the results.

2nd. In expressing in words the simplest rule or rules corresponding to the formula or result of such demonstration.

3d. In applying the rule or rules so derived, to practical examples with full and clear explanations; or in applying the formula direct to the examples, when it is too complex to be well expressed in words.

4th. In providing tables, so far as feasible, to meet the requirements of practice.

By means of these tables and the simple rules given therewith, most of the problems likely to occur with respect to the measurement of water in motion, as through vertical openings, over weirs, in pipes, in open streams and through nozzles; with respect to the quantity of water required for various mining purposes, and for the purposes of irrigation; and with respect to the power of water as a motor, are answered direct, or readily solved by anyone familiar with common arithmetic only, as well as by the skilled engineer.

P. M. RANDALL.

San Francisco, March 17th, 1886.

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Formulas, and Formulas and Rules corresponding ; "F" representing formula, and "R" rule ; page referring to rule ;