HYDRAULIC TABLES FOR THE CALCULATION OF THE DISCHARGE THROUGH SEWERS, PIPES, AND CONDUITS: BASED ON KUTTER'S FORMULA

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P. J. FLYNN

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Trieste

HYDRAULIC TABLES

FOR THE

CALCULATION OF THE DISCHARGE

THROUGH

SEWERS, PIPES AND CONDUITS;

BASED ON KUTTER'S FORMULA.

By P. J. FLYNN, Civil Engineer.

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ERRATA.

Page 19, 9th line from top,

$$\frac{81.26}{5} = 16.252 \text{ } \textit{should be} \text{ } \frac{81.24}{5} = 16.248.$$

Page 19, 5th line from bottom,

$$\frac{81.26}{1796.5} = .045232 \text{ } \textit{should be} \text{ } \frac{81.24}{1796.5} = .045221.$$

Page 26, third column, 4th line from bottom, 1.558 *should be* 1.458.

" 30, fifth column, 4th line from bottom, 80216 *should be* 80916.

" 35, third column, bottom line, .121286 *should be* .121268.

" 48, second column, 6th line from bottom, .004081623 *should be* .004081623.

" 51, second column, 4th line from top, .008546099 *should be* .008546099.

" 64, second column, 8th line from top, .001136752 *should be* .002136752.

" 65, second column, 3d line from bottom, .092057613 *should be* .002057613.

" 66, third column, 4th line from top, .045085 *should be* .045033.

" 68, second column, 1st line from top, .001944246 *should be* .001934236.

" 68, second column, 2d line from top, .008930502 *should be* .001930503.

" 90, second column, 3d line from top, .001290190 *should be* .001209190.

" 112, 14th line from top, .03271 *should be* .03371.

" 133, second column, 2d line from top, 2 156 *should be* 3.156.

" 133, fifth column, 1st line from top, 205.98 *should be* 208.58.

" 134, second column, 6th line from bottom, 12.999 *should be* 11.999.

PREFACE.

The usefulness of such tables as are presented in the following pages requires no demonstration in a preface. A glance at the explanatory text and tabular arrangement of the values will be sufficient to convince the practical engineer, who has ever had occasion to apply Kutter's formula, that the present collection is in an eminent degree of the labor saving kind.

EDITOR OF MAGAZINE.

Hydraulic Tables Based on Kutter's Formula.

THE tables given below are intended to facilitate the calculation of velocities, discharges, slopes and dimensions of sewers and other conduits, and their use will effect a great saving of time; as, for instance, instead of calculating the velocity and discharge by the use of a troublesome formula, the same result, practically, will be arrived at by taking the product of two factors given in the tables.

Kutter's formula is a complicated equation, and in its general form is:

$$v = c\sqrt{rs} \text{ in which}$$

$$c = \left\{ \frac{41.6 + \frac{1.811}{n} + \frac{.00281}{s}}{1 + \left((41.6 + \frac{.00281}{s}) \times \frac{n}{\sqrt{r}} \right)} \right\}$$

In this and the following formulæ,

v=mean velocity in feet per second.

c=coefficient of mean velocity.

s=fall of water surface (h) in any distance (l) divided by that distance=$\frac{h}{l}$=sine of slope.

r=hydraulic mean depth=area of cross section of water divided by wetted perimeter=$\frac{a}{p}$.

d=diameter of circular channel.

a=area of cross section of water.

p=wetted perimeter.

Q=discharge in cubic feet per second.

n=the natural coefficient depending on the nature of the bed, that is, the lining of the channel over which the water flows, which throughout this article, and in the preparation of the tables, has been taken at .015.

Mr. J. C. Trautwine, in his *Engineer's Pocket Book*, states that, "In consideration of the rough character of sewer brickwork generally," he has taken n=.015 in Kutter's formula when he calculated the velocities in sewers.

Mr. R. Hering, in a paper read before the American Society of Civil Engineers in 1878 on the velocity and discharge of sewers, gave:

"$n=.015$" for "foul and slightly tuberculated iron; cement and terra cotta pipes with imperfect joints, and in bad order; well dressed stonework and second-class brickwork." The tables do not apply to channels with smooth or plastered surfaces. They are intended to apply only to sewers, conduits and other channels whose surfaces exposed to the flow of water are of second-class brickwork, or have surfaces of other material equally rough, such, for instance, as those given above from Mr. Hering's paper.

The general form of Kutter's formula is:

$$v=c\sqrt{rs}=c\sqrt{r}\times\sqrt{s} \quad . \quad . \quad . \quad . \quad (1).$$

from which

$$c\sqrt{r}=\frac{v}{\sqrt{s}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

$$\sqrt{s}=\frac{v}{c\sqrt{r}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

$$s=\left(\frac{v}{c\sqrt{r}}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

$$Q=av=ac\sqrt{r}\times\sqrt{s} \quad . \quad . \quad . \quad . \quad (5).$$

from which

$$a=\frac{Q}{v} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

$$ac\sqrt{r}=\frac{Q}{\sqrt{s}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

$$\sqrt{s}=\frac{Q}{ac\sqrt{r}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8).$$

$$s=\left(\frac{Q}{ac\sqrt{r}}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

The values of $c\sqrt{r}$ and $ac\sqrt{r}$ for 173 diameters are given in Table 1, and the values of $\sqrt{s}$ for 1072 slopes are given in Table 2. It will then be seen that a large range of channels numbering 185456 are included in these tables. The velocity is found by the product of two factors $c\sqrt{r}$ and $\sqrt{s}$, and in a similar way the discharge is found by the product of the two factors $ac\sqrt{r}$ and $\sqrt{s}$.

In Kutter's formula given above the value of c is found from an equation in-