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

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Trieste

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FOR THE

## CALCULATION OF THE DISCHARGE

THROUGH

## SEWERS, PIPES AND CONDUITS;

BASED ON KUTTER'S FORMULA.

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# 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:

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

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

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:

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

from which

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

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

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

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

from which

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

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

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

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

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 involving the value of $r$, $n$ and $s$, so that any change in the value of $s$ would cause a change in the value of $c$, but as the influence of $s$ on the value of $c$ is not very marked in such slopes as are usually adopted for sewers and conduits, the value of the coefficient has been calculated for one slope, that of 1 in 1000 or $s = .001$. This value of the coefficient is *practically constant* for all values of $s$ with a steeper slope than 1 in 1000, and as sewers are generally designed with steeper slopes than 1 in 1000, the tables are well adapted to facilitate the calculations. For flatter slopes than 1 in 1000 up to even 2 feet per mile, or 1 in 2640, the tables give results showing a maximum error in the case of a sewer 2 feet in diameter of less than 2 per cent., and in the case of a sewer 8 feet in diameter less than ½ per cent.; therefore, for all practical purposes, the tables are sufficiently accurate.

The hydraulic mean depth of a cylindrical conduit flowing full is equal to one-fourth of the diameter.

The *mean velocity* in circular sewers