THE PATERSON ENGINEERING COMPANY LIMITED

THE TARRANT HYDRAULIC SLIDE RULE

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Specially designed for calculations of flow through pipes and circular sewers and in open channels. The formulæ chosen have been selected from the many exponential formulæ in general use for such calculations.

PIPE FLOW

The Hazen-Williams formula is very extensively used for pipe flow and with the variation of the coefficient C_1 covers a wide range of classes of pipes from those badly encrusted or old, to the smooth bore of concrete or asbestos-cement pipes.

The scales are calculated and arranged for $C_1 = 130$. The auxiliary scale marked C_1 on the lower edge of the slide allows for adjustments for other values of C_1. The Table appended to these notes gives approximate values of C_1 for different classes of pipes.

Four scales, with the use of C_1 scale where necessary, give the solution of the Hazen-Williams formula. One of those scales (the flow scale), used with the arrow B and two other scales for pipe diameter and velocity connect velocity and flow in pipes.

The scales in black are for cubic feet per second; those in red are used in the same way for metric units.

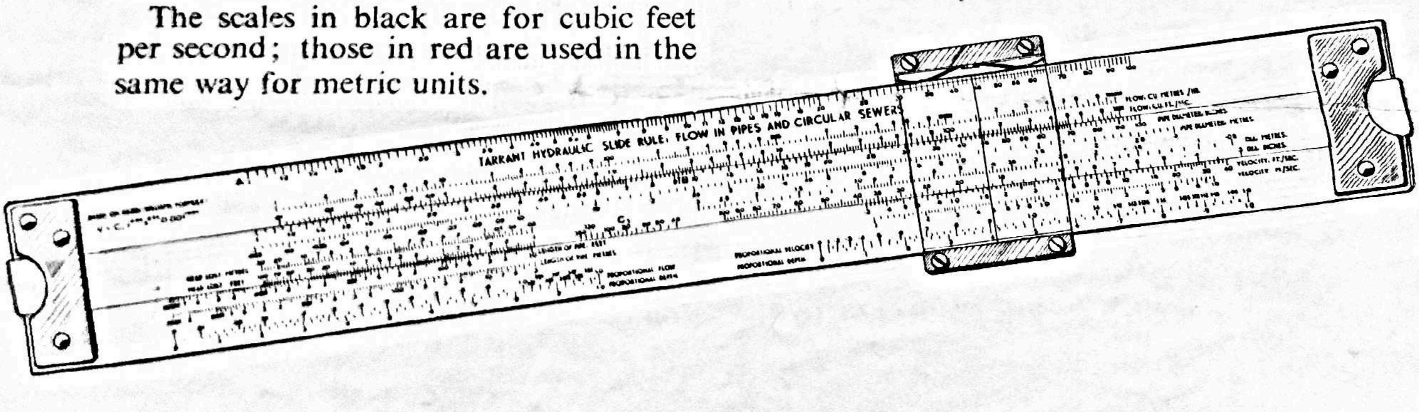
All of the scales described above are for the Hazen-Williams formula for pipes running full.

For pipes or sewers running only partly full, the scales of proportional depth, etc. on the lower edge of the rule are used in conjunction with the "running full" scales.

The scale marked A on the uppermost edge of the rule is the same as that for pipe diameter, inches, on the upper edge of the slide. With these two scales, ordinary multiplication and division can be performed.

SPECIAL PROBLEMS

Use of the rule will greatly reduce the time required for the solution of special problems in pipe flow, such as branching pipes, parallel pipes, and compound pipes.



OPEN CHANNELS

The Manning Formula is used here for flow in open channels. It has the advantage that the coefficient "n" is the coefficient used in the Kutter formula, for which it has established values for different types of surface of channel.

The scales on the upper part of the rule and on the lower left-hand part are straightforward for V, R, n and S. V and R are represented on black scales in feet-second units, with red scales for metric units. Scales for n and slope are common to black and red velocity and hydraulic radius scales.

The hydraulic radius is easily calculated for channel sections composed of straight lines (rectangular, trapezoidal, etc.) but is not so easily obtained for half-round channels when the depth is less than the radius of the channel. The scales on the lower right-hand part of the rule, in conjunction with the arrow D, can be used to find the hydraulic radius and the area of flow for such cases.

INSTRUCTIONS FOR USE OF THE RULE

PIPE FLOW

Scales: Flow, diameter, head lost, and length of pipe. Any three being known the fourth can be found.

Example: Place known pipe diameter *against* flow and read head lost against length of pipe.

For metric units the scales coloured red are used, with flow in cu. metres per hour; diameter of pipe, head lost, and length of pipe in metres.

For these scales, $C_1 = 130$ in the Hazen-Williams formula, and for other values of C_1 between 40 and 150 adjustment is made by using the scale marked C_1 in the following manner:

1. **For Flow:** Find flow for $C_1 = 130$. Then place cursor over found value of flow and bring given value of C_1 under the line. Then required value of flow is at $C_1 = 130$.
2. **For Diameter:** Place cursor over given flow, bring $C_1 = 130$ to the line and calculate using the flow figure found opposite the given C_1.
3. **For Head Lost:** Place cursor over length of pipe, then bring given C_1 under the line. Calculate using length opposite $C_1 = 130$.
4. **For Length of Pipe:** Calculate and obtain length of pipe for given flow, diameter and head lost. This is for $C_1 = 130$. Place $C_1 = 130$ opposite length and read required length opposite given C_1.

VELOCITY IN PIPE

Place arrow B against pipe flow, and against the diameter on the *lower* edge of the slide, read the velocity.

SCALE A

This is used in conjunction with the pipe diameter in inches on the upper edge of the slide for ordinary multiplication and division, e.g. for convenient conversion of units of flow.

PIPES OR SEWERS PARTLY FULL

(a) Given flow, diameter and slope. To find depth of flow and velocity :

Calculate **flow running full,** using appropriate value of C_1. Find proportional flow $\left(\frac{\textit{actual flow}}{\textit{flow running full}}\right)$ and on scales on left of lower edge of rule find proportional depth, so obtaining depth of flow.

Next calculate **velocity running full** and from proportional depth already found and scales on lower right hand edge find proportional velocity $\left(\frac{\textit{required velocity}}{\textit{running full velocity}}\right)$ so obtaining velocity in partly full pipe.

(b) Given depth, slope and diameter : to find flow. Calculate flow running full. From depth and diameter and proportional depth and flow scales obtain actual flow.

CHANNEL FLOW

Scales for velocity, hydraulic radius, slope and Kutter's "*n*" give solution of the Manning formula. The appropriate value of "*n*" is placed against the slope, and the velocity will be opposite the hydraulic radius. Two scales in red give velocity in metres/sec. and hydraulic radius in metres.

For channel sections bounded by straight lines the hydraulic radius $\left(\frac{\textit{area}}{\textit{wetted perimeter}}\right)$ is easily calculated.

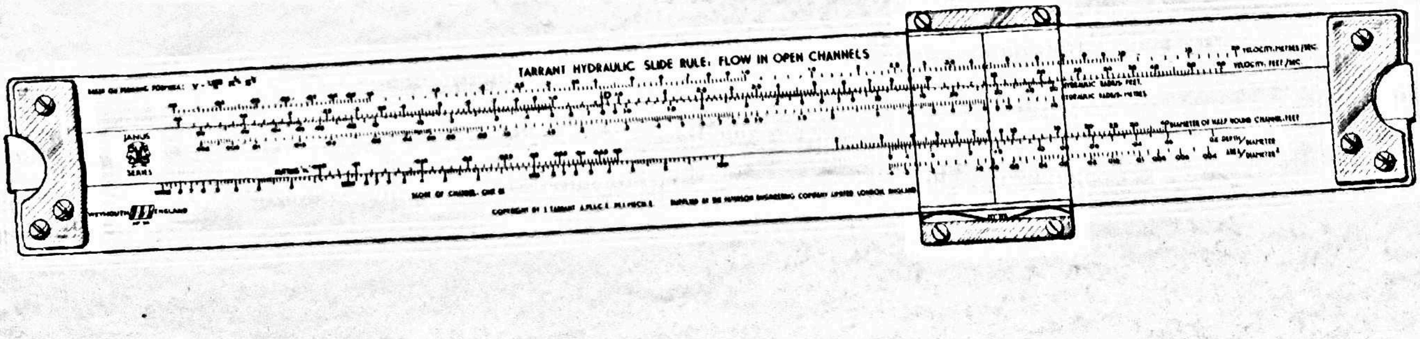
For Half-Round Channels having a depth of flow up to half the diameter, additional scales facilitate the calculation of hydraulic radius and the area of flow. Place the diameter of the half-round channel opposite the $\frac{\textit{depth}}{\textit{diameter}}$ ratio and the hydraulic radius is read against the pointer D. This value of the hydraulic radius is used for calculation as already described and, of course, the process can be reversed to find the depth of flow in a half-round channel.

From the $\frac{\textit{area}}{\textit{diameter}^2}$ scale figure which is opposite the $\frac{\textit{depth}}{\textit{diameter}}$ figure, the area of flow can be obtained, for use with the velocity to ascertain the rate of flow.

Values of C_1 in Hazen-Williams formula, taken from Williams and Hazen's book, "Hydraulic Tables" and other authorities.

C_1 = 145 :	Asbestos-cement pipe.
C_1 = 140 :	Bitumen-lined steel pipes ; smooth concrete pipe ; smooth pipes of brass, glass or lead.
C_1 = 130 :	New coated cast iron pipe ; small brass or copper pipe.
C_1 = 125 :	New uncoated cast iron pipe.
C_1 = 120 :	Smooth woodstave pipe.
C_1 = 110 :	Riveted steel pipe ; vitrified pipe.
C_1 = 100 :	Brick sewers.

For old or encrusted pipes the value of C_1 may be as low as 80 or less, depending on the actual condition.



VALUES OF KUTTER'S "*n*" FOR CHANNELS

n = ·009 : straight channels of smooth planed boards.
n = ·010 : the same in neat cement plaster.
n = ·012 : the same in unplaned boards; sand and cement plaster.
n = ·013 : the same in steel trowelled concrete; metal flumes.
n = ·014 : the same in wooden trowelled concrete.
n = ·015 : the same in ordinary brickwork or smooth masonry.
n = ·020 : channels in fine gravel; rough set rubble; or earth in good condition.
n = ·025 : canals and rivers in fair condition.
n = ·030 : canals and rivers in poor condition.
n = ·035 : canals and rivers in bad condition, say with bed strewn with stones and detritus.
n = ·040 : canals half full of vegetation.
n = ·050 : canals two-thirds full of vegetation.

As the Manning formula is sometimes used for flow in pipes, the following table of values of "*n*" may be useful. The value of V being found by the Manning formula on the "channels" side of the rule, this may be applied on the "pipes" side to find the flow.

VALUES OF KUTTER'S "*n*" FOR PIPES

n = ·010 : Asbestos-cement pipe.
n = ·011 : Concrete pipe ; very smooth.
n = ·012 : Clean coated cast iron pipe ; woodstave pipe.
n = ·013 : Clean uncoated cast iron pipe.
n = ·014 : Vitrified sewer pipe ; riveted steel pipe.
n = ·015 : Galvanised iron pipe.
n = ·016 : Concrete pipe with rough joints.
n = ·021 : Corrugated metal pipes.

Old or badly encrusted pipes will require higher values of "*n*", depending on the actual condition.

THE TARRANT HYDRAULIC SLIDE RULE

can be obtained from

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