SPECIAL SLIDE RULE

FOR

Natural Gas and Air Computations.

—

Computed and Arranged
by
FORREST M. TOWL, C. E.

26 BROADWAY, NEW YORK
JULY, 1910

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NATURAL GAS AND AIR PIPE LINES.

THIS Slide Rule is constructed principally for the calculation of the various problems encountered in the pipe line transportation of Natural Gas and of Air.

The flow of the fluid through the lines is based on the formula

$$Q = C\sqrt{\frac{(P_1+P_2)(P_1-P_2)D^5}{L}}$$

Q = cubic feet per hour (15 lbs. absolute).

P_1 = absolute Head or initial pressure in pounds per square inch.

P_2 = absolute Delivery or terminal pressure in pounds per square inch.

D = diameter of the pipe in inches.

L = length of the pipe in miles.

C = a Constant.

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The Constant used for Air computations is C=38.28.

The Constant for any other gas is inversely in proportion to the square root of the specific gravity of the gas.

The Rule is marked for a Constant for Natural Gas having a specific gravity of 0.59 which gives C=50.

These Constants have been checked by many tests on pipe lines of various diameters and lengths.

The first or upper scale of the Rule is graduated in *thousands* of cubic feet *per hour* of gas or air at 15 lbs. absolute pressure, and 60° Fahrenheit temperature.

On the second scale, the graduations are for the diameters of the pipe in inches. The red figures are for Natural Gas and the black for Air.

It will be noted that there are two red graduations for 16, 18 and 20 inches. The ones to the left, marked O. D., are for the regular outside diameter pipe, which is generally used for gas lines of about these sizes. The others are for pipes having inside diameters of the number of inches as indicated.

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The left hand side of the third scale is graduated for the sum of the head and delivery pressures. Gauge Pressures are used on this scale.

The right hand side of the third scale is graduated for the length of the line in miles.

The fourth scale is graduated for the difference of the head and delivery pressures. This scale is continued so that the product of the sum and difference of the *absolute* head and delivery pressures can be read. (In comparing with formula, note that the formula uses absolute pressures, but the Rule, when making pipe line computations, uses gauge pressures, the correction being made on the left end of scale 3.)

The operation of the Rule is shown below in several examples.

Question I: With a head pressure of 100 pounds per square inch (Gauge) and a delivery pressure of 10 pounds per square inch (Gauge), how much Natural Gas will be delivered per hour through an 8-inch pipe line 25 miles long?

Solution: The sum of the gauge pressures is 110 pounds, and the difference is 90 pounds.

Opposite 90 on the fourth scale, set "*" on the left side of the third scale, and below 110 on same scale, read 12,600 on the fourth scale. Then opposite the 12,600 on the fourth scale, set 25 miles on right hand side of third scale, and above the red 8-inch mark on the second scale read 203 thousand cubic feet per hour on the first scale.

For Air, you would use the black 8-inch mark on the second scale, and the result on the first scale would be 156 thousand cubic feet per hour.

Question II: What length of 8-inch pipe has the same capacity as 7 miles of 6-inch pipe?

Solution: Set the 7-mile mark on the third scale opposite 10,000 on fourth scale, note that the 6-inch black mark is opposite 128 on first scale, then move the 8-inch black mark to 128 on first scale, and the required equivalent length will be 29.5 miles, found on the third scale above the 10,000 mark on the fourth scale. (Making an ink or pencil mark on the first scale instead of taking a reading will usually be found more convenient. Any other point may be used in the same manner as the 10,000 point on the

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fourth scale, but in general it is best to adopt one point and stick to it.)

Question III: With 100 pounds head and 10 pounds delivery pressure, how many cubic feet of Natural Gas can be delivered per hour through a line composed of 25 miles of 8-inch and 7 miles of 6-inch pipe?

Solution: 7 miles of 6-inch is equivalent (in capacity) to 29.5 miles 8-inch. (Question II). Then the whole line would be equivalent to an 8-inch line 25+29.5, or 54.5 miles long. Set the 54.5 miles above the 12,600 on the fourth scale, as obtained in Question I, then above the red 8-inch mark on second scale read 138 thousand cubic feet per hour.

If a portion of the line is doubled with the same sized pipe, the length of the single line having the same capacity, is found by dividing the length of the doubled portion by 4, and adding this to the length of the single portion of the line.

Question IV: What is the "equivalent length" of a line composed of 8 miles of double line and 4 miles of single line?

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Solution: 8 divided by 4 equals 2, which added to the amount of single line, 4 miles, gives 6 miles. In other words, as much gas can be conveyed through a line composed of 8 miles of double pipe, of any size, and 4 miles of single pipe of the same size, as could be pumped through a single line 6 miles long of the same sized pipe.

Question V: If the capacity of a line 100 miles long is 250 thousand cubic feet per hour, how many miles of loop of the same sized pipe will be required to increase the capacity to 300 thousand?

Solution: Invert the slide so that the 100-mile mark on scale three, is opposite 250 thousand on scale one, then below 300 thousand read 69.5 miles on third scale. Subtracting this from 100 gives 30.5. Add one-third of this, or 10.2 miles, to the 30.5 and it gives 40.7 miles as the amount of the line which must be doubled to secure the increased capacity.

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GAS COMPRESSION COMPUTATIONS

The specific heat of Marsh Gas, the principal constituent of Natural Gas, at *constant pressure*, is 0.5929. The specific heat at *constant volume* is 0.4683.

$$r = \frac{.5929}{.4683} = 1.266$$

$$\frac{r-1}{r} = 0.21$$

The rise in temperature due to Adiabatic compression, is obtained from the following formula:

$$\text{Rise in Temperature} = \left(\frac{P_2}{P_1}\right)^{0.21} \times 521 - 521.$$

P_1 = absolute initial pressure.

P_2 = absolute final pressure.

521 = absolute temperature corresponding to 60° Fahrenheit.

$\frac{P_2}{P_1}$ = Ratio of compression.

For Air the formula is:

$$\text{Rise in Temperature} = \left(\frac{P_2}{P_1}\right)^{0.29} \times 521 - 521.$$

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The reverse side of the slide is graduated in red for Natural Gas Compressor and Gas Engine problems. In using the Rule for this purpose, the ratio of Compression is the ratio of the *Absolute* pressures. The pressure of 15 pounds absolute, (0. Gauge) at a temperature of 60°, is the base of all the calculations.

Question VI: What is the rise in temperature due to 5 compressions?

Solution: Set the 100° mark on the fifth scale (reversed second scale) below the 100 mark on the first scale, and above the ratio of compression 5, read 210. This is the rise in temperature in Fahrenheit degrees.

Question VII: What is the Compressor horse power required for Adiabatically compressing 200 thousand feet of Natural Gas, 4 compressions?

Solution: Set the H. P. for 1000 mark on scale 5 below the 200 thousand mark on first scale above 4 on the fifth scale, read 352, the required horse power based on the piston displacement of the compressor. The gas delivered by the compressor will probably be 10% or 15% less than the displacement volume.

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GAS ENGINE COMPUTATIONS

The basis of the graduation for gas engine computations which is on the reverse side of the slide is that 70 pounds of the mean effective pressure in the gas engine cylinder is available for outside work. This is about right for good four-cycle engines on Natural Gas of 1000 B. t. u.

Question VIII: What brake horse-power will be developed by a four-cycle gas engine on Natural Gas; length of stroke 30 inches, diameter of cylinder (or cylinders) 20 inches, running at 200 *explosions* per minute?

Solution: Opposite the diameter of the Cylinder, 20 inches on first scale, set length of stroke 30 inches on fifth scale, then below explosions per minute, 200 on sixth scale, read 335, the required horse power on fourth scale.

If the engine is of such a type that a m. e. p. of 70 is not correct, the result can be corrected by placing the 70 on the explosions per minute scale above the horse-power as obtained above. When this is done the corrected horse-power will be under the number on the explosions per minute scale, denoting the proper m. e. p.

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The Rules are graduated on Boxwood, and will be sold only to gas engineers, to whom they are furnished at cost price, which is as follows:

40-inch	Rule for pipe line computations,	$10.00
16- "	" " " " "	5.00
40- "	" reverse of slide also graduated,	12.00
16- "	" " " " " "	6.00

The Rules are hand graduated. The 40-inch Rules agree with the formula within about 1%. The 16-inch Rules are accurate within about 2.5%.

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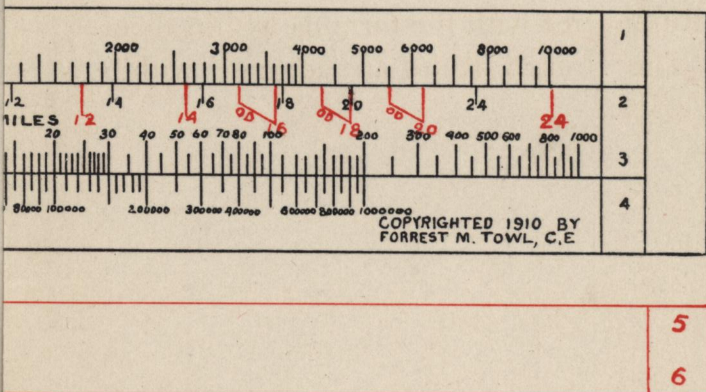

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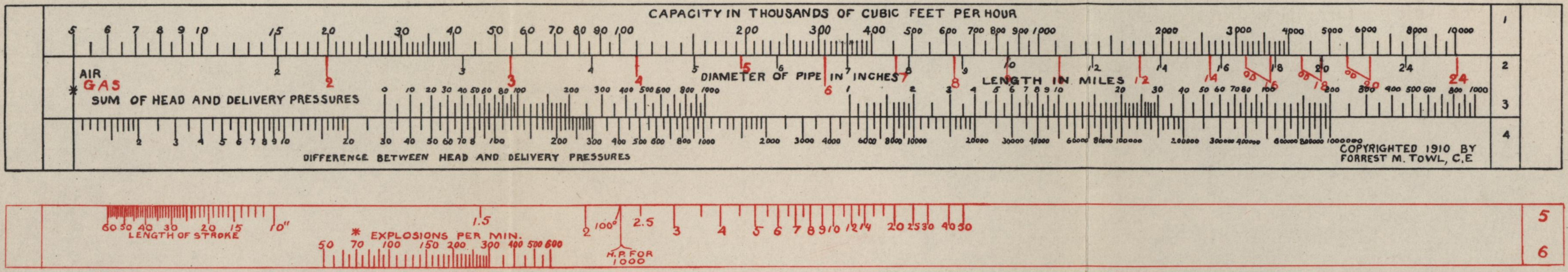

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