# DIRECTIONS

for using the

# Richardson Polymetric Slide Rule

No. 1776

(By J. J. Clark, M. E. Lehigh)



**The CI Scale**—The polymetric slide rule differs from the regular engineer's slide rule in that it has an inverted C scale extending along the middle of the slide. By **inverted** is meant turned upside down, thus causing the right index on this scale to indicate the same number as the left index of the C scale, and vice versa. This scale is marked CI (CI means C inverted), and the figures on it are printed in red, to call attention to the fact that numbers on the CI scale increase from **right** to **left** instead of from left to right, as on the other scales. Thus, to locate a number as 463, find the red figure 4, glance to the left and locate the long division mark that indicates 6, then just a little to the left of this, locate the position of 3, which will be three-fifths of the distance between 460 and 465. This setting is shown in Fig. 1. Note that it is always necessary to employ the runner when using the CI scale in making settings.

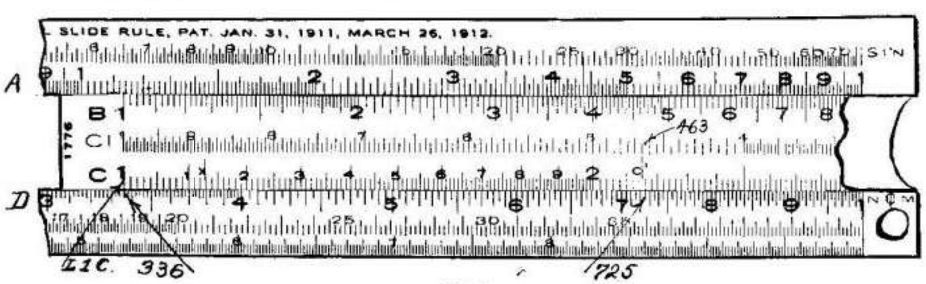



Fig. 1

**Reciprocals**—In order to understand properly the relations between the CI scale and scale C (or D), it is necessary to consider a few of the properties of reciprocals. The **reciprocal** of a number is 1 divided by the number; thus, the reciprocal of a is $\frac{1}{a}$, a being any number whatever. Denoting the **value** of the reciprocal by b, $b = \frac{1}{a}$, or $a \times b = 1$. From the last equation, $a = \frac{1}{b}$; in other words, a and b are said to be **mutually reciprocal,** or **reciprocals of each other.** From the second of the above equations, it is evident that the product of any two numbers that are reciprocals of each other is always 1; hence, one number must be greater than 1 and the other less than 1. For example, the reciprocal of 4 is $\frac{1}{4} = 0.25$, and $4 \times 0.25 = 1$; the reciprocal of 6 is $\frac{1}{6} = 0.16\frac{2}{3}$, and $6 \times 0.16\frac{2}{3} = 1$; the reciprocal of 0.4 is $\frac{1}{0.4} = 2.5$, and $0.4 \times 2.5 = 1$. The reciprocal of a common fraction is the fraction inverted; thus, the reciprocal of $\frac{4}{7}$ is $\frac{1}{4/7} = \frac{7}{4}$, and $\frac{4}{7} \times \frac{7}{4} = 1$.



If the reciprocal of a number is known and the number is used as a divisor, division may be changed into multiplication; or, if the number is used as a factor, multiplication may be changed into division. Thus, $\frac{a}{b} = a \times \frac{1}{b}$. For example, $\frac{216}{12} = 216 \times \frac{1}{12} = 216 \times 0.08\frac{1}{3} = 18$; $27 \times 16 = 27 \div \frac{1}{16} = 27 \div 0.0625 = 432$; also, $27 \times 16 = 16 \div \frac{1}{27} = 16 \div 0.037\ 1/27 = 432$.

Set the slide so that the indexes will be in line with those on the rule; bring the runner to some number on the CI scale; under the hair line, it will be noted that the number on the C (or D) scale is the reciprocal of that on the CI scale. Or, if the runner be brought to some number on C (or D), the number under the hair line on CI will be the reciprocal of that under the hair line on C (or D). The reason for this is plain when it is noted that the distance from the left index to the number on C added to the distance from the right index to the number under the hair line on CI is always exactly equal to the length of the slide, or 10, which may be regarded as 1. Since these spaces are logarithmic, this sum is really the product of the two numbers; and it has just been shown that if the product of two numbers is 1, the numbers are reciprocals of each other. For example, neglecting the decimal point, 2 on C is opposite 5 on CI, and $2 \times 5 = 10$; 8 on CI is opposite 125 on C, and $8 \times 125 = 1000$; 45 on CI is opposite 222 on C, and $222 \times 45 = 99990$, which is equivalent to 10000 in slide rule calculations.

**Multiplication with CI and D Scales**—To find the product of two numbers, bring runner to one of the numbers (factors) on D, bring the other number (factor) on CI to hair line, and opposite index on CI, read product on D.

Example—Multiply 7.25 by 463.

Analysis—Referring to Fig. 1, set runner to 725 D (this means 725 on scale D); move slide until 463 CI comes under the hair line; opposite L1C (this means left index on scale C), read 336 on D. This operation is evidently equivalent to dividing 725 by the reciprocal of 463; and, since there are obviously 4 integral places in the product, $7.25 \times 463 = 3360$. Observe also that 336 CI is opposite R1D.

Note that when the CI and D scales are used, the setting (insofar as the numbers are concerned) is exactly the same as for division, when using the C and D scales. The position of the decimal point is determined by the regular rule for multiplication, except that we note whether the slide projects to the **right.**

One great advantage of using the CI and D scales for multiplication is that we are never in doubt as to which index to use; one or the other (and only one) comes opposite the product on the D scale.

**Division with CI and D Scales**—As may be supposed, the setting for division when using the CI and D scales is the same as for multiplication when using the C and D scales. Bring one of the indexes to the dividend on D; set runner to divisor on CI; under the hair line, read quotient on D. To locate the decimal point, apply the regular rule for division, except that we note whether the slide projects to the **left.**

Example—Divide 21.75 by 3.14.

Analysis—Set L1C to 2175D; bring runner to 314 CI; under the hair line, read 693 on D. There is evidently 1 integral place in the quotient; hence, $\frac{21.75}{3.14} = 6.93$. This operation is evidently equivalent to multiplying 21.75 by the reciprocal of 3.14.

## SPECIAL OPERATIONS WITH CI SCALE

**Remark**—The operations now to be described all involve the use of the CI scale. While it may be that in some cases it would be more convenient to use the C scale, the reader is advised to work on his rule all the problems according to the settings here given; he will, in this way, get practice in using the CI scale, and can readily determine when it should be given preference over the C scale; he is also advised to study out the reasons for the settings.

**Diagrams of Settings**—The setting for the various operations are most conveniently presented by means of diagrams, since these show at a glance just what procedure is to be followed, and are much better for this purpose than a detailed explanation in words.

A necessary adjunct to a diagram is a formula to accompany it and indicate what operations are to be performed; the diagram then shows how the result is obtained. In the formula (which is printed at the left of the diagram), the letters a, b, c, d, etc., are used to represent the numbers, which may have any value, and the letter x is used to represent the answer sought, and the position of x on the diagram shows the scale on which the answer will be found.



The diagram represents the slide only, see Fig. 2, and the space above and below it represents the rule. The upper line represents the B scale, and immediately above this is the A scale; the middle line is the Cl scale; the lower line is the C scale, and immediately below this is the D scale. When the figure 1 occurs on the diagram, it indicates one of the indexes on the slide, either right or left, according to which has to be used. A straight line across the diagram indicates the hair line of the runner. The settings are supposed to occur in regular order, from left to right, in the diagrams. When the runner is used and it is brought to a number (letter), the straight line across the diagram comes **before** the number (letter); but when the runner is stationary and the number on the slide is brought to the hair line, the letter that represents the number is placed before the hair line. Bearing this in mind, the diagram in Fig. 2 is interpreted as follows: Bring runner to a on D; bring b

$x = a \times b \times c$

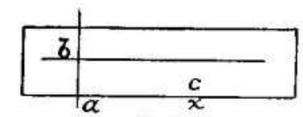



Fig. 2

$3.14 \times 62.75 \times 144 = 28370$

on CI to runner; opposite c on C, read x on D. The formula shows the object of the setting, and the example affords practice in making the setting. Note that three numbers are here multiplied together with one setting of the slide.

If the third number c lies beyond the end of the rule, we can proceed in one of two ways: (1) Shift the slide until the other index comes under the hair line; or (2) proceed as shown in Fig. 3. Here runner is brought to a on D, b on CI is brought to hair line, runner is shifted to the index on slide, c on CI is brought to hair line, and opposite index on CI read x on D. The first method involves but one setting of the slide (changing the index is not a setting), while the second method requires two settings of the slide. The writer prefers the second method, principally because the slide always moves through a shorter distance.

$x = a \times b \times c$

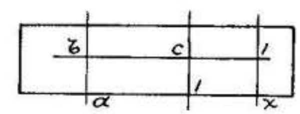



Fig. 3

$3.14 \times 62.75 \times 864 = 170{,}200$

The following diagrams illustrate the solution of various formulas with one setting of the slide.

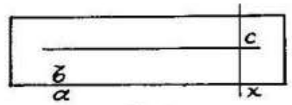
$x = \dfrac{a}{b \times c}$  $\dfrac{628000}{432 \times 25.7} = 56.6$

Fig. 4

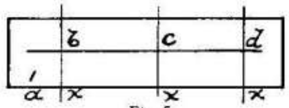
$x = \dfrac{a}{b}, \dfrac{a}{c}, \dfrac{a}{d}$, etc.  $\dfrac{1728}{24} = 72,\ \dfrac{1728}{36} = 48,$ etc.

Fig. 5

The setting in Fig. 5 may be used when it is desired to find a series of quotients, the dividend remaining constant.

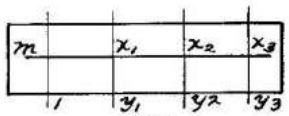
$m = x_1y_1 = x_2y_2 = x_3y_3$, etc.  $1728 = 24 \times 72 = 64 \times 27$, etc.

Fig. 6

The setting in Fig. 6 may be used when it is desired to find a series of sets of two factors of a number.

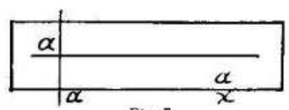
$x = a^3$  $3.14^3 = 31.0$

Fig. 7

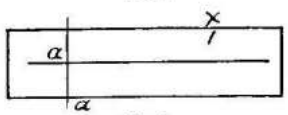
$x = a^4$  $3.14^4 = 97.2$

Fig. 8

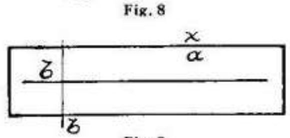
$x = ab^4$  $25.6 \times 3.14^4 = 2490$

Fig. 9

Note that in the last two diagrams x is found on the A scale.

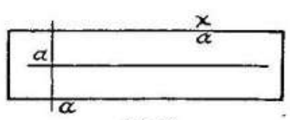
$x = a^5$  $3.14^5 = 305$

Fig. 10



$x = \dfrac{1}{a^4}$  $\dfrac{1}{3.14^4} = 0.01029$

Fig. 11.

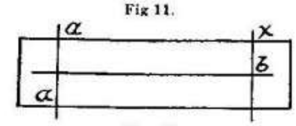
$x = \dfrac{1}{ab^2} = \dfrac{a}{a^2b^2}$  $\dfrac{1}{2.56 \times 3.14^2} = 0.397$

Fig. 12

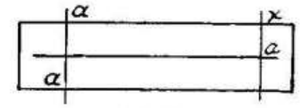
$x = \dfrac{1}{a^3} = \dfrac{a}{a^4}$  $\dfrac{1}{3.14^3} = 0.0323$

Fig. 13

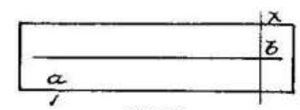
$x = \dfrac{1}{a^2b^2}$  $\dfrac{1}{2.56^2 \times 3.14^2} = 0.1548$

Fig. 14

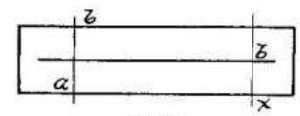
$x = \dfrac{1}{a\sqrt{b}} = \dfrac{\sqrt{b}}{a \times b}$  $\dfrac{1}{2.56\sqrt{3.14}} = 0.220$

Fig. 15

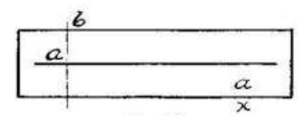
$x = a^2\sqrt{b}$  $2.56^2\sqrt{3.14} = 11.61$

Fig. 16

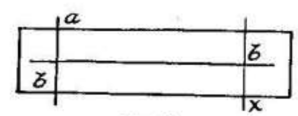
$x = \dfrac{\sqrt{a}}{b^2}$  $\dfrac{\sqrt{2.56}}{3.14^2} = 0.1623$

Fig. 17

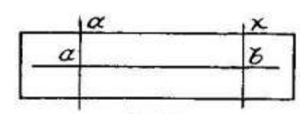
$x = \dfrac{b^2}{a^3}$  $\dfrac{2.56^3}{3.14^2} = 1.70$

Fig. 18

The second forms of the formulas in Figs. 12, 13, and 15 indicate the reasons for the settings shown by the diagrams.