Brief Instructions in the use of the

>W & G<

"DUALFACE" MODEL 454

Artillery & Survey SLIDE RULE

Published by

W. & G. RECORD PROCESSING CO. PTY. LTD.

MELBOURNE, AUSTRALIA

PRINTED IN AUSTRALIA BY G. W. GREEN & SONS PTY. LTD., MELBOURNE

THE >W & G<

"DUALFACE" MODEL 454

Artillery and Survey Slide Rule

As in other >W & G< DUALFACE Slide Rules, this Model 454 Artillery and Survey Slide Rule has all of the graduations and figures uniformly engraved on polished xylonite surfaces with hair line accuracy throughout and filled with special enamel.

The layout of the scales is the outcome of considerable research in order to make available a rule that will assist in ordinary mathematical calculations and also render possible a quick solution of triangles such as in artillery or surveying.

Should adjustment of the tension on the slide become necessary, loosen slightly the screws at both ends of the stock, make the adjustment and tighten screws, making quite sure, however, of the perfect line-up of scales A & D. The construction of the cursor permits adjustment of the hair line in a similar manner.

MULTIPLICATION

EXAMPLE: $25 \times 3 = 75$

Set 1 on the *C* scale to 2·5, *i.e.*, 25 on the *D* scale, and move the cursor hair line along to 3 on the *C* scale, and read off the answer 7·5, *i.e.*, 75 on the *D* scale.

It will be noted that 2·5 as marked on the rule can represent 2·5, ·25, 25, 250 or any other number which, multiplied or divided by 10, or a multiple of 10, gives a result of 2·5.

This principle applies to all numbers on the *A*, *B*, *C*, *D*, or *Reciprocal* scales, so in all further examples on these scales only the actual number in the problem under consideration will be mentioned, it being understood that the position of the decimal point is ignored as far as the location, or reading off, of the number on the scale is concerned.

EXAMPLE: $1{\cdot}8 \times 5{\cdot}5 = 9{\cdot}9$

Placing 1 of the *C* scale on 1·8 of the *D* scale, and bringing the hair line along to 5·5 on *C*, read off the answer 9·9 on *D*.

It becomes apparent now that had the multiplier been, say, 7, the answer could not have been found on the *D* scale with the rule in its present setting. There are two methods of overcoming this seeming difficulty. Firstly, the problem could have been worked out on the *A* and *B* scales, following the same method as above, *i.e.*, place 1 of the *B* scale on 1·8 of the *A* scale, and read off opposite 7 on the *B* scale the answer 12·6 on the *A* scale.

The other alternative would be to place 10 on the *C* scale over 1·8 on the *D* scale, realizing that now 1 on the *C* scale is also over 1·8 on an imaginary continuation to the left of the *D* scale, so that coming along to the multiplier, 7, on the *C* scale, opposite this on the *D* scale is the answer of 12·6.

It will be seen that problems of multiplication can be solved on either the *A* and *B* or *C* and *D* scales, but, whereas in using *A* and *B* a resetting of the slide is avoided, this fact is compensated for in using the *C* and *D* scales, by the greater measure of accuracy made possible by the broader spacing of the logarithmic unit.

The location of the decimal point in either multiplication or any other type of problem, can usually be determined by mentally converting the problem into round figures and applying simple arithmetic.

DIVISION

EXAMPLE: $87{\cdot}5 \div 2{\cdot}5 = 35$

Set the hair line to 87·5 on the *D* scale, and bring 2·5 on the *C* scale to correspond with it, and on the *D* scale opposite 1 on the *C* scale is the answer 35.

EXAMPLE: $41 \div 5 = 8{\cdot}2$

Having made the appropriate settings, 5 on the *C* scale to 41 on the *D* scale, it is noted that 1 on the *C* scale is beyond the graduations of the *D* scale, but whereas in multiplication a resetting of the slide is necessary, in division simply read off the answer on the *D* scale under 10 on the *C* scale, *i.e.*, 8·2. Obviously, this 10 bears exactly the same relation to the *D* scale as the 1 on the *C* scale does to an imaginary extension to the left of the *D* scale.

COMBINATION OF MULTIPLICATION AND DIVISION

EXAMPLE: $\dfrac{65{\cdot}6 \times {\cdot}048}{3{\cdot}68} = {\cdot}856$

Set the hair line to 65·6 on the *D* scale and bring 3·68 on the *C* scale to correspond with it, then transfer the hair line to ·048 on the *C* scale; and opposite this point on the *D* scale is the answer ·856.

EXAMPLE: $\dfrac{45{\cdot}5 \times 36 \times {\cdot}95}{38 \times 6{\cdot}8} = 6{\cdot}02$

Set the hair line to 45·5 on the *D* scale and bring 38 on the *C* scale to correspond with it, then transfer the hair line to 36 on the *C* scale and the first portion of the problem, *i.e.*,

$$\frac{45{\cdot}5 \times 36}{38}$$

is thus completed. Then divide this by 6·8 by bringing 6·8 of the *C* scale under the hair line. The last multiplication is automatically performed and the answer (6·02) is found on the *D* scale corresponding with the last multiplier ·95 on the *C* scale.

The *A* and *B* scales can, of course, be used for these problems combining multiplication and division.

SQUARES

The square or square root of a number can be obtained by a simple method due to the fact that the *A* and *B* scales consist of two logarithmic units, whereas *C* and *D* have only one.

By logarithms $n^2 = \log n + \log n$ or $2 \log n$. Thus the square of any number on the *C* or *D* scales is found directly above it on the *B* or *A* scales respectively, and, of course, to obtain this direct reading the hair line is used.

Thus to find the value of 14^2 place the hair line over 14 on the *D* scale and the answer 196·0 will be found on the *A* scale, corresponding with the hair line.

To find the value of $5{\cdot}7^2$, place the hair line over 5·7 on the *D* scale and read off the answer 32·5 on the *A* scale.

Or to find $\cdot029^2$ set the hair line over ·029 and read off the answer ·000841.

The solution of such problems as $(2{\cdot}56 \times 3{\cdot}1)^2$ is accomplished at a single setting by the following method.

Set 1 on the *C* scale at 2·56 on the *D* scale and, with the hair line at 3·1 on the *C* scale, read off the answer 63·0 on the *A* scale.

SQUARE ROOTS

To obtain the square root of a number the procedure is, of course, just the opposite to that of obtaining the square, the reading being taken from the *A* scale down to the *D* scale, or the *B* scale down to the *C* scale with the aid of the hair line. One of the most important factors in taking a square root of a number is to place it in the correct section of the *A* or *B* scales.

Whereas the square of, say, 6·5 is the same as the square of 65, excepting for the location of the decimal point, the square roots of 6·5 and 65 are vastly different.

In extracting the square root it would be correct to place 6·5 in the first section of *A*, 65 in the second section, 650 in

the first section, 6500 in the second section, and so on.

The following set of rules are to be applied :—

1. If the number be more than unity, mark off the digits in pairs to the left of the decimal, and if the number be less than unity, mark it off to the right of the decimal. Thus 1'01'05·6 or ·56'47'2.

2. Should the left-hand side group consist of only one significant figure as 1'01'05·6, use the first section of A.

3. Should the left-hand side group consist of two significant figures as ·56'47'2, use the second section of A.

4. The square root of a number above unity will have as many whole numbers as there are groups of two, or parts of groups contained in the original number, and the square root of a number below unity will have as many noughts immediately following the decimal point as there are groups of noughts immediately following the decimal point in the original number.

EXAMPLE : $\sqrt{4330{\cdot}0} = 65{\cdot}8$

Mark it off thus, 43'30·0, and as the left-hand group consists of two figures—43—therefore, by rule 3, set it on the second section of the *A* scale as 43·30 and on the *D* scale read off 658 ; as there are two groups to the left of the decimal, the square root will have two numbers to the left of the decimal (rule 4) or 65·8.

CUBES

The cube of a number can be found by using the *A*, *B*, *C*, *D* scales, but there is a more simple method by utilizing a special scale, graduated into three logarithmic units.

EXAMPLE : $1{\cdot}8^3 = 5{\cdot}83$

Place 1 of the *C* scale on 1·8 of the *D* scale and the hair line at 1·8 on the *B* scale ; and opposite this on the *A* scale will be found the answer 5·83. Obviously, what has been done is to square 1·8 and multiply the answer by 1·8.

However, by using the special scale (*Cu*), cubes or cube roots can be solved with a single setting of the hair line.

Thus to find 14^3 set the hair line to 1·4 on the *D* scale and read off 2·744 on the *Cu* scale.

EXAMPLE: $410^3 = 69{,}000{,}000$

Set the hair line at 4·10 on the *D* scale and read off 69·0 on the *Cu* scale.

CUBE ROOTS

In extracting the cube root of a number it must be placed in the correct one of the three logarithmic units which form the *Cu* scale.

1. If the number be more than unity mark off the digits in threes to the left of the decimal, and if the number be less than unity mark it off in threes to the right of the decimal.

2. Should the left-hand side group consist of only one significant figure as 1'456·8 or ·005'689, set it on the first section of the Cu scale.

3. Should the left-hand side group consist of two significant figures as 14'568·0 or ·056'890, use the middle section of the Cu scale.

4. Should the left-hand side group consist of three significant figures as 145'680·0 or ·568'90, use the third, or right-hand, section of the Cu scale.

5. The cube root of a number above unity will have as many whole numbers as there are groups of three, or parts of groups, contained in the original number to the left of the decimal point, and the cube root of a number below unity will have as many noughts immediately following the decimal point as there are groups of noughts immediately following the decimal point in the original number.

EXAMPLE: $\sqrt[3]{58411 \cdot 0} = 38 \cdot 8$

Mark it off thus, 58'411·0, and as the left-hand group

consists of but two figures—58—set the hair line over 58·411 on the middle section of the *Cu* scale (rule 3), and on the *D* scale read off 388.

As there are two groups or parts of groups to the left of the decimal, the answer is 38·8 (rule 5).

EXAMPLE: $\sqrt[3]{\cdot 000055} = \cdot 038$

Mark it off ·000'055. By rule 3 use the middle section of the *Cu* scale and obtain a reading on the *D* scale of 38, which, by rule 5, becomes ·038, as there was one complete group of noughts immediately following the decimal.

RECIPROCALS

The value $\frac{1}{n}$ can be obtained by a single setting of the hair line over *n* on the *C* scale, the corresponding value on the *Reciprocal* scale being the answer required.

EXAMPLE: The reciprocal of 105 = ·00952

Set the hair line over 105 on the *C* scale and the corresponding value on the *Reciprocal* scale of 952, actually ·00952, is the answer required.

The value $\frac{1}{n^2}$ is obtained by setting the hair line over *n* on the *Reciprocal* scale, and the corresponding value on the *B* scale is the answer required.

EXAMPLES: $\frac{1}{2^2} = \cdot 250$ $\qquad \frac{1}{3^2} = \cdot 111$

$\frac{1}{35 \cdot 2^2} = \cdot 0008$ $\qquad \frac{1}{\cdot 002^2} = 250{,}000$

The value $\frac{1}{\sqrt{n}}$ is obtained by setting the hair line over *n* on the *B* scale (in accordance with rules 2 and 3 Square Roots), and reading off the answer on the *Reciprocal* scale.

EXAMPLE: $\frac{1}{\sqrt{\cdot 0056}} = 13 \cdot 37$

By rule 3 on Square Roots, place the hair line at 56 on the *B* scale, and on the *Reciprocal* scale read off 1337.

In finding the value of $\frac{1}{n^3}$ and also $\frac{1}{\sqrt[3]{n}}$, care must be taken to have the slide so that numbers on the *C* and *D* scales coincide.

To obtain the value $\frac{1}{n^3}$ it is only necessary to place the hair line over n on the *Reciprocal* scale and read off the answer on the *Cu* scale.

EXAMPLE : $\frac{1}{2 \cdot 5^3} = \cdot 064$

Setting the hair line over 2·5 on the *Reciprocal* scale, read off 64 on the *Cu* scale.

The value $\frac{1}{\sqrt[3]{n}}$ is found by setting the hair line over n on the *Cu* scale, and the corresponding value on the *Reciprocal* scale is the answer.

EXAMPLE : $\frac{1}{\sqrt[3]{98 \cdot 5}} = \cdot 2164$

By rule 3 on Cube Roots, place the hair line over 98·5 in the middle section of the *Cu* scale, and on the *Reciprocal* scale read off the value ·2164.

EXAMPLE : $\frac{1}{\sqrt[3]{\cdot 775}} = 1 \cdot 09$

By rule 4 on Cube Roots, use the right-hand section of the *Cu* scale, and solve by the same method as the example above to arrive at the answer of 1·09.

LOGARITHMS

Bring the hair line over the number on the *D* scale and read off the logarithm under the hair line on the *L* scale. This scale gives only the mantissa of the logarithm, the characteristic being determined in the usual way.

Thus to find the logarithm of 54·8, set the hair line to 548

on the *D* scale and on the *L* scale read off 739. The logarithm is thus 1·739.

It will be seen that to find the mantissa, the decimal point in the original number is ignored as when tables are being used. Should antilogarithms be required, the procedure is to read from the *L* scale to the *D* scale.

INVOLUTION

Using logarithms and calling the answer z.

$$\log x^a = \log x \times a$$
$$= \log z$$
$$\text{Thus } z = \text{antilog}(\log x \times a)$$

Find the logarithm on the *L* scale of x on the *D* scale, and transfer this, with the correct characteristic to the *D* scale. Multiply by a on the *C* scale and read the product on the *D* scale. Set the mantissa of this on the *L* scale and find the antilogarithm on the *D* scale. The characteristic then determines the location of the decimal point.

EXAMPLE : $3^{4 \cdot 5} = 140 \cdot 3$
$\log 3 = \cdot 477$ (characteristic is 0)
$0 \cdot 477 \times 4 \cdot 5 = 2 \cdot 147$
$\text{antilog } 2 \cdot 147 = 140 \cdot 3$

EVOLUTION

To find the value $\sqrt[a]{x}$, the logarithm of x is first found on the *L* scale and transferred with the correct characteristic to the *D* scale. It is divided by a on the *C* scale and the quotient is read on the *D* scale. The mantissa of this is set on the *L* scale and the antilog is found on the *D* scale. The characteristic then determines the location of the decimal point.

EXAMPLE : $\sqrt[6 \cdot 075]{2000} = 3 \cdot 49$
$\log 2000 = \cdot 301$ (Characteristic 3)
$\frac{3 \cdot 301}{6 \cdot 075} = \cdot 543$
$\text{antilog of } 0 \cdot 543 = 3 \cdot 49$