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INSTRUCTIONS

for the use of the models
RIETZ and LOG-LOG

Diwa

SLIDE RULES

Instructions for the use of the models
RIETZ and LOG-LOG

Notice: To make possible the smooth movement of the slide the stock is elastic and is easily adjusted by bending it slightly inwards or outwards after removal of the slide and the cursor.

If the slide sticks the groove may be greased with solid paraffin. (Never use talc or sand-paper). Do not move the the slide quickly backwards and forwards to obtain a smoother movement.

The cursor must be replaced from the right with the spring upwards towards the bevelled edge.

The DIVINYL is most easily cleaned by means of a few drops of liquid soap on a ball of cottonwool. (Never use petrol, benzine, or the like).

Protect the slide rule against direct exposure to the sun and heat over 50° centigrade (120° F.), e. g., from strong electrical bulbs, radiators and the like.

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As an invention the slide rule is not new. Only a few years after the publication of Henry Brigg's treatise on common logarithms the first slide rule was constructed by Winsgate, England, in 1627, so it might seem somewhat difficult to understand why it should take 300 years for the slide rule to come into general use; this is mainly due to the fact that technical skill only recently has reached the high standard required for slide rule production. The crude hand-made slide rule of 300 years ago little resembles a DIWA slide rule of to-day, the manufacture of which calls for machinery and materials unknown even 35 years ago.

Although it is an advantage to have a fair knowledge of the fundamental theory of the slide rule, this is unnecessary for the practical application to general engineering and business calculations, just as it is possible to drive a car without knowledge of the basic principles of its construction.

No slide rule can be used for addition or subtraction, and such calculations as can be made on a slide rule have only a certain degree of accuracy; this, however, is sufficient for technical purposes, and after the acquirement of some skill differences will vary between 1 and 4 ‰ depending on the number of factors involved.

Various types of DIWA slide rules are available for different purposes. The following instructions deal with the most commonly used slide rule, the RIETZ. The model RIETZ SCHOOL, on which some scales have been omitted, and the LOG-LOG Slide Rules are dealt with on pages 12—14.

The slide rule consists of three main parts:

THE STOCK OR BODY has 4 logarithmic scales K, A, D, and L on the face (see fig. 3) and on the bevelled edge a double scale divided into milimetres and inches. The reversible centre SLIDE has on the face three scales B, CI, and C, and on the back three trigonometrical scales S, S & T, and T.

On the RIETZ SCHOOL model, however, the trigonometrical scales are placed on the face of the stock.

The CURSOR, (runner or indicator) has a transparent pane with one black and two red hairlines engraved.

The different scales are marked by letters at the left end.

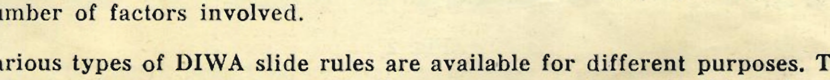


Fig. 1.

With a single exception all scales are divided logarithmetically, the divisions decreasing from left to right. The principal scales C & D (fig. 1) cover one logarithmic cycle, i. e., all numbers between 1 and 10. As seen from the figure the distance between 8 and 9 is much smaller than the distance between 1 and 2; consequently the subdivisions at the right end of the scale have not the same value as the subdivisions at the left end of the scale. Each logarithmic cycle is divided into 10 parts corresponding to the first significant figure in any number (fig. 2), each of these major divisions is subdivided into 10 parts corresponding to the second significant figure. In the interval from 1 to 2 these subdivisions are marked by the numbers 11, 12, 13, 14, and so on.

The left third of the scale is furthermore divided into ten tertiary parts, each of these has the value of "one" corresponding to the third significant figure, 1, 2, 3, and so on; the center part is divided into five parts, each of these has the value of "one" corresponding to the third significant figure 2, 4, 6, and 8; the right third is only subvided once, the line corresponding to the cipher 5. Fig. 2 shows several examples of how to read the scale.

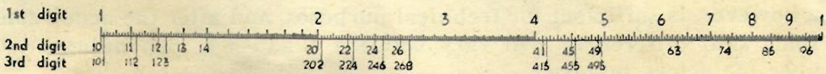


Fig. 2

To read three or four significant figures it is necessary to infer or interpolate between the tertiary divisions. 253 for instance lies between 252 and 254. 1253 lies between 125 and 126. After some practice it is possible to infer $\frac{1}{10}$th of a division.

It must be noted that by setting and reading the slide rule no attention is paid to the decimal point or to the total number of figures. The decimal point is not determined until the final result has been reached. The numbers 13200, 132, 1.32, and 0.0132 have the same setting as only the ciphers and the sequence of these are considered. Before the slide rule is taken into use it is necessary to familiarize oneself with the various settings and readings. As the scales A, B, and K are divided into more logarithmic cycles than the fundamental scale D, the subdivisions of these scales have not the same value, although the general trend is the same.

The scales on the face of the slide rule are used as follows:

SCALE C and D (Fundamental scales). These two scales, which are placed closely together on the slide and on the body, are exactly alike and used for multiplication, division, and other problems of this kind. The scale has a length af 250 mm and covers one logarithmic cycle.

SCALE A and B (Squares and square roots) are close together on the upper part of the body and the slide, covering two logarithmic cycles, each 125 mm long. They may either be used instead of the scales C and D for multiplication, division, etc., or together with the scales C and D for problems af squares and square roots.

SCALE K (Cubic scale). This top scale covers 3 logarithmic cycles, and is used to compute cubes and cube roots.

SCALE L (Logarithmic scale), is a uniformly graduated scale. Combined with scale D it is used for finding common logarithms of numbers.

SCALE CI (Reciprocal scale) on the slide is an inverted scale exactly like the scale C, with the divisions running from right to left. Opposite each number on scale C a corresponding number is found on CI; the product of these numbers equals 1.

Three scales used for solving trigonometrical problems are found on the reverse side of the slide on model RIETZ (on model SCHOOL two of these scales are placed on the face of the stock, the S & T scale being left out):

SCALE S which in conjunction with scale C gives the values of the trigonometric function "sine" from 0.1-1 (sin 5° 43' — sin 90°).

SCALE T which likewise in conjunction with scale C gives the values of the trigonometric function "tangent" from 0.1-1 (tg 5° 43' — tg 45°).

SCALE S & T. Since the values for "sin" and "tg" for small angles are nearly equal, this scale is common for values between 0.01 and 0.1 (35' — 5° 43').

INSTRUCTIONS FOR USE

To simplify explanations we will call the number 1 graduation mark at the beginning of all scales the left-hand index, and the number 1 graduation mark at the end of any scale the right-hand index.

MULTIPLICATION: To multiply one number by another place the left or the right index of the scale C over one of the numbers on the scale D, and read the answer on the D scale under the other number on the C scale.

a) 3×16. Opposite 3 on D set the left index of C, find 16 on scale C, and read the answer (48) on scale D.

b) 6.2×0.35. Opposite 62 on scale D set the right index of the slide, use the indicator to find 35 on scale C and read the answer (217) under the hair-line on scale D. The problem is solved without regard to the decimal point, but by mental calculation it is found to be 2.17. When multiplying three or more factors it is unnecessary to write down the result of each single multiplication, but the cursor is used to indicate and keep it temporarily fixed.

c) $3.2 \times 4.5 \times 36$. Place the right index over 32 on scale D, move the indicator to 45 on scale C without reading the answer (144), set the left index under the indicator-line, and find the answer (518) on scale D opposite 36 an scale C. The exact result is 518.4, and the error consequently less than 1/1000.

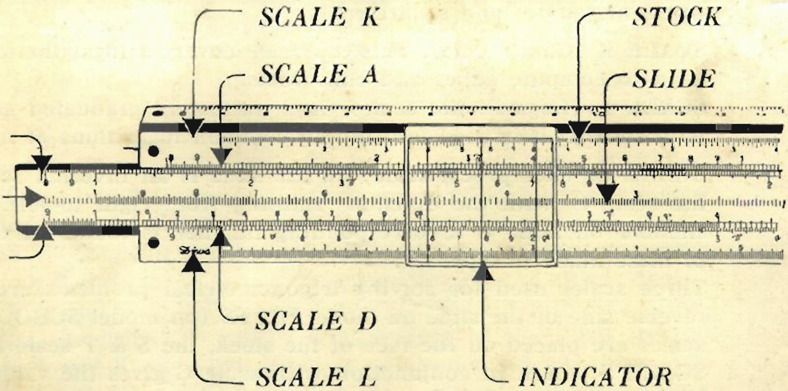


Fig. 3.

DIVISION: To divide one number by another set the divisor on scale C against the dividend on scale D — using the cursor — and read the answer on scale D either under the right or the left index. This operation is the reverse of multiplication; the result may be controlled by multiplying with the divisor; the answer being the dividend.

a) 18 ÷ 3. Find 18 on scale D, place 3 on scale C opposite this, and read the answer (6) under the right index.

b) 58 ÷ 250. Find 58 on scale D, place 25 on scale C opposite this, and read the answer (232) on scale D without regard to the decimal point. The right answer is easily seen to be 0.232.

COMBINED MULTIPLICATION AND DIVISION: Where an expression of the form $\frac{7 \times 5}{6}$ is to be evaluated, this may be done in one operation. Start by dividing 7 by 6 — setting 6 on scale C opposite 7 on scale D — without taking note of the intermediate result, the combined answer (583, i. e. 5.83) is found on scale D opposite 5 on scale C.

THE NUMBER OF DIGITS in a number larger than 1 is the number of figures to the left of the decimal point. In a decimal fraction the number of digits is a negative number numerically equal to the number of zeros between the decimal point and the first significant figure.

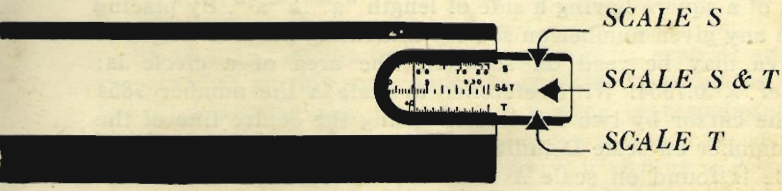
Examples:						
Number..........	637	63.7	6.37	0.637	0.0637	0.00637
Number of digits .	3	2	1	0	— 1	— 2

The decimal point in the result can be determined by the following

DIGITRULES:

a) When the slide projects to the left:

Multiplication: When two or more factors are multiplied together using the



D and C scales, the number of digits in the product is equal to the sum of the numbers of digits in the factors: $605 \times 22 = 13310$ $(3 + 2 = 5)$.

Division: The number of digits in the quotient is equal to the number in the dividend minus the number in the divisor: $242 \div 4 = 60.5$ $(3 - 1 = 2)$.

b) When the slide projects to the right the number of digits in the divisor or in one factor is counted 1 less than according to the rules above.

Multiplication: $15 \times 49 = 735$ $(2 + (2 - 1) = 3)$.

Division: $8.25 \div 500 = 0.0165$ $(1 - (3 - 1) = -1)$.

When deciding the decimal point according to the digit rules the extensions over the right and left index must not be used. In division this also applies to the right index on scale D on the stock when the slide projects to the right.

Ordinarily a quick mental calculation with approximate numbers will be sufficient to decide the decimal point.

SQUARES AND CUBES.

Opposite any number on the scale C or D read its square on scale B or A or its cube on scale K, using the hairline on the cursor for exact identification.

a) 3.2^2 Place the cursorline over 32 on scale D, and read the result (102 = 10.2) on scale A opposite 3.2.

b) 3.2^3 Place the line over 32 on scale D, and read 328 = 32.8 on scale K opposite 3.2.

c) $3.2^4 = (3.2^2)^2 = 10.2^2 = 104$.

SQUARE-ROOTS. The square-root of a number is found as follows: opposite the number on scale A, read the square root on scale D using the cursor; use the left half of D, if the number has an ODD number of digits, and the right half, if the number has an EVEN number of digits before the decimal point.

a) $\sqrt{169} = 13$ number of digits: ODD, left half.

b) $\sqrt{64} = 8$ number of digits: EVEN, right half.

c) $\sqrt{640} = 25.3$ number of digits: ODD, left half.

AREAS. The area of a square having a side of length "a" is "a^2". By placing the cursor line on any given number on scale D indicating the side length of a square, the area may be read on scale A. The area of a circle is: square of diameter × 0.7854. With reference to scale A the number 7854 is indicated on the cursor by two red lines. Placing the centre line of the cursor over any number on scale D indicating the diameter of a circle, the area of this circle is found on scale A under the lefthand red line. Conversely, if the area is known, the diameter is found by placing the centre line over the area on scale A, and reading the diameter on scale D under the righthand red line.

a) Sidelength or diameter: 3 ft. Area of square: 9 sqft. Area of circle: 7.07 sqft.

b) Area 13 sq. inches. Sidelength of square: 3,6 inches. Diameter of circle: 4.07 inches. Use the left or the right half of scale A according to the rules mentioned under "square-roots".

CUBE-ROOTS. The cube-root of a number is found as follows: Opposite a given number on scale K read the cube-root on scale D using the cursor. If the number of digits in the given number can be divided by 3, i. e. 0,3,6, etc. use the right third of the scale, if by dividing the number of digits with 3 the remainder is 2, i. e. — 1, 2, 5, 8 use the middle third. If the remainder is 1, (— 2, 1, 4, 7, etc.) use the left third of the scale K.

a) $\sqrt[3]{8000} = 20$ number of digits: 4 divided by 3, remainder 1 (left)

b) $\sqrt[3]{64} = 4$ — — 2 — 3 — 2 (middle)

c) $\sqrt[3]{125} = 5$ — — 3 — 3 — 0 (right)

d) $\sqrt[3]{640} = 8.62$ — — 3 — 3 — 0 (right)

RECIPROCALS. Opposite any number on scale C its reciprocal is read on scale CI (red).

a) Opposite 2 on C read $1 \div 2 = 0.5$ on scale CI.

b) Opposite 0.45 on C read $\frac{1}{0,45} = 2.22$ on scale CI.

Note that the subdivisions on scale CI read from right to left.
Besides permitting the reading of reciprocal numbers, the CI scale can be used in multiplication and division in conjunction with the D scale.
MULTIPLICATION. To multiply 2 numbers set the cursor on one of the factors on scale D, move the slide so that the other factor on the CI scale

is under the hairline, and read the product on the D scale under the right or the left hand index.

a) 27×31, set the cursor on 27 (scale D), bring 31 on scale CI under the hairline, and read the product (837) on scale D, under the right hand index.

DIVISION: is the reverse operation.

b) $42 \div 2.5$, set the right index over 42 on scale D and read the result (16.8) on this scale under 25 on scale CI using the cursor.

The CI-scale may also be used for finding corresponding numbers when their product is predetermined. As follows this may be used for solving 2nd degree equations of the form $x^2 + ax + b = 0$ by seeking among all pairs of numbers with the product b, those two the sum of which equals -a.

Example: $x^2 - 7.7x + 12.1 = 0$.

Place left index of C opposite 12.1 on scale D. Opposite 2 on scale D is 6.05 on scale CI, their sum being 8.05 or too high, opposite 3 is 4.03, their sum being too small. When slowly moving the cursor from 2 towards 3 the corresponding numbers 2.2 and 5.5 will be found to have the sum 7.7 and be the roots of the equation.

LOGARITHMS. The scale L is used to decide the mantissa or decimal part of the common logarithm of a number.

Opposite a given number on scale D read the mantissa of its logarithm on scale L. The characteristic is decided by use of rules with which the reader is assumed to be familiar. Determining the number when its logarithm is known is of course the reverse operation, using the characteristic to decide the number of digits, the mantissa to decide the numerical value.

a) log 32; read 505 giving the logarithm as 1.505.

b) $\log x = 2.70$; read $x = 501$.

TRIGONOMETRY: It is assumed that the reader is familiar with common trigonometrical problems. The following instructions are only valid for the model RIETZ.

SINE. If the value of any angle on the sine scale S is set opposite the index line in the slot on the reverse side of the rule, the right index on scale D will coincide with the sine value read on scale C.

a) sin 35°; read 0.574 on scale C.

For angles between 35' — 5° 43' use the S & T scale, which is common for both sine and tangent, reading the numerical values as mentioned above. The decimal point is determined in such a manner that the value is 0.01—0.1.

b) sin 4° = tan 4°; read 0.0698 on scale C.

TANGENT. Set the angle value on scale T opposite the index line on the pane in the slot on the reverse, and read the numerical value of the tangent on scale C over the right hand index. The numerical values of tg 5° 42'—45° are 0.1—1.

a) tg 18°; read 0.325 on scale C.

To find the tangent of an angle between 45°—84° use the formula $\tan A = \frac{1}{\tan(90 - A)}$, the value being read on scale D under the left-hand index of scale C.

To find the COSINE use the fact that $\cos A = \sin 90 - A$.

COTANGENT is found by the formula $\cot A = \frac{1}{\tan A}$

The following factors are of value when using the slide rule:

$\pi = 3.1416$ (ratio of circumference to diameter of circle).

$c = \sqrt{\frac{4}{\pi}} = 1.128$

$\varrho = 0.01745 = \frac{\pi}{180}$

These elementary instructions in the use of the slide rule are intended for the beginner who has no previous training in mathematics. It is impossible to describe briefly all the different uses of a slide rule, but more complete books of instruction are available, in which extensive information can be found, including the fundamental theory of the slide rule.

System RIETZ SCHOOL No. 701.

This model is all DIVINYL and very thin. Consequently all scales are placed on the face of the rule, the L-scale above the K-scale on top of the stock, and the two trigonometric scales below the D-scale on the lower part of the stock. S and T-scales are exactly as the corresponding scales on the reverse side of the slide of model RIETZ but differ in use. By being placed fixedly along the D-scale, the three scales together make up a set of tables of values of sine 6—90° and tangent 6—45° (numerical value: 0.01—0.1). The numerical value of any trig. function is found by placing the hairline over the angle read on the trig-scale, and reading the num. val. on the D-scale under the hairline and vice versa.

a) sine 31°, read 0.515 on scale D
b) tangent 31°, read 0.601 on scale D
c) sine 3° 30' = tg 3° 30', read 0.061 on scale D
d) find the angles corresponding to the values 0.45 af sine or tangent. Place the hairline on 45, scale D, and read sine 25, 75°, tangent 24,25°
e) find the angle corresponding to the value 0.045 of sine or tangent. As above and read sin = tan = 2° 34,7'.

By angles or functions outside the above mentioned intervals proceed as under RIETZ; for angels less than 6° the values of sin and tang may be substituted by the corresponding circular arch.

By compound calculations containing trig-functions it will be necessary to start or end with the trig-function.

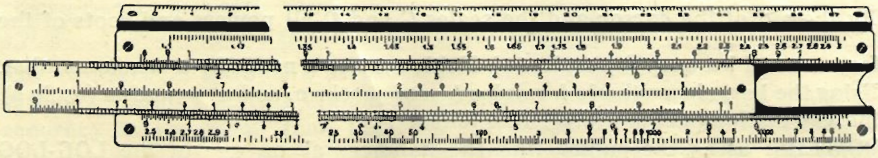


Fig. 4

LOG-LOG, NOS 361 and 561

The DIWA LOG-LOG slide rule differs from the DIWA RIETZ only in the following respects:
The L-scale is placed on top of the stock above the scale K, and below the scala D are placed three log-log scales LL1, LL2, and LL3 covering respectively the values $e^{0.01} - e^{0.1}$, $e^{0.1} - e^{1}$ and $e^{1} - e^{10}$, together giving all equations of the form a^{n} & a^{1-n} for values between 1.01 and 22000.
Multiplication, division, squares, square roots, cubes, and cube roots, and all trigonometrical calculations are performed in the same way and as easily as on the model RIETZ. On the other hand it is necessary to be fully acquainted with the use of the common slide rule and with basic mathematics to get the full benefit of a LOG-LOG slide rule.

The three log-log scales should be considered as one continous scale divided into three parts. The scales are so arranged that on the lower part $e^{0.01}$ coincides with the left hand index and $e^{0.1}$ with the right hand index, on the middle part $e^{0.1} = 1.105$ coincides with the left hand index 1, and $e^{1} = 2.7183$ with the right hand index, while the upper part has $e^{1} = 2.7183$ at the left hand index, and $e^{10} = 22026$ at the right hand index. The log-log scales can be used in conjunction with the scale D only, and does not cover numbers outside the above mentioned range.

NATURAL LOGARITHMS AND ANTI-LOGARITHMS.
Against any number on the LOG-LOG scale the natural logarithm of this number is found and vice versa.

Against	1.04	on scale	LL 1	read	$\ln 1.04$	$= 0.0392$	on scale	D
—	1.4	—	LL 2	—	$\ln 1.4$	$= 0.337$	—	D
—	140	—	LL 3	—	$\ln 140$	$= 4.94$	—	D
—	0.02	—	D	—	$e^{0.02}$	$= 1.0202$	—	LL 1
—	0.2	—	D	—	$e^{0.2}$	$= 1.221$	—	LL 2
—	2	—	D	—	e^{2}	$= 7.39$	—	LL 3

The common logarithm is found by multiplying the natural logarithm by 0.4343.

INVOLUTION AND EVOLUTION.

By the aid of the cursor and the scales C and D all powers and roots of the form a^n and $\sqrt[n]{a}$ may be evaluated. Neither *n* nor *a* needs be a whole number. Using the basic logarithmic formulas $ln\ a^n = n \times \ln\ a$, and $a^n = \text{anti-ln}\ (n \times \ln\ a)$, the calculations are performed as follows:
POWERS: using the cursor find the number "a" on one of the LOG-LOG scales, thereby deciding the ln of the number read on scale D; bring the right or left index of the slide under the cursor line and multiply by the exponent, finding the answer on the LOG-LOG scale by setting the cursor-line against the exponent.

EXAMPLES:
$1.4^2 = 1.96$. Bring the left index of the slide rule under 1.4 on scale LL 2 (using the cursor), and read the answer on scale LL 2, against 2 on scale C.
$1.4^{2.2} = 2.1$. Proceed as above but read the answer against 2.2 on scale C.
$1.4^{5.1} = 5.56$. Bring the right index of the slide under 1.4 on scale LL 2 (using the cursor) and read the answer on scale LL 3, against 5.1 on scale C, voluntary using the CI-scale according to rules.

COMPOUND INTEREST
The scale LL 1 is especially usable for calculating compound interest, this being a special case of power-calculation, the number usually being 1—1.08 while the exponent is a larger interger.
Example:
$1.045^8 = 1.422$. Bring the hairline over the number 1.045 on LL 1. Multiply on scale D by 8 and read the answer on scale LL = 1.422. This number is the factor by which a capital should be multiplied to find the value after eight years of compound interest at 4.5 % p. a. The final calculation will have to be performed on scale C and D, i. e.: £ 22 increase to 22×1.422 = £ 31.25 or £ 31.5.0 d.

ROOTS.

Roots of the form $\sqrt[n]{a}$ can be written as $a^{\frac{1}{n}}$. To find a root of any number proceed as under powers, but instead of multiplying divide by the exponent.

Example:
$\sqrt[4.6]{6.3} = 6.3^{\frac{1}{4.6}} = 1.492$. Set the cursor against 6.3 on scale LL 3 bring 4.6 on scale C under the cursor-line, and read the answer on scale LL 2 above the right hand index on the slide. The reciprocal scale CI can be used instead of the scale C, the proceeding by powers and roots being reversed. If it is necessary to operate with numbers outside the normal range of the

LOG-LOG scale, it will often be possible to find the result by simple circumscriptions as:

$0.7^{1.35} = 7^{1.35} \div 10^{1.35} = 13.8 \div 22.4 = 0.616.$

The two powers are found as above and the results divided.
Circumscriptions of this kind may sometimes be used to attain a greater accuracy in the result than the small divisions of the scale LL3 permit, although it must be remembered that the intermediate results are found with the normal inaccuracy.

Example:

$6^{4.8} = 2^{4.8} \times 3^{4.8} = 28 \times 194 = 5430\ (5434).$

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