Roots for any desired numbers

The exponent is set on D, the basic value being set, above it, on the LL scales, after which the result is found on the LL scales, above D 1 or D 10.

$\sqrt[4.4]{23} = 2{\cdot}04$; place cursor at D 4·4, then place LL_3 23 above it; place cursor at D 10, and find the result, 2·04, above it, on LL_2.

Examples for practice: $\sqrt[0.6]{15{\cdot}2} = 93{\cdot}5$; $\sqrt[5]{2} = 1{\cdot}149$; $\sqrt[5]{20} = 1{\cdot}82$.

Logarithms to any desired base

The base of the corresponding LL scale is placed above D 1 (or D 10) and the logarithm (on D) is then found underneath the number (on LL).

Example: $\log^{5} 25 = 2$; place LL_3-5 above D 1, then place cursor at LL_3-25, and find the logarithm, 2, underneath it, on D.

Examples for practice: $\log^{20} 400 = 2$; $\log^{5} 230 = 3{\cdot}38$; $\log^{20} 1{\cdot}82 = 0{\cdot}2$.

Logarithms to base 10

Move the slide to the left until LL_3-10 is above D 1. Readings can now be taken as follows: log 10 = 1; log 100 = 2; log 1000 = 3; log 200 = 2·301; log 2 = 0·301; log 20 = 1·301; log 1·1 = 0·0414.

Readings of the characteristics are taken simultaneously. Decimal point rule: Starting from LL_3, divide the numbers by 1; starting from LL_2, divide the numbers by 10.

The 2nd Sine Scale S'

is on the back of the slide and is used with the slide reversed. For settings the initial mark of the scale is marked by the index e of the LL_3 scale and the final mark of the scale by the index line for 90°.

As the scale is movable, multiplications and divisions of angular functions can be carried out simply without having to take readings of the functional values.

Example: $\sin 41^0 \times \sin 23^0 = 0{\cdot}2562$

Place the final mark of the scale over S 41 (lower body of rule) with the aid of the cursor line. Below S' 23 (centre of slide) we find the result 0·2562 on scale D.

For multiplications $a \times \sin \alpha \times \sin \beta$ we always start with a on scale D.

Example: $\tan b = \tan 40^0 \times \cos 12^0 = 0{\cdot}82$; $b = 39{\cdot}35^0$.

$$\tan \beta = \frac{\tan 37^0}{\sin 14^0} = 3{\cdot}117;\ \beta = 72{\cdot}2^0$$

$$\sin \beta = \frac{\cos 33^0}{\cos 48^0} = 0{\cdot}1254;\ \beta = 7{\cdot}2^0$$

The care of the slide rule:

CASTELL slide rules are valuable precision implements and require careful handling.

They are made of an ideal special plastic material. This is highly elastic and thus unbreakable provided it is competently handled. It will stand up to climatic conditions; it is moisture-proof and non-inflammable and will resist the majority of chemicals. These silde rules should nevertheless not be allowed to come in contact with corrosive liquids or powerful solvents, which are at all events liable to attack the colouring-agents applied to the graduation-marks even if they do not actually harm the material itself. If necessary, the smooth movement of the slide can be improved by the use of vaseline or silicon oil. In order not to detract from the accuracy of the readings, the scales and the cursor should be protected from dirt and scratches and should be cleaned with the special cleaning agents CASTELL No. 211 (liquid), or No. 212 (cleaning paste).

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No. 57/88
No. 57/89

FABER-CASTELL

Instructions

for the use of Students Slide Rules
System "Advanced Rietz" No. 57/88
System "Super Log-Log" No. 57/89

The faces of school slide rules No. 57/88 "Advanced Rietz" and No. 57/89 "Super Log-Log", have the full graduation of the Rietz system plus a supplementary tangential scale for angles of 45°-84·5°. Unlike most school slide rules on the market, therefore, these models enable the tangential functions of angles of over 45° to be set and read off direct.

Description of the slide rule

The slide rule consists of three parts:
The rigid main part, which is the actual **body of the slide rule.**
The movable **slide**, moving in the grooves of the main body.
The **cursor**, which has a number of graduation marks and which moves over the body of the rule and the slide.

Main scales

Scale **A**: square scale from 1 to 100 — on upper section of stock
Scale **B**: square scale from 1 to 100 — on upper edge of slide
Scale **CI**: reciprocal scale from 10 to 1 — on centre of slide (reading from right to left)
Scale **C**: basic scale from 1 to 10 — on lower edge of slide
Scale **D**: basic scale from 1 to 10 — on lower section of body

These main scales enable the most important types of calculation to be carried out, such as multiplication, division, the formation of tables, the calculation of proportions, the squaring of numbers and the extraction of square roots.

Supplementary scales

An inch-scale on the upper edge of the slide rule body.
K: cubic scale from 1 to 1000 — on upper section of body
L: mantissa scale from 0 to 1 — on centre of slide
S: sine scale from 5·5° to 90° — on lower section of slide
ST: sine-tangent scale 0·55° to 6° — on lower section of slide
T_1: tangent scale from 5·5° to 45° — on lower section of slide
T_2: tangent scale from 45° to 84·5° — on lower section of slide

Further supplementary scales of the slide rule No. 57/89

Scale LL_2: exponential scale from 1·1 to 3·2 on back of slide
Scale **S**: 2nd sine scale (sin, cos) from 5·5°-90°
Scale LL_3: exponential scale from 2·5 to 10^5 on back of slide

The decimal point

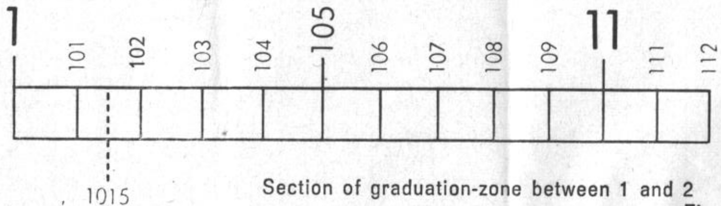
As the upper scales only extend from 1 to 100 — while the lower scales, in fact, only cover the values from 1 to 10 — the beginner may receive the impression that the slide rule only enables numbers within this range to be dealt with. This is a misconception. In slide rule calculations, the decimal value of a number — i.e. the position of the decimal point — is disregarded. If the reading taken from a scale is 3, this may just as easily denote 0·3, 300, 0·03, 30000, etc.

In the result, too, the user must himself insert the decimal point where required. In practical problems this never presents any difficulty.

The slide rule can thus be used for calculations involving **any** numbers.

Reading the scales

Not every graduation mark can be accompanied by its valuation number; space would not allow of this. There are thus only a limited number of "guide-figures". It should be noted, however, that the subdivisions are not uniform from end to end of the slide rule, since towards the right the marks are closer together.

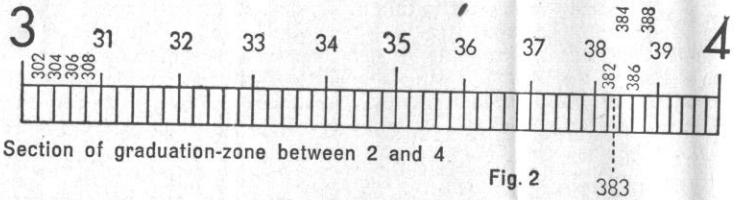


Section of graduation-zone between 1 and 2

Fig. 1

From guide figure 1 to guide figure 1·1 (Fig. 1)

10 subsections of 10 intervals each (= 1/100 or 0·01 per graduation-mark). This enables 3 figures to be read off accurately (e.g. 1-0-1) without any further operation. By **halving** the distance between 2 graduation-marks, 4 figures can be accurately set (e.g. 1-0-1-5). The last figure in such cases will invariably be a 5.

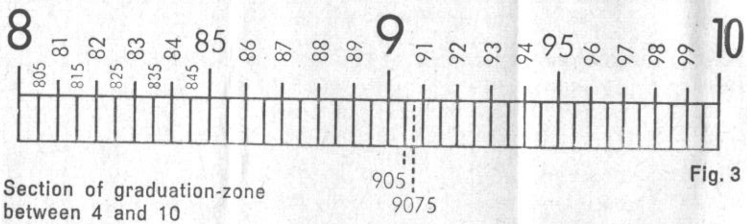


Section of graduation-zone between 2 and 4

Fig. 2

From guide figure 3 to guide figure 4 (Fig. 2)

10 subsections of 5 intervals each (= 1/50 or 0·02 per graduation-mark). This enables an accurate reading to be taken of 3 figures (3-8-2). The last figure will always be even (2, 4, 6, 8). If the intermediate spaces are halved, the odd numbers 1, 3, 5, 7, 9 will also be obtained (3-8-3).



Section of graduation-zone between 4 and 10

Fig. 3

From guide figure 8 to guide figure 10 (Fig. 3)

10 subsections (in each case) of 2 intervals each (= 1/20 or 0·05 per graduation-mark).
This enables 3 figures to be read off accurately if the last figure is a 5 (9-0-5). By halving the intermediate spaces it is even possible to obtain 4 exact figures. The last figure, in this case likewise, is invariably a 5 (9-0-7-5).

The marks π, M, $\frac{\pi}{4}$, ϱ, C and C_1

Various constants frequently used are specially marked:
$\pi = 3{\cdot}1416$ on the scales A, B, CI, C, D.

$M = \frac{1}{\pi} = 0{\cdot}318$ on the scales A and B.

Intermediate marking for $\frac{\pi}{4} = 0{\cdot}785$ on A and B.

$\varrho = \frac{\pi}{180} = 0{,}01745$

The marks C and C_1 (not to be confused with C 1 on left of the slide) facilitate the calculation of cross sections from a given diameter.

Example: If the cursor-line is used to place C above 2·82 inch on scale D (first placing the cursor-line above 2·82 on D, then placing mark C beneath it — the cross section (6·24 sq.in.) can then be seen on scale A above the initial 1 of the upper slide scale B (henceforth termed B 1 in all cases).

In place of mark C, mark C_1 could also have been used. (Not to be confused with the initial 1 of the lower slide scale C, henceforth termed C 1 in all cases). The result may then be seen, above B 100 (the 100 on scale B), on scale A. When setting, use the C or C_1 marks, whichever of the two entails least movement of the slide.

Forming tables

(1) To convert yards into metres.
Basic equivalent: 82 yards equal 75 metres. Use the cursor-line to bring the 82 on scale D and the 75 on scale C into line with each other. This is done by first placing the cursor-line above D 82 and moving the slide the required distance to the right, so that C 75 is underneath it and thus opposite D 82.

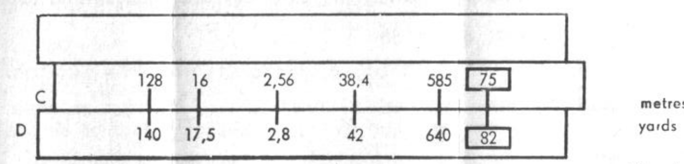


Fig. 4

The cursor-line is now placed above the known yard-value on D; the number of metres can then be seen above it on C, and vice versa:
For example: 17·5 yards = 16 m; 140 yards = 128 m; conversely, 38·4 m = 42 yards; 2·56 m = 2·8 yards, 585 m = 640 yards.

It may happen that certain values cannot be set up and read off because the slide would have to be pulled out too far to the left or to the right.

For 105 yards, for example, the equivalent (96 m) cannot be read. In this case recourse is made to the operation known as "moving the slide through", in other words, the re-setting is provided by placing the cursor-line above C 1, and the slide moved to the left until C 10 is underneath the cursor-line. A reading can now be taken of the remaining values as well.

(2) If a "unit value", e.g. 1 yard = 0·914 metres, is known instead of a "standard equivalent", then C 1 or C 10 (for 1 yard) is placed above 0·914 on scale D. The cursor-line again enables yards and metres to be read off from C and D.

(3) The value 1 inch = 25·4 mms. is often required. C 1 is placed above D 25·4 and readings are then taken by the aid of the cursor-line, e.g. 17″ = 43·2 cm, or 37″ = 94 cm. In the case of 42″, for example, we again find that we cannot set the rule and take a reading in the ordinary way, and have to replace C 1 by C 10.

(4) In all settings, see that the unit-value and the equivalent are at the ends of the scale, under C 1 and above D 10 respectively, and that readings can be taken in both directions. Thus, if C 1 is above D 25·4 (for 1″ = 25·4 mm), then the value 0·3937 will be found on scale C, above D 10 (for 1 cm = 0·3937″).

Multiplication

The chief scales used here are the main scales C and D.

Example: 2·45 × 3 = 7·35

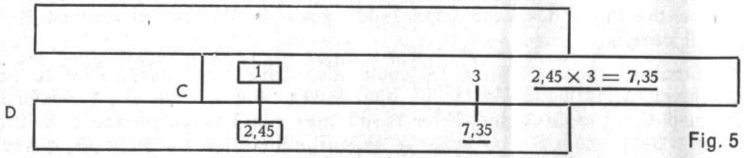


Fig. 5

The 1 at the beginning of the slide (**C** 1) is placed above 2·45 on the lower section of the rule (**D** 245), and the cursor-line above the 3 on the lower graduation of the slide (**C** 3); the product 7·35, is then shown, underneath the cursor-line, on the lower section of the rule (**D** 735).
Here again, it may happen that the second factor on scale C and the result on scale D cannot be set and read respectively, in the ordinary manner. As before, recourse is made to the operation of "moving the slide through"; the cursor-line is placed above C 1 and the slide pushed to the left, until C 10 is underneath the cursor-line. A practised user of the slide rule knows immediately the most advantageous setting to select.

Example: 7·5 × 4·8 = 36

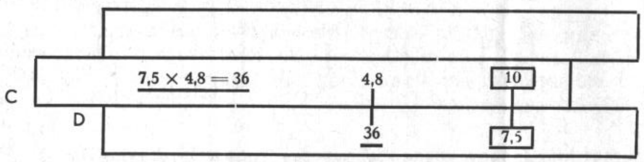


Fig. 6

C 10 is placed above D 7·5, the cursor-line is placed over the 2nd factor 4·8 on C, and the result 36 is found underneath it, on scale D.
The "C 10 setting" is generally used if the first two figures, when multiplied together, are greater than 10.
In a series of calculations when, for example, the number is first of all squared, multiplication-operations can continue on A and B.

Example: 2·5 × 3 = 7·5

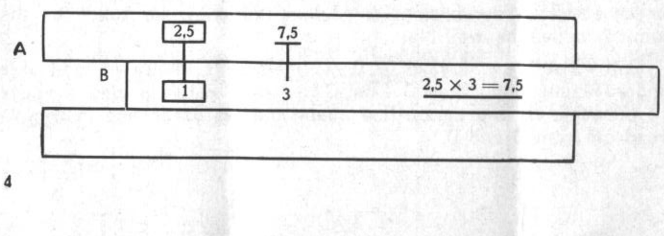


Fig. 7

The index figure of the slide scale (**B** 1) is placed under the 2·5 on the lower graduation of the rule (**A** 25), the cursor-line is placed above the 3 on the upper slide graduation (**B** 3), then the product 7·5, is to be found beneath the cursor-line on the upper section of the rule (**A** 75).

Examples for practice: Setting C 1: 1·82 × 3·9 = 7·1; 0·246 × 0·37 = 0·091
Setting C 10: 4·63 × 3·17 = 14·7; 0·694 × 0·484 = 0·336

Division

With the aid of the cursor-line, numerator and denominator on C and D are placed opposite one another; the result can then be found underneath the index figure of the tongue, C 1, or end of the tongue, C 10.

Example: 9·85 ÷ 2·5 = 3·94

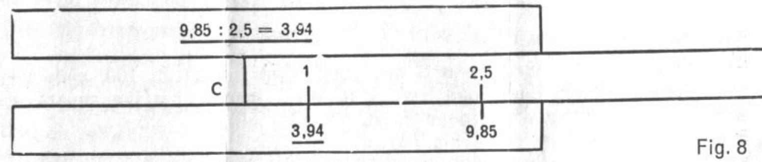


Fig. 8

The cursor-line is first of all placed above the numerator 9·85 on the lower scale D, and then the denominator 2·5 (on graduation C) under the cursor-line.
Numerator and denominator are now opposite each other, and underneath the beginning of the slide, C 1, the result (3·94) can be found on scale D. Division can naturally proceed on A and B likewise. Here again, the numerator (on A) and the denominator (on B) are placed opposite one another, with the aid of the cursor-line, and the result is found on scale A above B 1 or B 100.

Examples for practice: 970 ÷ 26·8 = 36·2; 285 ÷ 3·14 = 90·8;
0·685 ÷ 0·454 = 1·51.

Calculations with the reciprocal scale CI

This scale is subdivided from 1 to 10, and its system of graduations corresponds to that on scales C and D, but takes the opposite direction.

(1) If, for a given value a, the reciprocal 1 ÷ a is required, the former is set on C or CI, and the reciprocal can then be found above it on CI or underneath it on C. The reading can be taken merely by setting the cursor, without adjusting the slide.
Examples: 1 ÷ 8 = 0·125; 1 ÷ 2 = 0·5; 1 ÷ 4 = 0·25; 1 ÷ 3 = 0·333

(2) If **1 ÷ a^2 is required,** the cursor-line is moved to the value a on scale CI, and the result may be found above it, on B, likewise underneath the cursor-line.
Example: 1 ÷ 2·44^2 = 0·168 Quick guide to position of decimal point: Less than 1/5th = 0·2

(3) If 1 ÷ $\sqrt{a}$ is required, the cursor-line is placed at a on scale B, and the result is found on CI, likewise beneath the cursor-line.
Example: 1 ÷ $\sqrt{27{\cdot}4}$ = 0·191 Quick guide to position of decimal point: Less than 1/5th = 0·2

(4) **Scales D and CI also enable multiplications to be carried out.** (Division by the reciprocal = multiplication). This method is popular with many users.
Example: 0·66 × 20·25. Proceed as in division, i. e. first place the cursor-line above 0·66 on D, the 20·25 on CI then being placed under the cursor-line; the product, 13·37 can then be found on D under C 1.

(5) **Products with a number of factors** can thus be found very simply. The first two factors are multiplied, as in (4) in the foregoing, C 1 above, the result 13·37 immediately providing the setting for the multiplication with the next factor (the first multiplication-method studied).

Example: 0·66 × 20·25 × 2·38 = 31·8. We calculate 0·66 × 20·25 as under (4), and have the setting C 1 above the intermediate result; the cursor-line is now placed above the 3rd factor, 2·38 on C. The result, 31·8 may be found underneath it, on D.

This could now be immediately followed by a further multiplication, by placing the next factor, on Cl, underneath the cursor-line, the result being found on D, beneath C 1, (or C 10 as the case may be).

Multiplications can thus be carried out alternately by the aid of D and Cl followed by the use of C and D, in accordance with the first method studied.

Square and square root

Since the upper scales **A** and **B** are subdivided from 1 to 100, with the lower scales being subdivided from 1 to 10, it means that the square of any number on **D**, can be found on **A**.

Example: $2{\cdot}3^2 = 5{\cdot}29$ (Fig. 9 a)

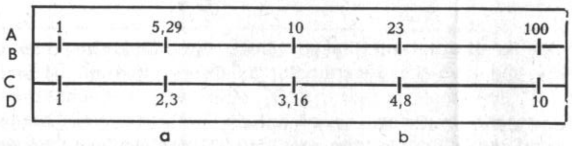


Fig. 9

The cursor-line is placed above the 2·3 on D, and the result, 5·29, is found under the cursor-line on A.

Examples for practice: $1{\cdot}345^2 = 1{\cdot}81$; $4{\cdot}57^2 = 20{\cdot}9$; $0{\cdot}765^2 = 0{\cdot}585$

The square root is obtained by setting the basic number on **A**, the result being the number shown underneath it, on **D**.

Example: $\sqrt{23{\cdot}1} = 4{\cdot}8$ (Fig. 9 b).

The cursor-line is placed above 23·1 on **A**, the result, 4·8, being found underneath the cursor-line, on **D**.

In the extraction of square roots, it is not immaterial which scale section of A or B is used, for values of 1 to 10 can only be set in the first half, whilst 10 to 100 must be taken on the second section.

Values outside this range in either direction have to be adjusted, by splitting up the powers, so that they come within the range 1-10 or 1-100, as the case may be, as shown in the following examples:

$\sqrt{1936}$. This is equivalent to $\sqrt{100} \times \sqrt{19{\cdot}36} = 10 \times \sqrt{19{\cdot}36} = 10 \times 4{\cdot}4 = 44$

$\sqrt{145{\cdot}8}$. This is equivalent to $\sqrt{100} \times \sqrt{1{\cdot}458} = 10 \times \sqrt{1{\cdot}458} = 10 \times 1{\cdot}207 = 12{\cdot}07$

If we wish to avoid "splitting off" the powers of 10, the following purely "mechanical" method of setting may be noted:

On the left-hand half, the figures must be set which have one, three, five, etc. digits in front of the decimal point, or one, three, five etc. noughts after the decimal point; on the right-hand half, those figures must be set which have two, four, etc. digits in front of the decimal point, or two, four etc. noughts (or no noughts at all) after the decimal point.

Cube and cube root

The cube scale consists of three equal sections, 1-10, 10-100 and 100-1,000, and is used in conjunction with **D**. The cursor is placed above the value on **D**, the cube being found above it, on **K**.

Examples: $2{\cdot}66^3 = 18{\cdot}8$; $1{\cdot}54^3 = 3{\cdot}65$; $2{\cdot}34^3 = 12{\cdot}8$; $6{\cdot}14^3 = 232$.

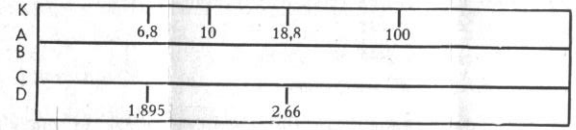


Fig. 10

If the cube root is to be extracted, the converse process is adpoted. The setting is made on **K** and the reading taken from **D**.

Examples: $\sqrt[3]{6{\cdot}8} = 1{\cdot}894$; $\sqrt[3]{4{\cdot}66} = 1{\cdot}67$; $\sqrt[3]{29{\cdot}5} = 3{\cdot}09$; $\sqrt[3]{192} = 5{\cdot}77$.

If the basic number is below 1 or above 1000, it must be adjusted (by "splitting off" appropriate powers) so that it falls within the 1-1000 range, as when extracting square roots.

The trigonometrical scales S, ST, T_1 and T_2

The trigonometrical scales S, ST, T_1 and T_2 are subdivided decimally, and show, in conjunction with the basic scale D, the angular functions; when the converse process is adopted, they indicate the angles.

Use as tables

When using the scales S, ST, T_1 and T_2 in conjunction with scale D, as a **trigonometrical table**, the following should be noted:

The S scale, in conjunction with the **D scale,** provides a **sine table.**

The S scale with the values of the complementary angles (increasing from right to left) provides — in conjunction with the **D scale** — a **cosine table.**

The two **T scales,** in conjunction with the **D scale,** provide a **tangent table,** up to 84·5°.

The two **T scales,** with the values of the complementary angles (increasing from right to left) provide — in conjunction with the **D scale** — a **cotangent table.**

To find:	Setting:	
sin 13° = cos 77° = 0·225	S 13° — D 0·225	Only the long cursor-line is required for these settings.
sin 76° = cos 14° = 0·97	S 76° — D 0·97	
cos 28° = sin 62° = 0·883	S 62° — D 0·883	
cos 78° = sin 12° = 0·208	S 12° — D 0·208	
tan 32° = cot 58° = 0·625	T_1 32° — D 0·625	
tan 57° = cot 33° = 1·54	T_2 57° — D 1·54	
cot 18° = tan 72° = 3·08	T_2 72° — D 3·08*	
cot 75° = tan 15° = 0·268	T_1 15° — D 0·268*	
	* or:	
cot 18° = tan 72° = 3·08	T_1 18° — Cl 3·08	Set with the long cursor-line, with the slide rule set to **zero.**
cot 75° = tan 15° = 0·268	T_2 75° — Cl 0·268	

The **ST scale** provides, with **D scale**, a table of the **arc function (circular measure of an angle)** and — when the correction-marks are used — a sine or tangent scale for the angles 0·55°—6°.

As an arc scale (for circular measurement of angles):

Set the angle value on ST and find the functional values on D (by the aid of the cursor-line).

Examples: arc 2·5° = 0·0436; arc 4·02° = 0·07; and conversely:

$\widehat{0{\cdot}04} = 2{\cdot}29°$; $\widehat{0{\cdot}021} = 1{\cdot}205°$.

The arc scale also applies to the ten-fold angle values, but the function must then be multiplied by 10.

Examples: arc 31° = 0·541; $\widehat{0{\cdot}64} = 36{\cdot}7°$.

As a **tangent scale or sine scale for small angles,** up to 3^0 in the case of the tangent or up to 5^0 in the case of the sine, in accordance with the equation $\tan \alpha \approx \text{sine } \alpha \approx \text{arc } \alpha$.

Examples: $\tan 2{\cdot}5^0 \approx \text{sine } 2{\cdot}5^0 = 0{\cdot}0436$

$\tan 4^0 \approx \text{sine } 4^0 = 0{\cdot}0697$

For an **exact** reading of tangent 4^0, the correction-mark to the **right** of the graduation-mark for 4^0 is used. The reading taken is 0·0699.
The following should be noted as regards the correction-marks for the tangent:

Tangent **greater** than arc, therefore use correction-mark to the **right** of the graduation-mark.

Example: $\tan 5^0 = 0{\cdot}0875$.

If the angle is in between the full graduations provided with correction-marks, the correction-interval must be transferred accordingly.

Example: $\tan 3{\cdot}5^0 = 0{\cdot}0612$; $\tan 4{\cdot}2^0 = 0{\cdot}0734$; $\tan 5{\cdot}33^0 = 0{\cdot}0934$.

If the functional value is known, and the angle is required, the correction-mark to the **left is used.**

For the sine, the correction-mark is provided to the **left** of graduation-mark 6^0. It applies to the range 5^0—6^0.

Here the operation is carried out as above, but in the opposite direction.

Calculations with trigonometrical scales S, ST, T_1 and T_2

As every function is a ratio "from side to side", all that has to be done in each case is to place the **graduated part of the D scale** alongside that of the **CI scale.** By dropping a perpendicular from the final point of this "series addition" on to the corresponding angle-function scale (ST for 0·1 x; S and T_1 for 0·1 x and T_2 for x) the angle-value can immediately be read off.

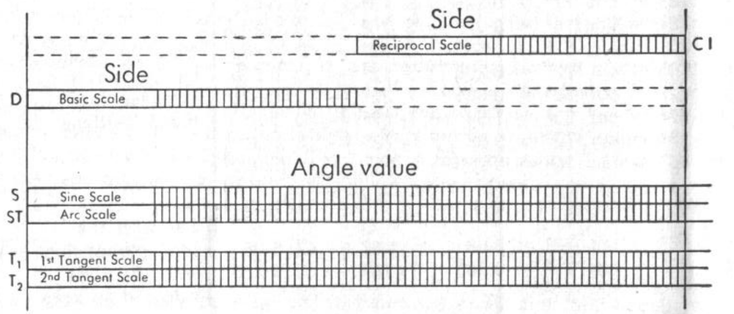


Fig. 11

Even when the angle and one side are known, however, the same system of calculations can be used, but in this case the angle-value first has to be found by the aid of the cursor-line and account taken of the corresponding side of the triangle, on scales D or CI.

Examples for the rectangular triangle

Example: 1. Known: a = 3, b = 4. To find α and c.

Place C 1 above D 3, place cursor-line on CI 4, and find the angle-value, $36{\cdot}9^0$, for α, on the T_1 scale. With the cursor at S $36{\cdot}9^0$, we now find the hypotenuse, 5, **on CI.**

2. a = 30, b = 4. To find α and c.

The **setting is carried** out as above, i.e. C 1 above D 3, cursor-line on CI 4, but find the angle, i.e. $82{\cdot}4^0$ for α, on the T_2 scale (since $30 \div 4$ is more than 1). To find c, move cursor to S $82{\cdot}4^0$; the value for c, i.e. 30·3 is now found on CI.

3. a = 3, b = 40. To find α and c.

The setting is carried out as above, but the angle i.e. $4{\cdot}28^0$ is found on ST (the first reading being $4{\cdot}3^0$ and a "correction towards the right" giving $4{\cdot}28^0$). Using this "corrected setting" $4{\cdot}28^0$, we find the value for c, i.e. 40·2 on CI.

4. a = 8·2, b = 21·6. To find c and α.

C 10 above D 8·2, cursor at CI 21·6, value of α ($20{\cdot}78^0$) found on T_1 scale. Place cursor at 20·78 of S scale, and find value of c (23·1) on CI.

5. a = 21·6, b = 8·2. To find c and α.

C 1 above D 21·6, cursor at CI 8·2, value of α ($69{\cdot}22^0$) shown on T_2 scale. Place cursor at 69·22 of S scale, and find value of c (23·1) on CI.

One further example with the use of the correction-mark:

6. a = 51·2, c = 612. To find α and b.

C 1 above D 51·2, cursor at CI 612. Reading ($4{\cdot}8^0$) taken from ST scale. Now move to the right by the distance of the tangent correction-interval, and take the reading b = 610 on CI.

Examples for scalene triangle:

This is governed by the equation $\dfrac{a}{\sin \alpha} = \dfrac{b}{\sin \beta} = \dfrac{c}{\sin \gamma}$

1. a = 38·3; $\alpha = 52^0$; $\beta = 59^0$; $\gamma = 69^0$. To find b and c.

Place C 383 above S 52^0. With the aid of the cursor-line, the results b = 41·7 and c = 45·4 can be found on C, above S 59^0 and 69^0.

2. $\alpha = 6^0$, $\beta = 5^0$, c = 165. To find a and b.

It is known that $\gamma = 180^0 - (\alpha + \beta) = 169^0$, and
$\sin \gamma = \sin (180^0 - \gamma) = \sin 11^0$.

We thus place C 165 above S 11^0 and can then find the angles, with the aid of the cursor-line, on the arc-scale and with the use of the correction-mark, the values for a = 90·4 and b = 75·4 then being shown on the C scale.

Cosine and cotangent are obtained by the aid of the complementary angles $\cos \alpha = \sin (90^0 - \alpha)$; $\cot \alpha = \tan (90^0 - \alpha)$.

Examples:

1. b = 1·17; a = 2·23. To find α and c.

Place C 1 above D 1·17 and place cursor at CI 2·23. Underneath, on the T_1 scale, the reading $62{\cdot}3^0$ is given for α (inverse, red figures). Now place cursor at (inverse, red figures) $62{\cdot}3^0$ on the S scale. The reading for c = 2·52 is given above, on CI.

2. b = 4·42; c = 46·2. To find α and a.

Place C 1 at D 4·42. Place cursor at CI 46·2. On ST (inverse) the reading $84{\cdot}52^0$ is given for α. (If account is taken of the "correction-value", i.e. one "graduation-mark width" to the **right**, we obtain the exact reading 84·5).

Now place cursor to (inverse) $84{\cdot}5^0$ of ST scale (take tangent correction into account) and obtain reading 46 for a on CI, above.

Use of ϱ-mark

The ϱ-mark can also be used to determine the circular measurement or arc function, in accordance with the equation

$$\varrho \times \alpha = 0{\cdot}01745 \times \alpha = \text{arc } \alpha.$$

If C 1 is placed above ϱ on D, this provides an arc table on D (angle-value on C).

Examples: arc $2{\cdot}5^0 = 0{\cdot}0436$; arc $0{\cdot}4^0 = 0{\cdot}00698$.

Use cursor for setting and reading.

The mantissa scale L

This operates in conjunction with scale D and enables readings to be taken of the logarithms to base 10 — in the zero-position (index line left of D 1).

Example: log 1·35 = 0·1303. Log 13·5 = 1·1303. Place the cursor-line above 1·35 of scale D and find result (1303) above it on L.

As usual, the user determines the characteristic himself.

Conversely, the basic number for the logarithm can be found by placing the cursor at L and finding the result underneath it, on D.

Examples for practice: log 3 = 0·477; log 36·2 = 1·5585; log 1·479 = 0·170; or alternatively, log sin 25^0 = log 0·4225 (on C) = 0·626—1 (on L) = 9·626—10; the cursor can thus be used to take a direct reading, L-626, starting from S 25^0 (only in zero position!).

The "Multi-line" cursor

The "Multi-line" cursor enables a number of important types of calculations to be performed.

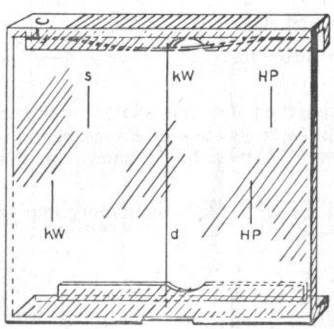


Fig. 12

(1) Calculation of the area of a circle, from a given diameter.
The central cursor line marked "d" or the right-hand lower cursor-line is placed above the diameter, 3·2 in., on the scale **D**, and the result (8·04 sq.in) is read off, from the "s", resp. "d" cursor-line to the left of it, on the scale **A.**

(2) Calculation of the volume of a cylinder.
We proceed as in example 1, but in this case the cross section (here s = 8·04 sq.in.) also has to be multiplied by the height (e.g. 12 in.). Result: 96·48 cub.in.

(3) Conversion of kW into HP and vice versa.
Example: 48 h.p. = 35·8 kW. The cursor-line "HP" is placed above the 48 on the scale **A**. Underneath the **kW** cursor-line the required number of watts, 35·8, is found, likewise on **A.**

Using both the cursor-lines HP and kW, the same conversion can also be performed on scales C and D.

Supplementary scales only for No. 57/89

The exponential scales LL_2 and LL_3

For calculations with the exponential scales LL_2 and LL_3, the slide is reversed before being inserted. LL_2 and LL_3 then slide along A and D respectively.

1. The transition from LL_2 to LL_3 (with the cursor-line) provides powers of 10:
   Examples: $1{\cdot}204^{10} = 6{\cdot}4$; $1{\cdot}365^{10} = 22{\cdot}5$; $1{\cdot}135^{10} = 3{\cdot}55$.
2. The transition from LL_3 to LL_2 provides the 10th root:
   Examples: $\sqrt[10]{75} = 1{\cdot}54$; $\sqrt[10]{6{\cdot}4} = 1{\cdot}204$; $\sqrt[10]{52} = 1{\cdot}485$.

Powers of e ≈ 2·718

These are obtained by setting the exponents on D, with the aid of the cursor, the e-mark being above D 1 (only in zero position!).
The power of e is then shown on the LL scales; with LL_3 for the D scale we have the range 1-10; with LL_2 we have the range 0·1-1.

Examples: $e^{1{\cdot}61} = 5$. Place the cursor-line above D 1-6-1 and obtain the result, 5, on LL_3.
$e^{0{\cdot}161} = 1{\cdot}175$. Place cursor-line at D 1-6-1, which, however, now denotes 0·161. Result: 1·175 on LL_2.
$e^{6{\cdot}22} = 500$. $e^{0{\cdot}622} = 1{\cdot}862$. $e^{2{\cdot}64} = 14$.

If the exponent of the power is negative, we use $e^{-n} = \frac{1}{e^n}$ thus calculating first of all with a positive n and then finding the reciprocal value.

Roots from e

The right-hand or left-hand e-mark is placed above the exponent, after which the value of the root is found, by the aid of the cursor line, above D 1 or D 10 (or underneath A 1 or A 100).

$\sqrt[4]{e} = 1{,}284$; $\sqrt[0{\cdot}25]{e} = 54{,}6$; $\sqrt[8]{e} = 1{,}133$; $\sqrt[0{\cdot}125]{e} = 2981$.

The Napierian logarithms

These are found by changing over from the LL scales to the basic scales. Here again, for the D scale, we have the range 1-10 when operating with LL_3 and the range 0·1-1 when operating with LL_2.

Examples: ln 25 = 3·22; place the cursor above LL_3 and find the result, 3·22, underneath it, on D.
ln 1·3 = 0·262; place the cursor above LL_2-1·3 and find the result, 0·262, underneath it, on D.

Examples for practice: ln 145 = 4·97; ln 26 = 3·26;
ln 1·84 = 0·61; ln 2·36 = 0·859.

The Napierian logarithms of numbers less than 1 are found by the equation $\ln a = -\ln \frac{1}{a}$

Powers of any desired numbers

Powers of the type a^n are obtained by setting the basic value on the LL scales above D 1 or D 10, then placing the cursor-line above the exponent on D, after which the result can be found on the LL scales.

Example: $3{\cdot}75^{2{\cdot}96} = 50$; place LL_3-3·75 above D 1, then place the cursor above D 2·96; the value, 50, is now found above it, on LL_3.

Examples for practice: $1{\cdot}89^{6{\cdot}05} = 47{\cdot}1$; $4{\cdot}2^{2{\cdot}16} = 22{\cdot}2$; $4{\cdot}2^{0{\cdot}216} = 1{\cdot}364$.
From the final example it can be seen that here again, the rule concerning the significance of the decimal point must be observed.