FABER-CASTELL

INSTRUCTIONS

for Use of

CASTELL PRECISION

POCKET SLIDE RULES

No. 67/39-Standard
No. 67/91-Standard-Trig
No. 67/87-Rietz
No. 67/87 R Rietz-Addiator
No. 67/98 b Electro
No. 67/98 R Electro-Addiator

$\sqrt[3]{527}$

4,32

$\frac{3750}{0{,}25 \cdot 4J}$

$D = \frac{\pi \, 32^2}{4}$

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Description of the Slide Rule

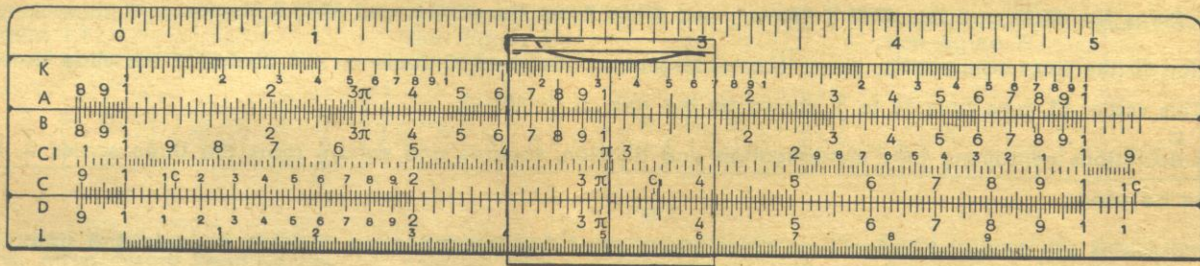


Fig. 1

Front of Slide Rule No. 67/87 System Rietz

Definition

In the following instructions, the several parts of the slide rule will be briefly referred to as follows: — The principal part is the "body", the part movable in the rule is the "slide", and the sliding perspex plate with lines across it, is the "cursor". —

For convenience, the scales are described by different letters.

The Main Scales

For the moment we will concentrate on the four most important scales on the face of the body and the slide:

A, along the lower edge of the upper part of the body
B, along the upper edge of the slide,
} From 1 to 100, shown on the rule as 1—1 (10)—1 (100).

C, along the lower edge of the slide,
D, along the upper edge of the lower part of the body.
} From 1 to 10, shown on the rule as 1—1 (10).

These are the 4 main scales — **A** and **B** move adjacent to each other (the "square" scale) and **C** and **D** likewise move alongside each other (the "basic" scale).

The Supplementary Scales

on **Slide Rules No. 67/87 and No. 67/87 R "Rietz"**, and **Slide Rules No. 67/98 b and 67/98 R Electro.**

In addition to the four main scales, there is a reciprocal, or reversed, **C** scale on the centre of the slide between **B** and **C**. This scale, **CI**, runs from 10 to 1, shown on the rule as 1 (10)—1.

For all calculations containing only multiplication and division, squares and square roots the three scales **C, D,** and **CI** should be used.

Additional scales are provided to facilitate calculations other than multiplication, division, squares and square roots:

The **Mantissa scale L** is used in conjunction with scale D for reading common logarithms and is found

on slide rules 67/87 and 67/87 R on the lower part of the rule body

on slide rules 67/91, 67/98 b and 67/98 R on the back of the slide.

The **cube scale K** is on the rule face above A. It is graduated from **1 to 1000**, shown on the rule as 1-1 (10)-1 (100)-1 (1000) and is used with scale D (only slide rules No. 67/87 and 67/87 R).

The **trigonometrical scales S** (sin, cos), **T** (tan, cot) are found on the back of the slide, and on the slide rule 67/87 R on the rule face.

The **trigonometrical scale ST** (sin/tan for small angles) is also found on the back of the slide, but only with slide rule 67/87. On slide rules 67/87 R it is found on the front of the slide rule.

The log-log scale **LL_2** on rules Nos. 67/98 b and 67/98 R is along the upper edge on the rule face, the continuation **LL_3** being on the lower edge.

The **W** and **V** scales are along the lower face of the rule. These are special scales used in electrical calculations.

Reading the Scales

Let us first examine scales C and D. These are graduated as follows:

From graduation figure 1 to graduation figure 1.2
(Section of scale reading 1 to 2)

From graduation figure 2 to graduation figure 3.
(Section of scale reading 2 to 5)

From graduation figure 5 to graduation figure 7.
(Section of scale reading 5 to 10)

Fig. 2

Each interval is equivalent to 2 subsections. An accurate reading can be taken of the values corresponding to 3 places. The odd numbers are obtained by halving the distance between two graduation marks.

Each interval is equivalent to 5 subsections. This provides an accurate reading of the values corresponding to 3 places, if the last figure is a 5.

Each interval is equivalent to 10 sub-sections. This provides an accurate reading of the values corresponding to 2 places, which moreover are identified by graduation marks.

Other **intermediate values must be estimated.** Example: To set to 318, first find 3-1-7-5 by halving the distance between 315 and 320, and then move the cursor line slightly to the right.

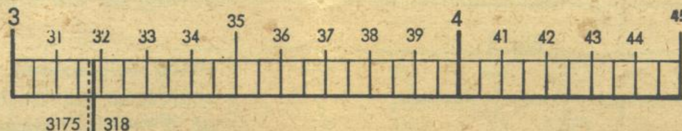


Fig. 3

A certain amount of practice should first of all be obtained in setting and reading the numbers, until one can do so with a fair degree of confidence. For this purpose, use should be made not merely of the cursor but also of the right-hand index figure 1 and left-hand index figure 1 on scale C. (On scale B also the right-hand and the left-hand figure 1 constitute index lines when setting values).

When you have become reasonably proficient at reading and setting the values, you can proceed to the use of the slide rule in actual practice.

Calculations with the Main Scales

a×b

Multiplication

Example: 2·5 × 3 = 7·5

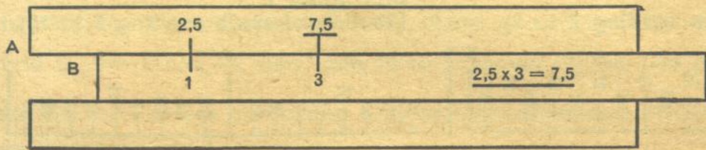


Fig. 4

The left index line 1 of the slide (scale **B**) is placed under the 2·5 of the upper "body" scale (**A** 25), the cursor line then being placed above the 3 of the upper slide scale (**B** 3). The product (7·5) can then be read off beneath the cursor line on the upper "body" scale (**A** 75).
Exactly the same procedure can be adopted on the lower scales.

Example: 2·45 × 3 = 7·35

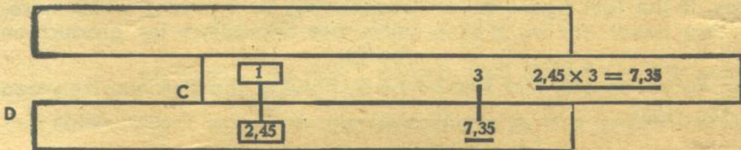


Fig. 5

The 1 on the slide (**C** 1) is placed above the 2·45 on the lower "body" scale (**D** 245), the cursor line then being placed above the 3 on the lower slide scale (**C** 3). The product (7·35) can then be read off underneath the cursor line on the lower "body" scale (**D** 735).
Setting on the C and D scales is more accurate.

Example: 7·5 × 4·8 = 36

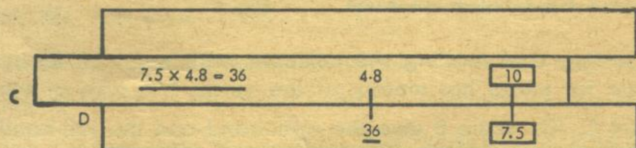


Fig. 6

When calculations are carried out on the lower scales, it will be found that the second factor of a multiplication problem sometimes cannot be selected within the scope of the lower "body" scale. In this case, **C** 10 is placed above the first factor, the cursor line then being placed above the second, after which the result can be read off, as before, beneath the cursor line.

Exercises: 1·82 × 3·9 = 7·1; 0·246 × 0·37 = 0·091; 213 × 0·258 = 54·95; 4·63 × 3·17 = 14·67; 0·694 × 0·484 = 0·336.

Division

E x a m p l e : 9·85 ÷ 2·5 = 3·94

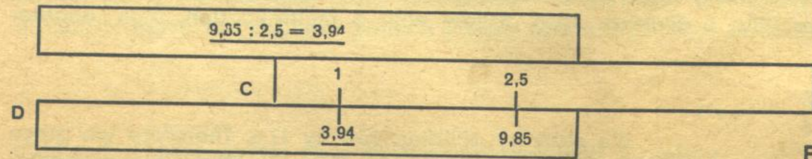


Fig. 7

Exercises:
970 ÷ 26·8 = 36·2
285 ÷ 3·14 = 90·7
7500 ÷ 835 = 8·98
0·685 ÷ 0·454 = 1·51
68 ÷ 258 = 0·264

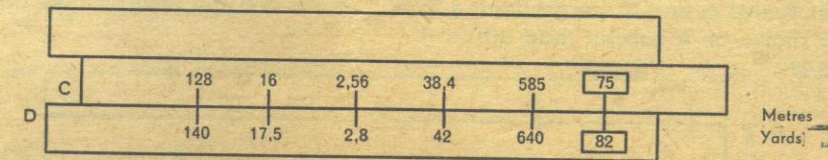
$\frac{a}{b}$

The denominator 2·5 on the lower slide scale (**C** 25) is placed above the numerator 9·85 on the lower "body" scale (**D** 985) and the quotient (3·94) is read off underneath the beginning of the slide (**C** 1).

This calculatory process can naturally be likewise performed on the upper scales. The result is read off above the beginning or the end of the slide (**B** 1 or **B** 100) on scale **A**.

Formation of Tables

E x a m p l e :
To convert yards into metres. (82 yds. equal 75 m.)



$\frac{a}{b} : \frac{c}{d} : \frac{e}{f}$

Fig. 8

Place **C** 75 over **D** 82. This automatically produces a comparative table, from which the following readings can be taken: 42 yds. are 38·4 m.; 2·8 yds. are 2·56 m.; 640 yds. are 585 m.; 16 m. are 17·5 yds.; 128 m. are 140 yds.; etc.
If the equivalent value in each case (e.g. 75 lbs. : 34 kgs.) is not known, but only the general relationship 1 lb. = 0·454 kgs, then **C** 1 (the beginning of the slide) is placed above D 4-5-4, and this provides the conversion from lbs. into kgs.

Compound Calculations

Multiplications and divisions in immediate sequence can easily be made with the slide rule. The intermediate results need not be read off if it is not necessary to know them, and, after the last setting, the correct final result will appear. It is best to begin such calculations with a division, then follow with a multiplication, then another division and again a multiplication and so on.

$$\frac{a \times b \times c}{d \times e \times f}$$

Example: $\frac{13{\cdot}8 \times 24{\cdot}5 \times 3{\cdot}75}{17{\cdot}6 \times 29{\cdot}6 \times 4{\cdot}96} = 0{,}491$

We start by dividing 13·8 by 17·6. Therefore we place **D** 138 and **C** 176 one under the other. Do not read off the answer — approximately 0·8 — but multiply it immediately by 24·5, by plac'ng the cursor-line on **C** 245. Similarly, no reading is taken of the answer — about 19 — and it is simply divided by 29·6. For this purpose, keep the cursor-line firmly in its position and slide **C** 296 under it. Once again, the result (0·65) is not "read" but multiplied at once by 3·75, this being done by placing the cursor-line on **C** 375. The result is merely "retained" by the cursor-line, as before, and divided by 4·96, by sliding **C** 496 under the cursor-line. Only then do we read off the figures of the final answer, 491, under **C** 10 and our rough calculation shows us that the actual answer is 0·491.

Squares and Square Roots

The fact that the upper scales **A** and **B** are graduated from 1 to 100 and the lower scales from 1 to 10 means that the square of any number shown on **D** can be read off on **A**.

E x a m p l e : $2{\cdot}3^2 = 5{\cdot}29$

a^2

$\sqrt{a}$

Exercises:

$1{\cdot}345^2 = 1{\cdot}81$

$4{\cdot}57^2 = 20{\cdot}9$

$0{\cdot}765^2 = 0{\cdot}585$

$67{\cdot}3^2 = 4530$

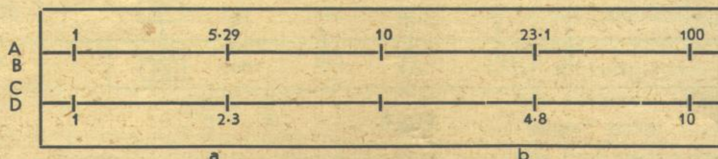


Fig. 9

Exercises:

$\sqrt{381} = 19{\cdot}52$

$\sqrt{0{\cdot}0028} = 0{\cdot}0529$

$\sqrt{18} = 4{\cdot}24$

$\sqrt{24{\cdot}3} = 4{\cdot}93$

The square root is obtained by selecting the radicand on **A** and referring to the number shown below it, on **D**. In this connection, however, it should be borne in mind that the figures from 1 to 10 are to be selected on the left-hand half of the scales **A** and **B** and those from 10 to 100 on the right-hand half. If the numbers are greater than 100 or smaller than 1, they must be brought into this range by extracting suitable powers of 10, as shown in the following examples:

$\sqrt{1922}$; move the decimal point two places to the left thus obtaining 19·22; now set the cursor line to 19·22 in the right-hand half of scale A and read above on scale D $\sqrt{19{\cdot}22} = 4{\cdot}385$. Now take $\frac{1}{2}$ of the required two places (1) and move then the value this one place back to the right and read the result 43·85.
$\sqrt{0{\cdot}746}$; move the decimal point two places to the right thus obtaining 74·6; $\sqrt{74{\cdot}6} = 8{\cdot}64$; therefore $\sqrt{0{\cdot}746} = 0{\cdot}864$.
$\sqrt{0{\cdot}000071}$; move the decimal point 6 places to the right thus obtaining 71; $\sqrt{71} = 8{\cdot}43$; therefore $\sqrt{0{\cdot}000071} = 0{\cdot}00843$.

Calculations with the Supplementary Scales

of Slide Rule Nos. 67/87, 67/87 R, 67/91, 67/98 b and 67/98 R.

The Reciprocal Scale CI (Nos. 67/87, 67/87 R, 67/98 b and 67/98 R)

1. In order to find the reciprocal value $1 \div a$ for any given number a, find a on **C** (or **CI**) and read above it on **CI** (or below it on **C**) the reciprocal value. Reading off is done therefore without any movement of the slide and entirely by setting the cursor line.

   Examples: $1 \div 8 = 0{\cdot}125$; $1 \div 5 = 0{\cdot}2$; $1 \div 4 = 0{\cdot}25$; $1 \div 3 = 0{\cdot}333$.

   $\frac{1}{a}$

2. To find $1 \div a^2$ move the cursor to a on scale **CI** and read the result above it on **B.**

   Example: $1 \div 2{\cdot}44^2 = 0{\cdot}168$.

   Estimated answer — less than $\frac{1}{5} = 0{\cdot}2$.

   $\frac{1}{a^2}$

3. To find $1 \div \sqrt{a}$, set the cursor line to a on scale **B** and find the result below it on **CI.**

   Example: $1 \div \sqrt{27{\cdot}5} = 0{\cdot}191$.

   Estimated answer — less than $\frac{1}{5} = 0{\cdot}2$.

   $\frac{1}{\sqrt{a}}$

4. **Products of three factors** can generally be reached with one setting of the slide. One sets, by means of the cursor, the first two factors against each other on **D** and **CI** respectively, moves the cursor to the third factor on **C** and reads below it on **D**, the final product.

Example: $0.66 \times 20.25 \times 2.38 = 31.8$ Estimated answer — more than $0.6 \times 20 \times 2.5 = 30$. $a \times b \times c$

5. **Compound multiplication and division**

$\frac{a}{b \times c}$

Example: $\frac{36.4}{3.2 \times 4.6} = 2.472$

One sets, by means of the cursor, the figures 3-6-4 on **D** against 3-2 on **C**. It is not necessary to read the intermediary result. Move the cursor line over 4-6 on scale **CI**, which is the same as multiplying by $\frac{1}{4,6}$ (= reciprocal value $\frac{1}{c}$). The result of 2·472 is then found under the cursor line on scale **D.**

Cubes and Cube Roots (Nos. 67/87 and 67/87 R)

The cube scale (**K**) consists of three equal sections 1—10, 10—100 and 100—1000, and is used in conjunction with **D.** Place the cursor above the value on **D**; the cube of this value is then shown above it on **K.**

Example: $2.66^3 = 18.8$.

a^3

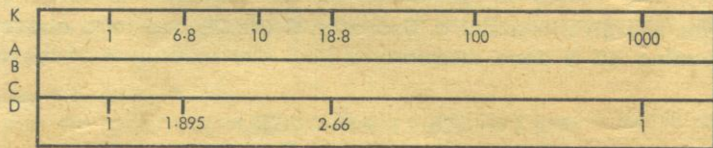


Fig. 10

Exercises:

$1.54^3 = 3.65$ $6.14^3 = 232$
$2.34^3 = 12.8$ $8.82^3 = 686$
$4.2^3 = 74.1$ $0.256^3 = 0.0168$

$\sqrt[3]{a}$

To extract the cube root, the reverse procedure is adopted. Set the cursor line to the given number on **K** and read the required root on **D** under the cursor line.

Example: $\sqrt[3]{6.8} = 1.895$.

If the radicand is less than 1 or more than 1000, it must be transferred to the interval 1—1000 by separating appropriate powers of 10 — as in the case of the square roots.

$\sqrt{1{,}260000}$; move the decimal point 6 places to the left thus obtaining 1·26; $\sqrt[3]{1.26} = 1.08$; now take $\frac{1}{3}$ of the above required 6 places = 2 places and move then the value 1·08 these two places back to the right and obtain 108.

$\sqrt[3]{14{,}000}$; move the decimal point 3 places to the left thus obtaining 14; $\sqrt[3]{14} = 2.41$; therefore $\sqrt[3]{14{,}000} = 24.1$.

The Trigonometrical Scales S, T and ST (Addiator Slide Rules see page 14)

To determine the value of sines and tangents of any angle the scales **S, T** and **ST** on the back of the slide are used. These scales are read against the index lines in the slots at either end of the back of the rule.

Reading off the sine values with Slide Rules 67/87

Example: sin 32° = 0·53

Set the angle 32° on the S-scale under the right-hand upper index line in the slot, turn the slide rule and read the value of the sine = 0·53 on scale C above D 1. All values on C must be taken as tenths.

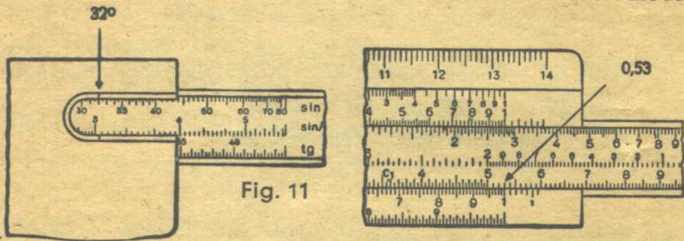


Fig. 11

Exercises:

sin 13° = 0·225; sin 76° = 0·97; sin 17°30′ = 0·301
sin 42° = 0·668; sin 26° = 0·437
cos 11° = sin (90°—11°) = sin 79° = 0·982
cos 28° = sin (90°—28°) = sin 62° = 0·883
cos 23° 30′ = 0·917

It is also possible to move the slide to the left, so that 32° comes under the upper left-hand reading mark. Over D 1 on scale C one can read off the result. Use this position preferably in case of small angles.

Example: sin 14° = 0·242

One moves the slide to the left until 14° comes under the upper left-hand index line in the slot, turns and finds over D 1 the figures on scale C 2-4-2. The cosine of an angle is found from the equation cos α = sin (90°—α).

Reading off the Sine values with Slide Rules 67/91 and 67/98 b

On these models the sine scale should be used in connection with the upper slide scale B, but all values on B must be divided by 100. After having the sine of an angle on the index of the sine scale, its value is found on B either under A 100 or under A 1.

Example: sin 32° = 0·53.

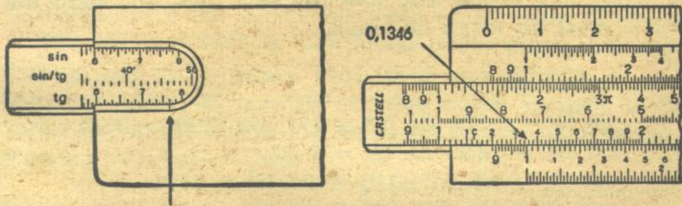
Set the angle 32° on the S-scale either under the right or the left hand upper index lines in the slots, and read off the value of the sine 0·53 on **B**, either under **A** 100 or under **A** 1. Exercises see above.

Reading off the Tan Values

The calculation of tangents and cotangents is always the same on models 67/87, 67/91, 67/98 b.

Example: tan 7° 40′ = 0·1346.

After turning the rule over, the slide is moved to the left until 7° 40′ on the tangent scale is above the left-hand reading-mark. The result, tan 7° 40′ = 0·1346, is found above **D** 1 on **C**.



7°40′ Fig. 12

Exercises:

tan 44° = 0·9655; tan 12°40′ = 0·2245; tan 8°20′ = 0·1465

tan 32° = 0·625; tan 15° = 0·268;

cotan 62° 10′ = tan 27° 50′ = 0·528

In the case of the tangent, the readings are to be divided by 10.

The cotangent of an angle is found on **D**, underneath **C** 10. It can also be found on **CI**, above **D** 1.

Example: cotan 7° 40′ = 7·43. cotan 42° 40′ = tan 47° 20′ = 1·085

With 7° 40′ on the T scale above the left index mark in the slot, read the cotan 7·43 on D, underneath C 1 or on CI, above D 1.

As the lower scale D only extends towards the right as far as 10, which in this case must be considered as 1, the tangent scale can only be extended to 45°, as tan 45° = 1. If we are concerned with angles between 45° and 90° and cotangent functions, they must be transferred into the usable interval, by means of the formulae tan α = cotan (90°-α)

and cotan $\alpha = \frac{1}{\tan \alpha}$; tan 57° $= \frac{1}{\text{cotan } 57} = 1{\cdot}54$

Examples: tan 70° = cotan 20° = 1 : tan 20°. Pull the slide out towards the left as far as the mark 20° and find tan 20° above D 1 but without taking any reading of it; the reciprocal, 1 : tan 20°, or tan 70°, is then found to be 2·75 under C 10 on D.

Scale ST for small angles (Only on slide rules 67/87)

Slide rules 67/87 have, in addition to **S** and **T** scales on the back of the slide, a scale **ST**, which enables sines and tangents of angles between 34′ and 5° 43′ to be found. Sines and tangents of such small angles are almost the same; the difference between sin 34′ and tan 34′ is only in the fourth decimal place, and that between the sine and the tangent of 5° 40′ is about 0·0005. The right-hand lower index mark is used with **ST** and the reading on scale **C** must be divided by 100. Cotangents, which are read on scale **D**, must be multiplied by 10.

E x a m p l e : sin 3° 38′ or tan 3° 38′ = 0·0634.

Set the angle, 3° 38′ on the **ST**-scale over the right-hand lower index line and read the required answer, 0·0634, on scale **C** over 10 on **D**.

Exercises: sin 2° 34′ or tan 2° 34′ = 0·0448; sin 2° or tan 2° = 0·0349

Slide Rules 67/91 and 67/98 b have no special scale ST for small angles. Their S-scale begins with 34′ and the tangent values are found by means of the S-scale, for sines and tangents of such small angles are always the same.

Marks ϱ′ and ϱ″ (on "Rietz"- and "Electro"-models)

The marks ϱ′ and ϱ″ are provided for reading the functions of very small angles.

Both are found on scale **C**, ϱ′ being between 3·4 and 3·5, and ϱ″ between 2 and 2·1.

ϱ′ is used when the angle is in minutes, ϱ″ when it is in seconds.

In the case of small angles, trigonometrical functions, sine and tangent are almost identical with the arc.

E x a m p l e : sin 17′ ≈ tan 17′ ≈ arc 17′ = 0·00495.

Set the mark ϱ′ over 1·7 on **D** and read the function on **D** under 10 on **C**.

E x a m p l e : sin 43″ ≈ tan 43″ ≈ arc 43″ = 0·0002085.

Set the mark ϱ″ over 4·3 on **D** and read the function on scale **D** under 1 on **C**.

With the slide rules that are fitted with the mark for centesimal measure (100^d to the quadrant), the same graduation (between 6·3 and 6·4 on **C**) is used for centesimal minutes and seconds.

E x a m p l e : sin $0{\cdot}17^d$ ≈ tan $0{\cdot}17^d$ ≈ arc $0{\cdot}17^d$ = 0·00267. sin $0{\cdot}0040^d$ ≈ tan $0{\cdot}0040^d$ ≈ arc $0{\cdot}0040^d$ = 0·0000628.

The Trigonometrical Scales S, T and ST on Addiator Slide Rules 67/87 R and 67/98 R

(but also for the models 67/87, 67/91 and 67/98 b)

The following chapter describes **the only means** of setting and reading the sin and tan values **on the Addiator slide rules** No. 67/87 R and 67/98 R. As an alternative to the method described on the preceding pages, No. 67/87, 67/91 and 67/98 b can also be used in this manner.

Use of the S, T and S-T Scales as Tables with Addiator-Slide-Rules 67/87 R

Addiator slide rules No. 67/87 R carry the trigonometrical scales on the front of the slide rule.

The angular functions or (with reverse reading) the angles are found by means of the cursor line in connection with scale D.

Above any angle on scale S you find the corresponding sin on scale D and above any angle on scale T you find the corresponding tan also on the scale D.

E x a m p l e : sin 32° = 0·53. Set the cursor line over 32° on scale S and read the answer, 0·53, on scale D also under the cursor line. (Divide the result by 10.)

E x a m p l e : tan 7° 40′ = 0·1346. Set the cursor line over 7° 40′ on scale T. Read the answer, 0·1346, on scale D also under the cursor line.

With the **S-T scale** the results are likewise to be read on the D scale, they are to be divided by 100.

E x a m p l e : sin 3° 38′ or tan 3° 38′ = 0·0634.

Set the cursor line on the angle 3° 38′ on the S-T scale and find below it on the D scale the sin and tan 0·0634.

The S-scale — or the T-scale — with the values of the complementary angles (increasing from right to left) provide in conjunction with the D-scale — a Cosine Table — or a Cotangent Table.

Use of the S and T Scales as Tables with Addiator-Slide-Rules 67/98 R and with 67/87, 67/91, 67/98 b

For setting and reading, reverse the slide in such a manner that the S scale is adjacent to the A scale and the T scale to the D scale. If in this position the indices of the scales of the slide coincide exactly with the indices of the scales of the rule body, the S and **A** scales (with **Addiator** slide rule 67/98 R, but also with 67/91 and 67/98 b) and the S and **D** scales (with slide rule 67/87) will be a table of sin (cos), the T and D scales with all models a table of tan (cot).

Setting and reading are done with the aid of the cursor hair-line. One finds now for every angle of the S scale the corresponding **sine:**

on scale A of slide rules **67/98 R**, **67/91** and **67/98 b**.

E x a m p l e : sin 32° = 0·53. Set the cursor line over 32° on scale S and read the answer, 0·53, **on scale A also under** the cursor line. (Divide the result by 100.)

E x a m p l e : tan 7° 40′ = 0·1346. Set the cursor line over 7° 40′ on scale T.

Exactly below it on the D scale will be found the tan of this angle, 0·1346.

The Mantissa Scale L

This scale is used with scale D for reading **common logarithms,** and may be used in place of a **three-figure table.** Naturally, it only gives the mantissae, the characteristic being found in the usual way.

E x a m p l e : lg 1·35 = 0·1303; lg 13·5 = 1·1303

Slide Rules 67/87 and 67/87 R: place the cursor line over 1·35 on scale D and read the answer on L under the cursor line.

Slide Rule 67/91 and 67/98 b:

E x a m p l e : log 1·35 = 0·1303. log 13·5 = 1·1303.

Set 1 on **C** to 1·35 on **D** and read the mantissa, 0·1303, on scale **L** against the lower index line at the right-hand end of the rule. The characteristic is found in the usual way; in this case it is 0. Therefore, log 1·35 = 0·1303.

Slide Rule 67/98 R: One reads off the logarithms with the turned slide.

For setting and reading, reverse the slide in such a manner that the S scale is adjacent to the A scale and the T scale to the D scale. If in this position the indices of the scales of the slide coincide exactly with the indices of the scales of the rule body, the **scale L** gives the mantissa in connection with scale D.

Example: lg 1·35 = 0·1303
For this example log 1·35 one sets the long cursor line over 1·35 on scale D and reads under the long cursor line on scale L the result 0·1303.

Instructions for the Use of the Four-Line Cursor

The four-line cursor makes possible, **without movement of the slide,** three very important mathematical operations:

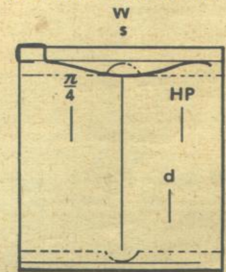


Fig. 13

1. Calculation of the area of a circular cross section from a given diameter.

Set the centre or lower right hand cursor line over the diameter, 3·2 inches, on the **lower** scale, **D,** and read on the **upper** scale, **A,** under the adjacent cursor line to the **left,** the area 8·04 sq. inches.

2. Calculation of the diameter of a circular cross section from a given area.

Set the middle or left hand cursor line over the area, 18·1 sq. inches on the **top scale, A,** and read 4·8 inches on scale **D** under the adjacent cursor line to the **right.**

The cursor lines "d" and "s" are usen for simplifying the calculation of the area of base and the volume of a cylinder.
Example: What is the volume of a cylinder 1·24 inch in diameter and 3·24 inches long?
Set the cursor line "d" on the diameter of the cylinder on scale **D** (1·24), then above it on scale **A** will be found the square of this diameter, and under the cursor line "s" on scale **A** the quotient $\frac{1{\cdot}24^2}{1{\cdot}273}$ = the cross section of the cylinder = 1·207 sq. inch.
To complete the calculation this cross section is not read off, but for the determination of the volume, the value under the cursor line "s" will ordinarily be multiplied by the length (3·24 inches). The required volume = 3·91 cub. inches.

3. The lines "W" and "HP" are used for converting Watts into HP and HP into Watts.

Example: How many Watts are 20 HP?

Set the cursor line "HP" over 20 on scale **A.** Under the cursor line "W" will be found 14,920 Watts on scale **A.**

Cursors for 67/39 and 67/91 have only one line for general calculations.

Special Scale Marks π, $\frac{\pi}{4}$, C and C_1

In order to facilitate calculations of circles there is a special mark on the rule for the number π.

Also the useful value $\frac{\pi}{4} = 0{\cdot}7854$ is marked by a small line on the **A** and **B** scales.

The marks C and C_1 on scale **C** facilitate the calculation of cross section from a given diameter.

Example: If C (or C_1) is placed above 2·82 in. on **D**, the cross section, 6·24 sq.in., can be found on **A**, above **B 1** (or **B 100**).

Select that one of the two marks which permits the greatest length of the slide to remain in the rule body.

Keeping the slide in the same position, the contents of a cylinder can be found by looking along scale **B** to the value corresponding to the height of the cylinder, and then reading off the value on **A**.

Example: If the height of the cylinder is 4 inch. the contents will be found = 25 cub. inch.

Additional Scales of Slide Rules "Electro" 67/98 b and 67/98 R

The log-log scales LL_2 and LL_3

The log-log scales on the slide rules 67/98 b and 67/98 R begin in the left top corner with 1·1 and extend to 3·2 (**LL_2**), and then continue below from the left, the portion from 2·5 to 3·2 being repeated, and end on the right below with 100,000 (**LL_3**). These two portions of the log-log scale are arranged in relation to each other and to the lower scale in a particular manner, which renders numerous applications possible.

1. Under each number of the upper log-log scale (**LL_2**) stands on the lower log-log scale (**LL_3**) its tenth power. The cursor line is used for setting.

   Example: $1{\cdot}1072^{10} = 2{\cdot}769$; $1{\cdot}204^{10} = 6{\cdot}4$;
   $1{\cdot}443^{10} = 39{\cdot}15$.

2. Over every number on the lower log-log-scale (**LL_3**) stands on the upper log-log-scale (**LL_2**) the tenth root.

   Example: $\sqrt[10]{3{\cdot}4} = 1{\cdot}1302$; $\sqrt[10]{4{\cdot}41} = 1{\cdot}16$;
   $\sqrt[10]{75} = 1{\cdot}54$.

3. Under every number **n** on scale **D** of the rule will be found e^n on the lower log-log-scale (**LL_3**).

   Example: $e^2 = 7{\cdot}39$ (Fig. 14a)
   $e^3 = 20{\cdot}1$ (Fig. 14b).

4. Over every number **n** on the lower scale (**D**) stands $e^{\frac{n}{10}}$ on the upper log-log scale (**LL_2**).

   Example: $e^{0{\cdot}23} = 1{\cdot}2585$ (Fig. 14c)
   $e^{0{\cdot}26} = 1{\cdot}2969$ (Fig. 14d), $e^{0{\cdot}336} = 1{\cdot}4$ (Fig. 14 e).

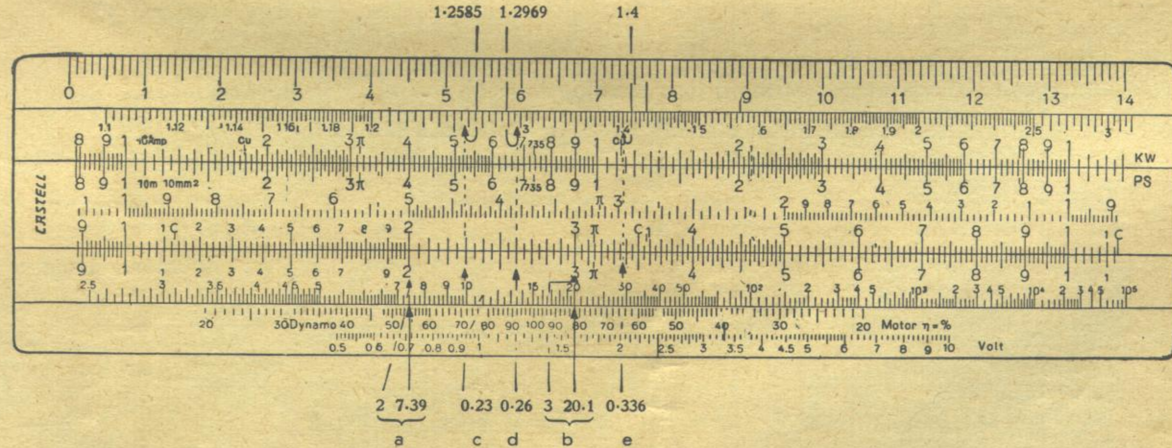


Fig. 14

5. If e^{-n} has to be worked out, read off first e^{+n} and then work out on the rule the reciprocal value.

Example: $e^{+5\cdot 2} = 181\cdot 3$, therefore $e^{-5\cdot 2} = 0\cdot 00551$.

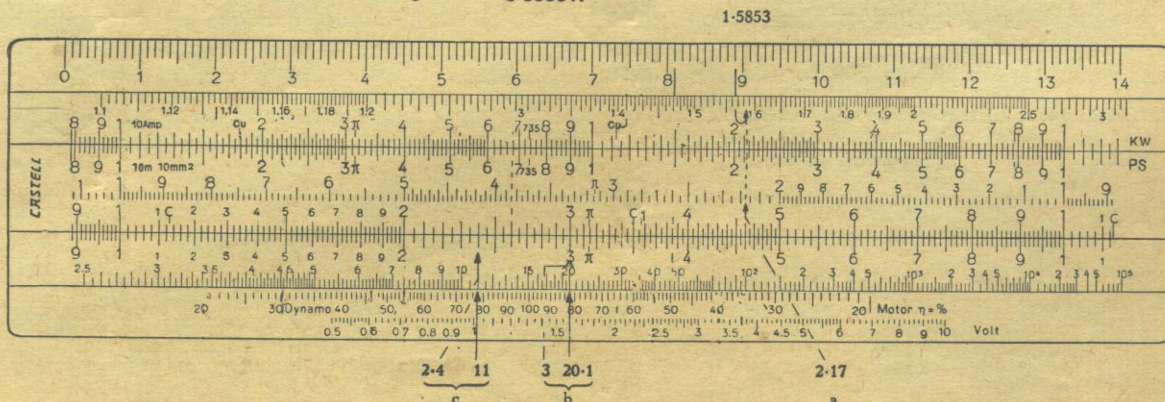


Fig. 15

6. If roots of e have to be extracted, then the exponent (such as 5) can be converted into a decimal (0·2) and the procedure of paragraph 4 followed. If the exponent is a fraction, scale **CI** may be used.

Example: $\sqrt[2\cdot17]{e} = 1\cdot5853$ (Fig. 15a)

8. If it is desired to calculate exponential equations of the form $e^{\frac{1}{y}} = \sqrt[y]{e} = a$, without determining the reciprocal value, this can be effected with the scale **CI.**

Example: $\sqrt[y]{e} = 1\cdot485$, $y = 2\cdot529$ (Fig. 16a).

7. If the exponential equation $e^x = a$ has to be solved, set a, according to its magnitude, either on the upper or lower log-log scale, and read x on the scale **D** of the rule.

Example: $e^x = 20\cdot1$; $x = 3$ (Fig. 15b)
$e^x = 11$ $x = 2\cdot4$ (Fig. 15c).

9. The values on scale **D** are the hyperbolic logarithms of the numbers on the log-log scale, so that the rule gives at once a table of hyperbolic logarithms ($\log_e$).

Example: $\log_e 94 = 4\cdot54$ (Fig. 16b)
$\log_e 1\cdot87 = 0\cdot626$ (Fig. 16c).

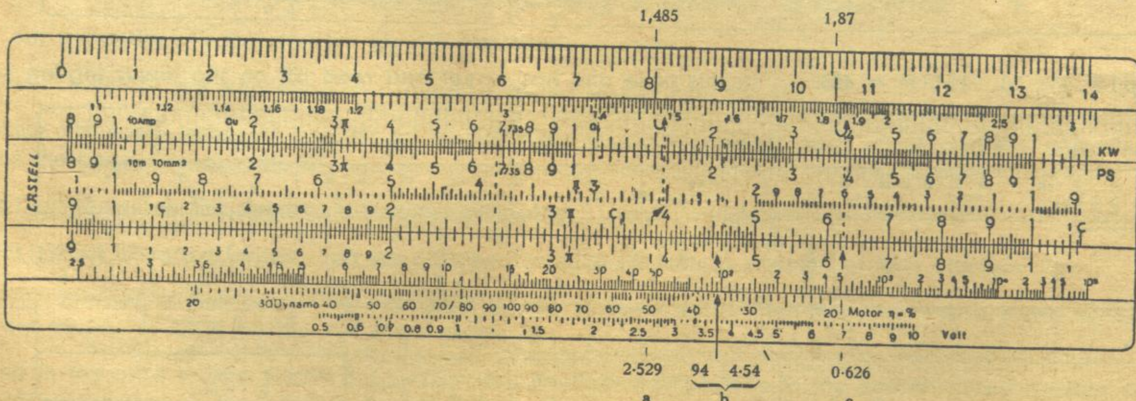


Fig. 16

Up to the present the cursor line only has been used; if the slide is employed then the following methods of calculation become possible.

10. **Powers with fractional exponents.** Example, Fig. 17: $1{\cdot}277^{2{\cdot}22} = 1{\cdot}72$.

With the cursor line, set 1 on scale **C** under 1·277 on scale LL_2 and over 2·22 on **C** read 1·72, the required answer, on LL_2 (Fig. 17).

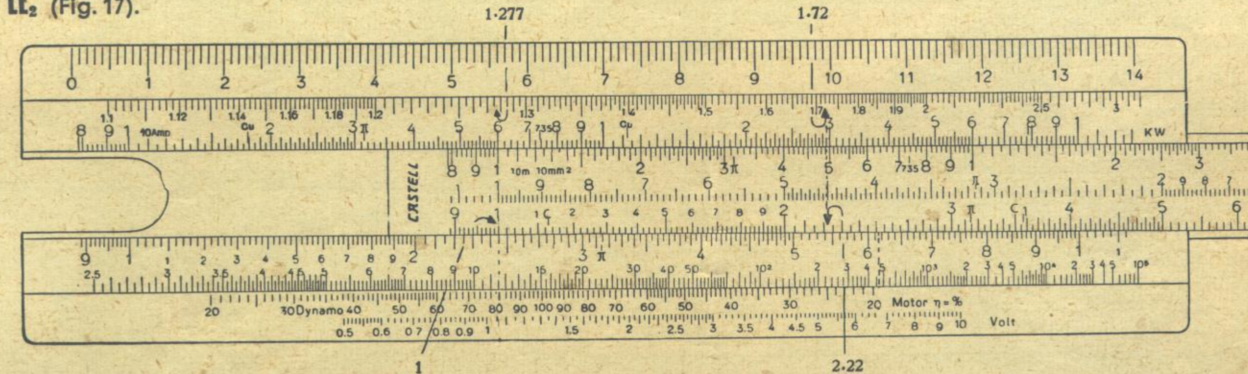


Fig. 17

Example, Fig. 18: $11{\cdot}5^{2{\cdot}53} = 483$. In this case one has to set and read off on the lower log-log scale (LL_3).

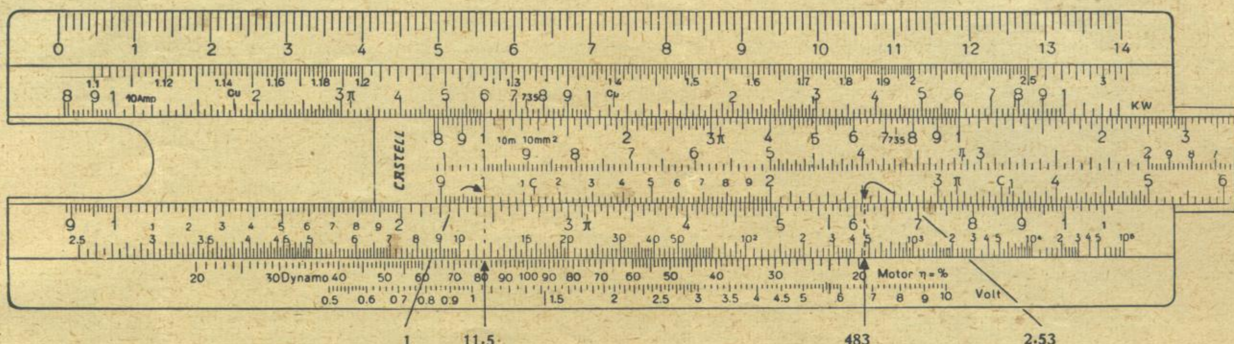


Fig. 18

If the division mark on **C** falls outside to the right, so that it is not possible to read above or below it, set the right end division (**C** 10) under the basic number.

If the exponent exceeds 10, the power can be calculated by making use of the change over from LL_2 to LL_3.

11. Exponential Equations of the Form $a^x = b$.

In this case 1 or 10 on **C**, with the help of the cursor line, has to be brought under or over a on the log-log scale, then the cursor line is placed over b on the log-log scale and x is read on **C**.

The Efficiency Scale W for Dynamos and Motors

It is assumed that either direct current or non-inductive alternating current is being dealt with. The upper of the two scales on the lower edge of the rule serves to calculate the efficiency of dynamos and motors (scale **W**).

The left half of the scale serves for working out the efficiency of dynamos. (Dynamo scale)

It carries out automatically the division by 746 (746 Watt = 1 HP).

Example: Calculate the efficiency of a dynamo giving 90 KW with 136 HP.

Set 90 on the KW scale (scale A) and 136 on the HP scale (scale B) against each other, and the cursor-line to **C** 1. (**C** 1 means the beginning of scale **C**).

The latter then shows on the dynamo scale 89% efficiency.

Example: What electrical output can be obtained with 30 HP from a dynamo of 88% efficiency?

Set **C** 1, with the aid of the cursor-line over 88% on the dynamo scale, then the cursor to **B** 3 (HP scale) and find above it the answer 19·7 KW on the KW scale (scale A).

If the result in the case before you is not satisfactory, the rule will provide in the above setting a table, from which, for every HP transmitted to the dynamo shaft, can be read off the electrical output delivered.

The right half of the scale W serves for the calculation of the efficiency of motors.

Example: What is the efficiency of a motor with 17·1 KW which delivers 20 HP?

Set the two numbers on the HP and KW scales (= A and B scales) respectively against each other, care being taken that **C** 1 actually does appear above the **Motor** scale (**right** half). Answer 87%.

Example: What power does a motor of 80% efficiency deliver with 500 Volts and 12 amp. (i. e. 6 KW)?

Move **C** 1, with the aid of the cursor to 80% on the motor scale, find the number 6 on the KW scale, and below it 6·45 HP on the HP scale.

The Voltage Drop Scale V

The voltage drop in a conductor is read on the lower red figured scale on the lower edge of the rule (Volt-scale). The **V**-scale, giving the loss of potential in copper conductors on direct current circuits, or alternating of unity power factor, lies parallel to the efficiency scale, thus conforming to the colour of the index marks relating to this scale on **A** and **B.**

These marks, "10 Amp.", "10 yd", and "10,000 circ-mil" on the face of the rule and slide mean that 1 on **A** must be read as 10 amperes, and 1 on **B** as 10 yards and 10,000 circular mils when using the voltage drop scale. From this it will be seen that current is taken on **A**, and length and cross-section are taken on **B**. The voltage drop scale is based on the formula

$$e = \frac{I \times L}{a \times c}; \text{ where}$$

I = current in amperes

L = total length of conductor in yards

c = 0·0327 ohm, conductivity of copper (mil yard) at 60° F

a = area of cross-section of conductor in circular mils.

In using the scale, the current and the length of conductor are multiplied together on the **A** and **B** scales, the area of cross-section of the conductor on **B** is brought to the product of these two on scale **A**, and the voltage is read against **C** 1 with the aid of the cursor-line on the red scale **V**. The **V**-scale is so graduated that division by c is not necessary.

To find the area of cross-section in circular mils, it is only necessary to square the diameter in mils — i. e., in thousandths of an inch. For instance, a wire of diameter 0·128 inch, or 128 mils, is 128 × 128 = 16,400 circular mils in area.

Example: Determine the voltage drop across the ends of a copper conductor 80 yards long and 70,000 circular mils in area when the current is 60 amperes.

Set the left hand index of **B** (**B** 1) to 60 amp. on **A** (taking the left hand index of **A** as 10 amp.), move the cursor-line over 80 yd. on **B** (the left hand index of **B** being 10 yards), bring 70,000 circ. mils on the left hand **B** scale under the cursor-line, and read with the aid of the cursor against **C** 1 the result 2·1 volts on the voltage drop scale.

Special Scale Marks on "Electro" - Slide Rules 67/98 b and 67/98 R

On slide rules 67/98 b and 67/98 R there are still other marks, viz.:

746 on scales **A** and **B**. This number says how many Watts a HP contains. It is useful for different calculations.

W (on scale **D** between 3 and 4) and

R (on scale **D** between 5 and 6) are used

for calculating the weights and resistances of copper conductors. **W** relates to **weight** and **R** to **resistance.**

Examples: Determine the weight of 640 yards of copper wire 0,048 inch in diameter. — By means of the cursor-line set 640 yards on **B** to **W** and over 48 mils, on **D**, read 13·4 pounds on **B.**

Determine the resistance of 250 yards of copper conductor 0,128 inch in diameter. — Set 250 yards on **B** to 128 mils on **D**, move the cursor over **R** and read the resistance, 0·466 ohms, on **B** under the cursor line.

The Care of Slide Rules

Geroplast slide rules are absolutely "climate-proof", as well as heat-proof and damp-proof, and they stand up to the effects of the majority of chemicals. Geroplast slide rules should not, however, be allowed to come in contact with corrosive liquids or strong solvents, benzine, petroleum, spirit, etc., as these — even if the material itself remains unaffected — are at any rate liable to cause the colour of the graduation marks to deteriorate. To preserve the legibility of the graduations, the facial scales and the cursor should be protected from dust and scratches, and cleaned with the special CASTELL cleaning medium No. 211 (liquid) or No. 212 (in paste form).

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