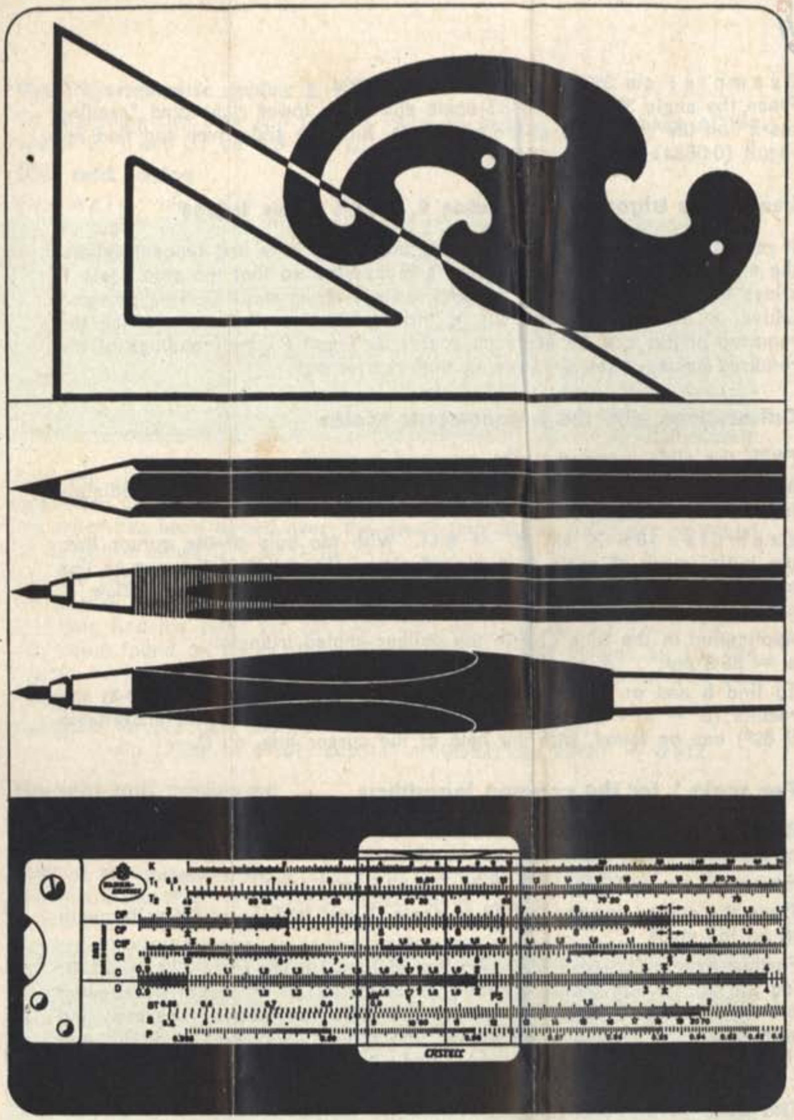


Advanced instruments for writing, drawing, calculating, measuring

FABER-CASTELL

A. W. FABER-CASTELL · STEIN BEI NÜRNBERG

Printed in Germany

1/799 e -

FABER-CASTELL

Slide Rule Primer

Contents:

Introductory Remark

These Instructions explain the use of the Slide Rules:
CASTELL STUDENTS COLUMBUS No. 57/86 (up to p. 14) and
CASTELL STUDENTS RIETZ No. 57/87 (up to p. 17).

CASTELL STUDENTS COLUMBUS No. 57/86

CASTELL STUDENTS RIETZ No. 57/87

General Details of the Slide Rule

Brief explanation of the slide rule

The slide rule consists of t h r e e parts:

(1) The rigid main part — the actual b o d y of the slide rule.

(2) The movable s l i d e , which moves within the grooves of the main part.

(3) The c u r s o r , which is provided with a number of reference lines and which moves over the main part and the slide.

The main scales:

Scale **A** — square scale from 1 to 100 — upper body of slide rule

guide groove

Scale **B** — square scale from 1 to 100— upper edge of slide

Scale **C** — basic scale from 1 to 10 — lower edge of slide

guide groove

Scale **D** — basic scale from 1 to 10 — lower body of slide rule

The additional scales:

(On the Students Rietz No. 57/87)

Scale **K**: Cube scale from 1 to 1000 — on upper body of slide rule.

Scale **CI**: Reciprocal scale for Scales C and D — in centre of slide.

Scale **L**: Mantissa scale — on lower edge.

Scale **S**: Sine scale (sin, cos) from 5° 40′ to 90° — on back of slide.

Scale **ST**: Scale for small angles from 34′ to 5° 40′ — on back of slide

Scale **T**: Tangent scale (tan cot) from 5° 40′ to 45° — on back of slide.

Both types of slide rules are provided with a measuring scale on the bevelled upper edge.

How to read the scales:

The most important requirement for accurate slide rule reading is the ability to read the scale markings correctly and to estimate the intermediate values. We have devoted particular attention to this problem, and our aim is to provide the beginner with very clear and intensive instruction in the reading of the scales. The accompanying "practice diagram", indicating the value of every graduation mark appearing on the Basic Scales C and D, will be found a valuable aid.
Owing to lack of space, the slide rule itself cannot contain the figures corresponding to all the graduation marks. It merely contains a few **main figures** by way of a guide, enabling the values of the remaining graduation marks to be recognized. (These values should be read off when using the "practice diagram"!).

Note the page numbers. Now proceed to page 5.

Calculations with the main scales A, B, C, D

We are now acquainted with the process of reading the scales and can therefore make a start with actual calculations.

On what system are slide rule calculations based?

If two ordinary rulers graduated in centimetres are placed one against the other as shown in the diagram below, we obtain — proceeding to the right — the result 3·5 + 4·5 = 8 (i.e. an **addition**),
or 8 — 4·5 = 3·5 (i.e. a **subtraction**) (Fig. 3).

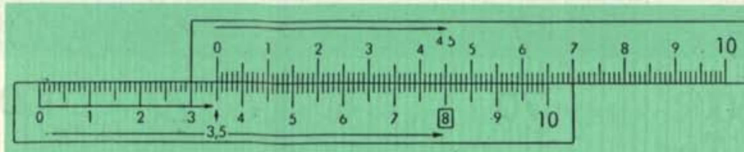


Fig. 3

With the help of the two millimetric scales, therefore, we have "calculated", by regarding the numbers 3·5 and 4·5 as "distances" and adding them together — or in the second case, by deducting the distance 4·5 from the distance 8.

The slide rule operates in exactly the same manner, except that its graduations are arranged in such a manner that adjacent "distances" do not indicate the **sum,** but the **product** of the numbers — or in the second case, the **quotient** instead of the **difference.**

If two scales of a slide rule are placed one against the other in the same manner as the aforementioned rulers, the result reads as follows:

3·5 × 4·5 = 15·75 (i.e. a **multiplication**) or
15·75 ÷ 4·5 = 3·5 (i.e. a **division**) (Fig. 4)

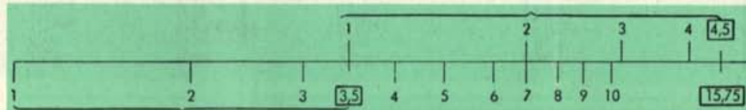


Fig. 4

Conclusion

If two "distances" are added together on the slide rule, this results in a multiplication, while if one is subtracted from the other this results in a division.

Let us "inwardly digest" this principle: adding two distances together = multiplying; subtracting one from another = dividing.

The following **examples,** which are also engraved on the back of the Columbus slide rule to assist the user's memory, can naturally be calculated mentally. Their purpose is to illustrate the process of calculation as simply as possible.

Important: Our scale reading exercises have hitherto been based on the long cursor line. In future the initial "1" or the final "10" of the scales C and D will also be required when setting the slide rule for the calculations.

Practice Diagram for Students

Giving numerical value of each graduation mark on Basic Scales C and D

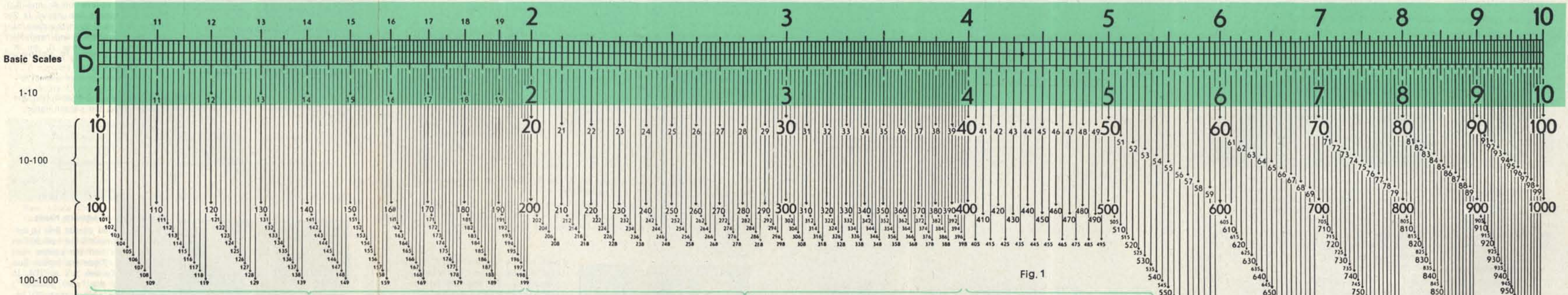


Fig. 1

Graduation Range from 1, to 2: Providing exact reaiings to 3 places (e.g. 1-0-1: this is the first mark following the 1). Each nark counts as 1.
Examples for practice: 1-6-3; 1-2-4; 1-4-6; 1-7-7; 1-·-9; 1-3-8; 1-2-7; 1-9-6; 1-3-3; 1-0-5; 1-5-5; 1-6-9; 1-4-3.

Graduation Range from 2 to 4: In this case certain marks have to be assumed, since owing to lack of space there are only 5 marks instead of 10 between 2-0 and 2-1. Each mark counts as 2.
Examples for practice: 2-6-8; 3-0-4; 2-9-2; 3-1-8; 2-7-4; 3-2-6; 3-5-6; 2-4-4; 3-6-6; 3-8-4.

Graduation Range from 4 to 10: Here again the scale is subdivided on different lines. From 4-0 to 4-1 only 1 mark is provided. This counts as 5 parts. Examples for practice: 6-2-5; 7-6-0; 5-9-5; 8-0-5; 9-1-5; 8-3-5; 7-4-5; 5-2-0.

Let us take a further look at the basic scales C and D. Similar subdivisions are already known to us in connection with ordinary rulers, thermometers, etc. On the slide rule scales, however, we immediately notice that the graduation marks are no longer at equal distances apart (as in the case of a cm scale, for example). The distances become shorter towards the end of the scale. The latter is subdivided logarithmically.

As the basic scales C and D only extend from 1 to 10 — the square scales A and B at the top only extending from 1 to 100 — the beginner receives the impression that calculations can only be performed within these ranges. This is a fallacy.

Note: If we read off the value 3, for instance, this may mean 0·3, 300, 0·03 or 3000 etc. Neither need the decimal value of a figure, i.e. the position of the decimal point, be taken into consideration. In other words, slide rule calculations can be performed with **all numbers.**

When setting and reading the slide rule, a good habit is to get the **sequence** of figures clearly fixed in one's mind.

If it is to be set to 324, for example, one should not say "three hundred and twenty four" but rather "three-two-four", i.e. first the hundreds, then the tens, then the units. This is the way in which we shall print the figures in all the examples for reading off.

For the following exercises in taking readings we will utilise the basic scales C and D.

Once we have familiarized ourselves with the way in which these scales are subdivided we shall understand the graduation of all the other scales without difficulty.

Exercise in scale readings.

We adjust the slide rule to the "zero" position; that is to say, the graduation marks of the scales DF and CF (top) and of the scales C and D (bottom) must be exactly opposite to one another. For the "setting exercises" we use the cursor line. Let us now refer to the diagram and work through the remarks printed on the green portions. We can compare our "setting exercises" on the actual slide rule with this diagram. (See above!)

Further intermediate values have to be **estimated.** Example (see small diagram on right): To set the slide rule to 5-1-8 we first of all halve the space between 5-1-5 and 5-2-0, to obtain the value 5-1-7-5, and then move the cursor line very slightly to the right.

To estimate the position of an intermediate value:

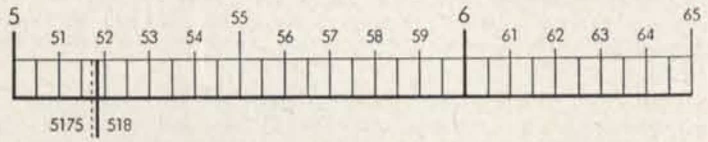


Fig. 2

General Details of the Slide Rule

Brief explanation of the slide rule

The slide rule consists of three parts:

(1) The rigid main part — the actual body of the slide rule.

(2) The movable slide, which moves within the grooves of the main part.

(3) The cursor, which is provided with a number of reference lines and which moves over the main part and the slide.

The main scales:

Scale **A** — square scale from 1 to 100 — upper body of slide rule

guide groove

Scale **B** — square scale from 1 to 100 — upper edge of slide

Scale **C** — basic scale from 1 to 10 — lower edge of slide

guide groove

Scale **D** — basic scale from 1 to 10 — lower body of slide rule

The additional scales:

(On the Students Rietz No. 57/87)

Scale **K**: Cube scale from 1 to 1000 — on upper body of slide rule.

Scale **CI**: Reciprocal scale for Scales C and D — in centre of slide.

Scale **L**: Mantissa scale — on lower edge.

Scale **S**: Sine scale (sin, cos) from 5° 40′ to 90° — on back of slide.

Scale **ST**: Scale for small angles from 34′ to 5° 40′ — on back of slide

Scale **T**: Tangent scale (tan cot) from 5° 40′ to 45° — on back of slide.

Both types of slide rules are provided with a measuring scale on the bevelled upper edge.

How to read the scales:

The most important requirement for accurate slide rule reading is the ability to read the scale markings correctly and to estimate the intermediate values. We have devoted particular attention to this problem, and our aim is to provide the beginner with very clear and intensive instruction in the reading of the scales. The accompanying "practice diagram", indicating the value of every graduation mark appearing on the Basic Scales C and D, will be found a valuable aid.
Owing to lack of space, the slide rule itself cannot contain the figures corresponding to all the graduation marks. It merely contains a few **main figures** by way of a guide, enabling the values of the remaining graduation marks to be recognized. (These values should be read off when using the "practice diagram"!).

Note the page numbers. Now proceed to page 5.

Calculations with the main scales A, B, C, D

We are now acquainted with the process of reading the scales and can therefore make a start with actual calculations.

On what system are slide rule calculations based?

If two ordinary rulers graduated in centimetres are placed one against the other as shown in the diagram below, we obtain — proceeding to the right — the result 3·5 + 4·5 = 8 (i.e. an **addition**),
or 8 — 4·5 = 3·5 (i.e. a **subtraction**) (Fig. 3).

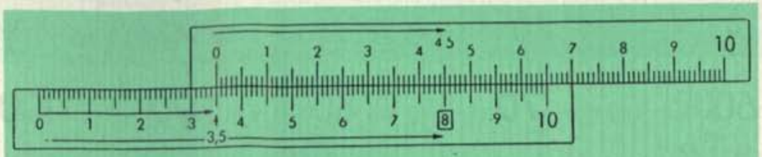


Fig. 3

With the help of the two millimetric scales, therefore, we have "calculated", by regarding the numbers 3·5 and 4·5 as "distances" and adding them together — or in the second case, by deducting the distance 4·5 from the distance 8.
The slide rule operates in exactly the same manner, except that its graduations are arranged in such a manner that adjacent "distances" do not indicate the **sum,** but the **product** of the numbers — or in the second case, the **quotient** instead of the **difference.**
If two scales of a slide rule are placed one against the other in the same manner as the aforementioned rulers, the result reads as follows:

3·5 × 4·5 = 15·75 (i.e. a **multiplication**) or
15·75 ÷ 4·5 = 3·5 (i.e. a **division**) (Fig. 4)

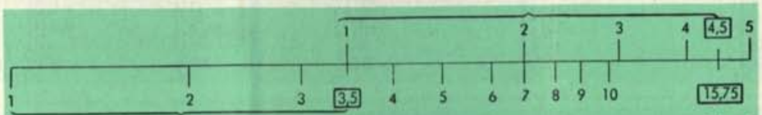


Fig. 4

Conclusion

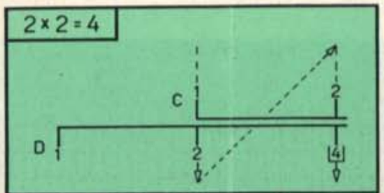
If two "distances" are added together on the slide rule, this results in a multiplication, while if one is subtracted from the other this results in a division.

Let us "inwardly digest" this principle: adding two distances together = multiplying; subtracting one from another = dividing.

The following **examples,** which are also engraved on the back of the Columbus slide rule to assist the user's memory, can naturally be calculated mentally. Their purpose is to illustrate the process of calculation as simply as possible.

Important: Our scale reading exercises have hitherto been based on the long cursor line. In future the initial "1" or the final "10" of the scales C and D will also be required when setting the slide rule for the calculations.

Multiplication



Setting Diagram 1

To the section extending as far as 2 on scale D the "distance 2" of the scale C is added, and the value 4 is read off, at the end of the total distance, on the scale D: Place the initial "1" of the slide scale C above the 2 on scale D, move the cursor line into position above the 2 on scale C, and read off the result, 4, underneath it.

Example: 2·45 × 3 = 7·35. (Fig. 5)

Solution: Place the initial "1" of scale C (which from now on will simply be referred to as C 1) above 2·45 on scale D (D 2-4-5), move the cursor so that its line is above 3 on scale C (C 3) and find the result — 7·35 — below it, on scale D.

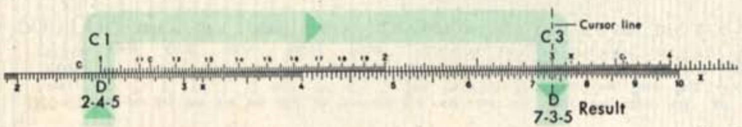


Fig. 5

Exercises: 24 × 1·8 = 43·2; 3·26 × 2·5 = 8·15; 17·6 × 16·3 = 287; 2·34 × 0·409 = 0·957.

With calculations on the Basic Scales C and D it may happen that the slide has been drawn out too far to the right, so that the cursor line can no longer be set to the second factor and the result read off underneath it. In this case a very simple process can be adopted: move the slide far enough to the left to ensure that the final "10" of scale C instead of the initial "1" of scale C is over the first factor. This process is known as "transposing the slide". The cursor line is then once more placed above the 2nd factor on C and the result read off underneath it on D.

Example: 7·5 × 4·8 = 36

Fig. 6

Solution: Place C 10 above D 7-5, place the cursor line above the 2nd factor 4-8 on C and read off the result (36) underneath it on D.

Even a beginner can easily avoid the necessity for "transposing the slide" if, in case of need, he immediately places C 10 above the first factor. After a certain amount of practice the user will immediately know what setting is required.

Exercises: 4·63 × 3·17 = 14·7; 0·694 × 0·484 = 0·336; 40·5 × 8·35 = 338.

With a series of calculations — when, for example, a number has first been raised to the second power — multiplication can continue on A and B.

Example: 2·5 × 3 = 7·5

Solution: Place B 1 under A 2-5, move the cursor line into position above B 3, and find the result (7·5) above it, on A. (Do not overlook the different scale graduation!).

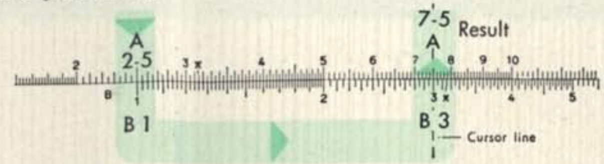
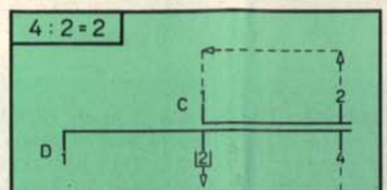


Fig. 7

When calculations are carried out on A and B, moreover, the process of "transposing the slide" is not necessary.

The user should nevertheless accustom himself — owing to the greater accuracy with which the reading can be taken — to multiplying on C and D only. A and B should only be used in the case of compound calculations!

Division



Setting Diagram 2

From the "total distance 4" on scale D, deduct the "distance 2" on scale C. The "residual distance 2" (indicated by the initial "1" of C) gives the result, 2: First place the long cursor line above 4 on scale D, then move the 2 on scale C into position underneath it. The initial "1" of scale C indicates the result, 2, on scale D.

Example: 9·85 ÷ 2·5 = 3·94.

Solution: Place the long cursor line above the numerator 9-8-5 on D, then place the denominator 2-5 (on C) underneath it. Under C 1, the result (3-9-4) can be read on D.

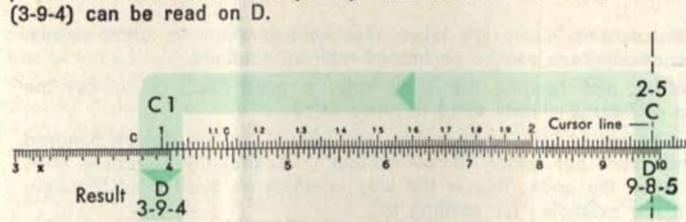
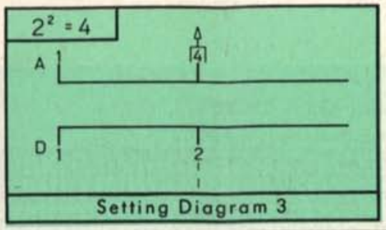


Fig. 8

Exercises: 970 ÷ 26·8 = 36·2; 285 ÷ 3·14 = 90·7; 0·685 ÷ 0·454 = 1·51.

Needless to say, division can also be carried out on A and B. Here again, the cursor line is used in order to bring the numerator (on A) and the denominator (on B) into position opposite each other, the result being read off on scale A, above B 1 or B 100.

Squaring of numbers



Setting Diagram 3

This is carried out with the cursor line. Above each number on scales C and D we find the corresponding square on A and B. Place the cursor line above D 2 (either D 2 or C 2, in the case of the "zero position") and read off the square (4) above it, on A (either A or B, in the case of the "zero position").

E x a m p l e : $2{\cdot}3^2 = 5{\cdot}29$.
Solution: Move the cursor line into position above D 2-3 and find the square (5·29) above it on A (and likewise underneath the cursor line).

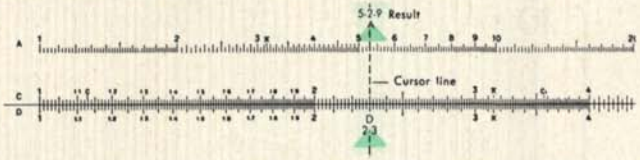
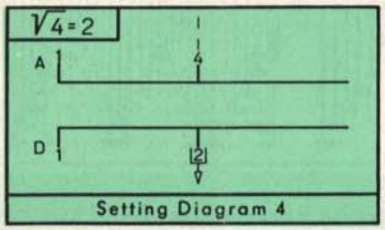


Fig. 9

Exercises: $1{\cdot}5^2 = 2{\cdot}25$; $1{\cdot}66^2 = 2{\cdot}75$; $5{\cdot}25^2 = 27{\cdot}6$; $10{\cdot}7^2 = 114{\cdot}5$; $4{\cdot}1^2 = 16{\cdot}8$

Extraction of square roots



Setting Diagram 4

Here again, the cursor line is sufficient. Underneath the radicant on A and B we find the square root on C and D. Place the cursor line above A 4 (either A 4 or B 4, in the case of the "zero position") and find the square root (2) below it, on D (either D or C, in the case of the "zero position").

E x a m p l e : $\sqrt{23{\cdot}1} = 4{\cdot}8$
Solution: Place the cursor line above A 23·1 and read off the result (4·8) on D, underneath the cursor line.

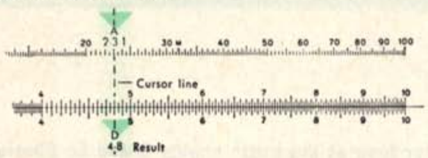


Fig. 10

In this case we have deliberately given the number and not the sequence of figures.

Note:
In the extraction of square roots it is no longer immaterial in which graduated half of A the setting is carried out. The values from 1 to 10 are to be set in the first half and those from 10 to 100 in the second half.
Higher or lower numbers have to be brought into the ranges 1-10 or 10-100 by the "isolation" of different powers, as shown by the following examples:
$\sqrt{1935}$. $\sqrt{1935}$ must be "analysed" into $\sqrt{100 \times 19{\cdot}35} = 10 \times \sqrt{19{\cdot}35} = 10 \times 4{\cdot}4 = 44$.
$\sqrt{145{\cdot}8} = \sqrt{100 \times 1{\cdot}458} = 10 \times \sqrt{1{\cdot}458} = 10 \times 1{\cdot}207 = 12{\cdot}07$.
If we wish to avoid "isolating" the powers of 10, we can note, on purely mechanical lines, how the setting is to be carried out.

The left-hand half is used for setting the numbers having one, three, five etc. p l a c e s i n f r o n t o f the decimal point, and the right-hand half for those having two, four etc. p l a c e s i n f r o n t o f the decimal point, or having no n o u g h t s , or two or four noughts, etc., a f t e r the decimal point.
We have now familiarized ourselves, with the help of the **examples** and the subsequent detailed explanations, with the basic types of calculation. The slide rule can be very widely applied for the formation of tables.

Formation of tables

(1) To convert yards into metres. Standard formula: 82 yds are 75 m. With the help of the cursor line, place the 82 on scale D and the 75 on scale C opposite each other: First place the cursor line above D 8-2 and then move the slide towards the right, until C 7-5 is underneath it and thus opposite D 8-2.

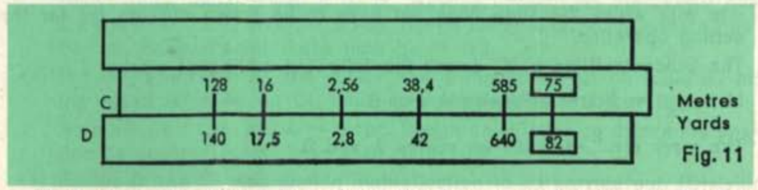


Fig. 11

Now place the cursor line above the known yard value on D; the number of metres can now be read on C, above it and vice versa: e.g. 17·5 yds = 16 m; 140 yds = 128 m; conversely, 38·4 m = 42 yds, 2·56 m = 2·8 yds, 585 m = 640 yds.
It again happens that settings or readings of certain values are impracticable because the slide extends too far to the left or right. For 105 yds. for example, no reading can be taken of the equivalent in metres (96). Here again, recourse is made to the operation known as "transposing the slide"; i.e. the setting of the table is maintained by placing the cursor line above C 1 and then moving the slide towards the left until C 10 is underneath the cursor line. Readings can now be taken likewise of the remaining values.

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

(3) We can also perform the frequently needed conversion of inches into mm (1″ = 25·4 mm). Place C 1 above D 2-5-4 and, with the aid of the cursor line, read 17″ = 43·2 cm, 37″ = 94 cm, etc.

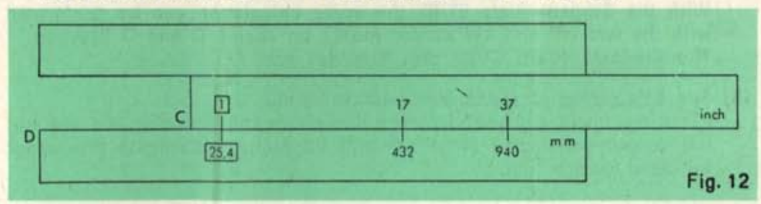


Fig. 12

With 42″, for example, we again find the reading and setting impossible, until we "transpose the slide", as before: C 10 in place of C 1.

(4) It should be noted that with all settings the "unit equivalent" and the corresponding value can always be read off from the ends of the scale, under C 1 or above D 10, and vice versa. 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″).

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

Various constants frequently required are shown separately:

$\pi = 3{\cdot}1416$ on scales A, B, C, D, (also on scale CI on Slide Rule 57/87).

The marks C or C_1 (not to be confused with C 1 at the beginning of the slide) facilitate the calculation of cross sections from a given diameter. Example: If the mark C, with the help of the cursor line, is placed above 2·82 cm on scale D (by first moving the cursor line into position above 2·82 on D and then placing the mark C underneath it) the cross section (6·24 cm^2) can be found on scale A, above the initial "1" of the upper slide scale B.

In place of the mark C, we could also have used the mark C_1 (not to be confused with the initial "1" of the lower "slide scale" C). The result then appears above B 100, on scale A. Of marks C and C_1, always choose the one with which the slide does not have to be drawn out too far for the setting operation.

The Students Rietz 57/87 bears the following additional marks:

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

The mark for $\frac{\pi}{4} = 0{\cdot}785$ on scales A and B.

The Multi-line Cursor

The multi-line cursor enables various important calculations to be carried out:

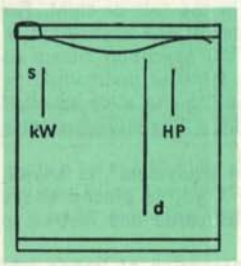


Fig. 13

(1) To calculate the area of a circle of a given diameter:
Place the cursor line marked "d" over the diameter (3·2 cm) on scale D and find the result (8·04 cm^2) on scale A, under the top-left-hand cursor line ("s").

(2) Conversion of kW to h.p. and vice versa: Example: 48 h.p. = 35·8 kW. Place the cursor line marked "HP" over 48 on scale D. The required number of watts (35·8) will be found underneath the cursor line marked "kW" and likewise on D.

With the Student Rietz 57/87 the same calculation can be performed with the two HP and kW cursor marks on scales C and D likewise. The Students Rietz 57/87 also provides for:

(3) The calculation of round iron bars in kg/m.
Place the lower right-hand cursor line above the diameter, e.g. 4·3 cm; the weight per metre (11·4 kg) will be found underneath the upper left-hand cursor line.

We have now familiarized ourselves with the calculations carried out on the main scales. These main scales are an essential part of the graduation systems of most slide rules, including the Castell-Columbus No. 57/86 and the Student-Rietz No. 57/87. The additional scales of the Students Rietz No. 57/87 will be explained on the following pages.

The Additional Scales of the Students-Rietz No. 57/87

The Reciprocal Scale CI

This is subdivided from 1 to 10, so that its graduation system corresponds to scales C and D, but it takes the opposite direction.

(1) If the reciprocal $1 \div a$ is required for any given number **a**, C or CI is set to the latter and the reciprocal read off on CI above it or on C below it respectively. The reading can be obtained with a mere setting of the cursor and without any adjustment of the slide.
Examples: $1 \div 8 = 0{\cdot}125$; $1 \div 2 = 0{\cdot}5$;
$1 \div 4 = 0{\cdot}25$; $1 \div 3 = 0{\cdot}333$

(2) If $1 \div a^2$ is required, the cursor line is moved to "a" on scale CI, the result being found above it on B, likewise underneath the cursor line. Example: $1 \div 2{\cdot}44^2 = 0{\cdot}168$. Rough calculation to determine position of decimal point: Less than $^1/_5 = 0{\cdot}2$.

(3) If $1 \div \sqrt{a}$ is required, the cursor line is moved to "a" on scale B, ano the result is found on CI, likewise underneath the cursor line.
Example: $1 \div \sqrt{27{\cdot}4} = 0{\cdot}191$. Rough calculation to determine position of decimal point: Less than $^1/_5 = 0{\cdot}2$.

(4) **Scales D and CI also enable multiplication to be carried out.** (Division by the reciprocal = multiplication). This method is popular with many users.
Example: $0{\cdot}66 \times 20{\cdot}25$. We proceed as in the case of division, i.e. first placing the cursor mark above 0·66 on D, then moving the 20·25 on CI into position underneath the cursor line, so that the product (13·37) can now be read on D, under CI.

(5) **Products with several factors** can thus be found very simply:
Multiply the first two factors as above, under (4); with the result C 1 above 13·37, we immediately have the setting for the multiplication by the next factor. (First multiplication method learnt; top of page 10).
Example: $0{\cdot}66 \times 20{\cdot}25 \times 2{\cdot}38 = 31{\cdot}8$. Calculate $0{\cdot}66 \times 20{\cdot}25$ as under (4); we now have the C 1 setting above the intermediate result and move the cursor line into position above the 3rd factor 2·38 on C. The result (31·8) appears below it, on D.

The Cube Scale K

The cube scale consists of three equal sections 1-10, 10-100 and 100-1000 and is used in conjunction with D. The cursor is placed above the value on D, and the cube can be read above it, on K.

Example: $2{\cdot}66^3 = 18{\cdot}8$; $1{\cdot}54^3 = 3{\cdot}66$; $2{\cdot}34^3 = 12{\cdot}85$; $6{\cdot}14^3 = 232$.

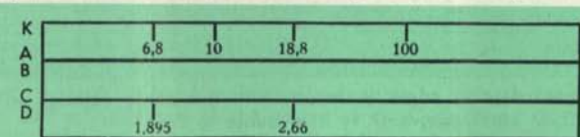


Fig. 14

If the cube root is to be extracted, the converse procedure is adopted. The setting is carried out on K and the reading taken from D.

Example: $\sqrt[3]{6{\cdot}8} = 1{\cdot}895$; $\sqrt[3]{4{\cdot}66} = 1{\cdot}67$; $\sqrt[3]{29{\cdot}5} = 3{\cdot}09$; $\sqrt[3]{192} = 5{\cdot}77$
If the radicand is below 1 or above 1000 it must be brought into the 1-1000 range by dividing it into suitable powers of 10, as when extracting square roots.

The trigonometric scales S, ST, T

To determine the sine and tangent value of angles, use is made of the scales S, T and ST on the back of the slide.

Sine and cosine

E x a m p l e : sin 32° = 0·53

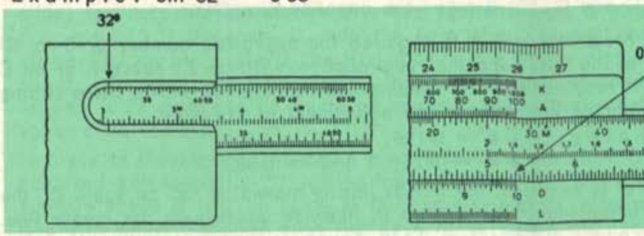


Fig. 15

Turn the slide rule over and place the angle 32° underneath either the right-hand or the left-hand index mark on the back of the slide rule; after the latter has been turned over, the result (sin 32° = 0·53) can be found on C, above either D 1 or D 10.

For the cosine we use the equation cos α = sin (90°—α). If, therefore, we require to find cos 78°, for example, we carry out the above setting and then find the value for 12° (90°—78°) on C, above D 1 (= 0·208). The value found on C for sine and cosine should be divided by 10. The figures of the complementary angles (proceeding from right to left) can likewise be used for the calculation of the cosine.

Examples for practice: sin 13° = 0·225; sin 76° = 0·97;
sin 17°30′ = 0·301; cos 11° = 0·982; cos 23°30′ = 0·917.

Tangent and cotangent

E x a m p l e : tan 7°40′ = 0·1346.

With the slide rule turned over, the slide is pushed to the left until the 7°40′ of the tangent scale is above the left-hand "reading mark".
The result tan 7°40′ = 0·1346 is found above D 1, on C.
In the case of the tangent the readings are to be divided by 10.

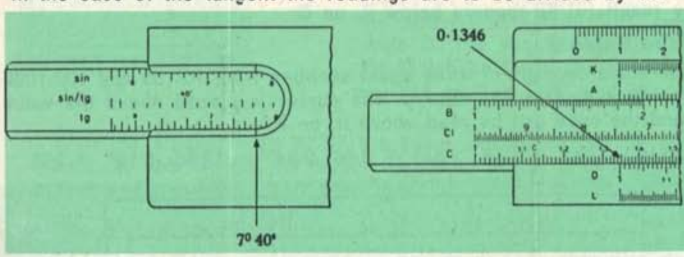


Fig. 16

The cotangent of this angle is found, with the same setting, on D and under C 10 or on CI above D 1; it amounts to 7·43.
As the tangent scale only extends to 45°, the equations

tan α = cot (90°—α) and cot $\alpha = \frac{1}{\tan \alpha}$ or tan $\alpha = \frac{1}{\tan (90° - \alpha)}$ must be used.

Examples for practice: tan 44° = 0·966; tan 12°40′ = 0·225;
tan 8°20′ = 0·1465; cot 18° = 3·08; tan 57° = cot (90°—57°) = 1·54.

Scale ST, for small angles

Sines and tangents of the angles between 34′ and 5°43′ are determined with the help of the scale ST.

E x a m p l e : sin 3°38′ or tan 3°38′ = 0·0634.
Place the angle 3°38′ of the ST scale above the lower right-hand "reading mark" on the rear slide of the slide rule, turn the slide over and find the result (0·0634) above D 10, on C.

Use of the trigonometric scales S, T and ST as tables

If readings are to be taken of a large number of sine and tangent values, the slide of the rule is turned over and inserted so that the sine scale S slides along scale A and the tangent scale T along scale D. This provides tables on which, with the help of the cursor line, the settings for the required angles can be made on scales S, T and ST and readings of the required values taken on scale D, and vice versa.

Calculations with the trigonometric scales

(With the slide inserted in the reversed position).

As readings of the functions are provided on D, they can be immediately followed by multiplications.

E x a m p l e : 18·5 × sin 26° = 8·11. With the help of the cursor line, the initial mark of scale S is placed above D 1-8-5 and the cursor line moved into position above S 26°; the result 8·11 is provided below it, on D.

Application of the Sine Law in the oblique-angled triangle:
a = 38·3 cm; α = 52°; β = 59°; γ = 69°.

To find **b** and **c**: using the cursor line, place S 52° above D 3-8-3; the results (b = 41·7 cm, underneath S 59°, and c = 45·3 cm, underneath S 69°) can be found, with the help of the cursor line, on D.

The scale L for the common logarithms

Readings of the logarithms are taken from the scale L on the lower edge of the body of the slide rule.

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

Place the cursor line above 1·35 on scale D, and find the result underneath it, on the scale L.

Further examples: log 3 = 0·477; log 36·2 = 1·5585; log 1·479 = 0·170; log sin 25° = log 0·4225 (reading provided on D) = 0·626—1 (reading provided on L) = 9·626—10. When the slide is inserted reversed, and with the "zero position", the cursor line should be placed at S 25°, and the mantissa (0·626) can then be found underneath it, on L.

The care of the CASTELL Student Slide Rules

CASTELL Student Slide Rules are made of an ideal material known as Geroplast. Geroplast is highly elastic and will therefore not break if properly handled. It is temperature-resisting, insensitive to moisture and non-inflammable, and will stand up to the action of most chemicals. Geroplast slide rules should nevertheless not be allowed to come in contact with corrosive liquids or powerful solvents (e.g. petrol); these substances will adversely affect the colouring of the graduation marks, even if they do not actually attack the material itself. If necessary, pure vaseline or silicon oil can be applied to the slide to make it move more smoothly. To ensure that the "reading accuracy" is not reduced, the scales and the cursor should be protected from dirt and scratches and be cleaned with the special CASTELL-Cleaning-Medium No. 211 (liquid) or No. 212 (cleaning paste).