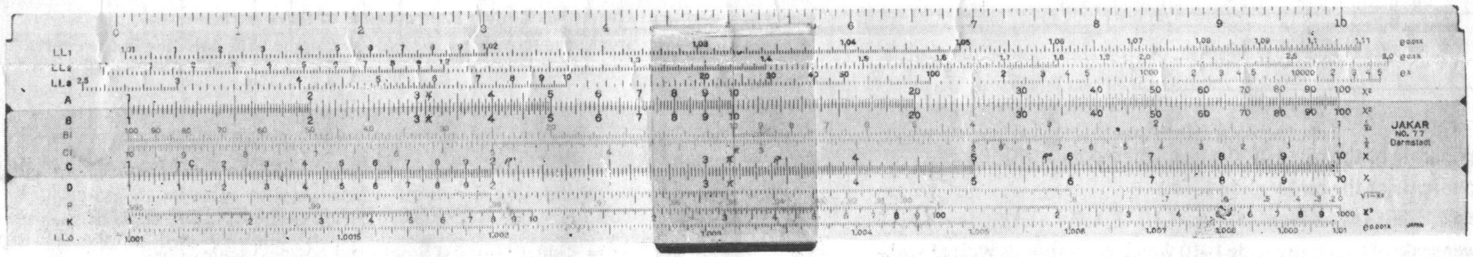
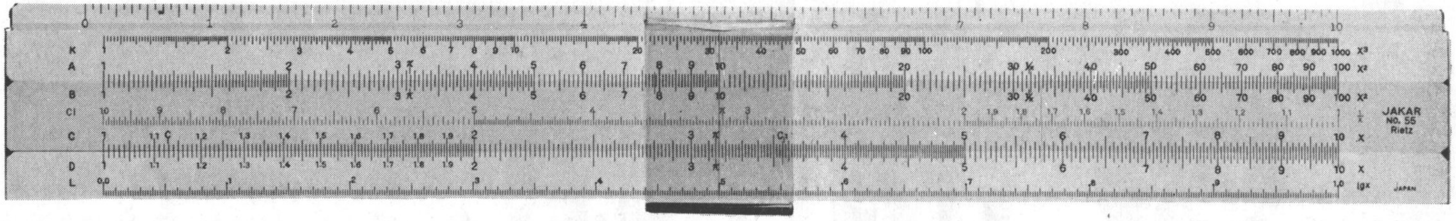
JAKAR



Precision SLIDE RULES

Instructions for using Nos:	11 · 55 Rietz	22 · 77 Darmstadt	66 Electro



LEFT INDEX CURSOR RIGHT INDEX

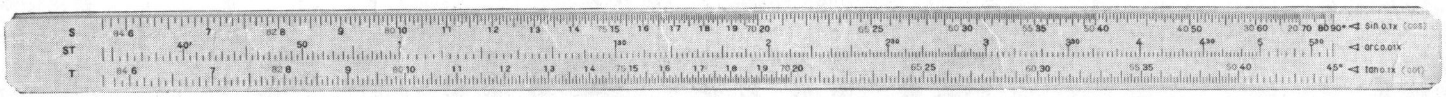
Nos. 11 and 55 Rietz

The JAKAR Slide Rule consists of three parts:
Stock, the movable slide and the Cursor with hair-line in the centre

K $=x^3$ Cubic scale
A $=x^2$ Upper scale of the rule 1–100 which corresponds with B scale
B $=x^2$ Upper scale of the centre slide 1–100
CI= Reciprocal or Inverse scale
C $=x$ Lower scale of the centre slide 1–10 which corresponds with D scale
D $=x$ Lower scale of the rule 1–10
L $=$lgx Mantissa-scale for determining common logarithms of all numbers

REVERSE SIDE OF CENTRE SLIDE

S $=\measuredangle$ sin 0·1x(cos) Sines (and cosines) scale
ST$=\measuredangle$ arc 0·01x Sine and tangent scale
T $=\measuredangle$ tan 0·1x(cot) Tangent (and cotangent) scale range 5·5° up to 45°



THE NORMAL SCALES

The scales A and B at the upper and C and D at the lower rabbet are the main scales of the Slide Rule. They are sufficient for nearly 90% of all practical computations and may therefore be called normal scales.

EXPLANATION OF DIVISION

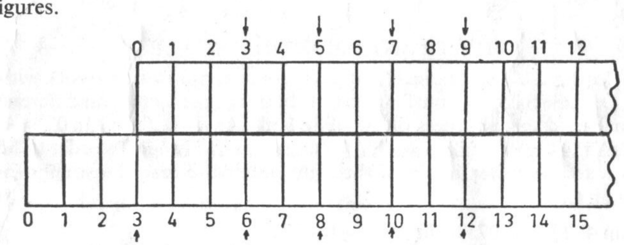
On an ordinary ruler, the centimetres are marked and numbered, whilst their sub-divisions—the millimetres—are only indicated by lines, the tenths of millimetres have to be estimated. It is the same with the Slide Rule, as we are not only concerned with whole numbers 1, 2, 3 etc. but with decimal fractions, e.g. 1·1, 1·2, 1·8, 2·75, 3·14, 5·41, 0·074 etc. But whereas on an ordinary ruler the divisions representing each a unit of length are all the same, the divisions of a Slide Rule scale are reduced in width the more one comes to the right-hand side. In order to avoid eyestrain some of the sub-divisions of the scales on the right had to be omitted.

The section 1–2 of scales C and D is sub-divided into 10 principal distances, which are marked 1·1, 1·2 up to 1·9 and 2. Each of these sub-divisions is again sub-divided into 10 distances (in case of the 5-in. Pocket Slide Rule, however, only into 5 distances). They are read 1·01, 1·02, up to 1·99 and 2·00 (in case of the 5 in. model 1·02, 1·04 up to 1·98 and 2·00).

The section 2–5 is also sub-divided into 10 principal distances such as 2·10, 2·20 up to 4·90 and 5·00. The sub-divisions of these are in fifths and are read 2·02, 2·04, 2·06 up to 5·00 (in case of the 5-in. Slide Rule the sub-divisions are in halves, 2·05, 2·10, 2·15 up to 5·00). In the last section 5–10 the sub-divisions progress by twentieths, 5·05, 5·10, 5·15 up to 9·95 and 10·00. (In case of the 5 in. model the sub-divisions are in tenths, 5·10, 5·20, 5·30 up to 9·90 and 10·00.)

HOW THE SLIDE RULE WORKS

When using the Slide Rule, calculations are not done by numbers but by distances. Figure 3 for example is represented by the distance between digits 1 and 3. The illustration below demonstrates the basic principle. Two ordinary scales divided in equal distances (inches or cm) are placed next to each other in such a way, that the initial point 0 or one of the rulers is coincident with point 3 of the other one. Now there is the possibility of graphical additions and subtractions. Below any number n of the upper scale we have $n+3$ on the lower scale. Conversely, opposite any number above the lower scale the graphical subtraction $n-3$ applies. With one scale being fixed and the other movable any addition and subtraction can be made. Any setting of the two scales results in a series of sums and different figures.



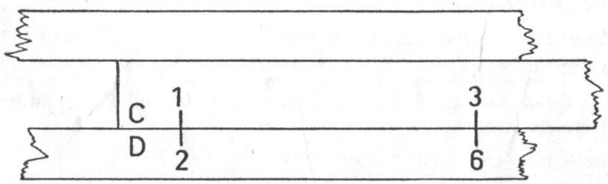
However, the practical importance of graphical additions is insignificant, this can easily be done by mental calculation. It would be more useful if the Slide Rule could perform multiplications and divisions. This indeed, can be done in the same way. According to the logarithmic principle, the lines on the scales are traced in variable distances and thus the Slide Rule gives the result and quotient in exactly the same way.

This information should be sufficient for the beginner.

MULTIPLICATION

For all computations the lower scales C and D should be used as they give more exact results than the shorter upper scales A and B.

Precept: Set the *left* index of C(1) opposite the factor on D, read the answer on D as per illustration:



Examples: Multiply $14\times 2=28$

Opposite 14 on D set *left* index of C,
opposite 2 on C read answer 28 on D.

Multiply $7{\cdot}70\times 0{\cdot}06=0{\cdot}462$

Opposite 770 on D set *right* index of C,
opposite 6 on C read answer 462 on D.

The decimal points have been disregarded in this operation. Rough mental calculation shows that the answer must be 0·462. Note in this case that the readings would have been "off scale" if the left index had been used.

CONTINUOUS MULTIPLICATION

To multiply three factors, first multiply two of them and then multiply the result by the third.

Example: Multiply $1{\cdot}5\times 3{\cdot}2\times 8=38{\cdot}4$

Opposite 15 on D set *left* index of C,
opposite 32 on C set the hair-line of the cursor,
opposite the hair-line set *right* index of C,
opposite 8 on C read answer 38·4 on D.

You need not read the intermediate answer $1{\cdot}5\times 3{\cdot}2=4{\cdot}8$

DIVISION

This operation is the inverse of multiplication.

Example: 28 divided by $2=14$

Opposite 28 on D, set 2 on C,
opposite *left* index of C read answer 14 on D.

COMBINED MULTIPLICATION AND DIVISION

Example: $\frac{3\times 4\times 7}{2\times 5}=8{\cdot}4$

Opposite 3 on D, set 2 on C,
opposite 4 on C, set the hair-line of the cursor,
opposite the hair-line, set 5 on C,
opposite 7 on C read 8·4 on D.

The reciprocal scale C1 has the same sub-divisions as the main scales C and D but runs in the opposite direction.

The A and B scales are alike, one being on the centre slide and the other on the stock. Either of them consists of two half-size C scales placed end to end. They are used in finding squares and square roots, and in other operations.

The K scale consists of three one-third size C scales placed end to end. It is used in finding cubes and cube roots.

After having gained some experience the intermediate results not indicated can easily be estimated with the help of the hair-line of the cursor. Thus numbers with three figures, such as 3·16, 5·08, 7·83, and in section 1–2 even four figures can be set and read.

The above examples refer to 5-in. and 10-in. Slide Rules. With a 20 in. model even more exact results can be achieved due to additional sub-divisions.

Note: No indication as to the setting of the decimal point is given by the Slide Rule. The value of 2·15 for instance can also be read 21·5, 215, or 0·215. A mistake, however, can not be overlooked as the result could only be read as 10 times too large or too small and this will be realized simply by estimation.

The Slide Rule gives the figures—the position of the decimal point or number of noughts which decide the magnitude have to be estimated.

The Reciprocal Scale C1

(Multiplication of more than 2 factors)

All JAKAR Precision Slide Rules have engraved in the middle of the slide (in red) a scale which runs from right to left, i.e. inversely. One finds on it the reciprocal values to scale C.

Note: Scale C1 permits two successive multiplications with a single setting of the slide.

Example: $2 \times 3 \times 4 = 24$

Opposite 2 on D, set hair-line of cursor,
set 3 on scale C1 below it,
opposite 4 on C read answer 24 on D

This method can be applied for all multiplications with more than 2 factors.

CALCULATIONS OF PERCENTAGE

This is a mere multiplication in which the number 100% represents one factor whereas the percentage expressed as decimal fractions is the other one.

Example: 70% of 650=455

Opposite 650 on D set *right* index of C,
opposite 70 on C read 455 on D

With the same setting of the slide one can read all other percentages of 650, such as 80%=520, 60%=390 etc. One may also use the upper scales A and B for this calculation. However, scales C and D should always be preferred as they are wider and therefore more exact.

SQUARES AND SQUARE ROOTS

Whereas you have on scales C and D one logarithmic distance 1–10, you have on scales A and B over the same length two such distances, 1–10 and 1–100.

Therefore opposite any number on C and D, read its square on A and B, thus:

Opposite 2·47 on D read 6·1 on A,
opposite 0·4 on D, read 0·16 on A.

Conversely, opposite any number on A, read its square root on D. use the LEFT half on A if the number has an ODD number of digits, such as 1, 3, 5. Use the RIGHT half of A if the number has an EVEN number of digits, 0, 2, 4 etc., thus

Opposite 4·58 on A (left) read 2·14 on D,
opposite 56·7 on A (right) read 7·53 on D.

CUBE AND CUBE ROOTS

The K scale is arranged in such a way that if the hair-line of the cursor is set over a number on D, its cube will be read on K under the hair-line, thus,

Opposite 4·2 on D, read 74 on K,
opposite 0·665 on D, read 0·294 on K.

Conversely, opposite a number on K, read its cube root on D. Use the right third of the scale if the number of digits in the sum is a multiple of 3 (−3, 0, 3, 6 etc.); use the centre third if the number of digits is one less than a multiple of 3 (−1, 2, 5, 8 etc.); use the left third if the number of digits is two less than a multiple of 3 (−2, 1, 4, 7 etc.)

Examples: Opposite 2 on K (left) read 1·26 on D,
Opposite 64 on K (middle) read 4 on D,
Opposite 125 on K (right) read 5 on D.

THE TRIGONOMETRIC SCALES

The scales S (for sinus), T (for tangent), and ST (for sinus and tanget) work with the lower scales C and D. Scale ST runs from 0·01 to 0·1. In this range there is no difference between sin α and tan α as to the exactness of the Slide Rule. As $\sin 0° 34' \approx \tan 0° 34' = 0{\cdot}01$ and $\sin 5° 44' \approx \tan 5° 44' = 0{\cdot}1$, take scale ST for angles in this range. In order to find $\sin \alpha \approx \tan \alpha$, draw α to the lower index of the right notch and read the sought-for function above D(10) on C.

Examples: sin 4° 12′=0·0732, sin 1° 37′=0·0282,
sin 52′ =0·7880

If α is between 5° 44′ and 90°, use scale S and the UPPER index of the right notch and read the result again above D(10) on C.

Examples: sin 9° 15′ =0·161, sin 39·5°=0·636,
sin 48° 40′=0·751

In order to find tan α (α between 34′ and 5° 44′) proceed in the same way as with sin α because there is no difference in the first three places.

Examples: tan 1° 50′=0·032, tan 3° 30′=0·061,
tan 50′ =0·0192

If the angle is between 5° 44′ and 45°, use the index of the left notch and see the function above D(1) on C.

Examples: tan 9° 5′ =0·160, tan 41°=0·869
tan 25° 10′=0·47

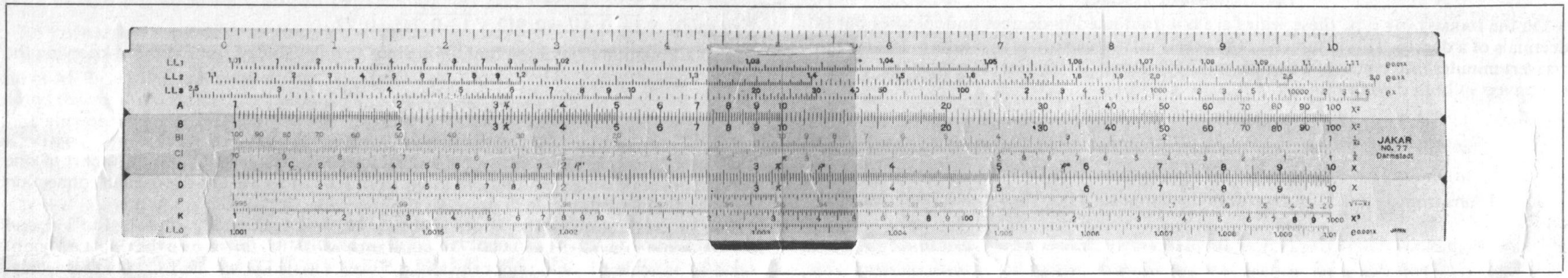
As $\cot \alpha = 1 : \tan \alpha$, you can find cot α (α between 5° 44′ and 45°) in finding tan α and seeking its reciprocal value.

Examples: cot 9° 15′ =6·14, cot 23° 30′=2·3,
cot 40° 40′=1·164.

As $\cos \alpha = \sin (90° - \alpha)$ the scales ST and S can also be used to find the cos function.

In order to find tangent or cotangent of an angle which is greater than 45°, the relations $\tan \alpha = \cot (90° - \alpha)$ and $\cot \alpha = \tan (90° - \alpha)$ are used.

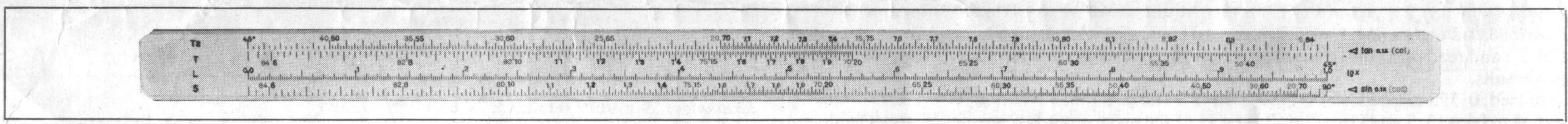
Nos. 22 and 77 Darmstadt



LL1	$=e^{0\cdot01x}$	Log/Log scale, range 1·01 up to 1·11
LL2	$=e^{0\cdot1x}$	Log/Log scale, range 1·1 up to 3·0
LL3	$=e^{x}$	Log/Log scale, range 2·5 up to 10^5
A	$=x^2$	Upper scale of the rule 1–100 which corresponds with B scale
B	$=x^2$	Upper scale of the centre slide 1–100
B1	$=\frac{1}{x^2}$	Reciprocal scale to B
C1	$=\frac{1}{x}$	Reciprocal or inverse scale
C	$=x$	Lower scale of the centre slide 1–10 which corresponds with D scale
D	$=x$	Lower scale of the rule 1–10
P	$=\sqrt{1-x^2}'$	Pythagorean scale
K	$=x^3$	Cubic scale
LL0	$=e^{0\cdot001x}$	Log/Log scale range 1·001 up to 1·01

REVERSE SIDE OF CENTRE SLIDE

T2	$=\sphericalangle$ tan 0·1x(cot)	Tangent (and cotangent) scale, range 45° up to 84·5°
T	$=\sphericalangle$ tan 0·1x(cot)	Tangent (and cotangent) scale, range 5·5° up to 45°
L	=1gx	Mantissa scale for determining common logarithms of all numbers
S	$=\sphericalangle$ sin 0·1x(cos)	Sines (and cosines) scale



DARMSTADT

ARRANGEMENT OF SCALES

This Slide Rule has the scales A, B, C1, C, D, and K in about the same arrangement as the type RIETZ and the instructions in the foregoing chapter may be used for same. This also applies to the scale of mantissa L, the trigonometric scales S and T which are engraved on the reverse side of the centre slide. In addition to these there is a P (Pythagorean) scale which is situated on the lower part of the stock (10 in. model) or on the reverse side of the centre slide (5 in. model).

Very important are the Log/Log (e-scales) on top and bottom of the stock, LL1, LL2, LL3 (on the 10 in. model an additional LL0 scale).

The Cursor

Generally speaking the cursor can be regarded as a scale—but with a limited amount of lines.

The Trigonometric Scales

On the DARMSTADT type these scales are not graduated in degrees and minutes but in decimals of a degree. This is sufficient for nearly all mathematical operations. In order to convert minutes into tenths of a degree, set C(60) above D(100) and get a table that allows to convert in both directions.

Examples: 44′=0·734°, 17·5′=0·292°
26′=0·434°.

(*a*) finding sin α and cos α:

Scale S runs from 5° to 90°. If α is within this range set M on sin α (black) and read sin α on D.

Examples: sin 9·25°=0·161, sin 39·5°=0·636
sin 48·7°=0·751.

In order to find cos α for $\alpha<5°$, find sin α, set M to D (sin α); it shows on $\sqrt{1-x^2}$ cos α

Examples: cos 14·5°=0·968, cos 13·25°=0·9733, cos 25°=0·906

Bring C1(1) in coincidence with D(10) and set M on tan α; then it shows on D tan α and on C1 cot α.

Examples: tan 25°=0·466, cot 25°=2·14, tan 18°=0·325
cot 18°=3·08. When $\alpha>45°$, use tan α=cot (90°−α)
and cot α=tan (90°−α).

Examples: tan 70°=cot 20°=1:tan 20°=2·75 cot 65°=
tan 25°=0·466.

If α is very near 90° set $\alpha=90°-\beta$, then tan α=cot β and cot α=tan β.

Examples: tan 89·65°=cot 0·35°=163·7.

THE SINUS-THEOREM

As the sinus-theorem is a proportion, you use the scales sin and C to form this proportion

Given a=17 m, b=26 m, and α=23°.

Set M on (sin) 23, proceed C(17) under M and move M to C(26). M shows on D sin β=0·598 and on (sin) 36·7°. Therefore γ=120·3°. Set M to (sin) 53·7°, which is like sin 120·3°, and read on D the third side c=35·1 m. As α is opposite the shorter side, there are two results.

Indeed, 0·598 can be also sin (180°−36·7°) and β'=143·3°. This gives γ'=13·7°. One sets M to (sin) 13·7 and finds c′=10·3 on D. If the given angle is opposite the greater side, there is only one solution.

Examples: Given a=66·4 m, b=41·1 m, α=48·2°.
Found c=86 m γ=104·2° (75·8°) and β=27·6°.
Given a=642 m, b=493 m, α=58·4°.
Found c=745 m, β=40·8° and γ=80·8°.

THE PYTHAGOREAN SCALE

Let us for short call this square root scale R. It corresponds with D, the numbers of which are to be read 0·1 to 1. If you set M to any number n on D (or R) you read on R (or D) $\sqrt{1-2^2}$. This scale is reciprocal and therefore engraved in red.

Examples: $\sqrt{1-0{\cdot}41^2}$=0·912 $\sqrt{1-0{\cdot}74^2}$=0·72.

This allows immediately to find the cosinus to any value of sinus without knowing the angle.

THE EXPONENTAL SCALES

[e-Scales] LL_1, LL_2, and LL_3

The three Log/Log scales LL_1, LL_2, and LL_3 are the first, second, and third part of one continuous scale whose graduations range from 1·01 to 5×10^4 and are used in connection with the fundamental scale D.

The LL_1 scale contains the values 1·01 to 1·11, the LL_2 scale the values 1·1 to 3·0, and the LL_3 scale values 2·5 to 50,000. The constant e=2·718 is found over the right end line of scale D on scale LL_2 and under the left end line of scale D on scale LL_3. On these scales the location of the decimal point is not variable as it is in the case with the fundamental scales.

The scales are so designed that for any setting along the graduation of LL_1 the corresponding 10ths power is produced on LL_2 (or 100ths on LL_3). Inversely, the 10ths root of any number set on scale LL_3 appears on LL_2 (or 100ths on LL_1).

(a) *Powers and roots with the exponent 10.* The transition from one stripe above it gives the tenth root, and the transition in the inverse direction gives the tenth power.

Examples: $\sqrt[10]{50}$=1·479, $\sqrt[10]{2}$=1·0718, $\sqrt[10]{145}$=1·645
$\sqrt[100]{105}$=1·0476, $1{\cdot}031^{10}$=1·357, $1{\cdot}425^{10}$=34·6, $1{\cdot}0456^{100}$=86·5, $1{\cdot}037^{100}$ =38.

(b) *Powers and roots of e.* On D is the exponent, on LL_1 the power. If the exponent is between 1 and 10, the power is to be found on LL_1.

Examples: $e^{2\cdot04}$=7·7, $e^{4\cdot25}$=70, $e^{8\cdot3}$=4000.

When n>10, we disjoin the exponent in factors.

Examples: $e^{12}=(e^6)^2=400^2$=160000.

If 0·1<n<1, LL_2 corresponds with D.

Examples: $e^{0\cdot344}$=1·41, $e^{0\cdot51}$=1·665, $e^{0\cdot435}$=1·545

If n<0·1, LL_3 gives the result.

Examples: $e^{0\cdot0355}$=1·0361, $e^{0\cdot0606}$=1·0625

In order to find roots, one uses $\sqrt[n]{e}=e^{\frac{1}{n}}$

Examples: $\sqrt[5]{e}=e^{0\cdot2}$=1·2215, $\sqrt[3]{e}=e^{0\cdot333}$=1·395

(c) Natural logarithms.

If the transition from D to LL_1 gives a power of e, the inverse transition from LL_1 to D must give the natural logarithms of a number.

Examples: ln 13=2·565, ln 1·3=0·262.
ln 1·026=0·02552.

(d) Logarithms of arbitrary basic numbers.

The transition from LL_1 to D gives the natural logarithm because LL_1 (e) coincides with D(1). When an arbitrary number b is brought in coincidence with D(1), we get the logarithms with b as a basic number. E.g. to find the decimal logarithms we set LL_1(10) above D(1). To find $4\cdot 5 \log 50=2\cdot 6$, you set LL_1 (4·5) above D(1) and read 2·6 under P(50).

(e) Powers and roots with arbitrary exponents.

In order to find these values, you have to move the slide. Find $1\cdot 15^{11\cdot 1}$. Bring with th aid of M P (1·15) in coincidence with D(1) and move M to (1—1—1). In this position M shows three values on the three parts of LL_1, and the user has to decide which of them is the right one. In a practical example this is never a problem. Here M shows on LL_2 $1\cdot 15^{1\cdot 11}=1\cdot 168$, on LL_3 $1\cdot 15^{11\cdot 1}=4\cdot 72$ and on LL_1 $1\cdot 15^{0\cdot 111}=1\cdot 0156$.

Find $3\cdot 1^{1\cdot 33}$. Set P(3·1) above D(1), above D(1·33) you read $3\cdot 1^{1\cdot 33}=4\cdot 5$, $3\cdot 1^{0\cdot 133}=1\cdot 162$, $3\cdot 1^{0\cdot 0133}=1\cdot 01515$.

If you proceed in the inverse direction, you get the roots.

Find $\sqrt[2\cdot 3]{30}$. Set LL_1 (30) above D(2–3), above D(1) you find the result 4·39. In order to find $\sqrt[3]{1\cdot 55}$, set LL_2 (1·55) above D(3) and read the cubic root 1·1575 above D(1) on LL_2. There are cases where the result must be read above D(10).

Examples: $\sqrt[7]{1\cdot 8}=1\cdot 0875$, $\sqrt[3]{9}=2\cdot 08$

If the exponent is negative, one uses the relation $a^n=1:a^n$. After a^n has been found, you take its reciprocal value in the known manner.

(f) It was explained how to work with the Log/Log scales, using the inverted scale. Indeed, this is the regular position if many examples must be solved. But if, in a series of examples, a single power of e is demanded, it can be found with the scale in the normal position. For this purpose the stock has two notches, one on the right and one on the left. Each of it has a cursor line which coincides with D(1) and D(10). As C is identical with D, C can be taken for D.

To find $2^{1\cdot 1}$ and $2^{2\cdot 12}$, 2 of LL_2 has to be moved beneath the line of the right notch. Then the cursor comes to C(1) and the slide moves to the left until C(1·1) is under the cursor line. At the right notch $2^{1\cdot 1}=2\cdot 144$ is read. If nothing is to be seen at this point, the left notch shows the result, e.g. $2^{2\cdot 12}=4\cdot 35$. Of course, the user has to estimate the result and, according to this estimation, the correct stripe of e must be taken.

(g) *Some hints on how to get on with difficulties.*

1. The e-scale runs from 1·01 until 5×10^4. The last part of e has very narrow distances, and readings in this range cannot be exact. Fortunately these parts are seldom used. But it is quite possible that a number smaller than 1·01 arrives in our computations. In this case the following relation are known:

Be ϵ a small number compared with 1, then is $(1+\epsilon)^{n'} \approx 1+n'\epsilon$ $\sqrt[n]{1+\epsilon}\approx 1+\frac{1}{n}\epsilon$; $e^{\epsilon}\approx 1+\epsilon$; $a^{\epsilon}\approx 1+\epsilon\cdot \ln(a)$ and $\ln(1+\epsilon)\approx \epsilon$, n may also be a fraction.

2. The Log/Log scale has no numbers smaller than 1. If we have to calculate with $a<1$ we take its reciprocal value 1 : a and perform the computation. If the result is r, 1 : r will be the result with $a<1$.

3. The result surmounts 5×10^4.

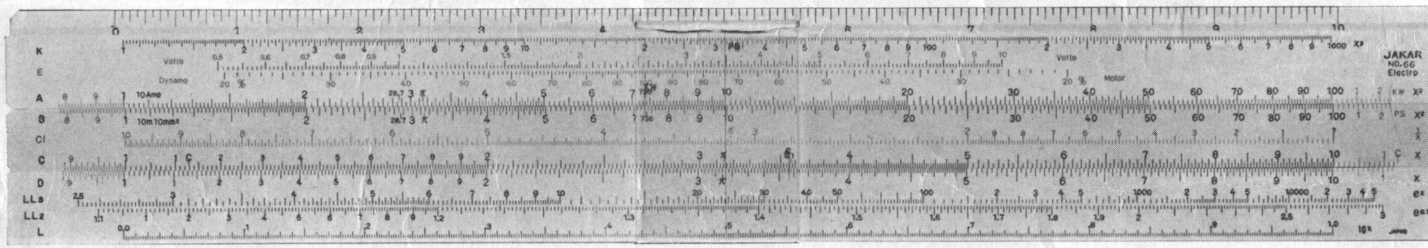
Make use of the algebraic theorems

$a^n=(a^p)^q$, if $p\cdot q=n$

$a^n=b^n\cdot c^n$, if $b\cdot c=a$

$a^n=\frac{k^n}{e^n}$, if $k:e=a$

No. 66 Electro



K	$=x^3$	Cubic Scale
E	=Volt	Voltage Drop Calculation Scale
		Dynamo/Motor Generator and Motor Efficiency Scale
A	$=x^2$	Upper Scale of the rule 1–100 which corresponds with B
B	$=x^3$	Upper Scale of the slide 1–100
C1	$=\frac{i}{x}$	Reciprocal or Inverse Scale
C	$=x$	Lower scale of the slide 1–10 which corresponds with D
D	$=x$	Lower scale of the rule 1–10
LL_3	$=e^x$	Log/Log Scale, range 2·5–50,000
LL_2	$=e^{0\cdot 1x}$	Log/Log Scale, range 1·1–3·0
L	=lgx	Mantissa scale for determining common logarithms of all numbers

REVERSE SIDE OF CENTRE SLIDE

S =sin 0·1x(cos) Sines (and cosines) scale

ST=arc 0·01x Sine and tangent scale

T =tan 0·1x(cot) Tangent (and cotangent) scale, range 5·5° up to 45°

ELECTRO

ARRANGEMENT OF SCALES

The JAKAR ELECTRO Slide Rule has the scales A, B, C1, C, D, L, K, S, ST, T as well as LL_3 and LL_2 in a similar arrangement as the models RIETZ and DARMSTADT. Therefore the instructions for these may be used in the foregoing paragraphs. In addition to these there are voltage and dynamo/motor scales and these are situated on the upper part of the stock.

CALCULATION OF AREA OF CIRCLE

The cursor is engraved with two short lines on its underside, either side of the cursor hair-line, one at top left and the other at lower right.

The area of a circle can read directly for a given diameter.

By placing the cursor hair-line over any number on scale D, indicating the diameter of a circle, the area of this circle is found on scale A under the left-hand red line. Conversely, if the area is known, the diameter is found by placing the hair-line over the area on scale A, and reading the diameter on scale D under the right-hand red line.

Diameter of circle—2 in.—place cursor centre line over 2 on scale D and read area on scale A under left-hand line—answer 3·14 (π) sq. in.

Area of circle—13 sq. in.—place cursor centre line over 13 on scale A and read diameter on scale D right-hand line—answer 4·07.

DYNAMO/MOTOR SCALE

The upper scale E marked dynamo and motor is used for calculating the efficiency, the output or the horse-power of dynamos and motors.

Efficiency of Dynamos

Determine the efficiency of a dynamo using 120 horse-power with an output of 80 kW. Using the scales A and B divide 80 by 120 and read the answer 90·5% by means of the indicator on the slide.

Corresponding values of horse-power and output in kW can be found by setting the indicator on the slide on any fixed efficiency.

Example: Efficiency 85% gives h.p./kW: 20/12·5 30/18·8 40/25 80/50.

Efficiency of Motors

Determine the efficiency of a motor of 35 h.p. with an input of 30 kW. Divide the input by the h.p. using the scales A and B and read the answer 86% on the motor scale at the indicator.

Note: **There exists a difference between one horse-power in British measure (1 h.p.= 550 ft/lb per sec.=746 watts) and one horse-power in the metric system (1 h.p.=75 kg= 736 watts) the indicator to the scale dynamo and motor and the corresponding mark on the Slide Rule are based upon the metric system of 1 h.p.=736 watts.**

Conversion of kW to h.p.

The interval between the centre hair-line and the upper right line represents the factor for converting kW to h.p. and *vice-versa* referred to readings along scale A.

For instance: When the centre line is over 20 kW the 27·1 h.p. is found under the upper right line of the cursor.

Inversely, by setting the h.p. line to 7 we read 5·15 kW under the centre hair-line.

Voltage Scale

This scale is used to calculate voltage drop, current strength, length or cross-section of a conductor, when three of these factors are known.

The voltage drop in a copper wire conductor with direct current or induction free, alternating current is

$$e=\frac{JL}{cq} \text{ where } e = \text{loss of potential in volts}$$

J =current strength in amps

L=length of conductor in metres

q =area of copper section in square millimetres

c =28·7 specific conductivity of copper 0·5

Example: Find the voltage drop for a copper conductor of 10 sq. mm section and 75 mm in length, current strength of 12 amps.

Using the A and B scales, multiply 12 by 75, divide the result by 10 and read the answer 3·13 volts at the end of the slide index on the voltage scale.

If this voltage drop is too high, the cross-section can be found for a loss of say, 2 volts, by leaving the cursor in the position arrived at by multiplying 12 by 75 and moving the centre slide so that the left-hand index comes in line with 2 on the voltage scale and the corresponding area read off the B scale under the cursor hair-line 15·7, that is a conductor of 16 mm² will be used.

The instructions in this booklet refer mainly to 10-in. Slide Rules. However, these are also suitable for 5 in. models.

The exactness of 10-in. Slide Rules is for nearly all mathematical operations sufficient, whilst 5-in. Pocket Slide Rules are normally used for rough calculations.

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DIVISION. BELOW SETTING +1.

MULTIPLICATION ABOVE SETTING -1.