Hellerman Slide Rule Instructions

27602 254 mm. (10 ins.)
27205 127 mm. (5 ins.)

1. SCALES

Scales on the face side — **Universal:**

L	log x	Logarithmic	on upper half of rule
P	$\sqrt{1-x^2}$	Pythagorean	on upper half of rule
K	x^3	Cubic	on upper half of rule
A	x^2	Square	on upper half of rule
B	x^2	Square	on slide
R	$\frac{1}{x}$	Reciprocal	on slide
C	x	Basic	on slide
D	x	Basic	on lower half of rule
T	tg	Tangent for division of circle into 360°	on lower half of rule
S	sin	Sine for division of circle into 360°	on lower half of rule
Arc	S-T	Common for sine and tangent from 30′ to 6°	on lower half of rule

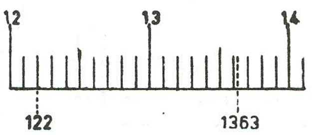
Scales on the reverse side — **Exponent:**

E_3	$e^{0,01x}$	Exponential	on upper half of rule
E_2	$e^{0,1x}$	Exponential	on upper half of rule
E_1	e^{x}	Exponential	on upper half of rule
π_I	πx	Circular arcs	on upper half of rule
π_{II}	πx	Circular arcs	on slide
$R\pi$	$\frac{1}{\pi x}$	Reciprocal of circular arcs	on slide
R_{II}	$\frac{1}{x}$	Reciprocal	on slide
C_{II}	x	Basic	on slide
D_{II}	x	Basic	on lower half of rule
E_I	e^{-x}	Exponential with negative exponents	on lower half of rule
E_{II}	$e^{-0,1x}$	Exponential with negative exponents	on lower half of rule
E_{III}	$e^{-0,01x}$	Exponential with negative exponents	on lower half of rule

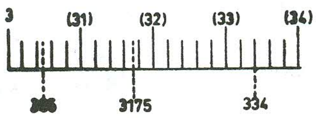
2. READING THE SCALES

The scales of the slide rule may be divided into three sections according to their respective graduation:

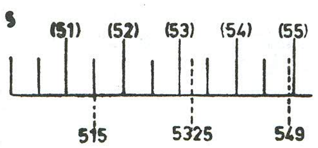
a) Reading is similar to that of a simple millimeter scale - each graduation mark corresponds to a unit increase in value. The next digit, i. e. the tenth of a graduation, is estimated (136 3).



b) In the second section the graduation mark on the scale represents an increase in value by two units. Further digits are estimated.



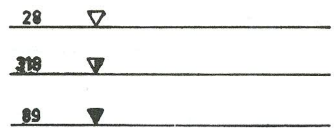
c) In the third section the graduation mark corresponds to 5 units, further digits are estimated.



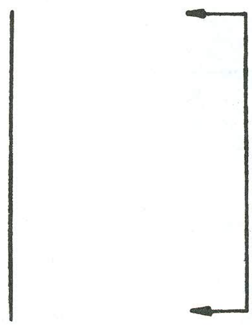
When a value is being read on the scale, the sequence of digits is determined only and not the order of the number. Therefore we read 3—1—7—5

3. AUXILIARY SYMBOLS

For a diagrammatic presentation of the computing operations on the slide rule auxiliary symbols for scales and calculation results are stated below.
The scales are marked with a straight line and a letter corresponding to that stated at the beginning of the instructions.



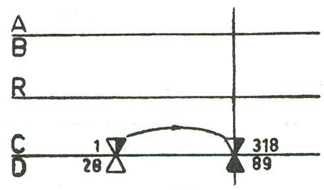
The blank triangle designates the beginning of the computing operation, the number represents the set value.
The black-and-blank triangle designates the next set value. The black triangle denotes the result of the operation.



The vertical line represents the central line on the cursor, or the index in the cut-out of the rule, the arrows showing the direction of the movement.

4. MULTIPLICATION (Graphical addition of two scales)

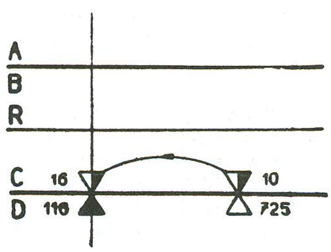
Example: 28 . 3.18 = 89



In order to achieve higher reading accuracy, basic scales C and D are used for multiplication. The beginning 1 of scale C on the slide is set against 28 of scale D on the rule. The line of the cursor is shifted to the value of the multiplier 3.18 and below the line on scale D the product 89 can be read.

The position of the decimal point is determined by estimate, e. g. 30 . 3 = 90.

Example: 0.725 . 16 = 11,6



Above the value of the multiplicant 0.725 set the right end number of the slide scale 10, as with the left end number of the scale 1 the value 16 on the slide lies outside the range of the rule.

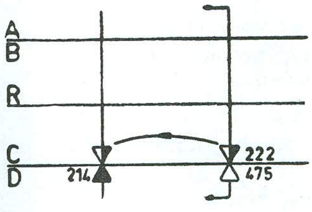
Estimate of the decimal point: 0.5 . 20 = 10.

b

5. DIVISION (Graphical subtraction of scales)

Example: $\dfrac{47.5}{22.2} = 2.14$

Division is the reciprocal operation of multiplication. With the aid of the cursor line set 22.2 against 47.5, shift the cursor to the left end mark of the slide scale 1 and read 2.14 below.



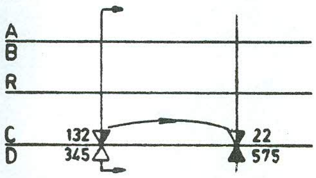
In case the left end mark is outside the range of the rule, read the right end mark 10 below.

Estimate of the decimal point. $\dfrac{50}{20} = 2{,}5$

6. COMBINED MULTIPLICATION AND DIVISION

Example: $\dfrac{345 . 22}{132} = 57.5$

First carry out the division and then the multiplication. By means of the cursor set 345 against 132 on the slide. Without determining the resulting quotient, shift the cursor to the right and set it against 22 on the slide. Below this value read the result 57.5.



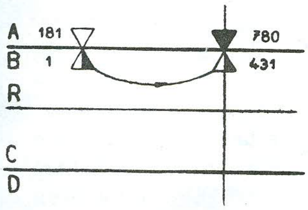
Estimate of the decimal point: $\dfrac{300 . 20}{100} = 60$

7. USE OF SQUARE SCALES

The problems mentioned above can also be solved on square scales A and B. However, the accuracy of reading is lower, as same are not provided with the same fine graduations as the basic scales.

Example: 18.1 . 4.31 = 78

Set the left end mark of the slide against the multiplicant 18.1 on scale A and below the cursor line shifted to the multiplier 4.31 on scale B of the slide read the product 78.0 on scale A.



Estimate of the decimal point: 20 . 4 = 80

8. PLACING THE DECIMAL POINT

Without estimate it is possible to determine the position of the decimal point as follows:

Multiplication:

Example: 242 . 35 = 8470
3 + 2 — 1 = 4

The result appears on the right of the set end mark of the slide, the number of digits is equal to the sum of the number of digits of both factors diminished by 1.

965 . 12 = 11580
3 + 2 = 5

The result appears on the left of the setting, the number of digits is equal to the sum of the number of digits of both factors.

Division:

Example: 186 : 44 = 4.227
3 — 2 = 1

The result appears on the right of the setting, the number of digits is equal to the difference in the number of digits of the dividend and divisor.

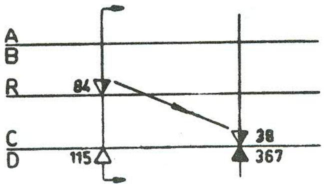
55 : 17 = 3.235
2 — 2 + 1 = 1

The result appears on the left of the setting, the number of digits is equal to the difference in the respective number of digits increased by 1. With both factors only the number of digits before the decimal point is taken into account, not the decimal fraction.

9. RECIPROCAL SCALE

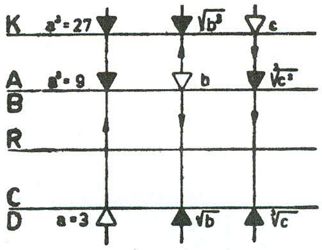
The reciprocal scale corresponds to scale C, it is divided, however, from right to left. To the value x on scale C corresponds the value $\dfrac{1}{x}$ on scale R.

Example: 1.15 . 8.4 . 38=367



If multiplying with the use of scale R, set one factor on scale R against another on scale D below the common mark of the cursor. The result appears under the right or left end mark of the slide. We can multiply the result by still another factor, so that two multiplications are achieved by shifting the slide once as shown in the example. Estimate of the decimal point: 1 . 8 . 40 = 320.

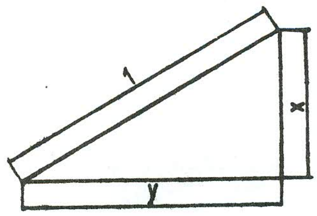
10. POWERS AND ROOTS



By setting the cursor line against any value on scale D it is possible to read its square on scale A and its. cube on scale K. Vice versa, the square or cube roots of values chosen on scales A or K can be read on scale D.

The decimal point is determined by estimate.

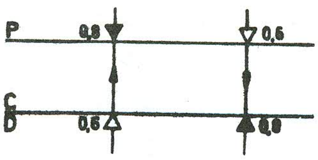
11. PYTHAGOREAN·SCALE $\sqrt{1-x^2}$



In a rectangular triangle with a hypotenuse of unit length relations $y = \sqrt{1-x^2}$ or $x = \sqrt{1-y^2}$ are valid. On the basis of these relations, it is possible to apply the $\sqrt{1-x^2}$ scale for various calculations:

a) $\sqrt{1-0.6^2} = 0.8$,
$\sqrt{1-0.8^2} = 0.6$

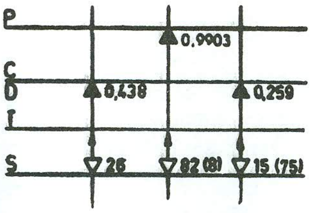
b) $\sin \alpha = \sqrt{1-\cos^2\alpha}$,
$\cos \alpha = \sqrt{1-\sin^2\alpha}$,
$\sin 20^0 = 0.342$,
$\cos 20^0 = \sqrt{1-0.342^2} = 0.9397$



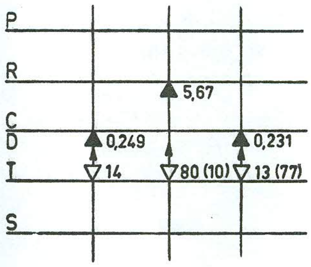
c) Apparent output of the electromotor 100 per cent, effective output 85 per cent, $\cos \varphi = 0.85$; wattless current can be determined from $\sqrt{1-0.85^2} = 0.527$, i. e. 52.7 per cent

12. TRIGONOMETRIC FUNCTIONS

The values of trigonometric functions are read on the basic scale D. For sine and cosine values scale $\sqrt{1-x^2}$ is also used. Tangent and cotangent values are found by means of the basic scale D and the reciprocal scale R.



$\sin 26° = 0.438,$
$\sin 82° = \sqrt{1-\cos^2 82°} =$
$= 0.9903$
$\cos 75° = 0.259$



$\mathrm{tg}\ 14° = 0.249$
$\mathrm{tg}\ 100° = -\mathrm{tg}\ 80° =$
$= \frac{1}{\mathrm{cotg}\ 80°} = -5.67;$
$\mathrm{cotg}\ 77° = 0.231$

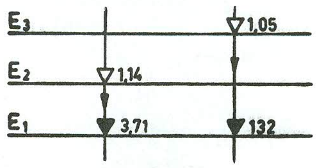
The trigonometric functions of small angles from 0 to 5° are determined by means of the value $\rho = \frac{\pi}{180}$ which is indicated on basic scales C and D. The values of the angle and ρ are multiplied.

Example: $\sin 0.5° = 0.5 \,.\, \rho = 0.00873$
$\mathrm{cotg}\ 89.7° = \mathrm{tg}\ 0.3° = 0.3\ \rho = 0.00524$

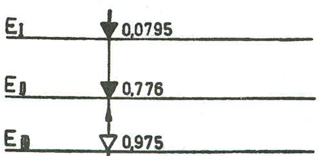
13. EXPONENTIAL SCALES Powers and roots

By means of scales E_1, E_2, E_3, $E_|$, $E_{||}$, $E_{|||}$, it is possible to raise the power of an arbitrary number within the range of the scale. Find the given number m on a suitable scale and read the result m^{100}, m^{10} on the scale with a higher exponent.

In the same way find the powers of numbers smaller than 1 on scales $E_|$ - $E_{|||}$. By means of exponential scales the power of arbitrary numbers can be raised.

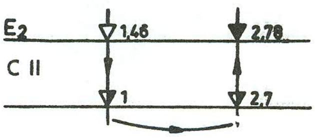


Find the given number on the convenient scale of the $E_|$ system and against it set the unity mark of the basic scale. Above the respective exponent read the result on the same scale of the $E_|$ system.



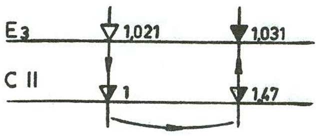
Example: $1.46^{2.7} = 2.78$

The given value and the result lie on the same scale E_2.



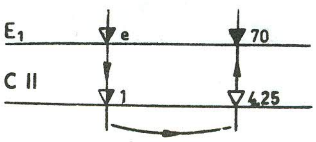
Example: $1.0211^{1.47} = 1.031$

The given value and the result are found on scale E_3.



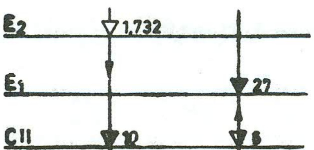
The powers of e^x are determined with the slide in basic position, e. g. $e^{4.25} = 70$.

Should the range of the rule prove insufficient, set the end of scale $C_{||}$ instead of its beginning against the given number. The result will appear, however, on the scale with an exponent ten times higher. Therefore, if the base is on scale E_3, read the result on scale E_2.



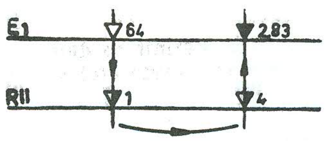
Example: $1.732^6 = 27.$

The roots are taken with the aid of the reciprocal scale. Set the unit of the reciprocal scale against the given number on scale E_1 and read the result on the same scale E_1 opposite the exponent of the root on the reciprocal scale.

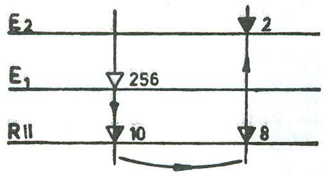


Example: $\sqrt[4]{64} = 2.828$

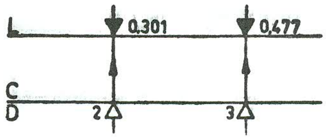
If the range of the rule is insufficient, set the mark 10 of scale $R_{||}$ against the given number on scale E_1 and read the result.



Example: $\sqrt[8]{256} = 2.$



14. LOGARITMIC SCALE



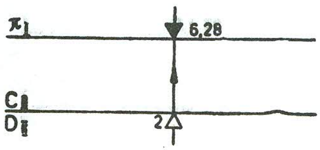
If the line of the cursor is set against the given number, it indicates the mantissa of the corresponding logarithm of base 10 on the logarithmic scale.

Example: $\log 2 = 0.30103,$
$\log 3 = 0.47712$

15. SCALE FOR CIRCULAR ARCS

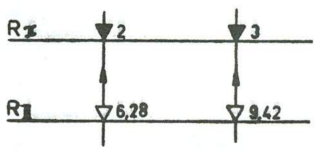
Scale π x:

If the diameter of the circle is set on scale $D_{||}$ the corresponding circumference is found on scale π_1.



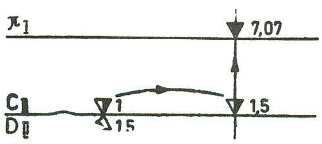
Example: For the diameter of 2 the circumference of 6.2832 is found

Scale $\frac{1}{\pi x}$



The basic reciprocal scale $R_{||}$ combined with the reciprocal scale of circular arcs $R\pi$ determines the diameter of a circle of a given circumference.

Example: Set the circumference 6.28 on scale $R_{||}$ and read the diameter 2 on scale $R\pi$.



Example: The area of a circle with a 1.5 radius is determined as follows: On scale $D_{||}$ find the radius 1.5, set the beginning of scale $C_{||}$ against it and above the value of 1.5 of this scale read the result along the cursor mark on scale $\pi_|$, 7.07.
$\pi \,.\, 1.5^2 = 7.0686$

16. SPECIAL MARKS AND THEIR USE

Mark	On scale	Meaning	Value
ρ	C, D| C||, D||	$\frac{\pi}{180}$	0,01745
ρ'	C, C||	$\frac{180}{\pi} \,.\, 60$	3438
ρ''	C, C||	$\frac{180}{\pi} \,.\, 60 \,.\, 60$	206265
C	C, C||	$\sqrt{\frac{4}{\pi}}$	1,128
C_1	C, C||	$\sqrt{\frac{40}{\pi}}$	3,57
π	A, B, R, C, D $\pi_\|$, $\pi_{\|\|}$, $R\pi$, $R_{\|\|}$ $C_{\|\|}$, $D_{\|\|}$	3,1416	

Marks ρ, p′, ρ'' permit to determine the arc corresponding to the given angle and vice versa.

Example:

$$\alpha = 12^\circ,\ \text{arc}\ \alpha = \alpha \,.\, \rho = 0{,}2094$$

$$\alpha = 12^\circ 15' = 735',\ \text{arc}\ \alpha = \frac{735}{\rho'} = 0{,}2138$$

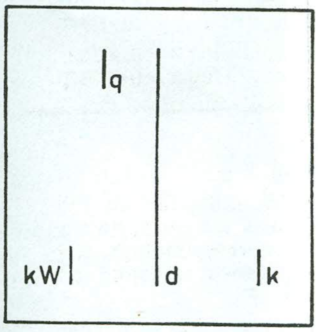
$$\alpha = 12^\circ 15' 18'' = 44118',\ \text{arc}\ \alpha = \frac{44118}{\rho''} = 0.2145$$

The diameter of the circular dial is 250 mm. What is the distance between two graduation marks for a division in ½° steps? (½° = 30′).

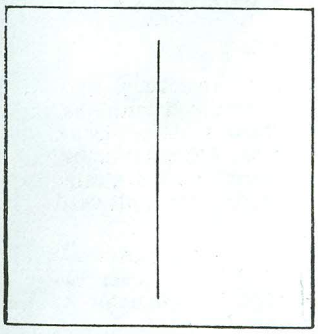
$$\frac{a \,.\, R}{\rho'} = \frac{30 \,.\, 125}{\rho'} = 1{,}09\ \text{mm}$$

By means of marks C, C1 the circular area with a known diameter is determined.

17. MARKS ON THE CURSOR



The left upper mark and the right lower mark are at a distance of $\frac{\pi}{4}$ = = 0.785 (measured on a square scale) from the central main line. If one of the marks is set against the given value (diameter of the circle) on the basic scale D, the circular area can be read under the next left mark on the square scale A.



Example: Area π corresponds to the value 2.

To the circular diameter of 42 mm corresponds its area of 1388 mm².

As the value 7.85 corresponds to the specific gravity of steel, it can be used for weight calculations of bar stock. Set the right mark against the diameter of the bar on scale D, under the central line on scale A read the area of the circular cross-section and simultaneously read the respective weight of the material under the left mark. By shifting the end mark of the slide against the value thus determined, find out the weight of the bar by the usual way of multiplication by its length.

The left and right lower marks are used for transformation of continental kW into HP and vice versa.

Example: While setting the left mark against 20 continental kW read 27.2 HP below the right mark. Inversely, for 7 HP read the corresponding value of 5.15 continental kW under the left mark.

MAINTENANCE OF THE SLIDE RULE

The slide rule is a valuable technical instrument and deserves careful handling. The scales and cursor should be protected from soiling and scratching in order not to impair the accuracy of reading.

Should it be necessary to clean the slide rule, use lukewarm water and soap, avoid all sorts of chemicals, petrol, alcohol, acetone, chloroforme, etc. To achieve a smooth movement of the slide in the rule, soap or wax can be applied to the sliding surfaces.

The slide rule is made of plastics. It is necessary to protect it from the direct influence of sun heat and radiators, as at a temperature of about 50 °C deformation of the material occurs.

TABLE OF IMPORTANT VALUES

Various numbers and units:

π	= 3.14159	cal	= 0.427 kgm
log π	= 0.49715		= 4.2 Ws
x	= 2.71828	kWh	= 860 k cal
$\log^x$	= 0.43429 ln x	kWh	= 367200 kgm
$\ln^x$	= 2.3026 log x	Ws	= 0.238 cal
g	= 9.81 m/sec²	kgm	= 2.34 cal
$\sqrt{2g}$	= 4.429	at	= 1.0333 kg/cm²
k = HP	= 75 kgm/sec	inch	= 25.4 mm
= PS	= 0.736 kW	mile	= 1609.5 m
	= 0.175 cal/sec	mile naut	= 1852 m
		s (of light)	= $3 \,.\, 10^{10}$ cm/sec

Specific gravities

Steel	= 7.85	Concrete	= 2.4
Cast iron	= 7.13	Stone	= 2.4—2.6
Aluminium, cast	= 2.6	Brick	= 1,75
Zinc, rolled	= 7.2	Sand, dry	= 1.4—1.6
Copper, rolled	= 8.9	wet	= 2.0
Lead	= 11.36	Glass	= 2.6
Oak, dried	= 0.7—1.0	Plexiglass	= 1.18
green	= 0.93—1.3	Celluloid	= 1.37
Pine, dried	= 0.31—0.76		
green	= 0.4—1.1		

Coefficient of linear thermal expansion $(\alpha \,.\, 10^6)$:

Steel, hard.	= 11.5	Zinc	= 26.7
not hard.	= 12	Lead	= 29.0
Cast iron	= 9.0	Glass	= 8 6
Copper	= 18.5	Plexiglass	= 50
Aluminium	= 23.8		

ESMOND HELLERMAN LIMITED

Hellerman House, Sunbury Trading Estate, Windmill Road,

Sunbury-on-Thames, Middlesex. TW16-7EW.

Telephone: Sunbury-on-Thames 84411.