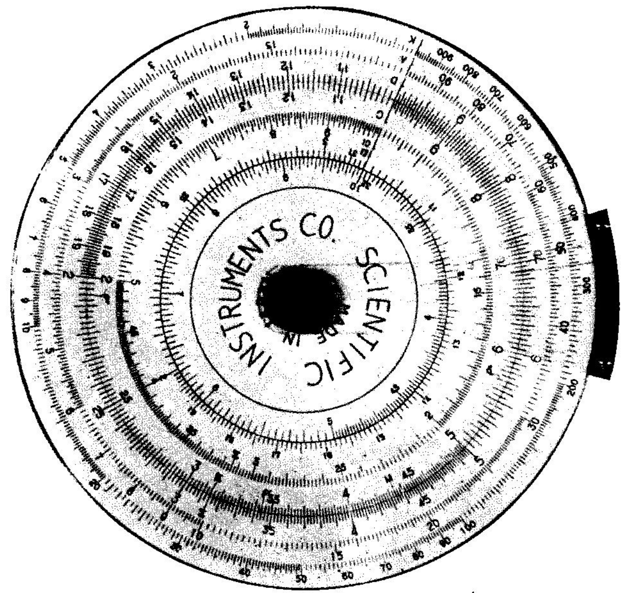
S I C

SLIDING DISK

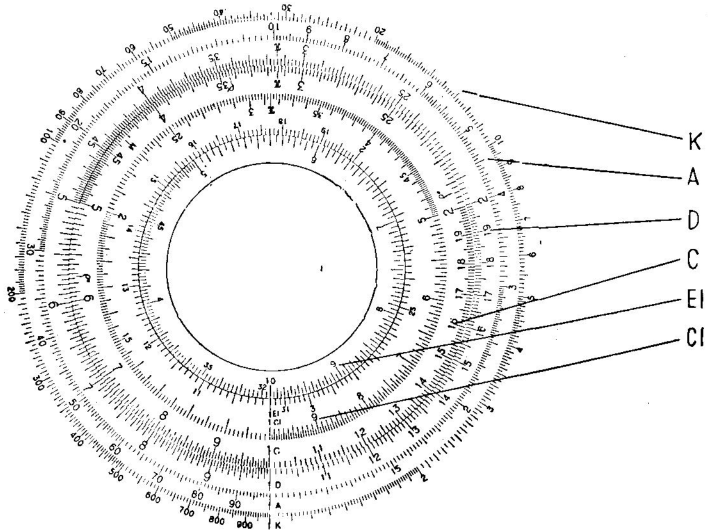
No. 130



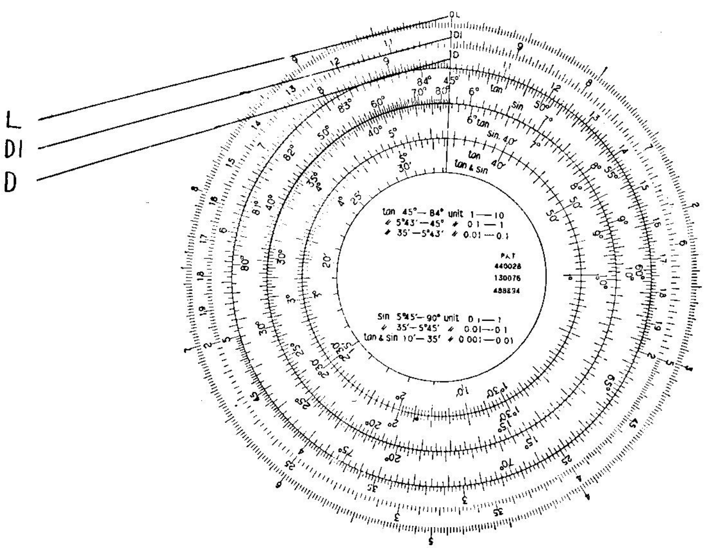
SCIENTIFIC INSTRUMENTS CO.

BERKELEY, CALI.

Front Face



Rear Face



HOW TO USE

I. Arrangement of Graduated Scales

This sliding disk is graduated in the following way, reading from the outside :

Front Face

Outer Fixed Disk	K —Third Power Scale A —Second Power Scale D —Fundamental Scale
Inner Rotating Disk	C —Fundamental Scale CI—C Scale graduated in inverse direction EI—Doubled CI Scale
Rear Face	L —Logarithmic Scale DI—D Scale graduated in inverse direction D —Fundamental Scale Tan and Sin Scale

II. How to Read Scales

All the lines on the scales represent numerical values. Intermediate values, not shown on the scales, must be estimated. For example, to locate 683, first find the lines for values on each side, in this case 680 and 685. The 683 point then is 3/5 of the space between from 680. Thus any numerical value can be located at some point on each scale. In finding these, consider only the significant figures, disregarding the decimal point. So 752, 75.2 and 0.752 are located at the same point on the scale. Since estimations by the eye have to be made for numbers composed of many digits, the accuracy of calculation is necessarily limited. Generally only the first three digits of numbers are used. (However, four digits can be used from 1000 to 2000, as that portion of the scale has lines for smaller divisions.) The lines marked "1" with red near the red letters on the front face are called "Index Lines".

III. How to Locate the Decimal Point

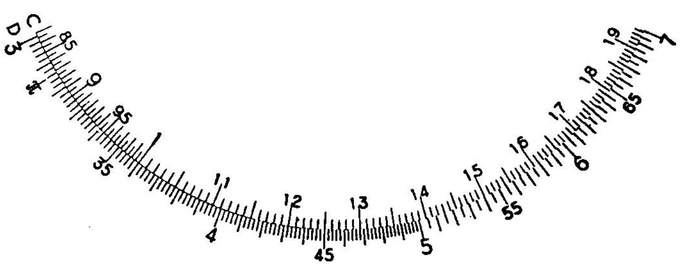
Because only significant figures are used in calculations, disregarding the decimal point, the answers obtained from the rule also are only significant numbers. So the position of the decimal point must be determined otherwise. Generally this is done by estimating an answer by very rough calculation to compare with the significant figures obtained by using the slide rule. For example, calculating $9.2\times4.5\times0.8$ can be estimated roughly as $10\times4\times1$ to see that the answer will be close to 40. Comparing this with the significant numbers 331 obtained by using the rule as explained below, it can be seen that the decimal point should be fixed at 33.1, which is the correct answer.

IV. Multiplication

1. For simple multiplication of two numbers, $\mathbf{a}\times\mathbf{b}$:
   (1) Over **a** on the D scale, set the index line of the C scale.
   (2) Under **b** on the C scale, read the product on the D scale.

Example : $3.6\times17=61.2$

Over 3.6 on the D scale, set the index line of the C scale. Then set the hairline of the cursor to 17 on the C scale, and read what it indicates on the D scale, which is 612. By rough calculation, $3\times20=60$, the decimal point can be fixed for the correct answer 61.2.



2. For multiplication of a constant number by various

numbers, $\mathbf{a}\times\mathbf{c}$, $\mathbf{a}\times\mathbf{d}$, $\mathbf{a}\times\mathbf{e}$, etc. :
   (1) Over the constant number **a** on the D scale, set the index line of the C scale.
   (2) Under each other number (**c**, **d**, **e**, etc.) on the C scale, can be found on the D scale the product of that number and the constant number, reading all without moving the Disk.
3. For continual multiplication, $\mathbf{a}\times\mathbf{b}\times\mathbf{c}\times\mathbf{d}$, etc. :
   (1) Over **a** on the D scale, set the index line of the C scale.
   (2) To **b** on the C scale, set the cursor line.
   (3) To the cursor line, again set the index line of the C scale.
   (4) Repeat (2) and (3) for all the rest of the numbers to be multiplied.
   (5) Under the last number on the C scale, read the product on the D scale.

See below for employing the CI scale to simplify such computations.

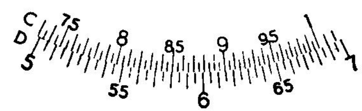
V. Division

Division is the inverse of multiplication.

1. For simple division, $\mathbf{a}\div\mathbf{b}$:
   (1) To the dividend, **a**, on the D scale, set the cursor line
   (2) To this cursor line set the divisor, **b**, on the C scale.
   (3) Read the answer on the D scale under the index line of the C scale.

Example : $56\div82=0.683$

To 56 on the D scale, set the cursor line, and to this also set 82



on the C scale. Then, under the index line on the C scale, read the significant number 683. By placing the decimal point properly as explained above, the correct answer 0.683 is determined.

2. For dividing $\frac{\mathbf{a}}{\mathbf{b}\times\mathbf{c}}$: After dividing **a** by **b** as explained above (1) and (2), merely repeat the procedure by :

(1) Set the cursor line to the index line of the C scale.

(2) To this cursor line set **c** on the C scale.

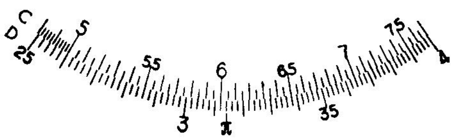
(3) Read the answer on the D scale under the index line of the C scale.

See below for employing the CI scale to simplify such computations.

VI. Combinations of Multiplication and Division $\frac{\mathbf{a}\times\mathbf{b}\times\mathbf{c}}{\mathbf{d}\times\mathbf{e}}$

Calculation involving both multiplication and division can be done by following the above operations successively. However, this can be done with fewer settings by doing one division operation first followed by a multiplication and thus alternating to completion.

Example : $\frac{26\times 7}{5}=36.4$



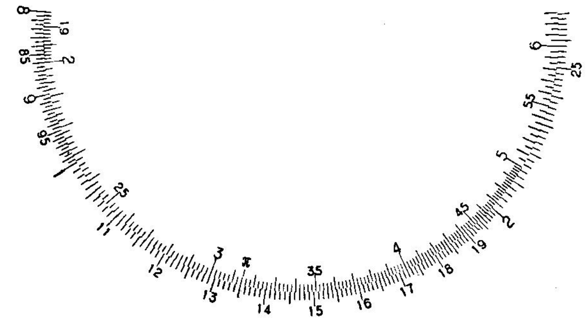
To 26 on the D scale, set 5 on the C scale. Under 7 on the C scale, read 364 on the D scale. Place the decimal point as explained above to get 36.4.

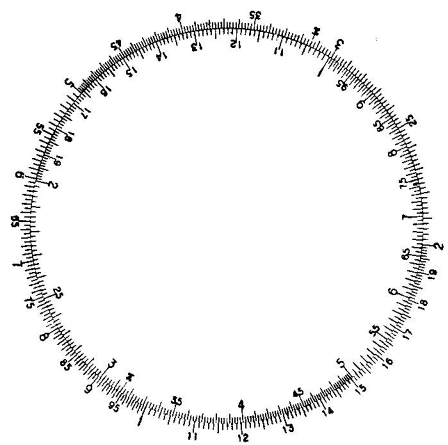
VII. Proportions

The slide rule can be advantageously used in problems involving computations of proportions. To find **a** in the proportion $\frac{\mathbf{a}}{\mathbf{b}}=\frac{\mathbf{c}}{\mathbf{d}}$ where **b**, **c** and **d** are known, there is a simple

and quick method. The proportion can be set up on the rule just as it stands. That is, over **d** on the D scale, set **c** on the C scale. Then over **b** on the D scale, read **a** on the C scale. This is the inverse of the usual procedure, but it can be seen quickly. Where any part of the proportion is unknown, the known parts can be set up on the scale and the unknown read. Where one part is variable, the fixed parts can be set up and the unknown for all variables determined with no resetting of the scale required.

Example of proportional distribution : Divide 8,600 into **a**, **b**, **c**, **d** and **e** in the proportions of 2, 3, 4, 5 and 6. First find the sum of 2, 3, 4, 5 and 6, which is 20. So





$\frac{20}{8,600}=\frac{2}{\mathbf{a}}=\frac{3}{\mathbf{b}}=\frac{4}{\mathbf{c}}=\frac{5}{\mathbf{d}}=\frac{6}{\mathbf{e}}$. Over 86 on the D scale, set 2 on the C scale. Beneath 2, 3, 4, 5 and 6 on the C scale can be read the respective proportions. Thus it is found **a** =860, **b** =1,290, **c** =1,720, **d** =2,150 and **e**=2,580.

Example of percentages : A mixture weighing 332 g.

contains 180 g. of **a**, 72 g. of **b**, 68 g. of **c** and 12 g. of **d**. What is the percentage of each of the ingredients? This can be set up as $\frac{332}{100}=\frac{180}{\mathbf{a}}=\frac{72}{\mathbf{b}}=\frac{68}{\mathbf{c}}=\frac{12}{\mathbf{d}}$. Over the index line on the D scale, set 332 on the C scale. Under 180 on the C scale, read **a** and so on. Answers : **a**=54.2%, **b**=21.7%, **c**=20.5 % and **d**=3.6 %.

VIII. Use of the CI Scale

The CI scale is the C scale to be read in the opposite direction, the "I" meaning "inverted". Of course, the hairline of the cursor must be used to read the CI scale in relation to the other scales. The CI scale has two applications, as follows :

1. Reciprocals

Any number on the CI scale is the reciprocal of the number directly below it on the C scale, and vice versa.

2. Continued multiplication or division can be done with fewer settings.

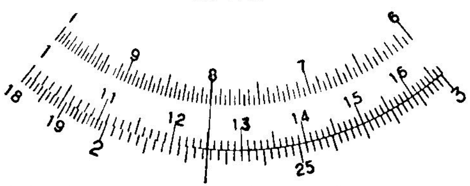
(1) Multiplication : $\mathbf{a}\times\mathbf{b}\times\mathbf{c}$

Over **a** on the D scale, set **b** on the CI scale. Beneath **c** on the C scale, read the answer on the D scale.

(2) Division : $\frac{\mathbf{a}}{\mathbf{b}\times\mathbf{c}}$

Over **a** on the D scale, set **b** on the C scale. Beneath **c** on the CI scale, read the answer on the D scale.

Example : $\frac{27}{15\times 8}=0.225$



Over 27 on the D scale, set 15 on the C scale. Beneath 8 on the CI scale, read the answer 0.225 on the D scale.

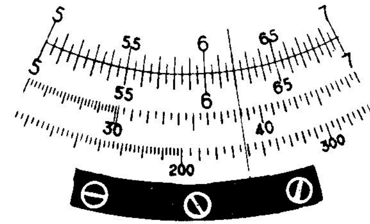
IX. Squares and Square Roots

To calculate squares and square roots, the A and D scales are used. The numbers on the A scale are the squares of the corresponding numbers on the D scale.

1. For squaring, $\mathbf{a}^2$, set the cursor line to **a** on the D scale and read under the line from the A scale.

Example : $6.2^2=38.4$

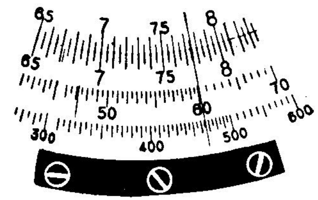
Set the cursor line to 6.2 on the D scale and read 38.4 on the A scale, fixing the decimal point by rough calculation as explained above.



2. For finding a square root, $\sqrt{\mathbf{a}}$, reverse the above procedure. Set the cursor line to **a** on the A scale and read under the line from the D scale.

Example : $\sqrt{60}=7.75$

To 60 on the A scale, set the cursor line and read 7.75 on the D scale.



Note the A scale has two sections, one with 6 and the other with 60. To determine which section of the A scale to use for numbers having other than only one or two figures before the decimal point, separate the number into groups of two figures each, from the decimal point, right or left in the direction of the leftmost significant figure. Add a zero on the right (but not left) end to complete a group if necessary. Then choose the section of scale according to the left hand group having one or two significant figures.

Examples: $\sqrt{600}=24.5$ and $\sqrt{0.06}=0.245$, while $\sqrt{6{,}000}=77.5$, $\sqrt{0.6}=0.775$ and $\sqrt{0.006}=0.0775$. Note 600 and 0.06 would use the same section of scale as 6, while 6,000, 0.60 and 0.0060 would use the other section with 60.

X. Cubes and Cube Roots

To calculate cubes and cube roots, the K and D scales are used. The numbers on the K scale are the cubes of the corresponding numbers on the D scale.

1. For cubing, $\mathbf{a}^3$, set the cursor line to **a** on the D scale and read under the line from the K scale.

Example : $3.6^3=46.6$

Set the cursor line to 3.6 on the D scale and read 46.6 on the K scale, fixing the decimal point as explained above.

2. For finding a cube root, $\sqrt[3]{\mathbf{a}}$ reverse the above procedure. Note the K scale has three sections. To determine which one to use, separate the number into groups of three figures each from the decimal point in the direction of the leftmost significant figure. Add zeros on the right (but not left) if necessary to complete a group. Then choose the 1—10, 10—100 or 100—1000 section of the K scale according to the lefthand group consisting of one, two or three significant figures respectively.

Examples : $\sqrt[3]{3.3}=1.49$, $\sqrt[3]{33,000}=32.1$ and $\sqrt[3]{0.33}=0.691$

Note 3.3 would use the 1—10 section of the scale, while 33,000 would use the 10—100 section and 0.330 the100—1000 section.

XI. Area of a Circle

This can be found by a single operation. Set the cursor line to the diameter of the circle on the D scale and read the area on the A scale under the short red hairline on the left side of the cursor surface.

Example : If diameter of a circle is 2, what is the area ?

To 2 on the D scale set the cursor line. Under the short red line. the required area of 3.14 is read from the A scale.

XII. Trigonometric Functions

The tan and sin scales on the rear face are used together with the D scale. These are six circles of scales in four rings, in order from the outside, as follows :

1st ring		tan	45°—84°	Unit 1—10
2nd ring	outside	sin	5°45′—90°	Unit 0.1—1
	inside	tan	5°43′—45°	
3rd ring	outside	sin	35′—5°45′	Unit 0.01—0.1
	inside	sin	35′—5°43′	
4th ring		tan & sin	10′—35′	Unit 0.001—0.01

To read a function, set the cursor line for the rear face over the angle and read the function from the D scale under the cursor line for the rear face. The decimal point for the function is as indicated by the unit for each ring. As you can see, the units are smaller by one decimal point as the rings move towards the center of the disk.

Example : sin 25° 18′=0.427

To sin 25° 18′ on the outside scale of the 2nd ring, set the cursor line. Read 427 from the D scale. As the unit for angles of this second ring is from 0.1 to 1, the correct answer is 0.427.

Example : tan 76° 25′

To tan 76° 25′ on the 1st ring, set the cursor line. Read 414 on the D scale. This being from the outermost ring, the value is between 1 and 10. Thus the answer is 4.14.

XIII. Logarithms

The L and D scales are used to determine common logarithms (Base 10). A logarithm consists of two parts, a positive or negative whole number known as the "characteristic" and a positive fraction known as the "mantissa".

If the number is greater than 1, the characteristic is positive and one unit less than the number of figures to the left of the decimal point. If the number is smaller than 1, the characteristic is negative and one unit more than the number of zeros between the decimal point and the first significant figure. The mantissa of logarithms for numbers is found by setting the hairline of the cursor on the number on the D scale and reading from the L scale. Antilogarithms are found by the reverse process.

Example : Find log 25.5

Corresponding to 25.5 on the D scale, read the mantissa 406 on the L scale. As the number has 2 digits to the left of the decimal point, the characteristic is 1. Therefore, log 25.5 is 1.406.

Example : Find antilog 3.885

Set the cursor line to 885 on the L scale, and 767 is read on the D scale. As the characteristic is 3, the answer is 7670.

Logarithms then can be multiplied and divided on this slide rule, as explained above for general numbers, for use according to normal rules of logarithmic calculations.

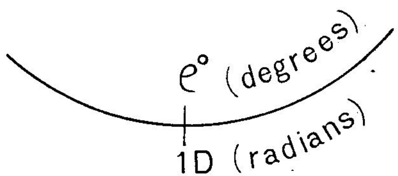
XIV. How to Use Gauge Marks

Conversion of Degrees to Radians

By making use of the lines marked as ρ°, ρ' and ρ'', it is possible to convert degrees to radians and vice versa.

1. Degrees ←→ Radians

Set ρ° on the C scale to the index line of the D scale. Readings on the C scale are degrees equivalent to the corresponding readings from the D scale in radians.



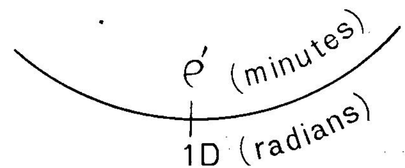
Example : Convert 37.6° to radian. Also 1.3 radians to

degrees.

Fix the C scale as described above. Set the cursor line on 376 on the C scale and read the corresponding number on the D scale which is 656. By rough estimation, since $57.3^\circ \fallingdotseq 1$ radian, fix the decimal for the correct answer of 0.656 radians. Next, set the cursor line on 1.3 on the D scale and read the corresponding number on the C scale. The correct answer is 74.5°.

2. Minutes ←→ Radians

This is done similarly as above by setting ρ' instead of ρ°.



Example : Convert 41.4′ to radian.

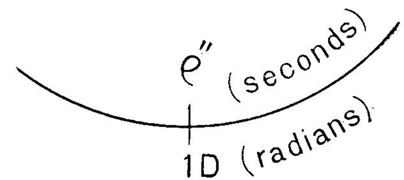
Set ρ' on the C scale to the index line of the D scale.

Set the cursor line to 414 on the C scale and read the corresponding figure 1203 on the D scale. By rough estimation, since $10' \fallingdotseq 0.003$ radian, the correct answer is 0.01203 radian.

Remark : In the conversion of 46°13′, rather than changing it all to minutes, it is simpler to change it to decimal as 46.2°.

3. Seconds ←→ Radians

Use ρ'' similarly as above.

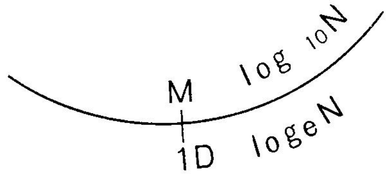


Example : Convert 45″ to radian

Set ρ'' on the C scale to the index line of the D scale. Set the cursor line to 45 on the C scale and read the corresponding number on the D scale which is 218. By rough estimation, since $10'' \fallingdotseq 0.00005$ radian, the correct answer is 0.000218 radian.

Natural Logarithms and Exponential Functions

M : By using this it is possible to obtain the values of natural logarithms and exponential functions.



1. Find natural logarithm $\log_e N$

Set M on the C scale to the index line of the D scale.

The rule is set for conversion of $\log_e$ N to $\log_{10}$ N.

Example : Find the value of $\log_e 4.73$.

As described above set the rotating portion of the rule. Set the cursor line to 473 on the D scale on the reverse side. Read the number under the cursor line on the L scale. This gives $\log_{10} 4.73=0.675$. Going back to the front face of the rule, set the cursor line to 675 on the C scale and read 1555 on the D scale. By rough estimation, since $M \fallingdotseq 0.4343$, $\log_e 4.73=1.555$.

2. Exponential function e^a

If $x = e^a$, then $\log_e x = a$, and the procedure is the reverse of the above.

Example : Find the value of $e^{3.52}$

Put $x = e^{3.52}$, then $\log_e x = 3.52$.

Similarly, set M on the C scale to the index line of the D scale. Set the cursor line to 352 of the D scale and read the number on the C scale, which gives $\log_{10} x=1.528$. Next, set the cursor line to 528 on the L scale on the reverse face of the rule and read 338 on the D scale. Since the characteristic is 1, $x=33.8$.

XV. How to Use the New EI Scale

The EI scale is the innermost scale on the rotating face of the rule. It is the doubled CI scale on both inner and outer sides of the line and the numbers represent the square

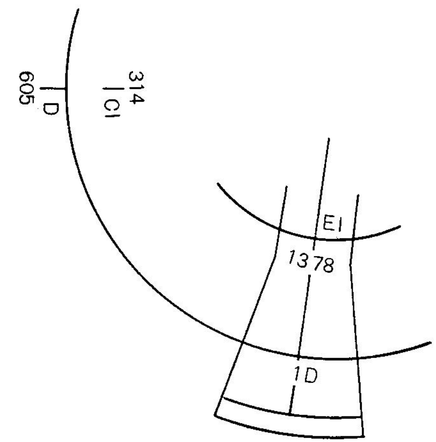
roots of the numbers on the CI scale. Hence the squarre of any number on the EI scale is obtainable from the CI scale. By using this EI scale, it is possible to obtain answers with accuracy, conveniently and efficiently, for the squares and spuare roots and multiplication and division involving these. In this respect, it is a marked improvement over the B scale of the usual straight ruler.

1. Type $\sqrt{ab}$

(1) As in usual multiplication to **a** on the D scale, set **b** on the CI scale.

(2) Set the cursor line to the index line of the D scale, and read the answer on the EI scale.

Example : $\sqrt{60.5 \times 3.14}$



To 605 on the D scale, set 314 on the CI scale. Next, set the cursor line to the index line of the D scale. By rough estimation, decide the decimal point. In this case read the answer 13.78 on the outside EI scale. Care should be taken not to mistake which of the EI scales to read, inner or outer. Rough estimation should indicate this easily.

2. Type $\sqrt{\frac{a}{b}}$

(1) As in usual division, to **a** on the D scale, set **b** on the C scale.

(2) Set the cursor line to the index line of the D

scale and read the answer on the EI scale.

Example : $\sqrt{\frac{13.45}{38.3}}$

To 1345 on the D scale, set 383 on the C scale. Set the cursor line to the index line of the D scale. By rough estimation to decide the decimal point, read 0.593 on the inside EI scale.

3. Type ab^2

(1) To **a** on the D scale, place **b** on the EI scale.

(2) Read the answer on the D scale corresponding to the index line of the C scale.

Example : 2.43×5.72^2

To 243 on the D scale, set 572 on the EI scale. Corresponding to the index line of the C scale, read the answer 795 on the Dscale. A rough estimation gives 79.5 as correct answer.

4. Type $\frac{a}{b^2}$

(1) To **a** on the D scale, set the index line of the C scale.

(2) Set the cursor line to **b** on the EI scale and read the answer on the D scale.

Example : $\frac{6.29}{5.11^2}$

To 629 on the D scale, set the index line of the C scale. Set the cursor line to 511 on the EI scale and read 241 on the D scale. By rough estimation, the correct answer is 0.241.

5. Type $\frac{a^2}{b}$

Consider this as the reciprocal of $\frac{b}{a^2}$ and the procedure is as follows :

(1) To **b** on the D scale, set the index line of the C scale.

(2) To **a** on the EI scale, set the cursor line.

(3) Keeping the cursor in place, set the index line of the C scale to that of the D scale and read the answer on the CI scale.

See below for employing the DI scale to simplyty the procedure.

Example : $\frac{3.56^2}{42.8}$

To 428 on the D scale, set the index line of the C scale. To 356 on the EI scale, set the cursor line. Keeping the cursor in place, set the index line of the C scale to that of the Dscale and read 296 on the CI scale under the cursor line. By rough estimation, the correct answer is 0.296.

Besides the above applications, it is possible to compute

$\frac{ab^2}{c^2}$, $\frac{a}{b^2c^2}$, $a^2\sqrt{b}$, $\sqrt{\frac{ab}{c}}$, etc.

XVI. How to Use the DI Scale

This scale is on the rear face and is the reverse of the D scale. It is convenient for various calculations using reciprocal numbers.

1. Type $\frac{b}{\sqrt{a}}$

This is calculated as the reciprocal of $\frac{\sqrt{a}}{b}$

(1) To **a** on the A scale, set **b** on the C scale.

(2) Set the cursor line to the index line of the C scale and read the answer on the DI scale.

Example : $\frac{4.85}{\sqrt{3.11}} = 2.75$

To 3·11 on the A scale, set 485 on the C scale. Set the cursor line to the index line of the C scale and read 275 on the DI scale on the rear face of the rule.

2. Type $\frac{b^2}{a}$

By considering this as $\frac{1}{a} \times b^2$, calculate as follows by using the EI scale. (See How to Use the EI Scale)

(1) Set the cursor line to **a** on the DI scale.
(2) Set **b** on the EI scale under the cursor line.
(3) Read the number on the D scale, corresponding to the index line of the EI scale

Example : $\frac{3.56^2}{4.28}=2.96$

Set the cursor line to 428 on the DI scale, and on the front face set 356 on the EI scale to the cursor line. Corresponding to the index line of the EI scale, read 296 on the D scale.

For further applications, such as $\frac{bc}{\sqrt{a}}$, $\frac{b^2c}{\sqrt{a}}$, $\frac{c}{a\sqrt{b}}$, etc., the calculations are easily made.

Example : $\frac{2.37^2 \times 4.62}{\sqrt{75.6}}=2.98$

To 75.6 on the A scale, set 462 on the C scale. Set the cursor line to 237 on the EI scale. Read 298 on the DI scale on the rear face.

3. Type $\frac{a}{\text{Sin }\theta}$

Calculate as the reciprocal of $\frac{\text{Sin }\theta}{a}$

(1) Set the cursor line to θ on the Sin scale on the rear face.
(2) Set **a** of the C scale under the cursor line.
(3) Set the cursor line to the index line of the C scale and read the number on the DI scale.

Example : $\frac{6.58}{\text{Sin } 18° \ 25'}=20.8$

Set the cursor to 18° 25′ on the Sin scale on the rear face. Without moving the cursor, set 658 on the C scale under the cursor line on the front face. Then set the cursor line to the index line of the C scale and read 208 on the DI scale on the rear face.

Similarly, it is possible to calculate $\frac{a}{\text{Tan }\theta}$ and $\frac{a}{\text{Cos }\theta}$

Example : $\frac{1.425}{\text{Tan } 24° \ 45'}=3.09$

4. Type Cot θ

Set the cursor line to θ of the Tan scale and read the number corresponding on the DI scale on the rear face.

Example : Cot 32° 45′=1.555

Set the cursor line to 32° 45′ on the Tan scale and read 1. 555 on the DI scale. Similarly, it is possible to calculate Cosec θ and Sec θ.

Examples : Cosec 26° 5′=2.27
Sec 43° 35′=1.380

5. Type log $\frac{1}{a}$ (or–log a)

(1) Set the cursor line to a on the DI scale. Read the corresponding number on the L scale as mantissa.
(2) First obtain the characteristic for log a. The required characteristic is obtained by subtracting 1 from the above characteristic with the reverse sign.

Example : $\log \frac{1}{38.1}=\bar{2}.419$

Set the cursor line to 381 of the DI scale. Corresponding to this on the L scale under the cursor line is 419 which is mantissa. Since the characteristic of 38.1 is 1, the index sought is $-1-1=-2$, so that the answer is $\bar{2}.419$.