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INSTRUCTIONS

FOR THE USE OF

"HEMMI" BAMBOO SLIDE RULES

Published by

HEMMI BAMBOO SLIDE RULE MFG. CO., LTD.

TOKIO, JAPAN

Printed in Japan

right. At the center, you read 10; then to the right you will read 20, 30, 40. . . . until you come to 100 at the right end. The space 1—2 is the broadest; the next broadest is 2—3; then 3—4 and so forth. The space 10—20 is just equal to that 1—2; 20—30 to 2—3, &c. &c. So the right half of the scales is just like the left. The ends are termed indices; the left one is the left index and the right one the right index. The center or the bisection of **A** or **B** is called the center index of **A** or **B** respectively.

The scales **C** and **D** are like **A** and **B**; only the readings that start with 1 at the left end as in the others, proceed until they reach 10 instead of 100 at the right end. So the readings do not repeat themselves as they do in **A** and **B**. Any space on **C** and **D** is just double its corresponding space on **A** and **B**, so it is divided more accurately than the other, so that you can read or calculate with **C** and **D** more accurately than with **A** and **B**.

The whole length of **C** or **D** 1—10 is called one logarithmic unit; and that of **A** or **B** two logarithmic units; 1—10 being one and 10—100 the other. Each logarithmic unit is divided into nine large divisions; and each large division is divided into ten sub-divisions. No sub-dividing marks are lettered except those between 1 and 2 on **C** and **D**. Yet you are to read them 1, 2, 3, ... to follow the figures of large divisions. The first sub-division following 2 is to be read 2.1 and the second 2.2, &c. The sub-divisions in 3—4, 4—5, 5—6, &c. are to be read in similar ways.

Each of these sub-divisions is divided into lesser divisions—some of them into ten, others into five and still others into halves, according to the length of the sub-division. The

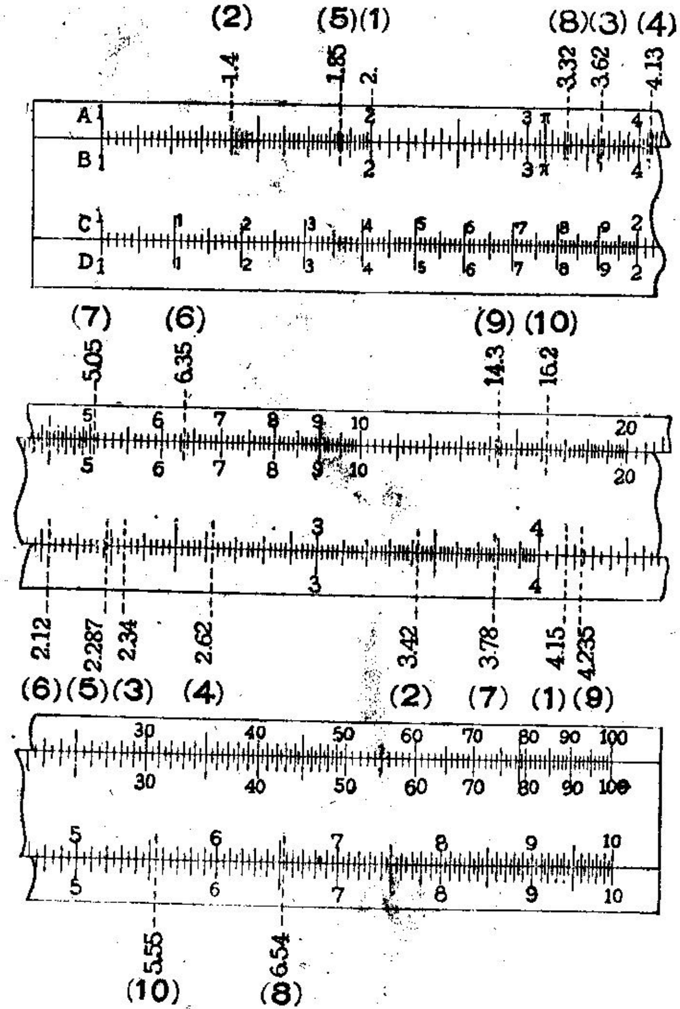
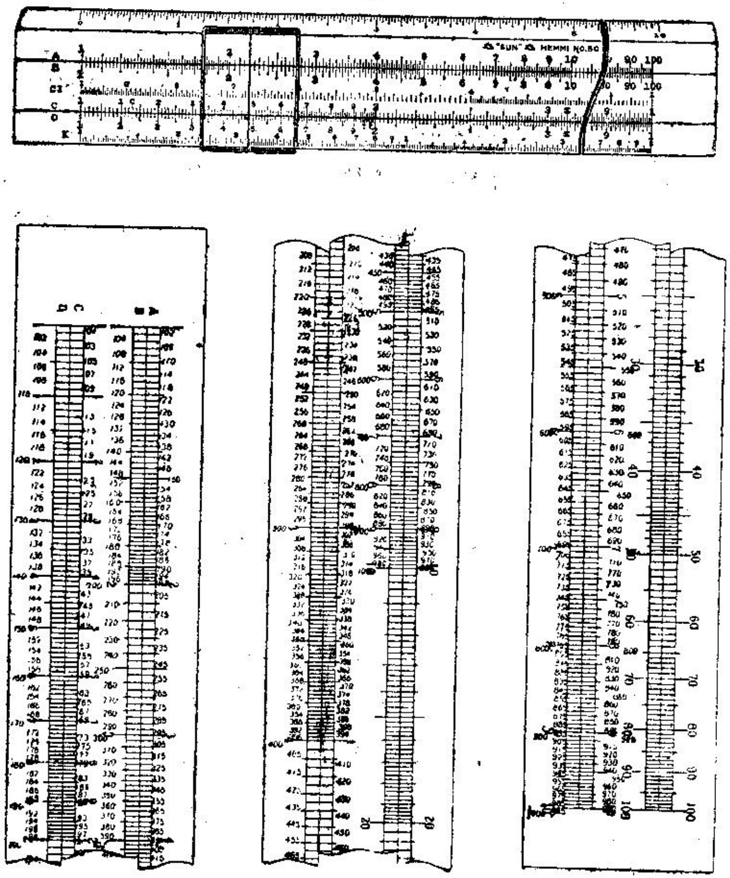


Fig. 1.

DIAGRAM ILLUSTRATING THE READING OF THE GRADUATIONS OF THE "HEMMI" BAMBOO SLIDE RULES



INSTRUCTIONS

FOR THE USE OF

"HEMMI" BAMBOO SLIDE RULES

CHAPTER I

"HEMMI" NORMAL SLIDE RULES

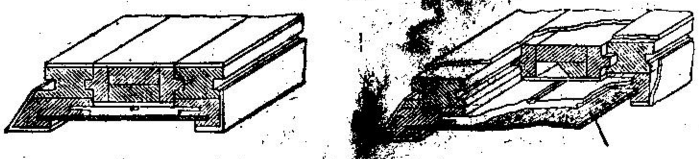
Section I. How to Read Graduations

On the face of a slide rule you see five scales, **A, B, CI C** and **D** and on the back face of the slide, you see three scales, **S, L** and **T.** Of these scales, **A, B, CI, C** and **D** are for multiplication, division, squaring, extraction of a square root, cubing and extraction of a cube root, **T** and **S** are for trigonometrical functions, a sine and a tangent respectively, and **L** for logarithms. Naturaly on the slide rules for beginners, the scales on the back face, S, **L** and **T** are often destroyed.

The greatest importance in using a slide rule is the reading. The accuracy in reading means the accuracy in calculation. Hence the practice of a slide rule is the practice of its reading.

Of these scales, **A** and **B** are exactly the same and so are **C** and **D.** To begin with **A** and **B,** you will read 1 at the left end of the scale, and then gradually 2, 3, ...to the

CONSTRUCTION AND SPECIALITIES OF THE "HEMMI" BAMBOO SLIDE RULES



Adjusting Plate

Wood Slide Rule.

As the Slide Rule is an instrument used of various complicated calculations by the aid of its logarithmically graduated scales, it is needless to say that absolute accuracy of graduation is an essential point of the Rule. The body of Slide Rule has hitherto been made invariably of seasoned hardwood such as mahogany or boxwood, but, as the wood usually tends to warp partly or wholly even if to a slight degree on account of change of temperature and humidity, as a natural consequence the scales *A. B. C.* and *D.* suffer loss of exactness which is vital to the Slide Rule. This deficit is common to all wood slide rule and can not be avoided by any treatment.

Construction of "Hemmi" Bamboo Slide Rule.

It has long been recognized by specialists that bamboo, which is one of Japan's special products, if well seasoned, does not shrink or lengthen under any change of atmospheric temperature.

Hemmi Bamboo Slide Rule was indeed designated with this point in view. The body of the Rule is taken from mature bamboo which is well seasoned and freed from greasy matters. As is seen in the above section the upper and the lower scales are composed of two pieces and the slide is of four pieces of such bamboo, each piece being joined to the other with the solid part outside. The upper scale is connected with the lower by the celluloid sheet with narrow groove in the middle, and also by adjusting plate of thin aluminium. Thus it will be seen that the body of the Rule is not of one solid piece, but consists of several pieces joined together with mechanical skill.

Characteristic features of "Hemmi" Bamboo Slide Rule.

1. Accurate and non-shrinking.

The surface of the Rule is covered by perfectly seasoned celluloid sheet, and the upper scale is entirely separated from the lower by the adjusting plate. The ingenuity of construction by which equal balance is acquired, and the special nature of Bamboo, combined, remove the probability of warp, twisting, shrinking or lengthening under any climate or humidity. This feature is more remarkable with longer rules.

2. Evenness and smoothness.

Bamboo Slide Rule does not absorb damp, so the slide moves always with ease.

Moving the slide just a little is generally found difficult in case of Wood Slide Rule, but Hemmi Bamboo Slide Rule does entirely away with this difficulty, and the slide will move at your will, which Wood Slide Rule can not attain in countries like England and Japan where humidity is far more than average.

3. Adjustment of Slide-groove.

If the movement of the slide is too stiff or too loose, draw it out, hold the upper scale with your right fingers and the lower scale with your left, pressing slightly inwards or outwards as the case may require, so that the width of the groove is adjusted to suit the slide.

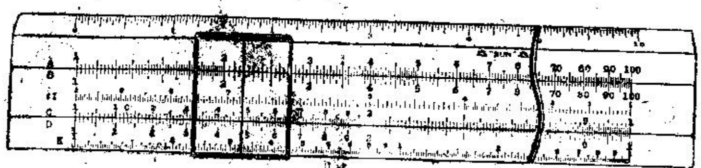
4. Distinctness and accuracy of graduation.

The Hemmi Bamboo Slide Rule is graduated by machine devised after our long year's experience, and the accuracy and distinctness of graduation, as well as the superiority of construction of its stock, are what we believe we can really be boast of.

TREATMENT
OF
"HEMMI" BAMBOO SLIDE RULES

1. The Slide Rule should always be kept in a dry, cool place, strictly avoiding the damp as well as the direct rays of the sun.
2. If the Slide Rule has to be used in a damp place, or if the Slide does not move with ease, it is advisable that some paraffin or vaseline is applied to the edges of the Slide and the grooves of its guides. The offener the application, the better the result.
3. If the movement of the Slide is too loose or too stiff, pull out the Slide, hold A scale with your right hand and D scale with your left, pressing slightly inwards or outwards as the case may require, so that the width of the Slide-groove may be adjusted. The thin metal plate fixed to the back of the Slide Rule, and the narrow groove in the middle of the bottom celluloid plate are provided for this adjustment.
4. Stains on the surface of the Slide Rule can be removed with rubber eraser, or rag moistened with petrol. Alcoholic solution must be avoided as it tends to dissolve celluloid.

PREFACE



1. What is the Slide Rule?

The Slide Rule is an instrument that may be used for saving time and labour in most of the calculations that occur in practice. By means of the slide rule, one can easily solve with a sufficient degree of accuracy not only all manner of problems involving multiplication and division such as proportion, squares and square roots, cubes and cube roots, but also complicated algebraic and trigonometrical calculations, without mental strain and in a small fractions of the time required to work them out by the usual figuring. For this reason, the slide rule has now become indispensable to students, business men, merchants, engineers, surveyors, draftmen or estimaters.

2. How much education is necessary?

Any one who has knowledge of decimal fractions can learn to use the slide rule.

3. How long will it take to learn?

Only about half an hour will be sufficient for an average person to learn how to use the Hemmi Bamboo Slide Rule by carefully reading this instructions. But such knowledge alone will not help him much to realize the merit of the Rule unless accompanied by constant practice, so that the users of the Rule are recommended to repeat practice until well acquainted with it. Short time keenly devoted to the study of its use will enable him to manage the Rule thoroughly, and he will be surprised at its handiness.

Hemmi Bamboo Slide Rule Mfg., Co., Ltd.

Tokio, Japan

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lesser sub-divisions represent each, either $^1/_{10}$ or $^1/_5$ or ½ of the sub-division, just like those on any rule of the decimal system. The only trouble for beginners would be the unequality or variation of divisions; but they will overcome it after a little practice.

Repeating the explanation, read first the large division, then the sub-division and then the lesser sub-division; these three figures put together in order represent the digit value of the point on the scale. A point between lines, or a point that is not marked, is to be read by inspection.

For examples ten points, (1), (2), (3) ...., (10) are taken on **A, B** and **C, D** scales (see Fig. 1): (1) on **A, B,** is to be read "2," (2) "1.4," (3) "3.62," (4) "4.13," (5) "1.85," &c. &c.; (1), (2), (3), (4), ...on **C, D** represent 4.15, 3.42, 2.34, 2.62, ...respectively.

Note the divisions on **C** and **D** scales of a 5" slide rule are exactly the same as those on the left half section of **A** and B of a 10" slide-rule.

Some abreviations.

LIC means the left index of the **C** scale.
RIC means the right index of the **C** scale.
LIA means the left index of the **A** scale.
CIB means the center index of the **B** scale.
LIR means the left index or mark on the back face of the rule.
RIR means the right index or mark on the back face of the rule.

Section II. Multiplication

(1) Multiplication

Rule 1. Set **LIC,** or **RIC** sometimes, to the multiplicand on **D,** against the multiplier on **C** read the product on **D,** through the help of the hairline.

Example 35×5=175 (See Fig. 2)

Set **RIC** to 35**D,** against 5**C** read 175**D.**

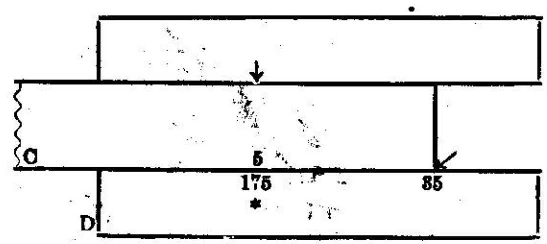


Fig. 2.

Rule 2. Take two simple readings one nearest to the multiplicand and the other to the multiplier, the product of these simple numbers must be very similar in punctuation to the product sought for.

Example 35×0.5=17.5

As for the digit value, you can get exactly in the same way as in the previous example. Take 30 as the nearest simple number to 35; 0.5 is simple enough as it is. Multiply 30 by 0.5, and the product 15 must be very similar to that sought here. So the result must be 17.5 instead of 1.75 or of 175.

Note: 1. You could employ **A** and **B** in place of **C** and **D**; but the result thus obtained must be less accurate as **A** and **B** are of half sized scales of **C** and **D.**

2. See the foot-note in chapter II.

Example 7.5×2.5=18.75 (Fig. 3)

Imagine 8×2=16 by heart, the product of 7.5 and 2.5 must not be very far from 16. Then set **RIC** to 75**D**, against 25**C** read 1875**D**, and the answer sought for must be 18.75.

Fig. 3.

(2) Continuous Multiplication

To multiply three factors, first multiply two of them, and then multiply the result by the third. Thus you can multiply as many factors as there may be, all in one continuation.

Example 35×420×0.21=3090

Set **RIC** to 35**D**, against 42**C** set the hairline on **D**.

Here you could read on **D** the product of 35×420, but you need not do so. Go on to the next task at once.

Set **LIC** to the hairline, against 21**C** read 309**D**.

For punctuation, 40×400×0.2=3200. So the answer of this example, must be 3,090.

You can do continuous multiplication in this way with either **C, D** or with **A, B**; but some slide rules such as HEMMI No. 50 have an inverse scale that enables you to multiply three factors at once. (See Chapter II, Slide Rules with an Inverse Scale and a Cube Scale.)

Section III. Division

(1) Division

Rule 1. Set the divisor on **C** to the dividend on **D**, against the index of **C** that falls on the rule read the quotient on **D.**

Example 8.25÷5.5=1.5 (Fig. 4)

First 8÷5=1.6 by heart, and you know that the answer to this problem is not very far off 1.6.

Just as you see in Fig. 4, set 55**C** to 825**D**, against **LIC** read 15**D**. And the answer must be 1.5.

Note: Division on a slide rule is exactly the reverse to multiplication; and you can do it with **A** and **B** as well.

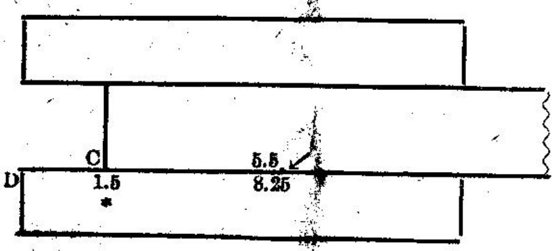


Fig. 4.

(2) Continuous Division

A division of two or more divisors is done thus:—Set the first divisor to the dividend on **D,** set the hairline at the index of **C** that happens to fall on **D,** move the slide so that the second divisor on **C** comes under the hairline, against the index of **C** that happens to fall on **D** read the answer on **D.**

Example $2.7 \div 0.3 \div 5 = 1.8$

For punctuation $3 \div .3 \div 5 = 2$ and you know the answer to this problem must be a number with an integral part of one place.

Set 3**C** to 27**D,** put the hairline at **RIC,** move the slide so that 5**C** comes under the hairline, against **LIC** read 18 **D.** So the answer is 1.8.

Section IV. Mixture of Multiplication and Division

(1) Mixture of Multiplication and Division

When multiplication and division are mixd together, you can of course do them one by one in continuation; but for rapidity there is a simpler way. You can do both multiplication and division at once. Such instances occur very often and you must learn the method at your finger's end.

Example $\frac{2 \times 30}{6} = 10$ (Fig. 5, 6)

We shall employ **A** and **B** for practice's sake, though we can of course do it with **C** and **D** as well.

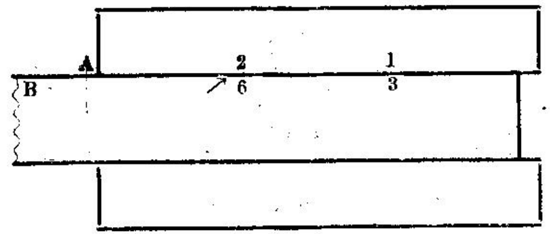


Fig. 5.

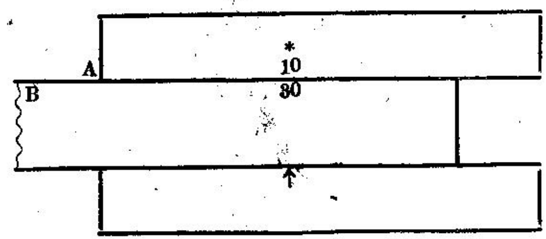


Fig. 6.

Set 6**B** to 2**A,** against 30**B** read 10**A.**

Fig. 5 shows that 6**B** is at 2**A,** and Fig. 6 shows that the hairline is at its final position.

Example $\frac{1.32 \times 32 \times 5}{3.6 \times 2} = 29.4$ (Figs. 7, 8)

First calculate $\frac{1.32 \times 32}{3.6}$, and then multiply $\frac{5}{2}$ to that result.

Set 36**B** to 132**A,** put the hairline at 32**B.** (See Fig. 7)

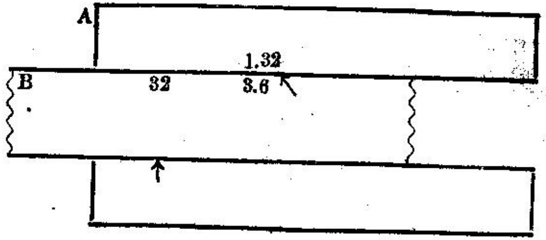


Fig. 7.

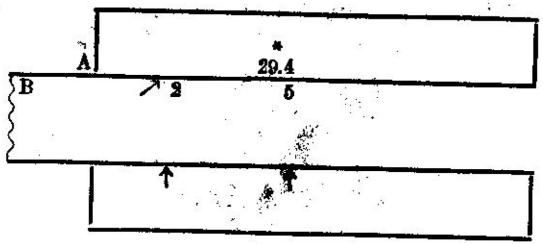


Fig. 8.

Move the slide so that 2B comes under the hairline, against 5B read 294A. (See Fig. 8)

Finally for punctuation $\frac{1\times30\times5}{3\times2}=25$. and the answer to the problem must be 29.4.

(2) Proportion

As an instance of the mixture of multiplication and division there is proportion to be dealt with.

Rule 4. In order to solve $a:b=c:x$, set a on **B** to b on A, and against c on **B** read x on **A**.

Example $5:2.4=8:x$ Ans. 3.84. (Fig. 9)

Set 5**B** to 24**A**, against 8**B** read 384**A**. For punctuation, 5:2.4 is to be as $8:x$; and the answer must be 3.84.

The slide rule can solve a group of proportions all at once, when the ratio of the first and second terms is constant.

Example 5:2.4 is the ratio of the first and second terms, common to all the following ratios. What is the value of x in each?

$3:x$	$x=1.44$	$8.2:x$	$x=3.94$
$4.5:x$	$x=2.16$	$7.7:x$	$x=3.7$
$9:x$	$x=4.32$	$5.32:x$	$x=2.558$

Just as the previous example, set 5**B** to 2.4**A**, put the hairline one by one at 3, 4.5, 9, 8.2, 7.7, 5.32, on **B** and the answers 1.44, 2.16, 4.32, 3.94, 3.7, 2.558 can be obtained on **A** respectively.

When the proportion is inverse or it is in the form of $a:b=x:c$, put $\frac{a\times c}{b}=x$ and you can calculate it by IV.

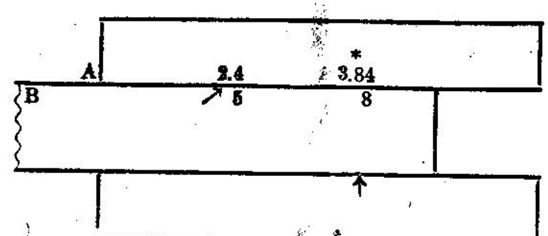


Fig. 9.

But when you have a group of inverse ratios as $x:c$ when $a:b$ is constant, some other measure should be taken.

Rule 5. To solve a group of inverse proportions, put the slide inverted and go on similarly as Rule 4.

Example There is a job for 5 men for 7 days. In how many days can 3 men do the job? Also how many days will 8 men take to do the job Ans's 11.7 days and 4.38 days.

Have the slide inverted, set **5B** to **7A.** With the help of the hairline, against 3**B** read 11.7**A** and also against 8**B** read 4.38**A.** 11.7 and 4.38 in days are the answers required. (Ref. Chapter II, Slide Rules with an Inverse Scale especially (2). Inverse Proportion)

Section V. A Square and a Square Root

(1) Squaring

Rule 6. To get a^2, put the hairline at a**D** and read a^2**A** under the hairline.

Example $3^2 = 9$ (Fig. 10)

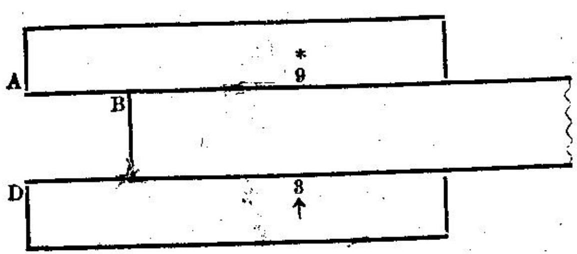


Fig. 10.

With the help of the hairline, read 9**A** across 3**D.** 9 is the result.

(2) A Square Root

Rule 7. For the punctuation of a square root, if the first useful digit of N expressed in the centesimal scale, be at the nth place on the lefthand side or on the righthand side of the centesimal point, the first useful digit of $\sqrt{N}$ in the decimal scale is at the nth place on the lefthand side or on the righthand side of the decimal point respectively.

Rule 8. The punctuation is read "n left" or "n right" according as the first useful digit is at the nth place on the lefthand side or on the righthand side of the point respectively.

Rule 9. When the first useful centesimal digit of a be less than 10, a is to be taken on the lefthand section of **A;** and if it be more than 10, a is to be taken on the righthand section of **A.**

For example 25826 or 02,58,26 is of "3 left," and so is $\sqrt{25826}$. 2582.6 or 25, 82.60 is of "2 left," and so is $\sqrt{2582.6}$. The digit value of $\sqrt{25826}$ is 1607 as it is calculated out on the lefthand section of the slide rule; and the real value thereof is 160.7. The digit value of $\sqrt{2582.6}$ is 753 as it is calculated out on the righthand section of the slide rule; and the real value thereof is 75.3.

Further 0.00065 or 0.00,06,50 is of "2 right'," and so is $\sqrt{0.00065}$ As it is calculated out on the lefthand section of the slide rule, the digit value of the square root is 256, and the real value is 0.0256.

Section VI. A Cube and a Cube Root

(1) A Cube

Rule 10. To get the cube of a, set one of the two indices of **C** to a on **D**, against a on **B** read a^3 on **A.**

Example $1.4^3=2.744$ (Fig. 10)

Set **LIC** to 1.4**D,** against 1.4**B** read 2.744**A.**

(2) A Cube Root

Rule 11. For the punctuation of a cube root, if the first useful millesimal digit of N expressed in the millesimal scale, be at the nth place on the lefthand side or on the righthand side of the millesimal point, the first useful digit of $\sqrt[3]{N}$ in the decimal scale is at the nth place on the lefthand side or on the righthand side of the decimal point respectively.

Rule 12. If the first useful millesimal digit of N be less than 10, N is to be taken on the lefthand section of **A;** if it be between 10 to 100, N is to be taken on the righthand section of **A;** if it be more than 100, N is to be taken on the lefthand section of **A.**

If the first millesimal digit of N be less than 100, the slide shall be projected out to your left.

Rule 13. Put the hairline at a on **A** as stated in Rule 12, shift the slide so that the reading on **B** under the hairline is just equal to that on **D** against one of the indices of **C.**

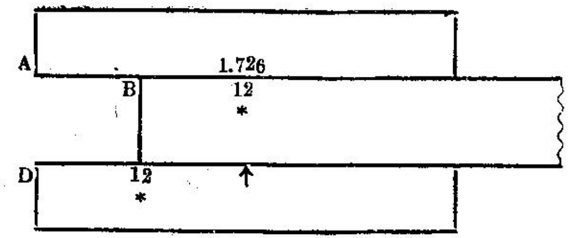


Fig. 11.

Example $\sqrt[3]{1,726}=12$ (Fig. 11)

By Rule 11, $\sqrt{1,726}$ must be of "2 left." As $1<10$ 1,726 is to be taken on the lefthand section of **A,** and the slide is to be projected out to your right. Put the hairline at 1,726**A,** shift the slide so that the reading on **B** under the hairline is just equal to that on **D** against **LIC.** Then it is 12**B** that comes under the hairline, while 12D faces **LIC** simultaneously. So 12 must be the result.

Section VII. Trigonometrical Functions

(1) Sines

Rule 14. To get the sine of a given angle a, set a on **S** on the back face of the slide to the mark at the right top end of the back of the rule, and read sin$a$ on **C** against the index of **D.** As for the punctuation, it is of "1 right" when sin$a$ is between 1 and 10 of **C.** That is the whole length of **C** shall be for one place; and **RIC** is 1.00, which is the sine of 90°, and **LIC** is 0.1 or sin 5°45′.

Example Sin32°=0.53 (Fig. 12)

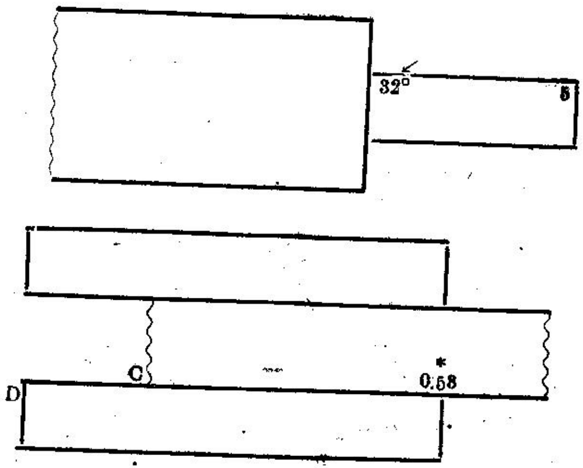


Fig. 12.

Project the slide to your right so that 32°**S** comes to the right top end of the back of the rule, **RIR**, and read 0.53**C** against **RID.**

(2) Cosines

The ordinary slide rule has no scale on directly for a cosine; but taking advantage of

$$\cos a = \sin(90° - a)$$

have the sine of the complement angle of *a*, and it is cos*a*.

(3) Tangents

Rule 15. To get the tangent of a given angle *a*, set *a* on **T** on the back face of the slide to the mark at the right back end of the rule, **RIR**, and read tan*a* on **C** against **RID.**

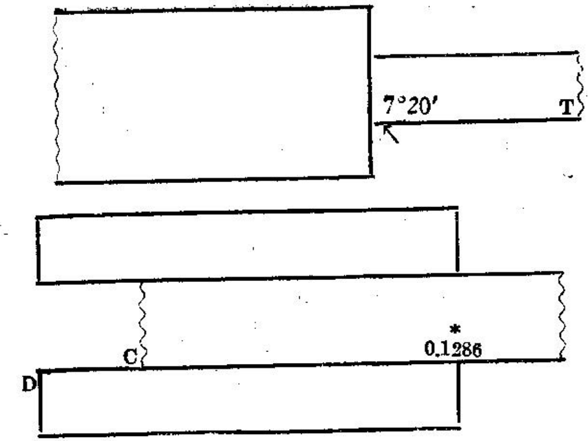


Fig. 13.

As for the punctuation, always take **RIC** as 1 or tan45° instead of 10, and **LIC** as 0.1 or tan 5°43′ instead of 1, the whole length of **C** being only for values of "1 right."

When you have to find many different values of sines and tangents, turn over the slide, put it in the normal position, and you have sine and tangent tables themselves before you. You can read sin*a* on **D** against any *a* on **S;** and also tan*a* on **D** against any *a* on **T,** without moving the slide.

Example tan 7°20′=0.1286 (Fig. 13)

Turn over the whole slide rule, set 7°20′ **T** to the mark at the right bottom end of the rule, **RIR,** and read 1286**C** against **RID.** And 0.1286 is tan7°20′.

(4) Other Trigonometrical Functions

To get cotangents, secants and cosecants, the following formulae for convertion are taken advantage of. The formulae are

$$\cot a = \frac{1}{\tan a}$$

$$\sec a = \frac{1}{\cos a}$$

$$\operatorname{cosec} a = \frac{1}{\sin a}$$

First take the tangent, cosine and sine of *a* and then get their reciprocals, and you will get cot*a*, sec*a* and cosec*a* respectively.

Section VIII. Logarithms

(1) Logarithms

When $a = 10^x$, we say *x* is the logarithm of *a*; and we express the fact by $\log a = x$. From this sourse we have

$$\log 10 = 1$$
$$\log 100 = 2$$
$$\log 1000 = 3$$

In general, the logarithm of a number consists of two parts: the *characteristic* or the integral part and the *mantissa* or the decimal portion. What the slide rule gives is only the mantissa, and the characteristic can be had easily by inspection. The characteristic is 1 less than the number of figures of the original number preceeding the decimal point. Thus the characteristic is 0 for a number of one place; and 1 for a number of two places and 3 for a number of four places. And a number whose first useful digit just follows the decimal

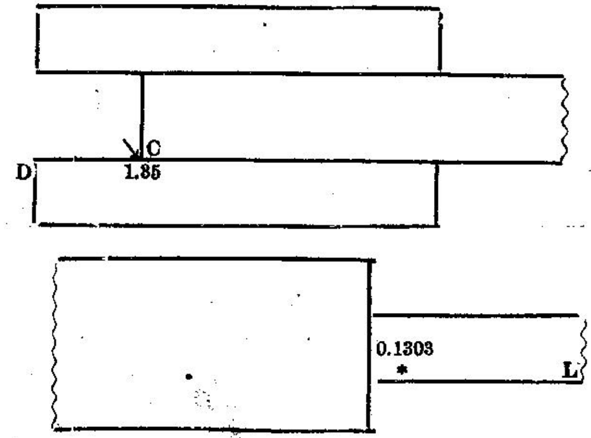


Fig. 14.

point has for its characteristic -1 which is expressed by $\overline{1}$ by convention; and so the characteristic is $\overline{2}$ for a number whose first useful digit is at the second place following the decimal point.

Rule 16. To get the logarithm log*a* of a number *a*, set **LIC** to *a* on **D,** turn over the whole slide rule, and against the mark on the right end of the rule read log*a* on **L.**

For the punctuation; the first useful figure in any reading on the **L** scale except the first 10% is to be at the very place following the decimal point. And the characteristic shall be determined by inspection.

Example log 1.35 = 0.1303 (Fig. 14)

Set **LIC** to 1.35**D,** turn over the whole slide rule, and read 0.1303 on **L** against the mark at the righthand end of the rule. And 0.1303 is the very logarithm sought for 1.35 which has only one figure preceding the decimal point.

Section IX. The Circumference and Area of a Circle

(1) A Circle

It is well known that between the diameter, **D** and the circumference, **P** of a circle, there is a rule, **P**$=3.1416\times$**D**. The constant 3.1416 which is the ratio of the circumference to the diameter, is usually represented by π. In the slide rule, there is a mark π on each of **C. D** scales, so that you could have the length of a circle whose diameter is known, or vice versa.

(2) The Area of a Circle

Between the area, A and the diameter, D of a circle, there is a relation

$$A=\frac{\pi}{4}D^2=\left(\sqrt{\frac{\pi}{4}}D\right)^2$$

or

$$A=\left(D\Big/\sqrt{\frac{4}{\pi}}\right)^2$$

On a slide rule, there is a marking at 1.128 with the lettering of c. So if you set c on **C** to the diameter on **D,** then you can read the area, A of the circle on **A,** against **LIC.**

(3) The Volume of a Cylinder

The volume of a cylinder, V can be had by

$$V=\frac{\pi}{4}\times D^2\times L$$

where L is the height of the cylinder; or

$$V=A\times L$$

So set c on **C** to the diameter on **D,** and read the volume V on **A** against the height, L on **B.** Sometimes you will find L on **B** off **A**; on such an occasion change the index and you can do.

CHAPTER II

The Slide Rule with the Inverse Scale (CI), and the Cube Scale (K)

It is of construction shown in Fig. 15; its only difference from the ordinary slide rule is that there is the inverse scale, **CI** in the middle of the slide, and the cube scale or the millesimal scale **K** at the bottom of the rule. The former scale is good for the calculation of a function of three factors and also for inverse proportion, &c. while the latter is very valuable for the calculation of cubes and cube roots.

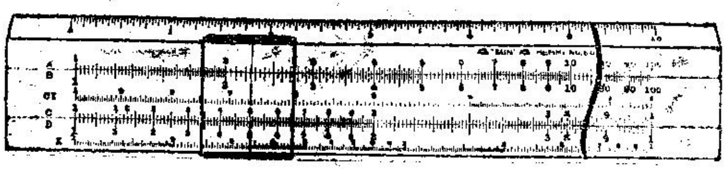


Fig. 15.

(1) Multiplication and Division

This slide rule is mainly for a function of three factors, yet when it is used for a function of two factors it is entirely treated like the ordinary slide rule.

Example $3\times5\times2=30$ (Fig. 16)

Set 3**CI** to 5**D** and against 2**C** read 30**D.**

Example $85\div2.3\div4.3=8.59$

Set 2.3**C** to 85**D,** against 4.3**CI** read 8.59**D.**

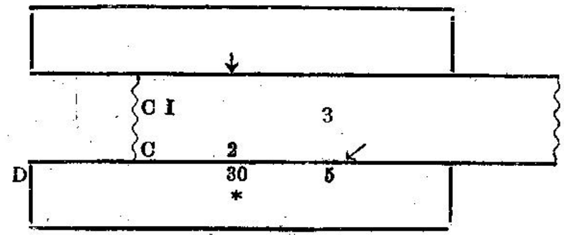


Fig. 16.

Example $\dfrac{125\times32}{18.5}=216$

Set 32**CI** to 125**D,** against 18.5**CI** read 216**D.**

Note: With a slide rule with the **CI** scale, make it a rule to employ **CI** and **D** for multiplication, and **C** and **D** for division, and you can get rid of the trouble of "re-setting."

(2) Inverse Proportion

With the ordinary slide rule, you had to invert the slide in order to solve inverse proportion with many unknown quantities. But with this slide rule, you can entirely dispense with the trouble of inverting the slide, because **CI** is **C** inverted.

Example There is a task for 3 men for 4 days; how many days will 2 men take to finish the work? Ans. 6 days (Fig. 17)

Set 3**CI** to 4**D,** against 2**CI** read 6**D.** The answer is 6 days.

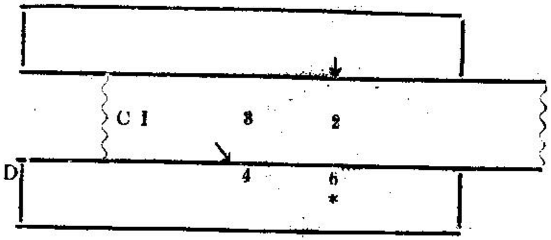


Fig. 17.

(3) A Cube and a Cube Root

The calculation of a cube, and the extraction of a cube root with the ordinary slide rule is very troublesome, but with this slide rule with a cube scale, **K** is very simple.

Example $3^3=27$ (Fig. 18)

Keep **K** at its normal position, with the help of the hair-line, read 27**K** ayainst 3**D** without moving the slide.

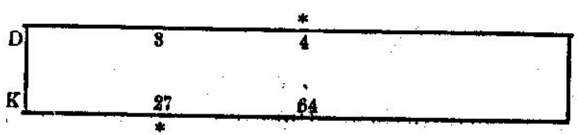


Fig. 18.

Note: When *a* is of one figure preceding the decimal point, read the result of a^3 as it is on **K**; when of two figures, a^3 on **K** should be made 1000 times, &c.

So $30^3=27000$; and $300^3=27,000,000$

Example $\sqrt[3]{64}=4$ (Fig. 18)

Read 4**D** against 64**K** with the help of the hairline.

Note: *a* is to be differentiated exacatly as explained in Chapter I **VI**, (2). 64,000 is of two millesimal digits, and so $\sqrt[3]{63000}=40$.

Note: When you will compute a function of two factors, you had better use the scale CI instead **of** the scale **C**

Example $5\times4.5=22.5$

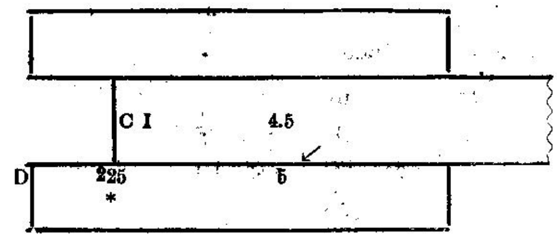


Fig. 19.

CHAPTER III

The Slide rule with the folded scales DF, CF.

The folded scales **CF** and **DF** are divided to eliminate the number of re-settings of the slide which result where only one straight pair of scales with consecutive graduations is employed.

These folded scales have been split at π and as π is very near to $\sqrt{10}$, the "1" on **CF** and **DF** lies very near the bisection of the scales.

The new patterns of the Japanese design have **CF** and **DF** split at $\sqrt{10}$ instead of at π, and readers must observe the difference.

The old design is good because π is a useful constant. The new one is good because it enables you to do what we call "cross-operation."

Example $6 \div 4 \times 8 = 12$

Set 4**C** to 6**D** and against 8 **CF** read 12 **DF.**

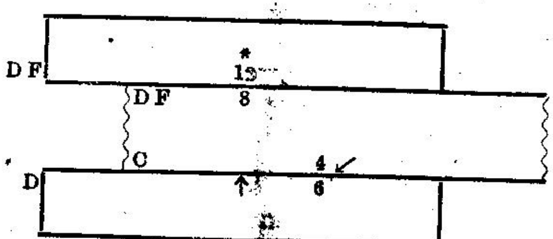


Fig. 20.

Example Complete the list below.

inches	2.06		3.19		4.56
cm.		4.44		17.6	

1″ = 2.54 cm.

Fig. 21.

Since 1″ = 2.54 cm., set 1 **CF** to 2.54 **DF.**

Against 2.06 **C** read 5.23 **D**
" 4.44 **D** " 1.745 **C**
" 3.19 C " 8.10 D
" 17.6 **DF** " 6.94 **CF**
" 4.56 CF " 11.55 **DF**

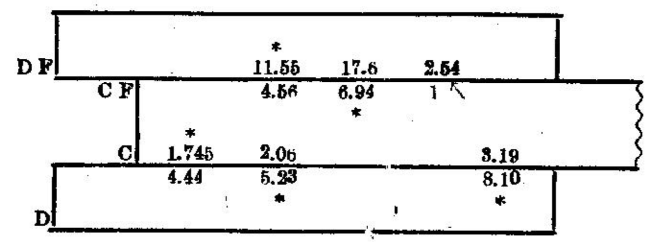


Fig. 22.

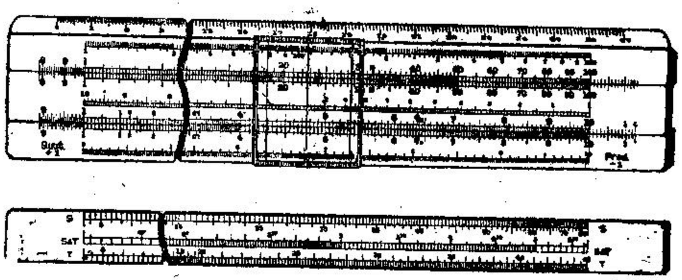
Keep at least half of the slide in the groove.

Problems in proportion and in anti-proportion are special cases of multiplication and division.

CHAPTER IV

The Rietz Slide Rule

This slide rule has its scales in a reformed order. The fundamental scales A, B, C and D have super-gladuations in red, by which you could avoid resetting, when the answer would go just little bit off the main scales. The super-graduation is also very handy for caluculation of a circle.



A, B, C, D in the figures are the fundamental scales, **L** is an equidivided scale for logarithms; **CI** the inverted **C** scale; and **K** the cube scale.

On the back face of the slide, there are the tangent scale **T,** the sine scale **S.** and the sine and tangent scale **(S&T)** for lesser angles than 6 degrees.

(1) Multiplication and Division

The following examples are of three factors. When it is used for two factors, it can be only treated like the

former part of the operation.

Example: 3×5×2=30 (Fig. 1)

Set 3 on **CI** to 5 on **D** and against 2 on **C** read the answer 30 on **D**

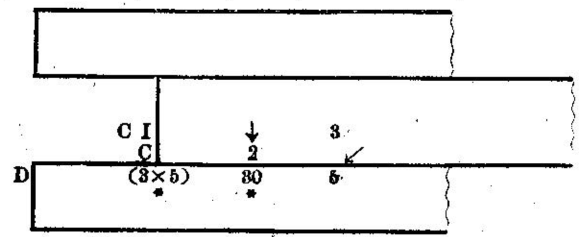


Fig. 1

Note: Under the left side index of **C,** you can get the answer 15 on D for the performance 3×5.

Example: 85÷2.3÷4.3=8.59 (Fig. 2)

Set 2.3 on **C** to 85 on **D** and against 4.3 on **CI** read the answer 8.59 on **D**

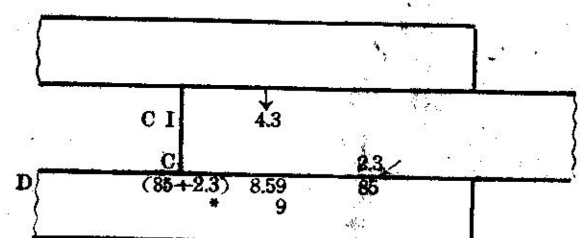


Fig. 2

Note: Under the left side index of **C**, you can get the answer 37 on D as the result of $85 \div 2.3$

Example: $\frac{125 \times 32}{18.5} = 216$

Set 32 on **CI** to 125 **D**, against 18.5 on **CI** read the answer 216 on **D**

Note: With a slide rule which provides the **CI** scale, make it a rule to use **CI** and **D** for multiplication, and **C** and **D** for division, and you can get rid of the trouble of "resetting".

The Use of super-graduations:—

When the result that you aim at happens to be nearly critical, you often require re-setting, because you could not foretell to which side you are to project out the slide.

But with this slide rule, you could avoid the re-setting as shown in a following example.

Example: $2 \times 9 \times 5.88 = 10.58$ (Fig 3)

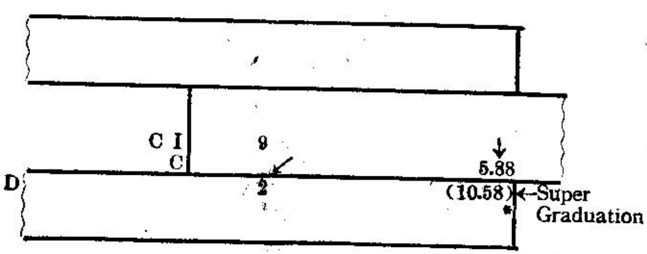


Fig. 3

(2) Proportions

As an instance of the mixture of multiplication and division there is proportion to be dealt with.

Example: 5:2.4 is the ratio of the first and second terms, that is—common to all the following ratios.

How much is the value of x in each

4.5:x	x=2.16
3:x	x=1.44
9:x	x=4.32 (Fig. 4)

Set 2.4 on **C** to 5 on **D**, put the hairline of the indicator one by one at 3, 4.5, 9, on **D** and the answer 1.44, 2.16, 4.32 can be obtained on C respectively.

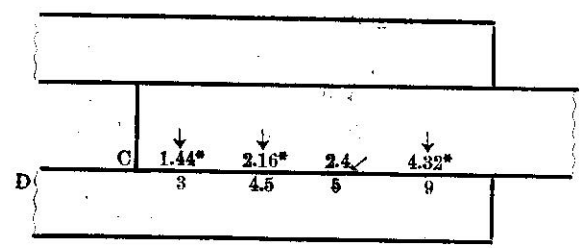


Fig. 4

Example: There is a job for 3 men to be done for 4 days; How many days will it take for 2 men to finish the job then? Ans. 6 days (Fig. 5)

This calculation belongs to the inverse proportion, and formally you had to invert the slide to solve inverse proportion with the ordinary Mannheim Slide Rule. But with this slide rule, you can entirely dispense with the trouble of inverting the slide, because **CI** is inverted **C.**

Above example can be done as follows:

Set 3 on **CI** to 4 on **D**, against 2 on **CI** read the answer 6 on **D.** Answer is 6 days then.

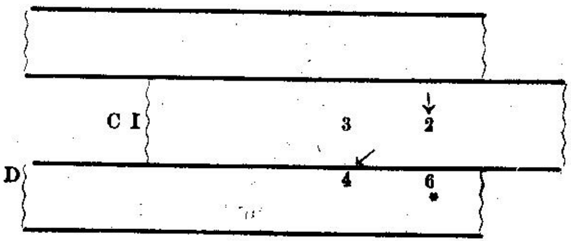


Fig. 5

(3) A Square and a Square Root

(a) Squaring

To get a^2, put the hairline at **a** on **D** and read the answer a^2 on **A** under the hairline.

Example: $3^2=9$ (Fig.6)

With the help of the hairline, read the answer 9 on **A** across 3 on D.

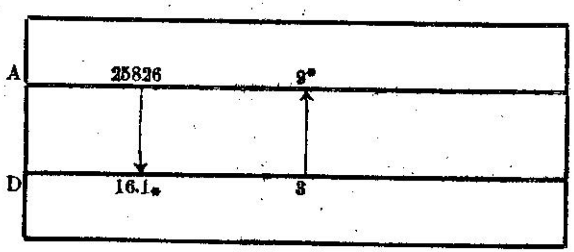


Fig. 6

(b) A Square Root

To get $\sqrt{a}$, put the hairline of **a** on **A** and read the answer $\sqrt{a}$ on **D** under the hairline.

If the first useful digit of **a** expressed in the centesimal scale, be nth place on the lefthand side or on the righthand side of the centesimal point of **a** be less than 10, **a** is to be taken on the lefthand section of **A;** and If it be more than 10, **a** is to be taken on the righthand section of **A**

For the decimalization of $\sqrt{a}$ we can decide easily as the nth place on the lefthand side or on the righthand side of the dicimal point respectively, comparing to the centesimal scale explained above.

Example: $\sqrt{258.26}=16.1$ (Fig. 6)

We can express 258.26 as '02'58.26 in the centesimal scale. The first useful centesimal digit is less than 10. So set the hairline to 25826 on the lefthand section of **A**, and read off the useful digit of the answer 161 on **D** under the hairline.

Comparing to the centesimal place, we can dicide the real value of $\sqrt{258.26}$ as 16.1

(4) A Cube and a Cube Root

(a) A Cube

To get the cube of **a,** set **a** on **D,** and read the answer a^3 on **K** under the hairline.

Example: $3^3=27$ (Fig. 7)

Set the hairline to 3 on **D** and read the answer **27** on **K** under the hairline

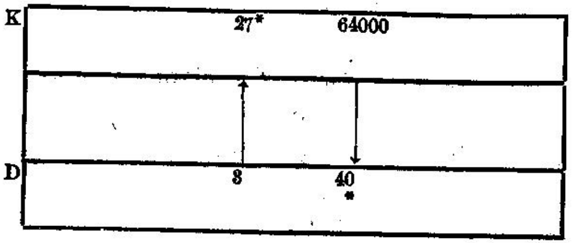


Fig. 7

(b) A Cube Root

To get $\sqrt[3]{a}$, put the hairline to **a** on **K** and read the answer $\sqrt[3]{a}$ on **D** under the hairline.

If the first useful digit of **a** expressed in the millesimal scale, be nth place on the lefthand side or on the righthand side of the millesmal point, and if the first useful millesimal digit of **a** be less than 10, **a** is to be taken on the lefthand section of **K**; if it be between 10 to 100, **a** is to be taken the middle section of **K**; if it be more than 100 **a** is to be taken on the righthand section of **K**.

For the decimalization of $\sqrt[3]{a}$ we can decide easily as the nth place on the lefthand side or on the righthand side of the dicimal point respectively, camparing to the millesimal scale explained above.

Example: $\sqrt[3]{64000}=40$

We can express 64000 as '064'000. in the millesimal

scale. The first useful millesimal digit is between 10 to 100. So we set the hairline to 64000 on the middle setion of K, and read off the useful digit of the answer 4 on D under the hairline.

Comparing to the millesinial place, we can decide the real value of $\sqrt[3]{64000}$ as 40.

Note: $a^{\frac{2}{3}}$ and $a^{\frac{3}{2}}$ can be easily abtained between **A** and **K**.

(5) Logarithm

This slide rule has an equi-divided scale **L** on the front face, and you can get the logarithm of a given number as follows:

To get **log A** read **log A** on **L** against **A** on **D** by the help of the hairline.

Example: Log 3.56=0.5516

Put the hairline at 3.56 on **D** and read the answer 0.5516 on **L** under the hairline.

The given number has one useful figure in the integral part only and the characteristics of this logarithm is 0. So the answer to this example is 0.5516.

(6) Trigonometrical Functons

(a) Sines

To get the sine of a given angle θ, set θ on **S** on the back face of the slide to the index mark at the right top end of the back of the rule, and read Sinθ on **C** against the righthand index of **D.**

Example: Sin $32° = 0.53$ (Fig.8)

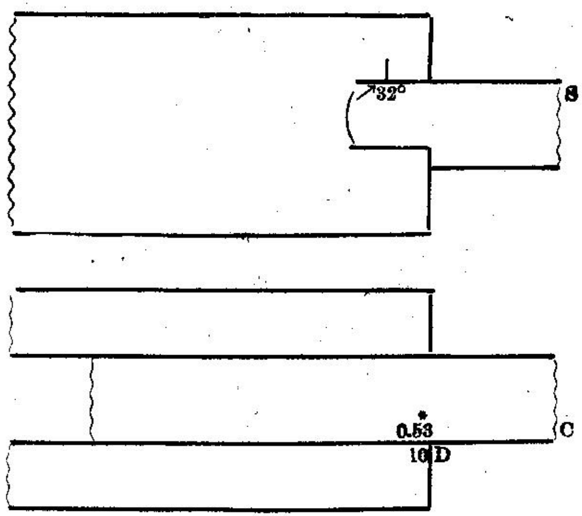


Fig. 8

Project the slide to your righthand side so that 32° on S comes to the right top end mark of the back of the rule, and read thte answer 0.53 on **C** against the righthand index of **D.**

(b) Cosines

This slide rule has no scale on directly for cosine; but taking advantage of $\cos\theta = \sin(90-\theta)$, get the sine

of the complement angle of θ, and then it is $\cos\theta$.

(c) Tangents

To get the tangent of a given ongle θ, set θ on **T** on the back face of the slide to the index mark at the left back end of the rule, and read $\tan\theta$ on **C** against the lefthand index of D.

(d) The Sine and Tangent Scale **(S&T)**

The sine and tangent of a small angle are nearly equal to each other. The **S&T** scale is on this basis, and is for the sine and tangent of an angles less than 6°.

It gives by far greater accuracy than either S or **T,**

CHAPTER V

Various Technical Examples

Area of a Circle

Set the right hand *I* of the slide to 0.7854 on the upper scale of the rule (this point is marked by a special line). Set the cursor to the diameter on the lower scale of the slide, and read the area on the upper scale of the rule.

If the three-line cursor is at hand, set the middle line of the cursor to the diameter on the lower scale of the rule, and read the area on the upper scale of the rule against the left hand line of the cursor.

Circumference of a Circle

Set 710 on the slide against 226 on the rule, and against the diameter on the rule read the circumference on the slide.

Ratio of Cylinder Areas

Set the smaller diameter on the lower scale of the slide to the larger diameter on the lower scale of the rule, and read the ratio on the upper scale of the rule over 1 on the slide.

Ohm's Law

Using the formula of Ohm's Law, $C=E/R$. set R on the slide to E on the rule, and read C on the rule against I on the slide.

Geometrical mean

The geometrical mean between two numbers, $=\sqrt{ab}$ is found by setting I on the slide to a on the upper scale of

the rule, and reading $\sqrt{ab}$ on the lower scale of the rule against b on the upper scale of the slide.

Ordinates of Indicator Diagrams

Using the ordinary formula of a rectangular hyperbola, $P=\frac{C}{V}$, invert the slide, and set I on the slide to C on the lower scale of the rule. Against V on the original lower scale of the slide (the upper since the inversion), read P on the lower scale of the rule.

Kinetic Energy

Using the ordinary formula $KE=\frac{WV^2}{2g}$, where $W=$ the weight in lbs., $V=$the velocity in feet per second, the $2g=64.4$ (London), set the cursor to V on the lower scale of the rule, set 64.4 on the upper scale of the slide to the cursor, and read the result on the upper scale of the rule above W on the upper scale of the slide.

Plotting Surveys by Co-ordinates

By means of co-ordinates a survey may be plotted with ease and accuracy, and any error in calculation will be confined to its own particular locality, and not carried through the whole plan as is the case with other methods.

With a slide rule the tedious preliminary calculations (which have always been a drawback to this method) can be computed with ease and despatch.

The length fo a line being known, its departure may be found by placing the angle on the scale of sines "S" against the index mark on the underside of the rule, and reading on the slide under the length of the line on the upper scale of the rule. By taking the complement of the angle the abscissa can be found in the same manner.

Cost per ton of Coal

The slide rule is specially useful for computing the Cost per ton which are usually calculated at collieries every week or fortnight. In order to divide a certain number of tons into any number of amounts of money with a view to ascertaining the cost per ton in pence, Set the dividing figure on the slide to 240 (the number of pence in one pound) on the rule, and opposite each of the amounts on the slide read the cost per ton on the rule.

Thus, if in a colliery producing 6000 tons of coal per week £130 is spent on timber, the cost of that item per ton of output will be found by placing 6000 on the slide against 240 on the rule, and reading the result (5.20 d) on the rule above 130 on the slide.

The result may be expressed in percentages by placing the total cost per ton on the slide opposite 100 on the rule, when opposite each of the items on the slide the percentages may be read on the rule.

Cord of an Arc

Place half the angle on the scale of sines at the index mark at the back of the rule, and read the cord on the upper scale of the slide against the diameter on the upper scale of the rule.

Tractive force of a Locomotive

Set the diameter of the driving wheels in inches on the upper scale of the slide to the diameter of the cylinders in inches on the lower scale of the rule, and over the stroke in inches on the upper scale of the slide read the tractive force per lb. of effective pressure on the upper scale of the rule.

Area of a Triangle

Being given two sides and the included angle, set the angle on the scale of sines to the index mark on the back of the rule, and bring the cursor to 2 on the upper scale of the slide. Then bring the length of one side on the upper scale of the slide to the cursor, set the cursor to 1 on the same scale, bring the length of the other side on the upper scale of the slide to the cursor, and read the area on the upper scale of the slide under the index, or 1, of the upper scale of the rule.

CHAPTER VI

The Electrical Engineer's Slide Rule

The electrical engineer's slide rule has, in addition to the scales on the ordinary slide rule, log-log scales, **M** and **N** thereon. Also it has an efficiency scale **E** and a drop scale **F** thereon inside the groove of the rule. These facilitates daily calculations for electrical engineers.

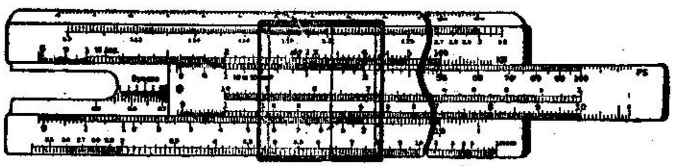


Fig. 19.

(1) The Log-log Scales

Two of the log-log scales, **M** and **N**, make a set. **M** which is placed at the top of the rule is graduated for the range of 1.1 to 3.2, and at the bottom of the rule there is **N** which is graduated for the range of 2.4 to 100,000. The value of $\varepsilon = 2.71828\cdots\cdots$, or the value of the base of the natural logarithm in each of **M** and **N**, is to coincide either with **LID** or **RID**.

These scales are for the calculation of a^x and $\sqrt[x]{a}$; and they are for the range of 1.1 to 100,000.

Example $\quad 1.3^{1.5} = 1.482$ (Fig. 20)

Set 1**C** to 1.3**M**, against 1.5**C** read 1.482**M**.

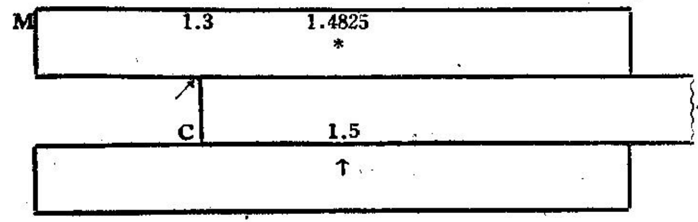


Fig. 20

Note: When the value of x on **C** falls off **M**, have a resetting and get a^x on **N** instead of **M**.

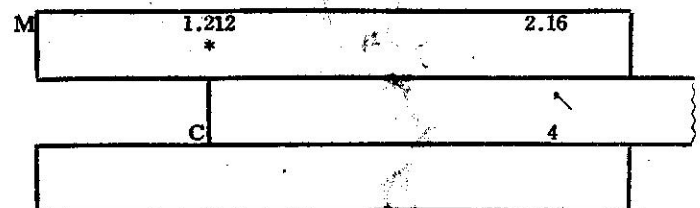


Fig. 21

Example $\quad \sqrt[4]{2.16} = 1.212$ (Fig. 21)

Set 4**C** to 2.16**M**, against **LIC** read 1.212**M**, which is the answer.

Note: The log-log scales are good for calculations on compound interest, though they give only round numbers.

You can also get ε^x and $\log_\varepsilon x$ very easily.

(3) Voltage Drop Scale

In an electric circuit shown in Fig. 24, the distance between the generator and the load is L m. The wire is of q square mm. in cross section; the electric current is I amperes. Then the voltage drop in the whole circuit, V is

$$V=\frac{I\times L}{28.7\times q}$$

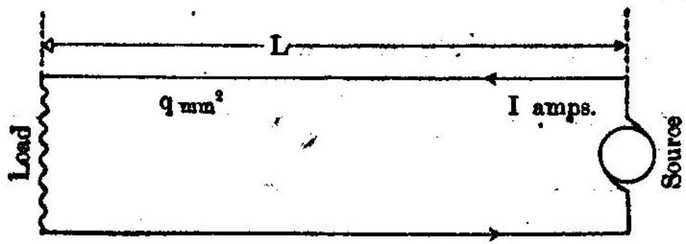


Fig. 24.

The scale **F** in the groove of the rule is for facility to calculate the voltage. I is taken on **A**, and the center of **A** or **CIA** is assumed to represent 100 Amperes. The section area of the wire q and the distance L are taken on **B**. For q, **CIB** is for 100 square mm. and for L, **CIB** is for 100 m.

Example The distance is 50 m, the section area of the copper wire is 30 sq. mm. What is the voltage drop when a current of 45 amperes is running? Ans. 2.61 volts. (Fig. 25)

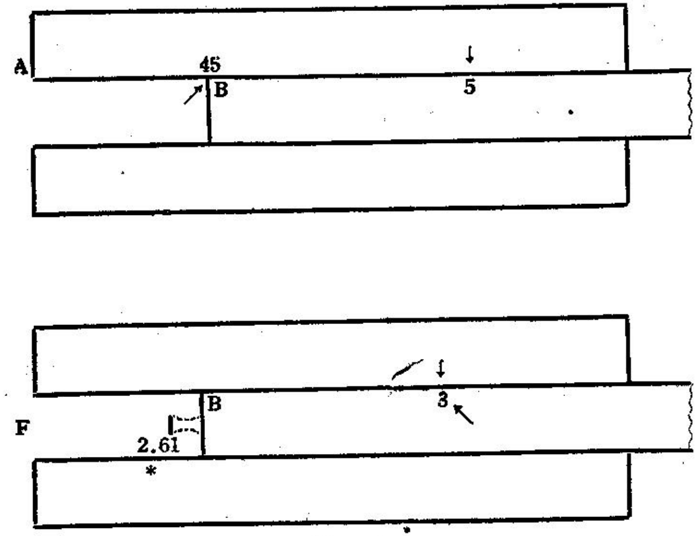


Fig. 25.

Set **LIB** to 45**A** and place the hairline at 5**B**; move the slide and set 3**B** and read 2·61F at the sharp blade of the metalic point.

(4) Marks for some Constants

On the electrical engineer's slide rule, there are marks.

At 28·7 on both **A** and **B**. It is the conductance of a copper wire of 1 sq. mm. in section and 2 m. in length and its reciprocal is the electric resistance.

At 736 on both of **A** and **B**. It is the number of watts in a French horse power.

K.W. on the right end of **A**, is the abreviation of Kilowatts.

P.S. on the right end of **B**, is for horse power.

Set 10 **B** or **CIB** to 736 **A**, and against so many kilowatts on **A**, read the number of horse powers corresponding the K.W. on **B**.

Three Hairline Cursor. This slide rule has a runner with three hairlines on it. The distance between the center and righthand lines corresponds to the distance from **LID** to the gange mark *c*; or 1.128 and that between the center and the lefthand lines from **CIA** to 7.36.

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