SLIDE RULE
INSTRUCTIONS

POST

FOR USE WITH

1448	1450L	1453L
1448L	1451	1454
1449	1451L	1454L
1449L	1452	1455
1449T	1452L	1455L
1449TL	1452T	1456
1450	1452TL	1456L
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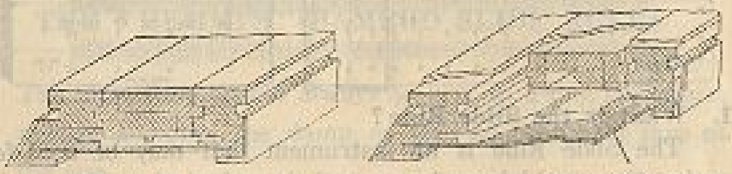
THE FREDERICK POST CO. - CHICAGO

CONTENTS

CONSTRUCTION AND SPECIALITIES OF THE "HEMMI'S" BAMBOO SLIDE RULES



Wood Slide Rule.

As the Slide Rule is an instrument used for 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 hard-wood 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's" 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's Bamboo Slide Rule was indeed designed 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's" 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's 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.

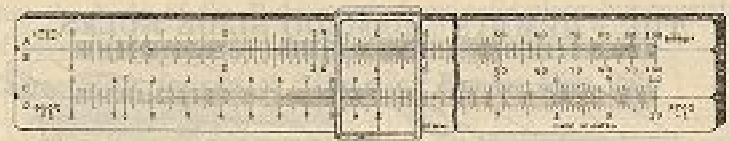
4. **Distinctness and accuracy of graduation.**

The Hemmi's Bamboo Slide Rule is graduated by the marhinery 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
THE "HEMMI'S" 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.

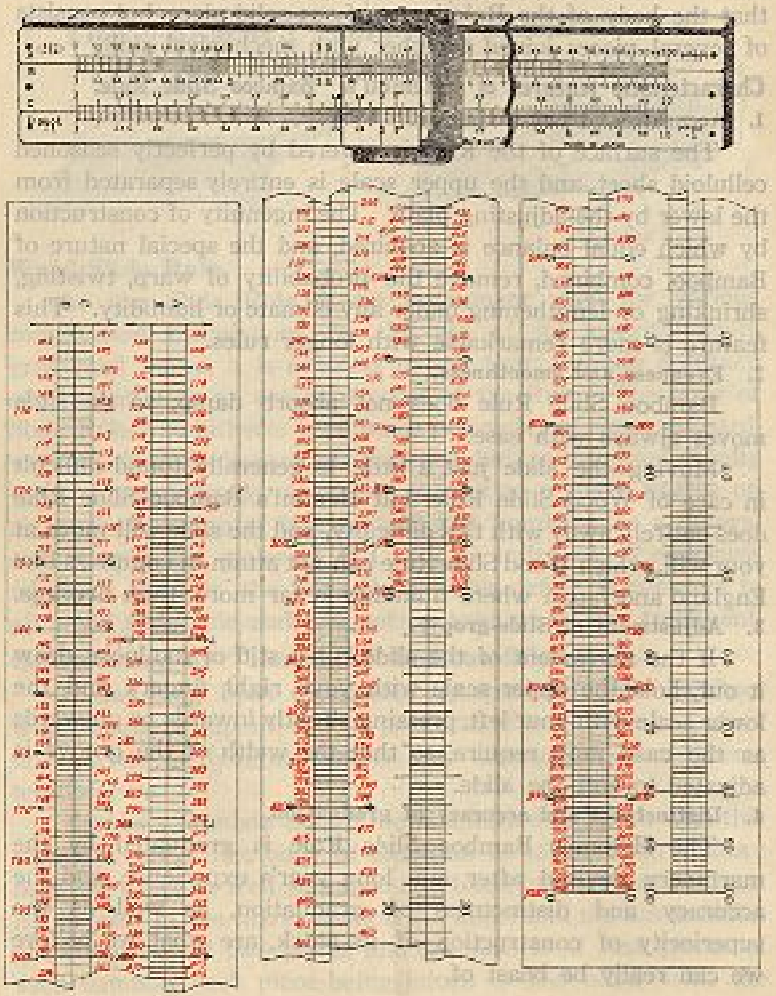
2. How much education is necessary?

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's 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.

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



INSTRUCTIONS

FOR THE USE OF

THE "HEMMI'S" BAMBOO SLIDE RULES

CHAPTER I

THE "HEMMI'S" NORMAL SLIDE RULES

Section I. How to Read Graduations

On the face of a slide rule, you see four scales, A, B, C and D and on the back face of the slide, you see three scales, S, L and T. Of these scales, A, B, C and D are for multiplication, division, squaring, extraction of a square root, cubing and extration of a cube root, T and S are for trigonometrical functions, a sine and a tangent respectively, and L for logarithms. Naturally 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, 4......to the 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 sub divisions represent each, either $^1/_{10}$ or $^1/_5$ or $^1/_2$ of the sub-division, just like those on any rule of the decimal system. The only trouble for beginners would be the un-equality 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 5C read 175**D**.

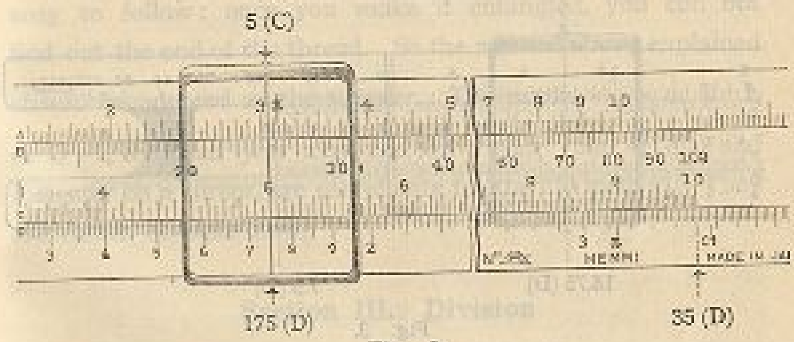


Fig. 2.

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.

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 lesser

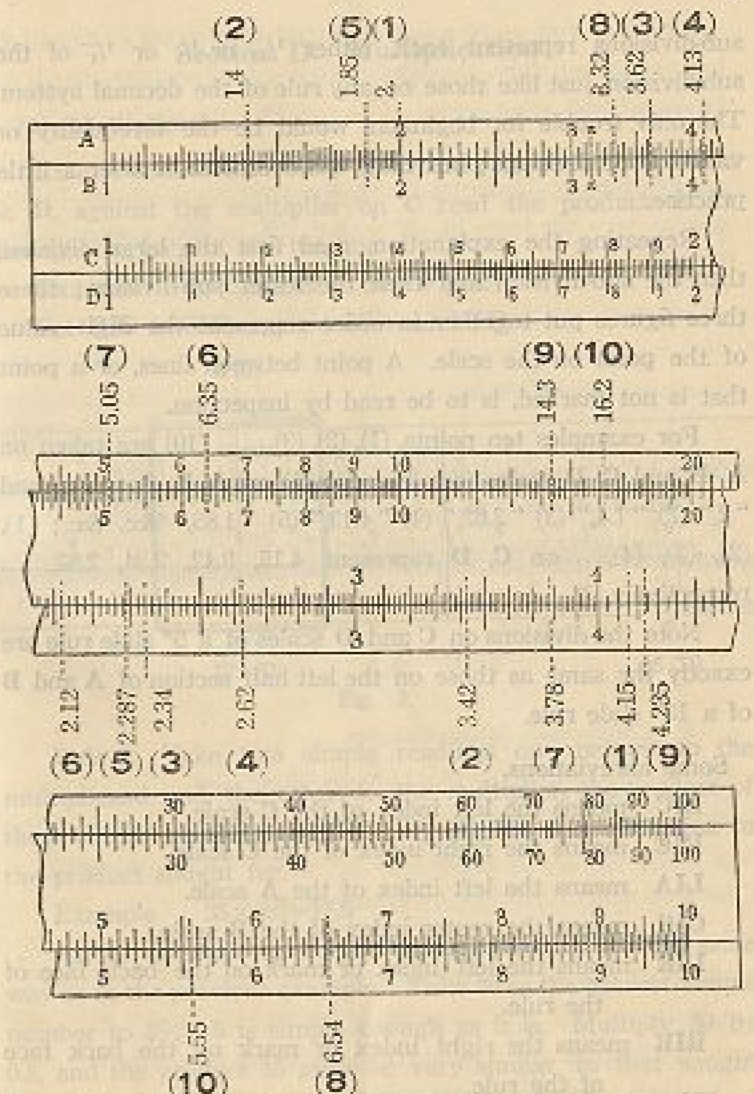


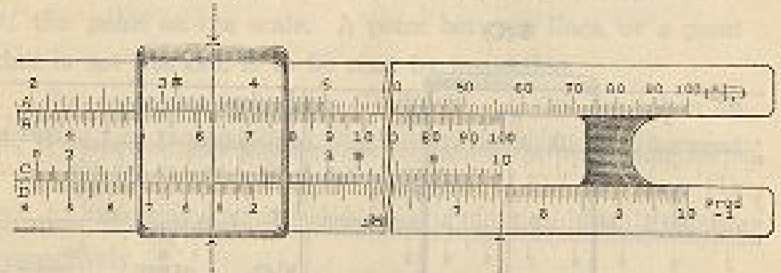
Fig. 1.

Note: 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**.

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 read 1875D. and the answer sought for must be 18.75.

2.5 (C)



18.75 (D) 7.5 (D)

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=3,090

Set **RIC** to 35**D**, against 42C 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 21C read 309**D**.

For punctuation, 40×400×0.2=3,200. 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'S ♯50 or ♯51 have an inverse scale that enables you to multiply three factors at once. (See Chapter III, Slide Rules with an Inverse Scale and a Cube Scale.)

Regarding the punctuation, the way of its determination as explained in Chapter VII is theoretical. But it is not very easy to follow; once you make it entangled, you can not find out the end of the thread. So the method above explained should be adopted as the simpler. The marks ←|→ or P−1, or Q+1, &c. that you may find on a slide rule, or dial and indicater on a cursor, are useful only for the old method. They are rather obsolete now.

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 55C 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.

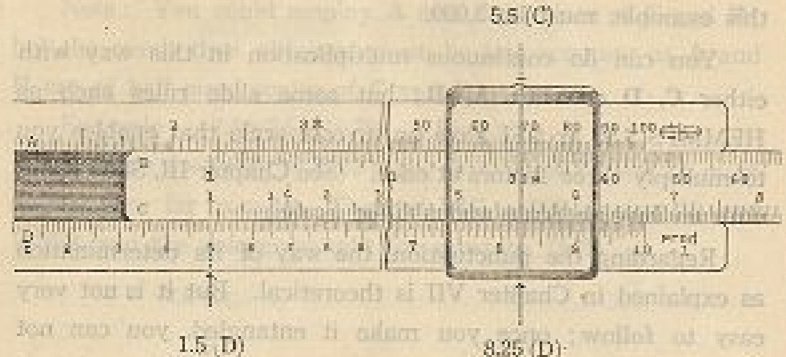


Fig. 4.

(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 divior on C comes under the hairline, against the index of C that happens to fall on D read the answer on D.

Example $2.7\div0.3\div5=1.8$

For punctuation $3\div.3\div5=2$ and you know the answer to this problem must be a number with an integral part of one place.

Set 3C to 27D, put the hairline at RIC, move the slide so that 5C 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 mixed 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 $\frac{2\times30}{6}=10$ (Figs. 5, 6)

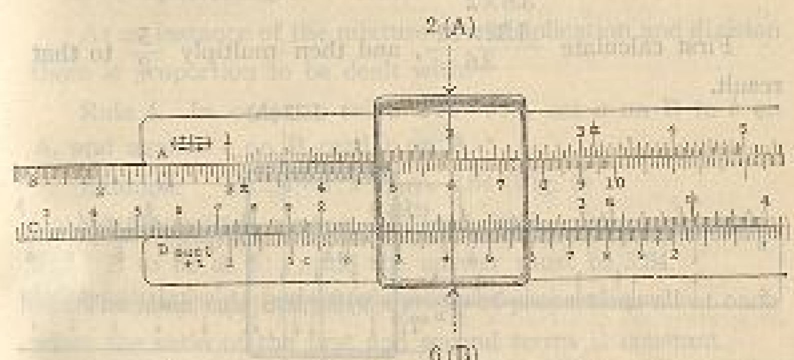


Fig. 5.

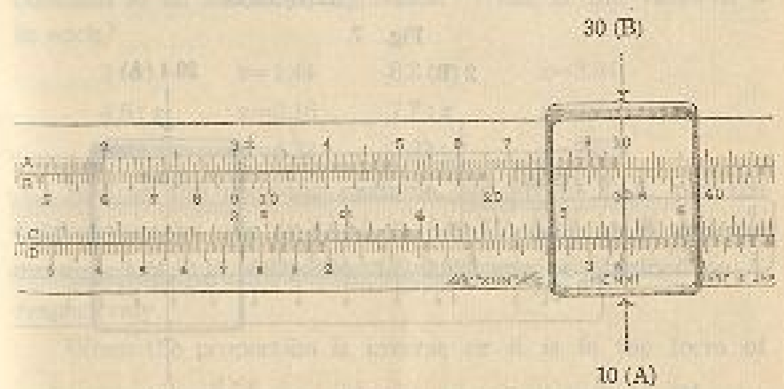


Fig. 6.

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

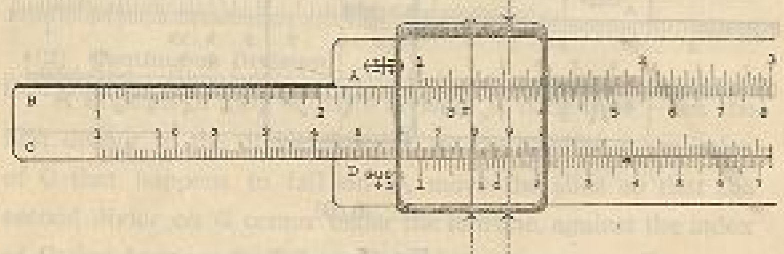
Set 6B to 2A, against 30B read 10A.

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

Example $\frac{1.32\times32\times5}{3.6\times2}=29.4$ (Figs. 7, 8)

First calculate $\frac{1.32\times32}{3.6}$, and then multiply $\frac{5}{2}$ to that result.

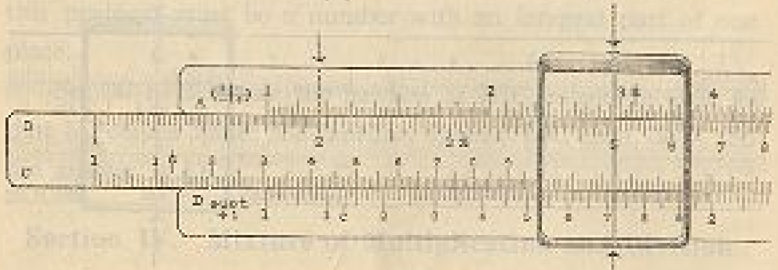
1.32 (A)



3.2(B) 3.6(B)

Fig. 7.

2 (B) 29.4 (A)



5 (B)

Fig. 8.

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

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 5B to 24A, against 8B read 384A. 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 5B to 2.4A, 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.

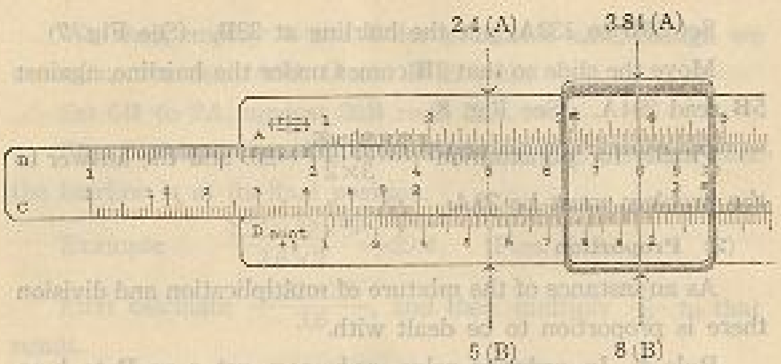


Fig. 9.

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 3B read 11.7A and also against 8B read 4.38A. 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 aD and read a^2A under the hairline.

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

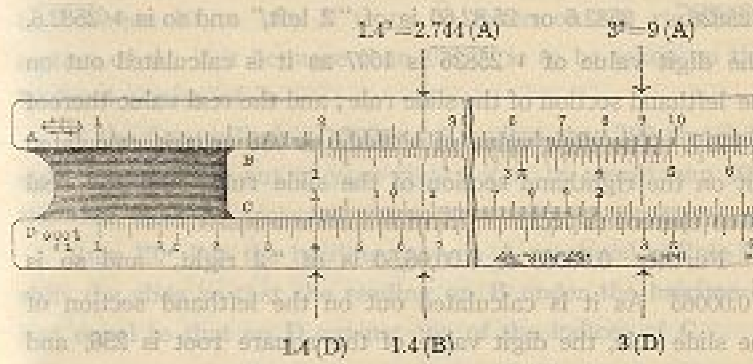


Fig. 10.

With the help of the hairline, read 9A across 3D. 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 1.4D, against 1.4B read 2.744A.

(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 right; if it be more 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**.

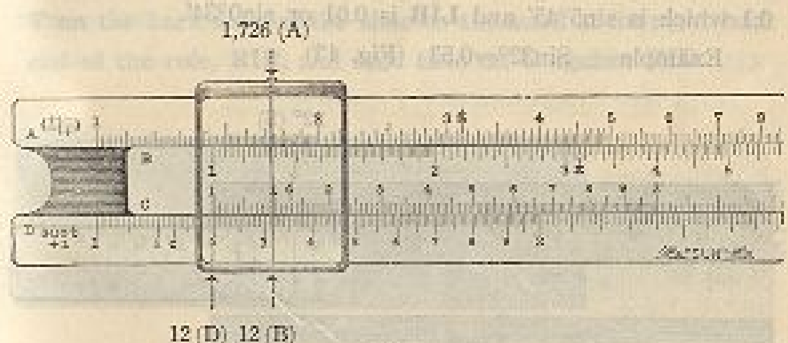


Fig. 11.

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 1,726A, shift the slide so that the reading on **B** under the hairline is just equal to that on **D** against LIC. Then it is 12B that comes under the hairline, while 12D faces LIC simultaneously. So 12 must be the result.

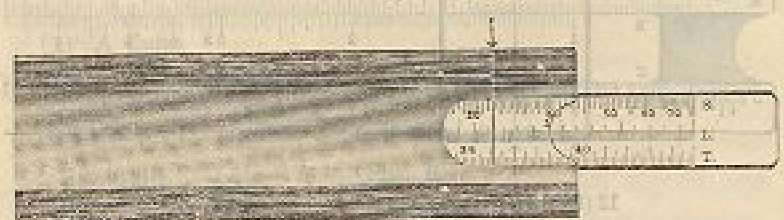
Section VII. Trigonometrical Functions

(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 B against 100A. As for the punctuation, it is of "1 right" when $\sin a$ is between 100 and 10 of B, and it is of "2 right" when $\sin a$ is between 10 and 1. That is the whole length of B shall be for two places; and RIB is 1.00, which is the sine of 90°, and CIB is 0.1 which is sin5°45′ and LIB is 0.01 or sin0°34′.

Example $\sin 32° = 0.53$ (Fig. 12)

32° (S)



Sin32°=0.53 (B)

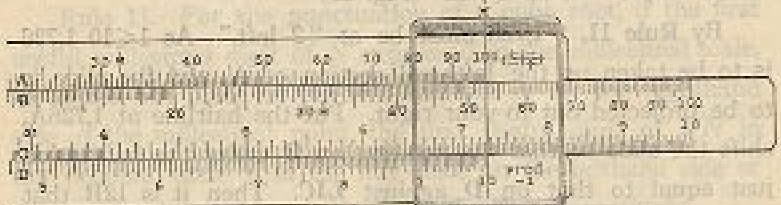


Fig. 12.

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 0.53B against RIA.

(2) Cosines

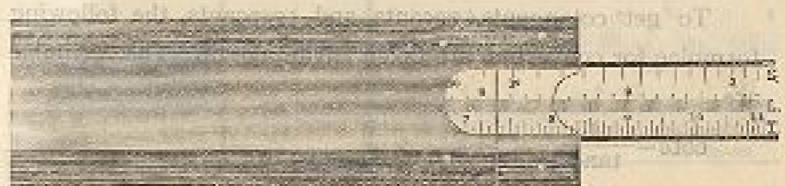
The ordinary slide rule has no scale on directly for a cosine; but taking advantage of

$$\cos a = \sin(90° - a)$$

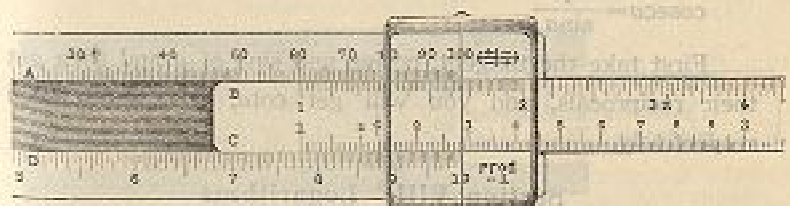
have the sine of the complement angle of a, and it is $\cos a$.

(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.



7°20 (T)



tan7°20′=0.1286(C

Fig. 13.

As for the punctuation, always take **RIC** as 1 or tan45° instead of 10, and **LIC** as 0.1 or tang5°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 **A** against any *a* on **S**; and also tan*a* on **D** against any *a* on **T**, without moving the slide.

Example tan7°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 1286C 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

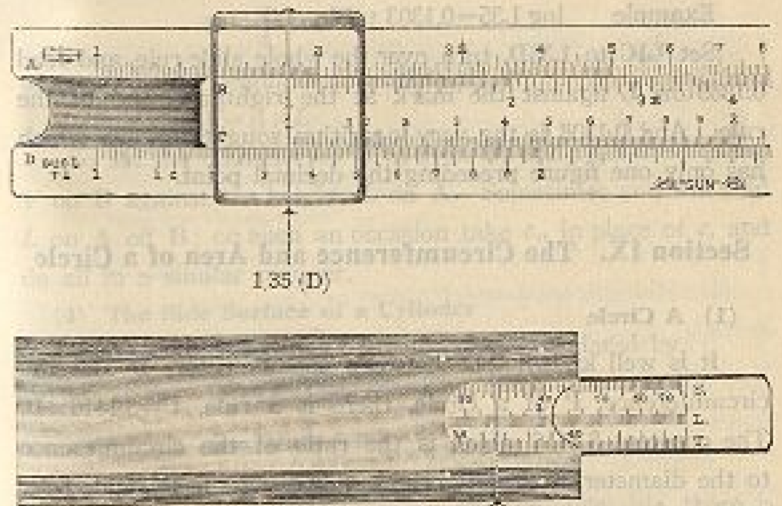
(1) **Logarithms**

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



1.35 (D)

log 1.35=0.1303 (L)

Fig. 14.

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.

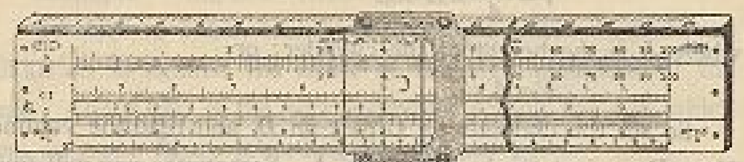


Fig. 15.

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

Example $85\div2.3\div4.2=8.59$

Set 2.3C to 85D, against 4.2CI read 8.59D.

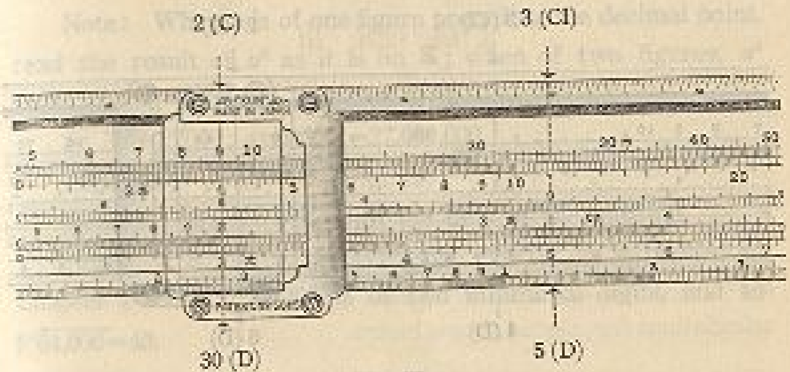


Fig. 16.

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

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

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

Example $e^{2.5}=12.2$

Keep the slide at the normal position and read 12.2N against 2.5D.

Example $\log_e 3.8=1.334$

Keep the slide at the normal position, and read 1.334D against 3.8N.

(2) The Efficiency Scale

The efficiency scale **E** is on the bottom face of the groove, on the top side. There is the marking 100 in the middle of the scale; then on each side of the "100" there is "90," "80," "70," &c. The righthand section of this scale is for electric motors, and the lefthand section of the scale is for generators.

Example 1. There is a generator of 20 K.W. that requires an input of 28 H.P. at full load. What is the efficiency of the generator? Ans. 97%. (Fig. 22)

Set 28 H.P. on the lefthand section of (B), instead of the righthand, to 20 K.W. A, and read 97% E at the sharp edge

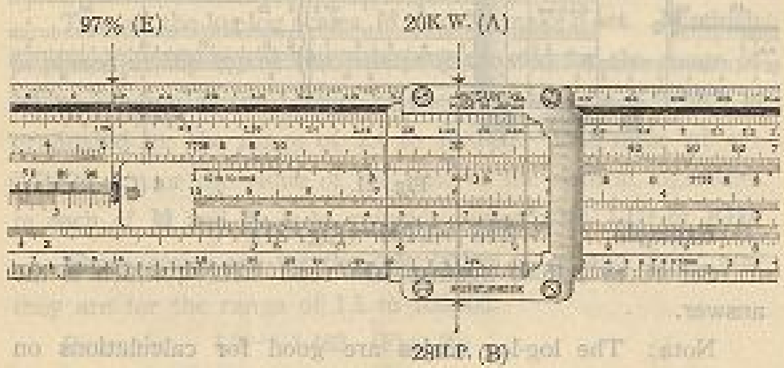


Fig. 22.

of the metalic point of the slide, which is on the bottom face of the groove of the rule. 97% is the answer.

Example 2. There is a motor of 38 K.W. input and 44 H.P. output. What is its efficiency? Ans. 85.1% (Fig. 23)

Set 44 H.P. on the lefthand section of **B** to 38 K.W. on **A**, and read 85.1% **E** at the point of the metalic blade.

Note: The H.P. here is meant the French horse power "de cheval" and corresponds 736 watts.

The efficiency scale in our old electrical engineer's slide rule is graduated on the basis of the British horse power 33,000 ft-lbs./sec.=746 watts, instead of the metric horse power.

The gauge marks 736 on the scales **A** and **B** are consequently to be changed to 746.

Therefore, the Examples in the text are calculated by one old electrical engineer's slide rule as follows:

Example 1. Set 28 H.P. on the lefthand section of **B** to 20 K.W. on **A**, and read the answer 95.5% on **E** at the metalic edge of the slide.

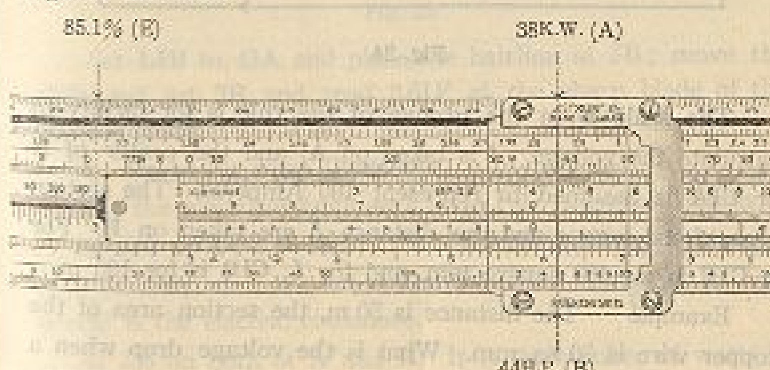


Fig. 23.

number whose first useful digit just follows the decimal point has for its characteristic −1 which is expressed by $\bar{1}$ by convention; and so the characteristic is $\bar{2}$ 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×**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 **A**, **B**, **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 the diameter on **C** to c on **D**, then you can read the area, A of the circle on **B**, against **LIA**.

(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 the diameter on **C** to c on **D**, and read the volume V on **B** against the height, L on **A**. Sometimes you will find L on **A** off **B**; on such an occasion take c_1 in place of c, and do all in a similar manner.

(4) The Side Surface of a Cylinder

The side surface, Q of a cylinder is calculated by

$$Q=\pi\times D\times L$$

or

$$Q=DL\Big/\frac{1}{\pi}$$

Put $M=\frac{1}{\pi}$, then $Q=\frac{D\times L}{M}$ On the slide rule, there is the marking of M on **A** and **B**. So set M on **B** against D on **A**, and against L on **B** you can read Q on **A**.

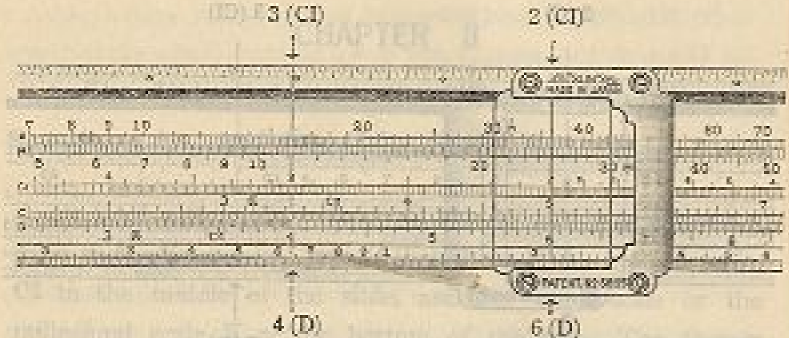


Fig. 17.

(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 hairline, read 27K against 3D without moving the slide.

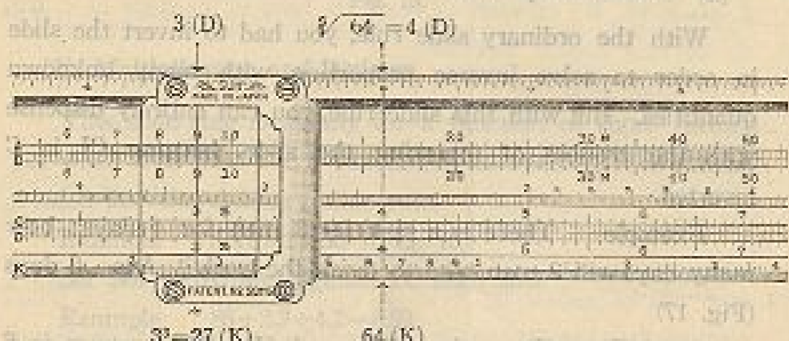


Fig. 18.

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

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

CHAPTER III

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.

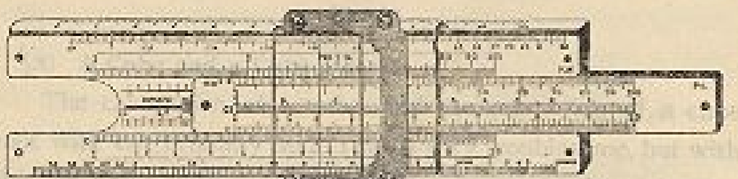


Fig. 19.

(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 $\epsilon=2.71828......$, 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 $1.3^{1.5}=1.482$ (Fig. 20)

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

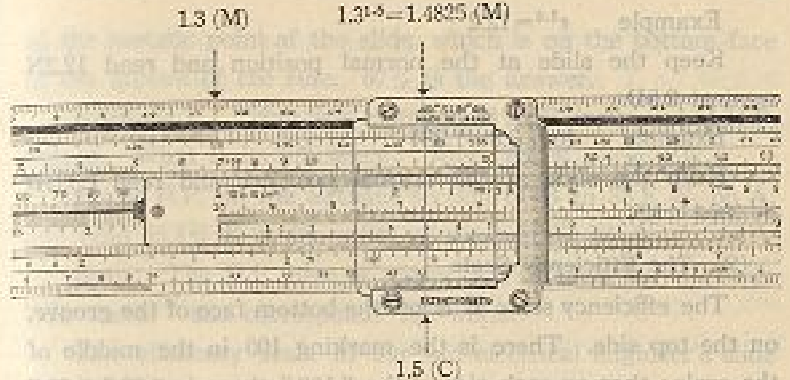


Fig. 20.

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

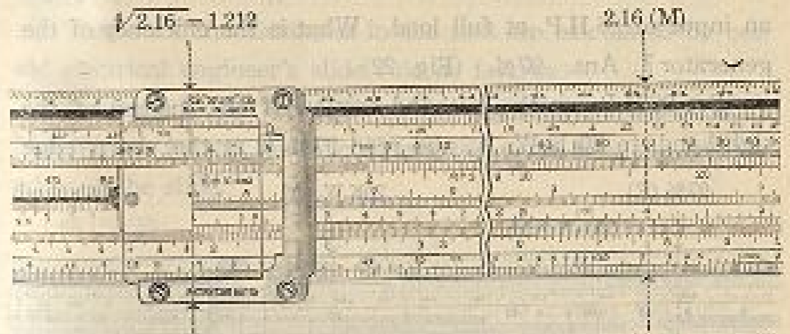


Fig. 21.

Example $\sqrt[4]{2.16}=1.196$ (Fig. 21)

Set 4C 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 $\log_\epsilon x$ very easily.

Example 2. Set 44 H.P. on the lefthand section or **B** to 38 K.W. on **A**, and read 86.3% on **E** at the metalic edge of the slide.

(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

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

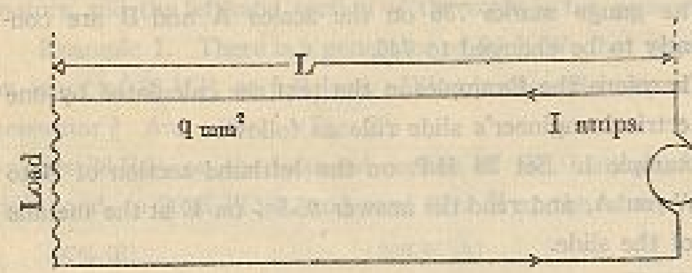


Fig. 24.

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)

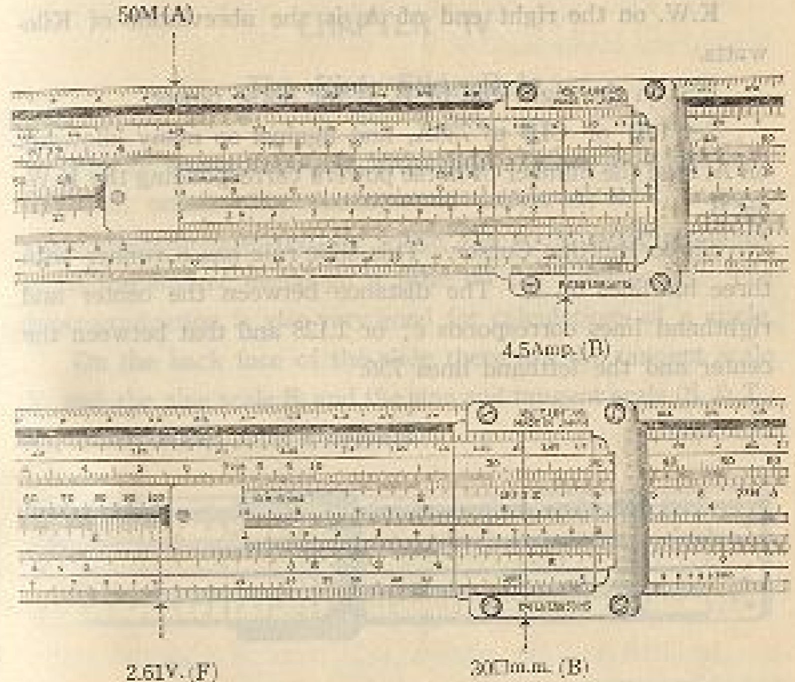


Fig. 25.

Set **LIB** to 45**A** and place the hairline at 5**B**; move the slide and set 3**B** and read 2.61**F** 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 c; or 1.128 and that between the center and the lefthand lines 736.

CHAPTER IV

The Rietz Slide Rule

Fig. 26 shows the Rietz Slide Rule. It has its scales in a reformed order. The fundamental scales, **A**, **B**, **C**, **D** have super-graduations in red, by which you could avoid resetting, when the answer would go a little off the main scales. The super-graduation is also very good for calculations of a circle.

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

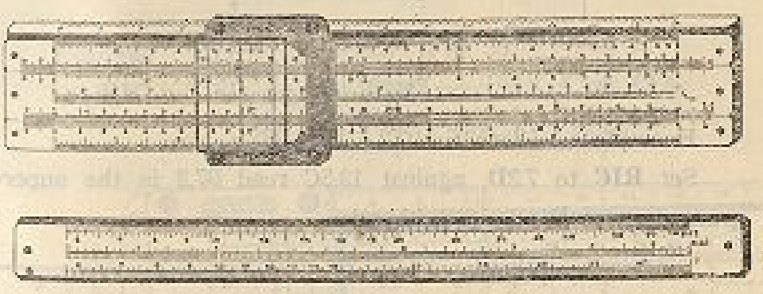


Fig. 26.

A, **B**, **C**, **D** in the figure are the fundamental scales; **L** is an equi-divided scale for logarithms; **CI** the inverse scale; **K** the cube scale.

The Use of Additional Scales. When the result that you aim at happens to be nearly critical, you often require resetting, because you could not foretell which side you are to project out the slide. But with this slide rule with super-graduated scales, you could avoid it.

Example 1.8×5.88=10.58 (Fig. 27)

Set **LIC** to 1.8**D**, against 5.88**C** read 10.58**D** in the super graduation of **D** on the right.

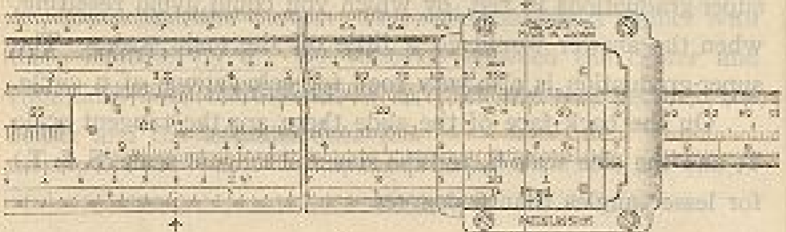


Fig. 27.

Example 7.2×13.5=97.2 (Fig. 28)

Set **RIC** to 7.2**D**, against 13.5**C** read 97.2 in the super-graduation of **D** on the lefthand.

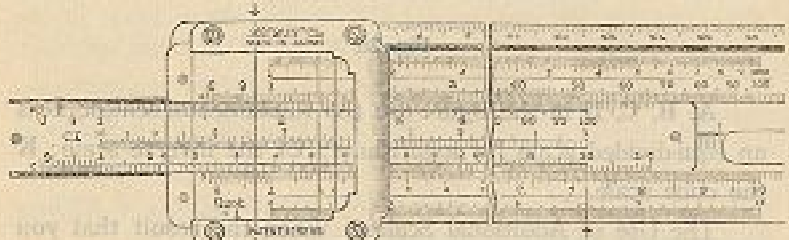


Fig. 28.

Example $(1.09\times9.8)^2=114.2$ (Fig. 29)

Set **LIC** to 1.09**D**, against 9.8**C** read 114.2**A** off **RIA**, by the help of the hairline.

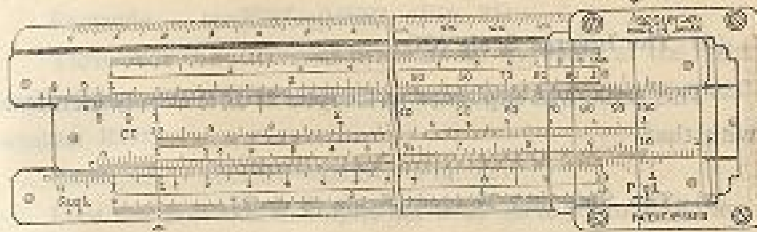


Fig. 29.

Example $(7.8\times1.25)^2=95.3$ (Fig. 30)

Set **RIC** to 7.8**D**, against 1.25**C** read 95.3 **A** off **LIA.**

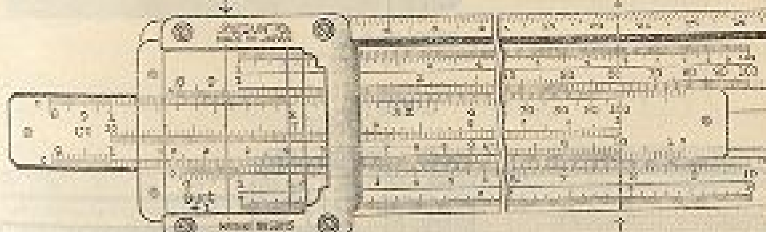


Fig. 30.

Example What is the area of a circle whose diameter is 8 ft.? Ans. 50.25 sq. ft.

Set **LIC** to 8D, against the left extreme end of the super-graduation of **B** read 50.25A.

You could as well do that in this way: set the right extreme end of C to 8D, against **RIB** read 50.25A

(1) The Inverse Scale (CI)

This scale was explained in Chapter II as it is only identical with that.

(2) The Sine and Tangent Scale (S & T)

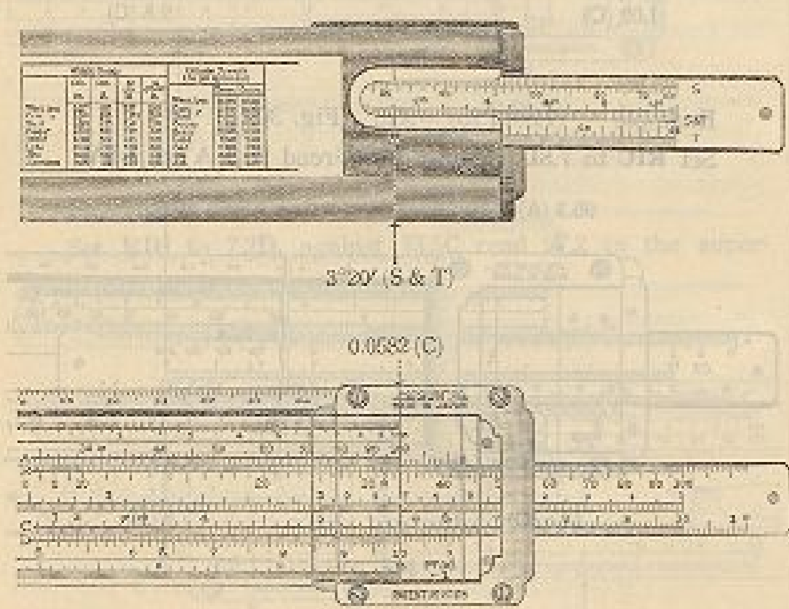


Fig. 31.

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 angle less than 6°-0′. It gives by far greater accuracy than either **S** or **T**.

Example tan3°20′=0.0582 (Fig. 31)

Turn over the slide rule, set 3°20′ to the mark at the right end of the rule **RIR**; then on the front face, read 0.0582C against **RID**.

Example sin2°05′=0.0364 (Fig. 32)

Like the previous example, set 2°05′ (S & T) to **RIR**, and against **RID** read 0.0364C.

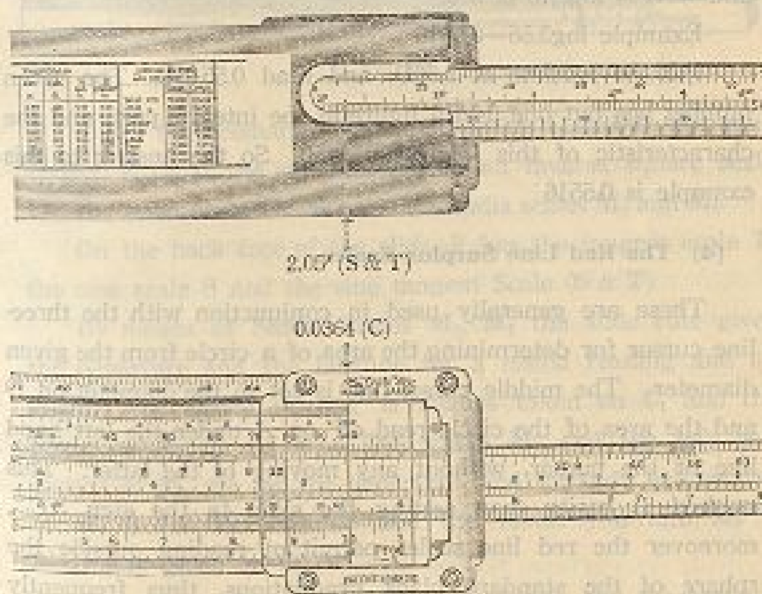


Fig. 32.

Note: For the punctuation of a trigonometrical function, the first useful digit of the reading is just after the decimal point where S or T is employed; and it is at the second place after the decimal point where the (S & T) scale is employed.

(3) To Get the Logarithm of a Given Number

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 $\log_{10}A$, read $\log_{10}A$ on **L** against A on **D** by the help of the hairline. For the punctuation, **L1L** is $\log_{10}1$ or 0, and **RIL** is $\log_{10}10$ or 1.0.

Example log3.56=0.5516

Put the hairline at 3.56D, and read 0.5516L. The given number has but one useful figure in the integral part, and the characteristic of this logarithm is 0. So the answer to this example is 0.5516

(4) The Red Line Surplus Scales

These are generally used in conjunction with the three-line cursor for determining the area of a circle from the given diameter. The middle cursor line is set to the diameter on D and the area of the circle read off on A under the left hand line of the cursor, without any moving of the latter. This method is easier than setting the slide to the sign "C", moreover the red line scales permit of reading outside the sphare of the standard black graduations, thus frequently avoiding troublesome reversing of the slide.

CHAPTER V

The Slide Rule with Stadia Scale

This is a very handy slide rule for a surveyor that works in the open field. See Fig. 33.

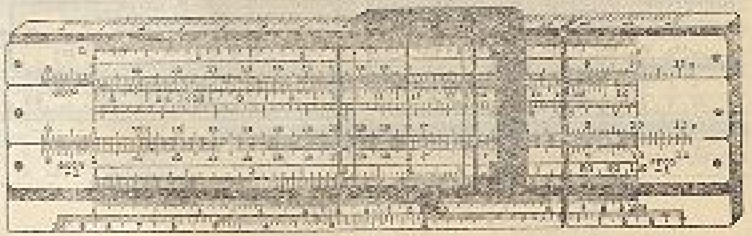


Fig. 33.

It has the ordinary logarithmic scales **C** and **D**, the equi-divided scale **L**, the square scale A, an inverse square scale IA, the cube scale **K**. It has also Stadia scales M_1 and M_2.

On the back face of the slide, it has the tangent scale T, the sine scale S and the sine tangent Scale (S & T).

By means of Stadia Scales M_1, M_2 the slide rule gives the departure and the latitude for a stadia reading and an angle. The stadia reading is always taken on C_1 and the angle on M_1 or on M_2. The whole M_1 and the left half section of M_2 are for the departure, and the right half section of M_2 is for the latitude and the result you aim at, is invariably given on C_1.

Example The stadia reading is 538 ft. and the angle is

12°30′; what are the departure and the latitude? Ans. 113.6 ft. and 513 ft. respectively. (Fig. 34)

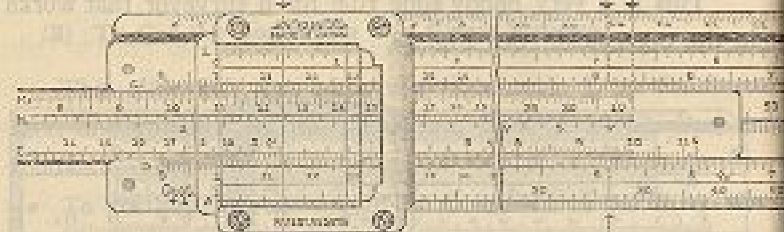


Fig. 34.

Set RIM_2 to $538C_1$, against 12°30′ M_2 on the left half section of M_2 read the departure $113.6C_1$. Keeping the slide as it is, and shifting the hairline only against 12°30′ on the right half section of M_2 read the latitude $513C_1$.

Note: The stadia scale on the ordinary slide rule has its scale divided on the basis, 4 right angles=360°; but of late some other slide rules have the basis: 4 right angles=400° instead of 360°.

(1) The Cube Scale (K)

It was explained thoroughly in Chapter II, on the Slide Rule with the Inverse Scale, the Cube Scale. This slide rule has entirely the same one.

(2) The Inverse Square Scale (IA)

Between this and A, you can get the reciprocal of any number.

Example $\frac{1}{12.5}=0.08$ (Fig. 35)

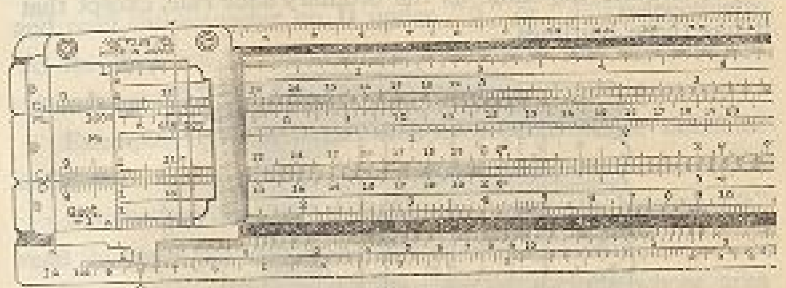


Fig. 35.

Put the cursor at 12.5A and read thereunder 0.08IA.

Note: The cursor is so designed that you should always employ the righthand hairline on the glass. (The cursor on the 20″ slide rule, however, is different. You should employ the middle hairline in the glass.)

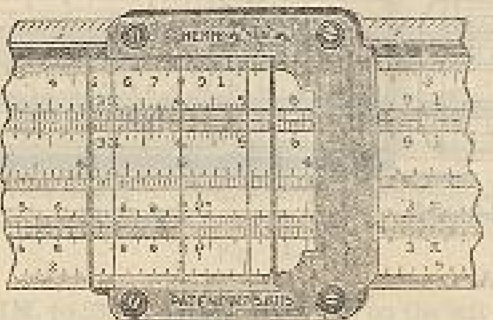
(3) The Sine-Tangent Scale (S & T)

This is exactly the same as that (S & T) which was explained in Chapter IV, Rietz Slide Rule.

CHAPTER VI

Three-Line Cursor

It is quite the same as the ordinary slide rule, except that it has three hairlines.



(2) (0) (1)

Fig. 36.

For explanation purposes denominate the three lines "2," "0" and "1" from left to right. Each of the three lines can be employed as well as the hairline on the ordinary cursor. But when they work in cooperation, they are more useful. "0" is at the midway between "2" and "1."

(1) **The Area of a Circle**

The advantage of the cursor is to give the area of a circle whose diameter is given without the trouble of setting the slide. Set the hairline, "0" to the diameter on **D** and read the area on **A** under the hairline "2" instead of "0." You might as well take "1" instead of "0," only then "0" must

be taken for "2." To the diameter on **D** you can put either "0" or "1," but you can not put "2" instead.

Reversely you can also get the diameter out of a given area of a circle. Set either "2" or "0" to the area on **A**, and read the diameter on **D** under "0" or "1" respectively. To the area on **A**, you can set either "0" or "2," but you can not set "1" instead.

Example What is the area of a circle whose diameter is 5.3 ft.?

Set the hairline "0" to 5.3**D**, and under the hairline "2" read the area 22.1 **A**. Ans. 22.1 sq. ft.

Example What is the diameter of a circle whose area is 38.5 sq. inches?

Set the hairline "2" to 38.5**A** under the hairline "0" read 7**D**. Ans. 7 inches.

CHAPTER VII

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, $C=ER$, 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, and $2g$= 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 methodes.

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 of 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 in 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 VIII

Marks and Tables

(1) $\begin{array}{c|c} + & - \\ \hline \leftarrow - & + \rightarrow \end{array}$

To do multiplication and division with **A** and **B**, it is used for the punctuation. The vertical line in the mark means the position of the decimal point. The arrows point the direction of sliding. The horizontal line shows a fraction, the reading above the line is the numerator, and that under the line is the denominator. Sometimes the numerator means the product of multiplication, and the denominator the quotient of division. For brevity, we shall explain by examples.

Example 255×156=39780

Take 2.55**A** for 255, or shift 2 places: +2 about $\begin{array}{c|} + \\ \hline \leftarrow \end{array}$ next take 1.56**B** for 156, or shift 2 places: +2 about $\begin{array}{c|} + \\ \hline \leftarrow \end{array}$. The total shifting is 2+2=4. So the product 3.978 on **A** should be 39780.

This rule holds good for division.

(2) $\frac{\textbf{Prod}}{\textbf{-1}}$ or **P−1**

This means that to do multiplication between **C** and **D**, if the product comes on the righthand side, the number of places is equal to the sum of the numbers of places of the two factors ninus one.

(3) $\frac{\textbf{Quot}}{\textbf{+1}}$ or **Q+1**

This means that to do division between **C** and **D**, if the quotient comes on the lefthand side of the dividend, the number of places of the quotient is equal to the difference between the numbers of places of the dividend and the divisor plus one.

(4) **M**

$M=\frac{100}{\pi}$ in digit value. It is for calculation of a circle, especially the circumference thereof.

(5) c, c_1

They are for the area of a circle whose diameter is known, or vice versa. See Chapter I, (9).

(6) ρ', ρ'' and ρ_{g}

All these are for coversion of the angular measure to the circular measure, and vice versa.

$\rho'=\frac{360\times 60}{2\pi}=3438$ in digit value. It is useful when the angle is in minutes.

$\rho''=\frac{360\times 60\times 60}{2\pi}=206265$ in digit value. It is useful when the angle is in seconds.

$\rho_{g}=\frac{400\times 100\times 100}{2\pi}=636620$ in digit value. It is good when 4 right angles=400°

Let α be the angle in the angular measure, and β the same in the circular measure, then in general

$$\alpha=\rho\beta$$

(7) **The Table for Conversion**

This is a card on the back face of the rule. It is very useful for conversion; it is a table of useful constants in another form. From left to right, (1) fractions of an inch into mm. (2) Mathematical constants. (3) proportional pairs for conversion. (4) specific weights of metals. They require little explanation, but we shall touch (3) only.

The proportional pairs are for conversion of lengths, areas, capacities, weights from in one units to another. Also for proportional conversions about circles, there is a guide for setting **C** to **D**.

Example

Scale C	Scale D	C	D
Dia Circle	Circumf. Circle	1	π

means the ratio of the diameter and circumference of a circle is $1:\pi$. Hence set **LIC** to π**D**, the reading of any point on **D** is the circumference of a circle whose diameter is read on **C** at the same point.

Some slide rules have scales on the sides and also inside the groove of the rule. They are usually plain rules for ordinary measuring. They have nothing to do with calculations. The rules on the sides are ordinary rules in daily life, but that inside the groove has a mechanical advantage; it is for measuring a thing longer than the rule for it serves as a box rule. Set the left end of the rule at one end of the thing, project

the slide until the outer end of the slide is just level with the other end of the thing, and you can read the length of the thing on the rule inside the groove of the rule at the inner end of the slide.