Supplement to
Manual M-12...

PICKETT

P. O. BOX 1515, SANTA BARBARA, CALIF. 93102

how to use

POWERS-OF-TEN DECIMAL-KEEPER SLIDE RULES

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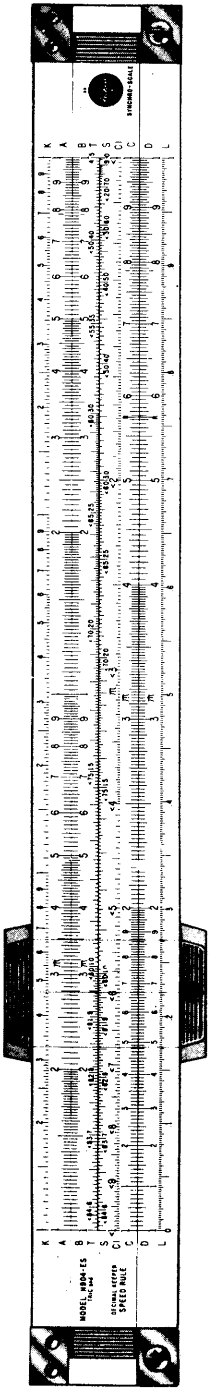
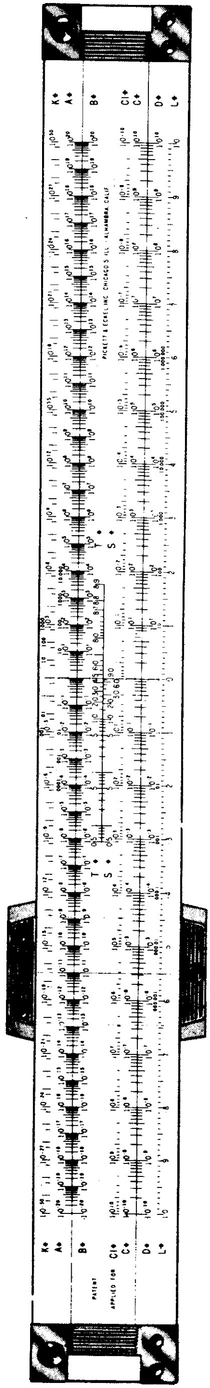
Price 50 Cents


MODEL N804-ES
DECIMAL KEEPER
SPEED RULE

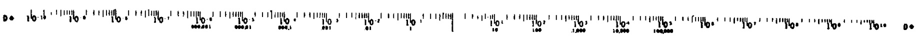

PATENT
APPLIED FOR

DECIMAL KEEPER SCALES

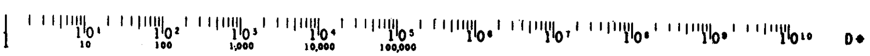
INTRODUCTION

Imagine that you have 20 ordinary slide rules and place them end-to-end in a straight line. Also imagine the blank spaces at each end are cut off so that the D scales can be put together to make one continuous scale. This would be a logarithmic scale about 200 inches (almost 17 feet) long. The *Decimal-Keeper* D* Scale is like this scale, but it is greatly *reduced* in length so all of it can be put on the body of an ordinary 10 inch slide rule.

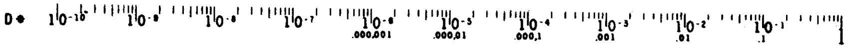
The numeral 1 is shown near the middle of a scale under a graduation mark called the "index." The main or "primary" divisions of the scale



"D*" SCALE REDUCED IN SIZE TO ILLUSTRATE 20 "PRIMARY" DIVISIONS OR CYCLES



10 "PRIMARY" DIVISIONS OR CYCLES TO RIGHT OF INDEX



10 "PRIMARY" DIVISIONS OR CYCLES TO LEFT OF INDEX

Fig. 1

have numerals under them. On the right-hand side of 1 the numerals are first 10^1 or 10, next 10^2 or 100, then 10^3 or 1000, and so on out to 10^{10}. Beyond 10^5 only the exponential form 10^6, 10^7, etc. is used because there is not room to show all of the zeros when the number is written in the ordinary way. Notice, however, that $10^6 = 1{,}000{,}000$ has 6 zeros when written out. Similarly, $10^7 = 10{,}000{,}000$ has 7 zeros, etc.

On the left-hand side of 1 the divisions represent decimal fractions. Reading toward the left the numerals are 10^{-1} or .1 ("one-tenth"), then 10^{-2} or. 01 ("one-hundredth"), and so on out to 10^{-10}. Beyond 10^{-6} or .000,001 only the exponential form 10^{-7}, 10^{-8}, etc. is used because there is not room to show all of the zeros when the number is written in the ordinary way. Notice, however, that 10^{-7}=.000,000,1 uses seven "places" at the right of the decimal point. Similarly, 10^{-8}=.000,000,01 uses eight "places", etc.

There is room for a set of subdivisions between each of these primary graduations, but there is not enough room to print numerals beside the subdivisions. In Figure 2 several enlargements of the scale show how some of these subdivisions would be numbered—that is, how they should be read.

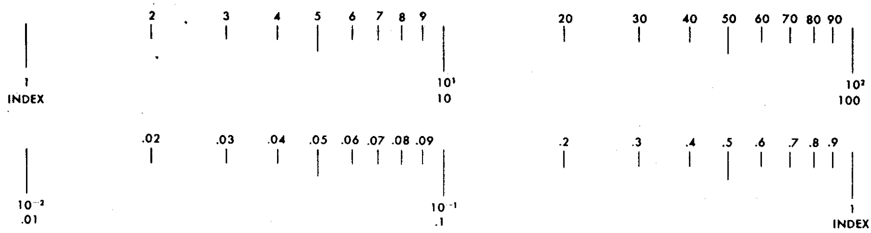


Fig. 2

It is important to notice that on the D* scale the subdivisions are read in order from left to right as 2, 3, 4, etc., or 20, 30, 40, etc., or .2, .3, .4, etc., or .02, .03, .04, etc.

On an ordinary D scale one mark is used to represent many different numbers. Thus the graduation labelled 2 is used to represent 20, 200, 2000, etc. It may also represent various decimal fractions such as 0.2, or 0.02, or 0.002, etc.

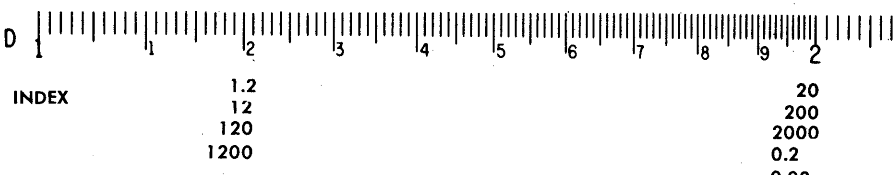


Fig. 3

The important thing to observe about the Decimal-Keeper D* Scale is that each graduation mark represents only one number. That is why it is called a *Decimal-Keeper* scale. The range of the scale is from 10^{-10} or 0.000,000,000,1 ("one ten-billionth") to 10^{10} or 10,000,000,000 ("ten billion"). Every number in this range is represented by a position on the scale and with the decimal point taken into account. To accomplish this, however, means that the accuracy is reduced and often only one significant digit of a number can be read. Therefore *Decimal-Keeper* scales are mainly useful in locating the decimal point in the answer. Ordinary scales are useful in obtaining results as accurate as possible with a slide rule, but with them the decimal point must be found by some other method—for example by using the Decimal-Keeper scales.

USING THE C* AND D* SCALES

The *Decimal Keeper* scales are used in exactly the same way as the corresponding ordinary scales. However, in making settings attention must be given to the location of the decimal point in the numbers.

- EXAMPLES:

(a) Multiply 2.34×36.8.
Set 1 of C* over 2+ of D*. Move hairline over 30+ of C*.

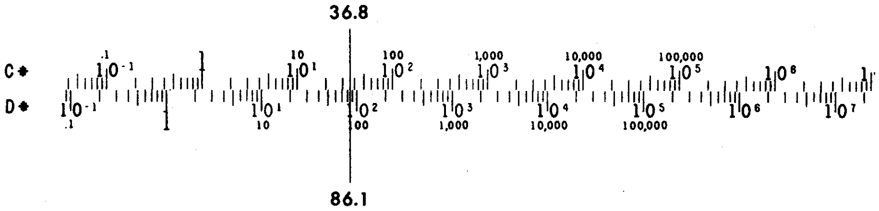


Fig. 4

Read 80+ on D*. In making the settings do not try to set more than the first digit accurately. In this example the rough settings will show you the result is about 80. It could not be as large as 800 or as small as 8. By using the C and D scales, the answer is found to be 86.1.

(b) Multiply 28.3×5.46.
Set 1 of C* over 28 of D*. Move hairline over 5 of C*. The result under the hairline of D* is more than 100 and less than 200. The use of more accurate settings on the C and D scales shows the answer is 154.5.

(c) Multiply 280×0.34.
Set 1 of C* over 280 on D*. Move the hairline over .3 on C*.

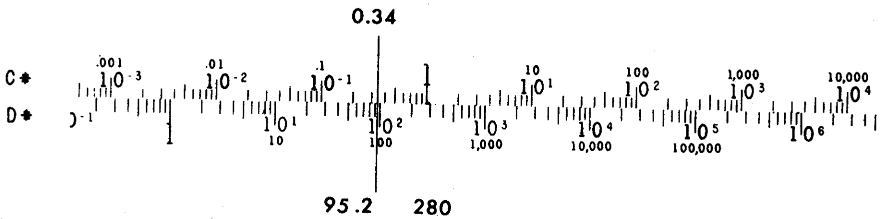


Fig. 5

Read 90+ on D* under hairline. By using the C and D scales, the answer is found to be 95.2.

(d) Multiply 230×.043.
Set 1 of C* over 230 on D*. Move hairline to .04+ on C*. Read answer as "about 10" on D*. By using the C and D scales the result is found to be 9.89.

LOCATING THE PROPER SCALE SECTION

The scale position of very small and very large numbers is indicated by exponential notation. For example, 0.000,001 equals 10^{-6} and 1,000,000 equals 10^{6}. The following rule provides an easy way of determining where to locate a number on the scale.

Rule.

Start at the right of the first non-zero digit in the number and count the number of digits and zeros passed over in reaching the decimal point. The result of the count is the numerical value of the exponent of 10 which shows the section of the scale on which the number is found. If the decimal point is toward the right (as in numbers larger than 1), *the exponent is positive* (+). If the decimal point is toward the left (as in numbers smaller than 1), the exponent is *negative* (--).

• EXAMPLE:

(a) 4 0230. count 4 — Number is between 10^{4} and 10^{5}

(b) 0.00006 2 count 5 — Number is between 10^{-5} and 10^{-4}

You can see from these examples that the count gives the exponent of 10 for the primary scale mark just to the left of the number. In other words, the number is always located on the section of the C* or D* scale at the right of the mark indicated by the count. The CI* scale is an inverted C* scale. It reads from *right to left.* Hence on this scale the number is located on the section at the *left* of the mark indicated by the count.

• OTHER EXAMPLES:

	Number	*Exponent of 10*	*Number is Between*
(a)	5,790,000.	6	10^{6} and 10^{7}
(b)	0.000283	−4	10^{-4} and 10^{-3}
(c)	461,328.	5	10^{5} and 10^{6}
(d)	0.000,000,537,1	−7	10^{-7} and 10^{-6}
(e)	0.000,000,002,6	−9	10^{-9} and 10^{-8}
(f)	520,000,000.	8	10^{8} and 10^{9}

(g) Multiply 0.000,047,1×1,850,000.
Note that 0.000,047,1 is larger than 0.000,01 (or 10^{-5}). Hence this number is found between 10^{-5} and 10^{-4} on D*. Set 1 of C* over 0.000,04+ on D*. Move hairline to 1,800,000 on C*. This number is larger than 1,000,000 (or 10^{6}) and thus is set between 10^{6} and 10^{7} on C*. Read 80+ on D*. A more accurate result is 87.1.

(h) Multiply 0.000,283×0.000,054,1.
Multiply 283×541 using the C and D scales to obtain the significant digits of the product, namely, 153. Note that 0.000,283 is located to the right of 10^{-4}. Set 1 of C* over 28 in the section of D* between 10^{-4} and 10^{-3}. Note that 0.000,054,1 is larger than 10^{-5}. Move hairline of cursor over 5 in the section of C* between 10^{-5} and 10^{-4}. The result on D* is between 10^{-8} and 10^{-7}. The answer has 8 figures between the 1 of 153 and the decimal point. It is 0.000,000,015,3. To obtain it easily, start at the right of the 1 in 153 (which was found earlier) and count 8 places to the left (−8), writing the necessary 7 zeros as you count.

DIVISION AND COMBINED OPERATIONS

It should now be clear that to do any computation with the *Decimal-Keeper* scales you can imitate step-by-step what you would do with the ordinary C and D scales. A few examples of division and combined multiplication and division will be worked out to show that the principle works with them too.

• EXAMPLES:

(a) Find 62.7÷0.0042. First, use the C and D scales to find 627÷42. The result, except for the decimal point, is 1493. Next, set 0.0042 on C* over 63 on D*. Observe that 1 of C* is to the right of 10^4 on D*. Hence the answer contains 4 figures to the right of the 1 in 1493, and therefore is 14,930.

(b) Find $\dfrac{1590\times 3.64\times 0.763}{4.39\times 930}$

The digits in the answer are 1081. To locate the decimal point, set hairline over 1590 on D*. Move slide until 4+ of C* is under hairline. Move hairline over 3+ of C*. Move slide until 930 is under hairline. Move hairline over 0.7+ on C*. The hairline of C* is then over 1 of D*, so the result is 1.081. Even if the settings are made quickly and only roughly, the result should be near enough to 1 that it could not be mistaken for 0.1 or for 10.

(c) Find 1÷0.000,68, using CI and CI*. Set hairline over 68 of C. Read 147 on CI. Set hairline over 0.000,68 of C*. Read 1470 on CI*.

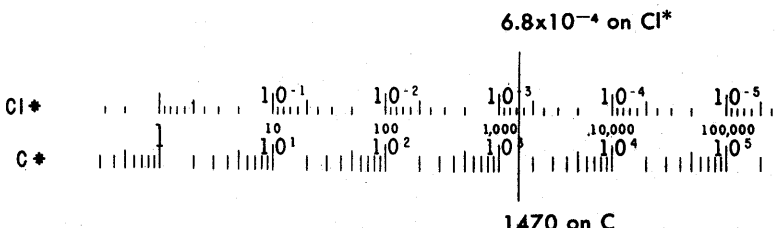


Fig. 6

(d) Find 1÷82,700. Set hairline over 827 on C. Read 121 on CI. Set hairline over 80,000 on C*. Read 121×10^{-5} or 0.000,012,1 on CI*.

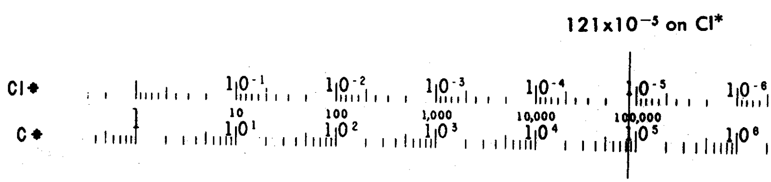


Fig. 7

(e) Find 374,000×0.000854×0.00622. Set hairline over 374 on D. Move slide so 854 on CI is under hairline. Move hairline to left index of C. Move slide again so 622 on CI is under the hairline. Under 1 of C read 1987 on D.

To locate the decimal point, set the hairline over 374,000 on D* (beyond 10^5). Move slide so 0.000,854 on CI* (to the left of 10^{-4}) is under the hairline. Move hairline over 1 on C*. Move slide so 0.006,22 on CI* (to the left of .001) is under the hairline. Under 1 of C* read 1.987 on D*.

USING THE S* AND T* SCALES

The S* scale is a reduced S scale. When the measure of any angle in degrees is set on S*, the value of the sine of the angle may be read on C* *with the decimal point taken into account.* The range of S* is from 0.05° to 90°.

- EXAMPLES:

(a) Find sin 9.6°. Set the hairline over 9.6 on S. Read 167 on C. Set the hairline over 9.6 on S*. Observe the hairline is between .1 and 1 on C*. Then sin 9.6° = 0.167.

(b) Find sin 2°. An ST scale for small angles is not provided on Decimal Keeper models. Observe, however, that the section of S* between 0.57° and 5.7° (that is, between $10^{-2}=0.01$ and $10^{-1}=0.1$ on C*) is really a greatly reduced ST scale. If the hairline is set on 2° of S*, the value of sin 2° may be read on C* as 0.035, approximately. Since a five-place table gives sin 2° = 0.03490, the error is remarkably small considering the short length of the scales used.

The value of the sine or tangent for angles less than 5.7° may be found by using the ordinary C and D scales. For small angles $\sin \alpha = \alpha$ and $\tan \alpha = \alpha$, where α is expressed in radians. For example, to find sin 2° or tan 2°, set 180 on C over π on D. Move the hairline over 2 on C, and read 349 on D. Use of the Decimal Keeper S* scales shows that with the decimal point located this result should be written 0.0349.

If only the decimal point in the value is to be found, it is seldom actually necessary to make any settings. By glancing at the S* scale one can observe that for very small angles (between 0.05° and 0.57°) the sine is between 0.001 and 0.01. For angles between 0.57 and 5.7° (found on the ST scale or middle section of the ST* scale), the sine is between 0.01 and 0.1. For angles between 5.7° and 90° the sine is between 0.1 and 1.

Notice, however, that the S* scale can be used in examples that involve computation, as shown below.

- EXAMPLES:

(a) Find 0.0014 sin 3°. If only one figure accuracy is required the S* and D* scales may be used. Set 1 of C* over 0.0014 on D*. Move the hairline over 3° on S*. Observe that the hairline is now near 7 of D* on the section between 10^{-5} and 10^{-4}. Hence the result is approximately 0.000,07.

If greater accuracy is required, it is necessary to change 3° to radian measure if the rule does not provide an ST scale. Set 180 on C over π on D. Move the hairline over 3 on C. Then 3° = 0.0523 radians may be read on D. However, it is not necessary to read this value. Instead, multiply by 0.0014 by moving the slide so that 14 on CI is under the hairline. Under 1 of C read the figures in the answer, 733, on D. Now to locate the decimal point, the method described first is used, and the answer is then written as 0.000,073,3.

(b) Find 0.0256÷sin 1.2°. First set the hairline over 0.256 on D*, and then move the slide so that 1.2 on S* is under the hairline. At 1 of C* read 1+ on D*. For a more accurate result, use the C and D scales. If no ST scale is provided, set 180 of C over π of D. Move hairline over 1.2 on C. The value of sin 1.2 may now be found under the hairline on D. The shortest method of dividing 0.0256 by this value is to pull the slide so that 256 on C is under the hairline, and read the answer as 1.22 on C over the left index of D.

The T* scale is used in ways similar to those described above for S*. The range of T* is from .05 to angles near 90°. As the angle approaches 90° the value of the tangent increases very rapidly but the T* scale is terminated.

- EXAMPLES:

(a) Find tan 8°. Set the hairline over 8° on T*, and read tan 8° = 0.14 on C*.

(b) Find 0.00036 tan 85°. Set 1 of C* over 0.00036 of D* (between 0.0001 and 0.001). Move the hairline over 85° on T*, and read 0.004 on D*. Ordinary slide rule scales do not have graduations for 85° so it's much more difficult to get the result more accurately by using them. It can, however, be done as follows. First, note that tan 85° = cot 5°. Express 5° in radians. Set 180 of C over π on D. Move the hairline over 5 on C. Next move the slide so 36 on C is under the hairline. Read 413 on C over 1 on D. The result is then 0.00413. This procedure may be explained as follows. As soon as the hairline is set over 5 on C, the value of 5° in radian measure, or 0.087, is on D under the hairline. For small angles cot $x = 1/x$, so cot $0.087 = 1/0.087 = 11.43$. This is the value of tan 85°, and must be multiplied by 0.00036. However, $0.00036 \times 11.43 = 0.00036/0.087$. Since 0.87 is already set on D, it is convenient to find first 0.087/0.00036, and then find the reciprocal of this. Thus 0.087 was divided by 0.00036, and the reciprocal of the answer read on C above 1 on D.

This example illustrates again the remarkable ease with which approximate answers are found on the Decimal Keeper scales.

THE A* AND B* SCALES

The A* scale is a greatly reduced and extended A scale, and similarly, the B* scale is a reduced and extended B scale. They may be used for computations involving square roots and squares in the same way that the ordinary A and B scales are used, but always with settings and readings that include the decimal points.

- EXAMPLES:

(a) Find $\sqrt{841}$. Set the hairline over 8+ on A*, in the section between 10^2 and 10^3. Read 29 on D*.

(b) Find $\sqrt{0.084}$. Set the hairline over 8+ on A*, in the section between 10^{-2} and 10^{-1} (that is, between 0.01 and 0.1). Read 0.29 on D*.

(c) Find $\sqrt{0.000,000,94}$. Set the hairline over 9+ on A*, in the section between 10^{-7} and 10^{-6}. Read 0.0009+ on D*.

(d) Find $\sqrt{42,300}$. Set the hairline over 4+ on A*, in the section between 10^4 and 10^5. Read 200+ on D*.

(e) Find $(47.9)^2$. Set the hairline over 48 on D*. Read 2,000+ on A*.
(f) Find $(0.00284)^2$. Set the hairline on 0.003− of D*. Read 0.000,008 on A*.

If the slide rule provides a B* scale on the slide, it may be used with C* in the same manner as described above for A* and D*. Also, combined operations with these scales may be carried out using the same procedures as are used with standard scales.

• Examples:
(a) Find $(20.6 \times 0.007)^2$. Set 1 of C* over 20+ on D*. Move hairline to 0.007 on C*. Read answer as 0.02, approximately, on A*.
(b) Find $0.000{,}062\sqrt{0.00046}$. Set hairline over 4+ on A* in the section between 10^{-4} and 10^{-3}. Move slide so 1 on C* is under hairline. Move hairline to 6+ on C* in section between 10^{-5} and 10^{-4}. Read answer as 0.000,001+ on D*. By using A, C, and D scales the answer may be found more accurately as 0.000,001,33, but without the decimal point located.

THE K* SCALE

The K* scale is a greatly reduced and extended K scale, and as with all other Decimal Keeper scales, is used in the same way as the standard K scale. The sections are very short, so the only graduations shown between the main ones are for 5, for 50, and for 500, etc. Nevertheless, the decimal point can usually be located with great confidence.

• Examples:
(a) Find $\sqrt[3]{40{,}000}$. Set the hairline over 4 on K* in the section between 10^4 and 10^5. Read 30+ on D*.
(b) Find $\sqrt[3]{0.000{,}008}$. Set the hairline over 8 on K* in the section between 10^{-6} and 10^{-5}. Read 0.02 on D*.
(c) Find 2090^3. Set the hairline over 2090 on D*. Read 8×10^9, approximately, on the section of K* between 10^9 and 10^{10}.
(d) Find $(0.000{,}7)^3$. Set the hairline over 0.0007 on D* in the section between 10^{-4} and 10^{-3}. Read 3×10^{-10} on K* in the section between 10^{-10} and 10^{-9}.

THE CF* AND DF* SCALES

The CF* and DF* scales are reduced and extended CF and DF scales. Since with Decimal Keeper scales a reading is very rarely "off the scale", they are not quite as useful as the ordinary CF and DF scales. These scales are not provided on all Decimal Keeper rules. One type of problem in which they are useful is in connection with the relation between the diameter and the circumference of circles. The diameter may be set on D* and the circumference read on DF*, with the decimal point located, and conversely.

• Examples:
(a) Find the circumference of a circle whose diameter is 0.016. Set 0.016 on D*. Read the circumference as 0.050 in. on DF*.
(b) Find the diameter of a circle whose circumference is 0.00086. Set the hairline over 0.00086 on DF*. Read the diameter as 0.000,27 on D*.

THE L* SCALE

The L* scale is a greatly reduced and extended L scale. The numerals beside the primary graduations represent the characteristics of logarithms of numbers located on the D* scale. The subdivisions represent the first figure of the mantissa of the logarithm. Thus the L* scale may be used to find the complete logarithm of a number; that is, both the characteristic and the mantissa. The accuracy is, however, very low.

- EXAMPLES:
  - (a) Find the logarithm of 628,000 (or 6.28×10^5). Set the hairline over 6.28×10^5 on the D* scale. Read 5.8 on the L* scale.
  - (b) Find the logarithm of 0.000,045. Set the hairline over 0.000,045 of the D* scale. Read -4.35 on the L* scale.

It should be observed that values on L* to the left of 0 are negative and the scale should be read from right to left. If the scale is read from left to right, the mantissa will be positive, as is usually the case when logarithmic tables are used, and then the characteristic is written in a special way. For example, if the number is 0.000,045, as in example (b) above, the characteristic is taken as -5 and the logarithm is written in the form $5.65 - 10$. When this form is used, all logarithms in the first section to the left of 0 are written in the form 9.___ -10, with the blank filled by reading the L* scale from left to right. All logarithms in the second section to the left of 0 are written 8.___ -10, with the blank filled by reading the scale as before. Similarly, the first figure of logarithms in the next section is 7, in the following section is 6, etc. In each case, 10 must be subtracted.

HOW TO ADJUST YOUR SLIDE RULE

Each rule is accurately adjusted before it leaves the factory. However, handling during shipment, dropping the rule, or a series of jars may loosen the adjusting screws and throw the scales out of alignment. Follow these simple directions for slide rule adjustment.

CURSOR WINDOW HAIRLINE ADJUSTMENT

Line up the hairline on one side of the rule at a time.

1. Lay rule on flat surface and loosen adjusting screws in end plates.
2. Line up C index with D index. Then align DF (or A) index with CF (or B) index.
3. Tighten screws in end plates.
4. Loosen cursor window screws. Slip a narrow strip of thin cardboard (or 3 or 4 narrow strips of paper) under center of window.
5. Align hairline with D and DF (or D and A) indices, and tighten cursor window screws. Check to see that *window surfaces do not touch or rub against rule surfaces.*

Note: The narrow strip of cardboard under the window will prevent possible distortion or "bowing in" of the window when screws are tightened. "Bowing in" may cause rubbing of window against rule surface with resultant wear or scratches.

Line up hairline on reverse side of rule.

1. Loosen all 4 cursor window screws.
2. Place narrow strip of thin cardboard under window to prevent "Bowing in" when screws are tightened.
3. Align hairline and indices on first side of rule, then turn rule over carefully to avoid moving cursor.
4. Align hairline with indices and tighten cursor screws.
5. Check to see that window surfaces do not touch surfaces of rule during operation.

SLIDER TENSION ADJUSTMENT • Loosen adjustment screws on end brackets; regulate tension of slider, tighten the screws using care not to misalign the scales. The adjustment needed may be a fraction of a thousandth of an inch, and several tries may be necessary to get perfect slider action.

SCALE LINE-UP ADJUSTMENTS • (1) Move slider until indices of C and D scales coincide. (2) Move cursor to one end. (3) Place rule on flat surface with face uppermost. (4) Loosen end plate adjusting screw slightly. (5) Adjust upper portion of rule until graduations on DF scale coincide with corresponding graduations on CF scale. (6) Tighten screws in end plates.

REPLACEABLE ADJUSTING SCREWS • All Pickett All-Metal rules are equipped with Telescopic Adjusting Screws. In adjusting your rule, if you should strip the threads on one of the Adjusting Screws, simply "push out" the female portion of the screw and replace with a new screw obtainable from your dealer, or from the factory. We do not recommend replacing only the male or female portion of the screw.

HOW TO KEEP YOUR SLIDE RULE IN CONDITION

OPERATION • Always hold your rule between thumb and forefinger at the ENDS of the rule. This will insure free, smooth movement of the slider. Holding your rule at the center tends to bind the slider and hinder its free movement.

CLEANING • Wash surface of the rule with a non-abrasive soap and water when cleaning the scales.

LUBRICATION • The metal edges of your slide rule will require lubrication from time to time. To lubricate, put a *little* white petroleum jelly (White Vaseline) on the edges and move the slider back and forth several times. Wipe off any excess lubricant. *Do not use ordinary oil as it may eventually discolor rule surfaces.*

LEATHER CASE CARE • Your Leather Slide Rule Case is made of the finest top-grain, genuine California Saddle Leather. This leather is slow-tanned using the natural tanbark from the rare Lithocarpus Oak which grows only in California. It polishes more and more with use and age.

To clean your case and to keep the leather pliable and in perfect condition, rub in a good harness soap such as Propert's Harness Soap.

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