A MANNHEIM TYPE SLIDE RULE

(WITH A, B, C, D, CI, K, S, T, L SCALES)

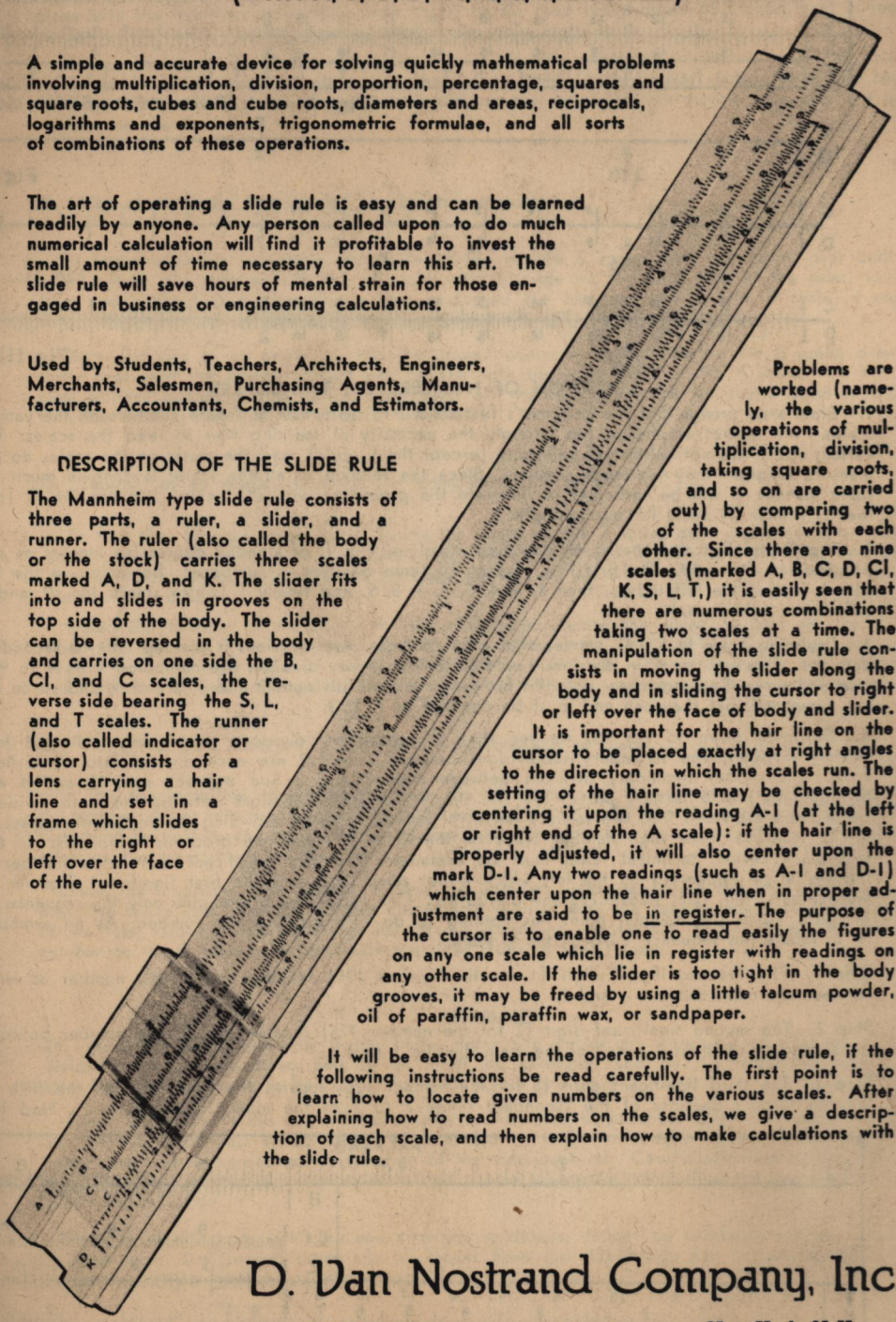
A simple and accurate device for solving quickly mathematical problems involving multiplication, division, proportion, percentage, squares and square roots, cubes and cube roots, diameters and areas, reciprocals, logarithms and exponents, trigonometric formulae, and all sorts of combinations of these operations.

The art of operating a slide rule is easy and can be learned readily by anyone. Any person called upon to do much numerical calculation will find it profitable to invest the small amount of time necessary to learn this art. The slide rule will save hours of mental strain for those engaged in business or engineering calculations.

Used by Students, Teachers, Architects, Engineers, Merchants, Salesmen, Purchasing Agents, Manufacturers, Accountants, Chemists, and Estimators.

DESCRIPTION OF THE SLIDE RULE

The Mannheim type slide rule consists of three parts, a ruler, a slider, and a runner. The ruler (also called the body or the stock) carries three scales marked A, D, and K. The slider fits into and slides in grooves on the top side of the body. The slider can be reversed in the body and carries on one side the B, CI, and C scales, the reverse side bearing the S, L, and T scales. The runner (also called indicator or cursor) consists of a lens carrying a hair line and set in a frame which slides to the right or left over the face of the rule.



Problems are worked (namely, the various operations of multiplication, division, taking square roots, and so on are carried out) by comparing two of the scales with each other. Since there are nine scales (marked A, B, C, D, CI, K, S, L, T,) it is easily seen that there are numerous combinations taking two scales at a time. The manipulation of the slide rule consists in moving the slider along the body and in sliding the cursor to right or left over the face of body and slider. It is important for the hair line on the cursor to be placed exactly at right angles to the direction in which the scales run. The setting of the hair line may be checked by centering it upon the reading A-1 (at the left or right end of the A scale): if the hair line is properly adjusted, it will also center upon the mark D-1. Any two readings (such as A-1 and D-1) which center upon the hair line when in proper adjustment are said to be in register. The purpose of the cursor is to enable one to read easily the figures on any one scale which lie in register with readings on any other scale. If the slider is too tight in the body grooves, it may be freed by using a little talcum powder, oil of paraffin, paraffin wax, or sandpaper.

It will be easy to learn the operations of the slide rule, if the following instructions be read carefully. The first point is to learn how to locate given numbers on the various scales. After explaining how to read numbers on the scales, we give a description of each scale, and then explain how to make calculations with the slide rule.

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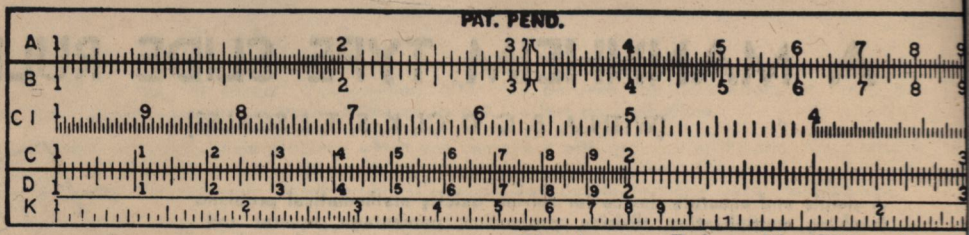


Fig. A. Rule with Slide closed

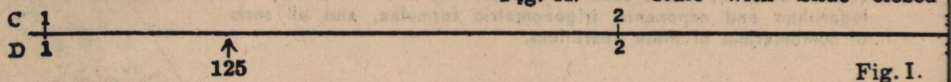


Fig. I.

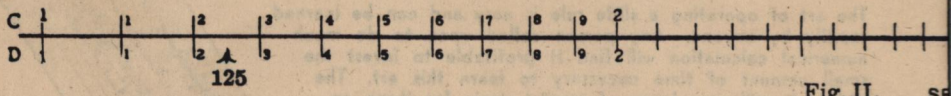


Fig. II.

Fig. III.

LOCATION OF NUMBERS ON THE SCALES

1. Experience proves that the beginner's first step is to learn how to locate numbers on the various scales. We cannot emphasize too strongly the necessity of learning how to read the scales. The various scales are not calibrated uniformly (except the L scale), and the marks on the scales do not measure lengths—they represent numbers. Since the reading of all the scales is done in much the same manner, it will be sufficient to illustrate the procedure with one scale. We use the C (and exactly similar D) scale for our example.

2. The C and D scales consist of nine **main** divisions, Fig. I, of steadily decreasing lengths as one proceeds to the right. The first line of each of these divisions is numbered: beginning at the left with 1 (called the left index), then 2, 3, 4, 5, 6, 7, 8, 9, and finally 1 (which stands for 10, and is called the right index).

3. Dropping down to Fig II, we see that each of these main divisions is divided into 10 **secondary** divisions. Between the main divisions 1 and 2. the secondary divisions are numbered from 1 to 9 in smaller figures. The secondary divisions between the main divisions 2 and 3, 3 and 4, and so on are not numbered, but they can and must be counted as 1, 2, 3, ... ,9.

4. Dropping down to Fig III, we see that the secondary divisions are again subdivided into **tertiary** divisions. The secondary subdivisions between 1 and 2 are each divided into 10 tertiary parts. The shorter secondary divisions between main 2 and 3 and between main 3 and 4 are divided only into 5 tertiary parts. The still shorter secondary divisions between the main divisions beyond 4 are divided into two tertiary parts (of course, to avoid crowding the scale with marks).

5. To locate a three digit number (say) on the C or D scale, one proceeds as follows: In the first place certain technical terms must be explained. The first significant digit of a number is the first digit appearing on the left which is not zero: thus, 1 is the first significant digit in all the numbers, 125, 12.5, 1.25, 0.125 and 0.0125 etc. One locates on a slide rule only the sequence of numbers, 1-2-5; the decimal point has nothing to do with locating the number. As an example, let us locate this sequence 1-2-5 on the C scale.

Step 1. The first significant digit (1 for the number 125) locates, Fig. I, the number as lying between the main divisions 1 and 2.

Step 2. The second significant digit (2 for the number 125) locates, Fig. II, the number between the **secondary** divisions 2 and 3 of the main division 1 to 2.

Step 3. The third significant digit (5 for the number 125) locates the number as on the fifth of the ten tertiary divisions of the secondary range 2 to 3 of the main division 1 to 2. Had the

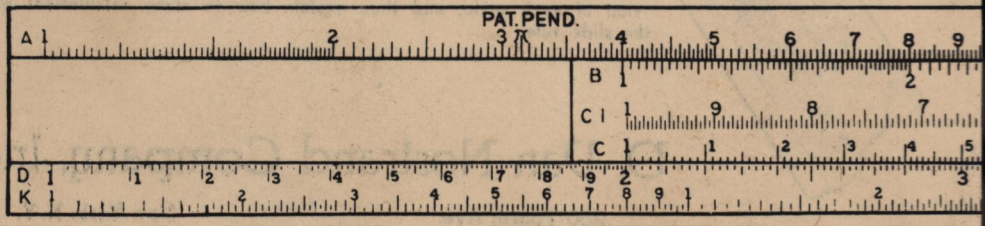
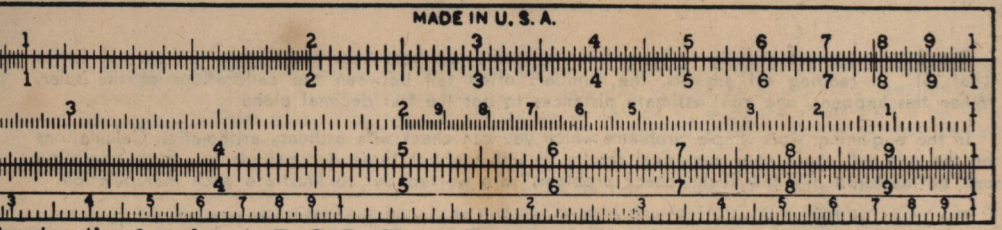
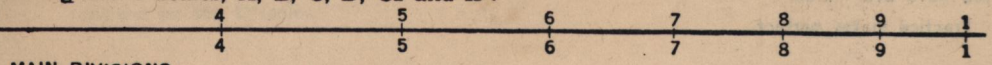


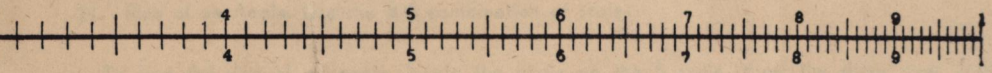
Fig. B. Rule with Slide set to right w



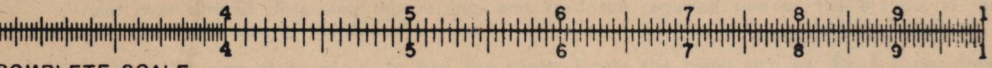
howing the 6 scales, A, B, C, D, CI and K .



MAIN DIVISIONS



CONDARY DIVISIONS



COMPLETE SCALE

number been 1257, we should then have located it 7/10 of the tertiary division between 1250 and 1260, this last shift being made by estimating the 7/10 by eye since there are no fourth order divisions.

The above procedure is to be followed for any number on the scale, except that it should be noted that the tertiary divisions toward the right end of the scale represent fifths (between main 2-3 and main 3-4) and halves (between main 4 and the right index). For example, the number 463 lies, first on the main division between 4 and 5, second on the secondary division between 460 and 470, and third 3/5 of the first tertiary division between 460 and 465, this 3/5 being estimated by eye.

6. The decimal point is ignored in operating the slide rule. At the end of a calculation, the decimal point is located by estimating the answer from rounding off the factors and divisors. One quickly learns how to carry out such estimations. There is a method of keeping account of the decimal point in slide rule calculations: this method depends upon the theory of logarithms, but is universally ignored even by those who have a working knowledge of its use.

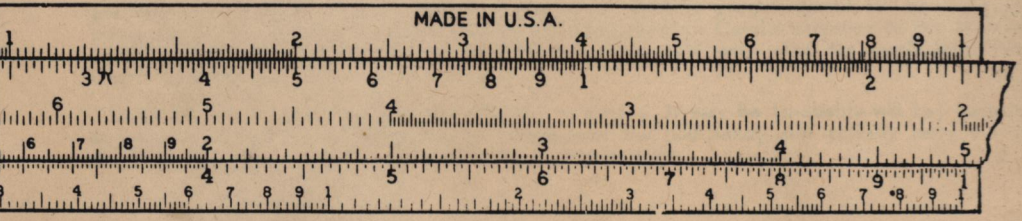
DESCRIPTION OF THE SCALES

7. The C and D scales, which are exactly alike, are calibrated in proportion to the logarithms of the actual numbers which are marked on these scales. It may be a satisfaction to the reader to understand the theory of logarithms, but will not be necessary in using the slide rule. The C-D combination is used for multiplying, dividing, and in ratio and proportion.

8. The CI or reciprocal scale is calibrated in the same way as the C and D scales except that it reads from right to left, namely, is the C scale reversed in direction. The CI scale may be used in reading off the reciprocal of a number as well as in multiplication and division.

9. Scales A and B, which are alike, are logarithmic scales just half as long as the C and D scales. If the left half of the A (and B) scale represents numbers from 1 to 10, the right half represents numbers 10 times as large, namely, from 10 to 100. Again, if the left half represents numbers from 100 to 1000, the right half represents numbers from 1,000 to 10,000 and so on. These scales may be used in finding squares and square roots.

10. The K scale is a logarithmic scale 1/3 as long as the C scale. The second third of the scale represents numbers 10 times as large as those of the first third. The right third of the K scale represents numbers 100 times as large as the first third, and 10 times as large as the second third of the scale. Thus the first, second, and third scales may represent numbers 1 to 10, 10 to 100, and 100 to 1,000 respectively.



th left index of C scale set over 2 on D scale.

11. The S scale (on the opposite side of the slider from the B, CI, and C scales) is used in finding the sines of angles.

12. The T scale (on the same side of the slider as the S scale) is used in finding the tangents of angles.

13. The L scale is uniformly calibrated, and is used in combinations with the C and D scales in finding the logarithms of numbers.

SLIDE RULE OPERATIONS

14. Multiplication. Use the C-D combination. To multiply two numbers, locate one factor on the D scale, set the index (either the left or right end) of the C scale in register with this factor on the D scale, locate the other factor on C, then in register with this reading on C the product will be found on the D scale.

For example, in Fig. B, the left index of C is set on the number 2 of the D scale. If the cursor be moved over to 3 on C, then under this number and in register with it the product 6 of 2x3 will be found on D. In register with C-4 and on D will be found the product 8 of 2x4. In register with C-5 and on D will be found the product 10 of 2x5. How about 2x9 (say)? A glance at Fig. B shows that C-9 is off the D scale. In this and similar examples, the slider is to be pulled to the left in the ruler until the right index of C is in register with the first factor appearing on D (in the present example 2), and then the answer is again to be read on D in register with the second factor as read on C.

15. Division. Use the C-D combination. Division is the inverse of multiplication. Locate the divisor on the C scale and set this reading in register with the dividend on the D scale: the quotient will be found on the D scale in register with the index of the C scale (with whichever index of C, left or right, that appears on the D scale). As an example, note that the divisor C-3 of Fig. B is in register with the dividend 6 on D, and that the quotient 2 lies on D in register with the left index of C. Note that with this setting of the slide rule, any number on the D scale divided by the number in register on C, gives 2 as quotient.

16. Squares and Square Roots. Use the A-D combination of scales. To find the square of any number, locate this number on the D scale, set the hair-line of the cursor upon this number, and read its square in register on the A scale.

To find the square root of any number, use the scales in reverse order. Thus, locate the given number whose square root is to be found upon the A scale (use the left half of A if this number has an odd number of digits, the right half if the number of digits is even), set the cursor upon this number, and read its square root in register on the D scale.

17. Cubes and Cube Roots. Use the D-K combination of scales. To find the cube of any number, locate this number on the D scale, set the cursor on this number, and read its cube in register on the K scale.

To find the cube root of any number, use the D-K combination in the reverse order. Thus, locate the given number whose cube root is desired upon the K scale (use the left third of K if the number has 1, 4, 7, etc. digits, namely if its number of digits is 1 plus a multiple of 3; use the middle third of K if the number of digits is 2 plus a multiple of 3, such as 2, 5, 8, etc. digits; and use the right third of K if the number of digits is an exact multiple of 3, such as 3, 6, 9, etc. digits), set the cursor upon this number, and read its cube root in register on D.

18. Proportion. Use the C-D combination of scales. Problems of proportion arise, for example, in the conversion of yards to feet, dollars to pounds, gallons to cubic feet, and so on. As an example of such use of the slide rule, let us set the rule for the yard-to-foot conversion. Place the index (either right or left) of the C scale upon the number 3 of the D Scale. Note the number of yards and fraction thereof on C, and read in register on D the corresponding number of feet. Conversely, locate the number of feet in any given distance upon the D scale, and in register with this number will be found on C this distance expressed in yards.

19. Reciprocals. Use the CI-D combination of scales. To find the reciprocal of any number, locate this number on the D scale and set the cursor upon this reading: the reciprocal of this number will be found in register on the CI scale. Alternatively, locate the number on the CI scale, set the cursor upon this number, and read its reciprocal in register on the D scale.

20. Further Uses of the CI Scale. Multiplication by use of the D-CI combination: To multiply two numbers together, locate one factor on the D scale, the other on the CI scale, set these two factors in register by use of the cursor, and read their product on D in register with the index of the CI scale. Since either the left or right index of CI will always be found upon the scale, this method of multiplication never requires the reversal of the slider which is frequently necessary when multiplying by use of the C-D combination (as in Par. 14).

Observe that this method of multiplication permits finding the product of three factors with one setting of the slider. As an example, let us calculate the volume of a wall 15.5 feet long, 8 feet high, and 0.55 feet thick. Solution: Set the cursor at 155 on D; draw the slider until 8 on CI coincides with the hair-line; move the cursor to 55 on C; read the product 68.2 cubic feet in register on D.

Division by use of the D-CI combination: To divide one number by another, locate the dividend on D, set the cursor on this number, draw the slider until its (right or left) index comes into register with the hair-line, locate the divisor on CI and set the cursor on this number, the quotient lies in register on the D scale.

21. Sine of an Angle. Use the B-S combination ot scales.

To find the sine of an angle, locate the angle on the S scale, draw the slider over until this angle comes into register with the celluloid reading edge on the back side of the ruler, turn the ruler over without disturbing this setting, and read the required sine on the B scale in register with the right index of the A scale.

Given the sine of an angle, to find the angle: locate the given sine on the B scale, draw the slider over until this number comes into register with the right index of the A scale, turn the ruler over without disturbing this setting, and read off the required angle on the S scale in register with the reading edge on the back of the ruler.

22. Tangent of an Angle. Use the C-T combination of scales.

To find the tangent of an angle, locate the angle on the T scale, draw the slider over until this angle comes into register with the reading edge on the back of the ruler, turn the ruler over without disturbing this setting, and read off the required tangent on the C scale in register with the right index of the D scale.

Given the tangent of an angle, to find the angle: locate the given tangent on the C scale (between 0.1 and 1 as explained above), draw the slider over until this number comes into register with the right index of the D scale, turn the ruler over without disturbing this setting, and read off the required angle on the T scale in register with the reading edge on the back of the ruler.

23. Logarithm of a Number. Use the C-L combination ot scales.

To find the logarithm of a number, locate the number on the C scale, draw the slider over until this number comes into register with the **right** index of the D scale, turn the entire ruler over without disturbing the setting and read off the required logarithm on the L scale in register with the reading edge on the reverse side of the rule.

Given the logarithm of a number, to find the number: locate the given mantissa on the L scale, draw the slider over until this number comes into register with the reading edge on the back side of the rule, turn the rule right side up without disturbing the setting, and read off the required number on the C scale in register with the right index of the D scale.

REMEMBER

24. Accuracy will follow only if the body, slider and cursor are carefully set. Factors, divisors, dividends, reciprocals, sines, and so on, must be carefully read on the respective scales. The ruler itself will be found to be correct to within about one-tenth per cent.

Speed in the use of this rule will follow only as the result of practice. Until the rules of operation are thoroughly learned, speed of operation should not even be sought—speed will be the natural consequence of a thorough understanding of the manipulations. Careful attention to the directions should be the learner's only care; speed will come when and only when the manipulator knows exactly what to do.

Study these directions with care and attention to details. It may be (probably will be) necessary to read them over several times. By all means have the rule handy and actually carry out the directions step by step as you study the rules of manipulation.

The first important step is to learn how to locate numbers accurately upon the several scales (Par. 5). In reading off answers, the numbers often fall between the calibrations of the ruler. When this happens, one must estimate distances to get the last decimal place.

In the beginning, work simple problems which you can check with ordinary arithmetic. Calculations on the rule will check your numerical results to within about three decimal places. Each operation can be mastered if a few such "check problems" are worked out to illustrate each manipulation.

The study of this slide rule will prove to be one of the most profitable investments of your time you have ever made.

Practice makes perfect.