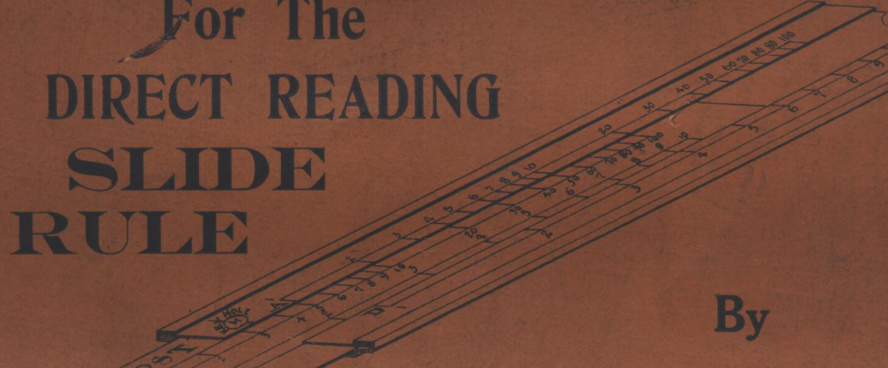
INSTRUCTION BOOK

For The DIRECT READING SLIDE RULE



By

Geo. W. RICHARDSON.

To Mr. Boolow,
with compliments of the
builder
Geo. W. Richardson
Chicago, Ill.
Jan 11-1910

GEO. W. RICHARDSON'S

DIRECT READING SLIDE RULE.

WITH A SYNOPSIS OF ITS APPLICATION TO THE SOLUTION OF PRACTICAL PROBLEMS

WRITTEN SO YOU CAN UNDERSTAND IT.

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PREFACE.

This little work has been written up as a guide rather than a treatise on the use of the slide rule.

So much has been written on the subject that there is not much left to write about. Nevertheless, there is much to be learned about the practical application of this valuable instrument, and therefore, the author's aim will be to deal with its practical application to the solving of problems rather than to enter into any long drawn out, confusing statements as to why such "is" or "is not" the case.

What your employer wants nowadays is "results" regardless of how you attain them, and the quicker you can do so the better he likes it.

Some time ago the author attempted to give instruction (by correspondence) on the use of the slide rule but had not proceeded far before he became aware that to give instruction on the use of the slide rule, the first and most important was to first develop a slide rule that would assist the student in solving the many problems, as the best rules on the market are too technical for the average operating engineer to understand, and he consequently gives up the subject in disgust.

With this point in view the author has developed a direct reading slide rule that will not only aid the student in learning the so-called mysteries of this valuable instrument, but it will keep him so interested in the subject that he will become, in time, as proficient in the operation of it as his college friend.

In designing the above-mentioned direct reading slide rule the author has also kept in mind that those who would like to know how to use the slide rule are in most cases unable to pay the high price for same as has been asked by dealers in the past.

After several years of untiring effort he has produced a slide rule that retains all the advantages of the well-known Mannheim rule, and in addition to this is direct reading for many problems, and can be made still farther so for any other special problems if so desired.

To accomplish this direct reading feature it became necessary to depart entirely from the present form of construction, with the gratifying result that a slide rule was produced which weighs 60 per cent less and can be retailed 70 per cent cheaper. Besides having many other advantages, such as aluminum being used for the stock, and the absence of wood in the construction of the rule none of the difficulties frequently met with, such as the sticking of the slide on account of atmospheric conditions are made possible.

Believing that when this rule becomes

universal it will pave the way for many individuals who have long wished to be enlightened in the use of this very valuable instrument which has, for the want of simplicity, laid dormant for the last 20 years. If this little book, together with the direct reading slide rule which accompanies it meets with favor amongst my engineering friends I will consider myself well paid for the many years I have spent in its development.

George W. Richardson.

Chicago, Ill., August, 1909.

Member Ill. No. 1 N. A. S. E.,

Member Ill. No. 1 U. C. C., of E.

Member Local No. 143 I. U. S. E.

DESIGNATION OF SCALES.

Upon examination of the slide rule you will observe that it consists of but three parts, namely: the stock, slide and runner. The latter can be dispensed with in most problems.

The stock of the rule consists of the upper scale A and the lower scale D, while the slide consists of two exactly similar scales and are known as the B and C scales.

It will be noted that each scale is marked with the letters A, B, C, D, at the extreme left-hand end of each scale, reference to which will be frequently made thereto.

The figure 1 on the extreme left of the scales will be known as the "left hand index," while the figures 10 and 100 on the extreme right will be known as the "right hand indexes."

The slide consists of the B and C scales and is free to slide between and adjacent to the A and D scales.

Upon withdrawing the slide to the "left" it will be noted that capital letters are printed in red ink, while drawing the slide to the "right," small letters are printed in same color. These letters will be known as "KEYS." The meaning of these "keys" may be ascertained by reference to the printed matter on the back of the rule.

It will be further noted that upon the face of the rule there are two circular holes, one at the left-hand upper corner, and one at the right-hand lower corner. These holes will be known and spoken of in the future as the "key holes."

It is this novel feature that the author claims as original with him, and by which the student will be materially assisted in solving problems, as by placing a suitable "key" in the "key hole" he makes the rule "Direct Reading" for that particular problem, thereby simplifying the operation to a minimum.

The runner is the small piece which is free to slip along the face of the rule aiding in reading from one scale to an-

other. Its use, while very handy, is not absolutely necessary as one's eye is in the majority of cases, more accurate than the aid of the runner.

The most confusing thing about the slide rule (to the uninitiated) is to give the correct value to the result obtained after the operation. A book could be written on this subject, yet after it was digested by the student, he would be none the wiser. Therefore I will dwell upon this point no more than to say that if we call the left-hand index 1. on the A, B, C or D scale, that value must be observed throughout the operation, while on the other hand, if we give it a value of 1-10 (one-tenth), likewise the answer must be one-tenth

Or, in other words, if we give the 1. a value of 10., 100. or 1,000., the answer must be as many times more than one as the value given to the index 1.

1st Case. For an illustration, suppose we say 4x4=16. If this operation is performed on the slide rule we simply bring 1. on the B scale to 4. on the A scale, and over 4. on the B, we read the answer 16. on the A scale.

2d Case. Suppose we said 40x4=160, the operation would be performed the same as in the first case, but in reading the result we would mentally remember that we added one digit, or cipher, to the problem, consequently we must add one cipher, or digit, to the result, which would be 16+0=160.

3d Case. Suppose we said 40x40=1,600, the operation would be exactly the same as in the first and second cases, but the answer would be different because we have added one digit, or cipher, to each of the fours. Consequently we must add two digits, or ciphers, to the answer, thus 16+00=1,600.

It is believed that sufficient has been said on this point, and that with little practice the student will soon be able to strike the correct result with little trouble. As stated before, the writer has found that the more that is said or written about the best method to adopt to ascertain the correct reading of the answer or the placing of the decimal point, the more the subject becomes confusing, therefore his reasons for leaving it to the judgment and practice of the progressive student.

RICHARDSON'S DIRECT READING SLIDE RULES.

The direct reading feature of this rule will be appreciated because the operation is very simple and in the author's opinion will get the student interested in the value of this very useful instrument, and will cause him to investigate further into its application to special problems fitting his class of work.

An explanation of a few of the many

uses the slide rule may be applicable to will now be given. The first explanation will have reference to the Richardson Direct Reading Slide Rule.

Gallons vs. Cubic Inches.

Ex. 1. Let it be required to know how many United States gallons there are contained in a vessel whose cubical contents measures 577 cubic inches.

On the back of the rule, under the head of Problems, we find that any number of gallons on the D scale will be found opposite and adjacent to any number of cubic inches on the C scale, when the key S, is placed in the "key hole."

Therefore, place the key S in the "key hole" and opposite 577 cubic inches on the C scale read 2.5 gallons on the D scale. It is evident that any other number of gallons could be found for a corresponding number of cubic inches or vice versa should the case call for it.

Gallons vs. Cubic Feet.

Ex. 2. How many gallons in 4 cubic feet?

Proceed similar as in Example 1. By referring to the back of the rule we find that the "key" for changing cubic feet to gallons is J; therefore, set the "key J" in the "key hole" and read under 4 cubic feet on C; 30 gallons on D.

Gallons vs. Lbs. Water.

Ex. 3. The fresh water in a cistern weighs 541 lbs. How many gallons does it contain?

As before, refer to back of the rule and find the key (c) and place the same in the "key hole;" then under 541 on the C scale, read the answer 65 gallons, nearly on the D scale.

Ex. 4. The height of water above a pump measures 90 feet. If a gauge is attached at the pump, how many pounds pressure per square inch will it show?

It will be found that the "key" for the solution of this problem is (g); therefore, read under the height, 90 feet, on A the pressure 39 lbs. per square inch on B.

Cubic Feet vs. Cubic Inches

Ex. 5. How many cubic feet in 6,050 cubic inches? The proper key for the solution of this question is found to be 0; consequently set the key 0 in the "key hole," and under 6.050 cubic inches on C, read the required number of cubic feet, 3.5 on D.

Circumference vs. Diameter Circle.

Ex. 6. The circumference of a circle equals 235.6 inches. Find the diameter of a circle of this circumference?

Place (j) in the "key hole" and find under 235.6 on A scale, the diameter 7.5 on the B scale.

Of course, it must be understood that placing a certain "key" in a "key hole" any other quantity can be given and ascertained as well, or instead of the problem just solved. It matters not what the problem is, providing the right "key" is selected.

Area vs. Diameter Circle.

Ex. 7. The area of a circle is 38.5 inches. What is its diameter? Referring same as before to the back of the rule we find the "key" for this sort of a problem is G. Consequently, placing the key G in the "key hole," we find by the aid of the runner placed at 38.5 on A, the diameter 7 inches on C.

Likewise, if it was the area required instead of the diameter we would simply place the runner to 7 on C, and read the area 38.5 on A.

Side of a Square vs. Diagonal.

Ex. 8. The side of an equal square is 5 inches. What is its diagonal? Place the key (f) in the key hole and find adjacent to 5″ on C, the answer 7.1″ on D as the required diagonal.

Ex. 9. How many meters in 98.42 inches? Set Q in the "key hole" and read 2.5 meters on A, over 98.42 inches on B.

Kilowatts vs Horsepower.

Ex. 10. If the product of the amperes multiplied by the voltage equals 5.5 kilowatts, how many horsepower will it be equal to? The key for a problem of this kind is found to be (e). Therefore, placing the "key" e in the "key hole," read 7.4 horsepower on D, under 5.5 kilowatt on C.

B. T. U. vs Horsepower.

Ex. 11. If 233.5 heat units (B. T. U.) is expended per minute in performing a certain piece of work, what is it equal to when expressed as horsepower?

The "key" for the solution of this problem we find to be m. Therefore place the same in the "key hole" and under 233.5 B. T. U. on A scale, read the answer 5.5 horsepower on B.

Evaporation From and At vs Boiler Horsepower.

Ex. 12. In an evaporation test on a boiler it was found that the evaporation from and at 212° amounted to 2,070 pounds water per hour. Required to find the equivalent standard boiler horsepower. P being the proper "key" for this problem we will place it in the "key

hole" and over 2,070 on the B scale we read the answer 60 horsepower on the A scale.

Direct Radiation vs. Size Grate.

Ex. 13. It is desired to heat by direct radiation a building of which there is a total of 1,800 square feet of radiation, including the mains. What should be the approximate square feet of grate area? The same "key" is used in this example as was used in finding the diameter of a circle when the area was known. Therefore set this "key" G in the "key hole" and over 1,800 square feet on the B scale, read 14 square feet of grate on the A scale.

Diameter Safety Valve vs. Square Feet Grate.

Ex. 14. What diameter of safety valve will be required for a grate surface of 36 square feet? Set d in the "key hole" and by aid of the runner placed at 36 A (on right end of the rule) read the diameter 4.8 inches on C.

Area vs. Side of an Equal Square.

Ex. 15. Find the side of an equal square when the area equals say 25 inches? Place E in the "key hole" and runner at 25 on A, then read the answer

5 on D. Also when this key E is in the "key hole" the "square root" of any number on A may be found by the aid of the runner on the D scale.

Cubic Feet Air Per Minute vs. Area Duct in Square Feet.

Ex. 16. The velocity of air in a duct used for ventilating is approximately 540 feet per minute. Therefore, if it is required to find the area in square feet of a duct to supply say 1,200 cubic feet of air per minute, place the "key" S in the "key hole" and over 1,200 on the B scale read area of the duct, 2.22 square feet on the A scale. Likewise any other size of duct may be ascertained similarly.

Diameter Steam Main vs. Square Feet Radiation.

Ex. 17. To find the diameter of a steam pipe to supply say, for instance, 1,600 square feet of direct radiation, place the "key" G in the "key hole" (use the right-hand end of the B and C scale) and by the aid of the runner placed over 1,600 on B, read the diameter 4 inches on the C scale. It will be observed that the area may also be found on the A scale without any other further adjustment.

Note: If "indirect" radiation is required add 75 per cent to the area or the radiation before selecting the diameter.

Piston Speed—Feet Per Min.

Ex. 18. Required to find the piston speed in feet per minute of an engine when the stroke equals 15 inches and the revolutions per minute equals 200.

Place the "key" p in the "key hole" and adjacent to the product of (15x200 =3,000) 3,000 on the A scale read 500 feet of piston speed per minute on the B scale.

Horse Power of Engine.

Ex. 19. The horsepower of an engine, pump, or similar piece of machinery may be calculated by first ascertaining the feet per minute of the piston same as in the preceding example No. 18, and the square of the diameter of the piston in inches as in example No. 25.

Let us assume the mean effective pressure to be 40 lbs. per square inch, and the diameter is 20 inches, the square of which will be 20x20=400 square inches, and the piston speed equals 420 feet per minute. Now multiply these values given, similar to examples Numbers 35 and 36, which would be in this case as follows: 40x400x420=6,720,000. Next place the "key" R in the "key hole" then over 6,720,000 on the B scale (672 will suffice) and read adjacent thereto on the A scale 160 horsepower.

To decide what value to give the answer as in the above case, all that is necessary is to know that for an engine of this size would not develop 1,600 horsepower, also that we know that it develops more than 16 horsepower, therefore it must be 160 horsepower.

Horsepower of a Water Fall.

Ex. 20. To find the horsepower of a waterfall, suppose the area of the water in square feet flowing over the dam is 4 square feet and the velocity of the water equals 150 feet per minute, and the height of the fall is 12 feet. Multiply these values together same as in the above example, as 150x4x12=7,200. Next place the "key" S in the "key hole" and over 72 on the B scale and in juxtaposition to same on the A scale read 13.5 horsepower.

Belting vs. Horsepower.

Ex. 21. To find the horsepower a single ply belt will transmit, when the diameter d of the pulley equals 23 inches, the r. p. m. equals 100 and the width w. equals 3.5 inches?

Proceed to multiply same as shown in examples 34 to 36, thus: dxr.p.m.xw =23x100x3.5=8,050, using the scales A and B (it will not be necessary to look on the A scale for the 8,050; ignore this because the horsepower is all that concerns you at present) in conjunction with the runner. Next place the "key" h in the "key hole" and under the runner on

the B scale read 2.93 horsepower as the answer.

Note. For double-ply belts, proceed in the same manner except use the "key" y in the "key hole."

To Square a Number.

To square a number is the simplest operation performed on the slide rule. To square a number none but the A and D scales are used.

Ex. 25. Find the square of 3.

Place the runner over 3 on D scale and read the answer 9 on the A scale.

To Find The Square Root of a Number.

Ex. 26. Find the square root of 64.

The square root of any number is the inverse operation of squaring a number. Therefore place the runner to 64 on A scale and read the answer 8 on the D scale.

To Cube a number.

To cube a number the four scales must be used.

Ex. 27. Find the cube of 3.

Place 1 C over 3 on D. Then over 3 on B read the cube 27 on A.

To Find The Cube Root of a Number.

The cube root of a number is the inverse operation of finding the cube of a number, therefore proceed accordingly.

Ex. 28. Find the cube root of 27?

Place 27 on A under the runner, then find by using the slide a number which will be the same on the B and D scales, i. e., when 1 on C is over 3 on D, 3 on B will be under the runner.

Ex. 29. Find the cube root of 64.

On the right-hand end of the rule place the runner to 64 on A, and it will be noted that when 4 on B is adjacent to the runner or 64 on A, the cube root 4 will be found on D scale adjacent to 1 C. Likewise any other cube root may be found.

To Reduce Vulgar Fractions to a Decimal.

Ex. 30. Find the decimal equivalent of ¾.

Place 3 on C to 4 on D and over 10 (or the right-hand index) on D; read the answer .75 on C.

Ex. 31. Find the decimal equivalent of 3-16.

Place 3 on C to 16 on D and over 1 D; read .1875.

To Find a Vulgar Fraction Equal to a Decimal.

Ex. 32. What is the vulgar fraction of the decimal .625?

Place 625 on C over the right-hand index D 10, and it will be seen that 5

on C is exactly over 8 on D; therefore ⅝ is the vulgar fraction of the decimal .625.

From what has been pointed out it should be plain to see that any other vulgar fraction could be changed to a decimal or vice versa.

Proportion.

Either the upper or the lower set of scales may be used, but as the lower set are drawn to a larger scale than the upper ones, it makes the latter preferable.

It will be noted that by moving the *slide* to the *right* until the left-hand index 1 C is adjacent to 2 on D, that any other number on D coinciding with a number on C gives a proportion equal to 2 to 1. Therefore, it matters not in what position the slide is placed, a corresponding proportion exists throughout the scales depending upon the first term of the proportion selected.

Ex. 33. Find the missing or fourth term of the proportion as given below:

$$180:25::28.8:x.$$

Using the lower set of scales, set 180 on C adjacent to 25 on D; then place the runner to 28.8 on C and read the fourth term 4 on D.

It follows that from any known three terms of a proportion the unknown term x may be found; all that is required that you remember that the first and the third terms are always found on one scale, while the second and fourth terms are found on the other scale adjacent thereto.

Multiplication.

Multiplication can be performed upon either the upper or lower set of scales.

Ex. 34. Multiply 4.2 by 1.5.

Set the index 1 of the B scale to 4.2 on the A scale and over 1.5 on the B scale read the answer 6.3 on the A scale.

Ex. 35. Multiplv 475 by 4.

Set index 1 B to 475 on A and over 4 on B read the answer 19 (read 1,900) on the A scale.

Ex. 36. Multiply 4.1x2.3x1.5x3.5.

Proceed similar to the preceding examples by setting 1 B to 4.1 on A, then move runner to 2.3 on B, next bring 1 B to the runner and move the latter to 1.5 on B and again bring the 1B to the runner, moving the latter to 3.5 on B and read the answer 49.5 on A under the runner.

Division.

It was no doubt observed that in multiplication the *slide* was continuously moved to the *right,* therefore, as division is simply the inverse of multiplication all that is required is that we move the *slide* to the *left* whenever we desire to divide.

Ex. 37. Divide 7.5 by 3.75.

Using the upper set of scales, place 3.75 on B adjacent to 7.5 on A and then

read the answer 2 on A over 1B.

Ex. 38. Divide 600 by 80.

Place 8 on B (calling it 80) adjacent to 60 (calling it 600) on A, and over 1B read the answer 7.5 on A.

Combination of Muliplication and Division.

Ex. 39. Solve the following?

$$\frac{22x37x3x23.5}{42x1.6x2.7x1.58}$$

As stated before, division is the inverse of multiplication, consequently to perform same upon the slide rule we have to move the slide to the right to multiply, and in the opposite direction to divide. In the above case we can multiply all above the line first, and then divide by all below the line, or if we choose we can divide part of all above the line and then multiply by part of below the line. The last method is preferable because when all the multiplication is done above the line, it so happens at least some times, that before the multiplication is finished the slide is withdrawn from the stock of the rule, therefore it is preferable to multiply several factors above the line, then change to dividing a few below the line, that the slide will not be continually drawn in the one direction.

Solution: Set 1B to 22 on A and place the runner to 37 on B, leaving the runner at rest. We will now proceed to divide by moving the slide towards the left. Thus move slide to 42 under the runner, then place runner to 1B and again move slide to the left until 1.6 on B shows under the runner. As we are now getting the slide well towards the left, we may once again proceed to multiply. Placing the runner to 3 on B and then moving the slide to the right until 1B shows under the runner. Then move runner to 23.5 on B. Then divide 2.7 by placing or moving the slide to the left until the factor 2.7 shows under the runner. Then bring the runner to 1B and move the slide to the left until 1.58 shows under the runner and the answer 2. will be found on A over the left index 1B.

While it takes a great many words to explain this operation it can be performed in one-tenth the time it takes to tell it.

A Few Practical Problems Met with in Practice.

The usual formula met with to ascertain the horsepower of the steam engine is as follows:

$$H.P. = \frac{d^2 x .7854 x P x L x N x 2}{33000}$$

By cancellation this formula can be very much simplified as shown below.

$$H.P. = \frac{d^2 x P x L x N}{21000}$$

If the above
d^2 = The diam of the cylinder sq'd.
M = " Mean effective pressure.
L = " length of stroke in *feet*.
N = " the number r. p. m.

Ex. 40. Given: Diameter, 16 inches; stroke, 1.5 feet; M. E. P., 35 lbs.; and r. p. m., 130. Required the horsepower of the engine.

$$H.P. = \frac{16^2 x 35 x 1.5 x 130}{21000} = 83$$

The above may be performed on the slide rule with accuracy and dispatch.

Solution: Place the runner to 16 on D and move 21 on B under the runner; next move the runner to 35 on B, then move 1B under the runner. Now move runner to 1.5 on B, bringing 1B under the runner. Then by aid of the runner placed at 130 on B, read 83 horsepower on A.

Safety Valve.

Ex. 41. A safety (lever) valve, 4 inches in diameter is required to blow at a pressure of 125 lbs. per square inch. If the distance of the ball from the fulcrum is 37 inches and the distance of fulcrum from the spindle, is 3 inches what will be the required weight of the ball?

Place the "key" G in the "key hole" and the runner to 4 on C. Then place 37 on B under the runner. Next move the runner to 3 on B and then bring 1B to runner and move the latter to 125 on B and read the answer on A adjacent to 125 B, which in this case equals 126 pounds.

The above expressed as an equation would be as follows:

$$W. = \frac{4^2x.7854x3x1.25}{37} = 126$$

Calculating The Size Motor.

It is desired to purchase a motor to run a "triplex" pump, 4 inches diameter by 5 inch stroke, 70 R. P. M., against a pressure of 90 pounds per square inch. Allowing a combined commercial efficiency for both pump and motor of 73 per cent calculate the horsepower of the motor.

The above expressed as an equation would be as follows:

Ex. 42.

$$H.P. = \frac{4^2x.7854x1.25x70x90}{.73x33000} = 4.1$$

Performing the above upon the slide rule is simplified by placing the "key" G in the "key hole" and the runner to 4 on C. Next place 33,000 on B under the runner, and move the runner to 70 on B. Next bring the slide to the right until 1B is under the runner and place the latter to 1.25 on B. Next bring 1B to the runner and the latter to 90 on B, then place 73 under the runner and read the answer 4.1 horsepower on A over the left index 1B.

Change Gears For Screw-cutting Lathes.

Ex. 43. It is desired to cut a thread of 5-16 pitch in a lathe of which the guide screw thread is ½ inch pitch.

If a wheel of 55 teeth is placed on the mandrel, what wheel must be placed on the guide screw to cut the above-mentioned thread; also what other pair of wheels may be used alternately if necessary?

In a problem of this kind all that is necessary is to find the ratio or proportion existing between the pitch of the guide screw and the pitch required.

By referring back to Ex. 31, it will be seen that the decimal equivalent of 5-16 equals .3125 and the decimal equivalent of ½ equals .5. Therefore, set 3,125 on A to 5 on B, and read over 55 on A 88 on B as the required number of teeth for the wheel on the lead screw.

With the slide set at the above ratio any other pair of wheels which will produce the same results may be found simply by moving the runner back and forth such as we find $\frac{15}{24}$ $\frac{25}{40}$ $\frac{90}{144}$ would suffice.

Testing a recording Wattmeter.

The application of the slide rule to this class of work exemplifies the value of this instrument. Of course, it is needless to say that a standard portable direct reading watt-meter and a stop watch are necessary to carry out this test. Also note must be made of the constant stamped on the face of the dial of the recording watt-meter to be tested. Thus, for instance, a meter with the constant of 1 means that 60 seconds times 60 minutes equals 3,600, while if the constant equaled ½, the number would be 1,800. Likewise, if the constant was 1.25, the number would be 3,600+900=4,500. Or if the constant was 2, then the setting of this number on the slide rule would be 7,200, etc.

Ex. 44. Supposing the meter dial constant was stamped ½ we would set the runner to 1,800 on D and if the stop watch showed 24 seconds, we would place this 24 on C under the runner. Then by moving the runner to 10 on C we read 750 watts on D. Then we note that the customers meter records 770 watts.

Placing this 770 on C under the runner we read 2½ per cent slow, which is indicated slow by the fact that the slide projects to the left, the 2½ per cent being recorded by the distance between 10 D and 10 C. Note: If the slide projected to the right instead of to the left the per cent would be fast. We will now take another example.

Ex. 45. The dial constant equals 1.25, the watts recorded by the customers meter showed 682, and the stop watch recorded

63 seconds. Find whether the meter was slow or fast and the per cent same.

Solution: Place 63 on C over 4,500 on D. Then the watts by the meter will be found on D under 10 C to equal 715. Placing the runner to 10 C and moving the slide until 682 is under the runner we read 4.8 per cent fast, because the slide 10 C projects to the right 4.8 per cent from 10 D.

APPENDIX.

The small space for printed matter on the back of the rule, limits the number of problems to those given: but this number is by no means the limit, or capacity of the rule.

Special marking will be made on the *Slide* for the solution of any desired problem, for a small additional fee.

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