The Maniphase
SLIDE RULE

Published by

EUGENE DIETZGEN CO.

Manufacturers

DRAFTING and SURVEYING SUPPLIES

CHICAGO SAN FRANCISCO NEW YORK
NEW ORLEANS PITTSBURGH
LOS ANGELES PHILADELPHIA WASHINGTON MILWAUKEE

M32

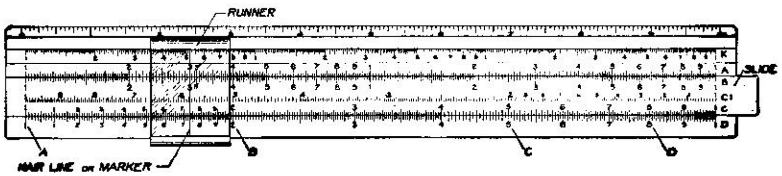
The Maniphase
SLIDE RULE

A self - teaching practical manual
with numerous illustrations
and problems

Copyright 1928 by
EUGENE DIETZGEN CO.

Peter F. Gattuso

THE MANIPHASE SLIDE RULE



NOTICE:—Scales K-A-B-CI-C and D
Slide
Runner
Hair Line or Marker on Runner

THE MANIPHASE SLIDE RULE

PREFACE

With the help of this book anyone, working alone, can learn the use of the Maniphase Slide Rule. It tells clearly and simply how to use the rule in all kinds of work. The book is divided into four parts:

PART I

FOR BEGINNERS

Ordinary Business Computing and Estimating

Part I teaches the use of the rule to the beginner. A grammar school education is all that is necessary to understand Part I.

PART II

HIGH SCHOOL AND COLLEGE

Part II teaches the use of the rule to those who are having or have had High School or College work. In addition to teaching multiplication and division Part II teaches POWERS and ROOTS, TRIGONOMETRY and the SOLVING OF TRIANGLES, LOGARITHMS and some advanced SPECIAL SETTINGS.

PART III

ENGINEERS AND ESTIMATORS

Part III teaches the special uses of the rule to TECHNICAL MEN, ESTIMATORS and ENGINEERS. Particular attention is given to questions of SPEED and ACCURACY and the use of the rule in ENGINEERING WORK and DESIGN WORK.

PART IV

TABLES AND CONVERSION RATIOS

Part IV contains tables of ratios, measures and settings used for the solution of problems and for practical work in ESTIMATING and DESIGN.

THE MANIPHASE SLIDE RULE

PART I

Ordinary Business Computing and Estimating

CHAPTER I

INTRODUCTION

The object of PART I of this book is to teach the beginner the use of the Maniphase Slide Rule.

ANYONE CAN LEARN TO USE THE RULE WHO HAS HAD A GRAMMAR SCHOOL EDUCATION.

FOLLOW DIRECTIONS CAREFULLY AND WORK ALL EXERCISES.

The directions and exercises must be followed just as they are given, and in the order in which they are given. Above all no new step should be taken until all the exercises coming before are understood. DO NOT SKIP IN PART I if you are a beginner. Go slowly and surely and much time will be saved. Do not hurry and do not think you understand unless you really do the exercises and examples and get the right answer. If you cannot do them and get the right answer, go over them AGAIN and AGAIN until you can get the right answer every time. Then go on to the next step. Much time will be saved if the work is done this way.

Part I Is Divided Into 8 Chapters

Chapter	I	INTRODUCTION
Chapter	II	KINDS OF WORK THE RULE WILL DO
Chapter	III	READING THE RULE
Chapter	IV	FIGURING SIMPLE COSTS
Chapter	V	CHANGING FROM ONE KIND OF MEASURE TO ANOTHER
Chapter	VI	MULTIPLYING
Chapter	VII	DIVIDING
Chapter	VIII	SPECIAL USES

Chapters I and II should be read very carefully and you should be sure you understand them before you go on to Chapter III. Remember that the KIND OF WORK THE RULE WILL DO must be clearly understood before you try to DO any work. If you do not understand what the rule will do, how close you need the answer and how close you can get the answer you cannot use the rule properly. If you DO understand WHAT KIND OF WORK THE RULE WILL DO you can use it properly.

Chapter III should be followed very closely and every exercise done;—even if you THINK you know how to do the examples, actually WORK all of them. If you DO know them it will take very little time, if you do NOT it will save you a great deal of time later. Chapter III is the most important chapter in Part I. If you do not know how to read the rule you cannot do even the simplest work. The better you know how to read the rule the quicker and easier you will be able to do the work that comes after. This Chapter III may become tiresome and you may want to skip over and do something more interesting. Remember you must be able to read the rule quickly and surely before you can hope to use it in a REAL PRACTICAL WAY.

Stick to Chapter III until you really can do ALL the exercises in it.

Chapters IV, V, VI, VII and VIII need not be explained here. These chapters will be easily understood by anyone if Chapter II is UNDERSTOOD and if all the examples and exercises in Chapter III are worked out correctly.

PART I—CHAPTER II

KINDS OF WORK THE RULE WILL DO

Closeness or Accuracy of Measurements

All practical work of figuring or computation depends on measurements of some kind. We sell goods by the yard, the pound, the quart, the ton, etc.,—all goods have to be measured. We cannot measure any of these things EXACTLY. It is of no use then to try to get results or answers exactly if the numbers used to get them are not exactly right.

It is of no use to get a result closer than the measurements which are used in getting it.

IF WE HAVE SEVERAL NUMBERS WHICH WE ARE MULTIPLYING OR DIVIDING THE EXACTNESS OR ACCURACY OF THE RESULT WILL BE NO BETTER THAN THE ACCURACY OF THE MOST INACCURATE OR INEXACT NUMBER WE USE.

You should understand JUST what this means. Put in another way it means that you can't take careless measurements and get close or accurate results by figuring.

It means that if you take measurements with a certain closeness or accuracy you cannot get results which are closer or more accurate than the numbers you use to get them.

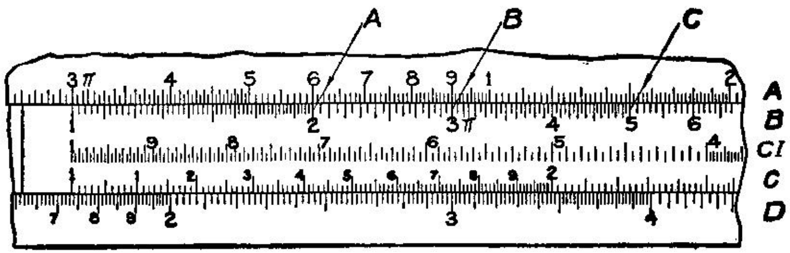
MANIPHASE RULE CLOSE ENOUGH FOR PRACTICAL WORK

If you understand this first paragraph you will see that while the Maniphase Slide Rule is not exact to five or six places of decimals, in practical work it may be and really can be used for most figuring. THE MANIPHASE RULE WILL GIVE RESULTS TO 1/10 OF ONE PER CENT. MOST PRACTICAL MEASUREMENTS ARE NOT MADE AS CLOSE AS THIS.

SPEED

The Maniphase rule not only figures things out easily and quickly but it cannot carry along figures which you must later throw away. The Maniphase slide rule will give in a few seconds results which it would take many minutes to get by the old methods.

DIAGRAM NO. 1



To give you some idea of how easily and simply the rule works, suppose you want to figure the costs of various lots of bolts at three cents each. Place 1 on left end of Scale B to the 3 on Scale A, that is, Set the rule as shown in Diagram #1

Using Scales A and B	Over the arrow A at 2 Scale B you read 6 on A
	Over the arrow B at 3 Scale B you read 9
	Over the arrow C at 5 Scale B you read 15

You can of course do these in your head and you know

2 bolts cost 6 cents
3 bolts cost 9 cents
5 bolts cost 15 cents

but the rule will figure out just as quickly as this and in the same way, with one simple setting, any number of bolts at a fixed price, and you can get the answers just as quickly as you can read them off. You will be taught this in Chapter III.

FOLLOWING ARE GIVEN SOME OF THE KINDS OF WORK THE RULE WILL DO

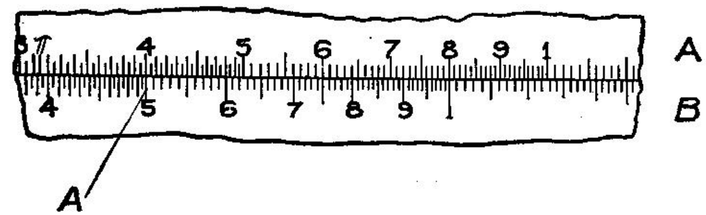
ESTIMATING

Remember you cannot get results closer than the measurements you use.

In estimating work or in figuring for bids 1/10 of one per cent is accurate enough. In estimating of all kinds the Maniphase rule will save an immense amount of time over the pencil and paper method.

The rule may be used by Engineers, Architects, Carpenters and Mechanics in all kinds of estimating work.

DIAGRAM NO. 2



Take a very simple example which you may know how to do and see how simply the rule does it.

How many bricks in a 4″ wall with 5 square ft. in the face?

Set the rule as in Diagram No. 2, 1 B to 8 A. Over the arrow A at 5 you see 40 bricks.

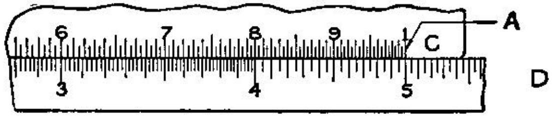
Remember, with this same setting you can get as fast as you can read them, the bricks in any 4″ wall for any area of face.

This example is given to SHOW YOU WHAT KIND OF WORK THE RULE WILL DO, not to teach you how to use the rule; that will be done in following Chapters.

COMMERCIAL WORK

In commercial work the Maniphase rule solves easily and quickly problems in costs, percentages, discounts, selling prices, etc.

DIAGRAM NO. 3



To show what the rule will do in this class of problems, suppose we take the very simple problem.

What per cent of 6 is 3?
Set the rule as in Diagram #3, 6 C to 3 D and read 50 under arrow A on D.

In addition the rule is of great help in checking payrolls, salary schedules, and financial statements. This work is usually done on listing or other machines in use in office work, but must be CHECKED by a subordinate official of the company. In some cases you will not be able to get the result to the nearest cent in this class of work but you can usually check the work closely enough. The following table is extremely simple and shows how close you can work in dollars and cents with an accuracy of 1/10 of one per cent using scales C and D. A and B will give half this accuracy.
From 1 to 10 dollars, to the nearest cent
From 10 to 100 dollars, to the nearest 10 cents
From 100 to 1,000 dollars, to the nearest 1 dollar
From 1,000 to 10,000 dollars, to the nearest 10 dollars

TEACHERS AND STUDENTS

Teachers and students in high schools and colleges will find the rule a great time and labor saver. In many engineering schools students are now required to use the slide rule and its use is spreading rapidly.

ENGINEERING WORK

In engineering work the rule has been used successfully for years and in problems in estimating and designing it is almost impossible to-day to get along without the slide rule. Many problems of design can hardly be done without its use.

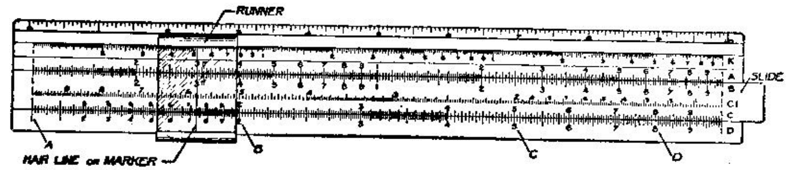
PART I—CHAPTER III

READING THE RULE

Before any real problems or exercises can be given the user MUST learn to READ THE RULE.

THE MANIPHASE SLIDE RULE

DIAGRAM NO. 4



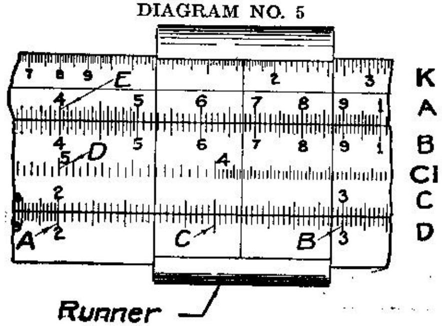
Notice six scales on the face of the rule,—K, A, B, CI, C and D.

Notice that A and B are double and that CI is like C and D except that it reads backwards or from right to left.
Arrow A is at 1 D. It is just as true that Arrow A is at 100 D.
Arrow B is at 2 D. It is just as true that Arrow B is at 200 D.
Arrow C is at 5 D. It is just as true that Arrow C is at 500 D.
Arrow D is at 8 D. It is just as true that Arrow D is at 800 D.

In reading the rule at Arrow B 2 can be read as 2
or 20
or 200
or 2000
or 20000
etc.
or .2
or .02
etc.

In Diagram #4 the runner is set on A at 300 or 3 or .03. If we want to set the runner to 30 A on the rule it should be in the same place as shown in Diagram #4.

DIAGRAM NO. 5



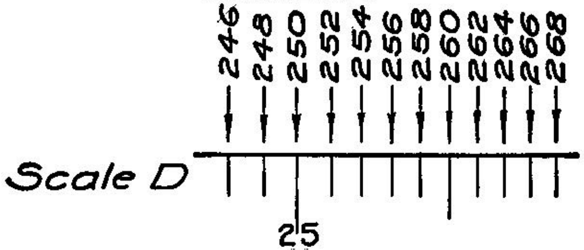
In Diagram #5

Arrow A is at 200 D, B at 300 D;
Arrow C is at 250 D;
Runner is at 260 D;
Arrow D is at 5 on the scale CI; and
Arrow E is at 4 on scale A.

HOW DO WE READ BETWEEN 250 AND 260 D?

Between 250 and 260 we have four marks and they, of course, **must** be as shown in Diagram #6.

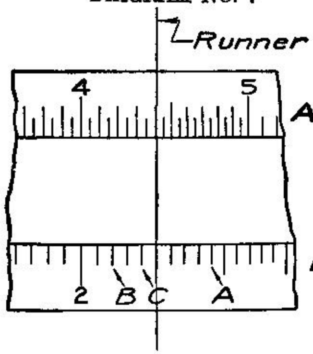
DIAGRAM NO. 6



Try this exercise without a diagram.

Set Runner to 200 D, then to 210 D, then to 212 D, then to 216 D. Read the arrow A in Diagram #7.

DIAGRAM NO. 7



If you have set 216 right, arrow A in Diagram #7 is on the next mark to the right, which is 218. Remember, 216 is the same as 21.6 or 2.16 on the rule.

Care must be taken in reading and setting such numbers as 202, 204, 206, etc.

In Diagram #7 Runner is at 210 D so 208-206, etc., must lie between 200 and 210.

Arrow B is at 204 D;

Arrow C is at 208 D.

You have now seen how the marks are read on scales C and D between 2 and 4 or 200 and 400.

On scales A and B you will see between 1 and 2 or 100 and 200 that the scales are marked in the same way.

On scale CI all the markings are the same as on C and D except that they read from right to left.

We will always call the left hand scale on A, LA and right hand scale on A, RA.

We will always call the left hand scale on B, LB and right hand scale on B, RB.

NOTICE: R stands for runner.

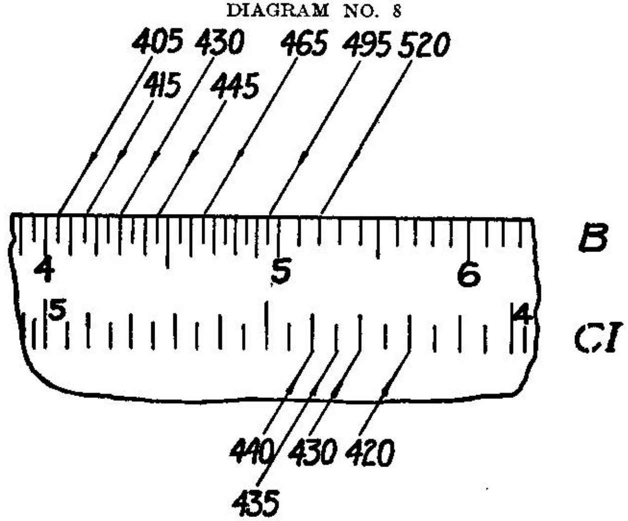
Exercise No. 1

		Write down readings in this column, putting decimal point to make them between 5 and 20.
R to 3 D.	Read under line on runner on scale A =	9
R to 4 D.	Read under line on runner on scale A =	
R to 3.26 D.	Read under line on runner on scale A =	
R to 3.44 D.	Read under line on runner on scale A =	
	These results should add to	47.4

Do this exercise over until you get 47.4.

Scales C, D and CI, 4 to 10, and scales A-B, 2 to 5, are marked alike. Diagram #8 shows the marking of these scales on CI and B. Notice that A, B, C and D read from left to right while CI reads from right to left.

DIAGRAM NO. 8



Exercise No. 2

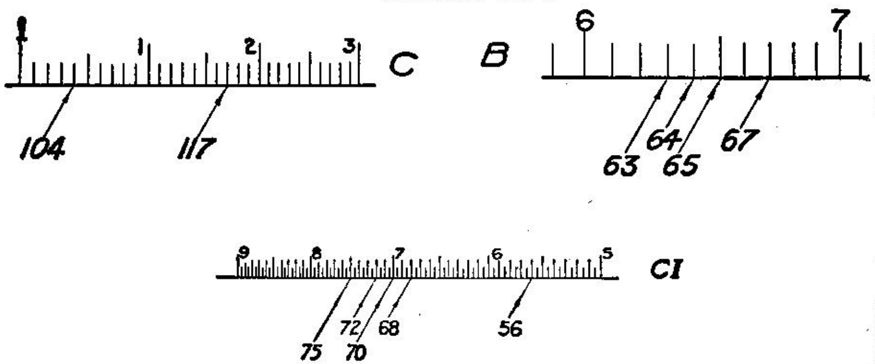
READING THE RULE

Write down readings in this column, putting decimal point so as to make each reading between 100 and 1000.

R to 344 D.	Read under R on A =	
R to 48 D.	Read under R on A =	
R to 485 D.	Read under R on A =	
R to 57 D.	Read under R on A =	
	These should add up to	908

Repeat this exercise until you get the right answer, 908.
Scales A-B between 5 and 10 and scales C, D and CI between 1 and 2, Diagram #9, are marked so that each mark means 1 and these scales are easily read.
Look out for 101 and 103, etc. Remember CI reads from right to left.

DIAGRAM NO. 9



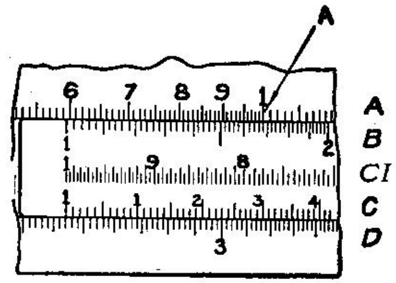
Exercise No. 3

READING THE RULE

Between 100 and 1000.

R to 130 LA.	Read under R on D =	114
R to 129 D.	Read under R on A =	
R to 102 D.	Read under R on A =	
R to 103 D.	Read under R on A =	
	These should add to	490

DIAGRAM NO. 10



Exercise No. 4

SETTING THE SLIDE

You will notice the figure one (1) on both ends of scales C and D and on both ends and the middle of A and B.

1 LC to 244 D is shown in Diagram #10. It means place the left hand 1 on scale C to the number 244 on scale D.
Take this example. See Diagram #10.

1 LC to 244 D; Read under M I A; 168 on B.
You will see 168 on scale B under arrow A which is at M 1 A.

Set

410 C to 1 RD should be same setting as in **Diagram #10.**

To 4 D put 164 C should be same setting **as in** Diagram #10.

To 610 D put 4 CI should be same setting as in Diagram #10.

In making the last two settings, set the runner first on the number on D and then set the number on the slide to the line on the runner.

EXERCISES IN READING AND SETTING

Exercise No. 5

Write down readings in this column, putting decimal point so as to make each reading between 100 and 1000.

Set 1 LC to 110 D.	Read on D under 24 C =	
Set 1 LC to 132 D.	Read on D under 318 C =	
Set 1 LC to 171 D.	Read on D under 38 C =	
	These should add up to	1334

Exercise No. 6

Write down readings in this column, putting decimal point so as to make each reading between 100 and 1000.

Set 1 LB to 152 LA.	Read on A over 395 LB =	____________
Set M 1 B to 91 LA.	Read on A over 385 RB =	____________
Set 1 RB to 64 RA.	Read on A over 320 LB =	____________
	These should add up to	1155

Exercise No. 7

In setting off numbers in this exercise put the runner to the number on A or D and move the slide until the number on the slide is under the line on the runner. Thus:—

To 262 D put R, to R put 218 C, R to 362 C, under R read 435 on D, or condensed:—

To 262 D put 218 C; Under 362 C read 435 D.

Write down readings in this column, putting decimal point so as to make each reading between 100 and 1000.

To 304 D put 169 C.	Under 306 C read on D =	____________
To 510 LA put 205 RB.	Over 450 RB read on A =	____________
To 104 RA put 59 RB.	Over 84 LB read on A =	____________
	These should add up to	810

Exercise No. 8

Results between 100 and 1000.

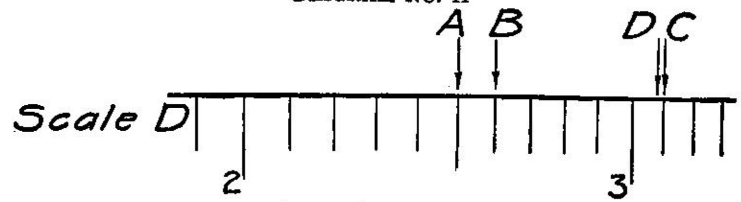
*To 405 D put 205 CI.	Under 1 C read on D =	830
To 320 D put 160 CI.	Under 41 C read on D =	
To 620 D put 365 CI.	Over 41 D read on C =	
To 29 RA put 950 CI.	Over 83 D read on C =	
	These should add up to	1383

*Special care should be taken, when setting on scale CI, to remember that it reads backwards;—that is, from right to left.

READING BETWEEN MARKS

You have been shown how to read the marks or graduations on the rule. As you can easily see the number you wish to set off or to read off may not come exactly on a mark. As an example, suppose you wish to set R or the runner to 1255 C; by looking at Diagram #11 you see the arrow A at 1250 and the arrow B at 1260—1255 then lies halfway between 1250 and 1260.

DIAGRAM NO. 11

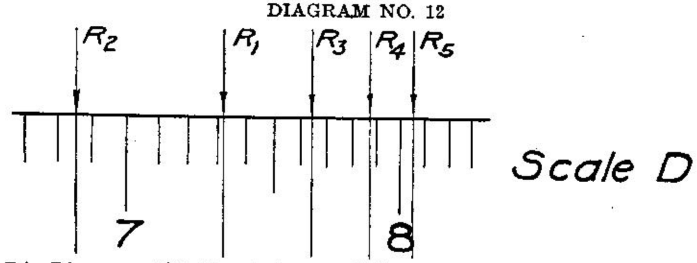


Arrow C is at 1310
Arrow D is at 1308

Set the runner to 2 on LA and read under it on D. The line is half way between 1410 and 1420 so call it 1415.

Do not get the idea that this is purely guess work. With a little practice you can read between the marks as quickly and as accurately as you can read the marks themselves.

DIAGRAM NO. 12



R1, Diagram #12, lies between 1730 and 1740 but nearer 1730 than 1740. You might read it 1732 or 1733—really it is nearer 1732, and that is the right reading.

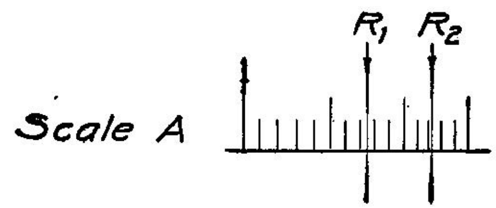
R2 reads 1685, R3 reads 1764, R4 reads 1787 and R5 reads 1805.

Set R to 72 D; Under R on A read 519.

Set R to 93 D; Under R on A read 865.

Where each space counts 2 the method is the same. In Diagram #13

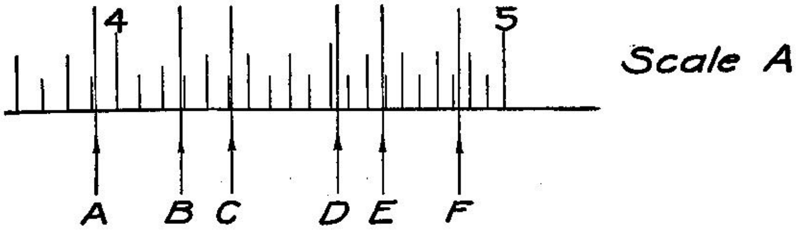
DIAGRAM NO. 13



the runner R1 is halfway between 1140 and 1160 so it reads 1150. The runner R2 is between 1240 and 1260, looking closer you see it is between 1240 and 1250 and you read it 1245. Or you might say if the distance between marks is 20, R2 is ¼ the distance or ¼ of 20 or 5 and read 1245.

Exercise No. 9

DIAGRAM NO. 14



Read the arrows as shown in Diagram #14. Put down the answers between 300 and 500 and add them.

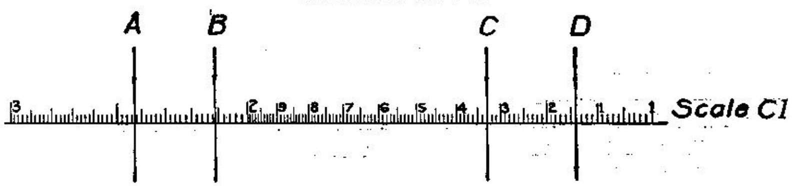
A =
B =
C =
D =
E =
F =

Sum of readings should be *2639

Exercise No. 10

Read the answers on scale CI as shown in Diagram #15 putting down the answers all between 100 and 300.

DIAGRAM NO. 15



A =
B =
C =
D =

Sum of readings should be 701

*Note: In this and following exercises the sum of several separate computations is given merely as a check. This sum does not indicate the accuracy obtainable.

ALL FRACTIONS MUST BE SET OFF AS DECIMALS

Remember all readings and settings on the rule must be in decimals.

If you are setting off 7½ you must set off 7.5 on the rule. ¾ would be set off as .75. 3/8 would be set off .375. YOU ARE SUPPOSED TO KNOW THE VALUES OF ¼, ½ and ¾ IN DECIMALS AS .25, .50 and .75. If a number like 15/16 is given you can on the rule change it to a decimal very quickly.

Set 16 C on 15 D; Result on D under 1 C; Read .938.

If you were setting off on the rule 15/16 you would find the value of 15/16 in decimals and set off .938.

Exercise No. 11

Find value of these fractions in decimals:—¼, 3/8, 5/16, 9/16, 11/16 and 13/16. If you have done this correctly the values will add up to 3.

1¼ would be set off as 1.25, 1¾ as 1.75, etc.

SETTING OFF MORE THAN 3 FIGURES

You have seen that we can read 3 figures always on the rule and sometimes 4 when the first one to the left is a 1.

You can set 1234 but you cannot set 9386.

Suppose you are getting 9 15/16—you would find on the rule 15/16 is 938 and you might try to set 9.938. Call it 994 and set. 994 is the nearest you can hope to set to 9.938.

How would you set 8753 or 8754 or 8752? As 875.

But you would set 8758 or 8759 or 8757. As 876.

When you drop a figure at the right end of a number if it is FIVE or GREATER you INCREASE the number by 1;—if it is LESS THAN FIVE the first three figures remain THE SAME.

Exercise No. 12

Set R to 1845 D. Read on A under R = ____________
Set 1 LC to 1845 D. R to 1845 C. Read on D under R = ____________

These readings should be the same.

Exercise No. 13

Set R to 207 D. Read on A under R = ____________
Set 1 LC to 207 D. R to 207. Read on D under R = ____________

These readings should be the same.

Exercise No. 14

Set R to 251 D.	Read on A under R	= ________
Set 1 LC to 251 D.	R to 251 C. Read on D under R	= ________
		These readings should be the same.

Exercise No. 15

Set R to 2515 D.	Read on A under R	= ________
Set 1 LC to 2515 D.	R to 2515 C. Read on D under R	= ________
		These readings should be the same.

Exercise No. 16

Place 1 LC to 1 LD.	(Place the scales together)	
Set R to 419 D.	Read on CI under R	= ________
Set R to 419 CI.	Read on D under P	= ________
		These readings should be the same.

Exercise No. 17

Write down readings in this column, putting decimal point so as to make each reading bewteen 100 and 300.

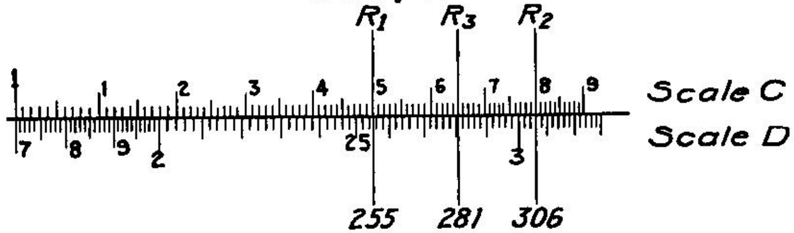
Set R to 1095 D.	Read under R on A =	________
Set R to 1430 D.	Read under R on A =	________
Set R to 109 D.	Read under R on A =	________
	These should add to	443

PART I—CHAPTER IV

FIGURING SIMPLE COSTS

Find the cost of 15 yards of cloth at 17 cents a yard.

DIAGRAM NO. 16



Set 1 LC to 17 D; under 15 C on D read 255. See R1, Diagram #16.

The rule does not set a decimal point. You know that 15 yards of cloth at 20 cents is three dollars; so the cost of fifteen yards at 17 cents is a little less than three dollars. The rule shows $2.55.

What is the cost of 18 yards at 17 cents a yard?

Keeping the slide the same, under 18 C on D read 306. See R2, Diagram #16.

Roughly (20 x 20) = 400 cents or $4.00—rule shows $3.06.

What is the cost of 16½ yards at 17 cents a yard?

Keeping the slide the same, under 16.5 read $2.81. See R 3, Diagram #16.

You can do problems in costs in the following way:—

(a) Set 1 C to the cost per yard, per pound, per gallon, etc., on D. All fractions must be set as decimals.

(b) Read the result on D under number of yards, pounds, etc., on C.

(c) Fix the dollars and cents or the decimal point by a rough estimate.

Take the following practical problems:—

Exercise No. 1

Figure the electric light bills. Use runner to read results.—

118 k.w. hrs. at 7½ cents.	Set 1 LC to 7½ D, that is, 7.5 D, and under.	118 C Read on D = $8.85.
114 k.w. hrs. at 7½ cents.		114 C Read on D = $8.55.
128 k.w. hrs. at 7½ cents.		128 C Read on D = $9.60.
101 k.w. hrs. at 7½ cents.		101 C Read on D = $7.58.

To fix the dollars and cents. 100 k.w. hrs. @ 10 cents an hr. = $10.00. All the bills therefore will be in the neighborhood of $10.00.

If you have another bill for 78 k.w. hrs. at 7½ cents, you will have to use the 1 RC and the setting will be:—

1 RC to 7.5 D. Under 78 C read answer on D (less than $10.00) we read $5.85.

If the number you want to find is off the rule put the other 1 on the number on D.

Exercise No. 2

Figure the water bills as given below at $2.25 per thousand cubic feet:—

A = 2400 cu. ft.	Set 1 LC to 225 D.	On D under 24 C Read ______
B = 3600 cu. ft.		On D under 36 C Read ______
C = 1800 cu. ft.		On D under 18 C Read ______
D = 2900 cu. ft.		On D under 29 C Read ______
E = 4300 cu. ft.		On D under 43 C Read ______
F = 830 cu. ft.	Set 1 RC to 225 D.	On D under 83 C Read ______
G = 630 cu. ft.		On D under 63 C Read ______
H = 510 cu. ft.		On D under 51 C Read ______

These bills should add to $38.20

Notice that you have to change from the left 1 to the right 1 between 44 and 45.

In the first bill A 1,000 cubic feet cost $2.25—2½ times $2.25 will be near $6.00. E will be almost twice that. F, G and H will be less than $10.00.

You can work costs on A and B as well as C and D but

A and B will give results to 1 in 500 or 1 cent in $5.00;

C and D will give results to 1 in 1,000 or 1 cent in $10.00:

So A and B would not be close enough in B, D and E.

COSTS WITH ONE DISCOUNT

What is the cost of a book listed at $1.60 with a 15 per cent discount?

With pencil and paper you would multiply 1.60 x .15 = 24 cents. Subtract 24 cents from $1.60 and get the result, $1.36.

On the rule set 1 LB to 85 LA. Read on A over 160 B = $1.36. 85 is (100 — 15) = 85 per cent.

What is the cost of a globe-valve listed at $2.80 with a 42 per cent discount?

(100 — 42) = 58. The price will evidently be about ½ of $2.80.

Set 1 LB to 58 LA. Read on A over 280 B = $1.62.

Notice in both these examples you have used scale A and B, because in these examples you can read to the nearest cent on these scales.

Rule:—

Scales A and B will not give results to the nearest cent with amounts much over—1 in 500—$5.00.

Scales C and D will not give results to the nearest cent with amounts much over—1 in 1,000—$10.00.

What is the cost of a bushing listed at 14 cents at a 15 per cent discount?

Which scale would you use? A and B. Accuracy of 1 in 14. 12 cents.

What is the cost of a valve listed at $18.40 at an 18 per cent discount?

Which scale would you use? C and D. Accuracy of 1 in 1800. $15.09.

EXAMPLES IN SIMPLE COSTS

In doing these exercises form the habit of doing the work in the following order.

(a) Decide about what the result will be and put it down.

(b) Decide what scales to use. (Remember A and B are good to 1 part in 500 or 1 cent in $5.00.)

(c) Make the setting. (Always using decimals.)

(d) Read the result and put it down. Put the decimal point in the right place.

What is the selling price of 12½ yards of goods at 17¼ cents a yard?

(a) 10 x 20 cents = $2.00.

(b) Accuracy 1 in 200 or nearest cent in $2.00. Scales A and B.

(c) Set 1 LB to 1725 LA, R to 125 B.

(d) Read under R on A, 216, and as the answer is about $2.00, put down $2.16.

Let us check by multiplication:—

```
   17.25
    12.5
  ------
    8625
   3450
  1725
  ------
 215.625 cents
```

Exercise No. 3

Figure the yardage given below at the prices stated:—

Quantity yards	Price per yard	Total	Check
17½	23c	______	17½ x 23 =
18¼	37c	______	18¼ x 37 =
21	48½c	______	21 x 48½ =
56	10¼c	______	56 x 10¼ =
60	8¾c	______	60 x 8¾ =
	Total	$31.96	

Exercise No. 4

Figure the cost price of the following with discount:—

List	Discount	Net	Check
$4.02	28%	______	.72 x 4.02 =
6.76	39%	______	.61 x 6.76 =
10.14	21%	______	.79 x 10.14 =
5.74	32%	______	.68 x 5.74 =
5.25	8½%	______	.915 x 5.25 =

Bills should add to $23.72

Exercise No. 5

Figure the selling price of the following adding 18% to cost:—

Cost	Selling Price	Check
$3.18	______	1.18 x 3.18 =
4.68	______	1.18 x 4.68 =
8.32	______	1.18 x 8.32 =
9.37	______	1.18 x 9.37 =
2.17	______	1.18 x 2.17 =
7.46	______	1.18 x 7.46 =
7.71	______	1.18 x 7.71 =

Total $50.61

These results should be obtained with one setting of the slide.

PART I—CHAPTER V

CHANGING MEASURE

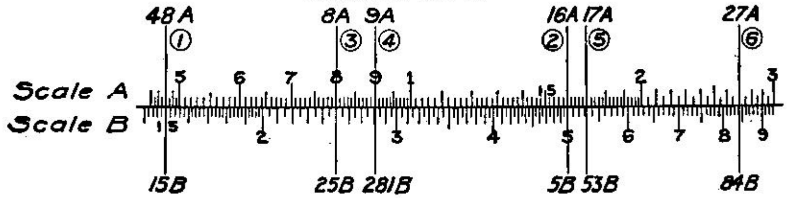
The Maniphase slide rule easily changes from on kind of measure to another, and as this is one of the most valuable uses or the rule it should be clearly understood.

By properly setting the slide you make a table of the rule so that you can read measures directly without moving the slide again.

As an example:—Change decimals of an inch to fractions of an inch, or fractions to decimals of an inch. Practically you wish to work to the nearest 32nd of an inch.

(1) Set 15 LB to 48 LA. See diagram #17.

DIAGRAM NO. 17



The numbers on A are 32nds of an inch, under each 32nd you will find the decimal. See Diagram #17 arrows are at each reading.

(2) Under 16 A or 16/32 read .5 on B. Use the runner to read with, slipping it along to each number you want.

(3) Under 8 A or 8/32 read .25 on B.

(4) Under 9 A or 9/32 read .281 on B.

(5) Under 17 A or 17/32 read .53 on B, etc.,—under the line on the runner.

(6) Under 27 A or 27/32 read .84.

Changing back from decimals to the NEAREST 32nd find decimals on B and over the decimal find the number of 32nds on A.

Over .5 inch find 16; that is 16/32.

Over .25 inch find 8; that is 8/32.

*Over .91 inch find 29; that is 29/32.

Another very practical change is from inches and fractions to decimals of a foot.—

Set 12 RB to M I A. Read feet on A and inches on B.

(Use the runner of course to read with.)

*Notice—29/32 is not exactly .91 inch. We are reading to the nearest 32nd and 29 is the nearest whole 32nd on A over 91 B.

Under 1 foot on A find 12 inches on B.

Under .5 feet on A find 6 inches on B.

Under .35 feet on A find 4.2 inches on B.

Under .68 feet on A find 8.15 inches on B.

By reading from B to A you change inches to decimals of a foot.

Over 6 inches on B find .5 feet on A.

Over 5½ inches on B find .458 feet on A, etc.

You will find on the back of the rule settings to use in changing from one measure to another. In Part IV you will find a more complete set.

To change ounces to grams. You will see on the back of the rule 6 to 170 which means 6 ounces is 170 grams. If you set 170 B to 6 A you read ounces on A and grams on B.

Set 170 RB to 6 LA. Why is this better than (170 LB to 6 RA)?

You can now read 6 ounces (on A) equals 170 grams (on B).

You can now read 1 ounce (on A) equals 28.3 grams (on B):

(6 into 170 about 30,)

You can now read 2½ ounces (on A) equals 71 grams (on B), etc.

Reading from B to A (that is, changing grams to ounces):

170 grams (on B) equals 6 ounces (on A).

1 gram (on B) equals .0353 ounces (on A):

6 divided by 200 = .03.

6 divided by 170 = about the same.

Or you might say, "30 grams to the ounce—1 gram is 1/30 of an ounce or about .03."

41 grams (on B) equals 1.45 ounces on (A).

385 grams (on B) equals 13.6 ounces on (A), etc.

Any of the settings on the back of the rule may be used in this way or any of the equivalent ratios given in Part IV. Or you may make your own table for your own work.

In estimating you may want to change cubic feet of masonry to number of brick.

Usually 40 cubic feet of masonry contain 1,000 brick.

Set 40 RB to 1 RA and read thousands of brick on A and cubic feet on B.

Read 40 cubic feet on B contain 1,000 brick on A.

Read 35 cubic feet on B contain 875 brick on A.

Read 290 cubic feet on B contain 7¼ thousand brick on A.

Read 1700 cubic feet on B contain 42½ thousand brick on A, etc.

Notice how you fix the decimal point, if 40 cubic feet contain 1 thousand.

Notice how you fix the decimal point:—

35 cubic feet will contain a little less than 1 thousand.

290 cubic feet will contain 29/40 = about 7 thousand.

1700 cubic feet will contain 170/4 = about 40 thousand.

The decimal point is easily fixed in each case by common sense.

In figuring selling prices where the same profit is to be added to the cost, the methods of this chapter can be used.

If you set 115 LB to 1 LA any number on B is 15 per cent greater than the number over it on A. If you set 1 RB to 85 RA you see that any number on A is 15 per cent less than the number under it on B.

So you have a table of discounts of 15 per cent, and profits of 15 per cent.

With 1 LB to 85 LA:

Discount of 15%:—Over 85 B read 72.3 A.
Over 151 B read 128 A.
Over $7.59 B read $6.45 A.
Over $3.68 B read $3.13 A.

With 115 LB to 1 LA:

15 per cent added:—Under 73.7 A read 85 B.
Under $9.45 A read $10.87 B—Accuracy.
Under $1.13 A read $1.30 B.

Exercise No. 1

Change the following number of gallons to cubic feet of water:—8900, 6300, 49300.

On back of rule see 800 gallons is 107 cubic feet.

Set 107 LB to 800 LA. Notice 1 on B is 7.5 gallons on A.

Gallons Cubic Feet

Under 89 A find 119 B; result—as 7.5 gallons in 1 cubic foot—is 1190.

Under 63 A find 843 B; result—as 7.5 gallons in 1 cubic foot—is 843.

Under 493 A find 659 B; result—as 7.5 gallons in 1 cubic foot—is 6590.

Exercise No. 2

Give the following decimals of an inch to the nearest 64th of an inch:—.351, .462, .187.

Set 64 RB to 1 RA.		No. of 64ths	
Set R to 351 A.	Read on B under R =	________	64ths.
Set R to 462 A.	Read on B under R =	________	64ths.
Set R to 187 A.	Read on B under R =	________	64ths.
	Should add to	64	64ths.

Exercise No. 3

Give the following inches in decimals of a foot:—3″, 4″, 8½″, 9¼″, 11½″, 3½″, 8¼″.

Set 12 RB to M 1 A.

	Inches		Decimals of Foot
Read decimals on A over inches on B.	3	=	________
Read decimals on A over inches on B.	4	=	________
Read decimals on A over inches on B.	8½	=	________
Read decimals on A over inches on B.	9¼	=	________
Read decimals on A over inches on B.	11½	=	________
Read decimals on A over inches on B.	3½	=	________
Read decimals on A over inches on B.	8¼	=	________
		Total	4.0

Exercise No. 4

How many thousand bricks to the following cubes of masonry, 40 cubic feet contain 1,000 bricks:—290 cu. ft., 483 cu. ft., 927 cu. ft., 1083 cu ft.?

Set 40 C to 1 RD.

	Thousand Bricks	
Under 40 C read 1 thousand bricks on D =	________	
Under 290 C read 1 thousand bricks on D =	________	Note change of
Under 1083 C read 1 thousand bricks on D =	________	☞ index here.
Under 483 C read 1 thousand bricks on D =	________	4 C to 1 LD.
Under 927 C read 1 thousand bricks on D =	________	
Total bricks	69.6	Thousands

PART I—CHAPTER VI

MULTIPLYING

Numbers may be multiplied on scales A and B or on scales C and D. By using C and D you get an accuracy of 1 part in 1,000 and using A and B, 1 part in 500.

To multiply 319 by 10.64: 10 × 300 = 3000, decimal point fixed—
1 LC to 10.64 D;
R to 319 C.

Under R see 339 D, and pointing off we have 3390.
Try the same problem on scales A and B.
1 LB to 1064 A (notice that you can hardly set to 1064 on A);
R to 319 B.

Over R see 339 on A or decimal point in the right place, the result is 3390.

To multiply 793 by 4.66: 800 × 5 = 4000, decimal point fixed—
1 LC to 793 D;
R to 466 C.

You see 466 C falls outside scale D. You should have used 1 RC. Trying this:—
1RC to 793 D;
R to 466 C.

Under R see 37 on D—result is 3700.
Rule:—To multiply scale C and D.
(1) Fix decimal point.
(2) Put 1 C to one number on D.
(3) Put runner to other number on C.
(4) Read answer under runner on D.

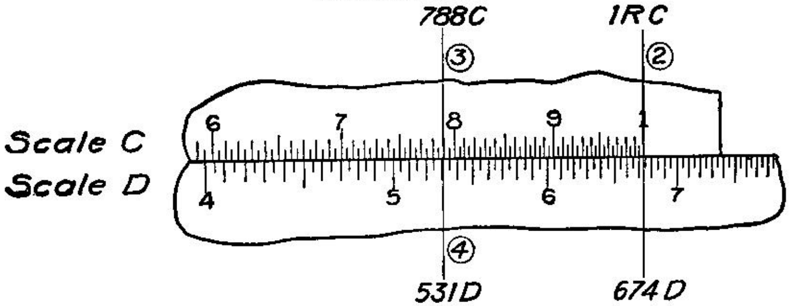
You will find as in the example above, the answer falls outside the scale unless you are careful to use the proper 1 C.

Rule.—Multiply the first figures of the number. If their product is less than 10 use left 1 C—if greater than 10 use the right 1 C.

This rule, while not absolute, will give the proper index in most cases.

Take an example:—7.88 × 6.74—and go through the work of multiplying on scale C and D. See Diagram #18.

DIAGRAM NO. 18



(1) 7 × 8 = 56 (mental). Fix decimal point and use 1 RC.

(2) 1 RC to 674 D. See (2) Diagram #18.
(3) R to 788 C. See (3) Diagram #18.

(4) Under R see 531 or 53.1 on D. See (4) Diagram #18.

In any example in multiplication where scales C and D can be used, you can also do the problem using D and Scale CI.

This has an advantage, for when you use D with CI you will NEVER have the result fall off the rule. You should become familiar with using D with CI.

Take this example:—

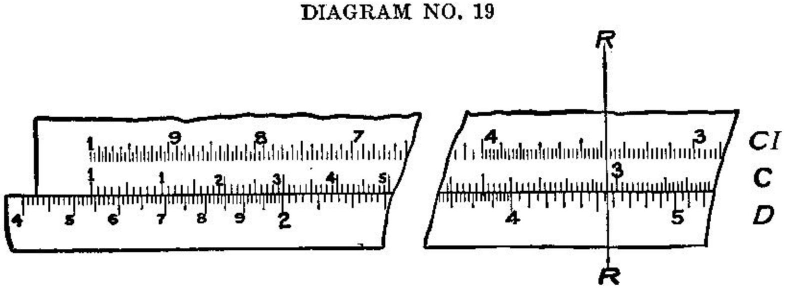
3.38 × 4.57.

(1) 4 ×4 = 16; decimal point fixed.

(2) 3.38 CI to 4.57 D. (See Diagram #19.)

(3) Read answer on D under 1 CI or 1 C, 154; or, pointing off, 15.4.

DIAGRAM NO. 19



In doing this example notice:

(1) Put the runner to 4.57 D.
(2) Put 3.38 CI to the runner.
(3) Take care in reading CI; it reads from right to left.

Exercise No. 1

(1)	3.18 × 4.67.	Use scales A-B.	Ans. about 15.	Result = ________
(2)	4.23 × 5.69.	Use scales D-CI.	Ans. about 24.	Result = ________
(3)	8.39 × 51.3.	Use scales C-D.	Ans. about 400.	Result = ________
(4)	10.14 × 13.12.	Use scales C-D.	Ans. about 130.	Result = ________
(5)	9.47 × 6.3.	Use scales D-CI.	Ans. about 60.	Result = ________
			Results should total	661.62

MULTIPLYING THREE NUMBERS

In multiplying 3 numbers you should always use scales C-D and CI for by so doing you can get the result in one setting of the slide. If you must use C-D alone it will require two settings of the slide.

Multiply 18.71 by 4.23 by 1.931.

(1) Accuracy 1 in 423; scales C-D-CI; 20×4×2 = 160.

(2) 4.23 CI to 18.71 D.

(3) Read answer on D under 1.931 C as 153 or, pointing off, 153.

If you do not understand how this is done, take this very simple example and follow it through. Settings are given in detail. Notice how the runner is used as a marker.

2 × 3 × 4.

(1) Accuracy and decimal fixed; scale C-D-CI; answer is 24.

(2) R to 2 D; 3 CI to runner (3 CI to 2 D).

(3) R to 4 C (read under R on D), 24 Ans.

Take this same simple example on scales C-D.

(1) Accuracy and decimal point fixed; 24 equals answer.

(2) 1 LC to 2 D (move slide).

(3) R to 3 C.

(4) 1 RC to R (move slide).

(5) R to 4 C.

(6) Read answer on D under R as 24.

You should be very familiar with BOTH of these methods, they are used much in practical work.

Exercise No. 2

		Scales	Results
3.811 × 6.93 × 1.731	4 × 7 × 2 = 56	C-D-CI	45.7
1.311 × 37.71 × 9.82	38 × 10 =380	C-D-CI	
4.72 × .831 × 6.01	4 × 6 = 24	C-D-CI	
1.011 × 12.13 × 7.88	8 × 12 = 96	C-D	
9.66 × 8.72 × .340	9 × 8 × 3 = 22	C-D	
	578	Results add to	679.5

Exercise No. 3

	Scales	Results
9.98 × .336 × 10.93	C-D	________
8.97 × 10.09 × 11.19	C-D	________
3.83 × 4.14 × 2.271	C-D-CI	________
2.21 × .0381 × 10.21	C-D-CI	________
	Results add to	1086.457

Exercise No. 4

Discounts are often given as 60—60 or 30—15, which means, in the 1st case a deduction of 60 per cent from the list and a further deduction of 60 from the price so obtained, and in the second case 30 percent from the list and 15 percent from price thus found. Find cost of following items.

List Price	Discounts	Cost
$18.20	60—30	

(1) The problem is therefore 18.20 × .40 × .70 or approx. $6.00;

.40 being (100%—60%)

.70 being (100%—30%)

Use scales C-D-CI; 1820 × 40 × 70.

(2) 40 CI to 1820 D.

(3) Read result on D under 70 C = $5.10.

Exercise No. 5

List Price	Discounts	Cost
$7.16	30—20	________
9.36	30—20	________
8.42	20—16	________
7.32	18—12	________
	Should add to	$20.19

Exercise No. 6

Check costs of the following using Scales C-D-CI:

	Quantity	Price	Discount	Net Cost
(a)	14½ yds.	$1.19	30%	$12.08
(b)	19¼ yds.	1.31	25%	18.91
(c)	19¾ yds.	1.29	33%	17.10
(d)	43½ yds.	2.31	11%	80.95
				$129.04

Correct cost should be $137 approx.

In (a) we have 14.5 × 1.19 × 70% (100—30) = somewhere near $14.00.

Exercise No. 7

Figure the cubic feet of concrete in the following walls:—

*2′-6″ × 8′-11″ × 43′-8½″—2 × 9 × 50 =	1,000 approx.
2′-2″ × 8′-11″ × 34′-6¼″—	
2′-8″ × 8′- 9″ × 31′-4¾″—	
3′-3″ × 8′- 5″ × 27′-3⅓″—	
	________
Total cubic feet between	3120 and 3130

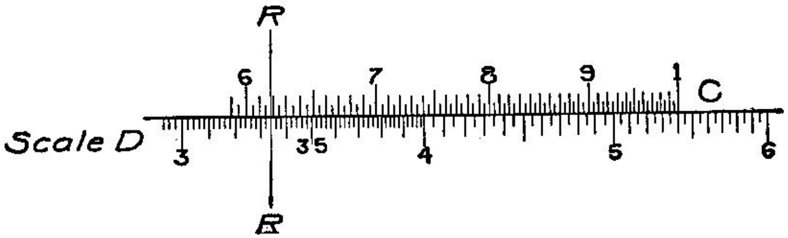
*First change to feet and decimals and then multiply.

PART I—CHAPTER VII

DIVIDING

To divide 3.34 by 6.18. Using scale C and D (see Diagram #20):—

DIAGRAM NO. 20



(1) 3 divided by 6 is ½ or .5.

(2) Set runner to 334 D.

(3) Set 618 C to runner.

(4) Read answer on D under 1 C as 540 or placing decimal point .540.

Rule:—Set the number you want to DIVIDE BY, to the number you want to DIVIDE and find the answer on the fixed scale (A or D) at 1 on the slide.

To divide 9.18 by 4.22. Using scale A and B—

(1) 9 divided by 4 or 9/4 is approx. 2.

(2) Set 4.22 B to 918 A.

(3) Answer on A over 1 B is 217, or placing the decimal point, 2.17. If you do not see how to do this, take this VERY SIMPLE example:

8 divided by 4:—

(1) 8 divided by 4 is 2. Accuracy and decimal point fixed.

(2) R to 8 A (move runner).

(3) 4 B to R (move slide).

(4) Answer to be read on A over 1 B is 2.

Notice that in division you do not have to pay any attention to the index in setting. Simply set one number on the other and the answer ALWAYS comes on the rule and can be read.

In all practical problems of division, do the work in the following order:

(1) Decide which scales to use; (A and B), or (C and D).

(2) Fix the decimal point.

(3) Set the number you want to divide by to the number your want divided.

(4) Read the answer and mark the decimal point.

Exercise No. 1

Divide $3.85 by 17 lbs. to find price per pound = ______
Divide 3.91 by 19 lbs. to find price per pound = ______
Divide 4.47 by 15 lbs. to find price per pound = ______
Divide 11.23 by 26 lbs. to find price per pound = ______
Divide 10.11 by 21 lbs. to find price per pound = ______
These should total $1.65

Exercise No. 2

W. P. C.

Divide 985 lbs. by 381 to find weight per carton = ______
Divide 1103 lbs. by 383 to find weight per carton = ______
Divide 1207 lbs. by 407 to find weight per carton = ______
Divide 1105 lbs. by 390 to find weight per carton = ______
Should add to 11.27

Exercise No. 3

Price (Cost)	Quantity	Cost Per Piece
$12.35	144	______
9.30	8 doz.	______
8.30	5 doz.	______
7.25	3 doz.	______
3.17	191	______
	Should add to	$0.539

Exercise No. 4

	Tons of Cement Required	Pounds in Bag	No. of Bags
Pier A	34.3	94	______
Pier B	47.2	94	______
Pier C	38.6	94	______
Pier D	33.7	94	______
Pier E	24.5	94	______
		Total bags	3794

$$\text{Check } \frac{178.3 \times 2000}{94} = \frac{356600}{94} = 3795^{*} \text{ (check).}$$

*Notice:—Using scale C and D you cannot be sure of this figure. Also notice that a difference of 2 or 3 bags of cement in a total of 4,000 is commercially or practically close enough.

PART I—CHAPTER VIII

SPECIAL USES

Combined Multiplication and Division

Sometimes you will wish to combine multiplication and division Take for example the following: To figure selling price from cost by adding profit of 15%—

Total Cost	Quantity	Selling Price Per Yard
$19.17	181 yards	________

To solve this problem divide $19.17 by 181 yards to give the cost price per yard and multiply this by 1.15 to give the selling price at a profit of 15 per cent.

First divide 19.17 by 181 as in Chapter VII; then multiply by 1.15 as in Chapter VI; as follows:

(1) 19.17 divided by 181 = 20 divided by 200 or about 10c, add 15% = about 11 cents a yard.

(2) R to 1917 D (move runner).

*(3) 181 C to R (move slide).

(4) R to 115 C (move runner).

(5) Answer on D under R, 122; or placing decimal, 12 cents.

Many problems in estimating can be done in this general way.

Exercise No. 1

Find the yardage of an excavation 8.5 × 2.17 × 19.5 ft. 1 cubic yard equals 27 cubic feet. Result to nearest cubic yard.

(1) 8 × 2 × 20 = 320. 320 divided by 30 equals about 10 + cubic yds.

(2) 27 C to 85 D.

(3) R to 217 C.

(4) 195 CI to R.

(5) Read result on D under 1 C = 13.3 cubic yards.

Exercise No. 2

Find the square feet of radiation necessary to heat a room 12′ 6″ × 10′ 9″ × 7′ 6″ if 1 sq. ft. of radiation is provided for 63 cubic feet of air.

*There is no need to read the answer of 1917 divided by 181 unless you want it. Notice it is 106 and in (4) and (5) you multiply 106 × 115. DO NOT in problems of this kind do your dividing first, read the answer, then set it over again and multiply.

The problem then is 12.5 × 10.75 × 7.5 divided by 63.

(1) 10 × 10 × 7 = 700; 700 divided by 70 = 10.

(2) 63 C to 75 D.

(3) R to 125 C.

(4) 1075 CI to R.

(5) Result on D under 1 C, 160, or 16 square feet to the nearest square foot.

Take another example of the same kind.

1483 pounds of castings are purchased for $71.32 and you wish to find the selling price to give a profit of 18 per cent.

(1) The cost will be 7,000 cents divided by 1500 pounds or about 4 cents a pound + 18% or 5 cents a pound. Use scales A and B.

(2) 1483 RB to 7132 LA.

(3) R to 118 B.

(4) Answer on A under R is 568 or 5.68 cents per pound.

If you want the price to the nearest cent, you would sell for 6 cents a lb.

If you want the price to the nearest ¼ cent, you would sell for 5¾ cents a lb.

NOTE:—In problems like this do the DIVISION FIRST.

Exercise No. 3

Wt. of Iron	Cost	Per Cent Profit	Selling Price Per Pound to ½ Cent
4963	$98.33	28	________
468	9.30	28	________
2334	47.10	28	________
7133	144.93	28	________
		These should total	10 cents

$100 or 10,000 cents for 5,000 lbs.; 2 cents for 1 lb.; add ¼ = 2 approx.

Accuracy required is ½ cent in 2 cents or 1 in 4, so scale A-B is close enough.

This type of work is so important that you should be sure that you can multiply three numbers and divide by one easily and quickly.

Exercise No. 4

			Results to nearest whole number
1.	3.18 × 4.26 × 5.38 divided by 38	=	________
2.	6.17 × 7.91 × 8.72 divided by 41	=	________

3.	101.3	× 18.67	× .72	divided by 29		=	______
4.	191	× 1.723	× 1.002	divided by 27		=	______
					These should total		71

CIRCLES

In computation or estimating work it is important that you know how to figure the circumference and areas of circles.

On the back of the rule you will see Diam. Circle: Circumference of circle = 113 : 355.

Set 113C to 355D (R to 355 D) (113 C to R).

Under diameters on C you will read circumference on D.

Under 2 on C you will read 6.28 on D.

Under 2.5 on C you will read 7.85 on D.

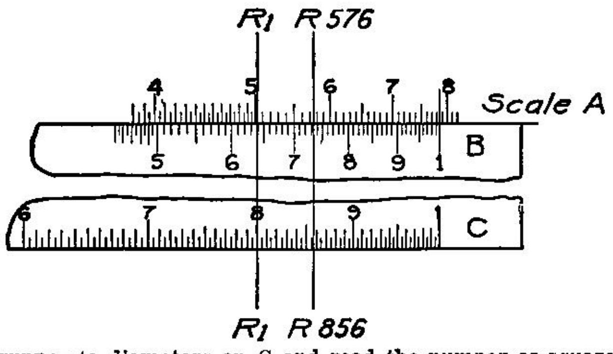
Under any diameter on C read circumference on D.

You will notice that about 32 is the limit you can set on scale C, for numbers with 4, 5, 6, 7, etc., change 1 RC for 1 LC (change index).

In placing the decimal point you will remember that the circumference is about 3 times the diameter.

To find the areas of circles set 1 RB to the long mark between 78 and 79 A. See Diagram #21.

DIAGRAM NO. 21



Set runner to diameters on C and read the number of square inches in the circle under the runner on A.

Example

Find area of circle whose diameter is 8.56 inches.

(1) Set slide as in Diagram #21.

(2) Circle is little less than square 8.56 × 8.56—say 8 × 8 approx. 64.

(3) R to 856 C.

(4) Read on A under R, 576, or 57.6.

R 1, Diagram #21, shows how to find the area of a circle whose diameter is eight inches.

Be sure you understand setting on C and reading on A. There are many settings of this kind in practical work.

Exercise No. 5

Diameter Circle		Area Circle
4.37		______
3.42		______
*10.2		______
	Total	152.4

*Notice that you must change indices in this example.

PART II

FOR STUDENTS IN HIGH SCHOOLS AND COLLEGES

INTRODUCTION

In many SCHOOLS and COLLEGES the students are required to know how to use the Slide Rule. In all High Schools and Colleges the use of the rule by both the student and the teacher will save much time and labor.

Part II teaches the use of the Maniphase to students in High Schools and Colleges. The examples and exercises in this part are such as occur in High School and College work.

The quick and accurate use of the Maniphase depends almost entirely upon PRACTICE. All exercises should be faithfully done, and in no case should you go ahead unless you understand the work that has gone before.

Before you take up anything in this Part II you MUST KNOW and UNDERSTAND two things:

(1) HOW CLOSE YOU WANT YOUR ANSWER.

(2) HOW TO READ THE RULE AND SET THE SLIDE.

In addition you MUST read the matter under (1), (2) and (3)—

(1) Read Part I—Chapter II, page 4, from the beginning of the Chapter to the paragraph on SPEED.

(2) Read Part I—Chapter II, page 5, paragraph on Estimating.

Work.

(3) Read Part I—Chapter II, page 6, paragraph on Commercial
You will see from this reading that you can get results to 1 part in 500 on A and B.

You will see from this reading that you can get results to 1 part in 1,000 on C and D.

Always use A and B if the accuracy required will allow it, and above all understand that even if the rule is not quite accurate enough tc meet the requirements of a PARTICULAR textbook it is ALWAYS very valuable in CHECKING RESULTS. And in practical work ALL RESULTS MUST BE CHECKED.

After you have decided whether you work is to be done on A and B or C and D you must know:

HOW TO READ THE RULE AND SET THE SLIDE.

Read and do all the exercises and examples in Part I, Chapter III.

PART II—CHAPTER I

MULTIPLICATION, DIVISION AND PROPORTION

Read carefully, and actually DO, all the exercises and examples in PART I, CHAPTER VI.

In all problems of multiplication, division, and proportion the work should be done in the order shown:

(1) Determine the scales to use.

(2) Estimate the answer and fix the decimal point.

(3) Make the setting.

(4) Read the answer and point it off.

Take a simple example, multiplying two numbers:

Multiply 3.45 × 2.2.

(1) Accuracy 1 in 22. So use scale A and B.

(2) Estimate the answer about 2 × 3.5 or approximately 7.0. This should be done in your head or on a scrap of paper.

(3) Set the left hand one on scale B to 22 on scale A. 1 LB to 22 A. Set the runner to 345 on Scale B. R to 345 B.

(4) Under hair line on runner read, on scale A, 760; point off as 7.60.

The method on C and D is exactly the same. Answer on C-D = 759. Why?

Do these additional exercises:

Exercise No. 1

		Add these answers
Multiply 17½ × 23	=	________
Multiply 18.25 × 37	=	________
Multiply 56 × 10.25	=	________
Multiply 8.75 × 60	=	________
Multiply 21 × 48.5	=	________
These should total		3196

Exercise No. 2

		Add these answers
Multiply 4.02 × 72	=	________
Multiply 6.1 × 6.76	=	________
Multiply .79 × 10.14	=	________
Multiply .68 × 5.74	=	________
Multiply 5.25 × .915	=	________
These should total		346.91

You will find that the answer falls outside the scale D, when C and D are used unless you are careful to use the proper 1 C.

RULE:—Multiply the first figures of the two numbers. If the result is less than 10, use 1 LC; if greater than 10 use 1 RC. This will in most cases indicate the proper index to use.

MULTIPLICATION OF THREE NUMBERS.

See PART I, CHAPTER VI, PAGE 25.

Do ALL the exercises and examples in CHAPTER VI, PART I, before taking up the work under dividing.

DIVIDING.

Read carefully, and actually do all the exercises and examples in PART I, CHAPTER VII.

Divide 2055 by 1735.

(1) Final accuracy 1 part in 1800. Use scales C and D.

(2) 20 divided by 17. Answer about 1.

(3) Set 1735 C to 2055 D.

(4) Answer on D under 1 C is 1184, pointing off 1.184.

The method using scales A and B is exactly the same as on C and D.

Notice—On A-B you would read 118. Why?

Do these additional exercises:

Exercise No. 3

Divide 4.38 by 8.42 =	________
Divide 5.31 by 6.22 =	________
Divide 8.75 by 9.46 =	________
These should total	2.299

Exercise No. 4

Divide 9.75 by 10.83 =	________
Divide 10.91 by 11.01 =	________
Divide 40.9 by 3.23 =	________
These should total	14.551

COMBINED MULTIPLICATION AND DIVISION.

Read carefully and do all the exercises and examples in PART I. CHAPTER VIII, under the head of combined multiplication and division.

This kind of setting is most important and MUST be THOROUGHLY UNDERSTOOD.

Take this example $\frac{8.18 \times 3.42}{4.14}$

(1) Accuracy 1 in 342; use scales A and B.

(2) $\frac{8 \times 3}{4} = \frac{24}{4} = 6.$

*(3) 414 LB to 342 LA (342 divided by 414). R to 8.18 LB.

(4) Answer on A under R 676, pointing off 6.76.

Exercise No. 5

Solve the following:

$$\frac{8.33 \times 10.13}{9.72} = \underline{\qquad\qquad};$$

$$\frac{7.18 \times 5.04}{4.17} = \underline{\qquad\qquad}.$$

$$\frac{6.56 \times 8.31}{6.28} = \underline{\qquad\qquad}.$$

Compare the answers to these problems.

Consider problems of this character: $\frac{3 \times 4}{2 \times 6}$.

(1) Use scales A and B.

(2) Answer is 1.

(3) 2 LB to 3 LA (move slide); R to 4 LB (move runner); 6 LB to R (move slide).

(4) Answer on A over 1 B is 1.

In this class of problems do first division, then multiplication, ALTERNATELY; choosing always numbers as nearly alike as possible.

$$\frac{3.83 \times 7.42}{2.93 \times 9.63} =$$

(1) Use scales A and B.

(2) $\frac{4 \times 7}{3 \times 9}$ about 1.0.

(3) 9.63 LB to 7.42 LA; R to 3.83 RB; 2.93 RB to R.

(4) Answer on A over 1B = 1005+; pointing off, 1.005.

Check this problem by doing the same problem on C and D.

*Notice on the first division choose the two numbers nearest alike; that is, divide 342 by 414, not 818 by 414. Why?

The square root of .2 is .4+; the square root of .02 is .1+; the square root of .002 is .04+, etc.

Exercise No. 2

Find the square roots of:

4.19 = ________		and 131,000 = ________	
.601 = ________		and .989 = ________	
7.93 = ________		and .0321 = ________	
Total	5.645	Total	363.174

CUBES

You will notice on the top of the face of the rule a scale marked K. This scale is a scale of cubes. Numbers on scale K are the cubes of numbers on D. If the runner is set to a number on D the cube of this number is read on scale K.

numbers on D. If the runner is set to a number on D the cube of this number is read on scale E at the mark on the metal bottom of the runner.

R to 2D. Note 8 (the cube of 2) on the scale K under R.

To find the cube of a number then:

(1) Estimate the result.

(2) Set R to number on D reading the result under R on K.

Find the cube of 3.77.

(1) $4 \times 4 \times 4 = 64$.

(2) R to 3.77 D.

(3) Read answer 536 on K under R; pointing off, we have 53.6 as the result.

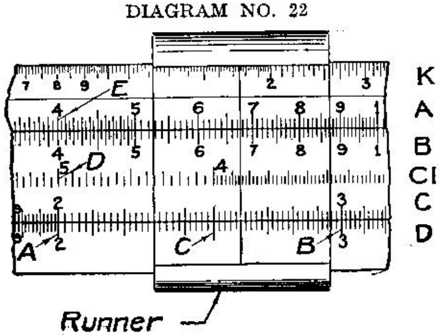
Exercise No. 3

Cube the following:

1.33 = ________		4.26 = ________	
.876 = ________		3.38 = ________	
9.41 = ________		.131 = ________	
Total	836.022	Total	115.90225

CUBE ROOTS

DIAGRAM NO. 22



To find the cube root of a number set runner to number on K. Read cube root on D under R.

Notice scale K is divided in 3 parts.

The left hand scale on K is used for finding cube roots of numbers between 1 and 10.

The middle scale on K is used for finding cube roots of numbers between 10 and 100.

The right hand scale on K is used for finding cube roots of numbers between 100 and 1,000;

The left hand scale on K is used for finding cube roots of numbers between 1,000 and 10,000;

The quickest and surest method, however, is to estimate the cube root and set on the scale which that estimate shows to be correct.

In estimating cube roots it is helpful to point off groups of three figures from the decimal point.

Example No. 1

391'381. has TWO groups, TWO figures to the left of the decimal in the root.

First figure in the root is approx. $\sqrt[3]{400}$;

$7 \times 7 \times 7 = 343$; approximate cube root is 70.

Example No. 2

'91. has ONE group, ONE figure to left of the decimal in the root.

$4 \times 4 \times 4 = 64$; approximate cube root is 4.

Example No. 3

.003'41; first figure to right of the decimal point $\sqrt[3]{.003}$.

$.1 \times .1 \times .1 = .001$; approximate cube root is .10.

In example (1) to find cube root of 391'381 we would set an approximate answer on scale D.

R to 7 D. This fixes the scale as RK.

So now we set

R to 391 RK;

Answer on D under R, 73.1.

In example (2) use middle K.

To find the cube root of 9.39:

In example (3) use LK.

$2 \times 2 \times 2 = 8$; use LK (it is the only scale on E from which you can get 2+ as an answer).

R to 9.39 LK;

Answer on D under R is 211; and pointing off, 2.11.

Exercise No. 4

Find cube roots:

.095 = ________		1.38 = ________	
.134 = ________		23.60 = ________	
.87 = ________		199.0 = ________	
Total	1.923	Total	9.82

RECIPROCALS

The numbers on CI are the reciprocals of numbers directly below on C. To find the reciprocal of a number (1 divided by the number), or $\frac{1}{n}$, set R to the number on C and read the reciprocal on CI.

Setting R to 2 C, 4 C, 5 C;

Read ½, ¼, ⅕ under R on CI as .5, .25, .2.

It may be easier to set the number on CI and find the reciprocal on B.

Remember that CI reads from RIGHT to LEFT.

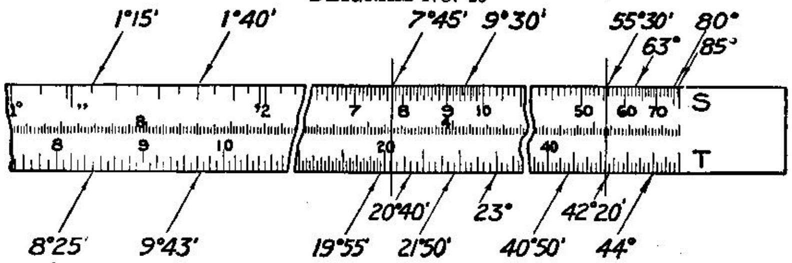
PART II—CHAPTER III

TRIGONOMETRY AND SOLVING TRIANGLES

In solving triangles it is necessary to find the sines, cosines and tangents of angles.

Remove the slide and put it back in the rule with the scales marked S and T out. Be sure you can read the scales S and T. See Diagram #23.

DIAGRAM NO. 23



S is a scale of sines of angles between 0° 34′ and 90°.

T is a scale of tangents of angles between 5° 43′ and 45°

SINES

Find sine of 18° 35′; R to 18° 35′ S; read under R on A, .319.

All sines on RA lie between .1 and 1 and on LA between .01 and .1.

Find sine of 7° 45′ = .135. See Diagram #23.

Find sine of 55° 30′ = .824.

Be careful in reading the sines between 75° and 90°.

Sine 80° is .985. Notice 85° is the last mark to the left of the end of the scale S at 90°.

SINES OF SMALL ANGLES

To find the SINE OF SMALL ANGLES expressed IN MINUTES. Sin 0° 01′ = .0003:

Find sine of 0° 18′;

Place long mark just to the left of 2° marked ′ at 18 RA;

Read over 1 LS—524 on A (pointing off since sin 1′ = .0003, sin 20′ = .006);

Result is .00524 = sin of 0° 18′.

Find the SINE of SMALL ANGLES expressed IN SECONDS in the same way. Use long mark just to the right of 1° 10′ marked ″.

Find the sines of these angles:

Exercise No. 1

45° 0′ = ________	0° 15′ = ________
38° 18′ = ________	1° 18′ = ________

66° 14′ = ________	10° 15′ = ________
18° 10′ = ________	8° 16′ = ________
Total 2.554	Total .34906

COSINES

To find cosines subtract the angle from 89° 60′ and find the sine of new angle—it will be the cosine desired.

Thus, to find the cosine of 36° 21′ subtract from 89° 60′

36° 21′

53° 39′

Then find the sine of 53° 39′ which will be the cosine of 36° 21′.

TANGENTS

Find tangents on D opposite angles on T in the same way as with sines. Notice T does not read beyond 45°. To find tangents of angles from 45° to 90°; subtract the angle from 89° 60′,—set the new angle on T to 1 D and read the tangent on D under 1 LT.

Tangents between 0° and 45° are between 0 and 1;

Tangents approx. 45° to 64° are between 1 and 2;

Tangents approx. 64° to 72° are between 2 and 3;

Tangents approx. 72° to 76° are between 3 and 4.

Find tangent 73° 27′ (89° 60′—73° 27′) = 16° 33′:

Set 16° 33′ T to 1 RD;

Under 1 LT read 3.37.

TANGENTS OF ANGLES SMALLER THAN 6°

Find all tangents below 6° as if they were sines. Sines and tangents of small angles are very nearly equal.

Exercise No. 2

Find the tangents of the following angles:

Tan. 38° 15′; read direct = ________

Tan. 70° 48′; subtract from 89° 60′ = ________

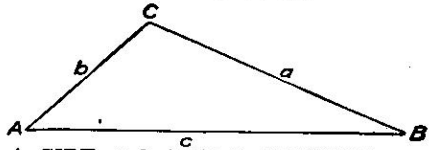
Tan. 2° 12′; same as sine = ________

Tan. 0° 15′; same as sine = ________

Total 3.70076

SOLUTION OF TRIANGLES.

DIAGRAM NO. 24



*(1) Given A SIDE and ANGLE OPPOSITE.

Let A = 41° 23′; B = 22° 43′; a = 83.6. First find (b). See

*Notice—two solutions when 2 sides and angle opposite one of them is given.

Diagram #24.

From trigonometry $\frac{\text{Sin A}}{a} = \frac{\text{Sin B}}{b}$:

41° 23′ S to 83.6 RA;

Over 22° 43′ S read 48.8 on A = b.

From trigonometry $\frac{\text{Sin }(A+B)}{c} = \frac{\text{Sin A}}{a}$: A = 41° 23′, B = 22° 43′; A + B = 64° 06′

179° 60′ − 64° 06′ = 115° 54′

41° 23′ S to 83.6 LA;

Over 64° 06′ S read 113.8 on A. Then C = 115° 54′

c = 113.8*

This example will illustrate method of solving triangles when a side and angle opposite are given.

(2) Given 2 sides and angle between. See Diagram #24.

a = 83.6; b = 48.8; C = 115° 54′.

From trigonometry $\frac{\text{Tan. } \frac{1}{2} (A - B)}{a - b} = \frac{\text{Tan. } \frac{1}{2} (A + B)}{a + b}$; or

$$\frac{\text{Tan. } \frac{1}{2} (A - B)}{34.8} = \frac{\text{Tan. } 32° 03'}{132.4}:$$

Set 32° 03′ T to 132.4 D;

Over 34.8 D find 9° 19′ T = ½ (A — B); note change of index (1 LT to 1 RT);

½ (A — B) = 9° 21′; A — B = 18° 42′; A = 41° 24′; for

$$\frac{(A - B) + (A + B)}{2} = A.$$

(3) Given 3 sides, a, b, c. See Diagram #24.

From trigonometry

$$\text{Sin } \tfrac{1}{2} A = \sqrt{\frac{(s-b)(s-c)}{bc}} \text{ where } s = \tfrac{1}{2}(a + b + c);$$

a = 83.6
b = 48.8
c = 113.8

s = 123.1; s — b = 74.3; s — c = 9.3;

$$\text{Sin } \tfrac{1}{2} A = \sqrt{\frac{74.3 \times 9.3}{48.8 \times 113.8}} = \sqrt{.124} = .353;$$

R to 353 RA; read under R on S, 20° 45′; ½ A = 20° 45′; A = 41° 30′.

Having A we can solve by method of (1).

*Accuracy of 1 in 1100 is too great to expect in this computation; but accuracy of 1 in 110 is about ⅕ that obtainable.

You will see by this explanation that you must know your TRIGONOMETRY in order to solve triangles.

Do not find functions—read and then multiply,—but multiply directly. Thus: 30.1 × Tan. 40° 35′.

1 RT to 301 D; R to 40° 35′ T; ans., 25.8 on D under R.

PART II—CHAPTER IV

LOGARITHMS AND FRACTIONAL POWERS

Suppose you write	1	2	3	4	5	6	7	8	(A);
and	(2)	(4)	(8)	(16)	(32)	(64)	(128)	(256)	(B).

The numbers in line (A) are the logarithms of numbers in line B. You can do some important things with logarithms or logs as they are usually called.

Multiply (2) × (4): add log (2), which is 1
to log (4), which is 2
—
3 Under 3 find answer (8).

Divide (64) by (16):
Subtract from log (64), which is 6
log (16), which is 4
—
2 Under 2 find answer (4).

Cube (4); multiply log (4), which is 2, by 3 = 6; under 6 find (64), answer.

Find the 4th root of (256); divide log (256), which is 8, by 4 = 2; under 2 find (4), answer.

You have then four rules.

(1) To multiply numbers add their logs, and find number corresponding to the sum.

(2) To divide numbers subtract log of one from log of the other, and find number corresponding.

(3) To find powers (squares, cube, etc.) multiply log of number by the power wanted and find number corresponding.

(4) To find roots (square, cube, etc.) divide log of number by the root, and find number corresponding.

You can use these last two rules to find powers and roots.

Between the scales S and T on the slide there is a scale of logarithms. Notice all the spaces are equal and the scale reads from right to left.

COMMON LOGARITHMS

In the common system of logarithms we have the following:

—3	—2	—1	0	1	2	3	4	A.
(.001)	(.01)	(.1)	(1)	(10)	(100)	(1000)	(10000)	B.

Any number then between 10 and 100 has a log between 1 and 2.
Any number then between 100 and 1000 has a log between 2 and 3.
Instead of writing — 1.132, etc., you write — 1 as 9. decimal — 10.
you write — 2 as 8. decimal — 10.

The Manniphase rule will give you the decimal of the logarithms.

You can determine the whole number by inspection.

Place the slide in the rule so S and T are out, but upside down and indices on slide and rule are together.

LOGARITHMS OF NUMBERS

Find the log of 300. It is between 2 and 3.

It will be therefore 2. plus a decimal which you will find on the rule. R to 300 D.

Read answer on middle scale on this slide (see Diagram #25).

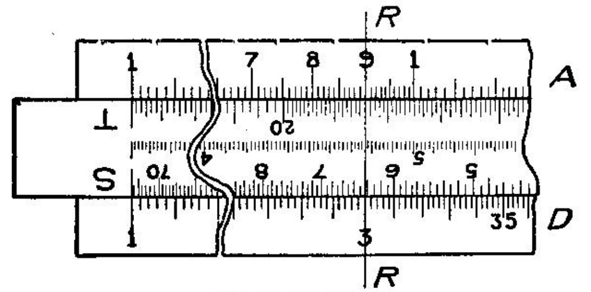


DIAGRAM NO. 25

Answer is 477. Log 300 = 2.477.

Find log of .3; it is between 0 and — 1. It is 9.477-10.

Find log of 3; it is between 0 and 1. It is .477.

Find log of 30; it is between 10 and 100. It is 1.477.

Remember the rule gives you the fraction;—you put down the whole number.

ROOTS AND FRACTIONAL POWERS

(Numbers greater than 1)

Find the fifth root of 87.3:

(1) $(3)^5 = 3 \times 3 \times 3 \times 3 \times 3 = 243$;
$(2)^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$;

Answer is little over 2.

Log of 87.3 is 1 + a decimal.

(2) R to 873 D; answer on log scale under R is .941; log of 87.3 = 1.941.

(3) By rule (4), page 48, divide 1.941 by 5 = .388.

(4) Set R to 388 log scale. Find answer on D under R = 245, and as you have estimated answer is a little over 2, you have 2.45.

You often have to find the 3/2 power of a number. This is the square root of its cube.

Find $(4.37)^{3/2}$:

(1) $(4)^3 = 64$; $\sqrt{64} = 8$, approximate answer. Log 4.37 is 0. + a decimal.

(2) R to 437 D; answer on log scale under R is .640.

(3) Log 4.37 is .640; .640 × 3 = $\frac{1.920}{2}$ = .960.

(4) Set R to 960 log scale. Find answer on D under R, 9.12.

An Alternate Method:

Place slide in rule with B and C out.

Find the log of 300:

(1) Lies between 2 and 3.

(2) To find decimal 1 LC to 300 D.

(3) Read middle scale on back of the rule at etched mark as .477.

(4) Log 300 = 2.477.

This method does not require changing the slide but it is not as accurate as the one first given.

ROOTS AND FRACTIONAL POWERS (Fractions)

Find the 5th root of .742:

(1) $1^5 = 1$; $(.9)^5 = .5$; answer is .9 +.

(2) R to 742 D; read on log scale, 870; log is 9.870 — 10. See A under COMMON LOGARITHMS.

(3) Divide 9.870 — 10 by 5 = 1.974 — 2; add 8 and subtract 8 = 9.974 — 10.

(4) R to 974 log scale; read answer on D under R = 942; pointing off, .942.

Notice in (3) you add 8 and subtract 8. It is advisable to get the log of a fraction in this form before you find the number corresponding.

Find the .405 power of .588:

(1) Square root of .6 = .7 +; cube root of .6 = .8 +; answer is near .8.

(2) R to 588 D; read on log scale .769; log is 9.769 — 10. See A under COMMON LOGARITHMS.

(3) (9.769 — 10) × .405 = 3.956 — 4.05; add 5.95 and subtract 5.95.

$$\begin{array}{rr} 3.956 & -\ 4.05 \\ 5.95 & 5.95 \\ \hline 9.906 & -\ 10 \end{array}$$

(4) R to 906 log scale; read .805, answer.

In finding fractional powers or roots do the work in this order.

(1) Determine decimal point.

(2) Find log.

(3) Multiply by power or divide by root, add and subtract in fractions to get a decimal — 10.

(4) Find number corresponding to the log.

Exercise No. 1

Find the logarithms of numbers given, to 3 decimal places.

8.39 =	______	.839 = 9.	— 10
4.76 =	______	.476 = 9.	— 10
343. =	______	.0343 = 9.	— 10
27.1 =	______	.00271 = 7.	— 10
Total	5.570	Total 38. 570	— 40
		or 8.570	— 10

Exercise No. 2

Find the $\frac{3}{2}$ power of .383. Check by finding the square root of the cube.

Find the $\frac{2}{3}$ power of .237. Check by finding the cube root of the square.

PART II—CHAPTER V

CONSTRUCTION AND SPECIAL SETTINGS

The construction of the slide rule is based on logarithms.

Placing the log scale out, read:

Log 1. = .000;

Log 2. = .301 on C and D; distance from 1 to 2 is log 2;

Log 3. = .477 on C and D; distance from 1 to 3 is log 3;

Log 4. = .602 on C and D; distance from 1 to 4 is log 4.

(1) When you add two distances you add logs, therefore multiply.

(2) When you subtract two distances you subtract logs, therefore divide.

Scales A and B are ½ as long as C and D. Therefore read on A square roots of numbers on D.

Take the simple example $2 \times 3 = 6$:

1 LC to 2 D; R to 3 C; ans. = 6.

Log 2 = .301; + log 3 = .477; = .778 = log 6.

SPECIAL SETTINGS

The following settings will be easily understood if the last paragraph is kept in mind.

MULTIPLYING SQUARES AND SQUARE ROOTS

(1) Type $(K)^2 \times Q$. Example $(3)^2 \times 4$:
M 1 B to 3 D;
R to 4 B;
Answer on A under R = 36.

(2) Type $\frac{(K)^2}{Q}$. Example $\frac{(3)^2}{4}$. Approx. 2:
4 B to 3 D (use runner to set);
Answer on A over 1 B = 2.25.

(3) Type $\frac{K}{(Q)^2}$. Example $\frac{5}{(4)^2}$. Approx. 25:
4 C to 5 A;
Answer on A over 1 B = .313.

(4) Type $\frac{(K)^2}{(Q)^2}$ Example $\frac{(7)^2}{(5)^2}$. Approx. 2:
5 C to 7 D;
Answer on A over 1 B = 1.96.

(5) Type $\sqrt{K} \times Q$. Example $\sqrt{12} \times 3$. Approx. 9.
1 RC to 12 RA;
Answer on D under 3 C = 10.4.

(6) Type $\frac{\sqrt{K}}{Q}$. Example $\frac{\sqrt{15}}{4}$. Approx. 1:
4C to 15 RA;
Answer on D under 1 C = .968.

(7) Type $\frac{K}{\sqrt{Q}}$. Example $\frac{9}{\sqrt{5}}$. Approx. 4:
5 LB to 9 D;
Answer on D under 1 C = 4.02.

(8) Type $\frac{\sqrt{K}}{\sqrt{Q}}$. Example $\sqrt{\frac{13}{7}}$. Approx. 1.5:
7 LB to 13 RA;
Answer on D under 1 C = 1.36.

The Maniphase rule allows one type of setting which is important and should be understood.

(9) To find the square of the product of three numbers, in one setting:

Example

$(3 \times 4 \times 5)^2$

(1) $(60)^2$ is 3600.

4 CI to 3 D;

Answer on A over 5 C is 36.

You should study these settings carefully. They are the basis of special settings on the Maniphase Rule. If you understand the principles of these settings you can make a great many special ones that fit your own work.

Notice: (a) You can multiply or divide by the square, or square root of any number as easily as you can multiply or divide by the number itself.

(b) You can read the square or square root of the answer as easily as you can read the answer itself.

Notice, however, that you must choose scales carefully. If a result falls on A you can find its square root by reading on D. But if a result falls on D you will have to read and reset in order to find the square root.

Take the following example: $\sqrt{\frac{3.18 \times 1.91}{5.2}}$; you must do the problem on A and B in order to read the square root on D.

(1) $\sqrt{\frac{3 \times 2}{5}} = \sqrt{\frac{6}{5}} = 1$ approx.

(2) 52 LB to 318 LA (use runner to set).

(3) Answer on D under 191 LB = 1.08 (use runner to read). If 191 RB were used in (3) you would have answer 342.

Before extracting the square root be sure number falls on proper scale of A.

Notice in this example $\sqrt{9/8} = \sqrt{1+}$, not $\sqrt{10+}$. If you ESTIMATE the answer you will have no trouble for you will use the scale on A which gives you the approx. answer.

Take the following example:

$$\left\{\frac{(1.73)^2 \times 9.1}{2.65 \times 7.91}\right\}^2$$

In order to square the quantity you must do the problem on C — D and read answer on A.

(1) $\left\{\frac{3 \times 9}{3 \times 8}\right\} = 1+$, approx. $1^2 = 1$.

(2) Notice if 1.73 is squared answer will fall on A, so multiply $(1.73 \times 1.73) = (1.73)^2$; 265 C to 173 D; R to 173 C; 791 C to R; over 9.1 C read answer on A = 1.69.

Exercise No. 1

$\frac{\sqrt{9.81}}{3.81}$ = ______

$\sqrt{\frac{7.38 \times 4.53}{66.7}}$ = ______

$\frac{(4.18)^2 \times 1.9}{5.32}$ = ______

Total 7.770

Exercise No. 2

$\frac{(3.36)^2 \times 2.13}{\sqrt{8.8}}$ = ______

$\frac{\sqrt{2.32} \times \sqrt{18.1}}{4.44}$ = ______

$\frac{7.41 \times \sqrt{1.03}}{\sqrt{3.31}}$ = ______

Total 13.70

PART III

FOR ENGINEERS AND TECHNICAL MEN

CHAPTER I

SCOPE OF THE SLIDE RULE IN ENGINEERING WORK

The MANIPHASE SLIDE RULE can be used for purposes of computation in a wide variety of technical and engineering problems. The 10″ rule, if properly used, will consistently give results correct to within $\frac{1}{10}$ of one per cent, that is, to one part in one thousand, or to three and sometimes four significant figures, if scales C and D are used.

A and B give one-half this accuracy.

The rule is founded upon the principle of logarithms and the 10″ rule will give results comparable with those obtained by using a four place table of logarithms.

It is perhaps safe to say that fully one-third the time spent in engineering or technical computations is wasted. This is because of a failure to understand and apply two simple propositions:

(1) No computation based on measurements can increase the accuracy of the original measurement.

(2) No computation should be carried out with greater accuracy than is desired in the result.

In engineering or technical work it is necessary to first decide upon the accuracy desired, then to take the measurements with the required degree of accuracy and then to compute using an accuracy consistent with the requirements and the measurements or the observed data.

It should be understood that great accuracy can be obtained only at great cost, and that from a practical or commercial standpoint it a vital mistake to obtain results with more accuracy that can be used.

One of the reasons why the slide rule is not more widely used is because even technical men do not appreciate the fallacy of very precise computations where the measurements or the data are inaccurate, and where the results cannot therefore be closer than the data warrant.

Take a very simple example as an illustration. Many problems of the engineer are based upon the assumption that a cubic foot of water weighs 62.5 pounds. As a matter of observation.

1 cubic foot of water at 45° Fahrenheit weighs 62.42; and

1 cubic foot of water at 60° Fahrenheit weighs 62.37.

If you have actually to do with water which weighs 62.37 and if we assume it weighs 62.50 you have an original error of 13 parts in 6,000, which is a greater error than would be introduced by slide rule computation.

Note:—The word "accuracy" is used in its popular sense and is synonymous with precision.

When you are computing for commercial rather than scientific purposes the matter is of even greater importance. In general, for estimating and design work the slide rule will give values as close as they can be used.

In computations having to do with design of structural steel, for example, it should be remembered that steel specifications allow a variation of 2½ per cent from areas and weights given in handbooks. It is extremely doubtful if work in brick or concrete can consistently be counted upon to approach an accuracy of one per cent.

Where measurements are taken with instruments of great precision, and where special care is taken in the technique of measurement, you may get an accuracy of one part in 10,000 and in some cases one part in 100,000.

It would, of course, be utterly foolish to use the slide rule for this class of computations although the slide rule is of great value in checking computations made by means of logarithms, or in other ways.

Computations should in all cases be judged both as to accuracy of results desired and accuracy of measurements taken, before rules are laid down as to methods of computation. Needless to say the shortest and cheapest method assuring proper results should be used.

As this question of accuracy is an important one, let us consider another example.

What accuracy would you use in computing the survey of 60 acres of land worth approximately $20 an acre? The owner desires to have a survey made for the purpose of determining his acreage with the object of selling his land.

It is probable that the owner would like an appraisal of his land within say $5. This would call for an accuracy of $5 in $1200 or 1 in 240, or about one-half of one per cent. If the land were worth $200 an acre, five dollars would mean $5 in $12,000 or 1 in 2400.

The operator of the rule, if he is a technical man or an engineer, should see clearly that the matter of accuracy or precision in computation is a PRACTICAL COMMON SENSE QUESTION OF COSTS, and the matter should be considered and judged as such.

Note:—

(1) Accuracy required.

(2) Accuracy of data must be consistent with (1).

(3) Adopt precision of computation so as to give you the results wanted.

PART III—CHAPTER II

ACCURACY AND SPEED IN COMPUTATION

If a problem is to be solved or a computation made using the slide rule, there are a few simple rules which will help to secure ACCURACY AND SPEED.

(1) DO NOT USE THE RULE FOR PRACTICAL WORK UNTIL YOU HAVE LEARNED ITS USE THOROUGHLY.

You must have considerable practice in reading and setting before you can hope to get results accurately and quickly. You must practice until you are SURE of your results. If you have followed the exercises in this book you should be able to work accurately, but great speed will come with more practice.

There are, however, several things which will help in both accuracy and speed, and after you have become familiar with the rule you will see that accuracy and speed are very closely allied, and what helps accuracy helps speed in many cases.

(2) FORM THE HABIT OF ESTIMATING THE ANSWER AND PUTTING IT DOWN.

This is the quickest and surest way to determine the decimal point. In addition it gives you a rough check on your result; but most important of all it forces you to go through the problem mentally step by step which will help you greatly when you come to set the problem on the rule. Do not get the idea that by using the slide rule you do not have to use your head, for you have to use it continually.

Take this example $\sqrt{\dfrac{3 \times 4.14}{5.22}}$.

Let us follow the mental steps which you take to estimate the answer.

(1) 4.14 divided by 5.22 is a little less than 1.

(2) Doing the division first you do not bother with the index.

(3) 3 times 1 is 3 or a little less.

(4) Square root of 3 — is, say 1.15.

(5) To get square root, division and multiplication must be done on A and B.

(6) Put down 1.5.

Then solve the problem.

(1) 522B to 4.14A.

(2) R to 3 LB (set to 3 LB because you want answer on D to be approximately 1.5).

(3) Answer on D under R is 1.543.

(3) ALWAYS USE A AND B IN PREFERENCE TO C AND D WHEN ACCURACY ALLOWS IT.

When you can, use scales A with B. These scales are double and if you are careful you will not have to change indices when using these scales.

(4) DECIDE WHICH INDEX TO USE BEFORE MULTIPLYING ON C AND D.

Much time is lost in multiplication when you find the number you want on the slide falls off the rule. The following rule will help in choosing the proper index. Multiply mentally the first figures of the numbers you wish to multiply on the scales C and D. If the result is less than 10 use the left hand index, if greater than 10 use the right hand index. This rule will suffice in most cases.

8.18 × 1.161; 8 × 1 = 8. Use left index on C.
8.18 × 4.13; 8 × 4 = 32. Use right index on C.

(5) IN CONTINUED MULTIPLICATION AND DIVISION TAKE CARE OF THE ORDER IN WHICH YOU DO YOUR MULTIPLICATION AND DIVISION.

$$\frac{8.33 \times 2.781}{2.121 \times 7.95}$$ Using Scales C and D.

(a) Always divide first.

(b) In dividing choose numbers as nearly alike as possible.

(1) The right way is:
7.95 C to 8.33 D;
R to 2.781C;
2.121 C to R;
Read result on D under 1 C, 1.375.

(2) The wrong way is:
2.121 C to 8.33 D;
R to 1 LC;
1 RC to R;
R to 2.781 C;
7.95 C to R;
Read result on D under 1 C, 1.375.

Notice the difference in speed between the two methods. (1) is not only more quickly done but is more accurate.

(6) MAKE AS FEW SETTINGS AS POSSIBLE.

In solving any particular problem, study the problem so as to arrive at the result with as few settings of the slide and the runner as possible. An extra setting of the slide or the runner not only takes time, but makes the answer less likely to be accurate.

Above all avoid reading and resetting on another scale, if it is possible to do so. Almost all problems can be solved without reading and resetting if you are careful to arrange your procedure properly.

Do not arrange your work so that a change of index is necessary if such a change can possibly be avoided.

A change of index means loss in both speed and accuracy.

(7) LEARN TO USE SCALE CI.

If you are to use the MANIPHASE rule with the greatest speed and efficiency, scale CI should be used consistently. You should learn to set and read scale CI as quickly and as easily as C and D are used.

Form the habit of using (where accuracy will allow) scale D with scale CI in

(1) Multiplication of two factors.

(2) Multiplication of three factors.

Notice that D with CI causes no trouble in choosing indices in multiplying.

In continued multiplication and division be ready to use CI instead of C when a change of index is necessary in using C.

It is of the greatest importance that you understand the use of CI if you wish to be both quick and accurate.

PART III—CHAPTER III

APPLICATIONS TO ENGINEERING FORMULAE

The operator should experience no difficulty in using the rule to obtain the numerical values resulting from substitutions in engineering formulae. There are a few simple principles which in this class of computation will save much time and effort.

ONE FACTOR VARYING (Linear)

It frequently happens that in a formula involving several variables one alone varies in a particular set of problems.

Example

Find the volumes of cones whose bases contain 39.3 square feet and of the following heights 3.87 feet, 4.93 feet and 8.64 feet.

Formula: $V = \frac{1}{3}$ (area of base) $\times$ (altitude).

You might multiply 39.3×3.87 and divide by 3;

And multiply 39.3×4.93 and divide by 3;

And multiply 39.3×8.64 and divide by 3.

It will be simpler to find the value of 39.3 divided by three and by placing the runner successively on 3.87, 4.93, and 8.64, read directly the volume.

You thus form a table so that you can read from volumes of cones (39.3 square feet in base) on one scale to heights on another scale.

(1) $\frac{1}{3}(39.3 \times 3.87) =$ approx. $10 \times 4 = 40$ cubic feet.

3 LB to 39.3 LA;

R to 3.87 B read on A under R 50.7; and

R to 4.93 B read on A under R, 64.6;

R to 8.64 R read on A under R, 113.+.

This is much easier than doing the problems separately. This principle should be used wherever one of the factors changes for a set of computations, the other factors remaining constant. This principle is of very wide application in practical work.

Consider an example in a slightly different form.

ONE FACTOR VARYING (Square)

Example:

Find the value of rivets in single shear, where allowable shearing stress is 7,500 pounds per square inch. Rivets have diameters of ½, ⅝, ¾, ⅞ inches respectively. Value (in pounds per square inch) of one

$$\text{rivet} = \frac{\pi d^2}{4}\,fs.$$

$fs = 7,500.$

$$(1)\ \frac{\pi d^2}{4}\,fs = .785 \times .25 \times 7,500 = 1470 \text{ for } \tfrac{1}{2}'' \text{ rivet.}$$

5 C to 147 RA.

A table is now formed such that if the diameter of rivet is set on C the value of the rivet in pounds per square inch is directly above on A. Using the runner to read between C and A you have over ½ or .5 C 1470 pounds per square inch on A.

Over ⅝" or .625 C—2,300 pounds per square inch, on A.

Over ¾" or .75 C—3,310 pounds per square inch, on A.

Over ⅞" or .875 C—4,510 pounds per square inch, on A.

AREAS

In finding areas of several similar figures, bear in mind that areas of similar figures vary as the square of any corresponding dimension.

If therefore the area of one figure is found, a table may easily be formed to read the areas of similar figures.

Consider a simple example:

Area of a triangle is 18.7 square inches—its base is 4.26 inches.

Find the areas of similar triangles with bases of 3.82, 4.75, 6.27:

Set 4.26 C to 18.7 LA;

Over 3.82 C find 15.0 A;

Over 4.75 C find 23.3 A;

Over 6.27 C find 40.5 A.

This type of setting will be found useful in finding areas of circles, ellipses, parabolic segments, etc.

VELOCITY HEIGHTS

This same principle can be used in formulas where the quantity varying appears squared. A common type is $h = \frac{v^2}{2g}$ and a table of velocity heights may be formed. Application to Hydraulic problems are numerous.

STRUCTURAL (Moment Curves)

The curve of moment on a beam uniformally loaded is a parabola with vertical axis. In problems of structural design it is very important to understand variation as the square and to solve proportions between scales A and C easily and surely. Let us consider a very simple example:

$$(a)\ \frac{3}{x} = \frac{(1)^2}{(2)^2};\ \text{or}\ (b)\ \frac{3}{(1)^2} = \frac{x}{(2)^2}.$$

Set the proportion just as shown above in **(b)**;

1 LC to 3 LA;

Over 2 C find 12 on A. Therefore $x = 12$.

Consider a beam as shown in Diagram #26.

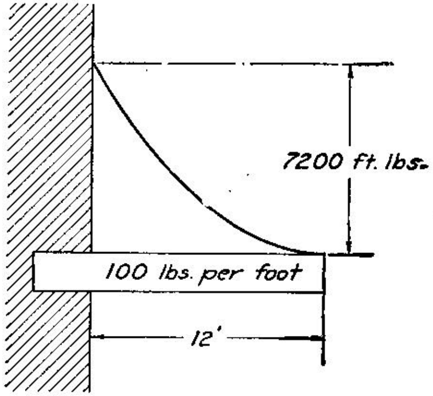


DIAGRAM NO. 26

Beam is 12 feet long loaded with 100 pounds per linear foot.

Moment at face of wall is 7,200 foot-pounds.

Moment at free end is 0.

Moment x at middle of beam is:

$$\frac{7200}{(2)^2} = \frac{x}{(1)^2}; \text{ or } \frac{7200}{(12)^2} = \frac{x}{(6)^2}.$$

2 C to 7200 LA;

Over 1 C find 1800 on A; which is moment 6 feet from the free end of the beam.

Find the moment at distances of 3, 5, 8, 9, 11 feet from the free end of beam.

12 C to 7200 LA;

R to 3 C; read on A, 450 foot-pounds.

R to 5 C (change index); read on A, 1,250 foot-pounds.

R to 8 C; read on A, 3,200 foot-pounds.

R to 9 C; read on A, 4,050 foot-pounds.

R to 11 C; read on A, 6,050 foot-pounds.

This method should be mastered thoroughly and you should be able to set for square variation as quickly as for linear.

You will encounter this same type of setting in finding areas of circles having given diameters, in finding weight of round and square bars, and in many other technical and engineering computations.

ONE FACTOR VARYING (Square Root)

In Hydraulic computations a type of formula of frequent occurrence is $Q = KA\sqrt{h}$:

Where Q is the discharge under head h, and K is a constant, the area of the orifice being A. For water, with circular orifice, $Q = 4.8 \times A\sqrt{h}$.

In the usual case the area of the orifice remains constant and h varies.

Example:

Find the discharge from a circular orifice of area .785 sq. ft. under heads of 2, 2.5, 2.75, 3 ft. $Q = 4.8 \times .785\sqrt{2}$. Result approx. 6.

1 RC to 2 LA;

R to 785 C;

1 LC to R,

Read answer under 48 C on D = 5.33.

For the rest of the values—

Set 2 RB to 5.33 D;

Under heads on B read discharge on D:

R to 2.5 RB; see 5.96 on D.

R to 2.75 RB; see 6.26 on D.

R to 3.0 RB; see 6.52 on D.

(2) This example may be done in another way.

Invert the slide so that scales A and C are in contact.

Set 5.33 on CI under 2 RA;

Read answer 5.96 on CI under 2.5 RA;

Read answer 6.52 on CI under 3.0 RA.

(1) will prove the easiest method for the beginner; (2) has advantages for the operator who is familiar with the rule.

YOU should understand both methods.

VARIATION AS THE CUBE

The volume of similar solids vary as the cube of corresponding dimensions. This furnishes a simple and practical way to determine the volumes of spheres, ellipsoids, cones, etc.

Example

Find the volumes of spheres with diameters of 6.23 feet, 8.42 feet, and 9.37 feet. Volume of a sphere $= \frac{\pi D^3}{6}$.

Let D = 1.

$$V = \frac{\pi}{6} = .524.$$

1 RC to 524 LK;

Under 6.23 C read 127 on K. V approx. $= .5 \times 6 \times 6 \times 6 = 100$;

Under 8.42 C read 313 on K. V approx. $= .5 \times 8 \times 8 \times 8 = 250$;

Under 9.37 C read 431 on K.

A table of spheres has been formed so that by setting the runner to diameters on scale C the volumes can be read on scale K.

Example

A conical hopper depth 5.32 feet contains 37.1 cubic feet. How deep must it be filled if it is to contain 5.3 cubic feet or one-seventh as much?

$$\frac{(x)^3}{5.3} = \frac{(5.32)^3}{37.1}. \text{ Approx. } x = \frac{\sqrt[3]{800}}{40} = 2+.$$

532 C to 37.1 MK;

Answer on C over 5.3 LK = 2.78 feet.

PART III—CHAPTER IV

APPLICATIONS TO ENGINEERING DESIGN

In problems of engineering design the MANIPHASE RULE is of the greatest value. For this reason we will consider the problem at some length.

The problem in design work is that of adapting commercial sizes to computed results, these results having been computed on the basis of the theory underlying the design.

In the design of a wooden, a steel or a concrete beam, for instance, the beam must be of a shape and size such as to offer sufficient resistance to the loads placed upon it and its shape and size must in general be determined by commercial considerations.

The theory of the design is PRACTICALLY LIMITED by the material which is obtainable on the market. Wooden beams come in commercial sizes and it is cheaper to use them than to have pieces sawed to order. Steel is rolled in certain shapes, sizes and weights and these must be used. Concrete beams are limited in width by certain practical considerations. Design therefore is an attempt to practically satisfy the theory.

This problem can in its simplest form be stated thus: Having given a result, to determine what practical factors will give this result. These factors must in most cases conform to commerical standards of quality and quantity.

The examples shown in this chapter are for the purposes of illustration only and are chosen primarily for their simplicity. It is believed that such examples will serve better than ones in more limited fields.

It is to be expected that the operator who reads this chapter has had some experience in making computations in connection with design work. He will readily recognize many ways in which the rule will be of great value in particular cases.

No attempt has been made to cover the whole or any large part of the field of design, but it is believed that this chapter will be suggestive enough to make it worth while.

In work of this kind the Maniphase Rule finds its most general use.

For the purpose of explanation let us consider an extremely simple case of design, in detail. Remember, in engineering design you have two fundamental conditions to meet.

You must

(1) Satisfy the theory.

(2) You must do it economically. (That is, use commercial material.)

Example

Design a cylindrical tank to hold 381 cubic feet of water. Owing to commercial conditions the diameter cannot be greater than 6′ 0″ and the clearance available limits its height to 15.50 feet. Measurements to the nearest tenth of a foot.

The volume of a cylinder is given by the formula $V = \frac{\pi d^2}{4} \times h$:

where d = diameter of the cylinder;
h = height of the cylinder.

$\frac{\pi}{4} = .7854$ (notice mark on RA and RB);

$V = .7854\ d^2h$.

In the above example $381 = .785\ d^2h$;

.785 RB to 381 RA;

Result is 486. on RA over 1 B.

The formula is now in the form

$486 = d^2h$ approx. if d = 10; h = 5.

You wish to find values for (d) and for (h) which satisfy the practical considerations of the problem as well as the theoretical considerations.

d must be less than 6 feet.

h must be less than 16.5 feet.

Put RIB to 486 RA;

RIC is at 6.97 D. Notice 6.97 is the square root of 48.6.

You have on the rule so that you can plainly see it one solution of the equation $486 = d^2h$.

This solution is $486 = (6.97)^2 \times 10$; d however is greater than 6 feet.

RIB is at 486 RA; R to RIB;

9 B to R;

See 735 under RIC on D. Another solution is therefore $486 = (7.35)^2 \times 9$.

Understand exactly what you are doing; squaring 7.35 and multiplying the answer by 9.

This last solution is further from the desired result than the first one obtained. So try

11 LB to R;

Read d (on D under 1 C) = 6.65 (d is still too large).

14 LB to R; h = 14;

d = 5.89 on D. You might therefore make the tank 14′ × 5.9′.

Notice that this tank is larger than is required for the diameter must be expressed in even tenths of a foot.

Try

15 LB to R; h = 15;

d in this case is almost exactly 5.7 feet.

So that all the conditions are met. The tank being 15.0 high and 5.7 feet in diameter.

Notice that R is at 486.

Set slide to number for (h) at runner, you find on D the corresponding (d) under 1 C.

(h)	(d)	$d^2h = 486$
10 B at Runner	6.97 under 1 C	
11 B	6.65 "	
14 B	5.89 "	
15 B	5.70 "	

Check this by substituting in the original formula.

$$V = \frac{\pi \times (5.7)^2 \times 15}{4}$$

4 LB to π A;

R to 5.7 C;

1 RB to R;

Answer on A over 15 B is .382 (check).

This method although given for an extremely simple case in the above example, is of very wide application and can be used constantly in design work.

The engineer will appreciate its value as applied to structural design. It may be used for instance wherever an internal statical moment of a rectangular section opposes an external moment.

For wooden beams $M = \frac{1}{6}\ fbh^2$.

For concrete beams $M = Kbh^2$.

Sometimes the factors form a simple product and you wish to find values for the factors so they may meet commercial conditions.

Example

In designing a truss, a compression member is made up of channels and plates. 25.3 square inches of the sectional area are to be made up of plates.

The plates may vary in thickness by sixteenths from ⅜ to ⅝ of an inch and may be from 16 to 18 inches wide.

The formula is 25.3 = w x t; t = total thickness of plates;
R1CI to 25.3 D w = width of plates;

Under 16 CI find 1.58 on D.

This means a width of 16 inches in plates calls for a total thickness of 1.58 inches.

Read widths on CI under R and total thickness on D under R.

Set R to 17 CI; 1.49 is under R on D.

Instead of setting RCI to 25.3 D, set 16 CI to 25.3 D and read the number of 16ths required on D.

17 CI is under R; 23.8 is under R on D; use 24/16; waste .2.

18 CI is under R; 22.5 is under R on D; use 23/16; waste .5.

16 CI is under R; 25.3 is under R on D; use 26/16; waste .7.

All these show that with widths 16, 17, 18 inches you cannot get plates to come out in even 16ths.

R to 16.5 CI; see on D under R, 24.6; use 25/16; waste .4.

Try 17½ CI; 23.2 is below on D; use 24/16; waste .8.

You see the best design is with a width of 17 inches.

Try 17¼ CI; 23.5 is below on D; use 24/16; waste .5.

A width of 17 inches is therefore best with total thickness of 24/16.

Use therefore 3 ½ inch plates.

This method is applicable to structural design particularly to the design of built up members such as box and plate girders. It may also be used in designing sewers of various sections, and in the design of piping.

Instead of a product the factors may be in the form $\frac{a}{b}$.

Example

Find the diameter and thickness of a steel pipe to stand a pressure of 500 pounds per square inch.

The formula is $\frac{2S}{P} = \frac{d}{t}$;

Where S is safe tensile strength for steel = 8,000 pounds per square inch.

d = diameter of pipe, in inches.

t = thickness of pipe, in inches.

P = pressure in pipe, in lbs. per sq. in.

$\frac{16000}{500} = \frac{d}{t}$;

$32 = \frac{d}{t}$.

Set M 1 B to 32 RA;

Numbers in contact on A and B have 32 for the quotient.

d on A — t on B;

A 32″ pipe would need to be an inch thick;

A 24″ pipe would need to be .75 of an inch thick, etc.;

Set 16 RB to 32 RA;

Now instead of reading decimals of inches on B you may read directly in 16ths of an inch.

A 24″ pipe calls for a thickness of 12/16″. See under 24 A, 12 on B.

For a good design you want a thickness of from ⅜″ to ⅝″ and the pipe of a commercial size, say 6″, 8″, 10″, 12″, 15″, 18″, 24″;

Over 9/16″ on B find an 18″ pipe on A;

An 18 inch pipe 9/16 inches thick will be safe against bursting at a pressure of 500 pounds per square inch.

You have really formed a table for pipes under 500 pounds pressure.

On A you read the diameter of the pipe in inches.

On B you read the thickness of the pipe in 16ths of an inch.

You can tell by glancing at the rule whether any pipe in question is safe.

The principles in this Chapter are of very wide and general application. Every engineer and technical man should appreciate the scope of the rule in problems of design.

PART IV

TABLES AND EQUIVALENT RATIOS

CONVERSION RATIOS ON BACK OF THE RULE

You will notice on the back of the rule proportions which can be used to change from one kind of units to another kind.

To change U. S. Gallons to pounds of water you find on the back of the rule the proportion U. S. Gallons : lbs. water = 3 : 25.

This means:—

(1) 3 Gallons equals 25 pounds of water.

(2) 1 Gallon therefore equals about 8 pounds.

If you set 3 C to 25 D you can read gallons on C and pounds on D.

Under any number of gallons on C you will find its equivalent in pounds on D.

Set 3 C to 25 D;

Under 3 C or under 3 gallons we find 25 pounds on D;

Under 4 C or under 4 gallons we find 33.3 pounds on D;

Under 5 C or under 5 gallons we find 41.7 pounds on D.

The ratios on the back of the rule are the ones in most common use and are given in condensed form. Other settings will be given in this chapter. They will be stated in a little different form, but the principles here stated apply just as directly to the ratios on the back of the rule as they do to the settings given in this division of the book.

THE RULE USED AS A TABLE

You can by making the settings given in this Part makes the rule into a table so that you can directly read from it values desired. One of the most practical uses of the rule is to convert one kind of units into another. In finding areas, volumes and weights in most cases, a setting can be made and a table formed so that values may be read directly, without setting the slide each time.

These settings are given in the simplest form, on the scales which will secure the greatest accuracy.

Take for an example the changing of inches to decimals of a foot, or the changing of decimals of a foot to inches.

By making the proper setting you form two tables at once and you can read inches under decimals of a foot or decimals of a foot over inches.

The setting is given in this form:

(1)	(2)	(4)	(3)	(5)
Inches	C	12	300	1
Foot decimals	D	1	25	.0833

(1) Shows the units to be changed.

(2) Shows the scales used to make the setting (this case, C and D).

(3) Shows the numbers to set (this case 300 C to 25 D).

(4) Shows number of inches in 1 foot.

(5) Shows number of feet (decimals of a foot) in 1 inch.

To form the table—

Set 300 C to 25 D;

Now all numbers on C mean inches, and all numbers on D mean decimals of a foot.

You see 12 C over 1 D or (reading) 12 inches equals one foot.

You see 833 under 1 C or (reading) 1 inch equals .0833 feet.

Notice that (4) and (5) will show you where to place the decimal point.

Change .438, .762, .156, .823 ft. to inches.

See setting:

Inches	C	12	300	1
Foot decimals	D	1	25	.0833.

(1) Set 300 C to 25 D (using runner).

(2) Check by reading 12 C over 1 D.

(3) R to .438 D read on C, 5.26.
R to 7.62 D read on C, 9.14.

See by setting 1 ft. = 12 in., that is, .5 ft. = 6″ so decimal point is fixed.

R to .156 D; read on C, 1.87.

R to .823 D; read on C, 9.88.

If decimal of a foot is greater than .833 notice that you must change index. You can tell this in advance, for setting shows 1 C over 833 D and 1 D under 12 C.

It is just as easy to set runner to numbers of inches on C and read decimals of a foot on D, which changes inches to decimals of a foot.

Sometimes a table is formed by setting C on A (using the runner to set) and reading results on A over numbers on C.

As an example: Form a table of areas of circles for any diameter; and together with it a table of diameters, having given the areas.

Setting is:

Area of circle........A	1	38	.785
Diam. of circle.......C	1.13	22	1

Set 22 C to 38 LA (to utilize as much of slide as possible);

Read areas on A and diameters on C.

Setting shows if area of circle is 1, diameter = 1.13 and if the diameter is 1 the area is .785. This is, of course, enough to fix the decimal point.

Example: Find the areas of circles whose diameters are 3.58″, 4.62″, .983″, 114.4″.

22 C to 38 LA;

R to 358 C; find under R on A, 10.07 square inches;

R to 462 C; find under R on A, 16.8 square inches;

R to 983 C; find under R on A, .759 square inches;

R to 114.4 C; find under R on A, 10300. square inches.

(1)

LENGTHS AND AREAS (Geometry)

Circumference of circle.....................C	1	22	3.1416
Diameter of circle.........................D	.318	7	1
Side of square..............................C	1	212	.707
Diagonal of square........................D	1.41	300	1
Area of circle...............................A	1	38	.785
Diameter of circle.........................C	1.13	22	1
Diameter of circle.........................C	1.41	300	1
Side of inscribed square ....D	1	212	.707

(2)

COMMON OR ENGLISH LENGTHS TO METRIC

(Meters, etc.)

Inches C	.0394	5	1
Millimeters ....D	1	127	25.4
Yards C	1.094	35	1
Meters ....D	1	32	.914
Feet C	3.28	82	1
Meters ....D	1	25	.305
Miles C	1	23	.621
Kilometers ....D	1.609	37	1

(3)

SQUARE MEASURES OR AREAS

Square inches C	.155	62	1
Square centimeters ....D	1	400	6.45
Square yards C	1.196	61	1
Square meters ....D	1	51	.836
Circular mils C	1.27	79	1
Square mils ....D	1	62	.785
Square feet C	10.76	140	1
Square meters ....D	1	13	.0929
Square miles C	.386	56	1
Square kilometers ....D	1	145	2.59
Acres C	2.47	42	1
Hectares ....D	1	17	.405

(4)

VOLUMES OR CUBIC MEASURE

Cubic feet	C	.1337	25	1
U. S. Gallons	D	1	187	7.48
Cubic inches	C	1	36	.0610
Cubic centimeters	D	16.39	590	1
Cubic yards	C	1.308	400	1
Cubic meters	D	1	306	.765
U. S. Gallons	C	.264	65	1
Liters	D	1	246	3.79
Cubic inches	C	231	6000	1
U. S. Gallons	D	1	26	.00433
U. S. Gallons	C	1.201	6	1
Imp. Gallons	D	1	5	.833
Cubic feet	C	.0353	6	1
Liters	D	1	170	28.3
Quarts	C	1.057	300	1
Liters	D	1	284	.946

(5)

WEIGHTS

Ounces Av.	C	1.097	90	1
Ounces Troy	D	1	82	.912
Tons (short)	C	1.120	65	1
Tons (long)	D	1	58	.893
Tons (long)	C	1	187	.984
Tons (metric)	D	1.016	190	1
Ounces Av.	C	.0353	6	1
Grams	D	1	170	28.3
Pounds	C	2.205	97	1
Kilos	D	1	44	.454
Tons (short)	C	1.102	300	1
Tons (metric)	D	1	272	.907

(6)

WEIGHT OF VOLUMES (Water)

Cubic feet of water	C	.0160	5	1
Weight in pounds	D	1	312	62.4
Cubic feet of water	C	.0353	6	1
Weight in kilos	D	1	170	28.3
U. S. Gallons of water	C	.120	6	1
Weight in pounds	D	1	50	8.33
U. S. Gallons of water	C	.264	28	1
Weight in kilos	D	1	106	3.79

(7)

VELOCITIES

Feet per second	C	1.467	22	1
Miles per hour	D	1	15	.682
Feet per minute	C	1	264	88
Miles per hour	D	.0114	3	1

SETTINGS FOR CONVERSION OF PRESSURES

Pressure conversion tables are of great importance in technical computations of all kinds. These settings will make it possible to duplicate conversion tables involving pressures.

Pounds per sq. in.	C	1	168	.491
Inches of Mercury	D	2.04	342	1
Pounds per sq. in.	C	14.70	485	1
Atmospheres	D	1	33	.068
Pounds per sq. in.	C	1	13	.434
Feet of water	D	2.31	30	1
Pounds per sq. in.	C	13.89	250	1
Tons per square foot	D	1	18	.072

Atmospheres to Pounds per sq. in.—see just above.

Atmospheres	C	1	18	.0295
Feet of water	D	33.9	610	1

Inches of mercury to pounds per sq. in. See above.

Inches of mercury	C	1	30	.882
Feet of water	D	1.133	34	1

Feet of water to inches of mercury, pounds per sq. in., and atmospheres; see above.

Atmospheres	C	1	274	.0334
Inches of mercury	D	29.9	8200	1
Atmospheres	C	1	85	.944
Tons per sq. foot	D	1.059	90	1

Inches of mercury to atmospheres. See above.
Tons per sq. foot to pounds per sq. in. and atmospheres. See above.

Feet of water	C	1	1700	32.1
Tons per sq. foot	D	.0312	53	1

METHOD OF COMPUTING A SETTING

Suppose a table is wanted, a setting for which is not given here. The setting is easy to find by combining given settings.

Suppose you wish to change Tons per square foot to inches of mercury.

See from above, .072 tons per square foot = 1 pound per square inch.

See from above, 2.04 inches of merucry = 1 pound per square inch.

Therefore .072 Tons per sq. foot is equivalent to 2.04 inches of mercury.

Set to $\frac{72\ C}{2040\ D}$ and $\frac{\text{read}}{\text{over}}$ $\frac{\text{tons per square foot on C}}{\text{inches of mercury on D}}$.

Note 1 inch of mercury = .0353 tons per square ft.
1 ton per sq. foot = 28.3 inches of mercury.

Complete setting would be:—

Tons per sq. foot	C	1	72	.0353
Inches of mercury	D	28.3	2040	1

DISCHARGE (Water)

Cubic feet per second	C	.00223	4	1
Gallons per minute	D	1	1795	449
Gallons per minute	C	15.85	840	1
Liters per second	D	1	53	.0631

STRUCTURAL TABLES

The slide rule may be used for forming tables of areas, weights, etc., of round and square bars. Such tables are of use in structural and other estimating and design work.

SQUARE BARS

Use runner to set:

Areas of bars in square inches	RA	.0039	4	.1
Thickness of bars in 16ths of inches	C	1	32	5.06
Weight of iron bars 1 ft. long in lbs.	RA	.0131	13.5	1
Thickness of bars in 16ths of inches	C	1	32	8.75

ROUND BARS

Circumference of bars in inches	C	.196	6.28	1
Diameters of bars in 16ths of inches	D	1	32	5.09
Areas of bars in square inches	A	1	π	.00307
Diameters of bars in 16ths of inches	C	18.1	32	1
Weight of iron bars 1 ft. long in lbs.	RA	.0102	10.5	1
Diameter of bars in 16ths of an inch	C	1	32	9.9

Example

In explanation of the use of these settings, take the following example:

Find the areas, and weights per foot, of round iron bars of the following diameters: 9/16", 5/8" and 1 3/16".

Use the two tables immediately preceding:

(1) Reduce diameters to 16ths of inches. 9, 10 and 19.

(2) To find areas set 32 C to π A. (Notice—18/16 gives an area of 1 square inch.)

Set R to 9 C; R to 10 C; R to 19 C;

Read on A .249 sq. in., .307 sq. in., 1.11 sq. in.

(3) To find weights set 32 C to 10.5 RA. (Notice—9.9/16 gives a weight of 1 pound.)

Set R to 9 C; R to 10 C; R to 19 C;

Read on A .83 pounds, 1.02 pounds, 3.70 pounds.

STEEL AND OTHER METALS

On the back of the rule will be found numbers giving the ratio of the weights of other metals to iron.

If copper is the material, notice on the back of the rule that copper weighs 550 pounds per cubic foot, and that to reduce to copper it is necessary to multiply the results for iron by 1.15; for steel the multiplication is 1.02.

TABLES

You should understand that when using the slide rule it is necessary to use very few tables. You can in nearly all cases use the rule in place of a table.

It is of advantage, however, in many kinds of estimating and design work to be able to change from numbers involving inches and common fractions of an inch to decimal fractions of an inch, without using the rule.

It is also convenient to change from inches and fractions to decimals of a foot. An example will illustrate this.

Example

Find the number of cubic feet of material in a wall 10' 8½" high × 23' 11" long × 1' 1" thick.

(1) Reduce 8½", 11", 1" to decimals of a foot (using the rule); you then have

(2) 10.71 × 23.9 × 1.083.

(3) Reset and multiply the numbers.

It is EASIER to find the fractions from Table II and then multiply.

TABLE I

FRACTIONS OF INCHES TO DECIMALS OF INCHES

Fraction	Decimal	Fraction	Decimal	Fraction	Decimal	Fraction	Decimal
1/64	.0156	17/64	.266	33/64	.516	49/64	.766
1/32	.0313	9/32	.281	17/32	.531	25/32	.781
3/64	.0469	19/64	.297	35/64	.547	51/64	.797
1/16	.0625	5/16	.313	9/16	.563	13/16	.813
5/64	.0781	21/64	.328	37/64	.578	53/64	.828
3/32	.0938	11/32	.344	19/32	.594	27/32	.844
7/64	.1094	23/64	.359	39/64	.609	55/64	.859
⅛	.125	⅜	.375	⅝	.625	⅞	.875
9/64	.1406	25/64	.391	41/64	.641	57/64	.891
5/32	.1563	13/32	.406	21/32	.656	29/32	.906
11/64	.1719	27/64	.422	43/64	.672	59/64	.922
3/16	.1875	7/16	.438	11/16	.688	15/16	.938
13/64	.203	29/64	.453	45/64	.703	61/64	.953
7/32	.219	15/32	.469	23/32	.719	31/32	.969
15/64	.234	31/64	.484	47/64	.734	63/64	.984
¼	.25	½	.5	¾	.75	1	1.000

Table I needs no explanation.

TABLE II

INCHES AND FRACTIONS TO DECIMALS OF A FOOT

	0″	1″	2″	3″	4″	5″
0	.0	.0833	.1667	.250	.333	.417
1/16	.0052	.0885	.1719	.255	.339	.422
1/8	.0104	.0937	.1771	.260	.344	.427
3/16	.0156	.0990	.1823	.266	.349	.432
1/4	.0208	.1042	.1875	.271	.354	.438
5/16	.0260	.1094	.1927	.276	.359	.443
3/8	.0312	.1146	.1979	.281	.365	.448
7/16	.0365	.1198	.203	.287	.370	.453
1/2	.0417	.1250	.208	.292	.375	.458
9/16	.0469	.1302	.214	.297	.380	.464
5/8	.0521	.1354	.219	.302	.385	.469
11/16	.0573	.1406	.224	.307	.391	.474
3/4	.0625	.1458	.229	.313	.396	.479
13/16	.0677	.1510	.234	.318	.401	.484
7/8	.0729	.1562	.240	.323	.406	.490
15/16	.0781	.1615	.245	.328	.412	.495

	6″	7″	8″	9″	10″	11″
0	.500	.583	.667	.750	.833	.917
1/16	.505	.589	.672	.755	.839	.922
1/8	.510	.594	.677	.760	.844	.927
3/16	.516	.599	.682	.766	.849	.932
1/4	.521	.604	.688	.771	.854	.938
5/16	.526	.609	.693	.776	.859	.943
3/8	.531	.615	.698	.781	.865	.948
7/16	.537	.620	.703	.787	.870	.953
1/2	.542	.625	.708	.792	.875.	.958
9/16	.547	.630	.714	.797	.880	.964
5/8	.552	.635	.719	.802	.885	.969
11/16	.557	.641	.724	.807	.891	.974
3/4	.563	.646	.729	.813	.896	.979
13/16	.568	.651	.734	.818	.901	.984
7/8	.573	.656	.740	.823	.906	.990
15/16	.578	.662	.745	.828	.912	.995

Notice in these tables that it is a very simple matter to find the value of 32nds and 64ths of an inch if it is desired to do so.

Notice the difference for 1/16 is .0052.

Therefore for 1/32 the difference is .0026.

Therefore for 1/64 the difference is .0013.

Therefore for 3/64 the difference is .0039.

Example

Find decimal of a foot corresponding to 1 23/32″.

Read on Table II, 1 22/32″ or 1 11/16″ = .1406′; add .0026′ = .1432′.

Example

Find decimal of a foot corresponding to 39/64″.

Read on Table II, 36/64″ or 9/16″ = .0469′; add for 3/64″, .0039′ = .0508′.

Contents—Part 1—Introduction and Commercial Work

Contents—Part II—For Students in High Schools and Colleges

Contents—Part III—For Engineers and Technical Men

Contents—Part IV—Tables and Equivalent Ratios