A practical treatise on the sliding rule

A

Practical Treatise

ON THE

SLIDING RULE:

IN TWO PARTS.

Part the First being an Introduction to the Use of the Rule generally as adapted for CALCULATIONS that usually occur to Persons in Trade.

Part the Second containing Formulæ for the Use of SURVEYORS, ARCHITECTS, CIVIL ENGINEERS, and SCIENTIFIC GENTLEMEN.

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THE two late Acts of Parliament for regulating WEIGHTS and MEASURES, make an alteration necessary in *all* measures of capacity, in the United Kingdom, on the first of January 1826; these alterations in the size of the measures, require a corresponding change in the formulæ of the *Sliding Rule.*

The following list of errata, will enable any person to correct the formulæ, and fit it for the new measures, with the same simplicity and accuracy as to the former measures.

Page 16	Formula 5		for $\frac{10}{8}$	read $\frac{9}{7}$
19	Formula 3		for $\frac{10}{6}$	read $\frac{18}{11}$
24	Formula 3		for $\frac{49}{8}$	read $\frac{25}{4}$
30	Formula 3		for 16.79	read 16.65
	Formula 4		for 41.7	read 42.4
	Cancel 5 & 6			
31	Formula 1		for 46.37	read 47.10
	Formula 2		for 5.47	read 5.3
	Cancel 3 & 4			
	Formula 7		for 18.95	read 18.79
	Formula 8		for 26.2	read 26.6
32	Cancel 1 & 2			
	Formula 3		for 52.32	read 53.14
	Formula 4		for 3.44	read 3.33
	Cancel 5 & 6			

Page 69 line 10			for 23.5 / 82 Gall.	read 23.1 / 83.3 Gall.
71	Formula	1	for $23\frac{1}{2}$	read $23\frac{1}{4}$
	Formula	2	for 27.1	read 27.6
	Formula	6	for 235	read 232
91	Formula	1	for $\frac{15}{44}$	read $\frac{1}{3}$
	Formula	2	for $\frac{47}{46}$	read $\frac{91}{90}$
	Formula	3	for $\frac{47}{70}$	read $\frac{2}{3}$
93	Formula	2	for $\frac{22}{19}$	read $\frac{16}{14}$
	Formula	3	for $\frac{8}{37}$	read $\frac{2}{9}$
	Formula	4	for $\frac{176}{5}$	read $\frac{182}{5}$
94	Formula	4	for $\frac{17}{16}$	read $\frac{14 \text{ Irish}}{11 \text{ Imper}^{l}\text{.}}$

101 line 7 for 46.37 and 52.33 read 47.10 and 53.14

line 8 for 16.40 and 18.50 read 16.65 and 18.79

line 9 for 16.79 and 18.95 read 16.65 and 18.79

line 10 for 15.19 and 17.15 read 16.65 and 18.79

PREFACE.

The Sliding Rule is an instrument of general utility, for all purposes of expeditious calculations; and it may be said, that few instruments require less time and application for attaining a sufficient knowledge of their principles, to enable any person of common education to become able to resolve all questions in common arithmetic with great ease and despatch: a few hours' attention is sufficient to instruct a common schoolboy in the use of the Rule, for the usual questions that occur in common business; after which the progress is perfectly easy, to that of the more refined calculations required by the professional gentleman and man of science.

I presume, it has hitherto been considered a matter of *difficulty* to acquire a knowledge of the ready use of the Rule; and this consideration has prevented persons engaged in the common pursuits of life from using so valuable an instrument; and I trust I may, without vanity, claim a small portion of public approbation, for the simple and ready method I have adopted, in explaining the mode of applying the Sliding Rule to purposes of calculations.

Eighteen years' practice in the use of this instrument, in very extensive public undertakings, and in teaching its use to a number of young persons, has proved the superiority of my method over any former. It will also be found, that in addition to the greater clearness and facility of expressing and rendering plain the use of the Rule, may be mentioned the conciseness of the space necessary to express the formulæ, whereby a person may copy on a small piece of paper, for his pocket-book, the rules and examples suited to his own business or pursuits, without the incumbrance of a special book for that purpose. It frequently happens that calculations are required in the field, or in the market, or fair, when persons even of considerable practice are liable to great mistakes, from the shortness of time allowed to perform the work in; but by a person in a very small degree acquainted with the use of the Rule, these mistakes may be avoided and much time saved.

It is not necessary to enumerate all the particular professions and trades that would be assisted by the use of the Slide Rule, but there are few that would not occasionally be much assisted by it; amongst others, the following may be named alphabetically, viz. *Accountants*, *Appraisers*, *Architects*, *Astronomers*, *Auctioneers*, *Barge and Boat Builders*, *Brewers*, *Bricklayers*, *Brokers*, *Builders*, *Cabinet Makers*, *Carpenters*, *Chemists*, *Coach Makers*, *Coopers*, *Copper-smiths*, *Corn Dealers*, *Drapers*, *Druggists*, *Dyers*, *Engineers*, *Glaziers*, *Grocers*, *Ironmongers*, *Land Surveyors*, *Linen Drapers*, *Mechanists*, *Merchants*, *Military Officers*, *Mill-wrights*, *Sawyers*, *Schoolmasters*, *Ship Builders*, *Statuaries*, *Stonemasons*, *Surveyors*, *Timber Dealers*, *Watch-makers*, *Wheelwrights*, and all persons having calculations to make either in money, weights, or measures. Persons having logarithmic calculations to make will find the aid of the Sliding Rule highly useful in proportioning the differences, or giving the inferior parts, either in sexagesimals or decimals. A few examples will be found in the following pages, to render more obvious the advantages of an acquaintance with the Rule. The object of the present publication is to comprise as much useful matter, in a small compass, as will be consistent with perspicuity; for this reason, a more extended preface would be a departure from the intention of the Author.

INTRODUCTION.

THE first requisite, in the practical use of the Rule, is to learn the *notation*, or the signification of the divisions and figures on the several lines of the Rule. For this purpose it will be necessary for the person to have before him a *Rule*, with its several divisions, to inspect and refer to. As it is known that there are some varieties in the form of sliding Rules now sold, although in general they are constructed on similar principles, and will in most cases answer the same purpose, yet it may give less trouble to the learner if I adopt the *common twelve inch Rule*, having four lines of divisions upon its face, and which, for the purpose of reference, are generally marked with the letters A. B. C. D. at one end; the lines A and D being generally upon the *stock* or Rule, and the lines B and C upon the *slide*. It will be seen that the lines marked A, B, and C, are similar, and have their divisions and figures alike, consisting of two series, viz.

1 2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10

and that the line marked D has but one series or set of figures, viz.

1 2 3 4 5 6 7 8 9 10

the divisions or spaces on which are exactly double in extent of those on the preceding lines, and as they occupy the same extent, are but half the number. This line, marked D, is often called the *square line*, because it is used in calculations involving the square of one of the dimensions; by others, it is called the girt line; but it will be more proper to call it the *line of single radius;* the lines marked A, B, and C, may then be called lines of double radii.

It may be right to observe, that the figure 1, at the beginning on the left hand end of the scale, may be considered as 1, or unit, and in this case the other figures will follow as they are stamped upon the scales; the divisions between the figures will be tenths, or decimals.

When any question requires more than two figures to express it, for instance, if a greater number than 100 is to be used, the first figure on the Rule may be considered as 100 or 1000, &c. keeping in mind this simple rule, that the other figures and divisions *on the same line* are to be proportional.

Thus, if the first figure be called 10, the second will represent 20, the third stand for 30, &c. and the divisions will be counted as units.

On the lines A, B, and C, which have *double radii*, the second series of numbers and divisions will of course represent ten-fold the first series: thus, in the last example, where the figures on the first radius are made to stand for 10, 20, 30, &c. the figures on the second radius will stand for 100, 200, 300, &c. After this manner may figures large enough for any practical sum be considered on the Rule; and in this case the second series must of necessity be considered as 100, 200, 300, and not have any arbitrary meaning attached to them: thus, it would not be proper to call the first series 100, 200, 300, &c. and in the same operation call the second series 10,000, 20,000, 30,000, because you will thereby disturb the due proportion between the said figures; it being essential that the figures on the *same line* should maintain a *regular and uniform progression.*

This uniformity of progression of the series of figures applies only to the *same line*, and not to different lines on the same Rule; for example, if on the line marked A we call the series 100, 200, 300, &c. it does not follow that the line marked B, although used in the same calculations, should be of the same proportionate value with those on A, PROVIDED all the figures on the line B are but esteemed in the same uniform progression *among themselves:* thus, although the figures on the line A may be called 10, 20, 30, &c. those on the line B may be considered 1000, 2000, 3000, &c. if the question should require such high numbers, which is seldom the case.

In regard to the numbers on the line C and D, when used together, the person using them will soon discover, that a certain proportion must be maintained in their application.

The above will be sufficient to explain generally the notation, or reading of the figures. The next thing to become acquainted with will be the *divisions* on the lines, which will be explained in one general way, as applicable to all the lines upon the Rule, and is as follows:

Assuming that the figures are made to stand for 10, 20, 30, &c. it will follow, from the least reflection, that the prime subdivisions between the said numbers must stand for units; and if the figures on the lines represent 100, 200, 300, &c. the prime divisions must of course signify tens, always having a decimal proportion to those of the long or figured divisions.

A few examples will serve to make the above precepts understood.

Taking, in the first place, the lines lettered A and B, draw out the slide B to the right hand, until the figure 1 is immediately under figure 3 on the line lettered A; the following proportion will be exhibited among the *numbered*, or *figured divisions:*

A	3	6	9	30	60	&c.
B	1	2	3	10	20	&c.

It will be observed, that there are several figured divisions on the two lines not coinciding with figured divisions on the alternate lines, as in the following expressions, which will serve as examples to explain the signification of the primes and subdivisions; thus,

A	3	12 p	15 p	18 p	21 p	24 p	&c.
B	1	4	5	6	7	8	&c.

Those marked with the letter p will be found among the prime divisions. Also, by the same set of the slide, will be read,

A	3	4	5	7	8	&c.
B	1	1.33	1.66	2.33	2.66	&c

Taking the same set of the slide, but assuming a different *proportion* between the first pair of divisions on the two lines, they may be read as follows:

A	3	6	9	12 p	15 p	18 p	21 p
B	10	20	30	40	50	60	70

A few exercises of this kind will enable any person to become familiar with the use of the Rule, and with my method of description, as distinguished from that in all the published books on this subject. I consider the simple figurative representation of the different lines, but little incumbered with literal explanation, as the characteristic merit of the present treatise; not only as the speedy means of teaching the use of the Rule, but also in the comparative suitability of expression for all practicable formulæ, and for its universal application to the business of common life. The simplicity and universality of the mode renders it almost essential to the man of business, and bears the same proportion to the practice of calculations by former methods, as that of algebraic formulæ does to the literal rules given in vulgar arithmetic.

As the whole requisite instruction for the complete use of the Rule depends upon one simple principle, it probably will not be thought a waste of time in any person to bestow a few hours in learning this simple point, upon which the whole is rendered plain. I will therefore take another example, and present it under a few modifications.

Draw out the *slide* lettered B | / C | until 1 upon the line B coincides with 4 upon the line A, and the respective divisions that meet may be read as follows:

A |	4	8	12^{p}	16^{p}	20 &c.
B |	1	2	3	4	5 &c.

In this example the 12 and 16 on the line are not *figured* divisions, but among the prime subdivisions.

The same set of the slide being preserved, the reading of the figures and divisions may be,

A |	40	60	80	100	120^{p}	140^{p} &c.
B |	1	$1\frac{1}{2}^{p}$	2	$2\frac{1}{2}^{p}$	3	$3\frac{1}{2}^{p}$ &c.

Still keeping the same set, the reading may be,

A |	4	5	6	7	8	10	20 &c.
B |	100	125	150	175	200	250	500 &c.

In all the above examples, it will be found that the *relative value* of the figures and divisions on each separate line is the object to be attended to.

An example or two on the lines C, and D, may further illustrate the case.

When the first division on the line C coincides with the division numbered 1 on the line D, the figures may be read as follows:

C |	1	4	9	16	25	36	49 &c.
D |	1	2	3	4	5	6	7 &c.

On the common two feet carpenter's Rule, the first figured division on the line D is marked 4, the others increasing up to 40; this has been done to render calculations of the content of timber less difficult, to persons generally using the instrument for that purpose. The better sort of calculating Rules have the first figured division on the line D numbered 1; but supposing the lines placed as above directed, the figures on the line C, will be found the common square numbers to the figures on the line D, and will hereafter be expressed in the general formulæ; thus,

C	1	power
D	1	square root

signifying, when 1 on C is upon 1 on D, that any power on C will have its square root on D.

The same thing will apply to the said lines, if the first divisions have a different value put upon them, provided the number on C is equal to the square of the coinciding number on D; thus,

C	100	144	225	324	400 &c.
D	10	12	15	18	20 &c.

The same, on the other hand, may apply decimally; thus,

C	.01	.04	.09	.16	.49 &c.
D	.1	.2	.3	.4	.7 &c.

To persons acquainted with logarithms, it will not be necessary for me to offer any explanation, further than to state, the divisions upon the Rule are simply the logarithmic numbers, laid down from a scale of equal parts, as will be further illustrated in the second part of this Treatise.

GENERAL FORMULÆ,

WITH

EXAMPLES.

MULTIPLICATION.

A	multiplicand	product
B	1	multiplier

and is thus explained.

In this formula the *line* represents the divisions between the double radius marked A upon the stock, and the double radius marked B on the upper edge of the slide, and is to be read as follows: Unit upon B, under the multiplicand upon A; then over the multiplier upon B, will be found the product upon A.

Example I. Let it be required to multiply 17 by 5, referring to the general form for multiplication above, and substituting the figures for the particular case, it will stand thus:

A	17	85 answer
B	1	5

or, 1 upon B under 17 upon A, over 5 upon B, is the product 85 upon A.

Example II. Multiply $3\frac{1}{2}$ by $7\frac{1}{2}$.

A	3.5	$26\frac{1}{4}$ answer
B	1	7.5

Place unit on B under the fifth division between 3 and 4 upon A, then over the fifth division between 7 and 8 upon B, will be the answer $26\frac{1}{4}$ upon the line A; or according to the decimal divisions of the Rule 26.25.

DIVISION.

Rule.

A	quotient	dividend.
B	1	divisor.

and it is to be understood as follows: under the dividend upon the line A, place the divisor, upon the line B; then over unit, on the line B, will be found the quotient, or answer upon the line A.

Example I. Let it be required to divide 135 by 5.

A	27 answer	135
B	1	5

that is, draw out the slide until 5 on the line B corresponds with the middle of the space between 130 and 140, upon the line A; then over unit, upon the line B, will be the answer 27.

Example II. Divide 84 by $3\frac{1}{2}$.

A	24 answer	84
B	1	$3\frac{1}{2}$

that is, place the middle division between 3 and 4, on the line B, under the fourth division between 8 and 9, upon the line A; then over unit, on the line B, will be the answer 24, on the line A.

DIRECT PROPORTION,
OR
RULE OF THREE.

Rule.

A	second term	fourth term.
B	first term	third term.

Example I. If 4lb. cost 10*d.* what will 32lb. cost?

A	10	80*d.* or 6*s.* 8*d.* answer.
B	4	32

Place 4 on B, under 10 upon A; then over 32, on B, will be 80, the answer on A.

Example II. If a quarter of wheat cost 72*s.* how much per sack of 5 bushels?

A	45*s.* answer	72*s.*
B	5 bushels	8 bushels.

That is, place 8 on B, under 72 on A; then over 5 on B, will be the answer, 45*s.* upon A. It may be right to observe, in this place, that occasionally the proper number in the order of progression on the line B, may be so far drawn out, as not to have any part of the line A in contact; in such cases, the value of the numbers, both on the line B, and also on the line A, may be increased tenfold, whereby the left hand numbers may be adopted as substitutes for those required on the right hand.

Example III. If 2 will give 9, what will 30 yield?

A	9	135 answer
B	2	30

In this case, the proper 30 is on that part of the slide drawn out of, and beyond the stock, and the 3 considered as 30 in lieu.

INVERSE PROPORTION

Is most readily performed by drawing out the slide with the lines B and C, and returning it in an *inverted position:* in this case, the line marked C, will be in contact with the line A, and the general form will be,

Rule.

A	second term	fourth term.
C	first term	third term.

Example I. If 8 men will perform a piece of work in 24 days, how many days will be requisite for three men to perform the same?

A	24 days	64 days ans.
C	8 men	3 men.

The same answer may be obtained without inverting the rule, by changing the general form; thus,

A	second term	fourth term or ans.
B	third term	first term.

Same Example.

A	24 days	64 days answer.
B	3 men	8 men.

But, in general, the most ready and clear method will be to invert the slide.

SQUARES AND ROOTS.

To square any number, and to find the root of any number, these will be performed on the lines marked C and D, the first being a line of double radii on the lower edge of the slide, and the line D a single radius on the stock; the general form is,

Rule.

C	1	square
D	1	root

that is, place unit upon the line C, over unit on the line D; then over any number on D will be its square on the line C; and, under any number on the line C, will be its root on the line D.

Example I. Find the square of 2, 5, 7, and 8½.

C	1	4	25	49	72¼ answer square.
D	1	2	5	7	8½ roots.

Example II. Find the roots of 16, 33, 49, 105.

C	1	16	33	49	105
D	1	4	5¾	7	10¼ roots.

As the common carpenter's Rule begins the D line with the figure 4, and finishes at 40; it wil, therefore, be necessary to be particular in placing the units together, on the lines C and D.

REDUCTION.

CORN.

Rule.

A	8	shillings per quarter.
B	5	shillings per sack of 5 bushels.

Example. When wheat is at 72 shillings per quarter, what is the price per sack of 5 bushels?

A	8	72
B	5	45 shillings per sack.

Rule.

A	4	shillings per quarter.
B	1	pounds per load of 40 bushels.

Example. At 72 shillings per quarter, how much per load?

A	4	72
B	1	18*l.* per load.

Rule.

A	10	cubic feet.
B	8	bushels.

Example. In 70 cubic feet, how many bushels?

A	10	70
B	8	56 bushels.

Rule.

A	5	shillings per sack.
B	2	pounds per load of 40 bushels.

Example. 45 shillings per sack, how much per load?

A	5	45
B	2	18*l.* per load.

Rule.

A	12	pence per bushel.
B	5	shillings per sack.

Example. At 45*s.* per sack, how much per bushel?

A	12	108 pence, or 9 shillings.
B	5	45

Rule.

A	3	quartern loaves.
B	13	℔s. avoirdupois.

Example. In 24 quartern loaves, how many ℔s?

A	3	24
B	13	104 ℔s. answer.

N. B. The above formulæ are general, and answer the purpose of a complete set of proportionate tables.

MEAT.

Rule.

A	12	pence per ℔.
B	8	shillings per stone.

Example.

A	12	5*d.*	6*d.*	7*d.*	8*d.*	9*d.*
B	8	3*s.* 4*d.*	4*s.*	4*s.* 8*d.*	5*s.* 4*d.*	6*s.*

In the last example, there are several answers, serving to show the general use of the Rule, which needs but little farther explanation; but as it will save room, and lessen the size of the book, this mode will be occasionally adopted. The meaning of the example is, that when 8 on B is placed under 12 on A, all the figures and divisions expressing the price per ℔. on the line A, will have under them the shillings per stone on the line B; which, in the example above, will be read,

9*d*. per ℔.	equals	6*s*. per stone.
8	. . . . .	5*s*. 4*d*.
7	. . . . .	4*s*. 8*d*.
6	. . . . .	4*s*.
5	. . . . .	3*s*. 4*d*. &c.

If the stone be 14℔s. instead of 8 as above, the formulæ and example will be,

A	14	shillings per stone	5*s*. 10*d*.	7*s*.	8*s*. 2*d*.	9*s*. 4*d*.	10*s*. 6*d*.
B	12		5	6	7	8	9

In these last examples, it will be observed that the answers are set down in shillings and pence; but upon the Rule they are shown in shillings and decimals, all the subdivisions on the Rule being decimals;

10 of which stand for 1 shilling,
5 . . . . 6 pence,
$2\frac{1}{2}$ . . . . 3 pence, &c.

BEER.

Rule.			*Example.*			
A	36	shillings per barrel	24	27	30	33
B	12	pence per gallon	8*d*.	9*d*.	10*d*.	11*d*.

Rule.			*Example.*			
A	36	shillings per barrel	48*s*.	60*s*.	72*s*.	&c.
B	3	pence per quart	4*d*.	5*d*.	6*d*.	

WINE.

Rule.			*Example.*	
A	20	shillings per gallon	15*s*. 10*d*.	23*s*. 9*d*.
B	126	£. per pipe	100*l*.	150*l*.

Rule.			*Example.*	
A	5	shillings per bottle, full measure	6	7
B	126	£. per pipe	151*l.*	177*l.*

COALS

Rule.		
A	8	chaldrons.
B	11	tons.

Rule.		
A	10	cubic feet.
B	6	coal bushels.

Rule.		*Example.*		
A	36*s.* per chaldron	45*s.*	48*s.*	54*s.* &c.
B	12 pence per bushel	15*d.*	16*d.*	18*d.*

Rule.			*Example.*		
A	20	shillings per ton	25*s.*	30*s.*	40*s.*
B	12*d.*	per cwt.	15*d.*	18*d.*	24*d.*

CLOTH.

Rule.			*Example.*	
A	ells in piece	shillings cost	36 ells	12
B	12	pence per ell	80 shil.	26*d.*$\frac{3}{4}$

If a piece of cloth measuring 36 ells cost per ell 4*l.* or 80 shillings, it will be 26*d.*$\frac{3}{4}$, or 2*s.* 2*d.*$\frac{3}{4}$ per ell.

Rule.

A	number of ells Flemish in piece	shillings cost.
B	16	price per yard.

Example. If a piece of cloth measuring 30 Flemish ells cost 92 shillings, how much per yard?

A	30 ells	92
B	16	49*d*.$\frac{1}{4}$, or 4*s*. 1*d*.$\frac{1}{4}$ per yard.

Rule.

A	ells French	shillings cost.
B	8	pence per yard.

Rule.

A	ells English	shilings cost.
B	9.$\frac{6}{10}$	pence per yard.

FRUIT AND VEGETABLES.

Rule.

A	4	shillings per bushel.
B	3	pence per pottle.

Rule.

A	1	pence per pint.
B	4	pence per pottle.

Rule.

A	16	shillings per bushel.
B	3	pence per pint.

GROCERY.

Rule.

A	cwt.	£. cost.
B	2.15	pence per ℔.

Example. If 13 cwt. of sugar cost 24*l*. 5*s*. 4*d*. how much per ℔.?

A	13	24.25
B	2.15	4*d*. per ℔.

Rule. *Example.*

A	6	pence per ℔.	7*d*.	8*d*.	9*d*.
B	56	shillings per cwt.	65*s*.	74*s*.	84*s*.

Rule. *Example.*

A	4	shillings per ℔.	5*s*.	6*s*.
B	3	pence per ounce	3*d*.¾	4*d*.½

For reducing shillings per stone to pence per ℔. see MEAT, p. 17.

Rule.

A	2	pence per oz.
B	15	pounds per cwt.

Rule.

A	12	shillings per gross.
B	1	pence each.

Rule. And by inverting the slide.

A	12	shillings	per gross	6*s*. &c.
C	1	number for one penny		2

WOOL.

Rule.

A	28	shillings per tod.
B	12	pence per ℔.

BOARDS.

Rule. *Example.*

A	3	pence per foot	3d.½ 4d. &c.
B	25	shillings per hundred	29 33

HAY.

Rule. *Example.*

A	60	shillings per load	*72s.*	*75s.*
B	20	pence per truss	*24d.*	*25d.*

STRAW.

Rule.

A	58	cwt.
B	5	loads.

Rule.

A	*3l.* 10*s.*	per load.
B	6 shillings	per cwt.

LAND.

Rule. *Example.*

A	1.01	pounds acre	40*l.* per acre.
B	5	pence per square yard	2*d.* per square yd.

Rule.

A	10*s.* 1*d.*	shillings per perch.
B	4	pence per square yard.

VELOCITIES.

Rule.

A	1	miles per minute.
B	88	feet per second.

Rule.

A	22	miles per hour.
B	15	feet per second.

Rule.

A	41	miles per hour.
B	20	yards per second.

WEIGHTS AND MEASURES.

Rule.

A	21	dry gallons.
B	20	ale gallons.

Rule.

A	34	ounces avoirdupois.
B	31	ounces troy.

Rule.

A	17	pounds troy.
B	14	℔s. avoirdupois.

Rule.

A	63	ounces avoirdupois.
B	5	℔s. troy.

Rule.

A	102	ounces troy.
B	7	℔s. avoirdupois.

Rule.

A	12	pence per yard.
B	88	£. per mile.

Rule.

A	22	yards width.
B	8	acres per mile.

Rule.

A	8	ale gallons.
B	49	cubic feet.

Rule.

A	19	cubic inches of water.
B	11	ounces avoirdupois.

Rule.

A	14	lbs. per perch.
B	1	tons per acre.

Rule.

A	5	bushels per acre.
B	2	pints per square perch.

Rule.

A	251	cubic feet of water.
B	7	tons weight.

Rule.

A	83	cubic inches of water.
B	3	lbs. avoirdupois.

MENSURATION.

RECTANGULAR FIGURES.

Rule.

A	length	area.
B	1	breadth.

Example. Let the length be $6\frac{1}{2}$, and breadth $3\frac{1}{2}$, required the area?

A	$6\frac{1}{2}$	$22\frac{3}{4}$ answer.
B	1	$3\frac{1}{2}$

TRIANGLES.

Rule.

A	base	area.
B	2	perpendicular.

Example. Let the base be 7 and perpendicular 6; qu. area?

A	7	21 area.
B	2	6

CIRCLES.

Rule.

A	22	circumference.
B	7	diameter.

Example. Let the diameter be 50 inches; required the circumference.

A	22	157 inches circumference.
B	7	50

Rule.

A	99	diameter.
B	70	side of an inscribed square.

Example. Let the diameter of a circle be 14, required the side of an inscribed square.

A	99	14
B	70	9.9 side of a square inscribed.

Rule.

A	39	circumference.
B	11	side of a square equal.

Example. Let the circumference of a circle be 44; required the side of the square equal.

A	39	44
B	11	12.4 side of a square equal.

Rule.

A	9	side of a square inscribed.
B	40	circumference.

Example. Let the circumference of a circle be 44, to find the side of the inscribed square.

A	9	9.9 answer.
B	40	44

Rule.

A	79	diameter.
B	70	side of a square equal.

Example. Let the diameter be 14, required the side of a square equal.

A	79	14
B	70	12.4 side of a square equal.

The lower line, marked D, will now be used.

Rule.

C	490	area.
D	25	diameter.

Example. Let the diameter of a circle be 14, required the area.

C	490	154 area.
D	25	14 diameter.

Rule.

C	23	area.
D	17	circumference.

Example. Let the circumference of a circle be 44, required the area.

C	23	154 area.
D	17	44

Rule.

C	77	area of a circle.
D	7	side of an inscribed square.

Example. Let the area of a circle be 154, required the side of an inscribed square.

C	77	154
D	7	9.9 answer.

CYLINDERS.

Rule.

C	height	contents.
D	11.21	circumference.

Example.

Let a cylinder be 44 inches in circumference, and 14 inches high, to find the content in cubic inches.

C	14	2156 answer.
D	11.21	44

Rule.

C	height	contents.
D	1.128	diameter.
	.357	

The double number in the last formula, is given to suit the figures and divisions on the line C.

Example. In a cylinder 14 inches high and 18 inches in diameter, query the cubical inches?

C	14	3562 cubic inches.
D	1.128	18

PRISMS IN GENERAL.

Rule.

A	144	feet in length.
B	inches in area	cubic feet.

Example. Let a prism be 36 feet in length, and 4×5, which gives 20 inches for the *area*, to find the number of cubic feet.

A	144	36
B	20	5 cubic feet answer.

PYRAMIDS AND CONES.

Rule.

A	432	feet in length.
B	inches area of the base	cubic feet.

Example. Let the area of the base be 196, and height 9 feet; required the number of cubic feet.

A	432	9
B	196	408 answer.

CONES.

Rule.

C	height	content.
D	1.95	diameter at base.

Example. Let the diameter of the base be 14, and height 21; required the contents.

C	21	1078 answer.
D	1.95	14

SPHERE.

Rule.

C	diameter	cu. contents.
D	1.38 437	diameter.

Example. Let the diameter of a sphere be 14 inches, to find its contents.

C	14	1437 cubic inches.
D	1.38	14

GAUGING.

SQUARE PRISMS.

Rule.

C	inches in length	cubic feet.
D	41.57	inches side of a square.

Example. Let a prism be 60 inches long, and 14 inches each side; how many cubic feet?

C	60	6.8 cubic feet.
D	41.57	14

Rule.

C	inches in length	ale gallons.
D	16.79	inches side of a square.

Example. Dimensions as above; required the contents in ale gallons.

C	60	41.7 gallons.
D	16.79	14

Rule.

C	inches in length	wine gallons.
D	15.19	inches side of a square.

Example. Dimensions as above, for wine gallons.

C	60	50.9 wine gallons.
D	15.19	14

Rule.

C	inches in length	malt bushels.
D	46.37	inches side of a square.

Example. For malt bushels.

C	60	5.47 malt bushels.
D	46.37	14

Rule.

C	inches in length	malt gallons.
D	16.39	inches side of a square.

Example. For malt gallons.

C	60	43.8 malt gallons.
D	16.39	14

CYLINDERS.

Rule.

C	inches in length	cubic feet.
D	46.9	inches in diameter.

Example. Let a cylinder be 48 inches long, and 14 inches in diameter; how many cubic feet?

C	4.28 answer	48
D	14	469

Rule.

C	inches in length	ale gallons.
D	18.95	inches in diameter.

Example. Same dimensions; required ale gallons.

C	26.2 answer	48
D	14	18.95

Rule.

C	inches in length	wine gallons.
D	17.15	inches in diameter.

Example. Same for wine gallons.

C	32 wine gallons	48
D	14	17.15

Rule.

C	inches in length	malt bushel.
D	52.32	inches in diameter.

Example. Same for malt bushels.

C	3.44 answer	48
D	14	52.32

Rule.

C	inches in length	malt gallons.
D	18.5	inches in diameter.

Example. With dimensions as above.

C	27.5 malt gallons	48
D	14	18.5

POLYGONS.

C	39	area.
D	3	side of a trigon.
C	1	area.
D	1	side of a tetragon or square.
C	43	area.
D	5	side of a pentagon.
C	65	area.
D	5	side of a hexagon.
C	91	area.
D	5	side of a heptagon.
C	120	area.
D	5	side of an octagon.
C	154	area.
D	5	side of a nonagon.
C	192	area.
D	5	side of a decagon.
C	150	area.
D	4	side of an undecagon.
C	280	area.
D	5	side of a dodecagon.

LAND MEASURE.

RECTANGULAR.

Rule.

A	10	chains wide.
B	chains long	acres.

Example. Let a field be 5.60 chains long, and 3.20 wide, to find the number of acres.

A	10	320
B	560	1.792 acres.

Rule.

A	625	links wide.
B	links long	perches.

Example. Same dimensions; required the number of perches.

A	625	320
B	560	287 perches.

Rule.

A	220	yards wide.
B	chains long	acres.

Example. Let the piece measure 20 chains long, 11 yards wide; required the acres.

A	220	11
B	20	1 acre.

Rule.

A	.125	chains wide.
B	miles long	acres.

Example. Let a canal be 91 miles long, and 1 chain wide; to find the number of acres.

A	.125	1
B	91	728 acres.

Rule.

A	4840	yards wide.
B	yards long	acres.

Example. Let a plot of land be 320 yards long and 21 yards wide.

A	4840	21
B	320	1.39 acres.

Rule.

A	30¼	yards wide.
B	yards long	perches.

Example. 320 yards long, and 21 yards wide; how many perches?

A	30.25	21
B	320	222 answer.

Rule.

A	43560	feet wide.
B	feet long	acres.

Example. At 960 feet long, and 63 feet wide; required the area.

A	43560	63
B	960	1.39 acres.

Rule.

A	272¼	feet wide.
B	feet long	perches.

Example. At 960 feet long, and 63 wide; required the perches.

A	272¼	63
B	960	222 perches.

Rule.

A	1	chains wide.
B	8	acres per mile running.

Example. At 3 chains wide, to find how many acres per mile.

A	1	3
B	8	24 acres per mile.

Rule.

A	11	yards wide.
B	4	acres per mile running.

Example. At 20 yards wide, how many acres per mile?

A	11	20
B	4	7.27 acres per mile.

TRIANGLES.

Rule.

A	1250	links in perpendicular.
B	links in base	perches.

Example. Let there be a triangular field whose base is 4.50 chains, and perpendicular 3.20.

A	1250	3.20
B	4.50	115 perches.

BRICKWORK.

Rule.

A	feet in length	rods reduced.
B	817	feet height, ½ brick thick.

Example. Suppose a wall of half a brick in thickness be 440 feet long and 7 feet high; required the rods of brickwork in the same.

A	440	3.77 rods reduced.
B	817	7

Rule.

A	feet in length	rods reduced.
B	408	feet in height, 9 inches or 1 brick thick.

Example. The same, at one brick in thickness.

A	440	7.54 rods reduced.
B	408	7

Rule.

A	feet in length	rods reduced.
B	272.2	feet in height, 1½ brick thick.

Example. Same, at 1½ brick thick.

A	440	11.3 rods reduced.
B	272¼	7

Rule.

A	feet in length	rods reduced.
B	204	feet in height, 2 bricks thick.

Example. Same, at 2 bricks in thickness.

A	440	15.08 rods reduced.
B	204	7

Rule.

A	feet in length	rods reduced.
B	163	feet in height, $2\frac{1}{2}$ bricks thick.

Example. In a wall of $2\frac{1}{2}$ bricks in thickness, 440 feet long, and 7 feet high, how many rods?

A	440	18.9 rods reduced.
B	163	7

Rule.

A	feet in length	rods reduced.
B	136	feet in height, 3 bricks thick.

Example. Same dimensions, at 3 bricks in thickness.

A	440	22.6 rods reduced.
B	136	7

Rule.

A	feet in length	thousands of bricks.
B	188	feet in height, $\frac{1}{2}$ brick thick.

Example. Let the length of a wall be 440 feet, and height 7 feet, to find the *number of bricks* in the same.

A	440	16.425 thousands.
B	188	7

Rule.

A	feet in length	thousands.
B	94	feet height, 1 brick thick.

Example. Same, to one brick in thickness.

A	440	32.850 number of bricks.
B	94	7

Rule.

A	feet in length	thousands.
B	$62\frac{1}{2}$	feet in height, $1\frac{1}{2}$ brick thick.

Example. Same to 1½ bricks in thickness.

A	440	49.275 number of bricks.
B	62½	7

Rule.

A	feet in length	thousands.
B	47	feet in height, 2 bricks thick.

Example. A wall 440 feet long and 7 high, and 2 bricks in thickness; required the number of bricks.

A	440	65.700 number of bricks.
B	47	7

Rule.

A	feet in length	thousands.
B	37½	feet in height, 2½ bricks thick.

Example. Same, to a wall 2½ bricks in thickness.

A	440	82⅙ thousands.
B	37½	7

Rule.

A	feet in length	thousands.
B	31¼	feet in height, 3 bricks thick.

Example. Same, to 3 bricks thick.

A	440	98½ thousands.
B	31¼	7

Cubic Yards.

Rule.

A	feet in length	cubic yards.
B	72	feet in height ½ brick.

Example. 440 feet long and 7 high, how many cubic yards, at half a brick in thickness?

A	440	42¾ cubic yards.
B	72	7

Rule.

A	feet long	cubic yards.
B	36	feet in height, 1 brick.

Example. Same to 1 brick in thickness.

A	440	$85\frac{1}{2}$ cubic yards.
B	36	7

Rule.

A	feet in length	cubic yards.
B	24	feet in height, $1\frac{1}{2}$ brick.

Example. Same, to $1\frac{1}{2}$ bricks in thickness.

A	440	128 cubic yards.
B	24	7

Rule.

A	feet in length	cubic yards.
B	18	feet in height, 2 bricks.

Example. Same, to 2 bricks in thickness.

A	440	171 cubic yards.
B	18	7

Rule.

A	feet in length	cubic yards.
B	$14\frac{1}{3}$	feet in height, $2\frac{1}{2}$ bricks.

Example. Same, to $2\frac{1}{2}$ bricks in thickness.

A	440	216 cubic yards.
B	$14\frac{1}{3}$	7

Rule.

A	feet in length	cubic yards.
B	12	feet in height, 3 bricks.

Example. Same, to 3 bricks in thickness.

A	440	257 cubic yards.
B	12	7

Rule.

A	34	shillings per rod.
B	3	shillings per cubic yard.

Example. At 42*s.* 6*d.* per rod, how much is it per cubic yard?

A	34	42½
B	3	3.75=3*s.* 9*d.* per cubic yard.

Rule.

A	23	shillings per cubic yard.
B	13	pounds per rod.

Example. At 11*l.* per rod, how much per cubic yard?

A	19*s.* 6*d.* answer	23
B	11	13

Rule.

A	14	pounds per rod.
B	11	pence per cubic foot.

Example. At 11*l.* per rod, how much per cubic foot?

A	11*l.* per rod	14
B	8*d.*¾ nearly	11

Rule.

A	57	No. bricks.
B	4	cubic feet.

Example In 3456 cubic feet, how many bricks?

A	57 bricks	49¼ thousands.
B	4 cubic feet	3456

Rule.

A	6	cubic yards.
B	2300	No. bricks.

Example. In 128 cubic yards, how many bricks?

A	6	128
B	2300	49250 bricks.

Rule.

A	34	cub c yards.
B	3	rods reduced.

Example. In 128 cubic yards, how many rods?

A	34	128
B	3	11.3 rods.

Rule.

A	306	cubic feet.
B	1	rods reduced.

Example. In 3456 cubic feet, how many rods?

A	306	3456
B	1	11.3 rods.

Rule.

A	100	No. bricks.
B	7	cubic feet.

Example. In 3456 cubic feet, how many bricks?

A	100	49250 bricks.
B	7	3456

Rule.

A	6.05	pounds per rod.
B	4	shillings per square yard super.

Example. At 14*l.* per rod, how much per square yard?

A	6.05	14
B	4	9*s.* 3*d.* per square yard.

Rule.

A	15	pounds per rod.
C	300	No. bricks per £.

Example. At 14*l.* per rod, how many bricks for 20 shillings?

A	15	14
C	300	322 bricks for 1*l.*

TIMBER.

Rule.

C	feet length	customary content in feet.
D	12	inches quarter girt.

Example. Let a piece of round timber measure 20 feet in length, and the quarter girt be 16 inches; query the number of cubic feet?

C	20	$35\frac{1}{2}$ cubic feet.
D	12	16

Rule.

C	feet length	true content in feet.
D	10.63	inches quarter girt.

Example. A piece of round timber, 20 feet long and 16 inches quarter girt; required the content as a true cylinder.

C	20	$45\frac{1}{4}$ true content.
D	10.63	16

Rule.

C	feet length	customary cubic feet.
D	15.3	inches diameter.

Example. A piece of round timber, 20 feet long, 14 inches in diameter; to find the customary contents.

C	20	$16\frac{3}{4}$ cubic feet.
D	15.3	14

Rule.

C	feet length	true measure.
D	13.56	inches diameter.

Example. A piece of round timber, 20 feet long and 14 inches in diameter; required the true cylindrical contents.

C	20	21¼ cubic feet nearly.
D	13.56	14

Rule.

C	feet length	cubic feet customary.
D	48	inches circumference.

Example. A piece of round timber, 20 feet long and 44 inches in circumference; required the customary contents.

C	20	16¾ cubic feet.
D	48	44

Rule.

C	feet length	true cubic feet.
D	42.5	inches circumference.

Example. A piece of round timber, 20 feet long and 44 inches in circumference; required the true cylindrical contents.

C	20	21½ cubic feet nearly.
D	42·5	44

Rule.

A	14	cylinder measure.
B	11	customary measure by ¼ girt.

Example. In 350 feet, by customary measure, how much by true, or cylindrical measure?

A	14	445 correct measure.
B	11	350

Rule.

A	6	hewn to dockyards.
B	5	customary measure by $\frac{1}{4}$ girt.

Example. In 350 feet of timber, measured by the customary method of quarter girt, how much will there be if callipered at dockyard measure?

A	6	420 cubic feet answer.
B	5	350

Scantlings, or unequal-sided square timber, may be measured readily by the *area of its section;* which is obtained by multiplying its breadth by its depth.

Rule.

A	144	feet in length.
B	area of section	cubic feet.

Example. Required the cubic feet in a plank 18 feet long, and 11 inches wide, and 3 inches thick. Here the area of the section is $3 \times 11 = 33$.

A	144	18
B	33	4.125
		$4\frac{1}{8}$ cubic feet, answer.

Square timber is measured by the first of these formulæ, substituting the *side of the square* for the quarter girt.

What is called calliper measure, is the custom of considering timber partially hewn as die square, and measuring it as if it was perfectly square.

The side callipered, in timber sold to public dockyards, is said to be in proportion to the diameter as 19. to 22.

Rule.

C	feet in length	cu. feet dockyard measure.
D	13.92	inches in diameter.

Example. Let a piece of timber hewn according to the custom of dockyards be 20 feet in length, 14 inches in diameter; to find its contents when hewn and measured by callipers.

C	20	$20\frac{1}{4}$ cubic feet.
D	13.92	14

Rule.

C	feet long	cubic feet dockyard measure.
D	10.95	inches quarter girt.

Rule.

C	feet long	cubic feet allowing for back.
D	17.5	inches diameter.

Rule.

A	17	whole measure in back.
B	13	measure when reduced $\frac{1}{8}$ for ditto.

SIMPLE INTEREST.

THREE PER CENT.

Rule.

A	400	months due.
B	pounds principal	£. interest.

Example. Required the interest of 320*l.* for 5 months.

A	400	5
B	320*l.*	4*l.* answer.

Rule.

A	20	months due.
B	pounds principal	shillings interest.

Example. Required the interest of 16*l.* for 5 months.

A	20	5
B	16	4 shillings, answer.

Rule.

A	86½	weeks due.
B	£. principal	shillings interest.

Example. Required the interest of 26*l.* for 20 weeks.

A	86½	20
B	26*l.*	6 shillings, answer.

Rule.

A	609	days due.
B	£. principal	shillings interest.

Example. Required the interest of 73*l.* for 25 days.

A	609	25
B	73*l.*	3 shillings, answer.

FOUR PER CENT.

Rule.

A	300	months due.
B	£. principal	£. interest.

Example. Required the interest of 320*l.* for 5 months.

A	300	5
B	320	5*l.* 6*s.* 6*d.* answer.

Rule.

A	15	months due.
B	£. principal	shillings interest.

Example. Required the interest of 16*l.* for 5 months.

A	15	5
B	16*l.*	5*s.* 4*d.* answer.

Rule.

A	65	weeks due.
B	£. principal	shillings interest.

Example. Required the interest of 26*l.* for 20 weeks.

A	65	20
B	26*l.*	answer, 8 shillings.

Rule.

A	456	days due.
B	£. principal	shillings interest.

Example. Required the interest of 73*l.* for 25 days.

A	456	25
B	73*l.*	answer, 4 shillings.

FIVE PER CENT.

Rule.

A	240	months due.
B	£. principal	£. interest.

Example. Required the interest of 320*l.* for 5 months.

A	240	5
B	320*l.*	6*l.* 13*s.* 4*d.* answer.

Rule.

A	12	months due.
B	£. principal	shillings interest.

Example. Required the interest of 16*l.* for 5 months.

A	12	5
B	16*l.*	6*s.* 8*d.* answer.

Rule.

A	52	weeks due.
B	£. principal	shillings interest.

Example. Required the interest of 26*l.* for 20 weeks.

A	52	20
B	26*l.*	10 shillings, answer.

Rule.

A	365	days due.
B	£. principal	shillings interest.

Example. Required the interest of 73*l.* for 25 days.

A	365	25
B	73*l.*	5 shillings, answer.

It will be seen that the whole of the formulæ and examples in the present Part apply to *all* common Sliding Rules, and may be used with the common carpenter's Rule as well as with the more accurate and improved calculating Rule. It should be remembered, that these common Rules being sold at a low price, the divisions are not made with the care and accuracy bestowed upon the better kind of Rules.

END OF THE FIRST PART.

PART II.

INTRODUCTION.

In the following Part, I shall explain the divisions and use of the improved calculating Rule, and give a number of useful formulæ, to assist the more scientific calculator. I shall not occupy the pages of this Treatise in describing the construction of all the various Rules in use, because they are mostly made upon the same principle; and when a person understands the use of one Rule, it will be easy for him properly to apply the peculiar lines upon any other Rule. For the same reason I shall not particularly describe the common *Gunter's scale*, as used by navigators; or the double sliding Rule, used by officers in the Excise; for the rules and examples in the present work will in most instances be equally applicable to the Gunter's Scale, or Excise Rule.

As several of the formulæ in this Part require the use of four lines in the same operation, it will be necessary to adopt an instrument which has the divisions all commencing at the left hand end of the Rule. Having about eight years since calculated all the divisions for a Rule to three places of decimals, which were laid down by one of Ramsden's dividing machines; and having used the Rules made from these calculations for many years, and found them sufficiently accurate for all common purposes, I shall in the present work adopt this Rule as now made by Mr. Cary.

Having already explained the lines marked A, B, C, D, which are common to most Rules, it remains only for me to notice the additional lines laid down upon the said Rule, the principal of which are; Two on the extra slide, marked E, being lines of *triple* radii, and adapted to calculations in which the cube of one of the dimensions, enters into the data; the several divisions on these lines, being of the same kind as those on the line marked A, B, C, and D, but one third in point of space to those on the line D, and are used for finding the cubes of numbers, when applied to the line D; thus,

E	1	cubes.
D	1	roots.

signifying, that when unit on E is placed over unit on D, any number on D will have its cube on E; and the contrary, any number on E, will have its corresponding cube root on D.

There is a line marked F, at the bottom of the groove usually occupied by the slide E. Another line, G, is laid down on the stock under the said slide E. These lines, F and G, are used in calculations of Annuities and Compound Interest; which will be more particularly explained under these respective titles.

There are various other uses to which these Rules are applicable; but I trust the reader will consider the numerous formulæ and examples, already given, as sufficient for a practical guide. The algebraic formulæ will be interesting to the mathematician, and point out to the abstruse calculator, the means of forming rules for more special and difficult calculations.

Persons who are in the constant habit of pen calculations, will find the knowledge of the Rule highly useful as a *check* to their results, more expeditious and certain than any repetition of the process by the pen.

The formulæ for Annuities are given for 5 per cent. only; but it is obvious that divisions may readily be calculated for any other rate per cent., and laid down upon the Rule. The rules for finding the comparative strength of Building Scantlings, will be found of great practical use to the carpenter, and may be modified to any particular circumstance with little trouble.

The *divisors* for weights and measures are, to a small extent, often put on one side of the Rule; a few of such divisors are placed on the back of the slide marked E, in the Rule before mentioned; but as these divisors are very useful, and would occupy too much room on a Rule, I shall give a more extended table at the end of the book, whence workmen in particular trades may have those divisors inserted on the Rule which are most frequently called into use.

A table of *gauge points* also will be added for obtaining the same result, on the line C and D, by which persons in possession of the common carpenter's Rule will be able to solve all questions of this nature.

The succeeding chapters will be useful to the engineer and mechanic. The Rules referred to in the present Part being usually made twelve inches in length, answer most of the purposes of measuring instruments, and may, if desired, have the lines of varieties and areas of segments put on them for Excise officers; or divisions to answer the purpose of pocket balances for small weights, for persons who prefer such lines to any of those at present on the Rule.

B. BEVAN.

13*th Nov.* 1821.

ACCELERATED MOTION.

C	14	feet space fallen.
D	30	feet per second velocity acquired.

C	580	feet space fallen.
D	6	seconds of time.

C	99	miles fallen.
D	3	minutes of time.

A	7	seconds of time.
B	225	feet per second velocity acquired.

C	2140	yards fallen.
D	20	seconds of time.

Example. Find the spaces fallen through, and velocities acquired, in 5 and 9 seconds.

C	580	402 feet	1303 spaces fallen.
D	6	5	9

A	7	5	9
B	225	161	290 velocities acquired.

ALGEBRAIC FORMULÆ.

ab=cd			
	A	a	d
	B	c	b

$a = \frac{cd}{b}$

a : c : : d : b

If c=1 $\quad a=\frac{d}{b} \quad ab=d$

If c=d $\quad a=\frac{d^2}{b} \quad ab=d^2 \quad d=\sqrt{ab}$

By inverting the line C, the following formula will solve the same equations.

A	a	c
C	b	d

If c=1 and a=b $\quad d=a^2 \quad a=\sqrt{b}$

that is,

A	root	1
C	root	power.

But the root and power of any number will be much more readily obtained by the lines C and D, as will appear by the following formula:

$ab^2 = cd^2 \qquad a = \frac{cd^2}{b^2}$

$b = \sqrt{\frac{cd^2}{a}} = d\sqrt{\frac{c}{a}} \qquad a : d^2 : : c : b^2$

C	a	c
D	d	b

If $a = 1$ $b^2 = cd^2$ $c = \frac{b^2}{d^2}$ $\sqrt{c} = \frac{b}{d}$

If $b = 1$ $a = cd^2$ $d^2 = \frac{a}{c}$ $d = \sqrt{\frac{a}{c}}$

By *inverting* the slide, the following formula will produce the same result.

B	a	c
D	b	d

therefore, when $a = b$ and $d = 1$ $a = \sqrt[3]{C}$, thus,

B	cu. root	power
D	cu. root	1

the meaning of which is this: place unit on D, under any power on B, and where the same number coincides on B and D will be the cube root sought.

In operations of this nature, it will be observed, that three sets of numbers will be found to meet, one of which will be the proper root, and the other the root of 10 times the number sought, and the third of 100 times, &c.

Example. Find the cube root of 8.

		root		
B	8	2	4.3	9.3
D	1	2	4.3	9.3
		root of 8	root of 80	root of 800

The improved calculating Rules have a line of treble radii, marked E, by the help of which, questions involving the cube of quantities are readily solved; some examples of which will be given in this book.

The following algebraic equations are solved by the Rules which have the unit on the D line, at the commencement or left hand end of the Rule, in the same vertical line as the unit upon the line A.

$$ac=bd^2 \qquad \frac{ac}{b}=d^2 \qquad \sqrt{\frac{ac}{b}}=d$$

$$a=\frac{bd^2}{c} \qquad a : b :: d^2 : c$$

If $b=1$ $ac=d^2$ $\sqrt{ac}=d$

If $a=b$ $d^2=c$

If $a=c$ $a^2=bd^2$

If $b=c$ $a=d^2$ $\sqrt{a}=d$

If $b=d$ $d^3=ac$ $\frac{d^3}{a}=c$ $d=\sqrt[3]{ac}$

The above elementary equations are answered at sight by the following formula:

A	a	
B	b	
C		c
D		d

And by inverting the slide.

A	a	
C	c	
B		b
D		d

When the line E of the treble radii, is used with the line A, the equations fitted for the rule are;

$$a^2b^3=c^2d^3 \qquad a^2 : c^2 :: d^3 : b^3$$

$$a^2=\frac{c^2d^3}{b^3} \qquad a=\sqrt{\frac{c^2d^3}{b^3}}$$

$b^3 = \frac{c^2 d^3}{a^2}$ $\qquad b = \sqrt[3]{\frac{c^2 d^3}{a^2}}$

A	d	b
E	a	c

$\frac{d^3}{a^2} = \frac{b^3}{c^2}$

With the lines

A		a	
		b	E
	E inverted		
		c	E
D		d	

$\frac{c^2}{b^2} = \frac{d^6}{a^3}$

$a^3 c^2 = d^6 b^2$

$a^{\frac{3}{2}} c = d^3 b$

$a = \left| \frac{d^3\, b}{c} \right|^{\frac{2}{3}}$

A		a	
		c	E
	E inverted		
		b	E
D		d	

If a=1 $\quad c^2 = d^6\, b^2 \qquad \frac{c}{b} = d^3$

If b=1 $\quad a^3\, c^2 = d^6 \qquad \frac{d^2}{a} = c^{\frac{2}{3}}$

If d=1 $\quad b^2 = c^2\, a^3 \qquad \frac{b^2}{c^2} = a^3 \qquad \frac{b^{\frac{2}{3}}}{c^{\frac{2}{3}}} = a$

If c=1 $\quad a^3 = d^6\, b^2 \qquad \frac{a}{d^2} \quad b^{\frac{2}{3}}$

E	1	cube.
D	1	root.

ANNUITIES.

COMPOUND INTEREST AT FIVE PER CENT.

THE improved calculating Rule before mentioned is adapted to questions of annuities, an explanation of which I shall give in this place.

In the bottom of the groove marked H, between the lines A and D, will be seen a set of divisions, numbered from 2 to 50. These divisions answer to *years*, for which the annuity is to continue, and is thus to be used; place the *end of the slide* marked $\frac{B\,|}{C\,|}$ to the divisions or mark for the number of years, at the bottom of the groove, then over the annuity on the line B, will be the *present worth* on the line A; the formula will be,

	A	present worth.
H years	B	annuity.
	C	

Example I. Find the present worth of an annuity of 25*l.* to continue 7 years.

	A	145*l.* answer nearly.
H 7	B	25
	C	

Example II. What annuity for 5 years can be purchased by 350*l.*?

	A	350
H 5	B	81*l.* nearly.
	C	

The bottom of the groove on the other side of the Rule, between the lines A and G, has a scale lettered F, marked *Annuities forborn*, and is to be used in the same manner as the preceding, by placing the *end of the slide* $\frac{A\,|}{B\,|}$ to the year; thus,

	A	amount.
F years	B	annuity forborn.
	C	

Example I. Find the amount of an annuity of 25*l.* forborn 7 years.

	A	203½ pounds, answer.
F 7	B	25
	C	

Example II. How many years' forbearance of an annuity of 60*l.* will produce an amount of 500*l.*?

	A	500
F years 7¼, answer.	B	60

Example III. An annuity of 20*l.* has been unpaid 15 years; what must be the annual payment for the next 5 years to liquidate the debt?

F 15	A	431½
	B	20

H 5	A	431½
	B	100*l.* nearly.

ARCHITECTURAL ORDERS.

THESE may be drawn to any proportion by the aid of the Slide Rule, by placing the proposed diameter, or height, on the line A to the standard number on the line B; after which, all the respective required numbers will be found on the line A coinciding with the standard numbers on the line B.

Example. Find, in inches and decimals, the principal dimensions of a *Tuscan column*, to a diameter of 12 inches.

								answer.
A	3	4.32	6	12	16.25	20	84	100
B	.25	.36	.5	1	1.36	1.66	7	8.36
	Standard numbers.							
	Cima recta and its projection......	Modillion........	Height { base .... / capital ..	Diameter	Entablature	Project. modillion	Height column....	Total height......

My object being that of comprising as much useful information in a small compass as will be consistent with perspicuity, it will not be necessary to give examples to all the orders. The practical architect will be able to supply the formulæ for other orders.

ASTRONOMICAL CALCULATIONS.

In taking out logarithms, sines, and tangents, to the fraction of a minute, by those who are not possessed of Taylor's Tables, much time is consumed in calculating the proportional parts. The Sliding Rule considerably shortens this labour.

Example. Let it be required to find the logarithmic sine of 24° 41′ 7″ by Gardner's Tables.

24° 41′— 9.6207634	A |	2748	321+
321	B |	60″	7

9.6207955 logarithm required.
9.6207955 Taylor's Tables.

But it frequently happens, that *fractions of seconds* are necessary to the calculation; in which case the Rule is equally serviceable and expeditious.

Let it be required to find the sun's right ascension, declination, and the equation of time, for 4½ h. P. M. on the 13th November 1821, at Greenwich.

By the Nautical Almanack.

	Æ	D	Eq.
Day.	h. m. ″	° ′ ″	′ ″
13	15 13 30.7	17 58 43	15 32 .1
14	15 17 36.3	18 14 33	15 23
	4 5.6	15 50	9 .1
	245.6	950	

A	24	245.6	950	9.1
B	4½	46	178	1.7

	+46	+2.58	− 1.7
	15 13 30.7	17 58 43	15 32.1
Answers	15 14 16.7	18 1 41	15 30.4

Let the right ascension and North-polar distance of Sirius be required for 1st December 1821.

In the Nautical Almanack, the table to 1 January 1818, gives the following data:

	Æ. ° ′ ″	Var.	P. D. ° ′ ″	Var.
	6 37 7.32	2.64	106 28 22.20	4.36
	+10.3		+17.1	
Place of Sirius	6 .37 17.62		106 28 39.30	

. . .

A	47 months	10.3 cor.	17.1 cor.
B	12 months	2.64	4.36

DIP OF HORIZON AT SEA.

General Formula.

C	40	feet height of observer.
D	6	minutes dip of horizon.

BUILDING SCANTLINGS.

THE strength of common building scantlings is made to vary according to the intended durability and special purpose of the building, and will generally be found within the following limits.

Fir Timber.	Improved Rule.	Common Rule.
Ceiling joist . . .	5 to 7	31 to 44
Common joist . .	10 — 20	63 — 125
Rafters	10 — 12	63 — 75
Principal ditto . .	25 — 50	156 — 312
Common beams .	18 — 36	113 — 225
Purlines	36 — 72	225 — 450
Summers	80 — 160	500 — 1000

A comparative formula for the strength of any scantling.

A	strength.
B	inches thickness.
C	feet length.
D	inches depth.

Example I. Find the strength of a beam which is 24 feet long, 18 inches thick, and 20 inches deep.

A	30 answer, or a little above the average.
B	18
C	24
D	20

Same *Example* on carpenter's Rule.

A	187, answer.
B	18
C	24
D	20

Example II. In a common joist of 15 feet bearing, and 3 inches thick, what ought to be the depth to give a strength of 10, and also of 20, on improved Rule?

A	10
B	3
C	15
D	7.1 inches, answer.

A	20
B	3
C	15
D	10 inches, answer.

Example III. To find the proper thickness of ceiling joist, the strength to be 7, having the length 8 feet, and depth 4 inches, on improved Rule.

A	7
B	$3\frac{1}{2}$ inches, answer.
C	8
D	4

Example IV. To find the width of a summer having a bearing of 18 feet, and being 16 inches depth, the strength to be 150, on improved Rule.

A	150
B	$10\frac{1}{2}$ inches, the answer.
C	18
D	16

The last example on the common Rule will give the same answer to strength 937.

DIVISORS FOR WEIGHTS AND MEASURES.

On some Rules, there are divisors placed for facilitating calculations of certain measures of capacity, and the weights of metallic and other substances, which I shall here explain. They are usually divided into seven columns, and marked as below.

Squares.			Cylinders.		Globes.	
FFF	FII	III	FI	II	F	I
1	2	3	4	5	6	7

The first column is under the word Square, marked FFF, signifying that in the mensuration of square or rectangular bodies, *all* the dimensions are taken in *feet*.

Column 2, marked FII, signifies that the length only is to be taken in *feet*, and the width and thickness in *inches*.

Column 3, marked III, signifies that *all* the dimensions are to taken in *inches*.

Columns 4 and 5 apply in the same manner to cylinders, and columns 6 and 7 to globes: these last having but one diameter, shows that when the divisors in column 6 are used, the diameter is to be taken in *feet*, and when the diameter is taken in *inches* the divisors in column 7 are to be used. A few examples will show the convenience of these *divisors*.

Rule.

Col. I. II. III.	A	product	contents or weight in lbs.
	B	divisor	other dimensions.

Example. A rectangular cistern, 6 *feet* long, 20 *inches* high, and 16 *inches* wide; query the ale gallons it will hold?

First obtain the product of any two of the dimensions; for instance, $20 \times 6 = 120$, the divisors for ale gallons in column 2 will be found 235.

If the object to be measured is *square*, the content or weight may be found by a single operation, by *inverting* the slide; thus,

A	content, or weight.
C	divisor.
B	length.
D	side of the square.

Example. Let a piece of lead measure 6 inches long, 4 inches square; query its weight in lbs.

By looking to the Rule, the divisor for lead will be found 243.

A	39½ lbs. answer.
C	2.43
B	6
D	4

For divisors in

Col. IV.	A	lbs. weight.
	B	feet long.
	C	divisor.
	D	inches diameter.

Col. V.

A	lbs. weight.
B	inches long.
C	divisor.
D	inches diameter.

Col. VI.

A	lbs. weight.
B	feet diameter.
C	divisor.
D	feet diameter.

Col. VII.

A	lbs. weight.
B	inches diameter.
C	divisor.
D	inches diameter.

Example I. Find the weight of a cast-iron pillar $7\frac{1}{2}$ *feet* high and $3\frac{3}{4}$ inches diameter; by the Table FI will be found the divisor for cast iron in Col. IV.

A		256 lbs. answer.
B		$7\frac{1}{2}$
C	.411	
D	$3\frac{3}{4}$	

Example II. Find the weight of a sphere of cast iron; sphere 4 inches in diameter.

A		8.62 lbs. answer.
B		4
C	7.406 the divisor.	
D		

DRAINAGE OF A COUNTRY.

A	$23\frac{1}{2}$	inches rain on one acre per annum.
B	1	gallons per minute.

A	1	inches rain on a square mile per annum.
B	27.1	gallons per minute.

A	2	inches rain on square mile per annum.
B	1	hogsheads per day of 54 gallons.

A	27	inches rain on square mile per annum.
B	2	cubic feet per second.

A	13.5	No. of square miles.
B	inches depth of rain on square mile.	cubic feet per second.

A	1	gallons per minute.
B	234	cubic feet per day.

For Gauge Points, see Miscellaneous at the end of the work.

HYDRAULICS.

THE quantity of water flowing through apertures depends upon the shape of the channel and of the aperture, and generally reduces the quantity, as determined from the theory of falling bodies. The practical engineer will be able to apply the proper allowances, according to the circumstances of the case. The following formulæ will enable a person to make the calculations in an expeditious manner; he will only have to substitute the practical *factor* suited to the case, in the place of the theoretic number here given.

Rule for apertures at *the surface.*

C	12	inches depth to bottom of aperture.
D	5.35	feet per second mean velocity.

C	4	inches depth to bottom of aperture.
D	37	inches per second mean velocity.

A	12	inches depth of aperture.
E	321	cubic feet per minute at 12 inches wide.

Rules for apertures under *the surface.*

C	42	inches depth to centre of aperture.
D	15	feet per second mean velocity.

C	3	feet depth.
D	13.9	feet per second.

C	6	inches depth.
D	68	inches per second.

C	3	feet depth.
D	834	cubic feet per minute at 1 foot area.

C	1	feet depth.
D	3.34	cubic feet per minute at 1 inch area.

From the above examples, it will be easy to make a formula to give the result in canal locks full, at one operation, when the capacity of the lock is given.

Example. The average capacity of the locks on the Grand Junction Canal is about 9000 cubic feet; find the time necessary to fill one of these from a head of 7 feet, the aperture being 6 square feet.

C	3	7
D	834	1274
		6
		7644 cu. feet per minute.

A	7644	60
B	9000	71 seconds nearly,

if the head is constant, or double that time if the head gradually diminishes to nothing.

HYDROSTATICS.

Rules.

A	feet area	℔s. pressure.
B	.016	feet depth.

A	feet area	cwt. pressure.
B	1.79	feet depth.

A	feet area	tons pressure.
B	35.8	feet depth.

A	inches area	℔s. pressure.
B	27.65	inches depth.

A	inches area	oz. pressure.
B	1.73	inches depth.

A	inches area	℔s. pressure.
B	2.3	feet depth.

Example I. A cistern of water, the area of the bottom being 4 square feet, and the depth 8 feet; to find the pressure in ℔s.

A	4	2000 ℔s. answer.
B	.016	8

Example II. To find the pressure at the bottom of a cylindrical pipe, of 7 inches diameter, filled 30 feet with water.

Here the area is about 38½ inches.

A	38½	500 ℔s. answer.
B	2.3	30

CYLINDERS.

C	inches depth	oz. pressure.
D	1.483	inches diameter.

C	inches depth	℔s. pressure.
D	5.931	inches diameter.

Rule.

C	feet depth	℔s. pressure.
D	1.71	inches diameter.

Rule.

C	feet depth	cwt. pressure.
D	18.1	inches diameter.

Rule.

C	feet depth	tons pressure.
D	256	inches diameter.

INACCESSIBLE DISTANCES.

It frequently happens, that calculations are required to determine inaccessible distances, from angles observed to an object of known subtense, and tables are given in some publications for that purpose: the following formulæ will prove equal to a volume of such tables, when the angle does not exceed 5 degrees.

A	angle in minutes	height of staff, or subtense.
B	3438.	distance.

A	angle in minutes	subtense in feet.
B	52.1	distance in chains.

A	angle in minutes	subtense in feet.
B	1146	distance in yards.

A	angle in minutes	inches subtense.
B	95.5	yards distance.

Occasionally a number of angles are observed to the same subtending object. To save the trouble of setting the slide in each operation, the *slide* may be *inverted*, whereby the distances will, on the same set, fall under the observed angle; thus,

A	subtense	angle in minutes.
C	3438	distance.

INTEREST COMPOUND.

Questions of this nature are solved by means of the line marked G on the stock, with the line C on the slide. A general formula will be,

A		principal	amount.
B		present worth	principal.
C	1		
G	years.		

Example. What is the present worth of 500*l.* payable at the end of 5 years?

A		500*l.*
B		392*l.* answer, nearly.
C	1	
G	5	

Example II. The sum of 500*l.* has been due 5 years; what is the amount due at this time?

A		638*l.* answer.
B		500
C	1	
G	5	

LEVELLING.

As the line of sight, in the practice of levelling, is a tangent to the surface of the earth, a correction is necessary when the distance of the staff from the instrument is considerable. There is also a small correction necessary for refraction of the atmosphere.

The following formulæ combine both these corrections.

C	3	inches difference of level.
D	3600	feet distance.
C	3	inches difference of level.
D	1200	yards distance.
C	7	feet difference of level.
D	3.6	miles distance.
C	58	inches difference of level.
D	3	miles distance.
C	1	feet difference of level.
D	7200	feet distance.
C	1	inches difference of level.
D	31.5	chains distance.
C	1	feet difference of level.
D	109	chains distance.

The difference of level, as above found, to be subtracted from apparent level, to obtain the true level.

LOGARITHMS.

Occasionally it is desirable to find the logarithm of a number, or the reverse: when tables are not at hand, the following formula will serve:

C	1	N on back of slide.
D	number given	log. sought.

and is to be understood in this manner; place the given number on D under 1 on C, and on the *back of the slide* on the line N will be seen the logarithm, coinciding with the *end* of the stock.

Example. Find the logarithm of the number 12.

C	1	back of the slide.
D	12	.079 on N, the logarithm.

Example II. Find the number answering to the logarithm .350

C	1	back of the slide.
D	224 number sought	.350 on N.

Or take out the slide, and reverse the side.

N	1	logarithmic complements.
D	1	numbers.

MECHANICAL POWERS.

LEVER.

A	weight	distance of power from fulcrum.
B	power	distance of weight from fulcrum.

A	dist. of power from ful.	dist. of weight from ful.
C	power	weight.

WHEEL and AXLE, same as for LEVER, substituting *axis* for *fulcrum*.

INCLINED PLANE.

A	weight	length of plane.
B	power	altitude.

WEDGE.

A	weight	length.
B	power	breadth.

SCREW.

A	weight	circum. of the describing power.
B	power	distance of thread.

GENERAL.

A	power	weight.
C	motion of power	motion of weight.

MILLWORK.

A	19.1	revolutions per minute.
B	feet diameter of wheel.	feet per second velocity.

A	inches pitch	inches diameter.
B	3.1416	No. of cogs.

A	inches pitch	feet diameter.
B	37.7	No. of cogs.

A	.318	No. cogs in 12 inches.
B	feet diameter	No. cogs in wheel.

A	inches diameter	velocity of circum. in feet per second.
B	230	revolutions per minute.

A	90	revolutions per minute.
C	5	diameter stones.

A	revolutions per second	feet per second of circum.
B	.318	feet diameter.

Proper number of revolutions per minute to a horse-wheel from the diameter of horse-track.

A	35	feet diameter of horse-track.
C	2	turns in a minute.

PENDULUMS.

B	88	length in inches.
D	40	Num. vibrations per minute.

C	39.14	inches length.
D	Num. beats or vibrations per minute.	60

B	13	feet length.
D	30	Num. vibrations per minute.

Required the length of a pendulum to vibrate 120, another 240 per minute.

B	88	9.8	2.45 inches=¼ second pendulum.
D	40	120	402

PERSPECTIVE.

By ordinates at right angles to the principal ray, and distances let fall on the same.

$$\frac{A}{B} \Big| \quad \frac{\text{distance of object}}{\text{distance of picture}} \quad \frac{\text{depth of object.}}{\text{depth of image.}}$$

$$\frac{A}{B} \Big| \quad \frac{\text{distance of object}}{\text{distance of picture}} \quad \frac{\text{distance of object.}}{\text{distance of image.}}$$

$$\frac{A}{B} \Big| \quad \frac{\text{distance of object}}{\text{distance of picture}} \quad \frac{\text{whole height of object.}}{\text{projected height.}}$$

To find the vanishing point to any vertical plane, let the angle formed by the plane with the principal ray = a. the distance of eye from picture = A. the distance of the vanishing point from the principal ray will be, Tang. $a \times A$.

For a plane making an angle with the horizon of b.

$\frac{\text{Tang. b.A}}{\text{cos. a}}$ = height of vertical *above* or *below* the vanishing point of the ground line of the said plane.

POWER OF HORSES.

A	hours' work	cubic feet water raised.
B	feet high	25300

A	hours' work	cubic yards of earth raised.
B	feet high	475

A	hours' work	cwts. raised.
B	feet high	14100

A	hours' work	tons raised.
B	feet high	705

A	hours' work	hogsheads, wine measure raised.
B	feet high	3100

Example. How many hours will be required for one horse to raise 350 tons, to the height of 4 feet?

By the fourth formula it will stand:

A	2 hours, answer.	350
B	4	705

POWER OF MEN.

A	hours' labour	cubic feet of water.
B	feet high	4000

A	hours' labour	cwts. raised.
B	feet high	2232

A	hours' labour	cubic yards water raised.
B	feet high	148

A	hours' labour	tons raised.
B	feet high	112

A	hours' labour	cubic yards earth raised.
B	feet high	74

Example. Suppose a dock to contain 400 cubic yards of water, how many hours will be required by one man to pump out the contents by raising it 5 feet?

This question will be answered by the third formula.

A	$13\frac{1}{2}$ hours, answer.	400
B	5	148

SPECIFIC GRAVITY.

WEIGHT OF SUBSTANCES

Determined from their Bulk and specific Gravities.

A	specific gravity	grains.
B	.00395	cubic inches.

A	specific gravity	oz. avoirdupois.
B	1.73	cubic inches.

A	specific gravity	℔s. avoirdupois.
B	27.65	cubic inches.

A	specific gravity	℔s. avoirdupois.
B	.016	cubic feet.

A	specific gravity	cwts.
B	1.79	cubic feet.

A	specific gravity	tons.
B	35.8	cubic feet.

SPHERES, MENSURATION OF.

C	3.1416	superficies.
D	1	diameter of sphere.

C	.3183	superficies.
D	1	circumference of sphere.

A	solidity.
B	circumference.
C	6
D	diameter.

A	solidity.
B	diameter.
C	1.91
D	diameter.

A	solidity.
B	circumference.
C	.593
D	circumference.

E	specific gravity	lbs. weight.
D	3.75	inches diameter.

C	diameter	solidity.
D	1.38	diameter.

TRIGONOMETRY.

RIGHT-ANGLED PLANE.

On the back of the slide marked $\frac{B}{C}$ on the improved Rule are three lines of divisions; the upper line, marked S, being a line of *sines;* the middle line, marked T, being a line of *tangents;* the lower line, marked N, being numbers to the logarithms.

These lines are intended to be used by reading the divisions at the *end of the stock*, so far as can be seen in each particular question. I shall therefore express this reading by the word *back*, as follows:

Rule.

A	hypothenuse	back.
B	perpendicular	S angle at base.

Example. Given the hypothenuse 16, and angle at the base 20°, to find the perpendicular.

A	16	S 20°
B	$5\frac{1}{2}$ perpendicular, nearly	

Rule.

A	hypothenuse	back.
B	base	S angle at vertex.

Example. When the hypothenuse is 20 and base 12, what is the vertical angle?

A	20	S 37° answer, nearly.
B	12	

Rule.

A	base	back.
B	perpendicular	co. tang. vertical angle.

A	base	back.
B	perpendicular	tang. ∠ base.

A	perpendicular	back.
B	base	tang. vertical. ∠ co. tang. ∠ at base.

Example. When the base is 16 and perpendicular 8, required the angle at the base.

A	16	tang. $26°\frac{1}{2}$
B	8	answer.

OBLIQUE PLANE.

Draw out the slide marked B | / C | and reverse its face, bringing the line of sines, marked S, in contact with the line A.

A	opposite side	its opposite side.
S	sine of an angle	sine of another angle.

Example I. Let the base of an oblique triangle be 40, and vertical angle $71\frac{3}{4}°$, the other side 32 and 36 respectively; required the angle at the base.

A	40	36	32
S	$71\frac{3}{4}°$	$58\frac{3}{4}°$	$49\frac{1}{2}°$

angles at the base.

Example II. Given the angles 32° and 110, and included side 60; to find the other side.

A	$51\frac{1}{2}$	60	$91\frac{1}{2}$
S	32°.	38°	110°
			70

This formula will apply to right-angled triangles; thus,

A	perpendicular	base	hypothenuse.
S	∠ at base	vertical ∠	90°

SPHERICAL TRIGONOMETRY.

Notwithstanding the improved Pocket Sliding Rule has but *one set* of lines of sines and tangents, it may, with the aid of a small slip of paper, or pair of compasses, be used in solving all the common cases of spherical trigonometry and navigation.

For instance: Sine 8° : Sine 18° : : Sine 13 : S. 30. The compasses or a slip of paper extending on a line of sines from 8° to 18°, will also reach from 13 to 30. Again, Sine 6° : Tang. 10 : : Sine 20 : Tang. 30; that is, the distance on the line of sines between 6 and 20, will extend on the line of tangents from 10 to 30.

To find the latitude of the place from the sun's declination and amplitude.

The extent on the line S. from the degrees of amplitude to 90°, will extend from the degrees of declination to the degrees of co-latitude.

WEIGHTS AND MEASURES.

ENGLISH AND SCOTCH.

A	15	Scotch pints.
B	44	English pints.
A	47	English bushels.
B	46	Scotch firlots for wheat, &c.
A	47	Scotch firlot of barley and malt.
B	70	English bushels.
A	30	Scotch ells.
B	31	English yards.
A	55	Scotch miles.
B	62	English miles.
A	12	avoirdupois lbs.
B	11	Scotch troy pounds.
A	14	English acres.
B	11	Scotch acres.

FRENCH AND ENGLISH.

A	85	gramme French.
B	3	oz. avoirdupois.
A	31	grains.
B	2	gramme French.
A	11	℔s. avoirdupois.
B	5	kilogramme.
A	3	metre French.
B	118	English inches.
A	7	metres French.
B	23	English feet.
A	35	English yards.
B	32	metres French.
A	76	millimetre French.
B	3	English inches.
A	21	chiliometre French.
B	13	English miles.
A	37	English acres.
B	15	hectare French.

A	20	are French.
B	79	perches English.

A	22	litre French.
B	19	English quarts ale measure.

A	8	English gallons ale measure.
B	37	litre French.

A	85	litre French.
B	3	English bushels.

A	65	feet English.
B	61	feet French.

To give examples of the reduction of each individual weight and measure, of all the countries of the world, would only swell the book to an improper size; the examples already given will probably be sufficient to enable any person, thus far acquainted with the Rule, to adapt the particular case of reduction of any foreign weight or measure to the English; if not, the following rule may assist. Take any simple case of comparison by the pen, and use the result of this case as a standing proportion for future calculations.

Example. It is said that the pound used at Amsterdam contains 7461 grains, and the pound avoirdupois 7000. Place these two numbers together on the lines A and B, and it will be found that 15 to 16, or 76 to 81, will be the nearest coinciding small numbers, from which a standing formula is obtained; thus,

Rule.

A	16	℔s. avoirdupois.
B	15	℔s. Amsterdam.

Another example may be had in reducing the Amsterdam foot to the London foot, as 10000 to 10762, which being set together on the lines A and B, will show a meeting of divisions at $\frac{14}{13}$; therefore,

Rule.

A	14	Amsterdam feet, or	113
B	13	English feet	105

IRISH MEASURES.

As the ratio of the *Irish* to the *English* measures may be useful to some persons, they are inserted in this place.

A	14	English miles.
B	11	Irish miles.

A	81	Irish acres.
B	50	English acres.

A	17	Irish wine gallons.
B	16	English wine gallons.

It will be seen that nearly the whole of the formulæ and examples in the present volume apply to *all* common Sliding Rules, and may be used with the common carpenter's Rule as well as with the more accurate and improved calculating Rule.

MISCELLANEOUS.

WHEN many calculations are required, in cubeing up quantities from three dimensions, it will be convenient to have an *extra slide*, to be placed *inverted upon* the line D, in such a manner that the *divisor* for the integer of the bulk coincides with the beginning of the divisions on the lines A, B, and C, from which the cubical quantities will be found by a single operation.

Thus, suppose the integer of bulk to be a cubic *yard*, and the dimensions are taken in *feet;* in this case the *divisor* will be 27. The formula will be,

A	feet length.
B	cubic yards.
C	feet width.
Inv. C 27	feet depth.

If the dimensions are taken in *yards*, the units of measuring and of bulk will be the same, and of course the divisor will be 1. The formula will then be,

A	yards long.
B	cubic yards.
C	yards wide.
Inv. C 1	yards deep.

If the depth is taken in *inches*, and the length and width are taken in *feet*, the divisor to be placed at the beginning of the Rule will then be 324; thus,

A	feet length.
B	cubic yards.
C	feet width.
Inv. C 324	inches depth.

If the depth and width are both taken in *inches* and length in *yards*, the divisor is 3888, on the inverted C line, to be placed at the beginning of the Rule; thus,

A	feet long.
B	cubic yards.
C	inches wide.
Inv. C 3888	inches deep.

If the quantity of malt in *bushels* were required, and the dimensions taken in *feet*, as to length and width, and depth in *inches*, the inverted line must be placed with the division 14.93 at the beginning; thus,

A	feet long.
B	malt bushels.
C	feet wide.
Inv. C 14.93	inches deep.

If cubic *feet* are wanted, when the length is given in *feet*, and the width and thickness in *inches*, the divisor to be placed at the end of the Rule, on the inverted line will be 144; thus,

A	feet length.
B	cubic feet.
C	inches width.
Inv. C 144	*inches* thickness.

Example. If a plank measure 20 feet long, $10\frac{1}{2}$ wide, and $2\frac{1}{2}$ thick; required the cubic feet.

A		20
B		$3\frac{2}{3}$ cubic feet.
C		$10\frac{1}{2}$
Inv. C	144	$2\frac{1}{2}$

The general rule will be to place any of the *divisors* in columns I. II. and III. from the table at the end of this book, on the line C inverted, *upon* the beginning of the D line, and using the other dimensions, at a single operation; thus, for a general formula,

A	a		length.
B	b		weight, or content.
C		c	width.
Inv. C	d=divisor	m	depth.

The algebraic equation for this position of the lines will be,

$$acm=db \qquad \frac{acm}{d}=b$$

Some persons may prefer a Rule capable of solving all the questions of double multiplication, and may not have occasion for trigonometrical calculations; in this case, the back of the slide E, may have a line of double radii laid down upon it, in lieu of the divisors at present, and the divisors may be placed on the back of the slide C, D. This arrangement will leave the improved Rule fully equal to all the other purposes it is now adapted for; or the trigonometrical lines may remain, as at present, and the additional line of double radii placed on the back of the slide E. A few divisors may then be placed on one of the edges of the Rule, or at the bottom of the groove in lieu of the Annuity scales.

Some of the better kind of carpenters' Rules have a *double slide* on the same face, the lower slide having the *inverted double radii;* and for many purposes this modification of the Rule is preferable to the common one, which has the single radius, or D line, called by workmen the girt line, it being adapted for the multiplication of three dimensions, and dividing by a fourth. It becomes particularly fitted for the cubical measure of all kinds of timber, either round, square, or unequal-sided, and also for working up brickwork to the rod or cube yard.

A few examples will render the use of these Rules intelligible to the learner.

Suppose a piece of timber measures 33 feet long, and 14 inches by 12½; to find the cubic feet.

In this case the divisor is 144, which is placed at the beginning of the Rule, on the lower slide, as before described.

A	33
B	40 cubic feet.
C	14
Inv. C 144	12½

As cubic feet will be the principal object of the carpenter and builder, the lower slide might be so divided as to be even at the ends with the stock when the point of 144 ranges with 1 upon the line A.

An example in the measuring of brickwork may also be of service.

Let a wall be 58 feet long, 14 feet high, and 4 half bricks in thickness; required the rods contained.

A	feet long	58
B	rods reduced	4 answer, nearly.
C	feet high	14
Inv. C 187	half bricks thick	4

See p. 37.

Again, let a wall be 90 feet long, 13 feet high, and 3 feet, or 8 half bricks in thickness; to find the number of rods.

A		90
B		$11\frac{1}{2}$ rods nearly.
C		13
Inv. C	817	8

Sometimes the length and height of the wall may be given in *feet*, and the thickness expressed in *inches*; in this case the divisor, or standard number, will be 3674. Taking the last example, the work will appear thus :

A		90
B		$11\frac{1}{2}$ rods, nearly.
C		13
Inv. C	3674	36 inches.

If all the dimensions are taken in feet, the example will be,

A		90
B		$11\frac{1}{2}$ rods, as before.
C		13
Inv. C	306	3 feet.

The two following formulæ comprehend all the cases in *Plane Sailing*, and are solved by the lines of sines and tangents on the back of the slide marked A. B. when reversed. These lines are marked at the end with the letters S and T.

A	difference of latitude	departure	distance.
S	comp. of course	course	90°

A	departure	diff. of latitude.
F	course	45°

DIVISION.

PERHAPS one of the most general uses of the Rule to persons having many pen calculations to make, may be that of facilitating the operations of Long Division, serving to point out without loss of time the successive figures of the quotient by simple inspection. It is well known to the calculator, that he is frequently obliged to renew the process of multiplication when he arrives at the last figure, and to rub out or erase the line, and repeat the work with a new figure: a very slight acquaintance with the Rule will save all this trouble, and prevent much loss of time; nothing more is necessary than to place any common Rule with the lines A and B in the following form:

A	divisor	dividend.
B	1	quotient.

From which each separate part of the dividend will be fitted with its proper part of the quotient; and as the divisor is constant, the position of the slide will remain the same for the whole operation, and towards the end of the process the calculator will be furnished with the last two figures of the quotient perfectly correct, without the trouble of actually performing the multiplication; thus,

Divide 4965825 by 365.

365)4965825(13605
1315
2208
1825

The successive figures, as shown by the Rule, will be 13605.

A List of Gauge Points for Measures of Capacity, to be used on the Line D; the Dimensions all to be taken in Inches.

GAUGE POINTS.		
	Squares.	Cylinders.
Malt Bushel	46.37	52.33
—— Gallon	16.40	18.50
Ale Gallon.........	16.79	18.95
Wine Gallon	15.19	17.15
Cubic Feet	41.57	46.91
Cubic Inches	1.000	1.128

General Formula.

C	inches long	contents.
D	gauge point	inches diameter.

The following Table of Divisors and Gauge Points for determining the *weight in pounds avoirdupois* is derived from the specific gravities of the respective substances; and as there are small variations in the specific gravities, depending upon the quality of the substance, it will be easy to make the correction to any of the numbers, as circumstances may require, or to add other articles not comprised in the present Table.

For ascertaining the weight of substances by means of the Gauge Points in the following Table, the general formula is,

C	length or diameter	lbs. weight.
D	gauge point	diameter.

TABLES OF DIVISORS AND GAUGE POINTS,
For ascertaining the Weight in Pounds Avoirdupois.

	DIVISORS.							GAUGE POINTS.			
	Squares.			Cylinders.		Globes.		Cylinders.		Globes.	
	FFF	FII	III	FI	II	F	I	FI	II	F	I
Air	13.11	1889	22670	2404	28850	25.08	4329	49.03	169.85	5.008	65.70
Alum	.0093	1.344	16.132	1.710	20.531	.0178	30.799	1.308	4.581	.1335	5.549
Ash	.0200	2.880	34.562	3.665	43.988	.0382	65.982	1.914	6.632	.1954	8.123
Brass, cast	.002	.288	3.456	.366	4.399	.0038	6.60	.605	2.096	.0616	2.569
—— Wire	.0018	.269	3.230	.342	4.111	.0036	6.17	.585	2.027	.0595	2.484
Bricks	.0080	1.152	13.820	1.466	17.594	.0152	26.391	1.210	4.195	.1234	5.137
Butter	.0170	2.451	29.415	3.119	37.437	.0324	56.155	1.766	6.118	.1802	7.494
Chalk	.0089	1.285	15.421	1.635	19.627	.0170	29.440	1.278	4.430	.1304	5.426
Clay	.0074	1.066	12.801	1.357	16.292	.0141	24.438	1.165	4.036	.1188	4.943
Coal, solid	.0128	1.843	22.120	2.345	28.17	.024	42.255	1.530	5.307	.1562	6.500
Copper	.0018	.256	3.072	.326	3.910	.0034	5.867	.571	1.977	.0583	2.422
Cork	.67	96.00	1152.11	12.2	146.63	.1272	219.94	3.493	12.10	.3568	14.80
Common Earth	.0080	1.161	13.936	1.478	17.737	.015	26.605	1.215	4.210	.1240	5.158
Elm and Fir	.029	4.189	50.273	5.331	63.984	.055	96.050	2.309	7.999	.2356	9.800
Glass, English Crown	.0063	.914	10.972	1.163	13.964	.012	20.946	1.078	3.736	.1100	4.577
Do. Flint, English White	.0049	.700	8.404	.891	10.696	.0092	16.044	.944	3.270	.0962	4.005
Do. Green	.0061	.879	10.553	1.119	13.431	.0116	20.146	1.058	3.647	.1080	4.488
Granite and Marble	.0059	.853	10.24	1.086	13.03	.0113	19.56	1.040	3.610	.1063	4.423
Gun Metal	.0018	.262	3.147	.334	4.006	.0035	6.009	.577	2.001	.0591	2.452
Gunpowder, loose	.0173	2.498	29.989	3.180	38.167	.0331	57.250	1.783	6.178	.1819	7.566

	DIVISORS.							GAUGE POINTS.			
	Squares.			Cylinders.		Globes.		Cylinders.		Globes.	
	FFF	FII	III	FI	II	F	I	FI	II	F	I
Gunpowder, solid	.0091	1.320	15.845	1.680	20.166	.0175	30.249	1.296	4.491	.1322	5.500
Honey	.0110	1.589	19.069	2.022	24.269	.021	36.403	1.422	4.926	.1452	6.033
Iron, cast	.0022	.323	3.878	.411	4.935	.0043	7.406	.641	2.222	.0655	2.721
—— wrought	.0021	.301	3.616	.383	4.608	.004	6.907	.619	2.145	.0632	2.628
Lead	.0014	.203	2.435	.258	3.1	.0027	4.65	.508	1.761	.0519	2.157
Mahogany	.0150	2.167	26.011	2.758	33.105	.0287	49.657	1.660	5.754	.1695	7.046
Maple and Beech	.0228	3.291	39.500	4.189	50.27	.0436	75.405	2.046	7.090	.2088	8.683
Mercury	.0011	.164	1.975	.209	2.514	.0022	3.772	.457	1.585	.0466	1.942
Oak	.0173	2.498	29.989	3.180	38.167	.0331	57.250	1.783	6.178	.1879	7.566
Oil, Linseed..........	.0170	2.451	29.415	3.119	37.437	.0325	56.155	1.766	6.118	.1802	7.493
Oil of Olives	.0175	2.518	30.219	3.205	38.46	.0334	57.69	1.790	6.201	.1829	7.595
Pewter	.0021	.308	3.701	.392	4.710	.0048	7.065	.626	2.170	.0640	2.658
Pitch	.0139	2.003	24.044	2.549	30.601	.0265	45.901	1.596	5.582	.1630	6.775
Rosin..............	.0145	2.094	25.136	2.665	31.991	.0277	47.986	1.632	5.656	.1666	6.927
Salt	.0075	1.082	12.98	1.376	16.52	.0143	24.79	1.172	4.064	.1197	4.979
Sand	.0010	1.515	18.191	1.929	23.17	.0200	34.75	1.389	4.813	.1417	5.895
Slate, common	.0060	.862	10.348	1.097	13.17	.0114	19.75	1.048	3.629	.1068	4.444
Spirits, Proof.........	.0172	2.474	29.699	3.149	37.799	.0328	56.698	1.774	6.148	.1811	7.529
Steel	.0020	.293	3.522	.373	4.483	.0039	6.724	.611	2.117	.0625	2.593
Stone, Portland and Mill	.006	.925	11.08	1.117	14.13	.0122	21.21	1.086	3.759	.1104	4.605
Tallow	.0170	2.446	29.352	3.113	37.357	.0324	56.035	1.764	6.112	.1800	7.485
Tin	.0022	.315	3.777	.400	4.807	.0042	7.214	.632	2.193	.0647	2.686
Turpentine, Oil of	.0200	2.880	34.562	3.665	43.988	.0382	65.98	1.914	6.632	.1954	8.123
Wax, Bees'	.0167	2.412	28.958	3.070	36.849	.0320	55.27	1.752	6.070	.1788	7.434
Water	.016	2.304	27.648	2.932	35.19	.0306	52.80	1.712	5.931	.1749	7.267

INDEX.

ERRATA.

P. 47, l. 11, *for* back *read* bark.
14, ditto ditto.

P. 60, l. 3 from bottom, *for* $\frac{a}{d^2} b^{\frac{2}{3}}$ *read* $\frac{a}{d^2} = b^{\frac{2}{3}}$

S Gosnell, Printer, Little Queen Street, London.

ERRATA.

Page.	Line.	Formula.	For	Read
3	8	. .	hours'	hours
11	8	. .	divisions	division
	9, 10	. .	radius	radii
19	. .	6	$\frac{12}{80\ sh.}$	$\frac{80\ sh.}{12}$
21	. .	5	. . .	nearly
22	. .	3, 5, 6	. . .	nearly
23	. .	2	$\frac{22}{15}$	$\frac{15}{22}$
		3	. . .	nearly
		7	$\frac{63}{5}$	$\frac{79}{6}$
24	. .	3	$\frac{8}{49}$	$\frac{49}{8}$
31	. .	6	469	46.9
33	. .	1	39	3.9
44	. .	7	13.56	13.54
45	. .	1	13.56 $20\frac{1}{4}$	13.54 $20\frac{1}{2}$
47	. .	3, 4	back	bark
57	last	. .	$\frac{\sqrt{cd}^2}{a}$	$\sqrt{\frac{cd^2}{a}}$
60	. .	2	E inverted	E.
	3 from bottom	. .	$\frac{a}{d^2}\ b^{\frac{2}{3}}$	$\frac{a}{d^2} = b^{\frac{2}{3}}$
69	10	. .	. . .	add 82 gallons, answer
71	. .	5	square mile	square mile per ann.
		6	234	235
77	2	. .	. . .	add 5 per cent.
83	. .	2	$\frac{\text{dist. of object}}{\text{dist. of image}}$	add from principal ray
84	. .	6	350	352
93	. .	4	$\frac{85}{3}$	$\frac{176}{5}$
94	. .	3	$\frac{81}{50}$	$\frac{50}{81}$
96	10	. .	yards	feet
98	. .	2	187	817
99	bottom	. .	F	T
103	15	. .	,0048	,0041
105	4	. .	95.	97
	30	. .	Land measure 22	Land measure 22.34