INSTRUCTIONS

FOR THE USE OF THE

PRACTICAL ENGINEERS' & MECHANICS'

IMPROVED SLIDE RULE,

AS ARRANGED BY

J. ROUTLEDGE,

ENGINEER, AND ALSO FOR THE

IMPROVED SLIDE RULE,

And its various Tables as laid down and arranged by

W. E. CARRETT, ESQ.,

ENGINEER, LEEDS,

Containing a full description of the various lines upon them, with copious directions for their use, and their applicability to Multiplication, Division, the Rule of Three, the Extraction of the Square and Cube Roots, Timber and Land Measuring, Cask and Malt Gauging, the Mensuration of Superficies and Solid Bodies, the Weighing of Metals and other Bodies, with much other matter extremely useful and valuable to the Practical Engineer and Mechanics generally; comprising also THE WHOLE OF THE TABLES FROM ROUTLEDGE'S RULE, now first presented in an intelligible form; and other Tables of Reference; the mode of Construction and Measurement of Angles; forming with either of the Improved Rules, a true, ready and convenient means of making all measurements and calculations, which no Practical Engineer or other Mechanic should be without.

LATEST EDITION, WITH ALTERATIONS AND CORRECTIONS.

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BOXWOOD, IVORY & other RULES,

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CONTENTS.

INSTRUCTIONS, &c.

DESCRIPTION OF THE RULE.

These Engineer's Rules, which for so many years past have been extensively used by Engineers and Mechanics, are manufactured of unique and superior description, by J. Rabone & Son. They are made by steam machinery, and are marked by a new process, which is used exclusively by themselves; and which—besides presenting uniformity and regularity of appearance—*ensures perfect truthfulness and unvarying accuracy in the various tables, &c.*, which cannot be guaranteed by any other makers. The advantages of such Rules being marked by one unvarying process, must be obvious. The Rules are made of good box wood or ivory, and are 24 inches long when open. One side of them is marked with inches and drawing scales, which serve all the purposes of the ordinary 2-ft. Rule. The edges are marked with decimals of a foot and inches divided into 10ths and 12ths. On the other side of the rules are the lines of numbers or the working slide, and upon Routledge's Rule a table of the gauge points required for measuring and weighing various bodies in squares, cylinders, or globes; the gauge points required for finding diameters of steam engine cylinders, to work pumps from 3 to 30 inches diameter—with a pressure of 10lbs. and 7lbs. on the square inch; a table of gauge points for estimating the contents of regular polygons of not more than 12 sides; and another for measuring the circumferences, diameters, and areas of circles, with the relative values of such circles to squares and triangles.

Upon Carrett's rule, instead of some of the above gauge points, will be found other drawing scales, so arranged as to measure off the edge, many valuable tables of weights and gauge points of various bodies, and much useful information, for which there is not space on Routledge's Rule.

Upon the joints of both rules will be found the relative value of the French metre or standard measure to English measure; also its subdivision into centimetres and millimetres, likewise expressed in English inches.

EXPLANATION OF THE LINES OF NUMBERS.

There are four lines, marked A, B, C, D. The first three lines, A, B, C, are all exactly alike, consisting of two radiuses, and numbered from the left to the right hand with the figures, 1, 2, 3, 4, 5, 6, 7, 8, 9—1, 2, 3, 4, 5, 6, 7, 8, 9, 10. The line D is a single radius, double the length of the others, and numbered from left to right with 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; the lines B and C slide between the other two, and by this operation are all questions answered upon the rule the same as by figures.

OF NUMERATION.

Numeration is the first thing to be learned upon this instrument, for when once that is perfectly understood, everything else will be rendered quite easy; in order that this may be made as plain as possible, let it be first observed, that the numbers and divisions upon the rule are all arbitrary, and the value set upon them must be such as the nature of the case requires, which will be easily discovered as soon as any question is proposed.

The figures 1, 2, 3, 4, and so on to 10, are called primes, and the long divisions tenths; and these again are subdivided into hundredth and thousandth parts of unity.

If the 1 next the joint represents 1 tenth, then will the middle 1 be 1 unit, or 1 whole number, and the other figures towards the right hand are likewise whole numbers, from the middle 1 to ten at the end; but if the first one represents 1 unit, then the middle 1 will be 10, and the 10 at the far end 100; if the first 1 is called 10, the middle 1 will be called 100; and that at the end 1000—always increasing in a tenfold proportion, according to the value you set upon the first one: the figures between them must be called after the same manner; so that if 1 at the beginning is 1 tenth, 2 will be 2 tenths, and the next 2 towards the right hand 2 units; but if 1 at the beginning is one unit, then 2 will be units, and the other 2 will be 20, and the next 2 is 200. They may be best represented in the following order: 1 tenth, 2 tenths, 3 tenths, 4 tenths, 5 tenths, 6 tenths, 7 tenths, 8 tenths, 9 tenths, unity; or 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. The above is the least that the primes are generally valued at; when a higher value is set on them, they will stand thus, beginning next the joint, and say 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000. By repeating them again, it would still increase their value ten times; but this at present will be unnecessary, it being designed to make this instruction as short but as plain as possible. A few examples are adduced for the learner's practice.

I.—Let it be required to find 17 on the top line, or line A, this being the line on which all the different gauge points in the table below the lines of numbers are to be found: look for the first or the middle 1 (it matters not which), and call it 10, then count 7 of the long divisions toward 2; this will be 17, the number sought for: it is also 170, 1700, 17000.

II.—Let the number 2450 be found; look for 2 and call it 2000, and 4 of the longest divisions toward 3 are 400, and 1 short division is 50, which altogether make 2450, the answer; they likewise stand for 245, 24.5 or 2.45.

III.—Let the following numbers be sought: 105, 205, 705. These and all such other like numbers that have no figures in the place of tens, are to be found in the following manner; look for 1 and call it 100, then 2 of the short divisions you call 2 each, and half of another short division is one, all of which make 105, the first number required. To find the second number you look for 2 and call it 200, and the first short division is 5, this will be the answer to the second number. Proceed in the same manner for the last number, find 7 and call it 700, and half of the first division is 5, the number sought.

The best way of pointing out any number required, is to slide the 1 upon the line B gently along, until you bring it opposite the number you look for upon line A.

From what has been said the learner will not find it difficult to point out on this rule any number in the table of gauge points.

MULTIPLICATION.

In this rule you have three numbers given to find a fourth, always calling unity one of the three. Whether they be whole numbers, mixed numbers, or decimal fractions, the proportion is—as unity on A is to the multiplier, on B, so is the multiplicand on A to the product on B.

I.—What is the product of 9 by 7?

Set 7 upon B to 1 upon A, and against 9 upon A is 63, the answer, upon B.

II.—What is the product of 6 by 8?

Set 6 upon B to 1 upon A, and against 8 upon A is 48 upon B.

III.—What will be the product of 64 by 15?

Set 15 upon B to 1 upon A, and against 64 upon A is 960, the answer, upon B.

IV.—What is the product of 86 by 14?

Set 14 upon B to one upon A, and against 86 upon A, is 1204, the answer, upon B.

V.—The product of 95 by 15 is required.

Set 15 upon B to one upon A, and against 95 upon A, is 1425 the answer, upon B.

Multiplication may also be performed the contrary way, by setting 1 upon B to the multiplier upon A, then against the multiplicand upon B is the product upon A. To make this more plain, we will repeat the last two examples.

Set 1 upon B to 14 upon A, and against 86 upon B is 1204 upon A; and set 1 upon B to 15 upon A, and against 95 upon B is 1425 upon A: both are the same answers as before.

It should here be observed, that where the product amounts to four figures or more, as in the last examples, the units are not easily discovered on the rule; therefore to ascertain their proper units, you must always multiply the units by the units in thought, as in example V, 5 times 5 are 25, so the product must end in the unit 5, as 1425, the answer above.

DIVISION.

As multiplication and division are each a proof of the other, they may both be performed the same way; only observe that in multiplication you have the answer on the same line with the multiplier; but in division you have the answer on the same line with the one you are making use of.

When one number is given to be divided by another, whether whole numbers, mixed numbers, or decimal fractions, the proportion is, as the divisor upon A is to unity upon B, so is the dividend upon A to the quotient on B; or, as the divisor upon B is to unity on A, so is the dividend upon B to the quotient on A.

I.—What is the quotient of 63 by 7?

Set 1 upon B to 7 upon A, and against 63 upon A is 9 upon B, the answer: or, set 7 upon B to 1 upon A, and against 63 upon B is 9 upon A, as before.

II.—What is the quotient of 960 by 15?

Set 15 upon B to 1 upon A, and against 960 upon B is 64, the answer upon A.

III.—Divide 1204 by 14.

Set 14 upon B to 1 upon A, and against 1204 upon B, is 86, the answer, upon A.

THE RULE OF THREE DIRECT.

In the Rule of Three Direct, you have always three numbers given to find a fourth, that shall have the same proportion to the third as the second has to the first.

The proportion is, as the first term upon A is to the second upon B, so is the third term upon A to the fourth upon B; or bring the first term upon B to the second upon A, then against the third term upon B is the answer upon A; always observing to take the first and third terms on the same line, and the second and fourth upon the other.

I.—If a man can walk 20 miles in 5 hours, how long will he be in walking 125 miles at the same rate?

Set 20 upon B to 5 upon A, and against 125 miles upon B is 31¼ hours, the answer, upon A.

II.—If 4 yards of cloth cost 38s., what will 30 yards cost?

Set 4 upon B to 38 upon A, and against 30 upon B are 285s., or £14 5s., the answer, upon A.

III.—If 1½-oz. of tobacco cost 4d, what will 2-oz. cost?

Set 1½ or 1.5 upon B to 4 upon A, and against 2 upon B is 5.33 or 5¼d. and about half a farthing, the answer, upon A.

IV.—If 4 cwt. of cast iron cost 26s., what will 30 tons come to?

Set 4 upon B to 26 upon A, and against 30 upon B is £195, the answer, upon A.

V.—If 3 cwt. cost 31s.6d., what will ten tons cost at the same rate?

Set 3 upon B to 31.5 upon A, and against 10 upon B is £105 the answer, upon A. The Rule thus set is a table of tons and pounds; for against any other number of tons upon B is the price in pounds and parts of a pound, upon A.

THE RULE OF THREE INVERSE.

In this rule there are three numbers given to find a fourth, that shall have the same proportion to the second as the first has to the third.

N.B.—If more requires more, or less requires less, the question belongs to the rule of three direct; but if more requires less or less requres more, it then belongs to the rule of three inverse

I.—If 6 men can do a certain piece of work in 8 days, how many men can perform the same in three days?

In inverse proportion the slide is to be inverted; then the question will be answered in the same way as in direct proportion.

Put the slide the wrong way into its place, and set 8 men upon C to 6 days upon A, then against three days upon C stands 16 men, the answer, upon A.

OF LEVERS.

In Mechanics there are three orders of the lever, or three varieties, wherein the weights, props, or powers, may be differently applied to the beam or inflexible bar, in order to effect mechanical operations in a convenient manner.

A lever of the first order has the power placed at one of its ends, and the weight to be raised is put at the other, and the fulcrum or prop somewhere between them.

A lever of the second order is when the power acts at one end, the prop or joint at the other, and the weight somewhere between them.

In a lever of the third order, the prop is planted at one end, the weight at the other, and the moving force somewhere between them.

II.—What weight, hung at 79 inches distance from the fulcrum of a steelyard, will equipoise 900lbs. freely suspended at two inches distant on the contrary side?

Invert the slide, and set 2 upon C to 900 upon A, and against 70 upon C is 25.71lbs. or 25¾lbs. nearly, the answer, upon A.

III.—What weight will a man be able to lift with a handspike 100 inches long, when he has one prop conveniently fixed at six inches from one end, and he presses upon the other end with a force equal to 150lbs?

Invert the slide, and set 94 upon C to 150 upon A, and against 6 upon C is 2350lbs., the answer, upon A.

IV.—A lever, 96 inches long, having the prop or centre fixed at one end, and a force of 50lbs. lifting at the other, what weight, hung at 16 inches from the prop, may be raised by the above force?

Set 80 upon C to 50 upon A, and against 16 upon C is 250lbs. the answer, upon A.

V.—There is a lever 9 feet long, at one end it is fixed by a prop or joint, and at the other is hung

$187\frac{1}{2}$lbs.: how far from the prop must $281\frac{1}{4}$lbs. be applied, in order to raise the weight?

Set 9 upon C to 187.5 upon A, then against 281.25 upon A is 6 feet, the answer upon C.

VULGAR AND DECIMAL FRACTIONS.

To reduce a vulgar fraction to its equivalent decimal expression, the proportion is, as the denominator upon A is to 1 upon B, so is the numerator upon A to the decimal required upon B.

I.—Reduce $\frac{1}{4}$ to its decimal expression.

Set 1 upon B to 4 upon A, then against 1 upon A is .25, the answer, upon B.

II.—Reduce $\frac{9}{12}$ to a decimal.

Set 1 upon B to 12 upon A, and against 9 upon A is .75, the answer, upon B.

III.—What is the decimal of $\frac{18}{28}$?

Set 1 upon B to 28 upon A, and against 18 upon A stands .643 upon B, the decimal required.

To find a multiplier to a divisor that shall perform the same by multiplication as the divisor would do by division, the proportion is as the divisor upon A is to unity or 1 upon B, so is unity upon A to the multiplier required upon B.

I.—Suppose 25 to be the divisor, what will be the multiplier to that number?

Set 1 upon B to 25 upon A, and against 1 upon A is .04, the multiplier, upon it.

II.—What will be the multiplier to 80?

Set 1 upon B to 80 upon A, and against 1 upon A is .0125 upon B.

III.—What will be the multiplier of 40?

Set 1 upon B to 40 upon A, and against 1 upon A is .05, the answer, upon B.

Having a multiplier given to find a divisor. The proportion is, as the multiplier upon A is to 1 upon B, so is the divisor upon B to 1 upon A.

I.—Let .04 be the multiplier given to find a divisor.

Set 1 upon B to .04 upon A, and against 1 upon A is 25 upon B.

II.—What will be the divisor for .0125?

Set 1 upon B to .0125 upon A, and against 1 upon A is 80 upon B.

III.—What will be the divisor for .7854?

Set 1 upon B to .7854 upon A, and against 1 upon A is 1273, the answer, upon B.

SQUARE AND CUBE ROOTS.

When the lines C and D are equal at both ends, C is a table of squares and D a table of roots; consequently, opposite to any number upon C is its square root upon D, as under:

Squares 1, 4, 9, 16, 25, 36, 49, 64, 81, upon C.

Roots 1, 2, 3, 4, 5, 6, 7, 8, 9, upon D; and in like manner may the squares and roots of all the intermediate numbers and divisions be found.

SOME USES OF THE SQUARE ROOT.

To find a geometrical or mean proportion between two numbers.

Set one of the numbers upon C, to the same number on D, and opposite the other number upon C, will be the mean number upon D.

I.—What is the mean proportion between 20 and 80?

Set 20 upon C to 20 upon D, and against 80 upcn C will be 40, the number sought, upon D.

II.—What will be the mean proportion between 16 and 256?

Set 16 upon C to 16 upon D, then against 256 upon C is 64, the answer, upon D.

III.—Suppose a tower, 30 feet high, stands on the opposite side of a river, which is 40 feet wide, what must be the length of a ladder that will reach from the near side of the river to the top of the tower?

Square the height of the tower and the breadth of the river, add them together, and the square root of the product will be the length of the ladder. Set your slide even at both ends, and against 30 upon D is 90, and against 40 is 160 upon C, which when added, are 250; then look for 250 upon C, and against it upon D, you have 50 feet for the length of the ladder.

Any number may be cubed, or multiplied into itself twice at one operation on the lines C and D, by setting any number on C to 1 or 10 upon D, and against the same number upon D will be its cube number on C.

Set 6 upon C to 10 upon D, and against 6 upon D is 216 upon C.

MENSURATION OF SUPERFICIES.

AS BOARDS, GLASS, PAINTING, WAINSCOTING, TILING, PAVING, PLASTERING, LAND, &c.

Boards are measured on the lines A and B; the length is always set to 12 on A (when it is given in feet), and opposite the breadth in inches on A is the answer in square feet on B.

I.—If a board be 20 feet long and 15 inches broad, how many superficial feet does it contain?

Set 20 upon B to 12 upon A, and opposite 15 upon A are 25 square feet upon B, the answer.

II.—How many superficial feet are contained in a door, height 6 feet 6 inches, and breadth 34 inches?

Set 6½ upon B to 12 upon A, and opposite 34 the breadth upon A are 18 feet 5 inches upon B, the answer.

III.—A window that is 5¾ feet high and 46 inches wide, how many feet does it contain?

Set 5¾ upon B to 12 upon A, and opposite 46 inches the breadth upon A, are 22 feet ½ inch upon B, the answer.

House painting is commonly measured by the square yard, or 9 square feet, which may be readily performed on the lines A and B, by setting the length in feet to 9 upon A, and opposite the height or breadth in feet upon A will be the answer, in square yards, upon B.

I.—How much is contained in a piece of painting, the length being 31 feet and the breadth 14 feet?

Set 31 upon B to 9 upon A, and opposite 14 upon A is 48 yards 2 feet, or 48 two-ninths yards, on B, the answer.

To find the number of inches in length at any given breadth to make a superficial foot.

Set 12 upon B to the breadth in inches upon A, and opposite 12 upon A are the number of inches upon B that will make a superficial foot.

I.—At 2 inches broad, how many inches in length does it require to make a foot?

Set 12 upon B to 2 upon A, and opposite 12 upon A is 72 upon B, the answer.

II.—Suppose you have a board 11 inches broad, how many inches in length will make a foot?

Set 12 upon B to 11 upon A, and against 12 upon A will be perceived 13 inches, and about 1 tenth of an inch upon B.

LAND MEASURING.

The gauge points for measuring land are the number of square chains, square perches, and square yards that are contained in an acre. If the dimensions are given in chains, the gauge point is 1 or 10 upon A; if in perches, it is 160; but if it is given in yards, the gauge point is 4840, which the length upon B must always be set to, and opposite the breadth upon A you will have the answer in acres and parts upon B.

I.—A field that is 20 chains 50 links in length, and 4 chains 40 links broad, how many acres does it contain?

Set 20.5 upon B to 1 upon A, and against 44 upon A are 9 acres, the answer upon B.

II.—What is the content of a field whose length is 142 perches, and breadth 45 perches?

Set 42 upon B to 160 (the gauge point) upon A, and against 45 upon A are 40.04 acres, the content, up B.

III.—How many acres are contained in a field, the length 35.25 perches, and breadth 22.5 perches?

Set 35.25 upon B to 160 upon A, and against 22.5 upon A, are 4.95 acres, the answer upon B.

IV.—If a piece of ground is 440 yards long and 44 yards broad, how many acres would it contain?

Set 440 upon B to 4840 (the gauge point for yards) upon A, and against 44 (the breadth) upon A are 4 acres, the answer, upon B.

The foregoing examples are sufficient to make the learner properly acquainted with the measurement of square superficies; others, such as circles, polygons, triangles, &c., will be treated under the head of miscellaneous questions.

MENSURATION OF SOLIDS.

The following is a Table of Gauge Points for squares, cylinders, and globes, part of which are shown on Routledge's Engineer's Rule; and in measuring and weighing solid bodies, their respective gauge points must always be made use of, and are to be ascertained by reference to the annexed table.

GAUGE POINTS FROM ROUTLEDGE'S RULE.

	SQUARE.			CYLINDER.		GLOBE.	
	FFT	FII	III	FI	II	F	I
Cubic In......	578	83	1	106	1273	105	191
Cubic Ft.	1	144	1728	1833	22	191	33
Old Ale Gal. ..	16	235	282	299	352	312	538
Old Wine Gal.	134	1925	231	245	294	235	441
Imperial Gal...	16	231	2773	294	353	3064	5295
Water........	16	231	2773	294	353	3064	5295
Gold	814	1175	141	149	179	155	269
Silver	15	216	261	276	334	286	5
Mercury	118	169	203	216	259	225	389
Brass	193	218	333	354	424	369	637
Copper	18	26	312	331	397	345	596
Lead	141	203	243	258	31	27	465
Wt. Iron......	207	297	357	378	453	394	682
Ct. Iron	222	32	384	407	489	424	733
Tin	219	315	378	401	481	419	723
Steel	202	292	352	372	448	385	671
Coal..........	127	183	22	233	28	242	42
F. Stone	632	915	11	1162	14	121	21
Oak	174	252	303	320	386	332	578
Mahogany	15	217	2605	276	333	286	49
Box	155	243	269	31	342	296	512
Red Deal	242	351	422	458	539	461	805
Marble	591	85	102	116	13	113	195
Brick	795	115	138	147	176	152	263
Oil	174	25	301	319	383	332	574
Bees' Wax	16	231	278	294	355	306	53
Sulphur	8	115	138	146	126	153	264
Alcohol	193	278	333	354	424	369	637
Air	128	1843	22118	2347	28162	244	42243
Malt Bushels..	125	179	2150	2276	2378	267	41

Observe, 1.—All the gauge points are to be found on the line A.

2.—All the lengths, whether square or round, must be on the line B, and are to be set to the gauge point on the line A.

3.—All the squares and diameters must be found on the line D.

4.—Opposite the squares or diameter on the line D, you have the content, or answer, on the line C; or say, as the length upon B is to the gauge point upon A, so is the square or diameter upon D to the content upon C.

There are three gauge points for everything that is mentioned in the table for squares; and first F.F.F., signifying that when the length and both the squares are feet, you are to find the gauge point under F.F.F., in the same line with what you are going to measure or weigh.

If the length is given in feet, and both the squares are inches, then the gauge point must be had under F.I.I.; but if the dimensions of both length and squares are in inches, then the gauge point is under I.I.I.

There are two gauge points for everything that is to be measured or weighed of a cylindric form; first, when the length is feet and the diameter inches, the gauge point is under F.I.

If the length be inches and the diameter inches likewise, then the gauge point will be under I.I.

There are also two gauge points to weigh or measure everything of a globular figure.

A globe having but one dimension, it must be either all feet or all inches. If it is feet, you have the gauge point under F.; if it is inches, you look for the gauge point under I.

The general rule for a globe is, as the gauge point on A is to the diameter on B, so is the content on C to the diameter on D; or, bring the diameter upon B to the gauge point upon A, and against the diameter upon D you have the content, or answer, upon C.

In measuring or weighing square timber, stone, metals, or any other bodies that are unequal sided a mean proportion must be found to ascertain the true square; this operation is explained in the use of the square root.

I.—Suppose a piece of timber 16 inches broad, 6 inches thick, and 20 feet long, how many solid feet does it contain?

Find the mean square, as before directed, by setting 16 upon C to 16 upon D, and opposite 6 upon C you have 9.8 inches upon D, the side of a square equal to 16 by 6; having thus found the true square, look for the gauge point for cubic feet, and under F.I.I. is 144; set 20 (the length) upon B to 144 upon A, and against 9.8 upon D are 13.3 cubic feet upon C.

II.—What is the content of a piece of timber 3 feet square and 20 feet long?

Here the dimensions are feet, and the gauge point under F.F.F. is 1. Set 20 upon B to 1 upon A, and against 3 upon D are 180 feet, the answer, upon C.

III.—To measure the same piece with the dimensions all in inches.

The gauge point for square, under I.I.I., is 1728. Set 240 (the length in inches) upon B to 1728 upon A, and against 36 (the square) upon D, are 180 feet upon C, as before,

Round timber is generally measured by the girt; which is done by putting a line round the middle of the tree, and taking one-fourth of the girt for the square. This is far from being a true way, but it is what is most commonly practised, and is performed upon this Rule (after the girt is taken) in the same way as the three last examples; it may nevertheless be necessary to show the different result there will be between the customary and true method of measuring round timber.

IV.—A round tree that is 30 feet long and measures 40 inches round the middle, how many cubic feet does it contain?

Here one-fourth of the girt is 10 inches. Set 30 (the length) upon B to 144 upon A, and against 10 upon D are 20.75 feet, the answer, upon C.

V.—If the circumference of the above tree is 40 inches, the diameter will be 12.73 inches.

Then set 30 (the length) upon B to 1833 (the gauge point) upon A, and against 12.73 upon D are 26.5 feet, the answer, upon C.

By this it will be seen that there is a difference of $5\frac{3}{4}$ feet between the customary and the true method of measuring.

OF CYLINDERS, GLOBES AND CONES.

I.—A cylinder that is 6 inches long and six inches diameter, how many cubic inches does it contain?

The gauge point for cubic inches is 1273. Set 6 upon B to

1273 upon A, and against 6 upon D are 169 cubic inches, the answer, upon C.

II.—How many cubic feet are contained in a cylinder that is six feet six inches long and 20 inches diameter?

Set 6.5 upon B to 1833 upon A, and against 20 upon D are 14.2 cubic feet upon C.

III.—What will be the content of a cylinder, globe, and cone, separately; the cylinder 12 inches high and 12 inches diameter; the globe also 12 inches diameter and the cone 12 inches high and 12 inches diameter at its base?

For the cylinder, set 12 upon B to 1273 upon A, and against 12 upon D are 1356 cubic inches, the answer, upon C.

For the globe, set 12 upon B to 191 upon A, and against 12 upon D are 904 cubic inches, the answer, upon C.

For the contents of the cone, take one third of its height, that is 4 inches, and set 4 upon B to 1273 (the round gauge point) upon A, and against 12 (the diameter) upon D, are 452, the answer, upon C.

Whether the last three answers are right or wrong, may be easily proved by the proportion they bear to each other; for a cylinder, the height and diameter of which are the same, is to its inscribed globe and cone as 3, 2 and 1; therefore, if you set the content of the cylinder upon B to 3 upon A, then against 2 and 1 upon A, you will have the content of the globe and cone, upon B respectively: for example,

Set 1356 upon B to 3 upon A, and against 2 upon A are 904, and against 1 upon A are 452 upon B, the answer, as before.

LIQUID MEASURE.

I.—A column of water 12 feet high and 14 inches diameter, how many old wine and imperial gallons will it contain?

Set 12 upon B to the respective circular gauge points for old wine and imperial measure (say 245 for old wine and 294 for imperial) upon A, and against 14 on D are 96 gallons old and 80 imperial, the answer, upon C.

II.—What number of old ale and imperial gallons are contained in a column of water 300 feet long and 12 inches diameter?

Set 300 upon B to the respective circular gauge point for old and imperial measure (say 299 for old ale and 294 for imperial) upon A, and against 12 upon D are 1440 old ale, and 1464 imperial gallons, the answer, upon C.

III.—What will be the contents in old ale and imperial gallons of a vessel that is 36 inches deep and 24 inches square?

Set 36 upon B to the respective square gauge points for ale and imperial measure (say 282 for ale and 2773 for imperial) upon A, and against 24 on D are 73.5 old ale and 74.5 imperial gallons, the answer, upon C.

CASK GAUGING

Is performed after a mean diameter is found exactly in the same manner as the last examples; casks are generally reduced to four varieties; and if the difference between the head and bung diameters does not exceed 6 inches, then their diameters may be found by multiplying the difference of the first by .68; the second by .62; the third by .55; the fourth by .5; the respective products of these numbers added to the head diameter will make a mean diameter.

I.—In a cask of the first variety, head diameter 24, bung 28, and length 30 inches, how many old ale and imperial gallons will it contain?

Set 30 upon B to the respective circular gauge points for the old ale and imperial measure (say 359 for old ale and 353 for imperial) upon A, and against 26.72 (the mean diameter) upon D are 59.73 old and 60.7 imperial gallons, the answer, upon C.

II.—How many old ale and imperial gallons are contained in a cask of the second variety, head diameter 18, bung diameter 23, and length 28 inches?

Set 28 upon B to the separate circular gauge points for old ale and imperial measure (say 359 for old ale and 353 for imperial) upon A, and against 21.1 (the mean diameter) upon D are 34.75 old and 35.3 imperial gallons, the answer, upon C.

III.—If a cask of the third variety is 20 inches at the head, 26 at the bung, and 29 inches long, what will be its contents in old ale and imperial gallons?

Set 29 upon B to the separate circular gauge points for old and imperial measures (say 359 for old ale and 353 for imperial) upon A, and against 23.3 (the mean diameter) upon C are 43.8 old and 44.6 imperial gallons, the contents, upon C.

IV.—A cask of the fourth variety, 34 inches long, head 26, and bung 32, how many old and imperial gallons will it hold?

Set 34 upon B to the separate circular gauge points, as in the foregoing questions upon A, and against 29 (the mean diameter) upon D are 79.8 old and 81 imperial gallons, the answer, upon C.

MALT GAUGING.

The old gauge points for malt are, for square measure 2150, and for circular measure 2378. Imperial gauge points are, for square measure 2218, and for circular measure 2824.

I.—How many old and imperial bushels are contained in a cistern or floor 72 inches long, 48 inches broad, and 1 inch deep?

Set 72 (the length) upon B to the respective square gauge points (say 2150 for old and 2218 for imperial) upon A, and against 48 (the breadth) upon A, are 1.6 bushels old and 1.558 imperial, the answer, upon B: this multiplied by any number of inches deep, will give the respective answers; or, set 1.6 or 1.558 bushels, as the case may be, upon B to 1 upon A, then against any number of inches deep upon A you will have the answer in bushels upon B.

II.—If a cistern is 84 inches long, 60 wide, and 32 inches deep, how many old and imperial bushels will it hold?

Set 84 upon B to the respective square gauge points (say 2150 for old and 2218 for imperial) upon A, and against 60 on A are the contents of 1 inch in depth, which place on B to 1 on A, and against 32 inches deep on A, are 65 old and 72.7 imperial bushels, the answer, on B.

III.—How many old and imperial bushels are contained in a round cistern, 32 inches deep and 60 inches diameter?

Set 32 upon B to the respective circular gauge points for old and imperial measure (2378 for old and 2824 for imperial) upon A, and against 60 upon D you have 42.07 old and 40.75 imperial bushels, the answer, upon C. In like manner are all other cisterns, couches, floors, &c., to be measured.

WEIGHING OF METALS, &c.

The weighing of any body or substance is performed after the same manner as measuring the same, and which has been fully described in pages 12, 13, 14, 15, and 16, for which purpose refer to the gauge points for solid bodies in the table on page 13, and to the instructions and formularies on page 14, only the answer you call pounds instead of cubic inches or feet, gallons, bushels, &c.

I.—What is the weight of a piece of cast iron, 3 inches square and 6 feet long?

The cast iron gauge point for feet and inches under the head of "square" is 32. Set 6 upon B to 32 upon A, and against 3 upon D are 168 lbs., the answer upon C.

II.—What will be the weight of a bar of wrought iron, 12 feet long and $1\frac{1}{2}$ inches square?

Set 12 upon B to 297 (the gauge point) upon A, and against 1.5 upon D are 91 lbs., the answer, upon C.

III—A cylinder that is 6 inches long and 6 inches diameter, what will be its weight in cast iron, wrought iron, and brass.

First, for cast iron, the gauge point is 489. Set 6 upon B to 489 upon A, and against 6 upon D are 44 lbs. upon C.

For wrought iron the gauge point is 453. Set 6 upon B to 453 upon A, and against 6 upon D are $47\frac{1}{2}$ lbs. upon C.

The gauge point for brass is 424. Set 6 upon B to 424 upon A, and against 6 upon D are 51 lbs. the answer, upon C.

IV.—How many pounds will a solid globe of brass weigh, 6 inches in diameter? The gauge point is 637.

Set 6 upon B to 637 upon A, and against 6 upon D are 34 lbs., the answer upon C.

V.—What will be the weight of a cone of brass that is 6 inches high and 6 inches diameter at its base?

Take one-third of the height, equal to 2 inches, and set 2 upon B to 424 (the circular gauge point) upon A, and against 6 upon D are 17 lbs. upon C.

The truth of these last three examples may be proved by ascertaining whether their proportions are to each other as 3, 2, and 1, the same as was done by the solid contents of the cylinder, globe and cone, in page 16.

Set 51 lbs. (the weight of the cylinder) upon B to 3 on A, then against 2 and 1 upon A, will be 34lbs. for the globe and 17lbs. for the cone as before.

The following are a few questions, with their respective answers annexed for the learner's practice.

I.—What is the weight of a cast iron shaft that is 4 inches square and 9 feet long, but somewhere in the shaft are two round necks, each 7 inches long and $3\frac{1}{2}$ diameter? This will require two operations.

The answer is 426lbs.

II.—What is the weight of a round piece of cast iron, 6 feet long and 6 inches diameter, with a round boss on it 9 inches long and 12 inches diameter?

Answer 730lbs.

III.—What is the weight of a flat bar of wrought iron, 1 inch thick, $2\frac{3}{4}$ inches broad, and 10 feet long?

Answer, 70lbs.

IV.—What is the weight of a globe of lead 12 inches diameter? Likewise the weight of another piece, in a cylindrical form, 12 inches long and 12 inches diameter?

Answers, globe 372lbs., cylinder 559lbs.

V.—A wrought iron piston rod, 13 feet long and 5 inches diameter; at one end it has a conical piece, 12 inches long, the thick end is 6 inches and the other $5\frac{1}{4}$ inches diameter. The weight of the rod is required.

Answer, 876 lbs.

VI.—What is the weight of a round piece of copper, 60 inches long and $1\frac{1}{4}$ inches diameter?

Answer, $23\frac{1}{2}$lbs.

VII.—What is the weight of a column of mercury 1 inch square and 29.5 inches long?

Answer, 14.5lbs. or $14\frac{1}{2}$lbs.

VIII.—What is the weight of a column of water, 1 inch square and 38 feet long?

Answer, 14.3lbs.

IX.—What is the weight of a millstone, 60 inches diameter and 12 inches thick?

Answer, 3080lbs.

X.—What is the weight of a solid yard of coal?

Answer, 2110lbs.

MISCELLANEOUS QUESTIONS.

Under this head are introduced many original questions, and likewise those that could not be introduced in the regular order in the foregoing rules.

OF A CIRCLE.

The following formulary will show most of the useful properties of the circle and the mode of finding its equal or inscribed square and inscribed equilateral triangle.

$$\text{Side of an equal square} = \begin{cases} \text{diameter} \times .886 \\ \text{or} \\ \text{circumference} \times .282 \end{cases}$$

$$\text{Side of an inscribed square} = \begin{cases} \text{diameter} \times .707 \\ \text{or} \\ \text{circumference} \times .225 \end{cases}$$

Side of an inscribed equilateral triangle = diam. ÷ 1.15

A circle whose diameter is 1 . . the area = .7854

" circumference is 1. the area = .0795

" diameter is 1 circumference = 3.141

I.—Having the diameter given to find the area, or the area given to find the diameter.

Set .7854 (the area of unity) upon C to unity or 10 upon D, then the lines C and D will be a table of areas and diameters; for against any diameter upon D is the area in square inches upon C.

II.—Having the circumference given to find the area, or the area given to find the circumference.

Set .0795 upon C to 1 or 10 upon D, then the lines C and D will be a table of areas and circumferences; for against any circumference upon D is the area in square inches upon C.

III.—Having the circumference given to find the diameter, or the diameter given to find the circumference.

Set 1 upon B to 3.141 upon A, then the lines A and B will be a table of diameters and circumferences; for against any diameter upon B you will have the circumference upon A.

IV.—To find the side of a square equal in area to any given circle.

Set .886 upon B to 1 upon A, then against any diameter of a circle upon A is the side of a square that will be equal in area upon B.

V.—To find the side of the greatest square that can be inscribed in any given circle.

Set .707 upon B to 1 upon A, and against any diameter of a circle upon A is the side of its inscribed square upon B.

VI.—To find the side of the greatest equilateral triangle that can be inscribed in any given circle.

Set 1 upon B to 1.15 upon A, against any diameter of a crcle upon A you have the length of a side of a triangle upon B.

A TABLE OF GAUGE POINTS.

To find the area of an equilateral triangle and regular polygons from 5 to 12 sides.

No. of Sides.	Gauge Points.
3	.433
5	1.72
6	2.598
7	3.634
8	4.828
9	6.182
10	7.694
11	9.366
12	11.196

RULE.

As the gauge point upon C is to unity upon D, so is the length of one side of any polygon upon D to the content or area upon C; or, set the gauge point upon C to 1 or 10 upon D, then against the length of one side of the polygon upon D is the content or area upon C.

I.—What will be the area of an equilateral triangle, each side 12 inches long?

Set .433 (the gauge point) upon C to 1 upon D, and against 12 upon D are 62.5 square inches, the answer, upon C.

II.—Required the area of a polygon with 7 sides, each side equal to 3.5 inches in length.

Set 3.634 (the gauge point) upon C to 1 upon D, and against 3.5 upon D are 44.6 upon C, the area in square inches.

III.—What is the area of a 10-sided figure, each side 5 inches long?

Set 7.694 (the gauge point) upon C to 1 upon D, and against 5 upon D are 192, the answer, upon C.

A TABLE OF GAUGE POINTS.

To find the solid contents of shafts or prisms that are polygonal-sided.

No. of Sides.	Gauge Points.
3	23
5	58
6	385
7	274
8	207
9	161
10	13
11	1063
12	833

RULE.

As the length of the prism on B is to the gauge point on A, so is the length of one of its sides upon D to the solid content in inches upon C; or, set the length upon B to the gauge point upon A, then against the length of one of its sides upon D you have the content in cubic inches upon C.

I.—What will be the solid content in cubic inches of a triangular prism, whose height is 24 inches, and length of each side 12 inches?

Set 24 upon B to 23 (the gauge point) upon A, and against 12 (the length of the side) upon D, are 1500 cubic inches, the answer, upon C.

II.—How many cubic inches are contained in a 5 sided body, the length of each side being 4 inches, and its height 12 inches?

Set 12 upon B to 58 upon A, and against 4 upon D are 331, the answer, upon C.

III.—What will be the content of a shaft, 60 inches long, with 8 sides, each side to be 2 inches?

Set 60 upon B to 207 upon A, and against 2 upon D is 1160, the answer, upon C.

All the others are answered by the same rule.

MACHINERY.

I.—To find the number of cogs or teeth in a wheel, having the pitch of the tooth and diameter of the wheel given.

If a wheel is 40 inches diameter at the pitch line, and the pitch of the tooth or cog is exactly 2 inches, how many teeth are in the wheel?

Set 2 (the pitch of the tooth) upon B to 3.14 (the gauge point) upon A, and against 40 (the diameter) upon B are 63 cogs upon A.

II.—To find the diameter, having the pitch and number of teeth given.

A pinion, to work in the above wheel is to have 21 cogs, what will be the diameter at the pitch line?

Let the slide remain as in the last example, and look opposite 21 (the number of cogs) upon A, and you have the diameter, 13.4 inches nearly, the answer, upon B.

III.—The diameter at the pitch line and number of teeth being given, to find the pitch of the tooth.

If a wheel is 70 inches diameter, and is to have 146 teeth, what will be the pitch of the tooth?

Set 70 upon B to 146 upon A, and against 3.14 (the gauge point) upon A, is 1.5 inches, the pitch of the tooth, upon B.

IV.—The revolution of two wheels given, with the diameter of one of them, to find the diameter of the other.

If a wheel that is 192 inches diameter, makes 4 revolutions in a minute, what will be the diameter of another wheel that works in it, and is to make 81 revolutions in the same time.

Invert the slide, and set 4 upon C. to 192 upon A, and against 81 upon C is 9.5 inches upon A, the diameter of the lesser wheel.

V.—The distance between two shafts and the number of their revolutions given, to find the diameters of two wheels that will turn them at any given velocities.

The fly shaft of a steam engine, making 22 revolutions in a minute, is to give motion, by a pair of spur wheels, to the tumbling shaft in a mill, which is to be turned exactly 15.5 times in a minute; the distance between the two shafts is 45.5 inches; the diameter of the two wheels is required.

Add the revolutions of the two wheels together (37.5), then set 37.5 upon B to 45.5 upon A, and against 22 upon B is 26.75 upon A for the tumbling shaft, and against 15.5 upon B is 18.75 inches upon A for the fly shaft. These numbers are half the diameters of each wheel, consequently must be doubled, or multipled by 2, and you will have 53½ and 37½ inches for the real diameters of the wheels.

VI.—How to find the diameter of a pulley or drum that shall have a given number of revolutions, either less or more, in a given time, than another pulley of a given diameter in the same time.

There are two shafts for the purpose of turning machinery, one makes 50 and the other 40 revolutions in a minute; the diameter of the drum upon the shaft that goes 50 times a minute, is 30 inches; what will be the diameter of a drum upon a shaft making 40 revolutions that will drive the machinery at the same speed as the shaft, making 50 revolutions in a minute?

Invert the slide, and set 50 upon C to 30 upon A, and against 40 upon C is 37.5 inches, the answer, upon A.

VII.—If the fly shaft of a steam engine makes 60, and the governor 38 revolutions in a minute, and the pulley on the shaft be 19 inches diameter, what will be the diameter of the governor pulley?

Answer, 30 inches.

PUMPS.

I.—Suppose the handle or lever of a pump is 84 inches long, the end where the bucket is fixed is 30 inches from the fulcrum or prop, the other end being 54 inches long, passes through a space of 19 inches. The stroke of the bucket is required?

Set 54 upon B to 19 upon A, and against 30 upon B is 10.57 inches, the answer, upon A.

II.—If the lever and pump, circumstanced as in the last example, have to raise water with a six-inch working barrel to the height of 24 feet above the surface of the water in the well, it is required to find the number of old ale, wine, and imperial gallons it contains; also its weight in lbs. avoirdupois; likewise what force must be applied to the other end of the lever in order to lift it, setting aside all friction. First look for the old ale, wine, and imperial gauge points for feet and inches: under F, is 299, for old ale, 245 for old wine, and 294 for imperial gallons.

Set the length, 24 feet upon B, to the respective gauge points (as above) upon A, and against 6, the diameter, upon D, are 28.8 old ale, 35.5 old wine, and 29.5 imperial gallons, the contents upon C; and its weight in water 295lbs., being ten times the quantity of imperial gallons; 10 lbs. being the weight of the imperial gallon of water, the form of the vessel being what it may. To find the power sufficient to work the pump, if it was pumping water, invert the slide, and set 30, the short end upon C, to 295lbs., the weight of the water upon A, and against 54, the long end of the lever upon C, is 164lbs., the answer, upon A.

III.—A lever or beam that is 22 inches long, one end is to make a stroke of 18 inches while the other end passes through a space of 30 inches; required at what distance the fulcrum or prop is to be placed from each end.

Add the strokes of both ends together, which will = 48 inches, then set 48 upon B to 72, the whole length of the lever, upon A, and against 18 and 30 the two strokes upon B will be 27 and 45 upon A, the distance of the fulcrum from each end.

PUMPING ENGINES.

The two following tables of gauge points are for finding the diameters of steam engine cylinders, that will work pumps from 3 to 30 inches diameter, and at given depth in yards. The first table loads its cylinders with 10lbs. upon every square inch of the area in their pistons; and the second table is calculated so as to load the different cylinders with 7lbs. weight upon every square inch in the area of their pistons.

Table of 10lbs. to the Inch.				Table of 7lbs. to the Inch.			
Diam. of Pump.	Gauge Points.	Diam. of Pump.	Gauge Points.	Diam. of Pump.	Gauge Points.	Diam. of Pump.	Gauge Points.
3	115	17	367	3	165	17	528
4	204	18	41	4	292	18	591
5	318	19	46	5	457	19	695
6	458	20	51	6	66	20	731
7	625	21	562	7	89	21	81
8	815	22	616	8	117	22	885
9	103	23	67	9	148	23	97
10	127	24	732	10	183	24	406
11	154	25	795	11	222	25	114
12	183	26	86	12	264	26	124
13	2125	27	928	13	308	27	134
14	25	28	99	14	358	28	143
15	2875	29	107	15	412	29	154
16	327	30	115	16	468	30	165

In making use of the two preceding tables, observe the following rule.

As a gauge point on A is to unity on B, so is the length of a column of water in yards on C to the diameter of the steam cylinder on D; or set unity on B to the gauge point upon A, then against any length of a column of water in yards on C, is the diameter of a cylinder that will work the pump on D.

I.—What will be the diameter of a steam cylinder sufficient to work a pump 16 inches diameter and 20 yards deep, the piston to be loaded with 10lbs. upon the inch?

In the first table you will find the gauge point for a 16-inch pump to be 327. Set unity upon B to 327 upon A and against 20 yards upon C is 25.5 or 25½ inches upon D, the diameter of the steam cylinder required.

When the slide is thus set to its proper gauge point for any diameter of a pump, the lines C and D are a table for that same diameter; for against any length in yards upon C you have the diameter of the steam cylinder in inches upon D. For example:

against	15	20	25	30	35 yards upon C
are	22.1	25.5	28.5	31.3	33.8 in. diam. on D,

and so of all the rest above or below 20 yards.

II.—What will be the diameter of a cylinder to work a pump 12 inches diameter, at 70 yards deep, and loaded with 7lbs. on the inch?

In the second table for a 12-inch pump is 264. Set 1 upon B to 264 on A, and against 70 yards upon C is 43 inches, the answer upon D.

For example:

against	15	20	25	30	35 yards upon C
are	19.8	23	25.6	28.1	30.4 in. diam. on D

How to find the size of a steam pan or boiler, to supply with steam a cylinder of any given diameter, whether the boiler be round, square, or any other figure or shape. The answers given upon the Rule are the square or superficial feet that must be contained in the surface of the water in the boiler.

Example. How many superficial feet must be contained in the area of a boiler that will supply a cylinder 43 inches in diameter.

Set 1.3 (the gauge point) upon C to 1 or 10 upon D, and against 43 upon D are 240 feet, the answer upon C.

The rule thus set is a table of cylinders and boilers.

Against these diameters of cylinders in inches upon D, are the areas of the boilers in superficial feet upon C.

Diameters of cylinders in inches upon D	Areas of the boilers in superficial feet upon C
15	29.2
20	52
25	81
30	117
35	160
40	207
45	264

How to divide a straight line of a given length into any number of equal parts required.

I.—Suppose a straight line, 60 inches long, to be divided into 45 equal parts, what will be the length of each part?

Set 45 upon B to 60 upon A, and against unity upon B is 1. inches, the length of each part upon A.

II.—A line, 90 inches long, divided into 62 parts, what will be the length of each part?

Set 62 upon B to 90 upon A, and against 1 upon B is 1.45 inches, the length of each part upon A.

FALLING BODIES.

The velocity acquired by heavy bodies falling near the surface of the earth is $16\frac{1}{12}$ feet in the first second; and as $16\frac{1}{12}$ feet are to the square of one second, or 1, so is the given distance to the square of the seconds required.

I.—Suppose a stone let go into a pit should find the bottom at the end of the sixth second, what is the depth of the pit?

16 1-12th upon C to 1 upon D, and against 6 upon D are 580 feet, the answer, upon C.

When the slide is thus set, the lines C and D are a table of seconds and feet :

against	2	4	6	8	10 seconds upon D
are	64.3	257	580	1030	1612 feet upon C.

PENDULUMS.

It has been found by experience that a pendulum 39.2 inches long, makes in this latitude 60 vibrations in one minute of time; and that the lengths of pendulums are to each other as the square of the number of their vibrations made in the same space of time.

I.—What will be the length of a pendulum that will beat half seconds; that is make 120 vibrations in a minute?

Invert the slide, and set 39.2 upon B to 60 upon D, and against 120 upon D are 9.8 inches upon B.

As the slide now stands, the lines B and D are a table of inches and vibrations; for against any length in inches upon B you have the number of vibrations on D.

against	157	88.5	56.5	39.2	28.1 inches upon B
are	30	40	50	60	70 vibrations on D.

II.—If the extreme end of the minute hand of St. Paul's clock should be observed to move forward at the rate of 30 inches in five minutes, what will be the length of the circumference of that part of the dial plate, and likewise the length of the minute hand?

Set 5 minutes upon B to 30 inches upon A, and against 60 minutes upon D (that being one revolution of the hand) stands 360 inches, the circumference of the dial, upon A: then set one upon B to 3.14 upon A (for which see page 21 on the properties of the circle), and against 360 upon A are 114.58 inches, the diameter of the dial plate; which divided by 2 gives the length of the minute hand, equal to 57.29 inches.

If a man sets out from Bolton to London, and walks at the rate of 3 miles an hour; another man at the same time sets off from London to Bolton, and walks at the rate of $3\frac{1}{2}$ miles an hour; at what distance from each place will they meet, it being 193 miles between the two towns?

Add 3 to $3\frac{1}{2}$, equal to 6.5 or $6\frac{1}{2}$, then set 6.5 upon B (the distance they both walk in an hour) to 193 miles upon A, and against 3 upon B are 89 miles upon A, the distance from Bolton, and against 3.5 upon B are 104 miles upon A, the distance from London.

In the following table the weight of cast iron pipes is stated from $\frac{1}{4}$ to 2 inches thick, and from 1 to 21 inches in the diameter of the bore, and 12 inches long: in the first column is the diameter of the bore, and at the tops of the other nine columns are the thicknesses of metal. Suppose you would find the weight of a pipe 5 inches bore, $\frac{3}{4}$ thick, and 12 inches long; look for 5 in the first column, and follow the line towards the right hand until you come underneath $\frac{3}{4}$, and in the angular meeting between 5 and $\frac{3}{4}$ you have 42lbs. for the weight of the pipe. When a greater length of pipe is wanted, multiply the answer to 1 foot by any number of feet, and you have the weight of the whole. In pipes that have flanges on the end, every two flanges may be reckoned equal to 1 foot of the pipe to which the flanges belong.

This table likewise affords an infinite number of entertaining questions for the Rule, which will bring the learner into proper practice, by working them in order to see whether the answers in the table will correspond with the Rule.

A single example will be sufficient to show how to weigh pipes by the Slide.

What will be the weight of a pipe 12 inches long, 8 inches bore, and $\frac{3}{4}$ thick?

Set 12 upon B to 489 upon A, and against 8 upon D are 157lbs. upon C: then twice $\frac{3}{4}$ added to 8, will be equal to 9.5, the outside diameter, look against 9.5 upon D, and you have 221lbs upon C; then subtract 157 from 221, and it leaves 64lbs. for the weight of the pipe.

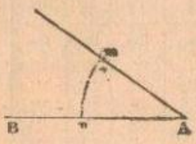
TABLE of the WEIGHTS of CAST IRON PIPES,

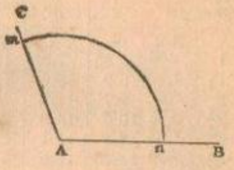
12 inches long, in lbs. Avoirdupois.

DIAM. OF BORE.	THICKNESS OF METAL, IN INCHES AND PARTS.								
	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2in.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	3.05	5.85	7.35	12.9	19.7	...	...	...	...
$1\frac{1}{2}$	4.28	6.9	10.6	16.6	24.4	...	...	...	...
2	5.5	8.7	12.2	20.2	29.25	39.5	...	...	...
$2\frac{1}{2}$	6.73	10.5	14.6	23.5	34.2	46.6	...	...	...
3	7.95	12.5	17.1	27.4	39.	51.75	...	...	...
$3\frac{1}{2}$	9.15	14.25	19.5	31.	43.9	58.	...	...	..
4	10.4	16	22.	34.7	48.8	64.75	80.5	...	...
$4\frac{1}{2}$	11.62	17.9	24.4	38.3	53.7	70.5	87.5	..	...
5	12.8	20.	26.8	42.	58.6	76.3	95.4	...	...
$5\frac{1}{2}$	...	21.8	29.3	45.6	63.5	82.5	103.	...	...
6	...	23.6	31.75	49.5	68.5	88.2	110.	133	156
$6\frac{1}{2}$	...	25.4	34.2	52.8	73.2	94.6	117.	141	166
7	...	27.	36.5	56.6	78.	101.	125.	150	176
$7\frac{1}{2}$	...	28.8	39.	60.3	83.	107.	132.	158	186
8	...	31.	41.4	64.	87.5	112.8	139.	166	196
$8\frac{1}{2}$	...	...	43.8	67.5	92.4	119.	146.	175	206
9	...	...	46.3	71.2	97.5	125.	154.	183	216
$9\frac{1}{2}$	...	...	48.6	74.8	102.5	131.	161.	192	226
10	...	...	51.1	78.5	107.	137.	169.	200	236
$10\frac{1}{2}$	...	...	53.6	82.5	112.1	143.	176.	209	246
11	..	...	56.2	86.	117.	149.	183.	217	255
$11\frac{1}{2}$	...	...	58.5	89.5	122.	155.	191.	227	265
12	...	...	61.	93.5	127.	161.	198.	235	275
$12\frac{1}{2}$	...	...	63.5	97.3	132.	167.	205.	243	285
13	...	...	66.	101.	137.	173.5	212.	252	294
$13\frac{1}{2}$	...	...	68.4	104.8	141.5	179.	219.	260	304
14	...	...	71.	108.2	146.	185.	227.	269	314
$14\frac{1}{2}$	...	...	73.4	112.3	151.	192.	234.	277	324
15	...	...	75.8	115.7	156.	198.	242.	286	334
$15\frac{1}{2}$	...	...	78.1	119.	161.	204.	250.	295	344
16	–	...	80.7	123.	166.	211.	257.	303	353
$16\frac{1}{2}$	...	...	83.1	126.5	170.5	217.	264.	312	363
17	...	...	85.5	130.	175.5	223.	271.	322	373
$17\frac{1}{2}$	...	...	87.8	133.5	180.5	229.	278.	330	383
18	...	...	90.5	137.	185.	235.	285.	338	393
$18\frac{1}{2}$	...	...	93.	140.5	190.	241.	293.	347	402
19	...	...	95.5	144.8	195.	247.	303.	354	412
$19\frac{1}{2}$	...	...	97.8	148.5	200.	253.	307.	363	422
20	...	...	100.	152.	205.	259.	315.	372	432
$20\frac{1}{2}$	...	..	102.5	156.	210.	265.	323.	381	442
21	...	...	105.	159.5	215.	271.	330.	390	452

OF THE LINE OF CHORDS.

One of the most general uses of the line of chords, is the construction and measurement of angles.



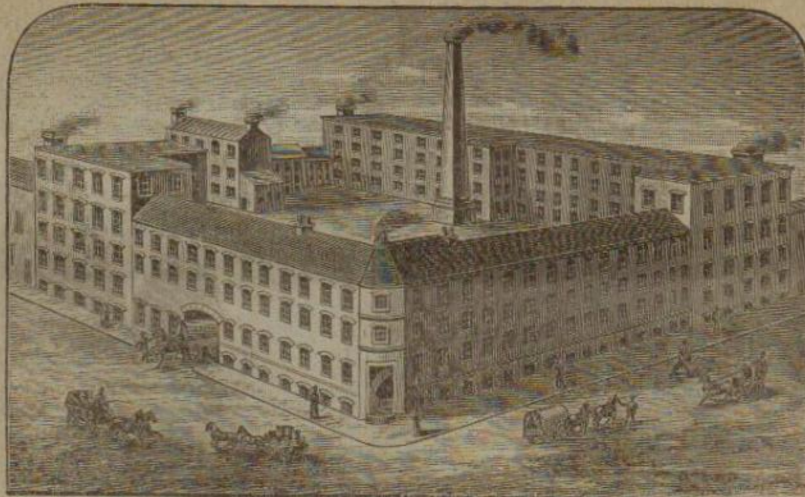


TO CONSTRUCT AN ANGLE OF ANY REQUIRED NUMBER OF DEGREES.—Draw the line A B, and having taken the first 60° from the scale of chords, describe from the point A with this radius the arc *m n*. Take in like manner a chord of the proposed number of degrees from the scale and apply it from *n* to *m*. Then the line A C being drawn from the point A through *m*, the angle C A B will be that required.

TO MEASURE AN ANGLE BY THE LINE OF CHORDS.—Any angle C A B being given, to find the number of degrees it contains. From the angle point A with the chord of 60° describe the arc *m n*, cutting A C, A B, in the points *m n;* then take the distance *m n* and apply it to the scale of chords, and it will show the magnitude of the angle in degrees. If the distance *n m* be greater than 90°, it must be taken at twice, and each part applied separately.

In the books of instruction (which are sold by other makers), for the use of Routledge's Engineers' Rules, a small and imperfect table of gauge points has been inserted toward the end of the work; but as in this edition, these with others have already been presented to the reader in a more intelligible form and with considerable additions in pages 13, 21, 22, 23 and 26, in connection with the various instructions for their use, it is therefore unnecessary here to repeat them.

FINIS.



HOCKLEY ABBEY WORKS, BIRMINGHAM.—JOHN RABONE & SONS.