INSTRUCTIONS

FOR THE

USE OF THE SLIDE-RULE,

APPLIED TO COMPUTATIONS

RELATING TO PRACTICAL HUSBANDRY;

AND OF

THE CATTLE GAUGE,

FOR ASCERTAINING

THE CARCASE WEIGHT OF OXEN.

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INVENTOR OF "THE IMPROVED CATTLE GAUGE," ETC.

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PREFACE.

THE title will, in some measure, explain the nature and design of the present publication; which, although only intended as a compendium of instructions for the use of a particular arrangement of the instrument, yet, from the introduction affording a somewhat comprehensive description of its construction, and the subsequent parts containing its application to the solution of questions in arithmetic—an ample epitome of mensuration—and the copiousness and variety of its application to practical subjects connected with the business of rural life, will render the present work an instructive manual for the use of the Slide-rule generally; at any rate, it will much assist a knowledge of the use of the Slide-rule, in its application to other purposes than those treated of in the subsequent pages.

All calculations by figures are attended with loss of time, and those, even of the simplest nature, are not exempt from mental labour; therefore, any contrivance by which computations are reduced in their operation, cannot but be appreciated by those to whom calculations may frequently occur. A book of tables of results of computations by inspection, if to an extent to render such tables sufficiently comprehensive to be of much use, even when embracing but a few of the numerous subjects treated of in the present work, would be inconvenient from its bulk, and, under the most judicious arrangment of its contents, would be attended with considerable loss of time in reference. Both of the objections, just mentioned, are completely obviated by the use of the Slide-rule; for, whilst the compass of results is almost unlimited, the instrument, especially in the form adopted in the FARMERS' SLIDE-RULE, may, at all times, be carried about the person without the slightest inconvenience; and, from the nature of its operation, results are instantaneously obtained by inspection without any mental effort. Therefore, apart from every other advantage in its use, the Slide-rule is a *more ready reckoner*, than any *ready reckoner* can be in the form of printed tables.

In the part of the present publication treating of the use of the Slide-rule, applied to practical purposes connected with agriculture, no matter, that can in any way be liable to question, has been admitted without the truth and usefulness of it, as it appears in the following pages, having been confirmed by the author's experience and observation; so that what appears in the present work is not the compilation of any thing that may be doubtful from extant works of others, but the result of the author's actual experience in what may continually occur, and be useful, to the husbandman in his business.

The knowledge of carcase weight, and consequently, the value of fat oxen, sheep, and swine, is a matter of great importance to the husbandman; and, to impart which, many publications on the subject have appeared from time to time, yet the books that have been published —the directions that have been given—and the modes that have been suggested, have all failed in attaining the professed object with any certain degree of accuracy. The most usual mode of determining this important matter, in some instances, gives a result pretty near the truth, but in the majority of cases the computed weight is very wide of the mark. Such failure has not arisen so much from the false principle of the mode adopted for the purpose, as to want of modification to meet the numerous exceptions to any general rule, applied to a subject of so intricate a nature, in which many circumstances exert a seperate and combined influence. If cattle were all of a similar shape, with an unvarying proportion of parts—a constant similarity of condition, and internal cavity—then some of the means that have been suggested might answer the purpose; the carcase weight of oxen, &c., might be deduced by some constant rule with a degree of accuracy, sufficiently close for practical purposes. But, when it is the fact, that scarcely two animals, not only of the same species, but of the same particular breed and in like condition,—nay, even in the near relation to each other of being the progeny of the same sire and dam,—are found to be of similar proportions, how useless must any constant rule be, when applied with a view to determine the carcase weight of animals of different breeds—in different states of fatness—of different sexes—and of mature and immature ages!

Endeavouring to discover the *rationale* of the live and carcase weight of oxen, sheep, and swine, and of the size and carcase weight of cattle, engaged much of the attention of the author during many years. The result of upwards of three thousand comparisons on the subject, by favour of the master butchers of Newcastle-upon-Tyne, North and South Shields, and Sunderland, will be found in tables at p.p. 67 and 70, and led to the arrangement and publication of the "IMPROVED CATTLE GAUGE," in July, 1844; the principle of the operation of which is founded on a modification both for shape peculiar to different breeds, and for different states of fatness. Since the publication of the instrument referred to, the author has had the satisfaction of acknowledgements of its utility, in most flattering terms, from numerous individuals well qualified to judge of its merits. The author must here in duty to himself assert his claim to the invention of the instrument known in the Birmingham trade as "Improved Cattle Guage;

rule 7065" : as several months after the publication of the instrument in question, by Mr. Cail, of Newcastle-upon-Tyne, Mr. Forbes, traveller for the firm of Messrs. Wilmot, Roberts and Daniel, factors, Birmingham, procured one published by Mr. Cail, whilst on his journey in the north of England, and furnished the same to one Thomas Aston, by whom it was closely copied, with the exception of omitting the author's name as the inventor, and *falsely* stamping his own name as "*the original maker;*" and so zealous had the Birmingham people been to copy the author's invention, that they actually adopted a *misplaced line* in the original instructions for the use of the instrument. The author would have refrained from making the foregoing statement, had the parties complied with his reasonable request of having the whole of the original title,—viz., "Improved Cattle Gauge arranged by John Ewart, Newcastle-upon-Tyne,"—stamped upon the instrument.

The CATTLE GAUGE, which now forms a distinct member of "THE FARMERS' SLIDE-RULE," is for the same purpose as the instrument referred to ; but altered in its results,—as justified by results arising from further experiments made since 1844,—considerably improved in arrangment, and extended in usefulness, by its application to some breeds of foreign cattle; and those supplied by the publishers of this work are expressly made from the author's original design.

THE PRESENT PUBLICATION, in conjunction with the instrument called "THE FARMERS' SLIDE-RULE AND CATTLE GAUGE," will be found a most complete *ready reckoner* for all engaged in rural business; will form a useful and pleasing study for youth intended for agricultural pursuits, either in the capacity of proprietor, agent, or tenant; and the use of the rule being easy of acquirement, may prove of service also to the ploughman, and to the labourer in husbandry.

NEWCASTLE-UPON-TYNE,
September, 1847.

INSTRUCTIONS, ETC.

ENUMERATION OF WHAT ARE CONTAINED ON THE FARMERS' SLIDE-RULE & CATTLE GAUGE.

THE instrument called the FARMERS' SLIDE-RULE and CATTLE GAUGE, of which the present work is intended as a book of instructions for its use, is formed of a piece of wood or ivory, eight and a-half inches long and two inches wide, divided or stamped on both sides or faces, on each of which is a thin slip of wood or metal, sliding in a groove.

ON ONE SIDE OF THE INSTRUMENT

Is a Logarithmic Slide-rule, for calculations; above which are tables of divisors or gauge points, by which the slide-rule may be applied to calculations most useful, and most commonly occurring, to the husbandman in his avocation. The tables referred to are :—

1st. The number of cubic feet in a ton weight of the most common mineral and earthy substances, by which the weight of a given bulk of any of them may be ascertained.

2nd. The number of cubic feet in a ton weight of roots, by which a similar result, to that above described, may be obtained in respect to them.

3rd. Divisors for finding the contents of sundry things, matters and vessels, in the denominations in which they are severally most usually expressed.

4th. Divisors for ascertaining the quantity of corn and hay in stacks, from their dimensions.

5th. The weight in lbs., per imperial gallon, of several liquid substances.

6th. The relative proportions of the Imperial Statute, and the Scottish, and the Irish acres.

Below the Slide-rule is a scale of equal parts, 30 divisions in an inch, on a fiducial edge, forming a scale for plotting, or for measuring distances or spaces on plans of farms or estates, laid down to 3 or 30 chains to an inch; or for a similar purpose with respect to plans of buildings, on a scale of 30 feet to an inch. The last part of the first side of the instrument here to be described, is the back side of the slide, which is divided into inches and subdivided into eighth parts of inches, and doubly numbered from each end, obversely, from 9 upwards; thus forming a measuring rule to any length beyond the length of the instrument, from either of its ends, up to 16½ inches.

ON THE OTHER OR REVERSE SIDE OF THE INSTRUMENT,

Commencing at the top, is a scale of equal parts, 20 divisions in an inch. By halving the distance expressed by the numbered divisions, and the decimal parts of such distances expressed by the single divisions, this part of the instrument may be used as a scale of one chain to the inch; or, by using two single divisions as a chain or foot, the scale becomes 10 chains to an inch for land, or 10 feet to an inch for buildings. In like manner, by multiplying the indications by 2, 3, or 4, it becomes a scale of 4, 6, or 8 chains, &c.; and, by dividing the indication by 4, when the single divisions are counted as chains, the scale becomes one of 5 chains to an inch. Below the scale just mentioned, is an arrangement of the logarithmic slide-rule, contrived expressly for ascertaining the carcase weight of oxen, in stones of 14 lbs. avordupois, from the length and girth of the animals, taken in feet, and the measurement over feet, in inches. This slide-rule is the Cattle Gauge. Under the Cattle Gauge are tables :—

1st. Directions for the use of the gauge points on the cattle gauge.

2nd. The relative proportions of the weights used in different parts of the United Kingdom, in dealing in cattle and flesh meat.

The back part of the slide is divided into inches and tenth parts of inches, and may be used for the same purpose as the division on the back side of the slide on the first described side of the instrument.

Before proceeding with any instructions in the practical use of either part of the instrument above succintly described, it will much aid the reader, in attaining a complete knowledge of what is hereinafter to be treated of, to describe

THE CONSTRUCTION OF THE LOGARITHMIC SLIDE-RULE.

The slide, from which the instrument takes its name, is a slip of wood or metal in a groove in the face of the rule. On the upper margin of the groove, and on both margins of the slide, are lines divided exactly alike, each half of which is divided into nine unequal parts. The divisions commence at the extremity to the left, and are respectively numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, and 1 at half the length of the lines; they are then exactly repeated, and numbered 2, 3, 4, 5, 6, 7, 8, 9, ending with 10 at the right-hand extremity of the whole length of the lines. The divisions just mentioned, are called primes, and the proportion which the space between any two of them bears to the space between any other two, is the same on all slide-rules, whatever their other modifications, applicable to peculiar purposes, may be. In all slide-rules, the primes are sub-divided decimally or into tenths; but a further uniform subdivision ceases: as in some rules there is no further sub-division; whilst in others, the spaces formed by the tenths are, all or part, further sub-divided into 2, 4, 5 or 10, as the purpose, or intended accuracy of the results of the computations by the instrument may require. The three lines just described, are, for distinction, marked at one or both their extremities, respectively with the letters A, B, C. On the lower margin of the groove, is a fourth line, marked with the letter D, the same length as the three before described; but it consists only of a single series of prime divisions: it is different, also, in its nature from that of the other three lines, in the division and numeration of its primes not being uniformly alike in all rules. In some rules the numeration of the line D, commencing from the left hand extremity, is 4, 5, 6, 7, 8, 9, 10, 20, 30 and 40,—4 and 40 at the extremities of this line coinciding with 1 and 10 on A, B, C; whilst in others, the numeration is 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10,—1 and 10 on this line coinciding with 1 and 10 at the extremities of A, B, C.

The numeration and division that have been adopted for the FARMERS' SLIDE-RULE are as follows, viz.:—

The primes, or principal divisions, on all the four lines, only are numbered, and the spaces included between all the numbered divisions are divided into tenths.

On the lines A, B, C, the tenths in the space between 1 and 2, on both sets of numbers of which these lines are composed, are sub-divided into 5, making 50ths; in the spaces between 2 and 4, in both sets of numbers, the tenths are sub-divided into 2, making 20ths; and the spaces between the remaining primes are divided into 10ths only.

On the line D, the numeration commences with 1, at the left hand extremity, and ends with 10 at the right. The tenths in the space between 1 and 2 are sub-divided into 10 making 100ths; the tenths in the spaces between 2 and 4 are sub-divided into 5, making 50ths; those between 4 and 6 into 2. making 20ths; and the spaces between all the other primes are divided into 10ths only.

In addition to the foregoing description of the Slide-rule, in order to render future explanation perfectly clear, and its use readily acquired and retained, it will be necessary to have a knowledge of the construction of the instrument.

The spaces included by the divisions of the first three lines (A, B, C,) of the Slide-rule, are measured by the common logarithms of the numbers that the divisions represent; but, before proceeding further in the present description, it will be necessary to pause, in order to explain briefly the nature of Logarithms.

Logarithms are a contrivance of artificial numbers, by which the operation of multiplication may be performed by addition,—that of division by subtraction,—that of raising the powers of numbers by multiplication,—and that of the extraction of roots of numbers by division. Logarithms may also be defined to be artificial numbers in arithmetical progression, answering to natural numbers in geometrical progression:—

As	0,	1,	2,	3,	4,	5,	6	in arithm. progn., are logs.
answering to	1,	2,	4,	9,	16,	32,	64	in geom. progn., are nos.

Or,

0,	1,	2,	3,	4,	5,	6	. . . . are logs.
1,	3,	9,	27,	81,	243,	729	. . . . are nos.

Or,

0,	1,	2,	3,	4,	5,	6	are logs.
1,	10,	100,	1000,	10000,	100000,	1000000	are nos.

From which exposition, it will be perceived, that the systems of logarithms to the same natural numbers, may be infinite in variety; but the last of the foregoing examples is that in common use, and, therefore, it will be used in the following elucidation of the definition of logarithms, and in the construction of the Slide-rule.

The sum of the logarithms of any two numbers is the logarithm of the product of such numbers.

	1000,	whereof	the log.	is	3
multiplied by	100	,,	,,	,,	2
product	100000	,,	,,	,,	5

The difference of the logarithms of any two numbers is the logarithm of the quotient arising from one of such numbers being divided by the other.

	1000,	whereof the log. is			3
divided by	100	,,	,,	,,	2
quotient	10	,,	,,	,,	1

The product of a logarithm multiplied by any number is the logarithm of a natural number raised to that power, of which the multiplier is the index.

	3,	which is the log. of	1000
multiplied by	2		
the product	6	is the logarithm of	1000000 the square or 2nd power of 1000.

The quotient arising from the division of a logarithm by any number, is the logarithm of that root of a natural number, of which the divisor is the index.

	6	which is the log. of	1000000
divided by	2		
the quotient	3	is the logarithm of	1000 the square root of 1000000.

It has previously been stated, that the spaces included by the divisions of the first three lines (A, B, C) of the slide rule, are measured by the common logarithms of the numbers that the divisions represent: therefore, the space included between 1 at the commencement of the lines, and 1 or 10 at the middle of the lines, will be measured by 1, the logarithm of 10; and the space of the whole length of the lines, included between 1 at the commencement, and 10 or 100 at the right-hand extremity, will be measured by 2, the logarithm of 100. The distances of all the intermediate divisions from the commencement of the lines, are also measured by the logarithms of the numbers which such divisions represent. The following are the logarithms measuring the spaces included, from the commencement, by the prime divisions on the lines A, B, C :—

First set of primes, commencing from the left-hand, ...	the log. of 1 is	·000
	2	·301
	3	·477
	4	·602
	5	·698
	6	·778
	7	·845
	8	·903
	9	·954
Ending at centre, and also the commencement of the second set of primes	10 is	1·
	20	1·301
	30	1·477
	40	1·602
	50	1·698
	60	1·778
	70	1·845
	80	1·903
	90	1·954
Second set of primes, ending at the right-hand extremity	100 is	2·

The tenths of the spaces between the primes are, in like manner, measured from the commencement of the lines by the logarithm of the number which any tenth division may represent. For instance, the tenths between the primes 1 and 2 in the first set, are measured by the logarithms of 1·1, 1·2, 1·3, 1·4, 1·5, 1·6, 1·7, 1·8, and 1·9; those in the second set by the logarithms of 11, 12, 13, 14, 15, 16, 17, 18, and 19. The subdivisions, in a similar way, are measured by the logarithms of the numbers that such sub-divisions may represent; and so on, to any desired extent of subdivision.

From the foregoing observations it may be perceived, that in the actual construction of the lines A, B, C, of the Slide-rule, the divisions may be set off by a scale of 200 equal parts of the same length as the lines intended to be divided, by which three places of decimals of the logarithms measuring the divisions can be accurately laid down; viz., two by inspection, and the third by estimation.

From what has been already shown, in the first place, of the nature of logarithms, and subsequently, of the construction of the lines A, B, C, of the Slide-rule, the reader will now readily comprehend, that addition of logarithms, or multiplication of corresponding natural numbers, is performed on the Slide-rule by drawing the slide to the right; and that subtraction of logarithms, or the division of one corresponding natural number by another, is also performed by drawing the slide to the left. For example, if it be required to multiply 3 by 2: by drawing the slide towards the right until 1 at the commencement of B coincides with 3 on A, then 2 on B will coincide with 6 on A, the product of 3 and 2 multiplied together; which, it will be perceived, is adding the space between 1 and 2, representing the logarithm of 2, to the space between 1 and 3, representing the logarithm of 3. Again, if it be required to divide 6 by 2: by drawing the slide towards the left, until 2 on B coincides with 1 on A, then 6 on B will coincide with 3 on A; which, it will be perceived, is the converse operation of the former example, or subtracting the space between 1 and 2, representing the logarithm of 2, from the space between 1 and 6, representing the logarithm of 6.

Having treated of the nature and construction of the lines A, B, C, at some length, and it is hoped with sufficient perspicuity to impart a clear comprehension of the subject, the nature and construction of the line D will next require consideration.

In describing, at a former page, the logarithmic Slide-rule, forming part of the instrument, to which this tract is intended as a companion, it was stated, that "on the line D, the numeration commences with 1, at the left-hand extremity, and ends with 10 at the right;" and it will be perceived, on inspection of the rule, that, when the first and last divisions of the slide coincide with the first and last divisions on the fixed part of the instrument, there will be the following coincidence of divisions on C with the prime divisions on D,—

On C.	1,	4,	9,	16,	25,	36,	49,	64,	81,	100 (10)
On D	1,	2,	3,	4,	5,	6,	7,	8,	9,	10

by which it will be seen that the numbers on C are the squares of the coinciding numbers on D. The intermediate divisions and sub-divisions on the two lines bear the same relation to each other. Then, when D is considered as a line of numbers, C forms a line of their squares; and, *vice versa*, when C is considered as a line of numbers, D is a line of their square roots. Hence the line D may be easily divided from C, by making the divisions on D coincident with divisions on C, representing the squares of the numbers represented by the divisions on D.

To construct D independently of C, it is only necessary, that the spaces from the commencement of the line to the different divisions be measured by double the logarithms of the numbers that the divisions represent, such divisions to be set off by the same scale of equal parts as the divisions on the lines A, B, C. This mode of constructing the line D will be perfectly understood by the reader, when he considers, that the logarithm of 4 is double of the logarithm of 2, the logarithm of 9, double that of three, the logarithm of 16, double that of 4, and so on.......Perhaps this property will be still more obvious, when the reader is reminded, that the logarithm of 100 (the square of 10) is 2, whilst the logarithm of 10 is but 1.

ON THE

USE OF THE SLIDE-RULE,

APPLIED TO THE

SOLUTION OF QUESTIONS IN ARITHMETIC.

FROM the foregoing description of the instrument, it may be understood, that any question, involving either Multiplication or Division in its solution, may be performed by the Slide-rule; and therefore, that all questions in proportion may be resolved by the use of the line A on the upper margin of the groove, and B on the upper margin of the slide; and that by the use of C on the lower margin of the slide, and D on the lower margin of the groove, the squares and square roots of numbers may also be found. In fact, every description of arithmetical calculation, excepting addition, subtraction, and the powers and roots of numbers beyond square, (such powers and roots being seldom required in ordinary practice,) can be performed by the Slide-rule.

NUMERATION.

THE first and most important step in acquiring the ready use of the Slide-rule, is the perfect understanding of Numeration. Without a complete knowledge of this first advance, confusion and difficulty will attend every attempt at further progress; but when proficiency in Numeration is once attained, every thing else becomes perfectly easy, and mental effort in arithmetical calculation is reduced to a mere mechanical operation, by which the results are obtained by inspection. It should be observed, however, that the numbers and divisions on the rule are all arbitrary, and their values must be determined according to the nature of the question to be resolved, which is easily discovered as soon as the question is proposed.

The divisions marked by figures are called primes; the first divisions of the spaces between the primes are tenths; and their sub-divisions hundredths, &c.

In the lines A, B and C, if 1 at the left-hand extremity is called 1-100th, then 1 in the middle is 1-10th, and 1 (10) at the right-hand extremity is 1; but if 1 at the beginning is called 1-10th, then 1 in the middle is 1, and 10 at the end is 10; and, again, if the first 1 is 1, then the middle 1 is 10, and 10 at the end is 100; and when 1 at the commencement is valued as 10, then the middle 1 is valued as 100, and 10 at the right-hand extremity becomes 1000; and so on, always increasing in a ten-fold proportion, according to the value set upon the first 1. The intermediate numbers must be valued also after the same manner; so that if 1 at the beginning be called 1-10th, then 2 in the first series will be called 2-10ths, 3 will be 3-10ths, &c.; 2 in the second series will be 2, 3 will be 3, &c. If 1 at the beginning be valued as 1, then 2 in the first series will be 2, 3 will be 3, &c.; and, in the second series 2 will be 20, 3 will be 30, &c. If 1 at the left-hand extremity be called 10, then the values of the figures on the lines will be as follows, viz: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000; and by repeating them continually, their values will be each time increased ten-fold.

With regard to the line D, it requires no remarks on the values of its numbers, as it has been already explained, in the description of its construction, that the numbers on C are the squares of the numbers on D.

The nature of Numeration having now, perhaps, been sufficiently explained, exercise in this step in the use of the Slide-rule will best promote proficiency in the learner; with which view the following are proposed as

EXAMPLES.

To find 24 on the line A:—

First look amongst the primes for 2, either in the first or second series of numbers, it matters not which, and call it 20; then count four divisions or tenths from 2 towards the next prime 3, and it will be the number on the line required, which may also represent 240, 2·4, ·24, ·024, &c., according as the 1 preceding the 2 may be valued as 100, 1, 1-10th, 1-100th, &c. Or any number thus found may be increased or diminished in ten-fold ratio, as any case may require.

To find 245 on the line A:—

Find 24 as directed in the foregoing example, and then the sub-division between 24 and 25, and it will be 245, the number required, which may be used also for 2450, 24·5, 2·45, ·245, ·0245 as any case may require.

To find ·785 on the line B:—

First look amongst the primes on the first series of numbers for 7, then take 8-tenths between 7 and 8 for 78, and lastly take one-half the space between 78 and 79 for 785, which, by calling 1 at the commencement of the line 1-10th, becomes ·785 the number required.

To find ·0795 on the line C:—

Find 795 in the same manner as directed in the preceding examples, which, by calling the 1 at the commencement of the line 1-100th, becomes ·0795, the number required.

MULTIPLICATION.

WHAT has already been stated in a previous page, when treating of the nature of logarithms and the construction of the lines, will have prepared the reader for the acquirement of the operation of multiplication by the Slide-rule, with comparatively very little trouble, and will require but few remarks in assistance of attaining proficiency. The reader has been informed, in the part of the work referred to, that, on the three alike divided lines, A, B, C, the spaces between the commencement of these lines and their divisions are the logarithms of the numbers that their divisions represent. It has also been shown, that the sum of the logarithms of any two numbers is the logarithm of their product; and that, by drawing the slide to the right-hand, until the commencement of the line B, on the slide, coincides with any given number on A, the coincidence on A with any other given number on B will be the sum of the logarithms of the given numbers on A and B, or the logarithm of their product. Therefore, when 1 on B coincides with a multiplicand on A, a multiplier on B will coincide with the product on A.

Thus,

On A.	multiplicand—	product
On B.	1	—multiplier

EXAMPLES.

To multiply 8 by 7 :—

Set 1 on B to 8, the multiplicand, on A; then 7, the multiplier, on B will coincide with 56, the product, on A.

If either the multiplicand or multiplier be a decimal, the product will be 5·6; if both be decimals, the product will be ·56. Again, if either multiplicand or multiplier be increased tenfold, the product will be 560; and, if both be increased ten-fold, then the product will be 5600; and so on.

To multiply 25 by 4 :—

Set 1 on B to 25 on A, then 4 on B will coincide with 100, the product, on A. As in the preceding example, the product may be also ·1, 1, 10, 1000, 10000, and so on.

To multiply 245 by 35 :—

Set 1 on B to 245 on A, then against 35 on B is 8575, the product, on A.

It must be here observed, that a product can be only *exactly* determined to three places of figures; viz., two by inspection, and the third by estimation, except when the third happens to be 5, and the first figure is between 2 and 4 of primes, or the third happens to be 2, 4, 6, or 8 within the space of 1 and 2 of primes: in such cases, three figures are determined by inspection, and a fourth by estimation; but, in all others, the fourth figure, if required, must be calculated mentally. The product 8575 may, for the reason given in the first example, be ·08575, ·8575, 8·575, 85·75, 857·5, 85750, 857500, and so on.

DIVISION.

When a knowledge of the use of the Slide-rule, in Multiplication is attained, few remarks will be necessary with respect to Division, as the operation of the latter is merely the converse of that of the former. In Division, the slide is worked from right to left, instead of from left to right, as in Multiplication. The divisor and dividend are both of them upon B, and the quotient is found upon A. The operation of Division on the Slide-rule, therefore, is to bring the divisor on B to coincide with 1 at the commencement of the line A; and, against the dividend on B, the quotient will be found on A. Thus,

On A.	1 —quotient.
On B.	divisor—dividend.

EXAMPLES.

To divide 56 by 7:—

Bring 7 on B to coincide with 1 on A; then against 56 on B is 8, the quotient, on A.

To divide 100 by 4.

Set 4 on B to 1 on A; then against 100 on B is 25, the quotient, on A.

To divide 8575 by 35:—

Set 35 on B to 1 on A; then 8575 on B will coincide with 245, the quotient, on A.

Since Division is the converse of Multiplication, the value of the digits of the results in the former operation will also be the reverse of the values of those of the latter: thus, 8575 divided by 3·5 the quotient will be 2450; when the divisor is ·35, the quotient will be 24500; if the dividend be 857·5, and the divisor 35, the quotient will be 24·5; when the dividend is 85·75, and the divisor 35, the quotient will be 2·45, and so on.

REDUCTION OF VULGAR TO THEIR EQUIVALENT DECIMAL FRACTIONS

Is performed by dividing the numerator of the fraction by its denominator, and the quotient is the equivalent decimal. The operation on the Slide-rule will, therefore, be to set the denominator on B to 1 on A; then against the numerator on B will be found the equivalent decimal on A.

EXAMPLES.

To reduce 3-4ths to its equivalent decimal:—

Set 4 on B to 1 on A; then against 3 on B is ·75, the equivalent decimal, on A.

To reduce 5-12ths to its equivalent decimal:—

Set 12 on B to 1 on A; then against 5 on B is ·416, the equivalent decimal, on A.

To reduce 15-23rds to its equivalent decimal:—

Set 23 on B to 1 on A; then 15 on B will coincide with ·652, the equivalent decimal, on A.

The reduction of any number of a lower denomination in Weights, Measures, &c., to the decimal of a higher denomination, is also performed by the operation above, by making the number of the lower denomination, required to be reduced to decimals, the numerator, and the number of the lower denomination contained in the higher, the denominator of a fraction:

thus, 3 pecks is 3-4ths of a bushel, or 3-64ths of a quarter; 8 lbs. is 8-14ths of a stone, 8-28ths of a quarter, or 8-112ths of a cwt.

EXAMPLES.

To reduce 3 pecks to the decimal of a quarter:—

There being 64 pecks in a quarter; therefore 3 pecks is 3-64ths of a quarter.

Set 64 on B to 1 on A; then against 3 on B is ·0468, the decimal of a quarter, on A.

To find the decimal of a cwt. in 8 lbs.:—

112 lbs. is a cwt.; therefore 8 lbs. is 8-112ths of a cwt.

Set 112 on B to 1 on A; then 8 on B will coincide with ·0714, the decimal of a cwt., on A.

What decimal of an acre is 24 perches?

There being 160 perches in an acre; therefore 24 perches is 24-160ths of an acre.

Set 160 on B to 1 on A; then against 24 on B is ·15, the decimal of an acre, on A.

To find the number of a lower denomination, in Weights, Measures, &c., from the decimal of a higher, set the number of the lower denomination contained in the higher on B to 1 on A; then against the decimal on A will be found the number of the lower denomination on B.

As this is merely the converse of the last case, it will be unnecessary to give any examples, as those given above, reversed, will be quite sufficient for practice.

MULTIPLIERS AND DIVISORS TO PRODUCE EQUAL RESULTS BY THEIR OPERATION

Are found by dividing unity by the divisor, for the multiplier; and by dividing unity by the multiplier, for the divisor. To find such by the Slide-rule, set the multiplier, or divisor, as the case may be, on B to 1 on A; then against 1, in the middle of the line B, will be found the divisor, or multiplier, as the case may require, on A.

EXAMPLES.

What divisor will produce the same result as the multiplier ·25?

Set ·25 on B to 1, at the commencement of the line A; then against 1, at the middle on B, will be found 4, the divisor to produce the same result as the multiplier ·25, on A.

What divisor will produce the same result as the multiplier ·07958?

Set ·07958 on B to 1 on A; then 1 on B will coincide with 12·56, the divisor to produce the same result as the multiplier ·07958, on A.

What divisor will produce the same result as the multiplier ·7854?

Set ·7854 on B to 1 on A; then 1 on B will coincide with 1·273, the divisor to produce the same result as the multiplier ·7854, on A.

Using the divisor, found in the foregoing examples, will afford practice in finding multipliers to produce the same results.

A knowledge of the conversion of multipliers and divisors, from one to the other, is a matter of considerable importance in the use of the Slide-rule; as divisors, in many cases, are more convenient in operations than multipliers, and, in others, multipliers may be more readily used than divisors. It is generally most convenient to use common divisors, or gauge points, on the first or A line of the rule, in which case common multipliers must be converted into divisors.

PROPORTION

Is of two kinds; viz., *direct* and *inverse*. When the conditions of a proportion are such that more requires more, or less requires less, it is said to be *direct;* but when more requires less, or less requires more, then it is called *inverse*. Proportion, in which three numbers are given to find a fourth, is called the *Rule of Three.*

RULE OF THREE DIRECT.

In the Rule of Three Direct, the fourth, or term sought, has always the same proportion to the third that the second has to the first: thus, the four numbers in both the series 2, 3, 4, 6, and 2, 8, 6, 24, which are in *direct proportion,* it will be seen, that 6 and 24 are in the same proportion to 4 and 6, as 3 and 8 are to 2. It will also be perceived, from the foregoing explanation, that the fraction formed by the first term, as a numerator, and the second term, as a denominator, is equal to the fraction formed by the third term, as a numerator, and the fourth term, as a denominator: thus, 2-3rds is equal to 4-6ths, or 2-8ths is equal to 6-24ths. A third property of Direct Proportion is, that the product of the extreme terms is equal to the product of the mean, or of any equidistant terms. Hence, in the Rule of Three Direct, the product of the first and fourth terms is equal to the product of the second and third. Thus, taking the above two series of numbers again, as examples, we have 2, the first term multiplied by 6, the fourth, equal to 3, the second term multiplied by 4, the third; the product in both cases being 12. The product of 2, the first term, multiplied by 24, the fourth, is 48, which is also the product of 8, the second term, multiplied by 6, the third. It follows, then, from the foregoing equations, that the fourth, or required term, of the Rule of Three Direct, is found by dividing the product of the second and third terms by the first. Therefore, the operation on the Slide-rule, for resolving questions in the Rule of Three Direct, is, to set the second term on B to the first term on A; then against the third term on A will be found the fourth, or required, term on B. Thus,—

On A. 1st term—3rd term.
On B. 2nd term—4th term.

N. B. When the second term on B is set to the first term on A, then all other numbers on A bear the same proportion to their coinciding numbers on B that the first term bears to the second. It should also be noted, that, in the Rule of Three Direct, the second term is always to be of the same nature and denomination as the fourth or required term, and they must always be on the same line of the Slide-rule; indeed, the rule of operation is, that terms of like nature shall be upon the same line; *e. g.*, the first and third on one line, and the second and fourth on the other, but it does not matter which line is used for either pair of terms.

EXAMPLES.

If 36 cwts. of turnips be consumed by 12 oxen, in a certain time, how many oxen will 144 cwts. serve for the same time?

Set 12, the number of oxen and second term of the proportion, on B to 36, cwts. of turnips, the first term, on A; then against 144, cwts. of turnips, the third term, on A will be found 48, the number of oxen sought or fourth term of the proportion, on B.

Or the same may also be resolved by—

Setting 36 on B to 12 on A; then against 144 on B is 48 on A.

The first mode of operation being the more conformable to the explanation of the construction of the Slide-rule, at a former page, it will alone be used in subsequent examples.

If 6 men can reap 2 acres of wheat in a day, how many acres per day will 20 men reap?

Set 2 on B to 6 on A; then against 20 on A is 6·66, or 6 and 2-3rds acres, on B.

If 20 sheep cost £25, how many may be purchased for £150, at the same rate?

Set 20 on B to 25 on A; then against 150 on A will be 120, the number of sheep sought, on B.

RULE OF THREE INVERSE,

Or when the conditions of the proportion are, that more requires less, or less requires more, is, when three numbers are given to find a fourth, which shall bear the same proportion to the second that the third bears to the first. Thus, the four numbers, 4, 6, 8, 3, are in *inverse proportion*, in which the fourth term, 3, bears the same proportion to the second term, 6, that the third term, 8, bears to the first term, 4. It will be perceived, that the product of the first and second terms is equal to the product of the third and fourth; both products being 24: from which it will follow, that the fourth term will be equal to the product of the first and second terms divided by the third. Therefore, the operation of the Rule of Three Inverse, on the Slide-rule, is, to set the first term on B to the third term on A, and against the second term on A will be the fourth term on B. Thus,—

On A. 3rd term—2nd term.
On B. 1st term—4th term.

The same result may be obtained by inverting the slide, and proceeding as in the Rule of Three Direct.

N. B. In the Rule of Three Inverse, as in the Rule of Three Direct, the given term of the same nature as the term sought must always be made the second term, and the term sought the fourth term of the proportion.

EXAMPLES.

Suppose 6 men can perform a certain quantity of work in 4 days, how many men must be set to work to have it done in 3 days?

By the first Rule.

Set 4, days, the first term, on B to 3, days, the third term, on A; then against 6, men, the second term, on A, is 8, men, the number sought or fourth term, on B.

N. B. Here it will be observed, that the terms of like nature are on different lines, instead of on the same, as in the Rule of Three Direct.

By Inversion of the Slide.

Set 6 on C to 4 on A; then against 3, on A, is 8, the number sought, on C.

If a horse with a load can perform a journey in 8 hours, when travelling at the rate of 3 miles an hour, in what time will he return light, at a pace of 5 miles per hour?

By the first Rule.

Set 3 on B to 5 on A; then against 8, on A, is 4·8 hours, the time sought, on B.

By Inversion of the Slide.

Set 8 on C to 3 on A; then against 5 on A is 4·8 hours, the time sought, on C.

If the distance travelled, in ploughing a piece of ground with a furrow 7 inches wide, be 18 miles, how far will be travelled in ploughing the same piece of ground with a 9 inch furrow?

By the first Rule.

Set 7 on B to 9 on A; then against 18 on A, is 14 miles, the distance sought, on B.

By Inversion of the Slide.

Set 18 on C to 7 on A; then against 9 on A is 14 miles, the distance sought, on C.

And so all questions in proportion, where more requires less, or less requires more, may be resolved on the Slide-rule, by either of the methods shown above; but the first is the legitimate mode, according to the property of the proportion.

SQUARES AND SQUARE ROOTS.

THE use of the Slide-rule, in finding the *squares* and *square roots* of numbers, will be understood from what has already been shown when treating on the construction of the line D; it will, therefore, require but few remarks, in addition to a reference to the construction of that line of the Slide-rule, to render the subject of the present chapter perfectly familiar.

USES OF THE SQUARE ROOTS.

1. To find a mean proportional, or a number whose square shall be equal to the product of any two given numbers.
2. To find the hypothenuse of a right-angled triangle from the other two sides being given.
3. To find a side of a right-angled triangle from the hypothenuse and the other side being given.

To find a mean proportional between any two given numbers, set one of the numbers on C to the same number on D; then against the other number on C will be the mean proportional on D.

EXAMPLE.

To find the mean proportional between 4 and 9.

Set 4 on C to 4 on D; then against 9 on C is 6, the mean proportional, on D.

As to the hypothenuse and sides of a right-angled triangle, it is demonstrated by the 47th prop. of 1st book of Euclid, that, "in any right-angled triangle, the square which is desciibed upon the side subtending the right angle, is equal to the squares described upon the sides which contain the right angle." By which theorem, the hypothenuse, or side subtending the right angle, is equal to the square root of the sum of the squares of the other sides; and either of the sides containing the right angle is equal to the square root of the difference of the squares of the hypothenuse and the other side.

Then, to find the hypothenuse of a right-angled triangle from the other sides being given, add together the squares on C, of the sides on D; then against the sum, on C, will be the hypothenuse on D. And to find either of the sides from the hypothenuse and the other side being given, subtract the square, on C, of the given side, on D, from the square, on C, of the hypothenuse, on D; then coinciding with the difference on C will be found the side sought on D.

EXAMPLES.

Required the length of rafter for a lean-to shed, 12 feet wide, with a pitch of roof of 5 feet.

After having set the line C even with D; then coinciding with 12 feet, the width of the shed, or one of the sides of a right-angled triangle containing the right angle, on D is 144, its square, on C; and against 5 feet, the pitch of roof, or other side of a right-angled triangle, containing the right angle, on D is 25, its square, on C; the sum of these squares, 144 and 25, is 169, which is the square of the side of a right-angled triangle subtending the right angle, which on C will coincide with its square root 13, the length of the rafter required, on D.

A ladder 13 feet long, having its feet 5 feet distant from the bottom of a wall against which it is reared, just reaches to the top of the wall, required the height of the wall.

Having set the lines of the Slide-rule as directed in the last example; then against 13 on D is 169, its square, on C; and against 5 on D is 25, its square, on C; the difference between 169 and 25 is 144, coinciding with which on C is its square root 12 on D, the height of the wall required.

CUBES.

The cube of a number is its third power, and is formed by multiplying a number by itself, and the product by the number again; or, it is the square of a number multiplied by the number again.

The operation on the Slide-rule is to multiply the number on C coinciding with a given number on D, by such given number. The same can be more conveniently performed at one operation, by setting the number to be cubed on C, to 1 or 10 on D; then against the same number on D will be its cube upon C.

EXAMPLE.

Required the cube of 7.

Set 7 on C to 10 on D; then against 7 on D will be 343, the cube of 7, on C.

The cube or any other root, than the square cannot be performed by the Slide-rule in its usual arrangements; but such operations as finding other roots than square are very seldom required in practice.

MENSURATION.

AFTER the exercises, in the use of the Slide-rule, that have already been given, in the previous part of this tract, it will, perhaps, be unnecessary to encumber the subject of the immediately succeeding pages with examples ; it will be sufficient to state the formula, and to point out its operation on the Slide-rule.

TO FIND THE AREA OF PLANE FIGURES, BOUNDED BY RIGHT LINES.

1. *Parallelogram*, (any kind).—Multiply the length by the breadth taken perpendicularly, or square to the length.

In the square, when the divisions at the extremities of the lines on the slide coinçide with the divisions on the extremities of the lines on the groove, the line C is a line of areas of squares coinciding with their sides on D.

In all other Parallelograms,—set 1 on B to the length on A; then against the breadth on B, will be found the area on A.

2. *Triangle* (or three-sided figures).—Multiply the longest side by the perpendicular distance of the same from the opposite angle, and divide the product by 2.

Set either dimension, side or perpendicular, it matters not which, on B to 2 on A; then against the other dimension on A, will be found the area on B.

3. *Trapezoid* (or four-sided figure, two of whose

opposite sides are parallel, but of different lengths).—Multiply the sum of the parallel sides by the perpendicular distance between them, and divide the product by 2.

Set the sum of the parallel sides on B to 2 on A; then against the perpendicular distance on A, will be found the area on B.

4. *Trapezium* (or four-sided figure, in which no two of the opposite sides are parallel).—Divide the figure into two triangles, by a line drawn between two opposite angles. Multiply the length of such line by the sum of the perpendicular distances from such line to the opposite angles and divide the product by 2.

Set the sum of the perpendicular distances on B to 2 on A; then against the length of the line drawn between opposite angles, on A, will be found the area on B.

5. *Polygon*, regular, (or equal-sided figure).—Multiply the square of the side by the number opposite to the number of the sides in the following table:—

NO. OF SIDES.	NAMES.	AREAS OR MULTIPLIERS.
3.	Trigon or Triangle .	0·433
4.	Tetragon or Square .	1.
5.	Pentagon	1·72
6.	Hexagon	2.598
7.	Heptagon	3·633
8.	Octagon	4·828
9.	Nonagon	6·181
10.	Decagon	7·694
11.	Undecagon . . .	9·365
12.	Dodecagon . . .	11·19

By the Slide-rule.

Set 1 on D to the tabular number, opposite the figure, the area of which is required, on C; then against the length of the side, on D, will be found the area on C.

6. *Right-lined Figure*, of any number of unequal sides.—Divide the figure into triangles and trapeziums; the sum of their areas (found as directed in 2 and 4) will be the area of the whole figure.

7. *Long Irregular Figures.*—If the variations of the breadth occur at equal distances, multiply the sum of all the breadths by the length, and divide the product by the number of breadths. In which case the operation of the Slide-rule will be—

To set the sum of the breadths on B to the number of breadths on A; then against the length on A, will be found the area on B.

But if the breadths be not at equal distances, compute all the parts separately as trapezoids (as directed in 3), and their sum will be the area of the figure.

OF THE CIRCLE.

8. *The Diameter given to find the Circumference,* or *the Circumference given to find the Diameter.*—Multiply the diameter by 3·1416 for the circumference, or divide the circumference by 3·1416 for the diameter.

Set 1 on B to 3·141 on A; then A will be a line of circumferences, and B a line of diameters.

9. *The Breadth and Height of a circular Arch, being given to find the Centre.*—Find a mean proportional between half the breadth of the arch, and its height, to which mean proportional add the height for the diameter, or double radius.

Find a mean proportional between half the breadth and the height, as directed in page 23, to which add the height for twice the radius.

10. *The Diameter given to find the Area.*—Multiply the square of the diameter by ·785.

Set 1 on D to ·785 on C; then D will be a line of diameters and C a line of areas.

11. *The Circumference given to find the Area.*—Multiply the square of the circumference by .0795.

Set 1 on D to ·0795 on C; then D will be a line of circumferences, and C a line of areas.

12. *To find the Area of the Space included between the Circumferences of two Concentric Circles.*—Find the areas of the two circles (by 10 or 11), and the difference of the areas is the area of the space between them.

13. *To find the Circumference of an Ellipsis.*—Multiply the sum of the two axes by 3·1416, and divide the product by 2.

Set 2 on A to 3·141 on B; then against the sum of the axes on A, will be found the circumference on B.

14. *To find the Area of an Ellipsis.*—Multiply the product of the two axes by ·7854.

Find a mean proportional between the two axes, as shown at page 23. Set 1 on D to ·785 on C; then against the mean proportional between the two axes on D, will be found the area on C.

OF SOLIDS.

15. *To find the Superficies of a Cube.*—Multiply the square of the side by 6.

Set 6 on B to 1 on A; then against the side of the cube, on D, will be found the superficies on C.

16. *To find the Superficies of a Prism or Cylinder.*—Multiply the perimeter or circumference by the length; to which add the areas of the ends when required.

Set 1 on B to the perimeter or circumference on A; then against the length on B, will be found the superficies on A;—to which add twice the area of the ends (to be found as directed in 5, 10 or 11), if required.

17. *To find the surface of a Pyramid or Cone.*—Multiply the perimeter or circumference of the base by half the length of the side; to which add the area of the base, if required.

Set the length of the side on B to 2 on A; then against the perimeter or circumference, on A, will be found the surface on B; to which add the area of the base (to be found as directed in 5, 10 or 11), if required.

18. *To find the Convex Surface of a Sphere.*—Multiply the diameter by the circumference.

Set 1 on B to the diameter on A; then against the circumference on B, will be found the convex surface on A.

19. *To find the Solidity of a Cube.*—Multiply the side of the cube by itself, and that product again by the side for the solidity required.

Set the side of the cube on C to 10 or 1 on D; then against the side of the cube on D, will be found the solidity on C.

20. *To find the Solidity of a Parallelopiped.*—Multiply the length by the breadth, and that product again by the depth, for the solidity required.

Find a mean proportion (as directed at page 23,) between any two of the dimensions; then set the dimension, between which and another the mean proportional has *not* been found, upon B to 1 on A; and against the mean proportional, above directed to be found, on D, will be found the solidity required on C.

21. *To find the Solidity of a Prism or Cylinder.*—Multiply the area of the base by the perpendicular height.

Set 1 on B to the area of the base, found as previously directed, on A; then against the length on B, will be found the solidity required on A.

Or, if the figure of the base be a regular polygon,—

Set the length on B to the number in the following table opposite to the required figure on A; then against the side of the base on D, will be found the solidity required on C.

NO. OF SIDES.	NAME.	DIVISORS.
3.	Trigon or Triangle .	2.3
4.	Tetragon or Square .	1·
5.	Pentagon	·581
6.	Hexagon	·384
7.	Heptagon	·275
8.	Octagon ·	·207
9.	Nonagon	·161
10.	Decagon	·129
11.	Undecagon. . . .	·106
12.	Dodecagon	·089

Or, for a cylinder,—

Set the length on B to 1·27, if the dimension be the diameter, or to 12·56, if the circumference, on A; then against the diameter or circumference on D, will be found the solidity required on C.

22. *To find the Solidity of the Substance of a Pipe or Hollow Cylinder.*—Multiply the area of the space included between the outside and inside circumferences (as found by 12), by the length.

Set 1 on B to the length on A; then against the area of the space, &c., on B, will be found the solidity required on A.

23. *To find the Solidity of a Cone or Pyramid.*—Multiply the area of the base by one-third the perpendicular height.

Set the area of the base on B to 3 on A; then against the perpendicular height, on A, will be found the solidity required on B.

Or,—

Set the perpendicular height on B to the tabular number, opposite to the figure the case may require, in the table below; then against the side or dimension on D, will be found the solidity required on C.

NO. OF SIDES.	NAME.	DIVISORS.
3.	Trigon or Triangle .	6·92
4.	Tetragon or Square	3·
5.	Pentagon	1·74
6.	Hexagon	1·15
7.	Heptagon	·825

NO. OF SIDES.	NAME.	DIVISOR.
8.	Octagon	·621
9.	Nonagon	·485
10.	Decagon	·389
11.	Undecagon	·32
12.	Dodecagon . . .	·268
Diameter of Circle for Cones .		3·82
Circumference of Do. for Do.		37·7

24. *To find the Solidity of a Sphere.*—Multiply the cube of the diameter by ·5236; or divide the cube of diameter by 1·9.

Set the diameter on B to 1·9 on A; then against the diameter on D, will be found the solidity required on C.

THE

USE OF THE SLIDE-RULE,

APPLIED TO

PRACTICAL PURPOSES CONNECTED WITH AGRICULTURE.

THE length to which the elementary part of the present tract has been extended may appear tedious to some; but the Author is aware that proficiency in the use of such an instrument as the Slide-rule can only be acquired by a thorough knowledge of the principles of its operation, and that acquirement can only be retained by the perfect comprehension, not only of the mode of its operation, but also by that of the principles of its construction. Therefore no apology is necessary for prolixity in that part of the present work now completed: the only question will be—Is it sufficiently explicit for the intended purpose?

LAND SURVEYING.

In a Statute Acre of land there are—

10	square	Chains
160	,,	Poles or Perches
4840	,,	Yards.

The area of any piece of ground having been determined, by the formula its figure may require, according to the preceding epitome of Mensuration,—

TO FIND THE ACRES IN ANY AREA,—

Divide the area by the number contained in an acre of the denomination of measurement in which the area is expressed, or in which the dimensions have been taken.

The operation of the problem on the Slide-rule, will be, to set 1 on B to the number of the denomination of measurement on A; then against the area on A, will be the acres on B.

EXAMPLES.

How many acres are there in a piece of land, the area of which is found to be 56 chains?

Set 1 on B to 10, the number of chains in an acre, on A; then against 56, the area, on A, is 5 and 6-10th acres, the number sought, on B.

Required the number of acres in a piece of land, the area of which is found to be 640 square perches.

Set 1 on B to 160, the number of square perches in an acre, on A; then against 640, the area, on A, is 4 acres, the number sought, on B.

How many statute acres are there in 7840 square yards?

Set 1 on B, to 4840, the number of square yards in a statute acre, on A; then against 7840 on A, is 1·62 statute acres on B.

If the figure of any piece of land, of which the quantity in acres may be sought, is rectangular, the problem may be performed at one operation on the Slide-rule, directly from the dimensions. Thus,—

Suppose a field to be 9·50 chains in length, and 7·60 chains in breadth, to find the area in acres,—

Set 9·5 on B to 10 on A; then against 7·6 on A, is 7·22 acres on B.

Suppose a piece of ground measures 80 perches in length by 30 perches in breadth, to find the area in acres,—

Set 80 on B to 160 on A; then against 30 on A, is 1·5 or 1½ acre on B.

A rectangular parcel of building ground is 600 yards long, and 500 yards broad; how many acres does it contain?

Set 600 on B to 4840 on A; then against 500 on A is 62 acres, very nearly, on B.

If the dimensions, given in the above examples, were the longest sides and perpendicular breadths of triangles, instead of the lengths and breadths of rectangles or parallelograms, the results would be double the area.

It is frequently necessary—

TO CONVERT DISTANCES FROM ONE DENOMINATION OF MEASURE TO ANOTHER: *e. g.* FROM CHAINS TO YARDS OR FEET; OR, *vice versa*, FROM YARDS OR FEET TO CHAINS.

The chain used in measuring land being 22 yards or 66 feet in length; therefore, when 1 on B is set to 22 on A, A will be a line of yards coinciding with equal distances expressed in chains on B; or, when 1 on B is set to 66 on A, A becomes a line of feet coinciding with equal distances in chains on B.

EXAMPLES.

Required the distance in yards in 3·25 chains.

Set 1 on B to 22 on A; then against 3·25 on B, is 71·5 yards on A.

What distance in feet is there in 4·55 chains?

Set 1 on B to 66 on A; then against 4·55 on B, is 300 feet on A.

How many chains are there in 1760 yards?

Set 1 on B to 22 on A; then against 1760 on A, is 80 chains on B.

Express 192 feet in chains.

Set 1 on B to 66 on A; then against 192 on A, is 2·9 chains on B.

What distance, expressed in chains, is 35 feet?

Set 1 on B to 66 on A; then against 35 on A, is ·53 chains on B.

TO CONVERT CUSTOMARY TO STATUTE ACRES, OR *vice versa*.

At one time a great variety of measures of land, peculiar to different districts, were in use in different parts of the kingdom; now, the statute acre, containing 4840 square yards, is the integer of land measure generally used in all parts throughout the united kingdom: there is yet, however, the old Irish acre, sometimes in use in Ireland, containing 7840 square yards; and also the ancient acre, containing 6150 square yards, sometimes yet in use in Scotland. The proportion which the different acres, above mentioned, bear to each is as follows:—

Statute acre . . .	1.
Scottish acre . . .	1.27
Irish acre	1.62

By setting 1·27 on B to 1 on A, B becomes a line of statute acres, coinciding with equal quantities of land expressed in Scottish acres on A. By setting 1·62 on B to 1 on A, B becomes a line of statute acres coinciding with equal quantities of land expressed in Irish acres on A; and, by setting 1·62 on A to 1·27 on B, A becomes a line of Scottish acres coinciding with equal quantities of land expressed in Irish acres on B.

EXAMPLES.

How many statute acres are equal to 40 Scottish acres?

Set 1·27 on B to 1 on A; then against 40 on A, is 50·8 statute acres on B.

How many statute acres are equal to 5 Irish acres?

Set 1·62 on B to 1 on A; then against 5 on A, is 8·1 statute acres on B.

To find how many Scottish acres are equal to 250 Irish acres—

Set 1·62 on A to 1·27 on B; then against 250 on B, is 319 on A.

DRAINING.

IN PARALLEL DRAINING TO FIND THE LENGTH, PER ACRE, OF DRAIN AT ANY GIVEN DISTANCE APART.

THE formula for this problem is, to divide 4840 by the distance in yards which the drains are apart; or, 14520 by the distance in feet which the drains are apart.

The operation on the Slide-rule is, to set 1 on B to the distance apart on A; then against 4840 or 14520, according as the distance apart may be in yards or feet, on A, will be the length in yards per acre on B.

EXAMPLES.

Required the length of drain, per acre, when the drains are 9 yards apart.

Set 1 on B to 9 on A; then against 4840 on A, is 538 yards, nearly, the length required, on B.

What length of drain is there in an acre when the drains are 35 feet apart?

Set 1 on B to 35 on A; then against 14520 on A, is 415 yards, nearly, the length of drain per acre, on B.

TO FIND THE CUBIC YARDS IN THE EXCAVATION OF DRAINS AND TRENCHES.

Having taken the breadth at top and bottom, and the average depth of the drain, in inches, and the length in yards; multiply the mean breadth by the average depth, and that product again by the length; and divide the last product by 1296 for the cubic yards in the excavation.

The operation of this problem on the Slide-rule will be, to set the length on B to 1296 on A; then against the mean proportional between the mean breadth and average depth on D, will be the cubic yards in the excavation on C.

EXAMPLE.

How many cubic yards will there be in 807 yards of drain, 12 inches wide at top, 4 inches wide at bottom, and averaging 42 inches deep?

The mean breadth of the drain is 8 inches, and the mean proportional between the mean breadth and average depth is 18·3 inches. Set 807 on B to 1296 on A; then against 18·3 on D, is 209 cubic yards in the excavation on C.

It may here be observed, that all earth occupies a much greater space thrown up loose in a heap than in its natural solid state; but there is a considerable difference in such increase of bulk in different descriptions of soil. The difference of bulk, in the solid and loose states of the different kinds of soil, noted in the following table, will be found pretty accurate in practical application.

	SOLID.			LOOSE.	
Strong clay or brick earth,	8	cubic yds.	is increased to	13	c. yds.
Strong loam	8	,,	,,	12	,,
Medium loam or garden mould	8	,,	,,	11	,,
Light loam	8	,,	,,	10	,,
Sand	8	,,	,,	9	,,

PLOUGHING.

However unusual it may be to apply calculation to such an operation as that now under consideration, yet the usefulness of such will, no doubt, be admitted as soon as the nature of the questions, to which calculation may be applied, is shown.

To expose the greatest possible surface of newly-turned soil to the action of the atmosphere without leaving any part unstirred is perfection in the operation of ploughing: such effect in the operation can only be produced by the furrow-slice being turned so as to rest at an angle of 45 degrees; and such position of the furrow-slice can be attained only when its breadth and depth bear a certain proportion to each other.

It is most elegantly demonstrated by Professor Low, in his "Elements of Practical Agriculture," (in a note, p.p. 76 and 77,) that the proportion between the breadth and depth of a furrow,—

TO EXPOSE THE GREATEST POSSIBLE SURFACE IN PLOUGHING,—

Is when the breadth is equal to the hypothenuse of a right-angled triangle, of which the other sides are each of them equal to the depth. Therefore, the breadth of a furrow-slice, to expose the greatest possible surface in ploughing, is the square root of twice the square of the depth; or, the depth is the square root of half the square of the breadth; and the profile of the maximum surface is equal to twice the depth.

EXAMPLES.

Suppose it be required to find the breadth of a furrow-slice, to expose the greatest possible surface in ploughing at a depth of 6 inches.

Coinciding with 6 inches, on D, is its square, 36, on C; then against 72, or twice 36, on C, is 8·48, its square root, or the breadth required, on D.

Required the depth to plough a furrow 9 inches wide to expose the greatest surface.

Against 40·5, or half 81, the square of 9 inches, on C, is its square root 6·36, the depth required, on D.

TO FIND THE QUANTITY OF LAND WORKED IN A DAY, HAVING GIVEN THE BREADTH OF FURROW OR BREADTH COVERED AT ONCE BY THE IMPLEMENT, AND THE DISTANCE TRAVELLED BY THE IMPLEMENT IN THE DAY'S WORK.

The requirement of this proposition is in direct proportion to the breadth of a furrow-slice in ploughing, or to the breadth of land covered at once by the implement in any other operation in tillage; and to the distance travelled in a day's work: thus involving a double proportion, which is not resolvable by one operation on the Slide-rule. It will be necessary, first, to find the quantity of land in proportion to one condition; and then to vary the quantity so found in proportion to the other. The distance travelled in ploughing an acre, with a furrow one inch wide, is exactly 99 miles; or, in travelling one mile ·0101 acre is ploughed, in two miles ·0202 acre, and so on. Then, again, if ·0101 acre is ploughed with one inch furrow, ·101 is ploughed with ten inch furrow, and so on.

The two operations in the solution of this problem on the Slide-rule will be as follows:—

First, set 1 on B, to ·0101 on A; then against the given distance, on B, will be found the quantity of land in acres for one inch in breadth on A: then, again, set 1 on B to the quantity, found by the former operation, on A; and against the given breadth, on B, will be found the quantity of land worked in proportion to both the conditions of the proposition, on A.

To reduce the solution of this problem to a single operation on the Slide-rule, the following table of the quantity of land worked in travelling distances of from ten to twenty miles at a breadth of one inch:—

For 10 miles	set	1	on B	to	·101	on A.
11	„	1	„		·111	„
12	„	1	„		·121	„
13	„	1	„		·131	„
14	„	1	„		·141	„
15	„	1	„		·151	„
16	„	1	„		·161	„
17	„	1	„		·171	„
18	„	1	„		·181	„
19	„	1	„		·191	„
20	„	1	„		·202	„

It may here be remarked that travelling 16 miles in the course of a day's work, in any tillage operation, is as much as can be expected from the most active men and good horses.

EXAMPLES.

It is required to find the quantity of land worked, once over, by Crosskill's six feet patent roller, in travelling 16 miles in a day's work.

Opposite 16 miles in the foregoing table is ·161. Set 1 on B to ·161 on A; then against 72 inches (6 feet), on B, is 11·6 acres, the quantity required, on A.

Find the quantity of land sown, by a double turnip sowing machine, on drills 27 inches apart, when a distance of 18 miles is travelled in a day's work.

Opposite 18 miles in the table is ·181. Set 1 on B to ·181 on A; then against 54, the breadth of two drills, on B, is 9·77 acres, the quantity required, on A.

Find the quantity of land ploughed, with a 9 inch furrow, in travelling 14 miles in a day's work.

Opposite 14 miles in the table is ·141. Set 1 on B to ·141 on A; then against 9 on B, is 1·27 acres, the quantity required, on A.

MANURING.

For drilled crops, such as turnips, potatoes, &c., the manure is usually spread in three adjoining drills from each cart load, and—

TO FIND THE DISTANCE WHICH EACH CART LOAD WILL MANURE, AT THE RATE OF ANY NUMBER OF LOADS PER ACRE, AND THE DRILLS AT ANY NUMBER OF INCHES APART,—

Is a problem of frequent occurrence to the husbandman; and, therefore, will be a useful subject in the present tract.

This problem, like the last, involves two seperate conditions in its requirements, viz: the distance of the drills apart, and the number of loads per acre; in which state it is not resolvable by one operation on the Slide-rule. By giving the result required by one condition in the problem, the requirement becomes dependant but on one, and resolvable by a single operation on the Slide-rule: for which purpose the following table is given of the distance it will require manure to be spread, at the rate of one load per acre, for any distance of drills apart, from ·12 to 36 inches.

12 inches	. .	48·4 yds.	25 inches	. .	23·2 yds.
13 ,,	. . . .	44·6 ,,	26 ,,	. . . .	22·3 ,,
14 ,,	. .	41·5 ,,	27 ,,	. .	21·5 ,,
15 ,,	. . . .	38·7 ,,	28 ,,	. . . .	20·7 ,,
16 ,,	. .	36·3 ,,	29 ,,	. .	20· ,,
17 ,,	. . . .	34·1 ,,	30 ,,	. . . .	19·3 ,,
18 ,,	. .	32·3 ,,	31 ,,	. .	18·7 ,,
19 ,,	. . . .	30·5 ,,	32 ,,	. . . .	18·1 ,,
20 ,,	. .	29· ,,	33 ,,	. .	17·6 ,,
21 ,,	. . . .	27·6 ,,	34 ,,	. . . .	17· ,,
22 ,,	. .	26·4 ,,	35 ,,	. .	16·5 ,,
23 ,,	. . . .	25·2 ,,	36 ,,	. . . .	16·1 ,,
24 ,,	. .	24·2 ,,			

It will readily be perceived that the results of the problem is in inverse proportion to both the conditions : *e. g.*, the closer the drills, the greater the distance; and the greater the number of loads the less the distance.

Having, by the table, the distance to be manured by a load, at the rate of one load per acre, for any distance of the drills apart from 12 to 36 inches; the operation on the Slide-rule, of the problem will be, to set 1 on A to the number of loads to be expended per acre on B; then against the distance given in the table above for any distance of drills apart on B, will be found the distance required for each load to be expended on A.

EXAMPLE.

Find how far each load of manure must serve to be spread in three drills at once; the manuring at the rate of 20 loads an acre, and the drills 27 inches apart.

Opposite 27 inches, the distance between the drills, in the table above, is 21·5. Set 1 on A to 20, the number of loads per acre required to be spread, on B; then against 21·5, the distance at one load per acre, on B, is 107·5 yards, the distance required, on A.

TO FIND THE QUANTITY OF SOIL, COMPOST, OR OTHER MATTER THAT WILL BE REQUIRED, PER ACRE, TO COVER LAND TO ANY GIVEN DEPTH.

There being 4840 square yards in an acre, it will require 4840 cubic yards to cover an acre to the depth of a yard or 36 inches; hence 134 cubic yards to cover an acre to the depth of an inch. Having the number of cubic yards that will be required to cover an acre one inch thick, the product of such number of cubic yards multiplied by any given number of inches will be the number of cubic yards that will be required to cover an acre to the given thickness.

The operation of the problem on the Slide-rule will be, to set 1 on B to 134 on A; then against the given thickness on B, will be the cubic yards required on A.

EXAMPLES.

What quantity of clay per acre will be required to cover a piece of bog land to a depth of 4 inches?

Set 1 on B to 134 on A; then against 4 on B, is 536 cubic yards, the quantity required, on A.

Or, for the Reverse of the Problem,—

Suppose it were required to determine to what thickness 400 cubic yards per acre of marle would cover a piece of land.

Having set 1 on B to 134 on A; then against 400 on A, is 3 inches, nearly, the depth required, on B.

SOWING.

TO DETERMINE THE DISTANCE THAT HALF A BUSHEL OF SEED-CORN WILL SOW LANDS OR RIDGES LAID OUT TO ANY BREADTH FROM THREE TO SIX YARDS, AT THE RATE OF ANY NUMBER OF BUSHELS PER ACRE.

THE result of this problem is in inverse proportion both to the quantity of seed per acre, and to the breadth of the lands. In order to render it resolvable, at one operation, on the Slide-rule, the following table is given of the distance that half a bushel will sow any breadth of land from 3 to 6 yards, at the rate of 1 bushel per acre:—

Ridges	or lands	3	yards	wide	806	yards	distance.
,,	,,	4	,,	,,	604	,,	,,
,,	,,	5	,,	,,	484	,,	,,
,,	,,	6	,,	,,	406	,,	,,

The operation on the Slide-rule will be, to set the given quantity of seed to be sown per acre on B to 1 on

A; then against the distance half a bushel of seed will sow at the rate of 1 bushel per acre, on any given breadth of land, as per table, on B, will be found the distance required on A.

EXAMPLE.

It is required to know the distance half a bushel of seed corn will sow lands laid out in 5 yard ridges, at the rate of 3 bushels per acre.

Opposite to 5 yards wide in the table is 484 yards distance. Set 3 bushels, the given quantity of seed per acre, on B to 1 on A; then against 484 yards, the tabular distance, on B, is 161 yards, the required distance, on A.

TO FIND THE WEIGHT, PER ACRE, OF CROPS.

THE weight per acre of any crop may be found by actually weighing a small definite proportion, and multiplying such weight by the number such aliquot part may be contained in an acre. Thus, if it were required to determine the weight per acre of a crop cultivated in equi-distant rows or drills, let a portion be fixed upon that may be judged as a fair average of the crop, and the produce of any length of the drill, say 10 yards, be carefully weighed. Now, if the drills were a yard apart, the length of drill in an acre is 4840 yards, and the produce of ten yards of drill the 484th part of the produce of an acre; therefore the weight upon 10 linear yards multiplied by 484 will be the weight upon an acre; or the crop per acre, in this case, is in direct proportion to the quantity weighed. But if, instead of 36 inches apart, the drills were only 12 inches from each other, then the length of drill in an acre, instead of being 4840 yards would be 14520 yards; so that the less the distance of the drills apart, the greater the weight of the crop per acre. The weight per acre of a drilled crop will, therefore, vary in a double proportion of the weight on a given length of drill directly, and as the distance of the drills apart inversely. The requirement of the problem involving a double proportion, its solution cannot be performed on the Slide-rule by one operation. The following is a table of numbers, by which the weight in pounds of 10 linear yards of drill being divided, the quotient is the weight per acre in tons, for any distance from 12 to 36 inches the drills may be apart; by which the operation of the problem on the Slide-rule becomes dependent upon but one proportion :—

DISTANCE OF DRILLS APART, IN INCHES.	DIVISORS.	DISTANCE OF DRILLS APART, IN INCHES.	DIVISORS.
12	1·54	25	3·21
13	1·66	26	3·34
14	1·79	27	3·47
15	1·92	28	3·60
16	2·05	29	3·72
17	2·18	30	3·85
18	2·31	31	3·97
19	2·43	32	4·1
20	2·56	33	4·23
21	2·69	34	4·36
22	2·82	35	4·49
23	2·95	36	4·62
24	3·08		

The operation of the problem on the Slide-rule is, to set 1 on B to the divisor, opposite the breadth of drill in the table above, on A; then against the weight in pounds of the produce of 10 linear yards on A, will be found the weight per acre in tons, on B.

The weight in tons per acre of broad-cast crops, may be found from the weight produced on 10 square yards of surface, by using 4·62 as the divisor.

EXAMPLES.

Required the weight per acre of a crop of turnips in drills 27 inches apart, the weight of which on 10 yards of drill is found to be 140 lbs.

Set 1 on B to 3·47, the divisor for drills 27 inches apart, on A; then against 140 lbs., the weight of ten yards of drill on A, is 40 3-10th tons, the weight of crop per acre, on B.

What is the weight per acre of a crop of potatoes in drills 30 inches apart, the weight on 10 yards of drill being found to be 40 lbs.

Set 1 on B to 3·85, the divisor for 30 inch drills, on A; then against 40 lbs., the weight on 10 yards of drill, on A, is 10 and 2-10th tons, the weight per acre, on B.

The weight of green clover mown from 10 square yards of ground is found to be 42 lbs; what weight per acre is the crop?

Set 1 on B to 4·62, the divisor for broad-cast crops, on A; then against 42 lbs., the weight on 10 square yards, on A, is 9 and 1-10th tons, the weight of the crop per acre on B.

TO FIND THE WEIGHT OF A HEAP OR BULK OF MINERAL OR EARTHY SUBSTANCES.

First find the solid content of the heap or bulk of the substance, the weight of which may be required, in cubic feet; then divide the result by the cubic feet contained in one ton, from the table below, and the quotient will be the weight of the heap in tons.

Cubic Feet in One Ton of

	SOLID.	DUG.		SOLID.	DUG.
Chalk	13·5	18	Lime	——	30
Clay	16	27	Limestone	12·26	16
Coal	30	40	Loam	18	27
Dung, F. Y.	—	54	Sand	24·54	27
Freestone	15	20	Slate	13·84	—
Gypsum	16·36	20·16	Whinstone	12·56	16·36
Do., burnt	——	25·7			

Having taken the mean length, breadth, and height of the heap or bulk; the operation on the Slide-rule will be, to set the length on B to the divisor in the table above, for the substance the weight of which is required, on A; then against the breadth or height, when such dimensions are equal, or the mean proportional between them, when unequal, on D, will be found the weight in tons on C.

EXAMPLES.

A pile of limestone is 20 feet long, 8 feet wide, and 4 feet high; how many tons weight does it contain?

A mean proportional between 4 and 8 is 5·65. Set 20 feet, the length on B to 16, the cubic feet in 1 ton of limestone dug, on A; then against 5·65 on D, is 40 tons, the weight of the pile required, on C.

By using 40 as a divisor on A, a pile of coal of similar dimensions is found to be 16 tons.

From the face of a freestone quarry has been worked, 10 feet in length, 8 feet in height, and 2 feet in thickness; what weight has been removed?

The mean proportional between 2 and 8 is 4. Set 10 feet, the length on B, to 15, the number of cubic feet in a ton of solid freestone, on A; then against 4 on D, is 10 and 6-10th tons, the weight, on C.

In the ordinary farm yard dunghill it requires about 54 cubic feet of its bulk to weigh a ton; what weight will there be in a heap 45 feet long, 12 feet wide, and 5 feet high?

The mean proportional between 5 and 12 is 7·73. Set 45 feet the length, on B to 54 on A; then against 7·73 on D, is 50 tons, the weight, on C.

TO FIND THE WEIGHT OF ROOT CROPS STORED IN HEAPS OR PIES.

Cubic Feet in One Ton of

Beet	48
Carrot	46
Parsnip	47
Potatoes	52
Turnip, swede . . .	46
" yellow . . .	51
" white . . .	56

Crops of the nature comprised in the foregoing table are usually stored in long prismatic-shaped heaps, sometimes called pies, first covered with straw and then with earth. The product of the length, breadth, and height multiplied continually together, is double the cubical content of such heaps. Whenever heaps of the description spoken of are measured, their mean dimensions should be taken, exclusive of the thickness of their covering; and the content found as directed above, divided by the number of feet in a ton, the quotient will be the weight in tons.

From the weight, found by the formula given above, it will be necessary to deduct an allowance for damage; which, however well the article may be preserved, will always occur to some extent, more or less, varying from five to ten per cent., or, on an average, about 1-12th part of the computed weight.

EXAMPLE.

What quantity of potatoes will there be in a heap measuring 50 feet long, 5 feet wide, and four feet high?

The mean proportional between 4 and 5 is 4·47. Set 25 feet, one half the length, on B to 52, the number of feet contained in a ton of potatoes, on A; then against 4·47 on D, is 9 and 6-10th tons, the weight of potatoes contained in the heap, on C.

———

TO FIND THE SOLID CONTENT AND QUANTITY OF CORN, HAY, OR STRAW, IN STACKS.

STACKS or ricks, in which hay and corn, in the straw, are stored, are usually of two kinds. In one the body of the stack is a parallelopiped, with a roof assimilated in shape to a prism. In the other the body is nearly cylindrical, or the frustrum of an inverted cone, with a roof assimilated in shape to a cone.

The solid content of a stack of the first described shape, is the continual product of the length, breadth, and height of the body; and the product of the length and breadth of the stick, multiplied by half the perpendicular height of the roof. Or, the height from the stand to the eaves, with half the perpendicular height added for the height for computation; which, multiplied by the length, and that product again by the breadth, will give the solid content, in the same denomination of measure in which the dimensions have been taken.

The content of a round stack with a conical roof is found by multiplying the square of the circumference by ·07958, and that product again by the height of the body of the stack, to which the content of the roof must be added; which is found by multiplying the product of the square of the circumference at the eaves of the stack, and ·07958 by one-third of the perpendicular height of the roof. Or, more succinctly, to the height from the stand to the eaves, add one-third the height of the roof for the height for computation; then multiply the square of the mean circumference by ·07958, and that product again by the height for computation, will give the solid content, in the same denomination of measure in which the dimensions have been taken.

It is generally very inconvenient to obtain the perpendicular height of the roof of stacks by actual measurement; but by a knowledge of the shape of the roofs of stacks, the perpendicular height of the roof may be estimated from the breadth of the stack, sufficiently accurate for any practical purpose. In a well formed roof of an oblong stack, the angle at the ridge approximates to a right angle; that is, the perpendicular height of the roof is equal to half the breadth of the stack. One half the perpendicular height of the roof of an oblong stack may be assumed for practical purposes, under different circumstances, to be as follows:—

For a high pitch of roof,	1-3rd	the breadth
„ medium „ „	1-4th	„ „
„ low „ „ „	1-5th	„ „

To be added to the height of the stack from its stand to the eaves, for the height for computation. In round stacks, also, the most perfect roof is a right cone; *i. e.*, having the perpendicular height equal to the semi-diameter. By assuming one-third of the perpendicular height of the conical roof, under different circumstances, to be,—

In a high pitch of roof,	1-18th	the mean circumference.
„ medium „ „	1-19th	„ „ „
„ low „ „ „	1-20th	„ „ „

To be added to the shaft, or height of the stack from its stand to its eaves for the height for computation, will prove sufficiently accurate for any practical purpose.

When the dimensions of an oblong stack are taken in feet, the content in cubic feet will have to be divided by 27, to bring it to cubic yards. In round stacks, when the dimensions,— the circumference and height for computation,— are taken in feet; then the content in cubic yards will be found by dividing the product of the square of the circumference and the height for computation by 339·2

EXAMPLES.

An oblong stack 50 feet long, 11 feet high from the stand to the eaves, and 16 feet wide; how many cubic yards does it contain?

1-4th the breadth of 16 feet is 4, which added to 11 feet, the height from the stand to the eaves, is 15 feet for the height for computation. The mean proportional between 15 and 16 is 15·48. Set 50 feet, the length of the stack, on B to 27, the cubic feet in a cubic yard, on A; then against 15·48, the mean proportional between 15 and 16, on D, is 444 cubic yards, the content of the stack, on C.

Or,—

Instead of finding a mean proportional between 15 and 16, find their product, by setting 1 on B to 15 on A; then against 16 on B, is 240 on A. Set 50 on B to 27 on A; then against 240 on A, is 444 on B.

A round stack is 50 feet in mean circumference, and 12 feet high from the stand to the eaves; required the cubic yards in the stack.

To 12 feet add 2½ feet, for 1-3rd the perpendicular height of the roof, which is 14½ feet for the height for computation. Set 14½ on B to 339·2 on A; then against 50 on D, is 106 and 8-10th cubic yards, the content of the stack, on C.

In estimating the weight of HAY STACKS, the circumstances of the state of growth of the grass when cut, the state in which the hay has been stacked, the age and kind of hay, and the size, particularly the height of the stack, influence the compactness or density of the hay; or, in other words, the quantity of its bulk required for a ton of weight. The following table has been formed from the observation of the author, during many years experience, and attentive consideration of the subject:—

	CUBIC YDS. IN A TON.
Large stacks of the best meadow hay, after standing over year, according to the size of the stack	6, 7, to 8
Smaller stacks of good, or large stacks of inferior meadow hay	9, 10, „ 11
Small stacks of inferior meadow hay	11, — „ 12
Hay of the best quality made from clover, or other seedling grass, according to the size of the stack.	10, 11, „ 12
Inferior hay made from clover or other seedling grass, according to the size of the stack . . .	12, 13, „ 14

The following table is the yield of corn stacks from close observation, during many years, by the author :—

	QUANTITY OF CORN IN ONE CUBIC YARD OF THE BULK OF THE STACK.
WHEAT.—When the straw is very long, or the heads small, the yield is about	3 pecks.
When moderate in both or either respects . . .	4 „
When the straw is very fine or short, or the heads large	5 „
RYE.—Indifferent yield	4 „
Medium yield	5 „
Very large yield	6 „
BARLEY.—Similar to rye	
OATS.—Indifferent yield	6 „
Medium yield	8 „
Very large yield	10 „
BEANS and PEAS are very uncertain in the yield, but it seldom exceeds	3 „

STRAW.—It is very usual in estimating the weight of straw in stacks, to assume it to be double the estimated weight of the grain; but the author has found, taking the average of all kinds of cereal corn, that allowing 1 cwt. for each cubic yard of the bulk of the stack, is a sufficiently correct estimate for practical purposes.

The following is a table of divisors, for finding the lowest extreme average, and highest extreme yield, of stacks, from their bulk, in cubic yards.

Wheat	in bushels	1·33	1	·8
Rye	„ „	1	·8	·66
Barley	„ „	1	·8	·66
Oats	„ „	·66	·5	·4
Meadow hay . .	in tons	6	9	12
Clover hay . . .	„ „	10	12	14

EXAMPLES.

It is required to find the weight of meadow hay in a stack containing 444 cubic yards.

Set 1 on B to 8, the cubic yards to 1 ton of meadow hay, on A; then against 444 on A, is 55½ tons, the weight required, on B.

What quantity of oats is there in a stack containing 106 cubic yards?

Set 1 on B to ·5, the divisor in the table above for the average yield of oats, on A; then against 106 on A, is 212 bushels, the quantity required, on B.

In order to render the present portion of this tract the more complete, the following table of divisors for finding the weight and quantity in stacks from dimensians in feet is given, by which the operation of the problem on the Slide-rule is much abridged. The results of hay stacks are in tons, and of corn stacks in bushels.

	DIVISORS FOR Oblong stacks.	Round stacks.
6 cubic yards to 1 ton . . .	162	2035
7 ,, ,, ,, ,, ...	189	2374
8 ,, ,, ,, ,, ...	216	2713
9 ,, ,, ,, ,, ...	243	3052
10 ,, ,, ,, ,, ...	270	3392
11 ,, ,, ,, ,, ...	297	3731
12 ,, ,, ,, ,, ...	324	4070
13 ,, ,, ,, ,, ...	351	4409
14 ,, ,, ,, ,, ...	378	4748
3 pecks to the cubic yard . . .	36	451·1
4 ,, ,, ,, ,, ...	27	339·2
5 ,, ,, ,, ,, ...	21·6	271.3
6 ,, ,, ,, ,, ...	18·	226·
7 ,, ,, ,, ,, ...	15·4	193·8
8 ,, ,, ,, ,, ...	13.5	169·6
9 ,, ,, ,, ,, ...	12·	150·7
10 ,, ,, ,, ,, ...	10·8	135·6

EXAMPLES.

What weight is there in a stack of clover hay, the length of which is 50 feet, the breadth 16 feet, and the height from the stand to the eaves 11 feet; the hay being supposed to be such as to require 12 cubic feet of its bulk to weigh a ton?

1-4th of 16, the breadth, is 4, which added to 11, the height, is 15, the height for computation. The mean proportional between 15 and 16 is 15·48. Set 50 feet, the length of the stack, on B to 324, the divisor in oblong hay stacks for 12 cubic yards to a ton, on A; then against 15·48 the mean proportional between the height for computation and breadth, on D, is 37 tons, the weight required, on C.

A stack of oats measures 50 feet in mean circumference, and 12 feet high from the stand to the eaves; its yield being supposed to be 8 pecks to the cubic yard of its bulk; what is the quantity of corn in the stack?

To 12 feet, the height from the stand to the eaves, add 2½ feet, for 1-3rd the perpendicular height of the roof, is 14½ feet, the height for computation. Set 14½ feet on B to 169·6, the divisor for round stacks yielding 8 bushels to the cubic yard, on A; then against 50 feet, the circumference, on D, is 213½ bushels, the quantity required, on C.

ON THE SIZE OF HAY STACKS.

In the formation of stacks much trouble and serious inconvenience frequently arise, from not observing a proper proportion between the quantity of hay to be put together, and the space to be occupied by the stack. From want of due attention in setting out the bases of stacks in proper proportion to the quantity of hay, it often happens that stacks are obliged to be made inconveniently high from their bases being made too small;

and, at other times, the quantity of hay is found insufficient for making the roofs of a proper shape to resist rain, from their bases being set out too large. The following table, deduced from practical experience, showing the space to be allowed for every 10 tons of hay that may be intended to be put together, will be found useful in avoiding the inconveniences above referred to :—

QUANTITY OF HAY TO BE PUT TOGETHER.	AREA OF BASE FOR EVERY 10 TONS OF HAY.
Under 15 tons	20 square yards.
Between 15 and 20 ,,	18 ,, ,,
,, 20 ,, 30 ,,	16 ,, ,,
,, 30 ,, 40 ,,	12 ,, ,,
,, 40 ,, 50 ,,	10 ,, ,,
,, 50 ,, 100 ,,	8 ,, ,,
Above 100 ,,	6 ,, ,,

The foregoing table is intended to apply to oblong stacks, and to hay made from the natural grasses ; a somewhat greater base,—say the next previous proportion in the table,— should be allowed for the different quantities, for hay made from clover, and other seedling grass.

It should also be borne in mind, that, in stack building, two-thirds the quantity of hay intended to be put together should be laid on to the stack before the slope of the roof is commenced.

TO FIND THE AREA OF THE SPACE TO BE OCCUPIED BY ANY GIVEN QUANTITY OF HAY.

Multiply the given quantity by the area in the foregoing table for the given quantity of hay, and divide the product by 10.

By the Slide-rule.

Set the tabular area on B to 10 on A ; then against the quantity of hay to be put together on A, will be found the area of the base, that the stack will require, on B.

HAVING DETERMINED UPON THE BREADTH OF AN OBLONG STACK, OF ANY GIVEN AREA OF BASE, TO FIND THE LENGTH.

Set 1 on B to the breadth on A; then against the area of the base on A, will be found the length on B.

EXAMPLES.

Required the area of the base of a hay stack to contain 65 tons of hay.

Set 8 on B to 10 on A; then against 65 on A, is 52 square yards, the area required, on B.

The area of the base of a stack is intended to be 75 square yards, and its breadth 5 yards; what should be its length?

Set 1 on B to 5 on A; then against 75 on A, is 15 yards, the length required, on B.

Hay loses, by evaporation, 8 to 12 per cent. of its original weight during the first twelve months after being put together; after which, further loss of weight is very trifling. The loss referred to varies according to the nature and growth of the grass, and the extent of exposed surface in proportion to the solid content of the stack. The greater the maturity of the grass when made into hay, and the less the exposed surface of the stack, the less evaporation takes place; for which latter-mentioned reason, small quantities of hay are usually put together in round stacks.

TO FIND THE QUANTITY OF CORN ON GRANARY FLOORS.

The imperial statute bushel contains 2218·192 cubic inches; therefore, on each square foot of floor covered to a depth of 15·4 inches is a bushel of grain. Hence the formula for computing the quantity of corn on a granary floor is, to multiply the area of the floor in feet by the depth of corn in inches, and to divide the product by 15·4 for bushels.

The operation of the problem on the Slide-rule is, to set the depth of corn in inches on B to 15·4 on A; then against the area of the floor in feet on A, will be found the quantity of corn in bushels, on B.

EXAMPLE.

Suppose a granary, 40 feet long by 24 feet wide, to be filled with corn to a depth of 21 inches; how much corn does the granary contain?

Set 1 on B to 40 feet, the length of the granary, on A; then against 24 feet, the breadth of the granary on B, is 960, the area of the floor in feet, on A. Set 21 inches, the depth of corn, on B to 15·4 on A; then against 960, the area of the floor, on A, is 1309 bushels, the quantity of corn in the granary, on B.

TO FIND THE CONTENTS, IN IMPERIAL GALLONS, OF TROUGHS, CISTERNS, AND CIRCULAR WELLS.

The following are the divisors or gauge points for finding the contents, in imperial gallons, of square and cylindrical vessels.

Troughs and cisterns, all dimensions, in inches	277·2
Tanks, the depth in feet and the other dimensions in inches	23·1
Cylindrical vessels, length and diameter both taken in inches	352·8
Circular wells, depth in feet and diameter in inches	29·4

For square or oblong vessels: set the length or depth on B to the divisor or gauge point on A; then against the mean proportional between the other two dimensions on D, will be the content, in imperial gallons, on C.

For circular wells or cylindrical vessels: set the depth or length on B to the divisor or gauge point on A; then against the diameter on D, will be the content in imperial gallons, on C.

EXAMPLES.

A cistern 6 feet long, 5 feet wide, and four feet deep; how many imperial gallons will it contain?

The mean proportional between 48 and 60, the depth and breadth, is 53·66. Set 72 the length on B to 277·2, the divisor, on A; then against 53·66, the mean proportional on D, is 748 imperial gallons, the content of the cistern, on C.

A tank is 15 feet deep and 5 feet square; how many gallons will it contain?

Set 15 feet on B to 23·1 on A; then against 60 inches or 5 feet on D, is 2337 gallons, the content required, on C.

A cylindrical vessel is 25 inches long and 16 inches in diameter; what is its content in imperial gallons?

Set 25 inches on B to 352·8 on A; then against 16 on D, is 1·81 gallons on C.

The water in a circular well, 42 inches diameter, is found to be 9½ feet deep; required the quantity of water.

Set 9½ feet on B to 29·4 on A; then against 42 on D, is 570 gallons on C.

Having one dimension given, the other dimensions of any cistern, trough, tank, or well, to contain any given number of gallons, may be found by the converse of this problem. Thus,—

Suppose it be required to know the diameter of a well 15 feet deep to contain 1000 gallons.

Set 15 on B to 29·4 on A; then against 1000 on C, is 44·27, or 44¼ inches, the diameter required, on D.

What will the side of a square tank 12 feet deep be required to be, to contain 1200 gallons?

Set 12 on B to 23·1 on A; then against 1200 on C, is 48 inches or 4 feet, the side required, on D.

And, in a similar manner, other useful exercises in the converse of this problem may be proposed.

THE STEAM ENGINE.

The Steam Engine, on the high pressure principle, having become a very general power for driving the fixed machinery on the farmery, the method of computing its power will not be out of place in the present work.

THE POWER OF THE HIGH-PRESSURE STEAM ENGINE

Is in direct proportion to the pressure of steam on the safety valve, and to the square of the diameter of the piston. One-tenth of the square of the diameter of the piston, in inches, will give a result in exact accordance with the estimate of Mr. Hawthorn, (the eminent engineer, and ingenious author of the Engineer's Slide-rule), of the horses power of a high-pressure steam engine, working with a pressure of steam of 40 lbs. on the square inch of the safety valve; and, as the power is in direct proportion to the pressure of steam, the formula for finding the horses power of an engine of any given diameter of piston, working at any given pressure of steam, will be, to multiply the square of the diameter of the piston, in inches, by the given pressure, and to divide the product by 400.

The operation of the problem on the Slide-rule will be, to set the pressure per square inch on the safety valve on B to 400 on A; then against the diameter of the piston, in inches, on D, will be the horses power of the engine on C.

It would not be prudent in a farmer to work a steam engine at a greater pressure than 30 lbs. on the square inch of the safety valve, although high pressure steam engine boilers are generally made with an intention of sustaining more than double that pressure; therefore, in the following examples, 30 lbs. per square inch will be considered as the *maximum* pressure.

EXAMPLE.

The pressure of steam on the safety valve of a high pressure engine, having a piston 15 inches diameter, is 25 lbs. on the square inch; at what power is the engine working?

Set 25 on B to 400 on A; then against 15 on D, is about 14 horses power on C.

A farmer desirous of putting up a high pressure steam engine of 6 horses power, when working at a pressure of steam of 30 lbs. to the square inch; what should be the diameter of the piston?

Set 30 on B to 400 on A; then against 6 on C, is nearly 9 inches, the diameter of piston required, on D.

ON THE MEASUREMENT OF TIMBER.

A Tree is not considered to be timber unless the circumference of its stem is 24 inches.

In computing the true solid content of a tree, its stem is supposed to be a cylinder, the circumference of which is equal to the girt of the tree at mid-length of its stem, the length of the cylinder being the length of the stem. The rule of Mensuration for finding the solid content of a cylinder is, to multiply the square of the circumference by ·0795, and the product again by the length. Such a process of calculation, however, is too tedious for practice, and a more concise method of calculation is generally adopted, in computing the content of growing timber, by multiplying the square of one fourth of the girth by the length.

The last given very concise method of computing the content of trees has frequently been the subject of objection, by writers on the measurement of timber, as not giving the exact content. The objection, however, is perhaps not well founded, as the difference between the true content and the result of the formula does not amount, in most cases, to the outside sapwood, which is nearly valueless. It may be observed, that the smaller the size of the timber the greater the proportion of sap; and it may easily be conceived, that in small timber, the difference between the true and computed contents may be less than the sap,—at a certain size, the heartwood and computed content may be equal,—and then beyond that certain size the difference between the true and computed contents may be greater than the sap. In general, if the sap were removed from oak timber of the girth of about 50 inches, the content of the remaining timber would be found very nearly equal to the result by the last mentioned method of computation. When timber is much less than 50 inches in girth, the result of such computation would exceed the quantity of heart-wood in the tree.

From the remarks just made, it will not appear necessary to alter a method so concise, at the same time, in most cases, perfectly just, and which has become conventional throughout the kingdom in estimating the value of timber, for an *attempt* at mathematical nicety.

In measuring timber the mean circumference must be taken. When timber is growing, it is usual to take the girth at mid-length of the stem, and in computing the the value, the stem only is priced; the branches, except when of considerable size, being generally made an increase to the price per foot of the stem, according to their usefulness. In felled timber, however, a more detailed estimate of the value is made, and every part of the tree is seperately computed according to its size and value.

Whatever method may be adopted in estimating the quantity of timber in a tree, an allowance must be made in the girth for the thickness of the bark; such allowance will necessarily vary with the circumstances of the nature, the age, and the size of the tree. The allowance very generally made is 1 inch in every 12 of girth for all kinds of timber; but the following table of allowance for bark will be found to be more correct:—

	2 to 3 ft. girth.	3 to 4 ft. girth.	4 to 5 ft. girth.	6 ft. girth.
	INCHES.	INCHES.	INCHES.	INCHES.
Oak and Elm	3	4	5	6
Ash, Beech, &c.	1½	2	2½	3

After the content of a tree is computed, a very important ingredient in the value of some kinds of timber still remains to be determined; *viz.*, the quantity of bark; for estimating which the following statement is taken from the "Planter's Guide :—"

	Every cubic foot of timber affords of bark
An oak 40 years old	9 to 12 lbs.
Ditto from 80 to 100 years old	10 „ 16 „
Larch Timber	8 „ 10 „
Birch, large, ...	11 „ 14 „
Willow, large, ...	9 „ 11 „

The length of timber is usually taken in feet, and the girth in inches: the length of boards and planks is generally taken in feet, and the breadth in inches.

TO FIND THE SOLID CONTENT OF ROUND TIMBER.

Set the length in feet on C to 12 on D; then against one-fourth the girth in inches on D, will be found the solid content in cubic feet on C.

Or,—

Set the length in feet on B to 144 on A; then against one-fourth the girth in inches on D, will be found the solid content in cubic feet on C.

TO FIND THE SOLID CONTENT OF SQUARE OR EQUAL-SIDED TIMBER.

Set the length in feet on B to 144 on A, or the length in feet on C to 12 on D; then against the side in inches on D, will be found the solid content in cubic feet on C.

TO FIND THE SOLID CONTENT OF UNEQUAL-SIDED TIMBER.

Find the mean proportional between the dimensions of the sides, which use as the side of square timber, as in the last problem.

TO FIND THE SUPERFICIAL CONTENT OF BOARDS AND PLANKS.

Set the length in feet on B to 12 on A; then against the breadth in inches on A, will be found the superficial content in square feet on B

THE SUPERFICIAL CONTENT OF BOARDS OR PLANKS, OF ANY GIVEN THICKNESS, THAT MAY BE EQUAL TO ANY GIVEN CONTENT OF SOLID TIMBER,

Is found by multiplying the given quantity of solid timber by the number of times the given thickness of the boards or planks is contained in 12 inches.

By the Slide-rule.

Set 1 on B to the content of the solid timber in cubic feet on A; then against the number of times any given thickness of board or plank is contained in 12 inches on B, will be found the superficial content of such boards or planks contained in the given quantity of solid timber on A.

EXAMPLES.

Required the quantity of timber in the stem of a tree, the length of which is 16 feet, and the quarter girth 14 inches.

Set 16 on C to 12 on D; then against 14 on D, is 21 and 3-4ths cubic feet, the content required, on C.

Or,—

Set 16 on B to 144 on A; then against 14 on D, is 21 and 3-4ths cubic feet, the content required, on C.

How many cubic feet are there in a balk of timber 18 feet long, and the square side 16 inches?

Set 18 feet on C to 12 on D; then against 16 inches on D, is 32 cubic feet, the content required, on C.

Or,—

Set 18 on B to 144 on A; then against 16 on D, is 32, the content required, on C.

Required the cubic feet in a piece of timber, 24 feet long, 21 inches wide, and 18 inches thick.

The mean proportional between 18 and 21 is 19·4. Set 24 on C to 12 on D; then against 19·4 on D, is 63 cubic feet, the content required, on C.

What is the superficial content of a plank, 19 feet long, and 20 inches wide?

Set 19 on B to 12 on A; then against 20 on A, is 31 and 2-3rds superficial feet, the content required, on B.

What superficial content of 3 inch plank, is equal to 63 cubic feet of timber?

3 inches, the given thickness of plank, is contained 4 times in 12. Set 1 on B to 63 on A; then against 4 on B, is 252 feet, the superficial content required, on A.

A load of round or unhewn timber is 40 cubic feet.
Ditto of squared or hewn timber is 50 „ „

ON THE CARCASE WEIGHT OF LIVE STOCK.

There are two methods by which judgment of the carcase weight of live stock—particularly that of neat cattle—may be assisted; viz., by deducting an allowance for offal from the live weight, and by measurement: in the consideration of which methods, the first-mentioned will be taken in priority, and the observations will be extended to SHEEP and SWINE as well as to OXEN.

ON ASCERTAINING THE CARCASE WEIGHT OF OXEN BY PROPORTION OF BEEF TO THE LIVE WEIGHT OF THE BEAST.

The judge of cattle will be aware that there are several circumstances, acting both seperately and in combination, which influence the proportion of the carcase weight of beef to the live weight of cattle, causing a considerable discrepancy, from uniformity in such proportion, to exist. The manner of the operation of the causes which occasion the discrepancy alluded to is discussed at considerable length in an essay by the author of the present tract, in the first volume of the "Plough," to which the reader is referred for detail.

The principal causes, occasioning want of uniformity in the proportion of the carcase weight of beef to the live weight of cattle, are the peculiarity of shape characterising different BREEDS OF CLASSES of OXEN, and the difference of CONDITION IN INDIVIDUAL BEASTS. The discrepancy arising from the first-mentioned cause may be met by the following classification:—

FIRST, those breeds which may be said to be cultivated and improved, with a view to large proportion of carcase weight to their whole weight when alive; SECONDLY, those breeds which naturally possess many good points in respect to a large produce of beef, but which have not received that attention to improvement of capabilities as those in the first division; and THIRDLY, those breeds which may be considered as primeval.

THE FIRST CLASS will thus include—The Durham Short-horns, the Herefords, and the breeds of Sussex and Devon.

THE SECOND CLASS—The best sorts of the long-horned cattle in the midland counties of England, in Lancashire, and in Ireland; the cattle of Lincolnshire, Galloway, Angusshire, Ayrshire, Aberdeenshire, Fifeshire, Suffolk, and the better sorts of Welsh cattle.

THE THIRD CLASS comprises the cattle of Argyleshire, the western islands of Scotland, and various breeds of mountain cattle.

By compounding the effect of condition with shape peculiar to the different breeds before specified, the following proportions of carcase weight to the live weight of cattle are deduced, the results of which have been most satisfactory in practice:—

CONDITION.	PER CENT. OF BEEF TO LIVE WEIGHT. Class 1.	Class 2.	Class 3.
Half fat	55 to 59	50 to 55	48 to 50
Moderately fat .	60 ,, 62	56 ,, 60	51 ,, 55
Prime to very fat .	63 ,, 66	61 ,, 63	56 ,, 60
Extraordinary fat .	67 ,, 70	64 ,, 66	61 ,, 66

To describe any quality in terms which may be applied in an arbitrary sense, raises objections to the use of such description, and the application of the foregoing table may, therefore, be matter of difficulty; the following table, very nearly agreeing in its results with those of the former, may probably be preferred:—

Proportion of Beef to the Live Weight of Oxen.

LIVE WEIGHT IN STONES, 14 LBS. AVOIRD.		PER CENT. OF BEEF. Class 1.	Class 2.	Class 3.
Above 150 .	steers	69 to 71	66 to 68	
,, 120 .	heifers	69 ,, 71		
From 120 to 150 .	steers	66 ,, 68	63 ,, 65	63 to 66
,, 100 ,, 120 .	heifers	66 ,, 68		
,, 100 ,, 120 .	steers	63 ,, 65	61 ,, 62	57 ,, 62
,, 90 ,, 100 .	heifers	63 ,, 65		
,, 80 ,, 100 .	steers	60 ,, 62	57 ,, 60	51 ,, 56
,, 70 ,, 90 .	heifers	60 ,, 62		
Under 70 . . .		— ,, —	— ,, —	47 ,, 50

The foregoing tables apply to bullocks and pure heifers only: when bulls are being weighed, to ascertain their carcase weight, a somewhat larger proportion of beef must be allowed; and for old cows, that have had several calves, somewhat less.

It is not improbable it may be doubted by some, who may not have had opportunities of comparison in beasts of extraordinary condition, that the proportion of carcase to live weight will reach upwards of 70 per cent.; but the cases stated hereinafter will show that such proportion may be met with.

Examples of the use of the foregoing tables, and of the operation of their use on the Slide-rule will be deferred until the proportion of mutton to the live weight of sheep, and of pork to the live weight of swine, have been stated; previous to which are given below two extracts from the author's essay in the first volume of the "PLOUGH," which may, perhaps, prove of interest to some readers.

The following are the OFFALS of oxen :—

	In general.	In rare instances.
Hide and horns . . .	4 to 7 st. (14 lbs.	8 to 9 stones.
Tallow	3 ,, 10 ,,	10 ,, 20 ,,
Head and tongue . .	2 ,, 3½ ,,	
Feet	1½ 2½ ,,	
Kidneys, the pair . .	2 ,, 4 lbs.	
Back collop	2 ,, 4 ,,	
Heart	6 ,, 9 ,,	
Liver, lungs, & windpipe	1½ 2 st.	
Stomachs and entrails	10 ,, 14 ,,	
Blood	3 ,, 4 ,,	

The proportion of the parts of a prime fat short-horn bullock of 70 stones carcase weight, and that of a short-horn heifer of 50 stones. The side being supposed to be divided with ten ribs to the forequarter.

BULLOCK OF SEVENTY STONES.

HIND QUARTER.			1ST QUALITY.		2ND.		3RD.	
	st.	lbs.	st.	lbs.	st.	lbs	st.	lbs.
Sirloin, steaks, and suet . .	6	4	6	4				
Rump	1	4			1	4		
Round	2	12			2	12		
Flank	4	0			4	0		
Leg	3	8					3	8
	18	0	6	4	8	2	3	8
FORE QUARTER.								
Fore chine	3	7	3	7				
Ribs	3	3			3	3		
Neck, breast, shoulder, & knee	10	4					10	4
	17	0	3	7	3	3	10	4
Side	35	0	9	11	11	5	13	12

HEIFER OF FIFTY STONES.

HIND QUARTER.			1ST QUALITY.		2ND.		3RD.	
	st.	lbs.	st.	lbs.	st.	lbs.	st.	lbs.
Sirloin, steaks, and suet . .	5	0	5	0				
Rump	0	13			0	13		
Round	2	2			2	2		
Flank	3	0			3	0		
Leg	2	0					2	0
	13	1	5	0	6	1	2	0
FORE QUARTER.								
Fore chine	2	7	2	7				
Ribs	2	8			2	8		
Neck, breast, shoulder, & knee	6	12					6	12
	11	13	2	7	2	8	6	12
Side	25	0	7	7	8	9	8	12

SHEEP.

Proportion of Mutton to the live Weight of Leicester Sheep.

LIVE WEIGHT IN STONES OF 14 LBS.	PER CENT OF MUTTON. In Wool.	PER CENT OF MUTTON. Newly shorn.
Above 20	71 to 72	— to 75
19 to 20	69 „ 70	73 „ 74
17 „ 19	67 „ 68	71 „ 72
16 „ 17	— „ 66	69 „ 70
14 „ 16	64 „ 65	67 „ 68
12 „ 14	62 „ 63	
11 „ 12	60 „ 61	64 „ 65
10 „ 11	— „ 59	
9 „ 10	— „ 57	62 „ 63
8 „ 9	55 „ 56	60 „ 61
7 „ 8	53 „ 54	— „ 59
6 „ 7	51 „ 52	— „ 57
5 „ 6	— „ 50	

The above table applies only to long-woolled sheep. When south down sheep are weighed in wool, 2 per cent. must be added to the proportion of mutton given in the table for sheep in wool.

SWINE.

Proportion of the Pork, including the Head and Feet of well-fed bacon Hogs to their live Weight.

LIVE WEIGHT OF SWINE IN STONES, 14 LBS. AVOIRD.	PER CENT OF PORK.
Above 40	87 to 88
35 to 40	84 „ 86
30 „ 35	83 „ 84
25 „ 30	81 „ 82
20 „ 25	— 80
15 „ 20	78 „ 79
Under 15	75 „ 77

To find the weight of carcase from the live weight of stock: set the proportion applicable to the case on B to the middle 10 or 100 on A; then against the live weight of the animal on A, will be found the carcase weight on B.

EXAMPLES.

An extraordinary fat ox, fed by the Duke of Richmond, and slaughtered by Mr. Story of Newcastle-upon-Tyne, at Christmas, 1841, weighed alive 169 stones; required his carcase weight.

71, the proportion of beef applicable to the case on B, being set to 100 on A; then against 169 on A gives 119·9 stones, or 120 stones nearly, for the carcase weight. The actual carcase weight of this beast was 121 st. 6 lbs.

The companion and own brother to the above mentioned ox, was killed by Mr. Story, same season, when his live weight was 171 stones.

71 on B to 100 on A; then against 171 on A, is 121·4 st. for the carcase weight. The actual carcase weight of this animal was 120 st. 6 lbs.

NOTE.—The weight of tallow in the first bullock was 12 st.; that in the latter 17 st. 3 lbs. The computed aggregate carcase weight of the two is 241 st. 9 lbs. The actual weight 242 st. 2 lbs., a difference of only 7 lbs.

An extraordinary fat heifer, bred and fed by the Duke of Northumberland, killed at Alnwick, at Christmas, 1844, weighed 177 stones alive.

71 on B to 100 on A; then against 177 on A is 125·6 stones, or 125 stones 9 lbs. by computation, when her actual weight of carcase was 126 stone 7 lbs.; showing, between the computed and actual carcase weight, a difference of 12 lbs. only.

An extraordinary fat Argyleshire bullock, fed by the Duke of Northumberland, killed by Mr. Story, of Newcastle-upon-Tyne, at Christmas, 1845, weighed alive 150 stones.

66, the tabular proportion for such a case, on B, set to 100 on A; then against 150 on A is 99 stones on B. The weight of this animal was 99 stones 12 lbs.

The following 5 sheep fed by the Duke of Northumberland, were slaughtered by Mr. March, of Greenside, near Gateshead, in the county of Durham, in January, 1846.

	LIVE WEIGHTS. st.	lbs.	ACTUAL CARCASE WEIGHTS. st.	lbs.
No. 1.	24	3	17	6
2.	22	12	16	10½
3.	22	0	16	1
4.	21	6	14	4
5.	19	11	14	3

Computations of the above by the Slide-rule.

No. 1. 24 stones 3 lbs., the live weight, is 339 lbs. Set 72, the required tabular number, on B to 100 on A; then against 339 on A is 244 lbs. for the carcase weight sought, on B, which is 17 stone 6 lbs.

2. 22 stones 12 lbs., the live weight, is 320 lbs. Set 72 on B to 100 on A; then against 320 on A is 230·4 lbs., the carcase weight sought, on B, which is 16 stones 6½ lbs.

3. 22 stones, the live weight, is 308 lbs. Set 72 on B to 100 on A; then against 308 on A is 221·7 lbs, the carcase weight sought, on B, which is 15 stones 11¾ lbs.

4. 21 stones 6 lbs., the live weight, is 300 lbs. Set 71 on B to 100 on A; then against 300 on A is 213 lbs., the carcase weight sought, on B, which is 15 stones 3 lbs.

5. 19 stones 11 lbs., the live weight, is 277 lbs. Set 70 on B to 100 on A; then against 277 lbs. on A is 194 lbs., the carcase weight sought, on B, which is 13 stones 12 lbs.

NOTE.—The aggregate computed carcase weight is 78st. 11¼ lbs., whilst the aggregate actual carcase weight was 78 st. 10½ lbs. a difference of only ¾ lb.

A two-year old Leicester wedder sheep, in fair condition, killed by Mr. Story of Newcastle-upon-Tyne, May 21, 1846, weighed alive, 9 stones 3 lbs.

9 stones 3 lbs., the live weight, is 129 lbs. Set 57, the tabular proportion applicable to the case, on B to 100 on A; then against

129 lbs, on A is 73·5 lbs., the carcase weight sought on B. The actual carcase weight was 72 lbs.

A ewe of the Cheviot breed, killed by Mr. Hawksby, Newcastle-upon-Tyne, in April, 1846, weighed alive 6 stones 9 lbs.

6 stones 9 lbs., the live weight, is 93 lbs. Set 51, the tabular proportion applicable to the case, on B to 100 on A; then against 93 on A, is 47·4 lbs., the carcase weight sought, on B. The actual carcase weight was 48 lbs.

Two newly shorn wedder sheep, of the Leicester breed, one year old, were killed by Mr. Robinson, Newcastle-upon-Tyne, March 26, 1847, when their weights alive, and their weights of carcase, were as follows :—

	LIVE WEIGHT.		CARCASE WEIGHT.
No. 1.	8st. 0 lbs.	or 112 lbs.	68 lbs.
2.	7 7	„ 105	62

For No. 1. Set 60, the tabular proportion required in the case, on B to 100 on A; then against 112 on A, is 67·2 lbs., the carcase weight sought, on B.

For No. 2. Set 59, the tabular proportion required in the case, on B to 100 on A; then against 105 on A, is 62 lbs., very nearly, the carcase weight sought, on B.

The machine best adapted for taking the live weight of animals, as well as for the general purposes of the farmer, is that invented and made by Mr. H. G. James, No. 44, Fish Street Hill (near the Monument), London.

TO CONVERT THE CARCASE WEIGHT OF CATTLE IN STONES OF 14 LBS. AVOIRDUPOIS, INTO ANY LOCAL WEIGHT.

The proportion between the stone of 14 lbs. avoirdupois, and the several denominations of weight by which the value of fat cattle is estimated, in different parts of the United Kingdom, is as follows :—

Imperial stone	14 lbs.	avoird.	1
London ,,	8 ,,	,,	·571
Score . . .	20 ,,	,,	1·428
Edinburgh st.	16 ,,	of 17½ oz.	1·25
Glasgow ,,	16 ,,	22 ,,	1·571

Set 1 on B to the tabular proportion of the denomination of weight required upon A; then A becomes a line of weights in stones of 14 lbs., and B a line of corresponding weights in the denomination required.

EXAMPLES.

To find how many London stones of 8 lbs., are equivalent to 126 stones of 14 lbs.

Set 1 on B to ·571 on A; then against 126 on A, is 220·6 London stones on B.

How many score weights are equivalent to 69 stones of 14 lbs.?

Set 1 on B to 1·428 on A; then against 69 on A, is 48·3 scores weight on B.

What weight would a beast of 100 stones of 14 lbs. be called in the Edinburgh market?

Set 1 on B to 1·25 on A; then against 100 on A, is 80 stones in Edinburgh weight on B.

Required the Glasgow weight, equivalent to 120 stones of 14 lbs. avoirdupois.

Set 1 on B to 1·571 on A; then against 120 on A, is about 76½, the weight in Glasgow stones, on B.

ON ASCERTAINING THE CARCASE WEIGHT OF CATTLE BY MEASUREMENT.

Besides the method pointed out in the preceding pages, the carcase weight of cattle may also be ascertained by computation from dimensions; but, unless provision be made for meeting the circumstances that influence the proportion of beef to the live weight of the animal, pointed out when treating of that branch of the subject, any attempt to ascertain the weight of an ox by such means, with any degree of certainty, is futile. To discover the weight of cattle by measurement, or by any other means, without at the same time being a judge of shape, condition, or other circumstances that effect their weight, is utterly impossible; but in the hands of those able to estimate the effect of circumstances that influence weight, then, and only in such case, can the measure,—with properly modified rules, founded upon long experience and close observation of the effects of the circumstances above referred to,—be of any practical use. The measuring tape is, with such knowledge and assistance, a valuable auxiliary to forming a correct judgment of the *carcase weight of oxen.*

THE DIMENSIONS TO BE TAKEN—

Are the length of the back of the animal, and his girth at the fore-ribs. The length should be taken from the junction of the cervical and dorsal processes, which point can very easily be discovered, in the fattest animals; as when the head is gently raised so high that the poll may be just level with the shoulder, a slight hollow will be perceived in front of the withers in most beasts, and in bulls, and in cattle in extraordinary condition the exact point will be shown by a slight plaiting of the hide on the upper part of the neck; the line should then be carried backward to the point of the upper part of the tail, from whence a plumb line would just include the whole of the beef of the buttock. The girth should be taken immediately behind the elbow, *squarely* round the body. Both dimensions must be taken in feet and inches with the most careful accuracy, when the beast is standing perfectly at his ease. The best position in which to take the dimensions of cattle is immediately after they have become voluntarily at rest after walking. In taking the girth, the line should be drawn as tightly as it can be done, without producing any creasing or nipping in of the hide.

Having taken the dimensions carefully according to the foregoing directions,—

THE RULE FOR COMPUTING THE CARCASE WEIGHT—

From them is: to multiply the girth by itself, and the product by the length; both dimensions in feet and inches; then to multiply the product last found by the decimal multiplier, to meet the particular case that may be required, according to the following table:—

CONDITION OF BEAST.	DECIMAL MULTIPLIERS.		
	Class 1.	Class 2.	Class 3.
Half fat	·23	·225	·22
Moderately fat. . . .	·24	·24	·23
Prime fat	·25	·25	·24
Very fat	·262	·26	·24
Extraordinary fat . .	·275	·27	·25

And for the following beasts not included in the above classification:—

Holstein cattle, in ordinary condition	·22
Shetland cattle, in prime condition	·2

And the product will give the carcase weight in stones, and decimals of stones of 14 lbs. avoirdupois.

The first operations of the rule may be performed by duodecimals; the duodecimals in the result being reduced to decimals, previous to using the decimal multiplier: or the inches over feet, in the dimensions, may be reduced to decimals of a foot, and the whole operation performed by multiplication of decimals.

The foregoing classification is on the same principles, both as to breed and condition, as that given at pages 66 and 67. Such readers as may desire to pursue the subject further are referred to the author's essay in the first volume of the "PLOUGH."

As a portion of the instrument, to which this tract refers, is designed for computing the carcase weight of cattle from dimensions, the use of which will be presently submitted to the reader's attention, it will be unnecessary to give any examples on the subject of the last foregoing pages.

ON THE CATTLE GAUGE.

In the spring of 1844, after a lengthened and careful attention to the subject, the author of the present tract made a special arrangment of the Slide-rule for the purpose of computing the carcase weight of cattle from dimensions, which has since been known in the Birmingham trade as the "Improved Cattle Guage; rule 7065." A modification of that instrument, in a considerably improved form, and extended in its usefulness,—the result of continued observations on the subject,—now forms the reverse of the Farmers' Slide-rule. The Cattle Gauge may be—

DESCRIBED AS FOLLOWS:—

On the upper margin of the groove, is marked the carcase weight of cattle in stones of 14 lbs. avoirdupois, extending in a gradation of single stones from 20 to 200.

On the upper margin of the slide is the girth in feet and inches from 4 feet 6 inches to 10 feet 6 inches.

On the lower margin of the slide are seven gauge points, marked respectively from left to right, with the letters G, F, E, D, C, B, and A, which, referring to the classification at page 66, are to be used as follows:—

	Class 1.	Class 2.	Class 3.
Half fat	C	B	B
Moderately fat	D	C	C
Prime fat	E	D }	D
Very fat	F	E }	D
Extraordinary fat	G	F	E
Holstein cattle, ordinary fat			B
Shetland cattle, prime fine			A

Giving results very nearly, though not quite exactly, the same as the use of decimal multipliers given at page 76.

On the lower margin of the groove is the length, marked in feet and inches, extending from 3 feet 6 inches to 7 feet.

Having taken the dimensions as directed at pages 75 and 76

TO USE THE GAUGE,—

Set the gauge point, applicable to the case, on the lower margin of the slide, to the length, on the lower margin of the groove; then against the girth, on the upper margin of the slide, will be found the carcase weight in stones of 14 lbs. avoirdupois, on the upper margin of the groove.

EXAMPLES.

A very fat short-horn bull, 6 years old, of excellent shape, measuring 5 feet 8 inches in length, and 8 feet 3 inches in girth, was killed by Mr. Carr of Newcastle-upon-Tyne, in May, 1844, when the actual weight of his carcase was 106 st. 12 lbs.

The gauge-point, in this case, is G, which set to length 5 feet 8 inches; then against the girth 8 feet 8 inches, is nearly 106 st., for carcase weight.

Two short-horn bullocks, in prime fat condition, both of them 4 years old, and of exactly the same dimensions, *viz.*, 5 feet 3 inches in length, and 7 feet in girth, killed by Mr. James Henderson, of Newcastle-upon-Tyne, in July, 1844, were not weighed seperately, but the actual aggregate carcase weight of the two was 130 stones.

The gauge point, in this case, is E, which, when set to length 5 feet 3 inches; then against the girth 7 feet, is 64½ st., for the carcase weight of each, or 129 st. for the two.

A short-horn heifer, 3 years and 9 months old, in extraordinary fat condition, bred and fed by the Duke of Northumberland, was 5 feet 8 inches in length, and 9 feet in girth, killed at Alnwick at Christmas, 1844, when the actual weight of her carcase was 126 st. 7 lbs.

The gauge point, in this case, is G, which set to length 5 feet 8 inches; then against girth 9 feet, is 126 st., for the carcase weight.

Mr. Michael Blenkinsopp, of Newcastle-upon-Tyne, killed a short-horn cow, moderately fat, 22nd May, 1845, measuring in length 5 feet, and in girth 6 feet 4 inches. Her carcase weight was 47 st. 12 lbs.

Set D to length 5 feet; then against girth 6 feet 4 inches, is 48½ stones.

A prime fat bullock of the Aberdeen polled breed, measuring in length 4 feet 8 inches, and 5 feet 8 inches girth, was killed by Mr. Edward Turnbull, of Newcastle-upon-Tyne, 22nd May, 1845. The carcase weighed 36 st. 6 lbs.

Set D to length 4 feet 8 inches; then against girth 5 feet 8 inches, is 36½ stones.

A short-horn heifer, in very fat condition, bred and fed by Mr. Fenwick, of Ulgham Grange, Northumberland, was 5 feet 3 inches in length, and 7 feet 1 inch in girth, killed by Mr. James Henderson, of Newcastle-upon-Tyne, June, 1845, when her actual carcase weight was 68 st. 12 lbs.

The gauge point, in this case, is F, which set to length 5 feet 3 inches; then against 7 feet 1 inch, is rather more than 69 st., for the carcase weight.

A prime fat short-horn heifer, 4 feet 10 inches in length, and 6 feet 6 inches in girth, killed by Mr. Story, of Newcastle-upon-Tyne, in June, 1845, when her actual carcase weight was 51 st. 10 lbs.

The gauge-point, in this case, is E, which set to length 4 feet 10 inches; then against girth 6 feet 6 inches, is 51½ st., for the carcase weight.

An extraordinary fat Argyleshire bullock, fed by the Duke of Northumberland, 5 feet 9 inches in length, and 8 feet 4 inches in girth, killed by Mr. Story, of Newcastle-upon-Tyne, at Christmas, 1845, when his actual carcase-weight was 99 st. 12 lbs.

The gauge point, in this case, is E, which set to length 5 feet 9 inches; then against girth 8 feet 4 inches, is 100 st., for the carcase weight.

Four short-horn heifers, in prime fat condition, killed by Mr. Story, of Newcastle-upon-Tyne, 25th March, 1846, the dimensions and actual carcase weight of which were as follows, *viz.*:—

	LENGTH.	GIRTH.	CARCASE WEIGHT.
No. 1.	5 ft. 0 in.	7 ft. 1 in.	61 st. 12 lbs.
,, 2.	4 10	6 8	54 6
,, 3.	5 1	6 11	60 8
,, 4.	4 10	6 7	52 4

In No. 1. Set E to length 5 feet; then against girth 7 feet 1 inch, is 62¾ stones.

In No. 2. Set E to length 4 feet 10 inches; then against girth 6 feet 8 inches, is 53¾ stones.

In No. 3. Set E to length 5 feet 1 inch; then against girth 6 feet 11 inches, is 61 stones.

In No. 4. Set E to length 4 feet 10 inches; then against girth 6 feet 7 inches, is 52½ stones.

A short-horn heifer, in prime fat condition, measuring in length 5 feet 1 inch, and 6 feet 7 inches in girth, was killed by Mr. Edward Turnbull, of Newcastle-upon-Tyne, 25th March, 1846, when her actual carcase weight was 55 st. 10 lbs.

Set E to length 5 feet 1 inch; then against girth 6 feet 7 inches, is 55½ stones, nearly.

A short-horn heifer, killed by Mr. Robert Thompson, of Newcastle-upon-Tyne, 9th July, 1846, was 4 feet 8 inches in length, and 6 feet 7 inches girth, the actual weight of carcase was exactly 53 stones. This heifer was only 2 years old, and was remarkably fat.

Set F to length 4 feet 8 inches; then against girth 6 feet 7 inches, is rather more than 53 stones.

Two prime fat Shetland heifers were killed by Mr. Nichol, of Newcastle-upon-Tyne, in July, 1846, the dimensions and actual carcase weights of which were as follows:—

	LENGTH.	GIRTH.	CARCASE WEIGHT.
No. 1.	4 ft. 0 in.	4 ft. 11 in.	19 st. 2 lbs.
,, 2.	4 2	5 1	21 12

The scope of the Cattle Gauge not including the carcase weights of animals of so small a size, their length must be increased by some multiplier, and the weights found from such increased lengths divided by the multiple of the lengths. Thus, by increasing the lengths by one half, we get three times half of the weights.

The gauge point in these cases is A, which set (in No. 1) to 6 feet, the length increased by one half; then against the girth, 4 feet 11 inches, is 29½ stones, for three times half the carcase weight, or 19⅔ stones for the carcase weight.

A set to 6 feet 3 inches, the length (in No. 2) increased by one half; then against the girth, 5 feet 1 inch, is nearly 32½ stones, for three times half the carcase weight, or nearly 21⅔ stones for the carcase weight.

A heifer; half-bred between a short-horn bull and a polled Aberdeenshire cow, in good moderate condition, 4 feet 10 inches in length, and 6 feet 3 inches in girth, killed by Mr. W. Maughan, of Newcastle-upon-Tyne, in June, 1847, when the actual carcase weight was 45 st. 4 lbs.

The gauge point in this case is D, which set to length 4 feet 10 inches; then against girth 6 feet 3 inches, is rather more than 45½ stones for weight of carcase.

In 18 beasts, under different circumstances influencing their carcase weight, given in the foregoing examples, the aggregate of their carcase weights, computed by means modified to meet the circumstances, amounts to 1091 stones; whilst the aggregate of the actual carcase weights is 1092 st. 3 lbs. The greatest difference in any of the cases, between the computed and true carcase weight, is only 12 lbs., and that on a weight of 106 st. 12 lbs.

SUPPLEMENT.

DRAINING.

Having determined the length of drains, per acre, by the formula given at page 36,—

THE NUMBER OF TILES OR PIPES—

May be found, by setting the length of drain, in yards per acre, on B, to the length of the tile or pipe, in inches, on A; then against 36 on A, will be the number of tiles or pipes, required per acre, on B.

EXAMPLE.

How many tiles, 18 inches long, will be required for 538 yards of drain?

Set 538 yards on B to 18 inches on A; then against 36 on A, is 1076, the number of tiles, on B.

THE END.

ERRATA.

Page 17, line 22, for *divisor* read *divisors*.
" 41, " 21, for *one load per acre*, read *one hundred loads per acre*.

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Do. Do. on Tripod Folding-staff	11	11	0
Twenty-inch Do. on jointed Legs .	13	0	0
Do. Do. on Tripod Folding-staff	14	0	0
Gravatt's Improved Dumpy Level, with floating Card, on round Legs	12	12	0

Do. with divided Silver Ring to Compass, Reflector, Erect, and inverting Eye-piece, &c., on Tripod Folding-staff	15	0	0
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Prismatic Compass	4	4	0
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