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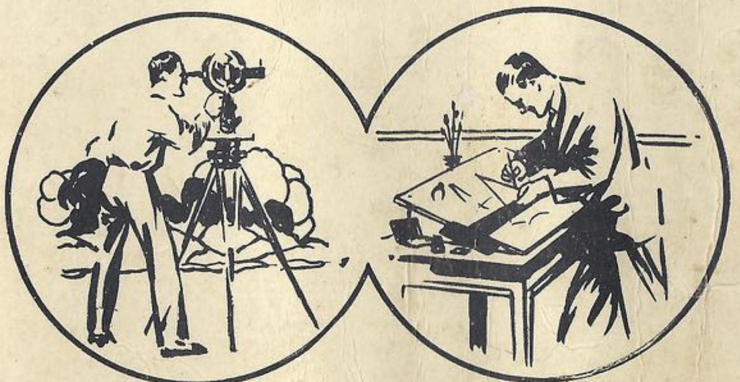

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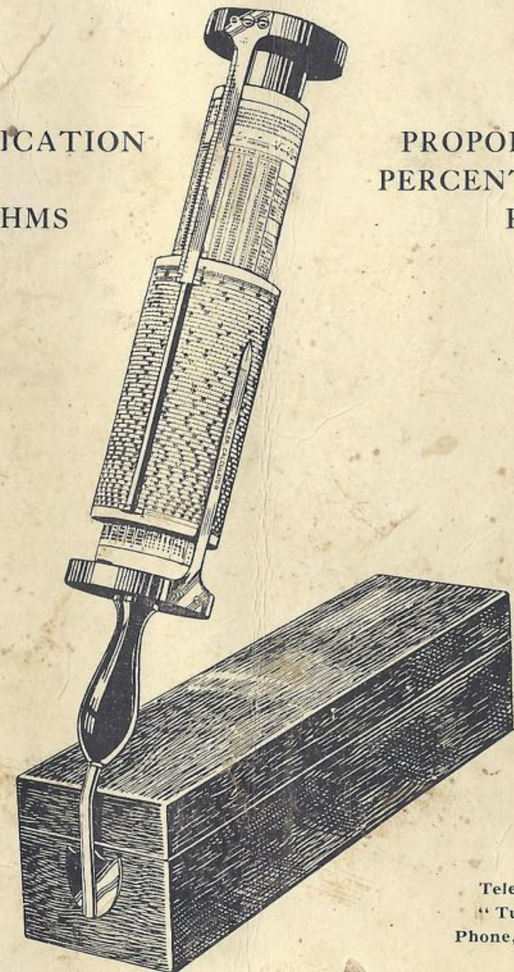
The Fuller Calculator

For Calculations involving

MULTIPLICATION
DIVISION
LOGARITHMS

PROPORTION
PERCENTAGES
ROOTS



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PROFESSOR FULLER'S

CALCULATORS

HAVING A

LOGARITHMIC SCALE OF NUMBERS
41 Feet 8 Inches in Length

GEORGE FULLER, M.Inst. C.E.,
FORMERLY PROFESSOR OF ENGINEERING
IN THE QUEEN'S COLLEGE, BELFAST.

INSTRUCTIONS FOR THE
— USE OF THE RULE —

TRADE **STANLEY** MARK

MODEL No. 1.

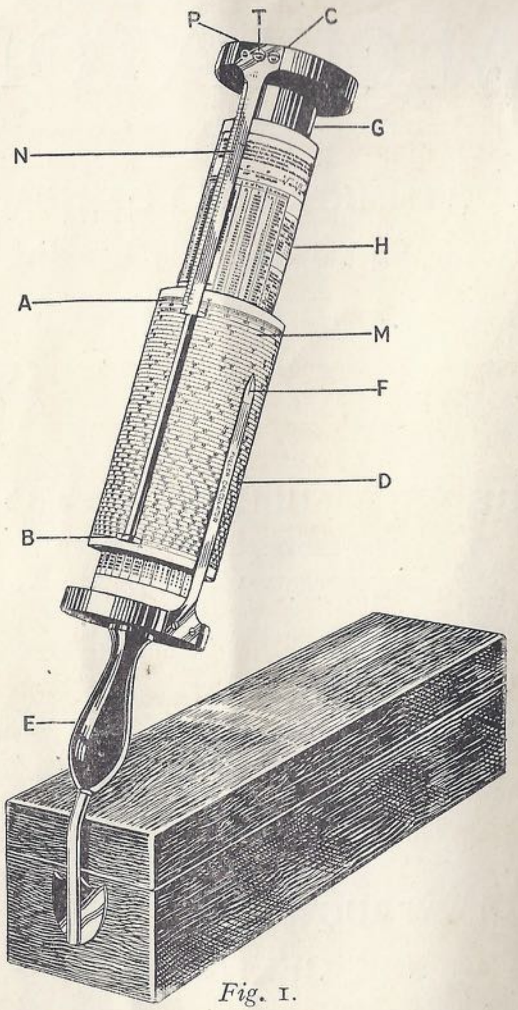


Fig. I.

The **Fuller Calculator** as used on its support, which is attached to the end of the box. When not in use the support is kept in a fitting inside the box.

THE
FULLER CALCULATOR.

is a logarithmic calculator. Its fundamental principle is precisely the same as the Mannheim Slide Rule, but it differs radically in mechanical construction.

The principles of logarithmic calculators are too well-known to those likely to be interested for it to be necessary to enlarge upon the subject here, especially as it is absolutely unnecessary to have any knowledge of the subject to use the calculator.

The **FULLER CALCULATOR** will perform all calculations involving :—

MULTIPLICATION	PERCENTAGES and
DIVISION	COMBINED MULTIPLICATION
PROPORTION	and DIVISION,

giving an accuracy of 1 in 10,000.

It costs only a fraction of the cost of an Arithmometer, and it is far less complicated to use. Its construction is so simple that there is nothing to get out of order, consequently maintenance charges are practically nil.

Anyone can calculate with the Fuller after a brief study of the following instructions **without any mathematical knowledge whatever.**

For **Percentage** and **Proportional Calculations** it is the most efficient calculator of its type in existence.

DESCRIPTION.

The Calculator consists principally of a cylinder *D* about 6 inches high by 3 inches diameter, on which is mounted the spiral logarithmic calculating scale, which is **500 inches in length.**

This revolves and slides on an inner cylinder *H*, which is held by a handle *E*. The settings are made and the calculations effected by use of the metal pointers or indexes *A* & *B* & *F* shown in the illustration.

As the accuracy of a Logarithmic Calculator is directly proportional to its length, the vast superiority of this calculator over all others working on the same principle is obvious.

The instrument is contained in a mahogany box, which is also adapted for use as a stand to save the fatigue of holding the instrument in the hand. *See Fig.* I.

Three different models are available. All are identical in construction but two of them bear additional scales on the inner cylinder *H*. A description of which will be found in the following pages.

MODEL No. 1.

For calculations involving :—

MULTIPLICATION	PERCENTAGES and
DIVISION	COMBINED MULTIPLICATION
PROPORTION	and DIVISION.

This model has no scale on the inner cylinder *H* which is occupied by a table of useful data.

The Spiral Scale is divided as follows :—

Each of the primary divisions, as far as 650, is divided into ten parts, and from thence to 1000 into five parts ; so that all numbers of four figures have either a mark upon the scale, or are midway between two marks. Thus 4786 is shown by a mark ; also 8432 ; but 8431 is not shown by a mark, but is midway between 8430 and 8432. In a large part of the scale the space between these secondary divisions is large enough to be easily divided into parts by the eye. Thus many numbers of five figures are easily shown ; for example, 26854. There are the first three figures at 268, then 5 is at the fifth secondary division, and the 4 must be estimated by the eye as $\frac{4}{10}$ of the space between 2685 and 2686. As the decimal point is arbitrary the same figures do not always mean the same amount. Thus to represent 26854, 2685·4, 268·54, 26·854, 2·6854, ·26854, ·026854, etc., the same point on the scale is used.

To fix the decimal point in the result obtained **(though this may *most frequently* be determined merely by inspection)**, rules will be given for this purpose founded on the characteristics of the logarithms of numbers.

The index of the logarithms of numbers

between	1000	and	9999	is	3,
,,	100	,,	999·9	,,	2,
,,	10	,,	99·99	,,	1,
,,	1	,,	9·999	,,	0,
,,	·1	,,	·9999	,,	$\bar{1}$,
,,	·01	,,	·09999	,,	$\bar{2}$,
,,	·001	,,	·00999	,,	$\bar{3}$.

INDEXES OR READERS. (Common to all three Models)

These are three in number. *See figure* 1.

(1). *F* the fixed index.

(2). *A* the top movable index.

(3). *B* the lower movable index.

The *A* and *B* movable indexes actually consist of two pairs of indexes, namely, one pair on the left, and one on the right. Those

on the left are usually the more convenient to use, as it is easier to read the scale when the previous graduations are visible. When using the indexes on the right of the bar the previous graduations on the scale are hidden from view, but these are sometimes more convenient when it is found necessary to set to a number which happens to be immediately under the fixed index, or when multiplying or dividing a lot of figures by the same number.

The bar carrying the movable indexes lies closely against the cylindrical scale, but the fixed index stands well away from the scale to allow the movable bar to pass freely under it and is pressed down by the thumb of the left hand when taking a reading.

Either *A* or *B* may be used and usually it is only possible to use one of them as the other will be off the scale. **Whenever possible *A* should be used in preference to *B*.**

The reading should be taken from the **top left hand** corner in the case of the *A* and *B* index, *see figure* 2.

Note Carefully.

When the Indexes *A* and *B* are to be moved, the term **set** is used.

When the Cylinder is to be moved, the term **bring** is used.

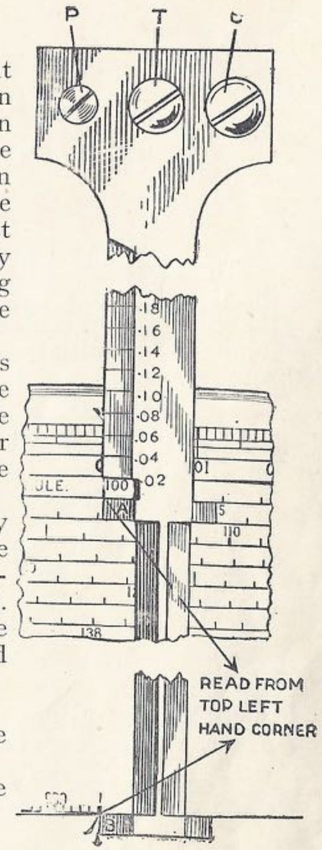


Fig. 2
Showing Position of Indexes A and B when correctly adjusted.

TO ADJUST THE INDEXES.

Before attempting to calculate it is as well to see that the Indexes *A* and *B* are in correct adjustment.

Referring to the illustration, it will be seen that they are fixed exactly the length of the spiral scale apart.

When the index *A* is set to the beginning of the scale, the index *B* should coincide with the last division on the scale. Should it not so coincide owing to the bar being out of adjustment, viz., not parallel to the axis of the cylinder, it can be adjusted by means of the screws fixing the bar to the inner cylinder at the top. *See figure* 2.

P is a pivotting screw. *T* is the tightening screw and *C* is not really a screw at all, but a **Cam**. If *P* is released and *C* turned, the bar will be seen to move from side to side, with respect to the Axis of the instrument. When it is in correct alignment, tighten *P* and *T* and the rule is ready for use.

INSTRUCTIONS FOR USING THE FULLER CALCULATOR.

MODEL No. 1.

The foregoing details of construction show that in operating the Calculator there can only be two different movements, viz., the moving of the Scale or the moving of the Indexes *A* and *B*. The former is a **multiplying movement** and the latter a **dividing movement.**

Therefore taking any factor of any calculation, if it is a Numerator it must be brought to the Index by **moving the Scale,** but if it is a Denominator it must be set by **moving the Index** *A* **or** *B* to the Scale.

Obviously, the same form of movement cannot be made twice in succession, that is, if the last movement was multiplying (moving the Scale), the next must be a dividing movement (moving the Index) to complete the sequence and give a result.

When no factor exists, the sequence of movement is completed by taking 1 as the factor. For instance, in simple or continuous multiplication the dividing movement is carried out using 1 as the factor, and moving the Index accordingly.

The Sequence of Movements is therefore the same whether for Multiplication, Division or both combined.

The only other points to remember in this connection are that the **first** and **last** movements must **always be multiplying** (moving the Scale), and the **Fixed Index** *F* **is used on these occasions only.** That is, a multiplying factor is first of all set to the Fixed Index and no further attention is paid to this Index until the answer is read under it.

EXAMPLE OF MULTIPLICATION.

$$\frac{173 \times 24}{1} = 4152.$$

Factor 173 is multiplying, therefore bring 173 to the Fixed Index *F*. The next movement must be **dividing** and the denominator factor is 1 understood, therefore set the movable Index *A* or *B* to 1 or Zero on the Scale.

The next movement must be multiplying, therefore bring 24 (240) to the **movable** Index *A* or *B*. The answer, 4152 is now under the Fixed Index *F*.

$$\frac{173 \times 24 \times 12}{1 \times 1} = 49824.$$

Having obtained the above answer, suppose we find it necessary to multiply further, say by 12, to bring feet to inches.

Simply continue the sequence of movements. The last movement was multiplying, therefore divide by 1 by setting the Index *A* or *B* to 1 on the Scale, and then multiply by bringing 12 to the movable Index, *A* or *B*. The answer, 49824 is now under the Fixed Index *D*. It should be noticed that the accuracy of the last figure 4, can be checked at once mentally.

EXAMPLE OF DIVISION.

$$\frac{286 \times 1}{24} = 11{\cdot}916. \qquad \frac{286}{24} \times \frac{1}{11} \times 1 = 1{\cdot}0833$$

Bring the multiplying factor 286 to the **Fixed Index** *F*.
Set the Index *A* or *B* to the dividing factor 24. To complete the sequence of movements, multiply by 1 understood, by bringing 1 on the Scale to the Index *A* or *B*. The answer, 11·916 is under *F* Index.

To divide further by, say 11, set the Index *A* or *B* to 11 on the Scale, complete the operation by multiplying by 1 understood, bringing 1 on the Scale to the Index. The answer, 1·0833 is under *F* Index.

COMBINED MULTIPLICATION AND DIVISION

$$\frac{25 \times 22 \times 16}{11 \times 29 \times 14} = 1.9704.$$

Bring 25 to F. Divide by setting *A* to 11. Multiply by bringing 22 to *A* or *B*. Divide by setting *A* or *B* to 29. Multiply by bringing 16 to *A* or *B*. Divide by setting *A* or *B* to 14. Complete sequence by bringing 1 to *A* or *B*. The answer 1·9704 (correct to four places) is under *F*.

It will be observed that these are operations of merely adding and substracting lengths on the Scale, adding for multiplication and subtracting for division

The following Tables cover all types of multiplication and division and set out the sequence of operations very clearly.

When the indexes are to be moved the term Set is used. When the cylinder has to be moved the term Bring is used.

MULTIPLICATION.

$$(a\times b)\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ to } 100\\ \text{Bring } (b) \text{ to } A \text{ or } B\\ \text{Product read at } F\end{array}\right. \qquad (a\times b\times c)\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ to } 100\\ \text{Bring } (b) \text{ to } A \text{ or } B\\ \text{Set } A \text{ to } 100\\ \text{Bring } (c) \text{ to } A \text{ or } B\\ \text{Product read at } F\end{array}\right.$$

$$(a\times b\times c\times d)\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ to } 100\\ \text{Bring } (b) \text{ to } A \text{ or B}\\ \text{Set } A \text{ to } 100\\ \text{Bring } (c) \text{ to } A \text{ or B}\\ \text{Set } A \text{ to } 100\\ \text{Bring } (d) \text{ to } A \text{ or } B\\ \text{Product read at } F\end{array}\right.$$

It will be seen that a similar sequence of operations applies to finding the production of any number of factors.

DIVISION.

$$\frac{a}{m}\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ or } B \text{ to } (m)\\ \text{Bring } 100 \text{ to } A\\ \text{Quotient read at } F\end{array}\right. \qquad \frac{a\times b}{m}\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ or } B \text{ to } (m)\\ \text{Bring } (b) \text{ to } A \text{ or } B\\ \text{Quotient read at } F\end{array}\right.$$

$$\frac{a\times b\times c}{m}\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ or } B \text{ to } (m)\\ \text{Bring } (b) \text{ to } A \text{ or } B\\ \text{Set } A \text{ to } 100\\ \text{Bring } (c) \text{ to } A \text{ or } B\\ \text{Quotient read at F}\end{array}\right. \qquad \frac{a}{m\times n}\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ or } B \text{ to } (m)\\ \text{Bring } 100 \text{ to } A\\ \text{Set } A \text{ or } B \text{ to } (n)\\ \text{Bring } 100 \text{ to } A\\ \text{Quotient read at } F\end{array}\right.$$

$$\frac{a\times b}{m\times n}\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ or } B \text{ to } (m)\\ \text{Bring } (b) \text{ to } A \text{ or } B\\ \text{Set } A \text{ or } B \text{ to } (n)\\ \text{Bring } (100) \text{ to } A\\ \text{Quotient read at } F\end{array}\right. \qquad \frac{a\times b\times c}{m\times n}\left\{\begin{array}{l}\text{Bring } (a) \text{ to } F\\ \text{Set } A \text{ or } B \text{ to } (m)\\ \text{Bring } (b) \text{ to } A \text{ or } B\\ \text{Set } A \text{ or } B \text{ to } (n)\\ \text{Bring } (c) \text{ to } A \text{ or } B\\ \text{Quotient read at } F\end{array}\right.$$

It will be seen that a similar sequence of operations applies to the division of the product of any number of factors by the product of any number of other factors.

TO FIX THE DECIMAL POINT.

GENERAL RULE FOR THE INDEX OF THE PRODUCT.

Take the sum of the indexes of the factors, and to this add one each time a factor is brought to *B*. The sum is the index of the product or number of figures before the decimal point.

GENERAL RULE FOR THE INDEX OF THE QUOTIENT.

Find the algebraical difference between the sum of the indices of the numerator, and the sum of the indexes of the denominator, and then every time a factor of the numerator is *brought* to *B* add one to this, and every time *B* is *set* to a factor of the denominator deduct one. The result gives the index of the quotient or number of figures before the decimal point.

It should be remarked that the sequence of operations in *every* case is the same both for multiplication and division.

EXAMPLES.

Multiplication.—48·42 × ·06434 = 3·1153. In this case 6434 is brought to *B*, so that the sum of the indices is 1—2+1=0 and the product is in units.

13·28 × 142·7 = 1895. In this case the sum of the indices is 1 + 2 = 3, and as neither factor is brought to *B* the product is in thousands.

What is the weight of a bar of iron 14 ft. × 3″ × 2″; weight of a cubic inch of iron ·277 lbs.?

14 × 12 × 3 × 2 × ·277 = 279·21 lbs. In this case 2 is brought to *B*, so the index of the product is 1 + 1 — 1 + 1 = 2 and the product is therefore in hundreds.

Division.—486·34 ÷ ·0723 = 6726·5. In this case ·0723 is set to *B* and the index of the quotient is 2 — (—2)—1=3 and the quotient is in thousands.

·01368 ÷ 12·64 = ·001082. In this case the index of the quotient is —2—1= —3 and the quotient is in thousands.

How many gallons will a cistern $4{\cdot}75' \times 3{\cdot}5' \times 2{\cdot}75'$ hold; a gallon is ·16037 cub. ft.?

$$\frac{4{\cdot}75 \times 3{\cdot}5 \times 2{\cdot}75}{{\cdot}16037} = 285{\cdot}08.$$ In this case 2·75 is brought to *B*, so that the index of the quotient is $-(-1) + 1 = 2$ and the quotient is in hundreds.

A stone $21{\cdot}75'' \times 15{\cdot}25'' \times 8\tfrac{1}{3}''$ weighs $268\tfrac{3}{4}$ lbs. How many cubic feet are there in 238 tons?

$$\frac{21{\cdot}75 \times 15{\cdot}25 \times 8{\cdot}333 \times 238 \times 2240}{268{\cdot}75 \times 1728} = 3172{\cdot}95.$$ In this case

15·25, 8·333 and 238 of the numerator are brought to *B*, and *B* is set to 268·75 and 1728 of the denominator, so that the index of the quotient is $1 + 1 + 2 + 3 - 2 - 3 + 3 - 2 = 3$ and the quotient is in thousands.

If 48 men working 8 hours a day for 7 days can dig a trench $235' \times 40' \times 28'$; in how many days can 12 men working 10 hours a day dig 156,060 cub. yds.?

Here

$$12 : 48 :: 7 : x$$
$$10 : 8$$
$$\frac{235 \times 40 \times 28}{27} : 156{,}060$$

$$\frac{7 \times 48 \times 8 \times 156060 \times 27}{12 \times 10 \times 235 \times 40 \times 28} = 358{\cdot}6$$

In this case 48, 8, 156,060, 27 and 100 of the numerator are brought to *B* and *B* is set to 10, 235, 40 and 28 of the denominator, so the index of the quotient is $1+5+1-1-1-2-1-1+5-4 = 2$ and the quotient is in hundreds.

These examples show that the rule gives very great facility for obtaining numerical results; also that the results are a sufficient approximation for most practical purposes.

LOGARITHMS, POWERS AND ROOTS.

To obtain powers not higher than the seventh, the quickest way is by direct multiplication.

For higher powers and roots. Place the upper movable index (c) to the number, and read the scales (n and m). These together give the *mantissa* of the logarithm of the number. To this the *index* has to be added. The index of the logarithm of a number greater than unity is *one less* than the number of figures in the integral part of that number. Thus the index of 5432 is 3, of 543·2 is 2, of 54·32 is 1, and of 5·432 is 0.

Multiply or divide the resulting number by the power or root, as shown above. Then place the cylinder so that it reads on the scales (n and m) the decimal part of the quotient. The power or root is then at the index (c). In the result the number of figures before the decimal point is *one more* than the number in the integral part of the above quotient.

The scale (n) is read from the *lowest line* of the top spiral and (m) from the vertical edge of the scale (n).

Examples.—5^{13}, on placing (A) to 500, scale (n) reads ·68 and scale (m) ·01897, which gives the logarithm of 5 — ·69897, the index being 0. Then $\cdot 69897 \times 13 = 9{\cdot}08661$. Now placing the cylinder so that it reads ·08661 on scales (n and m) the index (A) reads 12207, and the required power is 1220700000, having 10 figures, as the integral part of the above quotient is 9.

$\sqrt[5]{741}$ on placing (A) to 741, scale (n) reads ·86 and scale (m) ·00982 which gives the logarthim of 741 — 2·86982, the index being 2. Then $2{\cdot}86982 \div 5 = {\cdot}57396$. Now placing the cylinder so that it reads ·57396 on scales (n and m) the index (A) reads 37495, and the required root is 3·7495, having one figure before the decimal point, as the integral part of the above quotient is 0.

ROOTS OF DECIMAL FRACTIONS.

Write them as vulgar fractions, and multiply numerator and denominator by ten or a power of ten, so that the denominator may have a complete root. Then take the required root of the numerator by the method given above, and of the denominator by inspection.

$$\text{Thus} \sqrt{\cdot 4} = \sqrt{\frac{4}{10}} = \sqrt{\frac{40}{10^2}} = \frac{\sqrt{40}}{10}$$

$$\sqrt[3]{\cdot 04} = \sqrt[3]{\frac{4}{10^2}} = \sqrt[3]{\frac{40}{10^3}} = \frac{\sqrt[3]{40}}{10}$$

$$\sqrt[5]{\cdot 586} = \sqrt[5]{\frac{586}{10^3}} = \sqrt[5]{\frac{58600}{10^5}} = \frac{\sqrt[5]{58600}}{10}$$

$$\sqrt[3]{\cdot 00065} = \sqrt[3]{\frac{65}{10^5}} = \sqrt[3]{\frac{650}{10^6}} = \frac{\sqrt[3]{650}}{10^2}$$

$$(\cdot 0434)^{\frac{5}{6}} = \left(\frac{434}{10^4}\right)^{\frac{5}{6}} = \left(\frac{43400}{10^6}\right)^{\frac{5}{6}} = \frac{(43400)^{\frac{5}{6}}}{10^5}$$

The facility of obtaining and working with logarithms of numbers gives the rule a great additional value.

NOTE.—The Scales *N* and *M* have been replaced in Model 2 by a very long open scale on the inner cylinder. This Model is specially recommended for calculations involving the extended use of logs.

TABLES.

The tables printed on pages 27-32 have been made and selected as those considered most useful. Owing to our want of a decimal system, it has been deemed most important to have a series of tables which give for our measures of weight, length, time, etc., the equivalent decimal fraction of the larger for successive numbers of the smaller unit. This enables results to be obtained without the necessity of reduction. Thus to find the area of a rectangle whose sides are 24′ 6¼″ and 43′ 5½″. The table gives by inspection ·5208 and ·4583 opposite 6¼″ and 5½″ respectively, so that the area is obtained by multiplying 24·521 by 43·458. The result, as shown by the rule, is 1065·6. If the parts of a square foot are required in twelfths, the table shows that ·6 of a foot is equivalent to 7¼ twelfths, and the result reads 1065—7¼.

Directions for Performing Calculations Involving Percentages and Ratio.

For rapidity combined with accuracy the **Fuller Calculator** is probably the most efficient instrument in existence for calculating **Percentage Costs** and all **Proportional Values.**

When either of the movable indexes is at one number and the fixed index at another, and the cylinder is turned into any other position, though the numbers at the indices will be different, **their ratio will remain constant.**

Example.—To convert francs and centimes into sterling money, supposing exchange 25f. 25c. for 1*l*. The ratio between centimes and pence is 2525 to 240. Place the cylinder so that the fixed index is at 2525, and make one of the movable indexes point to 240. Then on moving the cylinder to read off different numbers of centimes at the fixed index, the corresponding value in pence will be read at the movable index.

Wages Table.—To find the wages for different times at 35*s*. per week of 57 hours. Place the cylinder so that the fixed index is at 57, and make one of the movable indices point to 420, the number of pence in 35*s*. Then on moving the cylinder to read off different numbers of hours at the fixed index, the corresponding wages in pence will be read at the movable index.

To determine Percentages.—Set the fixed pointer to the total number or quantity and the movable indexes to the 100 marks which are at the top and bottom of the scale. Then bring each of the component numbers in turn to the fixed pointer, when the percentage will be shown by whichever of the movable indexes is upon the scale.

Example.—What percentage of 840 are the following numbers

336	231	73·5	and	47·25
40%	27·5%	8·75%		5·625%

Bring 840 to the fixed index and set the movable indexes to the ends of the scale, that is, the 100 and 1,000 marks respectively; now shift the scale to bring 336 to the fixed pointer. The movable index then shows the percentage to be 40. Then bring the following numbers in turn to the fixed pointer, when the percentage will be simultaneously found at the movable index.

To Add or Subtract a Percentage.—Bring 100 to the fixed pointer and set the movable index to 100 plus or minus the required percentage. The percentage ratio is now set and any amount brought to the fixed pointer will reveal the corresponding amount under the movable index *A* or *B*.

Example.—Add $2\frac{1}{2}$% to £40; £120; £60—Bring 100 to the fixed pointer *F* and set movable index *A* to $102\frac{1}{2}$ or 102·5. Bring £40; £120; and £60 in succession to the fixed pointer *F* and the respective answers will be found under the movable index *A* namely £41; £123; and £61·5.

To subtract $2\frac{1}{2}$% the precedure is exactly the same, but the movable index *B* would be set to 100 — $2\frac{1}{2}$ or 97·5.

Insurance Brokerage Calculations as applied to the Fuller Calculator.

How much are 10%, 15%, 25%, $\frac{1}{2}$%, $4\frac{1}{2}$% and 45% of £586 18*s.* 3*d.*

Bring 100 to the fixed pointer to represent 100% and set the movable index to £586·9125, the decimal equivalent of £586 18*s.* 3*d.*; then bring each of the percentages to the fixed pointer, when whichever of the movable indices is upon the scale will show the answers as follows:—

			£	s.	d.
10% —	58·69125	or	58	13	10
15% —	88·035	or	88	0	9
25% —	146·73	or	146	14	7
$\frac{1}{2}$% —	2·9345	or	2	18	8
$4\frac{1}{2}$% —	26·411	or	26	8	3
45% —	264·11	or	264	2	2
	£586·9090		£586	18	2

Example 1.—£60,000 @ 5/6%—£165. Bring 600 (for 60,000) to the fixed pointer and set the upper movable index to 20; then bring 5·5 (for 5/6) to the lower movable index, when the pointer shows the answer to be 165.

Example 2.—£5,000 @ 7/5%—£18 10*s.* 10*d.* Bring 500 (for 5,000) to the pointer and set the upper index to 20; then bring 7·417 shillings to the lower index, when the pointer reads £18·541.

Example 3.—£12,000 @ 10/6%—£63. Bring 120 (for 1,200) to the pointer and set the lower index to 20; then bring 10·5 (10/6) to the upper index, when the pointer shows the answer as £63.

Example 4.—£400 @ 10/6—£2 2*s.* 0*d.* When dealing with small amounts it is sometimes more convenient to read the answer in shillings instead of in pounds and decimals, so bring 400 to the pointer, as usual, but place the upper index at 100 (1) instead of at the division 20. Then bring 10·5 (shillings) to the upper index, when the pointer gives the answer as 42/-.

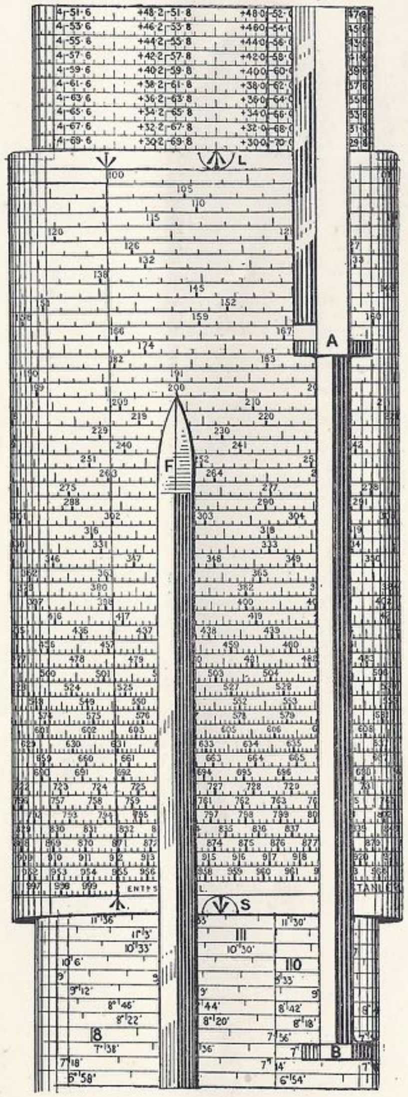
Example 5.—£250 @ 13/1½—£1 12*s.* 10*d.* Bring 250 to the fixed pointer, multiply by 13/1½ as previously, by setting the upper index 100 (1), bring 13·125 shillings to it, when the pointer reads 32·81 shillings.

Example 7.—£20,250 @ 18/9—£189 16*s.* 10*d.* Bring 2025 to the pointer and set the upper index to 20; then bring 1875 to the same index, when the pointer shows the answer as 18984, or £189 16*s.* 10*d.* In this example the last figure is approximate and might be read 3*d.* out in either direction, but even in such cases the Calculator affords a speedy means of checking results obtained by more lengthy methods.

Although in the above examples the calculations have been commenced by setting the capital sum to the pointer, this is quite immaterial, as one can just as well commence by bringing the rate to the pointer, then dividing by 20 and multiplying by the capital.

Example 8.—£110,550 @ 12/7½% less 10% and 15%. Bring 11055 to the pointer, and set the lower movable index to 20; then bring 12·625 to the upper index, when the answer to the first part of the problem may be read at the fixed index, as £697 certain, and 15/- approximated. Now subtract 10% by setting the lower index to 100 and bringing 90 (900) to it; finally, subtract 15% by placing the lower index again at 100 and bringing 85 to it. The answer will then be read at the pointer as £533 17*s.* The exact reading of the odd shillings being approximated as before.

FULLER CALCULATOR MODEL No. 2.



Two-thirds full size.
LOG. 2 = ·3010.
Fig. 3.

MODEL No. 2.

This is a Fuller Calculator with two extra Scales on the inner Cylinder in place of the Table of Data.

(1) A Scale of Logarithms to four decimal places.

(2) A Scale of Sines from 5° 45′ up to 88°.

INSTRUCTIONS FOR USING THE LOGARITHM SCALE.

A logarithm consists of two portions; a whole number portion or characteristic, and a decimal fraction or mantissa.

For numbers less than unity the characteristic is minus, for example :—

The log of 0·4821 = $\bar{1}$·6831, or — 1 + ·6831.

This may also be expressed as a quantity which is all negative, thus :—·3169.

Quantities in this form are much more easily handled when calculating with a slide rule, than quantities which are partly positive and partly negative. This fact has been made use of in graduating the logarithm scale of the Fuller Calculator.

The scale has been figured to read both ways, from right to left and from left to right. One set of readings (right to left) is marked + and deals with numbers of unity or more. The other reading is marked — and deals with numbers of less than unity.

To find the logarithm of a number :

If any number on the main scale be brought to the fixed index *F*, the logarithm of that number automatically appears on the inner cylinder under the index *L*, at the top of the movable cylinder. If the number dealt with is greater than unity the plus reading is taken, but if it is less than unity, the minus reading is the correct one.

EXAMPLES.

Find the log. of 4·4480. Bring 4448 to F and under L read: + ·6482, or — ·3518. As the number dealt with is greater than unity, obviously the plus reading is correct.

To find the log. of ·2590. Being less than unity, the log. will be minus. Bring 2590 to F, and under L read: — ·5867.

Suppose the log. of a still smaller number is required, say ·02590, obviously, the reading will be the same, prefixed by the characteristic " 1," *i.e.*, — 1·5867.

To find the antilog. of any number, the procedure is, of course, the reverse of the foregoing.

To find the value of $(24{\cdot}2)^{2\cdot3}$ Bring 24·2 to F, and under the index L, read: ·3838, the mantissa of the log.

The characteristic is 1, and the complete log. is 1·3838. Multiply this by $^{2\cdot3\cdot}$ by usual slide rule methods, and the result should be ·9225; set this to the index L, and under the index F, read: 8367, the antilog.

The answer is therefore + 8·367.

To find the value of $(\cdot3642)^{4\cdot2\cdot}$ Set ·3642 to F, and the log. = —·4387. (Being less than unity, the negative value is taken.)

Multiply this by 4·2 by usual method, and the result will be — 1·8425.

Bring — ·8425 to L, and read 1437 at F, which makes the answer ·01437.

THE SINE SCALE.

This scale occupies the lower half of the inner cylinder. Like the other scales it is a spiral, having a total length of approximately 32 ft. resulting in a very open reading.

Each division on the scale from 5° 45′ to 48° represents one minute, but from 48° onwards each division represents 5 minutes. This scale is recommended to **Engineers and Surveyors** for solving any expressions involving the use of Sines or Cosines. Calculations in **latitude** and **departure** can be solved in a fraction of the time spent in working with tables, and triangles can be solved with great rapidity and accuracy.

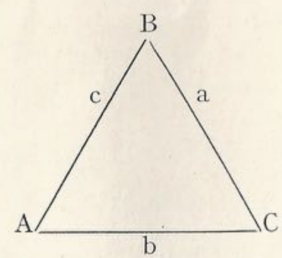
INSTRUCTIONS FOR USE.

If any angle on the Sine Scale is brought to the Index S *Fig.* 3, the Sine of the angle will be found on the movable cylinder against the fixed index F.

∴ Bringing any angle on the Sine Scale to the Index S is equivalent to setting F to the actual value of the Sine of the angle concerned.

Solution of Triangles.

From the general formula :—



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a = \frac{b \sin A}{\sin B} = \frac{c \sin A}{\sin C}$$

$$b = \frac{a \sin B}{\sin A} = \frac{c \sin B}{\sin C}$$

$$c = \frac{a \sin C}{\sin A} = \frac{b \sin C}{\sin B}$$

hence: **Given two angles and one side** or **two sides and the angle opposite one of them** we can solve the triangle by using one of the above formulæ.

Example I. Let $A = 75°$
$C = 24°$
$b = 126$ yards.
Then $B = 180 - (75° + 24°) = 81°$

To find *a*.

$$a = \frac{b \sin A}{\sin B} = \frac{126 \times \sin 75°}{\sin 81°}$$

Thus the calculation is performed as in ordinary combined multiplication and division, except that the index *S* is used for setting the sine values.

Move the cylinder until its index *S* marks 81° on the scale of sines: set the movable index to 126: move the cylinder until its index *S* marks 75° on the scale of sines: read a (12323) on the movable index.

i.e., $a = 123{\cdot}23$

To find *c*.

$$c = \frac{b \sin C}{\sin B} = \frac{126 \times \sin 24°}{\sin 81°}$$

Move the cylinder until its index *S* marks 81° on the scale of sines: set the movable index to 126: move the cylinder until its index *S* marks 24° on the scale of sines: read *c* (51888) on the movable index.

i.e., $c = 51{\cdot}888$ yards.

Where the sine of an angle greater than 90° is involved, we can make use of the following:—

$$\sin A = + \sin (180° - A).$$

Example II.

Let $A = 42°$
$C = 41°$
$b = 120$ yards.
$\therefore B = 97°.$

To find *C*.

$$c = \frac{b \sin C}{\sin B} = \frac{120 \times \sin 41°}{\sin 97°}$$

$$\sin 97° = \sin (180° - 97°) = \sin 83°.$$

Move the cylinder until its index *S* marks 83° on the scale of sines: set the movable index to 120: move the cylinder until its index *S* marks 41° on the scale of sines: read *c* (79318) on the movable index.

i.e., $c = 79{\cdot}318$ yards.

To find *a*.

$$a = \frac{b \sin A}{\sin B} = \frac{120 \times \sin 42}{\sin 97} = \frac{120 \times \sin 42}{\sin 83}$$

Move the cylinder until its index *S* marks 83° on the scale of sines: set the movable index to 120: move the cylinder until its index *S* marks 42° on the scale of sines: read a (8091) on the movable index.

i.e., $a = 80{\cdot}91$ yards.

Example III. **Two sides and one angle given.**

Let $a = 71{\cdot}3$ yards.
$b = 109{\cdot}0$ yards.
$B = 54°\ 15'$

To find A.

Since
$$\frac{a}{\sin A} = \frac{b}{\sin \mathrm{B}}$$

$$\therefore\ b \sin A = a \sin B$$

$$\therefore\ \sin A = \frac{a \sin B}{b} = \frac{71{\cdot}3 \times \sin 54°\ 15'}{109}$$

Move the cylinder until its index *S* marks 54° 15′ on the scale of sines: set the movable index to 109: move the cylinder to **bring** 71·3 to the movable index: read *A* (32° 3′ 40″) against the index *S* on the scale of sines.

$$A = 32°\ 3'\ 40''$$

To find C.

$$C = 180° - (A + B) = 180° - (32°\ 3'\ 40'' + 54°\ 15'\ 0'')$$
$$= 93°\ 41'\ 20''$$

To find c.

$$c = \frac{b \sin C}{\sin B} = \frac{109 \times \sin 93°\ 41'\ 20''}{\sin 54°\ 15'\ 0''}$$

(*Note*:—$\sin 93°\ 41'\ 20'' = \sin 86°\ 18'\ 40''$)

Move the cylinder until its index *S* marks 54° 15′ 0″ on the scale of sines; set the movable index to 109: move the cylinder until its index *S* marks 86° 18′ 40″ on the scale of sines: read *c* (13402) on the movable index.

i.e., $C = 134{\cdot}02$ yards

THE
FULLER-BAKEWELL CALCULATOR
FOR ENGINEERS AND SURVEYORS.

The replacing of the table of constants on the fixed cylinder of the FULLER CALCULATOR by two logarithmic scales, one of cosines squared and the other of sines multiplied by cosines is due to the suggestion of Mr. W. N. BAKEWELL, M.I.C.E., and it will be seen from the following that this alteration gives very great power to the instrument for the calculations required when **surveying and levelling with the Tacheometer.**

The formula for the horizontal distance between the Tacheometer station and the reading staff, when the latter is held vertical, is :—

$$d = \frac{f}{i} S^1 \cos.^2 a + (f+c) \cos. a \text{ with the ordinary telescope ; and}$$

$$d = \frac{f}{i} S^1 \cos.^2 a \text{ when the anallatic telescope is used.*}$$

For the difference of level between the centre of the telescope of the tacheometer and the point where its axis cuts the vertical staff.

$$v = \frac{f}{i} S^1 \cos. a \sin. a + (f + c) \sin. a \text{ with ordinary}$$

telescope ; and $v = \frac{f}{i} S^1 \cos. a \sin. a$ when the anallatic telescope is used.

Where f is the focal length of the field glass, i is the distance between the wires in the instrument, S^1 is the difference in reading between the upper and lower wires on the staff, c is a constant, being the distance between the axis of the instrument and the field glass of the telescope.

In some instruments i is constant and S^1 varies ; in others S^1 is constant and i varies.

To explain the use of the Calculator, the following model of a Field Book for a Tacheometrical survey is given.

* Stanley's *Surveying Instruments*, third edition, page 348.

MODEL OF FIELD BOOK.

With horizontal line of sight, the vernier reads 0°. $K = \frac{f}{i} = 100$. Foot the unit.

No. of Station	Height of Instrument	No. of Point	Angle Observed. Horizontal.	Angle Observed. Vertical.	Reading of wires m....... n.......	Difference m-n	Height of Axial wire above Station.	Horizontal Distance. $KS^1 \cos.^2 a$	Height $KS^1 \cos. a \sin. a$	Difference. Rise.	Difference. Fall $h+v$ or $h-v$	Height above datum. Of the Instrument.	Height above datum. Of the Point.	Remarks.
			θ	a		S^1	h*	d	v	$v-h$	†			
B	4·25		° ′	° ′								263·28	259·03	
		A	310·47	+2·26	5·68 / 1·00	4·68	3·34	467·2	19·84	16·50			279·78	Previous Station.
		1	298·32	+4·17	6·56 / 1·00	5·56	3·78	552·9	41·40	37·62			300·90	
		2	220·16	—3·35	13·45 / 1·00	12·45	7·23	1240	77·61		84·84		174·44	
		3	195·24	—1·52	9·65 / 2·00	7·65	5·82	764·1	24·90		30·72		232·56	
		4	184·17	+6·23	7·22 / 1·00	6·22	4·11	614·3	68·73	64·62			327·90	
		C	201·42	+0·15	11·15 / 1·00	10·15	6·07	1015	4·42		1·65		261·63	Next Station.

* $h = \frac{S^1}{2} + n$

† When there is a fall with an angle of elevation, i.e., $h > v$. Fall $= h - v$.
When there is a fall with an angle of depression. Fall $= h + v$.

The Calculator is for finding d and v. To use it—

1st. Bring the lower index line on the outer cylinder to read zero on the scales of the fixed cylinder.

2nd. Bring movable index to read KS^1 on the logarithmic scale of numbers.

3rd. Bring the lower index line on the outer cylinder until it reads the angle a on the lower fixed scale, and the distance d is read at the movable index on the logarithmic scale of numbers.

4th. When a is below 5° 46′ push up the outer cylinder until the bottom index line reads a on the upper fixed scale, and the height v is read at the movable index on the logarithmic scale of numbers. For angles greater than 5° 46′ the upper index line of the movable cylinder is used.

It will be seen that the instrument fails to give v for angles of less than 35′. The following table gives the sin. cos. for angles from 1′ to 34′.

1	·00029	13	·00378	25	·00727
2	·00058	14	·00407	26	·00756
3	·00087	15	·00436	27	·00785
4	·00121	16	·00465	28	·00814
5	·00141	17	·00494	29	·00843
6	·00174	18	·00524	30	·00872
7	·00204	19	·00553	31	·00902
8	·00233	20	·00582	32	·00930
9	·00262	21	·00611	33	·00960
10	·00291	22	·00640	34	·00990
11	·00320	23	·00669		
12	·00349	24	·00698		

When, therefore, a is below 35′, KS^1 has to be multiplied by the number opposite to the observed angle. Thus in the model field book given, the last vertical angle observed is 15′, and the height v is found by multiplying 1015 by ·00436 in the ordinary manner by the Calculator.

When the Tacheometer used has not an anallatic telescope it will be seen that to the calculated distance, as found above, $(f+c)$ cos. a has to be added; when, however, a is below 21°, which is most usual, $(f+c)$ may be taken for $(f+c)$ cos. a; and suppose $(f+c)=$ 1′ 6″, 1·5 ft. would have to be added to each value of d.

For the height v, when the angle a is not above 21°, $(f+c)$ is to be added to KS^1 and then multiplied by sin. a cos. a; the error from multiplying $(f+c)$ by sin. a cos. a instead of only by sin. a when $(f+c) =$ 1·5 ft., and $a =$ 21° is only ·037 ft.

TABLES AND FORMULAE

FOR USE WITH

FULLER'S CALCULATING RULES

	Cubic Ins.	Round Rod 1 ft. long. 1″ diam.	Square Bar 1 ft. × 1″ × 1″.	Plate 1 ft. × 1 ft. × 1″.
	lbs.	lbs.	lbs.	lbs.
Brass, cast	·298	2·81	3·58	43·0
,, wire	·308	2·91	3·70	44·4
Bronze	·303	2·86	3·64	43·7
Copper, sheet	·318	2·99	3·81	45·75
,, hammered	·322	3·03	3·86	46·3
Iron, cast	·257	2·42	3·08	37·0
,, wrought	·278	2·62	3·33	40·0
Lead	·412	3·88	4·94	59·3
Steel	·283	2·67	3·40	40·8
Zinc	·252	2·38	3·03	36·3

	Cubic Foot.	Tenacity Sq. Ins.	Mod. Elasticity Sq. In.	Mod. Rupture. Sq. In.
	lbs.	lbs.	lbs.	lbs.
Cast iron	444	16,500	17,000,000	—
Wrought iron	480	65,000	29,000,000	—
Steel bars	490	115,000	35,000,000	—
,, plates	—	80,000	—	—
Elm	34	14,000	1,000,000	7,500
Fir, Red Pine	37	13,000	1,600,000	8,000
,, Spruce	37	12,000	1,600,000	11,000
,, Larch	33	9,500	1,100,000	7,500
,, Yellow Pine	29	—	—	7,000
Oak, English	53	15,000	1,500,000	12,000
,, American	54	10,000	2,000,000	10,000
Teak	48	15,000	2,400,000	15,000

Decimals of a Degree or Hour.						Birmingham Wire Gauge.			
Min.	Deg.	Min.	Deg.	Min.	Deg.	No.	Ins.	No.	Ins.
1	·0167	21	·35	41	·6833	1	·300	21	·032
2	·0333	22	·3667	42	·7	2	·284	22	·028
3	·05	23	·3833	43	·7167	3	·259	23	·025
4	·0666	24	·4	44	·7333	4	·238	24	·022
5	·0833	25	·4167	45	·75	5	·220	25	·02
6	·1	26	·4333	46	·7667	6	·203	26	·018
7	·1167	27	·45	47	·7833	7	·180	27	·016
8	·1333	28	·4667	48	·8	8	·165	28	·014
9	·15	29	·4833	49	·8167	9	·148	29	·013
10	·1667	30	·5	50	·8333	10	·134	30	·012
11	·1833	31	·5167	51	·85	11	·120	31	·01
12	·2	32	·5333	52	·8667	12	·109	32	·009
13	·2167	33	·55	53	·8833	13	·095	33	·008
14	·2333	34	·5667	54	·9	14	·083	34	·007
15	·25	35	·5833	55	·9167	15	·072	35	·005
16	·2667	36	·6	56	·9333	16	·065	36	·004
17	·2833	37	·6167	57	·95	17	·058		
18	·3	38	·6333	58	·9667	18	·049		
19	·3167	39	·65	59	·9833	19	·042		
20	·3333	40	·6667			20	·035		

Multipliers for Converting.

Note.—The converse of these is obtained by dividing by the number instead of multiplying.

Common to hyperbolic log.	2·3026
Feet to links	1·5151
Square feet to square links	2·2957
Acres to square yards	4840
Tons to pounds	2240
Lbs. per sq. in. to lbs. per sq. foot	144
Lbs. avoir. to grains	7000
Cubic feet to gallons	6·2355
Rood masonry 2 ft. thick to cub. yds.	24
Rod brickwork 1′ 1½″ ,, ,,	11·333
Metres to feet	3·2809
Inches to millimetres	25·4
Square metres to square feet	10·764
Square inches to square millimetres	645·14
Cubic metres to cubic feet	35·317
Cubic inches to cubic millimetres	16386
Grammes to grains	15·432
Kilogrammes to lbs.	2·2046
Tons to tonneaux	1·0160
Gallons to litres	4·541
Kilogrammetres to foot lbs.	7·233
Kilogram. on square millimetre to lbs. on square inch	1422
Miles to kilometres	1·6093
Hectares to acres	2·4711
£ to francs	25·22
Francs to pence	9·516
Miles per hour to feet per second	1·467
Knots to feet per second	1·688
Cubic feet of water to lbs.	62·425
,, ,, sea ,,	64·05
One atmosphere to lbs. per sq. inch	14·7
,, ,, ,, ,, foot	2116
,, ,, ,, kilogs. per sq. metre	10333
,, ,, ,, millimetre of mercury	760
,, ,, ,, inches ,, ,,	29·922
,, ,, ,, feet of water	33·9

Decimals of a Foot.			
in.	ft.	in.	ft.
⅛	·01041	6· ⅛	·51041
¼	·02083	¼	·52083
⅜	·03125	⅜	·53125
½	·04166	½	·54166
⅝	·05208	⅝	·55208
¾	·0625	¾	·5625
⅞	·07292	⅞	·57292
1·	·08333	7·	·58333
⅛	·09374	⅛	·59374
¼	·10416	¼	·60416
⅜	·11458	⅜	·61458
½	·125	½	·625
⅝	·13541	⅝	·63541
¾	·14583	¾	·64583
⅞	·15625	⅞	·65625
2·	·16666	8·	·66666
⅛	·17707	⅛	·67707
¼	·1875	¼	·6875
⅜	·19791	⅜	·69791
½	·20832	½	·70832
⅝	·21874	⅝	·71874
¾	·22916	¾	·72916
⅞	·23958	⅞	·73958
3·	·25	9·	·75
⅛	·26041	⅛	·76041
¼	·27083	¼	·77083
⅜	·28125	⅜	·78125
½	·29166	½	·79166
⅝	·30208	⅝	·80208
¾	·3125	¾	·8125
⅞	·32292	⅞	·82292
4·	·33333	10·	·83333
⅛	·34374	⅛	·84374
¼	·35416	¼	·85416
⅜	·36458	⅜	·86458
½	·375	½	·875
⅝	·38541	⅝	·88541
¾	·39583	¾	·89583
⅞	·40625	⅞	·90625
5·	·41666	11·	·91666
⅛	·42707	⅛	·92707
¼	·4375	¼	·9375
⅜	·44791	⅜	·94791
½	·45833	½	·95833
⅝	·46875	⅝	·96875
¾	·47916	¾	·97916
⅞	·48958	⅞	·98958
6·	·5	12·	1·

$g = 32{\cdot}2$ feet seconds.
Unit of heat, 772 ft. lbs.
1 H.P. 550 ft. lbs. per second

Decimals of a Cwt.					
qr. lbs.	cwt.	qr. lbs.	cwt.	qr. lbs.	cwt.
1	·0089	1 10	·3393	2 19	·6696
2	·0179	11	·3482	20	·6786
3	·0268	12	·3571	21	·6875
4	·0357	13	·3661	22	·6964
5	·0446	14	·375	23	·7054
6	·0536	15	·3839	24	·7143
7	·0625	16	·3929	25	·7232
8	·0714	17	·4018	26	·7322
9	·0803	18	·4107	27	·7411
10	·0893	19	·4196	3 0	·75
11	·0982	20	·4286	1	·7589
12	·1071	21	·4375	2	·7679
13	·1161	22	·4464	3	·7768
14	·125	23	·4554	4	·7857
15	·1339	24	·4643	5	·7946
16	·1429	25	·4732	6	·8036
17	·1518	26	·4822	7	·8125
18	·1607	27	·4911	8	·8214
19	·1696	2 0	·5	9	·8303
20	·1786	1	·5089	10	·8393
21	·1875	2	·5179	11	·8482
22	·1964	3	·5268	12	·8571
23	·2054	4	·5357	13	·8661
24	·2143	5	·5446	14	·875
25	·2232	6	·5536	15	·8839
26	·2322	7	·5625	16	·8929
27	·2411	8	·5714	17	·9018
1 0	·25	9	·5803	18	·9107
1	·2589	10	·5893	19	·9196
2	·2679	11	·5982	20	·9286
3	·2768	12	·6071	21	·9375
4	·2857	13	·6161	22	·9464
5	·2946	14	·625	23	·9554
6	·3036	15	·6339	24	·9643
7	·3125	16	·6429	25	·9732
8	·3214	17	·6518	26	·9822
9	·3303	18	·6607	27	·9911

Decimals of a Lb.					
oz.	lbs.	oz.	lbs.	oz.	lbs.
¼	·0156	5	·3125	10½	·6562
½	·0312	5½	·3437	11	·6875
¾	·0468	6	·375	11½	·7187
1	·0625	6½	·4062	12	·75
1½	·0937	7	·4375	12½	·7812
2	·125	7½	·4687	13	·8125
2½	·1562	8	·5	13½	·8437
3	·1875	8½	·5312	14	·875
3½	·2187	9	·5625	14½	·9062
4	·25	9½	·5937	15	·9375
4½	·2812	10	·625	15½	·9687

Decimals of a Pound.

s. *d.*	£	*s.* *d.*	£
½	·002	1 . 2½	·0604
1	·0041	3	·0625
1½	·0062	3½	·0646
2	·0083	4	·0667
2½	·0104	4½	·0688
3	·0125	5	·0708
3½	·0146	5½	·0729
4	·0167	6	·075
4½	·0188	6½	·0771
5	·0208	7	·0791
5½	·0229	7½	·0812
6	·025	8	·0833
6½	·0271	8½	·0854
7	·0291	9	·0875
7½	·0312	9½	·0896
8	·0333	10	·0916
8½	·0354	10½	·0937
9	·0375	11	·0958
9½	·0396	11½	·0979
10	·0416	2 . 0	·1
10½	·0437	4 . 0	·2
11	·0458	6 . 0	·3
11½	·0479	8 . 0	·4
1 0	·05	10 . 0	·5
½	·0521	12 . 0	·6
1	·0541	14 . 0	·7
1½	·0562	16 . 0	·8
2	·0583	18 . 0	·9

Decimals of a Shilling.

d.	*s.*	*d.*	*s.*
½	·0417	6½	·5417
1	·0833	7	·5833
1½	·125	7½	·625
2	·1667	8	·6667
2½	·2083	8½	·7083
3	·25	9	·75
3½	·2917	9½	·7917
4	·3333	10	·8333
4½	·375	10½	·875
5	·4167	11	·9167
5½	·4583	11½	·9583
6	·5		

D. of Year.

D.	Y.
1	·0027
2	·0055
3	·0082
4	·0109
5	·0137
6	·0164
7	·0192
8	·0219
9	·0246
10	·0274
20	·0548
30	·0821
40	·1095
50	·1369
60	·1643
70	·1917
80	·2191
90	·2465
100	·2739
110	·3013
120	·3287
130	·3561
140	·3834
150	·4108
160	·4382
170	·4656
180	·4930
190	·5204
200	·5478
210	·5752
220	·6026
230	·63
240	·6574
250	·6848
260	·7121
270	·7395
280	·7669
290	·7943
300	·8217
310	·8491
320	·8765
330	·9039
340	·9313
350	·9586
360	·9861

D. of an Acre.

r *p.*	Acre.
1	·00625
2	·0125
3	·01875
4	·025
5	·03125
6	·0375
7	·04375
8	·05
9	·05625
10	·0625
11	·06875
12	·075
13	·08125
14	·0875
15	·09375
16	·1
17	·10625
18	·1125
19	·11875
20	·125
21	·13125
22	·1375
23	·14375
24	·15
25	·15625
26	·1625
27	·16875
28	·175
29	·18125
30	·1875
31	·19375
32	·2
33	·20625
34	·2125
35	·21875
36	·225
37	·23125
38	·2375
39	·24375
1 0	·25
2 0	·5
3 0	·75

$\pi = 3{\cdot}1416$. Surface of Sphere πd^2.
Volume of Sphere $\pi d^3 \div 6$.
Arc equal to radius $57{\cdot}296°$.

Cos A = sin (90 − A). Sec A = 1 ÷ cos A.
Tan A = sin A ÷ cos A Cosec A = 1 ÷ sin A.
Cot A = cos A ÷ sin A Versin A = 1 − cos A.

Natural Sines.

Deg.	0′	10′	20′	30′	40′	50′	1 2 3	4 5 6	7 8 9
0	0000	0029	0058	0087	0116	0145	3 6 9	12 15 17	20 23 26
1	0175	0204	0233	0262	0291	0320	3 6 9	12 15 17	20 23 26
2	0349	0378	0407	0436	0465	0494	3 6 9	12 15 17	20 23 26
3	0523	0552	0581	0610	0640	0669	3 6 9	12 15 17	20 23 26
4	0698	0727	0756	0785	0814	0843	3 6 9	12 15 17	20 23 26
5	0871	0901	0929	0958	0987	1016	3 6 9	12 14 17	20 23 26
6	1045	1074	1103	1132	1161	1190	3 6 9	12 14 17	20 23 26
7	1219	1248	1276	1305	1334	1363	3 6 9	12 14 17	20 23 26
8	1392	1421	1449	1478	1507	1536	3 6 9	12 14 17	20 23 26
9	1564	1593	1622	1650	1679	1708	3 6 9	12 14 17	20 23 26
10	1736	1765	1794	1822	1851	1880	3 6 9	12 14 17	20 23 26
11	1908	1937	1965	1994	2022	2051	3 6 9	11 14 17	20 23 26
12	2079	2108	2136	2164	2193	2221	3 6 9	11 14 17	20 23 26
13	2250	2278	2306	2334	2363	2391	3 6 8	11 14 17	20 23 25
14	2419	2447	2476	2504	2532	2560	3 6 8	11 14 17	20 23 25
15	2588	2616	2644	2672	2700	2728	3 6 8	11 14 17	19 22 25
Deg.	0′	10′	20′	30′	40′	50′	1 2 3	4 5 6	7 8 9
16	2756	2784	2812	2840	2868	2896	3 6 8	11 14 17	19 22 25
17	2924	2952	2979	3007	3035	3062	3 6 8	11 14 17	19 22 25
18	3090	3118	3145	3173	3201	3228	3 6 8	11 14 17	19 22 25
19	3256	3283	3311	3338	3365	3393	3 5 8	11 14 16	19 22 25
20	3420	3448	3475	3502	3529	3557	3 5 8	11 14 16	19 22 25
21	3584	3611	3638	3665	3692	3719	3 5 8	11 14 16	19 22 24
22	3746	3773	3800	3827	3854	3881	3 5 8	11 14 16	19 22 24
23	3907	3934	3961	3987	4014	4041	3 5 8	11 14 16	19 21 24
24	4067	4094	4120	4147	4173	4200	3 5 8	11 13 16	19 21 24
25	4226	4253	4279	4305	4331	4358	3 5 8	11 13 16	18 21 24
26	4384	4410	4436	4462	4488	4514	3 5 8	10 13 16	18 21 23
27	4540	4566	4592	4617	4643	4669	3 5 8	10 13 15	18 21 23
28	4695	4720	4746	4772	4797	4823	3 5 8	10 13 15	18 20 23
29	4848	4874	4899	4924	4950	4975	3 5 8	10 13 15	18 20 23
30	5000	5025	5050	5075	5100	5125	3 5 8	10 13 15	18 20 23
Deg.	0′	10′	20′	30′	40′	50′	1 2 3	4 5 6	7 8 9
31	5150	5175	5200	5225	5250	5275	2 5 7	10 12 15	17 20 22
32	5299	5324	5348	5373	5398	5422	2 5 7	10 12 15	17 20 22
33	5446	5471	5495	5519	5544	5568	2 5 7	10 12 15	17 19 22
34	5592	5616	5640	5664	5688	5712	2 5 7	10 12 14	17 19 22
35	5736	5760	5783	5807	5831	5854	2 5 7	9 12 14	17 19 21
36	5878	5901	5925	5948	5972	5995	2 5 7	9 12 14	16 19 21
37	6018	6041	6065	6088	6111	6134	2 5 7	9 12 14	16 18 21
38	6157	6180	6202	6225	6248	6271	2 5 7	9 11 14	16 18 20
39	6293	6316	6338	6361	6383	6406	2 4 7	9 11 13	16 18 20
40	6428	6450	6472	6494	6517	6539	2 4 7	9 11 13	15 18 20
41	6561	6583	6604	6626	6648	6670	2 4 7	9 11 13	15 17 20
42	6691	6713	6734	6756	6777	6799	2 4 6	9 11 13	15 17 19
43	6820	6841	6862	6884	6905	6926	2 4 6	8 11 13	15 17 19
44	6947	6967	6988	7009	7030	7050	2 4 6	8 10 12	15 17 19
45	7071	7092	7112	7133	7153	7173	2 4 6	8 10 12	14 16 18

NATURAL SINES.

Deg.	0′	10′	20′	30′	40′	50′	1	2	3	4	5	6	7	8	9
46	7193	7214	7234	7254	7274	7294	2	4	6	8	10	12	14	16	18
47	7314	7333	7353	7373	7392	7412	2	4	6	8	10	12	14	16	18
48	7431	7451	7470	7490	7509	7528	2	4	6	8	10	12	13	15	17
49	7547	7566	7585	7604	7623	7642	2	4	6	8	9	11	13	15	17
50	7660	7679	7698	7716	7735	7753	2	4	6	7	9	11	13	15	17
51	7771	7790	7808	7826	7844	7862	2	4	5	7	9	11	13	14	16
52	7880	7898	7916	7934	7951	7969	2	4	5	7	9	11	12	14	16
53	7986	8004	8021	8039	8056	8073	2	3	5	7	9	10	12	14	16
54	8090	8107	8124	8141	8158	8175	2	3	5	7	8	10	12	14	15
55	8192	8208	8225	8241	8258	8274	2	3	5	7	8	10	12	13	15
56	8290	8307	8323	8339	8355	8371	2	3	5	6	8	9	11	13	14
57	8387	8403	8418	8434	8450	8465	2	3	5	6	8	9	11	12	14
58	8480	8496	8511	8526	8542	8557	2	3	5	6	8	9	11	12	14
59	8572	8587	8601	8616	8631	8646	1	3	4	6	7	9	10	12	13
60	8660	8675	8689	8704	8718	8732	1	3	4	6	7	9	10	11	13
Deg.	0′	10′	20′	30′	40′	50′	1	2	3	4	5	6	7	8	9
61	8746	8760	8774	8788	8802	8816	1	3	4	6	7	8	10	11	12
62	8829	8843	8857	8870	8884	8897	1	3	4	5	7	8	9	11	12
63	8910	8923	8936	8949	8962	8975	1	3	4	5	6	8	9	11	12
64	8988	9001	9013	9026	9038	9051	1	3	4	5	6	8	9	10	11
65	9063	9075	9088	9100	9112	9124	1	2	4	5	6	7	8	10	11
66	9135	9147	9159	9171	9182	9194	1	2	3	5	6	7	8	9	10
67	9205	9216	9228	9239	9250	9261	1	2	3	4	6	7	8	9	10
68	9272	9283	9293	9304	9315	9325	1	2	3	4	5	6	7	9	10
69	9336	9346	9356	9367	9377	9387	1	2	3	4	5	6	7	8	9
70	9397	9407	9417	9426	9436	9446	1	2	3	4	5	6	7	8	9
71	9455	9465	9474	9483	9492	9502	1	2	3	4	5	5	6	7	8
72	9511	9520	9528	9537	9546	9555	1	2	3	4	4	5	6	7	8
73	9563	9572	9580	9588	9596	9605	1	2	2	3	4	5	6	7	7
74	9613	9621	9628	9636	9644	9652	1	2	2	3	4	5	6	6	7
75	9659	9667	9674	9681	9689	9696	1	1	2	3	4	4	5	6	7
Deg.	0′	10′	20′	30′	40′	50′	1	2	3	4	5	6	7	8	9
76	9703	9710	9717	9724	9730	9737	1	1	2	3	3	4	5	5	6
77	9744	9750	9757	9763	9769	9775	1	1	2	3	3	4	4	5	6
78	9781	9787	9793	9799	9805	9811	1	1	2	2	3	3	4	5	5
79	9816	9822	9827	9833	9838	9843	1	1	2	2	3	3	4	4	5
80	9848	9853	9858	9863	9868	9872	0	1	1	2	2	3	3	4	4
81	9877	9881	9886	9890	9894	9899	0	1	1	2	2	3	3	3	4
82	9903	9907	9911	9914	9918	9922	0	1	1	2	2	2	3	3	3
83	9925	9929	9932	9936	9939	9942	0	1	1	1	2	2	2	3	3
84	9945	9948	9951	9954	9957	9959	0	1	1	1	2	2	2	2	3
85	9962	9964	9967	9969	9971	9974	0	0	1	1	1	1	2	2	2
86	9976	9978	9980	9981	9983	9985	0	0	1	1	1	1	1	1	2
87	9986	9988	9989	9990	9992	9993	0	0	0	0	0	0	0	1	1
88	9994	9995	9996	9997	9997	9998	0	0	0	0	0	0	0	0	0
89	9998	9999	9999	1·000	1·000	1·000	0	0	0	0	0	0	0	0	0

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