KEY TO PALMER'S COMPUTING SCALE

Vol. .... Date .....

Property of ....

If this is borrowed by a friend,
Right welcome shall he be
To read, to study, not to lend,
But to return to me.

W. M. P.

IMPROVEMENT TO

PALMER'S ENDLESS SELF-COMPUTING

SCALE AND KEY;

ADAPTING IT TO THE DIFFERENT PROFESSIONS, WITH EXAMPLES AND ILLUSTRATIONS FOR EACH PROFESSION; AND ALSO TO COLLEGES, ACADEMIES AND SCHOOLS, WITH A

TIME TELEGRAPH,

MAKING, BY UNITING THE TWO, A

COMPUTING TELEGRAPH.

BY JOHN E. FULLER.

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1846.

STEREOTYPED BY
GEORGE A. CURTIS,
NEW ENGLAND TYPE AND STEREOTYPE FOUNDRY,
BOSTON.

PALMER'S

ENDLESS SELF-COMPUTING SCALE.

The proprietors of this invaluable work, beg leave to present the public with the following notice.

This Scale (the result of three years' incessant labor) is designed as an assistant in all arithmetical calculations. The simplicity, rapidity, and accuracy of its results, have astonished our best mathematicians. It consists of a logarithmic combination of numbers, arranged in two or more circles, one of which is made to revolve within the other; which process constantly changes the relation of the figures to each other, and solves an infinite variety of problems. Its advantages are,—

1st. *A complete saving of mental labor;* for, by the use of this Scale, the most intricate calculations are but a pleasurable exercise of the mind.

2d. *A great saving of time.* Computations requiring from three to four days, are wrought out by this Scale in the incredible short space of one minute.

3d. *Complete accuracy.* The results of the computations on this Scale, are infallible. Errors are entirely out of the question, except through sheer carelessness.

4th. *Mental improvement.* By this Scale, a knowledge of the philosophy of numbers, and their relation to each other, is soon obtained. So that, in a little time, many of the common calculations are wrought out by the mere exercise of the mind.

RECOMMENDATIONS

OF THE ENDLESS SELF-COMPUTING SCALE.

Rochester, Jan. 19, 1842.

THE "Self-Computing Scale," by A. Palmer, is a very ingenious and interesting instrument for performing most of the operations in arithmetic. The principle is very plain; and the accuracy, and certainty, and rapidity of the results are very striking.

C. DEWEY,
Principal of Collegiate Institute.

Rochester, January 19, 1842.

Having particularly examined Mr. Palmer's "Self-Computing Scale," I fully concur in the above testimonials of Dr. Dewey.

SAMUEL LUCKEY, D. D.

Attica, March 5, 1842.

From an examination of the "Self-Computing Scale," by Mr. Palmer, I can most cheerfully concur in the above recommendations, and hope it may be introduced into our schools and academies.

E. B. WALSWORTH,
Principal of Attica Academy.

Buffalo, April 5, 1842.

We have examined tne above mentioned Scale, and concur in the certificate of Professor Dewey.

W. K. SCOTT, *Civ. Eng.*
R. W. HASKINS, M. A.

Brockport, Feb. 19, 1842

I have carefully examined "The Endless Self-Computing Scale," by Mr. Aaron Palmer; and, without hesitation, give it as my opinion, that it will be found a very useful invention. All the problems in arithmetic can be readily solved upon it, and most of them with great expedition, particularly the rules for computing interest for months and days, at any per cent., the Rule of Three, and Fractions. In the apportionment of County, Town, and School Taxes, it will be found almost invaluable, as it requires to be set but once, to show each man's tax. JULIUS BATES, M. A.

Principal of Collegiate Institute.

Cambridge, Oct. 20, 1843.

I have examined Mr. Aaron Palmer's "Endless Self-Computing Scale;" it is simple and most ingenious, and I cheerfully concur in Mr. Julius Bates's judicious recommendations of its utility. BENJAMIN PEIRCE,

Perkins Professor of Astronomy and Mathematics in Harvard University.

Boston, October 24, 1843.

Mr. Palmer's "Self-Computing Scale" is certainly a very ingenious arrangement of numbers, and it will save a great amount of time in the hands of those who have computing to perform, whatever be the subject of the computation.

FREDERICK EMERSON,

Author of the North American Arithmetic.

I heartily concur in the above recommendation.

WILLIAM B. FOWLE,

Late Teacher of the Female Monitorial School, Boston

Boston, October 23, 1843.

Mr. Aaron Palmer,

Sir: Your "Self-Computing Scale" appears to me an exceedingly useful invention. I shall be glad to possess one of them, as it will save me much labor, and I doubt not that many persons will find the same advantage in its use.

Respectfully your servant,

JOHN S. TYLER,

Notary Public and Insurance Broker

Boston, October 24, 1843.

I have examined Mr. Aaron Palmer's "Self-Computing Scale;" it strikes me as being a very convenient labor-saving machine, and that it will be highly useful in calculating interest, general average, or dividends on a bankrupt's estate, and for other similar purposes. S. E. SEWALL,
Counsellor at Law

I have examined "The Endless Self-Computing Scale" of Mr. Palmer, and with pleasure express my high admiration of it. It is constructed on the only principle acknowledged by scientific men, since the invention of Logarithms, adequate to such purposes. Over all sliding Logarithmic Scales, it possesses a vast superiority, both in facility of use and accuracy of result. For this superiority, it is indebted to its circular form. With a diameter of about eight inches, it is equivalent to a common sliding scale of four feet with its slide of the same length, making when drawn out, a rod of about eight feet in length. It will be seen that its accuracy will be proportionably greater, as a circle can be constructed more exact than such a scale. G. C. WHITLOCK,
Professor of Mathematics and Natural Science in Genessee Wesleyan Seminary.

Mr. Aaron Palmer,

Sir: I have taken much pleasure in testing the power of your "Self-Computing Scale," by examples from nearly all the arithmetical rules. I am particularly struck with its great facility and accuracy in computing interest, apportioning dividends, and performing proportions generally. From the best examination I have been able to give it, I think it at once a most simple and wonderful invention; and I am confident, that when perfected, it will come rapidly into extensive public use, and will prove of singular benefit to those having occasion to make frequent computations in Bankruptcy, Insolvency, Insurance, Averages, Taxation, and the like branches of business. AMOS B. MERRILL,
10 *Court Street, Boston.*

THE TIME TELEGRAPH.

The Time Telegraph is composed of a beautiful steel plate engraving, neatly executed by G. G. Smith, of Boston, upon the surface of which is arranged in circles four lines or rows of numbers; upon the moveable circle is placed the names of the twelve calendar months, to which is affixed the number of days in each month, 365 making the entire circle; the inner row of numbers found upon the stationary circle, running from 1 to 365, is used for calculating time to come; the outer row of numbers on the stationary circle is reversed, and is used for the purpose of calculating time past. The manner of ascertaining the number of days from any given day in any month, is readily found by simply turning the moveable circle unto the day of the month from which you compute is directly opposite the gauge point affixed at the figures 365, then opposite the day of the month to which you wish to reckon is found the exact number of days required. Upon the stationary circle is also found the weeks, from one to 52; to these are added divisions of 30 days, so that any portion of the year can be brought into months as readily as the fingers of the hand can be reckoned. The Time Telegraph will be found of invaluable benefit in working equation of payments, &c.

INTRODUCTION.

The undersigned, proprietor of the Copy Right of Palmer's Endless Self-Computing Scale, and having been engaged in introducing and selling the same for about eighteen months past, and become extensively acquainted with the wants of the community, has been induced to introduce an improvement for which he has secured a Copyright, both for the Scale and Key, and is assured that all persons in commencing the use of the Scale will be very much assisted. The character of the Scale is too well established to need remarks. Having personally introduced it to about Four Thousand persons; by very many of whom he has had repeated assurances of their high appreciation of its value, he can with confidence refer others who may wish to possess it, to any of those who may have used it in any of the various rules of Arithmetic. His only desire is that its future patronage shall be proportionate to its true merits.

JOHN E. FULLER.

KEY TO THE SCALE.

DESCRIPTION OF THE SCALE.

THE figures on both parts of the scale, are precisely alike, and may be called whole numbers or parts of numbers, according to the nature of the problem to be solved. The large figure 1 may be called $\frac{1}{1000}$, or $\frac{1}{100}$, or $\frac{1}{10}$, or 1, or 10, or 100, or 1000, or 10000, &c., &c. If it be called $\frac{1}{1000}$, the large figure 2 will be $\frac{2}{1000}$, the large 3 will be $\frac{3}{1000}$, and so on; and the next sized figures between those large ones, will then be $\frac{1}{10000}$, $\frac{2}{10000}$, $\frac{3}{10000}$, &c.; and the still smaller ones will be $\frac{1}{100000}$, &c. If the large 1 be called 1, then 2 is 2, 3 is 3, &c.; and the next sized figures are tenths, and the third sized ones are hundredths, &c. If the large 1 be called 10, the large 2 is 20, 3 is 30, &c.; and the next sized figures are whole numbers—the first after the 1 is 11, the next 12, the next 13, &c. If the large 1 be called 100, 2 is 200, &c.; and the next sized figures then will read 10, 20, 30, &c.; and the smallest sized figures will then be whole numbers.

N. B.—Whenever fig. 1 is referred to, it means the large fig. 1 at the diamond—unless otherwise explained.

A TABLE OF GAUGE POINTS USED ON THIS SCALE.

I., at the diamond, is the gauge point for Multipli cation, Division, &c., &c.

A. Area of a Circle.

C. Circumference of a Circle.

B. G. Beer Gallons.

W. G. Wine Gallons.

15. for months, at 8 per cent.

for months, at 7 per cent.

2. for months, at 6 per cent.

for days, at 8 per cent.

for days, at 7 per cent.

for days, at 6 per cent.

107. Compound Int. for years, at 7 per cent.

106. do. do. do. 6 do.

160. for Acres.

144. for Square Timber.

9. Yds. Square.

886. Square and Circle, equal in Area.

707. Inscribed Square.

577. side of Inscribed Cube.

87. side of Inscribed Triangle.
589. side of Pentagon, (5 sides.)
5. side of Hexagon, (6 sides.)
437. side of Heptagon, (7 sides.)
383. side of Octagon, (8 sides.)
337. side of Nonagon, (9 sides.)
31. side of Decagon, (10 sides.)
282. side of Undecagon, (11 sides)
26. side of Dodecagon, (12 sides.)
464. diameter of 3 Inscribed Circles.
416. diameter of 4 Inscribed Circles.
785 . point for Area.
314 . point for Circumference.

To Perform Multiplication.

Rule.—First find the multiplier on the circular. Place it opposite 1, then opposite the multiplicand found on the fixed part, is the product on the circular.

Example.—What is the product of 4 by 2?

Place 2 opposite 1: then opposite 4 is the product = 8.

N. B.—Observe, now, that all the numbers and parts of numbers on the fixed part, are multiplied by 2, and their products are directly opposite them on the circular. So of any other multiplier.

What is the product of 12 by 7?

Place 7 opposite 1: then opposite 12 is 84, the answer.

Of 3 by 3?

Place 3 opposite 1: then opposite 3 is 9, the answer.

What is the product of 8 by $2\frac{1}{2}$?

Place 2·5 opposite 1: then opposite 8 is 20, the answer.

What is the product of 10 by 5?

Place 5 opposite 1: then opposite 10 is 50, the answer. Here you have to use the same figures both times, calling them 1 and 5 the first time, and adding a cypher to each the next time.

What is the product of 13 by 3?

Place 3 opposite 1, then opposite 13 (found between the large 1 and 2) is 39, the answer.

What is the product of 50 by 4?

Place 4 opposite 1: now we must call the large 5 50: opposite it is 200, the answer.

What is the product of 24 by 3?

Place 3 opposite 1: then opposite 24 (found between the large 2 and the large 3) is 72, the answer.

What is the product of 3 multiplied by ·2 (two tenths)?

Now we must call the large 2, two tenths. Place it opposite 1: then opposite 3 is ·6, (six tenths,) the answer.

Division.

Rule.—Find the divisor on the circular. Place it opposite 1: then opposite the dividend, found also on the circular, is the quotient on the fixed part.

Example.—2 is in 8, how many times?

Place 2 opposite 1: then opposite 8 is 4, the answer.

3 is in 12, how many times?

Place 3 opposite 1: then opposite 12 is 4, the answer.

How many times 4 in 14?

Place 4 opposite 1: then opposite 14 is 3 and five tenths, (3·5,) the answer.

NOTE.—Whenever a divisor is placed opposite 1, all the numbers and parts of numbers on the circular are divided by it. The quotients are on the fixed part.

Example.—Place the divisor 2 opposite 1: now opposite 2 is 1, opposite 12 is 6, opposite 4 is 2, opposite 6 is 3, opposite 14 is 7, opposite 24 is 12, opposite 125 is 62·5, opposite 75 is 37·5, &c.

TO MULTIPLY BY ONE NUMBER AND DIVIDE BY ANOTHER BY ONE SIMPLE PROCESS.

RULE.—Place the multiplier on the circular opposite the divisor: then, opposite the multiplicand is the result.

Example.—What is the result of 22 multiplied by 13 and divided by 14?

Place 13 opposite 14: then opposite 22 is 20·4+ the answer.

FRACTIONS.

TO CHANGE AN IMPROPER FRACTION TO A WHOLE OR MIXED NUMBER.

RULE.—Place the numerator found on the circular opposite the denominator: then opposite 1 is the answer.

Example.—A man spending $\frac{1}{6}$ of a dollar per day, in 83 days would spend $\frac{83}{6}$ of a dollar. How much would that be?

Place 83 opposite 6: then opposite 1 is $13 83, the answer.

In $\frac{8}{4}$ of a dollar how many dollars?

Place 8 opposite 4: then opposite 1 is $2, the answer.

To reduce a Mixed Number to an Improper Fraction.

Rule.—Place the mixed number opposite 1: then opposite the denomination to which you wish it reduced is the answer.

Example.—In $16\frac{5}{12}$ of a dollar, how many 12ths of a dollar?

Place $16\frac{5}{12}$ opposite 1: then opposite 12 is the number of 12ths in $16\frac{5}{12}$, viz., $197 = \frac{197}{12}$, the answer.

To reduce a Fraction to its lowest and all its Terms.

Rule.—Place the numerator found on the circular opposite the denominator: then all the numbers standing directly opposite each other, are other terms of said fraction; and the lowest of said numbers are its lowest terms.

Reduce $\frac{12}{16}$ to its lowest terms.

Place 12 opposite 16: now 9 is opposite 12 ($\frac{9}{12}$,) 6 is opposite 8 ($\frac{6}{8}$,) and 3 is opposite 4 ($\frac{3}{4}$,) the answer.

To divide a Fraction by a Whole Number.

Rule.—Place the whole number found on the circular opposite 1: then opposite the denominator is a number, which, placed opposite the numerator, is the answer.

Example.—If 2 yards of cloth cost $\frac{2}{3}$ of a dollar, how much is that per yard? Ans $\frac{1}{3}$

2 is in $\frac{2}{3}$ how many times? Place 2 opposite 1: then opposite 3 is 6. Now place this opposite 2, and it will read $\frac{2}{6}$, the answer $= \frac{1}{3}$.

2 is in $\frac{7}{8}$ how many times?

Place 2 opposite 1: opposite 8 is 16. This, placed opposite 7, makes $\frac{7}{16}$, the answer.

To multiply a Whole Number by a Fraction, or a Fraction by a Whole Number.

Rule.—Place the numerator found on the circular opposite the denominator: then opposite the whole number is the answer.

N. B.—Whenever a numerator is placed opposite a denominator, all the numbers on the circular are that fractional part of the numbers opposite them.

Example.—Place 3 opposite 4: this is $\frac{3}{4}$. Now the 3 is $\frac{3}{4}$ of 4; 6 stands opposite 8, being $\frac{3}{4}$ of 8; 9 is opposite 12; 12 is opposite 16, &c., &c. Now move the circular until 3 is opposite 5: now all the numbers on the circular are $\frac{3}{5}$ of those opposite them.

Note.—Whenever a numerator is placed opposite a denominator, thereby forming a vulgar fraction, the decimal of said vulgar fraction is opposite 1; hence,

To reduce Vulgar Fractions to Decimal Fractions.

Rule.—Place the numerator found on the circular opposite the denominator: then opposite 1 is the decimal fraction.

Example.—What is the decimal of $\frac{3}{4}$?

Place 3 opposite 4: now opposite 1 is ·75, the answer.

What is the decimal of $\frac{7}{8}$?

Place 7 opposite 8: opposite 1 is ·875.

To reduce Decimal Fractions to Vulgar Fractions.

Rule.—Place the decimal found on the circular opposite 1: then any two figures standing directly opposite each other is the answer.

Example.—What is the vulgar fraction equivalent to the decimal ·5?

Place 5 opposite 1: now 1 is opposite 2=½, the answer.

To multiply one Fraction by another.

Rule.—Reduce one to decimals: then place the numerator of the other opposite the denominator: then opposite the decimal is the answer in decimals, which, if desired, can be reduced to a vulgar fraction by the preceding rules.

To reduce the Different Currencies to Federal Money.

Rule.—Place the 1 *on the circular*, opposite the number of shillings and parts of a shilling composing a dollar of the currency to be reduced: then, opposite the given number of shillings is the answer.

Example.—Reduce 5 shillings, New York currency, to Federal money.

Place 1 (on the circular) opposite 8: then opposite 5 shillings, is ·625, the answer.

In 15 shillings, how much?

Opposite 15 is 1·875, the answer.

In 32 shillings, English currency, how much?

Place 1 (on the circular) opposite 4·5: then opposite 32, is $7·11, the answer.

In 9 shillings, how much?

Opposite 9 is $2, the answer.

INTEREST.

To compute Interest for Years.

Rule.—Place the rate per cent. found on the circular, opposite 1 : then opposite the principal is the interest.

Example.—What is the interest of $50 at 7 per cent. ?

Place 7 opposite 1 : then opposite 50 is $3·50, the answer.

What is the interest on $40 at 6½ per cent. ?

Place 6·5 opposite 1 : then opposite 40 is $2·60, the answer.

To compute Interest for Months.

Rule.—Place the principal, (found on the circular,) opposite the gauge point for months at the given per cent. : then opposite the given number of months is the answer.

Example.—What is the interest on $50 for three months at 7 per cent. ?

Place 50, (found on the circular,) opposite 1714, (the gauge point for months at 7 per cent.,) then opposite 3 months is ·875, the answer.

What is the interest on $60. for eight months at 6 per cent ?

Place 60 opposite ·2, (the gauge point for months at 6 per cent.,) then opposite 8 months is $2·40, the answer.

To compute Interest for Days.

Rule.—Place the principal, (found on the circular,) opposite the gauge point for days at the given per cent.: then opposite the number of days is the answer.

Example.—What is the interest on $55 for 15 days at 6 per cent?

Place 55 opposite ·600, (the gauge point for days at 6 per cent.,) then opposite 15 days is ·13 3-4.

The Principal and Interest being given, to find the rate per cent.

Rule for one Year.—Place the interest opposite the principal: then opposite 1 is the rate per cent.

Example.—Received $7·00 for the use of $50·00 for one year; what was the rate per cent.?

Place 7 opposite 50: then opposite 1 is 14, the answer, 14 per cent.

Gave $4·00 for the use of $80·00 one year: what was the rate per cent.?

Place 4 opposite 80: then opposite 1 is 5, the answer, 5 per cent.

Rule for Months.—Place the given interest opposite the given number of months: then observe the number opposite 12. Now place this number opposite the principal: then opposite 1 is the rate per cent.

Example.—Paid 25 cents for the use of $5·00 for 4 months: what was the rate per cent.?

Place 25 opposite 4: then opposite 12 is 75. Now place 75 opposite $5·00: then opposite 1 is 15, (15 per cent.,) the answer.

Gave 14 cents for the use of $60·00 one month: what was the per cent.?

Place 14 opposite 1: then opposite 12 is 1·68. Now place 1·68 opposite 60: then opposite 1 is 2·8, ($2\frac{8}{10}$ per cent.,) the answer.

Rule for Days.—Place the given interest opposite the given number of days: then observe the interest opposite 365 (the number of days in a year). Place this opposite the principal: then opposite 1 is the rate per cent.

Example.—Paid 14 cents for the use of $64·00 29 days: what was the rate per cent.?

Place 14 opposite 29: now opposite 365 is $1·76. Now place 1·76 opposite 64: then opposite 1 is 2·75, ($2\frac{3}{4}$ per cent.,) the answer.

Paid 23 cents for the use of $50·00, 21 days: what was the rate per cent.?

Place 23 opposite 21: now opposite 365 is 4. Place 4 opposite 50: then opposite 1 is 8 per cent., the answer.

The Rate per cent. and the Interest being given, to find the Principal.

Rule for one Year.—Place the per cent. opposite 1: then opposite the interest is the principal.

Example.—At 7 per cent. I paid $3·50 for the use of money 1 year: what was the principal?

Place 7 opposite 1: then opposite 3·50 is $50·00, the answer.

Rule for Months.—Place the interest opposite the given number of months: then opposite the point of the given per cent., for months, is the answer.

Example.—Gave $2·00 at 7 per cent. for three months: what was the principal?

Place 2 opposite 3: then opposite 1·714 is $114·30, the answer.

Rule for Days.—Place the given interest opposite the given number of days: then opposite the gauge point for days stands the principal.

Example.—At 7 per cent., gave 15 cents for 20 days: what was the principal?

Place 15 opposite 20: then opposite 521 (the gauge point for days at 7 per cent.) is $39·00, the answer.

The Rate per cent., Interest, and Principal being given, to find the Time.

Rule.—Place the interest of the given principal for one year opposite 12: then opposite the given interest will be the answer in months and decimals of a month. Or, place the interest of the given principal for one year opposite 365: then opposite the given interest will be the time in days.

Example.—Gave 87,5 cents at 7 per cent. for $50·00: how long did I have it?

The interest of $50·00 for one year, is $3·50. Place 3·50 opposite 12: then opposite ·875 is the answer, 3 months.

Gave 24 cents at 7 per cent. for the use of $50: how long did I have it?

Place $3·50 opposite 365: then opposite 24 is the answer, 25 days.

Compound Interest.

Rule.—Place the principal opposite fig. 1: then opposite the rate per cent. added to 100, on the fixed part, is the amount for one year. Place this amount opposite fig. 1: then opposite the same point is the amount for two years. Place this last amount opposite 1: then opposite the same point is the amount for 3 years, &c.

Example.—What is the compound interest on $5·00 for 5 years at 6 per cent?

Place 5 opposite 1: then opposite 106, (the per cent. added to 100,) is $5·30, the amount for 1 year. Now place $5·30 opposite 1: then opposite 106 is $5·62, the amount for 2 years. Now place $5·62 opposite fig. 1: then opposite 106 is $5·95. the amount for 3 years. Now place $5·95 opposite fig. 1: then opposite 106 is $6·31, the amount for 4 years. Now place $6·31 opposite fig. 1: then opposite 106 is $6·69, the amount for 5 years.

LOSS AND GAIN.

Bought a hogshead of molasses for $60: for how much must I sell it to gain 20 per cent.?

RULE.—Place 20 opposite 1: then opposite 60 is what must be added to the original cost to gain said per cent., viz.. 12: which added to 60=72.

Bought cloth at $2·50 per yard; but, being damaged, I am willing to sell it so as to lose 12 per cent. How must I sell it per yard?

Place 12 opposite 1: then opposite $2·50 is ·30, the amount to be deducted from $2·50, which will leave 2·20, the answer.

Bought cloth at 50 cents per yard: sold it for 10 cents advance from cost. What per cent. did I make?

Place 10 opposite 50: then opposite 1 is 20 per cent., the answer.

Another Method.—Place the original cost opposite 1: then opposite the rate per cent. added to 100, is the answer.

Example.—Bought corn at 50 cents per bushel: at how much must I sell it to gain 20 per cent.?

Place 50 opposite 1: then opposite 120, is 60 cents, the answer.

Bought cloth at $2 per yard, and sold it at $3 per yard: what per cent. did I make?

Place 2 opposite 1: then opposite 3 is 150, 50 per cent., answer.

RULE OF THREE, OR PROPORTION.

Rule.—Place the second term opposite the first: then opposite the third term, is the answer.

Example.—If 2 yards of cloth cost $4.00, what cost 8 yards?

Place 4 opposite 2: then opposite 8 is 16.

Note.—All numbers of yards at that rate, are now on the scale, and may be determined without moving the circular.

At $\frac{7}{8}$ of a dollar per yard, what cost 4 yards?

Place 7 opposite 8: then opposite the given number of yards, is the answer.

If 1 ton of hay cost $8·00, what cost 900 pounds? Place 8 opposite 2000, (the number of lbs. in a ton:) then opposite 900 is the answer; and so of any other number of pounds.

FELLOWSHIP.

Rule.—Place the whole gain or loss opposite the whole stock: then opposite each man's share of the stock is his share of the gain or loss.

Example.—A invested $30, B invested $20, and they gained in trade $12: what is each one's share of the gain?

Place 12 (the whole gain) opposite 60 (the whole stock): then opposite 20 (A's stock) is $4·80; and opposite 30 (B's stock) is $7·20.

EVOLUTION.

To extract the Square Root.

Rule.—Move the given number around until it is opposite the same number which is opposite 1; and that number is the answer sought.

Example.—What is the square root of 42?

Move 42 on the circular around until it comes opposite 6·48. Now 6·48 is opposite 1: hence that is the square root of 42.

To extract the Cube Root.

Rule.—Move the given number around until it comes opposite a number, the square of which at the same time is opposite 1; and that number is the root sought.

Example.—What is the cube root of 27?

Move 27 around until it comes opposite 3: at that time 9 is opposite 1: hence 3 is the answer.

TO APPORTION TAXES.

Rule.—Place the whole tax to be raised, found on the circular, opposite the whole valuation: then opposite each man's valuation, is his tax.

Example.—A tax of $1.500·00 is levied on a valuation of $200.000·00: what is a man's tax whose valuation is $700·00?

Place 1500 opposite 200.000: then opposite 700 is $5·25, the answer.

School Tax.

1550 days have been sent, and $33·20 tax is to be raised: how much is each man's tax?

Place 33·20 opposite 1550: then opposite the days each man has sent is his tax.

A has sent 28 days: his tax is 60 cents.

Opposite 70, the number of days B has sent, is his tax, $1·50; and so of every other man's tax, without moving the scale.

TO COMPUTE TOLL.

What is the toll on 6000 pounds, for 289 miles, at 4 mills per mile per 1000 pounds?

Place the 4 opposite 1000: opposite 6 is ·024 (two cents four mills). Now place this opposite 1: then opposite 289 is $6·936, the answer.

TO MEASURE SUPERFICES.

Rule 1.—Place the width in inches opposite 12: then opposite the feet in length, is the answer in feet and tenths of a foot.

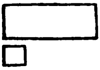
Example.—Give the contents of a board 6 inches wide, 14 feet long.

Place 6 opposite 12: then opposite 14 (the length), is the answer, 7 feet.

Rule 2.—Place the width in feet opposite 1: then opposite the length in feet, is the answer in feet.

How many square feet in a floor 20 by 20?

20×20=400, the answer.



How many square feet in a garden 96 by 54 feet?

96×54=5184 feet, answer.

Note.—If one side be inches and the other feet, place the given number of inches opposite the number of inches in a foot, viz. 12: then opposite the length in feet, will be the answer in feet. If one side be feet and the other rods, the answer will be in rods by placing the feet opposite the number of feet in a rod; &c., &c.

In a lot of land 120 rods long and 60 rods wide, how many acres?

Place 60 opposite 160 (the number of rods in an acre): then opposite 120, is 45 acres, the answer.

If a board be 8 inches wide, how much in length will make a square foot?

Place the width, 8 inches, opposite 1: then opposite 144 (the number of square inches in a foot) is the answer, 18 inches.

If a piece of land be 5 rods wide, how many rods in length will make an acre?

Place 5 opposite 1: then opposite 160 (the number of rods in an acre) is the answer, 32 rods.

Square Yards.

How many square yards of carpeting will it require to cover a floor 20 feet long and 14 feet wide?

Place 20 found on the circular opposite 9 (the gauge point for yards square): then opposite 14 on the fixed part is 31 yards, the answer.

The Width and Contents given, to find the Length.

Rule.—Place the contents on the circular opposite the width in feet: then opposite 9, on the fixed part, is the length in feet.

Example.—I have a room containing 20 square yards: I wish to cover it with a piece of carpeting $2\frac{1}{2}$ feet wide: how many feet in length will it require?

Place 20 on the circular opposite 2·5 ($2\frac{1}{2}$): then opposite 9, on the fixed part, is 72 feet, the answer.

To measure Land in Chains and Links.

Rule.—Place one of the sides in chains and links, opposite 1: then opposite the other side, in chains and links, are the number of acres and parts of an acre.

Example.—To find the acres in 7 chains and 50 links by 6 chains and 40 links.

Place 750 opposite 1: then opposite 640 is 4·80 ($4\frac{80}{100}$) acres, the answer.

To find the acres in 7 chains and 75 links by 9 chains and 64 links.

Place 775 opposite 1: then opposite 964 is $7\frac{47}{100}$ acres, the answer.

To find the amount of land in 1 chain and 80 links by 2 chains and 50 links.

Place 180 opposite 1: then opposite 250 is ·45 ($\frac{45}{100}$) of an acre, the answer.

To measure Square Timber.

Rule.—Place the product of the width by the thickness, opposite 144: then opposite the length is the answer in feet and tenths.

Example.—What is the solid contents of a stick 4 inches by 7, and 20 feet long?

$4\times7=28$. Place 28 opposite 144: then opposite the length, 20 feet, is 3·9 feet, the answer, $=3\frac{9}{10}$ feet.

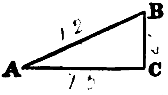
What is the solid contents of a stick of timber 18 inches by 18 inches, and 13 feet long?

The product of 18 by 18, is 324. Now place 324 opposite 144: then opposite 13 (the length) is 29·3, ($29\frac{3}{10}$,) the answer.

N. B.—If it be desired to have the answer in inches, instead of placing the product of the width by the thickness, opposite 144, place it opposite 1: then opposite the length in inches, will be the solid contents in inches.

Note.—Any bale, box, or chest may be measured by the preceding rule.

To measure a Hypotenuse.



AB *hypotenuse,* BC *perpendicular,* AC *base.*

Rule.—Square each of the sides and add their *products* together, the square root of which is the answer.

Example.—What is the hypotenuse of a right-angled triangle, one side of which is 3 feet, the other 4 feet?

$3 \times 3 = 9$ and $4 \times 4 = 16$: these two added together, make 25, the square root of which is 5 feet, the answer.

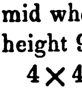
To measure a Triangle.

Place half the base opposite 1: then opposite the perpendicular height, is the area.

Example.—What is the area of a triangle whose base is 32 inches, and perpendicular height 14 inches?

Place 16 ($\frac{1}{2}$ of 32) opposite 1: then opposite 14 is 224 square inches, the answer.

To find the Solid Contents of a Pyramid.



Rule.—Multiply the area of the base by $\frac{1}{3}$ of the perpendicular height, whether it be a square, triangular, or circular pyramid.

Example.—What is the solid contents of a pyramid whose base is 4 feet square, and perpendicular height 9 feet?

$4 \times 4 = 16$, the base. Place this opposite 1. Now $\frac{1}{3}$ of 9 is 3. Opposite 3 is the solid contents, 48 feet.

There is a cone whose height is 27 feet, and whose base is 7 feet in diameter: what are its contents?

Place the square of 7 (49) opposite 1: then opposite A is the area of the base.

⅓ of 27 is 9. Place 9 opposite 1: then opposite the area (38·6) is the answer, 346½ solid feet.

To find the Solid Contents of a Frustrum of a Pyramid.

Rule.—To the product of one end by the other, add the sum of the squares of each end. Place this opposite 144. Then opposite ⅓ of the length, is the answer.

Example.—What are the contents of a stick of timber whose larger end is 12, whose smaller end is 8 inches, and whose length is 30 feet?

The product of one end by the other is 96, the square of 12 is 144, the square of 8 is 64. These, all added, make

```
  96
 144
  64
 ───
 304.
```

304. Place this opposite 144. then opposite 10 (⅓ of the length) is the answer, 21⅓ feet.

To find the Solid Contents of a Frustrum of a Cone.

Rule.—Multiply each diameter by itself separately, multiply one diameter by the other, add these three products together. Now place the length opposite 382: then opposite the products thus added, is the answer.

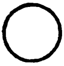
To find the Circumference of a Circle from its Diameter, or its Diameter from its Circumference.

Rule.—Place letter c, (found on the circular,) opposite fig. 1: then the figures on the fixed part are diameters, and those on the circle are circumferences. Opposite each diameter is its circumference.

Example.—What is the circumference of a circle whose diameter is 9 inches?

Place c opposite fig. 1: then opposite 9 is 28·2, (28 inches and 2 tenths,) the answer.

To find the Area of a Circle.

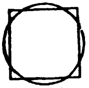


Rule.—Place the square of the diameter opposite 1: then opposite the letter A is the area.

Example.—What is the area of a circular garden whose diameter is 11 rods?

Place 121 (the square of 11) opposite 1: then opposite letter A is 95·03 rods, the answer.

To find the side of a Square equal in area to any given Circle.

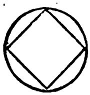


Rule.—Place '886, found on the circular, opposite fig. 1: then opposite any diameter of a circle upon the fixed part, is the side of a square equal in area, on the circular.

Example.—What is the side of a square equal in area to a circle 4 feet in diameter?

Place '886 opposite fig. 1: then opposite 4 is 3·55 feet, the answer.

To find the side of the greatest Square that can be inscribed in any given Circle.



Rule.—Place '707, found on the circular, opposite fig. 1: then opposite any diameter of a circle (found on the fixed part,) is the side of its inscribed square.

Example.—What is the side of an inscribed square equal in area to a circle 45 rods in diameter?

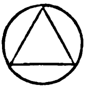
Place '707 opposite fig. 1: then opposite 45, on the fixed part, is 31·8 rods, the answer.

To find the length of one side of the greatest Cube that can be taken from a Globe of a given diameter.

Rule.—Place 577, found on the circular, opposite fig. 1: then opposite any diameter, on the fixed part, is the length of one side of the greatest cube.

Example. What is the length of the side of the greatest cube that can be taken from a globe 82 inches in diameter?

Place 577 (the gauge point for the side of an inscribed cube) opposite fig. 1: then opposite 82, on the fixed part, is 47·3 (47$\frac{3}{10}$) inches, the answer.



To find the length of the side of the greatest equilateral triangle that can be inscribed in a given circle.

RULE.—Place 87, found on the circular, opposite fig. 1: then opposite any diameter on the fixed part, is the length of the side of an inscribed triangle And opposite the length of the side of any triangle on the circular, is the diameter required to inscribe it in.

Example.—What is the length of one side of the greatest equilateral triangle that can be inscribed in a circle 62 inches in diameter?

Place 87 opposite fig. 1: then opposite 62, on the fixed part, is 54 inches, the answer.

What is the least diameter of a circle in which a triangle may be inscribed whose side is 6·5 inches (6½)?

Place 87 opposite fig. 1: then opposite 6·5, on the circular, is 7·48 (7$\frac{48}{100}$) inches, the answer.

To find the length of the side of the greatest figure that can be inscribed in a given circle.

Rule for a

Pentagon	(5 sides)	Place	589.
Hexagon	6 "	"	5.
Heptagon	7 "	"	437.
Octagon	8 "	"	3·83
Nonagon	9 "	"	337
Decagon	10 "	"	31
Undecagon	11 "	"	282
Dodecagon	12 "	"	26

opposite fig. 1: then opposite any given diameter on the fixed part, is the length of the side of the greatest figure that can be inscribed in it.

Example 1.—What is the length of one side of the greatest pentagon, or five-sided figure, that can be inscribed in a circle whose diameter is 51 inches?

Place 589 opposite 1: then opposite 51, on the fixed part, is 30 inches, the answer.

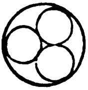
Example 2.—What is the length of one side of the greatest nonagon (*nine-sided* figure) that can be inscribed in a circle 82 feet in diameter?

Place 337 opposite fig. 1: then opposite 82, found on the fixed part, is 27·6 ($27\frac{6}{10}$) feet, the answer.

Example 3.—What is the least diameter of a circle in which may be inscribed an undecagon (eleven-sided figure.) one side of which is 13 inches long?

Place 282 opposite fig. 1: then opposite 13 inches, found on the circular, is 46·1 inches, the answer.

To find the greatest diameter of each of three equal circles that can be inscribed within a circle of a given diameter.

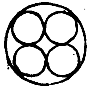


Rule.—Place, 464 opposite fig. 1: then opposite any diameter on the fixed part, is the diameter of one of the three inscribed circles.

Example.—What is the greatest diameter of each of three circles, that can be inscribed within a circle 25 inches in diameter?

Place 464 opposite fig. 1: then opposite 25 on the fixed part, is 11·6 inches, the answer.

To find the greatest diameter of four equal circles that can be inscribed within another circle of a given diameter.



Rule.—Place 416 opposite fig. 1: then opposite any given diameter on the fixed part, is the diameter of each of the four inscribed circles.

Example.—What is the greatest diameter of each of four equal circles that can be inscribed in another circle 22 inches in diameter?

Place 416 opposite fig. 1: then opposite 22, on the fixed part, is 9·15 ($9\frac{15}{100}$) inches, the answer.

To find the Solidity of a Cylinder, or to measure Round Timber.

Rule.—First find the area of the base by the rule for finding the area of a circle, place that area opposite 144, then opposite the length in feet, is the answer in feet and decimals of a foot.

Note.—If the diameter be given in feet, place the area opposite 1, instead of placing it opposite 144.

Example.—What are the solid contents of a cylinder 5 inches in diameter, and 13 feet long?

Place 25 (the square of 5) opposite 1: then opposite A is 1·965. Now place 1·965 opposite 144. then opposite 13 (the length) is 1·77 feet, the answer.

How many solid feet in a round log 15 inches in diameter, and 14 feet long?

Place 225 (the square of 15) opposite 1: then opposite A is 1·77 the area. Now place 1·77 opposite 144: then opposite 14 is 17·2 feet, the answer.

In a log 12 feet long, 14 inches diameter?
Answer, 12·8 feet.

In a log 16 feet long, 11 inches in diameter?
Answer, 10·5 feet.

In a log 7 inches diameter, 15 feet long?
Answer $4\frac{2}{100}$ feet.

Note.—If the diameter and length are both given in inches, place the square of the diameter opposite 1728: then opposite the inches in length, is the answer in feet.

Note.—A cylinder that is 12 inches in diameter and 12 inches long, and a globe that is 12 inches in diameter, and a cone that is 12 inches high and 12 inches diameter at its base, bear a proportion to each other as 3, 2 and 1. Therefore if you place the contents of any cylinder on the circular opposite to 3 on the fixed part, then opposite 2 on the fixed part is the contents of an inscribed globe, and opposite fig. 1 is the contents of an inscribed cone.

To find how many Solid Feet a Round Stick of Timber will contain, when hewn Square.

Rule.—Place double the square of half the diameter opposite 144: then opposite the length is the answer.

Example.—In a log 28 feet long, 22 inches diameter, half the diameter is 11, the square of which is 121. This doubled, is 242. Now place 242 opposite 144: then opposite 28 (the length) is 47+ the answer.

To find how many feet of Boards can be sawn from a Log of given Diameter.

Rule—Find the solid contents of the log **when**

made square, then place 12 opposite the thickness of the board (including the saw-calf:) then opposite the solid contents is the answer in feet.

To find the Area of a Globe or Ball.

Rule.—Place the diameter opposite 1: then opposite the circumference is the answer.

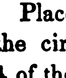
Example.—How many square inches of leather will cover a ball 3½ inches in diameter?

Place 3½ opposite 1: then opposite D. is 11, the circumference. Opposite 11 is the area, 38½ inches.

How many square feet on the surface of a globe 4 feet in diameter?

Place 4 opposite 1: then opposite D. is 12·55 feet, the circumference. Opposite 12·55 is 50·4, the answer.

To find the Solid Contents of a Globe or Ball.



Rule.—First find its area by the preceding rules: then multiply its area by ⅙ of its diameter.

Example.—What are the solid contents of a ball 14 inches in diameter?

Place 14 opposite 1: then opposite D. is 44 inches, the circumference. Opposite 44 is 617, the area. ⅙ of the diameter, is 2·33⅓. Place this opposite 1: then opposite 617 (the area) is 1437 inches, the solid contents.

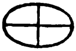
What are the solid contents of a ball 5 inches in diameter?

Place 5 opposite 1: then opposite D. is 15·7 inches, the circumference. Also, opposite 15·7 inches is 78·4 inches, the area. $\frac{1}{6}$ of 5 is ·835. Place this opposite 1: then opposite 78·4 inches (the area) is 654 inches, the solid contents.

There is a ball 20 inches in circumference: what are its solid contents?

Place 20 opposite letter D. Opposite 20 is 127, the area. $\frac{1}{6}$ of the diameter is 1·06. Place this opposite 1: then opposite 127 is 1350 inches, the solid contents.

To find the Area of an Ellipse.



RULE.—Place the product of the transverse diameter multiplied by the conjugate diameter opposite 1: then opposite letter A is the answer.

Example.—What is the area of an ellipse whose transverse diameter is 12 inches, and conjugate diameter 10 inches?

$10 \times 12 = 120$. Place 120 opposite 1: then opposite letter A is 94·25, the area.

Gauging Casks.

To find the Mean Diameter of a Cask.

Rule.—Add $\frac{2}{3}$ of the *difference* between the head and bung diameter to the head diameter. This reduces the cask to a cylinder. Then multiply the square of the *mean diameter* by the length. Place the product opposite 1: then opposite BG is the number of beer gallons, and under WG is the number of wine gallons.

Example.—There is a cask whose head diameter is 25 inches, bung diameter 31 inches, and whose length is 36 inches: how many beer gallons and how many wine gallons does it contain?

6 is the difference between 25 and 31. $\frac{2}{3}$ of 6 is 4. This, added to 25, makes 29 inches, the mean diameter. The square of 29 is 841. Place this opposite 1: then opposite 36 is 302+. Place this last opposite 1: then opposite BG is 85 gallons, and opposite WG is 103 gallons, the answer.

To find the Weight of an Iron Ball, from its Diameter.

Rule.—Place the cube of the diameter opposite 1: then opposite 14 is the weight.

Example.—What is the weight of an iron ball 6·7 inches in diameter?

$6 \cdot 7 \times 6 \cdot 7 = 45$, and $45 \times 6.7 = 301 \cdot 5$. Place 301·5 opposite 1: then opposite 14 is 42·29 pounds, the answer.

A ball 5·54 inches diameter?
Answer, 24 pounds nearly.

A ball 32 inches circumference?
Place 32 opposite D: then opposite 1 is the diameter. Now cube the diameter, and place that cube opposite 1: then opposite 14 is 148 pounds, the answer.

To find the Weight of a Leaden Ball from its Diameter or Circumference.

Rule.—Place the cube of the diameter opposite 1: then opposite 21·5 is the weight.
A ball is 6·6 inches in diameter: what is its weight?
Answer, 61·6 pounds.

A ball 5·3 inches in diameter?
Answer, 32 pounds nearly.

To find the Diameter of an Iron Ball from its Weight.

Rule.—Place the weight opposite 1: then opposite 7·11 is a product, the cube root of which is its diameter

What is the diameter of a 24 pound ball?
Answer, 5·54 inches.

To find the Diameter of a Leaden Ball from its Weight.

Rule.—Place 14 opposite 3: then opposite the weight is a product, the cube root of which is the answer.

A ball 8 pounds in weight is 3·34 inches in diameter.

Specific Gravity and Weight of Bodies.

	oz.		oz.
Pure Platina .	23000	Clay	2160
Fine Gold . .	19400	Brick	2000
Standard Gold .	17720	Common Earth .	1984
Quicksilver . .	13600	Nitre	1900
Lead	11325	Ivory	1825
Fine Silver . .	11091	Brimstone . .	1810
Common Silver .	10535	Solid Gunpowder	1745
Copper . . .	9000	Sand	1520
Copper Pence .	8915	Coal	1250
Gun Metal . .	8784	Mahogany . .	1063
Cast Brass . .	8000	Boxwood . . .	1030
Steel	7850	Sea Water . .	1030
Iron	7645	Common Water	1000
Cast Iron . . .	7425	Oak	925
Tin	7320	Gunpowd'r shook close	937
Crystal Glass .	3150	" in a loose heap	836
Granite . . .	3000	Ash	800
White Lead . .	3160	Maple	755
Marble . . .	2700	Beech	700
Hard Stone . .	2700	Elm	600
Green Glass . .	2600	Fir	550
Flint	2570	Cork	240
Common Stone .	2520	Air at a mean state	$1\frac{1}{3}$

NOTE.—The several sorts of wood are supposed to be dry. Also, as a cubic foot of water weighs just 1000 ounces, the numbers in this table express, not only the specific gravities of the several bodies, but also the weight of a cubic foot of each, in avoirdupois ounces; and therefore the weight of any other quantity, or the quantity of any other weight, may be found, as in the next two propositions.

To find the Magnitude of any Body from its Weight.

Rule.—Place the weight of the material in ounces under its specific gravity: then opposite 1728 is its magnitude in cubic inches; and opposite 1 is the answer in cubic feet.

Example.—How many cubic inches of gunpowder are there in one pound weight, shaken close?

Place 16 (the number of ounces in a pound) opposite 937: then opposite 1728 is its content or magnitude, 29½ inches.

How many cubic inches are there in 3 pounds of cast brass?

Place 48 (the number of ounces in 3 pounds) opposite 8000: then opposite 1728 is the answer, 103·5.

To find the Weight of a Body from its Magnitude.

Rule.—Place the contents of the body opposite 1728: then opposite its specific gravity is its weight in ounces.

How many ounces avoirdupois in 864 cubic inches of sand?

Place 864 opposite 1728: then opposite 1520 (the specific gravity of sand) is 760 ounces, the answer.

Measure, &c.

5,280 feet in a mile.
63,360 inches in a mile.
190,080 barley-corns in a mile.
32,000 ounces make one ton.
43,560 square feet in an acre.
4,840 square yards in an acre.
32 gills in one wine-gallon.
7·22 cubic inches in a gill.
28·875 cubic inches in a pint.
57·75 cubic inches in a quart.
2,150·4+ cubic inches in a bushel.
1·2444 cubic feet in a bushel.
3,600 seconds in an hour.
86,400 seconds in a day of twenty-four hours
31,557,600 seconds in a year.
1,728 cubic inches in a foot.
128 feet make one cord of wood.

Comparative Value and Weight of Different Kinds of Fire Wood, assuming as a standard the Shell-Bark Hickory.

	Lbs. in a Cord.	Compar. Val.	$ cts.
Shell-Bark Hickory	4469	100	7 40
Button Wood	2391	52	3 85
Maple	2668	54	4 00
Black Birch	3115	63	4 67
White Birch	2369	48	3 56
White Beech	3236	65	4 81
White Ash	3420	77	5 70
Common Walnut	4241	95	7 03
Pitch Pine	1904	43	3 18
White Pine	1868	42	3 11
Lombardy Poplar	1774	40	2 96
Apple Tree	3115	70	5 18
White Oak	3821	81	6 00
Black Oak	3102	66	4 89
Scrub Oak	3337	73	5 40
Spanish Oak	2449	52	3 85
Yellow Oak	2919	60	4 44
Red Oak	3254	69	5 11
White Elm	2592	58	4 29
Swamp Whortleberry	3361	73	5 40

NOTE.—It is estimated that a cord of wood contains, when green, 1443 pounds of water equal to 1 hogshead and 2 barrels of water.

TABLES OF SQUARES AND CUBES;

To facilitate the Mensuration of the Surfaces and Solidities of Bodies.

Number.	Square.	Cube.	Number.	Square.	Cube.
1	1	1	50	2500	125000
2	4	8	51	2601	132651
3	9	27	52	2704	140608
4	16	64	53	2809	148877
5	25	125	54	2916	157464
6	36	216	55	3025	166375
7	49	343	56	3136	175616
8	64	512	57	3249	185193
9	81	729	58	3364	195112
10	100	1000	59	3481	205379
11	121	1331	60	3600	216000
12	144	1728	61	3721	226981
13	169	2197	62	3844	238328
14	196	2744	63	3969	250047
15	225	3375	64	4096	262144
16	256	4096	65	4225	274625
17	289	4913	66	4356	287496
18	324	5832	67	4489	300763
19	361	6859	68	4624	314432
20	400	8000	69	4761	328509
21	441	9261	70	4900	343000
22	484	10648	71	5041	357911
23	529	12167	72	5184	373248
24	576	13824	73	5329	389017
25	625	15625	74	5476	405224
26	676	17576	75	5625	421875
27	729	19683	76	5776	438976
28	784	21952	77	5929	456533
29	841	24389	78	6084	474552
30	900	27000	79	6241	493039
31	961	29791	80	6400	512000
32	1024	32768	81	6561	531441
33	1089	35937	82	6724	551368
34	1156	39304	83	6889	571787
35	1225	42875	84	7056	592704
36	1296	46656	85	7225	614125
37	1369	50653	86	7396	636056
38	1444	54872	87	7569	658503
39	1521	59319	88	7744	681472
40	1600	64000	89	7921	704969
41	1681	68921	90	8100	729000
42	1764	74088	91	8281	753571
43	1849	79507	92	8464	778688
44	1936	85184	93	8649	804357
45	2025	91125	94	8836	830584
46	2116	97336	95	9025	857375
47	2209	103823	96	9216	884736
48	2304	110592	97	9409	912673
49	2401	117649	98	9604	941192

Number.	Square.	Cube.	Number.	Square.	Cube.
99	9801	970299	150	22500	3375000
100	10000	1000000	151	22801	3442951
101	10201	1030301	152	23104	3511808
102	10404	1061208	153	23409	3581577
103	10609	1092727	154	23716	3652264
104	10816	1124864	155	24025	3723875
105	11025	1157625	156	24336	3796416
106	11236	1191016	157	24649	3869893
107	11449	1225043	158	24964	3944312
108	11664	1259712	159	25281	4019679
109	11881	1295029	160	25600	4096000
110	12100	1331000	161	25921	4173281
111	12321	1367631	162	26244	4251528
112	12544	1404928	163	26569	4330747
113	12769	1442897	164	26896	4410944
114	12996	1481544	165	27225	4492125
115	13225	1520875	166	27556	4574296
116	13456	1560896	167	27889	4657463
117	13689	1601613	168	28224	4741632
118	13924	1643032	169	28561	4826809
119	14161	1685159	170	28900	4913000
120	14400	1728000	171	29241	5000211
121	14641	1771561	172	29584	5088448
122	14884	1815848	173	29929	5177717
123	15129	1860867	174	30276	5268024
124	15376	1906624	175	30625	5359375
125	15625	1953125	176	30976	5451776
126	15876	2000376	177	31329	5545233
127	16129	2048383	178	31684	5639752
128	16384	2097152	179	32041	5735339
129	16641	2146689	180	32400	5832000
130	16900	2197000	181	32761	5929741
131	17161	2248091	182	33124	6028568
132	17424	2299968	183	33489	6128487
133	17689	2352637	184	33856	6229504
134	17956	2406104	185	34225	6331625
135	18225	2460375	186	34596	6434856
136	18496	2515456	187	34969	6539203
137	18769	2571353	188	35344	6644672
138	19044	2628072	189	35721	6751269
139	19321	2685619	190	36100	6859000
140	19600	2744000	191	36481	6967871
141	19881	2803221	192	36864	7077888
142	20164	2863288	193	37249	7189057
143	20449	2924207	194	37636	7301384
144	20736	2985984	195	38025	7414875
145	21025	3048625	196	38416	7529536
146	21316	3112136	197	38809	7645373
147	21609	3176523	198	39204	7762392
148	21904	3241792	199	39601	7880599
149	22201	3307949	200	40000	8000000

Number.	Square.	Cube.	Number.	Square.	Cube.
201	40401	8120601	251	63001	15813251
202	40804	8242408	252	63504	16003008
203	41209	8365427	253	64009	16194277
204	41616	8489664	254	64516	16387064
205	42025	8615125	255	65025	16581375
206	42436	8741816	256	65536	16777216
207	42849	8869743	257	66049	16974593
208	43264	8998912	258	66564	17173512
209	43681	9123329	259	67081	17373979
210	44100	9261000	260	67600	17576000
211	44521	9393931	261	68121	17779581
212	44944	9528128	262	68644	17984728
213	45369	9663597	263	69169	18191447
214	45796	9800344	264	69696	18399744
215	46225	9938375	265	70225	18609625
216	46656	10077696	266	70756	18821096
217	47089	10218313	267	71289	19034163
218	47524	10360232	268	71824	19248832
219	47961	10503459	269	72361	19465109
220	48400	10648000	270	72900	19683000
221	48841	10793861	271	73441	19902511
222	49284	10941048	272	73984	20123648
223	49729	11089567	273	74529	20346417
224	50176	11239424	274	75076	20570824
225	50625	11390625	275	75625	20796875
226	51076	11543176	276	76176	21024576
227	51529	11697083	277	76729	21253933
228	51984	11852352	278	77284	21484952
229	52441	12008989	279	77841	21717639
230	52900	12167000	280	78400	21952000
231	53361	12326391	281	78961	22188041
232	53824	12487168	282	79524	22425768
233	54289	12649337	283	80089	22665187
234	54756	12812904	284	80656	22906304
235	55225	12977875	285	81225	23149125
236	55696	13144256	286	81796	23393656
237	56169	13312053	287	82369	23639903
238	56644	13481272	288	82944	23887872
239	57121	13651919	289	83521	24137569
240	57600	13824000	290	84100	24389000
241	58081	13997521	291	84681	24642171
242	58564	14172488	292	85264	24897088
243	59049	14348907	293	85849	25153757
244	59536	14526784	294	86436	25412184
245	60025	14706125	295	87025	25672375
246	60516	14886936	296	87616	25934336
247	61009	15069223	297	88209	26198073
248	61504	15252992	298	88804	26463592
249	62001	15438249	299	89401	26730899
250	62500	15625000	300	90000	27000000

THE STEAM-ENGINE.

The power of the steam-engine is measured by that of the horse. A horse-power, as fixed by Watt, is equal to 33,000 lb. avoirdupois, raised one foot high per minute; and one day's work of a horse, is this power, acting through eight hours. The pressure of our atmosphere is reckoned as equal to that of thirty perpendicular inches of mercury; or 14·70lb. per square inch, or 11·55lb. per circular inch.

To find the Horse's power of an Engine, according to the Rule given by Mr. Watt.

From the Diameter of the cylinder in inches, subtract 1, square the remainder, multiply the square by the velocity of the piston in feet per minute, and divide the product by 5640. The quotient will be the number required.

CONDENSING ENGINES.

Proportion of the Cylinder.—The best proportion is when the length is twice the diameter; because the cooling surface is then least, in proporton to the content of steam.

Proportion of the Air-Pump and Condenser.—In double condensing engines, these are made, by Boulton and Watt's rule, each to measure one-eighth the content of the cylinder.

Velocity of the Piston to produce the best effect.—In engines working the steam expansively, 100 times the square root of the length of the stroke in feet, is the best velocity in feet per minute.

In engines not working expansively, 103 times the square root of the length of the stroke in feet, is the best velocity in feet per minute.

To find the quantity of Water required for Steam and Injection.—Multiply the area of the cylinder in feet, by half the velocity in feet for *single*, and by the whole velocity in feet for *double* engines. Add 1-10th for cooling and waste; and this, divided by 1497 (at the common pressure on the valve of 2lb. per circular inch), wil give the quantity of water required for steam per minute.

The quantity of water for injection should be 24 times that required for steam.

The diameter of the injection-pipe should be 1-36th part of that of the cylinder.

The valves should be as large as practicable.

The boiler should be capable of evaporating about 12 gallons per hour for each horse power.

NON-CONDENSING, OR HIGH PRESSURE ENGINES.

The length of the cylinder should be at least twice its diameter.

The velocity of the piston, in feet per minute, should be 103 times the square root of the length of the stroke in feet; or 100 times, if the steam is worked expansively.

The area of the cylinder should be, to the area of the steam-passages, as 4800 is to the velocity of the piston, found as above.

Form and Direction of Steam-pipes.—Enlargements in steam-pipes succeeded by contractions, always retard the velocity of the steam—more or less according to the nature of the contraction—and the like effect is produced by bends and angles in the pipes. These should therefore be made as straight, and their internal surface as uniform and free from inequalities as may be practicable. The following proportions of velocity, from Mr. Tredgold, will exemplify this :—

The velocity of motion that would result from the direct unretarded action of the column of fluid which produces it, being unity - - - - -	1000	or 8
The velocity through an aperture in a thin plate by the same pressure is	.625	or 5
Through a tube from two to three diameters in length, projecting outwards	.813	or 6.5
Through a tube of the same length, projecting inwards - - -	.681	or 5.45
Through a conical tube, or mouth-piece, of the form of the contracted vein	.983	or 7.9

MARINE ENGINES.

The construction and arrangement of the Marine Steam Engine necessarily differ from that of the ordinary condensing Engine, on account of the peculiar form of the floating structure in which it is placed, and of the absence of that solid support which can be obtained for Engines on land. The importance of effecting economy of room and weight on board a steam-vessel, has led to the adoption of various methods of communicating motion to the paddle wheels; and vertical, oscillating, and other varieties of Engine have been introduced, with more or less success; but the more general form is that of the beam or lever Engine, the position of the beam being reversed on being placed on each side of the *bottom* of the cylinder. The arrangement of the condenser, air-pump, &c., is also necessarily accommodated to the space in which the machinery is required to be fixed.

The following Dimensions are given by Mr. Russell, for the Cylinders of Marine Engines of various power:

For 10 horse power,		20 inches diameter,		2 ft. 0 in. stroke.		
.. 20	..	27	..	2 ft. 6 in.	..	
.. 30	..	32	..	3 ft. 2 in.	..	
.. 40	..	35	..	3 ft. 6 in.	..	
.. 50	..	40	..	4 ft. 0 in.	..	

For 60 horse power,	43	inches diameter,		4 ft. 3 in.	stroke.
.. 70	..	46	..	4 ft. 6 in.	..
.. 80	..	49	..	4 ft. 9 in.	..
.. 90	..	52	..	5 ft. 0 in.	..
..100	..	55	..	5 ft. 6 in.	..
..125	..	59	..	6 ft. 0 in.	..
..150	..	62	..	6 ft. 3 in.	..
..175	..	66	..	6 ft. 6 in.	..
..200	..	70	..	7 ft. 0 in.	..
..250	..	76	..	7 ft. 6 in.	..
..300	..	82	..	8 ft. 0 in.	..
..350	..	87	..	8 ft. 6 in.	..
..400	..	92	..	9 ft. 2 in.	..
..500	..	100	..	10 ft. 0 in.	..

Economy of Steam-jackets.

The following Table presents the results of three experiments made in France to ascertain the economy of steam-jackets to the cylinders of Engines, in the consumption of fuel. In the 1st, the steam first entered the jacket round the cylinder, and passed from thence into the cylinder. In the 2nd, the steam entered the cylinder directly, without passing into the jacket. In the 3rd, the steam entered both the cylinder and jacket directly, by means of separate communications between them and the boiler. The result shows an increase in the consumption of fuel of nearly five-sevenths, in the second experiment, over that in the first

Experiments.	Duration of Experiments.	Total Consumption in pounds avoirdupois		Mean Pressure in Atmospheres.		Condenser.	Consumption per hour, in pounds.		Water evaporated by 1 lb. of Coal.
		Coals.	Water.	Boiler.	Cylinder.		Coals.	Water.	
1	43h 15m	1482.7	8387.1	3.82	2.57	.26	34.28	193.9	5.66
2	33h 30m	1992.12	11111.59	3.5	2.55	.28	58.16	331.7	5.61
3	32h 30m	1469.5	7822.23	3.5	2.73	.24	45.22	240.7	5.32

Friction of Steam-engines.

The difference in loss of power by friction, between beam and direct action engines is found by experiment to be so trifling, as to be unnecessary to be taken into account in estimating their relative advantages. The amount of pressure upon the piston, expended in each kind of engine in overcoming friction appears, on an average, to be not more than about 1 lb. to the square inch, in well-constructed engiues.

Steam-engines for Cotton and Paper Mills.

For Cotton Mills.—The best steam-engines for cotton-mills are the double-acting, working the steam expansively. The most advantageous mean pressure on the piston with low pressure steam is 5lb per circular inch, and each circular inch will suffice to drive three spindles of cotton yarn twist with the machinery.

For mule yarn, add 15 to the number of the yarn, and multiply the sum by ·26 ; the product will be the number of spindles for each circular inch of piston.

Or, one horse-power will drive 100 spindles with *cotton yarn*, and machinery. And for *mule yarn*, add

15 to the number of the yarn, and multiply by 8; the product will be the number of spindles for each horse-power. One horse-power will work 12 power-looms, with the preparatory machinery.—*Brunton.*

For Paper Mills.—A beating machine requires about 7 horse-power. The new paper machines require from 2 to 2 1-2 horse-power; 3 1-2 horse-power will prepare 1 ton old rope per week, working ten hours per day.—*Fenwick.*

Steam-power required to drive various kinds of Machinery.

A series of experiments instiuted by Mr. Davison, at Messrs. Truman and Co.'s Brewery, to ascertain the power required to drive various kinds of machinery, gave the following results:

1st. That an engine which indicated 50 horses power wnen fully loaded, showed, after the load and the whole of the machinery were thrown off, 5 horses, or one tenth of the whole power.

2nd. 190 feet of horizontal, and 180 feet of upright shafting, with 34 bearings, whose superficial area was 3300 square inches, together with 11 pair of spur and bevel wheels, varying from 2 feet to 9 feet in diameter, required a power equal to 7.65 horses.

3rd. A set of three-throw pumps, 6 inches in diameter, pumping 120 barrels per hour, to a height of 165 feet,=4.7 horses.

By the usual mode of calculation (viz., 33,000 lbs. lifted one foot high per minute), it would appear that there was, in this case, friction to the extent of 13 per cent.

4th. A similar set of three-throw pumps, 6 inches in diameter, pumping 160 barrels per hour, to a height of 140 feet,=6.2 horses.

By the same mode of calculation as before, there was here friction to the amount of 15 per cent.

5th. A set of three-throw pumps, 5 inches in diameter, raising 80 barrels per hour, to a height of 54 feet,=1 horse.

By calculation as before, the friction amounted to 12 1-2 per cent.

6th. A set of three-throw "starting" pumps, pumping 250 barrels of beer per hour, to a height of 48 feet, =4.87 horses.

By calculation as before, the friction amounted to 15 1-2 per cent.

7th. Two pair of iron rollers and an elevator, grinding and raising 40 quarters of malt per hour=8.5 horses.

8th. An ale-mashing machine, made by Haigh, of Dublin ; mashing at the time, 100 quarters of malt,= 5.68 horses.

9th. Two porter-mashing machines, made by Moreland, mashing at the time, 250 quarters of malt,=10.8 horses.

10th. 95 feet of horizontal Archimedes screw, 15 inches diameter, aud an elevator, conveying 40 quarters of malt per hour, to a height of 65 feet,=3.13 horses.

Mr. Tredgold's Estimate of the Distribution and Expenditure of the Steam in an Engine.

IN A NON-CONDENSING ENGINE.

Let the pressure on the boiler be	10·000	
Force required to produce motion of the steam in the cylinder will be	0·069	
Loss by cooling in the cylinder and pipes - - - - - -	0·160	
Loss by friction of piston and waste	2·000	
Force required to expel the steam into the atmosphere - -	0·069	
Force expended in opening the valvs, and friction of the various parts	0·622	
Loss by the steam being cut off before the end of the stroke -	1·000	
Amount of deductions		3·920
Effective pressure -		6·080

IN A CONDENSING ENGINE.

Let the pressure on the boiler be		10·000
Force required to produce motion of the steam in the cylinder -	0·070	

Loss by cooling in the cylinder and pipes - - - - -	0·160	
Loss by friction of the piston and waste - - - -	1·250	
Force required to expel the steam through the passages -	0·070	
Force required to open and close the valves, raise the injection water, and overcome the friction of the axes - - -	0·630	
Loss by the steam being cut off before the end of the stroke -	1·000	
Power required to work the air-pump	0·500	
Amount of deductions	——	3·680
Effective pressure -		6·320

Pressure and Density of Steam.

The following formula has been given by Mr. Wm. Pole for calculating the pressure and density of steam for engines working expansively, which is stated to produce a very near approximation to the truth; the mean error being only .0062 lb. per square inch:

Let P be the total pressure of the steam in lbs. per square inch, and V its relative volume, compared with that of its constituent water.

$$\text{Then } P = \frac{24250}{V-65}, \text{ or } V = \frac{24250}{P} \text{ plus } 65.$$

This formula is applicable, with little risk of error, to engines working with from 5 lbs. to 65 lbs. per square inch.

TABLE

Of the Pressure on a square and circular Inch, respectively, excited by the elastic force of Steam at various degrees of Temperature, with the Height of the column of Mercury it will support.

1. Pressure on a square Inch.				2. Pressure on a circular Inch.			
Tem'ture, Fahrenheit.	Pressure on square inch in lb.	Propor pressure on a circular inch in lbs.	Inches of Mercury supported.	Tem'ture, Fahrenheit.	Pressure on square inch in lb.	Propor. pressure on a circular inch in lbs.	Inches of Mercury supported
°				°			
220	2½	1.963	5.15	222	2½	3.183	6.56
222	3	2.356	6.18	224	3	3.819	7.87
223	3½	2.749	7.21	226	3½	4.456	9.18
225	4	3.141	8.24	228	4	5.093	10.5
227	4½	3.534	9.27	230	4½	5.729	11.8
228	5	3.927	10.3	232	5	6.366	13.1
230	5½	4.320	11.3	234	5½	7.002	14.4
231	6	4.712	12.3	236	6	7.639	15.7
233	6½	5.105	13.4	236	6½	8.276	17.0
234	7	5.498	14.4	238	7	8.912	18.3
235	7½	5.890	15.4	239	7½	9.549	19.7
236	8	6.283	16.5	241	8	10.18	21.0
237	8½	6.676	17.5	242	8½	10.82	22.3
239	9	7.068	18.5	244	9	11.45	23.6
240	9½	7.461	19.6	245	9½	12.09	24.9
241	10	7.854	20.6	247	10	12.73	26.2
242	10½	8.247	21.6	248	10½	13.36	27.5
243	11	8.639	22.6	250	11	14.00	28.9
244	11½	9.032	23.7	251	11½	14.64	30.1
245	12	9.424	24.7	252	12	15.27	31.5
252	15	11.78	30.9	259	15	19.09	39.3
261	20	15.71	41.2	270	20	25.46	52.5
269	35	19.63	51.5	278	25	31.83	65.6
276	30	23.56	61.8	287	30	38.19	78.7
283	35	27.49	72.1	294	35	44.56	91.8
289	40	31.41	82.4	300	40	50.92	105
294	45	35.34	92.7	305	45	57.20	118
300	50	39.27	103	309	50	63.66	131

To prevent Incrustation in boilers.—The introduction of potatoes and other vegetable substances will, in a great degree, prevent incrustation on the bottom and sides of a steam boiler, and animal substances, such as refuse skins, will accomplish it still more effectually.

Iron Cement for joining the Flanches of Iron Pipes, &c.—Take of Sal Ammoniac, 2 ounces; Flowers of Sulphur, 1 ounce; clean cast-iron Borings or Filings, 16 ounces: mix them well in a mortar, and keep them dry. When required for use, take one part of this powder, and twenty parts of clean iron borings or filings, mix them thoroughly in a mortar, make the mixture into a stiff paste with a little water, and apply it between the joints, and screw them together. A little fine grindstone sand added, improves the cement. A mixture of white paint with red lead, spread on canvas or woollen, and placed between the joints, is best adapted for joints that require to be often separated.

For Copper, a cement is used, composed of powdered quick lime, mixed to a proper consistence with serum of blood, or white of egg—and used immediately it is made.

THE MECHANICAL POWERS.

Power is compounded of the weight and expansive force of a moving body multiplied into its velocity.

The power of a body which weighs 40 lbs., and moves with the velocity of 50 feet in a second, is the same as that of another body which weighs 80 lbs., and moves with the velocity of 25 feet in a second; for the products of the respective weights and velocities are the same.

40 multiplied by 50–200; and 80 by 25–2000

Power cannot be increased by mechanical means.

Power is applied to mechanical purposes by the lever, wheel and axle, pulley, inclined plane, wedge, and the screw, which are the simple elements of all machines.

The whole theory of these elements consists simply, in causing the weight which is to be raised, to pass through a greater or a less space than the power which raises it; for, as power is compounded of the weight or mass of a moving body multiplied into its velocity, a weight passing through a certain space may be made to raise, through a less space, a weight heavier than itself.

Power is gained at the expense of space, by the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw.

LEVER.

Case 1.—*When the fulcrum of the lever is between the power and the weight.*

Rule.—Divide the weight to be raised by the power to be applied; the quotient will give the difference of leverage necessary to support the weight in equilibrio. Hence, a small addition either of leverage or weight will cause the power to preponderate.

Example 1.—A ball weighing 3 tons, is to be raised by 4 men, who can exert a force of 12 cwt., required the proportionate length of lever ?

$$3 \text{ tons} = 60 \text{ cwt.}; \text{ and } \frac{60}{12} = 5.$$

In this example, the proportionate lengths of the lever to maintain the weight in equilibrio, are as 5 to 1. If, therefore, an additional pound be added to the power, the power side of the lever will preponderate, and the weight will be raised. But, although the ball is raised by a force of only one-fifth of its weight, no power is gained, for the weight passes through only one-fifth of the space. The products, therefore, arising from the multiplication of the respective weights and velocities are the same.

Example 2.—A weight of 1 ton is to be raised with a lever 8 feet in length, by a man who can exert, for a short time, a force of rather more than 4 cwt.: required at what part of the lever the fulcrum must be placed ?

$$\frac{20 \text{ cwt.}}{4 \text{ cwt.}} = 5;$$ that is, the weight is to the power as 5 [to 1: therefore,

$$\frac{6}{\text{5 multiplied by 1}} = \text{1 foot and a third from the weight.}$$

EXAMPLE 3.—A weight of 40 pounds is placed one foot from the fulcrum of a lever; required the power to raise the same when the length of the lever on the other side of the fulcrum is five feet?

$$\frac{\text{40 multiplied by 1}}{5} = \text{8 lbs., Ans.}$$

Case 2.—*When the fulcrum is at one extremity of the lever, and the power at the other.*

RULE.—As the distance between the power and the fulcrum is to the distance between the weight and the fulcrum, so is the effect to the power.

EXAMPLE 1.—Required the power necessary to raise 120 lbs., when the weight is placed six feet from the power, and two feet from the fulcrum?

As 8 : 2 :: 120 : 30 lbs., Ans.

EXAMPLE 2.—A beam, 20 feet in length, and supported at both ends, bears a weight of two tons at the distance of eight feet from one end: required the weight on each support?

$$\frac{\text{40 cwt. multiplied by 8 ft.}}{\text{20 feet}} = \text{16 cwt. on the support}$$

furthest from the weight; and $\dfrac{40 \text{ multiplied by } 12}{20 \text{ feet}} = 24$ cwt. on the support nearest to the weight.

WHEEL AND AXLE.

Rule.—As the radius of the wheel is to the radius of the axle, so is the effect to the power.

Example.—A weight of 50 lbs. is exerted on the periphery of a wheel whose radius is 10 feet; required the weight raised at the extremity of a cord wound round the axle, the radius being 20 inches.

$$\frac{50 \text{ lbs. multiplied by } 10 \text{ ft.; by } 12 \text{ inches.}}{20 \text{ inches.}} = 300 \text{ lbs.}$$ [Ans.

PULLEY.

Rule.—Divide the weight to be raised by twice the number of pulleys in the lower block; the quotient will give the power necessary to raise the weight.

Example.—What power is required to raise 600 lbs., when the lower block contains six pulleys?

$$\frac{600}{6 \text{ multiplied by } 2} = 50 \text{ lbs., Ans.}$$

INCLINED PLANE.

Rule.—As the length of the plane is to its height, so is the weight to the power.

Example.—Required the power necessary to raise 540 lbs. up an inclined plane, five feet long and two feet high.

As 5 : 2 :: 540 : 216 lbs., Ans.

WEDGE.

Case 1.—*When two bodies are forced from one another by means of a wedge, in a direction parallel to its back.*

Rule.—As the length of the wedge is to half its back or head, so is the resistance to the power.

Example.—The breadth of the back or head of the wedge being three inches, and the length of either of its inclined sides 10 inches, required the power necessary to separate two substances with a force of 150 lbs.

As 10 : 1 1-2 :: 150 : 22 1-2 lbs., Ans.

Case 2.—*When only one of the bodies is moveable.*

Rule.—As the length of the wedge is to its back or head, so is the resistance to the power.

Example.—The breadth, length, and force, the same as in the last example.

As 10 : 3 :: 150 : 45 lbs., Ans.

SCREW.

The screw is an inclined plane, and we may suppose it to be generated by wrapping a triangle, or an inclined plane, round the circumference of a cylinder.

The base of the triangle is the circumference of the cylinder; its height, the distance between two consecutive cords or threads; and the hypothenuse forms the spiral cord or inclined plane.

Rule.—To the square of the circumference of the screw, add the square of the distance between two threads; and extract the square root of the sum. This will give the length of the inclined plane; its height is the distance between two consecutive cords or threads.

When a winch or lever is applied to turn the screw, the power of the screw is as the circle described by the handle of the winch, or lever, to the interval or distance between the spirals.

Velocity is gained at the expense of power by the lever, and the wheel and axle.

LEVER.

Case.—*When the weight to be raised is at one end of the lever, the fulcrum at the other, and the power is applied between them.*

Rule.—As the distance between the power and the fulcrum is to the length of the lever, so is the weight to the power.

Example.—The length of the lever being eight feet, and the weight at its extremity 60 lbs., required the power to be applied six feet from the fulcrum to raise it?

As 6 : 8 :: 60 : 80 lbs., Ans.

N.B. Any other example may be computed by reversing any of the foregoing operations.

4) 12 (?
16 (1