ADVERTISEMENT.

Geldard's Hand-book on Cotton Manufacture, designed for the use of Millwrights, Managers, Overseers, Operatives, and builders of Cotton and other Machinery. Containing rules and examples for finding the speed and dimensions of all the wheels and pulleys necessary for Mill Gearing, the wheels, pulleys, rollers, etc., etc., necessary to produce any desired result at each and every operation in a cotton mill, by an original and comprehensive system of calculations, deduced from Algebra and other sources, so simplified as to come within the comprehension of all who are acquainted with the fundamental rules of common arithmetic.

Rules and examples for finding (*at one operation*) all the necessary draughts, twist, doublings, and allowance for loss in working, to produce any given number of yarn.

Rules and examples for finding the weight and number of yarn, and the necessary allowance for waste and shrinkage in weaving, to produce any given kind of cloth.

Rules and examples for finding the number of yards of cloth per pound, and the proper price to pay for weaving any given kind of cloth.

Compendious tables adapted to the new system of

DODGEVILLE, ATTLEBOROUGH, MASS

HAND-BOOK

ON

COTTON MANUFACTURE;

OR,

A GUIDE TO

MACHINE-BUILDING, SPINNING AND WEAVING;

WITH PRACTICAL EXAMPLES, ALL NEEDFUL CALCULATIONS, AND MANY USEFUL AND IMPORTANT TABLES: THE WHOLE INTENDED TO BE A COMPLETE YET COMPACT AUTHORITY FOR THE MANUFACTURE OF COTTON.

BY JAMES GELDARD,
LONSDALE, R. I.

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PREFACE.

The utility of a suitable hand-book on Cotton Manufacture—which has become so important a branch of our national industry—can scarcely be a matter of question.

Several works have been published on the subject, both in this country and in England, each one of which has its peculiar merits: it may, perhaps, seem presumptuous in the author to add this to the number. All he asks, however, is that the judicious reader shall examine his pages, and decide for himself upon the value of their contents.

The work is designed especially for the Cotton Manufacturer, but it is hoped that it will be found useful to manufacturers of woollen and linen goods, to builders of machinery, to the general mechanic, and to the student intending to prosecute any branch of manufacture in which machinery is used.

The plan of the work is—

First. To make all necessary calculations as to the dimensions of the Mill Gearing, and the machinery to be employed.

Second. To introduce the cotton and show at a glance the draughts, and doublings, and necessary allowance for loss in working, to produce any required result. The author has had familiar acquaintance with *the best* of modern machines, American and English, and has based his calculations upon those most recently adopted in our first-class mills.

Some of the examples may seem to contain needless repetitions, but it is thought best that every feature of the statement should appear in each problem, in order that the whole may be seen and comprehended at once. The system of cancellation adopted will be found so ready an offset to these repetitions that, as will be seen, they can be easily afforded.

The work is entirely original, and although conceived amidst the noise of labor, and written in hours stolen from rest, the author has confidence in its theoretical and practical accuracy, and gladly stakes his reputation upon its success.

The author desires thus publicly to express his grateful acknowledgments for the kindness of Prof. B. F. Clark, of Brown University, who has encouraged him by pronouncing his manual mathematically correct.

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HAND-BOOK

ON

COTTON MANUFACTURE.

PART I.

MILL-GEARING.

Mechanicians have always disagreed as to the best mode of conveying power from the prime mover to the machinery to be impelled. Some prefer gearing, some belts and pulleys, while others prefer a mixture of both. Doubtless each system has its advantages. All agree, that, to convey the power by the shortest possible train, first to the heaviest and then the lighter machinery, is correct both in theory and practice.

Whatever system is adopted, the mode of finding the proper gears, pulleys, speed, etc., etc., is substantially the same.

Many prefer very light, well-balanced pulleys and shafting, and counter-balance the want of weight and strength by having a small driven wheel or pulley near the prime mover, and small driving pulleys near the machinery to be impelled, which gives a proportionately increased velocity to produce the same momentum. This system greatly reduces the inertia to be overcome, and tends to more uniform impulsion and utility of the power applied.

A steam-engine makes 50 double strokes per minute, and drives an upright shaft 180 revolutions per minute by a train of two pairs of wheels; the driving wheels have respectively 210 and 54 teeth.

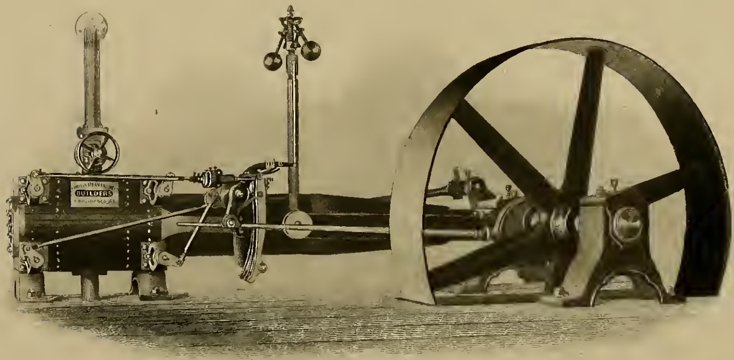
Required, the number of teeth respectively in the two driven wheels.

Revolutions per minute of the upright shaft, 180	50 Double strokes per minute of the steam-engine. 210 Teeth in the first driving wheel. 54 Teeth in the second driving wheel.

Worked Out.

1·2·18(0	5(0 210 54·6·3

(*Continued.*)



CORLISS ENGINE.
COLD MEDAL AWARDED
PARIS EXHIBITION, 1867

```
                210
                  5
              -----
               1050
                  3
              -----
B . . . .  10)3150
              -----
B . . . .     5)315
              -----
      A . . .  63)63
                 --
                  1
```

A. 63 ═ 63 Teeth in the first driven wheel.

B. $10 \times 5 = 50$ Teeth in the second driven wheel.

Answer.

N.B.—It will be perceived, by a little reflection, that the driven wheels are found by first dividing the product of the double strokes per minute of the steam-engine, and the number of teeth in the driving wheels by the revolutions per minute of the upright shaft, and the quotient by as many numbers as will divide without a remainder. The last divisors are classed according to the number and size of wheels required, which is dictated by location and other circumstances. The product of the numbers in each class gives the respective wheels.

From the particulars found in the preceding example, find the revolutions per minute of the upright shaft.

	50 Double strokes per minute of the steam-engine.
Teeth in the first driven wheel 63	210 Teeth in the first driving wheel.
Teeth in the second driven wheel 50	54 Teeth in the second driving wheel.

Worked out by Cancellation.

	50·1
1·7·63	210·30
1·50	54·6

$30 \times 6 = 180$ Answer.

The same without Cancellation.

Dividend . . $\dfrac{50 \times 210 \times 54}{63 \times 50} = 180$
Divisor . . .

Answer.

N.B.—The product of all the terms on the left-hand side of the perpendicular line into the answer will equal the product of all the terms on the right-hand side of this line. Thus: $63 \times 50 \times 180 = 567000$; $210 \times 54 \times 50 = 567000$. Hence we have the following rule to find any of the above terms: Place all the terms classed with the one sought on the left-hand side, for a divisor (less the term sought), and all the rest on the right-hand side for a dividend, and proceed by cancellation or multiplication: divide the product of the terms on the right-hand side by the product of the terms on the left-hand side, and the quotient will be the answer. This rule applies to all problems of this nature.

From the particulars found in the preceding example, find the number of teeth in the driven wheels.

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot2\cdot18(0 & 50\cdot1 \\ & 21(0 \\ 1\cdot50 & 54\cdot6\cdot3 \end{array}$$

21 × 3 = 63 Teeth in the first driven wheel.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\; & \dfrac{50 \times 210 \times 54}{180 \times 50} = 63. \\ \text{Divisor} \;.\;.\;.\;. & \end{array}$$

Answer.

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot3\cdot18(0 & 5(0 \\ 1\cdot7\cdot63 & 210\cdot30\cdot10 \\ & 54\cdot6\cdot1 \end{array}$$

10 × 5 = 50 Teeth in the second driven wheel.

Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend} \;\ldots & \dfrac{50 \times 210 \times 54}{180 \times 63} = 50\\ \text{Divisor} \;\ldots\ldots & \end{array}$$

Answer.

From the particulars found in the preceding example, find the double strokes per minute of the steam-engine, and the number of teeth in the driving wheels.

Worked out by Cancellation.

	180·20·10
1·21(0	63·3·1
1·2·6·54	5(0

$10 \times 5 = 50$ Double strokes per minute of the steam-engine.

Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend} \;\ldots & \dfrac{180 \times 63 \times 50}{210 \times 54} = 50.\\ \text{Divisor} \;\ldots\ldots & \end{array}$$

Answer.

Worked out by Cancellation.

1·50	180·30
	63·7
1·6·54	50·1

$30 \times 7 = 210$ Teeth in the first driving wheel.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ . \ . \ . & \dfrac{180 \times 63 \times 50}{54 \times 50} = 210. \\ \text{Divisor} \ . \ . \ . \ . & \end{array}$$

Answer.

Worked out by Cancellation.

$$\begin{array}{r|l} 1{\cdot}50 & 18(0 \\ 1{\cdot}21(0 & 63{\cdot}3 \\ & 50{\cdot}1 \end{array}$$

---

18 × 3 = 54 Teeth in the second driving wheel.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ . \ . \ . & \dfrac{180 \times 63 \times 50}{210 \times 50} = 54. \\ \text{Divisor} \ . \ . \ . \ . & \end{array}$$

Answer.

MIXING COTTON.

To mix together different qualities of cotton, so as to get the best possible combination for the purpose of making any given kind of yarn at the least possible expense, is an art of the very greatest importance.

The way of mixing cotton most commonly practised is to take as many bales as the mixing-room will conveniently hold, and spread them in layers on the top of each other, covering as large an area as the room will admit of. It is taken from top to bottom of the pile with a rake when wanted for use.

Some cotton-spinners obtain the best results by keeping the different qualities of cotton separate until they have passed through the cards, a system that has many arguments in its favor.

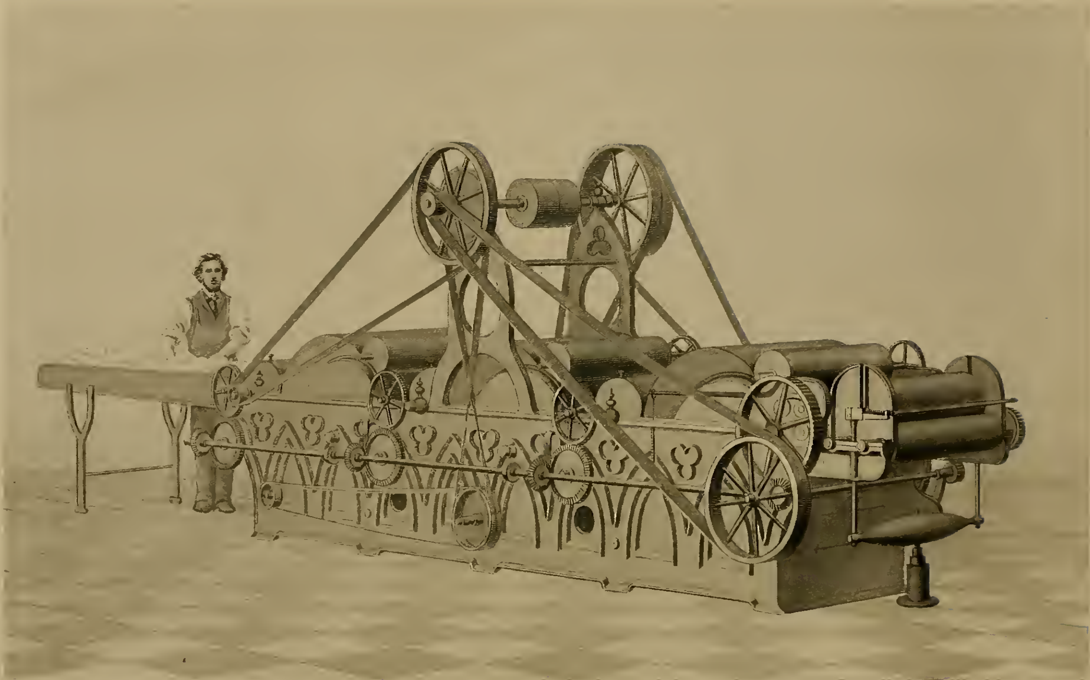
It is the most practicable way to make good, even yarn, to use one kind of cotton only, but this is not always the cheapest way; hence arises the necessity of mixing cottons.

Suppose a mill to consume 40 bales of cotton per week, each weighing 500 pounds, one half at 42 cents, and the other half at 36 cents per pound: the total cost of cotton per week would be $7,800, while, if the whole was at 42 cents per pound, the cost per week would be $8,400, a difference of $600 per week, or $100 per day, in favor of mixing.

THE WILLOW.

The Willow is the first machine to which the cotton is subjected in its process of manufacture.

The cylinder of a Bacon-Willow contains 1036 claws, and makes 500 revolutions, more or less, while the feed-rollers feed one pound of cotton, displaying 1036 × 500, = 518000, claws in rapid motion. These tease the



WHITIN'S IMPROVED PICKER

cotton into as many loose tufts, and, as far as is practicable, undo what has been done for convenience in transportation, free it from a superabundance of moisture and other impurities, and by the force of wind, created by the motion of the cylinder, carry it into a ventilated room convenient to the lapper.

THE LAPPER.

As will subsequently be shown, the lapper is the machine at which the cotton first receives definite form and size.

Some manufacturers contend that the size or decimal of a hank produced at a lapper cannot be depended upon as being positive; that at best it is but an approximation and guess at the quantity of cotton spread on to the lattice, substituting an "evener" for the old system of spreading a definite weight on to a definite length.

The Whiting Lapper is the one most generally appreciated in this neighborhood; being easy to manage, not liable to get out of order, and, with proper weighing, produces good and truthful results.

A lapper has three beaters. The first one makes 1800, the second 2000, and the third 2200 revolutions per minute. They are driven from an upright shaft, making 180 revolutions per minute by a train of three pairs of pulleys, and one pair of wheels. The driving wheel has 96 teeth, and the respective diameters of the driving pulleys are 40, 32, and 20 inches. How many teeth should there be in the driven wheel, and what should be the respective diameters of the driven pulleys, to drive the first beater at the speed above named?

Revolutions per minute of the first beater, 1800	180 Revolutions per minute of the upright shaft.
	96 Teeth in the driving wheel.
	40, Diameter of the first driving pulley in inches.
	32, Diameter of the second driving pulley in inches.
	20, Diameter of the third driving pulley in inches.

Worked out.

1·18(00	18(0·1
	96
	4(0
	32
	20

(*Continued.*)

	96
	4
	384
	32
	768
	1152
	12288
	20
A	2)245760
A	2)122880
A	2)61440
A	2)30720
A	2)15360
A	2)7680
B . . .	2)3840
B . . .	2)1920
B . . .	2)960
B . . .	2)480
B . . .	2)240
C . . .	2)120
C . . .	2)60

(*Continued.*)

D . .	2)30
D . .	3)15
C . . .	5)5
	1

A. $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$ Teeth in the driven wheel.

B. $2 \times 2 \times 2 \times 2 \times 2 = 32$, Diameter of the first driven pulley in inches.

C. $2 \times 2 \times 5 = 20$, Diameter of the second driven pulley in inches.

D. $2 \times 3 = 6$, Diameter of the third driven pulley in inches, which is on the same axis with the first beater.

Answer.

The first beater of a lapper is driven from an upright shaft making 180 revolutions per minute by a train of three pairs of pulleys and one pair of wheels. The driving wheel has 96, and the driven wheel 64, teeth. The respective diameters of the driving pulleys are 40, 32, and 20, and of the driven pulleys, 32, 20, and 6, inches. How many revolutions per minute does the first beater make?

	180 Revolutions per minute of the upright shaft.
Teeth in the driven wheel 64	96 Teeth in the driving wheel.

Diameter of the first driven pulley in inches 32	40, Diameter of the first driving pulley in inches.
Diameter of the second driven pulley in inches 20	32, Diameter of the second driving pulley in inches.
Diameter of the third driven pulley in inches 6	20, Diameter of the third driving pulley in inches.

Worked out by Cancellation.

	180
1·4·64	96·16·1
1·32	40·10
1·20	32·1
1·6	20·1

$$180 \times 10 = 1800$$

Answer.

The same without Cancellation.

Dividend . / Divisor . .

$$\frac{180 \times 96 \times 40 \times 32 \times 20}{64 \times 32 \times 20 \times 6} = 1800$$

Answer.

The lattice-roller and lattice are, in effect, equal to a roller 4 inches in diameter. On the same axis with the lattice-roller, there is a wheel that takes into a wheel with 9 teeth, on the feed-roller. On the feed-roller there is also a wheel that takes into a wheel with 42 teeth, on the under shaft. On the other end of the under shaft there is a wheel that takes into a wheel with 32 teeth, on the side-shaft. On the other end of the side-shaft there is a wheel that takes into a wheel with 32 teeth, on the clutch-shaft. On the clutch-shaft there is also a wheel that takes into a wheel with 100 teeth, on the calender-roller. On the other end of the calender-roller there is a wheel that takes into a wheel with 26 teeth, on the lap-roller. Suppose the wheels that have their dimensions given above to be driving wheels, what should be the dimensions of the driven wheels and the lap-roller to produce a draught of 3?

N.B.—The intermediate wheels are not taken into account in the above.

4, Diameter of the lattice-roller, including lattice, in inches.
9 Teeth in the wheel on the feed-roller.
42 Teeth in the wheel on the under shaft.
32 Teeth in the wheel on the side-shaft.

| 32 Teeth in the wheel on the clutch-shaft.
| 100 Teeth in the wheel on the calender-roller.
| 26 Teeth in the wheel on the lap-roller.
| 3, Draught of the lapper.

Worked out.

```
      26
     100
    ----
    2600
      32
    ----
    5200
    7800
   -----
   83200
      32
  ------
  166400
  249600
 -------
 2662400
      42
 -------
 5324800
10649600
--------
```

(*Continued.*)

	111820800
	9
	1006387200
	4
	4025548800
	3
C . .	13)12076646400
D . .	10)928972800
B	10)92897280
A	7)9289728
E . .	4)1327104
F . . .	4)331776
F . . .	4)82944
G . .	4)20736
G . .	4)5184
D	4)1296
B	3)324
E	3)108
E	3)36
C	3)12

(*Continued.*)

C . . . . . . 2)4
D . . . . 2)2
1

A. 7 = 7, Diameter of the lap-roller in inches.

B. 10 × 3 = 30 Teeth in the wheel on the lattice-roller.

C. 13 × 3 × 2 = 78 Teeth in the wheel on the feed-roller that takes into the wheel on the undershaft.

D. 10 × 4 × 2 = 80 Teeth in the wheel on the undershaft that takes into the wheel on the side-shaft.

E. 4 × 3 × 3 = 36 Teeth in the wheel on the side-shaft that takes into the wheel on the clutch-shaft.

F. 4 × 4 = 16 Teeth in the wheel on the clutch-shaft that takes into the wheel on the calender-roller.

G. 4 × 4 = 16 Teeth in the wheel on the calender-roller that takes into the wheel on the lap-roller.

Answer.

From the particulars found in the preceding example, find the draught of the lapper.

Worked out by Cancellation.

1·4	7·1
1·9	3(0·1
1·2·6·42	78·3

(*Continued.*)

1·2·32	8(0·4·2·1
1·2·32	36·4·1
1(00	16·1
1·26	16·1

3 Answer.

The same without Cancellation.

$$\begin{array}{l} \text{Dividend,} \\ \text{Divisor,} \end{array} \frac{7 \times 30 \times 78 \times 80 \times 36 \times 16 \times 16}{4 \times 9 \times 42 \times 32 \times 32 \times 100 \times 26} = 3$$

Answer.

The lattice-roller and lattice of a lapper are, in effect, equal to a roller 4 inches in diameter; and the lap-roller is 6.9875 inches in diameter. Suppose the lap-roller to be the driver of the lattice by a train of six pairs of wheels; the driving wheels to have respectively 9, 45, 32, 32, 100, 26, the driven wheels 30, 100, 72, 32, 15, and 16 teeth.

What would be the draught of the lapper?

Worked out by Cancellation.

1·4	6.9875·2.6875
1·9	30·3·1
1·15·45	100·1
1·2·32	72·8·2·1
1·32	32·1
1·100	15·1
1·2.6·26	16·1

2.6875 Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend,} & \dfrac{6.9875\times 30\times 100\times 72\times 32\times 15\times 16}{4\times 9\times 45\times 32\times 32\times 100\times 26}=2.6875\\ \text{Divisor,} & \end{array}$$

Answer.

The lattice and lattice-roller are, in effect, equal to a roller 4 inches in diameter; and the feed-roller is $1\frac{1}{2}$ inches in diameter. The lattice-roller has on a wheel with 30 teeth, that, by means of an intermediate, takes into a wheel with 9 teeth on the feed-roller.

Required the draught between the lattice and the feed-roller.

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot4 & 1.5\cdot.5 \\ 1\cdot3\cdot9 & 30\cdot10\cdot2.5 \end{array}$$

$$2.5\times .5 = 1.25$$

Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend} \;.\;.\;.\;.\;.\;.\;. & \dfrac{30\times 1.5}{4\times 9}=1.25\\ \text{Divisor} \;.\;.\;.\;.\;.\;.\;. & \end{array}$$

Answer.

The calender-roller is 4, and the lap-roller 6.9875 inches in diameter. The calender-roller has on a wheel with 16 teeth, that, by means of an intermediate, takes into a wheel with 26 teeth on the lap-roller.

Required the draught between the calender-roller and the lap-roller.

Worked out by Cancellation.

1·4	6.9875·1.075
1·6.5·26	16·4·1

1.075

Answer.

The same without Cancellation.

Dividend . . . . . . Divisor . . . . $\dfrac{6.9875 \times 16}{26 \times 4} = 1.075$

Answer.

The draught between the lattice and the feed-roller is 1.25, and between the calender-roller and the lap-roller, 1.075.

Required the draught between the feed-roller and the calender-roller, the total draught being 2.6875.

Worked out by Cancellation.

1·1.25	2.6875·2.15·2
1·1.075	

2

Answer.

The same without Cancellation.

$$\text{Dividend} \ldots\ldots \frac{2.6875}{1.075 \times 1.25} = 2 \quad \text{Divisor}$$

Answer.

From the particulars found in the preceding example, find the total draught of the lapper.

$$2 \times 1.25 \times 1.075 = 2.6875$$

Answer.

On the same axis with the lap-roller there is a wheel with 26 teeth, that, by means of an intermediate, takes into a wheel with 16 teeth on the calender-roller. On the calender-roller there is also a wheel with 100 teeth, that takes into a wheel with 15 teeth on the clutch-shaft. On the clutch-shaft there is a pulley 25.92 inches in diameter, driven from a pulley on the first driven shaft. On the first driven shaft there is a pulley 20 inches in diameter that drives a pulley 6 inches in diameter on the same axis with the first beater.

What should be the diameter of the pulley on the first driven shaft that drives the pulley on the clutch-shaft, to drive the lap-roller 5 revolutions per minute, the first beater making 1800 in the same time?

| 25.92, Diameter of the pulley on the clutch-shaft, in inches.

Teeth in the wheel on the calender-roller that takes into the wheel on the lap-roller	16	26 Teeth in the wheel on the lap-roller.
Teeth in the wheel on the clutch-shaft . .	15	100 Teeth in the wheel on the calender-roller that takes into the wheel on the clutch-shaft.
Diameter of the pulley on the same axis with the beater, in inches	6	20, Diameter of the pulley on the first driven shaft that drives the first beater, in inches.
Revolutions per minute of the first beater,	1800	5 Revolutions per minute of the lap-roller.

Worked out by Cancellation.

	25.92·1.44·.24·.08·.02
1·4·16	26
1·3·15	1(00
1·6	20·4·1
1·18(00	5

$26 \times 5 \times .02 = 2.6$ inches.

Answer.

The same without Cancellation.

$$\text{Dividend, } \frac{25.92 \times 26 \times 100 \times 20 \times 5}{16 \times 15 \times 6 \times 1800} = 2.6 \text{ Divisor,}$$

Answer.

From the particulars found in the preceding example, find the revolutions per minute of the first beater.

Worked out by Cancellation.

	5·1
1·4·16	26·10
1·3·15	100
1·2.6	25.92·8.64·1.44·.36
1·6	20·5

$$100 \times 10 \times 5 \times .36 = 1800$$

Answer.

The same without Cancellation.

$$\text{Dividend . . } \frac{5 \times 26 \times 100 \times 25.92 \times 20}{16 \times 15 \times 2.6 \times 6} = 1800 \text{ Divisor . .}$$

Answer.

The fan that takes the dust from a lapper is 1 yard in diameter, driven from an upright shaft making 180 revolutions per minute by a train of three pairs of pulleys and one pair of wheels. The driving wheel has 96 teeth, and the respective diameters of the driving pulleys are 40, 30, and 20 inches. How many teeth should there be in the driven wheel, and what should be the respective diameters of the driven pulleys, to give the circumference of the fan a velocity of 1728 yards per minute?

	180 Revolutions per minute of the upright shaft.
	96 Teeth in the driving wheel.
	40, Diameter of the first driving pulley, in inches.
	30, Diameter of the second driving pulley, in inches.
	20, Diameter of the third driving pulley, in inches.
	1, Diameter of the fan, in yards.
Velocity of the circumference of the fan per minute, in yards, 1728	3.1416, Circumference.

Worked out.

	180·15
	96·8
	40
	30
	20
	1
1·12·144·1728	3.1416·.2618

```
     15
      8
  -----
    120
     40
  -----
   4800
     30
  -----
 144000
     20
  -----
2880000
  .2618
  -----
23040000
 2880000
17280000
 5760000
 --------
```

(*Continued.*)

A . .	4)753984.0000
A	4)188496
A	4)47124
D . .	2)11781
B	2)5890.5
B	2)2945.25
B	3)1472.625
B	3)490.875
D . .	7)163.625
C .	23.375)23.375
	1

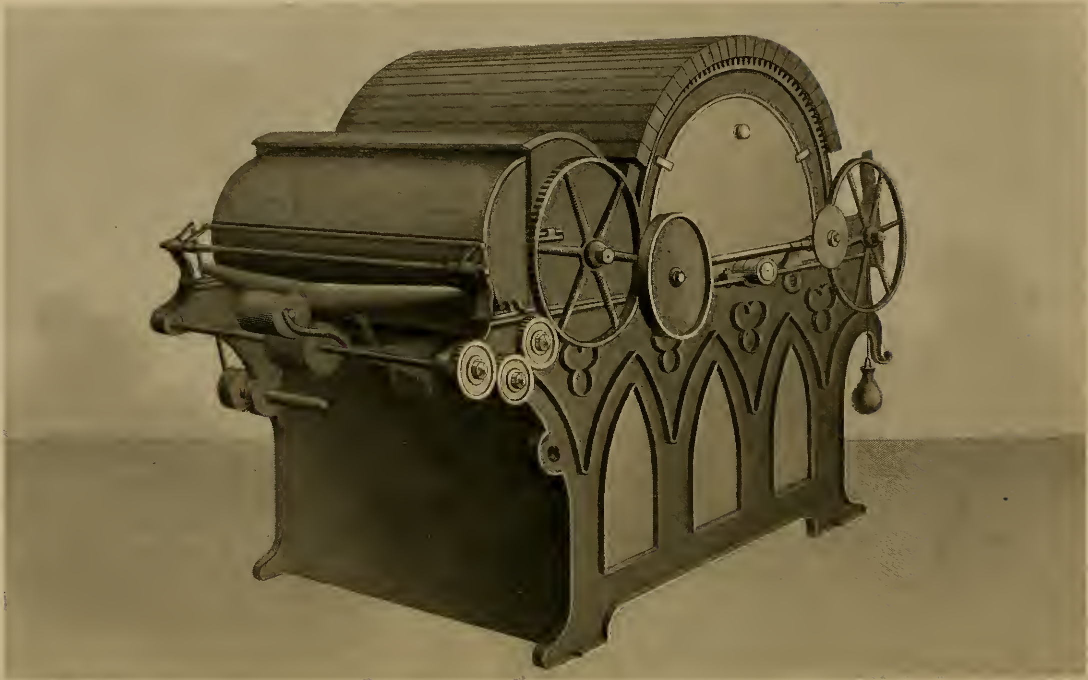
A. $4 \times 4 \times 4 = 64$ Teeth in the driven wheel.

B. $3 \times 3 \times 2 \times 2 = 36$, Diameter of the first driven pulley, in inches.

C. $23.375 = 23.375$, Diameter of the second driven pulley, in inches.

D. $7 \times 2 = 14$, Diameter of the third driven pulley, in inches. Answer.

From the particulars found in the preceding example, find the velocity of the circumference of the fan per minute.



WHITIN'S COTTON CARD.

Worked out by Cancellation.

	180·15·3
1·8·64	96·12
1·3·36	40·5·1
1·.935·4.675·23.375	30·10·5
1·2·14	20
	1
	3.1416·3.36·.48

$3 \times 12 \times 5 \times 20 \times .48 = 1728$ yards.

Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend,} & 180 \times 96 \times 40 \times 30 \times 20 \times 3.1416 \\ \hline \text{Divisor,} & 64 \times 36 \times 23.375 \times 14\end{array} = 1728.$$

Answer.

CARDING-ENGINE.

What the Willow and Lapper perform in part, the carding-engine completes in a thorough cleansing of the cotton.

The main cylinder of a common-sized carding-engine, when carding for medium numbers, makes about 120 revolutions per minute, and contains 22 sheets of clothing, each 30 × 4 inches, containing 400 teeth to the square inch, and cards one pound of cotton every 20 minutes, more or less. Hence every pound of cotton is picked from the feed-rollers, fibre by fibre, by 120 × 22 × 30 × 4 × 400 × 20 = 2534400000 diamond-pointed teeth, which by their traction and that of the top cards, or slats, untangles the fibres, and lays them more or less parallel to each other, and by suitable apparatus, delivers them formed into a "sliver."

The main cylinder of a carding-engine is driven from an upright shaft, making 180 revolutions per minute, by a train of one pair of wheels and one pair of pulleys. The driven wheel has 96 teeth, and the driven pulley is 12 inches in diameter. How many teeth should there be in the driving wheel, and what should be the diameter of the driving pulley, to drive the main cylinder 120 revolutions per minute?

Revolutions per minute of the upright shaft 180	120 Revolutions per minute of the main cylinder.
	96 Teeth in the driven wheel.
	12, Diameter of the driven pulley, in inches.

Worked out.

1·3·18(0	12(0·2
	96
	12·4

(*Continued.*)

$$
\begin{array}{rr}
 & 96 \\
 & 4 \\
\hline
 & 384 \\
 & 2 \\
\hline
\text{B . .} & 12)768 \\
\hline
\text{A . . .} & 64)64 \\
\hline
 & 1
\end{array}
$$

A. 64 = 64 Teeth in the driving wheel.

B. 12 = 12, Diameter of the driving pulley, in inches.

Answer.

From the particulars found in the preceding example, find the revolutions per minute of the main cylinder.

Worked out by Cancellation.

$$
\begin{array}{r|l}
 & 180\cdot15 \\
1\cdot12\cdot96 & 64\cdot8 \\
1\cdot12 & 12\cdot1 \\
\hline
\end{array}
$$

$$15 \times 8 = 120$$

Answer.

The same without Cancellation.

$$
\begin{array}{ll}
\text{Dividend . . . .} & \dfrac{180 \times 64 \times 12}{96 \times 12} = 120 \\
\text{Divisor . . . .} &
\end{array}
$$

Answer.

The main cylinder makes 120 revolutions per minute, and drives the doffing-cylinder by a train of two pairs of wheels. The driven wheels have each 180 teeth. How many teeth should there be in each of the driving wheels to drive the doffing-cylinder 9 revolutions per minute?

Revolutions per minute of the main cylinder, 120	9 Revolutions per minute of the doffing-cylinder.
	180 Teeth in the first driven wheel.
	180 Teeth in the second driven wheel.

Worked out.

1·12(0	9
	180·15
	18(0

```
 18
 15
 ——
 90
 18
 ——
270
  9
 ——
```

(*Continued.*)

A . . . . . . 10)2430

A . . . . 3)243

B . . . . . . 81)81

1

A. 10 × 3 ═ 30 Teeth in the first driving wheel.
B. 81 ═ 81 Teeth in the second driving wheel.

Answer.

From the particulars found in the preceding example, find the revolutions per minute of the doffing-cylinder.

Worked out by Cancellation.

	12(0·1
1·15·180	30·2·1
1·9·18(0	81·9

9

Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{120 \times 30 \times 81}{180 \times 180} = 9$
Divisor . . . .

Answer.

The lap-roller is 4½ inches in diameter, and has on a wheel, that, by means of an intermediate, takes into a wheel with 10 teeth on the feed-roller. How many teeth should there be in the wheel on the lap-roller, and what should be the diameter of the feed-roller to produce a draught of 1.1?

4.5, Diameter of the lap-roller, in inches.
10 Teeth in the wheel on the feed-roller.
1.1, Draught.

Worked out.

```
                 4.5
                  10
                ----
                45.0
                 1.1
               -----
                 450
                450
              ------
A . . . . .  3)49.50
              ------
A . . . . .  11)16.5
               -----
  B . . . .   1.5)1.5
                  ---
                    1
```

A. $11 \times 3 = 33$ Teeth in the wheel on the lap-roller.

B. 1.5 ═══ 1.5, Diameter of the feed-roller in inches.

Answer.

From the particulars found in the preceding example, find the draught between the lap-roller and the feed-roller.

Worked out by Cancellation.

1·3·4.5	1.5·1
1·10	33·11·1.1

1.1

Answer.

The same without Cancellation.

$$\text{Dividend} \;.\;.\;.\;.\;.\; \frac{33 \times 1.5}{10 \times 4.5} = 1.1 \;\; \text{Divisor} \;.\;.\;.\;.\;.\;.$$

Answer.

The doffing-cylinder is 15, and the drum at the railway that drives the belt (belt included) is 10, inches in diameter. They are connected by a train of four pairs of wheels and one pair of pulleys.

Suppose the drum to be the driver, and the driving wheels to have respectively 100.70, 40, and 20 teeth, and the driving pulley to be 4 inches in diameter. How many teeth should there be in the driven wheels respectively; and what should be the diameter of the driven pulley, to produce a draught of 1.04 between the doffing-cylinder and the drum at the railway?

Worked out.

1(0	15
	20
	4
	40
	70
	10(0
	1.04

```
    1.04
    10
 -------
   10.40
    70
 -------
  728.00
    40
 -------
   29120
     4
 -------
  116480
    20
 -------
 2329600
    15
 -------
11648000
2329600
 -------
34944000
```

E . .	10)34944000
D	5)3494400
A	5)698880
A	2)139776
A	2)69888
E . . .	2)34944
E . . .	2)17472
E	2)8736
B	2)4368
B	2)2184
B	2)1092
B	2)546
D	3)273
C	91)91
	1

A. $5 \times 2 \times 2 = 20$ Teeth in the first driven wheel.

B. $2 \times 2 \times 2 \times 2 = 16$ Teeth in the second driven wheel.

C. $91 = 91$ Teeth in the third driven wheel.

D. $5 \times 3 = 15$, Diameter of the driven pulley, in inches.

E. $10 \times 2 \times 2 \times 2 = 80$ Teeth in the fourth driven wheel.

From the particulars found in the preceding example, find the draught between the doffing-cylinder and the drum at the railway.

Diameter of the doffing-cylinder, in inches,	15	10, Diameter of the drum, in inches.
Teeth in the fourth driving wheel	20	80 Teeth in the fourth driven wheel.
Diameter of the driving pulley, in inches . .	4	15, Diameter of the driven pulley, in inches.
Teeth in the third driving wheel	40	91 Teeth in the third driven wheel.
Teeth in the second driving wheel . . .	70	16 Teeth in the second driven wheel.
Teeth in the first driving wheel	100	20 Teeth in the first driven wheel.

Worked out by Cancellation.

1·15	10·1
1·20	8(0·.2
1·4	15·1
1·40	91·13·1.3
1·7·70	16·4
1·10(0	20·1

$4 \times 1.3 \times .2 = 1.04$ Answer.

The same without Cancellation.

$$\frac{\text{Dividend, } 10 \times 80 \times 15 \times 91 \times 16 \times 20}{\text{Divisor, } 15 \times 20 \times 4 \times 40 \times 70 \times 100} = 1.04$$

Answer.

The feed-roller is driven from the doffing-cylinder by a train of two pairs of wheels. The driven wheels have respectively 60 and 50 teeth. How many teeth should there be in the driving wheels to produce a draught of 80 between the lap-roller and the railway-head, allowing a draught of 1.04 at the railway, and 1.1 between the lap-roller and the feed-roller, the feed-roller being $1\frac{1}{2}$, and the doffing-cylinder 15, inches in diameter?

N.B.—In all cases where the draught of the carding-engine is mentioned in this work, the draught at the railway is included.

Worked out.

1·1.5	15·1(0
	60
	50
	1.1
1·8(0	1.04·.13

(*Continued.*)

```
                60
                50
              ----
              3000
               1.1
           -------
              3000
             3000
           -------
            3300.0
               .13
           -------
             99000
            33000
           -------
A . . . .  3)429.000
           ---------
A . . . . .  11)143
                ---
  B . . . .   13)13
                 --
                  1
```

A. 11 × 3 = 33 Teeth in the first driving wheel.
B. 13 = 13 Teeth in the second driving wheel.

Answer.

From the particulars found in the preceding example, find the draught of the card.

Diameter of the feed-roller, in inches . . 1.5	15, Diameter of the doffing cylinder, in inches.

Teeth in the first driving wheel 13	60 Teeth in the first driven wheel.
Teeth in the second driving wheel . . . 33	50 Teeth in the second driven wheel.
	1.1, Draught between the lap-roller and feed-roller.
	1.04, Draught at the railway.

Worked out by Cancellation.

1·1.5	15·10
1·13	60·2
1·30·33	50
	1.1·1
	1.04·.08

$$50 \times 10 \times 2 \times .08 = 80$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . .} & 15 \times 60 \times 50 \times 1.1 \times 1.04 \\ \hline \text{Divisor . . .} & 1.5 \times 13 \times 33 \end{array} = 80$$

Answer.

The railway-head treated on below has four pairs of rollers with "Draper's Patent Evener" attached, adapted for 12 cards.

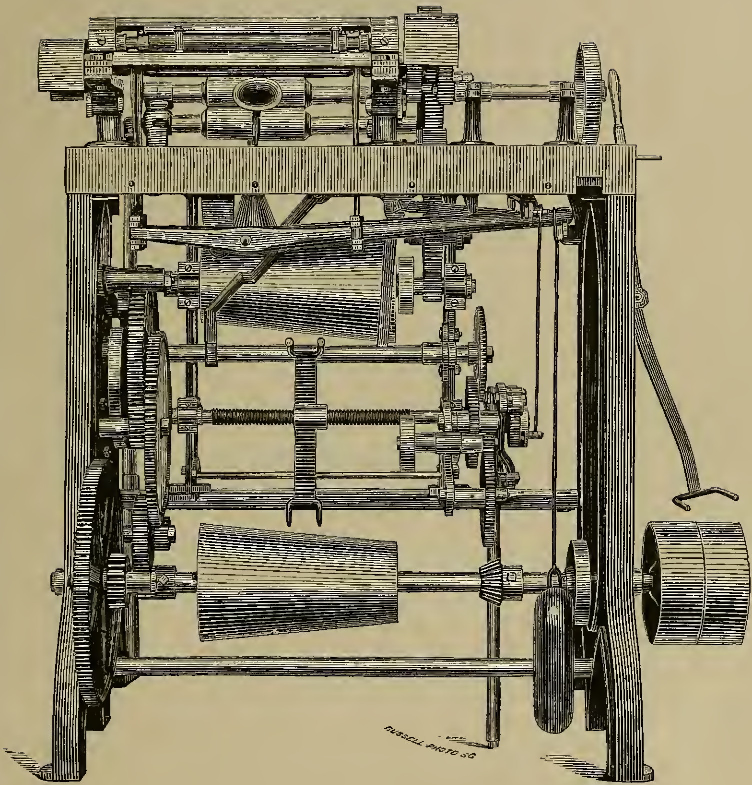
The roller next to the front-roller is called the front-middle-roller, and the roller next to the back-roller is called the back-middle-roller.

The front-roller is driven from the back-roller by a train of three pairs of wheels, and one pair of cones. The back-middle-roller and the front-middle-roller are each driven from the back-roller by an intermediate wheel.

The tube through which the sliver passes, and the apparatus for moving the belt on the cones, are so adjusted, that, if the fleece delivered from one of the cards should break, they will cause the belt to move from the large end of the driving cone sufficient to reduce the speed of the front-roller $\frac{1}{12}$; and, if the fleece should break from two cards, $\frac{2}{12}$, etc., etc.,—thus keeping the sliver delivered of a uniform size.

RAILWAY-HEAD.

The front-roller is $1\frac{1}{4}$ inches in diameter, and has on a wheel, that, by means of an intermediate, takes into a wheel with 80 teeth on the same axis with the delivering balls. How many teeth should there be in the wheel on the front-roller, and what should be the diameter of the delivering balls, to produce a draught of 1.02?



DRAPER'S RAILWAY HEAD.

Worked out.

| 1.02
| 1.25
| 80

```
                1.25
                  80
               -----
              100.00
                1.02
             -------
               20000
             100000
             -------
B . . .    3)102.0000
            ---------
A . . . . . . . 34)34
                   --
                    1
```

A. 34 ═══ 34 Teeth in the wheel on the front-roller.

B. 3 ═══ 3, Diameter of the delivering balls, in inches.

Answer.

The front-roller is $1\frac{1}{4}$, and the delivering balls 3, inches in diameter. The front-roller has on a wheel with 34 teeth, that, by means of an intermediate, takes into a wheel with 80 teeth, on the same axis with the delivering balls. Required the draught.

Diameter of the front-roller, in inches, 1.25	3, Diameter of the delivering balls, in inches.
Teeth in the wheel on the same axis with the delivering balls, 80	34 Teeth in the wheel on the front-roller.

Worked out by Cancellation.

1·1.25	3·2.4·.03
1·80	34

$$34 \times .03 = 1.02$$

Answer.

The same without Cancellation.

$$\begin{array}{lc} \text{Dividend} \;\ldots\ldots & 3 \times 34 \\ \text{Divisor} \;\ldots\ldots & \overline{1.25 \times 80} \end{array} = 1.02$$

Answer.

The front-roller is driven from the back-roller by a train of 3 pairs of wheels, and one pair of cones. The driven wheels have respectively 100, 18, and 51 teeth; and the driven cone is 3 inches in diameter at the small end.

How many teeth should there be in the driving wheels respectively, and what should be the diameter of the large end of the driving cone, to produce a draught of 2 at the railway-head, allowing a draught of 1.02 between the front-roller and the delivering balls, the front-roller being $1\frac{1}{4}$, and the back-roller, 1 inch in diameter?

N.B.—The belt is always at the large end of the driving cone, and, of course, at the small end of the driven cone, when the cards are utilizing their maximum quantity.

Worked out.

1·1.02	2
1·1.25	1
	100
	18
	3
	51·50·40

$$
\begin{array}{r}
40 \\
3 \\
\hline
120 \\
18 \\
\hline
960 \\
120 \\
\hline
2160 \\
100 \\
\hline
216000 \\
2 \\
\hline
432000
\end{array}
$$

A	10)432000
B	5)43200
B	5)8640
A	2)1728
A	2)864
A	2)432
D	2)216
D	2)108
D	2)54
D	2)27
B	3)13.5
C	4.5)4.5
	1

A. $10 \times 2 \times 2 \times 2 = 80$ Teeth in the first driving wheel.

B. $5 \times 5 \times 3 = 75$ Teeth in the second driving wheel.

C. $4.5 = 4\frac{1}{2}$, Diameter of the large end of the driving cone, in inches.

D. $2 \times 2 \times 2 \times 2 = 16$ Teeth in the third driving wheel Answer.

From the particulars found in the preceding example, find the total draught at the railway-head.

		1.02, Draught between the front-roller and delivering balls.
Diameter of the back-roller, in inches . .	1	1.25, Diameter of the front-roller, in inches.
Teeth in the first driven wheel	100	80 Teeth in the first driving wheel.
Teeth in the second driven wheel . . .	18	75 Teeth in the second driving wheel.
Diameter of the small end of the driven cone, in inches . .	3	4.5, Diameter of the large end of the driving cone, in inches.
Teeth in the third driven wheel	51	16 Teeth in the third driving wheel.

Worked out by Cancellation.

	1.02·.02
1	1.25
1·5·100	80·4·1
1·4·18	75·15·5
1·3	4.5·1
1·51	16

$16 \times 5 \times 1.25 \times .02 = 2$

Answer.

The same without Cancellation.

Dividend, $\dfrac{1.02 \times 1.25 \times 80 \times 75 \times 4.5 \times 16}{100 \times 18 \times 3 \times 51} = 2$
Divisor,

Answer.

From the particulars given to find the draught between the back-roller and the front-roller, and the particulars given to find the draught between the front-roller and the delivering balls, find the total draught.

Worked out by Cancellation.

1·1.25	3·1
1·80	34·1
1	1.25·1
1·100	80·1
1·4·18	75·.75·.5
1·3	4.5·1
1·1.5·51	16·4

$4 \times .5 = 2$

Answer.

The same without Cancellation.

Dividend, $\dfrac{3 \times 34 \times 1.25 \times 80 \times 75 \times 4.5 \times 16}{1.25 \times 80 \times 100 \times 18 \times 3 \times 51} = 2$
Divisor,

Answer.

From the particulars found in the preceding example, find the draught between the back and the front rollers.

Worked out by Cancellation.

$$\begin{array}{r|l} 1 & 1.25 \\ 1\cdot5\cdot100 & 80\cdot4\cdot1 \\ 1\cdot4\cdot18 & 75\cdot25\cdot5 \\ 1\cdot3 & 4.5\cdot1 \\ 1\cdot51 & 16\cdot.3\frac{7}{51} \end{array}$$

$$1.25 \times 5 \times .3\frac{7}{51} = 1.96\frac{4}{51}$$

Answer.

The same without Cancellation.

$$\begin{array}{l} \text{Dividend,} \\ \text{Divisor,} \end{array} \frac{1.25 \times 80 \times 75 \times 4.5 \times 16}{100 \times 18 \times 3 \times 51} = 1.96\frac{4}{51}$$

Answer.

The back and the back-middle rollers are each 1 inch in diameter. The back-roller has on a wheel with 21 teeth. How many teeth should there be in the wheel on the back-middle-roller to produce a draught of 1.05?

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot1.05 & 21\cdot20 \end{array}$$

20

Answer.

From the particulars found in the preceding example, find the draught between the back-roller and the back-middle-roller.

Worked out by Cancellation.

$$\frac{1{\cdot}20 \mid 21{\cdot}1.05}{1.05}$$

Answer.

The back-roller and the front-middle-rollers are each 1 inch in diameter. The front-middle-roller has on a wheel with 20 teeth. How many teeth should there be in the wheel on the back-roller to produce a draught of 1.25?

$$20 \times 1.25 = 25$$

Answer.

From the particulars found in the preceding example, find the draught between the back-roller and the front-middle-roller.

Worked out by Cancellation.

$$\frac{1{\cdot}20 \mid 25{\cdot}1.25}{1.25}$$

Answer.

From the wheels given to find the draught between the back-roller and the back-middle-roller; and the wheels given to find the draught between the back-roller and the front-middle-roller, find the draught between the back-middle-roller and the front-middle-roller.

Worked out by Cancellation.

1·20	25·1.19$\frac{1}{21}$
1·21	20·1

1.19$\frac{1}{21}$

Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{25 \times 20}{21 \times 20} = 1.19\frac{1}{21}$

Divisor . . . .

Answer.

From the particulars given to find the total draught, and the particulars given to find the draught between the front-roller and the back-roller, find the draught between the front-roller and the delivering balls.

Worked out by Cancellation.

	1.02
1	1.25·1
1·100	80·1
1·18	75·1
1·3	4.5·1

(*Continued.*)

1·51	16·1
1·1.25	1
1·80	100·1
1·75	18·1
1·4.5	3·1
1·16	51·1

1.02

Answer.

The same without Cancellation.

$$\frac{1.02 \times 1.25 \times 80 \times 75 \times 4.5 \times 16 \times 100 \times 18 \times 3 \times 51}{100 \times 18 \times 3 \times 51 \times 1.25 \times 80 \times 75 \times 4.5 \times 16}$$

$= 1.02$ Answer.

N.B.—The above result will be obtained by dividing the total draught by the draught between the back-roller and the front-roller. See the following example.

The draught between the back and front rollers is $1.96\frac{4}{51}$, and the total draught is 2. Required the draught between the delivering balls and the front-roller.

Worked out by Cancellation.

N.B.—$1.96\frac{4}{51} = \frac{100}{51}$.

	2
1·100	51·.51

$2 \times .51 = 1.02$ Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{51 \times 2}{100} = 1.02$
Divisor . . . .

Answer.

From the particulars given to find the total draught, the draught between the front-roller and the delivering balls, and the draught between the back-roller and the front-middle-roller, find the draught between the front-middle-roller and the front-roller.

Worked out by Cancellation.

1·1.25	3·1
1·80	34·1
1	1.25·1
1(00	80·1
1·4·18	75·3·1
1·3	4.5·1
1·51	16·4
1·3	1.25
1·34	8(0·$\frac{8}{51}$
1·25	2(0

$$4 \times 1.25 \times 2 \times \tfrac{8}{51} = 1.56\tfrac{44}{51}$$

Answer.

The same without Cancellation.

$$\frac{3 \times 34 \times 1.25 \times 80 \times 75 \times 4.5 \times 16 \times 1.25 \times 80 \times 20}{1.25 \times 80 \times 100 \times 18 \times 3 \times 51 \times 3 \times 34 \times 25}$$

$= 1.56\frac{44}{51}$ Answer.

The draught between the delivering balls and the front-roller is 1.02, and the draught between the back-roller and the front-middle-roller is 1.25. Required the draught between the front-middle-roller and the front-roller, the total draught being 2.

Worked out by Cancellation.

$$\begin{array}{r|l} & 2 \cdot 1.6 \cdot 1.56\frac{44}{51} \\ 1 \cdot 1.02 & \\ 1 \cdot 1.25 & \end{array}$$

$$1.56\frac{44}{51}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;\ldots\ldots & \dfrac{2}{1.25 \times 1.02} = 1.56\frac{44}{51} \\ \text{Divisor} \;\ldots\ldots\ldots & \end{array}$$

Answer.

The draught between the back-middle-roller and the back-roller is 1.05. The draught between the back-middle and the front-middle-roller $1.19\frac{1}{21}$. The draught between the front-middle-roller and the front-roller is $1.56\frac{44}{51}$. The draught between the front-roller and the delivering balls is 1.02.

Required the total draught.

$$\text{N.B.}—1.19\tfrac{1}{21} = \tfrac{25}{21}$$

$$1.56\tfrac{44}{51} = \tfrac{80}{51}$$

Worked out by Cancellation.

	1.05·.05
1·21	25
1·51	80
	1.02·.02

$$80 \times 25 \times .05 \times .02 = 2$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \; . \; . \; . & \dfrac{1.05 \times 25 \times 80 \times 1.02}{51 \times 21} = 2 \\ \text{Divisor} \; . \; . \; . \; . & \end{array}$$

Answer.

The can that receives the sliver stands upon and revolves with the disc, and, in practice, it is found that the velocity of its circumference should be to that of the delivering balls as 1 to 8.

The delivering balls are 3 inches in diameter, and drive the disc by a train of 2 pairs of wheels. The driven wheels have respectively 24 and 180 teeth. How many teeth should there be in the driving wheels respectively, and what should be the diameter of the can, to give its circumference a velocity $\frac{1}{8}$ of that of the delivering balls?

Worked out.

1·8	1
	3
	24·3
	180

	180
	3
	540
	3
B	2)1620
C	2)810
C	3)405
C	3)135
B	3)45
A	3)15
A	5)5
	1

A. 5 × 3 = 15 Teeth in the first driving wheel.
B. 3 × 2 = 6 Teeth in the second driving wheel.
C. 3 × 3 × 2 = 18, Diameter of the can, in inches.
Answer.

From the particulars found in the preceding example, find the ratio of velocity of the circumference of the delivering balls to that of the can, supposing that of the can to be 1:

		1	Ratio of velocity of the circumference of the can.
Diameter of the can, in inches	18	3,	Diameter of the delivering balls, in inches.
Teeth in the first driving wheel	15	24	Teeth in the first driven wheel.
Teeth in the second driving wheel . . .	6	180	Teeth in the second driven wheel or disc.

Worked out by Cancellation.

	1
1·18	3·1
1·3·15	24·8
1·2·6	180·10·5·1

8

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;. & \dfrac{3 \times 24 \times 180}{18 \times 15 \times 6} = 8 \\ \text{Divisor} \;.\;.\;.\;.\;.\;. & \end{array}$$

Answer.

DRAWING-FRAME.

As has been shown, the object attained by the previous processes in the carding department is a thorough cleansing of the cotton, untangling its fibres, laying them more or less parallel with each other, and forming them into a sliver.

The object to be attained at the drawing-frame is to repeatedly double and draw the slivers until they mutually correct any unevenness that may have occurred in their formation, and lay the fibres perfectly parallel with each other and the sliver.

The front-roller at the drawing frame is $1\frac{1}{4}$, and the delivering balls 3 inches in diameter. The front-roller has on a wheel with 27 teeth, that, by means of an intermediate, takes into the wheel on the same axis with the delivering balls. How many teeth should there be in the wheel on the same axis with the delivering balls to produce a draught of 1.08?

Diameter of the front-roller, in inches . . 1.25	3, Diameter of the delivering balls, in inches.

$$
\begin{array}{l|l}
 & \text{27 Teeth in the wheel on the front-roller.} \\
\text{Draught . . . . . 1.08} &
\end{array}
$$

Worked out by Cancellation.

$$
\begin{array}{r|l}
1\cdot 1.25 & 3 \\
 & 27\cdot 21.6\cdot 20 \\
1\cdot 1.08 &
\end{array}
$$

$$20 \times 3 = 60$$

Answer.

The same without Cancellation.

$$
\begin{array}{ll}
\text{Dividend . . . .} & \dfrac{27 \times 3}{1.08 \times 1.25} = 60 \\
\text{Divisor . . . .} &
\end{array}
$$

Answer.

From the particulars found in the preceding example, find the draught between the front-roller and the delivering balls.

Worked out by Cancellation.

$$
\begin{array}{r|l}
1\cdot 1.25 & 3\cdot 1 \\
1\cdot 20\cdot 60 & 27\cdot 21.6\cdot 1.08
\end{array}
$$

$$1.08$$

Answer.

The same without Cancellation.

$$
\begin{array}{ll}
\text{Dividend . . . . . .} & \dfrac{27 \times 3}{60 \times 1.25} = 1.08 \\
\text{Divisor . . . .} &
\end{array}
$$

Answer.

The front-roller is $1\frac{1}{4}$, and the back-roller is 1 inch in diameter. The front-roller wheel has 27 and the change wheel 36 teeth. How many teeth should there be in the top-carrier and the back-roller wheel to produce a draught of 4 at the drawing head, the draught between the front-roller and the delivering balls being 1.08 ?

Diameter of the front-roller, in inches . . 1.25	1, Diameter of the back-roller, in inches.
	27 Teeth in the wheel on the front-roller.
	36 Teeth in the change wheel.
Draught between the front-roller and the delivering balls . . 1.08	4, Total draught.

Worked out.

1·1.25	1
	27·25·20
	36
1·1.08	4

36
20
———
720

(Continued.)

```
                720
                  4
B  . . .   10)2880
B  . . . .   4)288
A  . . . . .  72)72
                  1
```

A. 72 = 72 Teeth in the top-carrier.

B. 10 × 4 = 40 Teeth in the back-roller wheel.

Answer.

From the particulars found in the preceding example, find the total draught at the drawing head.

Worked out by Cancellation.

1	1.25
1·36	40
1·27	72·2
	1.08·.04

40 × 2 × 1.25 × .04 = 4

Answer.

The same without Cancellation.

Dividend . . $\dfrac{1.25 \times 40 \times 72 \times 1.08}{36 \times 27} = 4$
Divisor . . .

Answer.

BOBBIN AND FLY-FRAME.

An upright shaft makes 180 revolutions per minute, and has on a wheel that takes into a wheel with 96 teeth on a lying shaft. On the lying shaft there is a pulley that drives a pulley 16 inches in diameter on a counter-shaft. On the countershaft there is a pulley that drives a pulley 10 inches in diameter on the first driven shaft of the fly-frame. How many teeth should there be in the wheel on the upright shaft, and what should be the diameter of the driving pulleys on the lying and the countershafts to drive the first driven shaft 288 revolutions per minute?

Revolutions per minute of the upright shaft, 180	288 Revolutions per minute of the first driven shaft. 96 Teeth in the wheel on the lying shaft. 16, Diameter of the driven pulley on the countershaft, in inches. 10, Diameter of the pulley on the first driven shaft of the fly-frame, in inches.

JAMES & BROWN'S PATENT SPEEDER

Worked out.

1·3·18(0	288·96
	96·16
	16
	1(0

$$
\begin{array}{lr}
 & 96 \\
 & 16 \\ \hline
 & 576 \\
 & 96 \\ \hline
 & 1536 \\
 & 16 \\ \hline
 & 9216 \\
 & 1536 \\ \hline
\text{A} \;.\;.\;.\;.\;. & 8)24576 \\ \hline
\text{B} \;.\;.\;.\;. & 6)3072 \\ \hline
\text{A} \;.\;.\;.\;.\;.\;. & 8)512 \\ \hline
\text{B} \;.\;.\;.\;. & 4)64 \\ \hline
\text{C} \;.\;.\;.\;.\;. & 16)16 \\ \hline
 & 1
\end{array}
$$

A. 8 × 8 = 64 Teeth in the wheel on the upright shaft.

B. $6 \times 4 = 24$, Diameter of the driving pulley on the lying shaft, in inches.

C. $16 = 16$, Diameter of the driving pulley on the countershaft, in inches.

Answer.

From the particulars found in the preceding example, find the revolutions per minute of the first driven shaft of the fly-frame.

Worked out by Cancellation.

	18(0
1·8·96	64·8
1·16	24·2
1(0	16·1

$18 \times 8 \times 2 = 288$

Answer.

The same without Cancellation.

Dividend . . . Divisor . . . $\dfrac{180 \times 64 \times 24 \times 16}{96 \times 16 \times 10} = 288$

Answer.

The first driven shaft of the fly-frame makes 288 revolutions per minute, and has on a wheel that takes into a wheel with 42 teeth on the spindle-shaft. On the spindle-shaft there is a wheel that takes into a wheel with 24 teeth on the spindle. How many teeth should there be in the wheel on the first driven shaft, and the driving wheel on the spindle-shaft, to drive the spindles 720 revolutions per minute?

Revolutions per minute of the first driven shaft of the fly-frame, 288	720 Revolutions per minute of the spindles. 42 Teeth in the driven wheel on the spindle shaft. 24 Teeth in the wheel on the spindle.

Worked out.

1·24·288	720·60
	42
	24·1

$$\begin{array}{lr} & 42 \\ & 60 \\ \hline \text{A} \ldots\ldots & 10)2520 \\ \hline \text{A} \ldots\ldots & 7)252 \\ \hline \text{B} \ldots\ldots & 36)36 \\ \hline & 1 \end{array}$$

A. 10 × 7 = 70 Teeth in the wheel on the first driven shaft of the fly-frame.

B. 36 = 36 Teeth in the driving wheel on the spindle shaft.

Answer.

The first driven shaft makes 288 revolutions per minute, and has on a wheel with 70 teeth that takes into a wheel with 42 teeth on the spindle-shaft. On the spindle-shaft there is also a wheel with 36 teeth that takes into a wheel with 24 teeth on the spindle. How many revolutions per minute does the spindle make?

	288 Revolutions per minute of the first driven shaft.
Teeth in the driven wheel on the spindle-shaft 42	70 Teeth in the wheel on the first driven shaft.
Teeth in the wheel on the spindle 24	36 Teeth in the driving wheel on the spindle-shaft.

Worked out by Cancellation.

	288·48
1·6·42	70·10·5
1·2·24	36·3

48 × 5 × 3 = 720

Answer.

The same without Cancellation.

$$\text{Dividend} \quad . \quad . \quad . \quad \frac{288 \times 70 \times 36}{42 \times 24} = 720$$
$$\text{Divisor} \quad . \quad . \quad . \quad .$$

Answer.

In treating on the epicyclic train of wheels, or what is technically called the differential coupling, it has been thought best to name each wheel and its use. The object to be obtained by the differential coupling is gradually to increase the speed of the bobbin at the same rate as its diameter increases, since it is essential that the bobbin and the front-roller have equal surface velocities.

The train of wheels in the differential coupling are 5 in number, 3 of which are on the same axis with the first driven shaft. The first wheel is made fast to the first driven shaft, and is called the fast internal wheel. The second or middle wheel revolves loose upon the first driven shaft, and is called the differential wheel. The third wheel is made fast to a hollow cylinder that revolves loose upon the first driven shaft, and is called the loose internal wheel. The other two (only one of which is necessary) are intermediate or carrying wheels, connecting the fast and loose internal wheels: they are fast to, and have their axis in the plane of the differential wheel. The fast and loose internal wheels are both of the same dimensions, and need not be taken into account; but there is a wheel outside of the differential coupling, called the external wheel, that is made fast to the same hollow cylinder as the loose internal wheel, which, with the differential wheel, will be found in the following examples, and will answer every purpose for calculating anything pertaining to the differential coupling.

It is obvious that if the differential wheel were held fast, the external wheel and the fast and loose internal wheels would all revolve at the same speed, and that, if it were made to revolve at the same speed as the fast internal wheel, the external wheel would stand still. Hence it is by having the differential wheel revolve in the same direction as the fast internal wheel, but at a slower rate, equal to the difference in speed between the flyer and the bobbin, that the surface velocity of the bobbin is made to keep pace with that of the front-roller.

N.B.—In the following example, the differential wheel is supposed to stand still.

The external wheel makes 288 revolutions per minute, and takes into a wheel with 42 teeth on the bobbin-shaft. On the bobbin-shaft there is a wheel that takes into a wheel with 40 teeth, to which the bobbin is made fast. How many teeth should there be in the external wheel, and the driving wheel on the bobbin-shaft, to drive the bobbin 720 revolutions per minute?

Revolutions per minute of the external wheel, 288	720 Revolutions per minute of the bobbin.
	42 Teeth in the driven wheel on the bobbin-shaft.
	40 Teeth in the wheel to which the bobbin is made fast.

Worked out.

1·2·24·288	720·60·5
	42·21
	40

```
                   21
                    5
                  ———
                  105
                   40
                  ———
A . . . . .  10)4200
                 ————
A . . . . .   10)420
                  ———
B . . . . . .  42)42
                   ——
                    1
```

A. $10 \times 10 = 100$ Teeth in the external wheel.

B. $42 = 42$ Teeth in the driving wheel on the bobbin-shaft. Answer.

N.B.—In the following example the differential wheel is supposed to stand still.

The external wheel makes 288 revolutions per minute, has 100 teeth, and takes into a wheel with 42 teeth on the bobbin-shaft. On the bobbin-shaft there is also a wheel with 42 teeth that takes into a wheel with 40 teeth, to which the bobbin is made fast. How many revolutions per minute does the bobbin make?

	288 Revolutions per minute of the external wheel.
Teeth in the driven wheel on the bobbin-shaft 42	100 Teeth in the external wheel.
Teeth in the wheel to which the bobbin is made fast 40	42 Teeth in the driving wheel on the bobbin-shaft.

Worked out by Cancellation.

	288·72
1·42	10(0
1·4(0	42·1

$72 \times 10 = 720$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ . \ . \ . & \dfrac{288 \times 100 \times 42}{42 \times 40} = 720 \\ \text{Divisor} \ . \ . \ . \ . & \end{array}$$

Answer.

The first driven shaft makes 288 revolutions per minute, and has on a wheel with 20 teeth, that takes into a wheel on the grooved shaft. On the other end of the grooved shaft there is a wheel with 100 teeth, that takes into a wheel on the front-roller. How many teeth should there be in the wheel on the grooved shaft, that takes into the wheel on the first driven shaft, and the wheel on the front-roller, to drive the front-roller 96 revolutions per minute?

Revolutions per minute of the front-roller . . 96	288 Revolutions per minute of the first driven shaft. 20 Teeth in the wheel on the first driven shaft. 100 Teeth in the wheel that takes into the wheel on the front-roller.

Worked out.

1·8·96	288·24·3
	20
	100

```
                20
                 3
                --
                60
               100
              ----
A . . . . . 10)6000
              ----
A . . . . .  10)600
               ---
  B . . . . . 60)60
                --
                 1
```

A. $10 \times 10 = 100$ Teeth in the wheel on the front-roller.

B. $60 = 60$ Teeth in the driven wheel on the grooved shaft. Answer.

The first driven shaft makes 288 revolutions per minute, and has on a wheel with 20 teeth that takes into a wheel with 60 teeth on the grooved shaft. On the other end of the grooved shaft there is a wheel with 100 teeth, that takes into a wheel with 100 teeth on the front-roller. How many revolutions per minute does the front-roller make?

[illegible]

	288 Revolutions per minute of the first driven shaft.
Teeth in the driven wheel on the grooved shaft 60	20 Teeth in the wheel on the first driven shaft.
Teeth in the wheel on the front-roller . . . 100	100 Teeth in the driving wheel on the grooved shaft.

Worked out by Cancellation.

	288·48
1·6(0	2(0
1·100	100·1

$$48 \times 2 = 96$$

Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{288 \times 20 \times 100}{100 \times 60} = 96$

Divisor . . . . . .

Answer.

The front-roller is $1\frac{1}{4}$ inches in diameter, and makes 96 revolutions per minute, and the spindle makes 720 revolutions per minute. How many turns of twist per inch is there in the roving?

Revolutions per minute of the front-roller . . 96	720 Revolutions per minute of the spindle.
Diameter of the front-roller, in inches . . 1.25	
Ratio of circumference to diameter . . . 3.1416	

Worked out by Cancellation.

1·8·96	720·60·7.5·6·1.9
1·1.25	
1·3.1416	

1.9

Answer.

The same without Cancellation.

Dividend 720
Divisor . . . . . 96 × 1.25 × 3.1416

$$\frac{720}{96 \times 1.25 \times 3.1416} = 1.9$$

Answer.

The spindle makes 720 and the front-roller 96 revolutions per minute. How many revolutions does the spindle make while the front-roller makes 1?

Worked out by Cancellation.

1·8·96 | 720·60·7.5

7.5

Answer.

N.B.—If it is admitted that the diameter of the empty bobbin is equal to that of the front-roller, the spindle making $7\frac{1}{2}$, while the front-roller makes 1 revolution, it will be evident that the bobbin will have to make 1 revolution less than the spindle in the same time, in order to wind on the roving as fast as it is delivered by the front-roller (making no allowance for shrinkage in twisting), until the first layer is wound on to the bobbin; therefore the bobbin will make $6\frac{1}{2}$, while the spindle makes $7\frac{1}{2}$ revolutions.

If the bobbin makes $6\frac{1}{2}$, while the spindle makes $7\frac{1}{2}$ revolutions, how many revolutions per minute will the bobbin make, if the spindle makes 720 ?

Worked out by Cancellation.

$$\begin{array}{r|l} & 720 \cdot 2400 \\ 1 \cdot .3 \cdot 1.5 \cdot 7.5 & 6.5 \cdot 1.3 \cdot .26 \end{array}$$

$$2400 \times .26 = 624$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \; . \; . \; . \; . \; . \; . \; . & \dfrac{720 \times 6.5}{7.5} = 624 \\ \text{Divisor} \; . \; . \; . \; . \; . \; . \; . & \end{array}$$

Answer.

The bobbin makes 624 revolutions per minute, while winding on the first layer of roving. The wheel to which the bobbin is made fast has 40 teeth, and takes into a wheel with 42 teeth on the bobbin-shaft. On the bobbin-shaft there is also a wheel with 42 teeth that takes into the external wheel, which has 100 teeth. How many revolutions per minute does the external wheel make?

		624	Revolutions per minute of the bobbin.
Teeth in the wheel on the bobbin-shaft that takes into the wheel to which the bobbin is made fast,	42	40	Teeth in the wheel to which the bobbin is made fast.
Teeth in the external wheel	100	42	Teeth in the wheel on the bobbin-shaft that takes into the external wheel.

Worked out by Cancellation.

	624
1·42	4(0·.4
1·10(0	42·1

$624 \times .4 = 249.6$ Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{624 \times 40 \times 42}{100 \times 42} = 249.6$
Divisor . . . . . .

Answer.

The first driven shaft makes 288, and the external wheel 249.6 revolutions per minute, while winding the first layer of roving on to the bobbin. How many revolutions per minute has the external wheel been retarded, admitting that it would have revolved at the same speed as the first driven shaft, if the differential wheel had stood still?

$$\begin{array}{r} 288.0 \\ 249.6 \\ \hline 38.4 \end{array}$$

Answer.

The wheel to which the bobbin is made fast has 40 teeth, and takes into a wheel with 42 teeth on the bobbin-shaft. On the bobbin-shaft there is also a wheel with 42 teeth that takes into the external wheel, which has 100 teeth. The differential wheel retards the external wheel 38.4 revolutions per minute. How many revolutions per minute is the bobbin retarded?

	38.4 Revolutions per minute that the external wheel is retarded.
Teeth in the wheel on the bobbin-shaft that takes into the external wheel 42	100 Teeth in the external wheel.

(*Continued.*)

Teeth in the wheel to which the bobbin-shaft is made fast . . . 40	42 Teeth in the wheel on the bobbin-shaft that takes into the wheel to which the bobbin is made fast.

Worked out by Cancellation.

	38.4
1·42	10(0·2.5
1·4(0	42·1

$$38.4 \times 2.5 = 96$$

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{38.4 \times 100 \times 42}{42 \times 40} = 96$

Divisor . . . . .

Answer.

N.B.—It will be observed from the above that the bobbin, while winding on the first layer of roving, is retarded exactly the same number of revolutions per minute as the front-roller makes, which is right (making no allowance for shrinkage in twisting), because the empty bobbin and the front-roller are both of the same dimensions, and the winding on is effected by the bobbin falling behind the spindle.

The first driven shaft makes 288 revolutions per minute, and has on a wheel with 20 teeth that takes into a wheel with 60 teeth on the grooved shaft. On the grooved shaft there is a pulley 5 inches in diameter that drives the cone at the small end.

On the same axis with the cone there is a wheel with 54 teeth that takes into a wheel on a short shaft. On the other end of the short shaft there is a wheel with 32 teeth that takes into the differential wheel. How many teeth should there be in the driven wheel on the short shaft and the differential wheel, and what should be the diameter of the small end of the cone, to drive the differential wheel 38.4 revolutions per minute?

N.B.—The belt is always at the small end of the cone at the commencement of the bobbin, when the winding on is effected by the bobbin falling behind the spindle; and every time the differential wheel makes one revolution, it reduces that of the external wheel the same.

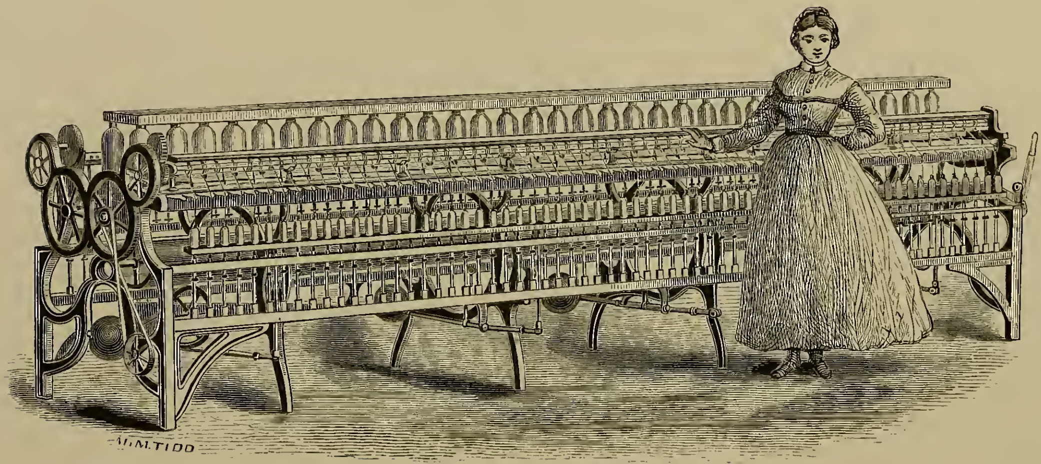
Revolutions per minute of the differential wheel	38.4	288	Revolutions per minute of the first driven shaft.
Teeth in the wheel on the grooved shaft .	60	20	Teeth in the wheel on the first driven shaft.
		5	Diameter of the pulley on the grooved shaft, in inches.

	54 Teeth in the wheel on the same axis with the cone.
	32 Teeth in the wheel that takes into the differential wheel.

1·3.2·38.4	288·24·8
1·3·60	20·1
	5
	54
	32·10

$$\begin{array}{lr}
 & 54 \\
 & 10 \\ \hline
 & 540 \\
 & 5 \\ \hline
 & 2700 \\
 & 8 \\ \hline
\text{C} \;.\;.\;. & 10)21600 \\ \hline
\text{B} \;.\;.\;.\;. & 10)2160 \\ \hline
\text{A} \;.\;.\;.\;. & 2)216 \\ \hline
\text{C} \;.\;.\;.\;. & 2)108 \\ \hline
\text{B} \;.\;.\;.\;.\;. & 2)54 \\ \hline
\end{array}$$

(*Continued.*)



FALES & JENKS' SPINNING FRAME.

$$\begin{array}{lr} \text{B} \ldots\ldots & 3\underline{)27} \\ \text{C} \ldots\ldots & 3\underline{)9} \\ \text{C} \ldots\ldots & 3\underline{)3} \\ & 1 \end{array}$$

A. 2 = 2 Diameter of the small end of the cone, in inches.

B. $10 \times 2 \times 3 = 60$ Teeth in the driven wheel on the short shaft.

C. $10 \times 2 \times 3 \times 3 = 180$ Teeth in the differential wheel.

Answer.

The first driven shaft makes 288 revolutions per minute, and has on a wheel with 20 teeth that takes into a wheel with 60 teeth, on the grooved shaft. On the grooved shaft there is a pulley 5 inches in diameter, that drives the cone at the small end, which is 2 inches in diameter. On the same axis with the cone there is a wheel with 54 teeth that takes into a wheel with 60 teeth, on a short shaft. On the other end of the short shaft there is a wheel with 32 teeth, that takes into the differential wheel, which has 180 teeth. How many revolutions per minute does the differential wheel make?

Teeth in the wheel on the grooved shaft .	60	288	Revolutions per minute of the first driven shaft.
Diameter of the small end of the cone, in inches	2	20	Teeth in the wheel, on the first driven shaft.
Teeth in the driven wheel, on the short shaft	60	5	Diameter of the pulley on the grooved shaft, in inches.
Teeth in the differential wheel	180	54	Teeth in the wheel on the same axis with the cone.
		32	Teeth in the wheel that takes into the differential wheel.

Worked out by Cancellation.

	288·24·8·4·1
1·3·60	20·1
1·2	5·1
1·5·60	54·6
1·5·20·180	32·6.4

$6.4 \times 6 = 38.4$ Answer.

The same without Cancellation.

Dividend . . $\dfrac{288 \times 20 \times 5 \times 54 \times 32}{60 \times 2 \times 60 \times 180} = 38.4$

Divisor . . .

Answer.

The first driven shaft makes 288 revolutions per minute, and has on a wheel with 20 teeth that takes into a wheel with 60 teeth, on the grooved shaft. On the grooved shaft there is a pulley 5 inches in diameter that drives the cone at the small end, which is 2 inches in diameter. On the same axis with the cone there is a wheel with 54 teeth, that takes into a wheel with 60 teeth, on a short shaft. On the other end of the short shaft there is a wheel with 32 teeth, that takes into the differential wheel, which has 180 teeth. The external wheel has 100 teeth and takes into a wheel with 42 teeth, on the bobbin shaft. On the bobbin shaft there is also a wheel with 42 teeth, that takes into a wheel with 40 teeth, to which the bobbin is made fast. How many revolutions per minute is the bobbin retarded?

N.B.—The above includes the whole train of wheels, pulley, and cone leading from the first driven shaft through the differential coupling to the bobbin.

		288	Revolutions per minute of the first driven shaft.
Teeth in the wheel, on the grooved shaft .	60	20	Teeth in the wheel, on the first driven shaft.
Diameter of the small end of the cone, in inches	2	5	Diameter of the pulley on the grooved shaft, in inches.

Teeth in the driven wheel, on the short shaft	60	54	Teeth in the wheel, on the same axis with the cone.
Teeth in the differential wheel	180	32	Teeth in the wheel that takes into the differential wheel.
Teeth in the driven wheel, on the bobbin shaft	42	100	Teeth in the external wheel.
Teeth in the wheel to which the bobbin is made fast	40	42	Teeth in the driving wheel, on the bobbin shaft.

Worked out by Cancellation.

	288·24·6·3
1·6(0	20·1
1·2	5·1
1·5·60	54·9·1
1·20·180	32
1·42	1(00
1·4(0	42·1

$32 \times 3 = 96$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} & 288 \times 20 \times 5 \times 54 \times 32 \times 100 \times 42 \\ \hline \text{Divisor .} & 60 \times 2 \times 60 \times 180 \times 42 \times 40 \end{array} = 96$$

Answer.

From the revolutions per minute of the front-roller, and the train of wheels, and the pulley and cone leading from the front-roller to the bobbin, find how many revolutions per minute the bobbin is retarded.

Worked out by Cancellation.

	96
1·100	100·1
1·2	5·1
1·2·10·60	54·6·1
1·2·18(0	32·16·4·2·1
1·42	1(00
1·4(0	42·1

96

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} & 96\times100\times5\times54\times32\times100\times42 \\ \hline \text{Divisor . .} & 100\times2\times60\times180\times42\times40 \end{array} = 96$$

Answer.

N.B.—Every time the bobbin is retarded or falls behind the spindle one revolution, it laps the roving once round the bobbin; consequently, the front-roller and empty bobbin both being of the same dimensions, the front-roller making 96 revolutions per minute, and the bobbin falling behind the spindle 96 revolutions per minute, the roving will be wound on to the bobbin as fast as it is delivered from the front-roller (making no allowance for shrinkage in twisting).

The front-roller wheel has 30 and the change-wheel 32 teeth, and the back-roller is one inch in diameter. How many teeth should there be in the top-carrier and the back-roller wheel, and what should be the diameter of the front-roller to produce a draught of 7?

Worked out.

| 30
| 32
| 8 = $\frac{8}{8}$ of an inch.
| 7

32
30
———
960
8
———
7680
7
———
A . . . 10)53760
———
B . . . 2)5376
———

(*Continued.*)

B . . .	2)2688
B . . .	2)1344
B . . .	7)672
C . .	96)96
	1

A. 10 = 10 Diameter of the front-roller in eighths of an inch.

B. $7 \times 2 \times 2 \times 2 = 56$ Teeth in the back-roller wheel.

C. 96 = 96 Teeth in the top-carrier.

Answer.

The front-roller is $1\frac{1}{4}$ and the back-roller one inch in diameter. The front-roller wheel has 30, the top-carrier 96, the change-wheel 32, and the back-roller wheel 56 teeth. Required the draught.

Diameter of the back-roller, in eighths of an inch	8	10 Diameter of the front in eighths of an inch.
Teeth in the change-wheel	32	56 Teeth in the back-roller-wheel.
Teeth in the front-roller	30	96 Teeth in the top-carrier.

Worked out by Cancellation.

1·8	1(0
1·4·32	56·7
1·3(0	96·12·3·1

7 Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{10 \times 56 \times 96}{8 \times 32 \times 30} = 7$
Divisor . . . .

Answer.

What should be the draught between the middle and front rollers, if 19 is drawn into 20 between the back and middle rollers, the total draught being 7?

Worked out by Cancellation.

	7
1·4·20	19·3.8·.95

$7 \times .95 = 6.65$

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{19 \times 7}{20} = 6.65$
Divisor . . . .

Answer.

The front-roller is $1\frac{1}{4}$ and the middle-roller one inch in diameter. The front-roller wheel has 30, and the change-wheel 35 teeth. How many teeth should there be in the top-carrier and the middle-roller wheel to produce a draught of 6.65 between the middle and the front rollers?

Worked out.

		3(0
		35
$\frac{10}{8}$ of an inch . . .	1(0	8 = $\frac{8}{8}$ of an inch.
		6.65

	6.65
	8
	53.20
	35
	26600
	15960
	1862.00
	3
B . . .	2)5586·00
A	3)2793
B	7)931

(*Continued.*)

5

B	7)133
A	19)19
	1

A. 19 × 3 = 57 Teeth in the middle-roller wheel.
B. 7 × 7 × 2 = 98 Teeth in the top-carrier.

Answer.

The front-r. ller is $1\frac{1}{4}$ and the middle-roller one inch in diameter. The front-roller wheel has 30, the top-carrier 98, the change-wheel 35, and the middle-roller wheel 57 teeth. Required the draught between the middle and the front-rollers.

Diameter of the middle-roller, in eighths of an inch	8	10, Diameter of the front-roller, in eighths of an inch.
Teeth in the change-wheel	35	57 Teeth in the middle-roller wheel.
Teeth in the front-roller wheel	30	98 Teeth in the top-carrier.

Worked out by Cancellation.

1·8	1(0
1·7·35	57·11.4·3.8
1·3(0	98·12.25·1.75

3.8 × 1.75 = 6.65 Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \; . \; . \; . \; . \; . \; . & 10 \times 57 \times 98 \\ \text{Divisor} \; . \; . \; . \; . \; . \; . & 8 \times 35 \times 30 \end{array} \qquad \frac{10 \times 57 \times 98}{8 \times 35 \times 30} = 6.65$$

Answer.

From the particulars given, to find the draught between the back and the front, and the middle and the front rollers. Find the draught between the back and the middle rollers.

Worked out by Cancellation.

1(0	8·1
1·1.9·5.7·11.4·57	35·5·1
1·7·49·98	30·1
1·8	1(0
1·4·32	56·8·2·1
1·30	96·12·6·2·1.05$\frac{5}{19}$

$1.05\frac{5}{19}$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \; . & 8 \times 35 \times 30 \times 10 \times 56 \times 96 \\ \text{Divisor} \; . \; . & 10 \times 57 \times 98 \times 8 \times 32 \times 30 \end{array} \qquad \frac{8 \times 35 \times 30 \times 10 \times 56 \times 96}{10 \times 57 \times 98 \times 8 \times 32 \times 30} = 1.05\tfrac{5}{19}$$

Answer.

The draught between the back and the front-rollers is 7, and the draught between the middle and the front-rollers is 6.65. Required the draught between the back and the middle rollers.

$$\frac{1 \cdot 6.65 \mid 7 \cdot 1.05\tfrac{5}{19}}{1.05\tfrac{5}{19}}$$

Answer.

A Fly-Frame is making coarse roving with a one-inch back-roller, a $1\frac{1}{4}$ inch front-roller, a 32 front-roller wheel, a 96 top-carrier 40 change-wheel, and a 64 back-roller wheel. Required the draught.

Worked out by Cancellation.

1·8	1(0
1·32	96·48·6
1·2·4(0	64·2·1

6

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;\ldots\ldots\ldots & 10 \times 96 \times 64 \\ \text{Divisor} \;\ldots\ldots\ldots & \overline{\;8 \times 32 \times 40\;} \end{array} = 6$$

Answer.

The first layer of roving on the bobbin is 6 inches long, containing 30 laps per inch; consequently, the copping-rail will have to traverse 6 inches, and the bobbin make $30 \times 6 = 180$ revolutions, while winding on the layer, and, as has been shown in preceding examples, the empty bobbin and the front-roller are both of the same dimensions, and in effect, both move at the same speed, while winding on the first layer of roving. The rack to which the copping-rail is made fast is driven from the cone-shaft by 5 pairs of wheels, and the wheel that takes into the rack. The driven wheels contain respectively, 90, 100, 60, 80, and 80 teeth, and the rack 4 teeth per inch. From the above particulars and the train of wheels, and the pulley and cone leading from the front-roller to the cone, find driving wheels that will make the copping-rail traverse 6 inches, while the front-roller makes 180 revolutions.

Revolutions of the front-roller	180		
Teeth in the wheel on the front-roller . .	100	100	Teeth in the wheel on the grooved shaft.
Diameter of the pulley on the grooved shaft, in inches	5	2,	Diameter of the small end of the cone, in inches.
		90	First driven wheel from the cone.

	100	Second driven wheel from the cone.
	60	Third driven wheel from the cone.
	80	Fourth driven wheel from the cone.
	80	Fifth driven wheel from the cone.
	4	Teeth per inch in the rack.
	6	Length of the first layer, in inches.

Worked out.

1·2·180	
1·100	100·1
1·5	2·1
	90·1
	100·20
	60
	80
	80
	4
	6

```
                                6
                                4
                               ---
                               24
                               80
                             ----
                             1920
                               80
                           ------
                           153600
                               60
                          -------
                          9216000
                               20
                       ----------
B . . . . .          10)184320000
                       ----------
     E . .            10)18432000
                        ---------
   C . . . . . .       10)1843200
                         --------
A . . . . . . .         10)184320
                          -------
     E . . . . .          2)18432
                            -----
    D . . . . . .          2)9216
                             ----
    D . . . . . .          4)4608
                             ----
    D . . . . . .          8)1152
                             ----
A . . . . . . . . . .       3)144
                              ---
   C . . . . . . . .         3(48
                               --
        F . . . .           16)16
                               --
                                1
```

A. 10 × 3 = 30 Teeth in the wheel on the same axis with the cone or first driving wheel.

B. 10 = 10 Teeth in the second driving wheel.

C. 10 × 3 = 30 Teeth in the third driving wheel.

D. 8 × 4 × 2 = 64 Teeth in the fourth driving wheel.

E. 10 × 2 = 20 Teeth in the fifth driving wheel.

F. 16 = 16 Teeth in the wheel that takes into the rack.

Answer.

From the particulars found in the preceding example, find the length of the first layer of roving on the bobbin.

Worked out by Cancellation.

	18(0·6
1·100	100·1
1·2	5·1
1·3·90	30·1
1(00	1(0
1·4·12·60	3(0·1
1(0·80	64·8·2·1
1·20·80	20·1
1·4	16·4·1

6 inches.

Answer.

The same without Cancellation.

$$\text{Dividend,}\quad \frac{180 \times 100 \times 5 \times 30 \times 10 \times 30 \times 64 \times 20 \times 16}{100 \times 2 \times 90 \times 100 \times 60 \times 80 \times 80 \times 4} = 6 \quad \text{Divisor,}$$

Answer.

From the particulars found in the preceding example, find how many revolutions the front-roller makes while the first layer of roving is being wound on to the bobbin.

Worked out by Cancellation.

	6·2·1
1·4·16	4·1
1·20	80·4·1
1·2·4·8·64	80·10·2·1
1·30	60·2·1
1(0	1(00
1·3(0	90
1·5	2
1·100	100·1

$$90 \times 2 = 180$$

Answer.

The same without Cancellation.

$$\text{Dividend,}\quad \frac{6 \times 4 \times 80 \times 80 \times 60 \times 100 \times 90 \times 2 \times 100}{16 \times 20 \times 64 \times 30 \times 10 \times 30 \times 5 \times 100} = 180 \quad \text{Divisor,}$$

Answer.

From the particulars found in the preceding example, find how many teeth there is in the reversing wheels.

N.B.—The reversing wheels take into the wheel with 10 teeth. They are two in number, only one of which is in operation at a time.

Worked out by Cancellation.

	180·2·1
1(00	100
1·2	5·1
1·90	3(0·1
	1(0
1·4·20·60	30·5·1
1·2·10·80	64·8·2·1
1·4·80	20·1
1·4	16·4·1
1·6	

100

Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend,} & \dfrac{180 \times 100 \times 5 \times 30 \times 10 \times 30 \times 64 \times 20 \times 16}{100 \times 2 \times 90 \times 60 \times 80 \times 80 \times 4 \times 6} = 100 \\ \text{Divisor,} & \end{array}$$

Answer.

SPINNING-FRAME.

An upright shaft in a spinning-room makes 180 revolutions per minute, and has on a wheel that takes into a wheel with 64 teeth, on a lying-shaft. On the lying-shaft there is a pulley that drives a pulley 12 inches in diameter, on a counter-shaft. On the counter-shaft there is a pulley that drives a pulley 8 inches in diameter, on the same axis with the cylinder of the spinning-frame. How many teeth should there be in the wheel on the upright shaft, and what should be the diameter of the driving pulleys on the lying and counter shafts, to drive the cylinder 900 revolutions per minute?

Revolutions per minute of the upright shaft. 180	900 Revolutions per minute of the cylinder.
	64 Teeth in the wheel on the lying shaft.
	12, Diameter of the driven pulley on the counter-shaft, in inches.
	8, Diameter of the pulley on the same axis with the cylinder, in inches.

Worked out.

1·3·18(0	90(0·30
	64
	12·2
	8

```
                    64
                    30
                  ----
                  1920
                     2
                  ----
                  3840
                     8
                 -----
A . . . .     10)30720
                 -----
    C . . . .   2)3072
                  ----
  B . . . .     6)1536
                  ----
  B . . . .      4)256
                   ---
A . . . . . .     8)64
                    --
    C . . . . .    8)8
                     -
                     1
```

A. 10 × 8 = 80 Teeth in the wheel, on the upright shaft.

B. $6 \times 4 = 24$, Diameter of the pulley on the lying shaft, in inches.

C. $8 \times 2 = 16$, Diameter of the driving pulley on the counter-shaft, in inches.

Answer.

From the particulars found in the preceding example, find the revolutions per minute of the cylinder.

Worked out by Cancellation.

	180·45
1·2·8·64	80·10
1·12	24·2·1
1·8	16·2

$$45 \times 10 \times 2 = 900$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ldots & \dfrac{180 \times 80 \times 24 \times 16}{64 \times 12 \times 8} = 900 \\ \text{Divisor} \ldots & \end{array}$$

Answer.

The cylinder makes 900 revolutions per minute, and the spindle-warls are one inch in diameter. What should be the diameter of the cylinder to drive the spindles 6300 revolutions per minute?

Worked out by Cancellation.

1·900	6300·7

7 Answer.

The cylinder makes 900 revolutions per minute, and on the same axis there is a pulley that drives a pulley 15 inches in diameter, on a stud. On the same axis with the pulley on the stud, there is a wheel that, by means of an intermediate, takes into a wheel with 70 teeth on the front-roller. What should be the diameter of the pulley on the same axis with the cylinder, and how many teeth should there be in the wheel on the same axis with the pulley on the stud, to drive the front-roller 60 revolutions per minute?

Revolutions per minute of the cylinder . . 900	60 Revolutions per minute of the front-roller.
	15, Diameter of the pulley on the stud, in inches.
	70 Teeth in the wheel on the front-roller.

Worked out.

1·3·9(00	6(0·2
	15·5
	7(0

(*Continued.*)

	7
	5
	35
	2
A . . .	7)70
A . . .	2)10
B . . .	5)5
	1

A. 7 × 2 = 14 Teeth in the wheel on the same axis with the pulley on the stud.

B. 5 = 5, Diameter of the pulley on the same axis with the cylinder, in inches.

Answer.

From the particulars found in the preceding example, find the revolutions per minute of the front-roller.

Worked out by Cancellation.

	900·60
1·15	5·1
1·14·70	14·1

60

Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{900 \times 5 \times 14}{70 \times 15} = 60$
Divisor . . . .

Answer.

The front-roller is one inch in diameter, and makes 60 revolutions per minute, and the spindles make 6300 revolutions per minute. Required the number of turns of twist per inch in the yarn.

Worked out by Cancellation.

1·6(0	630(0·105·8.75·33.42
1·.2618·3.1416	

33.42

Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{6300}{3.1416 \times 60} = 33.42$
Divisor . . . .

Answer.

The cylinder is 7 inches in diameter, and on the same axis there is a pulley 5 inches in diameter that drives a pulley 15 inches in diameter, on a stud. On the same axis with the pulley on the stud, there is a wheel with 14 teeth that, by means of an intermediate, takes into a wheel with 70 teeth, on the front-roller. Required the number of turns of twist per inch in the yarn, the front-roller being one inch in diameter.

Diameter of the front-roller, in inches . .	1	7, Diameter of the cylinder, in inches.
Circumference . .	3.1416	
Diameter of the pulley on the same axis with the cylinder, in inches	5	15, Diameter of the pulley on the stud, in inches.
Teeth in the wheel on the same axis with the pulley on the stud	14	70 Teeth in the wheel on the front-roller.

Worked out by Cancellation.

1	7·1
1·.4488·3.1416	
1·5	15·33.42
1·14	70·14·1

33.42

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . . . . .} & \dfrac{7 \times 15 \times 70}{3.1416 \times 5 \times 14} = 33.42 \\ \text{Divisor . . . . . .} & \end{array}$$

Answer.

The heart or traverse motion makes one revolution while two layers of yarn are being wound on the bobbin. On the same axis with the heart there is a wheel with 72 teeth driven by a worm. On the same axis with the worm there is a pulley 9 inches in diameter, driven from a pulley on a stood. On the same axis with the pulley on the stood there is a wheel with 32 teeth that takes into a wheel on the front-roller. How many teeth should there be in the wheel on the front-roller, and what should be the diameter of the pulley on the stood, to make each layer of yarn 15 yards long, the front-roller being one inch in diameter, making no allowance for shrinkage in twisting?

Layers wound on while the heart makes one revolution	2	1	Revolutions of the heart.
The worm is equal to one tooth, in effect .	1	72	Teeth in the wheel on the same axis with the heart.
		9,	Diameter of the pulley on the same axes with the worm, in inches.
		32	Teeth in the wheel on the same axis with the pulley on the stud.

Inches in one yard . . 36	1, Diameter of the front-roller, in inches.
	3.1416 Ratio of circumference to diameter.
Length of one layer of yarn, in yards . . . 15	

Worked out.

1·2	1
1	72·6·2·1
	9·3
	32
1·3·36	1
	3.1416·.62832
1·3·15	

```
                 .62832
                     32
                 ------
                 125664
                188496
                -------
               20.10624
                      3
               --------
A . . . . . . 2)60.31872
               --------
A . . . . . . 3)30.15936
               --------
```

(*Continued.*)

A . . . . . . 4)10.05312

B . . 2.51328)2.51328

1

A. $2 \times 3 \times 4 = 24$ Teeth in the wheel on the front-roller.

B. $2.51328 = 2.51328$, Diameter of the pulley on the stood, in inches.

Answer.

From the particulars found in the preceding example, find the number of yards in one layer of yarn.

Worked out by Cancellation.

1·2	1
1	72·6·2·1
1·2.51328	9·3
1·3·24	32·4
1·3·36	1
	3.1416·1.25

$1.25 \times 4 \times 3 = 15$ Answer.

The same without Cancellation.

Dividend . . . . Divisor . . . . $\dfrac{72 \times 9 \times 32 \times 3.1416}{2 \times 2.51328 \times 24 \times 36} = 15$

Answer.

MASON'S MULE.

An upright shaft in a mule-room makes 180 revolutions per minute, and has on a wheel that takes into a wheel with 60 teeth, on a lying-shaft. On the lying-shaft there is a pulley that drives a pulley 12 inches in diameter, on the twist-shaft. How many teeth should there be in the wheel on the upright shaft, and what should be the diameter of the pulley on the lying-shaft, to drive the mule $3\frac{1}{2}$ stretches per minute, the twist-shaft making 75 revolutions per stretch, and the time occupied in drawing out and twisting being three-quarters of the time necessary to perform the whole stretch?

N.B.—The twist-shaft makes from one to three revolutions, according to the size of the cop, while taking in the carriage, but there is a loss of about that amount while falling from the maximum to the minimum speed necessary for backing off.

Revolutions per minute of the upright shaft	180	75	Revolutions per stretch of the twist-shaft.
Time necessary for drawing out and twisting	3	4	Time necessary to perform the whole stretch.
		60	Teeth in the wheel on the lying-shaft.

12, Diameter of the pulley on the twist-shaft, in inches.
3.5 Stretches per minute.

Worked out.

1·3·180	75·25
1·3	4
	60·1
	12·4
	3.5

```
                25
                 4
               ---
               100
                 4
               ---
               400
               3.5
              ----
              2000
             1200
             -----
A . . . .   7)1400.0
            --------
A . . . . .  10)200
               -----
 B. . . . .   20)20
                 --
                  1
```

A. 10 × 7 = 70 Teeth in the wheel on the upright shaft.

B. 20 = 20, Diameter of the pulley on the lying-shaft, in inches.

Answer.

From the particulars found in the preceding example, find how many stretches per minute the mule will make.

Worked out by Cancellation.

1·5·15·75	180·3·1
1·60	70·17.5·3.5
1·4·12	20·5·1
1·4	3·1

3.5

Answer.

The same without Cancellation.

$$\text{Dividend} \; . \; . \; . \; . \; \frac{180 \times 70 \times 20 \times 3}{75 \times 60 \times 12 \times 4} = 3.5 \; . \; . \; . \; . \; . \; \text{Divisor}$$

Answer.

The cam that permits the belt to pass from the fast to the loose pulley makes one revolution per stretch. On the same axis with the cam there is a wheel that takes into a wheel with 36 teeth on the worm-wheel-shaft. On the worm-wheel-shaft there is also a wheel that takes into a worm on the twist-shaft. How many teeth should there be in the wheel on the cam-shaft, and the wheel that takes into the worm, to permit the twist-shaft to make 75 revolutions per stretch?

Worked out.

75 Revolutions per stretch of the twist-shaft.
36 Teeth in the driving wheel on the worm-wheel-shaft.

```
                75
                36
               ---
               450
              225
              ----
B . . . . .  5)2700
             ------
A . . . . . . 5)540
              -----
A . . . . . . 3)108
              -----
A . . . . . .  3)36
               ----
B . . . . . .  3)12
               ----
B . . . . . .   4)4
                 --
                  1
```

A. $5 \times 3 \times 3 = 45$ Teeth in the wheel that takes into the worm.

B. $5 \times 3 \times 4 = 60$ Teeth in the wheel on the cam-shaft.

Answer.

From the particulars found in the preceding example, find how many revolutions the twist-shaft makes per stretch.

Worked out by Cancellation.

	45·15
1·3·36	60·5

$15 \times 5 = 75$ Answer.

The same without Cancellation.

Dividend . . . . Divisor . . . . $\dfrac{45 \times 60}{36} = 75$

Answer.

The twist-shaft has on a wheel with 21 teeth that, by means of an intermediate, takes into a wheel on the front-roller. How many teeth are there in the wheel on the front-roller, if 68 revolutions of the twist-shaft turn out 59.816064 inches, the front-roller being one inch in diameter?

	68 Revolutions of the twist-shaft.
	21 Teeth in the wheel on the twist-shaft.
Length turned out, in inches . . . 59.816064	1, Diameter of the front-roller, in inches.
	3.1416 Circumference.

Worked out by Cancellation.

	68·34·17·1
	21·75
1·.28·4.76·9.52·19.04·59.816064	1
	3.1416·1

75

Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{68 \times 21 \times 3.1416}{59.816064} = 75$
Divisor . . . .

Answer.

The wheel that takes into the worm has 45 teeth. On the same axis with this wheel there is a wheel with 36 teeth that takes into a wheel with 60 teeth, on the cam-shaft. The spindle-warl is one inch, and the twist-pulley

17 inches in diameter, and the length of the stretch is 59.816064 inches. Required the twist per inch in the yarn.

	45 Teeth in the wheel that takes into the worm.
Teeth in the wheel on the same axis with the wheel that takes into the worm . . 36	60 Teeth in the wheel on the cam-shaft.
Diameter of the spindle warl, in inches . . 1	17, Diameter of the twist-pulley, in inches.
Length of the stretch, in inches . . 59.816064	

Worked out by Cancellation.

	45·15·21.31 +
1·3·36	60·5·1
1	17·1
1·.7037184·3.518592·59.816064	

21.31 +

Answer.

The same without Cancellation.

Dividend	$45 \times 60 \times 17$	$= 21.31+$
Divisor	36×59.816064	

Answer.

The Mason's Mule is so constructed as to take in and out the carriage by means of a spur-wheel and chain. The wheel has a certain number of spurs, and each spur takes into a link in the chain, and, taken together, they are, in effect, equal to a pulley and band 3 inches in effective diameter. On the same axis with the spur-wheel (the back shaft), there is a wheel driven from a wheel with 28 teeth, on an intermediate shaft. On the intermediate shaft there is also a wheel driven from a wheel with 30 teeth on the same axis with the front-roller. How many teeth are there in the wheel on the back shaft, and the driven wheel on the intermediate shaft, if the surface velocity of the front-roller and the traverse of the carriage are equal, the front-roller being one inch in diameter?

Worked out.

	28 Teeth in the driving wheel, on the intermediate shaft.
	30 Teeth in the wheel on the same axis with the front-roller.
Diameter of the front-roller, in inches . . 1	3, Effective diameter of the spur-wheel and chain, in inches.

```
                  28
                  30
                 ———
                 840
                   3
               —————
A . . . . .  12)2520
               —————
A . . . . . .  6)210
                ————
B . . . . . .  35)35
                  ——
                   1
```

A. 12 × 6 ═══ 72 Teeth in the driven wheel, on the intermediate shaft.

B. 35 ═══ 35 Teeth in the wheel, on the back shaft.

Answer.

From the particulars found in the preceding example, find how many inches the carriage will be taken out while the rollers deliver 59.816064 inches.

Worked out by Cancellation.

	59.816064
1·3·12·72	30·5·1
1·5·35	28·7·1
	3·1

59.816064

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \quad . & 59.816064 \times 30 \times 28 \times 3 \\ \text{Divisor} \quad . \quad . & 72 \times 35 \end{array} = 59.816064$$

Answer.

The wheel on the front-roller for taking out the carriage has 30 teeth, and the rollers deliver 59.816064 inches per stretch. How many inches will the rollers deliver with a wheel with 32 teeth?

Worked out by Cancellation.

$$\begin{array}{r|l} & 59.816064 \cdot 14.954016 \\ 1 \cdot 4 \cdot 32 & 30 \cdot 3.75 \end{array}$$

$$14.954016 \times 3.75 = 56.07756$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \quad . \quad . \quad . \quad . & 59.816064 \times 30 \\ \text{Divisor} \quad . \quad . \quad . \quad . & 32 \end{array} = 56.07756$$

Answer.

The front-roller delivers 56.07756, and the length of the stretch is 59.816064 inches. How many inches does the carriage gain per stretch?

$$\begin{array}{r} 59.816064 \\ 56.077560 \\ \hline 3.738504 \end{array}$$

Answer.

From the particulars found in the preceding example, find the draught at the carriage.

Worked out by Cancellation.

$$\frac{1{\cdot}56.07756 \mid 59.816064{\cdot}1.06}{1.06}$$

Answer.

The spur-wheel on the back shaft, and the chain by which the carriage is taken in and out are, in effect, equal to a pulley and band 3 inches in effective diameter. On the back shaft there is a wheel that takes into a wheel with 168 teeth, on an intermediate shaft. On the intermediate shaft there is a wheel that takes into the bottom sliding-rack. The relative velocity of the bottom to that of the top sliding-rack is as 5 to 4. On a second intermediate shaft there is a wheel with 21 teeth that takes into the top sliding-rack. On this shaft there is also a wheel that takes into a wheel with 24 teeth, on the same axis with the twist-pulley. How many teeth should there be in the wheel on the back shaft, the wheel that takes into the bottom sliding-rack, and the wheel on the second intermediate shaft that takes into the wheel on the same axis with the twist-pulley; and what should be the diameter of the twist-pulley and the spindle, to give the bare spindle a surface velocity equal to the velocity of the carriage while going in, the spindle-warl being one inch in diameter?

N.B.—There is nothing between the twist-pulley and the spindle-warl that needs to be taken into consideration in solving the above problem.

	3, Effective diameter of the spur-wheel and chain, in inches.
	168 Teeth in the wheel that takes into the wheel, on the back shaft.
	21 Teeth in the wheel that takes into the top sliding-rack.
	24 Teeth in the wheel on the same axis with the twist-pulley.
	1, Diameter of the spindle-warl, in inches.
Relative velocity of the top sliding-rack . . 4	5, Relative velocity of the bottom sliding-rack.

Worked out.

	3
	168
	21
	24·6
	1
1·4	5

```
                          168
                            3
                          ---
                          504
                           21
                          ---
                          504
                         1008
                        -----
                        10584
                            6
                        -----
                        63504
                            5
                      -------
E  .  .  .5)317520.0
                      -------
E  .  .  .5)635040.0
                      -------
D  .  .  .  7)1270080
                      -------
A  .  .  .  .  .  .  7)181440
                      -------
```

(Continued.)

C	. . . . . .	12)25920
A	. . . . . .	5)2160
D	. . . . . .	2)432
C	. . . . . .	8)216
B	. . . . . .	27)27
		1

A. $7 \times 5 = 35$ Teeth in the wheel on the back shaft.

B. $27 = 27$ Teeth in the wheel that takes into the bottom sliding-rack.

C. $12 \times 8 = 96$ Teeth in the wheel on the second intermediate shaft, that takes into the wheel on the same axis with the twist-pulley.

D. $7 \times 2 = 14$, Diameter of the twist-pulley in inches.

E. $.5 \times .5 = .25$, Diameter of the spindle, in inches.

From the particulars found in the preceding example, find how much yarn will be wound on to the bare spindle while the spur-wheel takes in 59.816064 inches of chain.

Worked out by Cancellation.

	59.816064
1·3·12·3	.25·1
1·14·168	35·7·1

(*Continued.*)

	27·9·3·1
1·5	4·1
1·3·21	
1·3·24	96·8·1
1	14·1

59.816064 inches. Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Div.} & \dfrac{59.816064 \times .25 \times 35 \times 27 \times 4 \times 96 \times 14}{3 \times 168 \times 5 \times 21 \times 24} = 59.816064 \\ \text{Divisor,} & \end{array}$$

Answer.

From the particulars found in the preceding example, find how many inches of chain will be taken in per stretch of 59.816064 inches.

Worked out by Cancellation.

	59.816064
1·.25	3·1
1·5·35	168·14·1
1·3·9·27	
1·4	5·20·5·1
	21·7·1
1·8·96	24·3·1
1·14	

59·816064 Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend,} & \dfrac{59.816064 \times 3 \times 168 \times 5 \times 21 \times 24}{.25 \times 35 \times 27 \times 4 \times 96 \times 14} = 59.816064 \\ \text{Divisor,} & \end{array}$$

Answer.

From the particulars found in the preceding example, find the diameter of the twist-pulley.

Worked out by Cancellation.

	1
1·7·35	168·14
1·.25	3·1
	21·3·1
1·4	5·1
1·3·9·27	
1·8·96	24·3·12·3·1

14 inches. Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . . } & \dfrac{168 \times 3 \times 21 \times 5 \times 24}{35 \times .25 \times 4 \times 27 \times 96} = 14 \text{ inches.} \\ \text{Divisor . . . } & \end{array}$$

Answer.

From the particulars found in the preceding example, find the diameter of the spindle.

Worked out by Cancellation.

	3·1
	21·7·1
1·4	5·1
1·3·9·27	
1·8·96	24·3·1
1·5·35	168·14·1
1·14	1·.25

.25 = $\frac{1}{4}$ of an inch.

Answer.

The same without Cancellation.

Dividend . . $3 \times 21 \times 5 \times 24 \times 168$
Divisor . . . $4 \times 27 \times 96 \times 35 \times 14$ = .25

$$\frac{3 \times 21 \times 5 \times 24 \times 168}{4 \times 27 \times 96 \times 35 \times 14} = .25$$

Answer.

How many revolutions must the spindle make to wind the yarn on to the bare spindle while the carriage is going in, the diameter of the spindle being a quarter of an inch, and the length of the stretch 59.816064 inches?

Worked out by Cancellation.

1·.25	59.816064·19.04·76.16
1·3.1416	

76.16 Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{59.816064}{3.1416 \times .25} = 76.16$
Divisor . . . . . .

Answer.

Find how many inches of chain the spur-wheel will take in, while the spindle makes 76.16 revolutions.

Worked out by Cancellation.

	76.16·19.04
1·14	
1·8·96	24·3·1
	21·7·1
1·4	5·1
1·3·9·27	
1·5·35	168·14·1
	3·1
	3.1416

$$3.1416 \times 19.04 = 59.816064$$

Answer.

The same without Cancellation.

Div., $\dfrac{76.16 \times 24 \times 21 \times 5 \times 168 \times 3 \times 3.1416}{14 \times 96 \times 4 \times 27 \times 35} = 59.816064$
Divisor,

Answer.

The length of the cop is regulated more or less by the copping-rail and shaper, and not wholly by the length of traverse of the nut on the screw in the recess of the builder. It is found by observation that a well proportioned and well built cop, having on 630 stretches of No. 40 filling, will measure from extreme point to extreme point, as much more than the traverse of said nut, as 19 is more than 14. On the same axis with the screw in the recess of the builder, there is a wheel that takes into a wheel with 27 teeth. On the same axis with the latter wheel there is a spur-wheel that moves one spur per stretch. How many threads per inch are there in the screw; how many teeth in the wheel on the same axis with the screw; how many spurs in the spur-wheel, and what is the length of the cop, if it contains 630 stretches, and the traverse of the nut on the screw in the recess of the builder, is to the length of the cop as 14 to 19?

	630 Stretches on the cop.
	27 Teeth in the wheel that takes into the wheel on the same axis with the screw.
Proportionate length of traverse of the nut in the recess of the builder 14	19, Proportionate length of the cop.

Worked out.

	630·90·45
	27
1·2·14	19

```
                 45
                 27
                ---
                315
                90
               ----
               1215
                 19
              -----
              10935
              1215
              -----
A . . . .   3)23085
            -------
B   . . .    6)7695
             ------
C . . .     3)1282.5
            --------
C . . .      3)427.5
             -------
B . . . .   10)142.5
            --------
A . . . .     3)14.25
              -------
D . .       4.75)4.75
                 ----
                    1
```

A. $3 \times 3 = 9$ Threads per inch in the screw.

B. $10 \times 6 = 60$ Teeth in the wheel on the same axis with the screw.

C. $3 \times 3 = 9$ Spurs in the spur-wheel.

D. $4.75 = 4.75$, The length of the cop, in inches.

Answer.

From the particulars found in the preceding example, find the length of the cop, in inches.

Worked out by Cancellation.

1·9	63(0·9·1
1·2·6(0	27·9·4.5·1
1·2·14	19·9.5·4.75
1·2·9	

4.75

Answer.

The same without Cancellation.

$$\begin{array}{l} \text{Dividend} \ldots\ldots \\ \text{Divisor} \ldots\ldots \end{array} \quad \frac{630 \times 27 \times 19}{9 \times 60 \times 14 \times 9} = 4.75$$

Answer.

From the particulars found in the preceding example, find the number of stretches on a cop.

Worked out by Cancellation.

	4.75·1
	9·3
1·3·27	60·15
	9·1
1·4.75·19	14

$$15 \times 14 \times 3 = 630$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;. & \dfrac{4.75 \times 9 \times 60 \times 9 \times 14}{27 \times 19} = 630 \\ \text{Divisor} \;.\;.\;. & \end{array}$$

Answer.

From the particulars found in the preceding example, find the number of threads per inch in the screw.

Worked out by Cancellation.

1·4.75	
	63(0·7·1
1·3·6(0	27·9
1·9	
1·2·14	19·4·2·1

$$9$$

Answer.

The same without Cancellation.

Dividend . . . . . .
Divisor . . . .

$$\frac{630 \times 27 \times 19}{4.75 \times 60 \times 9 \times 14} = 9$$

Answer.

From the particulars found in the preceding example, find the number of teeth in the wheel on the same axis with the screw.

Worked out by Cancellation.

	630·70·10
1·9	
	27·3
1·9	
1·2·14	19·4·2
1·4.75	

$$10 \times 3 \times 2 = 60$$

Answer.

The same without Cancellation.

Dividend . . . . . .
Divisor . . . .

$$\frac{630 \times 27 \times 19}{9 \times 9 \times 14 \times 4.75} = 60$$

Answer.

The back-roller is seven-eighths of an inch in diameter. The front-roller wheel has 30, and the change-wheel 36 teeth. How many teeth should there be in the top-carrier and the back-roller wheel, and what should be the diameter of the front-roller to produce a draught of 9?

Worked out.

7,	Back-roller in eighths of an inch.
30	Teeth in the front-roller wheel.
36	Teeth in the change-wheel.
9,	Draught.

```
             36
             30
           ----
           1080
              7
           ----
           7560
              9
          -----
A . . . . 4)68040
          -------
A . . . . 2)17010
          -------
B . . . .  5)8505
           ------
B . . . .  3)1701
           ------
```

(*Continued.*)

B . . . . . 7)567

C . . . . 81)81

1

A. $4 \times 2 = 8$, Diameter of the front-roller, in eighths of an inch.

B. $5 \times 3 \times 7 = 105$ Teeth in the top-carrier.

C. $81 = 81$ teeth in the back-roller wheel.

Answer.

From the particulars found in the preceding example, find the draught between the back and the front rollers.

Worked out by Cancellation.

1·7	8·4·1
1·2·30	105·15·1
1·9·36	81·9

9

Answer.

The same without Cancellation.

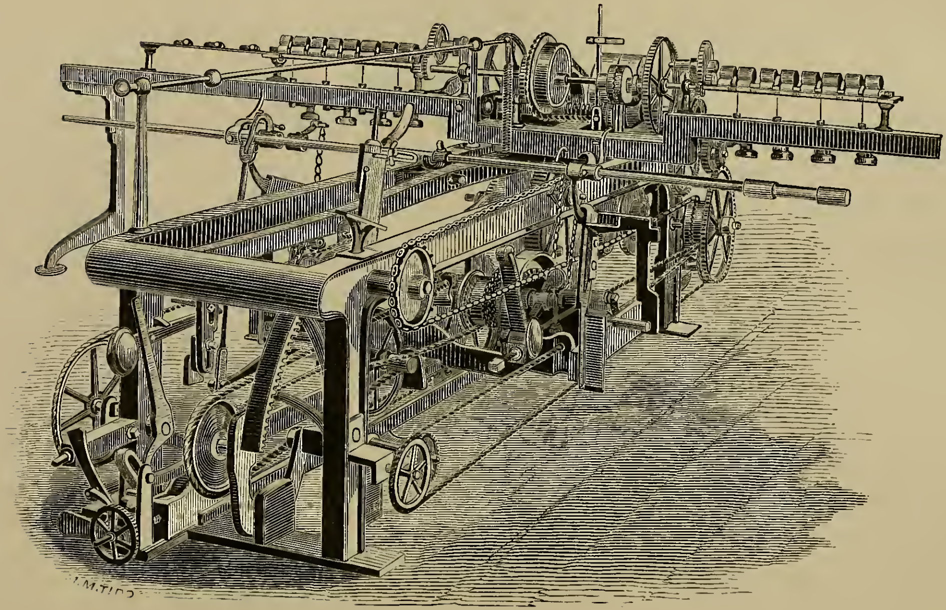
Dividend . . . .
Divisor . . . .
$$\frac{8 \times 105 \times 81}{7 \times 30 \times 36} = 9$$

Answer.

THE FRANKLIN MULE.

A mule is driven from an upright shaft making 180 revolutions per minute, by a train of three pairs of pulleys, and one pair of wheels. The driven wheel has 64 teeth, and the respective diameters of the driven pulleys are 20, 18, and 12 inches. How many teeth should there be in the driving wheel, and what should be the respective diameters of the driving pulleys, to drive the mule $3\frac{1}{4}$ stretches per minute, the twist-shaft making 72 revolutions per stretch, and the time occupied in drawing out and twisting being three-quarters of the time necessary to perform the whole stretch?

Revolutions of the upright shaft per minute, 180	72 Revolutions of the twist-shaft per stretch.
	3.25 Stretches per minute.
Time occupied in drawing out and twisting, 3	4 Time occupied in performing the whole stretch.
	64 Teeth in the driven wheel.
	20, Diameter of the first driven pulley, in inches.
	18, Diameter of the second driven pulley, in inches.



FRANKLIN MULE.

	12, Diameter of the third driven pulley (which is on the twist-shaft), in inches.

Worked out.

1·18(0	72·24
	3.25
1·3	4
	64
	2(0
	18·1
	12

```
 3.25
   24
 ----
 1300
 650
 ----
78.00
   4
 ----
 312
  64
 ----
1248
1872
----
```

(*Continued.*)

```
                 19968
                     2
                 -----
                 39936
                    12
                 -----
                 79872
                39936
                ------
A . . .       12)479232
               -------
A . . . .       6)39936
                 -----
        D . . . 8)6656
                  ----
        D . . .  2)832
                   ---
      C . . . .  2)416
                   ---
      C . . . . 10)208
                   ---
     B . . . .   20.8)20.8
                      ----
                         1
```

A. $12 \times 6 = 72$ Teeth in the driving wheel.

B. $20.8 = 20.8$, Diameter of the first driving pulley, in inches.

C. $10 \times 2 = 20$, Diameter of the second driving pulley, in inches.

D. $8 \times 2 = 16$, Diameter of the third driving pulley, in inches.

Answer.

A mule is driven from an upright shaft making 180 revolutions per minute, by a train of three pairs of pulleys and one pair of wheels; the driving wheel has 72, and the driven wheel 64 teeth. The respective diameters of the driving pulleys are 20.8, 20, and 16, and the driven pulleys 20, 18, and 12 inches. How many stretches per minute does the mule make, allowing the last driven pulley (which is on the twist-shaft), to make 72 revolutions per stretch, and the time occupied in drawing out and twisting being three-quarters of the time necessary to perform the whole stretch?

Revolutions of the twist-shaft per stretch . . 72	180 Revolutions of the upright shaft per minute.
Time occupied in performing the whole stretch 4	3, Time occupied in drawing out and twisting.
Teeth in the driven wheel 64	72 Teeth in the driving wheel.
Diameter of the first driven pulley, in inches 20	20.8, Diameter of the first driving pulley, in inches.
Diameter of the second driven pulley, in inches 18	20, Diameter of the second driving pulley, in inches.

Diameter of the third driven pulley (which is on the twist-shaft), in inches 12	16, Diameter of the third driving pulley, in inches.

Worked out by Cancellation.

1·72	18(0·1
1·4	3·1
1·8·64	72·1
1·2(0	20.8·2.6
1·18	20·10·1.25
1·3·12	16·4·1

$2.6 \times 1.25 = 3.25$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;. & 180 \times 3 \times 72 \times 20.8 \times 20 \times 16 \\ \hline \text{Divisor} \;.\;. & 72 \times 4 \times 64 \times 20 \times 18 \times 12 \end{array} = 3.25$$

Answer.

The twist-pulley is 17 inches in diameter, makes 72 revolutions per stretch, and drives the pulley on the drum-shaft. On the drum-shaft there is a wheel with 50 teeth that takes into a wheel on the same axis with the drum; the drum is 10 inches in diameter, and drives the spindles. How many teeth should there be in the wheel on the same axis with the drum ; what should be the diameter of the pulley on the drum-shaft, and the spindle-warl, and what should be the length of the stretch to put 20 turns of twist per inch into the yarn ?

	72 Revolutions per stretch of the twist-pulley.
	17, Diameter of the twist-pulley, in inches.
	50 Teeth in the wheel on the drum-shaft.
	10, Diameter of the drum in inches.
Turns of twist per inch in the yarn 20	

Worked out.

	72·36
	17
	50
	1(0
1·2(0	

36
17
——

(*Continued.*)

	252
	36
	612
	50
A	10)30600
B. . . .	10)3060
B	2)306
B.	3)153
C	51)51
D	1

A. 10 = 10, Diameter of the pulley on the drum-shaft, in inches.

B. $10 \times 2 \times 3$ = 60, Length of the stretch, in inches.

C. 51 = 51 Teeth in the wheel on the same axis with the drum.

D. 1 = 1, Diameter of the spindle-warl, in inches.

Answer.

The twist-pulley makes 72 revolutions per stretch, is 17 inches in diameter, and drives the pulley on the drum-shaft which is 10 inches in diameter. On the drum-shaft there is a wheel with 50 teeth that takes into a wheel with 51 teeth, on the same axis with the drum. The drum is 10 inches in diameter and drives the spindles, the warls of which is one inch in diameter. How many turns of twist per inch is there in the yarn, the length of the stretch being 60 inches ?

		72	Revolutions per stretch of the upright shaft.
Diameter of the pulley on the drum-shaft, in inches	10	17,	Diameter of the twist-pulley, in inches.
Teeth in the wheel on the same axis with the drum	51	50	Teeth in the wheel on the drum-shaft.
Diameter of the spindle-warl, in inches . .	1	10,	Diameter of the drum, in inches.
Length of the stretch, in inches	60		

Worked out by Cancellation.

	72·12·4
1(0	17·1
1·17·51	5(0
1	1(0
1·6(0	

5 × 4 = 20

Answer.

The same without Cancellation.

$$\text{Dividend} \;.\;.\;.\;.\;.\;.\; \frac{72 \times 17 \times 50 \times 10}{10 \times 51 \times 60} = 20 \;\text{Divisor}$$

Answer.

The twist-shaft makes 68 revolutions per stretch while in connection with the rollers, and has on a wheel with 18 teeth that, by means of an intermediate, takes into a wheel on the roller-shaft. On the other end of the roller-shaft, there is a wheel with 40 teeth that takes into a wheel on the front-roller. How many teeth should there be in the driven wheel on the roller-shaft, and the wheel on the front-roller, to turn out 60.0831 inches per stretch, the front-roller being one inch in diameter ?

68 Revolutions per stretch of the twist-shaft while in connection with the rollers.

18 Teeth in the wheel on the twist shaft.

40 Teeth in the wheel on the roller-shaft that takes into the wheel on the front-roller.

	1, Diameter of the froller, in inches.
Length turned out per stretch, in inches, 60.0831	3.1416, Circumference.

Worked out.

	68·32
	18·2
	40
1·2.125·19.125·60.0831	1
	3.1416·1

	32
	2
	64
	40
A	4)2560
A	2)640
A	4)320
A	2)80
B	40)40
	1

A. $4 \times 2 \times 4 \times 2 = 64$ Teeth in the driven wheel on the roller-shaft.

B. 40 ═ 40 Teeth in the wheel on the front-roller.

Answer.

The twist-shaft makes 68 revolutions per stretch while in connection with the rollers, and has on a wheel with 18 teeth that takes into a wheel with 64 teeth, on the roller-shaft. On the other end of the roller-shaft there is a wheel with 40 teeth, that takes into a wheel with 40 teeth, on the front-roller. How many inches will be turned out per stretch, the front-roller being one inch in diameter?

	68 Revolutions per stretch of the twist-shaft while in connection with the rollers.
Teeth in the driven wheel on the roller-shaft 64	18 Teeth in the wheel on the twist-shaft.
Teeth in the wheel on the front-roller . . 40	40 Teeth in the driving wheel on the roller-shaft.
	1, Diameter of the front-roller, in inches.
	3.1416 Circumference.

Worked out by Cancellation.

	68·17
1·8·16·64	18·9
1·40	40·1
	1
	3.1416·.3927

$17 \times 9 \times .3927 = 60.0831$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . . .} & \dfrac{68 \times 18 \times 40 \times 3.1416}{64 \times 40} = 60.0831 \\ \text{Divisor . . .} & \end{array}$$

Answer.

The front-roller is one inch in diameter, and has on a wheel that takes into a wheel with 40 teeth, on the roller-shaft. On the other end of the roller-shaft there is a wheel that takes into a wheel with 64 teeth, on the drawing-out shaft. On the other end of the drawing-out shaft there is a wheel that takes into a wheel with 40 teeth, on the scroll-shaft. How many teeth should there be in the wheel on the front-roller, the wheel on the roller-shaft that takes into the wheel on the drawing-out shaft, and the wheel that takes into the wheel on the scroll-shaft; and what should be the diameter of the scroll to give it a surface velocity equal to that of the front-roller?

40 Teeth in the wheel on the roller-shaft that takes into the wheel on the front-roller.

64 Teeth in the wheel on the drawing-out shaft that takes into the wheel on the roller-shaft.

40 Teeth in the wheel on the scroll-shaft.

1, Diameter of the front-roller, in inches.

Worked out.

```
                 64
                 40
               ----
               2560
                 40
             ------
C . . . 10)102400
             ------
A . . . . . 10)10240
             ------
A . . . . . . 2)1024
              -----
A . . . . . .  2)512
                ---
```

(*Continued.*)

C	2)256
B	2)128
B	2)64
B	2)32
B	2)16
B	2)8
D	2)4
D	2)2
	1

A. $10 \times 2 \times 2 = 40$ Teeth in the wheel on the front-roller.

B. $2 \times 2 \times 2 \times 2 \times 2 = 32$ Teeth in the wheel on the roller-shaft, that takes into the wheel on the drawing-out shaft.

C. $10 \times 2 = 20$ Teeth in the wheel that takes into the wheel on the scroll-shaft.

D. $2 \times 2 = 4$, Diameter of the scroll, in inches.

Answer.

The front-roller is one, and the scroll is 4 inches in diameter. The front-roller has on a wheel with 40 teeth that takes into a wheel with 40 teeth, on the roller-shaft. On the other end of the roller-shaft there is a wheel with 32 teeth that takes into a wheel with 64 teeth, on the drawing-out shaft. On the other end of the drawing-out shaft there is a wheel with 20 teeth that takes into a wheel with 40 teeth, on the scroll-shaft. What is the surface velocity per stretch of the scroll, if that of the front-roller is 60.0831?

N.B.—In practice it is necessary to add the diameter of the drawing-out band to that of the scroll.

		60.0831,	Surface velocity per stretch of the front-roller.
Diameter of the front-roller, in inches . .	1	4,	Diameter of the scroll, in inches.
Teeth in the wheel on the roller-shaft, that takes into the wheel on the front-roller .	40	40	Teeth in the wheel on the front-roller.
Teeth in the wheel on the drawing-out shaft that takes into the wheel on the roller-shaft	64	32	Teeth in the wheel on the roller-shaft, that takes into the wheel on the drawing-out shaft.
Teeth in the wheel on the scroll-shaft . .	40	20	Teeth in the wheel on the drawing-out shaft, that takes into the wheel on the scroll-shaft.

Worked out by Cancellation.

	60.0831
1	4·1
1·40	40·1
1·2·64	32·1
1·4(0	2(0·1

60.0831 Answer.

The same without Cancellation.

Dividend . Divisor . .

$$\frac{60.0831 \times 4 \times 40 \times 32 \times 20}{40 \times 64 \times 40} = 60.0831$$

Answer.

The spindle is $\frac{6}{25}$, the spindle-warl is one, and the drum is 10 inches in diameter. On the same axis with the drum there is a wheel with 51 teeth that takes into a wheel with 50 teeth, on the drum-shaft. On the drum-shaft there is also a wheel that takes into a wheel with 34 teeth, on the same axis with the winding-on drum. How many teeth should there be in the wheel on the drum-shaft that takes into the wheel on the same axis with the winding-on drum; and what should be the diameter of the winding-on drum, to give it a surface velocity equal to that of the bare spindle, when winding on the first stretch of yarn?

	.24, Diameter of the spindle, in inches.
Diameter of the spindle-warl, in inches . . 1	10, Diameter of the drum, in inches.
Teeth in the wheel on the same axis with the drum 51	50 Teeth in the wheel on the drum shaft that takes into the wheel on the same axis with the drum.
	34 Teeth in the wheel on the same axis with the winding-on drum.

Worked out.

	.24·.08
1	10
1·3·51	50
	34·2

50
2
———
100
10
———
1000
.08
———

(Continued.)

A . . . . . 10)80.00

A . . . . 2)8

B . . . . . . 4)4

1

A. $10 \times 2 = 20$ Teeth in the wheel on the drum-shaft that takes into the wheel on the same axis with the winding-on drum.

B. $4 = 4$, Diameter of the winding-on drum, in inches. Answer.

The spindle is $\frac{6}{25}$ of an inch in diameter, and has on a warl one inch in diameter, driven from a drum 10 inches in diameter. On the same axis with the drum there is a wheel with 51 teeth that takes into a wheel with 50 teeth, on the drum-shaft. On the drum-shaft there is a wheel with 20 teeth that takes into a wheel with 34 teeth, on the same axis with the winding-on drum. What is the surface velocity of the spindle when winding on the first stretch of yarn, if the winding-on drum throws off 60.0831 inches of chain, the winding-on drum being 4 inches in diameter?

| 60.0831 Inches of chain thrown off when winding on the first stretch of yarn.

Diameter of the spindle, in inches	.24	4,	Diameter of the winding-on drum, in inches.
Teeth in the wheel on the same axis with the winding-on drum	34	20	Teeth in the wheel on the drum-shaft that takes into the wheel on the same axis with the winding-on drum.
Teeth in the wheel on the drum-shaft that takes into the wheel on the same axis with the drum	50	51	Teeth in the wheel on the same axis with the drum.
Diameter of the drum, in inches	10	1,	Diameter of the spindle-warl, in inches.

Worked out by Cancellation.

	60.0831
1·.24	4·1
1·2·8.5·34	2(0·1
1·50	51·212.5·4.25·1
1(0	1

60.0831 Answer.

The same without Cancellation.

$$\frac{\text{Dividend} \quad 60.0831 \times 4 \times 20 \times 51}{\text{Divisor} \quad .24 \times 34 \times 50 \times 10} = 60.0831$$

Answer.

DRESSING-MACHINE.

A dresser is driven from an upright shaft, making 180 revolutions per minute, by a train of three pairs of pulleys and one pair of wheels; the driving wheel has 96 teeth, and the driving pulleys are 20, 18, and 10 inches in diameter, respectively. How many teeth should there be in the driven wheel; and what should be the diameter of the driven pulleys, respectively, to drive the first driven shaft of the dresser 100 revolutions per minute?

Revolutions of the first driven shaft of the dresser per minute . 100	180 Revolutions of the upright shaft per minute. 96 Teeth in the driving wheel. 20, Diameter of the first driving pulley, in inches. 18, Diameter of the second driving pulley, in inches. 10, Diameter of the third driving pulley, in inches.

Worked out.

1(00	180
	96
	2(0
	18
	1(0

```
            180
             96
           ----
           1080
          1620
          -----
          17280
              2
          -----
          34560
             18
         ------
         276480
         34560
         ------
B . . . 10)622080
         ------
B . . . .  3)62208
          -----
```

(*Continued.*)

C	3)20736
A	4)6912
A	2)1728
A	2)864
A	4)432
C	3)108
C	3)36
D	12)12
	1

A. $4 \times 2 \times 2 \times 4 = 64$ Teeth in the driven wheel.

B. $10 \times 3 = 30$, Diameter of the first driven pulley, in inches.

C. $3 \times 3 \times 3 = 27$, Diameter of the second driven pulley, in inches.

D. $12 = 12$, Diameter of the third driven pulley, in inches.

Answer.

From the particulars found in the preceding example, find the revolutions per minute of the first driven shaft of the dresser.

Worked out by Cancellation.

	18(0·6·2
1·2·8·64	96·12·1
1·3(0	20·5
1·9·27	18·2·1
1·12	10

$$10 \times 5 \times 2 = 100$$

Answer.

The same without Cancellation.

Dividend . . . $\dfrac{180 \times 96 \times 20 \times 18 \times 10}{64 \times 30 \times 27 \times 12} = 100$
Divisor . . . .

Answer.

The first driven shaft makes 100 revolutions per minute, and drives the centre beam by a train of 4 pairs of wheels and one pair of cones. The large end of the driving cone is 9 inches in diameter, and the driving wheels have 50, 20, 20, and 20 teeth respectively. What should be the diameter of the small end of the driven cone; and how many teeth should there be in the driven wheels, respectively, to give the empty beam a surface velocity of 4 yards per minute, the beam being 5 inches in diameter?

	100 Revolutions per minute of the first driven shaft.

	9, Diameter of the large end of the driving cone, in inches.
	50 Teeth in the first driving wheel.
	20 Teeth in the second driving wheel.
	20 Teeth in the third driving wheel.
	20 Teeth in the fourth driving wheel.
Inches in one yard . . 36	5, Diameter of the empty beam, in inches.
	3.1416, Circumference.
Surface velocity per minute of the empty beam, in yards . . 4	

Worked out.

	100
	9·3
	50
	20
	20
	20·5
1·3·36	5
	3.1416·.2618
1·4	

```
                  .2618
                      5
                 ------
                 1.3090
                      5
                 ------
                 6.5450
                     20
               --------
               130.9000
                     20
              ---------
              2618.0000
                     50
           ------------
            130900.0000
                      3
           ------------
            392700.0000
                    100
         --------------
E .   10)39270000.0000
         --------------
E . . .      10)3927000
              ---------
B . . . . . . 5)392700
               --------
B . . . . . .  5)78540
                -------
```

(Continued.)

B	2)15708
D	2)7854
C	5)3927
C	2)785.4
C	5)392.7
D	5)78.54
D	3)15.708
A	5.236)5.236
	1

A. 5.236 = 5.236, Diameter of the small end of the driven cone, in inches.

B. $5 \times 5 \times 2 = 50$ Teeth in the first driven wheel.

C. $5 \times 2 \times 5 = 50$ Teeth in the second driven wheel.

D. $5 \times 3 \times 2 = 30$ Teeth in the third driven wheel.

E. $10 \times 10 = 100$ Teeth in the beam-flange, or fourth driven wheel.

Answer.

From the particulars found in the preceding example, find the surface velocity of the empty beam per minute.

Worked out by Cancellation.

	100·1
1·2.618·5.236	9·1
1·50	50·1
1·5(0	2(0·1
1·3(0	2(0
1·100	20·5
1·4·36	5·1
	3.1416·1.2·.4

$$5 \times 2 \times .4 = 4 \text{ yards.}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Div.,} & \dfrac{100 \times 9 \times 50 \times 20 \times 20 \times 20 \times 5 \times 3.1416}{5.236 \times 50 \times 50 \times 30 \times 100 \times 36} = 4 \text{ yards.} \\ \text{Divisor,} & \end{array}$$

Answer.

N.B.—The surface velocity of the empty beam, as shown in the preceding example, is as quick as will probably ever be required for any kind of work; in practice it is found necessary to vary the velocity according to circumstances, such as facilities for drying, fineness of yarn, and the progressively increasing size of the beam, which is done by causing the belt to traverse on the cones.

As some kinds of work requires more wind than others, and as local circumstances has more or less to do with making it effective, it is impossible to lay down any rule that will answer in all cases with respect to quantity. It is estimated by some mechanicians that the circumference of a fan should have a velocity of 2600 yards per minute, to equal a storm of wind; the way to find which or any other velocity that may be required, will be found in the following example:

A fan, one yard in diameter, is driven from an upright shaft making 180 revolutions per minute, by a train of 3 pairs of pulleys and one pair of wheels. The driving pulleys are 42, 39, and 20 inches in diameter, respectively, and the driving wheel has 96 teeth. What should be the diameter of the driven pulleys, respectively, and how many teeth should there be in the driven wheel, to give the circumference of the fan a velocity of 2600 yards per minute?

Velocity of the circumference of the fan per minute, in yards, 2600	180 Revolutions per minute of the upright shaft.
	96 Teeth in the driving wheel.
	42, Diameter of the first driving pulley, in inches.

	39, Diameter of the second driving pulley, in inches.
	20, Diameter of the third driving pulley, in inches.
	1, Diameter of the fan, in yards.
	3.1416, Circumference.

Worked out.

1·13·26(00	18(0·9
	96
	42
	39·3
	2(0
	1
	3.1416

```
  96
   9
────
 864
  42
────
1728
3456
────
```

(Continued.)

36288
3

108864
2

217728
3.1416

1306368
217728
870912
217728
653184

A . . . . . 12)684014.2848

A . . . . . . 7)57001.1904

B . . . . 6)8143.0272

B . . . . 6)1357.1712

C . . . . . . 8)226.1952

C . . . . 4)28.2744

D . . . 7.0686)7.0686

1

A. $12 \times 7 = 84$ Teeth in the driven wheel.

B. $6 \times 6 = 36$, Diameter of the first driven pulley, in inches.

C. $8 \times 4 = 32$, Diameter of the second driven pulley, in inches.

D. $7.0686 = 7.0686$, Diameter of the third driven pulley, or pulley on the same axis with the fan, in inches.

Answer.

From the particulars found in the preceding example, find the velocity per minute of the circumference of the fan.

Worked out by Cancellation.

	180·80·10
1·7·84	96·8
1·6·36	42·6·1
1·4·32	39·6.5
1·2.25·7.0686	20·5
	1
	3.1416·1

$$10 \times 8 \times 5 \times 6.5 = 2600 \text{ yards.}$$

Answer.

The same without Cancellation.

Dividend,
Divisor,
$$\frac{180 \times 96 \times 42 \times 39 \times 20 \times 3.1416}{84 \times 36 \times 32 \times 7.0686} = 2600 \text{ yards.}$$

Answer.

In practice it is found, that on account of shrinkage in weaving a certain kind of cloth, that it takes 1.0472 yards of warp to make one yard of cloth. The warp is measured by the neck-roller, on the end of which there is a worm that takes into a wheel with 100 teeth, and every time the wheel makes a revolution it causes a mark to be made on the warp; this mark indicates where to cut the cloth into lengths called cuts (hence the term cut-mark). What should be the diameter of the neck-roller, to mark the warp into lengths requisite for weaving cuts of cloth 42 yards long ?

	42, Length of a cut of cloth, in yards.
	36 Inches in one yard.
Teeth in the wheel that takes into the worm. 100	
Ratio of circumference to diameter . . 3.1416	
	1.0472, Length of warp required for one yard of cloth, in yards.

Worked out by Cancellation.

	42·4.2·.42
	36·12
1·10·100	

(*Continued.*)

1·3·3.1416	
	1.0472·1

$12 \times .42 = 5.04$ inches.

Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{42 \times 36 \times 1.0472}{100 \times 3.1416} = 5.04$
Divisor . . . .

Answer.

From the particulars found in the preceding example, find the number of yards in a cut of cloth.

Worked out by Cancellation.

1·12·36	5.04·.42
	3.1416·3·1
	100
1·1.0472	

$100 \times .42 = 42$

Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{5.04 \times 3.1416 \times 100}{36 \times 1.0472} = 42$
Divisor . . . . .

Answer.

POWER-LOOM.

A loom is driven from an upright shaft making 180 revolutions per minute, by a train of two pairs of pulleys and one pair of wheels. The driving pulleys are $17\frac{1}{2}$, and 8 inches in diameter, and the driving wheel has 96 teeth. What should be the diameter of the driven pulleys, respectively, and how many teeth should there be in the driven wheel, to drive the loom 140 picks per minute?

Picks per minute of the loom 140	180 Revolutions per minute of the upright shaft.
	96 Teeth in the driving wheel.
	17.5, Diameter of the first driving pulley, in inches.
	8, Diameter of the second driving pulley, in inches.

Worked out.

1·7·14(0	18(0·9
	96
	17.5·2.5
	8

(*Continued.*)

```
                    96
                     9
                   ---
                   864
                     8
                  ----
                  6912
                   2.5
                 -----
                 34560
                13824
                ------
A . . . . . . . 8)17280.0
                ---------
A . . . . . . . . 8)2160
                    ----
    C . . . . . . 12)270
                     ---
   B . . . . . 22.5)22.5
                    ----
                       1
```

A. $8 \times 8 = 64$ Teeth in the driven wheel.

B. $22.5 = 22.5$, Diameter of the first driven pulley, in inches.

C. $12 = 12$, Diameter of the second driven pulley on the crank-shaft of the loom, in inches.

Answer.

From the particulars found in the preceding example, find how many picks per minute the loom will make.

Worked out by Cancellation.

	180·200
1·8·64	96·12·1
1·.9·4.5·22.5	17.5·3.5·.7
1·12	8·1

$200 \times .7 = 140$ Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{180 \times 96 \times 17.5 \times 8}{64 \times 22.5 \times 12} = 140$
Divisor . . . . .

Answer.

The ratchet wheel of the take-up motion has 80 teeth, and takes up one tooth every two picks, and the emery-roller wheel has 90 teeth. How many teeth should there be in the wheel that takes into the emery-roller wheel; and what should be the circumference of the emery-roller to produce cloth with 72 picks per inch?

	80 Teeth in the ratchet-wheel.
	2, Takes up one tooth every two picks.
	90 Teeth in the emery-roller wheel.

Picks per inch in the cloth 72	

Worked out.

	80·10
	2
	90·10
1·9·72	

$$
\begin{array}{lr}
 & 10 \\
 & 10 \\
\hline
 & 100 \\
 & 2 \\
\hline
\text{A} \ldots\ldots & 8)200 \\
\hline
\text{A} \ldots\ldots & 2)25 \\
\hline
\text{B} \ldots\ldots & 12.5)12.5 \\
\hline
 & 1
\end{array}
$$

A. $8 \times 2 = 16$ Teeth in the wheel that takes into the emery-roller wheel.

B. $12.5 = 12.5$, Circumference of the emery-roller, in inches.

Answer.

From the particulars found in the preceding example, find the picks per inch in the cloth.

Worked out by Cancellation.

	80·5·1
	2·4
1·16	90·18
1·.5·2.5·12.5	

$18 \times 4 = 72$

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{80 \times 2 \times 90}{12.5 \times 16} = 72$
Divisor . . . .

Answer.

From the particulars found in the preceding example, find the number of teeth in the ratchet wheel.

Worked out by Cancellation.

1·10·90	16
	12.5·1.25
	72·8·4
1·2	

$16 \times 4 \times 1.25 = 80$

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{16 \times 12.5 \times 72}{90 \times 2} = 80$
Divisor . . . .

Answer.

From the particulars found in the preceding example, find how many picks the loom makes while the ratchet-wheel moves one tooth.

Worked out by Cancellation.

$$\begin{array}{r|l} 1 \cdot 10 \cdot 90 & 16 \cdot 1 \\ & 12.5 \cdot 2.5 \\ & 72 \cdot 8 \cdot .8 \\ 1 \cdot 5 \cdot 80 & \end{array}$$

$$2.5 \times .8 = 2$$

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{16 \times 12.5 \times 72}{90 \times 80} = 2$
Divisor . . . .

Answer.

From the particulars found in the preceding example, find the number of teeth in the emery-roller wheel.

Worked out by Cancellation.

	16·.1
	12.5·2.5
	72·36
1·5·80	
1·2	

$36 \times 2.5 = 90$

Answer.

The same without Cancellation.

Dividend . . . . $16 \times 12.5 \times 72$
Divisor . . . . 80×2

$$\frac{16 \times 12.5 \times 72}{80 \times 2} = 90$$

Answer.

From the particulars found in the preceding example, find the number of teeth in the wheel that takes into the emery-roller wheel.

Worked out by Cancellation.

	90·18·1
	2·1
	80·40·8·16
1·.5·2.5·12.5	
1·2·36·72	

16 Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{90 \times 2 \times 80}{12.5 \times 72} = 16$

Divisor . . . .

Answer.

From the particulars found in the preceding example, find the circumference of the emery-roller.

Worked out by Cancellation.

1·16	90·10
	2·1
	80·5·1.25
1·4·8·72	

$10 \times 1.25 = 12.5$ inches.

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{90 \times 2 \times 80}{16 \times 72} = 12.5$

Divisor . . . .

Answer.

If the circumference of the emery-roller is $12\frac{1}{2}$ inches, what will be its diameter?

$12.5 \div 3.1416 = 3.9788 +$ inches.

Answer.

If a change-wheel with 16 teeth puts in 72 picks per inch, how many picks per inch will a change-wheel with 18 teeth put in?

Worked out by Cancellation.

$$\begin{array}{r|l} & 72{\cdot}4 \\ 1{\cdot}18 & 16 \end{array}$$

$16 \times 4 = 64$ Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{72 \times 16}{18} = 64$

Divisor . . . .

Answer.

The taking-up ratchet-wheel has 96 teeth, and on the same axis there is a wheel that takes into a wheel with 90 teeth, on the same axis with the emery-roller. How many teeth are there in the wheel on the same axis with the ratchet-wheel; and what is the circumference of the emery-roller, if the loom is putting in 100 picks per inch, and taking up one tooth every 2 picks?

	96 Teeth in the ratchet-wheel.
	90 Teeth in the wheel on the same axis with the emery-roller.
Picks per inch in the cloth 100	2 Picks put in while the ratchet-wheel takes up one tooth.

Worked out.

$$\begin{array}{r|l} & 96 \\ & 9(0\cdot.9 \\ 1\cdot10(0 & 2 \end{array}$$

$$\begin{array}{lr} & 96 \\ & .9 \\ \hline & 86.4 \\ & 2 \\ \hline \text{A} \;\ldots\ldots & 5)172.8 \\ \hline \text{A} \;\ldots\ldots & 3)34.56 \\ \hline \text{B} \;\ldots & 11.52)11.52 \\ \hline & 1 \end{array}$$

A. $5 \times 3 = 15$ Teeth in the wheel on the same axis with the ratchet-wheel.

B. $11.52 = 11.52$, Circumference of the emery-roller, in inches.

Answer.

From the particulars found in the preceding example, find the picks per inch in the cloth.

Worked out by Cancellation.

$$
\begin{array}{r|l}
 & 2 \\
 & 96 \cdot 100 \\
1 \cdot 3 \cdot 15 & 90 \cdot 7.5 \cdot 1.5 \cdot .5 \\
1 \cdot .96 \cdot 11.52 &
\end{array}
$$

$$100 \times 2 \times .5 = 100$$

Answer.

The same without Cancellation.

$$
\begin{array}{ll}
\text{Dividend} \;\dots\dots\dots & \dfrac{2 \times 96 \times 90}{15 \times 11.52} = 100 \\
\text{Divisor} \;\dots\dots\dots &
\end{array}
$$

Answer.

The taking-up ratchet-wheel containing 96 teeth takes up one tooth every 2 picks. On the same axis with the taking-up ratchet-wheel there is a wheel with 15 teeth that takes into a wheel on the same axis with the emery-roller containing 90 teeth. The diameter of the emery-roller is to that of the full beam as one to 3. The beam-flange containing 108 teeth takes into a wheel on a horizontal shaft. On the horizontal shaft there is also a wheel with 14 teeth that takes into a worm. On the same axis with the worm there is a wheel with 28 teeth that takes into a wheel on the same axis with the let-off ratchet-wheel; the latter wheel contains 120 teeth. How many teeth should there be in the wheel that takes into the beam-flange, and the wheel on the same axis with the let-off ratchet-wheel, if the latter wheel lets off one tooth per pick while weaving the first lap of a full beam, making no allowance for shrinkage in weaving?

Teeth in the taking-up ratchet-wheel . . . 96	.5, The taking-up ratchet-wheel takes up one tooth every 2 picks, which is equal to one half tooth per pick.
Teeth in the wheel on the same axis with the emery-roller . . 90	15 Teeth in the wheel on the same axis with the taking-up ratchet wheel.
Relative diameter of the full beam 3	1, Relative diameter of the emery-roller.
	108 Teeth in the beam-flange.
	14 Teeth in the wheel that takes into the worm.
	28 Teeth in the wheel that takes into the wheel on the same axis with the let-off ratchet-wheel.
	120 Teeth in the let-off ratchet-wheel.

Worked out.

1·8·96	.5
1·9(0	15·5
1·3	1
	108·9·1
	14
	28
	12(0·1.5

28
1.5
———
140
28
———
42.0
14
———
1680
420
———
588.0
5
———
2940.0
.5

(Continued.)

A	10)1470.00
B	7)147
B	7)21
A	3)3
	1

A. $10 \times 3 = 30$ Teeth in the wheel that takes into the beam-flange.

B. $7 \times 7 = 49$ Teeth in the wheel on the same axis with the let-off ratchet-wheel.

Answer.

From the particulars found in the preceding example, find how many teeth the let-off ratchet-wheel will move while the loom makes one pick.

Worked out by Cancellation.

1·2·8·96	12(0·4·1
	.5
1·9(0	15·5·1
1·3	
1·3·15·30	108·9·1
	14·2·1
1·7·49	28·4·2

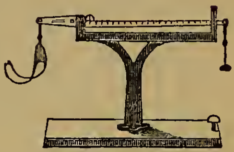
$2 \times .5 = 1$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . . } & \dfrac{120 \times .5 \times 15 \times 108 \times 14 \times 28}{96 \times 90 \times 3 \times 30 \times 49} = 1. \\ \text{Divisor . . . } & \end{array}$$

Answer.

WEIGHING YARN, SLIVER, ETC.



Correct instruments for weighing the sliver, roving, and yarn, in the various branches of carding and spinning, are of such vast importance in the manufacture of cotton that the author has taken the liberty to mention a very excellent kind of scales, made by J. R. Brown & Sharpe, Providence, R. I. They are intended for very delicate weighing, the tenth of a grain being easily estimated by them. Their general construction is so simple that the cut will show it without a description. The length of the beam is about eight inches, and the long arm, which has a small weight sliding upon it, is divided into a hundred parts; these divisions indicate grains, and are numbered so as to be easily read. On the end of the long arm of the beam is a small pan, or hook, on which other weights are placed when more than 100 grains are required to be weighed. The extra weights are numbered 100, 200, 400, and 800, so that any number, from one to 1600 grains, can be weighed by them.

As will be seen, the following tables are all made with a view to using some such scales as the above, but will answer equally well for any scales by which the weight in grains can be ascertained.

The following table for weighing with troy weight, and reckoning by avoirdupois weight, will be found useful to those who use ounces, pennyweights, and grains, with the "beam and pans" scales:

24 grains equal one pennyweight.

18 pennyweights 5½ grains, troy, equal one ounce avoirdupois.

16 ounces equal one pound.

The home-made weights too commonly used, made from bits of tin, wire, lead, or other small pieces of metal, cannot, as a general thing, be depended upon as being very correct, not because they cannot be made a definite weight, but rather because few have the means of making them so. Suppose that for want of sufficiently delicate tools in adjusting a weight of 175 grains, we should happen to make it 176 grains; the difference would be but one grain, yet the consequence would be considerable. 175 grains weight of No. 40 cotton yarn, is 840 yards in length, and 176 grains weight of the same is 844.8 yards in length, a difference of 4.8 yards per hank, or 192 yards per pound. Very true, yarn can be made as regular in size by using such weights; but as to the accuracy of the size, it cannot be called better than a mere guess.


SOCIAL MILLS,
WOONSOCKET, R.I.

PART II.

CARDING.

YARN, ROVING, AND SLIVER TABLES.

54 inches = 1 thread.
4320 inches = 80 = 1 lea.
30240 inches = 560 = 7 = 1 hank, or 840 yards.

Counts of yarn and hank-roving signify the number of hanks in one pound.

Whatever number of yards are weighed, multiply them by the number of grains in one pound avoirdupois, for a dividend, and their weight in grains by the number of yards in one hank for a divisor, and the quotient will be the number.

One hank contains 840 yards, and one pound avoirdupois contains 14 ozs. 11 dwts. 16 grains, troy, or 7000 grains. Hence, the yards in one hank are to the grains in one pound as 840 is to 7000, or 12 to 100.

N.B.—See tables on page 281.

Example.

If 50400 yards weigh one pound, what is the number?

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot 7(000 & 5040(0\cdot 720\cdot 60 \\ 1\cdot 12 & 1(00 \end{array}$$

$$60$$

Answer.

The same without Cancellation.

$$\text{Dividend} \; . \; . \; . \; . \; . \; . \; . \quad \frac{50400 \times 100}{7000 \times 12} = 60$$
$$\text{Divisor} \; . \; . \; . \; . \; . \; . \; . \; .$$

Answer.

How many yards are there in one pound of No. 60 yarn?

Worked out by Cancellation.

$$\begin{array}{r|l} & 70(00 \\ & 60 \\ 1(00 & 12 \end{array}$$

$$70 \times 60 \times 12 = 50400$$

Answer.

The same without Cancellation.

$$\text{Dividend} \; . \; . \; . \; . \; . \quad \frac{7000 \times 60 \times 12}{100} = 50400$$
$$\text{Divisor} \; . \; . \; . \; . \; . \; .$$

Answer.

N.B.—The same result will be found by multiplying the number of yards in one hank by the number.

Example.

$840 \times 60 = 50400.$

Answer.

What is the weight of 50400 yards of No. 60?

Worked out by Cancellation.

	50400·8400·700
1·6(0	
1·12	10(0

$700 \times 10 = 7000$ grains, or one pound avoirdupois.

Answer.

The same without Cancellation.

Dividend	$\dfrac{50400 \times 100}{60 \times 12} = 7000$
Divisor	

Answer.

N.B.—It is by the above rule that all the compendious tables are made.

Examples explanatory of the sliver, roving, and yarn tables.

What is the weight of 6 yards of No. .025 sliver?

No. of the sliver . . .025	6, Length of sliver, in yards.
$\frac{1}{70}$ of 840 12	100 $\frac{1}{70}$ of 7000.

Worked out by Cancellation.

1·.025	6·1
1·2·12	100·50·2000

2000 grains.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;. & \dfrac{6 \times 100}{.025 \times 12} = 2000 \text{ grains.} \\ \text{Divisor} \;.\;.\;.\;.\;.\;. & \end{array}$$

Answer.

If 6 yards of sliver weighs 2000 grains, what is the number?

Worked out by Cancellation.

1·2000	6·1
1·2·12	100·50·.025

.025 Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;.\;.\;.\;. & \dfrac{6 \times 100}{2000 \times 12} = .025 \\ \text{Divisor} \;.\;.\;.\;.\;.\;.\;.\;.\;. & \end{array}$$

Answer.

How many yards of No. .025 sliver will it take to weigh 2000 grains?

Worked out by Cancellation.

	20(00
	.025
1(00	12

$20 \times 12 \times .025 = 6$

Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{2000 \times .025 \times 12}{100} = 6$
Divisor . . . . . .

Answer.

What is the weight of 12 yards of a four-hank roving?

Worked out by Cancellation.

1·4	12·1
1·12	100·25

25 grains. Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{12 \times 100}{4 \times 12} = 25$ grains.
Divisor . . . . . .

Answer.

I 12 yards of roving weigh 25 grains, what is the number?

Worked out by Cancellation.

1·25	12·1
1·12	100·4

4 Answer.

The same without Cancellation.

Dividend . . . . $\frac{12 \times 100}{25 \times 12} = 4$

Divisor . . . .

Answer.

How many yards of a four-hank roving will it take to weigh 25 grains?

Worked out by Cancellation.

	25·1
	4·1
1·4·100	12

12 Answer.

The same without Cancellation.

Dividend . . . . $\frac{25 \times 4 \times 12}{100} = 12$

Divisor . . . .

Answer.

What is the weight of 840 yards or one hank of No. 40 yarn?

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot4(0 & 84(0\cdot7 \\ 1\cdot12 & 100\cdot25 \end{array}$$

$$25 \times 7 = 175 \text{ grains.}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \; . \; . \; . \; . \; . & 840 \times 100 \\ \text{Divisor} \; . \; . \; . \; . \; . \; . & 40 \times 12 \end{array} \qquad \frac{840 \times 100}{40 \times 12} = 175 \text{ grains.}$$

Answer.

If 840 yards of yarn weigh 175 grains, what is the number?

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot7\cdot175 & 840\cdot70\cdot10 \\ 1\cdot12 & 100\cdot4 \end{array}$$

$$10 \times 4 = 40$$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \; . \; . \; . \; . \; . \; . \; . \; . \; . & 840 \times 100 \\ \text{Divisor} \; . \; . \; . \; . \; . \; . \; . \; . & 175 \times 12 \end{array} \qquad \frac{840 \times 100}{175 \times 12} = 40$$

Answer.

How many yards of No. 40 will it take to weigh 175 grains?

Worked out by Cancellation.

	175
	4(0·.4
1·10(0	12

$175 \times 12 \times .4 = 840$ Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{175 \times 40 \times 12}{100} = 840$

Divisor . . . . . .

Answer.

If 30 ounces of cotton is spread 48 inches in length, what proportion of a hank is it?

Weight of a spread, in ounces 30	16 Ounces in one pound.
Inches in one yard . . 36	48, Length of a spread, in inches.
Yards in one hank . . .840	

Worked out by Cancellation.

30	16
9·36	48·4·1
70·840	

$16 \div 70 \times 30 \times 9 = 0.00084656\frac{16}{189}$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ . \ . \ . & \dfrac{16 \times 48}{30 \times 36 \times 840} = 0.00084656\tfrac{16}{189} \\ \text{Divisor} \ \ . \ . \ . & \end{array}$$

Answer.

If 30 ounces of cotton is spread on 48 inches of lattice, and the doublings are 3 at the finisher-lapper, 80 at the breaker-card railway, 8 at the finisher-card railway, 2 at the first head of drawing, 4 at the second head of drawing, 2 at the third head of drawing, and 2 at the fine fly-frame, what should be the draught at the mule, the fine fly-frame, the coarse fly-frame, the third head of drawing, the second head of drawing, the first head of drawing, the railway head, the finisher-cards, the breaker-cards, the finisher-lapper, and the breaker-lapper, to produce No. 40, making an allowance of 14 per cent. for loss in working?

Ounces in one pound .	16	30,	Weight of a spread, in ounces.
Length of a spread, in inches	48	36	Inches in one yard.
		840	Yards in one hank.
		40	No. produced.
Cent	100	86,	Cent less 14.
		3,	Doubling at the finisher-lapper.

	80, Doubling at the breaker-card railway.
	8, Doubling at the finisher-card railway.
	2, Doubling at the first head of drawing.
	4, Doubling at the second head of drawing.
	2, Doubling at the third head of drawing.
	2, Doubling at the fine fly-frame.

Worked out.

1·2·16	3(0
1·4·48	36
	84(0·7
	40
1(00	86
	3
	80
	8·1
	2·1
	4·1
	2
	2

(*Continued.*)

$$
\begin{array}{lr}
 & 36 \\
 & 3 \\
\cline{2-2}
 & 108 \\
 & 7 \\
\cline{2-2}
 & 756 \\
 & 40 \\
\cline{2-2}
 & 30240 \\
 & 86 \\
\cline{2-2}
 & 181440 \\
 & 241920 \\
\cline{2-2}
 & 2600640 \\
 & 3 \\
\cline{2-2}
 & 7801920 \\
 & 80 \\
\cline{2-2}
 & 624153600 \\
 & 2 \\
\cline{2-2}
 & 1248307200 \\
 & 2 \\
\cline{2-2}
\text{G} \;\;.\;\;.\;\;.\;\;. & 2)2496614400 \\
\cline{2-2}
\end{array}
$$

(*Continued.*)

D	2)1248307200
D	2)624153600
E	2)312076800
E	2)156038400
F	2)78019200
F	2)39009600
H	2)19504800
H	2)9752400
H	2)4876200
H	2)2438100
C	2)1219050
I	2)609525
I	2)304762.5
I	2)152381.25
I	2)76190.625
I . . .	5)38095.3125

(Continued.)

C	3)7619.0625
A	3)2539.6875
A	3)846.5625
J . . .	3)282.1875
H	5)94.0625
B	7)18.8125
K .	2.6875)2.6875
	1

A. $3 \times 3 = 9$, Draught at the mule.

B. $7 = 7$, Draught at the fine fly-frame.

C. $3 \times 2 = 6$, Draught at the coarse fly-frame.

D. $2 \times 2 = 4$, Draught at the third head of drawing.

E. $2 \times 2 = 4$, Draught at the second head of drawing.

F. $2 \times 2 = 4$, Draught at the first head of drawing.

G. $2 = 2$, Draught at the railway head.

H. $5 \times 2 \times 2 \times 2 \times 2 = 80$, Draught at the finisher-cards.

I. $5 \times 2 \times 2 \times 2 \times 2 = 80$, Draught at the breaker-cards.

J. $3 = 3$, Draught at the finisher-lapper.

K. $2.6875 = 2.6875$, Draught at the breaker-lapper.

Answer.

From the particulars found in the preceding example, find the number produced.

Worked out by Cancellation.

1·3(0	16·2·1
1·9·36	48·4·1
1·7·84(0	
1·2.6875·10.75·43·86	1(00
	2.6875·1
1·3	3·1
	80·1
1·80	80·40
1·8	2·1
1·2	4·1
1·4	4·1
1·2	4·1
	6·2·1
1·2	7·1
	9·1

40 Answer.

The same without Cancellation.

Dividend,
Divisor,

$$\frac{16\times48\times100\times2.6875\times3\times80\times80\times2\times4\times4\times4\times6\times7\times9}{30\times36\times840\times86\times3\times80\times8\times2\times4\times2\times2}=40$$

Answer.

From the particulars found in the preceding example, find the weight of a spread.

Worked out by Cancellation.

	16·2·1 Ounces in one pound.
1·9·36	48·4·1
1·7·84(0	
1·2.6875·10.75·43·86	10(0·5
	2.6875·1
1·3	3·1
	80·1
1·80	80·2·1
1·8	2·1
1·2	4·1
1·4	4·1
1·2	4·1
	6
1·2	7·1
	9·1
1·40	

$6 \times 5 = 30$ ounces. Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend,} & 16 \times 48 \times 100 \times 2.6875 \times 3 \times 80 \times 80 \times 2 \times 4 \times 4 \times 4 \times 6 \times 7 \times 9 \\ \hline \text{Divisor,} & 36 \times 840 \times 86 \times 3 \times 80 \times 8 \times 2 \times 4 \times 2 \times 2 \times 40 \end{array} = 30$$

Answer.

From the particulars found in the preceding example, find the length of a spread.

Worked out by Cancellation.

	36·4 Inches in one yard.
1·2·16	3(0·1
	84(0·12
1(00	86·21.5·5.375·2.6875·1
1·2.6875	
1·3	3·1
1·80	
1·2·80	80·1
1·2	8·1
1·4	2·1
1·4	4·1
1·4	2·1
1·3·6	
1·7	2·1
1·9	
	40·1

$12 \times 4 = 48$ inches. Answer.

The same without Cancellation.

Dividend,
Divisor,

$$\frac{36 \times 30 \times 840 \times 86 \times 3 \times 80 \times 8 \times 2 \times 4 \times 2 \times 2 \times 40}{16 \times 100 \times 2.6875 \times 3 \times 80 \times 80 \times 2 \times 4 \times 4 \times 4 \times 6 \times 7 \times 9} = 48$$

Answer.

From the particulars found in the preceding example, find the decimal of a hank of a spread.

Worked out by Cancellation.

	4(0
9	
7	2·1
3·6	
1·4	2·1
1·4	4·1
1·4	2·1
1·2	8·1
5·10·80	80·1
1·80	
1·3	3·1
1·2.6875	
5·10(0	86·21.5·5.375·2.6875·1

$$4 \div 9 \times 7 \times 3 \times 5 \times 5 = 0.00084656\tfrac{16}{189}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Div.} & \dfrac{40 \times 2 \times 2 \times 4 \times 2 \times 8 \times 80 \times 3 \times 68}{9 \times 7 \times 6 \times 4 \times 4 \times 4 \times 2 \times 80 \times 80} = 0.00084656\tfrac{16}{189} \\ \text{Divis.} & \quad \times 3 \times 2.6875 \times 100 \end{array}$$

Answer.

From the particulars found in the preceding example, find what the number would be if there was no loss in working.

Worked out by Cancellation.

1·5·30	16·2·1
1·4·36	48·4·2
1·7·84(0	
	2.6875·.5375
1·3	3·1
	80·1
1·80	8(0
1·8	2·1
1·2	4·1
1·4	4·1
1·2	4
	6·1
1·2	7·1
	9·1

$.5375 \times 2 \times 8 \times 4 = 34.4$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Div.} & \dfrac{16 \times 48 \times 2.6875 \times 3 \times 80 \times 80 \times 2 \times 4 \times 4 \times 4 \times 6 \times 7 \times 9}{30 \times 36 \times 840 \times 3 \times 80 \times 8 \times 2 \times 4 \times 2 \times 2} = 34.4 \\ \text{Divis.} & \end{array}$$

Answer.

N.B.—The particulars found in the fourteen following examples, are taken from the above.

From the particulars found in the preceding example, find the decimal of a hank, produced at the breaker-lapper, commencing at the length and weight spread on the lattice, making no allowance for loss in working.

Worked out by Cancellation.

$$\begin{array}{r|l} 30 & 16 \\ 9 \cdot 36 & 48 \cdot 4 \cdot 1 \\ 70 \cdot 840 & \\ & 2.6875 \end{array}$$

$$2.6875 \times 16 \div 70 \times 9 \times 30 = 0.00227 \tfrac{97}{189}$$

Answer.

The same without Cancellation.

$$\begin{array}{lll} \text{Dividend} \quad . \quad . \quad . & \dfrac{16 \times 48 \times 2.6875}{30 \times 36 \times 840} = 0.00227 \tfrac{97}{189} \\ \text{Divisor} \quad . \quad . \quad . & \end{array}$$

Answer.

Find the decimal of a hank produced at the breaker-lapper, commencing at the number produced, making no allowance for loss in working.

Worked out by Cancellation.

	34.4·8.6·.86
9	
7	2·1
6	
1·2·4	2·1
1·4	4·1
1·4	2·1
1·2	8·1
1·10·80	80·1
1·80	
1·3	3·1

$.86 \div 9 \times 7 \times 6 = 0.00227\tfrac{97}{189}$ Answer.

The same without Cancellation.

$$\text{Div.}\quad \frac{34.4 \times 2 \times 2 \times 4 \times 2 \times 8 \times 80 \times 3}{9 \times 7 \times 6 \times 4 \times 4 \times 4 \times 2 \times 80 \times 80 \times 3} = 0.00227\tfrac{97}{189}\quad \text{Divisor,}$$

Answer.

Find the decimal of a hank produced at the breaker-cards, commencing at the length and weight spread on the lattice, making no allowance for loss in working.

Worked out by Cancellation.

1·5·30	16·4·1
9·36	48·8

(*Continued.*)

21·84(0	
	2.6875·.5375
1·3	3·1
	8(0

$.5375 \times 8 \times 8 \div 21 \times 9 = 0.182\frac{2}{189}$

Answer.

The same without Cancellation.

Dividend, Divisor, $\dfrac{16 \times 48 \times 2.6875 \times 3 \times 80}{30 \times 36 \times 840 \times 3} = 0.182\frac{2}{189}$

Answer.

Find the decimal of a hank produced at the breaker-cards, commencing at the number produced, making no allowance for loss in working.

Worked out by Cancellation.

	34.4
9	
7	2·1
3·6	
1·4	2·1
1·4	4·1
1·2·4	2·1
1·2	8·2·1
1·80	80·1

$34.4 \div 9 \times 7 \times 3 = 0.182\frac{2}{189}$ Answer.

The same without Cancellation.

$$\text{Dividend,} \quad \frac{34.4\times 2\times 2\times 4\times 2\times 8\times 80}{9\times 7\times 6\times 4\times 4\times 4\times 2\times 80} = 0.182\tfrac{2}{189} \quad \text{Divisor}$$

Answer.

Find the decimal of a hank produced at the railway-head, commencing at the length and weight spread on the lattice, making no allowance for loss in working.

Worked out by Cancellation.

3·6·30	16
9·36	48·4·1
7·84(0	
·	2.6875·.5375
1·3	3·1
	80·1
1·80	8(0·1
1·8	2·1

$$.5375\times 16\div 3\times 9\times 7 = 0.0455\tfrac{5}{189}$$

Answer.

The same without Cancellation.

$$\text{Dividend,} \quad \frac{16\times 48\times 2.6875\times 3\times 80\times 80\times 2}{30\times 36\times 840\times 3\times 80\times 8} = 0.0455\tfrac{5}{189} \quad \text{Divisor,}$$

Answer.

Find the decimal of a hank produced at the railway-head, commencing at the number produced, making no allowance for loss in working.

Worked out by Cancellation.

	34.4·8.6
9	
7	2·1
3·6	
1·2·4	2·1
1·4	4·1
1·4	2·1

$8.6 \div 9 \times 7 \times 3 = 0.0455\frac{5}{189}$ Answer.

The same without Cancellation.

Dividend . . $\dfrac{34.4 \times 2 \times 2 \times 4 \times 2}{9 \times 7 \times 6 \times 4 \times 4 \times 4} = 0.0455\frac{5}{189}$
Divisor . . .

Answer.

Find the decimal of a hank produced at the first head of drawing, commencing at the length and weight spread on the lattice, making no allowance for loss in working.

Worked out by Cancellation.

3·6·30	16
9·36	48·4·1
7·84(0	

(*Continued.*)

	2.6875·.5375
1·3	3·1
	8(0·1
1·80	80·1
1·8	2·1
1·2	4·2

$$.5375 \times 16 \times 2 \div 9 \times 7 \times 3 = 0.091\tfrac{1}{189}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Div.} & 16 \times 48 \times 2.6875 \times 3 \times 80 \times 80 \times 2 \times 4 \\ \text{Divisor,} & 30 \times 36 \times 840 \times 3 \times 80 \times 8 \times 2 \end{array} = 0.091\tfrac{1}{189}$$

Answer.

Find the decimal of a hank produced at the first head of drawing, commencing at the number produced, making no allowance for loss in working.

Worked out by Cancellation.

	34.4·8.6
9	
7	2
3·6	
1·4	2·1
1·4	4·1

$$8.6 \times 2 \div 9 \times 7 \times 3 = 0.091\tfrac{1}{189}$$ Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend} \ldots\ldots & \dfrac{34.4\times2\times2\times4}{9\times7\times6\times4\times4} = 0.091\tfrac{1}{189} \\ \text{Divisor} \ldots\ldots & \end{array}$$

Answer.

Find the decimal of a hank produced at the third head of drawing, commencing at the length and weight spread on the lattice, making no allowance for loss in working.

Worked out by Cancellation.

3·6·30	16
9·36	48·4
7·84(0	
	2.6875·.5375
1·3	3·1
	8(0·1
1·80	80·1
1·8	2·1
1·2	4·1
1·4	4·1
1·2	4·2·1

$.5375\times16\times4 \div 9\times7\times3 = 0.182\tfrac{2}{189}$ Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Dividend,} & \dfrac{16\times48\times2.6875\times3\times80\times80\times2\times4\times4\times4}{30\times36\times840\times3\times80\times8\times2\times4\times2} = 0.182\tfrac{2}{189} \\ \text{Divisor,} & \end{array}$$

Answer.

Find the decimal of a hank produced at the third head of drawing, commencing at the number produced, making no allowance for loss in working.

Worked out by Cancellation.

	34.4
9	
7	2·1
3·6	

$$34.4 \div 9 \times 7 \times 3 = 0.182\tfrac{2}{189}$$

Answer.

The same without Cancellation.

Dividend . . . . . . $\dfrac{34.4 \times 2}{9 \times 7 \times 6} = 0.182\tfrac{2}{189}$

Answer.

Find the hank-roving produced at the coarse fly-frame, commencing at the length and weight spread on the lattice, making no allowance for loss in working.

Worked out by Cancellation.

1·5·30	16
9·36	48·4
7·84(0	
	2.6875·.5375

(*Continued.*)

1·3	3·1
	8(0·1
1·80	80·1
1·8	2
1·2	4·1
1·4	4·1
1·2	4·2·1
	6·1

$$.5375 \times 16 \times 4 \times 2 \div 9 \times 7 = 1.092\tfrac{4}{63}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Div.} & \dfrac{16 \times 48 \times 2.6875 \times 3 \times 80 \times 80 \times 2 \times 4 \times 4 \times 4 \times 6}{30 \times 36 \times 840 \times 3 \times 80 \times 8 \times 2 \times 4 \times 2} = 1.092\tfrac{4}{63} \\ \text{Divisor,} & \end{array}$$

Answer.

Find the hank-roving produced at the coarse fly-frame, commencing at the number produced, making no allowance for loss in working.

	34.4
9	
7	2

$$34.4 \times 2 \div 9 \times 7 = 1.092\tfrac{4}{63}$$

Answer.

Find the hank-roving produced at the fine fly-frame, commencing at the length and weight spread on the lattice, making no allowance for loss in working.

Worked out by Cancellation.

1·5·30	16
9·36	48·4
1·12·84(0	
	2.6875·.5375
1·3	3·1
	8(0·1
1·80	80·1
1·8	2·1
1·2	4·1
1·4	4·1
1·2	4·2·1
	6·1
1·2	7·1

$$.5375 \times 4 \times 16 \div 9 = 3.8\tfrac{2}{9}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Div.} & 16 \times 48 \times 2.6875 \times 3 \times 80 \times 80 \times 2 \times 4 \times 4 \times 4 \times 6 \times 7 \\ \hline \text{Divisor,} & 30 \times 36 \times 840 \times 3 \times 80 \times 8 \times 2 \times 4 \times 2 \times 2 \end{array} = 3.8\tfrac{2}{9}$$

Answer.

Find the hank-roving produced at the fine fly-frame, commencing at the number produced, making no allowance for loss in working.

	34·4
9	

$$34.4 \div 9 = 3.8\tfrac{2}{9}$$

Answer.

From the length and weight spread on the lattice, the doubling, and the particulars given, to find the draught at each and every machine from the lapper to the mule. Find the number produced, making an allowance of 14 per cent. for loss in working.

Worked out by Cancellation.

1·3(0	16·2·1
1·9·36	48·4·1
1·7·84(0	
1·2.6875·10.75·43·86	1(00
Single.	Breaker-Lapper.
1·4	6.9875·2.6875·1
1·9	30·3·1
1·15·45	100·1
1·2·32	72·8·2·1
1·32	32·1
1·100	15·1

(*Continued.*)

	1·2.6·26	16·1
Doublings	1·3	Finisher-Lapper.
	1·4	7·1
	1·9	3(0·1
	1·2·6·42	78·3·1
	1·2·32	8(0·4·2·1
	1·2·32	36·4·1
	1(00	16·1
	1·26	16·1
	Single.	Breaker Cards.
	1·1.5·4.5	1(0
	1(0	33·1
	1·13	6(0·3·1
	1·33	5(0·1
	1·20	80·40
	1·2·4	15·1(0
	1·8·40	91·13·1
	1·7(0	16·2·1
	1(00	20·1
Doubling	1·80	Finisher Cards.
	1·1.5·4.5	1(0
	1(0	33·1
	1·13	6(0·3·1
	1·33	5(0·1
	1·20	80·1
	1·2·4	15·1(0

(*Continued.*)

	1·8·40	91·13·1
	1·7(0	16·2·1
	1(00	20·1
Doubling	1·8	Railway Head.
	1	3·1
	1·80	34·1
	1·4·100	80·1
	1·4·18	75·3·1
	1·3	4.5·1
	1·.5·1.5·51	16·4·8·2·1
Doubling	1·2	First head of drawing.
	1	3·1
	1·6(0	27·1
	1·3·36	4(0·1
	1·27	72·6·2·1
Doubling	1·4	Second head of drawing.
	1	3·1
	1·6(0	27·1
	1·3·36	4(0·1
	1·27	72·6·1
Doubling	1·2	Third head of drawing.
	1	3·1
	1·6(0	27·1
	1·3·36	4(0·1
	1·27	72·6·1
	Single.	Coarse Fly-Frame.

(*Continued.*)

	1·8	1(0
	1·32	96·48·6·1
	1·2·4(0	64·2·1
Doubling	1·2	Fine Fly-Frame.
	1·8	1(0
	1·4·32	56·7·1
	1·3(0	96·24·8·1
	Single.	Mule.
	1·7	8·4·1
	1·2·30	105·15·1
	1·9·36	81·9·1

40

Answer.

LOSS IN WORKING.

The number shown by the draughts and doublings, and the number produced, are proportional to the weight of spread in an inverse ratio.

Example.

The number shown by the draughts and doublings is 34.4, but the number actually produced is 40. Required the loss in working, the weight of a spread being 30 ounces.

$$\begin{array}{r|l} & 3(0 \\ 1{\cdot}4(0 & 34.4{\cdot}8.6 \end{array}$$

$8.6 \times 3 = 25.8$ ounces utilized.

30 ounces weight of a spread.
25.8 weight utilized.

4.2 = 4 ounces and $87\frac{1}{2}$ grains loss in working from 30 ounces.

Answer.

The number shown by the draughts and doublings is 34.4, but the number actually produced is 40. Required the percentage utilized.

Worked out by Cancellation.

$$\begin{array}{r|l} & 10(0 \\ 1{\cdot}4(0 & 34.4{\cdot}8.6 \end{array}$$

$8.6 \times 10 = 86$

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{100 \times 34.4}{40} = 86$
Divisor . . . .

Answer.

The hank-roving shown by the draughts and doublings is $3\frac{1}{2}$, but the hank-roving actually produced is 4. Required the loss in working, the weight of a spread being 30 ounces.

$$\begin{array}{r|l} & 30 \cdot 7.5 \\ 1 \cdot 4 & 3.5 \end{array}$$

$7.5 \times 3.5 = 26.25$ ounces utilized.

30.00 ounces weight of a spread.

26.25 ounces utilized.

3.75 ounces loss in working 30 ounces.

Answer.

The hank-roving shown by the draughts and doublings is $3\frac{1}{2}$, but the hank-roving actually produced is 4. Required the percentage utilized.

Worked out by Cancellation.

$$\begin{array}{r|l} & 100 \cdot 25 \\ 1 \cdot 4 & 3.5 \end{array}$$

$25 \times 3.5 = 87\frac{1}{2}$ Answer.

The same without Cancellation.

Dividend . . . . Divisor . . . . $\dfrac{100 \times 3.5}{4} = 87\frac{1}{2}$

Answer.

N.B.—By the above rule the loss in working can be found at each and every operation, from the lapper to the mule.

A railway head works successively 10 hours per day, and produces a No. $.0455\frac{5}{189}$ sliver. The front-roller being $1\frac{1}{4}$ inches in diameter, how many revolutions per minute should it make to supply a certain number of mule-spindles that produce 312 pounds of yarn per day, allowing 4 per cent. for loss in working?

189	8.6, No. of sliver in 189ths.
	7000 Grains in one pound.
	312 Pounds of yarn produced.
$\frac{1}{70}$ of 7000 100	12, $\frac{1}{70}$ of 840.
Diameter of front-roller, in inches 1.25	36 inches in one yard.
Ratio of circumference to diameter . . . 3.1416	
Hours per day 10	
Minutes in one hour . 60	
Cent less 4 96	100 Cent.

Worked out by Cancellation.

3·21·63·189	8.6
	70(00·10·1

(*Continued.*)

	312·39·13
1·100	12·1
1·1.25	36·6·2·1.6
.31416·3.1416	
1(0	
1·6(0	
1·8·96	100·1

$$13 \times 8.6 \times 1.6 \div .31416 \times 3 = 189\tfrac{9391}{11781}$$

Answer.

The same without Cancellation.

Div. / Divis.

$$\frac{8.6 \times 7000 \times 312. \times 12 \times 36 \times 100}{189 \times 100 \times 1.25 \times 3.1416 \times 10 \times 60 \times 96} = 189\tfrac{9391}{11781}$$

Answer.

From the particulars found in the preceding example, find the percentage of loss in working.

Worked out by Cancellation.

	100·1
1·3·27·189	8.6·.86·.02
	7(000·1
	312·104·13·1
1·100	12·1
1·1.25	36·4·3.2·.8
1·.3927·3.1416	

(*Continued.*)

1·10	
1·5·60	
1·43·559·2236(000	11781·2356.2·6000

$6000 \times .8 \times .02 = 96.$

$100 - 96 = 4$ per cent.

Answer.

The same without Cancellation.

$$\begin{array}{ll}\text{Div.} & \dfrac{100 \times 8.6 \times 7000 \times 312 \times 12 \times 36 \times 11781}{189 \times 100 \times 1.25 \times 3.1416 \times 10 \times 60 \times 2236000} = 96. \\ \text{Divis.} & \end{array}$$

$100 - 96 = 4$ Answer.

A drawing-frame works successively 10 hours per day, and produces a No. $182\frac{2}{189}$ roving. The front-roller being $1\frac{1}{4}$ inches in diameter, how many revolutions per minute should it make for 4 deliveries to supply a certain number of mule spindles that produce 312 pounds of yarn per day, allowing 3 per cent. for loss in working?

189	34.4, No. of sliver in 189ths.
	7000 Grains in one pound.
	312 Pounds of yarn produced.
$\frac{1}{70}$ of 7000 100	12, $\frac{1}{70}$ of 840.
Diameter of front-roller, in inches . . . 1.25	36 Inches in one yard.

Ratio of circumference to diameter . .	3.1416	
Hours per day . . .	10	
Minutes per hour . .	60	
Number of deliveries .	4	
Cent less 3	97	100 Cent.

Worked out by Cancellation.

1·3·27·189	34.4
	70(00·10·8
	312·104
1·100	12·2
1·1.25	36·4·1
3.1416	
1(0	
1·6(0	
1·4	
97	100·1

$$104 \times 34.4 \times 8 \times 2 \div 3.1416 \times 97 = 187\tfrac{320147}{380919}$$

Answer.

The same without Cancellation.

Dividend,
Divisor,

$$\frac{34.4 \times 7000 \times 312 \times 12 \times 36 \times 100}{189 \times 100 \times 1.25 \times 3.1416 \times 10 \times 60 \times 4 \times 97} = 187\tfrac{320147}{380919}$$

Answer.

From the particulars found in the preceding example, find the percentage of loss in working.

Worked out by Cancellation.

	100·1
1·7·63·189	34.4
	7(000·1
	312·104·13·1.3
1·100	12·1
1.25	36·4·1
3.1416	
1·10	
1·5·60	
1·4	
8944·71552(000	380919·76183.8

$$76183.8 \times 1.3 \times 34.4 \div 8944 \times 1.25 \times 3.1416 = 97$$

$$100 - 97 = 3 \text{ per cent.}$$

Answer.

The same without Cancellation.

Div. / Divisor,

$$\frac{100 \times 34.4 \times 7000 \times 312 \times 12 \times 36 \times 380919}{189 \times 100 \times 1.25 \times 3.1416 \times 10 \times 60 \times 4 \times 71552000} = 97.$$

$$100 - 97 = 3$$ Answer.

A coarse fly-frame works successively 10 hours per day, and produces a No. $1.092\frac{4}{63}$ roving. The front-roller being $1\frac{1}{4}$ inches in diameter, how many revolutions per minute should it make for 40 spindles to supply a certain number of mule-spindles that produce 312 pounds of yarn per day, allowing 2 per cent. for loss in working?

63	68.8, Hank-roving in 63ds.
	7000 Grains in one pound.
	312 Pounds of yarn produced.
$\frac{1}{70}$ of 7000 100	12, $\frac{1}{70}$ of 840.
Diameter of the front-roller, in inches . . 1.25	36 Inches in one yard.
Ratio of circumference to diameter . . 3.1416	
Hours per day 10	
Minutes in one hour . 60	
Cent less 2 98	100 Cent.
Number of spindles . 40	

Worked out by Cancellation.

1·9·63	68.8
	7(000·1
	312
1·100	12·2·1.6
1·1.25	36·4·1

(*Continued.*)

3.1416	
1(0	
1·6(0	
98	100·1
1·4(0	

$$312 \times 68.8 \times 1.6 \div 3.1416 \times 98 = 111\tfrac{213294}{384846}$$

Answer.

The same without Cancellation.

Dividend, Divisor, $\dfrac{68.8 \times 7000 \times 312 \times 12 \times 36 \times 100}{63 \times 100 \times 1.25 \times 3.1416 \times 10 \times 60 \times 98 \times 40} = 111\tfrac{213294}{384846}$

Answer.

From the particulars found in the preceding example, find the number of coarse fly-frame spindles necessary to supply the mule-spindles.

Worked out by Cancellation.

	312·104
1·3·21·63	68.8
	7(000·1
1·100	12·2·1.6
1·1.25	36·12·1
.2618·3.1416	

(*Continued.*)

1(0	
1·6(0	
98	100·1
34344960(0	3078768

$3078768 \times 1.6 \times 68.8 \times 104 \div 34344960 \times 98 \times .2618 = 40$

Answer.

The same without Cancellation.

Dividend, $\dfrac{312 \times 68.8 \times 7000 \times 12 \times 36 \times 100 \times 3078768}{63 \times 100 \times 1.25 \times 3.1416 \times 10 \times 60 \times 98 \times 343449600} = 40$
Divisor,

Answer.

How many pounds of cotton per day should be weighed on to the lapper to supply a certain number of mule-spindles that produce 312 pounds of yarn in the same time; allowing 14 per cent. for loss in working?

	312
86	100

$312 \times 100 \div 86 = 362\frac{34}{43}$

Answer.

How many weighings of cotton per day will it require to supply a certain number of mule-spindles producing 312 pounds of yarn in the same time; allowing 30 ounces to a weighing, and 14 per cent. for loss in working?

CLINTON MILL, WOONSOCKET, R. I.

JAS. T. RHODES, TREAS.

Worked out by Cancellation.

$$\begin{array}{r|l} & 312\cdot104 \\ 1\cdot3(0 & 16 \\ 86 & 10(0 \end{array}$$

$$104 \times 16 \times 10 \div 86 = 193\tfrac{21}{43}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . . . . .} & \dfrac{312 \times 16 \times 100}{30 \times 86} = 193\tfrac{21}{43} \\ \text{Divisor . . . . .} & \end{array}$$

Answer.

SPINNING.

The back-roller of a mule is seven-eighths of an inch in diameter. The change-wheel has 40, and the front-roller wheel 24 teeth. How many teeth should there be in the back-roller wheel and the top-carrier, and what should be the diameter of the front-roller to produce No. 40 from an 8 hank-roving, run in double; the length of the stretch being 60, and the rollers deliver 58 inches?

$$\begin{array}{|l} 7, \text{ Diameter of the back-roller, in eighths of an inch.} \end{array}$$

		40 Teeth in the change-wheel.
		24 Teeth in the front-roller wheel.
		40, Number produced.
Hank-roving	8	2, Double-roving.
Length of stretch, in inches	60	58, Length delivered by the rollers, in inches.

Worked out.

	7
	4(0
	24·4
	40·5
1·8	2
1·6(0	58

$$
\begin{array}{r}
58 \\
2 \\
\hline
116 \\
5 \\
\hline
580 \\
4 \\
\hline
2320 \\
4 \\
\hline
9280 \\
7 \\
\hline
\end{array}
$$

(*Continued.*)

$$
\begin{array}{lr}
\text{B} \;.\;\;.\;\;.\;\;. & 10\overline{)64960} \\
\text{A} \;.\;\;.\;\;.\;\;.\;\;. & 8\overline{)6496} \\
\text{B} .\;\;.\;\;.\;\;.\;\;. & 7\overline{)812} \\
\text{C} \;.\;\;.\;\;. & 116\overline{)116} \\
 & 1
\end{array}
$$

A. 8 = 8, Diameter of the front-roller in eighths of an inch.

B. $10 \times 7 = 70$ Teeth in the back roller wheel.

C. 116 = 166 Teeth in the top-carrier.

Answer.

From the particulars found in the preceding example, find the number produced.

Worked out by Cancellation.

$$
\begin{array}{r|l}
1\cdot2 & 8\cdot2\cdot1 \\
1\cdot7 & 8\cdot1 \\
1\cdot4(0 & 7(0\cdot1 \\
1\cdot3\cdot24 & 116\cdot58\cdot2 \\
1\cdot29\cdot58 & 60\cdot20
\end{array}
$$

$20 \times 2 = 40$ Answer.

The same without Cancellation.

Dividend, ... $\dfrac{8 \times 8 \times 70 \times 116 \times 60}{2 \times 7 \times 40 \times 24 \times 58} = 40$

Divisor . . . . .

Answer.

From the particulars found in the preceding example, find the hank-roving.

Worked out by Cancellation.

	4(0·1
1·2·8	7·1
1·7(0	4(0·1
1·29·116	24·4
1·6(0	58·2
	2·1

$4 \times 2 = 8$ hank-roving.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;. & 40\times7\times40\times24\times58\times2 \\ \text{Divisor} \;.\;.\;.\;.\;. & 8\times70\times116\times60 \end{array} \quad \frac{40\times7\times40\times24\times58\times2}{8\times70\times116\times60} = 8$$

Answer.

From the particulars found in the preceding example, find the diameter of the back-roller.

Worked out by Cancellation.

1·2	8·2·1
1·4(0	
	8·2·1

(*Continued.*)

$$
\begin{array}{r|l}
1\cdot4(0 & 7(0 \\
1\cdot2\cdot4\cdot24 & 116\cdot58\cdot1 \\
1\cdot58 & 6(0\cdot1
\end{array}
$$

$7 = \frac{7}{8}$ of an inch. Answer.

The same without Cancellation.

$$
\begin{array}{ll}
\text{Dividend . .} & \dfrac{8\times8\times70\times116\times60}{2\times40\times40\times24\times58} = 7 = \frac{7}{8} \text{ of an inch.} \\
\text{Divisor . . .} &
\end{array}
$$

Answer.

From the particulars found in the preceding example, find the diameter of the front-roller.

Worked out by Cancellation

$$
\begin{array}{r|l}
1\cdot2\cdot8 & 2\cdot1 \\
 & 4(0\cdot1 \\
 & 7\cdot1 \\
1\cdot7(0 & 4(0\cdot2\cdot1 \\
1\cdot58\cdot116 & 24\cdot8 \\
1\cdot3\cdot6(0 & 58\cdot1
\end{array}
$$

$8 = \frac{8}{8}$ of an inch. Answer.

The same without Cancellation.

$$
\begin{array}{ll}
\text{Dividend .} & \dfrac{2\times40\times7\times40\times24\times58}{8\times70\times116\times60} = 8 = \frac{8}{8} \text{ of an inch.} \\
\text{Divisor . .} &
\end{array}
$$

Answer.

From the particulars found in the preceding example, find the number of teeth in the back-roller wheel.

Worked out by Cancellation.

	4(0·2
1·8	2·1
	40·5
1·8	7
1·58·116	24·3·1
1·2·6(0	58·1

$$7 \times 5 \times 2 = 70$$

Answer.

The same without Cancellation.

Dividend . . . . Divisor . . . .

$$\frac{40 \times 2 \times 40 \times 7 \times 24 \times 58}{8 \times 8 \times 116 \times 60} = 70$$

Answer.

From the particulars found in the preceding example, find the number of teeth in the change-wheel.

Worked out by Cancellation.

	70·10
1·2	8·2
1·4(0	

(*Continued.*)

1·7	8·1
1·3·24	116·58·1
1·58	6(0·2

$10 \times 2 \times 2 = 40$ Answer.

The same without Cancellation.

Dividend . . . . .
Divisor . . . . . .

$$\frac{70 \times 8 \times 8 \times 116 \times 60}{2 \times 40 \times 7 \times 24 \times 58} = 40$$

Answer.

From the particulars found in the preceding example, find the number of teeth in the top-carrier.

Worked out by Cancellation.

	24·3·1
1·8	2·1
	4(0·1
1·2·8	7·1
1·7(0	4(0·2
1·3·6(0	58

$58 \times 2 = 116$ Answer.

The same without Cancellation.

Dividend . .
Divisor . . .

$$\frac{24 \times 2 \times 40 \times 7 \times 40 \times 58}{8 \times 8 \times 70 \times 60} = 116$$

Answer.

From the particulars found in the preceding example, find the number of teeth in the front-roller wheel.

Worked out by Cancellation.

	116·2
1·2	8·2
1·4(0	
1·7	8·2·1
1·4(0	7(0·1
1·58	6(0

$$6 \times 2 \times 2 = 24$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;. & \dfrac{116 \times 8 \times 8 \times 70 \times 60}{2 \times 40 \times 7 \times 40 \times 58} = 24 \\ \text{Divisor} \;.\;.\;.\;.\;. & \end{array}$$

Answer.

From the particulars found in the preceding example, find how many inches the rollers deliver per stretch.

Worked out by Cancellation.

	6(0·1
1·2	8·2·1
1·4(0	

(*Continued.*)

1·7	8·2
1·4(0	7(0·1
1·4·24	116·29

$29 \times 2 = 58$ inches. Answer.

The same without Cancellation.

Dividend . . $\dfrac{60 \times 8 \times 8 \times 70 \times 116}{2 \times 40 \times 7 \times 40 \times 24} = 58$ inches.
Divisor . .

Answer.

From the particulars found in the preceding example, find the length of the stretch.

Worked out by Cancellation.

	58·1
1·8	2·1
	40·5
1·8	7·1
1·7(0	4(0
1·2·116	24·3

$5 \times 4 \times 3 = 60$ inches. Answer.

The same without Cancellation.

Dividend . $\dfrac{58 \times 2 \times 40 \times 7 \times 40 \times 24}{8 \times 8 \times 70 \times 116} = 60$ inches.
Divisor . .

Answer.

The back-roller is seven-eighths, and the front-roller eight-eighths of an inch in diameter. The front-roller wheel has 24, the top-carrier 116, the change-wheel 40, and the back-roller wheel 70 teeth. The rollers deliver 58, and the length of the stretch is 60 inches. Required the total draught at the mule.

Worked out by Cancellation.

1·7	8·4·1
1·4(0	7(0·1
1·6·12·24	116·2·1
1·58	60·10

10 Answer.

The same without Cancellation.

Dividend . . . . . . Divisor . . . . $\dfrac{8 \times 70 \times 116 \times 60}{7 \times 40 \times 24 \times 58} = 10$

Answer.

The number spun is 40 from an 8 hank-roving, run in double. Required the draught.

Worked out by Cancellation.

	40·5
1·8	2

$5 \times 2 = 10$ Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{40 \times 2}{8} = 10$
Divisor . . . .

Answer.

The back-roller is seven-eighths, and the front-roller eight-eighths of an inch in diameter. The front-roller wheel has 24, the top-carrier 116, the change-wheel 40, and the back-roller wheel 70 teeth. Required the draught at the rollers.

Worked out by Cancellation.

1·7	8·1
1·4(0	7(0·1
1·3·24	116·29·$9\frac{2}{3}$

$9\frac{2}{3}$

Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{8 \times 70 \times 116}{7 \times 40 \times 24} = 9\frac{2}{3}$
Divisor . . . .

Answer.

The length of the stretch is 60 and the rollers deliver 58 inches. Required the draught at the carriage.

Worked out by Cancellation.

$$\begin{array}{r|l} 1 \cdot 58 & 60 \cdot 1\frac{1}{29} \end{array}$$

$1\frac{1}{29}$ Answer.

The draught at the rollers is $9\frac{2}{3}$, and the draught at the carriage is $1\frac{1}{29}$. Required the total draught at the mule.

Worked out by Cancellation.

$$\begin{array}{r|l} 1 \cdot 3 & 29 \cdot 1 \\ 1 \cdot 29 & 30 \cdot 10 \end{array}$$

---

10 Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{29 \times 30}{3 \times 29} = 10$
Divisor . . . .

Answer.

The length of the stretch is 60, and the rollers deliver 58 inches. Required the gain of the carriage per stretch.

60
58
—
2 inches.

Answer.

The draught at the rollers is $9\frac{2}{3}$. The length of the stretch is 60, and the rollers deliver 58 inches. Required the number spun from an 8 hank-roving, run in double.

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot2 & 8\cdot4\cdot2 \\ 1\cdot3 & 29\cdot1 \\ 1\cdot2\cdot58 & 60\cdot20 \end{array}$$

$$20 \times 2 = 40$$

Answer.

The same without Cancellation.

Dividend . . . .
Divisor . . . .

$$\frac{8 \times 29 \times 60}{2 \times 3 \times 58} = 40$$

Answer.

If No. 40 is spun from a 4 hank-roving, with a change-wheel containing 40 teeth, how many teeth should there be in the change-wheel to spin No. 60 from a $7\frac{1}{2}$ hank-roving?

Worked out by Cancellation.

$$\begin{array}{r|l} & 40 \\ 1\cdot4 & 7.5\cdot1.25 \\ 1\cdot6(0 & 4(0\cdot1 \end{array}$$

$$40 \times 1.25 = 50$$ Answer.

The same without Cancellation.

Dividend . . . . / Divisor . . . .

$$\frac{40 \times 7.5 \times 40}{4 \times 60} = 50$$

Answer.

A set of cops weighs 11 lbs., and has on 630 stretches. Length of stretch, 60 inches; number of cops in the set, 352. Required the average number.

Worked out by Cancellation.

	352·32·8
1·3·36	60·5
1·21·84(0	
1·11	
	63(0·21·1

$8 \times 5 = 40$ Answer.

The same without Cancellation.

Dividend . . . . / Divisor . . . .

$$\frac{352 \times 60 \times 630}{36 \times 840 \times 11} = 40$$

Answer.

From the particulars found in the preceding example, find the number of stretches in the set.

Worked out by Cancellation.

	11·1
	40·5

(*Continued.*)

1·4·32·352	
	84(0·21
1·6(0	36·6

$21 \times 6 \times 5 = 630$ Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{11 \times 40 \times 840 \times 36}{352 \times 60} = 630$
Divisor . . . . .

Answer.

From the particulars found in the preceding example, find the length of the stretch.

Worked out by Cancellation.

	11·1
	40·5
1·4·32·352	
	84(0·21·1
	36·12
1·21·63(0	

$12 \times 5 = 60$ inches. Answer.

The same without Cancellation.

Dividend . . . $\dfrac{11 \times 40 \times 840 \times 36}{352 \times 630} = 60$ inches.
Divisor . . .

Answer.

From the particulars found in the preceding example, find the number of cops in the set.

Worked out by Cancellation.

	11
	4(0
1·7·21·63(0	
	84(0·28·4
1·6(0	36·6·2

$$11 \times 4 \times 4 \times 2 = 352$$

Answer.

The same without Cancellation.

Dividend . . . . . $11 \times 40 \times 840 \times 36$

Divisor . . . . . . 630×60

$$\frac{11 \times 40 \times 840 \times 36}{630 \times 60} = 352$$

Answer.

From the particulars found in the preceding example, find the weight of the set.

Worked out by Cancellation.

	352·88·22·11
1·21·84(0	
	63(0·21·1
1·4(0	
1·2·6·36	6(0·1

11 lbs.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;.\;.\; & \dfrac{352 \times 630 \times 60}{840 \times 40 \times 36} = 11 \\ \text{Divisor} \;.\;.\;.\;.\;.\;.\;.\; & \end{array}$$

Answer.

The power furnished for driving mules is sufficient to drive them 3 stretches per minute, and they utilize $\frac{14}{15}$ of the same. Required the product per spindle per day of 12 hours, the length of the stretch being 60 inches.

Inches in one yard . .	36	60, Length of stretch, in inches.
		3 Stretches per minute.
		60 Minutes in one hour.
		12 Hours per day.
Power furnished . . .	15	14, Power utilized.
Yards in one hank . .	840	

Worked out by Cancellation.

1·3·36	60·5·1
	3·1
	6(0·2
	12·1
1·3·15	14·2
1·7·84(0	

$2 \times 2 = 4$ hanks. Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . .} & \dfrac{60 \times 3 \times 60 \times 12 \times 14}{36 \times 15 \times 840} = 4 \text{ hanks.} \\ \text{Divisor . . .} & \end{array}$$

Answer.

A pair of mules, each containing 352 spindles, produce 4 hanks per spindle per day. How many hanks will that be per week, and what will the spinners' wages amount to, at $4\frac{1}{2}$ cents per 100 hanks?

352	Spindles in each mule.
2,	Number of mules.
4,	Product per spindle per day, in hanks.
6	Days per week.
4.5	Cents per 100 hanks.

$$352 \times 2 \times 4 \times 6 = 16896 \text{ hanks per week.}$$

$$16896 \times 4.5 \div 100 = \$7.60\tfrac{8}{25}$$

Answer.

To find the requisite number of turns of twist per inch for warp and filling.

Rule.

For warp, multiply the square root of the number by $3\frac{3}{4}$, and for filling, by $3\frac{1}{4}$, and the product will be the number of turns of twist per inch required.

Examples.

How many turns of twist per inch will be required for No. 40 warp?

```
     6)40(6.324+
       36
       ----
   123)400
       369
       ----
  1262)3100
       2524
       -----
 12644)57600
       50576
       -----
        7024
        ----

        6.324
         3.75
        -----
        31620
       44268
      18972
      --------
      23.71500
```

Answer.

How many turns of twist per inch will be required for No. 40 filling?

```
      6)40(6.324+
        36
        ----
    123)400
         369
         ----
   1262)3100
          2524
          -----
  12644)57600
          50576
          -----
           7024
```

$6.324 \times 3.25 = 20.553$ Answer.

Another way to find the requisite turns of twist per inch of yarn:—Admitting that 25 turns of twist per inch of yarn is sufficient for No. 50 warp, and the same for No. 60 filling, and that the twist in different numbers of yarn is as the square of the twist to the number of the yarn, we get the following

Rule.

As No. 50 is to the square of 25, so is the given No. to the square of the twist per inch required.

Example.

How many turns of twist per inch is required for No. 40 warp?

```
1·5(0 | 25 × 25 = 625·125
      | 4(0
```

```
     125
       4
    ----
   2)5`00(22.36+        Answer.
     4
    ----
  42)100
      84
     ----
 443)1600
     1329
    -----
4466)27100
      26796
      -----
        304
```

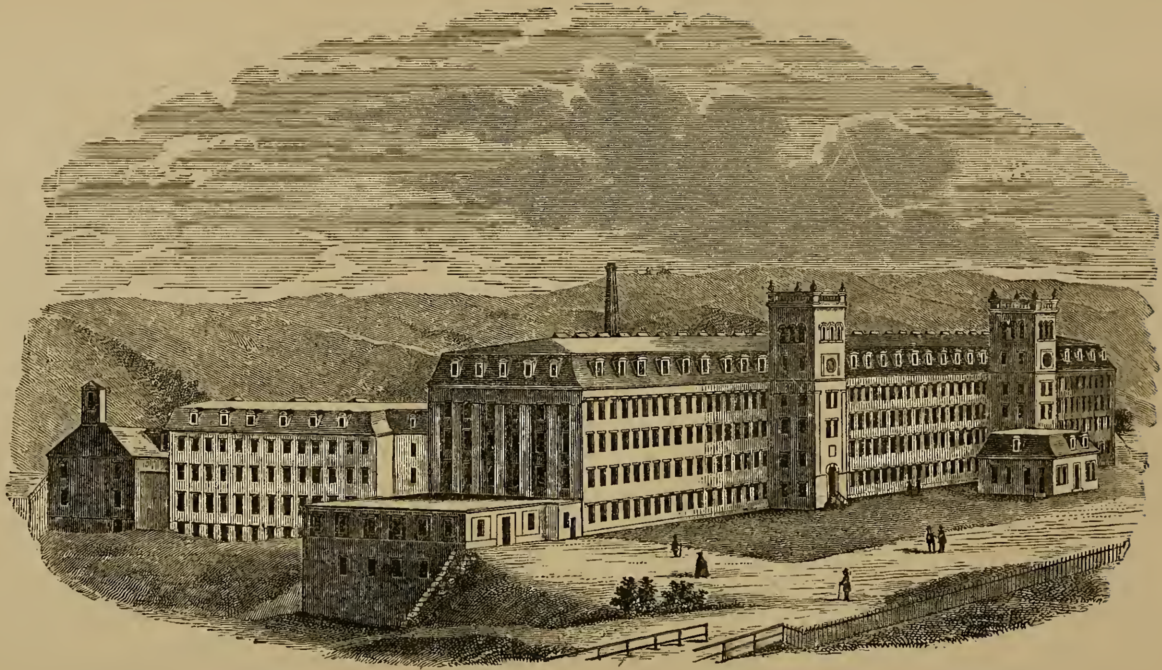
How many turns of twist per inch is required for No. 40 filling?

$$1{\cdot}6(0 \;\Big|\; \begin{array}{l} 25 \times 25 = 625 \\ 4(0{\cdot}.6666+ \end{array}$$

```
          .6666+
            625
          -----
          33330
         13332
        39996
       -------
   2)4'16,'62'50(20.41+        Answer.
     4
    -----
   404)1662
        1616
     -------
     4081)4650
          4081
          ----
           569
```

N.B.—There are many other rules in use for finding the requisite twist per inch of yarn, each of which has its advantages, but the above are generally considered the simplest and best.

The *practical* rule is, to try the yarn by breaking it. If the fibres draw out of warp instead of breaking off short, it has not twist enough; for filling, that need not be minded, if it works well in the mule and the loom.



ANDROSCOGGIN MILLS.

LEWISTON, MAINE.

MANUFACTURING.

How many hanks of yarn will be required to make a warp of 14 cuts, each 42 yards long, 30 inches wide at the reed, and 64 threads to the inch, allowing $\frac{1}{18}$ for shrinkage in weaving?

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot2\cdot84(0 & 42\cdot1 \\ & 3(0 \\ & 64 \\ & 14\cdot7 \end{array}$$

$64 \times 7 \times 3 + \frac{1}{18} = 1418.66+$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend . .} & \dfrac{42 \times 30 \times 64 \times 14}{840} + \frac{1}{18} = 1418.66 + \\ \text{Divisor . . .} & \end{array}$$

Answer.

How many hanks of filling will be required to fill a warp of 14 cuts, each 42 yards long, 30 inches wide at the reed, and 64 picks to the inch, allowing $\frac{1}{60}$ for waste?

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot2\cdot84(0 & 42\cdot1 \\ & 3(0 \\ & 64 \\ & 14\cdot7 \end{array}$$

$64 \times 7 \times 3 + \frac{1}{60} = 1366.4$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ldots\ldots & \dfrac{42 \times 30 \times 64 \times 14}{840} + \tfrac{1}{60} = 1366.4 \\ \text{Divisor} \ldots\ldots & \end{array}$$

Answer.

In 1418.666 hanks of No. 36, how many pounds?

Worked out by Cancellation.

$$\frac{1 \cdot 4 \cdot 32 \mid 1418.666 \cdot 177.333 \cdot 44.333}{44.333}$$

Answer.

In 1366.4 hanks of No. 30, how many pounds?

Worked out by Cancellation.

$$\frac{1 \cdot 3 \cdot 36 \mid 1366.4 \cdot 113.866 \cdot 37.955}{37.955}$$

Answer.

If 44.33+ pounds of yarn be sufficient for a warp of 14 cuts, each 42 yards long, including shrinkage in weaving, and 37.955 pounds of filling be sufficient to fill the same including waste, what will be the total weight of warp and filling necessary to make the 14 cuts?

44.333
37.955

82.288 pounds.

Answer.

If 82.288 pounds of warp and filling have been used in making 14 cuts of cloth, each 42 yards long, how many yards per pound is utilized ?

Worked out by Cancellation.

$$\begin{array}{r|l} & 42\cdot.5104 \\ & 14 \\ 1\cdot 82.288 & \end{array}$$

$$14 \times .5104 = 7.1456$$

Answer.

The same without Cancellation.

Dividend . . . . 42×14
Divisor 82.288

$$\frac{42 \times 14}{82.288} = 7.1456$$

Answer.

Another way to find the number of yards per pound utilized from the same particulars :—

$64+\frac{1}{60}$ Picks $=$	65.666	36 No. of filling.
$64+\frac{1}{18}$ Reed $=$	67.555	32 No. of warp.
	133.221	68
Width of the reed, in inches	30	
Warp and filling included	2	
		840 Yards in one hank.

Worked out by Cancellation.

$64+\frac{1}{60}=$	65.666	36
$64+\frac{1}{18}=$	67.555	32
	1·133.221	68·.51+
	1·3(0	
	1·2	
		84(0·28·14

$14 \times .51+ = 7.14+$ Answer.

Find the number of yards of cloth per pound from the following particulars :—

Count of reed 72

Width of reed . . . . . 42 inches.

Picks per inch	100
Counts of filling	40
Counts of warp	32
Shrinkage of warp in weaving	$\frac{1}{10}$

Worked out by Cancellation.

		42·3.5, Width of reed.
		100·25 Picks per inch.
No. of filling . . .	1·4(0	
	1·12	10(0

$25 \times 10 \times 3.5 = 875$ grains weight of filling in one yard of cloth.

		42·5.25, Width of reed.
		72·6, Count of reed.
No. of warp . . .	1·4·32	
	1·12	100·25

$25 \times 6 \times 5.25 + \frac{1}{10} = 866.25$ grains weight of warp in one yard of cloth.

866.25
875.00

174.25)7000.00(4+ yards.
6965.00

35.00 Answer.

Another way to find the number of yards of cloth per pound from the same particulars :

Worked out by Cancellation.

100 .	40
$72+\frac{1}{10} = 79.2$	32
———	—
1·179.2	72·.4+
1·42	
1·2	
	840·20·10

$10 \times .4+ = 4+$ Answer.

If it requires 866.25 grains of warp to make one yard of cloth, as seen in a preceding example, how many pounds will be required to make a warp of 10 cuts, each 40 yards long ?

Worked out by Cancellation.

	1(0
	4(0·.4
1·7·70(00	866.25·123.75

$123.75 \times .4 = 49.5$ Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{10 \times 40 \times 866.25}{7000} = 49.5$

Divisor . . . . .

Answer.

If it requires 875 grains of filling to make one yard of cloth, how many pounds will it require to make 10 cuts, each 40 yards long?

Worked out by Cancellation.

	1(0
	4(0·.4
1·7·70(00	875·125

$125 \times .4 = 50$ Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{10 \times 40 \times 875}{7000} = 50$
Divisor . . . .

Answer.

If it requires $49\frac{1}{2}$ pounds of warp, and 50 pounds of filling, to make 10 cuts of cloth, each 40 yards long, what is the total weight of warp and filling required?

$$\begin{array}{r} 49.5 \\ 50.0 \\ \hline 99.5 \end{array}$$ pounds.

Answer.

How many hanks of yarn will be required to make a warp of 10 cuts, each 40 yards long, to be woven in a 72 reed, 42 inches wide, making an allowance of $\frac{1}{10}$ for shrinkage in weaving.

Worked out by Cancellation.

	1(0
	40
	42·6
	72·6
1·7·84(0	

$40 \times 6 \times 6 + \frac{1}{10} = 1584$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;. & \dfrac{10 \times 40 \times 42 \times 72}{840} + \frac{1}{10} = 1584 \\ \text{Divisor} \;.\;.\;.\;. & \end{array}$$

Answer.

If 1584 hanks of yarn weigh $49\frac{1}{2}$ pounds, what is the number?

Worked out by Cancellation.

	1584·32
	84(0·12·1
1·49.5	
1·7(000	
1·12	1(00

32 Answer.

The same without Cancellation.

$$\text{Dividend} \ldots\ldots \quad \frac{1584 \times 840 \times 100}{49.5 \times 7000 \times 12} = 32 \quad \text{Divisor}$$

Answer.

In 10 cuts of cloth, each 40 yards long, woven in a reed 42 inches wide, 100 picks to the inch, how many hanks of filling?

Worked out by Cancellation.

	1(0
	40·10
	42·2
	100
1·21·84(0	

$100 \times 10 \times 2 = 2000$

Answer.

The same without Cancellation.

$$\text{Dividend} \ldots\ldots \quad \frac{10 \times 40 \times 42 \times 100}{840} = 2000 \quad \text{Divisor}$$

Answer.

If 2000 hanks of filling weigh 50 pounds, what is the number?

Worked out by Cancellation.

$$\begin{array}{r|l} & 2(000 \\ & 840{\cdot}120{\cdot}10 \\ 1{\cdot}50 & \\ 1{\cdot}7(000 & \\ 1{\cdot}12 & 100{\cdot}2 \end{array}$$

$$10 \times 2 \times 2 = 40$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;.\;. & \dfrac{2000 \times 840 \times 100}{50 \times 7000 \times 12} = 40 \\ \text{Divisor} \;.\;.\;.\;.\;.\;. & \end{array}$$

Answer.

Find the number of yards per pound of cloth from the following particulars:

Counts under the glass, 66 threads of warp and 80 of filling per inch.

Width of reed	33 inches.
Counts of warp	33
Counts of filling	40

Shrinkage in weaving of warp and filling, $\frac{1}{16}$.

Worked out by Cancellation.

	32·1, Width of reed.
	66·5.5 Threads of warp per inch.
Counts of warp . . 1·33	
1·12	100

$100 \times 5.5 + \frac{1}{16} = 584.375$ grains weight of warp in one yard of cloth.

	33·11, Width of reed.
	80·2 Picks per inch.
Counts of filling . . 1·40	
1·4·12	100·25

$25 \times 11 \times 2 + \frac{1}{16} = 584.375$ grains weight of filling in one yard of cloth.

```
584.375
584.375
―――――――――――――
1168.75(0)7000.00(0(5.9+        Answer.
          5843.75
          ―――――――
          1156.250
          1051.875
          ――――――――
           104.375
```

Another way to find the number of yards of cloth per pound from the same particulars:

Worked out by Cancellation.

Reed	66	33 Warp.
Picks	80	40 Filling.
	——	—
	1·2·146	73·1
	1·33	
	1·2	
		840·420·210·6.36

6.36 less $\frac{1}{16}$ = 5.9+

Answer.

How many pounds of No. 50 yarn will it take to make a beam of 10 cuts, according to the following particulars:

Length of cuts	60 yards.
Count of reed	92
Width of reed	42 inches.
Shrinkage in weaving . .	$\frac{1}{10}$

Worked out by Cancellation.

	1(0
	6(0·1.2
	42·3.5·.5

(*Continued.*)

	92
1·5(0	
1·7·84(0	

$$92 \times 1.2 \times .5 + \tfrac{1}{10} = 60.72$$

Answer.

The same without Cancellation.

$$\text{Dividend} \quad \frac{10 \times 60 \times 42 \times 92}{50 \times 840} + \tfrac{1}{10} = 60.72 \quad \text{Divisor}$$

Answer.

How many pounds of No. 60 filling will it take to fill 10 cuts, according to the following particulars?

Length of cuts	60 yards.
Width of reed	42 inches.
Picks per inch	108

Worked out by Cancellation.

	1(0
	60·1
	42·6
	108·9
1·12·84(0	
1·60	

$$9 \times 6 = 54$$ Answer.

The same without Cancellation.

$$\text{Dividend} \; \ldots\ldots \; \frac{10 \times 60 \times 42 \times 108}{840 \times 60} = 54 \; \ldots\ldots \; \text{Divisor}$$

Answer.

If there are 60.72 pounds of warp and 54 pounds of filling in 10 cuts of cloth, each 60 yards long, how many yards of cloth are there to the pound?

Worked out by Cancellation.

60.72	
54	
1·11.472·114.72	
	10·1
	60·5.2+

5.2+ Answer.

Find the number of yards per pound of cloth from the following particulars:

Count of reed	92
Width of reed	42 inches.
Picks per inch	108
Counts of warp	50
Counts of filling . . .	60

Shrinkage of warp in weaving, $\frac{1}{10}$.

Worked out by Cancellation.

$$\begin{array}{r|l} & 42{\cdot}3.5 \\ & 92 \\ 1{\cdot}50 & \\ 1{\cdot}12 & 100{\cdot}2 \end{array}$$

$92 \times 3.5 \times 2 + \frac{1}{10} = 708.4$ grains weight of warp in one yard of cloth.

$$\begin{array}{r|l} & 42{\cdot}7 \\ & 108{\cdot}9 \\ 1{\cdot}6(0 & \\ 1{\cdot}12 & 10(0 \end{array}$$

$10 \times 9 \times 7 = 630$ grains weight of filling in one yard of cloth.

$$\begin{array}{l} 708.4 \\ 630.0 \\ \hline 1338.4)7000.0(5.2+ \quad \text{Answer.} \\ 6692.0 \\ \hline 308.00 \\ 267.68 \\ \hline 40.32 \end{array}$$

Another way to find the number of yards of cloth per pound from the same particulars:

Worked out by Cancellation.

Reed $92 + \frac{1}{10} =$	101.2	50 Warp.
Picks	108	60 Filling.
	1·209.2	110·.52+
Width of reed . . .	1·42	
Warp and filling . .	1·2	
		840·20·10

$10 \times .52+ = 5.2+$ Answer.

Another way to find the number of yards of cloth per pound:

Rule.

Cut from the cloth a piece two inches square. The weight of this multiplied by half the width of the cloth, gives a product which, divided into 389, equals the number of yards per pound.

Example.

In the above example the cloth is 42 inches wide, consequently, one yard contains $42 \times 36. = 1512$ square inches, and weighs $708.4 + 630. = 1338.4$ grains. A piece of cloth 2 inches square contains $2 \times 2 = 4$ square inches. Hence, $1338.4 \times 4 \div 1512 = 3\frac{102.2}{189}$ grains weight of the 4 square inches.

If 4 square inches of cloth weigh $3\frac{102.2}{189}$ grains, how many yards are there to the pound?

N.B.—$3\frac{102.2}{189} = \frac{669.2}{189}$.

Worked out by Cancellation.

669.2	189·63·9
1·7·21	
	389

$389 \times 9 \div 669.2 = 5.2$ yards. Answer.

The same without Cancellation.

Dividend . . . . . $\dfrac{189 \times 389}{669.2 \times 21} = 5.2$ yards.
Divisor . . . . . .

Answer.

A piece of lawn is 36 inches wide, and counts, under the glass, 80×80. The filling is No. 80, and the warp No. 75; how many yards are there to the pound, admitting the warp and filling to shrink $\frac{1}{20}$ in weaving?

Worked out by Cancellation.

	36·3·1
	80
1·3·75	
1·12	100·4

$80 \times 4 + \frac{1}{20} = 336$ grains weight of warp in one yard of cloth.

	36·3
	80·1
1·80	
1·12	100

$100 \times 3 + \frac{1}{20} = 315$ grains weight of filling in one yard of cloth.

```
336
315
———
651)7000(10.7+          Answer.
    651
    ———
     4900
     4557
     ————
      343
```

Another way to find the number of yards of cloth per pound from the same particulars:

Worked out by Cancellation.

Reed . .	$80 + \frac{1}{20} = 84$	80 Warp.
Picks . .	$80 + \frac{1}{20} = 84$	75 Filling.
	1·2.4·168	155·77.5·32.2·10.7+
Width of cloth . .	1·3·36	
Warp and filling . .	1·2	
		840·70·1

10.7 Answer.

Suppose a loom to work successively at the rate of 140 picks per minute, how long would it be weaving a cut of 42 yards with 100 picks per inch?

Worked out by Cancellation.

$$\begin{array}{r|l} & 42\cdot3\cdot1 \\ & 36\cdot18 \\ 1\cdot14(0 & 1(00 \\ 1\cdot2\cdot6(0 & \end{array}$$

18 hours. Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;. & \dfrac{42 \times 36 \times 100}{140 \times 60} = 18 \text{ hours.} \\ \text{Divisor} \;.\;.\;.\;.\;. & \end{array}$$

Answer.

If the power furnished for driving a loom be sufficient to drive it 140 picks per minute, and the actual product is 34.125 yards, containing 100 picks per inch, in 18 hours, how much per cent. of the power does it utilize?

Worked out by Cancellation.

$$\begin{array}{r|l} & 100\cdot50 \\ & 34.125\cdot4.875\cdot1.625 \\ & 36\cdot2\cdot1 \\ 1\cdot7\cdot14(0 & 1(00 \\ 1\cdot18 & \\ 1\cdot3\cdot6(0 & \end{array}$$

$50 \times 1.625 = 81.25$ per cent. Answer.

The same without Cancellation.

$$\text{Dividend . . . } \frac{100 \times 34.125 \times 36 \times 100}{140 \times 18 \times 60} = 81.25 \text{ . . . Divisor}$$

Answer.

Suppose a loom to work successively at the rate of 128 picks per minute, how long will it be weaving a cut 46 yards long, containing 80 picks per inch?

Worked out by Cancellation.

	46·5.75
	36·3
1·8·16·128	80·10·2·1
1·5·60	

5.75 × 3 = 17.25 = 17 hours 15 minutes.

Answer.

The same without Cancellation.

$$\text{Dividend . . . . } \frac{46 \times 36 \times 80}{128 \times 60} = 17.25 \text{ . . . . Divisor}$$

Answer.

If the power furnished for driving a loom is sufficient to drive it 128 picks per minute, and the actual product is 28¾ yards, containing 80 picks per inch, in 12 hours, how much per cent. of said power does it utilize?

Worked out by Cancellation.

	100·25·6.25·3.125
	28.75
	36·3·1
1·4·16·128	8(0·1
1·12	
1·2·6(0	

$28.75 \times 3.125 = 89.84375$ per cent.

Answer.

The same without Cancellation.

Dividend . . Divisor . . . $\dfrac{100 \times 28.75 \times 36 \times 80}{128 \times 12 \times 60} = 89.84375$

Answer.

Admitting the power furnished for driving looms to be sufficient to drive them 120 picks per minute, and that they utilize 90 per cent. of the same, the cloth to be made into cuts each 45 yards long, containing 80 picks per inch, what will be the monthly wages of a five loom weaver at 36 cents per cut, allowing 12 hours to the day, and 24 working days to the month?

Worked out by Cancellation.

	36·1
1·8(0	12(0

(*Continued.*)

	6(0
	12
	24·3
	5·1
1(00	9(0·1
1·5·45	
1·36	

$12 \times 12 \times 6 \times 3 = \$25.92$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;. & \dfrac{36 \times 120 \times 60 \times 12 \times 24 \times 5 \times 90}{80 \times 100 \times 45 \times 36} \times \$25.92 \\ \text{Divisor} \;.\;.\;. & \end{array}$$

Answer.

Admitting the power furnished for driving looms to be sufficient to drive them 118 picks per minute, and that they utilize 75 per cent. of the same, the cloth to be made into cuts, each 60 yards long, containing 108 picks per inch, how much per cut should be paid to a three-loom weaver to make $36 per month, allowing 12 hours to the day, and 24 working days to the month?

Worked out by Cancellation.

	36·3·1
1·59·118	108·9·3
1·60	

(*Continued.*)

1·12	
1·2·24	
1·3	
1·3·75	100·4·2
	60·1
	36·18·$\frac{18}{59}$

$3 \times 2 \times \frac{18}{59} = \$1.83\frac{3}{59}$ Answer.

The same without Cancellation.

Dividend . . . Divisor . . . . $\dfrac{36 \times 108 \times 100 \times 60 \times 36}{118 \times 60 \times 12 \times 24 \times 3 \times 75} = \$1.83\frac{3}{59}$

Answer.

From the particulars found in the preceding example, find the weaver's monthly wages.

Worked out by Cancellation.

1·59	108·1 . . .	($\frac{108}{59}$ of \$1.)
1·108	118·2	
	60·1	
	12·1	
	24·6	
	3·1	
1·4·100	75·3	
1·60		
1·3·36		

$6 \times 2 \times 3 = \$36.$ Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \quad . \quad . \quad . & \dfrac{108 \times 118 \times 60 \times 12 \times 24 \times 3 \times 75}{59 \times 108 \times 100 \times 60 \times 36} = \$36. \\ \text{Divisor} \quad . \quad . \quad . & \end{array}$$

Answer.

Admitting the labor and skill required to weave 14 twill cuts per loom, on five looms per month, to be equal to that required to weave 16 cambric cuts per loom on 4 looms in the same time, and the price paid for the cambric 39 cents, and the twill 28 cents per cut, how much per cut should be advanced on the twills to make the monthly wages of the weavers equal, if the cambric is advanced to 42 cents per cut?

Worked out by Cancellation.

	42·6
1·5	4·.8
1·7·14	16·8

$8 \times 6 \times .8 - 28 = 10.4$ cents.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \quad . \quad . \quad . & \dfrac{42 \times 4 \times 16}{5 \times 14} - 28 = 10.4 \text{ cents.} \\ \text{Divisor} \; . \quad . \quad . \quad . & \end{array}$$

Answer.

From the particulars found in the preceding example, find the monthly wages of the twill and cambric weavers at the advanced price.

Twill	$38.4 \times 14 \times 5$	$= \$26.88$
Cambric	$42 \times 16 \times 4$	$= \$26.88$

Answer.

Admitting the labor and skill required to weave 16 cambric cuts per loom on 4 looms per month, to be equal to that required to weave 14 twill cuts per loom on 5 looms in the same time, and the price paid for the twill is 38.4 cents per cut, how much per cut should be paid for the cambric to make the monthly wages of the weavers equal?

Worked out by Cancellation.

$$\begin{array}{r|l} & 38.4\cdot4.8\cdot1.2 \\ 1\cdot4 & 5 \\ 1\cdot8\cdot16 & 14\cdot7 \end{array}$$

$$7 \times 5 \times 1.2 = 42 \text{ cents.}$$

Answer.

The same without Cancellation.

Dividend . . . . . . Divisor . . . . . .

$$\frac{38.4 \times 5 \times 14}{4 \times 16} = 42 \text{ cents.}$$

Answer.

If one weaver weaves 16 cambric cuts per loom per month on 4 looms, and another weaves 14 twill cuts per loom on 5 looms in the same time, and an advance of 6 cents per cut is made on the twill, how many cents per cut should the cambric be advanced to make the monthly advance of the weavers' wages equal?

Worked out by Cancellation.

	6·3
1·16	14·7·.4375
1·2·4	5

$$5 \times 3 \times .4375 = 6\tfrac{9}{16} \text{ cents.}$$

Answer.

The same without Cancellation.

Dividend . . . . . . $6 \times 14 \times 5$
Divisor . . . . . . 16×4

$$\frac{6 \times 14 \times 5}{16 \times 4} = 6\tfrac{9}{16} \text{ cents.}$$

Answer.

From the particulars found in the preceding example, find the monthly advance in the weavers' wages.

Cambric . . . . . . $6\tfrac{9}{16} \times 16 \times 4 = \$4.20$
Twill . . . . . . $6 \times 14 \times 5 = \$4.20$

Answer.

SLIVER TABLE,

Showing the size of sliver from No. .01 to .09, by the weight of 6 yards, in grains.

Number.	Grains.	Number.	Grains.	Number.	Grains.
.01	5000	.037	1351	.064	781
.011	4545	.038	1316	.065	769
.012	4167	.039	1282	.066	758
.013	3846	.04	1250	.067	746
.014	3571	.041	1220	.068	735
.015	3333	.042	1191	.069	725
.016	3125	.043	1163	.07	714
.017	2941	.044	1136	.071	704
.018	2778	.045	1111	.072	694
.019	2632	.046	1087	.073	685
.02	2500	.047	1064	.074	676
.021	2381	.048	1042	.075	667
.022	2273	.049	1020	.076	658
.023	2174	.05	1000	.077	649
.024	2083	.051	980	.078	641
.025	2000	.052	962	.079	633
.026	1923	.053	943	.08	625
.027	1852	.054	926	.081	617
.028	1786	.055	909	.082	610
.029	1724	.056	893	.083	602
.03	1667	.057	877	.084	595
.031	1613	.058	862	.085	588
.032	1563	.059	847	.086	581
.033	1515	.06	833	.087	575
.034	1471	.061	820	.088	568
.035	1429	.062	806	.089	562
.036	1389	.063	794	.09	556

SLIVER TABLE,

Showing the size of sliver from No. .091 to No. .236, by the weight of 6 yards, in grains.

Number.	Grains.	Number.	Grains.	Number.	Grains.
.091	549	.134	373	.186	269
.092	543	.136	368	.188	266
.093	538	.138	362	.19	263
.094	532	.14	357	.192	260
.095	526	.142	352	.194	258
.096	521	.144	347	.196	255
.097	515	.146	342	.198	253
.098	510	.148	338	.2	250
.099	505	.15	333	.202	248
.1	500	.152	329	.204	245
.102	490	.154	325	.206	243
.104	481	.156	321	.208	240
.106	472	.158	316	.21	238
.108	463	.16	313	.212	236
.11	455	.162	309	.214	234
.112	446	.164	305	.216	231
.114	439	.166	301	.218	229
.116	431	.168	298	.22	227
.118	424	.17	294	.222	225
.12	417	.172	291	.224	223
.122	410	.174	287	.226	221
.124	403	.176	284	.228	219
.126	397	.178	281	.23	217
.128	391	.18	278	.232	216
.13	385	.182	275	.234	214
.132	379	.184	272	.236	212

SLIVER TABLE,

Showing the size of sliver from No. .238 to No. 1, by the weight of 6 yards, in grains.

Number.	Grains.	Number.	Grains.	Number.	Grains.
.238	210	.292	171	.53	94
.24	208	.294	170	.54	93
.242	207	.296	169	.55	91
.244	205	.298	168	.56	89
.246	203	.3	167	.57	88
.248	202	.31	161	.58	86
.25	200	.32	156	.59	85
.252	198	.33	152	.6	83
.254	197	.34	147	.62	81
.256	195	.35	143	.64	78
.258	194	.36	139	.66	76
.26	192	.37	135	.68	74
.262	191	.38	132	.7	71
.264	189	.39	128	.72	69
.266	188	.4	125	.74	68
.268	187	.41	122	.76	66
.27	185	.42	119	.78	64
.272	184	.43	116	.8	63
.274	182	.44	114	.82	61
.276	181	.45	111	.84	60
.278	180	.46	109	.86	58
.28	179	.47	106	.88	57
.282	177	.48	104	.9	56
.284	176	.49	102	.92	54
.286	175	.5	100	.94	53
.288	174	.51	98	.96	52
.29	172	.52	96	.98	51
				1.	50

ROVING TABLE,

Showing the size of roving from No. .05 to No. 8, by the weight of 12 yards, in grains.

Number	Grains.	Number.	Grains.	Number.	Grains.	Number.	Grains.
.05	2000	.108	926	.185	541	.8	125
.052	1923	.11	909	.19	526	.85	118
.054	1852	.112	893	.195	513	.9	111
.056	1786	.114	877	.2	500	.95	105
.058	1724	.116	862	.205	488	1.	100
.06	1667	.118	847	.21	476	1.05	95
.062	1613	.12	833	.215	465	1.2	83
.064	1563	.122	820	.22	455	1.25	80
.066	1515	.124	806	.225	444	1.3	77
.068	1471	.126	794	.23	435	1.35	74
.07	1429	.128	781	.235	426	1.4	71
.072	1389	.13	769	.24	417	1.5	67
.074	1350	.132	758	.245	408	1.65	61
.076	1316	.134	746	.25	400	1.8	55
.078	1282	.136	735	.275	364	2.	50
.08	1250	.138	725	.3	333	2.25	44
.082	1220	.14	714	.325	308	2.75	36
.084	1190	.143	699	.35	286	3.	33
.086	1163	.146	685	.375	267	3.5	29
.088	1136	.149	671	.4	250	4.	25
.09	1111	.152	658	.425	235	4.5	22
.092	1087	.155	645	.45	222	5.	20
.094	1064	.158	633	.475	211	5.5	18
.096	1042	.161	621	.5	200	6.	17
.098	1020	.165	606	.55	182	6.5	15
1	1000	.169	592	.6	167	7.	14
.102	980	.173	578	.65	154	7.5	13
.104	962	.177	565	.7	143	8.	13
.106	943	.181	552	.75	133		

YARN TABLE,

Showing the size of yarn from No. 1 to No. 120, by the weight of one hank in grains.

No.	Grains.	No.	Grains.	No.	Grains.	No.	Grains.	No.	Grains.
1	7000	25	280	49	143	73	96	97	72
2	3500	26	269	50	140	74	95	98	71
3	2333	27	259	51	137	75	93	99	71
4	1750	28	250	52	135	76	92	100	70
5	1400	29	241	53	132	77	91	101	69
6	1167	30	233	54	130	78	90	102	69
7	1000	31	226	55	127	79	89	103	68
8	875	32	219	56	125	80	88	104	67
9	778	33	212	57	123	81	86	105	67
10	700	34	206	58	121	82	85	106	66
11	636	35	200	59	119	83	84	107	65
12	583	36	194	60	117	84	83	108	65
13	538	37	189	61	115	85	82	109	64
14	500	38	184	62	113	86	81	110	64
15	467	39	179	63	111	87	80	111	63
16	438	40	175	64	109	88	80	112	63
17	412	41	171	65	108	89	79	113	62
18	389	42	167	66	106	90	78	114	61
19	368	43	163	67	104	91	77	115	61
20	350	44	159	68	103	92	76	116	60
21	333	45	156	69	101	93	75	117	60
22	318	46	152	70	100	94	74	118	59
23	304	47	149	71	99	95	74	119	59
24	292	48	146	72	97	96	73	120	58

EXPLANATION OF THE REED TABLE.

1. Manchester, Stockport, and the United States count by the number of ends in one inch.

2. Bolton counts by the number of beers on $24\frac{1}{2}$ inches, 20 dents to a beer.

3. Blackburn counts by the number of beers on 45 inches, 20 dents to a beer.

4. 6-4ths, Preston, counts by the number of beers on 58 inches, 20 dents to a beer.

5. 9-8ths, Preston, counts by the number of beers on 44 inches, 20 dents to a beer.

6. 4-4ths, Preston, counts by the number of beers on 39 inches, 20 dents to a beer.

7. 7-8ths, Preston, counts by the number of beers on 34 inches, 20 dents to a beer.

8. Nankeen counts by the number of beers on 20 inches, 19 dents to a beer.

9. Scotch and Carlisle count by the number of dents on 37 inches.

Goods shrink about $\frac{1}{10}$ in bleaching or finishing.

The following table shows at a glance the number of dents in an inch, and the corresponding count of reed.

The first column contains the number of dents in one inch, opposite to which are the counts of the reeds according to the system of counting.

REED TABLE.

No. of Dents in one inch.	Manchester, Stockport, and United States.	Bolton.	Preston, 6-4ths.	Preston, 9-8ths.	Preston, 4-4ths.	Preston, 7-8ths.	Blackburn.	Nankeen.	Scotch and Carlisle.
20	40	24.25	58	44	39	34	45	21.05	740
21	42	25.46	60.9	46.2	40.95	35.7	47.25	22.1	777
22	44	26.67	63.8	48.4	42.9	37.4	49.5	23.15	814
23	46	27.88	66.7	50.6	44.85	39.1	51.75	24.21	851
24	48	29.1	69.6	52.8	46.8	40.8	54	25.26	888
25	50	30.31	72.5	55	48.75	42.5	56.25	26.31	925
26	52	31.52	75.4	57.2	50.7	44.2	58.5	27.36	962
27	54	32.73	78.3	59.4	52.65	45.9	60.75	28.42	999
28	56	33.95	81.2	61.6	54.7	47.6	63	29.47	1036
29	58	35.16	84.1	63.8	56.55	49.3	65.25	30.52	1073
30	60	36.87	87	66	58.5	51	67.5	31.57	1110
31	62	37.58	89.9	68.2	60.45	52.7	69.75	32.63	1147
32	64	38.8	92.8	70.4	62.4	54.4	72	33.68	1184
33	66	40.1	95.7	72.6	64.35	56.1	74.25	34.73	1221
34	68	41.22	98.6	74.8	66.3	57.8	76.5	35.79	1258
35	70	42.43	101.5	77	68.25	59.5	78.75	36.84	1295
36	72	43.65	104.4	79.2	70.2	61.2	81	37.89	1332

37	74	44.86	107.3	81.4	72.15	62.9	83.25	38.94	1369
38	76	46.07	110.2	83.6	74.1	64.6	85.5	40	1406
39	78	47.28	113.1	85.8	76.05	66.3	87.75	41.05	1443
40	80	48.5	116	88	78	68	90	42.1	1480
41	82	49.71	118.9	90.2	79.95	69.7	92.25	43.15	1517
42	84	50.9	121.8	92.4	81.9	71.4	94.5	44.21	1554
43	86	52.13	124.7	94.6	83.85	73.1	96.75	45.26	1591
44	88	53.35	127.6	96.8	85.8	74.8	99	46.31	1628
45	90	54.56	130.5	99	87.75	76.5	101.2	47.36	1665
46	92	55.71	133.4	101.2	89.7	78.2	103.5	48.42	1702
47	94	56.98	136.3	103.4	91.65	79.9	105.75	49.47	1739
48	96	58.2	139.2	105.6	93.6	81.6	108	50.52	1776
49	98	59.41	142.1	107.8	95.55	83.3	110.25	51.57	1813
50	100	66.62	145	110	97.5	85	112.5	52.63	1850
51	102	61.83	148.9	112.2	99.45	86.7	114.75	53.67	1887
52	104	63.04	151.8	114.4	101.4	88.4	117	54.72	1924
53	106	64.25	154.7	116.6	103.35	90.1	119.25	55.78	1961
54	108	65.46	157.6	118.8	105.3	91.8	121.5	56.84	1998
55	110	66.69	159.5	121	107.25	93.5	123.75	57.9	2035
56	112	67.9	162.4	123.2	109.2	95.2	126	58.9	2072
57	114	69.11	165.3	125.4	111.15	96.9	128.25	60	2109
58	116	70.33	168.2	127.6	113.1	98.6	130.5	61.05	2146
59	118	71.56	171.1	129.8	115.05	100.3	132.75	62.1	2183
60	120	72.75	174	132	117	102	135	63.15	2220

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LINEN YARN TABLE,

Showing the weight of one lea, or cut, in grains, from No. 1 to No. 200.

The first column is the number of the yarn, opposite to which is the weight, in grains, according to the length weighed, which, in the table, is one cut, or 300 yards.

One lea, or cut, of linen yarn contains 300 yards, and one pound avoirdupois contains 7000 grains troy; hence, the yards in one cut are to the grains in one pound, as 300 is to 7000, or 3 to 70.

To find the number.

Multiply the length in yards by 70, and divide their product by the weight, in grains, multiplied by 3.

Example.

If 2400 yards weigh 7000 grains, what is the number?

Worked out by Cancellation.

1·7(000	24(00·8
1·3	7(0·1

8 Answer.

The same without Cancellation.

Dividend . . . . $\dfrac{2400 \times 70}{7000 \times 3} = 8$
Divisor . . . .

Answer.

How many yards are there in one pound of No. 8?

Worked out by Cancellation.

$$\begin{array}{r|l} & 7000\cdot 100 \\ & 8 \\ 1\cdot 70 & 3 \end{array}$$

$$100 \times 8 \times 3 = 2400$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;.\;.\;. & \dfrac{7000 \times 8 \times 3}{70} = 2400 \\ \text{Divisor} \;.\;.\;.\;.\;.\;.\;. & \end{array}$$

Answer.

What is the weight of 2400 yards of No. 8?

Worked out by Cancellation.

$$\begin{array}{r|l} 1\cdot 8 & 2400\cdot 800\cdot 100 \\ 1\cdot 3 & 70 \end{array}$$

$100 \times 70 = 7000$ grains, or one pound.

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \;.\;.\;.\;.\;. & \dfrac{2400 \times 70}{8 \times 3} = 7000 \text{ grains.} \\ \text{Divisor} \;.\;.\;.\;.\;. & \end{array}$$

Answer.

LINEN YARN TABLE.

Number.	Grains.	Number.	Grains.	Number.	Grains.
1	7000	20	350	115	61
2	3500	25	280	120	58
3	2333	30	233	125	56
4	1750	35	200	130	54
5	1400	40	175	135	52
6	1167	45	156	140	50
7	1000	50	140	145	48
8	875	55	127	150	47
9	778	60	117	155	45
10	700	65	108	160	44
11	636	70	100	165	42
12	583	75	93	170	41
13	538	80	88	175	40
14	500	85	82	180	39
15	467	90	78	185	38
16	438	95	74	190	37
17	412	100	70	195	36
18	389	105	67	200	35
19	368	110	64		

WORSTED AND WOOLLEN YARN TABLE,

Showing the weight of one hank, in grains, from No. 1 to No. 200.

The first column is the number of the yarn, opposite to which is the weight in grains, according to the length weighed, which, in the table, is one hank, or 560 yards.

One pound avoirdupois contains 7000 grains troy, and one hank of woollen yarn contains 560 yards; hence, the yards in one hank are to the grains in one pound, as 560 is to 7000, or 14 to 175.

To find the number.

Multiply the length in yards by 175, and divide their product by the weight in grains multiplied by 14.

Example.

If 5600 yards weigh one pound, what is the number?

Worked out by Cancellation.

1·17.5·70(00	56(00·4·1
1·14	175·10

10 Answer.

The same without Cancellation.

Dividend . . . . 5600×175

Divisor . . . . 7000×14

$$\frac{5600 \times 175}{7000 \times 14} = 10$$

Answer.

What is the weight of 5600 yards of No. 10?

Worked out by Cancellation.

$$\begin{array}{r|l} 1(0 & 560(0 \cdot 40 \\ 1 \cdot 14 & 175 \end{array}$$

$$175 \times 40 = 7000 \text{ grains, or one pound.}$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ . \ . \ . \ . & \dfrac{5600 \times 175}{10 \times 14} = 7000 \text{ grains.} \\ \text{Divisor} \ . \ . \ . \ . \ . & \end{array}$$

Answer.

How many yards are there in one pound of No. 10?

Worked out by Cancellation.

$$\begin{array}{r|l} & 7000 \cdot 200 \\ & 10 \cdot 2 \\ 1 \cdot 35 \cdot 175 & 14 \end{array}$$

$$200 \times 14 \times 2 = 5600$$

Answer.

The same without Cancellation.

$$\begin{array}{ll} \text{Dividend} \ . \ . \ . \ . \ . & \dfrac{7000 \times 10 \times 14}{175} = 5600 \\ \text{Divisor} \ . \ . \ . \ . \ . \ . & \end{array}$$

Answer.

WORSTED AND WOOLLEN YARN TABLE,

Showing the weight of one hank, in grains, from No. 1 to No. 200.

Number.	Grains.	Number.	Grains.	Number.	Grains.
1	7000	20	350	115	61
2	3500	25	280	120	58
3	2333	30	233	125	56
4	1750	35	200	130	54
5	1400	40	175	135	52
6	1167	45	156	140	50
7	1000	50	140	145	48
8	875	55	127	150	47
9	778	60	117	155	45
10	700	65	108	160	44
11	636	70	100	165	42
12	583	75	93	170	41
13	538	80	88	175	40
14	500	85	82	180	39
15	467	90	78	185	38
16	438	95	74	190	37
17	412	100	70	195	36
18	389	105	67	200	35
19	368	110	64		

RAILWAY-HEAD.

WITH DRAPER'S PATENT EVENER ATTACHED.

The following tables and remarks were furnished by Mr. George Draper, Hopedale, Mass:

Below I give a table showing the actual result of the use of the Eveners in the Boott Cotton Mills at Lowell, from July 19 to August 4, 1866. The drawing from each of the heads was weighed carefully over 150 times. The

TABLE OF WEIGHTS WHERE THE EVENER WAS USED.

		73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88		
								3											
								1	1		1								
							2		1										
								1	1	1									
						1	2	3	3	1	2								
						1	4	2	5										
		1		4	1	2	3	2	1										
		1	1	4	3	3	1	1											
				2	2		1	2	1										
			1	1	6														
					2		4	1	2	1									
					2	1	1	2	3	1									
				1	1	1		2	3	1		1							
						2	4	1	2		1								
				3	1	3				3									
				1	2	1	1	3	2										
						1	4		3										
						1	3	1	3										
		2	2	16	20	17	31	25	30	9	3	1							

Standard aimed at was 79 grains (*between the black lines*) for a given length. The drawing was straightened out, a strip of board laid on, and the drawing cut off at each end with a sharp knife, and then carefully weighed. Mark the result—any weighing not varying more than 4 or 5 grains from the standard, either way, would make comparatively little difference. That weighing 72 in number 20 yarn, would vary one number one way, and 83 one number the other way. That with the Evener in weigh-

TABLE OF WEIGHTS WHERE THE EVENER WAS NOT USED.

		73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88		
					1		2												
					1	1				1									
									1		1			1					
				1	1									1					
				2	1	1	2	1	2	2	1								
			1		1	3	1	1	4				1						
		1		1	1	1	1	2		2	1	1	2		1				
				1	2		1			3		3	3		1				
					1	1		1	1	1		1	2						
							1		1		1		3	1			1		
				2	2		1	3		1		1							
					1		1	3		1	3				1				
		1	2			3		2	2										
			1		1		1	2		2		1			1	1			
			1		2	2	1	2	1				1						
				1	2		1	1	1		1			1		1			
				1	2		1	1			1	1							
				2	1		2	1	1										
		2	5	11	20	12	16	20	14	13	9	8	12	4	4	2	1		

ing 156 times in three weeks, varied more than that only 4 times, 2 times 73 and 2 times 74. Now look at the other weight at the same time, and under the same circumstances, *except* the Evener. Out of 153 weighings, that weighed 75—7 times and more than 83—23 times. The one with the Evener weighed right, or within one grain of right, 86 times, while the one without the Evener did but 50 times. In one the weighings are between 73 and 83—in the other scattered from 73 to 88.

N. B.—The above is by some called Hayden & Wyllys' Patent Evener.