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CALCULATIONS.

Grading of the Various Yarns Used in the Manufacture of Textile Fabrics According to Size or Counts.

The size of the yarns, technically known as their "*Counts*" or numbers, are based for the different raw materials (with the exception of raw silks) upon the number of yards necessary to balance one (1) lb. avoirdupois. The number of yards thus required (to balance 1 lb.) are known as the "*Standard*" and vary accordingly for each material. The higher the count or number, the finer the yarn according to its diameter.

COTTON YARNS.

Cotton yarns have for their standard 840 yards (equal to 1 hank) and are graded by the number of hanks 1 lb. contains. Consequently if 2 hanks, or 2 × 840 yards = 1680 yards are necessary to balance 1 lb. we classify the same as number 2 cotton yarn If 3 hanks or 3 × 840 or 2520 yards are necessary to balance 1 lb., the thread is known as number 3 cotton yarn. Continuing in this manner, always adding 840 for each successive number gives the yards the various counts or numbers of cotton yarn contain for 1 lb.

Table of Lengths for Cotton Yarns.

(From number 1 to 240's.)

No.	Yds. to 1 lb.	No.	Yds to 1 lb.	No.	Yds. to 1 lb	No.	Yds. to 1 lb.	No.	Yds. to 1 lb.
1	840	17	14,280	33	27,720	50	42,000	85	71,400
2	1,680	18	15,120	34	28,560	52	43,680	90	75,600
3	2,520	19	15,960	35	29,400	54	45,360	95	79,800
4	3,360	20	16,800	36	30,240	56	47,040	100	84,000
5	4,200	21	17,640	37	31,080	58	48,720	110	92,400
6	5,040	22	18,480	38	31,920	60	50,400	120	100,800
7	5,880	23	19,320	39	32,760	62	52,080	130	109.200
8	6,720	24	20,160	40	33,600	64	53,760	140	117,600
9	7,560	25	21,000	41	34,440	66	55,440	150	126,000
10	8,400	26	21,840	42	35,280	68	57,120	160	134,400
11	9,240	27	22,680	43	36.120	70	58,800	170	142,800
12	10,080	28	23,520	44	36,960	72	60,480	180	151,200
13	10,920	29	24,360	45	37,800	74	62,160	190	159,600
14	11,760	30	25,200	46	38,640	76	63,840	200	168,000
15	12,600	31	26,040	47	39,480	78	65,520	220	184,800
16	13,440	32	26,880	48	40,320	80	67,200	240	201,600

Grading of 2-ply, 3-ply, etc., Cotton Yarns.

Cotton Yarns are frequently manufactured into 2-ply. In such cases the number of yards required for 1 lb. is one-half the amount called for in the single thread.

For Example.—20's cotton yarn (single) equals 16,800 yards per pound, while a 2-ply thread of 20's cotton, technically indicated as 2/20's cotton, requires only 8400 yards, or equal to the amount called for in single 10's cotton (technically represented as 10's cotton). Single 7's cotton yarn has 5,880 yards to 1 lb., and thus equals 2-ply 14's cotton yarn; or 2/14's cotton yarn equals one-half the count (14÷2=7), or number 7 in single yarn.

If the yarn be more than 2-ply, divide the number of the single yarn in the required counts by the number of ply, and the result will be the equivalent counts in a single thread.

Example.—Three-ply 60's, or 3/60's cotton yarn, equals in size

Number of single yarn in required counts.		Number of ply.		Equivalent counts in a single thread
(60	÷	3	=	20)

single 20's cotton yarn, or 16,800 yards of single 20's cotton yarn weigh 1 lb., and 16,800 yards of 3/60's cotton yarn weigh also 1 lb. Again, 4-ply 60's or 4/60's cotton yarn equals in size

Number of single yarn in required counts.		Number of ply.		Equivalent counts in a single thread.
(60	÷	4	=	15)

single 15's cotton yarn; or single 15's cotton yarn has 12.600 yards, weighing 1 lb., which is also the number of yards required for 4/60's cotton yarn.

Rule for finding the Weight in Ounces of a given Number of Yards of Cotton Yarn of a known Count.

Multiply the given yards by 16, and divide the result by the number of yards of the known count required to balance 1 lb.

Example (single yarn).—Find weight of 12,600 yards of 30's cotton yarn. 12,600×16=201,600; 1 lb. 30's cotton yarn=25,200 yards. Thus, 201,600÷25,200=8.
Answer.—12,600 yards of 30's cotton yarn weigh 8 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/30's cotton yarn. 12,600×16=201,600; 1 lb. 2/30's cotton yarn=12,600 yards. Thus, 201,600÷12,600=16.
Answer.—12,600 yards of 2/30's cotton yarn weigh 16 oz.

Example—(3-ply yarn).—Find the weight of 12,600 yards of 3/30's cotton yarn. 12,600×16=201,600; 1 lb. 3/30's cotton yarn=8,400 yards. Thus, 201,600÷8,400=24 oz.
Answer.—12,600 yards of 3/30's cotton yarn weigh 24 oz.

Another rule for ascertaining the weight in ounces for a given number of yards of cotton yarn of a known count is as follows: Divide the given yards by the number of yards of the known count required to balance one ounce (being yards per lb.÷16).

Example (single yarn).—Find the weight of 12,600 yards of 30's cotton yarn. 25,200÷16=1,575 yards 30's cotton yarn=1 oz.; 12,600÷1,575=8.
Answer.—12,600 yards of 30's cotton yarn weigh 8 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/30's cotton yarn. 12,600÷16=787½ yards 2/30's cotton yarn=1 oz.; 12,600÷787½=16.
Answer.—12,600 yards of 2/30's cotton yarn weigh 16 oz.

Example (3-ply yarn).—Find the weight for 12,600 yards of 3/30's cotton yarn. 8,400÷16=525 yards 3/30's cotton yarn=1 oz.; 12,600÷525=24.
Answer.—12,600 yards of 3/30's cotton yarn weigh 24 oz.

Rule for finding the Weight in Pounds of a given Number of Yards of Cotton Yarn of a known Count.

Divide the given yards by the number of yards of the known count required to balance 1 lb.

Example (single yarn).—Find the weight of 1,260,000 yards of 30's cotton yarn. 30's cotton yarn=25,200 yards to 1 lb. Thus, 1,260,000÷25,200=50.
Answer.—1,260,000 yards of 30's cotton yarn weigh 50 lbs.

Example (2-ply yarn).—Find the weight of 1,260,000 yards of 2/30's cotton yarn. 2/30's cotton yarn=12,600 yards to 1 lb. Thus, 1,260,000÷12,600=100.

Answer.—1,260,000 yards of 2/30's cotton yarn weigh 100 lbs.

Example (3-ply yarn).—Find the weight of 1,260,000 yards of 3/30's cotton yarn. 3/30's cotton yarn=8,400 yards to 1 lb. Thus, 1,260,000÷8,400=150.

Answer.—1,260,000 yards of 3/30's cotton yarn weigh 150 lbs.

To find the Equivalent Size in Single Yarn for Two, Three, or More, Ply Yarn Composed of Minor Threads of Unequal Counts.

In the manufacture of fancy yarns the compound thread is often composed of two or more minor threads of unequal counts. If so, the rules for finding the equivalent in single yarn is as follows:

Rule.—If the compound thread is composed of two minor threads of unequal counts, divide the product of the counts of the minor threads by their sum.

Example.—Find the equal in single yarn to a two-fold thread composed of single 40's and 60's. $40 \times 60 = 2400 \div 100\ (40+60) = 24$.

Answer.—A two-fold cotton thread composed of single 40's and 60's equals a single 24's.

Rule.—If the compound thread is composed of three minor threads of unequal counts, compound any two of the minor threads into one, and apply the previous rule to this compound thread and the third minor thread not previously used.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 20's, 30's and 50's. $20 \times 30 = 600 \div 50\ (20+30) = 12$; $12 \times 50 = 600 \div 62\ (12+50) = 9\frac{21}{31}$.

Answer.—A 3-ply cotton yarn composed of 20's, 30's and 50's equals in size a single $9\frac{21}{31}$'s thread.

A second rule for finding the equivalent counts for a yarn when three or more minor threads are twisted together is as follows: Divide one of the counts by itself, and by the others in succession, and afterwards by the sum of the quotients. To prove the accuracy of this rule we give again the previously given example.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 20's, 30's and 50's.

$$\begin{array}{l} 50 \div 50 = 1 \\ 50 \div 30 = 1\frac{4}{6} \\ 50 \div 20 = 2\frac{3}{6} \\ \hline \qquad\quad 5\frac{1}{6} \end{array} \qquad 50 \div 5\frac{1}{6} = 9\frac{21}{31}$$

Answer.—A 3-ply cotton thread composed of 20's, 30's and 50's equals in size a single $9\frac{21}{31}$'s thread.

Example.—Find equal counts in a single yarn for the following 3-ply yarn composed of 40's, 30's, and 20's cotton threads.

$$\begin{array}{l} 40 \div 40 = 1 \\ 40 \div 30 = 1\frac{1}{3} \\ 40 \div 20 = 2 \\ \hline \qquad\quad 4\frac{1}{3} \end{array} \qquad 40 \div 4\frac{1}{3} = 9\frac{3}{13}$$

Answer.—The 3-ply yarn given in the example equals a single $9\frac{3}{13}$ cotton thread.

Memo.—In the manufacture of twisted yarns (composed either out of two, three, or more minor threads) a certain amount of shrinkage will take place by means of the twisting of the threads around each other. No doubt if both minor threads are of equal counts this shrinkage will be equal for both, but if the sizes of the yarns, or the raw materials of which they are composed, are different, such "*take-up*" will be different for each minor thread. For example: a strong and heavy minor thread twisted with a fine soft thread; in this case the finer thread will wind itself (more or less) around the thick or heavy thread, not having sufficient strength to bend the latter, thus the finer thread will take up more in proportion than the heavy thread. Twisting a woolen thread with a cotton thread, both supposed to be of the same counts, will stretch the former more than the latter; *i. e.* it will lose less in length during twisting compared to the latter. Again two or more minor threads twisted with different turns per inch will accordingly take up differently. In giving rules for any of the yarn calculations in 2, 3, or more ply yarn, no notice of shrinkage or take-up by means of twisting the minor threads is taken in account, since otherwise an endless number of rules of the most complicated character would be required with reference to raw materials, the different counts of threads, turns of twist per inch and tension for each individual minor thread during the twisting operation. Such rules would thus be of little value to the manufacturer since his practical experience regarding this subject will readily assist him to calculate quickly and exactly by rules given, with a proportional allowance for a take up of minor threads as the case may require.

WOOLEN YARNS.

A. "Run" System.

Woolen yarns are with the exception of the mills in Philadelphia and vicinity, graded by "*runs*" which have for their standard 1600 yards. Consequently 1 run yarn requires 1600 yards to 1 lb., 2 run yarn—3200 yards to 1 lb., 3 run yarn—4800 yards to 1 lb., etc., always adding 1600 yards for each successive run. In addition to using whole numbers only as in the case of cotton and worsted yarn, the run is divided into halves, quarters, and occasionally into eighths, hence—

200	yards	equal	$\frac{1}{8}$	run	1000	yards	equal	$\frac{5}{8}$	run
400	"	"	$\frac{1}{4}$	"	1200	"	"	$\frac{3}{4}$	"
600	"	"	$\frac{3}{8}$	"	1400	"	"	$\frac{7}{8}$	"
800	"	"	$\frac{1}{2}$	"	1600	"	"	1	" &c.

Table of Lengths for Woolen Yarns (*Run System*).

(From one-fourth Run to fifteen Run).

Run.	Yds. to 1 lb.	Run.	Yds. to 1 lb.	Run.	Yds to 1 lb	Run.	Yds to 1 lb.
¼	400	3	4,800	5¾	9,200	8½	13,600
½	800	3¼	5,200	6	9,600	8¾	14,000
¾	1,200	3½	5,600	6¼	10,000	9	14,400
1	1,600	3¾	6,000	6½	10,400	9½	15,200
1¼	2,000	4	6,400	6¾	10,800	10	16,000
1½	2,400	4¼	6,800	7	11,200	10½	16,800
1¾	2,800	4½	7,200	7¼	11,600	11	17,600
2	3,200	4¾	7,600	7½	12,000	12	19,200
2¼	3,600	5	8,000	7¾	12 400	13	20,800
2½	4,000	5¼	8,400	8	12,800	14	22,400
2¾	4,400	5½	8,800	8¼	13,200	15	24,000

Rule for Finding the Weight in Ounces of a Given Number of Yards of Woolen Yarn of a Known Count Graded After the Run System.

The run basis is very convenient for textile calculations by reason of the standard number equaling 100 times the number of ounces that 1 lb. contains; thus by simply multiplying the size of the yarn given in run counts by 100, and dividing the result into the number of yards given (for which we have to find the weight), gives us as the result the weight expressed in ounces

Example.—Find the weight of 7200 yards of 4 run yarn—$4\times100=400$. $7200\div400=18$.
Answer.—7200 yards 4 run yarn weigh 18 ounces.

Example.—Find the weight of 3750 yards of $3\frac{3}{4}$ run woolen yarn—$3750\div375=10$.
Answer.—3750 yards of $3\frac{3}{4}$ run woolen yarn weigh 10 ounces.

Rule for Finding the Weight in Pounds of a Given Number of Yards of Woolen Yarn of a Known Count Graded After the Run System.

If the weight of a given number of yards and of a given size of woolen yarn, run system, is required to be calculated in pounds, transfer the result obtained in ounces into pounds or fractions thereof.

Example.—Find the weight of 100,000 yards of 6¼ run yarn—100,000÷625=160 oz.÷16=10.
Answer.—100,000 yards of 6¼ run yarn weigh 10 lbs.

B. "Cut" System.

As heretofore mentioned, woolen yarn is also graded by the "cut" system. 300 yards is the basis or standard, consequently if 300 yards of a given woolen yarn weigh 1 lb., we classify it as 1 cut yarn; if 600 yards weigh 1 lb. we classify it as 2 cut yarn; if 900 yards weigh 1 lb. we classify it as 3 cut yarn, and so on; hence the count of the woolen yarn expressed in the cut multiplied by 300 gives as the result the number of yards of respective yarn that 1 lb. contains.

Table of Lengths for Woolen Yarns (*Cut System*).

(From 1 cut to 50 cut Yarn.)

Cut.	Yards to lb.	Cut.	Yards to lb.	Cut.	Yards to lb.	Cut.	Yards to lb.	Cut.	Yards to lb.
1	300	12	3,600	23	6,900	34	10,200	45	13,500
2	600	13	3,900	24	7,200	35	10,500	46	13,800
3	900	14	4,200	25	7,500	36	10,800	48	14,400
4	1,200	15	4,500	26	7,800	37	11,100	50	15,000
5	1,500	16	4,800	27	8,100	38	11,400	54	16,200
6	1,800	17	5,100	28	8,400	39	11,700	58	17,400
7	2,100	18	5,400	29	8,700	40	12,000	60	18,000
8	2,400	19	5,700	30	9,000	41	12,300	65	19,500
9	2,700	20	6,000	31	9,300	42	12,600	70	21,000
10	3,000	21	6,300	32	9,600	43	12,900	75	22,500
11	3,300	22	6,600	33	9,900	44	13,200	80	24,000

Rule for Finding the Weight in Ounces for a Given Number of Yards of Woolen Yarn of a Known Count Figured by the "Cut" Basis.

This rule is similar to the one given for cotton yarn. "Multiply the given yards by 16 and divide the result by the original number of yards for the given count of cotton yarn that 1 lb. contains."

Example.—Find the weight of 12,600 yards of 40-cut woolen yarn. 12,600×16=201,600; 1 lb. of 40-cut woolen yarn=12,000 yards. Thus, 201,600÷12,000=16.8.
Answer.—12,600 yards of 40-cut woolen yarn weigh 16.8 oz.

The other rule for ascertaining the weight in ounces for a number of yards of cotton yarn of a known count is as follows: Divide the given yards by the number of yards of the known count required to balance one ounce.

Example.—Find the weight for 12,600 yards of 40-cut woolen yarn. 12,000÷16=750 12,600÷750=16.8.
Answer.—12,600 yards of 40-cut woolen yarn weigh 16.8 oz.

Rule for Finding the Weight in Pounds of a Given Number of Yards of Woolen Yarn of a Known Count, Graded by the Cut Basis.

This rule is also similar to the one previously given for cotton yarn. Divide the given yards by the original number of yards for the given count of woolen yarn (cut basis) in 1 lb. The result expresses the weight in pounds, or fractions thereof.

Example.—Find the weight of 1,260,000 yards of 40-cut woolen yarn. 40-cut woolen yarn= 12,000 yards to 1 lb. Thus, 1,260,000÷12,000=105.

Answer.—1,260,000 yards of 40-cut woolen yarn weigh 105 lbs.

Grading of Double and Twist or more Ply Woolen Yarn.

Woolen yarns are sometimes manufactured in double and twist (*d&tw.*), seldom in a more ply.

If produced in *d&tw*, and if both single threads are of the same counts, the established custom is to consider the compound thread one-half the count of the minor. Thus, a *d&tw.* 6-run woolen yarn will equal a single 3-run; or either yarn figures 4,800 yards to a lb. A *d&tw.* $7\frac{1}{2}$-run woolen yarn will equal a single $3\frac{3}{4}$-run woolen yarn; or either yarn requires 6,000 yards per lb. A *d&tw.* 30-cut woolen yarn equals a single 15-cut, or both kinds of yarn required 4,500 yards per lb.

If the compound thread is composed of three or more single threads, divide the number of the single yarn by the number of ply, and the result will be the required counts in a single thread.

Examples.—Three-ply 10-run woolen yarn equals a (10÷3) $3\frac{1}{3}$-run single thread, or requires $5,333\frac{1}{3}$ yards per lb. A 3-ply 45-cut woolen yarn equals a (45÷3) 15-cut single yarn, or requires 4,500 yards per lb.

Double and twisted woolen yarns, used in the manufacture of "fancy cassimeres," are frequently composed of two minor threads of unequal counts. If so, the rule for finding the equal in a single thread as compared with the compound thread is as follows: Divide the product of the counts of the minor threads by their sum.

Example.—Find the equal counts in single woolen yarn (run basis) for a double and twist thread composed of single 3-run and 6-run woolen yarn. $3\times6=18\div9(3+6)=2$.

Answer.—A 3-run and 6-run woolen thread being twisted equal a single 2-run woolen thread.

Example.—Find the equal counts in single woolen yarn (cut basis) for a double and twist thread composed of single 20-cut and 30-cut yarn. $20\times30=600\div50\ (20+30)=12$.

Answer.—A 20-cut and 30-cut woolen yarn twisted equal single 12-cut woolen yarn.

As previously mentioned, we may in a few instances be called on to calculate for a 3-ply yarn. If such a compound thread is composed of three minor threads of unequal counts, compound any of the minor threads into one, and apply the previously-given rule for *d&tw.*

Example.—A 3-run, 6-run and 8-run thread being twisted together, what are the equal counts in one thread for the compound thread?

$3\times6=18\div9(3+6)=2$. (A 3-run and a 6-run thread compounded equal a 2-run single thread) Thus, $2\times8=16\div10(2+8)=1\frac{6}{10}=1\frac{3}{5}$.

Answer.—Compound thread given in example equals $1\frac{3}{5}$ run.

Example.—A 20-cut, 30-cut and a 36-cut thread, being twisted together, what is its equal size in a single yarn? $20\times30=600\div50(20+30)=12$, and $12\times36=432\div48(12+36)=9$.

Answer.—Compound thread given in example equals a single 9-cut thread.

As already mentioned, under the head of cotton yarns, a second rule for finding the equivalent counts for a yarn where three or more minor threads are twisted together is as follows: Divide one of the counts by itself, and by the others in succession, and afterwards by the sum of the quotients.

To prove this rule, we will use examples heretofore given.

Example.—Find equal counts in one thread for the following compound thread, composed of a 3-run, 6-run and 8-run thread.

$$8\div8=1$$
$$8\div6=1\tfrac{1}{3}$$
$$8\div3=2\tfrac{2}{3}$$
$$\overline{\quad 5 \quad}$$

$$8\div5=1\tfrac{3}{5}$$

Answer.—Compound thread given in example equals $1\frac{3}{5}$ run.

Example.—A 20-cut, 30-cut and 36-cut thread, being twisted together, what is its equal size in a single yarn?

$$\begin{array}{ll} 36 \div 36 = 1 & \\ 36 \div 30 = 1\frac{1}{5} & \qquad 36 \div 4 = 9 \\ 36 \div 20 = 1\frac{4}{5} & \\ \hline \quad\quad 4 & \end{array}$$

Answer.—Compound thread given in example equals a single 9-cut thread.

WORSTED YARNS.

Worsted yarns have for their standard measure 560 yards to the hank. The number of hanks that balance one pound indicate the number or the count by which it is graded. Hence if 40 hanks each 560 yards long, weigh 1 lb. such a yarn is known as 40's worsted. If 48 hanks are required to balance 1 lb. it is known as 48's worsted. In this manner the number of yards for any size or count of worsted yarns is found by simply multiplying the number or count by 560.

Table of Lengths for Worsted Yarn.

(From No. 1 to 200's).

No.	Yds. to 1 lb.	No.	Yds. to 1 lb.	No.	Yds. to 1 lb.	No.	Yds to 1 lb.	No.	Yds. to 1 lb.
1	560	15	8,400	29	16,240	46	25,760	74	41,440
2	1,120	16	8,960	30	16,800	48	26,880	76	42,560
3	1,680	17	9,520	31	17,360	50	28,000	80	44,800
4	2,240	18	10,080	32	17,920	52	29,120	85	47,600
5	2,800	19	10,640	33	18,480	54	30,240	90	50,400
6	3,360	20	11,200	34	19,040	56	31,360	95	53,200
7	3,920	21	11,760	35	19,600	58	32,480	100	56,000
8	4,480	22	12,320	36	20,160	60	33,600	110	61,600
9	5,040	23	12,880	37	20,720	62	34,720	120	67,200
10	5,600	24	13,440	38	21,280	64	35,840	130	72,800
11	6,160	25	14,000	39	21,840	66	36,960	140	78,400
12	6,720	26	14,560	40	22,400	68	38,080	160	89,600
13	7,280	27	15,120	42	23,520	70	39,200	180	100,800
14	7,840	28	15,680	44	24,640	72	40,320	200	112,000

Grading of 2-ply, 3-ply, etc. Worsted Yarns.

Worsted yarn is like cotton yarn, very frequently produced in 2-ply. If such is the case, only one-half the number of yards as required per pound for the single yarn are required to balance the pound of 2-ply yarn. Hence 40's worsted (technically for single 40's worsted) requires 22,400 yards per lb. and 2/80's worsted (technically for 2-ply 80's worsted) requires also 22,400 yards per pound. 2/60's worsted has 16,800 yards per pound corresponding to single 30's worsted.

If the yarn be more than 2-ply, divide the number of yards of single yarn by the number of ply.

Examples.—3-ply 90's (3/90's) worsted yarn equals in size (90÷3) a single 30's thread; or both kinds of yarn require 16,800 yards to balance 1 lb.—4/80's worsted yarn equals a (80÷4) single 20's.

Rule for Finding Weight in Ounces for a Given Number of Yards of Worsted Yarn of a Known Count.

Multiply the given yards by 16, and divide the result by the number of yards the given count of worsted yarn contains balancing 1 lb.

Example (single yarn).—Find the weight for 12,600 yards of 40's worsted. 12,600×16=201,600. 1 lb. of 40's worsted=22,400 yards, thus:—201,600÷22,400=9.

Answer.—12,600 of 40's worsted weigh 9 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/40's worsted. 12,600×16=201,600. 1 lb. of 2/40's=11,200 yards. Hence 201,600÷11,200=18

Answer.—12,600 yards of 2/40's worsted weigh 18 oz.

Example (3-ply yarn).—Find the weight of 12,600 yards of 3/40's worsted. 12,600×16=201,600. 1 lb of 3/40's=7,466$\frac{2}{3}$ yards, thus 201,600÷7,466$\frac{2}{3}$=27.

Answer.—12,600 yards of 3/40's worsted weigh 27 oz.

Another rule for ascertaining the weight in ounces for a given number of yards of worsted yarn of a known count is as follows: Divide the given yards by the number of yards of the known count required to balance 1 oz.

Example (single yarn).—Find the weight for 12,600 yards of 40's worsted. 22,400÷16=1,400. 12,600÷1,400=9.

Answer.—12,600 yards of 40's worsted weigh 9 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/40's worsted. 11,200÷16=700 12,600÷700=18.

Answer.—12,600 yards of 2/40's worsted weigh 18 oz.

Example (3-ply yarn).—Find the weight of 12,600 yards of 3/40's worsted. 7466$\frac{2}{3}$÷16=466$\frac{2}{3}$ and 12,600÷466$\frac{2}{3}$=12600÷$\frac{1400}{3}$=$\frac{12600 \times 3}{1400}$=27.

Answer.—12,600 yards of 3/40's worsted weigh 27 ounces.

Rule for Finding the Weight in Pounds of a Given Number of Yards of Worsted Yarn of a Known Count.

Divide the given yards by the number of yards of the known count required to balance 1 lb.

Example (single yarn).—Find the weight of 1,260,000 yards of 40's worsted yarn, 40's worsted=22,400 yds. to 1 lb. Thus, 1,260,000÷22,400=56$\frac{1}{4}$.

Answer.—1,260,000 yds. of 40's worsted weigh 56$\frac{1}{4}$ lbs.

Example (2-ply yarn).—Find the weight of 1,260,000 yards of 2/40's yarn. 2/40's worsted=11,200 yards to 1 lb. Thus, 1,260,000÷11,200=112$\frac{1}{2}$.

Answer.—1,260,000 yards of 2/40's worsted yarn weigh 112$\frac{1}{2}$ lbs.

Example (3-ply yarn).—Find the weight of 1,260,000 yards of 3/40's worsted yarn. 3/40's worsted=7,467 yards to 1 lb. Hence, 1,260,000÷7,467=168$\frac{3}{4}$.

Answer.—1,260,000 yards of 3/40's worsted yarn weigh 168$\frac{3}{4}$ lbs.

To Find the Equivalent Size in Single Yarn of Two, Three or More Ply Yarn Composed of Minor Threads of Unequal Counts.

Worsted yarn is also occasionally manufactured in 2, 3, or more ply yarn in which the minor threads are of unequal counts; if so the rules for finding the equivalent in a single yarn are similar to those given for cotton and woolen yarns.

If the compound thread is composed of two minor threads of unequal counts, divide the product of the counts of the minor threads by their sum.

Example.—Find the equal in single yarn to a 2-fold thread composed of single 20's and 60's. $20\times 60=1200\div 80\ (20+60)=15$.

Answer.—A 2-fold worsted yarn composed of 20's and 60's equals a single 15's.

If the compound thread is composed of 3 minor threads of unequal counts, compound any two of the minor threads into one, and apply the rule given previously to this thread and the third minor thread not previously used.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 20's, 40's, and 60's. $20\times 40=800\div 60\ (20+40)=13\frac{1}{3}$. $13\frac{1}{3}\times 60=800\div 73\frac{1}{3}\ (13\frac{1}{3}+60)=10\frac{10}{11}$.

Answer.—A 3-ply 20's, 40's, and 60's worsted thread equals in size a single $10\frac{10}{11}$'s.

These examples can be proved by the second rule, viz.: Divide one of the counts by itself and by the others in succession, and after this by the sum of the quotients.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 60's, 40's and 20's worsted.

$$\begin{array}{l} 60\div 60=1 \\ 60\div 40=1\frac{1}{2} \\ 60\div 20=3 \\ \hline \quad\quad\quad\ 5\frac{1}{2} \end{array} \qquad\qquad 60\div 5\frac{1}{2}=10\frac{10}{11}.$$

Answer.—A 3-ply 20's, 40's and 60's worsted thread equals in size a single $10\frac{10}{11}$'s.

SILK YARNS.

A. Spun Silks.

Spun silks are calculated as to the size of the thread, on the same basis as cotton (840 yards to 1 hank), the number of hanks one pound requires indicating the counts. In the calculation of cotton, woolen or worsted, double and twist yarn, the custom is to consider it as twice as heavy as single; thus double and twisted 40's (technically 2/40's) cotton, equals single 20's cotton for calculations. In the calculation of spun silk the single yarn equals the two-fold; thus single 40's and two-fold 40's require the same number of hanks (40 hanks equal 33,600 yards). The technical indication of two-fold in spun silk is also correspondingly reversed if compared to cotton, wool and worsted yarn. In cotton, wool and worsted yarn the 2 indicating the two-fold is put in front of the counts indicating the size of the thread (2/40's), while in indicating spun silk this point is reversed (40/2's), or in present example single 80's doubled to 40's.

B. Raw Silks.

The adopted custom of specifying the size of raw silk yarns is in giving the weight of the 1000 yards hank in drams avoirdupois; thus if one hank weighs 5 drams it is technically known as "5 dram silk," and if it should weigh $8\frac{1}{2}$ drams it is technically known as "$8\frac{1}{2}$ dram silk." As already mentioned the length of the skeins is 1000 yards, except in fuller sizes where 1000 yard skeins would be rather bulky, and apt to cause waste in winding. Such are made into skeins of 500 and 250 yards in length and their weight taken in proportion to the 1000 yards; thus if the skein made up into 500 yards weighs $8\frac{1}{2}$ drams, the silk would be 17-dram silk; if a skein made up into 250 yards weighs 4 drams the silk would be 16-dram silk. The size of yarn is always given for their "gum" weight; that is their condition "before boiling off," in which latter process yarns lose from 24 to 30 per cent. according to the class of raw silk used; China silks losing the most and European and Japan silks the least. The following table shows the number of yards to the pound and ounce from 1 dram silk to 30 dram silk. The number of yards given per pound in the table is based on a pound of gum silk.

Length of Gum Silk Yarn per Pound and per Ounce.

(From 1 dram to 30 drams.)

Drams per 1000 yards.	Yards per lb.	Yards per oz.	Drams per 1000 yards	Yards per lb.	Yards per oz.	Drams per 1000 yards.	Yards per lb.	Yards per oz.
1	256,000	16,000	5	51,200	3,200	16	16,000	1,000
1¼	204,800	12,800	5½	46,545	2,909	17	15,058	941
1½	170,666	10,667	6	42,667	2,667	18	14,222	889
1¾	146,286	9 143	6½	39,385	2,462	19	13,474	842
2	128,000	8,000	7	36,571	2,286	20	12,800	800
2¼	113,777	7,111	7½	34,133	2,133	21	12,190	762
2½	102,400	6,400	8	32,000	2,000	22	11,636	727
2¾	93,091	5,818	8½	30,118	1,882	23	11,130	696
3	85,333	5,333	9	28,444	1,778	24	10,667	666
3¼	78,769	4,923	9½	26,947	1,684	25	10,240	640
3½	73,143	4,571	10	25,600	1.600	26	9,846	615
3¾	68,267	4,267	11	23,273	1,455	27	9,481	592
4	64,000	4,000	12	21,333	1,333	28	9 143	571
4¼	60,235	3,765	13	19,692	1,231	29	8,827	551
4½	56,889	3,556	14	18,286	1,143	30	8,533	533
4¾	53,368	3,368	15	17,067	1,067			

LINEN YARNS.

Linen yarns are graded, or have for their standard 300 yards to the hank or "lea," which is the same basis for calculations with reference to size, count, or diameter of thread, as the one given for the woolen yarn, viz., (cut system); hence, rules given for woolen yarn (cut system), will also apply to linen yarns by simply changing the denomination.

Jute Yarns, Chinagrass and Ramie

Are also graded similar to the woolen yarn (cut system), with 300 yards to the hank, the number of hanks required to balance 1 lb. indicating the size or count of the yarn.

For Reproducing Fabrics in a Required Material From a Given Fabric Made Out of Another Material it is Often Necessary to Find the Equivalent Counts, Thus we Give

Rules for Finding the Equivalent Counts of a Given Thread in Another System.

A. COTTON, WOOLEN AND WORSTED YARN.

Rule.—The counts of a given thread are the counts of an equal thread (in size) of a different material, or a thread of the same material but figured after the different "standard" in the same proportion as the "standard number" of the one to be found is to the "standard number" of the one given.

Example.—**Cotton-Worsted.** Find equal size in worsted yarn to 20's cotton yarn.

(Cotton standard.) : (Worsted standard).
840 : 560 = 3 : 2

Thus $20:x::2:3$ and $3\times20=60\div2=30$.

Answer.—A thread of 20's cotton yarn equals (in size) a thread of 30's worsted yarn.

Example.—**Cotton-Wool** (run system). Find equal size in woolen yarn (runs) to 10's cotton yarn.

(Cotton standard.)	:	(Run standard.)	
840	:	1,600	=21 : 40

Thus 10:x::40:21 and 21×10=210÷40=5¼.

Answer.—A thread of 10's cotton equals (in size) a thread of 6¼-run (wool).

Example.—**Cotton-Wool** (cut system). Find equal size in woolen yarn (cut basis) to 10's cotton yarn.

(Cotton standard.)	:	(Cut standard.)	
840	:	300	= 14 : 5

Thus 10:x :: 5:14 and 14×10=140÷5=28.

Answer.—A thread of 10's cotton yarn equals (in size) a thread of 28-cut woolen yarn.

Example.—**Worsted-Wool** (run system). Find equal size in woolen yarn (run basis) to 20's worsted yarn.

(Worsted standard.)	:	(Run standard.)	
560	:	1,600	=7:20

Thus 20:x :: 20:7 and 7×20=140÷20=7.

Answer.—A thread of 20's worsted equals (in size) a thread of 7-run woolen yarn.

Example.—**Worsted-Wool** (cut system). Find equal size in woolen yarn (cut basis) to 15's worsted yarn.

(Worsted standard.)	:	(Cut standard.)	
560	:	300	=28:15

Thus 15:x :: 15:28 and 15×28=428÷15=28.

Answer.—A thread of 15's worsted equals (in size) a thread of 28-cut woolen yarn.

Example.—**Worsted-Cotton.** Find equal size in cotton yarn to 30's worsted.

30:x :: 3:2and 30×2=60÷3=20.

Answer.—A thread of 30's worsted equals (in size) a thread of 20's cotton yarn.

Example.—**Wool** (run system) **-Cotton.** Find equal size in cotton yarn to a 5¼-run woolen yarn

5.25:x :: 21:40 and 5.25×40=210÷21=10.

Answer.—A 5¼-run woolen yarn equals (in size) a 10's cotton yarn.

Example.—**Wool** (run system) **-Worsted.** Find equal size in worsted yard to a 7-run woolen yarn.

7:x :: 7:20 and 7×2=140÷7=20.

Answer.—A 7-run woolen yarn equals in size a 20's worsted yarn.

Example.—**Wool** (run system) **-Wool** (cut system). Find equal size in the cut basis for a 6-run woolen thread.

6:x :: 3:16 and 6×16=96÷3=32.

Answer.—A 6-run woolen thread equals (in size) a 32-cut thread of the same material.

Example.—**Wool** (cut system) **-Cotton.** Find equal size of cotton yarn to a 28-cut woolen yarn.

28:x :: 14:5 and 5×28=140÷14=10.

Answer.—A 28-cut woolen yarn equals (in size) a 10's cotton yarn.

Example.—**Wool** (cut system) **-Worsted.** Find equal size worsted yarn to a 28-cut woolen yarn.

28 : x :: 28 : 15 and $28 \times 15 = 420 \div 28 = 15$.

Answer.—A 28-cut woolen yarn equals (in size) a 15's worsted yarn.

Example.—**Wool** (cut system) **-Wool** (run system). Find equal size of the run basis for a 32-cut woolen yarn.

32 : x :: **16** : 3 and $3 \times 32 = 96 \div 16 = 6$.

Answer.—A 32-cut woolen yarn equals (in size) a 6-run woolen yarn.

B. SPUN SILK YARNS COMPARED TO COTTON, WOOLEN OR WORSTED YARNS.

As already stated in a previous chapter the basis of spun silk is the same as that of cotton; therefore the rules and examples given under the heading of "Cotton" refer at the same time to spun silk.

C. LINEN YARNS, JUTE AND RAMIE.

These yarns have the same standard of grading as woolen yarn (cut system); thus examples given under the latter basis will also apply to the present kind of yarns.

D. RAW SILK YARNS COMPARED TO SPUN SILK, COTTON, WOOLEN OR WORSTED YARNS.

Rule.—Find the number of yards per pound (in table previously given) in raw silk and divide the same by the standard size of the yarn basis to be compared with.

Example.—**Raw Silk-Cotton** (or spun silk). Find equal size in cotton yarn to 9-dram raw silk. 9-dram raw silk=28,444 yds. per lb. Thus $28,444 \div 840$ (cotton standard)$=33\frac{6}{7}$.

Answer.—2-dram raw silk equals (nearly) 34's cotton.

Or if calculating without a table proceed as follows: 1 lb.=16 oz. 1 oz.=16 drams. Thus $16 \times 16 = 256$ drams per lb.

(Counts given.)	:	(Yards in 1 hank.)		(Drams per lb.)	:	(Yards per lb.)
9	:	1000	::	256	:	x

$256 \times 1000 = 256,000 \div 9 = 28,444\frac{4}{9}$ yds. per lb. of 9 drams raw silk.

(Yards per lb.)	::	(Basis of yarn to compare with.)	
28,444	÷	840	$=33\frac{6}{7}$

being with the same result as before.

Example.—**Spun Silk or Cotton to Raw Silk.** Find equal size in raw silk to 38's cotton. 38's cotton=(38×840) 31,920 yds. per lb. Refer to previously given table for raw silk, where you will find 8 drams to equal 32,000 yards per lb.

Answer.—A 38's cotton thread equals (nearly) an 8-dram raw silk thread.

Or if calculating without table find result by:

Rule.—Divide the standard measure (number of yards per lb.) of the given yarn by 1000 (yards in one hank) and the quotient thus obtained into 256. (drams in 1 lb.)

Example.—Find the answer by this rule for previously given question. 38's cotton=31,920 yards. Thus $31,920 \div 1000 = 31.92$ and $256 \div 31.92 = 8.02$.

Answer.—A 38's cotton thread equals (nearly) an 8-dram raw silk thread.

Ascertaining the Counts of Twisted Threads Composed of Different Materials.

The above question may often arise when manufacturing fancy yarns and of which it is requisite to know the compound size for future calculations.

RULE A.---If the compound thread is composed of two minor threads of different materials, one must be reduced to the relative basis of the other thread and the resulting count found in this system.

Example.—Find equal counts in a single worsted thread to a 2-ply thread composed of 30's worsted and 40's cotton yarn.

40's cotton=60's worsted. Thus, $30 \times 60 = 1800 \div 90\ (30+60) = 20$.

Answer.—Compound thread given in example equals a single 20's worsted thread.

Example.—Find the equal counts in single cotton yarn to a 2-ply thread composed of single 30's worsted and 40's cotton yarn.

30's worsted=20's cotton. Thus, $40 \times 20 = 800 \div 60\ (40+20) = 13\frac{1}{3}$.

Answer.—Compound thread given in example equals a single cotton thread of number $13\frac{1}{3}$.

Example.—Find the equal counts in single woolen yarn (run basis) to a 2-ply thread composed of single 20's cotton yarn and 6-run woolen yarn.

20's cotton=$10\frac{1}{2}$-run woolen yarn. Thus, $10\frac{1}{2} \times 6 = 63 \div 16\frac{1}{2}\ (10\frac{1}{2}+6) = 3\frac{9}{11}$.

Answer.—Compound thread given in example equals a single woolen thread of $3\frac{9}{11}$-run.

Example.—Find the equal counts in single woolen yarn (cut basis) to a 2-ply thread composed of single 40's cotton and 28-cut woolen yarn.

40's cotton=112-cut. Thus, $28 \times 112 = 3136 \div 140\ (28+112) = 22\frac{4}{10}$.

Answer.—Compound thread given in example equals a single woolen yarn of $22\frac{2}{5}$-cut.

Example.—Find the equal counts in single worsted yarn to a 2-ply thread composed of single 20's worsted and 60's spun silk. 60's silk=90's worsted. Thus, $20 \times 90 = 1800 \div 110\ (20+90)\ 16\frac{4}{11}$.

Answer.—Compound thread given in example equals a single $16\frac{4}{11}$'s worsted.

RULE B.---If the compound thread is composed of three minor threads of two or three different materials, they must by means of their relative length be transferred in one basis and the resulting count found in this system.

Example.—Find equal counts in single woolen yarn, run basis, for the following compound thread composed of a 3-run, a 6-run woolen thread, and a single 20's cotton twisted together.

$$3 \times 6 = 18 \div 9\ (3+6) = 2.$$

(3-run and-6 run threads compounded, equal a single 2-run thread.)

20's cotton equals $10\frac{1}{2}$-run, thus $2 \times 10\frac{1}{2} = 21 \div 12\frac{1}{2}\ (2+10\frac{1}{2}) = 1\frac{17}{25}$.

Answer.—The three-fold thread given in example equals in count a single woolen yarn of $1\frac{17}{25}$ (nearly $1\frac{3}{4}$) run.

The previously given example may also be solved as follows:—20's cotton=$10\frac{1}{2}$-run woolen yarn, thus,

$$\begin{aligned} 10\tfrac{1}{2} \div 10\tfrac{1}{2} &= 1 \\ 10\tfrac{1}{2} \div 6 &= 1\tfrac{3}{4} \\ 10\tfrac{1}{2} \div 3 &= 3\tfrac{1}{2} \\ \hline & \quad 6\tfrac{1}{4} \end{aligned} \qquad 10\tfrac{1}{2} \div 6\tfrac{1}{4} = 1\tfrac{17}{25}.$$

Answer.—A 3-run, a 6-run woolen thread, and a single 20's cotton twisted together equal in size a $1\frac{17}{25}$-run woolen thread.

Ascertaining the Counts for a Minor Thread to Produce, with Other Given Minor Threads, Two, Three, or More Ply Yarn of a Given Count.

A. ONE SYSTEM OF YARN.

In some instances it may be required that the compound thread produced out of two, three, or more, minor threads must be of a certain count. We may be requested to twist with a minor thread of a given count a minor thread of unknown count (to be ascertained); both threads to produce a compound thread of known count. If such is the case proceed after the following *Rule*: Multiply the counts of the given single thread by the counts of the compound thread, and divide the product by the remainder obtained by subtracting the counts of the compound threads from the counts of the given single thread.

Example.—Find size of single yarn required (run basis) to produce with a 4-run woolen yarn a compound thread of 3-run. $4\times3=12\div1(4-3)=12$.

Answer.—The minor thread required in the present example is a 12-run thread, or a 4-run and a 12-run woolen thread compounded into a 2-fold yarn, are equal in counts to a 3-run single woolen thread.

Proof.—$4\times12=48\div16=3$-run, or compound thread, as required.

Example.—Find size of single yarn required (worsted numbers) to produce with a 48's worsted thread a compound thread the equal of 16's worsted yarn. $48\times16=768\div32(48-16)=24$.

Answer.—The minor thread required in the present example is a 24's worsted thread, or a 48's worsted thread and a 24's worsted thread compounded into a two-fold yarn, are equal in counts to a single 16's worsted thread.

Proof.—$48\times24=1152\div72=16$'s worsted or compounded size required.

Example.—Find size of single yarn required (cotton numbers) to produce with an 80's cotton thread a 2-fold yarn of a compound size of equal 30's cotton yarn. $80\times30=2400\div50(80-30)=48$.

Answer.—The minor thread required in the present example is a 48's cotton thread compounded into a 2-fold yarn equal in this compound size to a single 30's cotton thread.

Proof.—$80\times48=3840\div128=30$'s cotton, or compound size required.

If one of the minor threads is to be found for a 3-ply thread of which two minor threads are known, use the following *Rule:* Compound the two minor threads given into their equal in a single thread, and solve the question by the previously given rule.

Example.—Find minor thread required to produce with single 30's and single 60's worsted a 3-ply yarn to equal single 12's worsted. 60's and 30's worsted compound $=(60\times30=1800\div90-(60+30)=20)$ single 20's worsted.

Thus 20	×	12	=240÷8	(20	—	12)	=30
{Compound two minor threads of which size is known.}	×	{Known size of ply yarn.}		{Compound two minor threads of which size is known.}	—	{Known size of 3-ply yarn.}	

Answer.—The size of the third minor required to be ascertained in the given example is single 30's worsted yarn, or a 3-ply thread composed of single 30's, 60's, and 30's worsted yarn equals single 12's worsted counts as shown by the

Proof.—

$$60 \div 60 = 1$$
$$60 \div 30 = 2$$
$$60 \div 30 = 2$$
$$\overline{5}$$

$60\div5=12$'s worsted.

B. TWO SYSTEMS OF YARNS.

In the manufacture of fancy yarns we may be called on to select the proper minor thread required in another material. This, however, will not change previously given rules, for after finding the counts in the given system we only have to transfer the same to the required system.

Example (2-ply yarn).—Find the size of single worsted yarn required to produce with an 8-run woolen yarn a compound thread of 6-run yarn.

$8 \times 6 = 48 \div 2\ (8-6) = 24$-run woolen yarn required.

24-run woolen yarn=38,400 yards per lb. and $38,400 \div 560 = 68\frac{4}{7}$.

Answer.—The single worsted thread required in given example is $68\frac{4}{7}$'s.

Example (3-ply yarn).—Find the size of the spun silk required to produce with a 40's and 60's worsted a 3-ply yarn of equal count to single 12's worsted. $40 \times 60 = 2,400 \div 100\ (40+60) = 24$=compound size of 40's and 60's. $24 \times 12 = 288 \div 12\ (24-12) = 24$'s worsted size required to be transferred in spun silk.

$24 \times 560 = 13,440 \div 840 = 16$

Answer.—16's spun silk is required in present example.

Ascertaining the Amount of Material Required for Each Minor Thread in Laying Out Lots for Two, Three, or More Ply Yarn.

A. DOUBLE AND TWIST YARN.

Composed of Minor Threads of the Same Material.

For producing a certain amount of fancy double and twist yarn it is necessary to ascertain the amount of stock required for each minor thread. This question will readily be solved by—

Rule.—The sum of both counts is to the one of the counts, in the same proportion as the amount of double and twist yarn required is to the amount of the yarn required for producing the other minor thread.

Example.—Find amount of material required for each minor thread for producing 1000 lbs. of double and twist yarn made out of 6 and 7-run minor threads.

$(6+7) = 13 : 6 :: 1,000 : x$

$(6+7) = 13 : 7 :: 1,000 : x$

$6 \times 1,000 = 6,000 \div 13 = 461\frac{7}{13}$

$7 \times 1,000 = 7,000 \div 13 = 538\frac{6}{13}$

1,000

Answer.—In previously given example the following amount of yarn (of minor threads) is required :—$461\frac{7}{13}$ lbs. of 7-run yarn.

$536\frac{6}{13}$ " " 6-run yarn.

Proof.— $461\frac{7}{13}$ lbs. of 7-run yarn=$(461\frac{7}{13} \times 11,200) = 5,169,230\frac{10}{13}$ yds.

$538\frac{6}{13}$ lbs. of 6-run yarn=$(538\frac{6}{13} \times 9,600) = 5,169,230\frac{10}{13}$ yds.

Example.—Find amount of material required for each minor thread for producing 250 lbs. of double and twist yarn made out of 32's and 40's worsted for the minor threads.

$(32+40) = 72 : 32 :: 250 : x$

$(32+40) = 72 : 40 :: 250 : x$

$32 \times 250 = 8,000 \div 72 = 111\frac{1}{9}$

$40 \times 250 = 10,000 \div 72 = 138\frac{8}{9}$

250

Answer.—For producing 250 lbs. of double and twist worsted yarn composed of 32's and 40's for minor threads,

$111\frac{1}{9}$ lbs. of 40's and $138\frac{8}{9}$ lbs. of 32's are required.

Proof.— $111\frac{1}{9}$ lbs. of 40's worsted equal $(111\frac{1}{9} \times 22{,}400) = 2{,}488{,}888\frac{8}{9}$ yds.
$138\frac{8}{9}$ lbs. of 32's worsted equal $(138\frac{8}{9} \times 17{,}920) = 2{,}488{,}888\frac{8}{9}$ yds.

Example.—Find amount of material required for each minor thread for producing 1,000 lbs. of double and twist cotton yarn made with 60's and 80's for minor threads.

$$(60 + 80) = 140 : 60 :: 1{,}000 : x$$
$$(60 + 80) = 140 : 80 :: 1{,}000 : x$$
$$60 \times 1{,}000 = 60{,}000 \div 140 = 428\tfrac{4}{7}$$
$$80 \times 1{,}000 = 80{,}000 \div 140 = 571\tfrac{3}{7}$$
$$1{,}000$$

Answer.—For producing 1,000 lbs. of double and twist cotton yarn made out of single 60's and 80's the following amount of each are required:

$428\frac{4}{7}$ lbs. of 80's
$571\frac{3}{7}$ lbs. of 60's

Proof.— $428\frac{4}{7}$ lbs. of 80's cotton equal $(428\frac{4}{7} \times 67{,}200) = 28{,}800{,}000$ yards.
$571\frac{3}{7}$ lbs. of 60's cotton equal $(571\frac{3}{7} \times 50{,}400) = 28{,}800{,}000$ yards.

Composed of Minor Threads of Different Materials.

If the minor threads are of different materials transfer either one to the relative length of the other, and solve example by previously given rule.

Example.—Find amount of material required for each minor thread to produce 100 lbs. double and twist yarn made out of 40-cut woolen yarn and 60's spun silk.

60's spun silk equals 168-cut. Thus,

$$(40 + 168) = 208 : 40 :: 100 : x$$
$$(40 + 168) = 208 : 168 :: 100 : x$$
$$40 \times 100 = 4{,}000 \div 208 = 19\tfrac{3}{13}$$
$$168 \times 100 = 16{,}800 \div 208 = 80\tfrac{10}{13}$$
$$100$$

Answer.—To produce 100 lbs. of double and twist yarn as mentioned in example, $19\frac{3}{13}$ lbs. of 60's spun silk and $80\frac{10}{13}$ lbs. of 40- cut woolen yarn are required.

Proof.— $19\frac{3}{13}$ lbs. of 60's spun silk equal to $(19\frac{3}{13} \times 50{,}400) = 969{,}230\frac{10}{13}$ yards.
$80\frac{10}{13}$ lbs. of 40-cut woolen yarn equal $(80\frac{10}{13} \times 12{,}000) = 969{,}230\frac{10}{13}$ yards.

As already mentioned in a previous chapter, if twisting silk yarn with a woolen yarn the former thread will twist proportionately more around the latter, thus we must add an allowance for it to the silk yarn, which in turn we must deduct from the woolen yarn. But as this difference (or allowance) is regulated by the turns of twist per inch, also the tension of the yarn when twisting it will vary (as little as it will be) in each different *d & tw.* yarn; but will be readily ascertained by the manufacturer in his practical work.

B. THREE-PLY YARN.

Composed of Minor Threads of the Same Material.

Sometimes it may be required to find the amount of material for each minor thread for a given weight of a 3-ply yarn. If so the example must be solved by

Rule.—Transfer the given three counts to their equivalent in a single thread and find number of yards required to balance given weight. Afterwards divide each standard (number of yards necessary to balance 1 lb.) of the three given minor threads in the number of yards required, the result being pounds necessary for each count.

Example.—Find amount of material required for each minor thread for 100 lbs. of 3-ply yarn, produced out of 5, 6 and 7-run woolen yarn for the minor threads.

5, 6, and 7-run.

$7 \div 7 = 1$

$7 \div 6 = 1\frac{5}{30}$

$7 \div 5 = 1\frac{12}{30}$

$3\frac{17}{30}$ $7 \div 3\frac{17}{30} = 1\frac{103}{107}$ equivalent count in a single thread for 5, 6 and 7-run.

$1\frac{103}{107} \times 1{,}600 = 3{,}140\frac{20}{107}$ yards per lb., $\times 100$ lbs. (total amount of yarn wanted) $= 314{,}018\frac{74}{107}$ total number of yards of 3-ply yarn required.

314,018 ÷ 8,000 (Standard for 5-run) = 39.25
314,018 ÷ 9,600 (Standard for 6-run) = 32.71
314,018 ÷ 11,200 (Standard for 7-run) = 28.04

100.00

Answer.—The amount of yarn for each minor thread in given example is as follows:

39.25 lbs. of 5-run woolen yarn.
32.71 lbs. of 6-run woolen yarn.
28.04 lbs. of 7-run woolen yarn.

100 lbs. Total amount of yarn wanted.

Composed of Minor Threads of Different Materials.

If in a 3-ply yarn one of the minor threads is of a different material (compared to the other two), transfer this thread to its equivalent count of the other basis, and solve example by previously given rule.

Example.—Find amount of material required to produce 1,000 lbs. of 3-ply yarn made out of 30's worsted, 45's worsted and 60's spun silk.

60's spun silk equals 90's worsted yarn, thus:

30—45—90

$90 \div 90 = 1$

$90 \div 45 = 2$ $90 \div 6 = 15$'s equivalent count in single thread.

$90 \div 30 = 3$

6

$15 \times 560 = 8{,}400$ yards per lb. $\times 1{,}000$ lbs. (total amount of yarn wanted) $= 8{,}400{,}000$ total number of yards of 3-ply yarn required.

8,400,000 ÷ 16,800 (Standard for 30's worsted) = 500.00
8,400,000 ÷ 25,200 (Standard for 45's worsted) = 333.33 + ($\frac{1}{3}$)
8,400,000 ÷ 50,400 (Standard for 90's worsted) = 166.66 + ($\frac{2}{3}$)

1000.00

Answer.—The amount for each minor thread in given example is as follows:

500 lbs. of 30's worsted.
$333\frac{1}{3}$ lbs. of 45's worsted.
$166\frac{2}{3}$ lbs. of 60's spun silk.

1,000 lbs. Total amount of yarn wanted.

Ascertaining the Cost of Two, Three, or More Ply Yarn.

COMPOSED EITHER OF DIFFERENT QUALITIES (AS TO PRICE) OF YARN ONLY, OR OF THE LATTER ITEM IN ADDITION TO DIFFERENT COUNTS OF THE MINOR THREADS.

If a 2-ply yarn is composed of minor threads of equal counts, but different qualities, (as to cost) the average between the two prices will be the cost of the 2-ply thread.

Example.—Find the price for 2/40's worsted composed of minor threads worth respectively $1.00 and $1.36.

$$\$1.00+\$1.36=\$2.36\div 2=\$1.18.$$

Answer.—The price of the yarn in question is $1.18 per pound.

By means of the average we will also find the price for a three or more ply yarn provided the counts of each minor thread are the same.

Example.—Find the price for a 3-ply yarn composed of minor threads of equal counts, but costing respectively 60 cts., 80 cts. and $1.00 per pound.

$$\$0.60+\$0.80+\$1.00=\$2.40\div 3=\$0.80.$$

Answer.—The price for the yarn in question is 80 cents.

If a 2-ply yarn is composed of minor threads of unequal counts as well as of different price we must find the cost per pound of the compound thread by—

Rule.—Multiply each count by the price of the other yarn, next divide the sum of the products by the sum of the counts.

Example.—Find cost per pound for 2-ply yarn composed of 32's and 40's worsted. The price of the 32's to be $1.04 and that of the 40's $1.60.

$$\begin{array}{ll} 40\times\$1.04= & \$41.60 \\ 32\times\ \ 1.60= & \ \ 51.20 \\ \hline 72 & \$92.80 \end{array} \qquad \$92.80\div 72=\$1.28\tfrac{8}{9}$$

Answer.—The price for the yarn in question is 1.28\frac{8}{9}$ or nearly $1.29.

Proof.—40's and 32's.

$40\times 32=1{,}280\div 72(40+32)=17\frac{7}{9}$ compound size of thread.

$17\frac{7}{9}\times 560=9{,}957$ standard number of yards in compound thread, or number of yards of each minor thread required.

40's worsted = 22,400 yards per lb.

32's worsted = 17,920 yards per lb., thus:

$$22{,}400:1.60::9{,}957:x \text{ or } \frac{9{,}957\times 1.60}{22{,}400}=\$0.7112— = 71.12 \text{ cents.}$$

$$17{,}920:1.04::9{,}957:x \text{ or } \frac{9{,}957\times 1.04}{17{,}920}=\$0.5777— = 57.77 \text{ “}$$

Answer.— $128\frac{89}{100}$ cents = $1.29.

If one of the minor threads is of a different material than the other, reduce the one thread to its equivalent counts in the basis of the other and find the cost per pound of compound yarn by previously given rule.

Example.—Find cost per pound for 2-ply fancy cassimere yarn, composed of 5-run woolen yarn and 40's cotton yarn for minor threads. Value of the single woolen yarn 86 cents per pound, and value of the cotton yarn 36 cents.

40's cotton equals 21-run woolen yarn thus:

5-run at 86 cents, and 21-run at 36 cents.

$$\begin{array}{rr} 5\times36= & 180 \\ 21\times86= & 1{,}806 \\ \hline 26 & 1{,}986 \end{array} \qquad 1{,}986\div26=76.38$$

Answer.—The price of given 2-ply fancy cassimere yarn is $76\frac{38}{100}$ cents (or about $76\frac{1}{3}$ cents.)

Proof.—5 and 21-run.

$5\times21=105\div26(5+21)=4\frac{1}{26}$ compound size.

$4\frac{1}{26}\times1{,}600=6{,}461.5$ yards length of each minor thread.

5 run = 8,000 yards per lb.

21 " =33,600 " " " thus:

$$8{,}000:86::6{,}461.5:x \text{ or } \frac{86\times6{,}461.5}{8{,}000} = 69.46 \text{ cents.}$$

$$33{,}600:36::6{,}461.5:x \text{ or } \frac{36\times6{,}461.5}{33{,}600} = 6.92 \text{ cents.}$$

Answer.— $76\frac{38}{100}$ cents.

If a 3-ply yarn is composed of minor threads of unequal counts as well as of a different price, we must find the cost of the compound yarn by

Rule.—Find average price and compound counts between any two minor threads given, and afterwards proceed in the same manner between the respective results and the third minor thread.

Example.—Find cost per pound of 3-ply fancy yarn composed of the following minor threads: 60's worsted costing $2.00 per pound; 40's worsted costing $1.50 per pound; and 30's worsted costing $1.00 per pound.

60's at $2.00. 40's at $1.50

$$\begin{array}{rr} 60\times1.50= & 90 \\ 40\times2.00= & 80 \\ \hline 100 & 170.00 \end{array} \qquad 170.00\div100=1.70.$$

$1.70 average price between 60's worsted at $2.00, and 40's at $1.50.

$60\times40=2{,}400\div100\,(60+40)=24$. 24's worsted compound counts for 60's and 40's worsted; thus:

24's worsted at $1.70. 30's worsted at $1.00.

$$\begin{array}{rr} 24\times1.00= & 24.00 \\ 30\times1.70= & 51.00 \\ \hline 54 & 75.00 \end{array} \qquad 75.00\div54=1.3888.$$

Answer.—The price for the 3-ply yarn given in the example is $1.3888 or nearly $1.39.

Proof.—60's, 40's and 30's worsted.

$$\begin{array}{l} 60\div60=1 \\ 60\div40=1\frac{1}{2} \\ 60\div30=2 \\ \hline \qquad\quad 4\frac{1}{2} \end{array}$$

$60\div4\frac{1}{2}=13\frac{1}{3}$'s worsted compound counts for 60's, 40's and 30's.

$13\frac{1}{3}$ worsted $=13\frac{1}{3}\times560=7{,}466\frac{2}{3}$ yards per pound.

60's worsted=33,600 yards per lb. at $2.00

40's worsted=22,400 yards per lb. at $1.50

30's worsted=16,800 yards per lb. at $1.00

$$33{,}600 : 2.00 :: 7{,}466\tfrac{2}{3} : x \quad \frac{2.00 \times 7{,}466\frac{2}{3}}{33{,}600} = \$0.4444$$

$$22{,}400 : 1.50 :: 7{,}466\tfrac{2}{3} : x \quad \frac{1.50 \times 7{,}466\frac{2}{3}}{22{,}400} = \$0.5000$$

$$16{,}800 : 1.00 :: 7{,}466\tfrac{2}{3} : x \quad \frac{1.00 \times 7{,}466\frac{2}{3}}{16{,}800} = \$0.4444$$

Answer :—$1.3888

Answer.—The price as found before ($1.38) is correct.

If a 3-ply yarn is composed of minor threads of different materials as well as different prices, and we must find the cost per pound for the compound yarn, reduce the different counts to their equivalent counts in one basis and find the result by previously given rule.

To Find the Mean or Average Value of Yarns of Mixed Stocks.

In the manufacture of mixed yarns wools of different price are frequently mixed together. To ascertain the medium price of a mixture when the price and quantity of each ingredient are given, use—

Rule.—Divide the cost of all the ingredients by the sum of the quantities mixed, the quotient will be the average value.

Example.—Find the mean or average value of the following wool mixture:

160 lbs. costing 75¢ per lb.
160 " " 86¢ " "
40 " " $1.10 " "
40 " " 1.16 " "

400 lbs. total amount of wool used in this lot.

75¢ × 160 lbs. = $120.00
85¢ × 160 lbs. = 136.00
$1.10 × 40 lbs. = 44.00
$1.16 × 40 lbs. = 46.40

400 lbs. $346.40

(Cost of all the Ingredients.) (Sum of the Quantities.)
$346.40 ÷ 400 lbs. = $0.866

Answer.—The value of the wool mixture is $86\frac{6}{10}$¢ per lb.

Example.—Find the value per lb. for the following mixture of wool.

680 lbs. costing 65¢ per lb.
300 " " 68¢ " "
20 " " 98¢ " "

1,000 lbs. in lot.

65¢ × 680 = $442.00
68¢ × 300 = 204.00
98¢ × 20 = 19.60

$665.60

$665.60 ÷ 1,000 = $0.6656

Answer.—Wool mixture in question is worth $66\frac{56}{100}$¢ per lb.

Another question frequently appearing in the mixing of lots for the manufacture of "Mixed Yarns" is—

To Find the Quantity of Each Kind of Wool to Use in a Mixture of a Given Value.

In such a mixture the total loss on the kinds of wool used of the several prices or qualities must equal the total gain.

Rule.—Arrange the prices of the different kinds of wool, we have at our disposal, in a vertical column with the mean price at the left. Next find the gain or loss on one unit of each; take such an additional portion of any as will make the losses balance the gains or *vice versa.*

Example.—Two kinds of wool at respective values of 56¢ and 63¢ per pound are required to be mixed to produce a mixture worth 60¢. Find quantities of each kind wanted.

60	$56+4\times1=4$	gain.
	$63-3\times1\frac{1}{3}=4$	loss.

Answer.—1 part of the wool costing 56¢ and
$1\frac{1}{3}$ " " " " 63¢ are required for

$2\frac{1}{3}$ parts to produce a mixture of the required value of 60¢.

Proof.—

1	lb. @ 56¢	=56¢
$1\frac{1}{3}$	" @ 63¢	=84¢
$2\frac{1}{3}$		140¢

$140\div2\frac{1}{3}=140\div\frac{7}{3}=\frac{140\times3}{7}=420\div7=60$¢ average price of mixture per lb.

Example—Three different qualities of wool at respective values of 60¢, 68¢ and 70¢ per lb. are required to be mixed to produce a mixture worth 64¢ per lb. Find quantities of each kind required.

64	$70-6\times1=6$	
	$68-4\times1=4$	10¢ loss.
	$60+4\times2\frac{1}{2}=$	10¢ gain.

Answer.—To produce mixture of a value of 64¢ per lb., use—

1 part from the wool costing 70¢
1 part from the wool costing 68¢
$2\frac{1}{2}$ parts from the wool costing 60¢ in

$4\frac{1}{2}$ parts.

Proof.—

1	lb. @ 70¢	= 70¢
1	" @ 68¢	= 68¢
$2\frac{1}{2}$	" @ 60¢	=150¢
$4\frac{1}{2}$	lbs.	288¢

$288\div4.5=64$¢ average price of mixture per lb.

Example.—Four different qualities of wool at respective values of 80¢, 85¢, 96¢ and 98¢ per lb. are required to be mixed to produce a mixture worth 92¢. Find quantities of each kind required.

92	$80+12\times1=12$	
	$85+7\times1=7$	19¢ gain.
	$96-4\times1-4$	
	$98-6\times2\frac{1}{2}-15$	19¢ loss.

Answer.—To produce mixture of wool of a value of 92¢ use—

1	part of the wool costing 80¢	
1	part of the wool costing 85	
1	part of the wool costing 92	
2½	parts of the wool costing 98	in
5½	parts.	

Proof.—

1	lb. @	80¢=	80¢
1	lb. @	85 =	85
1	lb. @	96 =	96
2½	lbs. @	98 =	245
5½	lbs.		506¢

506¢÷5.5=92¢ being the average price of mixture per lb.

Another question frequently arising in laying out "wool-lots" is—

To Find the Quantity of Each Kind to Use When the Quantity of One Kind, the Different Prices of Each Kind and the Prices of the Mixture, are Given.

Example.—What quantity of each kind of wool costing 60¢, 80¢ and 90¢ must be mixed with 20 lbs. at 71¢ so as to bring the mixture to a value of 75¢ per lb.

	¢ ¢ lbs.	
75,	60+15× 1=15¢	
	71+ 4×20=80	95¢ gain.
	80— 5× 1— 5¢	
	90—15× 6—90	95¢ loss.
	28	

Answer.—Use

1	part or lb.	of the	wool	costing	60¢
20	parts or lbs.	"	"	"	71
1	part or lb.	"	"	"	80
6	parts or lbs.	"	"	"	90
28	parts or lbs. Mixture so as to bring the price of the latter to 75¢ per lb.				

Proof.—

1	lb. @	60¢=	60¢	
20	lbs. @	71 =	1,420	
1	lb. @	80 =	8	
6	lbs. @	90 =	540	or
28	lbs. at		2,100¢.	

Hence 2,100¢÷28=75¢ average price of mixture per lb.

Example.—Having four different lots of wool at respective values of 70¢, 74¢, 82¢ and 84¢ on hand, how many lbs. of each kind must we use to make up a lot of 500 lbs. costing us 78¢ per lb.

78	70+ 8×1 =8	
	74+ 4×1 =4	12¢ gain.
	82— 4×1½=6	
	84— 6×1 =6	12¢ loss.
	4½	

$500 \div 4\frac{1}{2} = 111\frac{1}{9}$.

$1 \times 111\frac{1}{9} = 111\frac{1}{9}$ lbs. @ 70
$1 \times 111\frac{1}{9} = 111\frac{1}{9}$ " @ 74
$1 \times 111\frac{1}{9} = 166\frac{6}{9}$ " @ 82
$1 \times 111\frac{1}{9} = 111\frac{1}{9}$ " @ 84

500 lbs.

Answer.—We must use

$111\frac{1}{9}$	lbs.	of the	lot	valued at	70¢	per lb.
$111\frac{1}{9}$	"	"	"	"	74	"
$166\frac{6}{9}$	"	"	"	"	82	"
$111\frac{1}{9}$	"	"	"	"	84	"

to make up a lot of 500 lbs. at a value of 78¢ per lb.

Proof.—

$111\frac{1}{9} \times 70¢ = \$77.77\frac{7}{9}$
$111\frac{1}{9} \times 74 = 82.22\frac{2}{9}$
$166\frac{6}{9} \times 82 = 136.66\frac{6}{9}$
$111\frac{1}{9} \times 84 = 92.33\frac{3}{9}$

$390.00—and 500 lbs. at 78¢ = also $390.00.

Reed Calculations.

The reed is named by numbers, the number in each case indicating how many splits are in each inch, Thus a number 8-reed means a reed with 8 splits in every inch over the required width. If we call for number $16\frac{1}{2}$-reed, we want a reed having $16\frac{1}{2}$ splits in one inch, equal to 33 dents in every 2 inches over the entire width of the fabric. Whole numbers or half numbers alone are used for grading of reeds.

Example.—Suppose we have a number 9-reed, four threads in one split or dent, how many ends are in one inch? How many are in full warp if 70 inches wide in reed?

Answer.— $9 \times 4 = 36$ ends of warp in one inch.
$\times 70$ width of warp in reed.

2,520 ends in warp.

Rule for ascertaining the number of ends in the warp if the reed number, the threads per dent and the width of the warp in the reed are known: Multiply the reed number by the threads per dent and multiply the result by the width of the warp in reed.

Example.—How many ends are in the warp if using $13\frac{1}{2}$-reed, 6 threads per dent, 80 inches wide in reed?

$$13\frac{1}{2} \times 6 = 81 \times 80 = 6{,}480.$$

Answer.—6,480 ends are in warp.

Rule for ascertaining the reed number, if the number of ends in the warp and the width in the reed are known, the threads per dent, either given or to be selected, according to the fabric: Divide the number of ends in the warp by the width in the reed, which gives the number of threads per inch; divide this result again by the number of threads in one dent according to the weave or pattern required, the answer being the reed (number) required.

Example.—6,480 ends in warp, 80 inches wide in reed. How many ends per inch and what reed is required if 6 ends per dent are to be used?

$$6{,}480 \div 80 = 81 \div 6 = 13\tfrac{1}{2}.$$

Answer.—81 ends per inch and $13\frac{1}{2}$ is the reed number required.

Rule for ascertaining the width of the warp in the reed if the reed number, the threads per dent, and the number of threads in the warp are known: Divide the number of ends in the warp by the number of ends per inch, giving as the result the number of inches the warp will be in the reed.

Example.—Find width in reed for fabric made with 3,600 ends in warp, reeded 3 threads per dent in a number 12-reed.

$$12 \times 3 = 36 \quad 3{,}600 \div 36 = 100.$$

Answer.—The width of the fabric in reed is 100 inches.

Example.—Find width in reed for fabric made with 4,752 ends in warp, reeded 4 threads per dent in a number $16\frac{1}{2}$-reed.

$$16\tfrac{1}{2} \times 4 = 66 \qquad 4{,}752 \div 66 = 72$$

Answer.—The width of the fabric in reed is 72 inches.

The number of ends to put in one dent has to be regulated according to the fabric and the weave. Experience is the only guide for this. The coarser the reed, to a certain extent, the easier the picks go into the fabric. The finer the reed, the smoother the goods, and with perfect reeds, the less reed marks.

The same number of ends are not always used in each dent, but in such a case the preceding rules may be used with the average number of threads per dent.

Example.—What are the threads per inch? Reed number 20, using one dent, 4 ends—one dent 5 ends.

		(Average threads per dent.)		(Number of reed.)		
$4+5=9 \div 2$	$=$	$4\frac{1}{2}$	$\times$	20	$=$	90

Answer.—90 threads per inch.

Example.—What are the threads per inch? Reed number 18, using 1 dent, 3 ends—1 dent, 4 ends—1 dent, 3 ends—1 dent, 6 ends.

		(Threads in four dents.)		(Average thread per dent.)		(Number of reed.)		
$3+4+3+6$	$=$	16	$\div$	4	$\times$	18	$=$	72

Answer.—72 threads per inch.

Sometimes it happens that the average number of threads includes an inconvenient fraction. To avoid a calculation with this fraction, multiply the sum of the contents of the dents by the dents per inch, and then divide by the dents per set.

Example.—What are the threads per inch, warp reeded as follows in number 12-reed: 1 dent, 5 threads—1 dent, 3 threads—1 dent, 3 threads.

$$3+3+5=11 \times 12 = 132 \div 3 = 44.$$

Answer.—44 threads per inch.

Example.—What are the threads per inch, warp reeded as follows in a number 15-reed:—1 dent, 4 threads—1 dent, 4 threads—1 dent 5 threads.

$$4+4+5=13 \times 15 = 195 \div 3 = 65$$

Answer.—65 threads per inch.

Warp Calculations.

TO FIND WEIGHT OF WARP IF NUMBER OF ENDS, COUNTS AND LENGTH ARE GIVEN.

Multiply number of ends in the width of the cloth by yards in length (dressed), and divide product by the number of yards of the given count per pound.

Example.—**Cotton Yarn.** Find weight of warp, 50 yards long, 2,800 ends, single 40's cotton in warp.

2,800×50=140,000 yards. 40×840=33,600 yards per lb. in 40's cotton.
140,000÷33,600=4$\frac{1}{6}$.

Answer.—The weight of the warp in the present example is 4$\frac{1}{6}$ lbs.

Example.—**Woolen Yarn** (run system). Find weight of warp, 40 yards long, 3,600 ends, 4$\frac{1}{2}$-run woolen yarn.

3,600×40=144,000 yards. 4$\frac{1}{2}$-run=7,200 yards. 144,000÷7,200=20.

Answer.—The weight of the warp in present example is 20 lbs.

Example—**Woolen Yarn** (cut system). Find weight of warp, 45 yards long, 4,800 ends, 32-cut woolen yarn.

4,800×45=216,000 yards. 32-cut=9,600 yards. 216,000÷9,600=22$\frac{1}{2}$.

Answer.—The weight of the warp in the present example is 22$\frac{1}{2}$ lbs.

Example.—**Worsted Yarn.** Find weight of warp, 60 yards long, 6,000 ends, 2/60's worsted yarn.

2/60's worsted=16,800 yards. 6,000×60=360,000 yards. 360,000÷16,800=21$\frac{3}{7}$.

Answer.—The weight of the warp in present example is 21$\frac{3}{7}$ lbs.

If two or more different kinds of yarn are used, ascertain number of threads in warp for each kind by proportion, and solve answer (for each kind) by previously given rule.

Example.—Find weight of warp, 50 yards long, 6,000 ends.

Dressed.—2 ends 2/60's worsted.
1 end 2/50's cotton.
———
3 ends in repeat.

6,000÷3=2,000
———
2,000×2=4,000 ends 2/60's worsted in warp.
2,000×1=2,000 ends 2/50's cotton in warp.
———
6,000, complete number of ends in warp.

4,000×50=200,000 yards. 2/60's worsted=16,800 yards. 200,000÷16,800=11$\frac{19}{21}$.
2,000×50=100,000 2/50's cotton=21,000 yards. 100,000÷21,000=4$\frac{16}{21}$

Answer.—The weights of the warp in present example are:

11$\frac{19}{21}$ lbs. of 2/60's worsted.
4$\frac{16}{21}$ " " 2/50's cotton.
———
16$\frac{14}{21}$ lbs.=16$\frac{2}{3}$ lbs. total weight of both kinds of yarn.

Example.—Find weight of warp for each kind of yarn separately in the following example:

Lengths of warp 50 yards. Number of ends 4,800.

Dressing.—4 ends	4-run woolen yarn		blue
4 "	4 " " "		black
4 "	4 " " "		brown
4 "	4 " " "		black
16 "	4 " " "		olive mix
2 "	4 " " "		blue
2 "	4 " " "		black
2 "	4 " " "		brown
2 "	4 " " "		black
8 "	4 " " "		olive mix

48 threads in repeat of pattern.

(Number of ends in warp.)		(Threads in one repeat of pattern.)		(Number of repeats of patterns in warp.)
4,800	÷	48	=	100

{Ends of each kind of yarn in one pattern.}	×	{Number of repeats of patterns in warp.}	=	{Threads of each kind of yarn in full warp.}
6 ends blue	×	100	=	600
6 " brown	×	100	=	600
12 " black	×	100	=	1,200
24 " olive mix	×	100	=	2,400
48 threads in one repeat of pattern.				4,800 threads in warp.

4-run woolen yarn=6,400 yards per lb.

$600 \times 50 = 30{,}000 \div 6{,}400 = 4\frac{11}{16}$

$600 \times 50 = 30{,}000 \div 6{,}400 = 4\frac{11}{16}$

$1{,}200 \times 50 = 60{,}000 \div 6{,}400 = 9\frac{6}{16}$ (or $9\frac{3}{8}$)

$2{,}400 \times 50 = 120{,}000 \div 6{,}400 = 18\frac{12}{16}$ (or $18\frac{3}{4}$)

Proof.— $4{,}800 \times 50 = 240{,}000 \div 6{,}400 = 37\frac{8}{16}$ (or $37\frac{1}{2}$)

Answer.—The different amounts of yarn required for given example are:

$4\frac{11}{16}$	lbs. of	4-run	blue	woolen	yarn.
$4\frac{11}{16}$	"	4 "	brown	"	"
$9\frac{3}{8}$	"	4 "	black	"	"
$18\frac{3}{4}$	"	4 "	olive mix	"	"

This method of finding the weight for different warp yarns is no doubt the easiest to understand by any student, and will solve the most complicated arrangements of dressings and variety of yarns used.

The latter example can also be solved by—

Rule.—Find total weight of warp yarn required and divide in proportion to each kind of yarn used.

$4{,}800 \times 50 = 240{,}000 \div 6{,}400 = 37\frac{8}{16}$ lbs. total weight.

6 blue =1
6 brown =1
12 black =2
24 olive =4
8

$37\frac{8}{16} \div 8 = 4\frac{11}{16}$ for each part.

Answer.—	$1\times4\frac{11}{16}=4\frac{11}{16}$	lbs. of	4-run	blue	woolen	yarn.
	$1\times4\frac{11}{16}=4\frac{11}{16}$	" "	4 "	brown	"	"
	$2\times4\frac{11}{16}=9\frac{3}{8}$	" "	4 "	black	"	"
	$4\times4\frac{11}{16}=18\frac{3}{4}$	" "	4 "	olive mix	"	"

$37\frac{8}{16}$ (or $37\frac{1}{2}$) lbs. total weight.

If weight of warp is required to be found for one yard only, the answer may be required expressed in ounces; if so, change fraction of pounds in ounces, or use rules given previously under "Grading of the Various Yarns," after finding the number yards of yarn required.

When required to ascertain the weight of a warp dressed with yarns of various counts, and answer required is for the total weight of warp only, we may solve question by finding the average counts of the threads in question, and deal with this average count and the entire number of ends dressed, the same as if all the yarns used are of one count.

The average counts of two or more threads we find by—

Rule A.—Multiply the compound size of the given counts of yarn by number of threads compounded, or we may use

Rule B.—Divide any one of the given counts by itself and by the others given in rotation, multiply each quotient by the numbers of threads of the kind used in one repeat of pattern; next multiply previously used common dividend with the numbers of threads in one repeat of pattern, and divide the product by the sum of the quotients obtained. Either of these two rules will find the average counts. Rule A answers when using short repeats of patterns, and Rule B is adopted for large repeats.

Example.—Find average counts for the following dressing of a warp:

2 ends 30-cut woolen yarn.
1 end 20-cut " "

3 ends in repeat of pattern.

Using Rule A, we get

$30\div30=1$ $\qquad 30\div3\frac{1}{2}=8\frac{4}{7}$ compound size.
$30\div30=1$
$30\div20=1\frac{1}{2}$ $\qquad 8\frac{4}{7}\times3=25\frac{5}{7}$ average counts.

$3\frac{1}{2}$

Answer.—The average counts are $25\frac{5}{7}$-cut.

Using Rule B, we get

		Quotient.		Threads of each kind in pattern.		
$30\div30$	=	1	×	2	=	2
$30\div20$	=	$1\frac{1}{2}$	×	1	=	$1\frac{1}{2}$
						$3\frac{1}{2}$

$30\times3=90\div3\frac{1}{2}=25\frac{5}{7}$

Answer.—The average counts by Rule B are also $25\frac{5}{7}$-cut.

Example.—Find weight per yard for a warp of 3,600 ends,

Dressed.—2 ends face 30-cut woolen yarn.
1 end back 20-cut woolen yarn.

3 ends in pattern.

2/30-cut and 1/20-cut=$25\frac{5}{7}$-cut average size.

$25\frac{5}{7}\times300=7{,}714\frac{2}{7}$ yards per lb.

$3{,}600\times16=57{,}600\div7{,}714\frac{2}{7}=7.46$

Answer.—Weight of warp per yard is 7.46 oz.

Proof.—

3,600 ends, dressed: $\begin{cases} \text{2 ends 30-cut.} \\ \text{1 end 20-cut.} \end{cases}$ $3{,}600 \div 3 = 1{,}200$

$1{,}200 \times 2 = 2{,}400$ yards of 30-cut (9,000 yards per lb.) $2{,}400 \times 16 = 38{,}400 \div 9{,}000 = 4.26$ oz.
$1{,}200 \times 1 = 1{,}200$ yards of 20-cut (6,000 yards per lb.) $1{,}200 \times 16 = 19{,}200 \div 6{,}000 = 3.20$ oz.

7.46 oz.

Example.—Find weight, per yard, for a warp of 4,800 threads, dressed as follows:

2 ends face 6-run. $6 \div 6 = 1 \times 2 = 2$
1 end back 4-run. $6 \div 4 = 1\frac{1}{2} \times 1 = 1\frac{1}{2}$

3 ends in pattern. $3\frac{1}{2}$

$6 \times 3 = 18 \div 3\frac{1}{2} = 5\frac{1}{7}$-run $\times 1{,}600 = 8{,}228.57$ yards.
$4{,}800 \times 16 = 76{,}800 \div 8{,}228.57 = 9.33$.

Answer.—Weight of warp, per yard is 9.33 oz.

Proof.—

4,800 ends, dressed: $\begin{cases} \text{2 ends 6-run.} \\ \text{1 end 4-run.} \end{cases}$ $4{,}800 \div 3 = 1{,}600$

$1{,}600 \times 2 = 3{,}200$ yards of 6-run (9,600 yards per lb.).
$1{,}600 \times 1 = 1{,}600$ yards of 4 run (6,400 yards per lb.).
$3{,}200 \times 16 = 51{,}200 \div 9{,}600 = 5.33$ oz.
$1{,}600 \times 16 = 25{,}600 \div 6{,}400 = 4.00$ oz.

9.33 oz.

Example.—Find the average counts for the following dressing of a warp:

2 ends 60's $60 \div 60 = 1 \times 2 = 2$
1 end 20's $60 \div 20 = 3 \times 1 = 3$
1 end 10's $60 \div 10 = 6 \times 1 = 6$

4 ends in repeat of pattern. 11

$60 \times 4 = 240 \div 11 = 21\frac{9}{11}$

Answer.—The average counts are $21\frac{9}{11}$'s.

Proof.—(Using the same rule, but a different count, for dividend.)

$10 \div 60 = \frac{1}{6} \times 2 = \frac{2}{6}$
$10 \div 20 = \frac{1}{2} \times 1 = \frac{3}{6}$
$10 \div 10 = 1 \times 1 = 1$

$1\frac{5}{6}$

$10 \times 4 = 40 \div 1\frac{5}{6} = \frac{40}{1} \div \frac{11}{6} = \frac{40}{1} \times \frac{6}{11} = 240 \div 11 = 21\frac{9}{11}$'s.

Proof.—(Using Rule A.)

$60 \div 60 = 1$
$60 \div 60 = 1$
$60 \div 20 = 3$
$60 \div 10 = 6$

11

$60 \div 11 = 5\frac{5}{11} \times 4 = 21\frac{9}{11}$'s.

Example.—Find weight per yard for a warp of 2,850 ends, dressed as follows

20 ends 40's cotton
1 end 50's "
16 ends 30's "
1 end 50's "
—
38 ends in repeat of pattern.

$40 \div 40 = 1 \times 20 = 20 = 20$
$40 \div 30 = 1\frac{1}{3} \times 16 = 21\frac{1}{3} = 21\frac{5}{15}$
$40 \div 50 = \frac{4}{5} \times 2 = 1\frac{3}{5} = 1\frac{9}{15}$
$\quad 38 \qquad 42\frac{14}{15}$

$40 \times 38 = 1{,}520 \div 42\frac{14}{15} = 35\frac{90}{161}$'s average counts.
$35\frac{90}{161} \times 840 = 29{,}869.56$ yards per lb.
$2{,}850 \times 16 = 45{,}600 \div 29{,}869.56 = 1.52$ oz.

Answer.—The weight of given warp in example is 1.52 oz.

Proof.— $2{,}850 \div 38 = 75$ repeats of pattern in warp.

$20 \times 75 = 1{,}500$ ends of 40's cotton. (33,600 yards per lb.)
$16 \times 75 = 1{,}200$ ends of 30's cotton. (25,200 yards per lb.)
$2 \times 75 = 150$ ends of 50's cotton. (42,000 yards per lb.)

$1{,}500 \times 16 = 24{,}000 \div 33{,}600 = 0.71$
$1{,}200 \times 16 = 19{,}200 \div 25{,}200 = 0.76$
$150 \times 16 = 2{,}400 \div 42{,}000 = 0.05$

1.52 oz. (being the same answer.)

Rules given refer to finding the weight of a warp in its original length, technically known as "dressed." During weaving and the process of finishing, in most cases, the warp will shrink or "take up," thus if figuring for weight of warp in a cloth from loom, or also when finished, we must calculate back to the original number of yards required dressed, to produce a certain number of yards of cloth either woven or finished; or in other words, take the percentage for either or both "take ups," as the case may require, into consideration. Rules governing the "take ups" in a fabric cannot be given. They are guided by the cloth required, nature of material, twist, amount of intersections in weave, process of finishing, etc., in fact, practical experience is necessary to designate accurately these points.

A table of relative lengths of inches dressed, and one yard woven, with reference to a "take up" during weaving, from 1 per cent. to 50 per cent., (which also can be used for "take up" of warps during finishing) is found in my *"Technology of Textile Design,"* on page 266, in the chapter on *"Ascertaining the weight of cloth per yard from the loom.*

TO FIND THE COUNTS FOR WARP YARN IF NUMBER OF ENDS IN WARP, AND AMOUNT OF MATERIAL, LENGTH AND WEIGHT TO BE USED, ARE GIVEN.

Multiply the ends in warp by the length, multiply the basis of the yarn in question bv the weight, next divide the latter product in the one previously obtained.

Example.—**Cotton Yarn.** Find counts of yarn required—2,800 ends in warp, 50 yards long, weight $4\frac{1}{6}$ lbs.

$$2{,}800 \times 50 = 140{,}000 \div 3{,}500 \ (4\tfrac{1}{6} \times 840) = 40$$

Answer.—40's cotton yarn is required.

Example.—**Woolen Yarn** (run system). Find counts of yarns required—3,600 ends in warp, 40 yards long, weight 20 lbs.

$$3{,}600 \times 40 = 144{,}000 \div 32{,}000 \ (1{,}600 \times 20) = 4\tfrac{1}{2}$$

Answer.—The yarn required to be used in example given, is $4\frac{1}{2}$-run.

Example.—**Woolen Yarn** (cut system). Find counts of yarn required—4,800 ends in warp, 45 yards long, weight $22\frac{1}{2}$ lbs.

$$4{,}800 \times 45 = 216{,}000 \div 6{,}750\ (300 \times 22\tfrac{1}{2}) = 32$$

Answer.—32-cut yarn is required.

Example.—**Worsted Yarn.** Find counts of yarn required—6,000 ends in warp, 60 yards long, weight of warp $21\frac{3}{7}$ lbs.

$$6{,}000 \times 60 = 360{,}000 \div 12{,}000\ (21\tfrac{3}{7} \times 560) = 30$$

Answer.—Single 30's (or 2/60's) worsted yarn are required.

TO FIND NUMBER OF THREADS IN WARP TO USE, IF COUNTS OF YARN, LENGTHS AND WEIGHT OF WARP, ARE GIVEN.

Multiply counts by basis of yarn and weight of warp, and divide product by length of warp.

Example.—**Cotton Yarn.** Find number of ends for warp, 40's cotton, 50 yards long to dress, weight of yarn on hand $4\frac{1}{6}$ lbs.

$$40 \times 840 \times 4\tfrac{1}{6} = 140{,}000 \div 50 = 2{,}800$$

Answer.—Use 2,800 ends in warp.

Example.—**Woolen Yarn** (run system). Find number of ends for warp $4\frac{1}{2}$-run woolen yarn, 40 yards long to dress, weight of yarn to use 20 lbs.

$$4\tfrac{1}{2} \times 1{,}600 \times 20 = 144{,}000 \div 40 = 3{,}600$$

Answer.—Use 3,600 threads in warp.

Example.—**Woolen Yarn** (cut system). Find number of ends for warp, 32-cut yarn, 45 yards long to dress, $22\frac{1}{2}$ lbs. weight of yarn on hand.

$$32 \times 300 \times 22\tfrac{1}{2} = 216{,}000 \div 45 = 4{,}800$$

Answer.—Use 4,800 threads in warp.

Example.—**Worsted Yarn.** Find number of ends for warp, 2/60's worsted, 60 yards length of warp required, $21\frac{3}{7}$ lbs. amount of yarn on hand.

2/60's worsted=1/30's; thus: $30 \times 560 \times 21\tfrac{3}{7} = 360{,}000 \div 60 = 6{,}000.$

Answer.—Use 6,000 threads in warp.

TO FIND THE LENGTH FOR A WARP, IF NUMBER OF ENDS IN WARP, COUNTS AND WEIGHT OF YARN, ARE GIVEN.

Multiply counts by basis of yarn and weignt on warp, and divide product by number of ends in warp.

Example.—**Cotton Yarn.** Find length of warp, 2,800 threads in width, 40's cotton yarn, weight of yarn on hand $4\frac{1}{6}$ lbs.

$$40 \times 840 \times 4\tfrac{1}{6} = 140{,}000 \div 2{,}800 = 50.$$

Answer.—The length for the warp is 50 yards.

Example.—**Woolen Yarn** (run system). Find length of warp, 3,600 threads in width, $4\frac{1}{2}$-run woolen yarn, weight of yarn on hand 20 lbs.

$$4\tfrac{1}{2} \times 1{,}600 \times 20 = 144{,}000 \div 3{,}600 = 40.$$

Answer.—The length for the warp is 40 yards.

Example.—**Woolen Yarn** (cut system). Find length of warp, 4,800 threads in width, 32-cut yarn, $22\frac{1}{2}$ lbs. weight of yarn on hand.

$$32 \times 300 \times 22\tfrac{1}{2} = 216{,}000 \div 4{,}800 = 45.$$

Answer.—The length for the warp is 45 yards.

Example.—**Worsted Yarn.** Find length of warp, 6,000 threads in width, 2/60's worsted, $21\frac{3}{7}$ lbs. weight of yarn on hand.

2/60's worsted=1/30's worsted; thus: $30 \times 560 \times 21\tfrac{3}{7} = 360{,}000 \div 6{,}000 = 60.$

Answer.—The length for the warp is 60 yards.

Example.—**Cotton Yarn** (2-ply). Find length of warp (for extra super ingrain carpet) 1,072 ends, 2/14's cotton yarn, weight of yarn on hand 50 lbs.

2/14's cotton=1/7's cotton. Thus: $7 \times 840 \times 50 = 294{,}000 \div 1{,}072 = 274\tfrac{17}{67}$

Answer.—The length for the warp is $274\frac{1}{4}$ (actual $274\frac{17}{67}$) yards.

Proof.—$\dfrac{274\frac{17}{67} \times 1{,}072}{5{,}880\ (7 \times 840)} = 274\tfrac{17}{67} \times 1{,}072 = 294{,}000 \div 5{,}880 = 50$, being the amount of lbs. of yarn on hand.

Example.—**Worsted Yarn** (3-ply). Find length of warp 4,800 ends in width of fabric, 3/60's worsted yarn, weight of yarn on hand 80 lbs.

3/60's worsted=1/20's worsted. Thus: $20 \times 560 \times 80 = 896{,}000 \div 4{,}800 = 186\tfrac{2}{3}.$

Answer.—The length for the warp is $186\frac{2}{3}$ yards.

Proof.— $\dfrac{186\frac{2}{3} \times 4{,}800}{11{,}200\ (20 \times 560)} = 186\tfrac{2}{3} \times 4{,}800 = 2{,}688{,}000 \div 11{,}200 = 80$, being the amount of pounds of yarn on hand.

When two or more different materials are used in the construction of a cloth, previously given rules for warp must be solved by combining one repeat, or the average of one repeat, of pattern in a compound thread; and if required by question, after finding answer in such a compound thread, we must transfer the same to the respective minor threads.

To give a clear understanding to the student, we give, correspondingly to previously given rules, one example in three different changes.

Example.—Find counts of yarn required, 4,800 ends in warp.

Dressed.—2 ends face. } Woolen yarn, run basis.
1 end back. }
—
3 ends in repeat.

Back-warp threads to be twice as heavy as to size as face warp threads. Length of warp, 50 yards. Weight of same to be 40 lbs.

$4{,}800 \div 3 = 1{,}600$ repeats of pattern, or 1,600 compound threads.

$1{,}600 \times 50 = 80{,}000 \div 64{,}000\ (1{,}600 \times 40) = 1\frac{1}{4}$-run compound size.

$1\frac{1}{4} \times 4 = 5$ $\quad\quad$ $1\frac{1}{4} \times 2 = 2\frac{1}{2}$

Answer.—The dressing in example given will be {
2 ends face @ 5-run.
1 end back @ $2\frac{1}{2}$-run.
—
3 ends in repeat.

Proof.— $5—5—2\frac{1}{2}$

$5 \div 5 = 1$
$5 \div 5 = 1$
$5 \div 2\frac{1}{2} = 2$
—
4

$5 \div 4 = 1\frac{1}{4}$ compound size.

4,800 ends in warp÷3 ends in repeat of dressing=1,600 compound threads of $1\frac{1}{4}$-run.

$$\frac{1{,}600\times 50 \text{ yards long.}}{80{,}000} \qquad 1\tfrac{1}{4}\times 1{,}600=2{,}000.$$

2,000 : 1 :: 80,000 : x =80,000÷2,000=40 lbs.=the weight given in the example.

Example.—Find number of ends for the following warp:

Dressing.—2 ends face warp, 5-run.
1 end backing warp, $2\frac{1}{2}$-run. Length of warp 50 yards. Weight of same, 40 lbs.

3 ends in repeat.

5÷5 =1
5÷5 =1 5÷4=$1\frac{1}{4}$ compound size of the 3 threads in repeat of pattern.
5÷$2\frac{1}{2}$=2
4 $1\frac{1}{4}$-run=2,000 yards per lb., hence

40×2,000=80,000 yards of the compound thread in the amount of weight required.

8,000÷50 (Length of warp.) =1,600
1,600×3 (Number of threads in compound count.) =4,800

Answer.—4,800 threads are required for warp given in example.

Proof.— 4,800 threads, dressed: 2 face 5-run.
1 backing $2\frac{1}{2}$-run.

3 threads in repeat.

4,800÷3=1,600
1,600×2=3,200 threads 5-run (8,000 yards per lb.)
1,600×1=1,600 threads $2\frac{1}{2}$-run (4,000 yards per lb.)

3,200×50 (length of warp) 160,000÷8,000=20 lbs.
1,600×50 (length of warp) 80,000÷4,000=20 lbs.

40 lbs. weight given in example.

Example.—Find length of warp required—4,800 threads in width of cloth.

Dressing.—2 ends face 5-run woolen yarn
1 end back $2\frac{1}{2}$-run woolen yarn | Weight of complete warp 40 lbs.

3 ends in repeat.

5÷5 =1 | 5 ÷4=$1\frac{1}{4}$ compound size.
5÷5 =1 | $1\frac{1}{4}$-run=2,000 yards per lb.
5÷$2\frac{1}{2}$=2 | 2,000×40=80,000 yards of the compound thread in the amount of weight required.
4

80,000÷1,600 (Number of compound threads in width.) =50.

Answer.—50 yards, length of warp required in given example.

Proof.—

4,800 threads { 2 face, 5-run; 1 back, $2\frac{1}{2}$-run } =1,600 threads $1\frac{1}{4}$-run.
3 threads repeat.

1,600×50 {Length of warp required by answer in example.} =80,000÷2,000 {Number of yards in $1\frac{1}{4}$-run or compound count.} =40 lbs. weight of complete warp, as given in example.

Filling Calculations.

TO FIND LENGTH OF FILLING YARN REQUIRED FOR PRODUCING ONE OR A GIVEN NUMBER OF YARDS OF CLOTH, IF PICKS PER INCH AND WIDTH OF CLOTH IN REED, (INCLUDING SELVAGE) ARE KNOWN.

Rule.—Multiply picks per inch by width of fabric in reed, the product will be number of inches of filling yarn required for one inch cloth, or, at the same time, number of yards of filling yarn required for one yard of cloth. By simply multiplying yards of filling required for one yard of cloth, with the yards of cloth given in example, we get in product number of yards of filling yarn required for given yards of cloth.

Example.—Find yards of filling required for *a*, one yard *b*, 8 yards of cloth woven 72 inches wide in reed, with 52 picks per inch.

52×72=3,744 | 3,744×8=29,952

Answer.—One yard cloth requires 3,744 yards filling. Eight yards cloth require 29,952 yards filling.

TO FIND WEIGHT OF FILLING YARN REQUIRED, EXPRESSED IN OUNCES, PRODUCING ONE YARD OF CLOTH, IF PICKS PER INCH, WIDTH OF CLOTH IN REED, AND THE COUNTS OF YARN ARE KNOWN.

Rule.—Multiply picks by width of warp in reed, and divide product by number of yards of the known count required to balance 1 oz.

Example.—Cotton Yarn. Find weight of filling required for one yard cloth of the following description: 64 picks per inch, 68 inches reed space occupied, single 20's cotton yarn.

64×68=4,352 yards. 1/20's cotton=16,800 yards per lb. or 1,050 yards per oz.
4,352÷1,050=4.14.

Answer.—The weight of filling required is 4.14 oz. per yard.

Example.—Woolen Yarn. Find weight of filling required for one yard cloth having 52 picks per inch, 72 inches reed space, 4-run yarn.

4-run=(4×100)=400 yards per oz. 52×72=3,744÷400=9.36

Answer.—9.36 oz. is the weight of the filling required per yard.

Example.—Worsted Yarn. Find weight of filling necessary for one yard cloth having 68 picks per inch, 61 inches reed space, 2/36's worsted yarn.

68×61=4,148. 2/36's worsted=10,080 yards per lb. or 630 yards per oz. 4,148÷630=6.59 oz.

Answer.—The weight of filling required is 6.59 oz.

TO FIND WEIGHT OF FILLING YARN REQUIRED (expressed in pounds or fraction thereof,) FOR ANY NUMBER OF GIVEN YARDS, IF PICKS PER INCH, WIDTH OF CLOTH IN REED, AND THE COUNTS OF YARN, ARE KNOWN.

Rule.—Multiply picks by width in reed and the number of given yards, next divide product thus derived by the number of yards of the known count per pound.

Example.—**Cotton Yarn.** Find weight of filling required for 40 yards of cloth woven with 68 picks per inch, 70 inches reed space and 30's cotton yarn.

$68 \times 70 = 4{,}760 \times 40 = 190{,}400$ $\quad 30 \times 840 = 25{,}200$ $\quad 190{,}400 \div 25{,}200 = 7\tfrac{5}{9}$.

Answer.—Weight of filling required in given example is $7\frac{5}{9}$ lbs.

Example.—**Woolen Yarn.** Find weight of filling required for 120 yards of cloth woven with 44 picks per inch, 71 inches reed space and 22-cut woolen yarn.

$44 \times 71 = 3{,}124 \times 120 = 374{,}880$ $\quad 22 \times 300 = 6{,}600$ $\quad 374{,}880 \div 6{,}600 = 56.8$.

Answer.—Weight of filling required in given example is 56.8 pounds.

Example.—**Worsted Yarn.** Find weight of filling required for 600 yards of cloth, woven with 64 picks per inch, 62 inches reed space, 2/32's worsted.

$64 \times 62 = 3{,}968 \times 600 = 2{,}380{,}800$. $\quad 16 \times 560 = 8{,}960$ $\quad 2{,}380{,}800 \div 8{,}960 = 265\tfrac{5}{7}$.

Answer.—Weight of filling required in given example is $265\frac{5}{7}$lbs.

If two or more different kinds of filling yarn are used, and it is required to ascertain weight of material for each kind, the solving of the example depends entirely on the arrangement of colors used and their respective counts.

If the counts are equal, and lots differ only in color or twist, ascertain the weight for the entire filling required by previously given rules, and find answer for each kind by proportion of picks as used of each kind.

Example.—Find weight (in ounces) for filling required per yard in the following fabric:

Arrangement of filling.—

4	picks	brown	6-run	woolen	yarn.
6	"	black	6-run	"	"
4	"	blue	6-run	"	"
6	"	black	6-run	"	"
20	picks in repeat of pattern.				

72 inches reed space of fabric. 84 picks per inch.

$84 \times 72 = 6{,}048$ yards of filling per yard cloth.

$6{,}048 \div 600$ {Yards of yarn per oz. in 6-run yarn.} $= 10.08$ oz. complete weight of filling required per yard cloth.

In one repeat we find:

Brown	4 picks=1		
Blue	4 picks=1		thus: $10.08 \div 5 = 2.016$
Black	12 picks=3		
	20 picks. 5		

Answer.—2.016×1 or 2.016 oz. brown filling
2.016×1 or 2.016 oz. blue "
2.016×3 or 6.048 oz. black "
} required per yard of cloth woven.

Proof.— (+) 10.080 total weight of filling required for one yard cloth woven.

Example.—Find weight in pounds of filling required for weaving 2,000 yards of cloth of the following dimensions: Reed space 64 inches—picks per inch 66.

Arrangement.—	2	picks	2/32's	worsted	black.
	2	"	2/32's	"	brown.
	2	"	2/32's	"	black.
	2	"	2/32's	"	olive.
	8	picks in repeat of pattern.			

$66 \times 64 = 4{,}224 \times 2{,}000 = 8{,}448{,}000$ yards of filling required for 2,000 yards of cloth.

2/32's worsted=8,960 yards and $8{,}448{,}000 \div 8{,}960 = 942\frac{6}{7}$ lbs. total weight of filling required for the 2,000 yards cloth.

Black	4 picks in one repeat of color arrangement	=2	
Brown	2 " " " " "	=1	
Olive	2 " " " " "	=1	
	8 picks.	4	Thus:

$942\frac{6}{7} \div 4 = 235\frac{5}{7}$

Answer.—
$235\frac{5}{7} \times 1 = 235\frac{5}{7}$ lbs. 2/32's olive worsted
$235\frac{5}{7} \times 1 = 235\frac{5}{7}$ " 2/32's brown "
$235\frac{5}{7} \times 2 = 471\frac{3}{7}$ " 2/32's black "
} Amount of filling required for weaving 2,000 yards cloth.

Proof.— (+) $942\frac{6}{7}$ lbs. total weight of all 3 kinds filling for 2,000 yards cloth.

If filling yarns of different counts or materials are used, find number of yards of yarn of each kind required for given number of yards, and transfer the same to their respective weight (in oz. or lbs. as required) by means of rules given previously under the heading of "Grading Yarns."

Example.—Find weight in ounces for filling required per yard in the following fabric:

Arrangement.—10 picks black 4-run woolen yarn.
2 " blue 6 " " "

12 picks in repeat of pattern.

70 inches reed space of fabric. 64 picks per inch.

$64 \times 70 = 4{,}480$ yards of filling required per yard of cloth.

10 picks black	=5	
2 picks blue	=1	
12 picks in repeat	6	Thus: $4{,}480 \div 6 = 746\frac{2}{3}$

$746\frac{2}{3} \times 1 = 746\frac{2}{3}$ yards blue 6-run
$746\frac{2}{3} \times 5 = 3{,}733\frac{1}{3}$ " black 4-run
} filling required for one yard of cloth.

$746\frac{2}{3}$ yards 6-run=($746\frac{2}{3} \div 600$)=1.24 oz.
$3{,}733\frac{1}{3}$ " 4-run=($3{,}733\frac{1}{3} \div 400$)=9.33 oz.

Answer.—1.24 oz. 6-run blue filling and
9.33 " 4-run black filling, or

10.57 oz. complete weight of filling required for weaving one yard cloth.

Example.—Find weight in pounds of filling required for weaving 3,500 yards of cloth of the following details: Reed space 72 inches, 84 picks per inch.

Arrangement.—2 picks 32-cut woolen yarn, brown.
1 pick 14 " " " black.
2 picks 32 " " " blue.
1 pick 14 " " " black.

6 picks in repeat.

84×72=6,048×3,500=21,168,000 complete yards of filling required.

2 picks 32-cut brown=1
2 " 32 " blue =1
2 " 14 " black =1

6 picks in repeat. 3 Thus:

21,168,000÷3=7,056,000 yards of filling required of each kind.

7,056,000÷9,600 (standard of 32-cut)=735 lbs.
7,056,000=4,200 (standard of 14-cut)=1,680 lbs.

Answer.—In given example the following amounts of filling are required:

735 lbs. 32-cut brown woolen yarn.
735 " 32-cut blue " "
1,680 " 14-cut black " " or

3,150 lbs. complete weight of filling required for weaving the 3,500 yards of cloth.

TO FIND THE COUNTS FOR A FILLING YARN REQUIRED TO PRODUCE A CERTAIN GIVEN WEIGHT PER YARD CLOTH (in which also the picks per inch and width in reed are known).

If such example refers to weight given in ounces for one yard, use—

Rule.—Multiply picks by width of fabric in reed, and divide product by number of oz. given, and the quotient by the sixteenth part of the number of yards in the basis of the yarn in question.

Example.—**Worsted Yarn.** Find counts for filling yarn required of following cloth. 90 picks per inch, 58⅓ inches width of fabric in reed. 5 oz. weight for filling to be used.

$$90\times58\tfrac{1}{3}=5{,}250\div5=1{,}050\div35(560\div16=35)=30.$$

Answer.—The counts for filling yarn required are either single 30's or 2/60's worsted yarn.

Proof.—90×58⅓=5,250(yards wanted)÷1,050(yards per oz.)=5 oz. weight of filling per yard.

Example.—**Woolen Yarn** (cut basis). Find counts for filling yarn required of following cloth: 45 picks per inch, 75 inches width of fabric in reed, 9 oz. weight for filling to be used.

$$45\times75=3{,}375\div9=375\div18\tfrac{3}{4}=20.$$

Answer.—The counts for filling yarn required are 20-cut woolen yarn.

If example refers to a given number of yards and weight is expressed in pounds, use—

Rule.—Multiply width of fabric (in loom or in reed) with the number of picks per inch, and the result with the given yards of cloth to be woven; the result thus obtained divide by the given weight, and the quotient by the basis of the yarn.

Example.—**Woolen Yarn** (run basis). Find counts for filling yarn required of following cloth: Reed space occupied $66\frac{2}{3}$ inches, 72 picks per inch, 40 yards length of cloth to be woven, 30 lbs. amount of filling to be used.

$$66\tfrac{2}{3}\times72=4{,}800\times40=192{,}000\div30=6{,}400\div1{,}600=4.$$

Answer.—Counts for yarn required are 4-run woolen yarn.

Example.—**Cotton Yarn.** Find counts for filling yarn required for following cloth. Reed space occupied 30 inches, 80 picks per inch, 70 yards length of cloth to be woven, 10 lbs. amount of filling to be used.

$$30\times80=2{,}400\times70=168{,}000\div10=16{,}800\div840=20$$

Answer.—Counts for yarn required are 20's cotton yarn.

TO FIND THE PICKS PER INCH FOR A CERTAIN PIECE OF GOODS OF WHICH THE COUNTS OF THE YARN, LENGTH OF CLOTH TO BE WOVEN, ITS WIDTH IN REED, AND THE AMOUNT OF MATERIAL TO BE USED, ARE GIVEN.

In such a case use—

Rule.—Multiply counts by basis of yarn and amount of material to be used, the product thus obtained divide by the yards given and the quotient by width of fabric in reed.

Example.—**Woolen Yarn** (run basis). Find number of picks necessary to produce the following fabric: 6-run woolen yarn, 80 inches width of cloth in reed, 40 yards length of cloth woven, 20 lbs. weight of filling to be used.

$$6\times1{,}600=9{,}600\times20=192{,}000\div40=4{,}800\div80=60$$

Answer.—60 picks are required.

Proof.—$60\times80=4{,}800\times40=192{,}000$ yards required.

$6\times1{,}600=9{,}600$. Thus: $192{,}000\div9{,}600=20$ lbs., weight of filling to be used.

Example.—**Worsted Yarn.** Find number of picks required to produce the following fabric: Single 15's worsted filling, 60 inches width of cloth in reed, 40 yards length of cloth woven, 22 lbs. weight of filling to be used.

$$15\times560=8{,}400\times22=184{,}800\div40=4{,}620\div60=77$$

Answer.—77 picks are required.

In some instances there may be two or more different counts of filling used. For example in fabrics made with one system of warp and two or more fillings, or fabrics made on the regular double cloth system, etc. **If the arrangement as to counts of a filling is of a simple form,** compound the counts of the respective number of threads in one thread, and solve answer in compound size by previously given rule. Next multiply compound number thus derived by number of picks compounded, and the result will be the answer for picks wanted in fabric.

Example.—**Woolen Yarn** (cut basis). Find number of picks necessary to produce the following fabric.

Arrangement of filling.—2 picks 32-cut woolen yarn (face).
1 pick 18 " " " (back).
—
3 picks in repeat.

36 yards length of cloth woven, $26\frac{5}{24}$ lbs. weight of filling to be used, 74 inches reed space to be occupied.

$32 \div 32 = 1$	$32 \div 3\frac{7}{9} = 8\frac{8}{17}$-cut compound size.
$32 \div 32 = 1$	$8\frac{8}{17} \times 300 = 2{,}541\frac{3}{17} \times 26\frac{5}{24} = 66{,}600$
$32 \div 18 = 1\frac{7}{9}$	$66{,}600 \div 36 = 1{,}850 \div 74 = 25$, compound number of picks required.
—— $3\frac{7}{9}$	25×3 (number of minor picks compounded) $= 75$

Answer.—75 picks are required.

Proof.—2 picks 32-cut.
1 pick 18-cut.
—
3 picks in repeat.

75 picks per inch.
36 yards length of cloth.
74 inches reed space occupied. Find weight ($26\frac{5}{24}$).

$75 \times 74 = 5{,}550 \div 3 = 1{,}850.$

1,850—18-cut—($18 \times 300 = 5{,}400$ yards per lb.)
3,700—32-cut—($32 \times 300 = 9{,}600$ yards per lb.)

$1{,}850 \times 36 = 66{,}600 \div 5{,}400 = 12\frac{1}{3} = 12\frac{8}{24}$ lbs.
$3{,}700 \times 36 = 133{,}200 \div 9{,}600 = 13\frac{7}{8} = 13\frac{21}{24}$ lbs.
——
$26\frac{5}{24}$ lbs., being the same weight as given in example.

If the arrangement of filling has a large number of picks in repeat, proceed as follows: Ascertain weight of filling for one repeat of number of yards required woven and find answer by proportion, for picks in one repeat are to their weight in the same proportion, as picks required (or x) to given weight.

Example.—**Cotton Yarn.** Find number of picks required for the following cloth:

Width of fabric in reed 30 inches.
Length of cloth woven 60 yards.
Weight of filling to be used 12 lbs.

Arrangement of filling.—20 picks single 20's cotton.
24 " " 12's "
—
44 picks in repeat.

$20 \times 30 = 600 \times 60 = 36{,}000$
$24 \times 30 = 720 \times 60 = 43{,}200$
} for one repeat of
—
44 picks.

20's cotton $= 16{,}800$ yards per lb. and 36,000 yards are required.
12's " $= 10{,}080$ " " " 43,200 " " "

$36{,}000 \div 16{,}800 = 2\frac{1}{7}$ lbs.
$43{,}200 \div 10{,}080 = 4\frac{2}{7}$ lbs.
+—
$6\frac{3}{7}$ lbs., weight required for one repeat (=44 picks) of given counts of cotton yarn.

$44 : 6\frac{3}{7} :: x : 12$ $\qquad$ $44 \times 12 = 528 \div 6\frac{3}{7} = 82\frac{2}{15}$

Answer.—82 picks (actually $82\frac{2}{15}$ picks) are required.

Proof.—$82\frac{2}{15} \times 30 = 2{,}464 \times 60 = 147{,}840 \div 44 = 3{,}360.$

$3{,}360 \times 20 = 67{,}200 \div 16{,}800 = 4$ lbs.
$3{,}360 \times 24 = 80{,}640 \div 10{,}080 = 8$ lbs.
——
12 lbs., weight of filling to be used in given example.

To ascertain the number of yards of cloth woven, a certain amount of yarn on hand will give. Such examples will frequently arise in working up old lots on hand; again every time at weaving the last pieces cloth of large orders, where the superintendent wants a final review before the last or last few looms may have to wait for filling, or cut warps short. In such instances, width of fabric in reed, counts of yarn, and picks per inch are known. Thus : find number of yards for which material on hand by—

Rule.—Ascertain weight of filling required per yard, and divide the latter into the total weight of yarn on hand.

Example.—**Woolen Yarn** (run system). Find number of yards of cloth we can weave with 92 lbs. 4-run woolen yarn filling in a fabric, which is set 70 inches wide in reed and for which we use 60 picks per inch.

Picks per inch		Width of fabric in reed.		Yds of filling wanted for 1 yard cloth.		6,400÷16 or yards per oz.	
60	×	70	=	4,200	÷	400	$=10\frac{1}{2}$ oz., weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz. in 1 lb.		Total amount of oz.		Oz of filling in 1 yard of cloth.	
92	×	16	=	1,472	÷	10.5	=140.19 yards.

Answer.—Filling in hand will weave 140 yards (140.19) of cloth.

Example.—**Woolen Yarn** (cut system). Find number of yards of cloth we can weave with 42 lbs. 32-cut woolen yarn filling in a fabric, which is set 72 inches in reed and for which we use 84 picks per inch.

Picks per inch.		Width of fabric in reed.		Yds. of filling wanted for 1 yard cloth.		9,600÷16 or yards per oz.	
84	×	72	=	6,048	÷	600	=10.08 oz.,weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz. in 1 lb.		Total amount of oz.		Oz. of filling in 1 yard of cloth	
42	×	16	=	672	÷	10.08	$=66\frac{2}{3}$ yards.

Answer.—Filling on hand will weave 66 yards ($66\frac{2}{3}$) of cloth.

Example.—**Worsted Yarn.** Find number of yards of cloth we can weave with 52 lbs. of 2/36's worsted filling in a fabric, which is set 62 inches wide in reed and for which we use 70 picks per inch.

Picks per inch.		Width of fabric in reed.		Yds. of filling wanted for 1 yd. of cloth.		10,080÷16 or yards per oz.	
70	×	62	=	4,340	÷	630	=6.888 oz.,weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz. in 1 lb.		Total amount of oz		Oz. of filling in 1 yard of cloth	
52	×	16	=	832	÷	6.888	=120.79 yards.

Answer.—Filling on hand will weave 120 yards ($120\frac{4}{5}$) of cloth.

Example.—**Cotton Yarn.** Find number of yards of cloth we can weave with 18 lbs. of single 40's cotton filling in a fabric, which is set 30 inches in reed and for which we use 60 picks per inch.

Picks per inch.		Width of fabric in reed		Yds. of filling wanted for 1 yard of cloth		33,600÷16 or yards per oz.	
60	×	30	=	1,800	÷	2,100	$=\frac{6}{7}$ oz., weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz. in 1 lb.		Total amount of oz.		Oz. of filling in 1 yard of cloth	
18	×	16	=	288	÷	$\frac{6}{7}$	=336 yards.

Answer.—Filling on hand will weave 336 yards of cloth.

(Answers are given in these examples without reference to any waste of material during the weaving process.)

Ascertaining the Amount and Cost of the Materials used in the Construction of Fabrics.

A. FIND THE TOTAL COST OF MATERIALS USED, and

B. FIND THE COST OF THE SAME PER YARD, FINISHED CLOTH.

Fancy Cassimere.

Warp.—3,600 ends 4-run brown mix. Price of yarn, 85 cents per lb. Length dressed, 50 yards. Reed, 12½×4.

Selvage.—40 ends, 2-ply 4-run. Reeded, 4 ends per dent. Price of yarn, 50 cents.

Filling.—52 picks, 3¾-run gray mix. Price of yarn, 65 cents per lb.

Length of fabric from loom, 43 yards. Length of fabric finished, 40 yards.

{Ends.} {Yards.} {Total yards.} {Yards per lb.} {Total lbs.} {Price per lb.}

$$\text{Warp.— } \frac{3{,}600 \times 50}{6{,}400} = (180{,}000 \div 6{,}400) = 28\tfrac{1}{8} \times 85¢ = \$23.905\text{, price of warp.}$$

{Total yards.} {Yards per lb.} {Price per lb.}

Selvage.—40×2=80 ends×50 yds.=4,000 ÷ 3,200=1¼ lbs. × 50¢ = 62½¢, price of selvage.

Filling.—3,600÷50=72 inches, width of warp in reed.

+ 1⅗ " width of selvage (80÷4=20÷12½=1⅗).

73⅗ inches, width of warp and selvage.

{Width.}		{Picks}		{Yards filling per yard cloth.}		{Yards Woven.}		{Total yards filling.}		{Yards per lb.}		{Weight of filling.}
73⅗	×	52	=	3,827½	×	43	=	164,582½	÷	6,000	=	27.43 lbs.
												×65¢, price per lb.
												$17.8295, price of filling.

$23.90½, price of warp.
62½, price of selvage.
17.83, price of filling.
$42.36, total cost of all.

$42.36÷40=$1.059 or $1.06, price of material per yard finished.

Answer.—A. $42.36, total cost of all materials.

Answer.—B. $1.06, cost of materials per yard of finished cloth.

Worsted Suiting.

Warp.—3,968 ends, 2/32's worsted. Price of yarn, $1.05 per lb. Length dressed, 45 yards. Reed, 16×4.

Selvage.—30 double ends, 2/30's worsted, 3 double ends per dent. Price of yarn, 75 cents per lb.

Filling.—66 picks, 2/32's worsted. Price of yarn, 95 cents.

Length of fabric from loom, 40 yards. Length of fabric finished, 39¼ yards.

Warp.—3,968×45=178,560 yards of warp wanted.

2/32's worsted=1/16's=8,960 yards per lb. 178,560÷8,960=19$\frac{13}{14}$ lbs., weight of warp.

$$19\tfrac{13}{14} \times 1.05 = \frac{279}{14} \times 1.05 = \frac{279 \times 1.05}{14} = 292.95 \div 14 = \$20.92\tfrac{1}{2}\text{, cost of warp.}$$

Selvage.—$60 \times 2 = 120 \times 45 = 5{,}400$ yards of selvage are wanted.

$2/30\text{'s} = 1/15\text{'s} = 8{,}400$ yards per lb.

$$5{,}400 \div 8{,}400 = \frac{54}{84} \text{ or } \frac{9}{14} \times \underset{\text{(Price per lb.)}}{75¢} = 675 \div 14 = 48\tfrac{3}{14}¢, \text{ cost of selvage.}$$

Filling.—$3{,}968 \div 64 = 62$ inches width of warp.

10 dents each side for selvage=20 (both sides) $\div 16 = 1\frac{1}{4}$ inches, width of selvage.

62 inches, width of warp.
$1\frac{1}{4}$ " " selvage.

$63\frac{1}{4}$, total width of fabric in reed, and $63\frac{1}{4} \times 66 = 4{,}174.5$ {Yards filling wanted per yard.}
$\times 40$ length of cloth from loom.

166,980 yards of filling wanted.

$166{,}980 \div 8{,}960 = 18\frac{285}{448}$ lbs. of filling wanted.

$$18\tfrac{285}{448} \times \underset{\text{Price per lb.}}{95¢} = 17.70\tfrac{195}{448} \div 100 = \$17.70\tfrac{1}{2}, \text{ cost of filling.}$$

Warp,	$20.92\frac{1}{2}$
Selvage,	$0.48\frac{3}{14}$
Filling,	$17.70\frac{1}{2}$
	$39.11\frac{3}{14}$, total cost of materials.

$39.1175 \div 39.25 = \$0.996$ or $99\frac{3}{5}¢$, cost of material per yard.

Answer A.—$\$39.11\frac{3}{4}$, (practically $39.12) total cost of all materials.

Answer B.—$ $0.99\frac{3}{5}$, (practically $1.00) cost of materials per yard of finished cloth.

Cotton Dress Goods.

Warp.—1,392 ends, single 18's cotton. Price of yarn, 22 cents per lb. Length dressed, 60 yards. Reed, 24×2.

Selvage.—12 ends, 2/20's cotton, 3 ends per dent. Price, 20 cents per lb.

Filling.—54 picks, single 26's cotton.. Price, 24 cents per lb.

Length of cloth from loom, 56 yards. Length of cloth finished, $56\frac{1}{2}$ yards.

Warp.—$1{,}392 \times 60 = 83{,}520 \div 15{,}120 (840 \times 18) = 5\frac{94}{189}$ lbs. $\times 22¢ = \$1.20\frac{178}{189}$, price of warp.

Selvage.—$24 \times 60 = 1{,}440 \div 8{,}400 = \frac{144}{840}$ or $\frac{6}{35}$ lbs.

$\frac{6}{35} \times 20 = (120 \div 35) = 3\frac{3}{7}¢$, price of selvage.

Filling.—$1{,}392 \div 48 = 29$ inches, width of fabric in reed.
$\frac{1}{3}$ inch " " both selvages.

$29\frac{1}{3}$ inches, total width of fabric and selvages.

$29\frac{1}{3} \times 54 = 1{,}584$ yards of filling wanted per yard.
$\times 56$ " length of cloth from loom.

88,704, total number of yards wanted.

$$88{,}704 \div \underset{\text{Yards per lb. in 26's cotton.}}{21{,}840} = \underset{\text{(lbs.)}}{4.061} \times 24¢ = .97\tfrac{46}{100}¢, \text{ price of filling.}$$

\$1.21, price of warp .03½, " " selvage .97½, " " filling ——— \$2.22, total price of material used in the fabric.	\$2.22÷56½=3$\frac{105}{113}$ or nearly 3⅞¢, price of material per yard finished.

Answer A.—\$2.22, total cost of material used.

Answer B.—\$ .03⅞, (practically 4 cents) cost of materials per yard finished cloth.

Woolen Tricot Suiting.

Warp.—4,608 ends, 32-cut woolen yarn. Price of yarn, \$1.15 per lb. Length dressed, 40 yards. Reed, 16×4.

Selvage.—40 ends, single 10-cut, 2 ends per dent. Price, 54 cents per lb.

Filling.—76 picks, 36-cut woolen yarn. Price, \$1.08 per lb.

Length of cloth from loom, 36 yards. Length of cloth finished, 32 yards.

Warp.—4,608×40=184,320÷9,600(300×32)=19.2 lbs×\$1.15=\$22.08, price of warp.

Selvage.—40×2=80×40=3,200÷3,000(300×10)=1$\frac{1}{15}$ lbs.×\$0.54=\$0.576, price of selvage.

Filling.—4,608÷64=72 inches, width of warp.
2½ " " " selvage. (40×2=80÷2=40÷16=2½)
———
74½ inches, total width of fabric.
74½×76=5,662 yards filling per yard.
×36 yards of cloth woven.
———
203,832, total yards filling wanted.
203,832÷10,800=18,873 lbs., weight of filling.
18,873 lbs.×\$1.08=\$20.383, cost of filling.

Warp, \$22.08 Selvage, .576 Filling, 20.383 ——— \$43.039, total cost.	\$43.039÷32=\$1.345, or \$1.34½, cost of materials per yard finished.

Answer A.—\$43.039, (practically \$43.04) is the total cost of the materials used; and,

Answer B.—\$1.34½, is the cost of the same per yard finished.

Worsted Suiting.

Warp.—3,960 ends. Length dressed, 45 yards. Reed, 16×4. Take up of warp during weaving, 12 per cent.

Dressed.—4 ends black 2/32's } 4 times over=24 ends.
2 " slate 2/36's }
4 " black 2/32's = 4 "
1 " 30/2's lavender spun silk = 1 "
1 " 30/2's red " " = 1 "
———
30 ends in pattern.

Price of black worsted, \$1.05. Price of slate worsted, \$1.12. Price of silk, \$6.50.

Selvage.—30 double ends, 2/30's worsted each side, 3 double ends per dent. Price of yarn, 75¢ per lb.

Filling.—66 picks per inch, 2/32's worsted.

Arrangement of colors.—28 picks black worsted 2/32's (price 95¢ per lb.)
1 pick lavender spun silk 30/2's (price $6.50 per lb.)
1 pick red " " 30/2's (price 6.50 per lb.)

30 picks in repeat. Loss in length during finishing, $1\frac{1}{2}$ per cent.

20	ends	black	2/32's	worsted	=10
8	"	slate	2/36's	"	= 4
2	"	spun silk	30/2's	"	= 1
30	ends	in pattern			=15

3,960÷15=264 repeats (of half patterns.)

264×10=	2,640	ends of 2/32's black worsted	×45=	118,800 yards.
264× 4=	1,056	" " 2/36's slate "	×45=	47,520 "
264× 1=	132	" " 30/2's lavender silk	×45=	5,940 "
	132	" " 30/'2s red silk	×45=	5,940 "
	3,960	ends of warp	×45=	178,200 yards.

2/32's=1/16's=16×560=8,960 yards per lb.

$118{,}800 \div 8{,}960 = 13\frac{29}{112}$ lbs. $\times \$1.05 = \frac{1{,}485}{112} \times 1.05 = (1{,}485 \times 1.05 = 155{,}925 \div 112 =)$ $13.921.

Price of 118,800 yards 2/32's black worsted is $13.92.

2/36's=1/18's=18×560=10,080 yards.

47,520÷10,080=$4\frac{5}{7}$ lbs. × $1.12=$5.28, price of 47,520 yards 2/36's slate worsted.

30/2's silk=25,200 yards per lb. 5,940÷25,200=0.235 lbs.×$6.50=$1.52750.

Price of 5,940 yards 30/2's lavender silk=$1.527. Price of 5,940 yards 30/2's red silk=$1.527.

Black worsted,	$13.92
Slate, "	5.28
Lavender silk,	1.527
Red silk,	1.527
	$22.254, total cost of warp.

Selvage.—2/30's=1/5's=15×560=8,400 yards per lb.

120×45=5,400 yards. $5{,}400 \div 8{,}400 = \frac{54}{84} = \frac{9}{14}$ lbs.×75¢=48.2¢, price of selvage

Filling.—3,960÷64=$61\frac{14}{16}$ inches, width of cloth in reed.

60÷3=20 dents÷16=$1\frac{4}{16}$=$1\frac{1}{4}$ inch, width of selvage.

$61\frac{14}{16}$, width of cloth.
$1\frac{4}{16}$, width of selvage.

$62\frac{18}{16}$ inches=$63\frac{1}{8}$ inches, width of cloth and selvage.

$63\frac{1}{8} \times 66 = \frac{505}{8} \times 66 = (505 \times 66 = 33{,}330 \div 8 =) 4{,}166\frac{1}{4}$ yards filling wanted for 1 yard cloth from loom.

45 yards length dressed.
— 5.4 " 12 per cent. take up.

39.6 yards, length of cloth woven.

4,166.25×39.6=164,983.5 yards, total amount of filling wanted.

164,983.5÷15=10,998.9	10,998.9×14=153,984.6 yards of 2/32's worsted wanted. 10,998.9× 1= 10.998.9 " " 30/2's silk wanted. 164,983.5

153,984.6÷8,960=17.185 lbs.×95¢=$16.326, price of the black worsted filling.

30/2's silk=25,200 yards per lb. 10,998.9÷25,200=0.436 lbs.×$6.50=$2.834, total price of silk.

$2.834÷2=$1.417, price for each kind silk.

$16.326 black worsted filling. 1.417 lavender silk " 1.417 red " " $19.160, total cost of filling.	Cost of warp, $22.254 " " selvage, .482 " " filling, 19.160 $41.896, total cost of materials.

39.6 yards, length of cloth woven. .594 " $1\frac{1}{2}$ per cent. loss in finishing. 39.006 yards, finished length.	41.896÷39.006=1.074, cost of materials per finished yard.

Answer.—A. Total cost of material, $41.90.

Answer.—B. Cost of materials per yard finished cloth, $1.07½.

Fancy Cassimere.

Warp.—4,032 ends. Reed, 14×4. Length of warp dressed, 50 yards. Take-up of warp during weaving, 10 per cent.

Dressed.—4 ends 5-run black } 4 times over - - - - - - - =32 ends.
4 " 5 " brown }
4 ends 5-run black - - - - - - - - - - - = 4 ends.
3 " 5 " brown - - - - - - - - - - - = 3 ends.
1 end twist { 5-run black wool and 30's blue spun silk twisted together; take up of silk, 12 per cent. / " " " wool, 3 per cent. } during twisting. } =1 end.
2 ends 5-run black } 9 times over - - - - - - - =36 ends.
2 " 5 " brown }
2 ends 5-run black - - - - - - - - - - - = 2 ends.
1 end 5 " brown - - - - - - - - - - - = 1 end.
1 " twist (the same as above) - - - - - - - = 1 end.

In pattern 80 ends.

Price of the 5-run warp yarn, 96 cents per lb. Price of the 5-run woolen yarn (soft-twist) as used in twist, 96 cents per lb. Price of the spun-silk as used in twist, $5.60 per lb.

Selvage.—40 ends of 2-ply 4-run listing yarn for each side, 4 ends per dent. Price of yarn, 50 cents.

Filling.—The same arrangement as the warp, only using 5½-run yarn in place of the 5-run. For twist use the same material for both minor threads as in warp. 60 picks per inch. Price of the 5½-run filling yarn, 85 cents. Loss in length of fabric at finishing (fulling), 6 per cent.

Warp.—4,032 ends. { 78 ends 5-run; 2 " twist 80 ends in repeat.	4,032÷80=50 repeats plus 32 ends.

50×78 =3,900+32=3,932 ends of 5-run   50×2=100 ends twist.

(Ends in warp.) (Yards long.) (Yards wanted.) (5×1,600)
3,932 × 50 = 196,600 ÷ 8,000 =24,575 lbs.@96¢=$23.592, price of 5-run warp.

100 ends of twist×50 yards (dressed)=5,000 yards, total length of twist yarn wanted.

Take-up of silk (during twisting) 12 per cent. Thus : (100 : 88 :: x : 5,000)=5,681.81 yards of 30's spun silk are wanted.

Take-up of wool (during twisting) 3 per cent. Thus : (100 : 97 :: x : 5,000)=5,154.64 yards of 5-run woolen yarn are wanted.

(30×840) (Weight wanted.) (Price per lb.)
5,681.81 ÷ 25,200 = 0.2254 lbs. × $5.60 = $1.262, price of silk yarn used in twist for warp.

(5×1,600) (Weight wanted.) (Price per lb.)
5,154.64 ÷ 8,000 = 0.6443 lbs. × 96¢ =$0.618, price of the 5-run minor yarn for twist.

$23.592 cost of 5-run warp yarn.		
1.262 " " 30's spun silk	for twist.	
0.618 " " 5-run soft twist		
$25.472, total cost of warp.		

Selvage.—80 ends×50 yards dressed=4,000 yards of yarn÷3,200 (2×1,600) =$1\frac{1}{4}$ lbs.

$1\frac{1}{4}$ lbs @ 50¢ = $62\frac{1}{2}$¢, price of selvage yarn used.

(Ends in warp.) (14×4)
Filling.—4,032 ÷ 56 = 72 inches, width of cloth in reed.

80 (ends selvage) ÷4 (ends per dent) =20 dents÷14=$1\frac{3}{7}$ inches, width of selvage.

72 inches, width of cloth,
$1\frac{3}{7}$ " " " selvage,

$73\frac{3}{7}$ inches, total width.

{Width of cloth.} {Picks per inch.}

$$73\tfrac{3}{7} \times 60 = \frac{514}{7}\times 60 = \frac{30,840}{7}\times 45 \left\{ \begin{array}{l} \ \ 50 \\ -\ \ 5 = 10 \text{ per cent. take up} \\ \ \ \overline{45} \end{array} \right\} = 198,257\tfrac{1}{7},$$

total number of yards of filling wanted.

$198,257\frac{1}{7}$÷40=4,956.43× 1= 4,956.43 yards of twist.
and 4,956.43×39=193,300.77 " " $5\frac{1}{2}$-run. } filling yarn are wanted.

$5\frac{1}{2}$-run=8,800 yards per lb. Thus :

193,300÷8,800=$21\frac{85}{88}$ lbs. @ 85¢=$18.671, price of the $5\frac{1}{2}$-run filling.

Twist yarn. { Silk take-up 12 per cent., thus : (100 : 88 :: x : 4,956.43)=$5,632\frac{27}{88}$ yards are wanted.
Wool " 3 " " " (100 : 97 :: x : 4,956.43)=$5,109\frac{70}{97}$ " " "

30's spun silk=25,200 yards per lb. Hence :

5,632÷25,200=0.2235 lbs., weight of silk wanted @ $5.60=$1.251, price of silk.

5-run woolen yarn=8,000 yards per lb. Hence :

5,109÷8,000=0.6386 lbs., weight of woolen yarn @ 96¢=61.3¢, price of the woolen yarn.

$18.671 cost of $5\frac{1}{2}$-run filling.		
1.251 " " 30's spun silk.	for twist.	
0.613 " " 5-run soft twist.		
$20.535, total cost of filling.		

$25.472, cost of warp.
0.625, " " selvage.
20.535, " " filling.

$46.632, total cost.

45 yards, woven length of cloth.
— 2.7 " (6 per cent. shrinkage in fulling).

42.3 yards, length of cloth when finished.

46.632÷42.3=1.124

Answer.—A. The total cost of materials used are $46.632 ($46.64) and

Answer.—B. The cost of the same per finished yard is $1.124 ($1.13.)

Fancy Cotton Dress Goods.

(27 inches finished width.)

2,204 ends in warp. Reed, 38×2. Length of cloth from loom, 80 yards.

Dressing:

1 end dark blue (ground) 1 end white "	} ×4	= 8 ends	1/20's
1 end light blue "		= 1 end	2/30's
2 ends " " (pile)		= 2 ends	2/24's
1 end " " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end flesh "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
1 end white "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
1 end dark blue " 1 end white "	} ×4	= 8 ends	1/20's
1 end maroon "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end white "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
24 ends tan "		=24 ends	1/20's

Dressing:—continued.

1 end dark blue (ground) 1 end white "	} ×4	= 8 ends	1/20's
1 end maroon "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end white "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
1 end light blue "		= 1 end	2/30's
2 ends " " (pile)		= 2 ends	2/24's
1 end " " (ground)		= 1 end	2/30's
1 end dark blue " 1 end white "	} ×4	= 8 ends	1/20's
1 end " "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end flesh "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
24 ends tan "		=24 ends	1/20's
Repeat of pattern,		152 ends.	

Take-up of ground-warps during weaving, 8 per cent.
Take-up of pile-warp during weaving, 70 per cent.

Price of warp yarns (including coloring or bleaching) as to their respective counts, are:

1/20's ground, 30 cents.
2/30's ground, 38 cents.
2/24's pile, 36 cents.

Selvage.—10 two-ply ends of 2/20's white cotton for each side. 2 double ends per dent. 8 per cent. take-up during weaving. Price of yarn, 22 cents.

Filling.—78 picks per inch.

Arrangement of colors.—

4	picks	white
8	"	tan
4	"	maroon
8	"	tan
6	"	white
8	"	tan
4	"	light blue
28	"	tan
70	picks in repeat.	

Counts for all the filling 1/20's cotton.
Price of all the filling yarn, inclusive of coloring and bleaching, 28 cents.
Length of cloth from loom to equal length finished.

Warp.—1/20's ground=112 ends in one pattern
2/30's " = 20 " " " "
2/24's pile = 20 " " " "

152 ends in one repeat of pattern.

2,204 (ends in warp) ÷152 (repeat of pattern) =$14\frac{1}{2}$ repeats of pattern in width of fabric.

Pattern, with reference as to counts, repeats twice in one repeat of pattern. Thus:

	Take-up during weaving.	Yards of yarn wanted per yard cloth woven.	Length of cloth woven.	Yards of yarn wanted for the entire piece.
$112\times14\frac{1}{2}$=1,624 ends of 1/20's cotton—	8 per cent. —	1,765.2174 ×	80	= 141,217.392 yds.
$20\times14\frac{1}{2}$= 290 " " 2/30's " —	8 " " —	315.2174 ×	80	= 25,217.392 "
$20\times14\frac{1}{2}$= 290 " " 2/24's " —	70 " " —	966.6666 ×	80	= 77,333.328 "

Yards of yarn wanted for the entire piece.		Yards per lb.		Lbs. of yarn wanted for the entire piece.		Price of the yarn per lb.		Value of yarn
141,217.392 yards.	÷	16,800	=	8.4058	×	30¢	=	$2.52
25,217.392 "	÷	12,600	=	2.0013	×	38	=	0.76
77,333.328 "	÷	10,080	=	7.6719	×	36	=	2.76
								$6.04, price of warp yarn.

Filling.—29 inches, width of fabric in reed.
$\frac{5}{19}$ " " " selvage in reed.

$29\frac{5}{19}$ inches, total width of cloth in reed.

$29\frac{5}{19}\times78=(\frac{556}{19}\times78)$=2,282.5263 yards of filling per yard cloth woven.

	Length of cloth woven.		Total yards of filling wanted.		20×840		Lbs. of yarn wanted.		Price of yarn per lb.		Value of total filling yarn.
2,282.5263 ×	80	=	182,602.1040 yds.	÷	16,800	=	10.8691	×	28¢	=	$3.04

Selvage.—40 ends. 8 per cent. take-up (100:92 :: x:40) required 43.478 yards yarn per yard cloth woven.

		Length of cloth woven.		Yards of selvage wanted for the entire piece.		10×140		Total weight of selvage.		Price per lb.	
43.478 yards	×	80	=	3,478.24 yards	÷	8,400	=	0.414 lbs.	×	22¢	=9¢, total price of selvage.

\$6.04 cost of warp,	
3.04 " " filling,	
0.91 " " selvage,	9.99÷80=12.487.
\$9.99, total cost.	

Answer.—A. The total cost of materials used in fabric is \$9.99, and

Answer.—B. The value of this stock, per finished yard, is 12.487 cents, practically $12\frac{1}{2}$ cents.

Worsted Suiting.

3,968 ends 2/32's worsted. Length of warp dressed, 45 yards. Reed, 16×4.

Arrangement of dressing.—4 ends black,
4 ends brown,
4 ends black,
4 ends indigo blue.

16 ends in repeat.

Price of yarn in the white, (scoured) \$1.05 per lb.

Allowance for waste during spooling, dressing and weaving, 5 per cent.

Selvage.—30 double ends of 2/30's white worsted for each side, 4 double ends per dent. Price, per lb., 75 cents.

Filling.—66 picks, 2/32's worsted. Same arrangement of colors as in warp. Price of yarn in the white, (scoured) 95 cents.

Allowance for waste during spooling and weaving, 6 per cent.

Length of fabric from loom, 40 yards. Length of fabric finished, $39\frac{1}{4}$ yards.

Cost of coloring yarn, black, 6 cents per lb.; brown, 6 cents per lb.; indigo blue, 15 cents per lb. (Weight of yarn before coloring to equal its weight when colored.)

Cost of weaving, 16 cents per yard, from loom. Cost of finishing, 12 cents per yard, finished.

General mill expenses, 10 cents per yard, finished cloth.

Warp.—

(Ends)		{Yards dressed.}		{Total yards.}		(16×560)		(Lbs.)		{Price per lb.}		(Cost.)
3,968	×	45	=	178,560	÷	8,960	=	19.928	×	\$1.05	=	\$20.9244
19.928 ÷ 4	=	4.982	×	1	=	4.982 lbs.	@	15¢ (indigo blue)			=	.7473
		4.982	×	3	=	14.946	"	" 6¢ (black and brown)			=	.8967
												\$22.5684
								5 per cent. allowance for waste,				1.1284
								Total cost of warp yarn,				\$23.6968

Selvage.—60 double ends 2/30's worsted = 20 single ends 2/30's.

120×45=5,400÷8,400=$\frac{54}{84}$=$\frac{9}{14}$ lb. @ 75¢=48.214¢
5 per cent. allowance for waste, 2.410

Cost of selvage, \$0.562

Filling.—Reed, 16×4=64 warp threads per inch.

(Ends in full warp.)	÷	(Ends per inch.)	
3,968	÷	64	=62 inches, width of cloth in reed.
			$\frac{15}{16}$ " width of selvage (60÷4=15 dents, reed 16=$\frac{15}{16}$ inch).
			$62\frac{15}{16}$ inches, total width of fabric (including selvage) in reed.

{ Width in reed. } { Picks per inch. } { Yards of filling wanted per yard of cloth woven. } { Yards from loom. }

$62\frac{15}{16} \times 66 = 4{,}153\frac{7}{8} \times 40$ =166,155 yards of filling wanted in cloth.
+ 9,969 yards, 6 per cent. allowance for [waste.

176,124 yards, total amount of filling wanted.

(Total length.) (15×560) (Total weight.)

176,124 ÷ 8,960 = 19.6567 lbs. @ 95¢ =\$18.6739, cost of filling yarn.
19.6567÷4=4.9141×1= 4.9141 lbs. @ 15 = 0.7371, " " indigo blue color.
4.9141×3=14.7426 lbs. @ 6 = 0.8845, " " black and brown colors.

\$20.2955, total cost of filling yarn.

40 ×16¢=\$6.40, cost of weaving.
$39\frac{1}{4}$×12 =\$4.71, " " finishing.
$39\frac{1}{4}$×10 =\$3.93, general mill expenses (office insurance, watchmen, mechanics, per cent. on capital, etc.)

\$23.70 cost of warp.
0.51 " " selvage.
20.30 " " filling.
6.40 " " weaving.
4.71 " " finishing.
3.93 general mill expenses.

\$59.55

\$59.55÷$39\frac{1}{4}$=\$1.517.

Answer.—A. \$59.55, total cost of the fabric.

Answer.—B. \$1.52, cost of fabric per finished yard.

Beaver Overcoating. (*Piece-dyed.*)

4,800 ends in warp. Reed, 10×6. 42 yards long, dressed.

Arrangement of dressing.—2 ends face, $5\frac{1}{2}$-run. Price of yarn per lb., \$1.25.
1 end back, 5-run " " " " " .84.

3 ends in repeat.

Filling.—2 picks face, $5\frac{1}{2}$-run. Price of yarn per lb., \$1.18.
1 pick back, $1\frac{3}{4}$-run. " " " " " .40.

3 picks in repeat.

80 picks per inch.

16 cents for weaving.
4 " general weave room expenses.

20 cents per yard from loom for weaving.

Selvage.—40 ends of 2-run listing yarn (each side). Price, 50 cents per lb. 3 ends per dent (outside dent 4).

Take-up of warp during weaving, 11 per cent. Take-up of cloth during finishing (fulling), 10 per cent. Flocks used during fulling process, 20 lbs. at 8 cents per lb. Cost of finishing and dyeing, 25 cents per yard, finished. General mill expenses, 10 cents per yard, finished.

Warp.—4,800÷3=1,600.

(Yards wanted.)

1,600×2=3,200 ends $5\frac{1}{2}$-run×42= 134,400 ÷8,800=$15\frac{3}{11}$ lbs. @ \$1.25=\$19.09.
1,600×1=1,600 ends 5-run ×42= 67,200 ÷8,000= $8\frac{2}{5}$ lbs. @ .84= 7.06.

Cost of warp, \$26.15.

(Yards wanted.)

Selvage.—80 ends 2-run × 42= 3,360 ÷ 3,200=1.05 lbs. @ 50¢=52½¢ (53¢), cost of selvage.

Filling.—Reed, 10 × 6=60 ends per inch and

4,800 ÷ 60=80 inches, width of cloth in reed.

2.6 " " " selvage (80 ÷ 3=26 dents=2.6 inches).

82.6 inches, total width.

82.6 × 80=6,608 yards (total amount of filling per yard woven).

6,608 ÷ 3=2,202⅔ and 2,202⅔ × 2=4,405⅓ yards face filling.

2,202⅔ × 1=2,202⅔ " backing.

11 per cent. take-up of warp during weaving.

100 : 89 :: 42 : x=89 × 42=3,738 ÷ 100=37.38 yards, woven length.

Hence: 4,405⅓ × 37.38=164,671.35 yards 5½-run=18.712 lbs. @ $1.18=$22.10

2,202⅔ × 37.38= 82,335.67 " 1¾ " =29.456 " @ .40= 11.78

Cost of filling, $33.88

37.38 × 20¢=$7.47, cost of weaving.

10 per cent. shrinkage of cloth during finishing. Hence:

100 : 90 :: 37.38 : x=(90 × 37.38=)3,360.20 ÷ 100=33.64 yards, finished length.

$26.15	cost of warp.	
.53	" " selvage.	
33.88	" " filling.	
7.47	" " weaving.	
8.41	" " finishing.	
3.37	" " general expenses.	
1.60	" " flocks.	
$81.41		

33.64 × 25¢=$8.41 cost of finishing.

33.64 × 10 = 3.37 general mill expenses.

20 × 8 = 1.60 cost of flocks.

81.41 ÷ 33.64=2.42.

Answer.—A. $81.41, total cost of the fabric.

Answer.—B. $ 2.42, cost of fabric per yard, finished.

Ingrain Carpet. (*Extra fine;* Cotton Chain, Worsted Filling)

832 ends in warp, 2/14's cotton, 5 per cent. take-up by weaving and shrinkage in finishing, etc. Finished length of fabric, 60 yards.

Cost of yarn,	17 ¢	per lb.
Cost of color,	5	" " (average price).
Winding and beaming,	2½	" "
	24½¢,	price of warp yarn per lb. on beam.

Selvage.—Four ends of 4/10's cotton on each side. Price, 20 cents per lb. (same amount of take-up as warp).

Filling.—10 pair, (in finished fabric) 36 inches, width of fabric in loom.

Yarn used: One-half the amount 5/8's single, light colors (50 yards per oz. in the grease). Price, 16½ cents per lb. in the grease, or 26½ cents per lb. scoured and colored. One-half the amount 5/8's single, dark colors (48 yards per oz. in the grease). Price, 12 cents per lb. in the grease, or 20 cents per lb. scoured and colored.

Loss (average) of weight for filling in scouring and dyeing, 15 per cent. Waste of filling (average) in winding and weaving, 15 per cent.

Length of the yarn to remain uniform from the grease to colored. Weaving and weave-room expenses, 10 cents per yard finished fabric. General mill expenses, 5 cents per yard finished fabric.

Warp.—832 ends 2/14's cotton, 5 per cent. take-up, 60 yards finished length, $24\frac{1}{2}$ cents per lb.

$100:95::x:832=83,200\div95=875\frac{15}{19}\times60=52,547.37$ yards, total amount of yarn wanted.

2/14's=5,880 yards per lb. Hence: $52,547.37\div5,880=8.9536$ lbs., total weight of yarn wanted.

8.9536 lbs. @ $24\frac{1}{2}$¢=$2.1936 (=$2.20) cost of warp-yarn.

Selvage.—$4\times2=8\times60=480$.

$100:95:x::480=48,000\div95=505.26$ yards, total length of selvage yarn wanted.

4/10's=2,100 yards per lb. Hence: $505.26\div2,100=0.24$ lbs., total weight.

0.24 lbs. @ 20¢=$4.\frac{8}{10}$¢ (=5¢) cost of selvage.

Filling.—20 picks per inch in finished fabric. 36 inches, width of fabric.

$36\times60=2,160\times20=43,200$ yards, total amount wanted in fabric.

= { 21,600 yards light colored yarn, at 50 yards per oz. in the grease.
21,600 yards dark colored yarn, at 48 yards per oz. in the grease. }

$50\times16=800$ yards per lb. for light colors. $48\times16=768$ yards per lb. for dark colors.

$21,600\div800=27$ lbs., weight in the grease.

$$100:85::27:x=\frac{85\times27}{100}=22.95 \text{ lbs., weight of yarn scoured and colored.}$$

22.95 lbs.@$26\frac{1}{2}$¢=$6.082, cost of light colored filling used in fabric.

$21,600\div768=28.12$ lbs., weight in the grease.

$$100:85::28.12:x=\frac{85\times28.12}{100}=23.90 \text{ lbs., weight of yarn scoured and colored.}$$

23.9 lbs. @ 20¢=$4.78, cost of dark colored filling used in fabric.

$ 6.082 light colored.
4.780 dark "

$10.862, total value of filling used in fabric, subjected to 15 per cent. waste of material in winding and weaving. Hence:

$$100:85::x:10.86=\frac{10.86\times100}{85}=12.776, \text{cost of filling, including of waste made in winding and weaving.}$$

Cost of warp,	$ 2.194		
Cost of selvage,	0.048		
Cost of filling,	12.776		$24.01\div60=0.40$
Weaving and weaveroom expenses,	6.000	(60 yards × 10 cents)	
General mill expenses,	3.000	(60 yards × 5 cents)	
	$24.018		

Answer.—A. $24.02, total cost of the fabric.

Answer.—B. 40 cents, cost of fabric per yard finished.

Ingrain Carpet. (*Extra Super;* Worsted Chain.)

1,072 ends in warp, 2/14's worsted, 5 per cent. take up by weaving and shrinkage in finishing, etc. Price of yarn, including coloring (average) and winding and beaming, $52\frac{1}{2}$ cents per lb.

Selvage.—Four ends of 4/10's cotton on each side.

Price, 20 cents per lb. (same amount of take up as warp).

Filling.—13 pair (in finished fabric) 36 inches, width of fabric in loom.

Arrangement.—1 pick double reel yarn (60 yards per oz. in the grease.) Price, 22 cents per lb. in the grease, or 33 cents per lb. scoured and dyed.

1 pick, 5/8's single, light color (50 yards per oz. in the grease). Price $16\frac{1}{2}$ cents per lb. in the grease, or $26\frac{1}{2}$ cents per lb. scoured and dyed.

1 pick, double reel (as before).

1 pick 5/8's, single dark color (48 yards per oz. in the grease). Price, 12 cents per lb. in the grease, or 20 cents per lb. scoured and dyed.

Loss of weight (average) for filling in scouring and dyeing, $12\frac{1}{2}$ per cent. Waste (average) of filling in, winding and weaving, $12\frac{1}{2}$ per cent. No shrinkage for yarn during scouring and coloring. Weaving and weaveroom expenses, 12 cents per finished yard. General mill expenses, 6 cents per finished yard.

Warp.—1,072 ends, 2/14's worsted, 5 per cent. shrinkage. Price, $52\frac{1}{2}$ cents per lb.

100:95 :: x : 1,072=107,200÷95=1,128.421×60=67,705.26 yards, total amount of warp yarn wanted.

2/14's=3,920 yards per lb. Hence: 67,705.26÷3,920=17.27 lbs., total weight.

17.27 lbs.@$52\frac{1}{2}$¢=$9.066, value of warp yarn.

Selvage.—(The same as in previously given Example) 5 cents.

Filling.—26 picks, 36 inches, 60 yards. Hence:

26×36×60=56,160 yards, total amount of filling wanted in fabric.

56,160÷4=14,040. Hence:

14,040×2=28,080 yards of double reel yarn@33¢ per lb.

14,040×1=14,040 " " 5/8's single light color@$26\frac{1}{2}$¢ per lb.

14,040×1=14,040 " " 5/8's single dark color@20 per lb.

60×16=960 yards per lb. and 28,080÷960=$29\frac{1}{4}$ lbs. @ 33 ¢=$9.652, value of double reel.

50×16=800 yards per lb. and 14.040÷800=17.55 lbs. @ $26\frac{1}{2}$ =$4.65, value of 5/8's light color.

48×16=768 yards per lb. and 14,040÷768=18.28 lbs. @ 20 =$3.656, value of 5/8's dark color.

$9.652 value of double reel.
4.650 " 5/8's light color.
3.656 " 5/8's dark color.

$17.958, total value of filling used in carpet (subject to $12\frac{1}{2}$ per cent. waste in winding and weaving).

100:87.5 :: x : 17.958=1,795.8÷87.5=$20.523, cost of all the filling in fabric and waste.

Memo.—The same answer as to the cost of filling, may be obtained by calculating the $12\frac{1}{2}$ per cent. loss of material during winding and weaving to the amount of filling wanted in the fabric, as follows:

56,160 yards total amount of filling wanted. Thus:

100:87.5 :: x : 56,160=5,616,000÷87.5=64,182.856÷4=16,045.714.

16,045.714×2=32,091.428÷960=33.428×33 =$11.031
16,045.714÷800=20.057×26.5= 5.315
16,045.714÷768=20.891×20 = 4.178

$20.523, being the same answer as before.

Cost of warp,	$ 9.066	40.437÷60=0.67.
Cost of selvage,	0.048	
Cost of filling,	20.523	
Weaving and weaveroom expenses,	7.200 (60 yards @ 12¢.)	
General mill expenses,	3.600 (60 yards @ 6¢.)	
	$40.437	

Answer.—A. $40.44, total cost of fabric.

Answer.—B. 67¢, cost of fabric per yard, finished.

STRUCTURE OF TEXTILE FABRICS.

To produce a perfect fabric the following points must be taken into consideration: The purpose of wear that the fabric will be subject to, the nature of the raw material to be used in its construction, the size or counts of the yarns and their amount of twist, the texture (number of ends of warp and filling per inch) to be used, the weave and "take up" of the cloth during weaving, the process of finishing and the shrinkage of the cloth during this operation.

THE PURPOSE OF WEAR THAT THE FABRIC WILL BE SUBJECT TO.

This point must be taken into consideration when calculating for the construction of a fabric for the following reasons: The more wear a fabric is subject to, the closer in construction the same must be; also the stronger the fibres of the raw material as well as the amount of twist of the yarn. For this reason upholstery fabrics, such as lounge covers, must be made with a closer texture and of a stronger yarn than curtains. Woolen fabrics, for men's wear, are in an average more subject to wear than dress goods made out of the same material; hence the former require a stronger structure. Again, let us consider woolen cloth for men's wear by itself, such as trouserings or chinchilla overcoatings. No doubt the student will readily understand that such of the cloth as is made for trouserings must be made of a stronger construction, to resist the greater amount of wear, compared to such cloth as made for the use of overcoatings which actually are subject to little wear, and for which only care must be taken to produce a cloth permitting air to enter and remain in its pores, assisting in this manner in producing a cloth with the greatest chances for retaining the heat to the human body.

THE NATURE OF RAW MATERIALS.

The selection of the proper quality of the material to use in the construction of a fabric is a point which can only be mastered by practical experience. No doubt a thorough study of the nature of raw materials, as well as the different processes they undergo before the thread as used by the weaver, (either for warp or filling) is produced, will greatly assist the novice to master this subject. For this reason the different raw materials, as used in the construction of textile fabrics and the different processes necessary for converting the same into yarn, have been previously explained.

As known to the student every woven fabric is constructed by raising or lowering one system of threads (technically known as warp) over threads from another system (technically known as filling). This will readily illustrate that the warp threads of any woven cloth are subjected to more or less chafing against each other during the process of weaving.

There will be more chafing the higher the warp texture, and the rougher the surface of the yarn. In some instances the manufacturer tries to reduce this roughness by means of sizing or starching the yarn during the process preceding weaving and known as "dressing;" but sizing will correspondingly stiffen the warp yarns, and reduce their chances for bending easily around the filling, and the warp will take up the filling harder than if the yarn was not sized. If, by means of sizing, the chafing is not dispensed with, we must reduce the warp texture to the proper point where perfect weaving is possible. No doubt the using of proper warp texture is so greatly neglected, that many a poor weaver's family is suffering by its cause.

To illustrate the roughness of the different yarns as used in the manufacture of textile fabrics the five illustrations, Figs. 1 to 5 are given: Fig. 1 represents a woolen thread; Fig. 2 represents worsted yarn; Fig. 3 represents mohair; Fig. 4 represents cotton yarn; Fig. 5 represents silk yarn.

An examination of these five illustrations shows the silk yarn to be the smoothest, followed in rotation, getting gradually rougher by cotton, mohair and worsted, until reaching the woolen thread which represents the roughest surface. These illustrations will also show that (in an average) a woolen fabric requires a lower texture than a worsted cloth, or a cotton cloth, and a silk fabric a higher texture

Fig. 1 | Fig. 2 | Fig. 3 | Fig. 4 | Fig. 5

compared to fabrics made out of other materials. In addition to the roughness of the surface of a thread, we must also take into consideration the pliability of the fibres, for the softer the pile of the yarn the less the chafing will influence the strength of the yarn, whereas a coarse and stiff fibre will produce the reverse result.

COUNTS OF YARN REQUIRED TO PRODUCE A PERFECT STRUCTURE OF CLOTH.

In speaking of the size or counts of a thread we mean the weight of solidity, or the bulkiness of a thread, or in other words the diameter of the same. These diameters in threads do not vary in the direct ratio to the respective counts, but do vary as to the square roots of their counts. Thus, if we find the diameter of a thread it will be easy for us to ascertain how many of those threads can rest side by side in one inch.

Rule for finding the number of ends which in Cotton, Woolen, Worsted, Linen and Silk Yarns can lie side by side in one inch.

Find number of yards per pound for the yarn in question and extract the square root of this number. From this square root deduct four per cent. for raw-silk yarns, seven per cent. for cotton, spun silk and linen yarns, ten per cent. for worsted yarns, and sixteen per cent. for woolen yarns. The answer in each case indicates the number of threads that will lie side by side in one inch (without being interlaced at right angles by another system).

Example.—Find number of threads of 1's cotton yarn which will lie side by side in one inch.

840 yards per lb. Thus: $\sqrt{840}=28.9$

$$\begin{array}{r} 28.9 \\ -\ 2.0 \\ \hline 26.9 \end{array} \quad \text{(7 per cent.)}$$

Answer.—$26\frac{9}{10}$ threads (practically 27) of single 1's cotton yarn will rest side by side in one inch.

Example.—Find number of threads of 2's cotton yarn which will lie side by side in one inch.

$840\times2=1680$ yards per lb. Thus: $\sqrt{1,680}=40.9$

$$\begin{array}{r} 40.9 \\ -\ 2.8 \\ \hline 38.1 \end{array} \quad \text{(7 per cent.)}$$

Answer.—$38\frac{1}{10}$ threads (practically 38) of single 2's cotton yarn will rest side by side in one inch.

Example.—Find number of ends of 2/50's cotton yarn which will lie side by side in one inch.

2/50's cotton=1/25's=840×25=21,000 yards per lb. Thus: $\sqrt{21,000}=144.9$

$$\begin{array}{r l} 144.9 & \\ -\ 10.1 & \text{(7 per cent.)} \\ \hline 134.8 & \end{array}$$

Answer.—$134\frac{4}{5}$ threads (practically 135) of 2/50's cotton yarn will rest side by side in one inch.

Example.—Find nnmber of threads of 6-run woolen yarn which will lie side by side in one inch.

6-run=9,600 yards per lb. Thus: $\sqrt{9,600}=97.97$

$$\begin{array}{r l} 97.97 & \\ -\ 15.67 & \text{(16 per cent.)} \\ \hline 82.30 & \end{array}$$

Answer.—$82\frac{3}{10}$ threads (practically 82) of 6-run woolen yarn will rest side by side in one inch.

Example.—Find number of threads of 22-cut woolen yarn which will lie side by side in one inch.

22-cut=6,600 yards per lb. Thus: $\sqrt{6,600}=81.24$

$$\begin{array}{r l} 81.24 & \\ -\ 12.99 & \text{(16 per cent.)} \\ \hline 68.25 & \end{array}$$

Answer.—$68\frac{1}{4}$ threads (practically 68) of 22-cut woolen yarn will lie side by side in one inch.

Example.—Find number of ends of 2/32's worsted that will lie side by side in one inch.

2/32's=single 16's=560×16=8,960 yards per lb. Thus: $\sqrt{8,960}=94.6$

$$\begin{array}{r l} 94.6 & \\ -\ 9.4 & \text{(10 per cent.)} \\ \hline 85.2 & \end{array}$$

Answer.—$85\frac{2}{10}$ threads (practically 85) will lie side by side in one inch.

Example.—Find number of threads of 40/3-ply spun silk which will lie side by side in one inch.

40/3-ply=33,600 yards per lb. Thus: $\sqrt{33,600}=183.3$

$$\begin{array}{r l} 183.3 & \\ -\ 12.8 & \text{(7 per cent.)} \\ \hline 170.5 & \end{array}$$

Answer.—$170\frac{1}{2}$ threads (practically 170) of 40/3-ply spun silk will rest side by side in one inch.

Example.—Find number of threads of 4-dram raw silk which lie side by side in one inch.

4-dram raw silk=64,000 yards per lb. Thus: $\sqrt{64,000}=252.9$

$$\begin{array}{r l} 252.9 & \\ -\ 10.1 & \text{(4 per cent.)} \\ \hline 242.8 & \end{array}$$

Answer.—$242\frac{4}{5}$ threads (practically 243) of 4-dram silk will rest side by side in one inch.

To illustrate clearly to the student that the diameter of a thread (*i. e.*, respectively the number of threads which will lie side by side in one inch) does not vary in the direct ratio to its counts, but in the ratio of the square root of its counts, we give three examples, using for the first example a single yarn; for the next the same number in 2-ply; and for the third the same number in 3-ply.

Examples.—Find number of threads that will lie side by side for the following yarns: Single 30's cotton, 2/30's cotton, and 3/30's cotton yarn.

30's cotton=25,200 yards per lb.

Thus: $\sqrt{25,200}=158.7$

$$\begin{array}{r l} 158.7 & \\ -\ 11.1 & \text{(7 per cent.)} \\ \hline \end{array}$$

147.6 threads (practically 148) of 30's cotton yarn will lie side by side in one inch.

2/30's cotton=12,600 yards per lb.

Thus: $\sqrt{12,600}=112.2$ 112.2
— 7.9 (7 per cent.)

104.3 threads (practically 104) of 2/30's cotton yarn will lie side by side in one inch.

3/30's cotton=8,400 yards per lb.

Thus: $\sqrt{8,400}=91.6$ 1.6
— 6.4 (7 per cent.)

85.2 threads (practically 85) of 3/30's cotton yarn will lie side by side in one inch.

Answer.—Single 30's cotton=148 threads per inch.
2/30's " =104 " " "
3/30's " = 85 " " "

Table Showing the Number of Ends of Cotton Yarn from Single 5's to 2/160's that Will Lie Side by Side in One Inch.

Counts. Single.	Counts. Double.	Yards per Pound.	Square Root.	7 Per Cent.	Diameter, or Ends per inch.	Counts. Single.	Counts. Double.	Yards per Pound.	Square Root.	Per Cent.	Diameter, or Ends per inch.
5	2/10	4,200	64.8	4.5	60.3	22	2/44	18,480	135.9	9.5	126.4
6	2/12	5,040	70.9	5.0	65.9	24	2/48	20,160	141.8	9.9	131.9
7	2/14	5,880	76.6	5.4	71.2	26	2/52	21,840	147.7	10.3	137.4
8	2/16	6,720	81.9	5.7	76.2	28	2/56	23,520	153.3	10.7	142.6
10	2/20	8,400	91.6	6.4	85.2	30	2/60	25,200	158.7	11.1	147.6
11	2/22	9,240	96.1	6.7	89.4	32	2/64	26,880	163.8	11.5	152.3
12	2/24	10,080	100.3	7.0	93.3	34	2/68	28,560	168.9	11.8	157.1
13	2/26	10,920	104.4	7.3	97.1	36	2/72	30,240	173.8	12.2	161.6
14	2/28	11,760	108.4	7.6	100.8	38	2/76	31,920	178.6	12.5	166.1
15	2/30	12,600	112.2	7.9	104.3	40	2/80	33,600	183.3	12.8	170.5
16	2/32	13,440	115.9	8.1	107.8	45	2/90	37,800	194.4	13.6	180.8
17	2/34	14,280	119.4	8.3	111.1	50	2/100	42,000	204.9	14.3	190.6
18	2/36	15,120	122.9	8.6	114.3	60	2/120	50,400	224.4	15.7	208.7
19	2/38	15,960	126.3	8.8	117.5	70	2/140	58,800	242.4	17.0	225.4
20	2/40	16,800	129.6	9.0	120.6	80	2/160	67,200	259.2	18.1	241.1

For Spun Silks use also above table, but only refer to single count column for reference for any number of ply of spun silk.

Table Showing the Number of Ends of Woolen Yarn "Run Basis," from 1-run to 10-run, that Will Lie Side by Side in One Inch.

Run.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.	Run.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.
1	1,600	40.0	6.4	33.6	4¾	7,600	87.2	14.0	73.3
1¼	2,000	44.7	7.2	37.5	5	8,000	89.4	14.3	75.1
1½	2,400	49.7	8.0	41.7	5¼	8,400	91.6	14.7	76.9
1¾	2,800	52.8	8.4	44.4	5½	8,800	93.8	15.0	78.8
2	3,200	56.5	9.0	47.5	5¾	9,200	95.8	15.3	80.5
2¼	3,600	60.0	9.6	50.4	6	9,600	97.9	15.6	82.3
2½	4,000	63.2	10.1	53.1	6¼	10,000	100.0	16.0	84.0
2¾	4,400	66.3	10.6	55.7	6½	10,400	101.9	16.3	85.6
3	4,800	69.2	11.0	58.2	6¾	10,800	103.9	16.6	87.3
3¼	5,200	72.1	11.5	60.6	7	11,200	105.8	16.9	88.9
3½	5,600	74.8	11.9	62.9	7½	12,000	109.5	17.5	92.0
3¾	6,000	77.4	12.3	65.1	8	12,800	113.1	18.1	95.0
4	6,400	80.0	12.8	67.2	8½	13,600	116.6	18.6	98.0
4¼	6,800	82.4	13.1	69.3	9.0	14,400	120.0	19.2	100.8
4½	7,200	84.8	13.5	71.3	10	16,000	126.4	20.2	106.2

Table Showing the Number of Ends of Woolen Yarn "Cut Basis," from 6-cut to 50-cut that Will Lie Side by Side in One Inch.

Cut.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.	Cut.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.
6	1,800	42.4	6.8	35.6	22	6,600	81.2	13.0	68.2
8	2,400	49.7	8.0	41.7	23	6,900	83.0	13.3	69.7
9	2,700	51.9	8.3	43.6	24	7,200	84.8	13.5	71.3
10	3,000	54.7	8.8	45.9	25	7,500	86.6	13.8	72.8
11	3,300	57.4	9.2	48.2	26	7,800	88.3	14.1	74.2
12	3,600	60.0	9.6	50.4	27	8,100	90.0	14.4	75.6
13	3,900	62.4	10.0	52.4	28	8,400	91.6	14.7	77.0
14	4,200	64.8	10.4	54.4	29	8,700	93.2	14.9	78.3
15	4,500	67.0	10.7	56.3	30	9,000	94.8	15.2	79.6
16	4,800	69.2	11.0	58.2	32	9,600	97.9	15.7	82.2
17	5,100	71.4	11.4	60.0	34	10,200	100.9	16.1	84.8
18	5,400	73.5	11.8	61.7	36	10,800	103.4	16.5	86.9
19	5,700	75.4	12.0	63.4	40	12,000	109.5	17.5	92.0
20	6,000	77.4	12.3	65.1	45	13,500	116.1	18.6	97.5
21	6,300	79.3	12.7	66.6	50	15,000	122.4	19.6	102.8

Table Showing the Number of Ends of "Worsted Yarn," from Single 5's to 2/160 that Will Lie Side by Side in One Inch.

Counts.		Yards per Pound.	Square Root.	10 Per Cent.	Diameter, or Ends per Inch.	Counts.		Yards per Pound.	Square Root.	10 Per Cent.	Diameter, or Ends per inch.
Single.	Double.					Single.	Double.				
5	2/10	2,800	52.9	5.3	47.6	22	2/44	12,320	110.9	11.1	99.8
6	2/12	3,360	57.9	5.8	52.1	24	2/48	13,440	115.9	11.6	104.3
7	2/14	3,920	62.6	6.3	56.3	26	2/52	14,560	120.6	12.1	108.5
8	2/16	4,480	66.8	6.7	60.1	28	2/56	15,680	125.2	12.5	112.7
10	2/20	5,600	74.8	7.5	67.3	30	2/60	16,800	129.6	13.0	116.6
11	2/22	6,160	78.4	7.8	70.6	32	2/64	17,920	133.8	13.4	120.4
12	2/24	6,720	81.9	8.2	73.7	34	2/68	19,040	137.9	13.8	124.1
13	2/26	7,280	85.3	8.5	76.8	36	2/72	20,160	141.8	14.2	127.6
14	2/28	7,840	88.5	8.8	79.7	38	2/76	21,280	145.8	14.6	131.2
15	2/30	8,400	91.6	9.2	82.4	40	2/80	22,400	149.6	15.0	134.6
16	2/32	8,960	94.6	9.4	85.2	45	2/90	25,200	158.6	15.9	142.7
17	2/34	9,520	97.5	9.7	87.8	50	2/100	28,000	167.3	16.7	150.6
18	2/36	10,080	100.3	10.0	90.3	60	2/120	33,600	183.3	18.3	165.0
19	2/38	10,640	103.1	10.3	92.8	70	2/140	39,200	197.9	19.8	178.1
20	2/40	11,200	105.8	10.6	95.2	80	2/160	44,800	211.6	21.2	190.4

Table Showing the Number of Ends of Raw Silk Yarn, from 20 Drams to 1 Dram, that will Lie Side by Side in One Inch.

Dram.	Yards per Pound	Square Root.	4 per Cent.	Diameter, or Ends per inch.	Dram.	Yards per Pound	Square Root.	11 Per Cent.	Diameter, or Ends per inch.
20	12,800	113.1	4.5	108.6	5	51,200	226.2	9.0	217.2
18	14,222	119.2	4.8	114.4	4¾	53,368	231.0	9.2	221.8
16	16,000	126.4	5.0	121.4	4½	56,889	238.5	9.5	229.0
14	18,286	135.2	5.4	129.8	4¼	60,235	245.4	9.8	235.6
12	21,333	146.0	5.8	140.2	4	64,000	252.9	10.1	242.8
10	25,600	160.0	6.4	153.6	3¾	68,267	261.2	10.4	250.8
9½	26,947	164.1	6.6	157.5	3½	73,143	270.4	10.8	259.6
9	28,444	168.6	6.7	161.9	3¼	78,769	280.6	11.2	269.4
8½	30,118	173.5	6.9	166.6	3	85,333	292.1	11.7	280.4
8	32,000	178.8	7.1	171.7	2¾	93,091	305.1	12.2	292.9
7½	34,133	184.7	7.4	177.3	2½	102,400	320.0	12.8	307.2
7	36,571	191.2	7.6	183.6	2¼	113,777	337.2	13.5	323.7
6½	39,385	198.4	7.9	190.5	2	128,000	357.7	14.3	343.4
6	42,667	206.5	8.2	198.3	1½	170,666	413.1	16.5	396.6
5½	46,545	215.7	8.6	207.1	1	256,600	505.9	20.2	485.7

Table Showing the Number of Ends of Linen Yarns from 10's to 100's that Will Lie Side by Side in One Inch.

Counts.	Yards per Pound.	Square Root.	7 Per Cent.	Diameter, or Ends Per Inch.	Counts.	Yards per Pound.	Square Root.	7 Per Cent.	Diameter, or Ends Per Inch.
10	3,000	54.7	3.8	50.9	40	12,000	109.5	7.6	101.9
12	3,600	60.0	4.0	56.0	42	12,600	112.2	7.8	104.4
14	4,200	64.8	4.5	60.3	44	13,200	114.8	8.0	106.8
16	4,800	69.2	4.8	64.4	46	13,800	117.4	8.2	109.2
18	5,400	73.5	5.1	68.4	48	14,400	120.0	8.4	111.6
20	6,000	77.4	5.4	72.0	50	15,000	122.4	8.6	113.8
22	6,600	81.2	5.7	75.5	55	16,500	128.4	9.0	119.4
24	7,200	84.8	5.9	78.9	60	18,000	134.1	9.3	124.8
26	7,800	88.3	6.1	82.2	65	19,500	139.6	9.8	129.8
28	8,400	91.6	6.4	85.2	70	21,000	144.9	10.0	134.9
30	9,000	94.8	6.6	88.2	75	22,500	150.0	10.5	139.5
32	9,600	97.9	6.8	91.1	80	24,000	154.9	10.8	144.1
34	10,200	100.9	7.0	93.9	85	25,500	159.6	11.2	148.4
36	10,800	103.9	7.2	96.7	90	27,000	164.3	11.5	152.8
38	11,400	106.7	7.4	99.3	100	30,000	173.2	12.1	161.1

TO FIND THE DIAMETER OF A THREAD BY MEANS OF A GIVEN DIAMETER OF ANOTHER COUNT OF YARN.

If the number of threads of a given count which will lie side by side (*i. e.*, its diameter) in one inch (without riding) are known, the required number of threads (which will also lie side by side) for another count of the same system can be found by—

Rule.—The given counts of which we know the diameter are to the counts for which we have to find the diameter in the same ratio as the given diameter squared is to the required diameter squared.

Example.—As shown in a previous example, 148 threads of single 30's cotton yarn will lie side by side in one inch (or the diameter of a thread of 30's cotton yarn is the $\frac{1}{148}$ part of one inch); required to find by rule given the number of threads that will lie side by side in one inch for 2/30's cotton yarn.

2/30's=single 15's.

{ Given counts. } : { Required counts. } :: { Diameter squared of the given counts. } : { Diameter squared of the required counts. }

$$30 : 15 :: 148^2 : x$$

$$\sqrt{\frac{15\times148\times148}{30}} \quad \text{Thus: } 15\times148\times148=328{,}560\div30=10{,}952, \text{ and } \sqrt{10{,}952}=104$$

Answer.—104 threads of 2/30's, or 1/15's cotton yarn, will lie side by side in one inch.

Proof.—2/30 cotton yarn=12,600 yards per lb.

Thus: $\sqrt{12{,}600}=112.2$ 112.2

— 7.9 (7 per cent.)

104.3 (practically 104) being the same answer as previously received.

Example.—85 threads of 2/32's worsted yarn will lie side by side in one inch, required to find the number of threads which will lie side by side in one inch with 2/40's worsted yarn.

2/30's=1/16's 2/40's=1/20's.

$$16:20::85^2:x, \text{ or } \sqrt{\frac{20\times85\times85}{16}} \text{ and } 85\times85\times20=144{,}500\div16=9{,}031 \; \sqrt{9{,}031}=95$$

Answer.—95 threads of 2/40's worsted yarn will lie side by side in one inch.

Proof.—2/40's worsted=560×20=11,200 yards per lb.

Thus: $\sqrt{11,200}=105$ $\quad 105 - 10$ (10 per cent.)

95, being the same answer as received by the previous process.

Example.—84 threads of $6\frac{1}{4}$-run woolen yarn lie side by side in one inch, required to find the number of threads which will lie side by side in 4-run woolen yarn.

$6\frac{1}{4}:4::84^2:x$ or $\sqrt{\frac{4\times84\times84}{6.25}}$ and $84\times84=7,056\times4=28,224\div6\frac{1}{4}=4,515$ and $\sqrt{4,515}=67.2$

Answer.—67 threads (actually 67.2) of 4-run woolen yarn will lie side by side in one inch.

Proof.—4-run=$4\times1,600$=6,400 yards per lb.

Thus: $\sqrt{6,400}=80.0$ $\quad 80.0 - 12.8$

67.2, being the same answer as previously received.

Example.—$68\frac{1}{4}$ threads per inch is the average number of threads which will lie side by side for 22-cut woolen yarn, required to find the number of threads for 30-cut woolen yarn.

$$22:30::68\tfrac{1}{4}^2:x \text{ or } \frac{68\frac{1}{4}\times68\frac{1}{4}\times30}{22} \text{ and}$$

$$68.25\times68.25\times30=139,741.875\div22=6,351.\ \sqrt{6,351}=79$$

Answer.—79 threads of 30-cut woolen yarn will lie side by side in one inch.

Proof.—30-cut woolen yarn=9,000 yards per lb.

Thus: $\sqrt{9,000}=94$ $\quad 94 - 15$ (16 per cent.)

79, being the same answer as received by previously given process.

TO FIND THE COUNTS OF YARN REQUIRED FOR A GIVEN WARP TEXTURE BY MEANS OF A KNOWN WARP TEXTURE WITH THE RESPECTIVE COUNTS OF THE YARN GIVEN.

A. Dealing with One Material.

If we know the number of ends of a given count of yarn that will lie side by side in one inch (technically their diameter), and we want to ascertain the counts of yarn required for a certain number of threads to lie side by side (diameter), we must use—

Rule.—As the given diameter squared is to the required diameter squared, so is the given count to the required count.

Example.—85 threads of 2/32's worsted lie side by side in one inch, required to find the counts of yarn for 95 threads per inch.

$$85^2 : 95^2 :: 16 : x$$
$$(85\times85):(95\times95)::16:x$$
$$7,225 : 9,025 :: 16 : x$$
$$9,025\times16=144,400\div7,225=20$$

Answer.—1/20's or 2/40's worsted yarn is the number of yarn wanted.

Proof.—2/40's or 1/20's worsted yarn=11,200 yards per lb.

Thus: $\sqrt{11,200}=105$ 105
— 10 (10 per cent.)

95 threads of 1/20's worsted will lie side by side; being the same answer as texture given in example.

Example.—84 threads of $6\frac{1}{4}$-run woolen yarn, lie side by side in one inch, required to find the counts of yarn for 68 threads per inch.

$$84^2 : 68^2 :: 6\tfrac{1}{4} : x$$
$$(84\times84):(68\times68) :: 6\tfrac{1}{4} : x$$
$$7,056 : 4,624 :: 6.25 : x$$
$$4,624\times6.25=28,900\div7,056=4.09$$

Answer.—4-run (actual counts 4.1-run) yarn must be used.

Proof.—4.1-run=6,560 yards per lb.

Thus: $\sqrt{6,560}=81$ 81
—13

68 threads of 4-run (4.1) woolen yarn will lie side by side in one inch, being the same number as given in example.

B. Dealing with Two or More Materials.

Frequently it happens that we have to reproduce a cloth from a given sample or texture, etc., in another material. For example, a worsted cloth may be required to be duplicated in woolen yarn. If such is the case, transfer counts of yarn given, or as ascertained from sample given, into its equivalent counts of the required grading, and take care of the difference of 6 per cent. between the diameters of threads that will lie side by side in one inch of a woolen yarn compared to worsted yarn. In a similar manner proceed if dealing with other yarns.

P. S.—The allowance for worsted yarn in all the samples given is based (as also previously mentioned) on 10 per cent.; for cotton yarn and spun silk on 7 per cent.; for raw silk on 4 per cent, and for woolen yarn on 16 per cent. These allowances refer to a perfect and smooth A^1 yarn; but if such should not be the case, we are required to make, according to the yarn, a proportional allowance of one, two, or three per cent. more.

INFLUENCE OF THE (AMOUNT AND DIRECTION) TWIST OF YARNS UPON THE TEXTURE OF A CLOTH.

The influence of the twist of a yarn upon the number of warp threads to use per inch depends upon the amount of the twist, as well as the direction of the latter. It will easily be understood by the student that the more twist we put in a yarn the less space the same will occupy; *i. e.*, the smaller its diameter, and the less chances for a chafing; hence, we can use a "heavier" texture (more ends per inch) with a hard-twisted yarn compared to a soft-twisted yarn. But it must be remembered that the amount of twist to use is again regulated by the character of the fabric the yarn is used for, since the yarn will lose on softness the harder we twist it, and that a hard-twisted yarn will reduce the fulling properties of the cloth during the process of finishing. Again, hard-twisted yarn will not bend as easily around the filling during weaving as a soft yarn, which no doubt might injure the general appearance of the face of the cloth. This will also illustrate another point; *i. e.*, the width of the cloth to use in loom. As previously mentioned, the harder we twist a yarn the less chances there are for fulling; hence, fabrics made with hard-twisted yarn must be set narrower in loom than fabrics made with a softer twisted yarn. Thus we will set a fancy worsted suiting (in an average) only from 60 to 62 inches wide in loom, and a fancy cassimere or fancy woolen suiting (in an average) from 70 to 72 inches wide, and yet the finished width for both will be 54 inches.

To explain the influence of the direction of the twist of the yarn upon the texture of a cloth, Figs. 6 and 7 are given. Fig. 6 illustrates the interlacing with yarns spun with its twist in the same direction; *i. e.*, from left to right (technically known as right hand twist.) Fig. 7 illustrates the interlacing of a similar cloth with right hand twist yarn for the warp, but left hand twist yarn (the direction of the twist being from the right to the left) for the filling. It will readily be seen by the student that if, using in both examples the same counts of yarn for warp and filling, the combination, as shown in Fig. 7, will allow a readier compressing of the filling for forming the cloth, compared to the

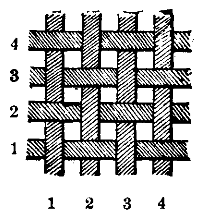


FIG 6

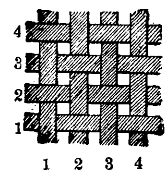


FIG. 7

using of warp and filling, as illustrated in diagram, Fig. 6; *i. e.*, if using the same direction of twist for warp and filling yarn, larger perforations will appear in the cloth than if using opposite twist for both systems, since in the first instance, the twist of both yarns will cross each other, thus resisting compression; whereas, if using opposite twist in the spinning of the two systems of yarns, the twist of both yarns will be in the same direction when interlacing, and thus a falling of the twist in each other be produced.

Rule.—We may use a heavier texture for warp and filling, if using opposite twist in the spinning of the yarns, than if using the same direction of twist for both systems.

The finer in quality and the longer in its staple the material is, as used in the manufacture of a yarn, the less twist is necessary to impart to the thread for giving it the requisite strength; whereas, the shorter and coarser the material the more twist we must use. The actual amount of twist to use depends entirely upon the material and counts of yarn, as well as weave and process of finishing required. For a fabric requiring a smooth, clear face, we must use more twist in the yarn than for such as used in the manufacture of cloth requiring a nap; *i. e.*, much giging, or "velvet finish."

TO FIND THE AMOUNT OF TWIST REQUIRED FOR A YARN, IF THE COUNTS AND TWIST OF A YARN OF THE SAME SYSTEM, (AND FOR THE SAME KIND OF FABRIC) BUT OF DIFFERENT COUNTS ARE KNOWN.

The points as to amount of twist to use for the different counts of yarn manufactured are based between each other upon the fact that the diameters of threads vary in the same ratio as the square roots of their counts.

Example.—Find twist required for a 40's yarn, if a 32's yarn of the same material requires 17 turns per inch (twist wanted in proportion the same).

$$32:40::17^2:x, \text{ or } \sqrt{\frac{40\times17\times17,}{32}} \text{ or } \sqrt{361.25}=19.$$

Answer.—19 turns per inch are required.

$$\text{or, } \sqrt{32}:\sqrt{40}::17:x \qquad \sqrt{32}=5.65 \qquad \sqrt{40}=6.32.$$

$$\text{Hence: } 5.65:6.32::17:x \qquad 6.32\times17=107.44\div5.65=19.$$

Answer.—19 turns per inch are required (being the same answer as previously received.

INFLUENCE OF THE WEAVE UPON THE TEXTURE OF A FABRIC.

In the previous chapter we have given a clear understanding as to the number of threads of any counts of yarn, and of any kind of material, that will properly lie side by side in one inch. We now take this same item into consideration, but in addition, with reference to the different weaves as used in the manufacture of textile fabrics; *i. e.*, give rules for constructing with a given weave and given count of yarn, a cloth which has a proper texture.

Rule.—The less floats of warp and filling (*i. e.*, the greater the number of interlacings between both systems) in a given number of threads of each system, the lower the texture of the cloth (the less number ends and picks per inch) must be; and consequently the less interlacings of warp and filling in a given number of threads of each system, the higher a texture in the cloth we can use. For example, examining the 8-harness twill shown in Fig. 8, we find each thread to interlace twice in one repeat of the weave, thus actually $8+2=10$ threads will lie side by side for each repeat (since by means of the interlacing of the filling with the warp the former takes, at the places of interlacing, the place, with regard to its diameter, of one thread of the latter system). Suppose we used 64 warp threads to one inch, we find the threads that will lie side by side in one inch as follows:

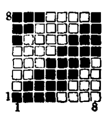


FIG. 8.

Warp threads in one repeat of the weave.	:	Warp and filling threads in one repeat of the weave.	::	Warp threads per inch.	:	Threads lying side by side in one inch.
8	:	10	::	64	:	x

and $\frac{10 \times 64}{8} = 80$

Answer.—8-harness 4—4 twill, 64 warp threads per inch, equals 80 diameters of threads per inch.

Example.—Find the number of diameter of threads per inch, using the same number of warp threads as before (64) per inch, and for weave the plain weave shown in Fig. 9.

The repeat of the latter weave is 2 threads, = 2 interlacings in repeat; thus, with reference to the 64 warp threads per inch used, we find 64 interlacings of the filling.


FIG. 9.

Hence: 2:4 :: 64: x and $\frac{4 \times 64}{2} = 128$

Answer.—Plain weave, 64 warp threads per inch, equals 128 diameters of threads per inch.

No doubt these two examples will readily demonstrate to the designer the value of examining the number of interlacings of any new weave. If, in given examples, the first mentioned "make up" 4—4 8-harness twill, 64 warp threads per inch, using the required material and counts of yarn is producing a perfect fabric, and we want to change to plain weaving, using the same yarn, we must deduct $\frac{3}{8}$ of the number of warp threads (and correspondingly also of the filling) to produce the same number of diameters of threads side by side as in previously given example; *i. e.*, we must only use 40 warp threads per inch, since those 40 diameters of the warp yarn, plus 40 diameters of the filling, by means of the principle of the interlacing of the plain weave, produce the (equal number as before) 80 diameters of threads side by side in one inch. Hence we may put down for—

Rule.—The weave of a cloth has an equal influence on the number of ends per inch to use as the counts of the yarn we are using. We mentioned previously that by the diameters of threads per one inch we mean the number of ends that could lie side by side per inch, providing there were no interlacings of both systems of threads; but since such interlacing or intertwining of the warp and filling must take place in order to produce cloth, we must deduct the number, or average number, of interlacings per inch from the originally obtained diameters of threads that will lie side by side per inch, to obtain the correct number of warp ends and picks we can use per inch. Thus far given explanations will readily assist the student to ascertain the number of threads of any material that will lie side by side (without riding) in one inch of the fabric (single cloth). Hence:

TO FIND THE TEXTURE OF A CLOTH USE—

Rule.—Multiply the number of threads of a given count of yarn that will lie side by side in one inch by the threads in one repeat of the pattern, and divide the product by the number of threads in repeat, plus the corresponding number of interlacings of both systems of threads found in one repeat of the weave.

By the number of interlacings of a weave we understand the number of changes from riser to sinkers, and *vice versa*, for each individual thread in each system.

Examples.—Fig. 10 represents one pick of the common twill known as $\frac{2}{2}\frac{1}{2}\frac{1}{2}$ and shown in one full repeat in Fig. 11. Diagram Fig. 12 illustrates the corresponding section to pick 1 shown in Fig. 10. The full black spots represent one repeat, whereas the commencement of the second repeat is shown in dotted lines. A careful examination of both diagrams, Figs. 10 and 12, will readily illustrate to the student the number of interlacings in one repeat (6), as indicated by corresponding numbers below diagram Fig. 12. Thus, in order to find the number of warp threads of a given count per inch for a cloth made with this weave, we must multiply the number of diameters of threads that will lie side by side with 10 (being one complete repeat of the weave) and divide the product thus derived by 16 (10 plus 6, or repeat plus number of interlacings). The result will be the required number of warp threads per inch. If given illustrations would refer to a 32-cut woolen yarn, we find answer as follows:

FIG. 10.

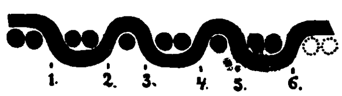


FIG. 12.

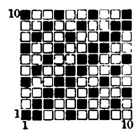


FIG. 11.

32-cut yarn=9,600 yards per lb.

32-cut yarn=82.2 threads will lie side by side.

Thus: $82.2 \times 10 = 822 \div 16 = 51\frac{1}{2}$, or

51 warp threads per inch (or actually $51\frac{1}{2}$ per inch, or 103 threads for every two inches) of 32-cut woolen yarn will be the proper number to use. In diagram Fig. 13 we illustrate a pick of another 10-harness twill weave. Fig. 14 represents the corresponding section, and Fig. 15 one complete repeat of the weave.

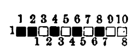


FIG. 13

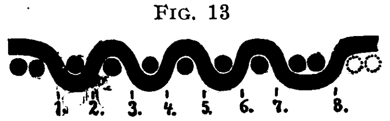


FIG. 14.

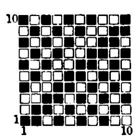


FIG. 15.

All three diagrams show 8 points of interlacings for each thread in one repeat; hence, if applying counts of yarn from previously given example for this case we find:

32-cut yarn=82.2 threads will lie side by side. Thus: $82.2 \times 10 = 822 \div 18 = 45\frac{2}{3}$, or 46 warp threads per inch (actually $45\frac{2}{3}$) of 32-cut woolen yarn are the proper number of threads if using the $\frac{2}{1}\frac{1}{1}\frac{1}{1}\frac{1}{2}$ 10-harness twill.

Answers.—For both given examples are as follows:

Warp yarn used 32-cut woolen yarn.

$\frac{2}{2}\frac{1}{2}\frac{1}{2}$ 10-harness twill=6 interlacings=$51\frac{1}{2}$ warp threads per inch.

$\frac{2}{1}\frac{1}{1}\frac{1}{1}\frac{1}{2}$ 10- " " =8 " =$45\frac{2}{3}$ " " "

A careful examination and recalculation of these two examples will readily illustrate to any student the entire modus operandi.

Example.—Find number of threads for warp for a fancy worsted suiting, to be interlaced with the 6-harness $\frac{3}{3}$ twill (see Fig. 16) and made of 2/32's worsted yarn. (Fig. 17 illustrates number 1 pick separated and Fig. 18 its corresponding section.)

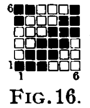


FIG. 16.

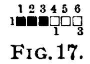


FIG. 17.

FIG. 18.

2/32=1/16=16×560=8,960 yards per lb.

$\sqrt{8,960}$ less 10 per cent.=85 threads of 2/32's worsted yarn will lie side by side in one inch. And

$$\left\{\begin{matrix}\text{Diameters}\\ \text{per inch.}\end{matrix}\right\} \times \left\{\begin{matrix}\text{Repeat of}\\ \text{weave.}\end{matrix}\right\} \qquad \left\{\begin{matrix}\text{Repeat of}\\ \text{weave}\end{matrix}\right\} + \left\{\begin{matrix}\text{Interlacings}\\ \text{in repeat.}\end{matrix}\right\}$$

$$85 \times 6 = 510 \div 8 \quad (6 + 2) = 64.$$

Answer.—64 ends per inch is the proper warp texture for fabric given in example.

Example.—Find proper number of threads to use for a woolen dress good, to be interlaced with the 9-harness $\frac{2}{1}\frac{1}{1}\frac{1}{1}\frac{1}{1}$ twill (see Fig. 19), and for which we have to use $6\frac{1}{4}$-run woolen yarn.

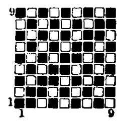


Fig. 19.

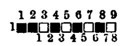


Fig. 20.

Fig. 21.

(Fig. 20 represents pick 1 separated, and Fig. 21 its corresponding section.)

$$6\text{-run}=10,000 \text{ yards per lb.}$$

$\sqrt{10,000}$, less 16 per cent.=84 threads of $6\frac{1}{4}$-run woolen yarn, will lie side by side in one inch.

$$84\times 9=756\div 17(9+8)=44\tfrac{8}{17}$$

Answer.—44 threads per inch (actually $44\frac{8}{17}$) is the proper warp texture for cloth given in example.

Example.—Find the proper number of warp threads to use for a cotton dress good, using the plain weave (see Fig. 22), with single 40's cotton yarn for warp.

Fig. 22.

$$40\text{'s cotton}=40\times 840=33,600 \text{ yards per lb.}$$

$\sqrt{33,600}=183-13$ (7 per cent.)=170 threads of 40's cotton yarn will lie side by side in one inch.

$$\frac{170\times 2}{2+2}=170\div 2=85$$

Answer.—85 threads of 40's cotton yarn, and interlaced with the plain, will produce a perfect texture.

It will be proper to mention here another point which must also be more or less taken into consideration. During the process of weaving both systems of threads press more or less against each other, thus each thread is pushed to a certain degree out of position, consequently we may add to each system a slight advance, according to counts, texture and quality of material in question, without influencing the process of weaving or the handling of the fabric; but in all cases such an advance in threads (and picks) will be very small and is readily ascertained after finding, by rules given, number of ends and picks per inch, that could be used if no pressure from one system upon the other was exercised.

If using a soft-twisted yarn for filling, the latter will have less influence for pressing the warp threads (harder-twisted yarn) out of position; *i. e.*, the filling will stretch and thus in proportion reduce the counts of the yarn, consequently a higher texture for such filling may be used. We may thus also mention this fact in the shape of a—

Rule.—The softer the filling yarn is twisted, the more readily the same will interweave and the higher a warp texture we can use. Warp yarns are in most all cases harder twisted than the filling yarn as used in the same fabric, for the simple reason that the warp threads are subject to more strain and wear during the process of weaving compared to the filling. The softer a yarn is twisted, the softer the finished cloth will handle; and, if we refer, regarding this soft twist specially to the filling, the easier the same can be introduced in the warp during the process of weaving. This will explain the general method of using a few more picks per inch compared to the warp threads as used per inch in reed. But as everything has a limit we also must be careful not to use too many of these additional picks, for if "piling-in" even a soft filling too hard in a cloth during weaving, it will ultimately result in an imperfect fabric when finished. Frequently we would thus produce fabrics which require too much fulling, or which with all the fulling possible, could not be brought to its required finished width. The same trouble will also refer to the setting of a fabric too wide in reed, for the sake of producing heavier weight of cloth. Again, if setting a cloth too loose, either in warp or filling, or both systems, it will produce a finished fabric handling too soft, flimsy or spongy; consequently great care must be exercised in the "setting of cloth" in order to produce good results, and rules given for foundation weaves (with reference to an average fair and most often used counts of yarn, producing what might be termed staple textures and correspondingly staple fabrics) will form a solid basis to build upon for other fabrics as may be required to be made. Special fabrics, such as Union Cassimeres, Chinchillas, Whitneys, Montagnacs and other pile fabrics, are left out of question.

Example.—Fancy Cassimere: Weave $\frac{2}{2}$ twill (see Fig. 23). Yarn to use, 22-cut.

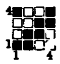


FIG. 23.

Question.—Find the proper number of threads for one inch to use.

22-cut=22×300=6,600 yards per lb. And

$\sqrt{6,600}$, less 16 per cent.=$68\frac{1}{4}$ threads of 22-cut woolen yarn will lie side by side in one inch.

$$\frac{68\frac{1}{4}\times 4}{4+2}=68\frac{1}{4}\times 4=273\div 6=45\frac{1}{2}.$$

Answer.—45 threads per inch (actually 91 threads for two inches) are the proper number of threads to use for the cloth given in example. In this weave ($\frac{2}{2}$ twill) warp and filling interlace after every two threads. In previously given example (the plain weave) warp and filling interlaced alternately; hence, if comparing the plain weave and the 4-harness even-sided twill we find:

Plain weave=4 points of interlacings in 4 threads.

$\frac{2}{2}$ twill=2 points of interlacings in 4 threads.

Previously we also mentioned that the space between the warp threads where the intersection takes place must be (or must be nearly as large) equal to the diameter of the filling yarn (also *vice versa*); thus, if comparing both weaves, using the same yarn for warp and filling in each example, we find in the plain weave:

4 points of interlacings of the filling in
4 warp threads, giving us
—
8 diameters of threads in four threads, or two repeats of the plain weave, and in the 4-harness even-sided twill we only find:

2 points of interlacings of the filling in
4 warp threads, giving us
—
6 diameters of threads in four threads, or one repeat of the $\frac{2}{2}$ twill weave.

Again in the plain weave we find:

4 intersections of each warp thread in
4 picks, giving
—
8 diameters of threads in four threads, or two repeats of the plain weave, and in the 4-harness even-sided twill we find:

2 intersections of each warp thread in
4 picks, giving
—
6 diameters of threads in four threads, or one repeat of the $\frac{2}{2}$ twill weave.

Hence, the proportion of the texture between a cloth woven with the plain weave and the 4-harness twill will be as 6:8 or 3:4.

Consequently if 60 ends per inch (in each system), woven with the plain weave, produce a well-balanced cloth, and we want to use the same yarn for producing a similar perfect cloth, woven with the $\frac{2}{2}$ twill, we find the number of threads required readily by the following proportion:

Ratio of the plain weave compared to the 4-harness twill.		::	Texture used with the plain weave.	:	Texture to be used with the 4-harness twill.
3 :	4	::	60	:	x.

$\frac{4\times 60}{3}=4\times 20=80$ threads must be used in proportion with the 4-harness even-sided twill to produce a well-balanced cloth structure.

This example will also explain that the less points of intersections we find in a given number of threads interlaced with one weave, compared to the same number of threads interlaced with another weave, the higher a texture we must employ, producing at the same time a proportional heavier cloth.

TO CHANGE THE TEXTURE FOR GIVEN COUNTS OF YARN FROM ONE WEAVE TO ANOTHER.

Rule.—The repeat of the given weave multiplied by repeat plus points of intersections of the required weave is to repeat of the required weave, multiplied by the repeat, plus points of intersections of the given weave, the same as the ends per inch of the given cloth are to the ends per inch for the required cloth. Thus we will find answer to previously given example by this rule, as follows·

$$(2\times(4+2)):(4\times(2+2)) :: 60: x \text{ and}$$
$$(2\times12) : (4\times4) :: 60: x \text{ and}$$
$$12 : 16 :: 60: x; \text{ hence,}$$

$\frac{16\times60}{12}=16\times5=80$ threads must be used, being the same answer as previously received.

Example.—Fancy Worsted Suiting. Weave $\frac{3}{\quad 3}$ 6-harness twill (see Fig. 24). Warp and filling 2/32's worsted. Texture, 64×64. Question: Find texture required for producing a well balanced cloth using the same counts of yarn with the $\frac{3 \quad 1}{2 \quad 3}$ 9-harness twill (see Fig. 25) for weave.

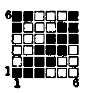


FIG. 24.

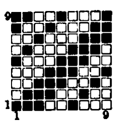


FIG. 25.

$$(6\times(9+4)):(9\times(6+2)) :: 64: x$$
$$(6\times13) : (9\times8) :: 64: x$$
$$78 : 72 :: 64: x$$
$$\frac{72\times64}{78}=\frac{12\times64}{13} \qquad 12\times64=768\div13=59\tfrac{1}{13}$$

Answer.—The number of ends to be used with 2/32's worsted, and the $\frac{3 \quad 2}{2 \quad 1}$ twill are 59 ends per inch.

TO CHANGE THE WEIGHT OF A FABRIC WITHOUT INFLUENCING ITS GENERAL APPEARANCE.

Previously we mentioned "the less points of interlacings we find in a given number of threads the higher a texture (more threads per inch) we can use in the construction of a cloth." This will also apply to the use of a heavier count of yarn, or both items (higher texture and heavier yarn) at the same time. In the construction of a new fabric we are frequently required to produce a fabric of a given weight per yard; hence, after we find by rules given that the yarn we intend to use will, with its corresponding texture and weave, produce a cloth either too heavy or too light, we must carefully consider how to remedy this. In some instances the difference could be balanced by either laying the cloth wider or narrower in the reed, or shorter or longer at the dressing, and regulate the weight during the finishing process; *i. e.*, full the flannel to the required weight. By some fabrics (of an inferior grade) we might also regulate the weight to some extent during the fulling process (by adding more or less flocks, the latter of which will felt during the fulling to the back, and partly between both systems of threads the fabric is composed of. But in most fabrics a too heavy or too little fulling or additional flocking (according to the class of cloth) would reduce or destroy the beauty of its face, and thus decrease its value; hence we must regulate texture, weave, and counts of yarn to be used, to a certain extent, to suit the weight per yard of the finished fabric required. Most always the heavier a weight is wanted, the heavier a yarn we must use, and in turn suit texture to the latter. Again, the lighter in weight a cloth is required, the finer counts of yarn we must use, also with a proportional regulation of the texture. If the weight per yard in a given fabric is required to be changed (either increased or reduced) without altering the weave, or the width in reed, or length dressed (*i. e.*, want the new cloth to be fulled about the same amount as the given), we must alter the counts of the yarn in the process of spinning, producing a heavier yarn if a heavier cloth is wanted, and a lighter yarn if a lighter cloth is wanted.

Rule.—The ratio between the required weight per yard squared and the given weight per yard squared, is in the same ratio as the counts of yarn in the given cloth are to the counts of yarn required for use in the new cloth.

Example.—Suppose we are making the following cloth :

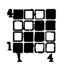


FIG. 26. Weave $\frac{2}{\ \ }\!\frac{\ }{2}$ twill.

Fancy Cassimere : 3,240 ends in warp. 10 per cent. take-up during weaving. Weave given in Fig. 26. 72 inches width in loom. Warp and filling, 22-cut woolen yarn. Weight of flannel from loom, 17.2 oz.

Question.—Find the proper counts of yarn to use if given weight, 17.2 oz., is to be changed to 19.1 oz.; *i. e.*, a flannel of 19.1 oz. is required (from loom).

Memo.—In this, as well as the following example, no reference to any selvage is taken.

Required weight squared.	:	Given weight squared.	::	Counts of yarn in given cloth.	:	Required counts for the new cloth.
19.1^2	:	17.2^2	::	22	:	x
(19.1×19.1)	:	(17.2×17.2)	::	22	:	x
364.81	:	295.84	::	22	:	x

$$\frac{295.84\times 22}{364.81}=17.9$$

Answer.—18-cut yarn is required.

Example.—Prove previously given example for each texture; *a*, as to weight, and *b*, as to the proper construction according to rules given.

1. Given Cloth.

a. Ascertain given weight (17.2 *oz.*).

Fancy Cassimere: 3,240 ends in warp. 10 per cent. take-up during weaving. Weave, $2\frac{\ \ }{\ }2$ 4-harness twill. 72 inches width in loom. 48 picks per inch. Warp and filling, 22-cut woolen yarn. 3,240 ends in warp. 10 per cent. take-up. How many yards dressed ?

100 : 90=x : 3,240 and 324,000÷90=3,600 yards of warp required dressed per yard of cloth woven.

22-cut=300×22=6,600 yards per lb.÷16=412½ yards per oz.; hence—

3,600÷412.5=8.8 oz. weight of warp.
72×48=3,456 yards of filling required per yard.
3,456÷412.5=8.4 oz., weight of filling.
Warp, 8.8 oz.
Filling, 8.4 oz.

Answer.— 17.2 oz., total weight per yard from loom.

b. Proof of Proper Structure of Given Cloth.

22-cut =6,600 yards per lb. and $\sqrt{6,600}$, less 16 per cent. =68¼ threads of 22-cut yarn will lie side by side in one inch.

$2\frac{\ \ }{\ }2$ twill =2 points of interlacings in one repeat of the weave.

Thus: $\frac{68\frac{1}{4}\times 4}{4+2}=68\frac{1}{4}\times 4=273\div 6=45\frac{1}{2}$, or practically—

Answer.—45 warp threads per inch should be used, and this is the number of ends used, since.—

(Threads in full warp.)	÷	(Width of cloth.)	=	(Ends per inch.)
3,240	÷	72	=	45

2. Required Cloth.

b. Find Proper Texture for Warp.

18-cut woolen yarn to be used $=18\times300=5{,}400$ yards per lb., $\sqrt{5{,}400}=73.49$, less 16 per cent. $(11.74)=61\frac{3}{4}$ threads of 18-cut woolen yarn will lie side by side in one inch.

4-harness twill contains 2 points of intersections in one repeat.

$$\frac{61\frac{3}{4}\times4}{4+2}=247\div6=41\tfrac{1}{6},\text{ or practically—}$$

Answer.—41 threads per inch must be used.

a. Ascertain Weight for Required Cloth.

Using the same width in reed as in the given cloth (72 inches).

$41\times72=2{,}952$ ends must be used (10 per cent. take-up).

$100:90::x:2{,}952$ and $295{,}200\div90=3{,}280$ yards warp required for one yard cloth from loom.

18-cut yarn $=5{,}400$ yards per lb. $\div16=337\frac{1}{2}$ yards, per oz.

$3{,}280\div337.5=9.7$ oz. warp yarn required.

$44\times72=3{,}168$ yards filling required, and $3{,}168\div337.5=9.4$ oz., filling required.

Warp, 9.7 oz.
Filling, 9.4 oz.

Answer.—19.1 oz., total weight per yard from loom, being exactly the weight wanted.

Memo.—In calculating weight for both fabrics we used three additional picks compared to the warp threads, which is done to illustrate practically the softer twist of the filling compared to the warp yarn (and which item has already previously been referred to). In the calculations we only used approximately the decimal fraction of tenth, since example refers only to illustrate the procedure. In examples we exclude any reference to selvage.

Example.—The following cloth we are making: Worsted Suiting. 3,840 ends in warp, 8 per cent. take-up, 60 inches width in loom, warp and filling 2/32's worsted, weight of flannel from loom, 14.6 oz. For weave, see Fig. 27. (No reference taken of selvage.)

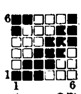


FIG. 27.
Weave ^{3}—$_{3}$
6-harness twill.

Question.—Find the proper yarn to use if given weight, 14.6 oz., must be changed to 16.3 oz. (from loom); *i. e.*, a flannel of 16.3 oz. is wanted (exclusive of selvage).

$$16.3^2 : 14.6^2 :: 16 : x$$
$$(16.3\times16.3):(14.6\times14.6)::16:x$$
$$265.69 : 213.16 :: 16 : x$$
$$213.16\times16=3{,}410.56\div265.69=12.9$$

Answer.—1/13's or 2/26's worsted yarn is required.

Example.—Prove previously given example for each structure; *a*, as to weight; *b*, as to the proper construction according to rules given.

1. Given Cloth.

a. Ascertain Given Weight (14.6 *oz.*).

Warp.—3,840 ends, 2/32's worsted, 8 per cent. take-up, weave ^{3}—$_{3}$ 6-harness twill. 60 inches width of cloth on reed.

Filling.—66 picks per inch, 2/32's worsted.

3,840 ends in warp, 8 per cent. take-up, how many yards dressed?

100 : 92 :: x : 3,840   384,000÷92=4,173$\frac{64}{92}$ yards (practically 4,174) of warp required dressed per yard of cloth woven.

2/32's worsted=16×560=8,960 yards per lb.÷16=560 yards per oz.

Hence: 4,174÷560=7.5 oz., weight of warp.

66×60=3,960 yards of filling required per yard.   3,960÷560=7.1 oz., weight of filling.

Warp, 7.5 oz.
Filling, 7.1 "

Answer.—14.6 oz., total weight per yard from loom.

b. Proof for Proper Structure of Given Cloth.

2/32's worsted =8,960 yards per lb., and $\sqrt{8,960}$—10 per cent. =85 threads of 2/32's worsted will lie side by side in one inch.

$\frac{3}{\quad}\!\!\!_{3}$ twill=2 points of interlacings in one repeat of the weave. Thus: $\frac{85\times6}{6+2}$=510÷8=64.

Answer.—64 threads per inch must be used, and since 3,840÷60=64, this is the number of ends used per inch in given cloth, the structure of the given cloth is perfectly balanced.

2. Required Cloth.

b. Find the Proper Texture for Warp.

2/26's worsted =13×560=7,280 yards per lb.

$\sqrt{7,280}$=85.3 less 10 per cent. (8.5)=76.8 diameters of threads of 2/26's worsted will lie side by side in one inch.

$\frac{3}{\quad}\!\!\!_{3}$ twill=2 points of interlacings in one repeat. Thus: $\frac{76.8\times6}{6+2}$=460.8÷8=57.6, or practically—

Answer.—58 threads per inch must be used.

a. Ascertain Weight for Required Cloth.

Using the same width in reed as in the given cloth (60 inches).

58×60=3,480 ends must be used (8 per cent. take-up).

100 : 92 :: x : 3,480.   348,000÷92=3,782 yards required for one yard cloth from loom.

2/26's worsted=7,280 yards per lb.÷16=455 yards per oz.; thus: 3,782÷455=8.3 oz. warp yarn required.

Using 61 picks we find—

61×60=3,660 yards filling (2/32's worsted) wanted.   3,660÷455=8 oz., weight of filling yarn wanted.

Warp, 8.3 oz.
Filling, 8.0 oz.

Answer.—16.3 oz., total weight of cloth (exclusive of selvage) from loom, being exactly the weight wanted.

To Find the Number of Ends per Inch in the Required Cloth.

The two examples previously given will also assist us to illustrate the next rule; *i. e.*, "Finding number of ends per inch in the required cloth."

Rule.—The weight per yard of the required cloth is to the weight per yard of the given cloth in the corresponding ratio of the warp ends per inch in the given cloth to the warp ends per inch in the required cloth.

Example.—Prove rule by previously given example of a fancy cassimere.

Given Cloth.—Weight per yard=17.2 oz. Ends per inch=45½ (for 45).

Required Cloth.—Weight wanted, 19.1 oz. Find ends per inch required, or x.

$19.1:17.2::45.5:x. \qquad \frac{17.2\times45.5}{19.1}=17.2\times45.5=782. \qquad 60\div19.1=40\tfrac{181}{191}$, or practically—

Answer.—41 warp threads must be used, and this is exactly the answer previously derived in the same example (see page 72).

Example.—Prove rule by previously given example of a worsted suiting.

Given structure.—Weight per yard, 14.6 oz. Ends per inch, 64.

Required structure.—Weight wanted, 16.3 oz. Find ends per inch required, or x.

$16.3:14.6::64:x \qquad \frac{14.6\times64}{16.3}=14.6\times64=9{,}344\div16.3=57\tfrac{53}{163}$ (See answer on page 73, being 57.6.)

Answer.—58 warp threads (practically) per inch must be used; this being the same number as derived previously in the same example. (See page 73.)

WEAVES WHICH WILL WORK WITH THE SAME TEXTURE AS THE $\frac{2}{2}$ 4-HARNESS TWILL.

The following few weaves (given for examples) have the same number of interlacings as the 4-harness even-sided twill:

Memo.—Weaves indicated by *u.* are uneven-sided twills. Weaves indicated by *e.* are even-sided twills.

4-harness twills:

$\frac{3}{1}$ u.

8-harness twills:

$\frac{5\quad 1}{1\quad 1}$ u.

$\frac{4\quad 1}{1\quad 2}$ u.

$\frac{3\quad 1}{1\quad 3}$ e.

$\frac{4\quad 2}{1\quad 1}$ u.

$\frac{3\quad 1}{2\quad 2}$ u.

$\frac{3\quad 2}{2\quad 1}$ u.

12-harness twills:

$\frac{7\quad 1\quad 1}{1\quad 1\quad 1}$ u.

$\frac{6\quad 1\quad 1}{1\quad 1\quad 2}$ u.

$\frac{5\quad 1\quad 1}{1\quad 1\quad 3}$ u.

$\frac{4\quad 1\quad 1}{1\quad 1\quad 4}$ e.

$\frac{6\quad 2\quad 1}{1\quad 1\quad 1}$ u.

$\frac{5\quad 3\quad 1}{1\quad 1\quad 1}$ u.

$\frac{4\quad 4\quad 1}{1\quad 1\quad 1}$ u.

$\frac{5\quad 2\quad 1}{2\quad 1\quad 1}$ u.

$\frac{4\quad 2\quad 1}{2\quad 1\quad 2}$ u.

$\frac{4\quad 3\quad 1}{2\quad 1\quad 1}$ u.

$\frac{3\quad 3\quad 1}{3\quad 1\quad 1}$ u.

$\frac{4\quad 2\quad 1}{3\quad 1\quad 1}$ u.

$\frac{3\quad 2\quad 1}{2\quad 2\quad 2}$ u.

$\frac{3\quad 3\quad 2}{1\quad 1\quad 2}$ u.

$\frac{2\quad 2\quad 5}{1\quad 1\quad 1}$ u.

$\frac{2\quad 2\quad 4}{1\quad 1\quad 2}$ u.

$\frac{2\quad 2\quad 3}{1\quad 1\quad 3}$ u.

$\frac{2\quad 2\quad 3}{2\quad 2\quad 1}$ u.

$\frac{2\quad 2\quad 1}{3\quad 3\quad 1}$ u.

$\frac{2\quad 2\quad 1}{5\quad 1\quad 1}$ u.

Proceeding in this manner, the student can readily find the different (common) twills which will work on the same basis of texture as the 4-harness even-sided twill.

Amongst "derivative weaves," working on the same basis of texture as the $\frac{2}{2}$ twill, we find—$\frac{3}{1}$ 4-harness broken twill and the following weaves given in my "*Technology of Textile Design,*" Figs. 398, 409, 411, 412, 416, 417, 420, 421, 445, 448, 449, 470 (476 ▫—▫), 479, 482, 492, 497, 499, etc., etc.

WEAVES WHICH WILL WORK WITH THE SAME TEXTURE AS THE $\frac{3}{3}$ TWILL, $\frac{4}{4}$ TWILL, Etc.

In the same manner as we previously found some of the different weaves to work on an equal basis with the $\frac{2}{2}$ twill, it will be advisable for the student to use different other "standard foundation weaves" on the same basis. For example: the $\frac{3}{3}$ twill, the $\frac{4}{4}$ twill, etc.

SELECTION OF THE PROPER TEXTURE FOR FABRICS INTERLACED WITH SATIN WEAVES.

As mentioned in my "*Technology of Textile Design*," fabrics made with satin weaves or "Satins" are characterized by a smooth face. The principles for the construction of satins are to arrange as much as possible distributed stitching, for the more scattered we arrange the interlacing of warp and filling the less these points of intersection will be visible in the fabric. Thus, the method of construction of this third class of foundation weaves is quite different from the other two classes (the plain and twill weaves); hence, the setting of the warp for fabrics interlaced with satins requires a careful studying and possibly a slight modification towards one, two, or three threads more per inch; but such an increase is regulated by the material. If we have an extra good and very smooth yarn we may do this, but if dealing with a rough or poorly carded yarn we must use ends per inch as found by rule.

As previously mentioned, in cloth interlaced with satin weaves we want a smooth face; hence, the warp yarn must cover the filling. Thus, as always one or the other of the threads in the repeat of the weave is withdrawn on every pick the remaining warp threads must cover this spot where the one warp thread works on the back of the cloth and the filling tries to take its place on its face; and, as according to rules given, the interlacing of the filling is dealt with similar to warp threads, the remaining warp threads in this instance would have to be spread so as to cover the filling, which, no doubt, is more readily accomplished by using a heavier texture of the warp; *i. e.*, putting two or three more threads per inch than actually will lie properly side by side, less the customary deduction on account of the nap of the yarn. If we resort to this plan, it will be readily understood by the student that this will produce a closer working of the threads than they properly should; hence, chafing or riding of threads (to a slight extent) will be the result. If, as previously mentioned, we are dealing with an extra good and smooth yarn and the warp yarn is properly sized and dressed, we may make use of those few ends, but otherwise in most every common fabric, threads as found by rule to lie side by side in one inch will do, since the nature of the weave (hence, cloth with it produced) will by itself hide the filling to a great extent by means of the warp being nearly all on the face, the filling forming the back and the one end warp as coming in the lower shed, having little power to pull the filling up, which for the main part forms the back of the structure.

Example.—Find threads of warp to use for weaving a "Kersey," with the 7-leaf satin (see Fig. 28), using 6-run woolen yarn. Width of cloth in reed (setting) to be 84 inches (exclusive selvage). 6-run woolen yarn =84 ends per inch, side by side. $84 \times 7 = 588 \div 9 = 65\frac{1}{3}$, or say 66 threads per inch. $66 \times 84 = 5{,}544$.

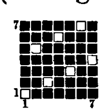


FIG. 28.

Answer.—5,544 threads texture for warp to use, but which may be increased to 5,700 ends if dealing with a good smooth yarn. 5,700 ends in warp equals nearly 68 threads per inch. $(68 \times 84 = 5{,}712)$ which is about 2 threads per inch in excess of proper number ascertained by the regular procedure.

SELECTION OF THE PROPER TEXTURE FOR FABRICS INTERLACED WITH RIB WEAVES.

As mentioned in my "*Technology of Textile Design*," fabrics interlaced with rib weaves require, for either one system of threads (warp or filling), a high texture.

Rib weaves classified as "warp effects," must have a high texture for warp, and

Rib weaves classified as "filling effects," must have a high texture for filling.

Warp Effects.

In the manufacture of fabrics interlaced with warp effect rib weaves, the warp forms the face and back of the fabric, whereas the filling rests imbedded, not visible on either side. This being the case there is no necessity for calculating (in the setting of the warp) for a space for the filling to interlace; thus, the texture is ascertained by the number of threads that will lie side by side per inch.

Example.—Find the warp texture for a fabric interlaced with the rib weave (warp effect) as shown in Fig. 29, using for warp 6-run woolen yarn.

6-run=9,600 yards per lb., and $\sqrt{9,600}$, less 16 per cent.=82.3.

Answer.—82 warp threads per inch must be used.

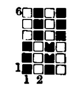


FIG. 29.

Example.—Find texture for a fabric interlaced with the rib weave, shown in Fig. 30, using for warp 2/40's worsted yarn.

2/40's worsted=11,200 yards per lb., and $\sqrt{11,200}$, less 10 per cent.=95.

Answer.—95 warp threads per inch must be used.

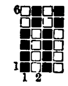


FIG. 30.

Filling Effects.

As previously mentioned, for filling effects we require a high number of picks, since the latter system has to form face and back of the cloth, and the warp the interior. In most instances the filling yarn as used for these fabrics is softer spun than the warp, for allowing a freer introducing of the former; thus, we may use even a few more picks per inch compared to the texture previously found for rib weaves warp effects.

Figured Rib Weaves.

If dealing with figured rib weaves, their texture for warp and filling is found by ascertaining the number of threads for both systems that will lie side by side in one inch.

Example.—Find texture for a cloth to be interlaced with the figured rib weave, shown in Fig. 31, using for warp and filling 2/36's worsted yarn.

2/36's=10,080 yards per lb., and $\sqrt{10,080}$, less 10 per cent.=90.

Answer.—90 warp threads and 90 picks per inch must be used.

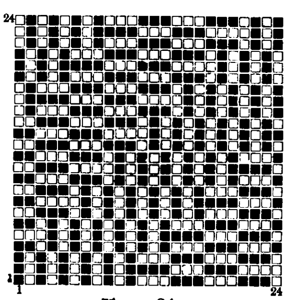


FIG. 31.

SELECTION OF THE PROPER TEXTURE FOR FABRICS INTERLACED WITH CORKSCREW-WEAVES.

On page 68 of my "*Technology of Textile Design*" I mentioned, amongst other points, referring to the method of construction of corkscrew weaves, "this sub-division of the regular 45° twills is derived from the latter weaves by means of double draws, which will reduce the texture of the warp for the face in the fabric; hence, a greater number of those threads per inch (compared to fabrics interlaced with the foundation weaves) are required."

A careful examination of the different corkscrew weaves (see Figs. 345 to 383 in "*Technology of Textile Design*,") with regard to their setting in loom, will readily illustrate their near relation to the warp effect rib weaves as explained in the previous chapter. In both systems of weaves (speaking in a general way) the warp forms the face and back of the cloth and the filling rests imbedded between the former; the only difference between both being that the break-line, as formed by the exchanging of the warp threads from face to back, is in the rib-cloth in a horizontal direction compared to the running of the warp threads, whereas in the corkscrews this break-line is produced in a oblique direction. But as this is of no consequence regarding structure (in fact only in preference of the forming of a better shed with the corkscrew weave, since not all the threads break—exchange positions—at the same time) we may readily use the setting of the number of warp threads per inch in corkscrews the same as done in rib weaves warp effects; *i. e.*, use the number of warp threads that will lie side by side in one inch for the texture of warp and again increase this texture one, two, three, or four ends, if dealing with an extra good yarn.

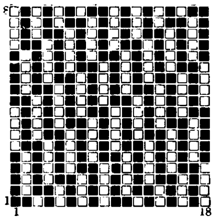


FIG. 32.

Example.—Find warp texture required for a fabric made with weave Fig. 32. Yarn to be used is 2/40's worsted. 2/40's worsted =11,200 yards per lb., and $\sqrt{11,200}$, less 10 per cent. =95.

Answer.—95 warp threads per inch must be used, and in case of extra good yarn we may increase this warp texture to 98 ends per inch.

Example.—Find number of threads in warp if fabric in previously given example is made 61 inches wide in loom. 95×61=5,795.

Answer.—5,800 threads in warp must be used to produce a perfect cloth; *i. e.*, perfect fabric, and 5,950 to 5,980 ends can be used with an extra good yarn (98×61=5,978).

Example.—Find *a*, texture of warp per inch; *b*, threads in warp to use if 61 inches wide in loom, for fabric interlaced with fancy corkscrew weave Fig. 33, using 2/60's worsted for warp.

2/60's worsted=16,800 yards per lb., and $\sqrt{16,800}$, less 10 per cent.=117.

Answer.—*a*, 117 warp threads per inch must be used; and 117×61 =7,137; thus *b*, 7,140 threads must be used in full warp.

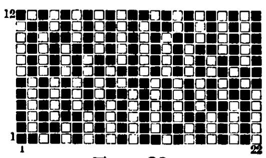


FIG 33

Memo.—In such fine yarn, and correspondingly high texture, it will be hardly necessary to use those two to four additional threads as made use of if dealing with a lower count of yarn.

SELECTION OF THE PROPER TEXTURE FOR FABRICS BACKED WITH FILLING; i. e., CONSTRUCTED WITH TWO SYSTEMS OF FILLING AND ONE SYSTEM OF WARP.

A thorough explanation of the construction of weaves for these fabrics has been given in my "*Technology of Textile Design*," on pages 105, 106, 107 and 108. Thus, we will now consider these points with reference to the setting of cloth in the loom, since, no doubt, the additional back filling will have more or less influence upon the setting of the face cloth. Weave Fig. 34 (corresponding to weave Fig. 558 and section Fig. 557 in Technology) illustrates the common 4-harness twill $^{2}\!-\!-_{2}$ for the face structure, backed with the 8-leaf satin.

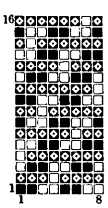


FIG. 34.

In this weave, as well as any similar combinations, the texture of the face warp can remain nearly the same as if dealing with single cloth, a deduction of 5 per cent. from the number ends per inch found for the single cloth is all that is required to be deducted for the same cloth made with a backing.

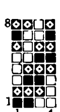


FIG. 35.

If we exchange the 8-leaf satin, as used for backing, with a twill, $^{3}\!-\!-_{1}$ as shown in weave Fig. 35, we must deduct 10 per cent. from the warp texture, as found for the face of the cloth, to produce the proper chances for weaving. If we back the 4-harness $^{2}\!-\!-_{2}$ twill with the arrangement of 2 picks face to alternate with 1 pick back, and use for the interlacing of the latter filling (and warp) the $^{3}\!-\!-_{1}$ 4-harness twill, (using every alternate warp thread only for interlacing) see weave Fig. 36, no deduction of the warp texture compared to single cloth is required; or, in other words, if using a weave 2 picks face to alternate with 1 pick back, and in which the backing is floating from $^{7}\!-\!-_{1}$ to $^{15}\!-\!-_{1}$ (or a similar average), no reference must be taken of the back filling in calculating the setting of the warp; or, in other words, the fabric is simply to be treated as pure single cloth. The most frequently used proportions of backing to face are: 1 pick face to alternate with 1 pick back, and 2 picks face to alternate with 1 pick back. Seldom we find other arrangements, as 3 picks face to alternate with 1 pick back; or irregular combinations, as 2 picks face 1 pick back, 1 pick face 1 pick back,=5 picks

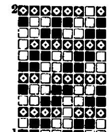


FIG. 36.

in repeat, etc. If using the arrangement "1 pick face to alternate with 1 pick back," be careful to use a backing yarn not heavier in its counts than the face filling; for a backing heavier in its counts than the face filling will influence the closeness of the latter, and in turn produce an "open face" appearance in the fabric.

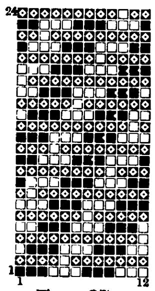


Fig. 37.

Weave Fig. 37 shows the ^{3}——$_{3}$ 6-harness twill for the face structure, backed with the 12-leaf satin. Arrangement: 1 pick face to alternate with 1 pick back. It will readily be seen by the student that this combination of weaves (also any similar ones) will be very easy on the warp threads; thus, the setting of the latter per inch in the reed is (about) designated by the counts of yarn used with reference to the single cloth weave (^{3}——$_{3}$ twill), being the same as if dealing with no backing, for the most allowance we would have to make for fabrics interlaced with this weave would be a deduction of 2 to $2\frac{1}{2}$ per cent. from the single cloth warp texture.

Weave Fig. 38 shows the same face weave (^{3}——$_{3}$ twill), arranged with 2 picks face to alternate with 1 pick back. There will be no difference experienced in the number of threads (warp) to use per inch between this weave and the single face weave (*i. e.*, the face weave if treated as single cloth); hence, the setting of the warp for both will be the same.

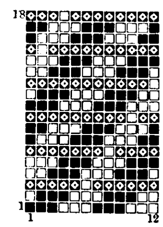


Fig. 38.

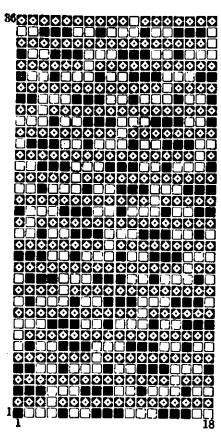


Fig. 39.

Example.—Find the proper number of warp threads to use for a worsted suiting, to be interlaced with the granite weave shown in Fig. 39. For warp yarn use 2/50's worsted.

2/50's worsted=14,000 yards per lb. and $\sqrt{14{,}000}$ less 10 per cent.=106.5

Points of interlacing in face weave=8

Warp threads in repeat of weave=18

106.5×18=19,170÷26 (8+18)=73.7

— 3.7 (5 per cent.)

70.0

Answer.—70 warp threads per inch of 2/50's worsted are required.

Example.—Ascertain for the previously given fabric the proper filling texture, if using the same counts of yarn as used for warp, and find weight of cloth per yard from loom (exclusive of selvage).

Required { Face filling, 74 picks per inch (2/50's worsted).
Backing, 74 " " " (single 24's worsted).

Width in loom, 60 inches (exclusive of selvage). Take-up of warp during weaving, 12 per cent.

70×60=4,200 warp threads in cloth. 100:88 :: x :4,200.

4,200×100=420,000÷88=4,772 yards of warp are wanted dressed for 1 yard cloth from loom.

14,000 yards per lb. in 2/50's worsted=875 yards per oz.

4,772÷875=5.45 oz., weight of warp,
74 × 60=4,440 yards face filling wanted,
4,440÷875=5.07 oz., face filling,
24's worsted=13,440 yards per lb.=840 yards per oz.
4,440÷840=5.28 oz., weight of backing.

Warp,	5.45	oz.
Face filling,	5.07	"
Backing,	5.28	"
	15.80	oz.

Answer.—Weight of cloth per yard from loom (exclusive of selvage) is 15.8 oz.

Example.—Find the proper texture for warp and filling, and also ascertain the weight of flannel per yard from loom (exclusive of selvage). Cloaking: Warp 5-run, filling 5-run, backing $2\frac{1}{2}$-run. Weave, see Fig. 40 (8 warp threads and 12 picks in repeat). Take-up of warp, 10 per cent. Width of cloth in reed, 72 inches (exclusive of selvage).

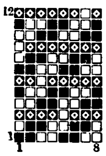


FIG. 40.

5-run=8,000 yards per lb.

$\sqrt{8,000}$, less 16 per cent.=75 ends of 5-run yarn will lie side by side in one inch.

75× 4= 300÷6=50 ends of warp must be used per inch, and

50×72=3,600 ends must be used in full warp.

100 : 90 :: x : 3,600

3,600×100=360,000÷90=4,000 yards of warp yarn are required per yard cloth woven.

5-run yarn=500 yards per oz. 4,000÷500=8 oz. of warp yarn are wanted.

52 picks (50+2 extra) of face filling, }
26 picks (corresponding to face picks) of back filling, } are wanted per inch

52×72=3,744 yards of face filling are wanted.

3,744÷500=7.5 oz., weight of face filling.

26×72=1,872 yards of backing are required.

1,872÷250 (yards of $2\frac{1}{2}$-run filling per oz.)=7.5 oz., weight of backing.

Warp,	8.00 oz.
Face filling,	7.50 "
Backing,	7.50 "
	23.00 oz.

Answer.—Total weight of cloth per yard from loom (exclusive of selvage), 23 oz.

SELECTION OF THE PROPER TEXTURE FOR FABRICS BACKED WITH WARP; i. e., CONSTRUCTED WITH TWO SYSTEMS OF WARP AND ONE SYSTEM OF FILLING.

To ascertain the texture of the warp in these fabrics we must first consider the counts of the yarn as used for the face structure, and secondly the weave.

After ascertaining this texture (for the single cloth) we must consider the weave for the back warp; *i. e.*, the stitching of the same to the face cloth. If dealing with a weave of short repeat for the back warp (for example a $\frac{1}{3}$ twill) we must allow a correspondingly heavy deduction from the threads as ascertained for the face cloth (about 20 per cent. for the $\frac{1}{3}$ twill); whereas, if dealing with a far-floating weave for the back (for example the 8-leaf satin) we will have to deduct less (about 10 per cent. for the 8-leaf satin) from the previously ascertained texture of the face cloth. Since the 8-leaf satin is about the most far-floating weave, as used for the backing, thus, 10 per cent. will be about the lowest deduction, and as the $\frac{1}{3}$ twill is the most frequently interlacing weave, in use in the manufacture of these fabrics, thus, 20 per cent. deduction from the respectively found texture of the face cloth is the maximum deduction. To illustrate the subject more clearly to the student we will give both weaves as previously referred to with a practical example.

Example.—Find warp texture for the following fabric: Fancy worsted trousering.

Weave, see Fig. 41. Face warp, 2/36's worsted. Back warp, single 20's worsted.

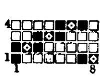


FIG. 41.

2/36's worsted =90 threads (side by side per inch).

Face weave $\frac{2}{2}$ twill =4 threads in repeat and 2 points of interlacing.

90×4=360÷6=60 threads, proper warp texture for the single structure.

60
—12 (20 per cent. deduction caused by the back warp ($\frac{1}{3}$) stitching in the face structure).
—
48

Face warp per inch, 48 threads 2/36's worsted.
Back warp " 48 " single 20's worsted.

96

Answer.—96 warp threads must be used per inch.

Picks per inch must be 52 (4 extra over the texture of the face warp). Use 2/36's filling and find weight of cloth per yard from loom (exclusive of selvage), allowing 10 per cent. take-up for face warp, and 12 per cent. for back warp, using 62 inches as the width of cloth in loom.

$48 \times 62 = 2,976$ ends of face warp, and
2,976 " " back warp.

5,952, total number of ends in the entire warp.

100 : 90 :: x : 2,976 $297,600 \div 90 = 3,306\frac{2}{3}$ yards or face warp are wanted per yard of cloth woven.
2/36's worsted$=10,080$ yards per lb. $\div 16 = 630$ yards per oz. $3,306.66 \div 630 = 5.25$ oz., weight of face warp.
100 : 88 :: x : 2,976 $297,600 \div 88 = 3,381\frac{9}{11}$ yards of back warp yarn are wanted per yard of cloth woven.
1/20's worsted$=11,200$ yards. 11,200 yards per lb. $\div 16 = 700$ yards per oz.
$3,381.81 \div 700 = 4.83$ oz., weight of the back warp.
52 picks per inch $\times 62 = 3,224$ yards of filling wanted.
$3,224 \div 630 = 5.12$ oz., weight of filling per yard of cloth woven.

Warp,	Face,	5.25 oz.
	Back,	4.83 "
Filling,		5.12 "
		15.20 oz.

Answer.—15.2 oz. is the weight of the cloth per yard (from loom exclusive of selvage).

To illustrate the difference regarding the weave as selected for interlacing the back warp, we will next calculate the previously given example with the same counts of yarn but with the weave as given in Fig. 42.

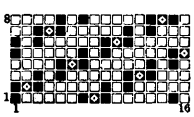


Fig. 42.

This weave contains the same face weave (^{2}—$_{2}$ twill) as previously used, the only difference being the interlacing of the back warp, for which we use the 8-leaf satin in place of the ^{1}—$_{3}$ twill as used in the former example.

Face warp and filling, 2/36's worsted. Back warp, single 20's worsted.

2/36's worsted$=90$ threads will lie side by side per inch.

Face weave ^{2}—$_{2}$ twill. $90 \times 4 = 360 \div 6 = 60$ threads is the proper texture for face structure, and
60
— 6 (10 per cent. deduction by means of the back warp stitching with the 8-leaf satin in the face structure).

54 Warp threads per inch 54 threads 2/36's worsted, for face.
54 " 1/20's " " back.

108 Thus: 108 warp threads per inch must be used.

Picks per inch, 58 (the same 4 extra pick as in previous given example).

Filling, 2/36's worsted. Take-up of face warp 10 per cent. Take-up of back warp 8 per cent. $62\frac{1}{2}$ inches for width of cloth in loom, since the 8-leaf satin will permit a readier milling (during the process of scouring) than the ^{1}—$_{3}$ twill.

Question :—Find weight of cloth per yard and compare it with previously given example.

$54 \times 62.5 = 3,375$ threads each of face and back warp are wanted.

100 : 90 :: x : 3,375. $337,500 \div 90 = 3,750$ yards of face warp are wanted per yard of cloth woven.
2/36's worsted$=630$ yards per oz. $3,750 \div 630 = 5.95$ oz., weight of face warp.
100 : 92 :: x : 3,375. $337,500 \div 92 = 3,668\frac{1}{2}$ yards of back warp are wanted per yard of cloth woven.
1/20's worsted$=700$ yards per oz.

$3,668.5 \div 700 = 5.24$ oz., weight of back warp per yard of cloth woven.

58 picks per inch $\times 62.5$ inches width of cloth in reed$=3,625$ yards of filling wanted, and $3,625 \div 630 = 5.75$ oz., weight of filling per yard of cloth woven.

Face warp,	5.95 oz.
Back warp,	5.24 "
Filling,	5.75 "
	16.94 oz.

Thus: 16.94 oz. (or practically 17 oz.) is the weight of cloth per yard from loom.

A comparison between both cloths results as follows:

	(Using weave Fig. 41.)	(Using weave Fig. 42.)	(Difference.)
Face warp,	5.25 oz.	5.95 oz.	0.70 oz.
Back warp,	4.83 "	5.24 "	0.41 "
Filling,	5.12 "	5.75 "	0.63 "
Weight per yard,	15.20 oz.	16.94 oz.	1.74 oz.

Or, the difference between using the 8-leaf satin or $\frac{1}{3}$ twill for the weave for the back warp is 1.74 oz.

Given two examples will readily illustrate to the student that he must select the weave for the backing with the same care as the face weave, for, as shown in examples given, we produced a difference of $1\frac{3}{4}$ oz. simply by changing the weave for the back warp, using the same counts of yarn for warp and filling, leaving the face weave undisturbed.

The most often used proportion of the arrangement between face and back warp is the one previously explained; *i. e.*, 1 end face to alternate with 1 end back, but sometimes we also use—

2 ends face warp	or	1 end face warp.
1 end back warp		1 end back warp.
—		2 ends face warp.
3 ends in repeat.		1 end back warp.
		—
		5 ends in repeat, or any similar arrangement.

If using the arrangement "1 end face warp to alternate with 1 end back warp," never use a heavier size of warp yarn for the back warp than for the face warp. (See previously given example and you find face yarn 2/36's worsted, (= single 18's) and for back warp, single 20's worsted yarn used.)

If using "2 ends face warp to alternate with 1 end back warp" a proportional heavier yarn can be used for the back warp. (See the previous example where 2 ends face warp, 2/36's worsted, alternate with one end back warp, $3\frac{1}{2}$-run woolen yarn).

Great care must be exercised in selecting the stock for the face warp and back warp for such fabrics as require any fulling during the finishing process. The material in the back warp, which can be of a cheaper grade, must have about, or as near as possible, the same tendency for fulling as the "stock" which is used in the face warp. The student will also readily see that there will be a smaller deduction (after finding the face texture) necessary if using the arrangement of 2 ends face to alternate with 1 end back than if using the simple alternate exchanging of face and back warp explained at the beginning of the chapter.

For example, take weave Fig. 43, illustrating an 8-harness Granite weave, backed 2 ends face warp, 1 end back warp. The back warp interlaces 1 pick up and 7 picks down = 8 picks in the repeat. Examining rules as given for the arrangement 1 and 1, we find a call for a deduction for the face texture of 10 per cent. (see weave Fig. 42), but which, if using the present arrangement, must be reduced to 5 per cent.; this being one-half less reduction to make for 2 face 1 back compared to 1 face 1 back.

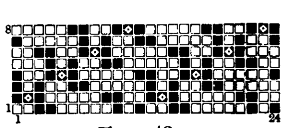


FIG. 43.

Weave Fig. 44 illustrates the $\frac{2}{2}$ twill, backed 2 ends face warp and 1 end back warp. The back warp interlaces 1 pick up, 3 picks down=4 picks in the repeat. Examining rules as given for the arrangement of 1 and 1, we find a call for a deduction from the face texture of 20 per cent. (see weave Fig 41), but which, if using arrangement to suit weave Fig. 44, must be reduced one-half; *i. e.*, deduct only 10 per cent.

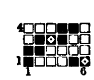


FIG. 44.

Example.—Find warp threads per inch for the following cloth: Worsted suiting, Face warp, 2/36's worsted yarn. Back warp, 3½-run woolen yarn. Use *a*, weave shown in Fig. 43; *b*, weave given in Fig. 44.

2/36's worsted $=\frac{1}{90}$ inch diameter. Face weave, { 8 threads in repeat, 4 points of interlacing.

$\frac{90\times8}{12}=60$ threads, proper warp texture for face.

$$\begin{array}{r} 60 \\ -\ 3\ \text{(5 per cent.)} \\ \hline 57 \end{array}$$

Answer.—If using weave Fig. 43, use 57 warp threads per inch for face.

Thus: 58 ends 2/36's worsted for face, and
+29 " 3½-run woolen yarn for back, giving us
—
87 ends of warp to be used per inch.

2/36's worsted $=\frac{1}{90}$ inch diameter. Face weave, { 4 threads in repeat, 2 points of interlacing.

$\frac{90\times4}{6}=60$ threads, proper warp texture for face.

$$\begin{array}{r} 60 \\ -\ 6\ \text{(10 per cent.)} \\ \hline 54 \end{array}$$

Answer.—If using weave Fig. 44, use 54 warp threads per inch for face.

Thus: 54 ends 2/36's worsted for face,
+27 " 3½-run woolen yarn for back, gives us
—
81 ends of warp as total number of ends to be used per inch.

SELECTION OF PROPER TEXTURE FOR FABRICS CONSTRUCTED ON THE DOUBLE CLOTH SYSTEMS; i. e., CONSTRUCTED WITH TWO SYSTEMS OF WARP AND TWO SYSTEMS OF FILLING.

Under double cloth we comprehend the combining of two single cloths into one fabric. Each one of these single cloths is constructed with its own system of warp and filling, while the combination of both fabrics is effected by interlacing some of the warp threads of the one cloth at certain intervals into the other cloth; hence, in ascertaining the warp texture of these fabrics we have to deal with a back warp and back filling, both exercising their influence upon the texture of the fabric at the same time.

As mentioned and explained in my "*Technology of Textile Design*," double cloth may be constructed with:

1 end face to alternate with 1 end back, in warp and filling.
2 ends face to alternate with 1 end back, in warp and filling.
2 ends face to alternate with 2 ends back, in warp and filling.
3 ends face to alternate with 1 end back, in warp and filling, etc.

The two first mentioned arrangements are those most often used; hence, we will use the same for illustrating the selection of the proper warp texture for the present system of fabrics.

1 End Face to Alternate with 1 End Back in Warp and Filling.

For face warp use 4-run woolen yarn. For back warp use 4½-run woolen yarn.

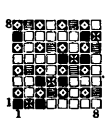


Fig. 45.

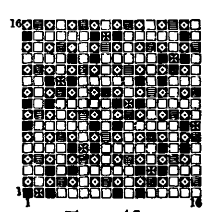


Fig. 46.

Question.—Find texture for warp yarn: *a*, if using weave Fig. 45; *b*, if using weave Fig. 46.

First we have to ascertain the warp texture for the face cloth, dealing with the same as with pure single cloth.

Face weave for both weaves is the $^{2}\!-\!_{2}$ 4-harness twill, and the yarn to use is 4-run woolen yarn.

4-run=6,400 yards per lb.
$\sqrt{6,400}=80$
—12.8 (16 per cent.)

67.2

$\frac{2}{2}$ twill = { repeat of weave, 4 threads,
points of interlacing in one repeat, 2.

$\frac{67.2\times 4}{6}=268.8\div 6=44.8$ threads (or practically 45) required to be used if dealing with a single cloth.

The next to be taken into consideration is the stitching of both cloths. In both weaves the back warp interlaces into the face cloth. In weave Fig. 45, we find the $\frac{1}{3}$ twill used for stitching, the proper allowance for the same is a deduction of 24 per cent. from the face structure; hence, in example:

45 threads, proper warp texture for face cloth, treated as single cloth.
—11 " (24 per cent. deducted for $\frac{1}{3}$ stitching).

34 threads per inch must be used for each system if using weave given in Fig. 45.

In weave Fig. 46, we find the 8-leaf satin used for stitching the same face cloth as previously used, the proper allowance for the same is a deduction of 16 per cent. from the face structure; In example given, we find—

45 threads, proper warp texture for face cloth, treated as single cloth.
— 7 threads (16 per cent. deducted for the $\frac{1}{7}$ stitching).

38 warp threads per inch must be used for each system if using weave given in Fig. 46.

Answer.—Double cloth fabrics given in question require the following warp texture:

a. If using weave Fig. 45, we must use—
34 warp threads 4 -run woolen yarn for face,
+34 warp threads $4\frac{1}{2}$-run woolen yarn for back.

or 68 warp threads per inch.

b. If using weave Fig. 46, we must use—
38 warp threads 4 -run woolen yarn for face,
+38 warp threads $4\frac{1}{2}$-run woolen yarn for back;

or 76 warp threads per inch.

2 Ends Face to Alternate with 1 End Back in Warp and Filling.

For face warp use 4-run woolen yarn (same counts as used in previously given example).
For back warp use $2\frac{1}{2}$-run woolen yarn.

Question.—Find texture for warp yarn: *a*, if using weave Fig. 47; *b*, if using weave Fig. 48.

The face weave in both weaves is the same as given in previous weaves, Figs. 45 and 46, or the $\frac{2}{2}$ twill, the counts of yarn being also the same; thus, we can use texture for face cloth required from previous example, being 45 threads per inch in loom.

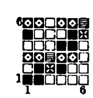


FIG. 47.

In weave Fig. 47, we used the plain weave for stitching, the proper allowance for the same is a deduction of 8 per cent. from the face structure; hence,

45 threads, proper warp texture for face cloth (single cloth),
— 3 " 8 per cent. (3.6 actual) deducted for the stitching $\frac{1}{1}$.

42 threads per inch to be used for the face system if using weave given in Fig. 47.

In weave Fig. 48, we find the 8-leaf satin used for stitching the same face cloth as previously used. The manner in which the stitching is done in this example will be of very little, if any, consequence to the face cloth; hence, the full number of ends (or as near as posible) as ascertained for the face cloth, treated as if single cloth, must be used. In the present example this would be 44 or 45 threads per inch to be used for face system if using weave shown in Fig. 48.

Answer.—Double cloth fabrics given in question require the following warp texture: *a.* If using weave Fig. 47, we must use—

42 warp threads 4-run woolen yarn for face.
+21 warp threads $2\frac{1}{2}$-run woolen yarn for back; or

63 warp threads per inch.

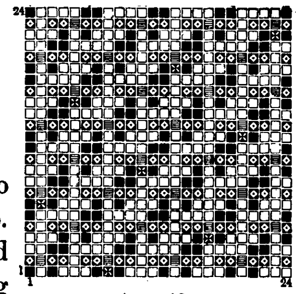


FIG. 48.

b. If using weave Fig. 48, we must use—

44 warp threads 4-run woolen yarn for face.
+22 warp threads $2\frac{1}{4}$-run woolen yarn for back; or

—

66 warp threads per inch must be used.

Example.—Ascertain texture of warp required for a worsted suiting, to be made with 2/40's worsted for face warp, and 2/28's cotton for back warp. Arrangement of warp and filling to be 2 ends face to alternate with 1 end back. Weave to be used, Fig. 48. Next, ascertain the proper counts of filling and the number of picks per inch, take-up of warp, width of cloth in reed, and ascertain total amount of each kind of material required per yard from loom (exclusive of selvage).

2/40's worsted=11,200 yards per lb. $\sqrt{11,200}$, less 10 per cent.=95 threads will lie side by side in one inch.

Face weave (in Fig. 48) is the ^{2}——$_{2}$ twill=4 threads in one repeat, with 2 points of interlacings; hence, $\frac{95\times 4}{6}=380\div 6=63\frac{1}{3}$, warp texture to be used for the face cloth, the same being treated as if single cloth.

In weave Fig. 48, the arrangement between face and back is 2:1; the weave used for the back is the 8-leaf satin, and, as we mentioned when laying down rules and examples, for setting double cloth fabrics in the loom, that the ^{1}——$_{7}$ requires no deduction on account of the stitching of the back warp in the face cloth, texture to use in this example must be

64 face warp threads (2/40's worsted), and
+32 back warp threads (2/28's cotton); hence,

—

96 warp threads per inch must be used.

Take-up of warp during weaving 12 per cent. for face and 10 per cent for back. The width of cloth to use in reed will be 62 inches.

For face filling use the same counts as for face warp, and for back filling use 3-run woolen yarn.

Picks, 66 face.
+33 back.

—

99, total picks to be used per inch.

$64\times 62=3,968$ threads in face warp—12 per cent. take-up. Thus:
$3,968\times 100=396,800\div 88=4,509$ yards of face warp yarn are necessary for 1 yard cloth woven
2/40's worsted=11,200 yards per lb.$\div 16=700$ yards per oz.
$4,509\div 700=6.44$ oz., weight of face warp.
$32\times 62=1,984$ threads in back warp—10 per cent. take-up. Thus:
$198,400\div 90=2,204$ yards of back warp yarn necessary for 1 yard cloth woven.
2/28's cotton=11,760 yards per lb.$\div 16=735$ yards per oz.
$2,204\div 735=3$ oz., weight of back warp.
$66\times 62=4,092$ yards of face filling are wanted.
$4,092\div 700=5.85$ oz., weight of face filling. $33\times 62=2,046$ yards of back filling are wanted.
3-run woolen yarn=300 yards per oz. $2,046\div 300=6.82$ oz., weight of back filling.

Hence: 6.44 oz., weight of face warp (2/40's worsted).
3.00 " " " back " (2/28's cotton).
5.85 " " " face filling (2/40's worsted).
6.82 " " " back " (3-run wool).

—

22.11 oz.

Answer.—Fabric given in example will weigh 22.11 oz. per yard from loom.

ARITHMETIC.

(Specially Adapted for Textile Purposes).

ADDITION.

Addition has for its object the finding of a number (called sum) equal to two, three, or more numbers.

The symbol + (read plus) is used to indicate the operation of addition. The symbol = (read is equal to, or are) is the sign of equality.

Example.— $3 + 4 + 7$ yards=14 yards.

If adding higher numbers than units place figures that represent units in each number in the same vertical line, those representing tens in the same vertical line and continue in this manner with the numbers representing hundreds, thousands, ten-thousands, hundred-thousands and millions. Next draw a horizontal line under the last number, and under this line place (in the same arrangement as to value of positions) the sum of the given numbers; *i. e.*, commencing to add the right-hand column, writing the units of the sum beneath, and adding the tens, if any, to the next column, and continue in this manner with all the columns until writing the entire sum of the last column.

Examples.—

206 lbs.	46 yards.
320 "	230 "
+54760 "	4377 "
	+57698 "
55286 lbs.	62351 yards.

Question.—Find number of threads in pattern dressed:

10 threads black.
2 " blue.
4 " brown.
24 " black.
+ 2 " blue.

Answer.— 42 threads in pattern.

Question.—Find total weight for the following lot of wool:

960 lbs. Domestic.
40 " Australian.

Answer.— 1000 lbs., total weight.

SUBTRACTION.

Subtraction is the process of taking away a number (called subtrahend) from a larger number (called minuend). The result of a subtraction is termed difference.

The symbol — (read minus, or less) denotes the operation of subtracting. To prove a subtraction, remember that the difference and subtrahend, added, must equal the minuend.

Example.— $8 - 3$ lbs. = 5 lbs. *Proof.*— $5 + 3 = 8$.

If subtracting higher numbers than units, write the subtrahend under minuend, placing units of the same order in the same column. Next draw a horizontal line under the subtrahend and begin to subtract with the units of the lowest order, and proceed to the highest, writing the result beneath.

If any order of the minuend has less units than the same order of the subtrahend, increase its units by ten and subtract; consider the units of the next minuend order one less, and proceed as before.

Examples.—

4322 lbs. (minuend)		4284 yards
—2111 " (subtrahend)		—3395 "
2211 lbs. (difference).		889 yards.

Question.—Weight of cloth required, 21 oz.; weight from loom, 19 oz. Find difference.

21 oz.
—19 "

2 oz.

Answer.—The cloth in question is 2 oz. too light.

Question.—The weight of a lot of wool in grease is 100 lbs.; its weight after being scoured and dried is 67 lbs. Find loss during scouring process.

100 lbs.
— 67 "

33 lbs.

Answer.—The lot of wool in question lost during scouring 33 lbs.

Question.—Basis of cotton yarn, 840 yards per lb.; basis of worsted yarn, 560 yards per lb. Find difference.

840 yards.
—560 "

280 yards.

Answer.—The worsted yarn basis is 280 yards less than the one for cotton yarns.

MULTIPLICATION.

Multiplication is the process of taking one number (called multiplicand) as often as another number (called multiplier) contains ones. The sum thus derived, or the result of a multiplication, is called the product or result.

The symbol × (read multiplied, or times) denotes the operation for multiplying.

Example.—

Multiplicand.		Multiplier.		Product.
4	×	3	=	12

Proof.—

4
4
+ 4

12

If multiplying higher numbers than units, begin the process with the ones, and write the ones of the product reserving the tens if any. Next multiply the tens of the multiplicand, adding number of tens reserved from the previous process, write tens in place for tens in product and reserve (if any) the hundreds; continue in this manner, always multiplying the next highest number of the multiplicand, adding number of same value (if any) from the previous part of the operation, until all the numbers of the multiplicand are taken up, writing in full the last operation.

Example.—If weaving 212 yards of cloth in one day, how many yards will be woven, under the same circumstances, in 3 days? $212 \times 3 = 636$.

Answer.—636 yards.

The product for multiplying a number by 10, is obtained by simply annexing 0 to the multiplicand.

Example.— 336 yards$\times$10=3,360 yards.

By annexing 00 to the multiplicand, we multiply the latter by 100; by annexing 000, with 1000, etc.

If required to multiply with a number having tens and zeros (0) for ones, we first multiply with the tens and annex 0 to the result.

Examples.— $36\times30=1,080$; $36\times300=10,800$; $36\times3,000=108,000$, etc.

Remember that the multipler and multiplicand can change places, without altering the product; thus, if zeroes are found in the multiplicand reverse factors so as to apply previously given rules.

Example.—How many picks per hour does a loom make if running 85 picks per minute? 1 hour=60 minutes; thus, $60\times85=5,100$.

Answer.—The speed per hour is 5,100 picks.

If the multiplier contains two parts, for example 5 and 60 (or 65), multiply the multiplicand first with the units (5 in example) and afterwards with the tens, using zero for ones (60 in example). In setting down this second result omit the zero, as it has no effect on the addition to be performed.

Example.—If one loom produces 235 yards of cloth in one week, how many yards will 23 looms produce in the same time and on the same work?

235$\times$23 Thus: 235$\times$ 3= 705
235$\times$20= 4700
——
5405

or, 235$\times$23
705 = (235$\times$ 3)
470 = (235$\times$20)
——
5405

Answer.—23 looms will produce 5,405 yards per week.

If the multiplier is made up of three parts, multiply with the units and tens as before, next the hundreds, using zeros for tens and units, but omitting both zeros in setting down the third result. For similar reasons any future value of figures in the multipler requires corresponding increase of zeros not set down in the respective result.

Example.— 783$\times$233

2349 =(783$\times$ 3= 2349).
2349 =(783$\times$ 30= 23490).
1566 =(783$\times$200=156600).

Answer.— 182439

In some instances we are requested to find the continued product of three, four, or more numbers. In such instances multiply the first two numbers, and multiply product derived with the third, etc.

Example.—Find number of yards of filling wanted to weave 32 yards cloth, 72 inches wide in loom, 45 picks per inch. Thus: $32\times72\times45$.

$$32\times72=2,304\times45=103,680$$

Answer.—103,680 yards of filling are wanted.

Some examples call for a number to be multiplied by itself once, twice, three times, or oftener. If so, the resulting products are called the second, third, fourth, etc., powers of the number. The process is termed involution, and the power to which the number is raised is expressed by the number of times the number has been employed as a factor in the operation. The raising of a number to the second power is called square; the raising to the third power being termed cube. Thus:

16 is the square of 4, because $4\times4=16$
64 " " cube " 4, " $4\times4\times4=64$

DIVISION.

Division is the process by which we find how many times one number (called divisor) is contained into another (called dividend) The quotient is the result of a division, and the part of the dividend not containing the divisor an exact number of times, is called the remainder.

The symbol of division is ÷ (read divided by), and is written between the dividend and divisor; for example, 8÷4; but is also frequently substituted, either by writing the divisor at the left of the dividend with a curve, for example, 4)8, or by writing the divisor under the dividend, both numbers to be separated by a horizontal line.

For example, $\frac{8}{4}$

Dividend.		Divisor.		Quotient.
8	÷	4	=	2

Example.—If dividing higher numbers than units, find how many times the divisor is contained in the fewest left-hand figures of the dividend that will contain it; write answer as the first number of the quotient. Next multiply this number by the divisor; subtract the product from the partial dividend used, and to the remainder annex the next dividend figure for a second partial dividend. Divide and proceed as before, until all the numbers of the dividend are called for, writing the last remainder (if there is one left), with the divisor under it (as common fraction), as a part of the quotient.

Example.—Find number of repeats of pattern in the following warp:

3,904 threads in warp. 32 threads in pattern.

```
3904÷32=122
32
--
 70
 64
 --
  64
  64
```

Answer.—In the warp given in the example there are 122 repeats of pattern.

Remember that the dividend is the product of the divisor and the quotient; hence, use this as proof for the division in question.

```
Divisor.    Quotient.
  32    ×     122     =    3,904 (Dividend.)
---------------------
   64
  64
 32
----
3904
```

If we have to divide a number by ten, simply insert a decimal point between the last two figures (toward the right) in the dividend, thus expressing at once the quotient.

Example.—4,220 end in warp, dressed with 10 sections. Find number of ends used in each section.

4,220÷10=422.0, or

Answer.—422 ends are used in each section.

If the divisor is hundred, thousand, or more, always move the decimal point correspondingly one more point toward the left in the dividend, so as to get the quotient.

Example.—125 lbs. of filling must weave 100 yards of cloth, how many pounds must be used per yard, to weave up all this filling?

125÷100=1.25

Answer.—1¼ lbs. yarn must be used per yard.

Dividing or multiplying the dividend and the divisor by one number does not alter the quotient; thus, if the divisor contains zeros for either units, units and tens, units, tens and hundreds, etc., we can shorten the process by throwing out such zeros and reducing the dividend correspondingly, by simply placing a decimal point in its proper place.

Example.—4,905 threads in warp, 30 threads in pattern. Find number of repeats of pattern in warp.

$$4905 \div 30 = 490.5 \div 3\not{0} = 163.5$$

```
 3
 ——
 19
 18
 ——
  10
   9
  ——
   15
   15
   ——
```

Answer.—There are $163\frac{1}{2}$ repeats of patterns in warp.

Previous example also explains the multiplying of both the dividend and the divisor (without altering the proper quotient) towards the close of the division, when 1.5 is to be divided by 3.

$$\frac{1.5 \times 10 = 15}{3 \times 10 = 30} \text{ or } \frac{1}{2} \text{ or } 0.5.$$

PARENTHESIS OR BRACKETS.

A parenthesis (expressed by symbol ( )), is used in calculations for enclosing such numbers as must be considered together. Hence, the whole expression which is enclosed is affected by the symbol preceding or following the parenthesis.

Hence, $(18\times4)\div(4\times2)=72\div8=9$; whereas without parenthesis example would read as follows:

$$18\times4\div4\times2=(18\times4=72\div4=18\times2=)\ 36$$

If the main operation, as in the present example, is a division, we may use in the place of the parenthesis, the vinculum (expressed by symbol ——), writing the dividend above the line, and the divisor below; thus, previously given example would read $\frac{18\times4}{4\times2}=9$

$240\div(7+4\times2)$ means that twice the sum of $7+4$ equal 22 is to be divided into 240. It might also have been written $\frac{240}{7+4\times2}$

$(3\times4—2)\times(6\times9+4)+43$ means: Subtract 2 from the product of 3 multiplied by 4, and multiply the remainder (10) by the sum of 6 multiplied by 9, plus 4 (58), and add to the product $(10\times58=580)$ thus obtained 43, which gives 623 as the result or answer.

Frequently brackets are made to inclose one another, if so, remove the brackets one by one, commencing by the innermost.

Example.—

$$(2+5\times(4+82)+8)\times(3+10).$$
$$(2+5\times\ \ 86\ \ +8)\times(3+10).$$
$$(\ 7\ \times\ \ 86\ \ +8)\times(3+10).$$
$$(\ \ 602\ \ \ \ +8)\times(3+10).$$
$$610\ \ \times\ \ 13$$

Answer.—$(2+5\times(4+82)+8)\times(3+10)=7{,}930.$

Example.—

$$(3\times(6+9\div2\times(4\times8)+8)\,)\times2.$$
$$(3\times(6+9\div2\times\;32\;+8)\,)\times2.$$
$$(3\times(\qquad248\qquad)\,)\times2.$$
$$744\qquad\times2.$$

Answer.—$(3\times(6+9\div2\times(4\times8)+8)\,)\times2=1{,}488.$

PRINCIPLE OF CANCELLATION.

Example given in previous chapter on brackets $\frac{18\times4}{4\times2}$ we will also use to explain the subject of cancelling or shortening calculations. The rule for this process is: Strike out all the numbers common to both dividend and divisor, and afterward proceed as required by example.

$$\frac{18\times4}{4\times2}=\frac{18\times\cancel{4}}{\cancel{4}\times2}=\frac{18}{2}=18\div2=9.$$

Another point for cancellation is to ascertain if a number in the dividend and in the divisor have the same common factor.

Example.—
$$\frac{36\times9}{18\times5}=\frac{\overset{2}{\cancel{36}}\times9}{\underset{1}{\cancel{18}}\times5}=\frac{2\times9}{1\times5}=18\div5=3\tfrac{3}{5}.$$

Proof.—
$$\frac{36\times9}{18\times5}=\frac{324}{90}=324\div90=3\tfrac{3}{5}.$$
$$\begin{array}{l}270\\\hline\end{array}$$
$$\frac{54}{90}\;\Big|\;\frac{6}{10}\;\Big|\;\frac{3}{5}$$

For reducing fractions to their lowest denomination as in previous example $\frac{54\div9=}{90\div9=}\frac{6}{10}\frac{\div2=3}{\div2=5}$ as well as for assisting the student quickly to find the same common factor for two numbers, we give herewith rules by which he can quickly ascertain if a number is exactly divisible by 2, 3, 4, 5, 6, 7, 8, 9, 10 or 11.

If the last figure of the number is either zero or an even digit, such a number is exactly divisible by 2.

Examples.— $420\div2=210$, $336\div2=168$.

If the sum of the figures is divisible by 3, such a number is exactly divisible by 3.

Example.— $38{,}751\div3=12{,}917$.

If the last two figures of a given number are divisible by 4, such a number is exactly divisible by 4.

Example.— $396{,}564\div4=99{,}141$.

If the last digit in a number is either 0 or 5, such a number can be exactly divided by 5.

Examples.— $320\div5=64$, $38{,}745\div5=7{,}540$.

When the last three figures of a number are divisible by 8, such number can be divided by 8

Example.— $376{,}256\div8=47{,}032$.

A number is exactly divisible by 9, when the sum of its digits is divisible by 9.

Example.— $887{,}670\div9=98{,}630$.

A number is exactly divisible by 11, when the difference between the sum of the digits in the uneven places (commencing with the units) and the sum of the digits in the even places, is either zero or divisible by 11.

Example.— $514{,}182{,}746\div11=46{,}743{,}886$.

COMMON FRACTIONS.

A common fraction is a fraction in which we write the numerator above, and the denominator below, the dividing (— or /) line.

Example.— $\frac{1}{2}$ $\begin{array}{l}= \text{numerator of the fraction} \\ = \text{denominator of the fraction}\end{array}$ } Both being the terms of the fraction.

The horizontal dividing line is the one most frequently used, but the oblique (1/2) answers the same purpose.

The *denominator* of a fraction indicates in how many equal parts the unit is divided; and the *numerator* shows how many of those parts are taken.

There are two kinds of fractions:

(*a*) **Proper Fractions,** which have for their terms a numerator which is less than the denominator. For example, $\frac{3}{4}$, $\frac{5}{8}$, $\frac{6}{7}$, etc.

(*b*) **Improper Fractions,** which have for their terms a numerator, which is greater than the denominator. For example, $\frac{4}{3}$, $\frac{8}{5}$, $\frac{7}{6}$, etc.

An *improper fraction* can be changed to a *mixed number* by dividing the numerator by the denominator, setting down the quotient as the integral part, and making the remainder the numerator of the fractional part of the mixed number, whose denominator is the denominator of the original fraction.

An integer (= whole number) can be expressed as an improper fraction, without reducing its value, for example, $6=\frac{6}{1}$, $8=\frac{8}{1}$, etc. The combination of an integer and a fraction is termed a mixed number. For example, $7\frac{3}{4}$ (7 Integer. $\frac{3}{4}$ Numerator. Denominator.)

A *mixed number* can be changed to an *improper fraction* by multiplying the integer by the denominator of the fraction, adding to the product the numerator of the fraction. This sum is the numerator of the improper fraction of which the denominator is the denominator of the given fraction.

Example.— $2\frac{4}{7} = \frac{2 \times 7 + 4}{7} = \frac{18}{7}$ improper fraction.

A fraction is expressed in its lowest terms (*i. e.*, cannot be reduced) when the numerator and denominator have no common factor except unity, or in other words, when both terms are not dividable by any number except one. For example. $\frac{5}{12}$, $\frac{3}{7}$, etc.

Thus, to reduce a fraction to its lowest terms, use

Rule.—Divide the numerator and the denominator by their highest common factor.

The highest common factor of a fraction is the highest number which will exactly divide each of the terms of a fraction; for such small numbers, as are generally used for fractions, the highest common factor is found at a glance. For example: $\frac{6}{8}$. Readily the student will see that both the 6 and the 8 can be divided by 2. Thus: $\frac{6}{8} \div 2 = \frac{3}{4}$, or $\frac{6}{8} = \frac{3}{4}$.

If dealing with large numbers, the highest common factor cannot always be determined by inspection, but is found by

Rule.—Divide the higher number of the fraction by the lower, and the latter (the divisor of the first operation) by the remainder; continue the process until no remainder is left, the divisor used last being the highest common factor for the fraction.

Example.—Reduce to its lowest terms $\frac{2166}{2888}$; *i. e.*, find the highest common factor for 2166 and and 2888, by previously given rule.

$$\left.\begin{array}{l} 2166)2888=1 \\ \quad 2166 \\ \quad\overline{722)2166=3} \\ \qquad\quad 2166 \end{array}\right\}$$ or, 722 is the highest common factor.

$$\frac{2,166 \div 722 = 3}{2,888 \div 722 = 4}$$

Answer.— $\frac{2166}{2888}$ expressed in its lowest terms equals $\frac{3}{4}$

Frequently we must change a given fraction to terms of a known denominator; if so, proceed as follows: Divide the required denominator by the denominator of the given fraction and multiply by the quotient thus obtained with both terms of the given fraction.

Example.—Change $\frac{5}{12}$ to equivalent fraction expresseed in 60's.

$$60 \div 12 = 5 \text{ and } \frac{5 \times 5 = 25}{12 \times 5 = 60}$$

Answer.— $\frac{5}{12}$ equals $\frac{25}{60}$ in value.

If two fractions are to be changed to equivalent fractions (fractions having the same denominator) find the lowest common multiple (see * below for explanation for lowest common multiple) for the two given denominators, which is the new denominator for each fraction. Next find the new numerators for both fractions, by means of previously given method for changing a given fraction to terms of a known denominator. This rule also applies for three or more fractions.

Example.—Change $\frac{3}{4}$ and $\frac{5}{7}$ to equivalent fractions, having the same denominator.

4×7 (prime numbers) $= 28$, new denominator.

$$28 \div 4 = 7 \qquad 28 \div 7 = 4$$

$$\frac{3 \times 7 = 21}{4 \times 7 = 28} \qquad \frac{5 \times 4 = 20}{7 \times 4 = 28}$$

Answer.— $\frac{3}{4} = \frac{21}{28}$ and $\frac{5}{7} = \frac{20}{28}$.

Example.—Change $\frac{2}{3}$, $\frac{3}{4}$ and $\frac{5}{7}$ to equivalent fractions, having the same denominator.

$3 \times 4 \times 7$ (prime numbers) $= 84$, new denominator.

$$84 \div 3 = 28 \qquad 84 \div 4 = 21 \qquad 84 \div 7 = 12$$

$$\frac{2 \times 28 = 56}{3 \times 28 = 84} \qquad \frac{3 \times 21 = 63}{4 \times 21 = 84} \qquad \frac{5 \times 12 = 60}{7 \times 12 = 84}$$

Answer.— $\frac{2}{3} = \frac{56}{84}$ $\qquad \frac{3}{4} = \frac{63}{84}$ $\qquad \frac{5}{7} = \frac{60}{84}$

* *The lowest common multiple* of two or more numbers is the lowest number which is exactly dividable by each of them, and is obtained for two numbers by dividing one of the numbers by the highest common factor, and multiplying the quotient by the other number. If numbers are prime, their product is the lowest common multiple.

If we have to find the lowest common multiple of three or more numbers, find the lowest common multiple of any two, next find the lowest common multiple of the resulting number, and of a third of the original numbers, and so on, the final result being the lowest common multiple wanted.

ADDITION OF COMMON FRACTIONS.

Only fractions having the same denominators can be added; thus, change fractions given to equivalent fractions having the lowest common denominator. Next add the numerators of the equivalent fractions and place the result as the numerator of a fraction whose denominator is the common denominator of the equivalent fractions.

Example.—Find sum of $\frac{1}{8}$ and $\frac{1}{3}$ oz.

$$8 \times 3 = 24, \text{ lowest common denominator.} \quad \begin{array}{ll} 24 \div 8 = 3 & 24 \div 3 = 8 \\ \frac{1 \times 3}{8 \times 3} = \frac{3}{24} & \frac{1 \times 8}{3 \times 8} = \frac{8}{24} \end{array} \quad \Big| \quad \frac{3}{24} + \frac{8}{24} = \frac{11}{24}$$

Answer.— $\frac{1}{8}$ oz. + $\frac{1}{3}$ oz. = $\frac{11}{24}$ oz.

Example.—Find sum of $\frac{3}{20}$, $\frac{4}{15}$ and $\frac{1}{10}$ inches.

The lowest common denominator of 20, 15 and 10 is 60, since

$$\begin{array}{lll} 60 \div 20 = 3 & 60 \div 15 = 4 & 60 \div 10 = 6 \\ \frac{3 \times 3}{20 \times 3} = \frac{9}{60} & \frac{4 \times 4}{15 \times 4} = \frac{16}{60} & \frac{1 \times 6}{10 \times 6} = \frac{6}{60} \end{array} \quad \Big| \quad \frac{9}{60} + \frac{16}{60} + \frac{6}{60} = \frac{31}{60}$$

Answer.— $\frac{3}{20} + \frac{4}{15} + \frac{1}{10} = \frac{31}{60}$ inches.

Example.—Find the total yards for the following three pieces of cloth containing respectively $3\frac{7}{16}$, $8\frac{2}{16}$, and $108\frac{4}{20}$ yards.

The lowest common denominator of 16 and 20 is 80, since 80÷16=5 and 80÷20=4.

$$\frac{7 \times 5}{16 \times 5} = \frac{35}{80}, \text{ thus: } 3\tfrac{7}{16} = 3\tfrac{35}{80} \qquad \frac{2 \times 5}{16 \times 5} = \frac{10}{80}, \text{ thus: } 8\tfrac{2}{16} = 8\tfrac{10}{80} \qquad \frac{4 \times 4}{20 \times 4} = \frac{16}{80}, \text{ thus: } 108\tfrac{4}{20} = 108\tfrac{16}{80}$$

$$3\tfrac{35}{80} + 8\tfrac{10}{80} + 108\tfrac{16}{80} = 119\tfrac{61}{80}$$

Answer.—The total yards for the three pieces cloth given in question are $119\frac{61}{80}$ yards.

If the sum derived is an improper fraction, the same can be changed (if required) to a mixed number, by dividing the numerator by the denominator, the quotient obtained being the integer. The remainder is the numerator of the fraction which has the given denominator of the improper fraction for their denominator.

Example.—Find sum of $\frac{5}{7}$ and $\frac{8}{9}$ lb.

The lowest common denominator of 7 and 9 is 63, since 63÷7=9, and 63÷9=7.

$$\frac{5 \times 9}{7 \times 9} = \frac{45}{63} \text{ and } \frac{8 \times 7}{9 \times 7} = \frac{56}{63} \quad \Big| \quad \frac{45}{63} + \frac{56}{63} = \frac{101}{63}\ (101 \div 63) = 1\tfrac{38}{63}$$

Answer.— $\frac{5}{7}$ lb. + $\frac{8}{9}$ lb. = $\frac{101}{63}$, or $1\frac{38}{63}$ lbs.

Previously given rule also applies if adding improper fractions.

Example.—Find sum of $\frac{8}{5}$ and $\frac{7}{3}$ yards.

The lowest common denominator of 5 and 3 is 15, since 15÷3=5, and 15÷5=3.

$$\frac{8 \times 3}{5 \times 3} = \frac{24}{15} \qquad \frac{7 \times 5}{3 \times 5} = \frac{35}{15} \quad \Big| \quad \frac{24}{15} + \frac{35}{15} = \frac{59}{15}\ (59 \div 15) = 3\tfrac{14}{15}.$$

Answer.— $\frac{8}{5}$ yard + $\frac{7}{3}$ yard = $3\frac{14}{15}$ yards.

If adding mixed numbers, first add the fractions; if their product is a proper fraction, reduce the same to their lowest equal terms; but if an improper fraction, change the same to a mixed number and put the fraction part down for the fraction of the sum. Next add the integral parts of the given mixed numbers plus the integral part from the addition of the fractions.

Example.—Find the sum of $3\frac{2}{3}$, $4\frac{6}{8}$ and $2\frac{1}{7}$ inches.

The lowest common denominator of 3, 8 and 7 is 168, since 168÷3=56; 168÷8=21; 168÷7=24.

$$\begin{array}{r} 3\tfrac{2}{3}(\tfrac{2}{3} \times \tfrac{56}{56}) = 3\tfrac{112}{168} \\ 4\tfrac{6}{8}(\tfrac{6}{8} \times \tfrac{21}{21}) = 4\tfrac{126}{168} \\ 2\tfrac{1}{7}(\tfrac{1}{7} \times \tfrac{24}{24}) = 2\tfrac{24}{168} \\ + \\ \hline 9\tfrac{262}{168} \end{array} \qquad 9\tfrac{262}{168} = \left\{ \begin{array}{r} 262 \div 168 = 1\tfrac{47}{84} \\ +9 \\ \hline 10\tfrac{47}{84} \end{array} \right\} 10\tfrac{47}{84}$$

Answer.— $3\frac{2}{3} + 4\frac{6}{8} + 2\frac{1}{7}$ inches = $10\frac{47}{84}$ inches.

SUBTRACTION OF COMMON FRACTIONS.

Only fractions having the same denominator can be subtracted; thus, change fractions given to equivalent fractions having the lowest common denominator. Next deduct the numerator of the smaller of the equivalent fractions from the numerator of the greater fraction. The difference place as the numerator of a fraction whose denominator is the common denominator of the equivalent fraction. This fraction is the difference of the given two fractions (can be reduced to its lowest terms by previously given rule).

Example.—Find the difference between $\frac{6}{8}$ and $\frac{2}{7}$.

The lowest common denominator of 8 and 7 is 8×7, or 56; and $56 \div 8 = 7$; $56 \div 7 = 8$.

$$\frac{6 \times 7}{8 \times 7} = \frac{42}{56} \qquad \frac{2 \times 8}{7 \times 8} = \frac{16}{56} \qquad \Big| \qquad \frac{42}{56} - \frac{16}{56} = \frac{26}{56} = \frac{13}{28}$$

Answer.— $\frac{6}{8} - \frac{2}{7} = \frac{13}{28}$.

Example.—Find the difference between the weight of two pieces of cloth weighing respectively $23\frac{5}{7}$ and $20\frac{2}{9}$ lbs. The lowest common denominator of 7 and 9 is 7×9 or 63.

$$63 \div 7 = 9 \qquad 63 \div 9 = 7.$$

$$\begin{aligned} 23\tfrac{5}{7} &= 23\tfrac{45}{63} \\ 20\tfrac{2}{9} &= 20\tfrac{14}{63} \\ - & \\ \hline & 3\tfrac{31}{63} \text{ lbs.} \end{aligned}$$

Answer.—The difference between the two pieces of cloth given in example is $3\frac{31}{63}$ lbs.

Previously given rule also applies, if dealing with improper fractions. In some instances we may have to deduct a fraction or a mixed number in which the value of the fraction of the subtrahend is greater than the one of the minuend. If so, we must change the fraction by adding one unit of the integer (changed to a fraction of the same denominator) to the fraction of the minuend.

Example.—Find the difference between the weight of two pieces of cloth weighing respectively $28\frac{3}{7}$ and $28\frac{6}{8}$ ounces. The lowest common denominator of 7 and 8 is 8×7, or 56.

$$\begin{aligned} 28\tfrac{3}{7} &= 28\tfrac{24}{56} = 27\tfrac{80}{56} \\ 22\tfrac{6}{8} &= 22\tfrac{42}{56} = 22\tfrac{42}{56} \\ - & \\ \hline & 5\tfrac{38}{56}, \text{ or } 5\tfrac{19}{28} \text{ oz.} \end{aligned}$$

Answer.—The difference in weight between the two pieces of cloth, given in example, is $5\frac{19}{28}$ ozs.

MULTIPLICATION OF COMMON FRACTIONS.

A fraction is multiplied by an integer, by multiplying the numerator of the fraction by the integer and leaving the denominator of the fraction unchanged, or divide the denominator of the fraction by the integer and leave the numerator unchanged.

Example.—Multiply $\frac{3}{8}$ with 2.

$$\frac{3}{8} \times 2 = \frac{3 \times 2}{8} = \frac{6}{8} \text{ or } \frac{3}{4}$$

Or,

$$\frac{3}{8} \times 2 = \frac{3}{8 \div 2} = \frac{3}{4}$$

Example.—If 1 lb. filling weaves $\frac{5}{8}$ yards cloth, how many yards will 26 lbs. weave?

$$\frac{5}{8} \times 26 = \frac{5 \times 26}{8} = \frac{130}{8}, \text{ or } 130 \div 8 = 16\tfrac{1}{4}.$$

Answer.—26 lbs. filling will weave $16\frac{1}{4}$ yards cloth.

A fraction is multiplied by a fraction by writing the product of the numerators over the product of the denominators. The product thus divided change either to a fraction of the lowest term, or, if an improper fraction to a mixed number.

Example.—Multiply $\frac{3}{13}$ by $\frac{4}{15}$ inches.

$$\frac{3}{13} \times \frac{4}{15} = \frac{3 \times 4}{13 \times 15} = \frac{\not{3} \times 4}{13 \times \underset{5}{\not{15}}} = \frac{4}{13 \times 5} = \frac{4}{65}$$

Answer.— $\frac{3}{13} \times \frac{4}{15} = \frac{4}{65}$.

Example.—Multiply $\frac{7}{8}$ by $2\frac{3}{7}$.

$$\frac{7}{8} \times 2\frac{3}{7} = \frac{7}{8} \times \frac{17}{7} = \frac{7 \times 17}{8 \times 7} = \frac{\not{7} \times 17}{8 \times \not{7}} = \frac{17}{8} \text{ or } 17 \div 8 = 2\tfrac{1}{8}$$

Answer.— $\frac{7}{8} \times 2\frac{3}{7} = 2\frac{1}{8}$.

Example.—If one pound of filling weaves $\frac{5}{8}$ yards of cloth, how many yards will $38\frac{3}{4}$ lbs. filling weave.

$$\frac{5}{8} \times 38\tfrac{3}{4} = \left(\frac{5}{8} \times \frac{155}{4}\right) = \frac{5 \times 155}{8 \times 4} = 775 \div 32 = 24\tfrac{7}{32}$$

Answer.— $38\frac{3}{4}$ lbs. of filling will weave $24\frac{7}{32}$ yards.

Previously given rules also apply to improper fractions. In the application of the rules to mixed numbers, change the latter to their equivalent value in improper fractions and proceed as in the foregoing example.

Example.—Find square inches for a sample cut to the rectangular shape of $3\frac{2}{5} \times 4\frac{1}{6}$ inches.

(Mixed numbers.)		(Improper fractions.)
$3\frac{2}{5}$	=	$\frac{17}{5}$
$4\frac{1}{6}$	=	$\frac{25}{6}$

$$\frac{17}{5} \times \frac{25}{6} = \frac{17 \times \overset{5}{\not{25}}}{\not{5} \times 6} = \frac{17 \times 5}{6} = \frac{85}{6} \text{ or } 85 \div 6 = 14\tfrac{1}{6}.$$

Answer.—The surface of the sample in question is ($3\frac{2}{5} \times 4\frac{1}{6}$) $14\frac{1}{6}$ inches.

DIVISION OF COMMON FRACTIONS.

A fraction is divided by an integer by multiplying the denominator of the fraction by that number, leaving the numerator unchanged; or by dividing the numerator of the fraction by the integer, and leaving the denominator unchanged.

Example.—(**Fraction ÷ Integer.**) Divide $\frac{4}{9}$ by 2.

$$\frac{4}{9} \div 2 = \frac{4}{9 \times 2} = \frac{4}{18} = \frac{2}{9}, \quad \text{or } \frac{4}{9} \div 2 = \frac{4 \div 2}{9} = \frac{2}{9}$$

Answer.— $\frac{4}{9} \div 2 = \frac{2}{9}$.

Example.— $\frac{7}{8}$ lb. of filling weave 3 yards cloth, ascertain amount used per yard.

$$\frac{7}{8} \div 3 = \frac{7}{8 \times 3} = \frac{7}{24}$$

Answer.—The amount of filling used per yard, is $\frac{7}{24}$ lb.

If we have to divide an integer by a fraction, we must change the integer to a fraction, and use the same rule as given next for

Dividing Fractions by Fractions.

Rule.—Invert the divisor and proceed as in multiplication of fractions.

Example.—(**Fraction ÷ Fraction**). Divide $\frac{11}{12}$ by $\frac{3}{15}$.

$$\frac{11}{12} \div \frac{3}{15} = \frac{11}{12} \times \frac{15}{3} = \frac{11}{12} \times \frac{\overset{5}{\cancel{15}}}{\cancel{3}} = \frac{11 \times 5}{12} = \frac{55}{12} \text{ or } 4\tfrac{7}{12}$$

Answer.— $\frac{11}{12} \div \frac{3}{15} = 4\frac{7}{12}$.

Proof.—The product of the quotient and the divisor must equal the dividend, thus:

$$4\tfrac{7}{12} \times \tfrac{3}{15} = \frac{55}{12} \times \frac{3}{15} = \frac{\overset{11}{\cancel{55}} \times \overset{1}{\cancel{3}}}{\underset{4}{\cancel{12}} \times \underset{3}{\cancel{15}}} = \frac{11 \times 1}{4 \times 3} = \tfrac{11}{12} \text{ or}$$

$$4\tfrac{7}{12} \times \tfrac{3}{15} = \tfrac{11}{12}, \text{ the same as } \tfrac{11}{12} \div \tfrac{3}{15} = 4\tfrac{7}{12}$$

Example (**Integer ÷ Fraction**). Divide 8 by $\frac{3}{9}$.

$$8 \div \tfrac{3}{9} = \frac{8}{1} \div \frac{3}{9} = \frac{8}{1} \times \frac{9}{3} \text{ or } \frac{8 \times \overset{3}{\cancel{9}}}{1 \times \cancel{3}} = \frac{8 \times 3}{1} = 24$$

Answer.— $8 \div \frac{3}{9} = 24$.

In the application of the rules for mixed numbers, change the latter to an improper fraction, and proceed as in the foregoing examples.

Example.—(**Mixed Number ÷ Fraction.** Divide $9\frac{3}{8}$ by $\frac{7}{9}$.

$$9\tfrac{3}{8} \div \tfrac{7}{9} = \frac{75}{8} \div \frac{7}{9} = \frac{75}{8} \times \frac{9}{7} = \frac{75 \times 9}{8 \times 7} = \frac{675}{56} = 12\tfrac{3}{56}$$

Answer.— $9\frac{3}{8} \div \frac{7}{9} = 12\frac{3}{56}$.

Example.—(**Mixed Number ÷ Mixed Number**). Divide $4\frac{7}{8}$ by $1\frac{4}{9}$.

$$4\tfrac{7}{8} \div 1\tfrac{4}{9} = \frac{39}{8} \div \frac{13}{9} = \frac{39}{8} \times \frac{9}{13} = \frac{\overset{3}{\cancel{39}} \times 9}{8 \times \cancel{13}} = \frac{27}{8} = 3\tfrac{3}{8}$$

Answer.— $4\frac{7}{8} \div 1\frac{4}{9} = 3\frac{3}{8}$.

DECIMAL FRACTIONS.

A decimal fraction is a fraction whose unit is divided into tenths, hundreths, thousandths, ten-thousandths, hundred thousandths, etc. and is expressed without a denominator by means of the decimal point.

Value of decimal fractions commonly termed decimals.

Decimal point. Tenths. Hundredths. Thousandths. Ten-thousandths. Hundred-thousandths. Millionths.

.123456 (. 1 2 3 4 5 6) and so on, each digit decreasing tenfold advancing to the right.

Above number reads: One hundred twenty-three thousand four hundred fifty-six millionths.

The denominator of a decimal fraction (which as already mentioned, is not put down, but indicated by the decimal point) is 1 plus as many zeros annexed as there are places in the fraction.

Hence: .4 reads, 4 tenths, $\frac{4}{10}$.

.73 seventy-three hundredths, $\frac{73}{100}$.

.821 eight hundred twenty-one thousandths, $\frac{821}{1000}$, etc.

Some parties also use a zero one point to the left to indicate that the fraction contains no integer parts; thus, foregoing fractions may also be written 0.4, 0.73, 0.821, without changing their value or their reading.

Zeros affixed to a decimal do not change its value.

Hence, .38=.380=.3800, etc., 0.693=0.6930=0.69300 etc.

Mixed numbers are made up of an integer and a decimal. For example: 3.25 read, three and twenty-five hundredths. 347.3 reads, three hundred forty-seven and three tenths. 1873.472 reads, one thousand eight hundred seventy-three and four hundred and seventy two thousandths.

To change a decimal fraction to common fraction of equivalent value, omit the decimal point and write the proper denominator as explained previously, next change the fraction to its lower terms.

Example.—Change .25 to a common fraction.

$$.25 = \frac{25 \div 25}{100 \div 25} = \frac{1}{4}$$

Answer.— .25 equals $\frac{1}{4}$.

Example.—Change 43.625 to a mixed number having a common fractional part.

$$43.625 = 43\tfrac{625}{1000} = (\tfrac{625}{1000} \div \tfrac{125}{125} = \tfrac{5}{8}) \quad 43\tfrac{5}{8}.$$

Answer.— 43.625 equals $43\frac{5}{8}$.

To change a common fraction to a decimal fraction, add decimal ciphers to the numerator, divide by the denominator, and point off as many decimal figures in the quotient as there are ciphers annexed.

Example.—Change $\frac{1}{4}$ to a decimal.

$$1.00 \div 4 = 0.25$$

```
10
 8
--
 20
 20
--
```

Answer.— $\frac{1}{4}$ equals .25 or 0.25.

Example.—Change $43\frac{5}{8}$ to a decimal.

$$\tfrac{5}{8} = 5.000 \div 8 = 0.625.$$

```
50
48
--
 20
 16
 --
  40
  40
  --
```

```
  43.000
+  0.625
--------
  43.625
```

Answer.— $43\frac{5}{8}$ equals 43.625.

If the division does not terminate, or has been carried as far as necessary, the remainder may be expressed in the result as a common fraction, or may be rejected if less than $\frac{1}{2}$, or unimportant, and the incompleteness of the result marked at the right of the fraction by +. If $\frac{1}{2}$, or more than $\frac{1}{2}$, the last digit of the decimal may be made to express one more.

Example.—Change $\frac{7}{9}$ to a decimal.

$$7.000 \div 9 = 0.777+$$

```
70
63
--
 70
 63
 --
  70
  63
  --
   7
```

Answer.— $\frac{7}{9} = 0.777\frac{7}{9}$, or $\frac{7}{9} = 0.777+$, or $\frac{7}{9} = 0.778$.

ADDITION OF DECIMAL FRACTIONS.

Rule.—Place the decimals to be added one under another, decimal point under decimal point. Next add the figures as if dealing with whole numbers, and place the decimal point for the sum under the others.

Example.— Add 0.22, 0.384, and 0.054.

$$\begin{array}{r} 0.220 \\ 0.384 \\ +\ 0.054 \\ \hline 0.658 \end{array}$$

Answer.— 0.22 + 0.384 + 0.054 = 0.658.

If the numbers to be added be mixed numbers, place integers in front of the decimals, in their proper position, and proceed as before.

Example.— Add 3468.12; 483.39; 27.0003 and 3.18

$$\begin{array}{r} 3468.1200 \\ 483.3900 \\ 27.0003 \\ +\ 3.1800 \\ \hline 3981.6903 \end{array}$$

Answer.— 3468.12 + 483.39 + 27.0003 + 3.18 = 3981.6903.

Find total cost of a piece of cloth in which the value of the warp is $22.32; of the filling, $16.02; of the selvage, $0.64, and (general) manufacturing expenses are $5.00.

$$\begin{array}{r} \$22.32 \\ 16.02 \\ 0.64 \\ +\ 5.00 \\ \hline \$43.98 \end{array}$$

Answer.—The total cost of the piece of cloth in question is $43.98.

SUBTRACTION OF DECIMAL FRACTIONS.

Rule.—Place the subtrahend below the minuend, keeping the different values of positions under each other, also point under point. Next subtract as if dealing with whole numbers, and place decimal point for the difference under point of the subtrahend.

Example.—Subtract 0.27 from 0.473

$$\begin{array}{r} 0.473 \\ -0.270 \\ \hline 0.203 \end{array}$$

Answer.— 0.473 — 0.270 = 0.203.

If dealing with mixed numbers, place integers in front of the decimals, in their proper place, and proceed as before.

Example.—Find cost of filling in a cut of cloth in which the value of warp and filling is $56.32, and the value of the warp is $32.19

$$\begin{array}{r} \$56.32 \\ -\ 32.19 \\ \hline \$24.13 \end{array}$$

Answer.—The value of the filling in example is $24.13

MULTIPLICATION OF DECIMAL FRACTIONS.

Rule.—Multiply as if dealing with whole numbers, and point off in the product a number of decimal places equal to the sum of the number of decimal places in both factors. If there are not figures enough in the product, prefix the deficiency with zeros, and put the point on the left of these factors. Whole numbers and mixed numbers are dealt with alike.

Example.—Multiply 0.26 by 0.35.

```
0.26 × 0.35
 ───
 130
 78
 ───
 910
```

Four decimal places are in both factors; hence
Answer.— $0.26 \times 0.35 = 0.0910$, or 0.091.

Example.—Multiply 4.32 by 2.81.

```
   4.32 × 2.81
 ────
    432
  3456
  864
 ────
 12.1392
```

Four decimal places in factors; hence
Answer.— $4.32 \times 2.81 = 12.1392$.

Example.—Ascertain value of 432 lbs. of wool, costing $1.31 per lb.

```
   432 × 1.31
 ────
   432
  1296
  432
 ────
  565.92
```

Answer.—The value of the lot of wool in question is $565.92.

DIVISION OF DECIMAL FRACTIONS.

Rule.—If the dividend is a mixed number, or a fraction, and the divisor an integer, divide as if dealing with whole numbers, and mark off in the quotient as many decimal places as there are decimal places in the dividend.

Example.—Divide 39.42 by 2.

```
39.42 ÷ 2 = 19.71
2
──
19
18
──
 14
 14
──
002
  2
──
  0
```

Answer.— $39.42 \div 2 = 19.71$.

Example.—Divide 0.84 by 4

```
0.84 ÷ 4 = 0.21
8
──
04
 4
──
 0
```

Answer.— $0.84 \div 4 = 0.21$.

Rule.—If the divisor is a decimal, change to a whole number by moving the decimal point a sufficient number of places to the right, annexing zeros if required, and then divide as if dealing with integers. If the dividend is an integer, the quotient will be an integer; and if the dividend is a decimal, the quotient will be a decimal of the same order.

Example.—Divide 0.924 by 0.033.

$$0.924 \div 0.033 = 924 \div 33 = 28$$

```
66
---
264
264
---
```

Here the quotient is an integer, because the dividend is an integer ; hence

Answer.— $0.924 \div 0.033 = 28.$

Example.—Divide 3.876 by 10.2.

$$3.876 \div 10.2 = 38.76 \div 102 = .38$$

```
306
---
 816
 816
---
```

Here the dividend is a decimal of the second order ; thus the quotient correspondingly also a decimal of the second order ; therefore

Answer.— $3.876 \div 10.2 = 0.38$

Example.—Divide 38.76 by 10.2.

$$.38.76 \div 10.2 = 387.6 \div 102 = 3.8$$

```
306
---
 816
 816
---
```

In this instance the dividend is a decimal of the first order ; hence, the quotient is a decimal of the first order, therefore

Answer.— $38.76 \div 10.2 = 3.8$

Example.—Divide 0.0924 by 3.3

$$0.0924 \div 3.3 = 0.924 \div 33 = 0.028$$

```
66
---
 264
 264
---
```

Here the dividend is a decimal of the third order, thus the quotient also a decimal of the third order, hence :

Answer.— $0.0924 \div 3.3 = 0.028$

If the divisor does not terminate, or has been carried as far as necessary, the remainder may be expressed as a common fraction being part of the quotient, or may be rejected if less than $\frac{1}{2}$ or unimportant, and the incompleteness of the result marked at the right of the fraction by +, or if the remainder is $\frac{1}{2}$ or more, the last digit of the decimal may be made to express one more.

Example.—Divide 409.6 by 8.5 to three decimals.

$$409.6 \div 8.5 = 4096 \div 85 = 48.188$$

```
340
---
 696
 680
 ---
  160
   85
  ---
   750
   680
   ---
    700
    680
    ---
     20
```

Answer.— $409.6 \div 8.5 = 48.188\frac{20}{85} = 48.188\frac{4}{17}$ or
$409.6 \div 8.5 = 48.188+$ or
$409.6 \div 8.5 = 48.188$

Example.—If $437\frac{3}{4}$ lbs. wool cost $\$529.67\frac{3}{4}$ what will one pound cost ?

$$529.67\tfrac{3}{4} \div 437.75 \text{ or } 52967.75 \div 43775 = 1.21$$

```
43775
-----
 91927
 87550
 -----
  43775
  43775
  -----
```

Answer.—The value of one pound of wool given in example is $1.21

SQUARE ROOT.

The square root of a given number is such a number which, being multiplied by itself, will produce the given number. Hence, the square root of 36 is 6, because 6×6 (or the square of 6) is 36.

The symbol $\sqrt{}$ or $\sqrt[2]{}$ placed at the left of a number denotes that the square root of that number is to be taken; hence, $\sqrt{49}$ reads: take the square root of 49, which is 7, since $7\times7=49$.

The square root of a number contains either twice as many figures as the root, or twice as many less one. For example:

$\sqrt{64} = 8$ (since $8\times8=64$) 2 figures in square. 1 figure in root.

$\sqrt{100} = 10$ (since $10\times10=100$) 3 figures in square. 2 figures in root.

A small figure 2 placed to the right and above a number is the symbol that the square of that number is to be taken, hence 4^2 denotes the square of 4 or $4\times4=16$.

A number which has a whole number for its square root is termed a perfect square, and such perfect squares, not greater than 100, must be committed to memory; *i. e.*, $2^2=4$, $3^2=9$, $4^2=16$, $5^2=25$, $6^2=36$, $7^2=49$, $8^2=64$, $9^2=81$, $10^2=100$. An imperfect square is a number whose root cannot be exactly found.

Rule.—**For finding the square root for any number.**

Separate the given number into periods of two figures each, beginning at the unit places.

Find the greater square in the left hand period, and place its root as the first figure of the root; deduct its square from the first period, and to the remainder (if any), bring down the next period for a dividend.

Divide this new dividend, omitting the right hand figure by double the first figure of the root, and place the quotient to the right of the first figure of the root, and also to the right of the partial divisor. Multiply the complete divisor by the last figure of the root, subtract the product from the dividend, and to the remainder bring down the next period for a new dividend.

Divide this new dividend, omitting the right hand figure by double the whole root so far found, and place the quotient to the right of the root, and also to the right of the partial divisor. Multiply the complete divisor by the last figure of the root, subtract product from dividend, and to the remainder bring down next period for a new dividend.

Continue the operation as before until all periods are brought down.

If the last remainder is zero, the given number is a perfect square.

Example.—Find square root of 729.

```
  √7 | 29 = 27.
   4
  ———
47)329
   329
  ———
   000
```

Answer.— $\sqrt{729} = 27$.

Proof.— $27 \times 27 = 729$.

Example.—Find square root of 148,225.

```
√14 | 82 | 25=385
  9
 ———
68)582
   544
 ———
765)3825
    3825
```

☞ **In dividing 58 by 6 the quotient is 9, but if we add this to complete the divisor (6 and 9=69 × 9=621) the latter would become 69, which if multiplied by 9 would give 621, a number larger than the dividend 582, thus 8 in place of 9 must be used.**

Answer.— $\sqrt{14 | 82 | 25}=385$.

Proof.— $385\times385=148,225$.

Example.—Find square root of 89,401.

$\sqrt{8 \mid 94 \mid 01} = 299$

```
       4
    ----
  49)494
     441      The division of 49 by 4 illustrates the same remarks as made in previous example.
    ----
 589)5301     The second remainder (53) is in this example greater than the divisor (49), a result not uncommon.
     5301
    ----
```

Answer.— $\sqrt{89401} = 299$ *Proof.*— $299 \times 299 = 89401$.

If the dividend at any time does not contain the complete divisor, place a zero in the root, and add the next period for a new dividend.

If an integral number is not a perfect square and its root is to be found, annex as many periods of ciphers as there are to be decimal places in the root. The more periods of ciphers we use, the nearer approximation of the root is obtained.

Example.—Find square root of 36469521.

$\sqrt{36 \mid 46 \mid 95 \mid 21} = 6039$

```
          36
       -------
 1203)  4695      Here in the process as 0 occurs in the root, we annex the 0 to the divisor 12, and
        3609      annex the next period to the corresponding dividend.
       -------
 12069)108621
       108621
       -------
```

Answer.— $\sqrt{36469521} = 6039$.

Square Root of Decimal Fractions.

For finding the square root of a decimal fraction, make the decimal such that the index of its order is an even number; also, since every period of two figures in the square equals one figure in the root, we must use as many periods in the decimal part of the square as there are to be decimals in the root.

Example.—Find the square root of 0.139 to three places of decimals.

$\sqrt{0.13 \mid 90 \mid 00} = 0.372+$

```
      9
    ----
 67)490
    469
    ----
742)2100
    1484
    ----
     616
```

Answer.— $\sqrt{0.139} = 0.372+$

Proof.— $0.372 \times 0.372 = 0.138384$

\+ Remainder, 0.000616

0.139000

The square root of a decimal of an odd order is always a non-terminating decimal. See symbol + for it at the right hand of the decimal fraction of the square root in previous example.

Example.—Find square root of 0.8436 to two places of decimals.

$\sqrt{0.84 \mid 36} = 0.91+$, or 0.92

```
      81
    ----
181)336
    181
    ----
    155
```

For this example the index is of an even order but not terminating; hence, symbol + at the right of the root. The last figure of the root is $\frac{1}{10}$, which we may change to $\frac{2}{10}$, as the remainder, 155, is more than $\frac{1}{2}$ of the divisor, 181; thus:

Answer.— $\sqrt{0.8436} = 0.92.$

Square Root of Common Fractions.

If we have to extract the square root of a common fraction, change the fraction to its lowest terms; if both terms are perfect squares, take the root of each; if imperfect squares, change the fraction to a decimal, and find root as before.

Example.— $\sqrt{\frac{9}{64}}$ $\frac{\sqrt{9}}{\sqrt{64}} = \frac{3}{8}$ *Answer.*— $\sqrt{\frac{9}{64}} = \frac{3}{8}$

Example.—Find square root of $\frac{39}{81}$

$$\sqrt{\frac{39}{81}} = \sqrt{\frac{13}{27}} = \frac{\sqrt{13}}{\sqrt{27}}$$

```
√ 13  =3.60555+
  9
 66)400
    396
 7205)40000
      36025
 72105)397500
       360525
 721105)3697500
        3605525
          91975
```

```
√ 27  =5.19615+
  25
 101)200
     101
 1029)9900
      9261
 10386)63900
       62316
 103921)158400
        103921
 1039225)5447900
         5196125
          251775
```

$\sqrt{\frac{39}{81}} = \sqrt{\frac{13}{27}} = \frac{3.60555}{5.19615}$ or $3.60555 \div 5.19615$

```
36055500000÷519615=0.69388+
3117690
 4878600
 4676535
  2020650
  1558845
   4618050
   4156920
    4611300
    4156920
     454380
```

Answer.— $\sqrt{\frac{39}{81}} = 0.69388$

To prove the correctness of the above example, we will next find answer by changing the common fraction $\frac{39}{81}$, for which we have to find the square root in a decimal.

$$\frac{39}{81} = 39.0 \div 81 = 0.481481+$$

```
324
---
 660
 648
 ---
  120
   81
  ---
  390
  324
  ---
   660
   648
   ---
    120
     81
    ---
     39
```

$$\sqrt{0.481481} = 0.69388+$$

```
        36
        --
  129)1214
      1161
      ----
 1383)5381
      4149
      ----
13868)123200
      110944
      ------
138768)1225600
       1110144
       -------
        115456
```

Answer.— $\sqrt{\frac{39}{81}} = 0.69388 +$ being the same result as before.

Another method of proving this example, is to find the square root out of the common fraction without reducing it to its lowest terms. If correct it will also demonstrate to the student that the reducing of a common fraction (for drawing the square root) to its lowest terms is correct, and either may be made use of or not.

$$\sqrt{\frac{39}{81}} = \frac{\sqrt{39}}{\sqrt{81}} \qquad \sqrt{39} = 6.24499+$$

```
                 36
                 --
       122)     300
                244
                ---
      1244)    5600
               4976
               ----
     12484)   62400
              49936
              -----
    124889)  1246400
             1124001
             -------
   1248989) 12239900
            11241901
            --------
              997999
```

$$\sqrt{81} = 9$$

```
81
--
```

$$\sqrt{\frac{39}{81}} = \frac{6.24499+}{9} \text{ or } 6.24499 \div 9$$

```
9)6.24499=0.69388+
  54
  --
   84
   81
   --
    34
    27
    --
     79
     72
     --
     79
     72
     --
      7
```

Answer.— $\sqrt{\frac{39}{81}} = 0.69388+$ or the same answer as already proven.

Note.—This example will also demonstrate to the student that the reducing of a fraction to its lowest terms is not always the shortest course; *i. e.*, always examine in which fraction you find either one or both terms a perfect square; 81 is a perfect square, whereas 27 is not.

Square Root of Mixed Numbers.

If we have to extract the square root of a mixed number composed of an integer and a common fraction, change the same to its equivalent value either in an improper fraction, or a mixed number expressed by integer and decimals, and proceed as explained before.

Example—Find square root of $9\frac{36}{64}$. *a.* Use decimals. *b.* Use improper fraction.

a. $\sqrt{9\frac{36}{64}}$ $\frac{36}{64} = 36 \div 64 = 0.5625$; thus: $9\frac{36}{64} = 9.05625$ and,

$\sqrt{9.56 \mid 25} = 3.092+$

```
        9
       ----
 609)  5625
       5481
       -----
6182) 14400
      12364
      -----
       2036
```

Answer.— *a.* 3.092+ is the square root of $9\frac{36}{64}$.

b. $\sqrt{9\frac{36}{64}} = \sqrt{\frac{612}{64}} = \frac{\sqrt{612}}{\sqrt{64}}$

$\sqrt{6 \mid 12} = 24.739+$

```
         4
        ---
   44)212
      176
      ---
  487) 3600
       3409
       -----
 4943) 19100
       13929
       ------
49469) 517100
       445201
       ------
        71899
```

$\sqrt{64} = 8$
64

$\sqrt{9\frac{36}{64}} = \frac{24.739+}{8}$ and

```
24.739 ÷ 8 = 3.092 +
24
--
 73
 72
 --
  19
  16
  --
   3
```

Answer.— *b.* 3.092 + is the square root of $9\frac{36}{64}$.

Table of Square Roots.

(From 1 to 240.)

Number	Square Root.	Number	Square Root.	Number	Square Root.	Number	Square Root.
1	1.0000	19	4.3589	37	6.0828	75	8.6603
2	1.4142	20	4.4721	38	6.1644	80	8.9443
3	1.7321	21	4 5826	39	6.2450	85	9.2195
4	2.0000	22	4.6904	40	6.3246	90	9.4868
5	2.2361	23	4.7958	41	6.4031	95	9.7468
6	2.4495	24	4.8990	42	6.4807	100	10 0000
7	2.6458	25	5.0000	43	6.5574	110	10.4881
8	2.8284	26	5.0990	44	6.6332	120	10.9545
9	3.0000	27	5.1962	45	6.7082	130	11.4018
10	3.1623	28	5.2915	46	6.7823	140	11.8322
11	3.3166	29	5.3852	47	6.8557	150	12.2474
12	3.4641	30	5.4772	48	6.9282	160	12.6491
13	3.6056	31	5.5678	49	7.0000	170	13.0384
14	3.7417	32	5.6569	50	7.0711	180	13.4164
15	3.8730	33	5.7446	55	7.4162	190	13.7840
16	4.0000	34	5.8310	60	7.7460	200	14.1421
17	4.1231	35	5.9161	65	8.0623	220	14.8323
18	4.2426	36	6.0000	70	8.3666	240	15.4919

CUBE ROOT.

If a number is multiplied twice by itself, the product is called the cube of the number; hence 216 is the cube of 6, since $6 \times 6 = 36 \times 6 = 216$.

To extract the cube root of a given number, is to find one of the three factors producing.

The symbol $\sqrt[3]{\ }$ placed before a given number, indicates that the cube root is wanted.

There are two kinds of cubes, perfect cubes, being such which have an integer for its cube root; and imperfect cubes, containing a mixed number or fraction for its cube root.

The following numbers of less than 1,000 are perfect cubes:

8 is the cube of 2; 27 is the cube of 3; 64 is the cube of 4; 125 is the cube of 5;
216 is the cube of 6; 343 is the cube of 7; 512 is the cube of 8; 729 is the cube of 9.

Rule for Finding the Cube Root of a Given Number.

Separate the numbers into periods of three figures each, beginning at units place.

Find the greatest cube root of the left hand period and place its root at the right. Subtract the cube of this root from the left hand period, and to the remainder annex the next period for a new dividend. Next place three times the first figure of the root to the extreme left and three times the square of the first figure of the root, with two ciphers affixed to it, to the left near the dividend for a trial divisor. Divide the dividend by this trial divisor and put the quotient at the right of the extreme left situated number and also as the second figure of the root.

Read extreme number and quotient as one number, and multiply the same by the seccnd figure of the root. Put this product below the trial divisor and add both; multiply this sum again by the second figure of the root, and put product below the dividend. Next subtract, and if a remainder, annex a new period, form second extreme left number, second trial divisor and quotient (= next figure for root) and proceed as before.

Example.—Find cube root of 110,592.

(Extreme left number)	(Quotient)		$\sqrt[3]{110 \mid 592}$ = 48 (Cube root)	Specified figuring.
			64	$4 \times 4 \times 4 = 64$
		4800	——	$4 \times 3 = 12$
12	8	1024	46592	$4 \times 4 = 16 \times 3 = 48$ (4800)
		5824	46592	$128 \times 8 = 1024$
			——	$5824 \times 8 = 46592$
			00000	

Answer.— $\sqrt[3]{110592} = 48$ *Proof.*— $48 \times 48 = 2304 \times 48 = 110592$

If required to extract the cube root of a decimal fraction, divide the fraction also into periods of three figures each, commencing from the decimal point toward the right. If in the last period only one figure is left, annex two ciphers; if two figures are left over annex one cipher, or in other words, the decimal fraction must be some multiple of 3.

Example.—Find cube root of 553.387661.

			$\sqrt[3]{553.387 \mid 661}$ = 8.21	Specified figuring.
			512	$8 \times 8 \times 8 = 512$
24 —	2 —	19200	——	$8 \times 3 = 24$
		484	41387	$8 \times 8 = 64 \times 3 = 192 = (19200)$
		19684	39368	$242 \times 2 = 484$
			——	$19684 \times 2 = 39368$
				$82 \times 3 = 246$
246 —	1 —	2017200	2019661	$82 \times 82 = 6724 \times 3 = 20172$ (2017200)
		2461	2019661	$2461 \times 1 = 2461$
		209661		$2019661 \times 1 = 2019661$

Answer.— $\sqrt[3]{553.387661} = 8.21.$ *Proof.*— $8.21 \times 8.21 = 67.4041 \times 821 = 553.387661.$

The cube root of a common fraction is found either by taking the cube roots of their terms or by reducing the common fraction to a decimal and proceeding as before.

Example.—Find cube root of $\frac{27}{343}$

$$\sqrt[3]{\frac{27}{343}} = \frac{\sqrt[3]{27}}{\sqrt[3]{343}} \quad \Big| \quad \sqrt[3]{27} = 3 \qquad \sqrt[3]{343} = 7; \text{ hence,}$$

$$\sqrt[3]{\frac{27}{343}} = \frac{3}{7}$$

or $\sqrt[3]{\frac{27}{343}}$ change $\frac{27}{343}$ to a decimal. $(27 \div 343 = 0.078717+)$ and find

$$\sqrt[3]{0.078 \mid 717} = 0.42+$$

```
                         64
12  —  2  —  4800    ———————
              244 | 14717
            ————— | 10088
             5044  ———————
                    4629
```

Answer.— $\sqrt[3]{\frac{27}{343}} = 0.42+$

Proof.— Change $\frac{3}{7}$ to a decimal $3 \div 7 = 0.42+$

If we have to extract the cube root of a mixed number composed of an integer and common fraction, change the same to its equivalent value, either in an improper fraction or to a mixed number expressed by integer and decimals, and proceed as explained before.

Table of Cube Roots.

(From No. 2 to 50.)

Number	Cube Root.	Number	Cube Root.	Number	Cube Root.	Number	Cube Root.
2	1.259921	14	2.410142	26	2.962496	38	3.361975
3	1.442250	15	2.446212	27	3.000000	39	3.391211
4	1.587401	16	2 519842	28	3.036589	40	3.419952
5	1.709976	17	2.571282	29	3.072317	41	3.448217
6	1.817121	18	2.620741	30	3.107232	42	3.476027
7	1.912931	19	2.668402	31	3.141381	43	3.503398
8	2.000000	20	2.714418	32	3.174802	44	3.530348
9	2.080084	21	2.758924	33	3.207534	45	3.556893
10	2.154435	22	2.802039	34	3.239612	46	3.583048
11	2.223980	23	2.843867	35	3.271066	47	3.608826
12	2.289428	24	2.884499	36	3.301927	48	3.634241
13	2.351335	25	2.924018	37	3.332222	50	3.684031

AVERAGE AND PERCENTAGE.

Average.—The average of two, three or more groups of numbers, is found by adding the numbers and dividing the sum by the number of groups used.

Example.—Find average counts between 5 and 6-run yarn.

$$\begin{array}{r} 5 \\ +6 \\ \hline 11 \div 2 = 5\frac{1}{2} \end{array}$$

Answer.— $5\frac{1}{2}$-run.

Example.—Find average lengths of the following 5 pieces of cloth measuring respectively 42 yards, 43 yards, $42\frac{1}{2}$ yards, $41\frac{3}{4}$ yards, 42 yards.

$$\begin{array}{r} 42 \\ 43 \\ 42\frac{1}{2} \\ 41\frac{3}{4} \\ +42 \\ \hline 211\frac{1}{4} \end{array} \qquad 211\tfrac{1}{4} \div 5 = 42\tfrac{1}{4}$$

Answer.— The average length of the pieces of cloth in question, is $42\frac{1}{4}$ yards.

Percentage.—The symbol of percentage is %, and reads per cent. For example: 32% white wool, reads 32 per cent. white wool.

Per cent. means by the hundred, thus 32 % means 32 of every hundred. For example, we speak about a mixture of wool as gray mix, 40 % white, the remainder black; this means, that in every hundred pounds wool there are forty pounds white, and sixty pounds black; thus, if the lot of wool contains 450 lbs. wool, we used 180 lbs. white wool, 270 lbs. black wool.

The *Rate* per cent, is the number of hundreths.

The *Base*, is the number on which the percentage is estimated.

Rule for finding the percentage: Multiply the base by the rate per cent.

Example.—Find 12 per cent. of 430 lbs. $430 \times \frac{12}{100} = 51.60.$

Answer.— 12 per cent. of 430 lbs. is 51.6 lbs.

Proof.—

$$\begin{array}{l} 100 \\ 12 \text{ and } 88 \text{ per cent. of } 430 = 430 \times \frac{88}{100} = 378.40 \\ \hline 88 \;+\; 12 \quad \text{“} \quad \text{of } 430 = (\text{See example.}) = 51.60 \\ \hline \qquad\qquad\qquad 430.00 \text{ lbs.} \end{array}$$

Rule for finding the rate per cent.—Divide the percentage by the base.

Example.—In a lot of wool of 400 lbs., there are 20 lbs. red wool and 380 lbs. black; how many per cent. of red wool are used in this lot?

$$20 \div 400 = \tfrac{20}{400} = \tfrac{5}{100}.$$

Answer.— 5 per cent. of red wool are used.

Proof.— $400 \times \frac{5}{100} = 20.$

Rule for finding the base.—Divide the percentage by the rate per cent.

Example.—Received 138 lbs. of yarn marked as 8 per cent. of the entire lot, how many pounds are in the whole lot?

$$138 \div \tfrac{8}{100} = 1725$$

Answer.— 1,725 lbs. yarn are in the entire lot of yarn.

Proof.— $138 \div 1725 = 0.08 = \frac{8}{100}$ or 8 per cent.

RATIO.

Ratio is the relation which one number (called the *Antecedent*) has to another number (called the *Consequent*) of the same kind, and is obtained by dividing the first by the second; thus, the ratio of 20 to 5 is $20 \div 5$ or 4.

The symbol of ratio is a colon (:), or the ratio may be written as a fraction; thus, 20 to 5 may be expressed either as 20:5 or $\frac{20}{5}$.

Both terms of a ratio are called a *Couplet*.

Simple Ratio is the comparing of two numbers; for example, $18 : 6 = 3$.

Compound Ratio is the comparison of the products of the corresponding terms of two or more ratios; *for example.*—find the ratio of 2:4, 8:3, and 6:2.

$$\left.\begin{matrix}2:4\\8:3\\6:2\end{matrix}\right\} = \frac{2\times8\times6}{4\times3\times2} = \frac{\overset{2}{\not{2}}\times\overset{2}{\not{8}}\times\not{6}}{\not{4}\times\not{3}\times\not{2}} = \frac{2\times2}{1} = \frac{4}{1} = 4$$

Answer.—The simple ratio for example is 4 : 1 or 4.

This example will give us the rule for changing a compound ratio to a simple ratio as follows: Multiply the antecedents together for a new antecedent, and the consequents for a new consequent, and reduce both to their lowest equivalent terms.

As previously mentioned the ratio is a fraction, consequently its terms may be treated like those of a fraction, thus the following

Principles of Ratio.

The ratio is equal to the antecedent divided by the consequent.

Multiplying the antecedent, multiplies the ratio.

Multiplying the consequent, divides the ratio.

Dividing the antecedent, divides the ratio.

Dividing the consequent, multiplies the ratio.

Multiplying or dividing the antecedent and consequent by the same number, does not effect the ratio.

The product of two or more simple ratios, is the ratios of their products.

PROPORTION.

Proportion consists in the equality of two ratios, and is expressed by the symbol of equality (=) or the double colon (::).

Every proportion consists of two couplets, or four terms. For example.— 8 : 12 = 4 : 6.

The Antecedents are the first and third terms (8 and 4 in example).

The Consequents are the second and last terms (12 and 6 in example).

The Extremes are the first and last terms (8 and 6 in example).

The Means are the second and third terms (12 and 4 in example.)

Principles of Proportion.

In a proportion the product of the means is equal to the product of the extremes.

(12 × 4 = 48, product of the means.
8 × 6 = 48, " " extremes.)

The product of the extremes divided by either mean will give the other mean.

Product of the extremes.	÷	One mean.	=	The other mean.
48	÷	12	=	4
48	÷	4	=	12

The product of the means divided by either extreme will give the other extreme.

Product of means.	÷	One extreme.	=	The other extreme.
48	÷	8	=	6
48	÷	6	=	8

There are two kinds of proportions; single and compound proportion.

Single proportion is an equality between two simple ratios, and is used to find the fourth term of a proportion where the other three terms are given. Two terms of the given three must be of the same kind and constitute a ratio; and the third term (of the given three) must be of the same kind as the regular term, and constitute with it another ratio equal to the first.

Example.— 16,800 yards of yarn weigh 16 oz., find the weight of 3,900 yards.

Yards.		Yards.		oz.		oz.
16800	:	3900	::	16	:	x

3,900 × 16 = 62400 (product of the means).

$$\left\{\begin{matrix}\text{Product of}\\ \text{the means.}\end{matrix}\right\} \div \left\{\begin{matrix}\text{The given}\\ \text{extreme.}\end{matrix}\right\} = \left\{\begin{matrix}\text{The other}\\ \text{extreme.}\end{matrix}\right\}$$

$$62400 \div 16800 = 3\tfrac{12}{168} \quad \text{or } 3\tfrac{5}{7}.$$

Answer.— 3,900 yards weigh $3\frac{5}{7}$ oz.

Proof.— 3,900 × 16 = 62,400 product of the means.
16,800 × $3\frac{5}{7}$ = 62,400 " " extremes.
(16,800 × $3\frac{5}{7}$ = 16,800 × $\frac{26}{7}$ and 16,800 × 26 = 436,800 ÷ 7 = 62,400.)

A Compound Proportion is a proportion in which either one or both the ratios are compound.

The rule for finding the answer is as follows: Place the number which is of the same kind or denomination as the answer required for the third term, form a ratio of each remaining pair of numbers of the same kind, the same as done in simple proportion, using each couplet without any reference to the other. Next, divide the product of the means by the product of the given extremes, and the quotient is the fourth term (= answer.)

Example.—If weaving 1,536 yards of cloth on 8 looms in 12 days, how many yards will be woven on 34 looms in 16 days.

(Looms to Looms.) 8 : 34
(Days to Days.) 12 : 16
(Yards to Yards.) 1,536 : x

$$\frac{16 \times 34 \times 1{,}536}{12 \times 8} = x \quad \text{or} \quad \frac{\overset{2}{\not{16}} \times 34 \times \overset{128}{\not{1536}}}{\not{12} \times \not{8}} = 2 \times 34 = 68 \times 128 = 8704$$

Answer.— 8,704 yards will be woven.

Proof.—8 looms 12 days = 8 × 12 = 96 looms running 1 day.
1,536 yards are woven on 96 looms in one day; thus, 1536 ÷ 96 = 16 yards per day (per one loom).
34 looms 16 days = 34 × 16 = 544 looms running 1 day; thus,
544 × 16 = 8,704 yards will be woven either on 544 looms in 1 day, or on 34 looms in 16 days.

Example.—If weaving 9,448 yards of cloth on 12 looms in 9 days, running the looms 10 hours per day, how many yards of cloth will 20 looms, running 11 hours per day, produce in 12 days.

(Looms to Looms.) 12 : 20
(Days to Days.) 9 : 12
(Hours to Hours.) 10 : 11
(Yards to Yards.) 9448 : x

$$\frac{11 \times 12 \times 20 \times 9448}{10 \times 9 \times 12} = x$$

$$\frac{11 \times \not{12} \times \overset{2}{\not{20}} \times 9448}{\not{10} \times 9 \times \not{12}} = \frac{11 \times 2 \times 9448}{9}$$

$$11 \times 2 = 22 \times 9448 = 207856$$

$$207856 \div 9 = 23095\tfrac{1}{9}$$

Answer.—23,095$\frac{1}{9}$ yds. will be produced.

Proof.—12 looms, 9 days, 10 hours = 1,080 hours for one loom
9,448 are woven in 1,080 hours on one loom; thus,
9,448 ÷ 1,080 = $8\frac{101}{135}$ yds. per hour on one loom.
20 looms, 11 hours, 12 days = 2,640 hours; thus,
2,640 × $8\frac{101}{135}$ = $23{,}095\frac{1}{9}$ yds. will be woven either in 2,640 hours on one loom, or on 20 looms running 11 hours per day in 12 days.

ALLIGATION.

Alligation has for its subject the mixing of articles of different value and different quantities.

Alligation Medial.

Rule.—Multiply each quantity by its value and divide the sum of the products by the sum of the quantities.

Example.—Find the average value per pound for the following lot of wool containing mixed:

380 lbs. @ 74¢ per lb.
400 " " 78 " "
200 " " 79 " "
20 " " 94 " "

380 × 74 =	$281.20	
400 × 78 =	312.00	
200 × 79 =	158.00	770.00 ÷ 1000 = 0.77
20 × 94 =	18.80	
1000	$770.00	

Answer.—The price of the mixture is 77¢ per lb.
Proof.— 77¢ × 1000 = $770.00.

Alligation Alternate.

Rule.—Place the different values of the articles in question under each other, and the average rate wanted to the left of them. Next find the gain or loss on one unit of each, and use an additional portion (of one, two or more) of any that will make the gains balance the losses.

Example.—How much of each kind of wool at respective values of 80¢, 84¢ and 98¢, must be mixed to produce a mixture to sell at 88¢ per lb.

88	80	+ 8 × 1 =	8	
	84	+ 4 × 1 =	+ 4	= 12 gain
	98	− 10 × $1\frac{1}{5}$ =		= 12 loss

Answer.—We must use 1 part wool from the lot @ 80¢.
1 " " " " " " 84
$1\frac{1}{5}$ " " " " " " 98 in

$3\frac{1}{5}$ parts, to produce a mixture to sell at 88¢ per lb.

Proof.— By alligation medial.

1 lb. × 80¢ .... 80¢
1 lb. × 84 84
$1\frac{1}{5}$ lbs. × 98 .... $117\frac{3}{5}$

$3\frac{1}{5}$ lbs. $281\frac{3}{5}$¢ and $3\frac{1}{5}$ lbs. × 88¢ = also $281\frac{3}{5}$¢

To Find the Quantity of Each Kind Where the Quantity of One Kind or of the Mixture is Given.

Example.—A manufacturer has 200 lbs. of wool of a value of 92 cents on hand which he wants to use up and produce a lot worth 80 cents per lb. He also has another large lot (2400 lbs.) of wool worth 73 cents per lb. on hand. How much of the latter must he use to produce the result; *i. e.*, a mixture worth 80 cents per lb?

$$80 \begin{cases} 92 \\ 73 \end{cases} \begin{vmatrix} -\ 12 \times 200 = 2{,}400 \text{ loss.} \\ +\ \ 7 \times 342\tfrac{6}{7} = 2{,}400 \text{ gain.} \end{vmatrix}$$

Answer.—He must mix 200 lbs. of the lot at 92 cents per lb. on hand and add $342\frac{6}{7}$ lbs. of the lot at 73 cents per lb. to produce a mixture worth 80 cents per lb.

Proof.—

200 lbs. × 92¢ =	$184.00	
$342\frac{6}{7}$ lbs. × 73¢ =	$250.28\frac{4}{7}$	
$542\frac{6}{7}$	$\$434.28\frac{4}{7}$	and $542\frac{6}{7}$ lbs. @ 80¢ = also $\$434.28\frac{4}{7}$.

U. S. MEASURES.

Measures of Length.

12 inches (in.)	=	1 foot (ft.).
3 feet	=	1 yard (yd.).
$5\frac{1}{2}$ yards	=	1 rod (rd.).
40 rods	=	1 furlong (fur.).
8 furlongs	=	1 mile (mi.).
3 miles	=	1 league (lea.).
1760 yards	=	1 mile.
6 feet	=	1 fathom.

Avoirdupois Weight.

16 drachms (dr.)	=	1 ounce (oz.).
16 ounces	=	1 pound (lb.).
28 pounds	=	1 quarter (qr.)
4 quarters	=	1 hundred weight(cwt.).
20 hundredweight	=	1 ton.
1 pound *Avoirdupois*	=	7,000 grains, *Troy*.
1 ounce "	=	$437\frac{1}{2}$ " "

Surface Measure.

144 square inches (sq. in.)	=	1 square foot (sq. ft.).
9 " feet	=	1 " yard (sq. yd.)
$30\frac{1}{4}$ " yards	=	1 " rod (sq. rd.).
40 " rods	=	1 rood (ro.).
4 roods	=	1 acre (ac.).
4840 square yards	=	1 acre.
60 acres	=	1 square mile.

Measure of Capacity.

60 minims	=	1 fluid drachm (fl. dr.).
8 fluid drachms	=	1 fluid ounce (fl. oz.).
20 fluid ounces	=	1 pint (pt.).
2 pints	=	1 quart (qt.).
4 quarts	=	1 gallon (gall.).
2 gallons	=	1 peck (pk.).
4 pecks	=	1 bushel (bus.).
8 bushels	=	1 quarter (qr.).

1 minim equals 0.91 grain of water.

Cubic Measure.

1728 cubic inches (cu. in.)	=	1 cubic foot (cu. ft.).
27 cubic feet	=	1 cubic yard (cu. yd.).

Angle Measure.

60 seconds (″)	are	1 minute (′).
60 minutes	"	1 degree (°).
360 degrees	"	1 circumference (C).

Counting.

12 ones	=	1 dozen (doz.).
12 dozen	=	1 gross (gr.).
12 gross	=	1 great gross (gr. grs.).
20 ones	=	1 score.

Troy Weight.

24 grains (gr.)	=	1 pennyweight.
20 pennyweights	=	1 ounce.
12 ounces	=	1 pound.

Paper.

24 sheets	=	1 quire.
20 quires	=	1 ream.
2 reams	=	1 bundle.
5 bundles	=	1 bale.

Apothecaries' Weight.

20 grains	=	1 scruple.
3 scruples	=	1 dram.
8 drams	=	1 ounce.
12 ounces	=	1 pound.

METRIC SYSTEM.

The Metric System, of weights and measures, is formed upon the decimal scale, and has for its base a unit called a metre.

Units.—The following are the different units with their English pronunciation:

The Metre (meter).—The unit of the Metric Measure is (very nearly) the ten millionths part of a line drawn from the pole to the equator.

The Litre (leeter).—The unit for all metric measures of capacity, dry or liquid, is a cube whose edge is the tenth of a metre (or one cubic decimetre).

The Gram (gram).—The unit of the Metric Weights, is the weight of a cubic centimetre of distilled water at 4° centigrade.

The Are (air).—is the unit for land measure. (It is a square whose sides are ten (10) metres.)

The Stere (stair).—is the unit for solid or cubic measure. (It is a cube whose edge is one (1) metre.)

Measure of Length.

Metric Denominations and Values.		Equivalent in Denominations used in the United States.	
	Meters.	Inches.	
Myriametre (Mm.)	or 10000 equals	393707.904 =	6.21 miles.
Kilometre (Km.)	" 1000 "	39370.7904 =	3 280 ft. 10 in
Hectometre (Hm.)	" 100 "	3937.07904 =	328 ft. 1 in.
Decametre (Dm.)	" 10 "	393.707904 =	32.8 ft.
Metre (M.)	" 1 "	39.3707904 =	3.28 ft. almost 40 in.
Decimetre (dm.)	" 0.1 "	3.9370790 =	almost 4 in.
Centimetre (cm.)	" 0.01 "	0.3937079	
Millimetre (mm.)	" 0.001 "	0.0393707	

U. S. Measures.	Metric Measure.	U. S. Measures	Metric Measures.
1 Inch =	2.5399 Centimeters.	1 Foot =	3 0479 Decimetres.
1 Yard =	0.9143 Metre.	1 Mile =	1609.32 Metres.

Measure of Capacity.

Metric Denominations and Values.			Equivalent in United States Denominations.
Myrialitre (Ml.)	= 10000 litres	= 10 cubic meters	= 2200.9670 gallons
Kilolitre (Kl.)	= 1000 "	= 1 " metre	= 220.0967 "
Hectolitre (Hl)	= 100 "	= 100 " decimetres	= 22.0097 "
Decalitre (Dl.)	= 10 "	= 10 " decimetres	= 2.2009 "
Litre (L.)	= 1 "	= 1 " decimetre	= 1.7608 pints
Decilitre (dl.)	= 0.1 "	= 100 " centimetres	= 6.1027 cubic inches
Centilitre (cl.)	= 0.01 "	= 10 " centimetres	= 0.61027 " "
Millilitre (ml.)	= 0.001 "	= 1 " centimetre	= 0.061 " "

Measure of Weight.

Metric Denominations and Values.			Equivalent in United States Denominations.
Myriagram (Mg)	= 10000 grams.	= 10 cu. decimetres of water	22 046 lbs., Avoir
Kilogram (Kg.)	= 1000 "	= 1 " " " "	2.204 " "
Hectogram (Hg.)	= 100 "	= 100 " centimetres " "	3.527 oz., "
Decagram (Dg.)	= 10 "	= 10 " " " "	154.323 grams
Gram (G.)	= 1 "	= 1 " " " "	15 432 "
Decigram (dg.)	= 0.1 "	= 100 " millimetres " "	1.543 "
Centigram (cg)	= 0.01 "	= 10 " " " "	0 154 "
Miligram (mg.)	= 0.001 "	= 1 " " " "	0.015 "

INDEX AND GLOSSARY.

Those marked thus * belong to Volume II, and those not marked belong to Volume I.

A

Avoirdupois Weight.—One pound avoirdupois is the weight of 27.7015 cubic inches of distilled water at 39.83° F., the barometer being 30 inches.

B

Backed Cloth.—This name applies to cloth which, in addition to the face fabric, bears bound underneath a layer either of extra filling, extra warp or another cloth.

Backing.—The filling which produces by interlacing with warp threads, the lower or back structure in a fabric.

Backwashing.—The process of washing wool a second time, i.e. after the same has been transferred by carding in a sliver.

Baize.—A coarse woolen stuff, principally manufactured for linings, and generally made either in scarlet or green.

Balling-Head.—The same is a modification of the common side-drawing spool-system, consisting in appliances for winding the sliver in balls, under considerable pressure.

Bandannas.—Handkerchiefs of cotton or silk, in which spots or figures are left in white or some bright color upon a ground of red or blue

Barras.—A coarse kind of cloth ; sack-cloth.

Barrege.—An open fabric resembling gauze, but more open in texture and stouter in thread. It was made of various materials, but is best known as made of silk warp and worsted filling. When it became fashionable, it was imitated in all-wool, and subsequently cotton warps were used. The fabric takes its name from the district in which it was first manufactured, the especial locality being a little village named Arosons, in the beautiful valley of *Barreges*, France.

Basket-weaves.—A sub-division of the plain weave.

—— For the construction of these weaves see pages 42 and 45 of Technology of Textile Design.

Batten.—A part of the Jacquard machine; the frame which carries the cylinder in its motion to and from the needle-board.

Baudekin.—A very rich silk, woven with gold. A rich cloth now called *brocade*. The name originates from *Baldacus*, Babylon

Beaver.—A beautiful fur, once used exclusively in the manufacture of hats, and now bearing a limited sale for articles of dress.

—— The name given at present also to smooth-face finished overcoatings made on the double cloth system.

Berlin Wool.—Known also as German wool. A material for working in needle-work.

Bicarbonate of Soda.—Is obtained by exposing the carbonate in an atmosphere of carbonic acid gas.

Binder-warp.—The warp threads producing the foundation of a fabric ; interior warp ; this warp is generally not visible in the finished fabric. Used in Astrakhans, Velvets, Brussels carpets, Upholstery fabrics, etc.

Blanket.—A woolen cover, soft and loosely woven.

Bleaching.—From the Fr. *blanchir*, to whiten. Originally known as whiting.

Blending.—Technically for mixing various materials or different qualities of the same material.

Bleach Cotton.—*Bucking.*—The cotton yarn or fabric is first boiled in water. When sufficiently boiled, 4 lbs. 7 oz. caustic soda and 4 lbs. 6½ ozs. silicate of soda, both previously dissolved, are added for each 220½ lbs. cotton material. Boiling preferably under pressure is continued for three or four hours. *Chloring.*—The material is rinsed, squeezed or wrung, and entered in the chloring vat, containing a solution of chloride of lime, ½ deg. to ¾ deg. B., at a temperature of 86 deg. F. The material remains in the bath for three or four hours. For 100 lbs. material, use about 4 lbs. chloride of lime. *Neutralising.*—Take out the material, let it drip off well, and then enter it for thirty or forty minutes in a sulphuric acid bath, which, for each 100 lbs of material to be treated, contains about 6 or 8 lbs. of acid. Then take out, beat and wash carefully in cold water. Enter in a boiling soap bath containing a little soda, rinse and blue, after the material has been sufficiently boiled. If this is not sufficient, repeat the entire process. *Blueing.*—For this process it is best to take a vat about 3 feet deep and 28 to 32 inches in diameter, fill it with water of 77 deg. to 86 deg. F., and add a proper quantity of ultramarine. The hanks are pressed through singly, and when the bath becomes too pale, add more ultramarine. The hanks are wrung out and placed upon a stand. When a certain quantity has been blued, it is entered in the press. Should the blue change, or should the material have a smell of sulphuretted hydrogen, it has been rinsed insufficiently.

Bleach Cotton Fabrics.—*1. With alkaline lye.*—Boil the cotton fabrics in water, after which add 2 lbs. of caustic soda, and same quantity of silicate of soda per 100 lbs. of material (the caustic soda and the silicate of soda should be previously dissolved). Then boil under pressure for three or four hours. *2. With chlorine.*—The goods are rinsed, pressed or wrung out, and placed in a chlorine vat, which has previously been prepared with a solution of chloride of lime, ½ to ¾ deg. B., at a temperature of 30 deg. They remain from 3 to 4 hours in the bath, 4 lbs of chloride of lime being used to each 100 lbs. of cotton. They are then acidified, by being first drained and then placed in a bath containing sulphuric acid, of the strength of 6 lbs. to 8 lbs. of sulphuric acid per 100 lbs of cotton. They should remain from 30 to 40 minutes in this bath, and when taken out, carefully washed in clean water and then placed in a boiling soap bath containing a small quantity of soda. They are again rinsed, and blued if required. If not sufficiently bleached, the chloring should be repeated *3. With chlorate of potash.*—First wash articles clean with soap. Afterwards dip into a bath of 100 to 104 deg. F., containing 1 lb of chlorate of potash per 100 lbs. of goods, and acidify with chemically-prepared, pure hydrochloric acid, until it obtains a distinctly acid smell, the trace of acid being afterwards removed by the goods being placed in a bath containing ½ per cent. of borax, after which rinse in flowing water, and dry in the air. With chlorate of potash great care is required. It should not be allowed to come in contact with concentrated acids or inflammable substances, such as sulphur or phosphorus, as accidents may occur. This process, though simple, meets with disfavor.

Bobbin.—The filling is wound on the bobbin, and the latter placed in the shuttle.

Bombasin.—A light silken stuff for mourning; also called bombazin or boratto.

Boss of a Roller.—The body of a roller, thus distinguished from the axle on which the same turns.

Bouchon.—The actual inventor of the principle of the Jacquard machine.

Brussels Carpet.—The same were introduced to Wilton, England, from *Tournai* Belgium, rather more than a century ago. For construction of the same, see my Technology of Textile Design, page 188.

Brocade.—A silk fabric with a pattern of raised figures.

Brocatel or *brocadel.*—A coarse brocade, chiefly used for tapestry.

Broken Twills.—Are twill weaves in which the direction of the characteristic twill line is arranged to run partways of the repeat in the weave from left to right, and partways from right to left. For their principle of construction, see page 52 of Technology of Textile Design.

Bur.—The prickly head of some plants which adheres to clothes like a flock of wool. The word *burr*, a peculiarity of speech, comes from the same source, and literally means to speak as if a flock of wool were in the throat.

Burl.—*Burling*, to pick the burrs or burls (also knots caused in spinning, dressing or weaving) from the surface of woolen cloth.

C

Caffa.—A rich *mediæval* stuff, probably of silk.

Calculations.—See Textile Calculations.

Calendering.—The process by which stuffs of various kinds are subjected to great pressure between rollers to make them smooth and finished.

Calico.—A common cotton cloth. The name is derived from *Calicut*, a city on the coast of Malabar, discovered by the Portugese in 1498, from where it was first imported. All early calicoes, until Hargreaves invention of the spinning jenny, were composed of linen warp yarn and cotton filling.

Cambric.—Derived from *Cambray*, a city in the French Netherlands, well known for its linen manufactures, especially cambrics.

Cam Loom.—A loom in which the harnesses are actuated on by cams.

Canvas.—From the *Lat. cannabis*; is literally hempen cloth.

Cap.—A steel cup (just large enough to cover the spinning bobbin) placed, mouth downwards, over the spindle of a cap frame.

Capuchin.—A hooded cloak for women, worn about the middle of the 18th century, and so called from resembling those worn by the order of friars of that name.

Carbonate of Soda.—Is obtained from sea salt by a series of chemical decompositions and processes.

Card.—A toothed instrument for disentangling and laying parallel the fibres of wool or cotton, preparatory to spinning.

Cardinal.—A short cloak, first worn with a scarlet hood, worn about the middle of the eighteenth century.

—— Engine.—Its inventor is not positively known, Louis Paul patented in 1748 in England, two different machines for carding, in one of which the cards were arranged on a flat surface, and in the other on a drum.

Carding of Cotton.. 29

—— of Flax.. 201

—— of Jute.. 211

—— of Wool.. 118

Carriage.—The technical name of a part of the Piano Card stamping machine ; see page 88 of The Jacquard Machine Analyzed and Explained.

—— The technical name of a part of the Repeating Machine ; see pages 93 and 96 of The Jacquard Machine Analyzed and Explained.

—— The technical name of a part of the Mule and Spinning machine.

Carriers.—Technically for carrying rollers; being small rollers supporting the slubbing or roving, between the front rollers of drawing machines, spinning frames, etc.

Carpet.—Carpets have been quite diverted from their original use, which was in covering tables (in this sense is derived the proverbial phrase "On the carpet" that is, brought to the table for discussion) sideboards, or cupboards. The manufacture of carpets so-called, is traced back in the records of French monastic orders as far as the tenth and eleventh centuries, but in all likelihood these were mere embroidered and not woven fabrics. The actual manufacture of carpets in Europe is assigned to the reign of Henry IV. of France, between 1589 and 1610, and is said to have been introduced there from Persia. An artisan, who had quitted France in disgust established the industry in England about 1750. (See Brussels carpet, Ingrain carpet, etc.)

Cartwright, Edmund.—The inventor of wool-combing and weaving by machinery.

Carrying Comb.—That portion of the nip-comb which carries the wool from the nip to the circle.

Cashmere Goat...

Cashmere Shawls.—These celebrated articles are made in the beautiful valley of *Cashmere*, in the northwest of India, and are produced from the woolly undercoat of the fur of the *Cashmere goat*. The high price of the fabric is due to two facts; first, in order to produce a single shawl 1½ yards square, at the least ten goats are robbed of their natural covering, since a single goat only produces from three to four ounces of it; secondly, their high price is due to the slow and laborious process of manufacture, which is such that a fine shawl having a pattern over its entire surface is sometimes a year on the loom, and even an ordinary shawl will take from sixteen to twenty weeks. It is claimed that in some instances over $3,000 have been paid for a single shawl, that very few of the finest of them find their way into Europe or this country. The commonest qualities range in price as low as $50. The annual produce of the country is estimated at 30,000 shawls, occupying about 16,000 looms, and near 50,000 work-people. Under the Mogul emperors Cashmere found work for 30,000 looms. The fabric is principally woven in strips, which are afterwards ingeniously joined together; the borders are worked in needlework by hand, each color employed occupying a separate needle. No shawls are made except upon order, and according to patterns already approved. The French, in factories at Lyons, Nismes, and Paris, are believed to have been most successful in copying these fabrics, though very fair imitations have been produced in England, at Paisley, Norwich and Edinburgh.

Cassimere.—Derived from Kerseymere, a finer description of Kersey, which is said to have taken its name from the factory at which it was originally manufactured having stood on a *mere* or brook running through the village of *Kersey*. It is at present the common name for fancy woolen suitings and trouserings.

Cellulose.—The chemical composition of full ripe cotton ; being a combination of carbon, hydrogen and oxygen technically expressed by $C_6 H_{10} O_5$.

Centigrade and Fahrenheit Scales Compared, Approximate.

Centigrade		Fahrenheit.	Centigrade.		Fahrenheit.	Centigrade.		Fahrenheit.	Centigrade.		Fahrenheit.
100°	=	212°	80°	=	176°	60°	=	140°	40°	=	104°
98	"	208	78	"	172	58	"	136	38	"	100
96	"	205	76	"	169	56	"	133	36	"	97
94	"	201	74	"	165	54	"	129	34	"	93
92	"	198	72	"	162	52	"	126	32	"	90
90	"	194	70	"	158	50	"	122	30	"	86
88	"	190	68	"	154	48	"	118	28	"	82
86	"	187	66	"	151	46	"	115	26	"	79
84	"	183	64	"	147	44	"	111	24	"	75
82	"	180	62	"	144	42	"	108	20	"	68

Challis.—A fabric of silk and worsted, with designs either produced in the loom or printed, first introduced in 1832 at Norwich, England. In construction the fabric is similar to crape, only thinner and softer, composed of much finer materials, without gloss, and very pliable and clothy.

Cotton.—The soft, downy substance growing around the seeds of various species of cotton plant, Gossypium O. Malvaceæ.

Counts.—The number given to any thread (except raw silk) according to the number of yards that weigh one pound.

—— The number of hanks of yarn in one pound weight.

—— The system of indicating the fineness of yarn, written by placing 's after the figures, signifying the number of hanks per pound; thus, "60's"; otherwise *number*.

Counterpane.—A corruption of counterpoint, the old name derived from the French *courtepoint* or *point contre*, stitch against stitch, denoting something sewed on both sides alike. This method was and is used when bed coverings were stuffed with some warm material, wadding, and were sewed through and through to keep the wadding in place.

Coverlet.—The outermost of the bed clothes. That cover under which the rest is concealed.

Crape.—A thin, transparent, crisp (crumpled) or smooth silk, worsted, or silk and worsted stuff, usually black, and used in mourning. If crisp or crumpled *double*, they express a closer or deeper mourning than if smooth or *single*. The invention of this stuff came originally from Bologna, Italy.

Creel.—A frame in which feed bobbins are placed.

Crochet.—Fancy knitting made by means of a small hook.

Cross-Weaving or Gauze.—The second main division of weaving. See page 228 of Technology of Textile Design.

Crown of Card Clothing.—The number of wires in one inch along a sheet of card clothing.

Curved-Twills.—Weaves produced by the combination of regular-twills and steep-twills. For their construction see page 62 of Technology of Textile Design.

D

Damask.—A stuff denoting by its name the place where it was originally manufactured. It is true that figured fabrics have been known from time immemorial among the Chinese, and similarly can be traced among stuffs of Babylonian origin; but it was not until the 12th century, when *Damascus* attained a perfection in weaving then unexampled, that we find splendid patterned stuffs becoming common or generally known Damascin or Damascus cloth became thus synonymous with excellence and splendor, and in time came to denote any stuff of rich working and elaborate design. Italy is the European home of this manufacture, and for a long period it flourished there exceedingly, so that as late as the 17th century, Genoa supplied nearly all Europe. True damasks are wholly of silk, but the term is now applied to any fabric of wool, linen or cotton, woven in the manner of the first damasks It is only since the manufacture has thus included all materials that it has been generally worn, those of silk being far too expensive for the average lot of people, and when purchased by the rich being handed down from generation to generation as heirlooms.

Dew-Retting 193

Delaine.—A light worsted cloth of specially selected long, fine and strong staple in the material when producing the yarn.

—— A fine wollen fabric, originally called *mousselines de laine*, or muslins of wool, an expressive title, which signifies fully what manner of fabric they properly should be. They are indeed figured muslins, which should always be made of wool, but they are frequently of mixed material.

Dent.—The space between the wires of a reed, also called *split*.

Diameter of Threads.—To find the same for the various counts of yarns *58

—— To find the same by means of a given diameter of another count of yarn *62

—— Cotton *60

—— Wool (Run system) *60

—— Wool (Cut system) *61

—— Worsted *61

—— Raw Silk *61

—— Spun Silk *60

—— Linen *62

Diaper.—A sort of linen cloth wrought with flowers and other figures ; a towel, a napkin. The word owes its origin to the town of Ipre (Ypres) in Flanders, once famous for its manufacture.

Differential Motion.—The wheels which make a bobbin revolve at a varying speed as it becomes fuller, independently of the flyer.

—— 56

Division *88

Division of Common Fractions *95

Division of Decimal Fractions *99

Dobbies.—Also called *Index machines*, *Witches*, etc., are small Jacquard machines, or machines constructed upon its principle.

Dobson and Barlow's Comb 45

Doeskin.—Cloth resembling the skin of a doe.

Doffer.—The drum removing the fleece of fibres from the swift.

Doffing.—The process of removing bobbins or cops from the spindles.

Doily.—A small napkin used at dessert.

Domestic Sheep 83

Domett.—A loosely woven flannel, cotton warp wool filling, used either for shrouds or in place of wadding by dressmakers.

Donisthorpe, G. E.—The part inventor of Lister's Nip Comb and of the Noble Comb.

Dorset Sheep 86

Double Burring Machine with feed rollers attached 127

Double Carding Engines 38

Double Cloth.—A fabric produced by combining two single cloths into one structure. For construction see page 129 of Technology of Textile Design.

—— Selection of Texture for *82

Double Cylinder Saw-Gin 19

Double Cylinder Worsted Card 153

Double-Deck Condenser 132

Doubling.—The combination of two or more laps, slivers or threads.

Double-Lift Double-Cylinder Jacquard Machine.—For its principle of construction see page 69 of The Jacquard Machine Analyzed and Explained.

Double-Lift Single-Cylinder Jacquard Machine.—For its principle of construction see page 67 of The Jacquard Machine Analyzed and Explained.

Double Pile Fabrics.—For their principle of construction see page 194 of Technology of Textile Design.

Double-Rubber Condenser 132

Double Satins.—A sub-division of the regular satin weaves. For their method of construction see page 84 of Technology of Textile Design.

Doup.—Also called doup heddle ; required in gauze weaving to produce the douping or twisting of the whip-threads around the ground-threads.

Draft.—The elongating of one or more ends of sliver or slubbing delivered by a pair of rollers into one thinner end by means of another pair of rollers.

Drag.—The resistance of a bobbin on the spindle and washer as it is pulled round by the yarn during the spinning process.

Draught.—The amount of attenuation of a lap or sliver.

Drawer-In.—The operative performing the drawing-in of the warp in its harness.

Drawing-Frame for open drawing 169
—— for flax spinning 204
—— for cotton spinning 49

Drawing for jute spinning 211
—— for worsted spinning 167
—— Its principle 48

Drawing Machinery for worsted spinning built upon the French system 171

Drawing of Flax 203

Driven.—A wheel or pulley which is driven, although it may again drive others, and which, if its size is decreased, causes those following it to work at an increased speed.

Driver.—A wheel or pulley which drives others, although it may itself be driven, and which if decreased in size causes those which follow it to work at a decreased speed.

Dressing for Leather Belts.—Sponge them on the outside with warm water, then rub in some dubbin. This done once every four or six weeks keeps the belts supple, and prevents them from cracking.

Dromedary or African camel 93

Drop-Box.—The drop-boxes for looms were invented in 1760 by Robert Kay, a son of John Kay, the inventor of the fly shuttle.

Drugget.—A coarse woollen cloth used as a protection for carpets.

Dry Spinning of Flax 208

E

Earth Flax.—See Asbestos.

East India Sea Island Cotton 13, 15

Ecru Silk 185

Eggs or Seeds.—The first stage of the silkworm 176

Egyptian Cotton 13, 15

Electric Stop-Motion for Drawing Frames 51

Eli Whitney.—The inventor of the saw-gin; a native of New Haven, Conn. (1793.)

End.—One strand of sliver, roving or yarn.

English Merino 90

Entwining-Twills.—A sub-division of the regular twill. For their construction see page 75 of Technology of Textile Design.

Exhaust Opener 25

Exmoor Sheep 87

Extra Fine.—A two-ply ingrain carpet constructed with 832 threads warp (36 inches wide fabric) exclusive of selvedge. For construction see page 74 of The Jacquard Machine Analyzed and Explained.

Extra Super.—A two-ply ingrain carpet constructed with 1072 threads in warp (36 inches wide fabric) exclusive of selvedge. For construction see page 75 of the Jacquard Machine Analyzed and Explained.

Equivalent Counts of a Given Thread in Another System.—To find the *14

F

Fabric.—The structure of anything; the manner in which the parts of anything are united by art and labor, workmanship, texture, make, etc.

Falcon.—The inventor of the cylinder and the Jacquard cards, both parts of the Jacquard machine.

Faller for can-gill box 168
—— for preparer 155

Find Circumference of Pulleys, Etc.—Multiply the diameter by 3.141592.
Example.—A pulley is 14 inches in diameter. What is the circumference?
$14 \times 3.141592 = 43.982288$ inches is the circumference of the pulley.
Find the Contents of a Tank.—Multiply the diameter by the diameter in inches, then by the depth; then multiply by .0034. The answer will give the number of gallons in the tank.
Example.—Tank 60 inches diameter, 45 inches deep.
$60 \times 60 = 3600 \times 45 = 162000 \times .0034 = 550\frac{4}{5}$ gallons.
Find the Number of Cuts for a Small Sample of Yarn.—Multiply length in yards by $23\frac{1}{3}$, and divide by the number of grains it weighs.
Find the Number of Runs for a Small Sample of Yarn.—Multiply the yards by $4\frac{3}{8}$, and divide by the number of grains the sample in question weighs.

Flax.—The same is the product of the common (annual) flax, Linum usitatissimum.
Fleece.—The coat of wool shorn from a sheep at one time.

Floats.—Threads that have by accident not been intersected in the body of a fabric, but lay loose upon its surface.
Flocks.—The waste from finishing machines in woollen mills. *Shear flocks* such as produced at shearing, also brushing. *Gig flocks* such as produced by giging. A cheaper grade of flocks are such as produced from woollen rags.
Flocks are used in the process of fulling cheap grades of woollen fabrics, both for cheapening fabrics, besides making the same bulky.

Floss-Silk.—The ravelled silk broken off in winding the *cocoons*, which is afterwards carded and spun, and known as spun silk.

Flyer.—A horizontal steel bar with two vertical arms, each with an eye or twizzle at their lower extremities, which is placed on the spindle. Around one arm the yarn is wound in its passage onto the bobbin. The rotary speed of the flyer being greater than that of the bobbin, puts the twist into the yarn.

Flyings.—The loose short fibres liberated during picking, carding, combing, drawing, spinning.

Fly-Shuttle.—Invented by John Kay, a native of Walmersley, Lancashire, England, in 1733. Previously to Kay's invention of the fly-shuttle it required two men to work a broad loom, one at each side of the loom, and the shuttle was thrown from one to the other alternately. The inventor died in France, in obscurity and poverty, to the disgrace of his countrymen. The invention has been described by him in his patent, No. 542, May 20th, 1733, as follows: "And that he hath likewise found out and contrived a newly-invented shuttle, for the better and more exact weaving of broad-cloths, broad-bays, sail-cloths, or any other broad goods, woollen or linen, which shuttle is much lighter than the former, and by running on four wheels moves over the lower side of the well spring, on a board put under the same and fastened to the layer, and which new contrived shuttle, by the two wooden tenders, invented for that purpose, and hung to the layer, and a small cord commanded by the hand of the weaver, sitting in the middle of the loom, with great ease and expedition, by a small pull at the cord, casts, or moves the said new invented shuttle, from side to side at pleasure, and also strikes the layer, by his pulling it in the middle, uniformly over the piece, making it unavoidably even, and much truer and better than any method hitherto used."

Foundation Weaves.—Plain, twill and satin weaves.

Frame.—Technical grading of Brussels carpets.

Fuller's Earth.—A species of clay, of a greenish white, greenish grey, olive and olive green and sometimes spotted color. It is usually opaque, very soft and feels greasy. It is used by fullers to take grease out of cloth before they apply the soap. When of a good quality it falls into powder in water, appears to melt on the tongue like butter, communicates a milky hue to water, and deposits very little sand when mixed with boiling water.

Full, Fulling.—To press cloth in a mill, to scour or thicken in a mill. The old method of fulling cloth was to tread it with the feet; hence come our surnames of *Fuller*, *Walker* and *Tucker*, fullers being known as walkers or tuckers, from walking on or kneading the cloth when under treatment. The object of fulling is to work the fibres so that the surface may not show the naked transverse threads, but form a felted mass, fulling being really only a kindred process to felting. Manual labor is of course superseded, and the old fulling or tucking mills have already years ago been replaced by vastly-improved machinery.

G

Garter.—A band or ribbon to tie up stockings from the Welsh *gar*, the shank, or Fr. *gartier*, *Jarretieres-Jarret*, the hough of the leg.

Gauge.—The distance from centre to centre of splindles or rollers.

Gauze.—A name given to a woven fabric of transparent texture, first introduced into Europe from *Gaza*, a city of Palestine. Gauzes are fabrics characterized by not having their warp threads parallel near each other, as observed in ordinary weaving. For construction of either plain or figured gauze see my Technology of Textile Design, page 228 to 250.

Gigging.—The process of producing a nap on cloths

Gill Box.—A machine used in the process of worsted spinning for elongating and levelling the sliver, either previously or succeeding the process of combing, by means of a pair of feeding and a pair of delivery rollers, with a set of fallers travelling between them by means of screws.

H

Highland Sheep 87

Holden, Isaac.—The inventor of the square motion comb.

Holdsworth's Differential Motion 57

Honeycomb-Weaves.—For their construction see page 98 of Technology of Textile Design.

Hungarian Merino 90

Hydraulic Scouring Machine 101

I

Imbs Comb 46

Ingrain Carpets.—Ingrain as applied to carpets was originally intended for a fabric where the wool was colored before carding and spinning, but which is not true at present, as the yarn is mostly manufactured before coloring. The great variety of colors used in an ingrain carpet at the present time, the constant changing of styles, besides the saving of expense by coloring the yarn after spun, are the reasons for it. Ingrain carpet in our country means the same as Scottish or Kidderminster in Europe. For construction of the fabric, see my "Jacquard Machine Analyzed and Explained," pages 71, 72, 81, 82, 92, 106, 116 and my Technology of Textile Design, page 225.

Intermediate Feeding Machines 130

Intermediate Frame for Cotton Spinning 53

Irish Sheep 87

J

Jack.—A part of the harness-motion in a loom.

Jack-in-the-Box, or **Jack Frame** 56

Jacquard, Joseph Marie.—The inventor of the Jacquard machine, born in Lyons, France, 1752. For more details, see history of the Jacquard machine. in "The Jacquard Machine Analyzed and Explained "

Jacquard Loom.—A loom furnished with the Jacquard arrangement.

Jean.—A twilled cotton cloth, generally supposed to derive its name from *Jaen*, Spain.

Jersey Cloth.—A fabric characterized by its great amount of elasticity; generally produced by knitting.

Jute.—The name for the bast fibres of *corchorus olitarius* and *corchorus capsularis.*

Jute.—Its color 209

Jute.—Its place of growth 209

Jute fibres, magnified 209

Jute Line 211

Jute Spinning 209

Jute Tow 211

Jürgen, Johann.—A native of Wolfenbüttel; the inventor of the spin-wheel.

K

Kemp.—A horny kind of hair, mostly found on poorly-bred sheep, resisting the amalgamation required by spinning. The same will neither take a uniform color with the rest of the wool in dyeing.

Kentucky Sheep 84

Knitting.—The formation of a continuous web or fabric by making loops in a single thread; the destruction of one loop threatens the structure of the whole piece, unless the meshes are reunited. The simplicity of the operation, and the ease with which it may be learnt and performed, make it probable that this kind of knitting (with needles), as well as others, was known and practiced; if not by the antediluvians, by their immediate descendants.

L

Lace.—There are two kinds of lace, point and pillow.

Point lace, which is a much more ancient art than the making of pillow lace, is made with the needle.

Point or needle-made lace is said to have been invented by the Italians at a very early period, and during the 16th and 17th centuries became of very general use in England, as may be observed in the huge frills, collars and ruffs worn in the time of Queen Elizabeth, Charles I., and Charles II.

On the other hand, pillow lace is of more recent date, and the history of its invention is known, for Beckmann, with evident satisfaction, says: "I will venture to assert that the knitting of lace is a German invention, first known about the middle of the 16th century; and I shall consider it as true, until it be fully contradicted, the account given us, that this art was found out before the year 1561, at St. Annaberg, by Barbara, wife of Christopher Uttmann. This woman died in 1575 in the sixty-first year of her age." The statement does not appear to have ever been disproved, and it is recorded upon her tomb. Uttmann was a master miner, and his wife, observing that the girls made caps for the miners, taught them to make them on this new plan. She afterwards set up a workshop at Annaberg for the making of lace of different patterns; and it is this description of lace, or pillow lace, with which we are now concerned. There are several varieties of it, such as Brussels, Alençon, Lisle, Honiton, etc., which differ according to the meshes, twistings, thick or thin threads, and other details, but not in the principle of the operation. The production of pillow lace is effected simply by twisting together a number of threads in the order and combination necessary to produce the desired pattern. To do this, the design is first drawn upon a piece of parchment, and holes are made in the outline of the design for the insertion of pins. Round these pins the threads are twisted, so as to form meshes. Thick and thin threads can be combined, or three or more together. As the lace is made the pins are moved. In the process of knitting the operation is different, in order to form the fabric. Knitting, in its simplest form, is effected by using one thread only, upon which a series of loops are made, and they are connected together by intersecting each other, as is well understood in the common process of knitting. Knitting and lace making are therefore widely different in their modes of production; but nearly all the first attempts for the making of lace were tried upon modifications of the stocking-frame.

In the production of figured lace it is requisite that the threads should be arranged in such manner that they can be twisted round each other any number of times, and in any quantity and arrangement. In bobbinet it is also requisite that the threads should be twisted around each other, and follow the arrangement necessary for the production of meshes of uniform size and order.

Lace-making.—Consists in twisting any desired number of threads round each other in such a manner as to form meshes, or, according to the definition given by Johnson, it is "Anything reticulated or decus ated at equal distances, with interstices between the intersections." The threads may be twisted either two, three or more together, or thick and thin threads may be so combined. For the formation of any desired pattern or figure, it is requisite that any one or more of the threads may be twisted round any one or more of the adjoining threads. It is not necessary that the threads should be able to pass completely from side to side of the lace and then be made to twist round the most distant threads, but so long as they can be moved a moderate distance, with perfect freedom, to be twisted together with one or more of the neighboring threads, that is all that is required for making ordinary lace.

Lantern.—The iron extension put on the cylinder of Jacquard machines. The cylinder is turned by means of the catches working on the lantern.

Lappet-weaving. - For illustration and explanation of same, see page 123 of Technology of Textile Design.

Lay, Lathe or Batten.—A part of the loom. To it are secured the shuttle-boxes and the reed.

Lawn.—A sort of fine linen cloth. The name is derived from the French *Linon*. Remarkable for being originally used in the sleeves of bishops.

Lead.—The excess of the revolution of a bobbin, flyer, or traveller over each other.

Leaf.—The same as harness; thus either 3-leaf twill or 3 harness twill, etc.

Leash.—Two or more harness cords combined and adjusted to one neck-cord.

Leonardo da Vinci.—The inventor (?) of the spindle (1452.)

Levantine.—A stout twilled silk, so named from having originally been brought from the Levant.

Licker-in.—The first roller of a carding engine, or a metallic breast, with which the wool, after leaving the feed-rolls comes in contact.

Lifter.—Also called carriage. The plate which travels up and down the spindles of a drawing box or spinning frame, and on which the bobbins rest.

Lincoln Sheep 84

Line System for flax spinning 205

Linen Yarns.—Their grading *14

Linsey Woolsey.—Cloth of linen and woollen mixed together, of different and unsuitable parts; vile, mean.

List (Listing)—Is derived from *liciæ*, which, in the age of corrupt Latin, was used for the inclosures of fields and cities, as being anciently made with cords interlaced; or from *listæ quia campum clandebant instar listarum panni;* as enclosing the ground after the manner that a list does a piece of cloth. List, in manufacturing, denotes the border of a stuff, or that which bounds its width on each side. In addition to being a necessity to the fabric, they contribute to good appearance. (See also Selvage.)

Lister's Nip Comb 157

Little and Eastwood's Comb 166

Llama or Yamma 94

Loom.—Literally, *an utensil;* from the Anglo-Saxon *loma*, furniture utensils. (See also power loom.)

Long-Wool Sheep 84

Lustre.—The glossy or shiny appearance which certain kinds of cotton, worsted, silk, flax and ramie yarns possess, and which causes fabrics made of them to look bright.

Lustreing.—One of the processes comprised in silk finishing 185

M

Macarthy Double-Roller Gin 21

Macarthy Gin 21

Mails—Are made of metal, and form the centre part of twine heddles; in the eye of the mail the warp threads are drawn.

Manufacture.—Derived from *manus*, the hand, and *factura*, a making. In its etymological sense means any system or objects of industry executed by hands; but in the vicissitude of language it has now come to signify every extensive product of art which is made by machinery, with little or no aid of the human hand, so that the most perfect manufacture is that which dispenses entirely with manual labor.

Mate Threads.—Technical name used in two-ply ingrain carpets, reversible overcoatings constructed upon the double cloth system, etc. One ground-thread and its corresponding figure thread.

Material Required for Two or More Ply Yarn *19

Measure.—Derived from *mensura*, a measure. That by which extent is ascertained or expressed; a stated quantity.

Measures.—U. S. *112

——— Metric system *113

Medium or Short-Wool Sheep 85

Merino Sheep 89

Metallic Breast 129

Metallic Feed Rolls for breaker cards 125

Mexican Sheep 83

Michotte's Decorticator 216

Minor Thread Required to Produce, with Given Others, Two, Three or More Ply Yarn of a Given Count *18

Mitten.—Gloves (covering the fingers) made of linen or woollen, whether knit or stitched. Mittens have been in use from time immemorial.

Mitts.—Derived from *mitan*, middle, because they are *chirothecæ veluti dimidiatæ*, leaving the fingers unconfined.

Mixing of Cotton 23

Mixing of Wool 113

Mixing-Picker 117

Mohair.—Of *Mojacar*, an Indian word. The fine silken hair of the Angora goat of Asia Minor. It is largely used in the manufacture of light weight dress goods, characterized by their lustre. In pile fabrics, as plushes, velvets, Astrakhans, etc., of a plain or figured denomination, mohair is frequently used for pile-warp, while the ground or body is made of cotton.

Moire.—Watered silk, from *moirage*, the French term for watering of stuffs.

Monge.—A noted French savant. He discovered first the serrated surface of the wool fibres.

Motes.—Fragments of broken seeds or leaves in cotton.

Moth *or Adult.*—The fourth stage of the silk-worm 177

Mouflons or Wild Sheep 81

Mountain Flax.—See Asbestos.

Mulberry Silk-Worm 176

Mule for cotton spinning 66

Mule for worsted yarns 175

Mule for wool spinning 144

Multiplication *86

Multiplication of Common Fractions *94

Multiplication of Decimal Fractions *99

Mungo.—The waste produced from hard-spun or felted cloth, and which is used again in the manufacture of low grades of woollen fabrics.

Muslin.—A fine fabric of cotton having a downy nap upon its surface. The origin of the word has been traced to its downy surface through the French *mousse*, moss.

N

Nankeen, *Nankin, Nanquen.*—A stuff made from a cotton of brownish yellow tint. The fabric came originally from Nankin, China Blue, white and pink varieties have been made, but brownish-yellow variety, so often seen in wear for trousers by gentlemen, and known to be worn in corsets by ladies, is the Nankin with which the name is most generally associated.

Nap.—The woolly substance on the surface of cloth. The ends of fibres extending, fur-like, outside a thread; most prominently found in woollen yarn.

Napkin.—Derived from Fr. *nappe.* Literally means a little cloth.

Neck-Cord.—The cord combining leash and hook in a Jacquard harness.

Neps.—Small knots or tangles of fibres.

New Differential Motion 58

Nip-Comb 157

Noble Comb 162

Noble, James.—The same and G. E. Donisthorpe are the inventors of the Noble comb.

Noil.—The short wool fibres as separated from the long by means of combing.

Norfolk Sheep 87

Nose.—The extreme upper point of a cop.

Nurmah *or Deo Parati.*—The Indian name for Gossypium arboreum.

O

Obtain Speed of a Machine, when speed of shaft, size of driving pulley and pulley on machine are given.—Multiply revolutions of shaft per minute by diameter of driving pulley in inches, and divide by the size of driven pulley in inches.

Example.—Speed of shaft, 100 revolutions per minute; size of driving pulley, 10 inches; size of driven pulley, 5 inches

$100 \times 10 = 1000 \div 5 = 200$, or speed of machine.

Obtain Required Speed of Shafting, when size of driving pulley, and the required speed for machine, with size of driven pulley are given.—Multiply the speed of machine by the diameter of driven pulley in inches, and divide by the size of driving pulley in inches.

Example.—Speed of machine, 100; driving pulley, $12\frac{1}{2}$ inches; driven pulley, 10 inches.

$100 \times 10 = 1000 \div 12\frac{1}{2} = 80$, or required speed of shafting.

Obtain the Size Required for Driving Pulley when speed of machine and size of driven pulley, and speed of driving shaft are given.—Multiply speed of machine by diameter in inches of driven pulley, and divide by the revolutions per minute of the driving shaft.

Example.—Speed of shaft, 80 revolutions; speed of machine, 100; driven pulley, 10 inches.

$100 \times 10 = 1000 \div 80 = 12\frac{1}{2}$ inches, or size of driving pulley.

Obtain the Speed of a Driven Shaft.—Multiply the number of revolutions of driving shaft by the diameter of driving pulley in inches, and divide the product by the diameter of the driven pulley in inches.

Example.—Revolutions of driving shaft, 80; diameter of driving pulley, 12 inches; diameter of driven pulley, 10 inches. $80 \times 12 = 960 \div 10 = 96$. *Answer.*—96 turns is the speed of the driven shaft.

Open-Shed Loom.—The name of a loom which by means of its harness motion changes the position of the harness only when so required by the weave, consequently acts as easy as possible on the yarn; and this with an additional allowance for high speed.

Orleans Cloth.—Figured dress goods made of cotton warp and worsted filling, and first manufactured in *Orleans*, France.

Osnaburg.—A kind of coarse linen, principally made in and named from that province in Hanover.

P

Paramatta.—The name of a fabric which manufacture originated in Bradford, England, being an imitation in cotton and worsted of merino. The name is derived from Paramatta, a town in New South Wales, from where the first wool for the manufacture of these fabrics was imported.

Pick.—The insertion of a thread of filling in the warp (at the loom).

Piecing.—The uniting of two ends of sliver, roving or yarn.

Pile Fabrics.—Articles characterized by a soft covering overspreading the ground-structure of the fabric.

Plain-Weave.—Also called cotton weave; in this weave, warp and filling cross each other at right angles, and interweave alternately.

Ply.—The thicknesses or layers of fabrics—for example, two-ply, three-ply, etc. cloth referring to double or triple cloth.

Pointed Twills.—A sub-division of the regular twills. For their construction see page 80 of Technology of Textile Design.

Positive Motion.—A motion driven by gearing, distinct from one driven by friction or some non-positive force.

Potash—Is obtained principally from the ashes of burnt wood and plants. The ashes are boiled in water, and the solution is evaporated to dryness. This is ordinary pearl ashes.

Potash Soaps—Are made from carbonate of potash, causticised with lime or with pure caustic potash. A potash soap is a better cleanser than a soda soap.

Potassium-Carbonate 98

Pot-Eye.—The small cup with a slit in it, set in a spinning-frame for the thread to run down, and to avoid friction.

Power-Brakes.................... 194

Power Brake for hemp manufacture.................... 221

Power Loom.—Automatic looms constructed to be worked by other than manual labor. Dr. Gennes, a French naval officer, published in 1768 the description of a "new engine to make linen cloth without the aid of an artificer," which practically anticipated the modern power loom, and to this futile endeavor to supersede hand labor is generally ascribed the honor of first attempting to facilitate production. Lewis Paul (a well-known English inventor), thirty years previous, had constructed and patented a machine with that object, although, as with that of Dr. Gennes, nothing came of it. About 1750, a swivel loom was produced by Vaucanson (the well-known inventor of the principle of the Jacquard machine), and tried in 1765 at Manchester.

The next endeavor was made in 1784 by an English clergyman, Dr. Edmund Cartwright, and with so much success that modern machines are only modifications of his first power loom, although, after spending a sum of from £30,000 to £40,000 in patent fees, experiments, and efforts to establish his inventions, he yet had ultimately to abandon all hope of success. The one obstacle which defied all efforts to obviate it was the tenderness of the warp yarn, which frequently broke, and then necessitated the stoppage of the machine to join it. Subsequently the warp was sized to strengthen it, but the machine still had to be stopped at intervals, and a man needed at each loom for this purpose. The cost of this still prevented the machines paying their way, and the difficulty was not overcome until 1804 by the invention of the dressing machine, which sized the warp before it entered the loom.

Dr. Cartwright has himself narrated the use and progress of his invention as follows: "Happening to be at Matlock, in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed that as soon as Arkwright's patent expired so many mills would be erected, and so much cotton spun, that hands never could be found to weave it. To this observation, I replied that Arkwright must then set his wits to work to invent a weaving mill. This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and, in defence of their opinion, they adduced arguments which I certainly was incompetent to answer, or even to comprehend, being totally ignorant of the subject, having never at that time seen a person weave. I controverted, however, the impracticability of the thing, by remarking, that there had lately been exhibited in London an automaton figure which played at chess. 'Now, you will not assert, gentlemen,' said I, 'that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game.' Some little time afterwards, a particular circumstance recalling this coversation to my mind, it struck me that, as in plain weaving, according to the conception I then had of business, there could only be three movements, which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas, I immediately employed a carpenter and smith to carry them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such materials as sail cloth is usually made of. To my great delight, a piece of cloth, such as it was, was produced. As I had never before turned my thoughts to anything mechanical, either in theory or practice, nor had ever seen a loom at work, or knew anything of its construction, you will readily suppose that my first loom was a most rude piece of machinery. The warp was placed perpendicularly, the reed fell with the weight of at least half a hundred weight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket. In short. it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my great simplicity, that I had accomplished all that was required, I then secured what I thought a most valuable property by a patent, April 4th, 1785. This being done, I then condescended to see how other people wove; and you will guess my astonishment when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw, I made a loom, in its general principles nearly as they are now made. But it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st, that year."

The first endeavor to make use of this invention took place at Doncaster, where the principal part of Dr. Cartwright's expenditure occurred. Another effort was made on a large scale at Manchester in 1791, under a license from the patentee, but the mill, calculated to hold four hundred looms, was burned down by incendiaries.

Dr. Cartwright then gave up attempting profit by his discovery, but in 1808 a public grant of £10,000 was made to him as some compensation for his outlay and disappointments.

Selvage or **Selfedge.**—Derived from salvage, because it strengthened and preserved garments; but obviously self-edge, that which makes an edge of itself without hemming The edge of the cloth woven in such a manner as to prevent ravelling. Also called List or Listing.

Serge.—A twilled worsted fabric, which, according to some writers, was at one time made from silk, and thus through the Latin *sericum*, silk, derived its name.

Serrations.—The fine teeth-like points projecting from the body of wool fibres. The same interlock with each other in the process of felting.

Shaper or Copping-Rail.—A part of the mule; the same varies the backing-off of the cam as the building of the cop proceeds. The mechanism by which the shape of a cop is determined.

Shearing.—The process of clipping the fleece from a sheep. The process of cutting by machinery the superfluous nap of various fabrics.

Shed.—The opening made in the warp, when in loom, for the passage of the shuttle.

Shoddy.—Properly it means the waste thrown off in wool-spinning, but now applied to the disintegrated or shredded wool of old cloth, reduced to this condition to be remanufactured. The trade has assumed such proportions that at present large qualities of woolen rags are now annually imported to be made up again into cloth.

Shot-About.—The alternate exchange (filling ways) of figure up and ground-up in two-ply ingrain carpet.

Shuttle Raceway.—The part of the lay on which the shuttle travels to and fro.

Silk.—The pale yellow buff colored, or white fibre, which the silk worm spins around about itself, when entering the pupa or chrysalis state.

Single.—A length of sliver, roving or yarn, consisting of only one strand.

Spinning Woolen Yarn 144

Split.—See dent.

Spooling of Woolen Yarn 150

Spread Board 199

Spreading for jute spinning 211

—— of flax 199

Square Motion Comb 161

Square Root *101

Standard Harness.—The harness frame carrying the standard heddle; through the latter the doup is threaded.

Staple.—The length of individual fibres.

Steep Twills, or **Diagonals**—Are a sub-division of the regular twills. For their construction see page 56 of Technology of Textile Design.

Stifling.—The process of destroying the vitality of the chrysalis 178

Stocking-Frame.—An invention of 1589, by which the operation of knitting was performed automatically, an invention the chief motive of which remains unchanged and unimproved upon to this day. The inventor was William Lee, an English clergyman.

The actuating motive has been variously assigned to a desire to aid his wife in her efforts to maintain them, in poverty, to which both had been brought by an unequal marriage, or to a similar desire to assist a lowly knitter to whom he was devoted, or to a wish to be revenged on being refused by her. The scene of his labors has been said at times to have been in Cambridge, Oxford, Sussex, Leicestershire, and Nottinghamshire. The history of his life has been given with great variation, and almost all particulars relating to the invention have at times been disputed or differently stated, so that the historian has had to sift the truth from a multitude of conflicting versions.

William Lee was a M. A. of St. John's College, Cambridge. After maturing his machine he resigned his office and commenced the manufacture of stockings at Calverton, the scene of his ministerial labors, but finding the prejudice against his work too strong to be overcome, went with his brother and chief helper, James, and other relatives to London, where, by the intervention of Lord Hunsdon, it was brought to the notice of Elizabeth, and her patronage requested. Elizabeth, finding the material used to be worsted, not silk, and so appearing likely in her opinion to deprive many of her poorer subjects of a means of subsistence, refused a monopoly, and Lee set to work to adapt the machine to silk hosiery. This he accomplished in 1598, but found that Elizabeth then was as little inclined to countenance this as the other. James was equally impracticable, and Lee, having offers of reward, privileges and honors from Henry IV. of France, went over to Rouen, and found there the favor denied him in England. It is even said that the French king and many of his nobles learnt the art; that a frame of silver was made for the royal use, and the honor of carrying a sword conceded to all who were willing to serve an apprenticeship to frame-work knitting. But the assassination of Henry by Ravaillac took place at the very time when Lee was in Paris waiting for a special grant of privilege. The new Regent, on account of his Protestantism, ignored Lee's claims and suspected his motives, and, finding himself unprotected and in danger in a foreign land, he fell into distress despair and poverty, and in 1610 died, after nearly twenty-five years of deferred hope, an outcast from his native land, and an alien in his adopted country.

His brother James then brought the art and his machines back to England, and was immediately successful. The trade increased rapidly, and early in the 17th century the frame-work knitters formed themselves into a trade association, regulating prices and resisting non-apprenticed workmen, the manufacture even at this early date settling in the shires of Nottingham, Derby and Leicester.

Stockings were first made of cotton in 1730, from cotton of four and five threads spun in India. The duplication of the number of threads caused the hose to be so costly that, to show the fact, the custom was established of putting as many eyelet holes in the welt as there were threads in the yarn, a plan which became universal, whatever the material; but these eyelet holes were not reduced in number when one-thread cotton was ultimately found to be workable.

Stop Motions for Drawing Frames 50

Stop Motion For Spinning Frames 64

Straight-Duster 113

Stretch.—The longitudinal traverse of a mule carriage. The movement of the roving rolls, to and from the spindles in a spinning machine.

Strippers.—The small rollers of a carding engine which carry the wool from the workers back to the main cylinder.

Sulphate of Soda is obtained from a combination of common salt and sulphuric acid or vitriol.

Super.—A two-ply ingrain carpet constructed with 960 warp threads (36-inch wide fabric) exclusive of selvedge. For their construction see page 76 of The Jacquard Machine analyzed and explained.

Swift.—The largest roller, or the main cylinder of a carding engine.

Swivel Loom.—A loom capable of two different movements ; the swivel and the plain weaving movements.

Swivel-Weaving.—A method of weaving for producing figures upon fabrics otherwise interlaced with a regular warp and filling ; used in the manufacture of figured dress goods, ribbons, etc.

T

Tail-Cords.—The substitutes of the regular hooks as used in the ingrain carpet machine.

Tapestry.—Documentary evidence exists establishing in French convents the art of making a kind of carpet ornamented with designs of natural objects or religious subjects ; but the palm undoubtedly belongs to to the celebrated hanging representing the conquest of England by the Normans, and known as "The Bayeux Tapestry," or the tapestry of Queen Matilda.

Up to the latter end of the eleventh or beginning of the twelfth century, it is probable that all such works were laboriously worked with the needle, as no trace can be found proving the use of the loom. The first workmen after the new manner appear to have been called *Sarazins* or *Sarazinois*, and it is believed from this that the improvement was due either to its introduction into Europe by the Saracens of Spain, or was acquired by the Flemings, among whom it was first developed during one of the Crusades against the Saracens in the East. In 1344, Edward IV. passed a law regulating the tapestry manufacture.

Chaucer includes among his pilgrims "a tapisser," and pieces of English-made tapestry still preserved—one representing the marriage of Henry VI., now in St. Mary's Hall, Coventry, and another in the possession of the Vintners' Company, make it probable that the art continued to be practised through the fourteenth and fifteenth centuries. But the first attempt to give the manufacture "a local habitation and a name," does not appear to have been made before the reign of Henry VIII., when, in 1509, William Sheldon, with the assistance of the master tapestry maker, Robert Hicks, established a manufactory at Barcheston in Warwickshire, Eng. ; but this workshop did not assume any industrial importance until the following century.

In the reign of James I., the most famous tapestry factory, that at Mortlake in Surrey, was founded by Francis Crane, who was liberally patronized by the king, and afterwards by his son. James is said to have contributed £2,000 towards the expenses, and Charles I. not only allowed the founder £100 per annum, but gave orders so freely that he was in debt in the first year of his reign to the establishment to the extent of £6,000. In 1623, a famous artist named Francis Cheyne, a native of Bostock in Lower Saxony. was employed as limner, and he "gave designs both in history and grotesque which carried these works to great perfection." Workmen came over from the Continent and were employed in reproducing the cartoons of Raphael, and several of the royal seats—Windsor, Hampton Court, Greenwich, St. James' and Norwich—were furnished with hangings from Mortlake. The Civil War ruined the establishment, Parliament seizing it as the property of the Crown ; but after the Restoration, Charles II. accorded to the manufacture the same protection as his father, passing in 1663 two Acts for the several purposes of encouraging the tapestry manufactures of England, and for discouraging the "very great importation of foreign tapestry," which then appears to have come from Flanders, and to have been wrought "with hair," "with caddas," "with silk," "with gold or silver," and "with wool," being valued at from 2s. 8d. to £8, the Flemish ell.

Charles II. engaged Verrio to make designs, and sent again to the factory the cartoons of Raphael, which Cromwell, to preserve them for the nation, had bought at the sale of the effects of Charles I.

Mortlake continued to flourish, until the death of Francis Crane brought about the closing of the establishment, which has never been reopened.

There was a small atelier established at one time in Soho in London to compete with Mortlake, and afterwards another, principally producing furniture fabrics, at Fulham, but neither was successful. With the exception of a small factory first opened at the end of the seventeenth century, and subsequently transferred to Exeter, no effort was made to revive the manufacture of tapestry until the present reign of Queen Victoria, when a manufactory, under the patronage of Her Majesty, and with the aid of well-known artists, has been founded at Windsor.

Tapestry Carpet—A warp pile (terry pile) fabric, closely resembling Brussels carpet; in which the figures are produced by means of correspondingly printing the pile warp. For their construction see page 185 of Technology of Textile Design.

Teasel.—A kind of thistle, the flower-heads of which have long stiff bracts with hooked points. These points remain after the flowers have died, and are admirably adapted for raising or teasing the surface of cloth, to raise a nap upon it, for which purpose they have been used from time immemorial.

Temple.—Attachment to each side of a loom, on each side of the selvedge, for holding the last woven part of the fabric in even width with the width of the fabric in its reed, thus preventing as much as possible useless chafing of the warp.

Terry Pile.—The pile in a fabric in which the loop is left intact.

Testing of Hard Water.—Put a few drops of soap dissolved in alcohol into a glass of the water to be tested. If it is hard it will become milky.

Textile.—Derived from the Latin *textilis-texo*, *textum*, to weave, anything woven or suitable for weaving. Any kind of fabric woven in a loom. The first English invention with reference to textile fabrics on record is a patent issued to Abraham Hill, March 3d, 1664 No. 143, for "an instrument or an engine for breaking of hemp and flax, and dressing the same in a new way; as also for washing of all sorts of linen."

Also see for it my Technology of Textile Design and The Jacquard Machine Analyzed and Explained.

Texture.—Number of warp and filling ends to one inch in a fabric.
There are two textures, *a*, for the fabric from loom; *b*, for the finished fabric.

Three-Ply Cloth.—A fabric produced by combining three single-cloth fabrics into one structure.

Throstle.—A spinning frame, derived its name from a low musical hum, due to the high speed which it attains, which is supposed to resemble the note of the *throstle* or *thrush*.

Top.—A ball of combed wool from which the noil has been separated.

Trap-Boards.—Or lifter-boards, used in the Jacquard machine as used for two-ply ingrain carpets.

Traveller.—A small steel hook, which runs round on the ring of a ring spinning frame by means of the yarn put through it.

Trevette—Or cutting knife used for cutting (by hand) the pile in warp-pile fabrics.

Tricot.—Fabrics more or less elastic as compared to other woven articles, and produced by a system of weaves known as tricot weaves. For their construction see page 126 of Technology of Textile Design.

Twit.—A thin place in a piece of yarn, caused by uneven drawing or too much draft in the process of spinning.

Twist.—The number of turns per inch in a thread or yarn.

Twisting.—The same is the process by means of which two, three or more threads are brought side by side and twisted in one thread.

Twaddell and Specific Gravity Compared.—To change degrees Twaddell in specific gravity, multiply by 5, add 1000 and divide by 1000.

Example.—Change 160° Tw. into specific gravity:

$$160 \times 5 = 800 + 1000 = 1800 \div 1000 = 1.8 \text{ specific gravity.}$$

To change specific gravity into degrees Twaddell the reverse rule is applied, viz., multiply by 1000, subtract 1000 and divide by 5.

Example.—Change 1.8 specific gravity into degrees, Twaddell.

$$1.8 \times 1000 = 1800 - 1000 = 800 \div 5 = 160° \text{ Tw.}$$

U

V

Velveteens.—Filling pile fabrics. For their construction see page 149 of Technology of Textile Design.

W

Wadding.—Or interior filling, used in the manufacture of chinchillas, matelasses, piques and similar fabrics. In the first mentioned class of fabrics it is solely used for increasing the bulk, while in the latter fabrics it is used to give, in addition, a rich, embossed effect to the design.

Wale.—A ridge on the surface of cloth, having a similar origin with wale or wheal, a mark raised upon the skin by a blow. Wide-wale; a wide or broad ridge on the surface of a fabric; a wide or broad twill effect.

Warp.—The threads running lengthwise in a cloth.
—— Yarn forming the longitudinal threads in a fabric.

Water Frame.—Arkwright's first spinning frame, which, in conjunction, withNeed and Strutt, his partners, was originally employed in a mill on the Derwent at Cromford, in Derbyshire, Eng. This was the first water spinning mill ever erected, and the parent of that great factory system which has contributed so much to the fame of England as well as our country. The fact that the machines were moved by water power led to their being called water-spinning machines, and the yarn produced was known as water twist.

Watered Stuffs.—Fabrics which have been subjected to a process by which the surface assumes a variety of shades, as if the cloth were covered with a multitude of waving and intersecting lines, and, which are produced by the following process: The piece of web, of cloth is folded, from one end to the other, in triangular folds, without attending to regularity; and being thus reduced to a comparatively small length, it is put upon a roller and rolled under a calender of very great weight. When taken out, the strong threads of the filling are found to have impressed lines upon both surfaces, which are variously waved, in consequence of the foldings previously referred to. As it is only intended to have one side waved, the fabric is made up for the press with pasteboards between each second fold, so as to allow one side of the fabric to be wholly without the pasteboards. The fabric is next hot-pressed, and that side which was covered with pasteboard comes out glazed, while the other remains watered. When it is wanted to be creased, it is folded, in the first instance, selvage to selvage.

Weaving.—Pliny gives the honor of the invention of weaving to the Egyptians, but its origin is really unknown, and was certainly prehistoric. The Egyptians undoubtedly attained wonderful excellence in weaving. Many Biblical references prove the Hebrews to have been equally facile, and Persia, Babylon, and other ancient nations likewise earned fame in this particular. In England, the Anglo-Saxons were thoroughly acquainted with the making of cloth, and the weavers of London form the most ancient guild of that city.

Weft.—The English name for filling.

Weighting or *loading*, is to silk what sizing is to cotton. For explanation of process see page 186.

Whip Roll.—A part of the loom. The warp threads pass from the warp-beam over the whip-roll towards the harness.

Whip Thread.—Or douping warp, one of the systems of threads necessary for gauze weaving. The crossing thread in gauze weaving.

Whirl.—Also called *wharl*. The small pulley fastened onto the spindle, on which the band runs which drives the spindle.

Wool.—In the hairy covering of several species of *mammalia;* it is softer than the actual hair, also more flexible and elastic, besides having a wavy character.

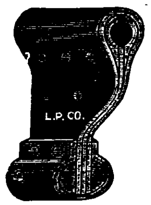
Worsted.—Fabrics made of yarn combed straightly and smoothly in their process of manufacture, as distinct from woolens, which are woven from yarn crossed and roughed in the carding and spinning process. Manufacture of worsted yarns.. 152

Worsted Coating.—A double cloth, in which the stitching is arranged to form designs. For their manufacture see page 138 of Technology of Textile Design.

Y

Yarn.—Any spun thread. The fully elongated and twisted roving.

Yolk.—A natural secretion from the glands of a sheep, on which the softness and flexibility of the living fleece depends, but which is an undesirable quality in the wool for commercial purposes, as if left in, it ferments, and leaves the wool in a hard and harsh state and unfit for spinning, consequently is removed by scouring previous to carding or gilling.



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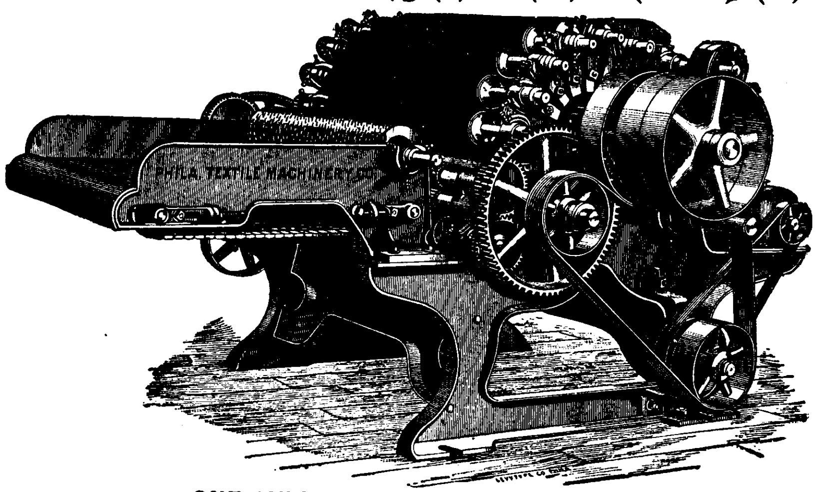

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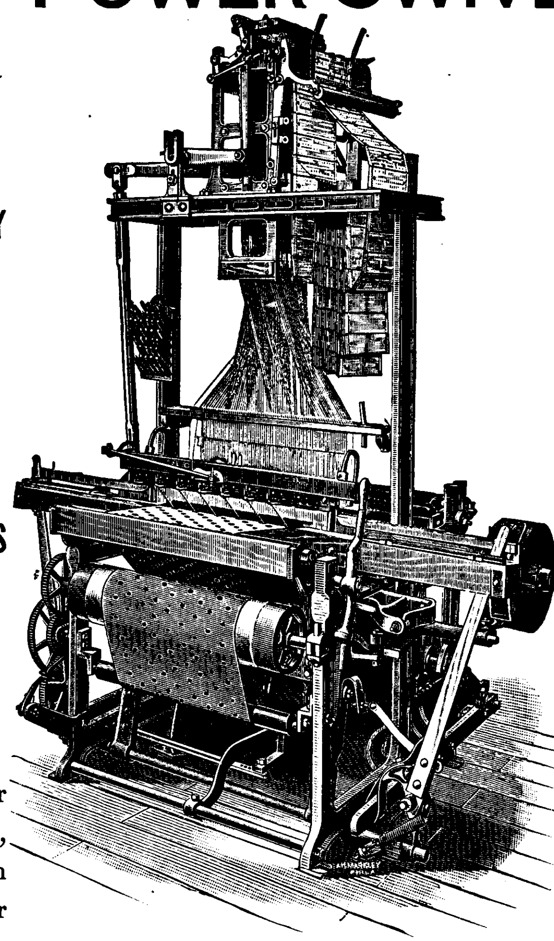

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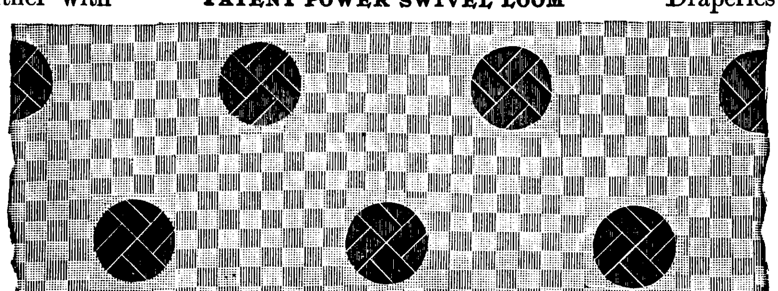

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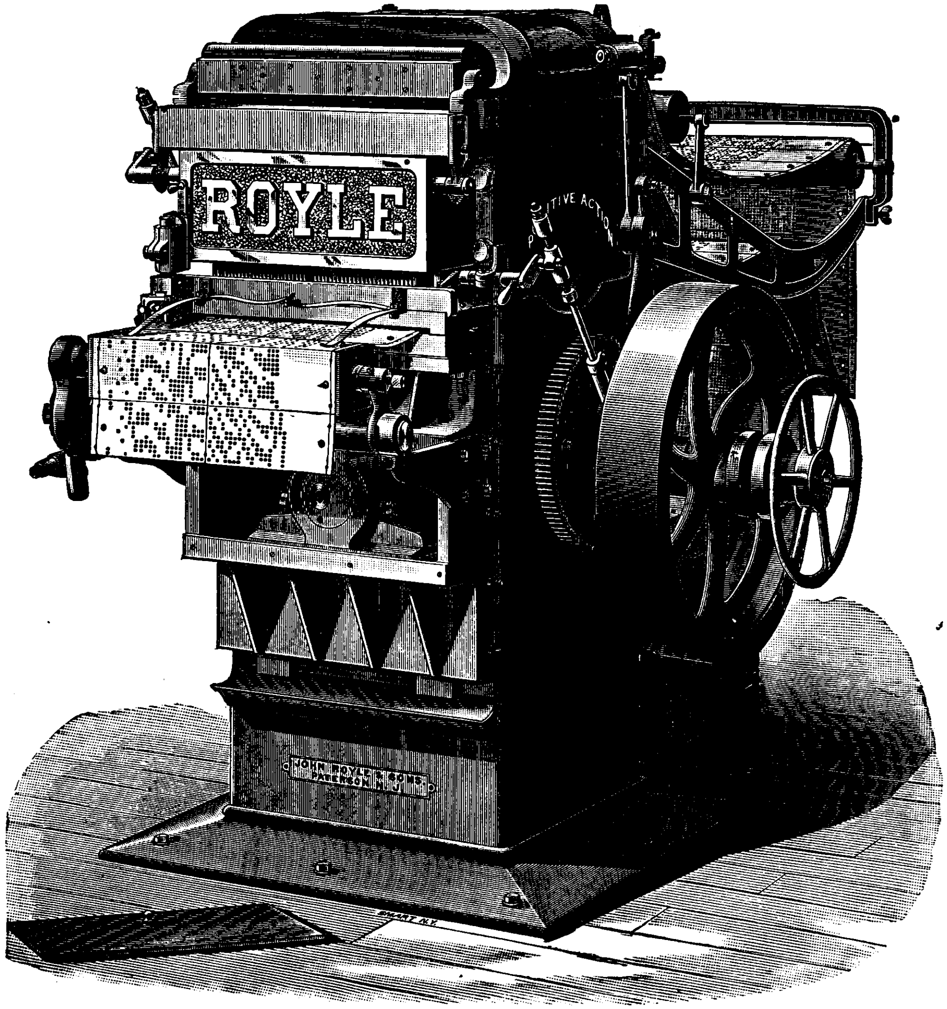

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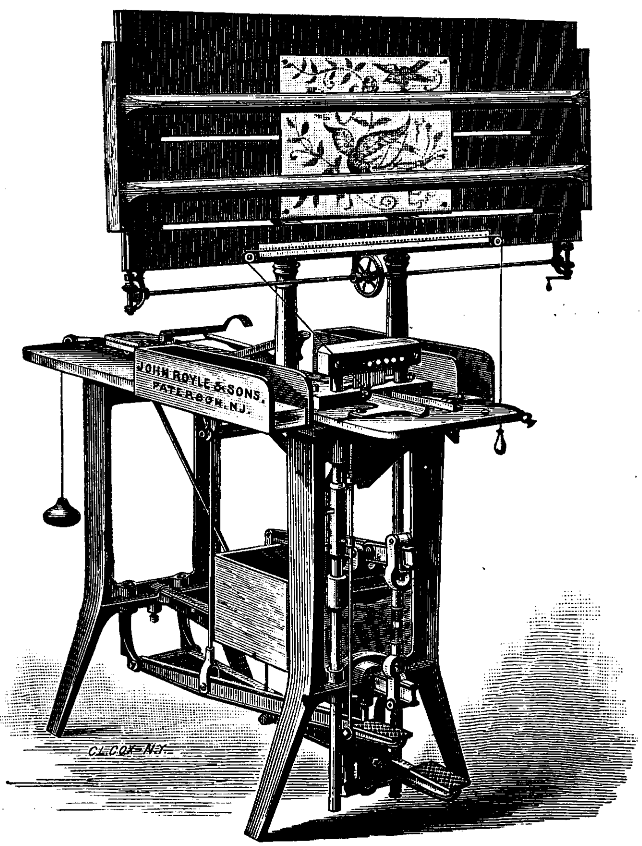

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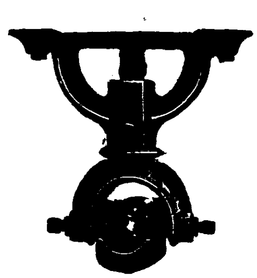

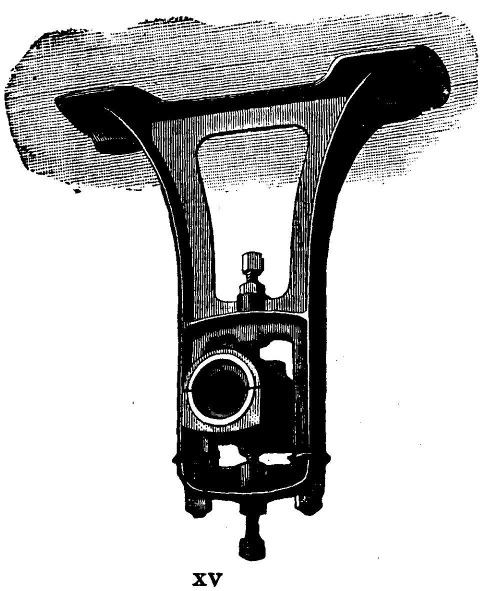

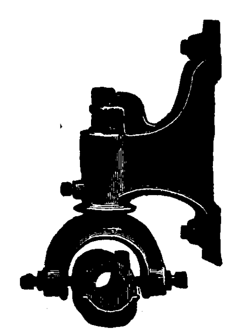

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—BY—

E. A. POSSELT,

Head Master Textile Department Pennsylvania Museum and School of Industrial Art, Philadelphia, Pa.
Author of "The Jacquard Machine analyzed and explained, the Preparation of Jacquard Cards, and Practical Hints to Learners of Jacquard Designing."

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Division of Textile Fabrics According to their Construction.

SQUARED DESIGNING PAPER FOR THE DIFFERENT TEXTILE FABRICS.
Purpose of the Squared Designing Paper—Practical Use of the Heavy Squares in Designing Paper—Selection of Designing Paper for Textile Fabrics.

WEAVES FOR TEXTILE FABRICS AND THE METHODS OF THEIR CONSTRUCTION.

FOUNDATION WEAVES.

THE PLAIN OR COTTON WEAVE.
Construction—Influence of the Twist of the Yarn—Fancy Effects Produced by Using Threads of Different Sizes; or by the Combination of Two or More Colors.

TWILLS.
Construction—Influence of the Twist of the Yarn Upon the Various Textures—Division of Twill-Weaves—Combination of Two or More Colors for Producing Different Effects.

SATINS.
Methods and Rules for Constructing the Various Satin-Weaves—Influence of the Twist of the Yarn Upon Fabrics Interlaced with Satin-Weaves—Arrangement of Satins for Special Fabrics.

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Description of the Operation—Principle of a Drawing-in Draft—Methods Used for Preparing Drawing-in Drafts—Division of Drawing-in Drafts—STRAIGHT DRAWING-IN DRAFTS—FANCY DRAWING-IN DRAFTS—*A.* Broken Draws—*B.* Point Draws—*C.* Section-Arrangement Draws (1st Plain, 2d Double)—*D.* Skip Draws—*E.* Mixed or Cross-Draws—Other Points a Drawing-in Draft May Require in Addition to the Indications for Drafting on Certain Harnesses—DRAFTING OF DRAWING-IN DRAFTS FROM WEAVES—PREPARING THE HARNESS-CHAIN BY FANCY DRAWING-IN DRAFTS—RULES FOR ESTIMATING THE NUMBER OF HEDDLES REQUIRED FOR EACH HARNESS—*a.* For Straight Drawing-in Drafts—*b.* For the Various Fancy Drawing-in Drafts—THE REED, AND RULES FOR CALCULATIONS.

(Continued on next page.)

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I. Broken-Twills—Using Two or More Colors for Producing Various Effects Upon Fabrics Interlaced with Broken-Twills—II. Steep-Twills of 63° Grading or Diagonals—III. Steep-Twills of 70° Grading—IV. Steep-Twills having a Grading of 75°—V. Reclining-Twills or Twills having a 27° Grading—VI. Curved-Twills—VII. Skip-Twills—VIII. Combination of Two Different Common Twills to Steep-Twills of 63° Grading—IX. Corkscrew-Twills—*A.* Derived from One Regular Twill—*B.* From Two Regular Twills—*C.* Figuring with the Filling Upon the Face—*D.* Curved Corkscrew-Twills—*E.* Corkscrew Weaves composed of Warp and Filling Twills—*F.* Corkscrew Weaves Figured by the Warp—*G.* Corkscrew Weaves in which the Face and Back of the Fabric is produced by the Filling—X. Entwining-Twills—XI. Twills having Double Twill-Effects—XII. Twill Weaves Producing Checkerboard Effects—XIII. Combination of Warp and Filling Effects from a 45° Twill Weave after a Given Motive—XIV. Fancy Twill Weaves—XV. Pointed-Twills.

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PILE FABRICS PRODUCED BY THE FILLING.

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CHENILLE AS PRODUCED IN THE MANUFACTURE OF FRINGES.

PILE FABRICS IN WHICH THE PILE IS PRODUCED BY A SEPARATE WARP IN ADDITION TO THE GROUND WARP.

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—— APPENDIX. ——

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IV. Woolen Yarns by Runs to Cotton Yarns by Numbers.—V. Woolen Yarns by Runs to Woolen Yarns by Cuts.—VI. Woolen Yarns by Runs to Worsted Yarns by Numbers.
VII. Woolen Yarns by Cuts to Cotton Yarns by Numbers.—VIII. Woolen Yarns by Cuts to Woolen Yarns by Runs.—IX. Woolen Yarns by Cuts to Worsted Yarns by Numbers.
X. Worsted Yarns by Numbers to Cotton Yarns by Numbers.—XI. Worsted Yarns by Numbers to Woolen Yarns by Runs.—XII. Worsted Yarns by Numbers to Woolen Yarns by Cuts.

MISCELLANEOUS YARN CALCULATIONS.

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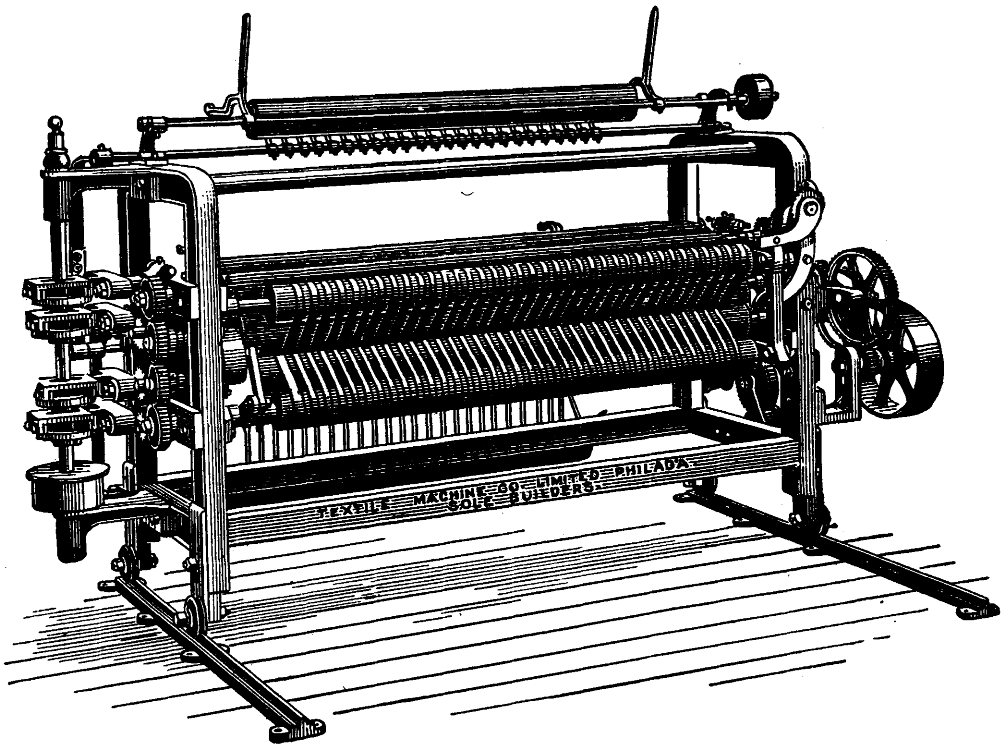

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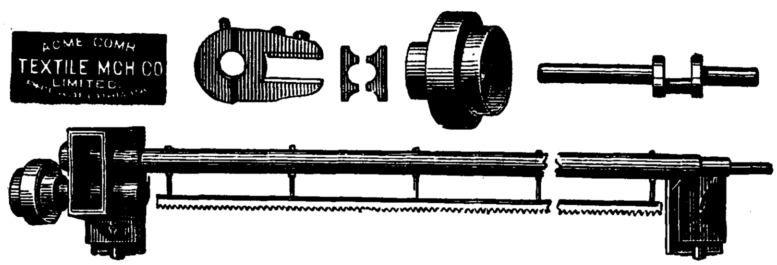

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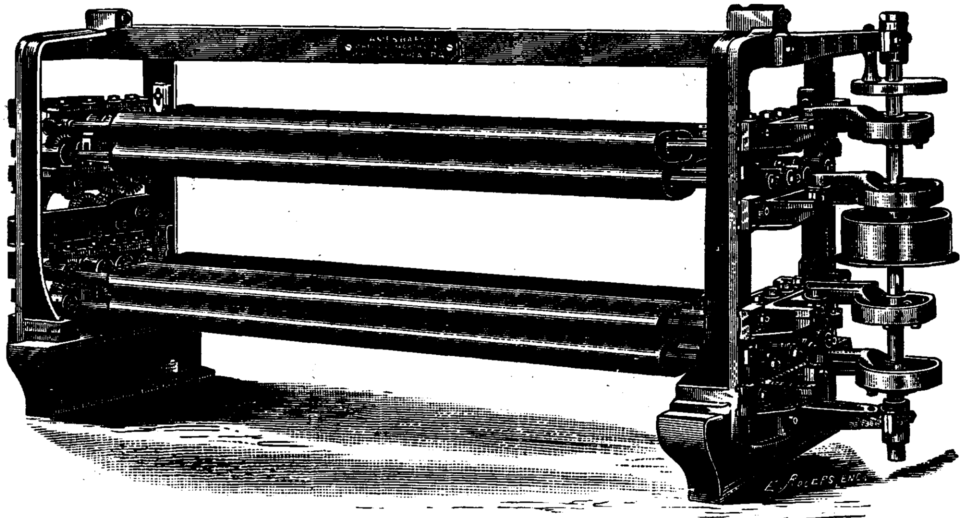

We Manufacture Barker's Patent Noiseless Fast-Running Doffing Comb.

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OUR CLAIMS ARE

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2d. On account of their Great Rubbing Power we can turn off more slubbing than any other make of Rubbing motion.

3d. Our slubbing being better Rubbed than by the ordinary methods it is much Rounder and Sounder than any other machine will give.

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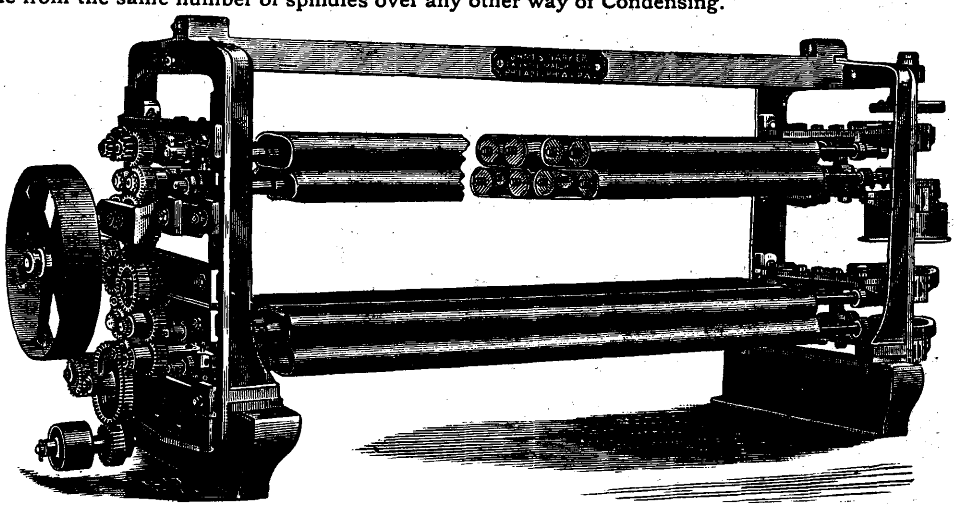

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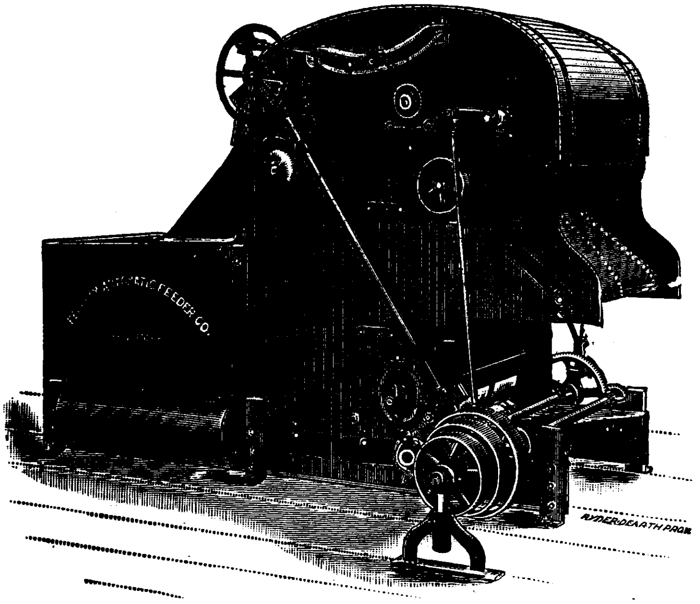
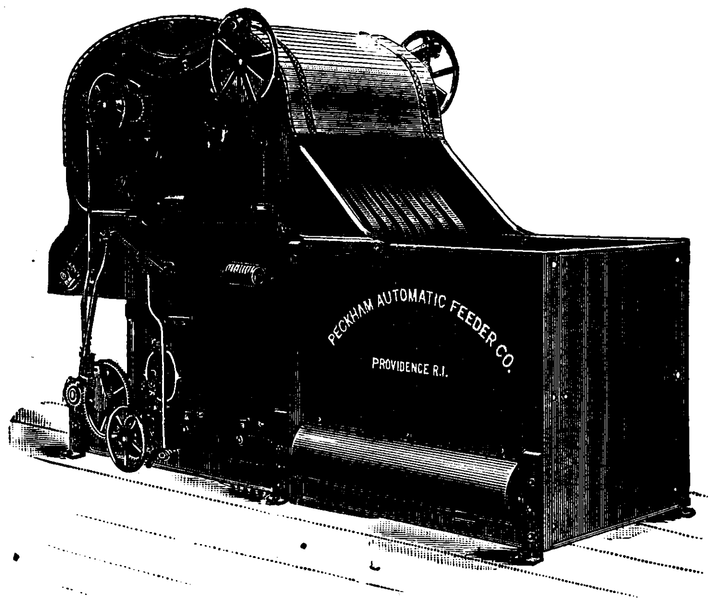
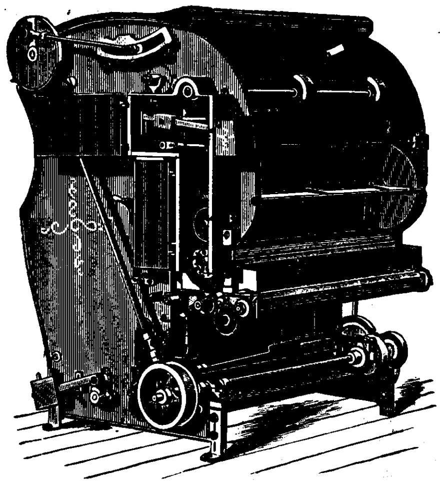




THE PECKHAM AUTOMATIC FEEDER



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Guaranteed to feed evenly, combs out the fibre, thus avoids rolling the stock.

Full information furnished on application.

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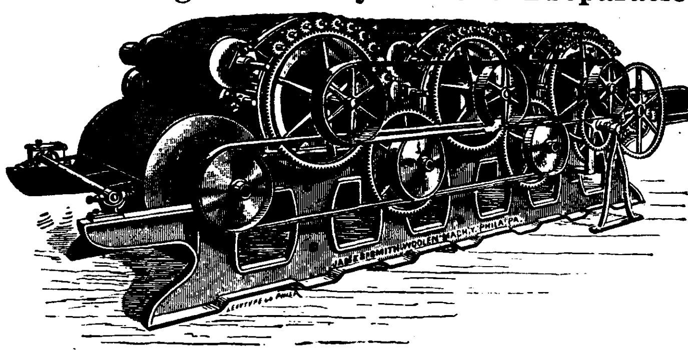

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METALLIC LICKER-INS, BURR PICKERS,
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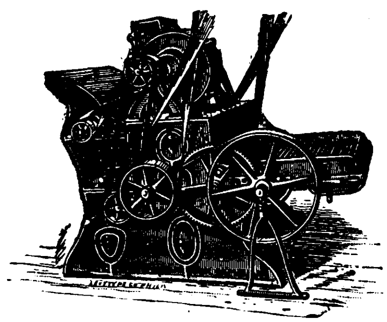

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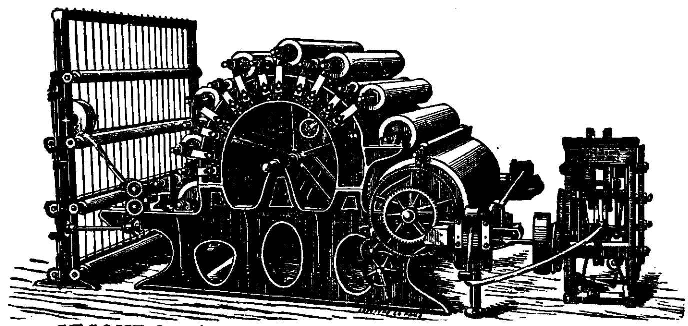
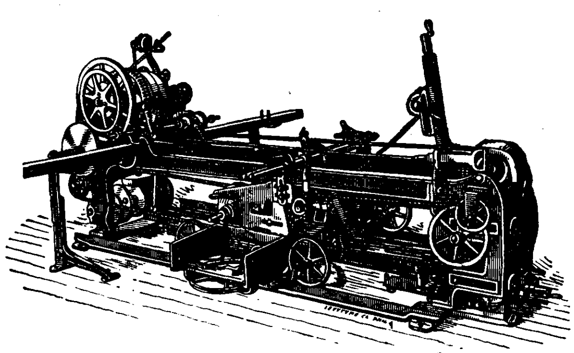


SECOND BREAKER CARD WITH BANK CREEL AND IMPROVED BALLING HEAD.



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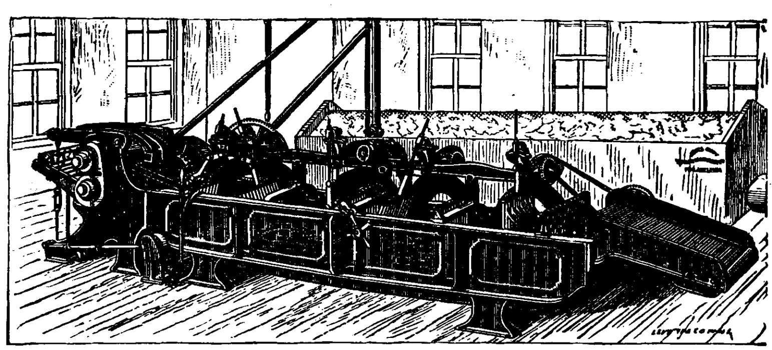

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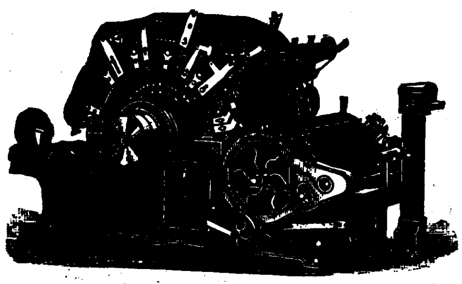

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110 FLATS, 43 WORKING.

RIGID BEND, MATHEMATICALLY CORRECT AT ALL STAGES OF WEAR OF THE WIRE. THE PERFECT CONCENTRICITY OF FLATS TO CYLINDER CANNOT BE DESTROYED.

THE SIMPLICITY, ACCURACY AND SUPERIORITY OF THIS CARD IS UNEQUALLED.

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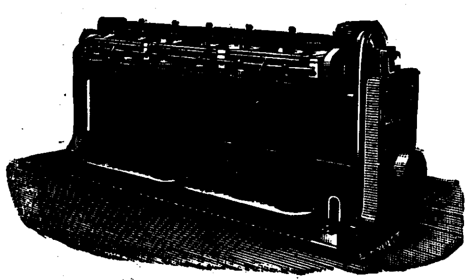

OVER **28,000** DELIVERIES ALREADY WORKING.

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WASTE, INGLE AND ROLLER LAPS ARE PREVENTED, PRODUCTION INCREASED AND GREAT SAVING IS EFFECTED.

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Slubbing, Intermediate AND Roving Frames

MADE ENTIRELY BY TOOL WORK AND COMBINING MANY VALUABLE PATENTED IMPROVEMENTS

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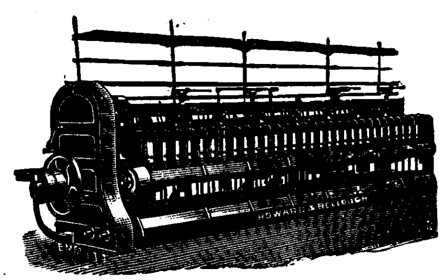

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SPINDLES, FLYERS, FLUTED ROLLS, ETC., ETC.

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EMBRACING THE

Davis & Furber Patent Mule AND THE New Patent Wright Spinner

Mill Shafting, Patent Couplings and Hangers, and Light Handsome Pulleys, also Mill Gearing made without Patterns.

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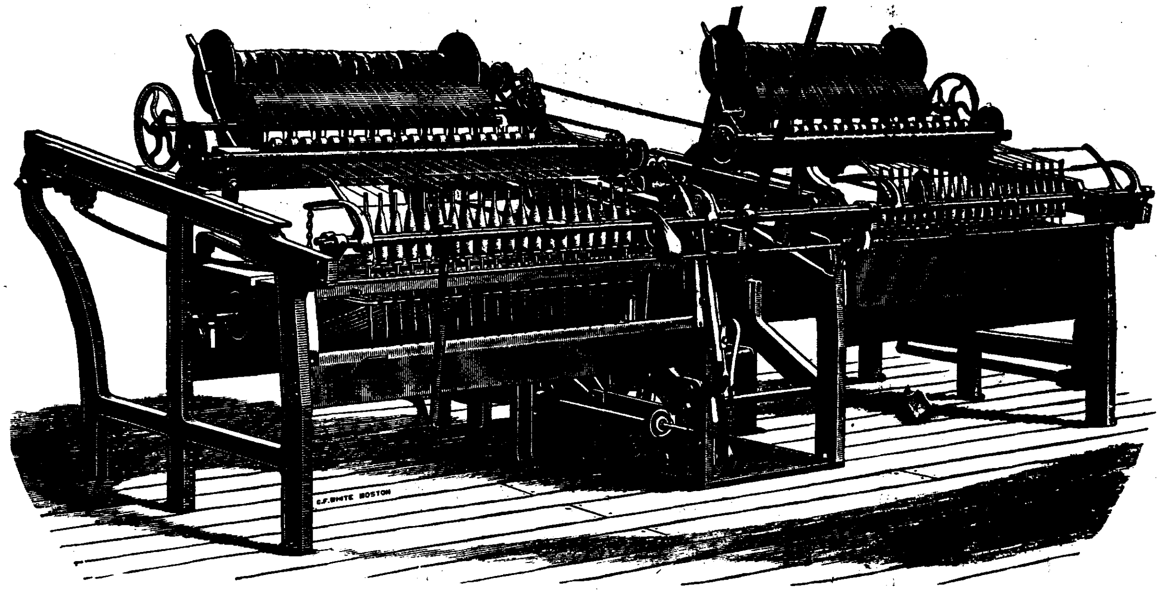

FRONT VIEW, SHOWING BUT TWO SECTIONS, OF THE NEW WRIGHT SPINNING MACHINE.

Carding Machines fitted with Patent Seven, Nine, Eleven and Fifteen Roll Rubber Condensers.

ALSO PATENT APRON AND ROLL RUBBER CONDENSER

Spinning Mules and Jacks, Card Grinders, Lathes for turning off Cylinders

WARP DRESSERS for Worsted and Woolen Yarns, **PATENT WARP REELS, PATENT WARP SPOOLERS,** Extra Heavy **BEAMING MACHINES** for placing the warp on Loom Beam, Cone Dusters, Wool Dusters, Waste Dusters, Broad and Narrow Flannel and Blanket Looms with or without Drop Boxes, Gigging Machines of all descriptions, including Double Reversible Continuous Gigs, Up and Down Gigs, Flannel Gigs and Blanket Gigs, Banding Machines, and **IMPROVED HEAVY MIXING PICKERS.**

All the above Machines from new designs and remodelled patterns.

We also make a specialty of **WORSTED CARDING MACHINES** built after the English plan.