BOOK TWO

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CHAPTER ONE.

THE GRADING OF YARNS.

1. Textile Fibres. Materials for the weaving of textiles are obtained from all three kingdoms of nature. The vegetable and animal kingdoms show more substances suitable for the manufacturing of threads, than does the mineral kingdom.

The vegetable kingdom yields cotton, flax, hemp, jute, ramie, pineapple fibres, caoutchouc (indian rubber or elastic), china grass, etc. The animal kingdom produces wool, camel, cow, goat and horse hair; and silk. Gold, silver, copper, brass, iron, glass, asbestos, etc., are obtained from the mineral kingdom.

These different materials require different processes of preparation before they can be used for weaving; for this reason they are divided into (1) such which are spun into a thread, as cotton, wool, linen, spun silk, camel's hair, etc; (2) those which are formed into threads by a process of rolling or stretching, such as gold, silver, copper, etc.; (3) materials which are converted into threads by splitting or dividing, such as long-fibred woods, caoutchouc, etc.; and (4) those which originally appear as threads, as silk from the cocoons (raw silk), straw, willows, etc.

The materials mostly used in the manufacture of textiles are those which are converted into threads by the process of spinning. Threads spun may be composed of material of the same grade or of more grades mixed, such as a long-fibred wool with that of a shorter fibre, etc.; or they may be composed of mixtures of several materials, such as wool with cotton, wool mixed with shoddy, etc.

2. Standard Numbers. Threads are spun of various thicknesses, some of which measure 2,800 yards to the pound and others which measure 32,000 yards per pound, etc. The different yarns are graded according to their number of yards per pound. (The grading of raw-silk yarns is based upon the weight of a certain yardage, and is entirely different from the grading of all other yarns, therefore it will be taken up in a later chapter.) In order to simplify the numbering of the different yarns *Standard Numbers* have been created. The standard number, or standard, is based upon the number of yards of yarn per *Hank*. Yarns of the various materials are wound into hanks of different sizes (as to yardage), therefore a different standard number is required for nearly every kind of yarn.

Cotton Yarns. The standard number for cotton yarns is 840; i.e., these yarns are wound into hanks of 840 yards. The number of hanks required to balance one (1) pound indicates the size of the yarn. The size of a thread is better known as its *Count* or *Number*. If it requires eight hanks of a certain cotton yarn to balance one (1) pound, then it is known as eight's or 1/8's cotton; if it should require twenty (20) hanks, then it would be known as twenty's or 1/20's cotton, etc.

Spun Silk. This also has a standard hank of 840 yards; i.e., the standard number for spun-silk yarns is 840. The counts are indicated in the same manner as in cotton.

Other silk yarns generally classed as spun silks are those known as floss, chappe, filosella, etc.

Worsted Yarns. The standard number of these yarns is 560; i.e., it takes 560 yards of No. 1's worsted yarn to balance one (1) pound.

Woolen Yarns. These yarns are graded according to two (2) systems, (*a*) the Run System, and (*b*) the Cut System.

The Run System is mostly used in the New England States, and the Cut System in the Middle States. The Run System has a standard hank of 1,600 yards, while the standard number for the *Cut System* is 300. In both systems the number of hanks required for the balancing of one (1) pound indicates the count of the yarn.

Linen. This has a standard hank of 300 yards. In this case the hank is spoken of as a *Lea*. The numbering is done in the same manner as in the yarns mentioned above.

Ramie, Jute, China Grass. All of these yarns have a standard number of 300, the grading or numbering is done in the same manner as above; i.e., they are graded according to the number of hanks required to balance one pound.

Cotton, spun silk, worsted, wool, linen, jute, ramie and china grass, are all spun, and for their various computations the same rules are applied. Raw silk, or silk obtained by the process of reeling direct from the cocoons, is computed in an entirely different manner and will not be taken up until the student thoroughly understands the calculations of the yarns named above.

3. To find the count, number or size of any yarn (excepting raw silk), when the number of yards per pound* are given.

Rule: Divide the number of yards per pound by the standard number of the yarn in question.

Example: If 16,800 yards of cotton yarn weigh one (1) pound, what is its count?

*Avoirdupois.

Solution: 16,800, the number of yards per pound, divided by 840, the standard for cotton; i.e., 16,800 ÷ 840 = 20. *Answer*, 1/20's cotton.

Example: If 6,400 yards of woolen yarn weigh one (1) pound, what is its count in the Run System?

Solution: 6,400 ÷ 1600 (which is the standard for run wool), = 4. *Answer*, 4 run wool.

4. To find the number of yards per pound of any yarn,* when the count or size and the material are given.

Rule: Multiply the standard number of the yarn in question by its count.

Example: Find the number of yards per pound of a 1/40's worsted.

Solution: 560 (the standard for worsted) times 40 (the count of yarn in question); i.e., 560 × 40 = 22,400. *Answer:* 22,400 yards of 1/40's worsted per pound.

Example: Find the number of yards per pound of an 18 cut wool.

Solution: 300 (the standard for cut wool) times 18 (the count of the yarn in question); i.e., 300 × 18 = 5,400. *Answer:* 5,400 yards of 18 cut wool per pound.

5. To find the number of yards per ounce of any yarn, when the count and the material, of the yarn in question, are given.

Rule: Multiply the standard number of the yarn in question by its count and divide the product by 16 (the number of ounces per pound).

Example: Find the number of yards per ounce of a 30's lea linen.

Solution: 300 (standard of linen) times 30 (the count of yarn in question) divided by 16 (the number of ounces per pound); i.e., 300 × 30 = 9,000 yards per pound. 9,000 ÷ 16 = 562.5. *Answer:* 562.5 yards of 30's lea linen per ounce.

Example: Find the number of yards per ounce of a 1/36's cotton.

Solution: 840 (the standard number for cotton) times 36 (the count) divided by 16 (the number of ounces per pound); i.e., 840 × 36 ÷ 16 = 1,890. *Answer:* 1,890 yards of 1/36's cotton per ounce.

6. To find the weight in pounds of any amount of yarn when the count, material and the amount of yarn, in yards, are given.

Rule: Divide the given number of yards of yarn by the number of yards per pound, of the yarn in question.

*These rules are all given with the exception of raw silk.

Example: Find the weight in pounds of 324,840 yards of 1/40's cotton.

Solution: 840 × 40 = 33,600 yards of 1/40's cotton per pound. 324,840 ÷ 33,600 = 9.668 pounds. *Answer:* 324,840 yards of 1/40's cotton weighs 9.668 pounds.

Example: Find the weight in pounds of 1,372,000 yards of four (4) run wool.

Solution: 1,600 × 4 = 6,400 yards of four (4) run wool per pound; hence, 1,372,000 ÷ 6,400 = 214.375 pounds. *Answer:* 1,372,000 yards of four (4) run wool weigh 214.375 pounds.

7. To find the weight in ounces of any amount of yarn, when the count, material, and amount of yarn, in yards, are given.

Rule: Divide the given number of yards of yarn by the number of yards per ounce of the yarn in question.

Example: Find the weight of 2,250 yards of 16 cut wool in ounces.

Solution: 300 × 16 ÷ 16 = 300 yards of 16 cut wool per ounce; hence, 2,250 ÷ 300 = 7.5 ounces. *Answer:* 2,250 yards of 16 cut wool weigh 7.5 ounces.

Example: Find the weight of 7,560 yards of 1/24's worsted, in ounces.

Solution: 560 × 24 ÷ 16 = 840 yards of 1/24's worsted per ounce; hence, 7,560 ÷ 840 = 9 ounces. *Answer:* 7,560 yards of 1/24's worsted weigh 9 ounces.

CHAPTER TWO.

EQUIVALENT COUNTS, PLY YARNS AND THEIR SINGLE EQUIVALENTS.

8. To find the equivalent count in a given material to the given count of another material.

Rule: Divide the number of yards per pound of the given count by the standard number of the material in which the answer is required.

Example: Find the equivalent count of a 1/20's cotton in the worsted system.

Solution: 840 × 20 = 16,800 yards of 1/20's cotton per pound. 16,800 ÷ 560 (the standard number for worsted) = 30's worsted. *Answer:* 1/30's worsted is the equivalent count to a 1/20's cotton.

Another and more expedient process is to carry out this rule by cancellation, thus:

$$\frac{\overset{10}{\cancel{20}} \times \overset{3}{\cancel{840}}}{\underset{2}{\cancel{560}}} = 10 \times 3 = 30.$$

Answer: 1/30's worsted.

Note: The standard numbers of cotton (840) and worsted (560) cancel down to three and two respectively. Therefore when changing the counts from cotton to worsted, or from worsted to cotton, the standard number for cotton can be replaced by *three* (3) and the standard number for worsted can be replaced by *two* (2).

Example: (In accordance with the above note.) Find the equivalent count of a 1/24's worsted in the cotton system.

Solution: 24 × 2 ÷ 3 = 16's cotton. *Answer:* The equivalent to a 1/24's worsted is a 1/16's cotton.

Proof: 560 × 24 = 13,440 yards per pound of 1/24's worsted. 13,440 ÷ 840 = 16. *Answer:* 1/16's cotton.

Proof No. 2: 840 × 16 = 13,440 yards of 1/16's cotton per pound. 13,440 ÷ 560 = 24. *Answer:* 1/24's worsted.

Note: From these two proofs it can be seen that a 1/24's worsted thread is as heavy as a 1/16's cotton, for they both have the same number of yards per pound.

Example: Find the equivalent count in the run wool system to a 24 cut woolen yarn.

Solution: 300 × 24 = 7,200 yards of 24 cut wool per pound. 7,200 ÷ 1,600 = 4.5. *Answer:* 4.5 run wool is the equivalent count to a 24 cut wool.

9. It is often the case that two or more threads of cotton and worsted are twisted together; they are then known as ***ply yarns***. Ply yarns may be made by twisting two or more threads of the same count and material together, or the counts may vary and each thread may be of a different material. Ply yarns composed of threads of the same count and material are mostly indicated by writing the number of single threads, composing the ply yarn, first, and the size or count of the individual threads last; a division line being placed between the two numbers, thus: 2/40's – indicating a ply thread made up of two threads, each being equivalent to a 1/40's. The number two indicates the ply and 40 indicates the count and is the indicated count.

Two or more ply threads do not occur as often in woolen yarns as they do in cottons and worsteds, but spun-silk yarns nearly always come two or more ply.

The ply thread is generally known as the *compound* thread and the threads which comprise the compound are known as the *minor* threads.

To find the single equivalent count of a compound thread composed of minor threads of the same count and material. (Excepting raw and spun silk yarns.)

Rule: Divide the indicated count by the ply.

Example: Find the single equivalent to a 2/40's cotton.

Solution: 40 ÷ 2 = 20. *Answer:* The single equivalent to a 2/40's cotton is a 1/20's.

Example: Find the single equivalent of a 2/36's cut wool.

Solution: 36 ÷ 2 = 18. *Answer:* 18 cut wool is the single equivalent to a 2/36's.

Example: Find the single equivalent of a 3/48's worsted.

Solution: 48 ÷ 3 = 16. *Answer:* 1/16's worsted is the single equivalent to a 3/48's worsted.

Example: Find the single equivalent of a 4/40's cotton.

Solution: 40 ÷ 4 = 10. *Answer:* 1/10's cotton is the single equivalent to a 4/40's cotton.

10. Spun silk is nearly always two or more ply; in this case the indicated count equals its single equivalent and is indicated thus: 40/2, meaning that the size of the compound thread is equivalent to a 1/40's spun silk, i.e., having 840 × 40 yards of yarn per pound in a two-ply form. Again, 60/2 means a spun-silk thread made of two finer threads which, together, equal a 1/60's. Therefore, in this case the rule is: The indicated count of spun-silk yarns stands for its single equivalent, the ply stands for the number of finer threads required to produce the indicated size. A 60/2 may be made of 2/120's = 1/60's, or of a 1/100's and a 1/150's, these two together being equivalent to a 1/60's.

Note: In all calculations involving two or more ply yarns, the single equivalent of the yarn should be used in computations.

11. Compound threads are also composed of minor threads of different counts and of the same or different materials.

To find the single equivalent count of a compound thread composed of two minor threads of different counts, both being of the same material, when the counts and material of the minor threads are given.

Rule: Multiply the single-equivalent count of one minor thread by that of the other, and divide this product by the sum of the counts.

Example: Find the single equivalent of a compound thread composed of a 1/60's and a 1/40's worsted.

Solution: $60 \times 40 = 2{,}400$, the product of the two counts. $60 + 40 = 100$, the sum of the two counts. $2{,}400 \div 100 = 24$. *Answer:* The single equivalent of a compound thread composed of a 1/60's and a 1/40's worsted, is a 1/24's worsted.

Solution: This sort of example is better done in cancellation, thus:

$$\frac{60 \times 40}{(60+40)} = \frac{6\not{0} \times 4\not{0}}{1\not{0}\not{0}} = 24.$$

Answer: 1/24's worsted.

Example: Find the single equivalent of a compound thread composed of an 18's and a 24's cut wool.

Solution:

$$\frac{18 \times 24}{(18+24)} = \frac{\overset{3}{\not{1}\not{8}} \times 24}{\underset{7}{\not{4}\not{2}}} = \frac{72}{7} = 10.286.$$

Answer: An 18's and a 24's cut wool make a compound thread which is equivalent to a 10.29 cut wool.

12. To find the single equivalent of a compound thread composed of two minor threads of different counts and material, when the counts and materials of the minor threads are given.

Rule: Change the counts of the minor threads to their single equivalent in the material in which the answer is required, then multiply the count of one minor thread by that of the other and divide this product by the sum of the counts.

Example: Find the single equivalent of a compound thread composed of a 2/40's cotton and 60/2 spun silk. Give answer in the cotton system.

Solution: 2/40's cotton $= 40 \div 2 = 1/20$'s cotton. 60/2 spun silk $= 1/60$'s spun silk $= 1/60$'s cotton (as both cotton and spun silk have the same standard).

$$\frac{20 \times 60}{(20+60)} = \frac{\overset{15}{\cancel{20} \times \cancel{60}}}{\underset{4}{\cancel{80}}} = 15.$$

Answer: A compound thread composed of a 2/40's cotton and a 60/2 spun silk is equivalent to a 1/15's cotton.

Example: Find the single equivalent of a compound thread composed of a 2/36's worsted and a 1/40's cotton. Give answer in the worsted system.

Solution: 2/36's worsted $= 36 \div 2 = 1/18$'s worsted. 1/40's cotton $= 40 \times 3 \div 2 = 60$, or 1/60's worsted.

$$\frac{18 \times 60}{(18+60)} = \frac{18 \times 60}{78} = 13.846+$$

Answer: A compound thread composed of a 2/36's worsted and a 1/40's cotton is equivalent to a 1/13.8's worsted.

13. To find the single equivalent count of a compound thread composed of three minor threads of different counts of the same material.

First Method.

Rule: Take the single equivalent count of any two of the minor threads and find the single equivalent of the compound thread they would form. Then take this single equivalent and combining it with the third minor thread find the single equivalent of the compound thread they would make. This last single equivalent will be the answer.

Example: Find the single equivalent of a compound yarn, composed of a 1/60's, a 1/60's, and a 1/40's worsted.

Solution: 1/60's, 1/60's, and 1/40's are the counts of the minor threads. Taking the first two counts 1/60's and 1/60's and combining them, they equal a

$$\frac{60 \times 60}{(60+60)} = \frac{\overset{30}{\cancel{60} \times \cancel{60}}}{\underset{2}{\cancel{120}}} = 30, \text{ or } 1/30\text{'s worsted.}$$

Taking this 1/30's and the third minor thread, 1/40's, and combining them they equal $30 \times 40 \div 70 = 17.14+$. *Answer:* A compound thread composed of a 1/60's, a 1/60's and a 1/40's worsted is equivalent to a 1/17.14+'s worsted.

Example: Find the single equivalent of a cotton compound thread composed of a 1/45's, a 1/60's and a 1/80's cotton.

Solution: 1/45's, 1/60's and 1/80's are the counts of the given minor threads. Combining the two first gives $45 \times 60 \div (45+60) = 45 \times 60 \div 105 = 25\frac{5}{7}$ cotton. Taking this single equivalent and the third minor thread equals $25\frac{5}{7} \times 80 \div (25\frac{5}{7}+80) = 25\frac{5}{7} \times 80 \div 105\frac{5}{7} = 19.46-$. *Answer:* A compound thread composed of a 1/45's, a 1/60's and a 1/80's cotton is equivalent to a 1/19.46–'s cotton.

Second Method.

Rule: Take the highest count of the three minor threads and use it as a dividend, and divide it by itself, then divide it in turn by the counts of the other minor threads; add up the quotients and then divide the dividend (the highest count of the minor threads) by their sum.

Example: Find the single equivalent count of a worsted compound thread composed of a 1/30's, a 1/60's and a 1/90's worsted.

Solution: The highest count of the three minor threads is 1/90's. This is used as the dividend thus:

$$90 \div 90 = 1$$
$$90 \div 60 = 1.5$$
$$90 \div 30 = 3$$

The sum of the quotients is 5.5

Dividing the dividend (90) by the sum of the quotients (5.5) gives $90 \div 5.5 = 16.36+$. *Answer:* The single equivalent of a compound thread composed of a 1/30's, a 1/60's and a 1/90's worsted, is a 1/16.36's worsted.

Example: Find the single equivalent count of a cotton compound thread composed of a 1/45's, a 1/30's and a 1/90's cotton.

Solution: 1/90's is the highest of these three counts.

$$90 \div 90 = 1$$
$$90 \div 45 = 2 \qquad 90 \div 6 = 15.$$
$$90 \div 30 = 3$$

Sum of quotients, 6.

Answer: The single equivalent of a compound thread composed of a 1/45's, a 1/30's and a 1/90's cotton, is a 1/15's cotton.

14. To find the single equivalent count of a compound thread composed of three minor threads of different counts and materials, the counts and materials of the minor threads being given.

Rule: Change all the counts to the single equivalent of the material in which the answer is required; then use either one of the above methods of finding the single equivalent count of compound threads composed of three minor threads of different counts of the same material.

Example: Find the single equivalent count of a compound thread composed of a 2/60's worsted, a 60/2 spun silk, and a 1/45's cotton in the worsted system.

Solution: 2/60's worsted $=60 \div 2=1/30$'s worsted. 60/2 spun silk $=1/60$ spun silk $=60 \times 3 \div 2=1/90$'s worsted. 1/45's cotton $=45 \times 3 \div 2=1/67.5$'s worsted. Of the three minor threads 1/90's is the highest count.

$$\begin{array}{l} 90 \div 90 \quad =1 \\ 90 \div 30 \quad =3 \\ 90 \div 67.5=1\frac{1}{3} \\ \hline \quad 5\frac{1}{3} \end{array} \qquad 90 \div 5\tfrac{1}{3}=16\tfrac{7}{8}$$

Answer: A compound thread composed of a 2/60's worsted, a 60/2 spun silk and a 1/45's cotton is equivalent to a $1/16\frac{7}{8}$'s worsted.

Example: Find the single equivalent of a compound thread composed of a 32 cut wool, a 6 run wool, and a 1/20's worsted, in the worsted system.

Solution: 32 cut wool $=32 \times 300 \div 560=17\frac{1}{7}$ worsted. 6 run wool $=6 \times 1{,}600 \div 560=17\frac{1}{7}$ worsted. The counts of the three minor threads in the worsted system are $1/17\frac{1}{7}$'s, $1/17\frac{1}{7}$'s and 1/20's. As these are badly broken up numbers the first method is the better one to use in this case. $17\frac{1}{7} \times 17\frac{1}{7} \div 34\frac{2}{7}=8\frac{4}{7}$. $8\frac{4}{7} \times 20 \div 28\frac{4}{7}=6$. *Answer:* A compound thread composed of a 32 cut wool, a 6 run wool, and a 1/20's worsted is equivalent to a 1/6's worsted.

15. To find the single equivalent count of compound threads composed of four or more minor threads of different sizes and either the same or different materials, when the counts and materials of minor threads are given.

First Method.

Rule: Change the counts of all the minor threads to their single equivalent of the material in which the answer is required, then take any two counts of the minor threads and find their single equivalent. Then take the counts of two other minor threads and find their single equivalent; then take the single equivalent of the two first minor threads and that of the two second minor threads and find their single equivalent; this answer will then be the single equivalent of a four-ply compound thread. If the compound thread is more than four ply, then this last equivalent is combined with the fifth minor thread and their single equivalent is found, etc.

Example: Find the single equivalent of a compound woolen thread composed of an 8 run wool, 1/20's cotton, 1/24's worsted and a 40/2 spun silk. Give answer in run wool system.

Solution: The counts in the run wool system are 8 run wool 1/20's cotton $= 20 \times 840 \div 1,600 = 10.5$ run wool. 1/24's worsted $= 24 \times 560 \div 1,600 = 8.4$ run wool. 40/2 spun silk $= 40 \times 840 \div 1,600 = 21$ run wool. The single equivalent of the first two minor threads is $8 \times 10.5 \div 18.5 = 4.54+$ run wool. The single equivalent of the two other minor threads is $8.4 \times 21 \div 29.4 = 6$ run wool. Taking the single equivalent of the first two minor threads and that of the last two, equals $4.54 \times 6 \div 10.54 = 2.584+$. *Answer:* The single equivalent of a compound thread composed of an 8 run wool, 1/20's cotton, 1/24's worsted and 40/2 spun silk, is a 2.584 run wool.

Second Method.

Rule: Change the counts of all the minor threads to their single equivalent of the material in which the answer is required. Then take the highest count and use it as a dividend, dividing it by itself and then in turn by all the other counts; the quotients are then added up and the dividend (the highest count) is divided by their sum. This last quotient will be the answer.

Example: Find the single equivalent count of a compound thread composed of a 1/60's worsted, 1/40's worsted, 40/2 spun silk, 8 run wool and 1/30's cotton, in the worsted system.

Solution: The single equivalent counts of the various minor threads in the worsted system are 1/60's worsted, 1/40's worsted, 40/2 spun silk $= 40 \times 3 \div 2 = 1/60$'s worsted. 8 run wool $= 8 \times 1,600 \div 560 = 1/22\frac{6}{7}$'s worsted, and 1/30's cotton $= 30 \times 3 \div 2 = 1/45$'s worsted. The highest count of these five minor threads is 1/60's. Using this as the dividend and dividing it by itself and in turn by the counts of all the other minor threads equals

$$
\begin{aligned}
60 \div 60 &= 1 \\
60 \div 40 &= 1.5 \\
60 \div 60 &= 1 \\
60 \div 22\tfrac{6}{7} &= 2.625 \\
60 \div 45 &= 1.25 \\
\hline
\text{The sum of quotients is} \quad & \quad 7.375
\end{aligned}
$$

$60 \div 7.375 = 8.136 -$. *Answer:* A compound thread composed of a 1/60's worsted, 1/40's worsted, a 40/2 spun silk, an 8 run wool and a 1/30's cotton, is equivalent to a 1/8.136's worsted.

16. It is often necessary to find the size of a minor thread, which, together with a given minor thread, will form a compound thread of a required count. To find the count of the required minor thread, when the count of one minor thread and that of the compound thread desired are given.

Rule: Multiply the single equivalent count of the compound thread by the count of the given minor thread and divide this product by the difference of the given counts.

Example: A compound thread equivalent to a 2/40's worsted is to be made by twisting another worsted thread to a 1/60's worsted. What size minor thread is required?

Solution: 2/40's worsted $= 40 \div 2 = 1/20$'s worsted is the single equivalent of the compound thread. $20 \times 60 \div (60-20) = 20 \times 60 \div 40 = 30$. *Answer:* A 1/60's worsted together with a 1/30's worsted will make a compound thread equivalent to a 2/40's worsted.

Example: Find the count of the minor thread required to be twisted with a 1/20's cotton. A compound thread equaling a 2/30's cotton is to be made.

Solution: 2/30's cotton $= 30 \div 2 = 1/15$'s cotton. $15 \times 20 \div (20-15) = 15 \times 20 \div 5 = 60$. *Answer.* A 1/60's cotton thread must be twisted with that of a 1/20's cotton in order to produce a compound thread equaling a 2/30's cotton.

17. To find the count of a required minor thread, which, when twisted with a given minor thread of another material, will make a compound thread of a given count, the count and material of one minor thread and that of the compound thread being given.

Rule: Change the given counts to their single equivalent in the system in which the answer is required. Then multiply the single equivalent of the minor thread by that of the compound thread and divide this product by the difference between the counts of the given minor and compound threads; the quotient will be the count of the required minor thread.

Example: It is desired to twist a worsted thread with a 40/2 spun silk yarn. The compound thread required is a 2/20's worsted.

Solution: 40/2 spun silk $= 40 \times 3 \div 2 = 1/60$'s worsted. 2/20's worsted $= 20 \div 2 = 1/10$'s worsted. $60 \times 10 \div (60-10) = 60 \times 10 \div 50 = 12$. *Answer:* In order to make a compound thread equivalent to a 2/20's worsted, a 1/12's worsted thread must be twisted with a 40/2 spun silk.

Example: It is desired to make a compound thread equivalent to a 2 run wool, by twisting a 32 cut woolen thread to another woolen thread which is graded according to the run system.

Solution: 32 cut wool $= 32 \times 300 \div 1{,}600 = 6$ run wool. $6 \times 2 \div (6-2) = 6 \times 2 \div 4 = 3$. *Answer:* To make a compound thread equaling a 2 run wool in combination with a 32 cut wool, a 3 run woolen yarn is required.

CHAPTER THREE.

GRADING OF RAW-SILK YARNS.

18. Dram, or English System. Raw-silk yarns are not spun but reeled direct from cocoons; various numbers of cocoons are reeled together, forming one thread. This results in threads of various weights and thicknesses.

Raw or Gum Silks (as they are often termed) are graded according to the weight of a standard number of yards, the weight of the yarn indicating its count or size.

In the English System (better known as the *Dram System*), of grading raw-silk yarns, one thousand (1,000) is the standard number of yards of yarn weight; the *Dram* is the unit of weight used. The number of drams required to balance 1,000 yards of raw-silk yarn indicates the count or size of the yarn. For instance: If 1,000 yards of raw silk weigh four (4) drams, the silk will be graded as four-dram silk; if it should weigh six (6) drams, then it would be six-dram silk. From this it can be seen that the higher the number or count of the yarn, the coarser it will be; as a yarn of which 1,000 yards weigh four (4) drams must be finer than one of which 1,000 yards weigh six (6) drams. This method of grading is exactly the opposite of that used in the grading of other yarns, as for instance cotton: where the higher the count the finer the yarn. For, if in the cotton system 80×840 yards of a certain yarn should weigh one (1) pound, it must be finer than another cotton yarn of which 20×840 yards will weigh one (1) pound.

In coarser numbers of dram silk, the standard hank of 1,000 yards is broken up into hanks of 500 and 250 yards, as full hanks would be too bulky to be handled advantageously. In this case the yarns are graded in proportion to the full hank of 1,000 yards. For instance: If a hank of 250 yards weighs four (4) drams, the yarn would be graded as 16-dram silk, as 250 is one-fourth of 1,000; 1,000 yards will weigh four times as much as 250. If a hank of 500 yards weighs six (6) drams, the yarn will be graded as 12-dram silk, as 500 is one-half of 1,000; 1,000 yards will weigh twice as much as 500.

19. To find the number of yards per pound of any dram silk yarn, the count of the yarn being given.

Rule: Multiply 256 (the number of drams per pound) by 1,000 and divide this product by the count of the yarn.

Example: Find the number of yards of yarn per pound of an 8-dram silk.

Solution: $256 \times 1{,}000 \div 8 = 32{,}000$. *Answer:* 32,000 yards of 8-dram silk per pound.

Example: Find the number of yards of yarn per pound of a 4-dram silk.

Solution: $256 \times 1{,}000 \div 4 = 64{,}000$. *Answer:* 4-dram silk has 64,000 yards per pound.

20. To find the number of yards per ounce of any dram silk yarn, when the count of the yarn is given.

Rule: Multiply 16 (the number of drams per ounce) by 1,000 and divide the product by the count.

Example: Find the number of yards per ounce of a 4-dram silk.

Solution: $16 \times 1{,}000 \div 4 = 4{,}000$. *Answer:* 4,000 yards per ounce of 4-dram silk.

Example: Find the number of yards per ounce of a 1.5-dram silk.

Solution: $16 \times 1{,}000 \div 1.5 = 10{,}666\frac{2}{3}$. *Answer:* $10{,}666\frac{2}{3}$ yards per ounce of 1.5-dram silk.

21. To find the single equivalent count of any dram silk yarn in another system, when the count of the silk yarn is given.

Rule: Multiply $256 \times 1{,}000$ and divide the product by the count of the silk yarn. This gives the number of yards per pound. Divide the number of yards of silk, per pound, by the standard number, of the material, in which the answer is required.

Example: Find the single equivalent in the cotton system of a 16-dram silk.

Solution: $256 \times 1{,}000 \div 16 = 16{,}000$ yards per pound, and $16{,}000 \div 840 = 19.097+$. *Answer:* 1/19's cotton is the single equivalent to a 16-dram silk.

Example: Find the single equivalent in worsted to a 10-dram silk.

Solution: $256 \times 1{,}000 \div 10 = 25{,}600$ yards per pound, and $25{,}600 \div 560 = 45.71+$. *Answer:* A 1/45.7's worsted is the equivalent to a 10-dram silk.

22. To find the equivalent count of any yarn from any system in the dram silk system, when the count and material of the yarn are given.

Note: There are quite a number of rules by which the equivalent count in the dram system may be found, the shortest, however, is this one.

Rule: Find the number of yards per pound of the given count, then divide the number of yards of 1-dram silk per pound by the number of yards per pound of the given count. (There are 256,000 yards per pound of 1-dram silk.)

Example: Find the equivalent count in the dram silk system to a 1/120's cotton.

Solution: $120 \times 840 = 100,800$ yards per pound. $256,000 \div 100,800 = 2.5399-$. *Answer:* A 2.54− dram silk is the equivalent to a 1/120's cotton.

Example: Find the equivalent in the dram silk system to a 1/60's worsted.

Solution: $560 \times 60 = 33,600$ yards per pound. $256,000 \div 33,600 = 7.619+$. *Answer:* The equivalent to a 1/60's worsted is a 7.6+ dram silk.

23. Denier or Continental System. In this system the same basis is followed as in the dram system; i.e., the count of the yarn is based upon the weight of a certain amount (length) of yarn, the weight indicating its size or count. The difference between the dram and denier system lies in the unit of weights and measures used. For the dram system the English yard and dram are used, while the denier system employs the French *Aunes* and *Denier*. In this case the standard number of yards of yarn weight is 400 aunes = 476 metres = 520.56 yards; the weight of 400 aunes in deniers indicates the size or count of the yarn. Therefore, if 400 aunes of any raw-silk yarn weigh 40 deniers, the yarn will be classed as 40-denier silk, etc.

24. To find the number of yards per pound of any denier silk, when the count of the yarn is given.

Rule: Multiply 8,540.16 by 520.56 (the standard number of yards for the denier system), and divide this product by the count.

Note: There are 8,540.16 deniers per pound avoirdupois.

Example: Find the number of yards per pound of a 36-denier silk.

Solution: $8,540.16 \times 520.56 = 4,445,665.6896$ yards per pound of 1-denier silk. $4,445,665.6896 \div 36 = 123,490.7+$. *Answer:* One pound of 36-denier silk contains 123,490.7 yards.

Example: Find the number of yards per pound of a 40-denier silk.

Solution: $8,540.16 \times 520.56 \div 40 = 111,141.64+$. *Answer:* There are 111,141.64+ yards per pound of 40-denier silk.

25. To find the number of yards per ounce of any denier silk, when the count of the yarn is given.

Rule: Multiply the number of deniers per ounce by 520.56, and divide this product by the count.

Note: There are 533.76 deniers per ounce.

Example: Find the number of yards per ounce of a 32-denier silk.

Solution: 533.76×520.56=277,854.1056 yards of 1-denier silk per ounce. 277,854.1056÷32=8,682.9408. *Answer:* 8,682.94+ yards of 32-denier silk weigh one ounce.

Example: Find the number of yards per ounce of a 40-denier silk.

Solution: 533.76×520.56÷40=6,946.35+. *Answer:* 6,946.35+ yards of 40-denier silk weigh one ounce.

26. To find the equivalent count in the denier system, to a given count in the dram system.

Rule: Multiply the equivalent count to 1-dram silk in the denier system (17.366) by the count.

Note: 1 dram=33.36 deniers. 1 metre=39.37 inches. 470 metres=18,740.12 inches=520.56 yards. There are 256,000 yards per pound of 1-dram silk. There are 4,445,665.69 – yards per pound of 1-denier silk. 1-dram silk=17.366 denier silk.

Example: Find the equivalent count of a 4-dram silk in the denier system.

Solution: 17.366×4=69.464. *Answer:* 69.5 – denier silk is equivalent to a 4-dram silk.

Example: Find the equivalent count of a 2-dram silk in the denier system.

Solution: 17.366×2=34.732. *Answer:* 34.7+ denier is the equivalent of 2-dram silk.

27. To find the equivalent count in the dram system to a given count in the denier system, the count of the yarn being given.

Rule: Divide the given count by the equivalent count of one-dram silk.

Example: Find the equivalent to a 46-denier silk in the dram system.

Solution: 46÷17.366=2.648+. *Answer:* 2.65 – dram is equivalent of 46-denier silk.

Example: Find the equivalent count in the dram system to an 18-denier silk.

Solution: 18÷17.366=1.0365+.. *Answer:* 1.04 dram is equivalent to 18-denier silk.

28. To find the equivalent count in any system (excepting dram silk) to a given count in the denier system.

Rule: Divide the number of yards per pound of 1-denier silk (4,445,665.6896) by the given count and divide this quotient by the standard number of the system in which the answer is required.

Example: Find the equivalent count of a 60-denier silk in the cotton system.

Solution: $4,445,665.6896 \div 60 = 74,094.428+$. $74,094.428 \div 840 = 88.2+$. *Answer:* 1/88.2's cotton is the equivalent of 60-denier silk.

Example: Find the equivalent count in the spun silk system of an 80-denier silk.

Solution: $4,445,665.6896 \div 80 = 55,570.82+$. $55,570.82 \div 840 = 66.16-$. *Answer:* 1/66 spun silk is equivalent of an 80-denier silk.

29. To find the equivalent count in the denier system of any given count of another system (excepting raw silk).

Rule: Divide the number of yards per pound of 1-denier silk by the number of yards per pound of the yarn in question.

Example: Find the equivalent count to an 80/2 spun silk in the denier system.

Solution: $80/2 = 1/80$'s. $840 \times 80 = 67,200$. $4,445,665.6896 \div 67,200 = 66.156-$. *Answer:* 66.156– denier silk is the equivalent to 80/2 spun silk.

Example: Find the equivalent count to a 1/120's worsted in the denier system.

Solution: $560 \times 120 = 67,200$. $4,445,665.6896 \div 67,200 = 66.156-$. *Answer:* 66.156– denier silk is the equivalent to a 1/120's worsted.

Note: Raw-silk yarns are very susceptible to moisture, which varies the count of the yarns considerably, as in a dry place they weigh considerably less than when they are exposed to dampness. On this account the minimum and maximum count of a silk yarn are generally given when graded according to the denier system, thus: 36/40 denier, meaning that the count is somewhere between 36 and 40 deniers under normal conditions, but that it may be as fine as 36's denier in a dry place and as coarse (heavy) as 40's denier when exposed to dampness.

The counts of yarns graded according to the dram silk system, are given in one figure only, thus: 2-dram silk, etc.

CHAPTER FOUR.

CALCULATIONS PERTAINING TO CLOTH ANALYSIS.

30. Samples. The cloth to be analysed, or the *Sample,* is mostly a small piece ranging from one (1) square inch to, perhaps, forty (40) square inches and more. The smaller samples are of course more frequent than those larger, the average size of samples being about twelve (12) square inches. From this it can be seen that in calculating yarns and cloths from a sample, the figures, which must all be obtained from the cloth, are necessarily small and figures must be carried to three and four decimal places in order to receive the best results. To better illustrate this idea, supposing that a thread has been removed from a sample, the thread measuring three and one-eighth inches ($3\frac{1}{8}$), now supposing that 100 of these threads have been removed, they would give a total length of $3.125 \times 100 = 312.5$ inches of yarn. If the fraction (.125 or $\frac{1}{8}$) had been dropped, which is only one-eighth of an inch, in 100 threads this one-eighth of an inch would amount to twelve and one-half inches (12.5″), which amounts to four threads. Therefore, accuracy in measurement is necessary in order to obtain a correct analysis of any textile fabric.

The measurements taken from a sample are its width and length, and the length of the threads after being removed from the cloth and straightened out. The number of warp threads (ends) per inch, and number of filling threads (picks) per inch are then counted.

All calculations, when analysing a sample, are based upon one yard (in length) of the goods. The widths vary, as nearly every class of textile fabrics is manufactured in different widths. For instance: Worsteds and woolens (broad goods) are generally made in six-quarter widths, equivalent to 54 inches. In some States these goods are made 56 inches wide, but they come on the market anywhere from 54 to 58 and 60 inches. Velvets and plushes come as narrow as 18 inches, and cotton goods generally average 40 inches.

31. The Take-Up in Weaving. The warp being raised and lowered during weaving, and the filling threads passing through the shed, cause both warp and filling to contract in length while they are woven into a fabric. The lost length can always be recovered upon removing the threads from the goods, i.e., if the goods have not been shrunk previously. The take-up of the filling is harder to determine than that of the warp, on account of the goods having a tendency to shrink in width due to the softness of the filling.

To find the percentage of take-up in warp during weaving, from a small sample.

Rule: Measure the length of sample, thus obtaining the *cloth length* of the ends; then remove an end, straighten it out and measure, thus obtaining the *straight-length.* Subtract the cloth length from the straight length, thus obtaining the *take-up in inches.*

Multiply the take-up in inches by one hundred (100) and divide this product by the straight length.

Note: When straightening the threads, care must be taken that they are straightened and not stretched.

Example: Find the percentage of take-up of a warp thread which measures 4.125 inches in the cloth and straightens out to 4.5 inches.

Solution: 4.5 4.125 = .375 inches is the take-up in inches. $.375 \times 100 \div 4.5 = 8\frac{1}{3}$. *Answer:* The take-up in weaving, of a warp of which an end straightens from $4\frac{1}{8}$ to $4\frac{1}{2}$ inches, is $8\frac{1}{3}\%$.

Example: Find the percentage of take-up of an end which straightens from 8 to $8\frac{5}{8}$ inches.

Solution: $8\frac{5}{8} - 8 = \frac{5}{8}$ inches, take-up in inches. $\frac{5}{8} \times 100 \div 8\frac{5}{8} = 7\frac{17}{69}$. *Answer:* The take-up of an end straightening from 8 to $8\frac{5}{8}$ inches is $7\frac{17}{69}\%$.

Note: It is always best to do these examples in common fractions as dropping decimal places, in the percentage, amounts to considerable when figuring a whole warp.

32. To find the total number of yards of warp yarn in one yard of cloth, including the percentage of the take-up, when the number of ends per inch, percentage of take-up, and the finished width of the goods, are given.

The number of ends per inch are counted in the finished cloth, as the sample from which the analysis is made must necessarily be a piece cut from finished cloth. As nearly all goods are wider in the loom, than they are finished, there are more ends per inch in the finished goods than in the loom, or reed width.

Rule: Multiply the number of ends per inch by the width, in inches, of the fabric; then multiply this product by one hundred (100) and divide the product by one hundred (100) minus the percentage of take-up (100 percentage of take-up).

Example: A sample contains 72 ends per inch, the goods is 54 inches finished and the warp has a take-up of 8% during weaving; how many yards of warp yarn is there in one yard of cloth?

Solution: $72 \times 54 = 3{,}888$ ends in the cloth. $3{,}888 \times 100 \div (100 - 8) = 3{,}888 \times 100 \div 92 = 4{,}226\frac{2}{23}$. *Answer:* 4,226 yards ($4{,}226\frac{2}{23}$ yards), is contained in one yard of the goods.

Explanation: Every end in the goods, of one yard of cloth, is the length of one yard plus the take-up. As the ends were the original length before they were woven into the fabric, the length of the goods (one yard) is the difference obtained after subtracting the take-up from the original length of the warp (ends). After having multiplied the number of ends per inch by the width of the fabric, the number of ends in the goods has been found, also the number of yards of warp yarn in one yard of cloth, minus the percentage of take-up. Therefore this product, the number of ends per inch times the width of fabric, is only a certain percentage of all the yarn contained in one yard of the goods. In case of the above example it was 92% of the total amount. 3,888 yards being 92%, 1% would be $3{,}888 \div 92 = 42.26087-$ yards, which makes 100% amount to $42.26087 \times 100 = 4{,}226.087-$, or $4{,}226\frac{2}{23}$ yards. Multiplying the number of ends in warp by 100, before dividing, does away with fractions.

Example: Find the total number of yards of warp yarn in one yard of cloth having 32 ends per inch, 36 inches wide, and a take-up of 12%.

Solution: $32 \times 36 = 1{,}152$ ends in warp. $1{,}152 \times 100 \div (100 - 12) = 115{,}200 \div 88 = 1{,}309\frac{1}{11}$. *Answer:* The above fabric has a total of $1{,}309\frac{1}{11}$ yards of warp yarn per yard of cloth.

33. To find the total number of yards of filling yarn per yard of cloth, when the number of picks per inch and the width of warp in reed are given.

Rule: Multiply the number of picks per inch by the width, in inches, of the warp in reed.

Example: Find the number of yards of filling contained in one yard of cloth, 64 inches wide in the reed, having 36 picks per inch.

Solution: $64 \times 36 = 2{,}304$. *Answer:* The above fabric contains 2,304 yards of filling per yard of cloth.

Explanation: When calculating the amount of filling contained in one yard of cloth, it is easier to first find the loom (reed) width of the goods by removing a pick from the sample, obtaining its cloth and straight length, and then by proportion finding the loom width. If, for instance, a pick is found to measure 8 inches in the cloth and $8\frac{3}{4}$ inches straightened, the fabric being 54 inches finished, the proportion would be $8 : 8\frac{3}{4} :: 54 : x = 8\frac{3}{4} \times 54 \div 8 = 59\frac{1}{16}$ inches, width of warp in loom. As goods have a tendency to shrink in width this method of finding the loom width is not always practical; a vast amount of practice is necessary to always obtain the right width of fabric in loom from a finished sample.

Multiplying the number of picks per inch by the width of fabric in loom, gives the number of inches of filling per inch of cloth; in 36 inches (one yard) of cloth, there will be 36 times as many inches of filling, or, taking the above example, $36 \times 64 \times 36 = 82,944$ inches of filling per yard of cloth. Reducing this number of inches to yards, it must be divided by 36, thus bringing it back to $36 \times 64 = 2,304$, or *multiply the number of picks per inch by the width of warp in reed.*

The width of warp in reed is used, because every pick that enters the goods is the length of the width of warp in reed. The pick is beaten-in before the take-up in width is noticed and while the warp is spread to its full width by the reed.

Example: Find the number of yards of filling per yard of cloth of a fabric which has $67\frac{1}{2}$ picks per inch, and is 42 inches wide in the loom.

Solution: $67\frac{1}{2} \times 42 = 2,835$. *Answer:* The above fabric contains 2,835 yards of filling per yard of cloth.

34. To find the number of yards of each kind of yarn used, per yard of cloth, from a small sample.

Rule: By counting, find the total number of ends per pattern; then find the number of ends of each color or material in pattern. Divide the total number of yards of warp yarn per yard of cloth by the number of ends per pattern, then multiply this quotient, in turn, by the number of ends of each color or material in the pattern. The different answers obtained will be the number of yards of each color or material per yard of cloth.

Example: A sample is found to have 42 ends per inch, the goods are 54 inches finished (width) and have 10% take-up. The sample has the following color pattern—2 ends of 2/40's blue worsted, and 4 ends of 2/40's black worsted. How many yards of yarn of each color are there per yard of cloth?

Solution: 2/40's blue worsted 2 ends
2/40's black worsted 4 "

Total number of ends per pattern 6

$42 \times 54 \times 100 \div (100 - 10) = 2,520$ yards of warp yarn per yard of cloth.

$2,520 \div 6 = 420$. $420 \times 2 = 840$ yards of blue
$420 \times 4 = 1680$ " " black.

Total number of yards 2,520

Answer: These goods contain of 2/40's blue worsted 840 yards, and of 2/40's black worsted 1,680 yards.

When figuring filling this same rule is used. After the number of yards of filling per yard of cloth is found, the number of yards of each kind of filling (color or material) is found in exactly the same manner.

Example: Find the number of yards of each kind of filling per yard of cloth, from a sample which has 44 picks per inch, is 54 inches finished and 58 inches wide in the reed. The filling used is 2/48's worsted throughout, and the pattern is

Blue 3 picks
Black 3 picks.

Solution: 2/40's blue 3 picks
2/40's black 3 "

Total number of picks per pattern 6

$44 \times 58 = 2,552$ yards of filling per yard of cloth.
$2,552 \div 6 = 425\frac{1}{3}$. $425\frac{1}{3} \times 3 = 1,276$ yards of blue
$425\frac{1}{3} \times 3 = 1,276$ " " black

Total number of yards 2,552

Answer: There are 1,276 yards of blue and 1,276 yards of black filling per yard of cloth of the above description.

35. Another method used for finding the number of yards of each kind (color or material) of warp yarn per yard of cloth, is given in the following rule.

Rule: Divide the number of ends in the warp by the number of ends per pattern, thus finding the number of patterns in the warp; then multiply the number of patterns in the warp by the number of ends of each color (or material), thus finding the number of ends of each color in the warp. Then multiply the number of ends of each kind of yarn by 100 (taking one kind of yarn after the other), and divide the various products by 100 minus the percentage of take-up.

Note: This rule gives better results if large patterns are concerned, but is more lengthy and complicated. Filling should never be figured by this rule, as weaving one yard after the other will make an average which will be obtained by the use of the other rule.

When the number of patterns in the warp do not come out even, which is often the case with large patterns, then the first ends of the pattern are used in place of the fraction.

Example: Find the number of yards of each kind of warp yarn per yard of cloth from a sample which has 72 ends per inch, is 54 inches finished, having 12% take-up, and the following pattern:

pattern:					
2/40's cotton, black	1 1	1 1 2 2	2 2	1 1	48
2/60's worsted, olive	1	1	2	1	22
2/60's worsted, twist	1	1	2	3	24
2/60's worsted, red		1 1			2
	8		6		
Total number of ends per pattern					96

Solution: $72 \times 54 = 3{,}888$ ends in warp. $3{,}888 \div 96 = 40.5$ patterns in warp. There are 40 whole patterns and $\frac{1}{2}$ pattern in the warp. Taking the 40 patterns first, and multiplying them by the number of ends of each kind of yarn and then adding the number of ends of each kind of yarn, in the first half of the pattern, to the respective products, gives:

$40 \times 48 =$	$1{,}920 + 26 =$	1,946	ends of black cotton
$40 \times 22 =$	$880 + 11 =$	891	" " olive worsted
$40 \times 24 =$	$960 + 9 =$	969	" " twist worsted
$40 \times 2 =$	$80 + 2 =$	82	" " red worsted
Total		3,888	ends in warp.

$1{,}946 \times 100 \div (100-12) =$	$2{,}211\frac{4}{11}$	yards of black cotton
$891 \times 100 \div (100-12) =$	$1{,}012\frac{1}{2}$	" " olive worsted
$969 \times 100 \div (100-12) =$	$1{,}101\frac{3}{22}$	" " twist worsted
$82 \times 100 \div (100-12) =$	$93\frac{4}{22}$	" " red worsted
Total	$4{,}418\frac{2}{11}$	" " yarn per yard.

Answer: The above goods contain $2{,}211\frac{4}{11}$ yards of 2/40's black cotton, $1{,}012\frac{1}{2}$ yards of 2/60's olive worsted, $1{,}101\frac{3}{22}$ yards of 2/60's twisted worsted, and $93\frac{4}{22}$ yards of 2/60's red worsted, per yard of cloth; a total of $4{,}418\frac{2}{11}$ yards.

Proof: 3,888 ends in the warp, 12% take-up. $3{,}888 \times 100 \div (100 - 12) = 4{,}418\frac{2}{11}$ yards of warp yarn per yard of cloth.

36. To find the count of any yarn from a small sample.

Rule: Measure the straight length of a thread which has been removed from the sample, and multiply this length by the number of threads removed (at least 100 inches of yarn should be removed). Weigh the removed yarn carefully, with grain weights. Multiply the number of inches of yarn weight by 7,000 (the number of grains per pound) and divide this product by the weight of the yarn; this gives the number of inches of yarn per pound. Divide the number of inches of yarn per pound by 36 (reducing inches to yards), and divide this product by the standard number of the yarn in question. [If the yarn is raw silk, then the number of yards of 1-dram silk (or 1-denier silk), per pound is divided by the number of yards per pound of the yarn in question].

Example: If 148 inches of worsted yarn weigh 1.4 grains, what will be its count?

Solution: $148 \times 7{,}000 \div 1.4 = 740{,}000$ inches of yarn per pound. $740{,}000 \div 36 = 20{,}555\frac{5}{9}$ yards of yarn per pound. $20{,}555\frac{5}{9} \div 560 = 36.7+$. *Answer:* 1/36.7's worsted is the count of the yarn.

Example: Find the count in the dram system of a raw silk yarn of which 240 inches weigh $\frac{7}{8}$ grain.

Solution: $240 \times 7{,}000 \div \frac{7}{8} = 1{,}920{,}000$ inches of yarn per pound. $1{,}920{,}000 \div 36 = 53{,}333\frac{1}{3}$ yards of yarn per pound. $256{,}000 \div 53{,}333\frac{1}{3} = 4.8$. *Answer:* 4.8 dram silk is the count of this raw-silk yarn.

37. To find the weight of one yard of cloth in ounces from a small sample, when the size of the sample, in inches, and the width of the finish fabric are given.

Rule: After trimming the sample accurately, find the length of two of its adjoining sides in inches and multiply the length of one side by that of the other, thus obtaining the number of square inches in the sample. Weigh the sample with grain weights. Multiply the width, in inches, of the finished goods by 36 (the number of inches in one yard), thus obtaining the number of square inches in one yard of cloth.

Divide the number of square inches per yard of cloth by the number of square inches in the sample, and multiply this quotient by the weight of the sample, thus obtaining the weight of one yard of cloth in grains; divide this number of grains by 437.5 (number of grains per pound avoirdupois), the quotient will be the weight of one yard of cloth in grains.

Example: A piece of woolen goods, 4 by 3 inches, weighs 60 grains, what will be the weight of one yard of cloth, 54 inches wide?

Solution: $4 \times 3 = 12$ square inches in sample. $54 \times 36 = 1{,}944$ square inches in one yard of cloth. $(1{,}944 \div 12) \times 60 = 9{,}720$ grains, weight of one yard of cloth. $9{,}720 \div 437.5 = 22.217+$ ounces. *Answer:* The weight of one yard of cloth is 22.2+ ounces.

Example: Find the weight of one yard of cotton sheeting 48 inches wide. A sample, 4 by 4 inches, weighs 10.5 grains.

Solution: $4 \times 4 = 16$ square inches, size of sample. $48 \times 36 = 1{,}728$ square inches per yard of the goods. $(1{,}728 \div 16) \times 10.5 = 1{,}134$ grains, weight of one yard of the sheeting. $1{,}134 \div 437.5 = 2.592$ ounces. *Answer:* One yard of this sheeting will weigh 2.6 – ounces.

CHAPTER FIVE.

ANALYSIS OF CLOTH.

38. Points to be looked for when Analysing a Textile Fabric.

1. Find the material, or materials, of which the sample is composed.
2. Find which side of the sample is the face and which the back.
3. Find which system of threads is the warp and which the filling.
4. Find the weight, per yard, of the finished goods.
5. Find the take-up, of warp, during weaving.
6. Find the width of warp in reed.
7. Find the finished count of warp and filling yarns.
8. Find the loom counts of the warp and filling yarns, in case the goods have lost in weight during finishing.
9. Find the number of ends and picks per inch in the finished goods.
10. Find the color pattern of warp and filling.
11. Find the amount of warp yarn and amount of filling yarn required, in ounces, to weave one yard of cloth.
12. Find the amount of weighting matter in the sample.
13. Find the weight of one yard of cloth from the loom.
14. Find the weave.

Note: These points have been given in the rotation in which, one after the other, they can readily be obtained; as some points are necessary to establish others, it is best for the student to adhere to this rotation.

38a. Explanation of Points 1, 2 and 3.

1*a*. Materials, in some fabrics, may be told apart by the naked eye, and in many classes of goods made of only one material throughout, it can readily be determined without any testing; as for instance in all cotton goods, such as sheetings, shirtings, bed-spreads, etc., and some all wool and all silk goods. In some fabrics it is next to impossible to tell what material they are made of, in which cases many tests are often necessary before it can be determined.

There are two classes of tests, *a* physical and *b* chemical. To find whether a fabric is composed of all wool, the easiest test to apply is the physical, i.e., by burning the fabric, or separating threads from it, and examining the construction of the different fibres.

Cottons. The threads have a smooth appearance and are composed of short fibres. Under a microscope the different fibres have a twisted, ribbon-like appearance, the fibres lying parallel side by side. Upon burning, they burn with a flash and leave but little ashes, which gives off a slight, pleasant odor.

Wool. These threads have a rough appearance and are made up of fibres which are cylindrical in shape and inclined to curliness. The fibres do not lie parallel side by side in the threads, but are rather in a jumbled-up condition, running in every direction; they stick off from the threads, thus making woolen threads appear fuzzy. They burn slowly, leaving a hard mass for ashes which has a strong, disagreeable odor. Woolen threads are more elastic than cotton threads, which stretch but little.

Worsted. These threads are made of the same raw material as woolen threads (wool) but are smoother in appearance and the fibres lie more evenly and parallel in the threads. This is due to the extra combing, gilling, and drawing, material, destined to be made into worsted threads, undergoes before it is spun into yarn. The fibres are usually of a longer staple than those used for woolen threads, as it is only within a short time that short-fibred wools have been used for worsted yarns. Cheviot yarns (mostly worsted) are very hairy.

Cotton, Wool and Silk. It is often the case that goods are composed of both woolen (worsted) and cotton threads, or that the threads are made up of part wool and part cotton. In that case it is necessary to apply one of the many chemical tests in use. With the help of these tests the percentage of each material contained in the fabric can readily be found. The test most readily applied for fabrics which are to be of either all wool, or all silk, but are suspected of containing cotton: this can readily be determined by placing the sample in a concentrated solution of caustic soda or potash; the wool or silk fibres will dissolve, while the cotton or other vegetable fibres will remain. The percentage of cotton contained in the goods can be found by weighing the sample before placing it in the solution of caustic soda, and by again weighing it (if any is left) after it has been thoroughly dried. The weighing should always be done when the sample is thoroughly dry, i.e., at about 120 degrees F. The percentage can then be found by multiplying the weight of the sample, after it has been treated, by 100 and dividing this product by the original weight of the sample.

Silk and Wool. Wool, hair and fur are blackened by heating with a solution of plumbite of soda; the silk, which does not contain sulphur, will remain unchanged.

Cotton and Linen. A strong potash solution will dye linen a deep yellow, while it will barely stain cotton. A mixed cloth, after being treated in this solution, would be striped or spotted.

2*a*. The face of the goods has a higher finish than its back, the color pattern is more noticeable (excepting in cloakings and steamer rugs), and has a smoother and softer feeling.

2*b*. When a fabric is made of two qualities of yarn it is customary to throw the cheaper one on the back of the goods.

2*c*. The twill line (if there is one visible), generally runs to the right on the face, and, if one side of the goods appears to be woven closer than the other, the closer woven side will be the face.

2*d*. In serges, etc., the face only is sheared.

3*a*. The warp yarn is usually of a harder twist than the filling.

3*b*. Prominent stripes run in the direction of the warp, and sometimes reed marks are noticeable which also run in the direction of the warp.

3*c*. The nap runs in the direction of the warp, also the selvage.

3*d*. If one system of threads is many times heavier than the other, the heavier threads are usually the filling. When it is found that one system of threads is two-ply and the other single, the single yarn is the filling.

3*e*. If one system of threads is all wool and the other cotton, the cotton, in most cases, is the warp.

39. Explanation of Points 4 to 8, inclusive.

6. See Section 33, Chapter IV, Book II.

7. The results obtained, when following rule given under Section 36, Chapter IV, of Book II, are the counts of the yarns after they have gone, in the shape of a woven fabric, through the finishing processes.

8. Goods which are heavily fulled, gigged and sheared, have a certain amount of loss during finishing. They lose through the washing, which removes oils and other fatty matters from the goods, and shearing and gigging, which cause a lot of loose fibres to fall to the floor, etc. This loss is often made up by the fulling, which decreases the goods in length at times as much as 10% and over. The shrinkage in width of a fabric does not increase its weight (the weight of one yard), as there is nothing to replace the shrunken parts; but in length it is different. For instance: if a piece of goods shrinks from ten to eight yards, all the material, which at first made up ten yards of goods, is now contained in but eight, etc.

If goods lose, through the loss of oils, 8% during finishing, the finished count of the yarn must necessarily be 8% finer than the loom count. To find the loom count from a given finished count the following rule will apply.

Rule: Divide the number of yards per pound of the finished count by 100 plus the percentage of loss during finishing, and multiply this quotient by 100. Then divide this product by the standard number of the yarn in question.

Example: A piece of goods loses 12% in weight during finishing, the finished count is $1\frac{1}{8}$ run wool; what is the loom count?

Solution: $1{,}600 \times 1.125 = 1{,}800$ yards per pound. $1{,}800 \div 112 = 16.071+$. $16.071 \times 100 = 1{,}607.1$ yards per pound for the loom count. $1{,}607 \div 1{,}600 = 1.004+$. *Answer:* One run wool is the loom count.

40. Explanation for Points 9, 10 and 11.

9. The ends and picks, in most cases, can be counted by means of a pick glass and picking-out needle. Where they can not be counted in this manner, it is a good plan to find the number of ends and picks in one repeat of the weave (if the weave is visible), and then count the number of repeats of the weave, per inch, and multiply the number of ends in one repeat of weave by the number of repeats per inch.

A better way still is to fringe the edges so that the ends and picks will protrude. Cut these protruding ends and picks so that one inch (in width) of them remains. Count the number of ends and picks left protruding.

If this method can not be employed, then trim your sample to one square-inch, remove the threads, keeping ends and picks separate, and count them.

10. The color pattern may be counted the same time the number of ends and picks, per inch, are found; the same methods can successfully be employed.

11. The amount of warp and filling yarns, in ounces, required per yard of cloth, is found from the number of yards of yarn per yard of cloth, the rule for which has been given under Section 34, and Section 35, of Chapter IV. To find the weight, in ounces, of these various amounts of yarn the rule is given under Section 7, Chapter I.

41. Explanation of Points 12, 13 and 14.

12. Weighting matter consists of various materials, depending upon the class of goods to be weighted. Cotton goods are weighted with chalks, talkum, fuller's earth, etc., while woolen goods are made heavier by flocking, i.e., waste flocks of wool, made during the shearing of other goods, are filled into the

cloth which is sewed into the shape of a bag. After the flocks have been distributed evenly, the goods are fulled. During this process the fibres of the flocks will combine with those protruding from the fabric. This combination is not very permanent, as the flocks wear off in the course of time. Silks are weighted by means of iron, zinc, lead and dye-stuffs, which are added in solutions.

The exact amount of weighting matter used can, in many instances, be determined only by an exhaustive chemical analysis. In the case of cotton goods it can often be determined by simply washing a sample, weighing same before and after, and then finding the percentage of weighting matter by the loss of weight the sample shows. When woolen goods are weighted with flocks, the amount of weighting can be determined reasonably correct by scraping the back of the goods with a dull-edged instrument, weighing the sample before and after. The amount of weighting materials in silk can be determined only by chemical analysis, which can not be taken up within the scope of this book.

13. When finding the weight of one yard of cloth from the loom it is necessary to use the loom counts (if they differ from those in the finished goods), for figuring the weights. Allowances must also be made for the shrinkage of fabric in length, and loss of weight in scouring (washing) and shearing.

14. After all the weights, number of ends per inch and number of picks per inch, have been found, then the remainder of the sample is used for finding the weave.

This is best accomplished by removing a sufficient number of picks so that the ends have a fringe of about one-half inch. Warp threads are also to be removed, sufficient to give the picks a fringe of about one-half to three-quarters of an inch. Then take hold of the picks between the thumb and first finger and bring the sample over the first finger and under the second. A pick is then somewhat brought forward into the fringed ends, the back of the first finger serving as a rest for the picking-out needle and a backing for the sample. The pick is followed and note is taken of the number of ends which pass over and those passing under it; these ups and downs of the ends are recorded on some squared or point designing paper. After the first pick has been followed for more than one repeat of the weave, it is removed and the next pick taken, etc.

At times it is possible to obtain the weave by means of the pick glass, and again it is possible to read it with the naked eye straight from the sample. If the fabric is a double cloth of very high texture, it is best to remove all the back threads, after which the face weave may be found, then, from another piece of the sample, remove the face threads and find the back weave. The stitching can be placed at the most convenient points.

CHAPTER SIX.

WARP CALCULATIONS.

42. Preparing the Warp. Those threads running lengthwise in goods are termed the *Warp;* the separate threads being termed *Warp Threads* and are generally referred to as *Ends*. Any number of ends from about 400 to 12,000, and more, comprise a warp. Warps are made in various ways, the process being different for nearly every kind of material or yarn used. The making, or *Dressing*, of warps consists of the measuring of the different ends so that all will be of the same length, and at the same time laying them side by side.

Different warps have different numbers of ends per inch. The number of ends per inch is generally termed the *Texture;* in cotton and linen goods the number of ends per inch is generally termed the *Sley*. (In this book the term texture is used in preference to the term sley.)

After the warp has been dressed it is placed on a *beam*, or *warp beam*, at a tight and even tension. After the beaming the different ends are drawn in separately through the eyes of the *heddles*, or wires, on the *harness-frames*. These harness-frames consist of two horizontal bars of wood, one on top and the other at the bottom, fastened together by two perpendicular strips of wood; two metal rods, one on top and a little below the top wooden bar and the other at the bottom and a little above the bottom wooden bar, run across this frame. On these metal rods, or shafts, the heddles are placed. At least two harness-frames are required in the process of weaving; from that up, any number may be used to 30, and at times over.

After the warp has been drawn-in, it is *reeded*, i.e., the ends are drawn through the *reed*. The reed consists of a series of wires running perpendicularly between two ribs; reeds are made with anywhere from 6 to 120 of these wires per inch (these are round outside numbers, coarser and finer reeds have been made and used). The openings between the different wires are termed *reed-splits* or *dents*. Generally two, three, four, five, etc., ends are drawn into each one of these splits. Sometimes one end only is drawn into every reed-split; this, however, is not practical. After the entire warp has been reeded it is placed, warp, harness, reed and all, in the loom.

43. To find the number of ends in a warp, when the number

of reed-splits per inch, number of ends per reed-split, and width of warp in reed (in inches) are given.

Rule: Multiply the number of reed-splits per inch by the number of ends per reed-split, and this product by the number of inches in the width of warp in reed.

Example: Find the number of ends in a warp which is reeded in a reed with 14 reed-splits per inch, 4 ends per reed-split and 64 inches wide.

Note: The texture, or number of reed-splits per inch and number of ends per reed-split, is generally written 14×4; meaning that a reed with 14 dents per inch is used, each dent having 4 ends. $14 \times 4 \times 64''$ would be read: 14 reed, 4 ends per dent, and 64 inches wide.

Solution: $14 \times 4 = 56$ ends per inch. $56 \times 64 = 3{,}584$ ends.
Answer: 3,584 ends are in a warp which is reeded in a 14 reed, 4 ends per dent, 64 inches wide.

Example: Find the number of ends in a warp which is reeded $32 \times 2 \times 32''$.

Solution: $32 \times 2 = 64$ ends per inch. $64 \times 32 = 2{,}048$ ends.
Answer: 2,048 ends in the warp.

44. The Pattern. In weaving we consider two kinds of patterns, the *weave pattern* and the *color pattern.* The weave pattern is determined by the size of the weave, or the number of ends on which the weave repeats; the color pattern is determined by the colors used in the warp. The first of these patterns never interferes with the calculation of the warp, while the latter must always be considered.

To find the number of ends in each color pattern, when the number of ends of each color, in rotation, is given.

Rule: First, add all the ends of the different colors separately, then add the number of ends of each color together.

Example: Find the number of ends per pattern in a warp which is dressed 2 ends of black, 2 ends of slate, 2 ends of black, 2 ends of blue, 2 ends of black, 2 ends of slate, 1 end of black and 1 end of red.

Solution: In the pattern there are the following colors:

Black	2		2		2		1		7
Slate		2				2			4
Blue				2					2
Red								1	1
Total									16 ends

Answer: In the above pattern there are 7 ends of black, 4 ends of slate, 2 ends of blue and 1 end of red; together 16 ends per pattern.

Example: Find the number of ends in the following pattern, 64 ends of green, 32 blue, 4 green, 2 yellow, 4 green, 2 yellow, 4 green, 32 blue, 64 green, 8 blue, 3 brown, 8 blue, 3 brown and 8 blue.

Solution: In the pattern there are the following colors and ends of each color:

Green	64		4		4		4		64						140
Blue		32						32		8		8		8	88
Yellow				2		2									4
Brown											3		3		6
Total															238 ends

Answer: In the above pattern there are 140 ends of green, 88 ends of blue, 4 ends of yellow, and 6 ends of brown; making a total of 238 ends per pattern.

45. To find the number of patterns in any warp, when the texture and width of warp in reed and the number of ends per pattern are given.

Rule: Divide the number of ends in the warp by the number of ends per pattern.

Example: Find the number of patterns in a warp which contains 6,720 ends, and has 32 ends per pattern.

Solution: $6{,}720 \div 32 = 210$ patterns. *Answer:* 210 patterns are in the above warp.

Example: Solve the following. A warp $24 \times 3 \times 68''$ has the following color pattern:

2/36 worsted, black	1		1					1
4 run wool, black		1						
2/36 worsted, slate				1		2		
4 run wool, slate					1		1	
	4 times							

How many patterns in warp?

Solution: $24 \times 3 = 72$ ends per inch. $72 \times 68 = 4{,}896$ ends in warp.

Black worsted	1		1					1	9
Run wool, black		1							4
Slate worsted				1		2			3
Run wool, slate					1		1		2
	4 times				Total				18 ends

$4{,}896 \div 18 = 272$ patterns. *Answer:* In the above warp there are 4,896 ends, 18 ends per pattern, making it a total of 272 patterns in the warp.

46. To find the total number of ends of each color in any warp, when the number of ends in the warp and the number of ends of each color per pattern, are given.

Rule: Divide the number of ends in the warp by the number of ends per pattern, and multiply the quotient by the number of ends of each color in the pattern.

Note: If there are a number of ends over, when finding the number of patterns in the warp, then the number of patterns in the warp are multiplied by the number of ends of each color, regardless to the remaining ends; and then as many ends from the beginning of the pattern as there were ends left over, are added to their respective colors.

Example: Find the number of ends of each color required to dress a warp $28\times3\times30''$, with the following color pattern:

Black	8						8	16
Blue			24		24			48
Red		2				2		4
Green				24				24
							Total	92 ends per pattern

Solution: $28\times3=84$ ends per inch. $84\times30=2{,}520$ ends in warp.

$2{,}520\div92=$ 27 patterns and 36 ends over.
$16\times27=432$ ends of black in 27 patterns,
$48\times27=1{,}296$ " " blue " " "
$4\times27=$ 108 " " red " " "
$24\times27=$ 648 " " green " " "

To this must be added 36 ends which are in the warp above the 27 patterns. These 36 ends are taken from the beginning, or front of the pattern, thus: to the 432 ends of black 8 ends are added (these 8 ends being the first in the pattern) making it 440 ends of black, and leaving 28 of the 36 ends left over $(36-8=28)$. To the 108 ends of red 2 more are added (these two ends being the tenth and eleventh ends in the pattern) making it 110 ends of red, and leaving 26 of the 36 ends left over $(36-8-2=26)$. To the 1,296 ends of blue 24 more are added (these 24 ends are the twelfth to thirty-fourth ends, inclusive, of the pattern), making it 1,320 ends of blue, and leaving 2 of the 36 ends left over $(36-8-2-24=2)$. To the 648 ends of green 2 more are added (these being the thirty-fifth and thirty-sixth ends of the pattern), making it 650 ends of green, and using up the rest of the 36 ends left over $(36-8-2-24-2=0)$, giving a total of 440 ends of black, 1,320 ends of blue, 110 ends of red and 650 ends of green.

Answer: The above warp requires 440 ends black
1,320 ends blue
110 ends red
650 ends green

Total number of ends in warp 2,520

Example: Find the number of ends of each color required to dress a warp 22×3×66″, with the following color pattern:

Black	2				4	2				8
Slate		1		1		2				4
Twist			1		1			1		3
Red									1	1

Total of 16 ends per pattern

Solution: 22×3=66 ends per inch. 66×66=4,356 ends in warp.

4,356 ÷ 16 = 272 patterns and 4 ends over.
8×272+2=2,178 ends of black,
4×272+1=1,089 ends of slate,
3×272+1= 817 ends of twist,
1×272 = 272 ends of red.

Answer: The above warp requires
2,178 ends of black
1,089 ends of slate
817 ends of twist
272 ends of red

Total number of ends in warp 4,356

47. To find the number of yards of warp yarn required to dress a warp any given length, when the texture, width of warp in reed, and length of warp to be dressed, are given.

Rule: Multiply the number of ends in the warp by the length it is to be dressed.

Example: Find the number of yards of warp yarn required to dress a warp with a texture of 62 ends, 36 inches wide, 500 yards long.

Solution: 62×36=2,232 ends in warp. 2,232×500= 1,116,000 yards. *Answer:* It requires 1,116,000 yards of warp yarn to dress a warp 500 yards long, with a texture of 62 ends per inch, 36 inches wide.

Example: Find the number of yards of warp yarn required in a warp 72″ wide, 48 ends per inch, which is to be dressed 450 yards long.

Solution: 48×72=3,456 ends in warp. 3,456×450= 1,555,200 yards. *Answer:* 1,555,200 yards of warp yarn are required to dress the above warp.

48. To find the number of yards of yarn of each color (or each kind used), required to dress a warp a given length, when the number of ends in warp, its length, and the pattern, are given.

Rule: Multiply the number of ends of each color (or kind of yarn) by the length of warp to be dressed.

Example: Find the number of yards of yarn, of each color, required to dress a warp 104 yards long. Having the same texture, width in reed, and color pattern as in first example under Section 46.

Solution:	Black	440 × 104 = 45,760	yards
	Blue	1,320 × 104 = 137,280	"
	Red	110 × 104 = 11,440	"
	Green	650 × 104 = 67,600	"

Answer:	It requires	45,760	yards of black
		137,280	" " blue
		11,440	" " red
		67,600	" " green
	A total of	262,080	yards

Example: Find the number of yards of yarn of each color required to dress a warp 62 yards long; having the same texture, width in reed, and color pattern as in second example under Section 46.

Solution:	Black	2,178 × 62 = 135,036	yards
	Slate	1,089 × 62 = 67,518	"
	Twist	817 × 62 = 50,654	"
	Red	272 × 62 = 16,864	"

Answer:	It requires	135,036	yards of black
		67,518	" " slate
		50,654	" " twist
		16,864	" " red
	A total of	270,072	yards

49. To find the weight of any warp in ounces or pounds, when the number of yards of warp yarn required, the count and material of the yarn are given.

Rule: Divide the number of yards of warp yarn required by the number of yards of yarn per pound of the yarn in question.

Note: If the weight is required in ounces, then the total number of yards of yarn required must be divided by the number of yards per ounce of the yarn in question.

If different kinds of yarns are used in the same warp, and the weight of each is required, then the number of yards required of each kind of yarn must be divided by its respective number of yards per pound (or, if the answer is required in ounces, per ounce), and the different weights added together, thus obtaining the total weight of warp.

Example: Find the weight in pounds of each kind of yarn required to dress a warp with 56 ends per inch, 61 inches wide, and 104 yards long; having the following color pattern, 2/30's worsted being the count of all yarns used.

Black	1		1		1			1		1		1		1	19
Twist		1				2			1				1		11
Slate				1			1				1				9
Red														1	1
	4 times							4 times				Total			40 ends per pattern

Solution: $56 \times 61 = 3{,}416$ ends in the warp.

$3{,}416 \div 40 = 85$ patterns and 16 ends in warp.

$85 \times 19 + 8 = 1{,}623$ ends of black in warp.

$85 \times 11 + 4 = 939$ ends of twist in warp.

$85 \times 9 + 4 = 769$ ends of slate in warp.

$85 \times 1 = 85$ ends of red in warp.

Total of 3,416 ends in warp.

$1{,}623 \times 104$ (length of warp to be dressed) $= 168{,}792$ yards of black.

$939 \times 104 = 97{,}656$ yards of twist.

$769 \times 104 = 79{,}976$ yards of slate.

$85 \times 104 = 8{,}840$ yards of red.

Total of 355,264 yards of yarn in the warp.

2/30's worsted = 1/15's; $560 \times 15 = 8{,}400$ yards.

$168{,}792 \div 8{,}400 = 20.094+$ pounds of black.

$97{,}656 \div 8{,}400 = 11.626-$ pounds of twist.

$79{,}976 \div 8{,}400 = 9.521-$ pounds of slate.

$8{,}840 \div 8{,}400 = 1.052+$ pounds of red.

Total of $42.293+$ pounds of yarn.

Answer: For the above warp 20.094 pounds of 2/30's black worsted, 11.626 pounds of 2/30's twist, 9.521 pounds of 2/30's slate and 1.052 pounds of 2/30's red worsted yarn is required.

Note: To change the decimal fractions of pounds into ounces, the first remainder, after having found the complete number of pounds, must be divided by the number of yards per ounce, of the yarn in question.

If in the foregoing example all yarns should have happened to be of different counts, then it can be carried out in the same manner until the weight of the required number of yards of each kind of yarn is found; in which case a different divisor must be used for every kind of yarn which has a different count.

50. To find the count of warp yarn required to dress a warp of which the material, number of ends, length, and weight are given.

Rule: Multiply the number of ends in the warp by its length, and divide this product by the standard number of the yarn (material) in question times the weight of the warp.

Example: Find the count of warp yarn required to dress a warp of 2,800 ends of worsted, 200 yards long, weighing 50 pounds.

Solution: $2{,}800 \times 200 = 560{,}000$ yards of warp yarn required. 560 (standard for worsted) $\times 50 = 28{,}000$ yards of 1/1's worsted per 50 pounds. $560{,}000 \div 28{,}000 = 20$'s worsted. *Answer:* A 1/20's or 2/40's worsted is required to dress the above warp in order to obtain the required number of ends, length and weight.

51. To find the number of ends in warp, when the counts of yarn, length and weight of warp are given.

Rule: Multiply the count by the standard number of the yarn in question and this product by the weight of the warp, then divide this latter product by the length of warp to be dressed.

Example: Find the number of ends required to dress a warp with 2/40's cotton, 400 yards long, weighing 40 pounds.

Solution: 2/40's = 1/20's cotton. $840 \times 20 \times 40 = 672{,}000$ yards of 2/40's cotton per 40 pounds. $672{,}000 \div 400 = 1{,}680$ ends. *Answer:* 1,680 ends of 2/40's cotton are required to dress the above warp in order to obtain the required length and weight.

52. To find the length of any warp, of which the count of the yarn used, number of ends, and its weight are given.

Rule: Multiply the count by the standard number of the yarn in question and this product by the weight of the warp, then divide this latter product by the number of ends in the warp.

Example: Find the length of a warp of 4 run wool, having 2,400 ends in the warp and weighing 42 pounds.

Solution: $1{,}600 \times 4 = 6{,}400$ yards of 4 run wool per pound
$6{,}400 \times 42 = 268{,}800$ yards in warp.
$268{,}800 \div 2{,}400 = 112$ yards long.

Answer: The warp must be 112 yards long in order to obtain the required weight with the above count and number of ends in warp.

CHAPTER SEVEN.

FILLING CALCULATIONS.

53. The Filling. Under this term those threads are understood which run crosswise in the goods. As a whole they are termed the *filling*, but separate or single filling threads are termed *picks*. When talking of the number of filling threads per inch in a fabric, it is customary to say this fabric has 30 picks per inch, etc., meaning that 30 filling threads are lying side by side in one inch of the fabric. In this case, the same as in warps, the number of picks per inch in the goods is referred to as its *texture;* in cotton goods the term *sley* is used.

To find the number of yards of filling yarn required in one yard of cloth, when the number of picks per inch and the number of inches in the width of warp in reed are given.

Rule: Multiply the number of picks per inch by the number of inches in the width of the warp in reed.

Example: Find the number of yards of filling yarn required to weave one yard of cloth 64 inches wide in reed, 53 picks per inch.

Solution: $53 \times 64 = 3{,}392$ yards. *Answer:* 3,392 yards of filling yarn is required to weave one yard of cloth.

Proof: 53 picks per inch $\times$ 64 inches wide $= 3{,}392$ inches of filling yarn per inch of cloth. $3{,}392 \times 36$ (number of inches per yard) $= 122{,}112$ inches of filling yarn is required per yard of cloth. $122{,}112 \div 36$ (number of inches per yard) $= 3{,}392$ yards of filling per yard of cloth.

Note: To find the number of yards of filling yarn required in any number of yards of cloth. Multiply the number of yards of filling yarn required in one yard of cloth by the number of yards of cloth required.

54. To find the number of pounds of filling yarn required to weave any amount of cloth, when the picks per inch, width of warp in reed (expressed in inches), count and material of filling, and length of cloth to be woven, are given.

Rule: Multiply the number of picks per inch by the width of warp in reed and this product by the length of cloth to be woven, then divide this latter product by the count of the yarn times its standard number.

Example: Find the amount of filling (in pounds) required to weave 48 yards of cloth, with 4 run wool filling, 30 picks per inch, 72 inches wide.

Solution: $30 \times 72 = 2{,}160 \times 48 = 103{,}680$ yards of filling required. $103{,}680 \div (4 \times 1{,}600) = 16.2$ pounds. *Answer:* 16.2 pounds of 4 run wool is required to weave 48 yards of cloth, 72 inches wide, and 30 picks per inch.

55. To find the amount of filling expressed in ounces, required, per yard of cloth, when the number of picks per inch, width of warp in reed, and count and material of the yarn, are given.

Rule: Multiply the number of picks per inch by the width of warp in reed and divide this product by the number of yards per ounce of the yarn in question. (Or, divide the product by the count times the standard number and multiply this quotient by 16, the number of ounces per pound.)

Example: Find the weight of one yard of cloth, in ounces, which has 72 picks per inch, 68 inches wide, using 2/48's worsted filling.

Solution: $72 \times 68 = 4{,}896$ yards of filling per yard of cloth. 2/48's = 1/24's = $560 \times 24 = 13{,}440 \div 16 = 840$ yards of 2/48's worsted per ounce. $4{,}896 \div 840 = 5.83-$ ounces. *Answer:* 5.83 − ounces of 2/48's worsted filling is required to weave one yard of cloth.

Note: When more than one kind of filling is used, and it is desired to find the weight of each kind required in one yard, or any amount, of cloth, then the number of yards of filling per yard of cloth must first be found, after which, by proportion, the number of yards of each kind of filling yarn, required, is found; from which results the weights of the different yarns are found the same as in the above rule, i.e., by dividing the number of yards of yarn required by the number of yards per ounce, of the yarn in question.

Example: Find the weight of each kind of filling required to weave (*a*) one yard (expressed in ounces), (*b*) to weave 48 yards (expressed in pounds), of cloth, with 64 picks per inch, 72 inches width of warp in reed. The filling is arranged:

2/40's worsted, black	4		4		4		4		4		20
2/40's worsted, blue		2						2			4
2/40's worsted, brown				24						8	32
2/40's worsted, green						24					24
Total of											80 picks per pattern

Solution: $64 \times 72 = 4{,}608$ yards of filling per yard of cloth. $4{,}608 \times 20$ (picks of black per pattern) $\div 80$ (picks per pattern) $=$ 1,152 yards of black filling per yard of cloth. $4{,}608 \times 4$ (picks of blue per pattern) $\div 80 = 230.4$ yards of blue filling per yard of cloth. 4,608×32 (picks of brown per pattern)÷80=1,843.2 yards of brown filling per yard of cloth. 4,608×24 (picks of green per pattern)÷80=1,382.4 yards of green filling per yard of cloth.

2/40's worsted=40÷2=1/20's worsted. 560×20÷16=700 yards of 2/40's worsted per ounce.
1,152 ÷700=1.646– ounces of black per yard of cloth.
230.4÷700= .329+ ounces of blue per yard of cloth.
1,843.2÷700=2.633+ ounces of brown per yard of cloth.
1,382.4÷700=1.975– ounces of green per yard of cloth.

Totals 4,608 yards 6.583– ounces of filling per yard of cloth.

Answer: (*a*).
Black, 1.646 ounces.
Blue, .329 "
Brown, 2.633 "
Green, 1.975 "

1.646×48÷16=4.938 pounds of black, per 48 yards of cloth.
.329×48÷16= .987 pounds of blue, per 48 yards of cloth.
2.633×48÷16=7.899 pounds of brown, per 48 yards of cloth.
1.975×48÷16=5.925 pounds of green, per 48 yards of cloth.

Total 19.749 pounds of filling per 48 yards of cloth.

Answer (*b*):
Black, 4.938 pounds.
Blue, .987 "
Brown, 7.899 "
Green, 5.925 "

Note 2: When all the yarns are of the same count and material, like in the example above, then the weight of one yard of cloth can be found directly, and the weights of the different colors required are found by proportion from that. Thus: Total weight of one yard of cloth (from above example), 6.583 ounces. Of black there is required 6.583×20÷80=1.646 – ounces of blue, 6.583 × 4÷80=.329 ounce of brown, 6.583 × 32÷80 = 2.633 ounces and of green 6.583×24÷80=1.975 ounces.

56. To find the required number of picks per inch to weave a piece of cloth, when the count and material of the filling, width of warp in reed, length of cloth to be woven, and weight of filling to be used, are given.

Rule: Multiply the count of the yarn by its standard number and this product by the weight of material to be used, then divide this quotient by the width of warp in reed times the length of cloth to be woven.

Example: Find the number of picks per inch required to use

40 pounds of 1/30's cotton filling in a piece of goods 32 inches in reed, 420 yards long.

Solution: $30 \times 840 \times 40 = 1{,}008{,}000$ yards of filling to be used. $1{,}008{,}000 \div (32 \times 420) = 75$ picks per inch. *Answer:* It requires 75 picks per inch.

57. To find the number of yards of cloth that can be woven, when the number of picks per inch, width of warp in reed, count and material of the yarn, and the weight of filling to be used, are given.

Rule: Multiply the count by its standard number and this product by the weight of yarn to be used, then divide this product by the number of picks per inch times the width of warp in reed.

Example: Find the number of yards of cloth that can be woven with 40 pounds of 1/30's worsted, 72 picks per inch, 68 inches wide.

Solution: $30 \times 560 \times 40 = 672{,}000$ yards of filling to be used. $72 \times 68 = 4{,}896$ yards of filling required per yard of cloth. $672{,}000 \div 4{,}896 = 137.25+$ yards. *Answer:* 137.25 yards of cloth can be woven with 40 pounds of 1/30's worsted, of the above fabric.

Note: No allowance for waste is made in any of these examples.

58. To find the count of the filling, when the number of picks per inch, width of warp in reed, material, length of cloth to be woven, and weight of filling, are given.

Rule: Multiply the number of picks per inch by the width of warp in reed and this product by the length of cloth to be woven, then divide this latter product by the standard number of the yarn (material) used times the total weight of filling.

Example: Find the size (count) of yarn in the run wool system, to be used as filling to weave 100 yards of cloth 70 inches in the reed, 48 picks per inch, the filling weighing 42 pounds.

Solution: $48 \times 70 \times 100 = 336{,}000$ yards of filling to be used. $1600 \times 42 = 67{,}200$ yards of 1 run wool per 42 pounds. $336{,}000 \div 67{,}200 = 5$ run wool. *Answer:* A 5 run woolen yarn must be used.

CHAPTER EIGHT.

THE SELVAGE, TAKE-UP OF WARP DURING WEAVING, WASTE OF WARP AND FILLING DURING WEAVING.

59. The Selvage is a series of threads running along on each side of the warp, and interweaving with the filling the same as the warp. It serves as a protector of the goods and, on this account, is generally made stronger than the rest of the goods. The threads are termed ends, the same as in the case of the warp; from two (2) to forty (40) and more ends may be used for the selvage on each side of the goods. The extreme outside ends are generally drawn two or more into one heddle; at times all the selvage threads are drawn-in in this manner, two in every heddle.

On woolens and worsteds, for men's wear, the selvage is from one-fourth to three-fourths, and sometimes to one inch wide, on each side of the goods; while in dress goods it is hardly ever wider than one-half inch.

The selvage is figured the same as the warp, but separate from same. When finding the total number of ends in a warp, it is customary to give the width of warp proper (inside of selvage), and use this width for the computation. The selvage is given outside of this width, either as to the number of ends (for selvage) used on each side or the width of the selvage (on each side) in the reed. For instance: The texture of the warp may be given as $16 \times 4 \times 60''$ inside of selvage, using 24 ends, for selvage, on each side; in this instance the selvage would be reeded the same as the warp; i.e., four ends per dent, unless otherwise stated, which would make it three-eighths of an inch on each side, widening the goods (in the reed), by three-fourths of an inch. Or the texture may be given as $16 \times 4 \times 64''$ inside of selvage, allowing three-eighths of an inch for selvage, on each side of the goods. The texture can also be given as $16 \times 4 \times 64\frac{3}{4}$ overall, allowing three-eighths inches on each side of the goods for selvage.

When calculating the filling, the width of warp in reed, including the selvage, must be used; as the filling interweaves as well with the selvage as with the warp proper, and every pick is required to be as long as the width of the warp proper plus the space taken up by the selvage on each side of the goods.

In many instances a stronger as well as heavier yarn is used for the selvage than that used for the warp, as there is more strain on the selvage threads, due to the pulling of the filling when the shuttle crosses over to the further side. It is also customary to have a fancy, or otherwise noticeable, end on the inside of the selvage; i.e., where the selvage ends and the warp proper commences. At times the selvage is dressed according to a color pattern, as in mills where goods are made for various commission houses a selvage of a different pattern is employed for each firm. In some mills they use a different pattern in the selvage for every quality of goods.

"Listing" is another name for "Selvage."

60. To find the length of fabric from loom, when the length of warp dressed (minus the allowance for waste), and the percentage of take-up, are given.

Rule: Multiply the given length by the percentage of take-up, divide this product by 100 and subtract this quotient from the given length of the warp.

Note: It must be remembered that the warp dressed is the *base*, the percentage of take-up the *rate per cent*, and the woven goods the *difference*.

Example: Find the number of yards of cloth which can be woven from a warp 62 yards long, and having a take-up of 8%.

Solution: $62 \times 8 = 496 \div 100 = 4.96$. $62 - 4.96 = 57.04$ yards. *Answer:* 57.04 yards of cloth can be woven.

61. Waste of warp and filling during weaving. When dressing a warp it is customary to allow one and one-half to two and one-half yards for waste; i.e., dress the warp for that number of yards longer than is required by the length of cloth to be woven plus the allowances for take-up; this extra length is used for tying the warp into the loom and the extra length necessary at the end of the warp, as a certain length must remain in the harness frames still attached to the warp-beam. This is the only waste of warp made after it has been beamed; there is a certain amount made during the dressing and also in the spooling of the yarn before it is ready for the dressing of the warp. This however is not of much consequence as the percentage of waste remains very small.

Filling is wasted by the changing of the shuttles when renewing the supply of filling and by removing the filling from cloth (picking out) woven defective, which warrants the picking out. The amount of filling wasted during weaving depends entirely upon the size of the yarn used, as less coarse yarn can be wound on one bobbin than that of a finer count and naturally requires to be renewed oftener. Some goods are woven with yarn and weaves which cause considerable trouble during the weaving, thus making defective cloth which has to be picked out; while other goods will weave so well that no defective cloth will result in the entire length, thus avoiding all waste of filling caused by picking out.

Different allowances are made for the waste of filling, and must be left entirely to judgment and experience as it may range from $\frac{1}{2}\%$ to 10% and over. In all further calculations in this book, waste of filling during weaving will not be considered. It is customary to add a suitable percentage to the amount of filling required in the goods, sufficient warranted by former experiences.

CHAPTER NINE.

EXAMPLES ILLUSTRATING THE CALCULATIONS FOR FINDING THE COST OF MATERIALS, ETC., FOR VARIOUS CLASSES OF FABRICS.

62. Blue Serge Suiting. Warp — 16 reed, 4 ends per dent, 62 inches wide, of 2/36's worsted at $1.20 per pound. Filling— 68 picks per inch of 1/14's worsted at 85 cents per pound. Selvage — 32 double ends of 2/28's worsted at 70 cents per pound. The fabric is to be 48 yards from loom allowing 8% for take-up and 2 yards for waste.

Find the total weight of fabric from loom, cost of materials required, and cost of one yard of cloth finished, allowing 12 cents per yard for the weaving and general weaving-room expense and 20 cents per yard for finishing and dyeing.

Solution: Warp yarn required. 16×4×62=3,968 ends in warp. 48×100÷(100−8)=52.174, length of warp woven. 52.174+2=54.174 yards, length of warp to be dressed. 3,968× 54.174=214,962.432 yards of warp yarn required. 2/36's= 36÷2=18's worsted. 560×18=10,080 yards of 2/36's worsted per pound. 214,962.432÷10,080=21.326− pounds of warp yarn required. 21.326×$1.20=$25.59+ cost of warp yarn required. Filling, 63 (width including selvage) ×68×48= 205,632 yards of filling required. 1/14=560×14=7,840 yards of 1/14's worsted per pound. 205,632÷7,840=26.228+ pounds of filling required. 26.228×$0.85=$22.29+ cost of filling required. Selvage, 32×2×2=128 ends of selvage required. 128×54.174=6,934.272 yards of selvage yarn required. 2/28= 28÷2=14's worsted. 560×14=7,840 yards of 2/28's worsted per pound. 6,934.272÷7,840=.884+ pounds of selvage yarn required. .884×$0.70=$0.62− cost of selvage yarn required. 3,968×52.174 (length of warp woven)=207,026.432 yards of warp yarn in 48 yards of cloth. 207,026.432÷10,080=20.538+ pounds of warp yarn. 128×52.174 (length of warp to be woven) =6,678.272 yards. 6,678.272÷7,840=.852− pounds of selvage yarn required to weave 48 yards of cloth.

$25.59 cost of warp yarn.
22.29 cost of filling yarn.
.62 cost of selvage yarn.

$48.50 cost of materials for 48 yards of cloth.

$48.50÷48=$1.01+ cost of materials for one yard of cloth

$1.01 cost of materials.
.12 cost of weaving, etc.
.20 cost of finishing and dyeing.

$1.33 cost of one yard of cloth finished.

Answer: *A*. 47.618 pounds of material required.
B. $48.50 cost of materials.
C. $1.33 cost per yard of finished cloth.

63. Cotton Sheeting. Warp — 26 reed, 3 ends per dent, 48 inches in reed (inside of selvage), of 1/30's cotton at $0.26 per pound. The warp is dressed to weave 6 double-cuts of cloth, each cut 46 yards long; allowing 2 yards for waste and 5% for take-up during weaving.

Selvage—One-quarter of an inch on each side, containing 24 ends of 1/24's cotton at $0.22 per pound, allowing the same take-up and waste as for warp proper.

Filling—68 picks of 1/24's cotton per inch. The filling costs $0.20 per pound.

Find the length of warp dressed; weight of fabric from loom; cost of materials required; cost of one yard of cloth from loom, and number of yards of cloth per pound.

Solution: 26×3×48 = 3,744 ends in warp. 46×2×6 = 552 yards of cloth required. 552×100 ÷ (100–5) = 581.052+ length of warp woven. 581.052+2 = 583.052 yards, length of warp dressed. 583.052×3,744 = 2,182,946.688 yards of warp yarn required. 1/30's = 840×30 = 25,200 yards of 1/30's cotton per pound. 2,182,946.688 ÷ 25,200 = 86.625+ pounds of warp yarn required. 86.625×.26 = $22.52+, cost of warp.

24×2 = 48 ends of selvage used. 583.052×48 = 27,986.496 yards of selvage yarn required. 1/24's = 840×24 = 20,160 yards of 1/24's cotton per pound. 27,986.496 ÷ 20,160 = 1.388+ pounds of selvage yarn. 1.388×.22 = $0.31–, cost of selvage yarns.

48.5 (width of warp in reed including selvage)×68 = 3,298 yards of filling per yard of cloth. 3,298×522 = 1,721,556 yards of filling required. 1/24's = 840×24 = 20,160 yards of 1/24's cotton per pound. 1,721,556 ÷ 20,160 = 85.395–. 85.395×.20 = $17.08–, cost of filling.

581.052×3,744 = 2,175,458.688 yards of warp yarn in 552 yards of cloth. 2,175,458.688 ÷ 25,200 = 86.328+ pounds of warp yarn in 552 yards of cloth.

581.052×48 = 27,890.496 yards of selvage yarn in 552 yards of cloth. 27,890.496 ÷ 20,160 = 1.383+ pounds of selvage yarn in cloth.

Answer: *A*. 583.052 yards, or 583 yards, length of warp dressed.

B. 86.328 pounds, weight of warp.
1.383 " " " selvage.
85.395 " of filling.

173.106 pounds, weight of fabric from loom.

C. $22.52 cost of warp yarn.
.31 " " selvage yarns.
17.08 " " filling.

$39.91 cost of materials.

D. $39.91 \div 552 = \$0.0723-$, or 7.25 cents cost of materials per yard.

Note: To find the cost of one yard of cloth finished, the cost of weaving, bleaching and finishing must be added to this answer.

E. $173.106 \times 16 = 2{,}769.696$ ounces, total weight of cloth.
$2{,}769.696 \div 552 = 5.018-$ ounces, weight per yard of cloth.
$16 \div 5.018 = 3.189-$ yards, or about 3.2 yards of cloth per pound.

Note: If the goods have been starched, then the amount of starch used must be added to the total weight of the goods and from that the number of yards of cloth per pound is found in the same manner as above.

64. Cassimere Suiting. Warp. 8 reed, 4 ends per dent, 70 inches wide (inside of selvage), of 2-run oxford mix, at 64 cents per pound. The warp is to be dressed 250 yards long, allowing from this length 2 yards for waste and from the remainder 10% for take-up. The goods lose 4% in length and 3% in weight during finishing.

Selvage. Is made of the same material as the warp, using 24 double-ends on each side, reeded 4 double-ends per dent. The same allowances for take-up, etc., are made as for the warp proper.

Filling. 36 picks of $2\frac{1}{4}$-run oxford mixed per inch, at 68 cents per pound.

A. Find the length of fabric from loom; *B*. Find the length of finished cloth; *C*. Find the total weight of fabric from loom, and the total weight of fabric finished; *D*. Find the weight per yard finished (in ounces); *E*. Find the cost of materials; *F*. Find the cost of one yard of cloth finished; allowing 28 cents per thousand ends for drawing-in, 6 cents per yard for weaving, 8 cents per yard for weaving and dressing-room expense, and 8 cents per yard for the finishing.

Note: These costs are given with the understanding that they serve only for an illustration and are not claimed to be right according to present prices.

Solution: $8 \times 4 \times 70 = 2{,}240$ ends in warp. $2{,}240 \times 250 = 560{,}000$ yards of warp yarn required to dress the warp. 2-run wool $= 1{,}600 \times 2 = 3{,}200$ yards of 2-run wool per pound.

$560{,}000 \div 3{,}200 = 175$ pounds of warp yarn required. $175 \times \$0.64 = \$112.00$ cost of warp yarn.

$250 - 2 = 248$ yards length of warp woven. $248 - 10\% = 223.2$ yards length of cloth from loom. $223.2 - 4\% = 214.272$ yards, length of goods finished.

$248 \times 2{,}240 = 555{,}520$ yards of warp yarn in 248 yards of warp. $555{,}520 \div 3{,}200 = 173.6$ pounds of warp in cloth, after weaving. $173.6 - 3\% = 168.392$ pounds, weight of warp yarn after finishing.

$24 \times 2 \times 2 = 96$ ends of selvage used. $96 \times 250 = 24{,}000$ yards of yarn required for selvages. $96 \times 248 = 23{,}808$ yards of selvage in cloth. $24{,}000 \div 3{,}200 = 7.5$ pounds of selvage yarn required. $23{,}808 \div 3{,}200 = 7.44$ pounds of selvage yarn in the cloth. $7.44 - 3\% = 7.217 -$ pounds of selvage yarn after finishing. $7.5 \times \$0.64 = \$4.80$ cost of selvage yarn required.

70 inches, width of warp in reed inside of selvage; selvage contains 24 double-ends on each side, 4 double-ends per dent $= 24 \times 2 \div 4 = 12$ dents required by selvage. Reed has 8 dents per inch; 12 dents $= 12 \div 8 = 1.5$ inches width of selvages in reed. $70 + 1.5 = 71.5$ inches, width of warp in reed including selvage. $71.5 \times 36 = 2{,}574$ yards of filling per yard of cloth.

$2{,}574 \times 223.2$ (length of fabric from loom) $= 574{,}516.8$ yards of filling required to weave 223.2 yards of cloth. $2\frac{1}{4}$-run wool $= 1{,}600 \times 2\frac{1}{4} = 3{,}600$ yards of filling yarn per pound. $574{,}516.8 \div 3{,}600 = 159.588$ pounds, weight of filling from loom. $159{,}588 - 3\% = 154.8+$ pounds, weight of filling after goods are finished. $159.588 \times \$0.68 = \$108.52 -$, cost of filling required.

Answer: *A*. 223.2 yards length of fabric from loom.

B. 214.272 yards, or 214 yards, length of fabric finished.

C. 173.6 pounds, weight of warp.
7.5 pounds of selvage yarn.
159.588 pounds of filling yarn.

340.688 pounds, weight of fabric from loom.

168.392 pounds, weight of warp yarn after finishing.
7.44 pounds, weight of selvage after finishing.
154.8 pounds, weight of filling after finishing

330.632 pounds, weight of finished fabric.

D. 330.632 ×16 = 5,290.112 ounces, weight of finished fabric in ounces.
5,290.112 ÷ 214.272 = 24.7 − ounces, weight per yard finished.

E. $112.00 cost of warp yarn.
4.80 cost of selvage yarn.
108.52 cost of filling yarn.

$225.92 cost of materials required.

F. $225.92 cost of materials; 2,240+96 (ends in warp and selvage) = 2.336 × $0.28 −
.65 + cost of drawing-in of warp. 223.2 yards (length of fabric from loom) = 223.2 × $0.06
13.39 + cost of weaving. 223.2 × $0.08
17.86 − dressing and weaving-room expense 214.272 yards (length of fabric finished) = 214.272 × $0.08
17.14 + cost of finishing

$274.96 total cost of finished fabric.
$274.96 ÷ 214.272 = $1.283 −, or $1.28, cost per yard of finished cloth.

Note: At times it is necessary to make allowances for winding, spooling and burling, besides the allowances made in the above example. Besides all of these allowances a certain per cent is added to the total cost of the goods, to allow for the capital invested for looms, buildings, etc.

65. Fancy Worsted Dress Goods. Warp. The ground warp is reeded 24 reed, 2 ends per dent, 38 inches wide (inside of selvage), of 2/40's, worsted at $1.45 per pound. The figure warp is reeded along with the ground warp, regardless of the number of ends per dent, as long as there are two ground ends in every one; this latter warp is made of 2/24's worsted at $1.20 per pound. Weave 48 yards, allowing 12% take-up for ground warp and 4% for figure warp; and 3 yards for waste. Warp dressed:

Figure Warp									
Ground	1	1	1	36	1	1	1	36	96
Blue	1		1			1			12
Green		1			1		1		12
	3	6	3		3	6	3		120 ends

per pattern.

Selvage. 16 double-ends of 2/30's white worsted, at $1.10 per pound, on each side; 2 double-ends per dent. 12% take-up during weaving.

Filling. 46 ground picks per inch; 1/20's worsted, at $0.90 per pound. The fillings are arranged:

Figure Picks									
Ground	1	1	1	44	1	1	1	44	104
Blue	1		1			1			8
Green		1			1		1		8
	2	4	2		2	4	2		120 picks

per pattern. The figure filling is 1/15's worsted, at $0.78 per pound.

A. Find the weight of each kind of material required.
B. Find the cost of materials.
C. Find the cost per yard of cloth.

Note: In this example more stress will be placed on the uneven texture of warp and filling, than on the various expenses in the manufacturing of the goods.

Solution: Warp. $24 \times 2 \times 38 = 1,824$ ground ends in warp. $1,824 \div 96$ (ground ends per pattern) $= 19$ patterns in warp. 12 (number of blue figure ends per pattern) $\times 19 = 228$ blue figure ends in warp. 12 (number of green figure ends per pattern) $\times 19 = 228$ green figure ends in warp.

	1,824 ends of ground
	228 ends of blue
	228 ends of green
Total number of ends	2,280

$48 \times 100 \div (100 - 12) = 54.545+$ yards, length of ground warp woven. $54.545 + 3 = 57.545$ yards, length of ground warp dressed. $48 \times 100 \div (100 - 4) = 50$ yards, length of figure-warp woven. $50 + 3 = 53$ yards, length of figure warp dressed. $1,824 \times 57.545 = 104,962.08$ yards of ground-warp yarn required. $228 \times 53 = 12,084$ yards of blue figure warp yarn required. $228 \times 53 = 12,084$ yards of green figure warp yarn required. 2/40's worsted $= 40 \div 2 = 20$; $560 \times 20 = 11,200$ yards of 2/40's worsted per pound. $104,962.08 \div 11,200 = 9.37+$ pounds, weight of ground warp. 2/24's worsted $= 24 \div 2 = 12$; $560 \times 12 = 6,720$ yards of 2/24's worsted per pound. $12,084 \div 6,720 = 1.798+$ pounds of blue figure warp yarn required. 12,084 ÷ 6,720 = 1.798+ pounds of green figure warp yarn required.

	9.37	pounds of ground warp
	1.798	pounds of blue figure
	1.798	pounds of green figure
Total weight of warps	12.966	pounds.

9.37 × 1.45 =	$13.587 –	cost of ground warp
1.798 × 1.20 =	2.158 –	cost of blue figure warp
1.798 × 1.20 =	2.158 –	cost of green figure warp
	$17.903	total cost of warp yarns

Selvage. 16 × 2 × 2 = 64 ends of selvage used. 64 × 57.545 (length of ground warp dressed) = 3682.88 yards of selvage yarn required. 2/30's worsted = 30 ÷ 2 = 15; 560 × 15 = 8,400 yards of 2/30's worsted per pound. 3682.88 ÷ 8,400 = .438+ pounds of selvage yarn required. .438 × 1.10 = $0.482 –, cost of selvage yarn.

Filling. 46 × 36 = 1,656 ground picks per yard of cloth. 1,656 × 48 = 79,488 ground picks in 48 yards of cloth. 79,488 ÷ 104 (number of ground picks per pattern) = 764 patterns and 32 ground picks. 79,488 × 38⅗″ (width of warp in reed including selvage), ÷ 36 = 85,376 yards of 1/20's worsted filling used. 1/20's = 560 × 20 = 11,200 yards per pound. 85,376 ÷ 11,200 = 7.62+ pounds, weight of ground filling. 764 × 8 = 6,112 + 4 (blue figure picks to the first 32 ground picks), = 6,116 picks of blue figure filling. 764 × 8 = 6,112 + 4 (green figure picks to the first 32 ground picks), = 6,116 picks of green figure filling. 6,116 × 38⅗″ (width of warp in reed including selvage), ÷ 36 = 6,569 yards of each kind of figure filling is required. 1/15's worsted. = 560 × 15 = 8,400 yards per pound. 6,569 ÷ 8,400 = .782+ pounds, weight of blue figure filling. .782+ weight of green figure filling.

7.62	pounds weight of ground filling
.782	pounds weight of blue figure filling
.782	pounds weight of green figure filling
9.184	pounds total weight of filling yarns

7.62 × .90 =	$6.858	cost of ground filling
.782 × .78 =	.61 –	cost of blue figure filling
.782 × .78 =	.61 –	cost of green figure filling
	$8.078	total cost of filling yarns.

Answers: *A*. 9.4 pounds of 2/40's worsted, 1.8 pounds of 2/24's blue worsted, 1.8 pounds of 2/24's green worsted, .438 pounds of 2/30's worsted for selvage, 7.62 pound of 1/20's worsted, .782 pounds of 1/15's blue worsted and .782 pounds of 1/15's green worsted.

B. The total cost of materials is,

warp	$17.90
selvage	.482
filling	8.078
	$26.460

cost of all materials required.

C. $26.46 \div 48 = \$0.55+$ cost per yard of cloth.

66. Electric Tape. Under this name a narrow fabric (tape) is placed on the market, used for insulating electric wires, etc. Some of this tape is woven on narrow fabric looms, and some is made by cutting up sheetings into narrow strips. The first method gives better results, as tape woven on narrow fabric looms will not unravel as that cut from broad goods.

In this example electric tape woven on narrow fabric looms is to be calculated.

$\frac{3}{4}''$ width of tape finished, $\frac{7}{8}''$ in the reed, 54 ends of 1/26's cotton, at 48 cents per pound, in the width of tape; 60 picks per inch of 1/24's cotton, at 38 cents per pound.

Of this tape 5,000 gross (144 yards per gross), is to be woven. Allowing 6% of take-up for warp during weaving, and one (1) yard of warp for every gross of tape, for waste. The weaving costs seven cents per gross and the weave-room expense amounts to eight cents per gross. The looms run 160 picks per minute, 40 shuttles per loom; i.e., 40 warps are woven in every loom at the same time. Allow 1.5% of the filling for waste during spooling and weaving; the spooling costs 1.5 cents per pound.

A. How many pounds of warp and filling yarn are required?
B. What is the cost of the yarns? (Not including the cost of spooling the filling.)
C. Find the weight of one gross of tape.
D. Find the cost of one gross of tape.
E. Find the time required to weave 5,000 gross of this tape; allowing 10% of the time the looms must run, at 160 picks per minute without any stop, for stoppages. 60 hours constitute one working week, and 10 hours one working day.

Solution: Warp. $54 \times 144 = 7{,}776 \times 100 \div (100 \quad 6) = 8{,}272.3+$

yards of warp yarn per gross of tape. 8,273.4 × 5,000 = 41,361,500 yards of warp yarn in 5,000 gross of tape.

1/26's cotton = 840 × 26 = 21,840 yards per pound. 41,361,500 ÷ 21,840 = 1,893.84+ pounds of warp yarn contained in 5,000 gross of tape.

5,000 × 54 = 270,000 yards of waste. 41,361,500 + 270,000 = 41,631,500 yards of warp yarn required. 41,631,500 ÷ 21,840 = 1,906.2+ pounds of warp yarn required.

1,906.2 × $0.48 = $914.976, cost of warp yarn required.

Filling. 60 × .875 = 52.5 yards of filling per yard of tape. 52.5 × 144 × 5,000 = 37,800,000 yards of filling contained in 5,000 gross of tape.

1/24's cotton = 840 × 24 = 20,160 yards per pound. 37,800,000 ÷ 20,160 = 1,875 pounds of filling in the goods. 1,875 × 100 ÷ (100 − 1.5) = 1,903.55+ pounds of filling required, including the allowance for waste. 1,903.55 × $0.38 = $723.3490, or $723.35, cost of filling yarn required.

Cost of Manufacturing. 1,903.55 × .015 = $28.55325, or $28.55, cost of spooling filling.

5,000 × .07 = $350.00, cost of weaving. 5,000 × .08 = $400.00, weave-room expenses.

Time Required. 60 × 36 = 2,160 picks per yard of tape. 2,160 × 144 = 311,040 picks per gross of tape. 311,040 × 5,000 = 1,555,200,000 picks in 5,000 gross of tape.

160 × 60 = 9,600 picks from each shuttle per hour. 9,600 × 40 = 384,000 picks from each loom per hour. 384,000 × 10 = 3,840,000 picks per hour from 10 looms.

1,555,200,000 ÷ 3,840,000 = 405 hours 10 looms must run, without stopping, in order to produce 5,000 gross of tape.

405 + 10% = 405 × 1.10 = 445.5 hours, including stoppages, is required to produce 5,000 gross of tape, or 445.5 ÷ 60 = 7 weeks, 2 days and 5.5 hours.

Answer: A.	1,906.2	pounds of warp yarn
	1,903.55	pounds of filling yarn
Total	3,809.75	pounds of yarn required.
B.	$914.98	cost of warp yarn
	723.35	cost of filling yarn
Total	$1638.33	cost of yarns.
C.	1,893.84	pounds of warp yarn in 5,000 gross of tape
	1,875.00	pounds of filling yarn in 5,000 gross of tape
Total	3,768.84	pounds of yarn in 5,000 gross of tape.

3,768.84 × 16 ÷ 5,000 = 12.06 + ounces, the weight per gross of tape.

D. $1,638.33 cost of yarns
28.55 cost of spooling filling yarn
350.00 cost of weaving
400.00 weave-room expense

Total $2,416.88 cost of 5,000 gross.

2,416.88 ÷ 5,000 = .4834, or 49⅓ cents, cost per gross.

E. It requires 7 weeks, 2 days, and 5.5 hours to weave 5,000 gross of this tape on 10 looms with 40 shuttles each.

67. Kersey Overcoating. (Piece Dye). The warps are arranged two of face to one of back, and the filling three of face to one of back. The face warp—3,200 ends of 5½ run wool at $0.90 per pound. The back warp—1,600 ends of 3½ run wool at $0.76 per pound. Dressed, one beam, 64 yards long; 1½ yards of this goes to waste, after which the warp takes up 12% during weaving and shrinks 8%, in length, during finishing.

Selvage. ¾ inches on each side, consisting of 32 ends of 2 run wool, at $0.48 per pound.

Filling. The warp is 80 inches in reed, inside of selvage; 72 picks per inch. The face filling is 5½ run wool, at $0.86 per pound, and the back filling is 1½ run wool at $0.45 per pound. The weaving costs $0.18 per yard, and $0.06 per yard for general weaving-room expenses.

Finishing and Dyeing. The cost of finishing and dyeing is $0.30 per yard and other mill expense $0.10 per yard on finished goods. During the fulling 16 pounds of flocks are added to the goods. The flocks cost $0.10 per pound.

A. Find the cost of yarns required.

B. Find the cost of one yard of cloth finished.

Solution: Warp. 3,200 ends of face = 3,200 × 64 = 204,800 yards of 5½ run wool required. 5½ run wool = 1,600 × 5.5 = 8,800 yards per pound. 204,800 ÷ 8,800 = 23.27 + pounds of face warp required.

1,600 ends of back warp = 1,600 × 64 = 102,400 yards of 3½ run wool required. 3½ = 1,600 × 3.5 = 5,600 yards of 3½ run wool per pound. 102,400 ÷ 5,600 = 18.29 − pounds of back warp required.

23.27 × .90 = $20.943, cost of face warp. 18.29 × .76 = $13.90, cost of back warp.

Selvage. 32 × 2 = 64 ends of selvage; 64 × 64 = 4, 096 yard of selvage yarn required. 2 run wool = 1,600 = 3,200 yards of 2 run wool per pound. 4,096 ÷ 3,200 = 1.28 pounds of selvage yarn required.

1.28 × .48 = $0.614 +, cost of selvage yarn.

Filling. 72 picks per inch; 3 picks of face to 1 pick of back = 72 ÷ 4 = 18 × 3 = 54 picks of face and 18 picks of back, per inch. 54 × 81.5 (width including selvage) = 4,401 yards of face filling per yard of cloth. 64 yards, length of warp dressed, less 12% take-up = 56.32 yards of cloth to be woven. 4,401 × 56.32 = 247,864.32 yards of 5½ run filling required. 5½ run = 8,800 yards per pound. 247,864.32 ÷ 8,800 = 28.17+ pounds, weight of face filling. 18 × 81.5 = 1,467 yards of back filling per yard of cloth. 1,467 × 56.32 (length of goods woven) = 82,621.44 yards of back filling required. 1½ run wool = 1,600 × 1.5 = 2,400 yards per pound. 82,621.44 ÷ 2,400 = 34.43 – pounds of back filling required.

28.17 × .86 = $24.226+ cost of face filling, 34.43 × .45 = $15.494 – cost of back filling.

Other Costs. 18 cents, cost of weaving per yard
6 cents per yard, general weave-room expense

24 cents per yard, cost of weaving, etc.

56.32 × .24 = $13.52 – cost of weaving, 16 × .10 = $1.60 cost of flocks.

56.32 = 8% (lose in length during finishing) = 51.81 + yards, length of goods after finishing and dyeing.

30 cents per yard, cost of dyeing and finishing
10 cents per yard, other mill expense

40 cents per yard, cost added to finished goods.

51.81 × .40 = $20.72 cost of finishing.

Answers: *A*.
$20.943 cost of face warp
13.90 cost of back warp
.614 cost of selvage
24.226 cost of face filling
15.494 cost of back filling

Total $75.177 cost of yarns, or $75.18.

B.
$75.177 cost of yarns
13.52 cost of weaving
1.60 cost of flocks
20.72 cost of finishing

Total $111.02 or $112.80.

111.02 ÷ 51.81 = $2.14 + or $2.14, cost per yard finished.

CHAPTER TEN.

THE DIAMETER OF THREADS, THE NUMBER OF THREADS THAT WILL WEAVE SIDE BY SIDE WITH ANY GIVEN WEAVE. DIFFERENT SIZES OF YARNS USED FOR WARP AND FILLING.

68. The diameter of threads. To find the number of threads which will lie side by side per inch without any interlacing, and without any of the threads riding nor any spaces left between them.

Rule: Find the number of yards per pound of the yarn in question, from which number extract the square root. From the square root of the number of yards per pound of the yarn in question, the following percentages are then subtracted: for silk yarns 4%, for cotton and linen 7%, for worsted 10%, and for wool 16%.

Example: Find the number of threads which will lie side by side per inch without any interlacing (the diameter) of a 2/20's worsted.

Solution: 2/20's worsted $=1/10$'s $= 560 \times 10 = 5{,}600$ yards per pound. The square root of $5{,}600 = 74.83+$. $74.83 - 10\%$ (worsted) $=67.35$. *Answer:* 67.35 threads of 2/20's worsted will lie side by side per inch without any interlacing, or the diameter of 2/20's worsted $=\frac{1}{67.35}$ of an inch.

Example: Find the number of threads that will lie side by side per inch, without any interlacing, of a 2/40's cotton.

Solution: 2/40's cotton $=1/20$'s $=840 \times 20 = 16{,}800$ yards per pound. The square root of $16{,}800 = 129.61+$. $129.61 - 7\%$ $=120.54-$. *Answer:* 120.54 threads of 2/40's cotton will lie side by side per inch, without any interlacing.

☞ **69. To find the number of ends and picks per inch that will weave side by side with any interlacing (weave), when warp and filling are of the same counts.** The filling interlacing with the warp, and *vice versa*, separates that system of threads so that a space equivalent to the diameter of the separating thread must be allowed for every point of interlacing. For instance: the plain weave weaves $\frac{1}{1}$, repeating on two ends and picks and having two points of interlacing in one pattern. Now if the warp and filling are both of the same diameter, two ends will take up the space of the diameter of two ends plus the space of the diameter of two picks; in all, two ends will require the space of four. In this case, of the plain weave, an end comes up or goes down between every two picks, and a pick comes between every two ends, due to the alternate working of the ends and picks; therefore, if the counts of warp and filling are the same, every two ends require the space of four (allowing for the picks which pass between them), and every two picks require the space of four (also allowing for the ends which pass between them.)*

In the case of a $\frac{2}{2}$ twill, there are two points of interlacing for every four ends and picks, thus requiring for every four ends the space of six (when warp and filling are of the same size), and for every four picks the space of six, etc.

In such weaves, where the face and back of the goods are made up of the warp, the filling lying between the upper and lower layer of warp threads, like the rib weaves, hardly any space is taken up by the interlacing; therefore nearly as many threads may weave side by side as will go side by side without any interlacing. In warp-rib weaves a lower texture may be used for the filling while in filling-rib weaves the texture of the warp is smaller.

To obtain the proper texture for satin weave the same method may be employed as that used in finding the right texture for twills, i.e., the points of interlacing must be allowed for. Every weave has at least two points of interlacing in one repeat (pattern), and any number, from that up, as there are changes, of the warp and filling, from the face to the back, and *vice versa*.

To find the number of ends which will weave side by side with any given single cloth weave (excepting rib weaves), when the number of threads that will lie side by side without any interlacing is given, and the counts of both systems of threads are the same.

Rule: Divide the number of threads that will lie side by side per inch without any interlacing, by the number of threads in one repeat of the weave plus the points of interlacing, then multiply this quotient by the number of threads in one repeat of the weave.

Example: Find the number of threads of a 2/20's worsted that will weave side by side in one inch, when the plain weave is used for the interlacing.

Solution: According to the example under No. 68, of this chapter, there are 67.35 threads per inch that will lie side by side without any interlacing.

The plain weave repeats on two ends and two picks, and has

*Upon examining Fig. 1, of Book 1, this will be better understood.

two points of interlacing for every repeat; thus $2+2=4$. $67.35 \div 4 = 16.84 \times 2 = 33.68$ threads per inch. *Answer:* 33.68 or nearly 34 threads per inch of 2/20's worsted will weave side by side when using a plain weave for the interlacing.

The amount of twist in the yarn at times will influence this texture, as the more twist the harder the yarn, and the less twist the softer the yarn. More threads may be placed per inch of a hard yarn than of one softer, because the harder yarn is generally much stronger than when it has a smaller number of turns of twist per inch.

Example: Find the number of threads of a 2/40's cotton yarn that will weave side by side when the ${}_1{}^1{}_1{}^1{}_1{}^1{}_1{}^1{}_1{}^4$ 16-harness twill is used for the interlacing.

Solution: From a previous example it has been found that 120.54 threads of 2/40's cotton will lie side by side without any interlacing. There are ten points of interlacing in the above 16-harness twill.

$120.54 \div (16+10) = 4.64 - \times 16 = 74.24$.

Answer: 74.24 or practically 74 threads per inch will weave side by side of a 2/40's cotton using the ${}^1{}_1{}^1{}_1{}^1{}_1{}^1{}_1{}^4{}_1$ twill for the interlacing.

70. When warp and filling are of different counts.

Rule: First find the diameters of both systems of threads, then find the fraction of the inch taken up by the ends in one repeat of the weave (when the number of ends per inch is to be found, but when the number of picks per inch is to be found then the space taken up by the picks in one repeat of the weave is found), and to this add the fraction of an inch taken up by the filling passing between the ends in one repeat. Multiply the number of threads, which will lie side by side per inch without any interlacing, by the space required by the ends, in one repeat of the weave, and divide this product by the sum of the space required by the ends plus that required by the picks in one repeat of the weave. This quotient will be the number of ends which will weave side by side per inch.

Example: Find the number of ends and picks per inch that can be put into a piece of cloth woven with a five-harness satin. The warp is made of 1/48's worsted and the filling is a 3-run wool.

Solution: 1/48's worsted $= 26{,}880$ yards per pound. The square root of $26{,}880 = 163.95+$. $163.95 - 10\% = 147.55+$, or nearly 148 warp threads per inch will lie side by side without any interlacing, that is a diameter of $\frac{1}{148}$ of an inch.

3-run wool $= 1{,}600 \times 3 = 4{,}800$ yards per pound. The square root of $4{,}800 = 69.28+$. $69.28 - 16\% = 58.19+$, or practically 58 filling threads per inch will lie side by side without any interlacing, or the diameter is $\frac{1}{58}$ of an inch.

A five-harness satin repeats on five ends and five picks, and every end and pick has two points of interlacing in one repeat.

For warp: $\frac{1}{148} \times 5 = \frac{5}{148}$ $\quad \frac{1}{58} \times 2 = \frac{2}{58}$ $\quad \frac{5}{148} + \frac{2}{58} = \frac{586}{8584}$ of an inch taken up by five warp threads.

$$148 \times \frac{5}{148} \div \frac{586}{8584} = \frac{148 \times 5 \times 8584}{148 \times 586} = 73.24+ \text{ ends per inch.}$$

For filling: $\frac{1}{58} \times 5 = \frac{5}{58}$ $\quad \frac{1}{148} \times 2 = \frac{2}{148}$ $\quad \frac{5}{58} + \frac{2}{148} = \frac{856}{8584}$ of an inch taken up by five picks.

$$58 \times \frac{5}{58} \div \frac{856}{8584} = \frac{58 \times 5 \times 8584}{58 \times 856} = 50.14 + \text{ picks per inch.}$$

Answer: In the above goods 73 or 74 ends of 1/48's worsted and 50 picks of 3-run wool may be placed per inch.

Note: In some satins it would be advisable to place a few more ends or picks per inch than the rule calls for. For it must always be borne in mind that a piece of satin is to be smooth and not show the points of interlacing on the face of the goods. In the above example it is evident that the warp is to make up the face, therefore the texture of the warp may be increased by adding from four to ten ends per inch. This, however, can only be done when the warp yarn is strong enough to stand the chafing and extra strain put on the warp by a crowded texture.

If the yarn used for filling has the opposite twist of that used for the warp, then the textures may also be increased over that obtained by following the above rules; as yarns of opposite twist, for warp and filling, combine more readily.