ARITHMETICAL

CALCULATIONS

FOR . . . . .

WEAVING STUDENTS.

YARN AND CLOTH.

NEVILLE.

James Thompson
28 Lynthorp Road
Blackburn

James Thompson
28 Lynthorp Road
~~24 Abbotsford Avenue~~
Blackburn

Arithmetical Calculations

FOR

Weaving Students,

COMPILED

BY

H. NEVILLE,

Principal of the Textile Department of the Blackburn Municipal Technical School.

PART I.—YARNS AND CLOTH.

Blackburn:

"Standard and Express" Office,

41 Church Street.

1904.

PREFACE.

The following compilation has been devised primarily with the object of bringing before students, and others interested in Cotton Weaving, a number of Textile Rules and Examples in as simple and concise a form as is possible with such subject matter. The arrangement followed is such as to allow one to trace step by step that course of operations which from experience has been found necessary for converting yarns into a woven fabric. All explanatory and argumentative matter has been left to the teacher, and the Author hopes that this will be an inducement to the busy business man to use these pages as a ready book of reference. The questions set as exercises at the end of the book have been gathered from, or have been based upon, the questions set by the City and Guilds of London Institute, the Union of Lancashire and Cheshire Institutes, and our own Local and other Examination papers in the subject of Cotton Weaving.

The Author's great hope is that these pages may be found useful.

H.N.

Blackburn, 1904.

Arithmetical Calculations

I.—INTRODUCTORY.—Notes on Various Trade Names given to Yarns.

Yarn is a generic term applied to all threads used for textile purposes. Fibres of cotton, wool, silk, flax, &c., or any of these put together, are employed in thread manufacture producing, as the result of specific operations, two kinds of yarn, viz.:—(*a*) Warp yarns, from which are taken those threads running lengthwise of a piece of cloth, and (*b*) those less strong and compact weft threads which run from side to side of a woven fabric.

But there are many trade names given to yarns other than "warp" and "weft," among which we have the following:—

Mule and Ring Frame Yarns.—Yarns which have been respectively spun on the Mule or Ring Spinning Frame. From each of these machines we have both warp and weft yarns.

"*Throstle*" *Yarn.*—Yarns which have been spun on "fly" frame known as a throstle.

Water Twist.—Folded warp yarns of several strands which have been run through water during the process of doubling.

Gassed Yarns.—Yarns which have been run through jets of gas in order to singe away all loose and projecting surface fibre.

Crape Yarns.—Yarns which have received an extra amount of spinning twist, so that, when released from all tension they shall loop, curl, and crinkle.

Granderelle Yarns.—Folded threads made up of two or more strands each of different colour. Thus, red with black, or blue with orange, or brown and red with blue, would produce granderelle threads on being twisted together.

Printed Yarns.—Yarns which have received some regular or irregular colour impression prior to the operation of weaving. This results in undecided pattern definition when such are woven into cloth.

Fancy Yarns.—Yarns of variegated colour; of mixed material: of irregular thicknesses purposely produced: threads of unequal thicknesses twisted together in some regular or irregular twist: threads so twisted with each other as to form loops, knops, and pearls with one or other of the threads. A great variety of such yarns are used in the fancy dress-goods trade.

Mercerised Yarns.—"Mercerising" yarns is based upon a discovery made in 1850 by Mr. John Mercer. He found by experiment that if cotton fibres were soaked in a solution of caustic soda of a specific gravity of 1.3 or 1.4, they became thicker and stronger, resulting in yarn and cloth having a fuller "handle" and better appearance, and that yarn thus treated became more receptive of dye matter and finished up with a high degree of lustre. Thus yarns which have been been mercerised, dyed, and polished as a finishing operation, are full, round, and glossy, having much of the appearance of spun-silk threads.

Net and Lace Yarns.—Terms often applied to yarns used in fancy leno work: more strictly, yarns used for net and lace making.

Cop-Dyed and Cop-Bleached Yarns.—Yarns which have been dyed or bleached in the cop. These are economical processes, since they save the reeling of yarn into hanks, and are generally successful in giving uniformity of colour tone.

Hank Yarns.—Yarns which have been reeled into hanks for dyeing or bleaching purposes.

Pirn Weft.—Weft yarns which have been wound upon paper or wooden pirns for weaving purposes.

Ball Warps.—Generally warps which have been made on the mill warper, taken off the mill as a rope of yarn, and made into a ball either by hand or machine.

Half-Beer Warps.—Warps which have been run upon the weaver's beams in half-beers of nineteen or twenty ends..

Sized Warps.—1. Slasher sized: warps sized upon the slasher sizing frame. 2. Ball sized: Warps sized in the rope and balled. 3. Hank sized: warp yarns which have been sized in the hank.

Chenille Yarn.—A weft yarn having a brush-like surface the result of a weaving and cutting operation. The fabric resulting from using such weft has a velvety plush-like surface of low pile.

"American" and "Egyptian" Yarns.—Terms applied to yarns spun from American and Egyptian cottons.

Cotton-Dyed Yarns.—Yarns produced from cotton dyed previously to being made into a thread.

Roving Yarns.—Yarns of a soft, coarse character, having but few turns of spinning twist per inch, mostly used as weft yarns.

Waste Yarns.—Yarns spun from clean waste, and as a rule, very coarse in counts.

Whip Yarns.—An indiscriminate term for all sorts of threads used as extra figuring threads in such fabrics as lappets, etc.

Heald Yarn.—Multiple folded yarn of counts such as 9/50's, 12/40's, 18/50's, etc., used in the making of weaver's healds.

Bundle Yarns.—Yarns of any kind reeled and made up into bundles for sale. A bundle of cotton yarn is generally 10lbs. weight, made up of as many hanks of a given count as shall make the required weight. The manner of reeling the yarn into hanks depends on the ultimate use the yarn has to be put to. Thus, the hank may be reeled into seven leas, each lea kept separate by a lease band; or reeled into one lea hanks of 120 yards, or into hanks of 840 yards, or into double hanks of 1,680 yards. In reeling, the yarn may be cross-wound, or straight-wound:—cross-wound, by being wound on a reel having a quick traverse which superimposes the several layers diagonally across each other: straight-wound, by which the threads comprising the several layers of the hank are practically parallel to each other.

II.—To Find the Standard Spinning Twist or Turns per inch for Single Cotton Yarns.

For American Cotton :—

Mule Weft	$\sqrt{\text{Counts}}$	× 3.25
,, Twist	,,	× 3.75
,, ,, hard spun	,,	× 4.00
Ring ,, ...	,,	× 4.00
,, Weft	,,	× 3.50

For Egyptian Cotton :—

Mule Weft	$\sqrt{\text{Counts}}$	× 3.183
,, Twist	,,	× 3.606
Reeled Yarn	,,	× 3·394

Note.—The twists or turns per inch for Ring Weft will largely depend upon the quality of cotton used. The reeled yarn mentioned above is a sort of "bastard" yarn chiefly used for doubling purposes.

Example.—What are the standard twists or turns per inch for: (*a*) 40's ordinary mule weft; (*b*) for 32's ordinary mule twist; and (*c*) for 36's ring frame twist?

(*a*) $\sqrt{40} = 6.3245.$
$\therefore 6.3245 \times 3.25 = 20.55$ turns per inch.

(*b*) $\sqrt{32} = 5.6568.$
$\therefore 5.6568 \times 3.75 = 21.213$ turns per inch.

(*c*) $\sqrt{36} = 6.$
$\therefore 6 \times 4 = 24$ turns per inch.

III.—Having found the "Standard" Twists or Turns per Inch of one, to find the Twists or Turns per Inch of another Thread of like Structure.

Rule.—As the square root of one count is to the square root of another count, so is the twists or turns per inch for one count to the twists or turns per inch for another count.

Example.—A 36's yarn has 22.5 turns per inch; what number of turns will be required in a 40's yarn of like structure?

(1) As $\sqrt{36} : \sqrt{40} :: 22.5 : x$.

(2) „ $6 : 6{\cdot}3245 :: 22.5 : x$.

(3) ∴ $6 : 6.3245 :: 22.5 : 23.71$ the required turns per [inch.

IV.—To find the Diameter of a Cotton Thread.

The equal density theory of thread structure assumes that all threads are true cylinders; that like counts have like diameters and hence have equal sectional areas; that the areas occupied by such sections will be to each other as the " counts" of the thread; and that their diameters will be as the square root of such counts. This must be so if it is true that the diameter of circles vary as the square roots of their areas. But the diameter of a thread under longitudinal strain is not its true diameter. To meet this and other conditions of manufacturing operations, certain allowances, which go by the name of " co-efficients of friction," have to be made. These allowances are:—For cotton, silk, and worsted, 10 per cent.; for woollen, 16 per cent. Hence the following rule for finding the diameter of a thread: —

Rule.—The square root of the counts, minus the co-efficient of friction, equals the diameter of that thread.

Example.—What is the diameter of a 40's cotton thread?

(1) $40 \times 840 = 33609$.

(2) $\sqrt{33600} - 10\% = 165$ the diameter of a 40's thread, or, the number that would lie side by side in one inch.

V.—Having found the Diameter of one to find the Diameter of Another Thread of like Structure.

Rule.—As the square root of one count is to the square root of another count, so is the diameter of the given yarn to the diameter of the required yarn.

Example.—If a thread of 16's cotton have a diameter of 1-104 part of an inch, what is the diameter of a 36's thread?

(1) As $\sqrt{16} : \sqrt{36} :: 104 : x$.

(2) ,, $4 : 6 :: 104 : x$.

(3) ∴ ,, $4 : 6 :: 104 : 156$ the diameter of a 36's thread.

VI.—To Test Cotton Yarns for Breaking Strain.

A rule in common use for finding the breaking strain of ordinary cotton yarns, measured in pounds avoirdupois, is stated thus:—

Rule.

For "Egyptian" twist, 1800 ÷ counts = breaking strain in lbs.
For "American" twist, 1600 ÷ counts = ,, ,, ,,
For Weft Yarns, 1400 ÷ counts = ,, ,, ,,

Tabulating a few results from this Rule we have:—

Counts.	*Dividend.*		*Breaking strain in pounds.*	
	Egyptian	*American*	"*Egyptian*" *Twist.*	"*American*" *Twist.*
20's	—	1600	—	80
30's	—	,,	—	53.33
40's	1800	,,	45	40
50's	,,	,,	36	32
60's	,,	—	30	—
70's	,,	—	25.71	—
80's	,,	—	22.5	—

The following table published by Messrs. Howard and Bullough, gives a general idea of the comparative strength of mule twist yarns having, for the American cotton, the "Standard" turns or twist per inch:—

20's Twist. American cotton = 80 lbs.
30's ,, ,, ,, = 54 ,,
40's ,, ,, ,, = 40 ,,
50's ,, ,, ,, = 28 ,,

40's Twist.	Egyptian	cotton	= 50	lbs.
50's ,,	,,	,,	= 37	,,
60's ,,	,,	,,	= 30	,,
70's ,,	,,	,,	= 26	,,

These values approximate very nearly to the values given by the above Rule.

VII—To Test the Elasticity of a Cotton Thread.

The elasticity of a cotton thread, or the length a given measure of thread will stretch when put under longitudinal strain, is equal to its increase in length when strained to breaking point. According to Dr. Herzfeld the elasticity of cotton yarns should be about:—

For counts from	20's to 30's	4.5 to 5.0 per cent.
,, ,, ,,	30's ,, 40's	4.0 ,, 4.5 ,,
,, ,, ,,	40's ,, 60's	3.8 ,, 4.0 ,,
,, ,, ,,	60's ,, 80's	3.5 ,, 3.8 ,,
,, ,, ,,	80's ,, 120's	3.0 ,, 3.5 ,,
,, ,, ,,	120's ,, 140's	2.5 ,, 3.0 ,,

But the elasticity of threads will vary with the variableness in quality of the cotton from which they are spun and the conditions under which the threads are tested. Also, as the conditions of spinning and the amount of spinning twist imparted to the threads, are regular or irregular. There are several instruments by which elasticity of threads may be tested, but we may proceed to measure off a given length of thread, and by any method stretch it to breaking point, carefully noting its gain in length at the time of rupture. Then:—

Rule.—As the measured length is to the gain in length, so is 100 to the per cent. of stretch or elasticity.

Example.—If 36in. of thread gain 1.25 in. of stretch at breaking point, what is its per cent. of elasticity?

As 36 : 1.25 : : 100 : 3.47 per cent.

VIII.—To Test Cotton Yarns for Moisture.

On receipt all yarns should be tested for moisture. This is a matter of importance, since cotton yarns are highly hygroscopic, having the power to hold large quantities of moisture other than that naturally absorbed from the atmosphere. This natural moisture will amount to about 8.5 per cent. under normal conditions of atmosphere; that is, the amount of moisture the thread will re-absorb on exposure to the air after prolonged drying in hot air, will be about 8.5 per cent. But in commercial yarns much higher per centages may be found. To test such, proceed as follows:—Carefully weigh any convenient amount of yarn which should then be dried for several hours in a water-oven kept at a temperature of about 110°C., then re-weighed, the difference in weights being the amount of moisture discharged. The per cent. may then be found as follows:—

> Rule.—As the original weight is to the difference in weights so is 100 to the per cent. From this must be deducted the natural moisture per centage.

Example.—A newly wrapped hank of cotton yarn weighed 175 grs., but on being dried was found to have lost 25 grs. of its original weight: What was (*a*) its receipt counts, (*b*) its dry counts, (*c*) its per cent. of moisture, and (*d*) its per cent. of added moisture?

(*a*) $7000 \div 175 = 40$'s the receipt counts.

(*b*) $7000 \div 150 = 46.66$ the dry counts.

(*c*) As 175 : 25 :: 100 : 14.28 per cent. of moisture.

(*d*) $14.28 - 8{\cdot}5 = 5.78$ per cent. of added moisture.

The following per centages of "Regain" for various yarns have been gathered from various authoritative sources, and are generally accepted by Yarn Testing and Yarn Conditioning Houses:—

Cotton	$8\frac{1}{2}$	per cent.
Worsted	$18\frac{1}{4}$	,,
Flax and Hemp	12	,,
Silk	11	,,
Jute	$13\frac{3}{4}$	,,
Carded Woollen Yarn	17	,,

The drying temperature to be 105 to 110 degrees Centigrade, these temperatures being equivalent to 221-230 degrees Fahrenheit.

IX.—Measuring Yarns: The Basis of the several Counts Systems.

The localisation of specific textile manufacture has had a very marked effect on the naming of yarns used for textile purposes. Local custom long ago decided by what method a yarn should be weighed and measured so as to determine its fineness or coarseness relative to some acknowledged standard. Though much of this was arbitrary many of these old methods still maintain their full significance, and are matters of every day practice.

Cotton.—The unit of length in the Cotton System is a hank of 840 yards, measured on a reel 54in. in circumference, 80 revolutions of which give a lea of 120 yards, seven such leas making the hank. The number of hanks to the pound indicates the counts. This in the form of a table gives the following:—

54 inches = $1\frac{1}{2}$ yards = 1 thread, or round of the reel.
120 yards = 80 threads = 1 lea.
840 yards = 560 threads = 7 leas = 1 hank.

Spun Silk.—The same as cotton as regards the length of hank, and the number of hanks to the pound being equal to the counts number. But spun silk counts are always actual counts though written as 40's/2., 80's/2, etc.—the 2 simply indicating that the thread is a double one.

Worsted.—The worsted reel is 36in. in circumference, 80 revolutions of which give a skein of 80 yards, seven such skeins making the worsted hank of 560 yards. The number of hanks to the pound indicate the counts number. Tabulating this we have:—

36 inches = 1 yard = 1 thread or round of the reel.
80 yards = 80 threads = 1 skein.
560 yards = 560 threads = 7 skeins = 1 hank.

Mohair.—Mohair has the same length of hank as worsted viz., 560 yards, the number of hanks to the pound equalling the counts number.

Linen.—The linen reel is 90in. in circumference, 120 revolutions of which give a lea of 300 yards. The counts equal the number of leas in one pound, as 40 lea, 30 lea, etc. Tabulated this gives:—

90 inches = 1 thread = 2.5 yards, one round of the reel.
120 threads = 300 yards = 1 lea.

Jute.—Jute is measured in the same way as linen.

Woollen.—In the West of England the skein is one of 320 yards, and the times 320 yards are contained in a pound equals the counts, or so many skein yarn. This is based upon the number of times 20 yards are contained in one ounce, which is equal to the number of times 320 yards are contained in a pound.

By the Yorkshire skein system the counts equal the number of times 256 yards are contained in one pound. This is based upon the number of yards per dram, which equals the times 256 yards are contained in one pound.

There are several other systems in use in the woollen trades of this country and Scotland, but the two here given are probably the best known, and in most general use.

Raw Silk.—In naming Raw Silk yarns there are three systems in use, viz.:—

1. The Ounce System.—By this system if a hank of 1,000 yards weigh one ounce, the yarn is said to be 1's, consequently there are 16,000 yards of 1's in one pound.

2. The Dram System.—Here again a 1,000 yards hank is used, but if this hank weigh 1 dram the yarn is known as 1 dram silk. Reduced as above, this system gives 256,000 yards to the pound of 1 dram silk.

3. The Denier System.—The "Denier" is a weight which has been variously estimated, but the London Silk Conditioning House authorities give $533\frac{1}{3}$ deniers as being equal to 1 ounce avoirdupois, which makes 1 denier to equal .8203 + of a grain. The same authorities give the hank for this system as being one of 400 French ells, or 520 yards English. For this system a reel is used, 400 revolutions of which give a hank of 476 metres. As a metre is equal to 39.37 English inches we shall have $39.37 \times 476 \div 36 = 520.56$ yards English as the length of a hank by this system.

X.—To find the Equivalent Counts of a given Yarn in another Yarn System.

Rule.—As the length of hank in required system is to the length of hank in given system, so is the given counts to the required counts.

Example.—What is the equivalent counts of a 40's cotton thread in the worsted system?

As 560 : 840 : : 40's : 60's.

XI.—To Test Cotton Yarn for Counts.

(1.) By the wrap reel.—Reel one hank, then:

Rule I.—Divide 7,000, the number of grains in one pound avoirdupois, by weight in grains of the hank The quotient equals the counts.

Rule II.—The number of grains in a pound divided by the counts of the hank, equals the weight of the hank in grains.

Examples.—A hank of cotton yarn weighs 350 grains. What is its counts?

$$7000 \div 350 = 20\text{'s counts.}$$

What is the weight in grains of a hank of 40's cotton yarn?

$$7000 \div 40 = 175 \text{ grs.}$$

But it is not necessary to have a whole hank in order to find counts; one or more leas may be taken and practically the same results obtained. Suppose one lea of 120 yards to be wrapped. Since one lea, whose weight in grains is to be used as a divisor, is only one-seventh of a hank, it will only be necessary to use for a dividend the corresponding fraction of a pound weight. Thus:—

For	1 lea	use	1,000	as a	dividend.
,,	2 ,,	,,	2,000	,,	,,
,,	3 ,,	,,	3,000	,,	,,
,,	4 ,,	,,	4,000	,,	,,
,,	5 ,,	,,	5,000	,,	,,
,,	6 ,,	,,	6,000	,,	,,
,,	7 ,,	,,	7,000	,,	,,

This may be illustrated as follows:—

Leas.	Dividend.		Weight of Lea or Leas in Grains.		Counts.
1	1000	÷	25	=	40.
2	2000	÷	50	=	40.
3	3000	÷	75	=	40.
4	4000	÷	100	=	40.
5	5000	÷	125	=	40.
6	6000	÷	150	=	40.
7	7000	÷	175	=	40.

From this we have:—

Rule.—For every lea wrapped add 1,000 to the dividend, which, divided by the weight in grains of the lea or leas, gives the counts.

Example.—One lea and five leas of cotton yarn weigh respectively, 30 and 120 grains. What are their respective counts?

(a) 1000 ÷ 30 = 33.33 counts.
(b) 5000 ÷ 120 = 41·66 ,,

It may occur that a lea of yarn is not obtainable, but there is no reason why shorter lengths than a lea should not be measured on the wrap reel. Thus: If six yards of yarn, four rounds of the reel, weigh 2 grains, what is its counts? Here, 6 yards equals one-twentieth of a lea, then one-twentieth of one thousand must be used as the dividend. Therefore 50 ÷ 2 = 25's the counts. Or the same result may be obtained by proportion:—

(a) As 6 yards : 120 yards :: 2 grains : 40 grains.
(b) 1000 ÷ 40 = 25's the counts.

(2.) But the counts as well as very short lengths of yarn can be tested by such "balances" as the Arc, the Micrometric, the Precision, Dietze's, the Steel, and Staub's.

The principle of construction in all these balances is practically the same, viz.: that corresponding fractional parts of a hank and a pound are employed as the units of length and weight. Thus, for Staub's balance, a number of threads are wound about, or stretched across, a templet which is a given fraction of a hank in length. Cut to the length of the templet the threads are then hung on the end of a balance weighted with a weight of that fraction of a pound corresponding to the hank fraction of length. So many threads as bring the balance to a state of equipoise indicate the counts of the threads. Such a balance is eminently suited to cases where small samples of cloth are forwarded for analysis and quotation.

(3.) The counts of yarn is sometimes ascertained by comparing submitted with known yarns which are kept as "standards." This is an unsatisfactory proceeding, especially for the higher counts, unless the person making the tests has acquired considerable skill by experience in such matters.

XII.—To Find Resulting Counts when Two or More Threads of the same Material are Twisted Together.

Rule.—Find the weights of the several threads in grains: then the grains in one pound divided by the sum of the weights equals the resulting counts.

Example.—What is the resulting counts when 40's and 50's cotton yarns are twisted together?

40) 7000 (175
50) 7000 (140

---

315) 7000 (22.22 resulting counts.

Note.—It is a moot point as to what is the proper number of doubling twists or turns per inch to impart to folded yarns. Yet, for given kinds of yarn, there are certain multiplying constants recognised by the trade. These are:

For Soft Yarn	3.00
„ Knitting Yarn	3.25
„ Fine Counts	3.75
„ Medium Counts	4.00
„ Coarse Counts	4.25
„ Hard Twisted	5.00
„ Extra Hard	6.50

With these multipliers the Rule for finding the doubling twists or turns per inch is as follows:—

Rule.—The square root of the resulting counts multiplied by the constant, equals the standard turns or twists per inch.

Example.—Two threads of 40's cotton are to be twisted together: using 4 as the constant, how many turns per inch of the folded thread will there be?

I. 2 threads of 40's = 20's resulting counts.

II. $\sqrt{20} \times 4 =$

III. $4.4721 \times 4 = 17.8884$ turns per inch.

XIII.—When Threads of Different Materials are Twisted Together to Find Resulting Counts.

Rule.—(*a*) Reduce all to the same counts system; (*b*) find the weight of each thread in grains; (*c*) then, the grains in one pound divided by the sum of the weights equals the resulting counts.

Example.—What is the resulting counts of 20's cotton and 40's worsted twisted together?

(a) By Rule X, 40's worsted equals 26.66 cotton.

(b) $\begin{cases} 7000 \div 20 = 350. \\ 7000 \div 26.66 = 262.56. \end{cases}$

(c) 612·56) 7000 (11.42 resulting counts in the cotton system.

XIV.—To Produce a given Count of Folded Yarn by Twisting Known with Unknown Counts.

Rule.—The difference in the weights of the required and known counts equals the weight of the unknown counts.

Example.—What is the counts of a thread which, twisted with 50's, shall produce a folded thread of 20's counts? $7000 \div 20 = 350$ and $7000 \div 50 = 140$. Then $350 - 140 = 210$ the difference in weights of required and known counts. The counts of a thread having a weight of 210 grains. equals $7000 \div 210 = 33.33$ the counts of the unknown thread.

XV.—To Find the Required Weight of each Yarn, when Twisting Two or More Threads Together, to Produce a given Weight of Folded Yarn.

Rule.—(a) Find the counts resulting from twisting the several threads together; then (b) the total required weight multiplied by the resulting counts and divided by one of the counts equals the required weight of that count.

Example.—40's and 60's are to be twisted together to produce 100lbs. of folded yarn. What weight of each count will be required?

(a) 40) 7000 (175
60) 7000 (116 66

291.66) 7000 (24's resulting counts.

(b) $100 \times 24 \div 40 = 60$lbs of 40's.
$100 \times 24 \div 60 = 40$ lbs of 60's.

XVI.—To Find the Cost of Two or More Ply Cotton Yarns.

(1) When two threads of the same counts are twisted together the counts of the resulting thread is reduced one-half. Thus, two threads of forty-hank to the pound yarn twisted together results in a thread of twenty hanks to the pound. But such threads, though of the same counts, may be of different qualities as to price. When such cases occur the cost of the folded yarn is the average of the several prices. From this we have:

> Rule.—The sum of the prices of the several threads divided by the number of threads folded, equals the price of the resulting yarn.

Example.—Two yarns costing 7 and 7.75 pence per pound respectively, are twisted together: What is the price of the doubled thread?

(*a*) $7 + 7.75 = 14.75$ the sum of the prices.
(*b*) $14\,75 \div 2 = 7.375$ pence per pound for the donbled thread

And so for any number of threads of like counts.

(2) When two threads of different prices and counts are twisted together, to find the price of the resulting thread.

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

Example.—Find the cost of a doubled thread composed of 40's at 8.5 pence, and 32's at 7.75 pence per pound.

$$\begin{array}{lcl} 40 \times 7.75 & = & 310 \\ 32 \times 8.5 & = & 272 \\ \hline 72 & &)\,582\,(8.083 \text{ pence per pound.} \end{array}$$

(3.) When three threads of different prices and counts are twisted together to find the price of the resulting thread.

To find the required result proceed as follows:—

(*a.*) Take any two threads as a pair and treat them as in our last example.

(*b.*) Find the resulting counts of the two threads so treated.

(*c.*) Having found the resulting counts and price, this new thread along with the third thread, are now treated as a pair, and the resulting price found as per last rule.

Example.—Three threads, 60's at 13.5 pence, 50's at 13 pence, and 40's at 8.5 pence per pound are twisted together: What is the price of the resulting thread?

(*a*) 60 × 13 × 780
50 × 13.5 × 675

110) 1455 (13.227 + the price of the first pair of threads.

(*b*.) But the counts resulting from twisting 60's and 50's together is:

60) 7000 (116.66
50) 7000 (140.00

256.66) 7000 (27.27's counts. We now have 27.27's at 13.227 pence, and 40's at 8.5 pence per pound.

(*c*.) Treating these as a pair and proceeding as before we have:

27.27 × 8.5 = 231.79
40 00 × 13.227 = 529.08

67.27) 760.87 (11.45 pence, the price of the three fold yarn.

(4.) To find the resulting price when four threads of different values are twisted together.

Rule.—Divide the number of threads to be twisted into two pairs and treat each pair simply as two threads. Then, having found the price and resulting counts of each pair use these as two new threads and proceed as as before.

Example.—Four threads, 60's at 13.5 pence; 50's at 13 pence; 40's at 8.5 pence, and 30's at 7.5 pence per pound, are twisted together: What is the price of the resulting thread?

60 × 13 = 780
50 × 13.5 = 675

110) 1455 (13.227 pence for 60's and 50's twisted together.

40 × 7·5 = 300
30 × 8.5 = 255

70) 555 (7.928 pence for 40's and 30's twisted together.

But the resulting counts of 60's and 50's and of 40's and 30's are 27.27's and 17's respectively, whilst their prices, as found above are 13.227 pence and 7.928 pence per pound. These form our new pair of threads, which are now treated as previous pairs, thus:

$$\begin{array}{llll} 27.27 & \times\ 7.928 & = & 216.19 \\ 17.00 & \times 13.227 & = & 171.95 \\ \hline 44{\cdot}27 & &) & 388{\cdot}14 \end{array}$$

(8.76 pence per pound for the four-fold thread

NOTE.—If the threads to be folded are of different materials such as cotton and worsted, or cotton and linen, etc., all must be reduced to one counts system as per Rule XIII. They can then be treated by the methods shown as threads of the same material.

XVII.—When Ends and Length are given to find the Number of Hanks of Yarn on a Beam.

RULE.—Multiply ends by length and divide by the yards per hank.

EXAMPLE.—A beam contains a warp of 1,800 ends 500 yards: How many hanks of yarn are there in the warp?

$$1800 \times 500 \div 840 = 1071.42 \text{ hanks.}$$

XVIII.—When Ends, &c., are Given, to Find the Weight of Yarn in a Warp.

RULE.—Multiply ends by length and divide by length of hank and counts.

EXAMPLE.—A warp containing 3,000 ends of 40's twist is 500 yards long: What is its weight?

I. $(3000 \times 500) \div (840 \times 40) =$

II. $1500000 \div 336000 = 44.64$ lbs.

XIX.—When Ends, &c., are Given to Find the Counts of Yarn in a Warp.

Rule.—Multiply ends by length and divide by yards and weight.

Example.—A warp of 2400 ends 700 yards long weighs 40lbs. what is its counts?

I. $(2400 \times 700) \div (840 \times 40) =$

II. $1680000 \div 33600 =$ 50's counts.

XX.—When Weight, &c., are Given to Find Ends in a Warp.

Rule.—Multiply weight of yarn by its counts and by its length of hank, and divide by the yards of warp required.

Example.—If 5lbs. of 40's cotton are to be made into a warp 75 yards long, how many ends will it contain?

$5 \times 40 \times 840 \div 75 = 2240$ ends.

XXI.—When Weight &c., are Given to Find Yards in Length of Warp.

Rule.—Multiply weight of yarn by its counts and by its length of hank, and divide by the number of ends required.

Example.—10lbs. of 32's twist are to be made into a warp containing 2000 ends: What will be the length of warp?

$10 \times 32 \times 840 \div 2000 = 134.4$ yards.

XXII.—To Find the Average Counts of Yarn in a Warp Containing Several Different Counts.

Rule.—Proceed to find the resulting counts as if twisting the several counts together: then, the resulting counts multiplied by the ends in a pattern equals the average counts.

EXAMPLE.—(*a*.) What will be the average counts of yarn in a warp beamed with alternate threads 40's and 10's?

40) 7000 (175
10) 9000 (700

875) 7000 (8's the resulting counts; and
8 × 2 = 16's the average counts.

EXAMPLE.—(*b*.) A warp is made up of 8 ends of 40's and 1 end of 5's cotton: What is its average counts?

40) 7000 (175 × 8 = 1400
5) 7000 (= 1400

2800) 7000 (2.5 the resulting counts, 2.5 × 9 = 22.5 the average counts.

XXIII.—TO FIND PERCENTAGE OF SIZE ON A BEAM OF YARN.

RULE.—Find the unsized weight of yarn per beam: then, as the weight of yarn is to the weight of size so is 100 to the per centage.

EXAMPLE.—A warp 1,000 yards long containing 2,000 ends of 32's twist, weighs 150lbs., what per cent. of size is there on the yarn?

(*a*) $\dfrac{2000 \times 1000}{840 \times 32}$ = 74.40 lbs of yarn.

(*b*) 150 – 74.40 = 75.60 lbs of size on the yarn.

(*c*) As 74.40 : 75.60 :: 100 : 101.61 per cent. of size.

XXIV.—TO FIND THE WEIGHT RESULTING FROM ADDING A GIVEN PERCENTAGE OF SIZE TO A BEAM OF YARN.

RULE.—Multiply the weight of yarn by the per cent., and divide by 100; the quotient read in hundreds is the size weight to be added to the yarn weight.

Example.—A warp containing 75lbs. of yarn is to be sized with 60 per cent. of size: What should be its sized weight?

(a) 75 × 60 = 4500, marking the hundreds we have

(b) 75 + 45 = 120 lbs the weight of sized warp

XXV.—To Find the per Cent. of Size or other Filling in a Piece of Grey Cloth.

Proceeding.—Take any conveniently squared piece of cloth and note its weight. Then (a) thoroughly wash in running water; (b) boil for one hour in a 1 per cent. solution of caustic soda and again wash; (c) boil in a 1 per cent. solution of hydrochloric acid for one hour and again wash; (d) again boil and wash in pure water and dry in water oven. Then:

1. Where the weight discharged is less than the cloth weight.

Rule.—As the filled weight is to the clean weight, so is 100 to the per cent.

2. When the weight discharged is greater than the weight of cloth remaining.

Rule.—As the clean weight is to the weight discharged so is a 100 to the per cent.

Note.—In all cases 8.5 per cent. must be deducted from the resulting per cent. in order to allow for "natural moisture,"—a quality common to cloth as to yarn. (See Section VIII.)

Example.—(1.) A piece of cloth weighing 30 grains loses 18 grains in testing: What is the per cent. of loss?

I. As 30 : 18 :: 100 : 60 per cent.

II. 60—8.5 = 51.5 per cent of added matter.

Example.—(2.) A piece of cloth weighing 70 grains is found to lose, on analysis, 40 grains of its original weight: What is the per cent. of discharged matter?

I. As 30 : 40 :: 100 : 133.33 per cent.

II. 133.33—8.5 = 124.83 per cent.

XXVI.—Healds and Heald Knitting.

All healds should be knitted to the counts of the reed to be used so that the yarn coming through them shall stand "square" to the dents through which it ultimately has to pass; in other words the ends per inch in the healds should be the ends per inch in the reed. But further, all healds should be knitted to the draft, or order of drawing-in the warp, to be employed. If this is not done the warp threads are "drawn-over" into bunches as they pass through the healds,—a thing to be avoided where good weaving is desired. Such errors as are here indicated may be avoided, and correct instructions sent to the knitter, by the application of a few simple Rules.

(*a.*) To find the total number of healds required on all the shafts.

> Rule.—Ends per dent × dent per inch × inches in width equals total healds reauired.

Example.—A reed containing 30 dents per inch is to be filled 2 ends in a dent 36in. wide: What total number of healds is required?

$$2 \times 30 \times 36 = 2160 \text{ total healds.}$$

(*b.*) When knit to a draft to find total healds required and number of knitting patterns.

> Rule.—Ends per dent × dents per inch × inches in width divided by ends in one repeat of draft equals number of patterns in width; and patterns × ends per pattern equals total healds required.

Example.—A set of healds 5 staves to the set is drafted with a point draft to a reed having 30 dents per inch, 36 inches wide, 2 ends in a dent: What will be the total number of healds on all the staves and knitting patterns required?

I. $2 \times 30 \times 36 = 2160$ total heaids.

II. $2160 \div 8 = 270$ patterns.

(*c.*) To find the number of healds required on each stave.

> Rule.—First find total healds and number of patterns. then, multiply the number of times the thread is drawn in on each shaft in one repeat of the pattern by the number of patterns in the width.

Example.—How many healds must be knitted on each stave for a warp drawn to the following draft in a 64 reed Stockport counts, 2 ends in a dent, 36in. wide?

							7						7					
						6		6				6		6				
					5				5		5				5			
Draft				4						4						4		
			3														3	
		2																2
	1																	

= 18 ends per repeat.

I. $2 \times 32 \times 36 = 2304$ total healds required.

II. $2304 \div 18 = 128$ total patterns.

III.

No. 1 shaft.	1×128	= 128	healds.
No. 2 shaft.	2×128	= 256	,,
No. 3 shaft.	2×128	= 256	,,
No. 4 shaft.	3×128	= 384	,,
No. 5 shaft.	4×128	= 512	,,
No. 6 shaft.	4×128	= 512	,,
No. 7 shaft.	2×128	= 256	,,
		2304	healds on all the shafts.

(*d.*) To find the required number of healds per inch of knitting.

I. When a straight draft is used.

Rule.—Divide the ends per inch by the number of shafts.

Example.—A piece is woven 72 ends per inch in the reed with a straight draft on 8 staves of healds: How many healds per inch per stave will be required?

$72 \div 8 = 9$ per inch per inch per stave.

II. When drafts other than straight are used.

Rule.—Divide the number of ends per inch by the number of ends in the draft (thus obtaining the relation of draft repeats to one inch of knitting), and multiply by the number of ends drawn on each shaft of the draft.

Example.—How many healds per inch will be required on each stave for the following draft if the reed contain 64 ends per inch?

Draft

						7						7					
					6		6				6		6				
				5				5		5				5			
			4						4						4		
		3														3	
	2																2
1																	

= 18 ends per repeat.

I. 64 ÷ 18 = 3.555 repeats per inch.

II.	No. 1 stave.	1 × 3.555 =	3.555	per inch.
	No. 2 stave.	2 × 3.555 =	7.110	per inch.
	No. 3 stave.	2 × 3.555 =	7.110	per inch.
	No. 4 stave.	3 × 3.555 =	10.665	per inch.
	No. 5 stave.	4 × 3.555 =	14.220	per inch.
	No. 6 stave.	4 × 3.555 =	14.220	per inch.
	No. 7 stave.	2 × 3.555 =	7.110	per inch.
			63.990	

NOTE.—This result, owing to the repeating character of the decimals, gives one-tenth of one heald too little per inch.

(*e.*) To find the rate of knitting for a set of healds.

I. Where the healds are equal and regular all across on all the staves the following Rule is applicable:—

RULE.—The number of ends per inch in the reed is multiplied by the number of ends in a pattern on one shaft, divided by the number of ends in a pattern on all the shafts.

EXAMPLE.—40 ends per inch, 4 shafts to a set, pattern a four-end twill.

Draft

			4
		3	
	2		
1			

= 4 ends to a pattern. Then

$$\frac{40 \times 1}{4} = 10 \text{ per inch per stave.}$$

Thus one heald will equal 1-10th of an inch per stave, and 10 per inch will be the rate per stave of the knitting.

II. When the healds are made up of recurring regular spacings.

An example will best illustrate this:

Example.—I. 72 ends per inch, 2 ends in a dent on 8 shafts knitted to the following draft:—

Draft

															8				8				8
														7				7				7	
													6				6				6		
												5				5				5			
			4				4				4												
		3				3				3													
	2				2				2														
1				1				1															

= 24 ends to a pattern and three repeats of such to an inch.

If this example were treated by the above Rule we should have 72 × 3 ÷ 24 = 9 healds per inch per stave, and 9 would be the rate of knitting. We certainly want 9 healds per inch per stave, but it is obvious that some modification in the knitting and placing of the healds upon the staves must be made, or the knitting will not agree with the spacing required by the draft, much less will it agree with the denting of the reed. Proceed then, as follows:—Let a dent of the reed to be used equal the unit of measurement.

A 72 Stockport reed has 36 dents per inch. Therefore 1 dent equals 1-36th of an inch, and 36 will be the rate per inch per stave of the knitting. Being drawn 2 ends in a dent the order of knitting is shown in the following plan:—

Dents.

Staves	1	2	3	4	5	6	7	8	9	10	11	12	
8								8		8		8	3 Healds
7								7		7		7	3 ,,
6							6		6		6		3 ,,
5							5		5		5		3 ,,
4		4		4		4							3 ,,
3		3		3		3							3 ,,
2	2		2		2								3 ,,
1	1		1		1								3 ,,

= 24 × 3 = 72 Healds per inch on all the staves.

12 dents = $\frac{1}{3}$ of an inch.

The order of knitting will be:—For staves 1 and 2, knit 1 miss 1 knit 1 miss 1 knit 1 miss 1 miss 6; for staves 3 and 4, miss 1 knit 1 miss 1 knit 1 miss 1 knit 1 miss 6; and similarly for staves 5, 6, 7 and 8. Thus in one repeat of the pattern we have 12 units of knitting per stave, and having three repeats per inch, we therefore have 12 × 3 = 36 units of knitting per stave per inch these units being distributed as has been shown.

Example.—II. A crammed stripe is to be woven 8 dents 2 in a dent and 8 dents 4 in a dent, reed 96 Stockport counts, with the following draft: What is the knitting rate per stave?

Staves																
8									8	8	8	8	8	8	8	8
7									7	7	7	7	7	7	7	7
6									6	6	6	6	6	6	6	6
5									5	5	5	5	5	5	5	5
4		4		4		4		4								
3		3		3		3		3								
2	2		2		2		2									
1	1		1		1		1									

16 dents = $\frac{1}{3}$ of an inch.

Again making one dent of the reed to be used the unit of measurement, we have:—

A 96 Stockport reed has 48 dents per inch. Therefore 1 dent equals 1-48th of an inch, and 48 will be rate per inch per stave of the knitting. The order of knitting will be:—For staves 1 and 2, knit 1, miss 1, knit 1, miss 1, knit 1, miss 1, knit 1, miss 1, miss 8. For staves 3 and 4, miss 1, knit 1, miss 1, knit 1, miss 1, knit 1, miss 1, knit 1, miss 8. But for staves 5, 6, 7 and 8 the order will be miss 8, knit 8. Thus in one repeat of the pattern we have 16 units of knitting per stave, and having three repeats per inch. We therefore have $16 \times 3 = 48$ units of knitting per stave per inch, the units being distributed as has been shown.

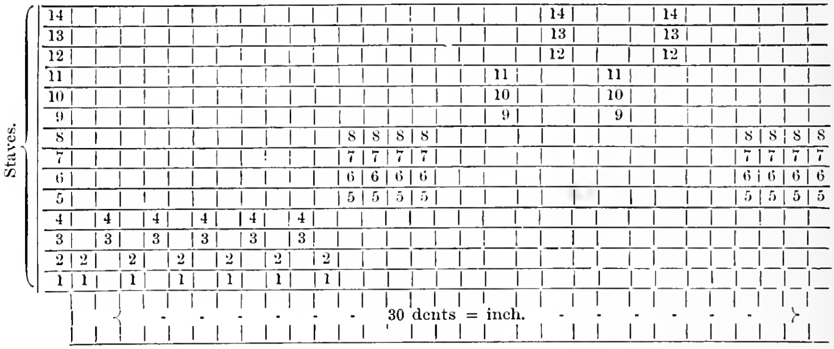
III. When healds have to be irregularly knitted to meet the irregular denting of a reed.

Example.—A piece of cloth has to be woven with the drafting and denting shown in the following plan, 14 staves to the set, the reed being a 60 Stockport counts: Give the rate and order of knitting.

Particulars of ends, staves, and denting:—

22 ends	on staves	1, 2, 3, 4,	2 in a dent	= 11 dents		
16 ,,	,, ,,	5, 6, 7, 8,	4 ,, ,,	= 4 ,,		
				2 ,,	empty	
3 ,,	,, ,,	9, 10, 11,	3 ,, ,,	= 1 ,,		
				1 ,,	empty	
3 ,,	,, ,,	12, 13, 14,	3 ,, ,,	= 1 ,,		
				1 ,,	empty	
3 ,,	,, ,,	9, 10, 11,	3 ,, ,,	= 1 ,,		
				1 ,,	empty	
3 ,,	,, ,,	12, 13, 14,	3 ,, ,,	= 1 ,,		
				2 ,,	empty	
16 ,,	,, ,,	5, 6, 7, 8,	4 ,, ,,	= 4 ,,		
66 ,,	,, ,,	14 staves		30 ,,		

Proceeding to arrange from these details a plan of draft, heald–staves, and denting, we have the following:—



The reed to be used, a 60 Stockport counts, has 30 dents per inch, therefore 1 dent equals 1-30th of an inch. Requiring one heald per dent per stave, 30 per inch per stave will be the rate of knitting, whilst the placement of the healds on the staves follows similarly to those in previous examples. Thus the dent becomes the knitting rate unit, giving results fine enough for all practical purposes, and quite as fine as healds can be knitted and adjusted on the staves by our present systems of knitting.

Note.—In addition to the number of healds required for patterns, a certain number extra must be allowed for selvedges. These may be placed on the same staves if such staves give the required selvedge weave, if not extra staves must be added or some selvedge motion called into requisition.

To Find the Rate of "Dropping" when a Set of Healds Knitted for a Fine is to be Used for a Coarser Count of Reed.

In places where frequent changes are made heald knitting becames a serious item in the cost of production. To prevent accumulation it is better to use up, than throw into stock, all healds where they can possibly be made use of. This can readily be done with all healds which are equally knitted all across on every stave when they are required for a lower counts of reed than that for which they were knitted.

Rule.—Reed to be used ÷ (reed for which healds were knitted—reed to be used).

This in the form of a fraction gives the repeats of the draft to be taken and missed.

Example.—A set of healds knitted for a 72 has to be used for a 64 reed Stockport counts: What is to be the rate of dropping?

$$\frac{64}{72-64}=\frac{64}{8}=\frac{8}{1}$$

or eight full drafts and one missed. Thus on four shafts we could take 32 full and 4 empty healds twice over per inch, or 64 full and 8 empty if more convenient. For Jacquard work it is absolutely necessary to adopt some such method as is here shown for building a harness is too costly a matter to have it to re-build for every change of reed. Thus harnesses are built to fine count of reed and are "dropped" as required as in the above example.

XXVII.—Reeds and Reed Systems.

The systems still in use for naming reeds are almost as varied as the districts in which reeds are used, though, particularly in Lancashire, several of the older complicated systems have given way to more simple methods of reed counting. Still, there is no standardisation. But a general division may be made by which the several systems fall to one or other of two methods, viz.:— (*a*) Where the number of dents in a given space equals the reed count, and (*b*) where the number of ends in a beer and the number of beers in a given width are made the basis of reed counting.

(*a*.) By the number of dents in a given width.

Radcliffe and Pilkington	system, based upon the number of dents in	1 inch.
Huddersfield, new	,, ,, ,, ,, ,, ,, ,, ,,	1 ,,
Stockport	,, ,, ,, ,, ,, ,, ,, ,,	2 ,,
Macclesfield	,, ,, ,, ,, ,, ,, ,, ,,	36 ,,
Manchester for Silk and fine Dress Goods	,, ,, ,, ,, ,, ,, ,, ,,	36 ,,
Scotch	,, ,, ,, ,, ,, ,, ,, ,,	37 ,,

Silk Reed: Name of reed, number of ends per dent, and width of cloth, as 2,000, 4 thread, 20 inches.

(*b.*) Reeds based on 19 dents, or 38 ends to a beer.

Nankin	the number of times 19 beers are contained on 20 inches
Huddersfield	,, ,, ,, ,, ,, ,, 30 ,,
Dewsbury	,, ,, ,, ,, ,, ,, 90 ,,

Reeds based upon 20 dents or 40 ends to a beer.

Bolton	the number of beers contained on $24\frac{1}{4}$ inches
Blackburn	,, ,, ,, ,, ,, 45 ,,
Bradford	,, ,, ,, ,, ,, 36 ,,
Dundee	,, ,, ,, ,, ,, 37 ,,
Worsted	,, ,, ,, ,, ,, 54 ,,
Preston 7/8 reed	,, ,, ,, ,, ,, 34 ,,
,, 4/4 ,,	,, ,, ,, ,, ,, 39 ,,
,, 9/8 ,,	,, ,, ,, ,, ,, 44 ,,
,, 6/4 ,,	,, ,, ,, ,, ,, 58 ,,

Note.—To count reeds by the Stockport system, viz., the number of dents on two inches, has now become general in Blackburn and immediate districts.

(1.) When sett or count of reed is given, to find ends per inch.

Rule.—Multiply together sett or count and ends per beer for a dividend, and divide by number of inches upon which the system is based.

Examples —

Bradford ...... 70 sett $= \dfrac{70 \times 40}{36} =$ 77.7 ends per inch.

Bolton .... 70 sett $= \dfrac{70 \times 40}{24\ 1/4} =$ 115.4 ends per inch.

Huddersfield .. 70 sett $= \dfrac{70 \times 38}{30} =$ 88.66 ends per inch.

Preston 9/8... 70 sett $= \dfrac{70 \times 40}{44} =$ 63.63 ends per inch.

(2.) When ends are given to find count or sett of reed.

Rule.—Multiply together ends and inches made the basis, and divide by ends per beer.

EXAMPLES.—

Bradford ...... 60 ends per inch $= \dfrac{60 \times 36}{40} = 54$ sett or count.

Bolton .... 60 ends per inch $= \dfrac{60 \times 24\frac{1}{4}}{40} = 36.37$ sett or count.

Huddersfield .. 60 ends per inch $= \dfrac{60 \times 30}{38} = 47.37$ sett or count.

Preston 9/8 ... 60 ends per inch $= \dfrac{60 \times 44}{40} = 66.00$ sett or count.

(3.) To find the equivalent of a given reed in another reed system.

RULE.—Multiply together given count, dents per beer, and inches in basis of required reed system for a dividend, and divide by the product of inches in basis of given reed and dents per beer in required reed system. The quotient equals equivalent counts.

EXAMPLE.—What is the equivalent of a 50 Bradford reed in the Bolton, and Huddersfield systems?

$$\frac{50 \times 40 \times 24\frac{1}{4}}{36 \times 20} = 67.36 \text{ Bolton counts.}$$

$$\frac{50 \times 40 \times 30}{36 \times 19} = 87.72 \text{ Huddersfield counts.}$$

XXVIII.—RULES FOR FINDING LENGTH CONTRACTION IN WARP AND WEFT.

The shortening of warp and weft threads, owing to their intersecting with each other during the process of weaving, is known as contraction. To provide for this shortening, so that the cloth shall be of stated length and width particulars when lying on the table, so over-length of material must be allowed. But the per cent. of this over-length allowance will be as variable as the conditions under which a "piece" is manufactured. Theoretically, no one rule has been formulated which will meet all cases, but in practice the following are in regular use, and are said to satisfy ordinary requirements.

Rule.—(*a*.) One yard in twenty for medium counts of yarn and ends and picks per inch is to be allowed to meet contraction.

This is equal to an allowance of 5 per cent. for contraction. According to the Blackburn Standard List, all weft from 30's to 60's both included, and all twist from 28's to 45's both included, are reckoned medium counts. If such are the "medium counts" of our Rule it is but an indifferent one to follow.

Rule.—(*b*) Picks per quarter inch multiplied by 12, and divided by counts of weft for 24's to 50's twist, and for 10 to 20 picks per quarter inch. For higher picks 13 must be used as a multiplier. This is only applicable to plain cloth.

Example.—A cloth is to be made with 15 picks per quarter inch of 36's weft, what per cent. must be allowed for warp contraction?

$$\frac{15 \times 12}{36} = 5 \text{ per cent.}$$

It has often been asserted that, in practice and under ordinary conditions, this rule gives very workable results, which suggests a warp contraction table on lines similar to the following:—

Counts of Twist.	Picks per Quarter.	Counts of Weft used.							
		20's	25's	30's	35's	40's	45's	50's	
24's to 50's	10	6.0	4.8	4.0	3.42	3.0	2.66	2.4	Percentages of Warp Contraction.
,,	11	6.6	5.28	4.33	3.77	3.3	2.93	2.64	
,,	12	7.2	5.76	4.8	4.11	3.6	3.2	2.88	
,,	13	7.8	6.24	5.2	4.45	3.9	3.46	3.12	
,,	14	8.4	6.72	5.6	4.8	4.2	3.73	3.36	
,,	15	9.0	7.2	6.0	5.14	4.5	4.0	3.6	
,,	16	9.6	7.68	6.4	5.48	4.8	4.26	3.84	
,,	17	10.2	8.16	6.8	5.82	5.1	4.53	4.08	
,,	18	10.8	8.64	7.2	6.17	5.4	4.8	4.32	
,,	19	11.4	9.12	7.6	6.51	5.7	5.06	4.56	
,,	20	12.0	9.6	8.0	6.85	6.0	5.33	4.8	

Note.—The error of such a proceeding lies in the fact that an increasing length contraction is provided for increasing picks. But it is a well-known fact that, either set of threads may be so increased, or otherwise influenced, that one set will do all the bending, whilst the other set lies in a comparatively straight line in the cloth.

Rule.—(*c*) Picks per inch multiplied by length of piece in yards divided by counts of weft, equals inches to be added to cloth length of warp. This is only applicable to plain cloth.

Example.—A piece of 40 yards long has 60 picks per inch of 40's weft: What allowance must be made for warp contraction?

$60 \times 40 \div 40 = 60$ inches to be added to warp. This allowance is equal to 4.16 per cent., which, referred to the above table, shows a difference of .34 per cent. resulting from the two Rules for the same kind of cloth. This Rule, like the last, gives increasing length allowances for increasing picks.

Rule.—*(d)* In dealing with several kinds of shrinkage, or contraction in plain cloths, Staub gives the following rule for what he terms "Normal or Reciprocal" shrinkage: that is, shrinkage in which both sets of threads are deflected somewhat equally by their intersecting with each other. For his purpose he uses certain "constants" to which he gives the names, "co-efficients of skrinkage." These are,—for cotton and silk, 0.567; for wool, 0.88; for linen, 1.6.

(1.) For warp contraction:

$$\frac{\text{Picks per quarter inch squared} \times \text{co-efficient}}{\text{Counts of weft used.}} = \text{per cent. for warp contraction.}$$

(2.) For weft contraction:

$$\frac{\text{Ends per quarter inch squared} \times \text{co-efficient}}{\text{Count of warp used.}} = \text{per cent. for weft contraction.}$$

Example.—A cotton cloth has to be made with 16 ends of 32's twist and 16 picks of 36's weft, per quarter inch: What per centage of contraction is to be allowed?

(1.) $$\frac{16 \times 16 \times 0.567}{36} = 4.032 \text{ per cent. for warp contraction.}$$

(2.) $$\frac{16 \times 16 \times 0.567}{32} = 4.536 \text{ per cent. for weft contraction.}$$

Staub recognises that these Rules give increasing length per centages of contraction for increasing picks, and proceeds to deal with the matter by other Rules in which he considers the sum of the diameters of the two threads intersecting with each other, on the principle that, the deflection of such threads can never exceed the sum of both diameters. But these Rules are too complicated for general use.

Proceeding to consider "Abnormal, or one-sided skrinkage." due to one set of threads predominating over the other, as is instanced in fabrics of the "cord" class, Staub gives the following Rules to meet such instances:—

(1.) To find warp contraction—the weft straight:—

> RULE.—Picks per quarter inch squared multiplied by co-efficient, and divided by a number corresponding to the sum of the diameters of the counts employed.

(2.) To find weft contraction—the warp straight:—

> RULE.—Ends per quarter inch squared multiplied by co-efficient, and divided by a number corresponding to the sum of the diameters of the counts employed.

EXAMPLE.—What is the warp contraction in a piece made as follows:—15 picks per quarter-inch of 16's weft, and 30 ends per quarter-inch of 36's warp?

I. $\sqrt{16 \times 840} - 10\% = \frac{1}{104}$ of an inch the diameter of 16's.

II. $\sqrt{36 \times 840} - 10\% = \frac{1}{157}$ of an inch the diameter of 36's.

III. $\frac{1}{104} + \frac{1}{157} = \frac{1}{63}$ and a thread having this diameter equals 6's in counts.

IV. By rule. $\frac{15 \times 15 \times 0.567}{6} = 21.262$ per cent. for warp contraction.

And so in a similar manner may be found the shrinkage or contraction for weft when the warp is straight. Staub also recognises that what would satisfy the requirements of plain, would not equally satisfy the requirements of figured cloth shrinkage or contraction, and so gives the following.

> RULE.—First find contraction as for plain cloth: then multiply percentage of contraction by intersections in weave to be used, and divide by ends per repeat of that weave.

EXAMPLE.—What is the warp contraction for a four-end twill cloth to be made with 16 ends of 32's twist, and 16 picks of 36's weft, per quarter inch?

I. $\frac{16 \times 16 \times 0.567}{36} = 4.032$ per cent. for plain cloth.

II. $\frac{4.032 \times 2}{4} = 2.016$ required per cent. of contraction for four end twill.

NOTE.—The same example is used here as was used for plain cloth in order to show the variableness produced by mere change of pattern.

Ordinarily, for such fabrics as cotton brocades, it is the ground, not the figure weave, which is considered in calculating for contraction. These, being generally plain, twill, or satin as regards the ground weave, can be treated by the foregoing rules.

XXIX.—TO FIND THE AMOUNT OF MATERIAL IN A "PIECE."

RULES.—(*a.*) For Warp:—

$$\frac{\text{Ends per inch} \times \text{inches in width} \times \text{Length of piece plus allowance for contraction}}{\text{Length of hank} \times \text{counts of yarn}} =$$

weight of twist in piece.

(*b.*) For Weft:—

$$\frac{\text{Length of piece} \times \text{picks per inch} \times \text{Width of piece plus allowance for contraction}}{\text{Length of hank} \times \text{counts of yarn}} =$$

weight of weft in piece.

EXAMPLE.—What weight of material is there in a piece of the following particulars:—39in. wide, 37½ yards long, 64 ends and 64 picks per inch, 32's twist and 36's weft, allowing 5 per cent. for contraction in length and width?

(*a.*) Warp—$\dfrac{64 \times 39 \times 39.3}{840 \times 32} = 3.64$ lbs

(*b.*) Weft—$\dfrac{37.5 \times 64 \times 40.9}{840 \times 36} = 3.24$ lbs

6.88 lbs

These results might be multiplied by the price per pound of the yarn in pence, and the sum of the results would be the cost in pence of the material in the piece. If 32's twist and 36's weft were respectively 8 pence and $7\frac{3}{4}$ pence per pound, the cost of the above material would be:—

(*a.*) Warp 3.64lbs. at 8 pence = 29.12 pence.

(*b.*) Weft 3.24lbs. at 7.75 pence = 25.11 pence.

54.23 pence,

the cost of the 6.88lbs. of material in the piece. But the better practice is to take the price per pound of each material as factors in the first calculation. Thus :—

(*a.*) Warp—$\dfrac{64 \times 39 \times 39.3 \times 8}{840 \times 32} = 29.19$ pence.

(*b*) Weft—$\dfrac{37.5 \times 64 \times 40.9 \times 7.75}{840 \times 36} = 25{\cdot}12$ pence.

NOTE.—The slight fractional differences in the two results is due to the interminate character of the decimals.

XXX.—To Find the Amount of Material Required to Make a "Piece."

In addition to allowances for contraction of material, an allowance for waste must be made when finding the amount of material required to make a piece of cloth. In effect this waste reduces the effective length of the hank, the amount largely depending on the care with which the material is handled. Thus, if $2\frac{1}{2}$ per cent. of waste is made in either yarn the length of the hank is practically reduced to 820 yards, and so for any other per cent. of allowance.

RULES.—(*a.*) For Warp :—

$$\frac{\text{Ends per inch} \times \text{inches in width} \times \text{length of piece plus allowance for contraction}}{\text{Length of hank minus waste allowance} \times \text{counts of yarn}} =$$

weight of twist required.

(*b.*) For Weft:—

$$\frac{\text{Length of piece} \times \text{picks per inch} \times \text{Width of piece plus allowance for contraction}}{\text{Length of hank minus waste allowance} \times \text{counts of yarn}} =$$

weight of weft required.

Example.—What weight of material will be required to make a piece of the following particulars:—39in. wide, $37\frac{1}{2}$ yards long, 64 ends and 64 picks per inch, 32's twist and 36's weft, allowing 5 per cent. for contraction in length and width, $2\frac{1}{2}$ per cent. for waste in twist, and 5 per cent. for waste in weft?

(*a.*) Warp—$\frac{64 \times 39 \times 39.3}{820 \times 32} = 3.73$ lbs

(*b.*) Weft—$\frac{37.5 \times 64 \times 40.9}{800 \times 36} = 3.40$ lbs

7.13 lbs

Note.—These weights are equal to adding $2\frac{1}{2}$ per cent. and 5 per cent. respectively to the weights found in our last example.

XXXI.—To Find by Proportion the Hanks of Each Colour or Kind of Weft Material in a Piece.

Rule.—Find the total hanks as if one weft were being used: then, as the total picks to pattern is to the picks per pattern of each colour or kind, so is the total hanks to the hanks of that colour or kind.

Example.—A piece contains 200 hanks of weft the pattern being of three colours in the proportion of 36, 10, and 4 respectively: How many hanks of each does the piece contain?

(*a.*) 200 hanks.

(*b.*) $36 + 10 + 4 = 50$ picks to pattern.

(*c.*) Then as 50 : 36 : : 200 : 144
,, ,, 50 : 10 : : 200 : 40
,, ,, 50 : 4 : : 200 : 16

200 hanks.

XXXII.—To Find the Total Ends in the Width of a Piece when each Dent of the Reed does not Contain an Equal Number of Ends.

Rule.—Divide the total dents in the width of piece by the number of dents occupied by one pattern, and the quotient multiplied by the ends in a pattern shall equal the total number of ends in the piece.

Example.—A striped fabric is to be made 36in. wide in a reed having 30 dents per inch, the pattern being 20 ends, 2 in a dent, and 20 ends 4 in a dent: How many ends does the warp contain?

(a). $36 \times 30 = 1080$ dents in width of piece.

(b). $10 + 5 = 15$ dents per pattern.

(c). $1080 \div 15 = 72$ patterns in width of piece.

(d) 40 ends per pattern $\times 72 = 2880$ ends in warp plus the necessary ends for selvedges.

XXXIII.—From Given Data to Find Ends or Picks per Inch to use up a Given Amount of Material.

In the following examples 5 per cent. for length and width contraction, and $2\frac{1}{2}$ per cent for waste in both kinds of yarn, have been allowed.

(*a*.) When weight, counts, width, and length are given, to find picks per inch.

Rule.—Multiply together for a dividend weight, counts, and yards per hank, and divide by width multiplied by length.

Example.—Having 5lbs. of 20's cotton weft with which to make a piece 39 inches wide, $37\frac{1}{2}$ yards long: How many picks per inch will the piece contain?

$$\frac{5 \times 20 \times 820}{40.9 \times 37.5} = 53.46 \text{ picks per inch.}$$

(*b*.) When weight, counts, width, and length are given, to find ends per inch.

RULE.—For a dividend multiply together weight, counts, and yards per hank, and divide by width multiplied by length.

EXAMPLE.—If 3lbs. of 50's cotton twist be made into a piece 40in. wide 40 yards long: How many ends per inch will the cloth contain?

$$\frac{3 \times 50 \times 820}{40 \times 42} = 73.21 \text{ ends per inch.}$$

The inversion of these calculations will give width or length of piece resulting from the use of a given amount of material.

XXXIV.—When Picks per Inch and Width are Given to Find the Ounces of Weft Required to Produce One Yard of Cloth.

RULE.—Picks per inch multiplied by inches wide in reed, divided by yards per ounce of counts of weft used.

EXAMPLE.—A fabric standing 40 inches in the reed is to be made 72 picks per inch of 30's weft: How many ounces of weft per yard will be required? Nothing to be allowed for waste.

I. $72 \times 40 = 2880$.

II. $840 \times 30 = 25200$ yards per pound, or 1575 yards per ounce.

$\therefore$ $2880 \div 1575 = 1.82$ ounces per yard.

XXXV.—From Given Data to Find Counts of Weft for a Given Ounce to the Yard Cloth.

RULE.—Multiply picks per inch by inches wide in reed and divide by the product of required weight and one-sixteenth of the length of hank used.

EXAMPLE.—A fabric standing 40 inches in the reed and having 72 picks per inch is to be 1.82 ounces per yard: What counts of weft must be used?

I. $40 \times 72 = 2880$.

II. $1.82 \times (840 \div 16) = 95.550$.

III. $2880 \div 95.550 = 30$'s the counts required.

XXXVI.—From Given Data to Build a Cloth of Any Desired Pattern, Ends and Picks per Inch, and Counts.

All fabric structure is based upon the generally accepted definition that, a plain cloth having threads of equal diameters and number in both directions, and whose threads are equally bent out of the straight and are equal distances apart, is a "balanced" cloth. Hence, such a cloth is known as a "square" cloth, a "firm" cloth, and, a cloth made up of equal thread and space.

In using such terms as "balance," and "firm," in relation to fabric structure, we mean to imply that, the ratio of thread to space must be maintained in changing from one count to another count of yarn, or from one to another number of ends and picks per inch, or from one pattern of a given to another pattern of a different number of intersections. In the same connection the term "units of space" refers to so much thread and so much space as making up any pattern of a given size of repeat. Thus in plain cloth there are two threads and two intersections of threads in one repeat of the pattern, so that ends plus intersections equals four units of space in one repeat of plain cloth. And so for any other pattern.

(*a.*) When counts of yarn is given to find the number of threads to make a "firm" plain cloth.

Rule.—1. The diameter of the yarn used divided by 2, equals the number of threads per inch for that count.

Example.—A plain cloth is to be made with 32's yarn: How many threads per inch will be required to make a "firm" cloth?

I. $\sqrt{32 \times 840} - 10\% = 148$ the diameter of 32's.

II. $148 \div 2 = 74$ the threads per inch required.

Rule.—2. Diameter of yarn used multiplied by ends in pattern, and divided by units of space in one repeat, equals ends required.

Example.—A plain cloth is to be made with 40's yarn: How many threads per inch are required?

I. $\sqrt{40 \times 840} - 10\% = 165$ the diameter of 40's.

II. $165 \times 2 \div 4 = 82.5$ ends per inch required.

(*b.*) When counts of yarn are given, to find threads per inch for patterns other than plain cloth.

> Rule.—As the units of space in the required cloth is to the number of threads in the pattern, so is the diameter of the yarn to be used to the number of threads required.

Example.—A seven-end twill 4 up, 1 down, 1 up, 1 down, is to be made from 28's twist: How many threads per inch will be required?

I. 7 threads and 4 intersections equals 11 units of space.

II. $7+4 : 7 :: 138 : x$.

III. $11 : 7 :: 138 : 87.81$ threads per inch.

(c.) When threads per inch are given for one pattern, to find threads per inch to give equal firmness in another pattern.

> Rule.—Take an equal number of threads in complete repeats of given and desired patterns. Then,—Multiply threads per inch by threads plus intersections in number of threads taken of given cloth, and divide by ends plus intersections in number of threads taken of desired cloth.

Example.—Wishful to make a three-end twill of the same firmness as a plain cloth having 80 threads per inch: How many threads per inch will the new cloth require?

I. $80 \times (6 + 6) \div (6 + 4) =$

II. $80 \times 12 \div 10 =$

III. $960 \div 10 = 96$ ends per inch.

Example.—In changing from a three-end twill with 96 ends per inch to a three up and three down six-end twill: How many threads per inch ought the new cloth to have?

I. $96 \times (6 + 4) \div (6 + 2) =$

II. $96 \times 10 \div 8 =$

III. $960 \div 8 = 120$ ends per inch.

And so for any other pattern; care being taken to consider an equal number of threads from each fabric.

(d.) Retaining the same number of threads per inch, but changing counts, to find the counts necessary to give equal firmness in cloths of different patterns.

> Rule.—As the units of space in pattern of given cloth is to units of space in pattern of proposed cloth, so is the square root of the counts of yarn in given cloth to the square root of the counts of yarn in proposed cloth.

Example.—Desiring to make a four-end twill with the same number of threads per inch as a plain cloth woven with 36's yarn: What counts will be required to make the proposed cloth as firm as the plain cloth?

Taking an equal number of threads for each cloth, we have

4 ends and 4 intersections in the plain cloth,—8 units of space.

4 ends and 2 intersections in the twill cloth,—6 units of space.

From this we have:—

I. As $8 : 6 :: \sqrt{36} : \sqrt{x}$.

II. $8 : 6 :: 6 : 4.5$.

III. $4.5^2 = 20.25$ the counts required.

(*e.*) Retaining pattern but changing the threads per inch, to find the counts to give equal firmness in any proposed cloth.

Rule.—Multiply the square root of the counts of yarn in given cloth by threads per inch in required cloth, and divide by threads per inch in given cloth.

Example.—A given cloth is made with 64 threads of 32's yarn per inch: What counts will be required to make a cloth of equal firmness having 56 threads per inch?

I. $\sqrt{32} \times 56 \div 64 =$

II. $5.6568 \times 56 \div 64 =$

III. $316.7808 \div 64 = 4.9497$.

IV $4.9497^2 = 24.499$ the counts required.

(*f.*) Retaining pattern and threads per inch, but changing counts of yarn to find counts for proposed cloth.

Rule.—Threads per inch in given cloth multiplied by square root of counts for required cloth, divided by square root of counts in given cloth, equals threads per inch in required cloth.

Example.—Desiring to make a cloth from 50's yarn to be of the same firmness as one having 72 threads per inch of 36's yarn: How many threads per inch will be required?

I. $72 \times \sqrt{50} \div \sqrt{36} =$

II. $72 \times 7.071 \div 6 = 84.852$ threads per inch.

(*g*.) From given data to alter weight and retain the same firmness.

Altering the weights of cloths where the same perfection of firmness is to be maintained in based upon the principle that such weights will vary as the square roots of the counts of yarn used. This accounts for the fact that coarser and fewer threads are rejuired for heavier, whilst an increased number of finer threads are required for lighter fabrics.

Rule.—1. The square root of the counts employed multiplied by weight of given cloth, divided by weight of proposed cloth equals counts of yarn for required cloth.

Rule.—2. Threads per inch in given cloth multiplied by its weight, divided by weight of proposed cloth, equals threads per inch for proposed cloth.

Example.—A cloth having 80 threads of 50's yarn per inch weighs 10lbs.: What counts of yarn and threads per inch will be required to make a similar fabric 13lbs. weight?

By Rule 1. I. $\sqrt{50} \times 10 \div 13 =$

II. $7.071 \times 10 \div 13 = 5.44.$

III. $5.44^2 = 29{\cdot}59$ required counts.

By Rule 2. I. $80 \times 10 \div 13 =$

II. $800 \div 13 = 61.53$ required threads per inch of above counts.

Example.—2. A cloth having 80 threads per inch of 50's yarn per inch weighs 10lbs.: What counts of yarn and threads per inch will be required to make a similar fabric 8lbs. weight?

By Rule 1. I. $\sqrt{50} \times 10 \div 8 =$

II. $7.071 \times 10 \div 8 = 8.839$

III. $8.839^2 = 78.13$ required counts.

By Rule 2. I. $80 \times 10 \div 8 =$

II. $800 \div 8 = 100$ required threads per inch of above counts.

XXXVII.—On Costing a Piece of Cloth.

To arrive at the cost of producing a piece of cloth is not so easy a matter as many imagine, and presents many difficulties even to those who are most concerned with mill economics. To those less familiar with what is implied in mill management the mere recital of the considerations involved would present a tangle of intricate detail to which there would seem no end. If the matter were a mere consideration of wages plus the price of the material in a piece, the problem were an easy one to solve. But the case is not so simple as all that, as among items affecting the cost of production, which the counting house is called upon to deal with, we have:—Rent, rates, taxes and insurance: coal, lighting, and stores, including sizing materials; salaries and wages of every kind; carriage of yarn and cloth, and travelling expenses; commissions and discounts; depreciation and up-keep of plant, buildings, and machinery; interest on every form of capital—bank, loan, share, and annuities, if any; returns on waste account; balances on profit and loss account; allowances on cloth rejected for various reasons; profit or loss on joint shipping accounts, loss of interest on stocks of yarn and cloth; per cent. loss of materials in working; printing, stationery, auditing, and sundry miscellaneous expenses. Nor does the complication end here, for any fluctuation in the prices and values of the raw and manufactured necessaries of cloth production: the arrangement and condition of machinery and plant; the quantity, quality, and adaptability of labour: the situation of the mill as regards water, coal, lighting, and cartage of all materials; the terms of lease engagements, and a score of other local and general conditions under which the manufactory is carried on, affect the cost of producing a piece of cloth. And so varied are all these that, probably no two places can be found running under exactly the same conditions of working. It follows that, unless some specific case were quoted, any attempt which one may make in "costing" a piece of cloth, must be made in terms arbitrary in every particular, except those of immediate wages which may be worked up from accepted "standard lists."

There are many who say that the sum of all charges, other than immediate wages, will amount to from 44 to 54 per cent. of the weaving price, for a mill on plain work. This gives foundation for the general statement that, the sum of twice the weaving price plus cost of material, equals the cost of producing a piece. But such statements need qualifying, and for two reasons—the heavier the sett of a cloth, the greater is the amount of labour in preparation, whilst an increased or decreased "average" correspondingly affects the cost of production. Evidently, then, the question of the actual cost incurred in producing a piece of cloth is only to be gained by actually engaging in such matters, and the knowledge so acquired strictly belongs to the privacy of the counting-house. Recognising this, we shall only attempt to deal with the matter in a general sort of way.

Particulars of Piece, &c.

500 looms; average weekly earnings, 6s. per loom.

Average weekly production per loom, 5.136 pieces.

Cloth Particulars:—38" wide; 40 yards long; 72 ends and 72 picks per inch; 34's twist at 9 pence, and 36's weft at 10 pence per pound; the piece to weigh 10lbs. Allowances: 5% for contraction in width and length; 2½% for twist, and 5% for weft waste; 20 ends extra for selvidges; 2% for loss of size in working. Cloth to be full in all particulars.

Twist.—

(38 × 72) + 20 = 2,756 ends.
(2,756 × 42) ÷ (840 × 34) = 4.05lbs. + 2½% = 4.15lbs. required.

Weft.—

(39.9 × 40 × 72) ÷ (840 × 36) = 3.80lbs. + 5% = 3.99lbs. required.

7.85lbs. 8.14lbs. required.

Winding.—

4.15lbs. at 37lbs. for 12 pence = 1.34 pence per piece.

Warping.—

At $2\frac{1}{16}$ pence for 1,000 yads. of 460 ends = .519 pence per piece of 42 yards. of 2,756 ends.

Size.—

10 − 7.85 = 2.15 + 2% for loss in working = 2.19lbs. required.
2.19lbs. ¾d. per lb. = 1.64 pence per piece.

Taping.—

100 cut of 25yds. for 21 pence = .3528 pence per piece of 42yds.

Drawing-in.—

5¼ pence per 1,000 ends. 30 cuts per beam = .482 pence per piece.

Overlooking.—

100 looms at 1s. 4d. in the pound = .932 per piece.

Management and Sundry Wages.—

£17 0s. 0d. per week for 500 looms = on the above production 1.59 pence per piece.

Weaving Price.—

As per "Standard List" = 13.98 pence per piece.

Working and Fixed Expenses.—

50% of weaving price = 6.99 pence per piece.

Summary of Cost.—

Twist 4.15lbs. at 9 pence			= 37.35	pence.
Weft, 3.99lbs. at 10 pence			= 39.00	,,
Weaving price			= 13.98	,,
			90.33	,,
Winding	= 1.34	pence.		
Warping	= 0.519	,,		
Taping	= 0.352	,,		
Size	= 1.64	,,		
Drawing-in	= 0.482	,,		
Overlooking	= 0.932	,,		
Management & Sundry Wages	= 1.59	,,		
Working and Fixed Charges	= 6.99	,,	13.845	,,
Cost of Piece			104.175	,,

NOTE.—The Author desires it to be distinctly understood that the above calculation is only meant to show the considerations involved, and the method which may be pursued in costing.

QUESTIONS.

Questions.

1. A cop is known to contain 500 yards of yarn, and there are 40 to a lb.: What is the counts?

2. If 7½lbs. of waste was made out of a skip of cops weighing 240lbs, what would be the per centage of waste?

3. If one lea of yarn be wrapped from each of four cops, and the total wrappings are found to weigh 4dwts. 8grs., what is the counts?

4. If 500 hanks of cotton yarn weigh 4lbs., what is its counts?

5. Having 7lbs. 4ozs. of cotton yarn, which, upon wrapping, is found to be 80's counts, how many hanks should there be?

6. If a quantity of cotton yarn contains 440 hanks and wraps 110's, what is its weight?

7. If 8ozs. of 60's cotton yarn contains 30 hanks, what will be the counts of 2ozs., the length to be the same?

8. What would be the counts of a cotton thread 1,050 yards of which weigh 175grs?

9. What "standard" turns or twists per inch will be required for 20's, 40's, and 60's twist and weft?

10. Four cops of twist yarn, weighing 6½ozs., are found on being wrapped to be 60's: what length of yarn will they contain?

11. If a 36's yarn has 22.5 twists per inch, what twist will be required in a 60's yarn to be of the same character?

12. What are the respective diameters of 10's, 20's, 30's and 40's cotton yarns?

13. If the diameter of a 40's cotton thread be 1-165 of an inch, what is the diameter of a 46's thread?

14. If 60yds. of cotton thread weigh 18grs., what is its counts? Also, what counts will be required to twist with 40's in order to produce a thread of 18's counts?

15. A Grandrelle cotton thread of 20's counts is required. It is to be composed of white, red, and blue. If the white is 60's, and the red 50's, what counts of blue will be needed? Also, what will be the cost per lb. of such a yarn, if the white is 13d., the red 15d., and the blue 17d. per lb., the cost of doubling to be 1½d. per lb.?

16. What counts of folded yarn would result if 18's, 24's, and 36's cotton were twisted together; and what weight of each would there be in 240lbs. of the folded yarn?

17. If one thread of 20's and one of 35's single cotton yarn be twisted together, what is the resulting counts?

18. How many hanks will be contained in one pound weight of 3-fold yarn, made by twisting together one thread each of 10's and 30's single cotton with one of 50's single worsted?

19. If one thread of two-fold 40's cotton, and one thread of two-fold 40's worsted be twisted together, what is the resulting counts?

20. What is the weight of 200 hanks of Grandrelle yarn made by twisting together one thread of 20's red and one thread of 18's blue cotton?

21. If one thread of 40's woollen (West of England) be twisted with one thread of 50's woollen (Huddersfield), what will be the resulting counts?

22. Requiring a Grandrelle thread equal to 10's counts, and having 60's red and 30's blue, what counts of white will be required to double with them?

23. What quantity of 80's single cotton and 32's single worsted will be required to produce a 100lbs. weight of the two folded together?

24. A two-fold yarn which wraps 36's is produced by twisting 144lbs. of one count with 216lbs. of another count: What are the respective counts employed?

25. Give the average counts of yarn in any cloth composed alternate threads of single 16's and single 40's cotton yarns.

26. What is the average counts of material in one square yard of a fabric composed of 56 ends of 18's twist and 160 picks of 38's weft, both yarns cotton?

27. A warp is made up of 40 ends of 60's and 10 ends of 10's cotton yarns: What is the average counts?

28. What is the cost of a folded thread made up of 60's at 13.5d., 40's at 8.5d., and 20's at 6.5d. pence per ℔ respectively?

29. A skip of yarn weighing 240lbs., is delivered and invoiced as 40's counts. On testing, the yarn is found to contain 15 per cent. of moisture. Allowing for natural moisture what is the real weight and counts?

30. How much 60's twist will be required for a set of slasher's beams, the whole set to contain 2,360 ends, 18,000yds. long?

31. It is required to make a warp 400yds long, weighing 90lbs., there must be two threads of single 24's yarn (worsted) to one thread of 9's yarn (worsted): How many ends, and what weight of each yarn will be required?

32. A warp of 1,035 ends, 750 yards long, weighs 33lbs., what is its counts?

33. A warp containing 1,720 ends, 420 yards long, is to be made on a ball warping mill 18 yards in circumference. Supposing 200 bobbins are put in the creel, how many journeys must the heck make, and how many revolutions in each direction must the mill make; also what length of yarn will be taken from each bobbin? Describe how the "lease" is formed by means of the "heck."

34. Allowing $1\frac{1}{2}$ per cent. for waste in winding, what weight of 32's twist must be given out to the winders in order to produce 500 bobbins each containing 10 hanks of yarn? Also, what would be the cost of winding if 36lbs. of yarn are wound for 12 pence?

35. How many hanks—for each colour—must be sent to the dye-house in order to produce 50 warps, all striped to the accompanying pattern, each warp to have 1,280 ends, and to be 110 yards long, after an allowance of $2\frac{1}{2}\%$ has been made for waste in working?

> *Pattern.*—5 red, 4 indigo, 2 sky, 4 fawn, 10 red, 4 fawn, 2 sky, 4 indigo, 5 red. Total, 40.

36. From 800lbs. of 40's twist you are required to make a set of six warpers' beams each containing 14,000yds., $1\frac{1}{2}$ per cent. being allowed for waste in preparation. What number of ends will you put on each beam?

37. You have 160 bobbins of 30's twist, each containing 8ozs. of yarn, and wishing to use all the yarn (allowing 5 per cent. for material left on the bobbins and waste) in a warp of 3,600 ends, what length should the warp be?

38. A warp, containing 2,560 threads, all of which are 320 yards long, is to be made on a warping-mill whose circumference is 18 yards, and from a maximum of 200 bobbins, what weight of 50's twist will it contain? How many journeys will

the "heck" make in order to provide the required number of threads? And how many times will the mill revolve in one direction to give the length?

39. How much 60's twist will be required to make a set of back beams which contain 2,364 ends of 18,000 yards, if $1\frac{1}{2}$% is allowed for waste?

40. There are 190 bobbins, each containing 12ozs. of 16's T, from which it is desired to make a warp of 2,400 ends. What length can be obtained if the wasted material and that left on the bobbins equal 6% of the whole?

41. If you had to make a warp containing 4,000 ends, how many yards could you make from 200 warping bobbins if each contained $\frac{1}{2}$lb. of 32's yarn? (Allow 40 yards per hank for waste and yarn left on bobbins.) What do you understand by the terms "counts," "bundle," "hank," and "cross-reeled" as applied to cotton yarn?

42. What length of warp will 64lbs. of 2/70's twist give, if there are 2,260 threads, and if in winding and warping $1\frac{1}{4}$% of the material is wasted?

43. Suppose a 1,000lbs. weight of 32's twist loses 3 per cent. in preparation, how many 39in., $37\frac{1}{2}$yd. 16 by 15 shirtings will be produced?

44. If four cops from one skip weigh respectively 30, 31, $29\frac{1}{2}$ and $32\frac{1}{2}$ grains per lea, what is the average counts? If we ordered warps from the spinner 800yds long, 920 ends, 24's counts, what should be the weight? Also give the counts, supposing the warps 6lbs. too light.

45. What would be the cost of labour per 100yds. in preparing a warp containing 3,000 ends of 24's yarn 800yds. long; winding, 7d. per 10lb. bundle; warping, 8d. per 1,000 hanks; beaming, $1\frac{1}{2}$d. per 120 yards; drawing-in, $6\frac{1}{2}$d. per 1,000 ends?

46. A piece contains 250 hanks of weft of three colours, the proportion being 40, 12 and 8: How many hanks of each colour does the piece contain?

47. Allowing $1\frac{1}{2}$ per cent. for waste in winding, what weight of 32's twist must be given out to the winders in order to produce 500 bobbins each containing 10 hanks of yarn? Also what would be the cost of winding, if 36lbs. are wound of 12 pence?

48. How many hanks of each colour will be required to make a pattern warp 500 yards long of 2,760 ends? Pattern: 40 grey, 2 light brown, 2 chocolate, 4 red, 2 chocolate, 2 light brown, 40 grey.

49. Having a warp of 1,800 ends, 1,000 yards long, of 32's twist on which is put 65 per cent. of size, what is its weight?

50. A warp before sizing weighed 80lbs., and after sizing 95lbs. What percentage of size has been added?

51. A warp contains 3,200 ends. It is 730 yards long. It is sized to the extent of 24%, and weighs 150lbs. What is the count of the pure yarn?

52. A warp of 2,400 ends, 200 yards long, is warped 2 ends of 30's and 1 end of 10's: What is its weight?

53. How many hanks of yarn will be required to make a warp of 1,800 ends broad, 140 yards long?

54. If the nett weight of yarn upon a beam weigh 32lbs., and the ends are 2,520 of 36's twist, what is the length of warp?

55. A warp contains 2,700 ends of 30's twist, its length being 10 cuts of 40 yards each: How many hanks, and what weight of material are there on the beam?

56. A striped warp contains 2,400 ends, 30 patterns, each pattern containing 60 ends of 40's, and 20 ends of 20's. How many hanks and what weight of each count will there be in the warp, supposing it to be 100 yards long?

57. How many hanks of each colour will there be in a warp of the following particulars: 2,760 ends, 500 yards long; pattern, 40 grey, 2 light brown, 2 chocolate, 4 red, 2 chocolate, 2 light brown, and 40 grey? 20 bleached ends extra on each side for selvidges..

58. What weight of yarn of each count would you require, and how would you warp, size, and put into the looms 20 beams of cord stripes of the following particulars:—10 cuts, 80yds. each per beam; pattern, 60 ends of 40's twist and 24 ends of 20's twist per inch, 50 patterns?

59. On being doffed from the sizing machine a beam is found to weigh 150lbs., the tare being 25lbs., and contains twenty 40yds. cuts of 2,000 ends of 32's twist. What per centage of size is there on the yarn?

60. How would you warp, size, and put into the looms the ends required to make the following cloth:—50 inches wide, 144 yards long, cord stripes, with 60 ends of 42's twist and 24 ends of 20's twist to the inch?

61. You are required to prepare a set of warpers' beams for the following order:—200 pieces, 38 inches wide, 50 yards long, 32's twist, 78's reed, cloth to contain 23 picks of 38's weft per quarter inch. What number of beams will you warp and of what length? What weight of twist ought there to be on each beam?

62. What percentage of size remains upon the warp threads when in a plain fabric, if the piece weighs 12lbs., and is constructed as follows:—30 yards long, 44 inches wide, 14 by 14 ends and picks per quarter inch of 20's warp and 22's weft; full and true in every particular?

63. What is the value of the material in a striped fabric consisting of satin and plain weaves, the former having 72 ends of 50's at 9d. per lb., and the latter 48 ends of 24's at 6¼d. per lb. in each of 40 repeats of this pattern; the piece to be 110 yards long, 50 inches wide, and to contain 70 picks per inch of 50's weft at 7½d. per lb? The contraction warp-way is, for the satin 5%, for the plain 10%, and weft-way 6%.

64. What is the cost of the piece of cloth named below:—28 inches wide, 50 yards long, 82's reed (Stockport counts), 24 picks per quarter inch, made from 2/40's twist at 11d. per lb., and 20's weft at 7d. per lb.; weaving, 4s.; expenses, 4s. 3d.?

65. What is the cost of the undermentioned piece of cloth: 40 inches wide, 120 yards long, 80's reed (Stockport counts), 21picks per quarter inch, made from 50's twist at 9½d. per lb., and 50's weft at 8d. per lb.; weaving, 4s. 2d.; expenses according to your own estimate? Show how you estimate the expenses for each department and for standing charges.

66. What is the cost of the following cloth:—48 inches, 81 yards, 108's reed, 28 picks per quarter-inch; 90's twist at 23d. per lb.; 110's weft at 18d. per lb.; weaving 5s.; other expenses to be estimated in detail by you?

67. What is the cost of material in a piece of cloth of the following particulars: 36in. wide; 80yds. long; with 72 ends per inch of 32's twist at 7 pence per pound, and 72 picks per inch of 10's weft at 7⅛d. per pound?

68. What counts of weft will be required to make the following cloth:—38 inches wide, 38 yards long, 50's reed, 10 picks per quarter inch, 34's twist, with 120 per cent. of size added; piece to weigh 8¼lbs.?

69. What percentage of size will be put on the warp yarn to make a piece of cloth to the following particulars:—36 inches wide, 38 yards long, on the counter, 57's reed (Stockport counts), 14 picks per quarter inch, 32's twist, 34's weft, piece to weigh 8¼lbs.?

70. Work out the weight of twist and weft required to make a piece to the following particulars:—42 inches wide, 80 yards long, on the counter, 96's reed (Stockport counts), 24 picks per quarter inch, 60's twist, 64's weft. What is the cost of the piece with twist at 10½d. per lb., weft at 9d., the price paid for weaving being 3s. 7d., and other expenses adding up to 3s. 3½d.?

71. How much per yard will a fancy stripe cost woven to the following particulars:—Brocade stripe of 3in., and sateen stripe of 4in. alternate, 40in. wide in reed; brocade 2 in a dent, sateen 4 in a dent, twist 40's throughout; 64 reed, Stockport; 96 picks per inch of 30's weft at $9\frac{1}{4}$d. per lb.; cost of twist in loom $14\frac{1}{2}$d. per lb.; expenses 10 per cent. more than weaving; weaving price $\frac{3}{4}$d. per yard?

72. Calculate the cost per yard (loom state) for the following cloth to particulars given, viz.:—100 yards cloth from 108 yards of warp, 42 inches wide, and 66 ends per inch in reed of 32 twist at $8\frac{1}{4}$d. per lb. in the cop, and woven with 16 picks to $\frac{1}{4}$ inch of 28 cops at $6\frac{1}{2}$d. per lb.

For winding cops on to warper's bobbins, allow 1d. per lb.

„ warping, allow 3d. per 1,000 hanks.

„ Slasher sizing, allow $\frac{1}{4}$d. per lb.

„ twisting, allow 3d. per 1,000 ends (based upon a 500 yard warp).

„ weaving, allow 2d. per pick per $\frac{1}{4}$ inch for 100 yards cloth.

„ extra charges to cover engine-power, rents, taxes, and standing expenses; allow three-fourths of weaving cost; allow 5 per cent. waste both in warp and weft. Fractional parts of ounces or pence need not be reckoned.

73. What is the cost of the following cloth:—50 inches wide, 120 yards long, on the counter, containing 60 ends of 60's twist and 40 ends of 28's twist per inch, and 18 picks of 60's weft to the quarter inch? Twist, 60's at $10\frac{1}{2}$d. per lb., 28's at $6\frac{3}{4}$d. per lb.; weft, 60's at $8\frac{3}{4}$d. per lb.; weaving 4s. 9d.; expenses, 5s. 3d.

74. A piece of cloth, 38 inches wide and 38 yards long, on the counter, containing 62 ends and 58 picks per inch, weighs 9lbs. On being analysed it is proved to have been one-third size, and the warp and weft threads are found to be similar counts. What is the counts of the yarn?

75. What is the value per yard grey of the following quilting cloth (show all calculations), 72 reed Stockport counts, 31 inches in the reed:—

Face warp 2 ends in dent 60's twist 1.25 yards of warp per yard of cloth.

Back warp 1 end in dent 32's twist 1.1 yards of warp per yard of cloth.

Total picks 180 per inch, in the order of 10 picks of face weft 50's to 2 picks of back weft 12's.

Weaving 2¼d., and general expenses 2½d. per yard.

Prices of yarn in loom, 60's 16d., 32's 14½d., 50's weft 13½d., 12's weft 9¾d.

76. Find the quantity of yarn, and amount of each colour, required to produce 25 pieces of cloth, 120 yards long, from 128 yards warp. 24's warp, 2,400 ends, 40ins. wide in reed, 15 picks per ¼in., 20's cops.

5 pieces	warp	pattern,	all	blue.
5	,,	,,	,,	8 white, 8 blue.
5	,,	,,	,,	12 white, 8 blue.
5	,,	,,	,,	2 white, 6 blue.
5	,,	,,	,,	3 white, 1 blue.

All to have 16 ends, 2/36 white for selvage at each side. Allow 40 yards per hank for waste in both warp and weft.

77. A plain cloth 40 inches wide, 40 yards long, having 60 picks of 50's weft and 60 ends of 50's twist per inch is spotted over with lappet spots ½in. long with an average float of ½in. The spots are 4in. apart from centre to centre, the warp contraction of which is 300 per cent. more than that of the ground cloth: What is the total weight of material in the piece if the counts of the figuring thread is equal to 10's cotton?

78. A striped fabric is made as follows:—Pattern, 40 ends of 30's cotton, 2 ends in a dent, and four ends of 10's cotton 1 in a dent; 36 inches in reed, reed 30 dents per inch; what weight of warp will there be in 80 yards of such cloth?

79. What would be the cost per yard of the following cloth: 660 yards cloth from 700 yards warp 36 dents per inch in reed, 72 picks per inch 24's soft blue weft?—

Warp Pattern.

40 Blue	in	20 dents.
2 Prlnt	in	1 dent.
4 Blue	in	2 dents.
8 White	in	2 dents.
4 Blue	in	2 dents.
2 Print	in	1 dent.
——		——
60 ends		28 dents.
43 patterns + 40 Blue		43 + 20
——		——
180		84
240		112
40		20
36		18
——		——
3,656 ends in		1,242 dents.

	s.	d.	
20 Twist at ...	0	7	per lb.
24 Weft at ...	0	7½	,,
Dyeing Blue ..	0	3½	,,
Printing ...	0	6	,,
Bleaching ...	0	7	per bundle.
Sizing Twist	0	6	,,
Winding Warp..	0	6	,,
,, Weft..	0	9	,,
Warping ..	1	2	per 1,000 hanks.
Section Beaming	0	1	per 100 yards.
Drawing-in ...	0	8½	per 1,000 ends.
Weaving ...	2	6	per 70 yards of warp.
Expense ...	3	9	per 70 yards of warp.
Finishing ...	1	6	per 66 yards of cloth.

80. What would be the cost per yard of the following terry towelling cloth:—200 yards cloth from 208 yards of ground warp and 728 yards of terry warp, 16 inches wide in reed, 50 picks per inch of 20 cops? The warp to be beamed, and the red and white terry threads run from bobbins when beaming. Allow 40 yards per hank for waste in weft and wound warp. Ground warp 476 ends 20's grey.

Terry Warp.

8	Grey	3/20's
6	Red	3/24's
6	White	3/20's
6	Red	3/24's
150	Grey	3/20's
6	Red	3/24's
6	White	3/20's
6	Red	3/24's
8	Grey	3/20's
202		

Prices.

20's Yarn in warp	6d. per lb.
3/20 " "	8d. "
3/24 " hank	8d. "
3/20 " hank	$7\frac{3}{4}$d. "
20 Cops	$4\frac{3}{4}$d. "
Sizing Warps	$\frac{3}{4}$d. "
Dyeing and sizing red... ...	$4\frac{1}{2}$d. "
Bleaching and sizing white ...	1d. "
Winding white and red ...	$\frac{1}{8}$d. "
Beaming	1d. per 60 yards.

With 2d. per warp extra for running ends from bobbins.
Drawing. 1s. per 1,000 ends.
Weaving, 2s. 6d. per 100 yards cloth.
Other expenses, 5s. per 100 yards cloth.

81. Presuming that the relative diameters of cotton yarns are as the square root of their counts, what counts of yarn will give the same firmness in a 2 and 2 twill that 30's would give in a plain cloth, the threads being equal in number both ways?

82. A 5-end sateen is being made with 19 threads of 34's twist and 30 picks of 38's weft to the quarter-inch. You are required to make a cloth equally firm with an 8-end sateen weave. Using the same counts of yarn, what number of ends and picks will you require? Using the same number of ends and picks, what counts of yarn will you require? What will be the weight in each case for 42 inches 90 yards?

83. A cloth is made with 40's cotton yarn. Requiring a cloth 1-ten heavier but of similar character, what counts of yarn should be used?

84. What will be the cost of the following cloth, with twist and weft at $8\frac{1}{2}$d. per lb.:—32 inches, $117\frac{1}{2}$ yards, 72's reed, 15 picks per quarter, 60's twist, 72's weft; weaving $2\frac{1}{8}$d. per pick; other expenses according to your estimate?

85. In changing from plain cloth with 80 threads per inch to a five end satin, how many ends per inch will be required to make the satin of equal "balance" with the plain cloth?

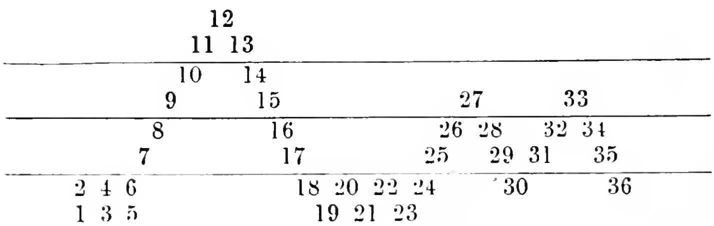
86. What does a 40 Bolton reed equal by the Radcliffe, Stockport, and Scotch systems of naming reeds?

87. What is meant by a 74's reed (Stockport counts)? A cloth made with 3,420 ends is dented as follows, the whole width in the reed being 40 2-3rd inches:

10 dents,	2 = 20 ends		- - -	20
20 ,,	1 = 20 ,,	60 times		
6 ,,	2 = 12 ,,	60 times		
1 dent,	0 = 0 ,,	60 times	-	3360
6 dents,	2 = 12 ,,	60 times		
1 dent,	0 = 0 ,,	60 times		
6 dents,	2 = 12 ,,	60 times		
20 ,,	1 = 20 ,,		- - -	20
10 ,,	2 = 20 ,,		- - -	20
				3,420 ends.

What count of reed will be used?

88. What counts of healds would you chose to use for each shaft of the following draft, and how would you drop them in order to avoid unnecessary friction, if required to be woven 72 ends per inch in the reed? Also, supposing it was considered advisable to order healds knit specially to pattern, in what form would you give out instructions for same—the warp to contain 2,322 ends (including selvage), and to stand 34¼ inches in width?



89. How many tokens of 20 healds each will you have on each stave in a five-end satin with a total of 1,600 ends? Also, what space will each token stand in suppose the healds are knitted for a 50 reed, Stockport counts?

90. Write out a copy of instructions you would give to your drawers-in for a doria, satin stripe, or any other striped cloth irregularly dented; pattern to occupy not less than 60 dents.

91. Give full instructions to heald knitter for 5 end satin 4 in a dent, and plain 2 in a dent, 50 reed Stockport, a pattern being 1½in., 1-3rd satin 2-3rds plain, half a plain stripe at each selvedge, 36in. in the reed.

92. If weaving 8 end satin 40 inches in reed 56 reed Stockport counts, how many healds would you require on each stave in 2 inches? Also how many healds on each stave if for a 14 end pattern drawn in on 8 stave centred backwards and forwards?

93. A set of healds knitted for a 78 reed has to be used with a 64 reed. How many eyes must be left empty, and in what order?

94. Give the rate and order of knitting the healds for a striped fabric consisting of three shaft twill, three ends in a dent, and six shaft sateen, four ends in a dent. The reed to be a 70, Stockport count, the pattern to repeat on two inches of width, the twill stripe to be 3-5ths, and the satin stripe 2-5ths of a repeat. The piece to be 36 inches wide, and a twill stripe to join each selvage.

95. Calculate the number of healds required on each stave for the draft as below if the yarn were to stand 40 inches wide in a reed having 30 dents per inch.

5 10 14 19 23 28

4 9 11 13 18 20 22 27 29

3 8 12 17 21 26 30

2 7 16 25 31

1 6 15 24 32

96. A Jacquard harness has been tied-up for a 96 reed, but desiring to use the same for an 80 reed how would you drop the harness?