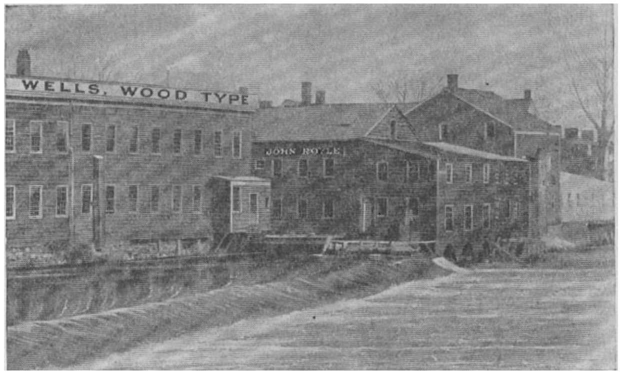
HAND BOOKS OF THE TEXTILE INDUSTRY, VOL. 4

FABRIC ANALYSIS

E. A. POSSELT, PHILADELPHIA



Original shop of John Royle & Sons at Paterson, N. J.

Forty Years of Progress

in the Manufacture of Jacquard Card-Cutting and Lacing Machinery

Absolute accuracy is the first essential in machinery for cutting and lacing Jacquard cards, and this fact was thoroughly appreciated by John Royle and his two sons, when they started, forty years ago, to build piano machines in the little shop shown at the right in the illustration above. Already they had acquired an enviable reputation as makers of high-class machinery for wood-engravers and wood-type manufacturers; so that they had the advantage of experience and suitable equipment, for work of an exacting character.

At first, only foot-power piano machines were made, but five years later, in 1883, they brought out the positive-action power-operated repeater; and about 1890 developed the first successful automatic lock-stitch lacer. Within more recent years they have introduced a power-operated piano machine, and a hand operated type of repeater.

From the beginning of their business John Royle & Sons have adhered rigidly to the highest possible standards of material and workmanship, and have brought to bear on their work a family talent for mechanical design, which has found its highest expression, so far, in the many inventions of Vernon Royle, the present head of the firm. The result has been a continual series of improvements so that Royle machines of to-day represent all that is best in twentieth-century machine building as well as in fitness for the special duties they must perform.

It is worthy of mention also, that the little shop shown above has been succeeded by a series of four and five story brick buildings which contain many thousand feet of floor space and are equipped with a complete assortment of modern machine tools and other manufacturing facilities. In addition to Jacquard card machinery, this firm manufactures a wide line of machinery for photo-engravers, and a third line for rubber working establishments.

FABRIC ANALYSIS

COVERING

Wool, Worsted, Silk, Cotton, Artificial Silks, etc.

FROM

Fiber to Finished Fabric

BY

E. A. POSSELT

Consulting Expert on Textile Designing and Fabric Structure

Editor and Publisher of "Posselt's Textile Journal", "Technology of Textile Design", "Textile Calculations", "Recent Improvements in Textile Machinery Relating to Weaving", "Cotton Manufacturing Part 1 and 2", "Wool, Cotton Silk, from Fibre to Finished Fabrics, covering Woven and Knit Goods", "Silk Throwing", giving the various Processes Raw Silk is subjected, when converting into Yarn", "Manufacture of Narrow Woven Fabrics, giving the Construction and Weave", and "Novelties of Fabric Structure", Dictionary of Weaves Part 1 and 2, a collection of over ten thousand weaves, from four to sixteen harnesses, conveniently arranged for handy use", "Dictionary of Textile Terms".

Richly Illustrated **Price: Four Dollars**

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FABRIC ANALYSIS.

Richly Illustrated.

FABRIC ANALYSIS.

The analysis of textile fabrics forms an interesting and at the same time most important subject for the designer, superintendent, manufacturer, the sales agent, as well as others connected with the textile industry.

The object aimed at is to ascertain by experience, tests and calculations, full details as to the construction and characteristics of a fabric, cost of its production, etc., items which, if carefully solved, mean success.

A complete fabric analysis comprises not only the picking out of the arrangement of interlacing warp and filling (the weave) but also ascertaining the nature of the materials the latter are composed of, their texture, quality, counts and twist of yarn used, weight of fabric per yard and amount for each different kind of yarn used in the construction of the fabric; also the various processes commonly designated as dyeing and finishing the fabric has to be subjected to, to bring it into saleable condition for the market.

This complete analysis referred to may not always be necessary, in fact the experienced designer, in his line of goods, may rely very frequently on his experience only—having made similar fabrics before—and in most instances can tell at a glance the construction and average cost of fabric. Such men, however, are few, and again even such men will come in contact with fabrics not as well acquainted with; the mill may change on a different class of goods, again a designer may change his connection to a mill making a different class of goods he has been accustomed to, features which may compel him to make at least a part if not the complete analysis.

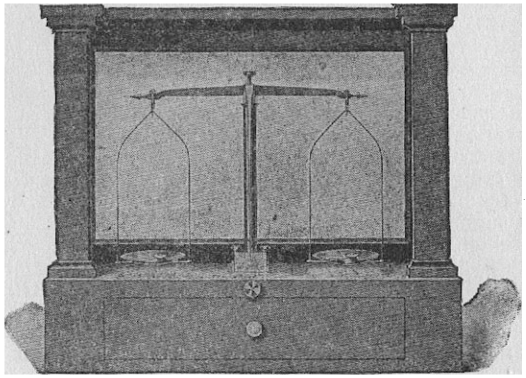
A thorough knowledge of weave-formation and fabric-structure will greatly simplify the work of the analyst. Not only will he become convinced that his pick-out is correct, but for instance, the harder a weave takes-up the filling, *i. e.*, the closer the interlacing, the stronger the warp-yarn must be, both as to quality of stock as well as twist.

We will now in turn take up the various divisions of a complete analysis, with rules and practical examples.

Ascertaining Weight per Yard of Finished Sample.

The outfit necessary is:

A pair of most delicate scales, weighing at least to the one hundredth part of a grain.



SCALE FOR ANALYSIS OF YARNS AND FABRICS.
Built by Henry Troemner, Phila.

An inch rule, compass, pair of sharp scissors and a collection of cardboards in duplicate, of known sizes, say for example 2 by 2, 3 by 2, 3 by 3 inches, etc., to suit the various sizes of samples submitted.

In place of the latter, a steel die or *cutter,* of a known size may be used, or two or more sizes of such cutters may be kept on hand.

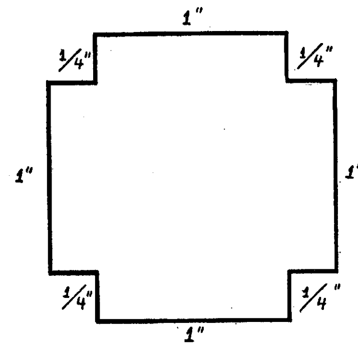
The sample given for analysis is usually small. Cut this sample most carefully to the largest possible known size. The larger the sample to be tested, the more accurate the analysis, *i. e.,* the weight per yard, in this instance will be. For trimming, *i. e.,* cutting your sample to a known size, select the most appropriate size of your cardboard guides, the periphery of which mark with a crayon, pencil or in ink on the fabric and cut on these lines with a sharp pair of scissors, or place sample between two cardboards of corresponding size, carefully adjusting them in your left hand, so they are exactly one above the other, with the ends of the sample protruding between them; the latter then clip with your shears, held in the right hand, holding the two cardboards tight against each other with the left hand. This will give you a good trim, applicable to most any size of samples submitted, the various cardboard gauges being readily made, at no cost, and can be preserved for years,

whereas steel cutters, as will be later-on referred to in detail, are expensive, easily damaged, not always true, and most often one measurement only is kept on hand, in turn preventing frequently the use of larger samples when such are at our disposal. When dealing with smaller samples than the cutter we have, the latter becomes useless.

After the sample has been trimmed to its proper size, set your compass to the corresponding proper dimension, place sample on a contrasting background and see by means of the compass that said sample was perfectly cut, rectifying carefully any possible variation if such should be found to exist.

Some Mills or Commission Houses, for the sake of easy work, prefer to stamp a known size from the sample submitted for testing by what is known as a cutter, *i. e.,* a steel die of a known size. They can be made in most any size, from one square inch to sixteen or more square inches; 4, 6 and 9 square inches are the sizes most often met with.

A very useful shape for a cutter more particularly when dealing with very small samples, is what is known as a *cross shaped cutter* and of which a plan view is given. This shape of a cutter gives us an area which is exactly 2 square inches. The length and width of the centre por-



PLAN VIEW OF CROSS CUTTER (*Actual Size*).
To Cut Fabric Sample exactly 2 square inches; Permitting also handy counting of Warp and Filling Texture for the Unit of one inch.

tions is 1½ inches, leaving the protruding four ends each 1 inch wide, giving afterwards in further analysis an opportunity for the designer to count the number of warp-threads and picks in one inch in the sample, with a chance to prove it with a second count if necessary.

In using any cutter for stamping out a known size of fabric for weighing purposes, care must be taken by the person who handles the device that the same is kept sharp all the time and that no nicks are made by careless handling. Use the proper smooth surface for placing on the sample to be stamped, so that the former will not injure the sharp blades of the cutter.

Having obtained a sample of a known size, the same is now weighed most carefully on a balance and its weight recorded.

RULE: Divide the number of square inches the sample contains into the number of square inches one yard of the fabric contains. Multiply result with the weight in grains of your sample previously recorded and divide the product by 437.5 (number of grains on one ounce) which will give you the ounces per yard for the fabric in question.

The width of a fabric varies with reference to woolen and worsted men's wear and dress goods, cotton and silk goods in all their varieties, narrow ware and broad fabrics, upholstery goods, carpets, etc.

Example: Fancy Cassimere, 54 inches wide; cut sample 3 by 3 inches, equal 9 square inches; to weigh 25 grains.

54×36 (inches in one yard) $=$
1944 square inches in one yard of cloth
$1944 \div 9 = 216 \times 25 = 5400 \div 437.5 = 12.34$

Answer: 12⅓ oz., weight of fabric per yard.

Example: Worsted Trousering, 56 inches wide; cut sample 3 by 4 inches, equal 12 square inches; to weigh 40.5 grains.

$56 \times 36 = 2016$ square inches.
$2016 \div 12 = 168 \times 40.5 = 6804 \div 437.5 = 15.55$

Answer: 15½ oz. weight of fabric per yard.

Example: Cotton Dress Goods, 36 inches wide; cut sample 2 by 3 inches, equal 6 square inches; to weigh 10.54 grains.

$36 \times 36 = 1296$ square inches.
$1296 \div 6 = 216 \times 10.54 = 2276.64 \div 437.5 = 5.204$

Answer: 5⅕ oz. weight of fabric per yard.

Example: Silk Dress Goods, 24 inches wide, cut sample 2 by 2 inches, equal 4 square inches, to weigh 3.268 grains.

$24 \times 36 = 864$ square inches.
$864 \div 4 = 216 \times 3.268 = 705.888 \div 437.5 = 1.614$

Answer: 1.614 oz. weight of fabric per yard.

If dealing with narrow ware fabrics, Ribbons, Edgings, etc., and provided less than one yard is submitted, count length of sample expressed in inches and fractions of

inches, next weigh it as before and ascertain its weight per yard (36 inches) by proportion.

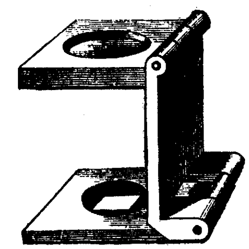
Example: Ribbon, sample furnished 3½ inches long; to weigh 15.126 grains.

$3.5 : 15.126 :: 36 : x$
$15.126 \times 36 = 544.536$
$544.536 \div 3.5 = 155.58$

Answer: One yard of this ribbon weighs 155.58 grains, or $7000 \div 155.58 = 45$ yards of this ribbon weigh one pound.

Ascertaining the Weave.

This procedure, frequently termed ***picking-out,*** has for its object to ascertain and record on the point paper the plan (weave) by which warp and filling interlace with each other in a sample under consideration.



PICK GLASS.

There are two methods practised for determining the weave used in a given cloth, *viz:* by ***synthesis*** and by ***analysis.***

The first method is out of reach of the beginner, who must follow the laborious process of the second procedure, *i. e.,* of investigating the interlacing of every warp-thread and pick in the repeat of the weave in a sample, whereas the experienced designer, following the first mentioned procedure, will simply pull out a warp-thread or pick in order to confirm his surmise regarding what weave is used and proceed at once to build up the weave upon experience combined with a thorough comprehension of the theory of weave formation in all its varieties.

If dealing with heavy fulled woolen fabrics, or fabrics having their filling threads more or less broken during the process of finishing, the analysis (*i. e.,* separating picks and warp-threads from each other) will require a considerable amount of skill and patience.

Magnifying Glasses.

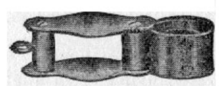
In connection with cotton, silk and linen fabrics the use of a low, or medium power microscope will be found of advantage, since it will reveal the interlacing of warp-threads

Doublet Magnifier.
Spencer Lens Company.

and picks most thoroughly. These microscopes, as used by the textile analyst, are known by various names: Pick-glasses, Doublet Magnifiers, Triple Aplanatic Magnifiers, Magnifiers Cloth Counting Glasses and Dissecting Microscopes.

The Pick-glass or pick-counter as also called, is a microscope of a magnifying power varying from 7 to 10 times. It is made to permit folding when not in use, and is equipped with 1 x 1 , ½ x ½ , ¼ x ½ , ¼ x ¼ or ¼ *dia.*, openings expressed in inches, and when not in use can be conveniently carried in the vest pocket. According to size of opening and power of lense, they range in prices from 50 cents to $ 2.

The Doublet Magnifier is a microscope of a magnifying power varying from 6 to 24 times. These doublet magnifiers are composed of two separate plano convex lenses set in a black lacquered mount and held in a nickeled framing, with handle for convenient use. They range in prices from $ 1 to $ 1.50, a 12 × lense being (considered in an average) the most useful.



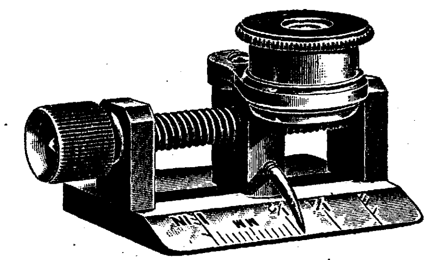
Triple Aplanatic Magnifier.
Equipped with Folding Case.
Spencer Lens Company.

Triple Aplanatic Magnifiers. Their lenses are remarkable for their great working distance and their unusually large, flat field. They are perfectly achromatic and free from distortion and made to magnify in all dimensions from 6 to 24 times, and are equipped either with hexagon handle or

folding case. They are sold at the uniform price of $ 3.50 each, for either magnification quoted.

The Magnifiers Cloth Counting Glass has a base divided into spaces of ¼, ½ and 1 inch, the space between the ½ and 1 inch marks being divided into 10 mm. The focusing eye-piece with pointer attached can be made to traverse the whole scale by means of quick acting screws. The price of the instrument is $ 7.50.

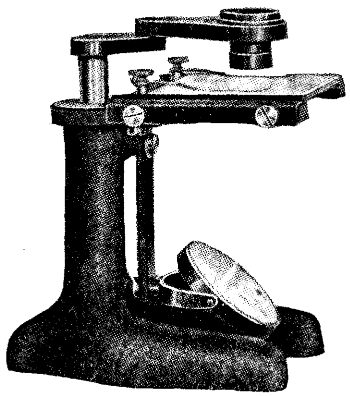
The Dissecting Microscope has its stand all brass, or of a rich black lacquered mounting, with broad circular Base and large firm Stage; Jointed Arm to carry the Lenses, with Rack-and-pinion adjustment of Focus; Concave Mirror with complete adjustments; Single or Double Lenses, of Doublet, Coddington or Triple Aplanat Formulæ. The stage has countersunk in its centre a circular shaped (removable) glass plate, and is provided with two spring clips for holding the sample securely in position while picking out weave or texture of the fabric. The price of these Dissecting Microscopes ranges from $ 6.75 to $ 15.



Magnifiers Cloth Counting Glass.

To secure the best results with all simple magnifiers, the observer must place the eye as near as possible to the eyepiece of the magnifier.

Since synthesis can only be acquired by years of practice and experience we will define our explanations, with reference to the picking-out process more particularly for the beginner. For him it will be advisable to begin his study with simple, single cloth fabric structures, of a loose texture, where every thread is readily distinguished and separated from its joining one, or its mate interlacing threads. The harder twisted these threads are, the easier he will master the subject. Coarse textured cotton fabrics interlacing with simple weaves will be the ones most suitable for him to start with, after which he then can take up low textured worsteds, to be followed by woolens. Never touch backed or double cloth samples until you fully have mastered the picking-out of single cloth, as well as the theory of constructing backed cloth and that of double cloth.



DISSECTING SINGLE MICROSCOPE.

The Point Paper.

To keep a record of the weave when picking-out a sample, a special kind of ruled paper, known as textile design, or point paper, is made use of; it is a paper ruled horizontally and vertically with lines, 8 or more to the inch, each way, every eighth line being in turn, each way, either ruled heavier than the others, or over-ruled in a different color, in order to simplify counting-off a certain number of spaces on the paper, when so required.

Eight (8) is the number most frequently selected for this over-ruling, for the fact that it is the most suitable number for this purpose; not only on account of 8 in itself comprising the repeat of the most often met with weaves, it besides claims the 4-harness weaves, on account of covering two repeats of the latter; at the same time it furnishes a convenient multiple for most all other frequently used repeats of weaves. For instance, $1\frac{1}{2}$ heavy squares cover 12 threads, 2 heavy squares cover 16 threads, $2\frac{1}{2}$ heavy squares cover 20 threads, and 3 heavy squares cover 24 threads, all being repeats of frequently met with weaves in practical work. Again, should a weave call for 10 threads for its repeat, instinct will tell the eye to grasp the one heavy ruled-off space (of 8 light lines) *plus* 2 light spaces, in preference to

counting 10 spaces, provided the paper was not over-ruled into heavy squares.

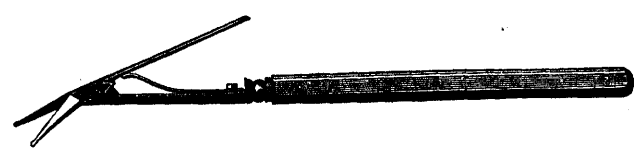
Over-ruling of the point paper, besides simplifying matters to the designer, at the same time prevents mistakes in counting-off the repeat of a weave, a feature possible to occur otherwise, more particularly if dealing with a weave of a large repeat. It, at the same time, will guide the designer when picking out samples of a large repeat, since certain fancy ends may come near one of these heavy ruled lines, which thus become a guide for him while picking out other picks.

Besides point paper ruled over in 8, each way, technically written 8×8 paper, we also find other kinds of ruled paper, for example, 4×4, 10×10, 12×12, etc.; however, 8×8 is the kind of design paper generally used, when picking-out the weave from a sample.

In connection with any kind of design paper, the distance between two lines, taken in a vertical direction, represents one warp-thread, and each distance between two lines, taken in a horizontal direction, represents one pick. The different small squares thus formed indicate the place where a certain warp-thread and pick meet, one of which must be up and the other down. A filled square, a cross, a dash or any other mark in said square indicates that the warp-thread in this instance is up and the filling down. Provided the reverse should be required, we then must indicate on the weave-plan that whatever marks made stand for sinkers or warp down, and empty squares then for risers or warp up; but if no memorandum to that effect is made on the weave-plan, we always will consider filled, cross, or dash or whatever mark made for risers (warp up).

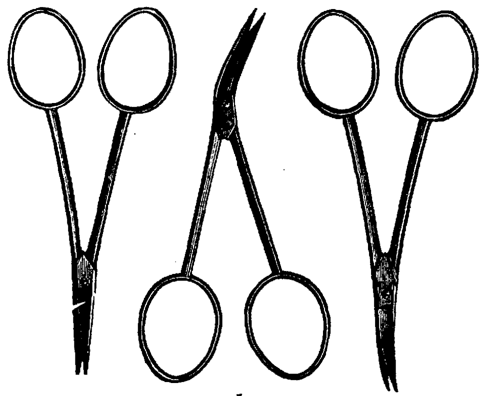
Clear Face Desired.

Previously to beginning the dissecting of a sample, the first question to ascertain is whether the interlacing of warp and filling in the sample is clear and distinct to



SCISSORS FOR DISSECTING; with Spring Applied.

the naked eye, since most of the intricate picking out of samples has to be done in this way. Provided this is not the case, and the face of the fabric is covered with protruding fibres, felt or nap, as is frequently the case in woolen goods, then the sample must be prepared so that the interlacings of the threads become more or less well defined, and which can be done by removing the loose fibres. felt or nap either by cutting-off with curved scissors or shaving with a sharp knife, or said nap is singed-off over a flame. Either method requires care, since, if the surface of the structure is in any



a b c

SCISSORS FOR DISSECTING.
a Straight Blades;
b Elbow Blades;
c Blades Curved on the Flat.

way impaired thereby, the sample may become useless for dissecting, since then, in spite of all care by the analyst the threads will draw apart (break) during picking-out. Even if the weave is fairly clear, some designers singe such samples slightly, in order to remove all the little points of fibres standing in the hollows, and which it is not possible to remove by cutting or shaving, without at the same time injuring the threads.

Distinguishing Warp from Filling.

Let us now consider a sample before us, of which nothing is known, but which has to be reproduced. Then the first consideration is to ascertain which is warp and which is filling, also whether it is single cloth, backed or figured with an extra warp or extra filling, or double cloth in one of their varieties. The latter, as a rule, can be readily ascertained

after we know which threads are warp and which are filling, pulling out a few warp-threads and picks and observing whether they keep on one side of the fabric or not. If one series of threads form the face, and another series the back, while the picks interweave both face and back, then the fabric is backed with warp, and it will be necessary to find not only the face weave but also the backing ties. Filling might be used as backing instead of warp, when there would be two series of filling threads, or picks as they are termed, and one of warp, and when the interweaving of each must be obtained the same as in the case of warp backing. Should there be both, back warp and back filling, then the fabric will usually be a double cloth, in which case three points must be decided: firstly, the face weave; secondly, the back weave, and thirdly, the system of tying the back cloth to the face. Having decided by a brief examination under which heading the pattern to be analyzed comes, the analyst can proceed by details given later on.

For the beginning it is advisable for the student to analyze single cloth samples only; the harder twisted the yarn used in the samples and the looser their texture, the better for him to get used to the work.

The following points will assist in explaining the subject of distinguishing warp from filling:

With napped goods, the nap shows the direction of the warp, said nap being raised during gigging or napping, on the face of the goods warp-ways. With woolen goods which are not gigged or napped, like cheviots, meltons, etc., and provided there are no special characteristics, such as selvage (and which runs warp-ways), etc., it is more difficult to decide the direction of the warp. After shaving or singeing such samples, their face should be closely examined, since interlacings protruding a little beyond the surface, most frequently show the warp ends.

If the threads in one system are harder twisted than in the other, the former threads are generally the warp system. The filling threads as a rule are not only softer, but at the same time heavier in count than the warp.

In such structures as twills, sateens, covert cloth, etc., and in which one set is two ply yarn and the other single, the two ply is the warp.

The counts of yarn used in each system will often assist in ascertaining which is the warp and which the filling, since in most instances the yarn used for warp is of a higher count than that of the filling.

If a fabric has cotton yarn for one system of the threads, and woolen for the other (union fabrics) the cotton yarn is generally the warp.

The conditions of weaving are such that the yarn employed as warp must possess sufficient strength and elasticity to stand the strain imposed during weaving, whereas most any material may be employed for filling which will hold together while the shuttle is carrying it across the shed. Therefore, if one system of threads is stronger than the other, although alike in other respects, the stronger material will almost invariably be the warp.

If in the sample submitted for analysis, the one system of threads is found to have been sized or starched and the other not, the former is the warp.

In many fabric structures the warp-threads appear to be straighter than the filling. During weaving and finishing, the filling is allowed to contract more than the warp, on account of the tension applied in both operations lengthwise to the fabric.

If the sample contains reed marks (or imperfections known to the weaver as can only be caused to the warp system) such imperfections readily characterize that system of threads.

If the portion of cloth under consideration contains part of the list, edge, self-edge, or selvage, as variously called, this will indicate the warp.

Another guide, for distinguishing the warp from the filling, is found in the style of the fabrics submitted for picking-out. Fabrics having a striped character, or check effects in which the one direction of the lines is more prominent, compared with the others, the direction of the stripes, or the prominent lines in the check, indicate the warp system. If the checks are of the same color but somewhat longer one way than the other, the warp, as a rule, runs the longer way.

In almost all cloths of a twill character the direction of the twill is more towards the upright or warp direction than to the horizontal. Diagonals will for this reason readily explain themselves.

In fabrics composed of two systems of filling (face and back) and one system of warp, the heavy and soft-spun filling, known as the backing, indicates itself, and thus the system of threads.

Exceptions to these instructions occur but seldom. In many fabrics the difference and the reasons for said difference in the yarn are so clear as to require little examination. That the warp-thread is usually the smoothest, strongest, also of the longest and best material is a very safe rule to follow.

If it should be found impossible to distinguish warp from filling, proceed with the picking-out, and when then the weave obtained will in most cases explain which threads are warp and which the filling.

How to Pick Out the Weave from a Sample.

The instrument required for picking-out is a strong needle, having a fairly sharp point, also a handle which will permit a convenient grasping of it, like you would hold a pencil. In few instances a pick-glass (as previously explained) may be found of help, which however for woolens and the average worsted samples will be of little assistance, and when picking out over your fingers remains the better way.

With silk fabrics and higher textured cotton goods one of the previously referred to magnifying glasses becomes a necessity. The sample, if using the dissecting microscope, is then secured by the two spring clips to the stage of the microscope; this arrangement then takes the place of your left hand in connection with the common picking-out process. You then proceed with the picking-out needle, in your right hand, in the usual manner.

Having decided which is the warp and which the filling in a sample, it now remains to consider whether it is more advisable to pick the filling out of the warp-threads or vice versa the warp out of the filling. In a great many instances the latter will be the advisable plan, obtaining in some instances the formation of the weave quicker, like for instance a diagonal, a corkscrew, or similar weaves, and where the interlacing of 2 or 3 warp-threads at the most will indicate the complete repeat of the weave we deal with. At the same time the changes of the interlacing (of such fabrics handled this way) will come in bunches of 2, 3, 4 or more ends, whereas if picked the other way, any number of close interlacing like 1 up 1 down or 1 up 2 down would occur, and which on account of twisting around each other are hard to designate as to their proper rotation in the sample.

Picking the filling out of the warp-threads again has the advantage that the latter are in most instances of a harder twist, hence will resist the wear caused by the picking out process more satisfactory. The subject will be dealt with afterwards more in detail, the first object being to give rules of how to proceed to pick out the weave, and for which purpose we will consider picking the filling out of the warp; this at the same time explains picking-out of the warp from the filling by placing the sample in the proper position.

Loosen with your picking-out needle, and take out with the help of the latter, your fingers or a forcep, a number of picks, so that the warp-threads form a fringe about one-fourth inch free of any filling. Provided you have a large sample given, you may pick-out a few more picks, since you will be then less liable to make mistakes in dissecting, more particularly if a beginner.

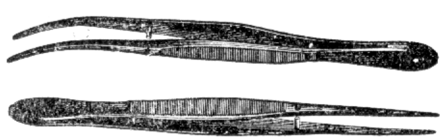
The best picking-out needle to use is a common heavy crocheting needle, of which file the hook away—adding in place of it a fairly fine point, but not too fine since the latter might catch in the core of your threads in the sample you handle.

Should your sample contain a fancy thread, if possible prepare it so *this* thread will be the initial thread for starting to pick out.

Next, liberate, in the same way, on the left hand side of the sample, a few warp-threads from the filling, so that the latter ends also protrude singly from the structure, the same as the warp-threads do, in order to get a good start for the picking out.

It will always be advisable, when dealing with fabrics interlaced with a rather complicated weave, to have a sample sufficiently large to contain at least two repeats of the weave so as to be able to verify your analysis.

A sample may again be larger than needed for picking-out the weave and when handling such a sample (pick for pick, throughout its entire width) would only retard the work for the designer; again a portion of the sample may be needed for reference by the dyer, the finisher, the office, the commission house, etc., and when then with such a large sample, after ascertaining size needed for the pick-out, you then cut with your scissors at those places warp and filling-ways into the sample, and thus protect that portion of sample



Forceps.

not actually needed, from having warp or filling pulled out of its structure.

Fig. 1 is given to illustrate how to prepare the sample. *A, B, C* and *D* is the size of sample submitted. *e,* the cut made into the filling threads, to preserve the right hand portion of the sample. *f,* the cut made into warp-threads, to preserve lower portion of sample. *s,* the place where the first warp-thread and first pick meet, *i. e.,* the starting point for your picking-out.

Illustration also shows how warp and filling ends have been liberated, to obtain its required condition for convenient picking out, showing also a fancy (heavy) end as the initial

warp-thread to come under consideration when picking-out. This is not necessary to be done with the filling and where we may start with any pick, since we can indicate details of any pick taken out, on the point paper in its proper place.

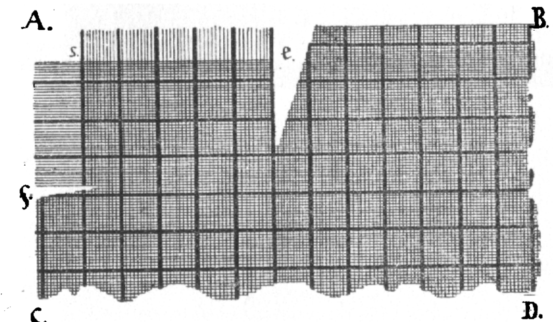


Fig. 1

The filling thread, lying first in the sample, is then carefully loosened (with the point of the needle) from its hold in the woven structure and pushed slightly, say about $\frac{1}{16}$ part of an inch, forward, into the loosely protruding fringe of warp-threads, after having previously drawn the sample tightly over the point of your left index finger, using the thumb and middle finger to assist in keeping the sample in place. Fig. 2 is given to illustrate the procedure, showing a different sample from that used in Fig. 1.

The warp-threads are then examined singly, with the needle, from left to right, as to whether they lie over or under the thus loosened pick.

Such of the threads as lie over the filling are indicated by a cross, or any other mark, upon the design paper (which you had placed conveniently on the table or desk before you) in the space (squares) intended. Push the warp-threads, as they are examined by you, slightly to the left, carefully under the point of the thumb, where they must be held out of the way. Proceed in this manner with a sufficient number of warp-threads, until two repeats of the interlacing of the filling thread (pick) are obtained.

In order to avoid errors, it is advisable to mark, by a dot, in its respective square on the design paper, such warp-threads as are lying under the filling. For example: suppose that in taking out a pick, we found the position of the warp-threads to be as follows:

4 *down* 2 *up,* 2 *down* 3 *up,* 1 *down* 1 *up,* etc., then the

recording on the design paper must be performed every time when the number of up-lying threads have been pushed under the thumb, and as indicated herewith by commas: ····xx, ··xxx, ·x, etc.; in other words, note on your design paper each and every change as you pick out. Do not try and keep several changes in your mind, since it is apt to mislead you — do not trust to memory — and thus prevent mistakes. The work may progress somewhat slower in this manner, but the result

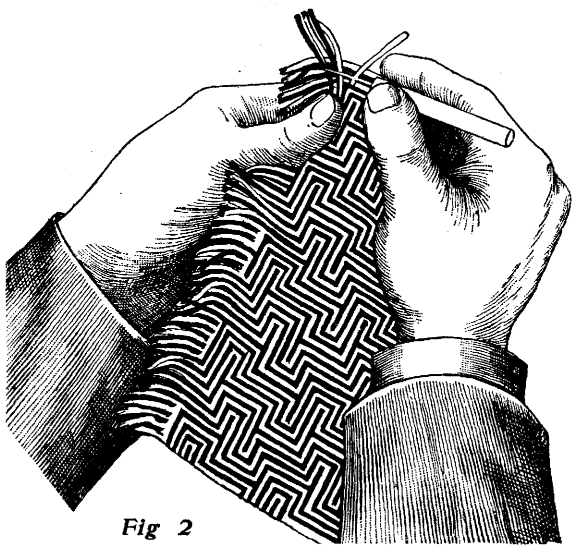


Fig 2

will be more reliable, and to keep any possible errors out of your weave record is what you are after. It will save you the trouble of having to go all over your work again, and which will be the case provided you slight your work in the first place.

When all the warp-threads lying above and below the first pick have been carefully recorded on the design paper, before removing said pick, examine said record carefully and see where the repeat of the weave will come in. If theory tells you that there is a chance for an error, go over your work again. Starting your first pick right will go a long way towards simplifying the rest of the pick-out to you.

There is a chance, that in connection with complicated weaves, the repeat is larger than it appears at a first glance, and when mistakes are prevented by carefully ascertaining the proper repeat of the weave.

When the repeat of the weave has been finally established, in connection with fancy colorings in the warp, indicate them on top of your record on your design paper, up to the end of the first repeat, and see that the coloring of the warp in the second, etc., repeat corresponds to that of the first repeat, otherwise keep a record of it.

Repeat of weave and repeat of the warp pattern (dressing) do not always correspond, sometimes one repeat of the warp pattern covers 2 or more repeats of the weave, again, the reverse may be the case, and when then the complete design, *i. e.,* effect does not show until both (warp pattern and weave) repeat simultaneously.

Having ascertained and recorded the interlacing of the first pick, the same is carefully liberated from its fringe of warp-threads and the procedure repeated with the next pick in the same manner; continue in this way, pick for pick, until you find the pick which will correspond, with reference to its interlacing, to the first pick.

Here, however, is where the novice, not versed in weave-formation, may come in trouble, for the fact that in connection with derivative weaves, duplicate picks, either single, or in sets of 2 or more picks, often occur, previously to obtaining the complete repeat of your weave. This will make no trouble to the experienced designer, he will know from theory at once the number of picks when the final repeat will occur, thus clearly demonstrating the advantage of theory and practice going hand in hand. Alone, either is grasping its way in the dark, combined they simplify your work, and make the latter a pleasure.

If dealing with a soft-spun filling yarn be careful in raising the pick, to avoid breaking the thread; also be careful that after the interlacing of a pick has been ascertained, the same is entirely removed, so that no small pieces of the thread remain in the fringed part of the warp, since this might lead to trouble or mistakes when examining the next pick.

Some designers use forceps for drawing the picked-out threads from the protruding fringe of the sample that holds it; forceps are not apt to split the threads like using the needle for this purpose.

Cases will occur in practical work where the sample submitted does not contain one complete repeat of the weave. In this instance pick out the interlacing of the amount of sample furnished to the best of your ability and construct the remaining part of the weave from theory; easy to say, —but often lots of trouble to the designer.

As will be readily understood, when dealing with our foundation weaves, plain twills or satins, or our standard derivative weaves, like broken twills, skip twills, diagonals. rib weaves, basket weaves, etc., 2 or 3 ends picked out and recorded, will be all that is needed, the balance of the repeat of the weave being then readily made out by theory.

In connection with any kind of pick-out which refers to the use of two or more colors, or counts of yarns, in warp or filling, or both, be sure to note on your pick-out plan, *i. e.,* design paper the particular color or count of the thread under consideration—it will save you trouble afterwards, and prevent any chances of mistakes in the weave-room. A good plan to observe is to save the threads thus drawn out of the sample for ascertaining kind and quality of stock used; as guides for the carder, spinner, dyer, or finisher, as the case may require.

Some designers, in order to facilitate their work, place the sample when in their hand, upon a white back-ground if of a dark color, or upon a black back-ground if dealing with a light colored sample. This back-ground (paper) is then put around the index finger of your left hand, and held there underneath the fabric to be analyzed.

When to Pick Warp Out of Filling.

With a great many fabrics, like corkscrews, diagonals, etc., it will be found advisable to pick out the warp from the filling in place of picking the filling out of the warp-threads, as was previously explained. It will make work easier, on account of the less frequent change of the interlacings met with in a given number of ends.

When picking warp out of the filling, whether we deal with single or double cloth, remember that you obtain in your pick-out sinkers where there should be risers for the warp-threads in the weave, and vice versa, you have risers where there should be sinkers. For this reason, while picking out, indicate filling ends up with *dots,* or leave squares empty, and indicate filling ends down with *crosses,* or paint the squares *full,* or use whatever mark you are accustomed to make for indicating risers in a weave. After pick-out is completed, turn the same 45 degrees and your weave for the loom is obtained.

The procedure will be readily explained by considering weaves Figs. 3, 4, 5 and 6.

For instance, consider weave Fig. 3, the 11-harness cork-

screw. Examining in this weave the filling, we find the same to interlace with the warp as ${}_{4}^{1}{}_{1}^{1}{}_{1}^{1}$ for each pick, whereas if considering the interlacing of the warp-threads with the filling, for a similar number of threads in the weave, we find it to be ${}^{4}{}_{2}{}^{3}{}_{2}$; in other words, in connection with picking filling out of warp, we have four changes from risers to sinkers, in every eleven threads of the repeat of the weave, whereas when picking the warp out of the filling we only find two changes from risers to sinkers, in every eleven threads of the repeat of the weave.

This explains that picking the warp out of the filling in this instance is the easier plan, since there is nothing more bewildering in picking out, than any amount of 1 *up* 1 *down* in a high textured fabric. This is characteristic to the warp texture of the corkscrews, and other weaves in which the warp predominates to that of the filling. You will often not be sure whether the 1 *up* or the 1 *down* is the next thread to be considered, whereas the threads interlacing in sets of 2, 3, 4, or more, the ends will prominently rest side by side, when examined with the needle by the analyst.

In the same manner, the diagonal Fig. 4, repeating on 11 warp-threads and 11 picks, will be easier picked out warp from filling, it being easier to pick out ${}_{4}^{2}{}_{3}^{2}$ for every eleven ends in the repeat of the weave if picking the warp out of the filling, compared to picking out ${}^{2}_{1}{}^{2}_{1}{}^{2}_{1}{}^{1}_{1}$ respectively for every eleven warp-threads across each pick.

Weave Fig. 5, a skip-twill repeating on 16 warp-threads and 8 picks, will show that it will be easier to pick-out ${}_{3}^{3}{}^{1}_{1}$ compared to ${}^{1}_{1}{}^{1}_{1}{}^{1}_{1}{}^{2}_{2}{}^{1}_{1}{}^{2}_{2}$, *i. e.,* it will be found easier to pick-out the warp-threads from the filling than vice versa.

Double Cloth.

Having mastered picking-out of single cloth structures, the analysis of fabrics constructed with

2 systems warp and 1 system filling,

1 system warp and 2 systems filling, and

2 systems of warp and filling, or full double cloth, can be taken up.

Two plans of procedure may be observed, *viz:*

1st: Proceed the same as if dealing with single cloth, and which in many cases will be the best plan all around, although possibly more tedious for the analyst.

2nd: Get details of the fabric structure, each item separately. Shave off or singe, *i. e.,* clear face and back of fabric, and:

(*a*) Ascertain weave for the back.

(*b*) Ascertain arrangement, *i. e.,* proportion of face to back threads, inserting for this purpose, two pins about one inch apart from each other, into the fabric and counting the threads between, on face and back. This will readily indicate whether the arrangement is 2 face 1 back, or 1 face 1 back, the two most often met arrangements, or any other combination that might have been used.

(*c*) Remove the back warp, or
Remove the back filling, or
In connection with double cloth, remove back warp and back filling.

Lift these threads carefully out of the structure, gradually loosening them with the needle out of their interlacings. A pair of fine forceps may be found convenient to assist in their removal.

(*d*) You now have the face structure of the single cloth, and which then pick-out in the regular way.

(*e*) Construct now the complete double cloth weave by theory from facts obtained.

We will now deal with picking-out these fabrics in the regular way, *i. e.,* treat them as single cloth.

2 Systems Warp, 1 System Filling.

The same will pick-out easier warp out of filling, on account of the high warp texture characteristic to these fabrics.

(*a*) Ascertain arrangement of face to that of back, *i. e.,* whether 2 : 1, or 1 : 1 or any other combination.

(*b*) Prepare sample in the regular way for the picking-out.

ARRANGEMENT: 1 FACE 1 BACK.

Pick-out and record interlacing of the first face thread you can get hold of.

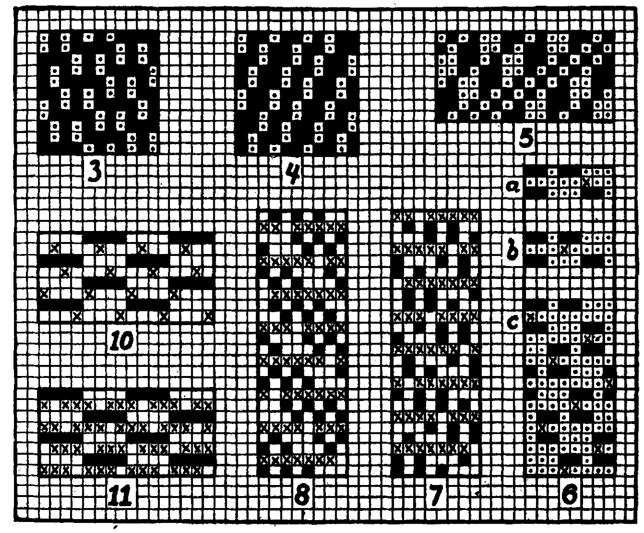
Pick-out and record interlacing of first back thread you can get hold of.

Pick-out and record interlacing of the next face thread.

Examine on your record on the design paper the position where the back warp stitches to face filling.

If the same stitches, *i. e.,* is *up* between two face warp-threads rising at the same pick, you are under average circumstances proceeding correctly with your pick-out and may continue that way, taking alternately hold of one end back one end face, until the repeat of weave is obtained. If, however, you find on your record on the design paper that on said pick one of the face warp-threads is up and the other one down, you then have not struck the correct arrangement

of face and back warp-threads to each other in the sample you are picking-out, *i. e.,* you have liberated either the wrong face or back warp-thread ahead of the one you should have used, and what you then have to correct on your design paper, having then a guide where to hunt for a face or back warp-thread. If you deal with a face weave where a perfect stitching is not possible, you then have to pick-out more of



the sample, possible the complete repeat of the weave, and then solve the question by theory.

Fig. 6 is given to explain the subject, showing three different ways how you may get hold of the two systems of warp-threads when picking-out. The face warp-threads are shown in the same position in all three diagrams. The pick-out is shown in the position as you will obtain it from sample, and after picking-out has to be turned 45 deg. for regular position of weave.

Filling up, in the pick-out is shown by *dot* type on all warp threads. *Full* type in the weave indicates face warp-threads *up* in the weave. *Cross* type in the weave indicates back warp-threads *up* in the weave.

6^a shows that we have liberated from the sample one back thread too much previously to starting the picking-out.

In this instance start picking-out for a perfect arrangement of face and back warp by taking a face thread next, in place of the back that you would have otherwise taken before, and when weave will come correct.

6*b* shows that we left one back warp-thread in the sample that should have been pulled out, previously to starting picking-out. Pull out one back warp-thread from your sample without recording the same on the designing paper and when sample will then pick correct.

6*c* shows the correct start, *i. e.*, sample was prepared correctly for picking-out. This diagram also explains the advantage of picking warp out of filling in this instance, since picking-out $_2{}^1{}_2{}^3$ and $_7{}^1$ is easier, compared to picking-out ${}^3{}_3{}^1{}_1{}^1{}_7$, provided we picked the filling out of the warp-threads, and where you are always apt to mix face and back warp, which in this instance are most always of the same count.

Arrangement: 2 Face 1 Back.

Explanations previously given in connection with the arrangement of 1 face 1 back will fully explain how to proceed with the present combination of face and back, remembering that 2 face warp-threads are always picked out in rotation before using 1 back warp-thread. At the start, after having recorded the interlacing of your first face warp-thread, be careful and experiment if the back warp-thread or another face warp-thread is the next to be used by you. Careful consideration will guide you to start at once with the proper arrangement of face and back warp. Remember that you must master the subject of picking-out yourself, by actual work.

In practical work start and end these weaves with 1 end face warp, and not start 2 face 1 back. It will result in a better flannel from the loom, since the reed wires, if drawing three ends in one dent, will then come between two face threads and thus assist in hiding the back warp-thread from the face of the cloth, the reeding observed most frequently being 3 or 6 threads per dent. It will cover already in the loom more perfectly the interlacing of the back warp to the face structure, and which interlacings, with the back warp-thread working against the wires of the reed, would show them up more prominently, resulting, in turn, also in small openings, running the length of the fabric, technically known as reed marks, in the woven cloth.

Picking-out samples, constructed with 2 systems warp, it will be advisable to indicate upon the designing paper which are the face threads, and at the same time any fancy threads among them, also do the same with the back warp-threads provided a fancy arrangement is used; it will facili-

tate the work of picking-out, since you are able to compare pick-out as it is building up, with the sample under work; the picking-out will be made easier, besides you will be able, at any time to detect errors, which may happen even with the most experienced analyst, and be able to correct them at once.

1 System Warp 2 Systems Filling.

Fabrics thus constructed, are picked-out in the same manner as single cloth samples, picking always the filling out of the warp. Close attention must be paid during picking-out, to the serial succession of the two systems of fillings.

If, in the picking-out of such a pattern it should happen that the back pick has been recorded and drawn out of the sample before the proper face pick had been taken out, the result, if not noticed, then will be a wrong weave-plan, and which, before being used for practical work, must be corrected. As soon as you see such an error, during picking-out the sample, correct it at once, or better, start picking-out over again. If you fail to record a pick in its proper place, and such a pick is pulled out before you noticed it, the same as with a single cloth sample, leave a horizontal row of squares on your design paper empty, and insert interlacing by theory after you have obtained the repeat of weaves for the sample.

The fundamental rules of weave-formation, to be observed in the construction of this system of weaves, will greatly assist you here in overcoming difficulties, and when by knowing and adhering to these rules it is very easy to correct a stitching or misplacement of picks, which has been marked incorrectly, a feature readily explained in connection with diagrams Figs. 7 and 8, and of which Fig. 7 shows an arrangement in which a back pick has been taken out before the proper face pick, and was so recorded on the point paper, whereas in diagram Fig. 8 the picks are taken out in proper rotation.

In the construction of weaves of this kind, the following rules must be always observed: "Stitch your back filling to your face structure with a warp-thread which is down in the face pick preceding and following this backing pick; at the same time distribute this stitching, as good as possible, over all the warp-threads in the repeat of the weave, *i. e.*, use them as uniformly as possible for stitching said back filling."

Weave Fig. 8, in order to give the face of the fabric a close texture, shows the ratio of the face to the back picks to be as 2 : 1, and which is the arrangement most frequently met with in connection with these fabric structures.

Rules and explanations given will at the same time show how to proceed if dealing with a sample, the arrangement of the filling of which is 1 pick face to alternate with 1 pick back.

2 Systems Warp 2 Systems Filling.

This fabric structure is technically known as *double cloth,* and comprises some of the hardest sample to pick-out. It can only be mastered after being thoroughly familiar with the analysis of fabric structures dealt with so far, since it comprises all rules and explanations thus far given.

The experienced designer will, as a rule, handle these fabrics minus picking-out, or at the most, take from one end of the fabric, its back ply away, ascertain proportion of face and back for warp and filling, ascertain face weave, and in turn construct the double cloth weave required, by experience.

Again, there may be samples met with, where he as well as the less experienced designer will have to resort to picking-out the sample after the single cloth procedure. In that case, be careful to notice how the combining of the two cloths is done, *i. e.,* whether the back warp stitches into the face filling or the face warp into the back filling. This information will guide you in your work. How in turn to again analyze such a pick-out as to the weave for its face and back ply, texture and stitching of the two plies, will be dealt with later on in a special chapter when referring to diagrams given collectively in Fig. 12.

In some instances, it may be found of advantage to remove one of the systems of back threads, the warp or the filling, which ever easier and more advantageously removed, and proceed according to explanations given previously when dealing with arrangements 2 : 1 or 1 : 2.

Having mastered the analysis of double cloth, you will have little difficulty to master special subjects, like additional binder warps, binder picks, stuffer warps, stuffer picks, 3-ply cloth, etc., hence no reference necessary; again, they may come up in such a variety that an explanation would only bewilder—they belong only within reach of the experienced designer.

How to Pick Out Pile Fabrics.

By pile fabrics, in this instance, we refer in the woolen industry to overcoatings or cloakings, also known as Montagnacs, Floconès, etc., presenting either a wool, alpaca or fine camel's hair face, *i. e.,* pile picks; the body and the backing picks to be wool, the warp to be either wool (rather hard twisted) or merino or cotton yarn. The stuffer filling, if such is used to increase the bulk and warmth of fabric, is, as a rule, a woolen yarn, carrying any amount of shoddy.

The picking-out of these fabrics is generally commenced with singeing or shaving off the fuzz on the back of the sample so as to be able to ascertain that weave. Next ascertain texture for warp and filling. After this remove carefully

back warp and back filling, ascertaining at the same time also their counts. Provided the fabric contains a stuffer pick the same will then rest loosely before your eyes. Ascertain also its texture as well as its count.

We now have a new structure for the fabric. Singe, or shave the same and begin picking-out the face structure; pick-out carefully. No great trouble will be experienced, but it will be advisable to proceed with care and judgment.

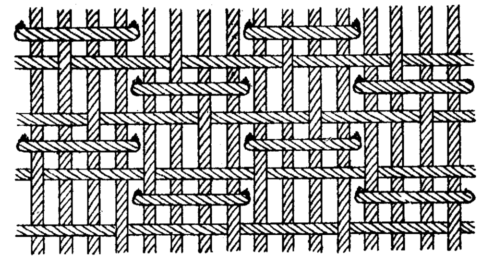


Fig. 9

In Fig. 9 a back view (enlarged) of a stripped Floconè is given, as it appears after the backing structure and stuffer picks have been removed. The remaining threads of the face structure have been shown with excessively large perforations between the threads, in order to make matters clear.

In Fig. 10 the weave for fabric structure Fig. 9 is given on designing paper, taking into consideration that the latter illustrates the back view of the fabric.

For practical work on the loom we now must reverse diagram Fig. 10, *i. e.,* exchange risers for sinkers, in turn obtaining diagram Fig. 11.

Fig. 9 explains the construction of the fabric. We can in this illustration clearly distinguish the ground picks from the pile picks, also the places where the latter have been torn or broken on the gig and the ends thus produced changed into flakes, *i. e.,* loose pile ends.

When dissecting the face structure, ascertain the nature of the raw materials used, counts of yarns employed, as well as texture of warp and filling. Next ascertain, by comparison of textures for face and back structure, the arrangement, *i. e.,* proportion of face to back in warp and filling.

The most important point to make sure of is the pile pick, its counts, its proportional arrangement to the ground pick, also whether it refers to a single, two or more-fold pick, and whether the latter have been entered single or coming from one bobbin.

We now must add the back structure to diagram Fig. 11, guided by data gained when liberating the same before from the original sample.

How to Analyze a Double Cloth Weave.

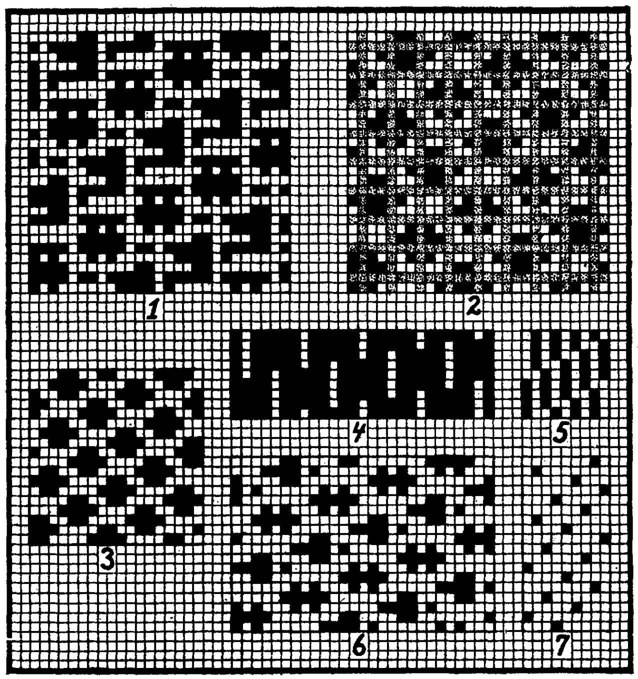


Fig. 12

Provided we picked out a complete double cloth weave after the principle of dealing with single cloth, as previously referred to, we then must analyze said double cloth weave so as to be sure that the pick-out is correct, also to know the interlacing of face and back weave, their proportion used, as well as the method of stitching employed, all of which are items of value to be known by the designer to plan for a

correct duplication or improvement in the construction of the fabric under consideration.

Again, a double cloth, *i. e.*, heavy-weight structure may have to be produced in light-weights, or with 2 systems of warp and 1 system filling, or 2 systems filling and 1 system warp, hence the single cloth weave for the face structure must be known in either one of the three cases quoted, to have in the last two instances an extra warp or filling added to it by the designer, by theory.

The collection of the seven diagrams shown in Fig. 12 is given to explain how to proceed to analyze a double cloth weave obtained by means of picking out.

Diagram 1 shows such a pick-out of a double cloth weave, repeating on 27 warp-threads and 27 picks. Examining this weave closely shows us the arrangement of face and back used, to be 2 : 1, both for warp and filling.

To obtain the face weave from this pick-out, cover every third end of it, warp and filling ways, *i. e.*, every back warp-thread and back pick (starting and ending the procedure with one end face) with a different color, as shown in diagram 2, and where *stenciled* type shows this color as painted onto the back warp-threads and back picks of pick-out shown in diagram 1. This then brings us the face weave prominently before us (see *full* type in diagram 2) and which we then copy, omitting every stenciled square, warp and filling ways. The result (face weave) is shown in diagram 3, a granite weave repeating on ($27 \div 3 = 9 \times 2 =$) 18 by 18.

To obtain the weave for the back structure and the stitching for the two plies, copy every third pick, *i. e.*, every back pick of weave diagram 1 for a new plan, obtaining in turn diagram 4. In the same every third thread (2, 5, 8, 11, 14, 17, 20, 23 and 26) refers to the interlacing of the back-ply, *i. e.*, to those places in which the back warp is raised and where all the face warp-threads have been raised at the same time so as not to interlace with the back picks.

Separating the nine threads quoted before, from diagram 4, gives us diagram 5, *i. e.*, the 9-harness corkscrew, for the weave of the back ply.

Subtracting diagram 4 from weave 1 gives diagram 6, which shows the face weave plus the places of stitching the back warp into the face filling so as to unite the two plies into one structure, and which is technically known as the stitching.

Separating these back warp-threads from diagram 6, and combining them by themselves, results in diagram 7, it being a displaced satin, filling effect, repeating on 9 warp-threads and 18 picks and which is the stitching used in the double cloth weave shown in diagram 1, originally picked out.

Ascertaining Texture of Finished Fabric.

Having obtained the weave for sample submitted, the next point to ascertain is the number of warp-threads and picks there are in the unit of one inch, in the fabric, the result being what is known as the texture of the (finished) sample. In expressing the same, the texture of the warp-threads refers to the first numeral, thus 42×36 means that there are 42 warp-threads and 36 picks per inch in the sample.

Multiplying warp-threads per inch in (finished) sample with the width of the finished fabric the sample picked out refers to, gives us then the number of threads to use in the complete warp.

From the picks per inch in (finished) sample, by carefully examining the construction of the fabric (texture, weave, finish, handle etc.) under consideration, by experience we then have to judge how many picks per inch to put in the cloth, on the loom. This subject will be later on dealt with in detail.

There are two ways of ascertaining warp and filling texture (in the finished fabric) from a sample, one by counting the individual threads in one inch or fraction of an inch, the other by calculating from the design-effect in the fabric after the repeat of the weave has been ascertained by picking-out. Some samples can be handled easier by one or the other procedure, using both in some instances in order to verify counting.

Obtaining Texture by Counting.

For this purpose use the protruding fringe of the warp-threads as left to you after picking-out the weave, straighten them carefully between your fingers so they rest (protruding from the fabric) perfectly parallel, side by side, the same as they were resting in the woven sample.

Next, with a compass set one inch wide, indicate carefully this distance on your sample close to the last pick as left in the latter, and with your picking-out needle carefully arrange the loose ends, designating which ones on each side of the arms of the compass belong to the *one inch to be counted.* Either mark or paint the first and last thread of this one inch wide fringe with your red paint brush, or indicate them in any other way; again you may clip the fringe of those threads which do not belong to the *one inch unit* on either side. This will give you a chance to handle, *i. e.,* count the threads in the unit of one inch at your leisure; repeat your count while at it, so as to be sure of no error.

Duplicate the same procedure with the filling so as to ascertain the filling texture, *i. e.,* picks per inch in finished sample.

Provided the fringe as left from the picking-out process is too much disturbed or mixed up, prepare such fringes of warp and filling specially for counting texture, on a different place from that where you picked-out.

In some instances, more particularly with heavy felted woolen samples, you may have to use less than one inch fringe for counting, since you may not be able to get the threads in one inch of the sample clear.

With expert work it may be advisable to count each texture in two different places of the sample, provided the size of the latter permits it. In this way you verify your count; if both counts differ, a third count will settle any possible dispute.

Fabrics having a fancy arrangement, either in the warp or in the filling or in both systems of threads, *i. e.,* containing different counts or colors of yarns, may compel you to count more than one inch; again, in some patterns you may find it advisable to count the number of threads in one repeat of the pattern and then ascertain its width in inches or fraction of inches, and in turn calculate texture by proportion, a feature later on referred to in detail.

In some instances you may facilitate your work by placing a cardboard, or paper, contrasting in color below sample, in order that the liberated ends, to be counted by you, show up distinctly. By this we mean, have for example a black background if dealing with white or light colored yarns, or a white background if dealing with black or dark colors for your yarns.

Obtaining Texture by Calculations.

When dealing with fancy, loud or pronounced patterns, we can readily ascertain warp and filling texture by the use of a pair of compasses, taking by means of the latter, either one or more inches or fraction of an inch, as a unit for measurement of the pattern and ascertain result by counting; again, we may take one or more repeats or fraction of repeats of the pattern in the grasp of the compass, ascertain its measure expressed in inches and fractions of an inch, and from it ascertain the texture of the threads in the sample, by calculation. Both procedures will be referred to.

Example: Ascertain warp and filling texture of

Fancy Cotton Dress Goods

shown in Fig. 13, actual size reproduction of fabric.

WARP CALCULATIONS.

Reading-off the arrangement of the warp from the left to the right in sample, we find the same to be:

12 ends dark
12 ends white, mercerized
12 ends dark
2 ends white (cord)
10 ends white
2 ends white (cord)
10 ends medium
2 ends white (cord)
10 ends white
2 ends white (cord)
—
74 ends repeat of pattern.

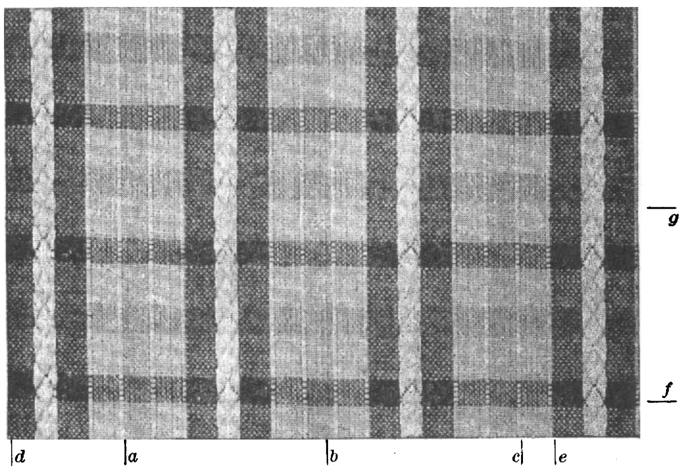


Fig. 13

a to *b*, below fabric, shows unit of an inch.

a to *c* equals two inches (*Proof*). Neither measurement calls for a solid repeat, or repeats.

a to *b* = one repeat of the pattern plus (or half of the 10) 5 ends medium, or (74 + 5 =) 79 warp-threads per inch.

Proof: d to *e* below fabric comprises three repeats of the pattern and which measure exactly $2\frac{13}{16}$ inches.

$74 \times 3 = 222$ warp-threads in $2\frac{13}{16}$ inches, width of fabric.

$222 \div 2\frac{13}{16}$

$222 \times 16 = 3552$ and

$3552 \div 45 = 79$ ends per inch. *Ans.*

The finished texture of the fabric thus ascertained, multiplied by the finished width of the fabric, gives us the number of ends in the complete warp to use. Calculating the fabric to be 27 inches wide finished, then gives us $79 \times 27 = 2133$ ends in warp, to which, for practical work, we can add 13 ends if so desired to obtain even repeats of patterns used, *i. e.* use 29 patterns @ 74 ends or 2146 ends in warp.

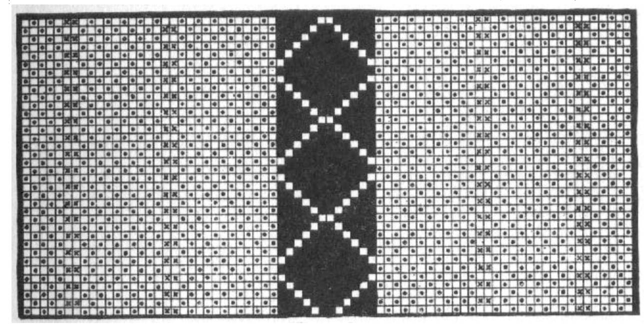


Fig. 14

FILLING CALCULATIONS.

Distance of *f* to *g*, on side of fabric sample, equals one inch.

The arrangement of the filling, reading from *f* upwards, is:

10 picks dark
14 picks white
10 picks medium
14 picks white
—
48 picks, repeat of pattern; *plus*
10 picks dark and
9 picks white, giving us
—
67 picks per inch as the filling texture of the sample.

Fig. 14 shows the pick-out of the sample, showing one repeat widthways, three repeats in height.

Full type indicates white mercerized.

Dot type on either side of the above, indicates dark warp, the next section white, and the two outside half sections medium.

Cross type, the white cords as separating the dark, white and medium sections of plain weaving.

Example: Ascertain Warp and Filling texture of

Worsted Trousering

shown in Fig. 15, actual size reproduction.

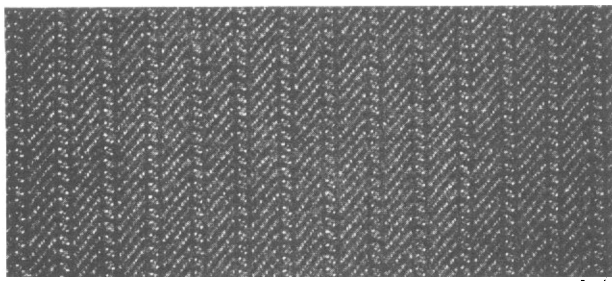


Fig. 15

WARP CALCULATIONS.

Pick-out, obtained and shown in Fig. 16 gives us the following arrangement of warp-threads for one repeat of the pattern.

2 ends black (*full* type).
1 end light gray (*dot* type).
2 ends medium gray (*shaded* type).
1 end light gray (*dot* type).
2 ends black (*full* type).
10 ends lt. and med. gray tw. (*cross* type).

18 ends repeat of pattern.

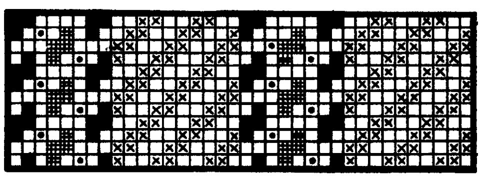


Fig. 16

a to *b,* below fabric, shows a distance of 3 inches, the same containing 13 full repeats of the pattern or $(13 \times 18 =)$ 234 ends.

$234 \div 3$ inches $= 78$ ends per inch *Ans.*

Dealing with a fabric 56 inches wide, this will mean $(78 \times 56 =)$ 4368 ends for warp to use.

FILLING CALCULATION.

Distance of *c* to *d,* on side of fabric Fig. 15, is one inch. The main weave used in the construction of weave Fig. 16 is the 2 *up* and 2 *down* 4-harness twill. Using a light warp in connection with a black filling clearly reveals the twill lines in the sample and of which there are 16 in the distance *c* to *d,* or in one inch, hence $(16 \times 4 =)$ 64 picks per inch in finished sample.

Example:—Ascertain warp and Filling texture of

Woolen Trousering

shown in Fig. 17 in actual size reproduction.

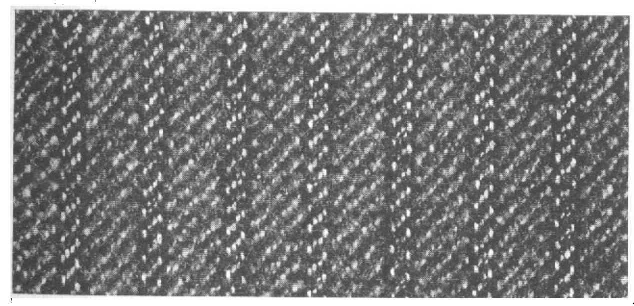


Fig. 17

WARP CALCULATIONS.

Pick-out has shown us that the weave used was the 4-harness cassimere twill, and that the arrangement of the pattern used is:

1 end spun silk, white
2 ends black worsted and silk tw.
1 end spun silk, white
1 end wool, black
10 ends wool, gray and white tw.
1 end wool, black

16 ends, repeat of pattern.

Distance of *a* to *b,* below fabric, shows six repeats of the pattern, covering $2\frac{9}{16}$ inches. 6 repeats = 96 ends.

$96 \div 2\frac{9}{16} = 37\frac{19}{41}$ ends (practically $37\frac{1}{2}$) in proportion to one inch. *Ans.*

Dealing with a fabric 56 inches wide we find:—

$37\frac{19}{41} \times 56 = 2098$ threads required for complete warp.

FILLING CALCULATION.

Distance of *c* to *d*, on side of fabric sample, is one inch, showing 9 interlacings of the 4-harness twill, hence (9 × 4 =) 36 picks per inch in finished sample.

We will next deal with a sample, where the number of warp-threads in proportion to one inch can only be obtained from the design of the fabric by calculation, the fabric itself being constructed with two different textures.

Silk Waisting.

Fig. 18 shows the reproduction of the fabric, actual size; a neat floral stripe effect upon a plain striped ground. Examining the sample by a single microscope or a pick-glass

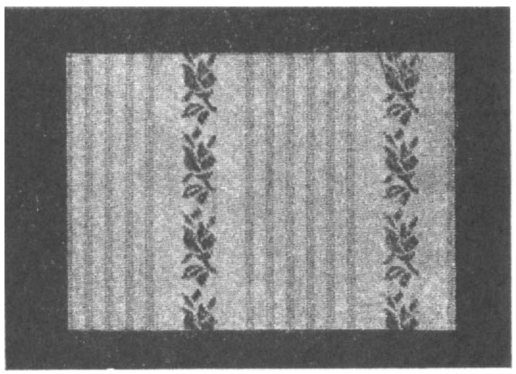


Fig. 18

gives us the following data as to arrangement of the warp-threads used:

30 ends white, ground, plain.
72 ends, one end dark to alternate with one end white; the 36 ends dark are used for the floral stripe, the white ends interlacing plain.
30 ends white, ground, plain.
114 ends, 9 ends dark to alternate with 12 ends white, forming the six small stripes on the plain ground effect of the pattern.

246 ends in repeat of pattern.

Fig. 19 shows the interlacing, *i. e.*, pick-out as we can call it, of one of the floral figures used in the stripe; show-

ing also some of the joining plain ground on either side, and of which there are 175 threads in the complete repeat of the weave, in place of the 29 shown.

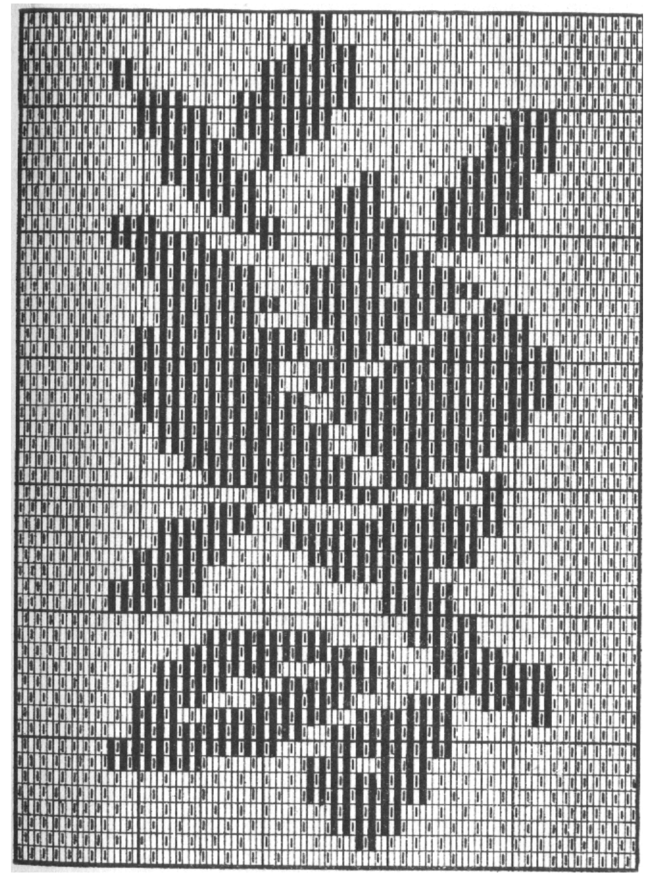


Fig. 19

WARP CALCULATIONS.

Considering widthways one repeat of the design in sample Fig. 18, we find the same to measure $1\frac{1}{16}$ inches, hence:

$246 : 1\frac{1}{16} :: x : 1$ and

$246 \div 1\frac{1}{16} = 231\frac{9}{17}$ (practically $231\frac{1}{2}$) warp-threads (considered in an average) per inch. *Ans.*

If dealing with a fabric 20 inches wide finished, the same then will call for 4630 warp-threads.

FILLING CALCULATION.

Three repeats of pattern in floral stripe, according to fabric sample shown in Fig. 18, call for $1\frac{1}{4}$ inches. Each pattern, according to pick-out Fig. 19, calls for 56 picks, hence ($3 \times 56 =$) 168 picks are contained in $1\frac{1}{4}$ inches of fabric, giving us in turn ($168 \div 1\frac{1}{4} =$) 134 picks per inch, in finished sample. *Ans.*

Ascertaining Materials Used in Construction of Fabrics.

To determine the raw materials of which any yarn or fabric under consideration is composed, there are two methods to follow, *viz:* physical and chemical tests.

Physical Tests.

These tests are based upon the structure and consequent appearance and feel of the various fibres, and may be considered under three divisions, viz: (*a*) practical knowledge, (*b*) by means of the microscope and (*c*) by burning.

In the mill, men who handle yarns and fabrics daily, year after year, to a certain extent can by feel readily distinguish of what materials the same are composed. However, even the most experienced man will sometimes be in doubt and have to resort to one or the other physical or chemical test, to convince himself if his judgment is correct, more so will this be the case if dealing with yarns or fabrics composed of two or more kinds of raw materials used in their construction.

The microscope will in most instances reveal the constituent parts of a yarn or fabric, whether pure or mixed.

Textile fibres of commerce belong to two distinct varieties: (*a*) animal fibres, (*b*) vegetable fibres.

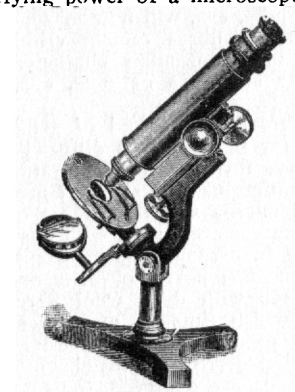
Of these, the first variety comprises (1) wool, hair and fur, each having formed the covering of an animal, and (2) silk, as spun by the silkworm at its entry into the chrysalis.

With reference to vegetable fibres, the first place belongs to cotton, the next to flax jute, ramie, etc. Besides these two chief varieties, a third, artificial silk may come under consideration.

The Microscope.

By means of it, yarns or fibres can be examined under a lens either by bringing them within or beyond focal length; in the first instance obtaining an enlarged picture on the side next the object, whereas in the other case, the enlarged picture is formed in an inverted position on the opposite side of the

lens. To obtain high magnifying power, these two conditions are combined in the compound microscope, which consists in its main parts of a tube some six or seven inches in length, closed at the upper end by a large glass lens (of greater focal length—placed nearest the eye, hence termed *eye piece*) and at the lower end by a smaller glass lens (of smaller focal length—placed nearest the fibres to be examined, hence *object piece*), both pieces being capable of vertical movement. This tube is blackened on the inside to exclude extraneous light. The total magnifying power of a microscope is thus the sum



MICROSCOPE.

of the powers of the *object piece* and the *eye piece*. The tube carrying the two pieces for adjustment in the regular microscope, is raised or lowered by a rack and pinion motion, while in connection with a high class microscope, an extra, *i. e.*, fine adjustment, is afterwards made by the micrometer screw, as provided to such microscopes.

On the stand of the microscope we find fixed an arrangement for supporting the stage (pierced with a small circular aperture for the passage of the reflected light), as well as a small circular concave reflector, movable in any direction.

The most important quality of a good microscope is, that its lenses produce a well defined, clear picture, distinctly showing every detail of structure in the object under examination.

The best source of illumination for carrying on investigation by means of the microscope is diffused daylight, with a sky evenly covered with a white veil of clouds. In connection with artificial light, a glass bulb, filled with a dark blue solution of ammoniacal copper oxide, interposed between the source of light and the condenser, will be found of advantage.

When dealing with wool fibres an important factor is that the illumination used for the examination of the structure of the scales, the cortex or the medulla (if present) should be entirely modified when it is desired to observe the disposal of the coloring matter in the cortex. In the first case the light is suitably restricted by means of the iris diaphragm with which the microscope used for this work is fitted out, while in the latter case the diaphragm is thrown completely open, and as much light as possible from some uniform source is directed through the fibres. All appearance of scales, medulla, etc., will now disappear, and only the faintest profile of the fibres remain visible, however, the pigment disposal, in the peculiar characteristic manner of lines and irregular congeries of dots, etc., will stand out as clearly as possible.

As mentioned before, no method of artificial illumination is so satisfactory for this work as diffused daylight, though the more conspicuous forms of fibre coloration can, in default of this, be seen by interposing a sheet of ground or whitened glass between the mirror and the source of artificial light, of which the ordinary mantle used with gas (or better, with a petroleum lamp) is, perhaps, the most suitable.

Where the pigment is nearly obsolete or where comparison has to be made with dyed wool fibres of such faint brownish and yellowish tints as may be employed with a view to resemble natural (colored) wool fibres, artificial light cannot be satisfactorily employed.

If these precautions are observed, the essential differences between dyed and natural (colored) fibres can be quickly determined, although fabrics are seldom met with in which the normal shades of most can be so closely imitated so as not to be detected at once by the naked eye.

Any dyed fibre, unless of so faint a tint as to appear colorless under the microscope, will show a complete uniformity of coloring throughout, from edge to edge; whereas the distribution of the pigments in the cortex of natural brown fibres occupy definite restricted areas, as mentioned before. The method of such disposal, however, varies largely in different classes of animal fibres, and often affords a means of distinguishing one kind of fibre from another.

When a material, such as that used for the natural undyed underwear is examined, it will be seen that the admission of the small proportion of brownish and yellowish fibres introduced in the mixing process into the bulk of the white fibres produces an irregular appearance of small patches of color, so that to imitate this, it would not do to employ a uniformly dyed yarn, but specifically dyed fibres, of the colors of sheep's wool, must be introduced in the same fashion. It is here that the microscope can be of infallible service in detecting the

dyed fibres by revealing the differences before mentioned, between the pigment disposal of the natural fibre, and the uniform, clear, unbroken transparent color of the dyed fibre.

It is even possible in some cases where natural brown fibres have been dyed, should the latter not have rendered the fibre too opaque, to see coexistent in the same fibre the lines and areas of pigment showing through the clear and uniform dyed color.

A precaution may here be noted against classing as *dyed,* such fibres that for one reason or the other have become artificially colored, such as may have been stained by the sheep's urine or fæcal matter; however such fibres rarely are present in large numbers. Their color is weak and irregular in distribution, their scaly structure usually more or less impaired, so that the analyst can generally without difficulty discount their presence.

Water is the usual medium in which wool fibres can be microscopically examined. The scaly structure of the fibre can be well seen by oblique illumination, by throwing the iris diaphragm out of the optical axis of the instrument. The fibres then have a striking silvery appearance, the projecting edges of the scales catching the light, and the cylindrical nature of the fibres being clearly shown.

Much of what has been said about the wool fibre is also applicable to the examination of vegetable fibres, though in many cases the use of higher powers may be required.

For ascertaining the difference of certain fibres, *i. e.,* silk and artificial silk, the microscopical appearance of cross-sections will often be found of use. In making such cross-sections paraffin wax of fairly high melting-point is the most suitable medium. A bundle of the fibres is straightened, as far as possible, immersed in the wax at a temperature a little above its melting-point, and the mass then twisted between the finger and thumb until a solid rod is obtained.

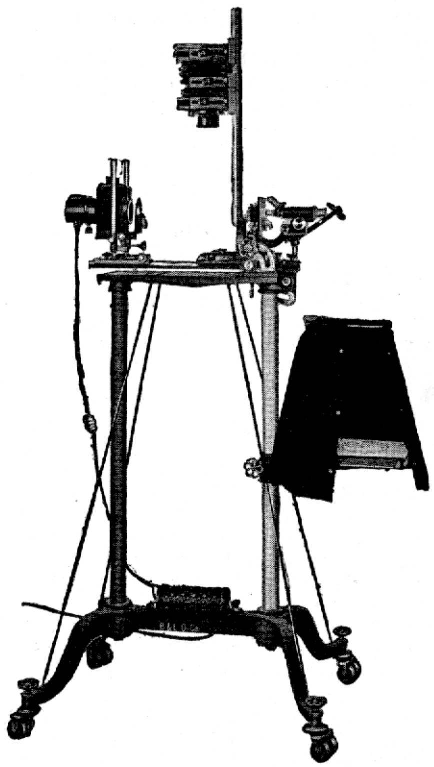
Cross-sections may easily be cut from this by means of a microtone, or with a sharp razor with a little practice.

How to Prepare Yarns and Fibres for Microscope.

Yarns to be examined under the microscope, whether in their pure state or liberated from a woven or knitted, etc. fabric, after proper removal of all dirt, so that the passage of the light will be unrestricted, are then untwisted by hand, in order to transfer the yarn back into a mass of loose fibres; selecting then a proper amount of these fibres for testing. Immersing the fibres to be tested, whether in the raw state or taken from yarns or fabrics, in boiling water, or better still in glycerine or Canada balsam, will increase their transparency. The fibres thus prepared are then separately laid, side by side, on a glass slide and covered with a thin cover glass and are then ready for magnifying.

The Photomicrographic Apparatus.

Microscopic objects are reproduced in industrial laboratories by two methods, *i. e.*, drawing or tracing from greatly magnified images and reproduction on photographic plates, or photomicrography.



With the apparatus illustrated above both drawing and photographing can be done and in addition images of the fibres can be projected against a screen.

This apparatus manufactured by BAUSCH & LOMB, Optical Co., of Rochester, New York, and marketed in the Textile Field by Alfred Suter, 200 Fifth Avenue, New York, consists in the main of a strong iron stand, on which are mounted

either an arc lamp or a Mazda lamp in special metal container which can be raised or lowered and otherwise adjusted horizontally or on an oblique for surface illumination.

This lamp is provided with an aspheric condenser to diffuse or condense the light rays upon the object to be examined and in this way the right density of illumination can be had.

A camera is mounted on a lever permitting to photograph the objects either horizontally or vertically.

The microscope is mounted on the right hand side and has a mechanical stage by means of which the object slides can be moved across the field of vision to examine all parts of the fibres. The drawing table shown half way up on the right hand stand has a black velvet curtain to shield the image projected by a small mirror reflector from extraneous light.

By the addition of a vertical illuminator the surface of opaque objects such as woven fabrics can be examined for defects which appear only on one side of the cloth.

By using different combinations of objectives and eyepieces on the microscope different magnifications are obtainable so that very fine single fibres as well as groups of even the coarsest fibres may be examined at one time.

For studying the solubility of dye stuffs in water or acids it is best to use an oil immersion Objective which gives a 1200 diameter magnification.

Where very large magnification is desired it is best to project the image against a screen in a dark room; this latter being extensively used in Institutions and lately in some of the larger cotton, wool and silk mills to teach a whole class in knowledge of the aspects, the qualities and defects of raw materials, following same through the different processes of manufacture until the finished article is projected on the screen in perfect and faulty condition.

For fine cotton spinners it is very important to know what percentage of ripe and unripe or otherwise imperfect fibres the stock contains, a number of these firms now examine samples well mixed first in a small sample card by means of the photomicrographic apparatus. The same applies to the silk fibre which by the very nature of its origin shows a large number of irregularities, some of which if detected in advance of being put into process, will prevent the right kind of silk being used in the wrong place and vice versa.

The photographs and prints of silk, cotton, wool, and other fibres shown in the following chapters were all made on an apparatus as described above.

Wool.

Wool viewed under the microscope appears as a solid rod-shaped substance, the surface of which presents a peculiar scaly appearance, being covered externally with small plates or scales, the edges of which either protrude from the body of the fibre or are only surface markings. These scales are more strongly and regularly developed in proportion to the fineness of the wool. The cylindrical shape of the wool fibre

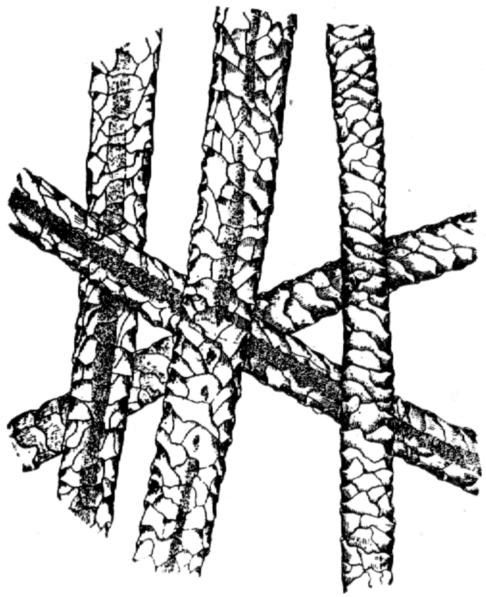


Fig. 20

is best observed (when viewed under the microscope) where two fibres cross one another. A central core of medullary matter, running longitudinally in the fibre is sometimes visible, particularly in the coarser types of wool.

Fig. 20 shows five wool fibres as seen by means of the microscope, and of which three of the fibres show this central core of medullary matter, previously referred to, which however is missing in the other two; all five fibres being specimens of coarse long staple wool fibres. In the better classes of wool, this medullary portion is entirely absent, its presence or absence depending upon the breed, health and care of the sheep and also the part of the body upon which the wool is grown.

Besides their scaly surface structure, wool fibres are characterised by their wavy structure, technically known as the

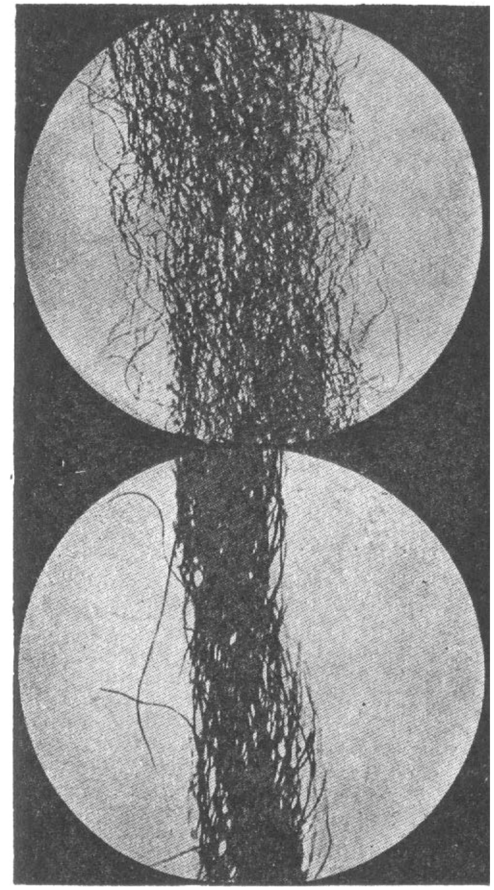


Fig. 21

Fig. 22

wave of the crimp being another item depending upon the breed of the sheep; the finer the quality, the more of these waves to one inch of fibre.

Yarns made of wool are classed as wool spun and worsted. The latter, in opposition to the woolen yarn, consists of wool fibres brought by means of combing and drawing parallel to each other, the first mentioned process at the same time combing out of the stock any fibres below the standard length for which the machine is set, and for which reason worsted yarn means a yarn composed of wool fibres nearly all of a uniform length.

These two points, parallelization as well as equalization of the fibres, characteristic of worsted yarn, constitute the principle difference between worsted and woolen yarn. The parallelization of the fibres in a worsted thread will be readily noticed by its smooth surface as compared to that of wool spun yarn, which presents a fuzzy surface in order to assist in the formation of the nap in the finishing of the fabric.

To ascertain the length of the fibres used in a thread, liberate the individual fibres composing the same by untwisting, and when a comparison of the length of fibres used can be readily made.

To illustrate the difference between a woolen and a worsted thread, the appearance of its roving or sliver previously to spinning is given in Figs. 21 and 22, and of which Fig. 21 shows a condensed woolen sliver (roving) previous to spinning, Fig. 22 showing a combed and drawn worsted sliver previous to spinning.

Having given a description of a true wool fibre, the analyst may be called upon to ascertain in a lot of wool, yarn, or a fabric the cause of imperfections, *i. e.,* the presence of poor wool fibres, chiefly among which are found ***untrue*** fibres and *kemps.*

Untrue Fibres.

Under true or even fibres, we classify those having a nearly uniform diameter throughout their entire length, whereas, fibres wanting this character are termed untrue or uneven, the latter being characterized by variations in diameter on the same fibre, a feature which will seriously interfere with the working quality of the wool. Specimens of untrue fibres are shown in Fig. 23 which will readily show that where these abnormal forms occur, there are changes in the form and size of the outer scales as well as in the diameter of the fibre, consequently the internal structure of the fibre must be equally affected, thus reducing the strength and elasticity of such fibres. It is well known that a chain is no stronger than its weakest link, and, in a similar manner, we may say that the strength of a wool fibre is proportionate to its smallest cross section; so that the buyer, in judging of such a wool would measure its value to him by this very defect. Untrue fibres are found most frequently in the fleece

of inferior bred or neglected sheep, or are the result of sickness of the animal. In some instances we find a sudden contraction in diameter of the fibre at certain points, which is frequently sufficient to give the edge of the fibre a decidedly notched appearance, whereas in other cases we find a more gradual contraction.

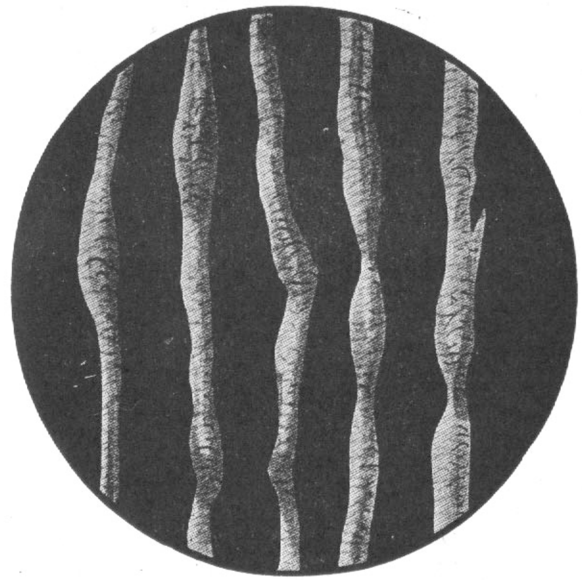
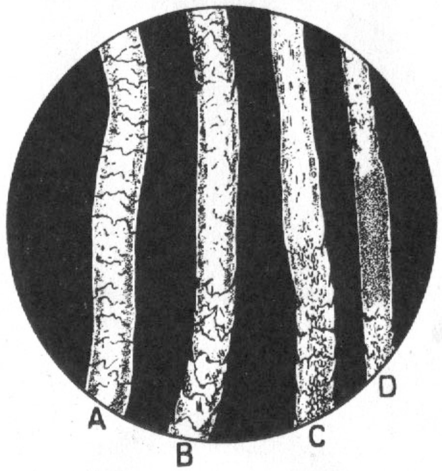


Fig. 23

Kemps.

They are another kind of imperfect fibres met with in wool. The characteristic of an ordinary kemp fibre is a hair of dead silvery white, thicker and shorter than the good wool. Kemp fibres do not seem to differ considerably in their chemical composition from the good or true wool fibres, but possess no absorbent power, thus resisting either entirely, or partly, the entrance of dyestuffs, in the latter case producing a different shade from that imparted to the good fibres of the same lot, hence kemp fibres will be readily detected in dyed lots of wool, yarns or fabrics. The presence of kemp fibres in a lot of wool will also result in poor spinning and poor yarn, since they will not thoroughly combine with the good wool, neither will they felt.

Fig. 24 shows four different kempy wool fibres and of which *A* shows a kempy fibre, seen by reflected light; *B* a fibre, part wool and part kemp, seen by reflected light; *C* a fibre, part wool and part kemp, seen by transmitted light and *D* a fibre, part wool and part kemp, with kempy part opaque when seen by transmitted light.



Comparing Hair and Wool.

Examining hair (wool is only a variety of it) under a powerful microscope, we find that the same lies straight and even, and presents a comparatively smooth surface compared to the serrated surface of the wool fibre. Figs. 25 and 26 are given to explain subject, and of which the first shows a wool fibre treated with caustic soda, and the latter a hair (human) treated in the same way, so as to show the serrations distinctly.

Other animal fibres used by the textile industry are: the coverings obtained from the Cashmere Goat, the Angora Goat, the Alpaca, the Camel, the Common Goat and the Cow, also the hair of the Horse.

Cashmere Wool and Hair.

The same are the covering of the Cashmere Goat, *viz:* a soft, woolly, white or grayish undercoat, and a covering

of long hairs. The woolly undercoat is the valuable fibre, and is true wool fibre in its structure, varying in length

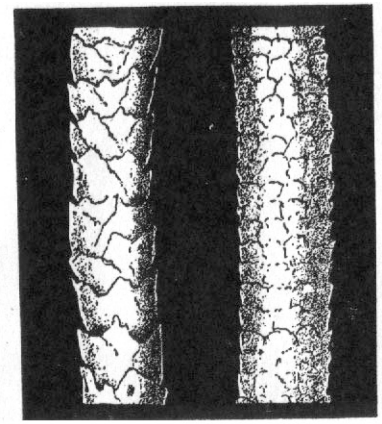


Fig. 25 ***Fig. 26***

from $1\frac{1}{4}$ to $3\frac{1}{2}$ inches and possesses no medullary substance. The outer hairs are of a length of from $3\frac{1}{2}$ to $4\frac{1}{2}$ inches,

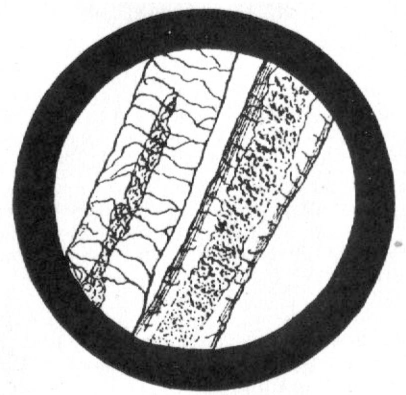


Fig. 27

and possess the central or medullary substance, as shown in Fig. 27.

MOHAIR.

Mohair is the name given to the hairy covering of the Angora goat. It is of a pure white color (more rarely gray) rather fine, more or less curly, of high lustre, and on an average of from 5 to 6 inches long, although in some cases it may be as long as 12 inches. The outer scales are extremely delicate, and can only be observed with high powers, if at all. They are regular and encircle the whole hair, giving the fibres a spotted appearance all over their surface, as shown in Fig. 28, illustrating such fibres magnified. In most cases the pith is absent, although it is sometimes seen in the form of a canal occupying more than one half of the diameter of the fibre.

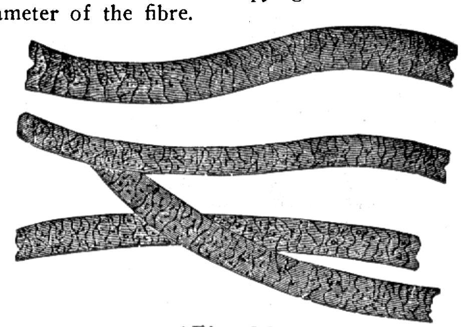


Fig. 28

Besides the mohair, there grows upon the Angora goat a short, stiff hair (kemp), a relic of the common goat. Its presence depends upon the kind of breed, being nearly nil in the pure animal. This kemp fibre in mohair always reduces its value, in proportion to the amount that is present.

ALPACA.

Alpaca and similar wools are obtained from a group of animals comprising the Alpaca, the Llama, the Vicugna and the Guanaco, and of which the one mentioned first is the most important.

The Alpaca, a domesticated animal, furnishes a fine fibre about 6 to 18 inches long, except when the animal is only sheared once in two years, and when the fibre then is considerably longer. Its color is white, gray, brown or black. It is a lustrous fibre, although this lustre is inferior to that of mohair. The outer scales of the fibre are extremely fine, and the central or medullary substance is present either throughout its entire length or in small elongated masses. Fig. 29 shows some of these fibres magnified.

The Llama furnished a coarse, long, unelastic, white and brown wool, mingled with true hair.

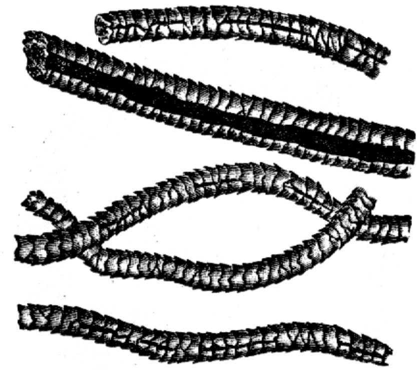


Fig. 29

The Vicugna furnishes two different kinds of fibres, *viz:* a fine woolly under hair, covered with scales and free from medulla, and a coarse upper or beard hair, having the

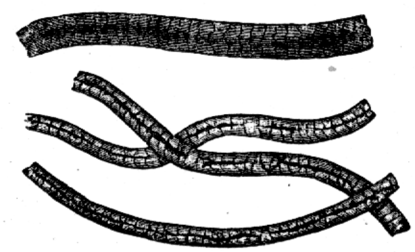


Fig. 30

medullary substance strongly developed. Fig. 30 shows some of these fibres magnified.

The Guanaco yields fibre of varying quality; however, it is of less importance than the Vicugna.

Hair.

Camel Hair is of two kinds, *viz:* fine, curly, soft, reddish or yellow brown hairs, about 4 inches in length and

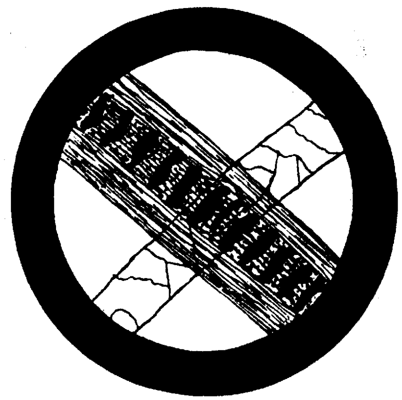


Fig. 31

known in commerce as camel wool, the other being coarse straight, stiff, dark brown to blackish body hairs, about 2 to 2½ inches long, and known as beard hair. Both kinds of hair show (under the microscope) faint scales. The medullary substance always appears in the coarse hair, whereas in the fine hair it is either wanting or appears in insulated masses. Fig. 31 shows camel hair fibres magnified. The fibres from the Alpaca, Llama and Vicugna are frequently referred to in the market collectively as Camels hair.

Goat Hair. The Common Goat, when raised in the open air, has a woolly fur which is shed in the spring and which hair is adapted for spinning (with wool) into coarse yarns.

Cow and Calf Hair are coarse, stiff fibres, of a white, reddish brown or black color, possessing a light lustre, and in turn are spun (mixed with low grades of wool) into coarse yarns. Fig. 32 shows a specimen of the fibre, showing the central or medullary portion of it, whereas the fibre indicated by *P* shows a pointed end of one of these hairs.

Horse Hair. Of this, two kinds are met with in commerce, *viz.:* "tail hair," or the long hair, measuring at least 23 inches, though it occasionally attains a length of 32 to 34 inches, and "mane hair," or the short hair, and which rarely

exceeds 19 inches in length. White and black are the colors most esteemed, while red, gray, etc., hair is less valuable.

Artificial Wools.

The same according to their source, are divided into four classes, *viz.:* Shoddy, Mungo, Extract and Flocks. Of these

Shoddy is the best, being the wool fibre recovered from worn, but all wool materials (known as "softs") which had never been fulled, or if so, only slightly, and which vary in their length from ⅜th to 1⅜th inches. Shoddy fibres, when seen under the microscope, are sometimes found to be spoiled by scales being worn off, or the ends of the fibres broken. In most instances, dyed shoddy can be detected from similarly dyed new wool in the yarn or fabric, for the reason that the color of the former will betray the inferior article compared to new wool, since the rags or waste, previous to the re-dyeing, except when coming from white softs, had been dyed different colors and which will consequently influence the final shade of color obtained by re-dyeing. Considered all around, with the exception of the two cases quoted, shoddy is hard if not impossible to distinguish from new wool (under the microscope) since a good quality of shoddy does not differ in its fibre structure from new wool

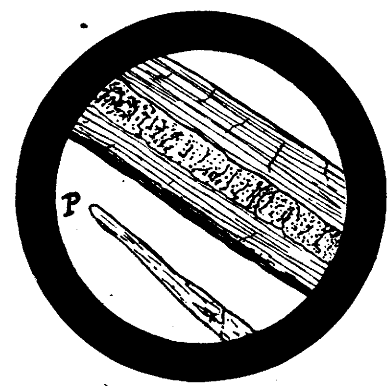


Fig. 32

and in fact in many cases may be superior to some kinds of new wool. Fig. 33 shows shoddy fibres magnified, clearly showing the epidermal scales characteristic to the (new) wool fibre.

MUNGO is obtained by reducing to fibre pure woolen rags from cloth originally heavily fulled, and when the natural consequence of the strong resistance to disintegration offered

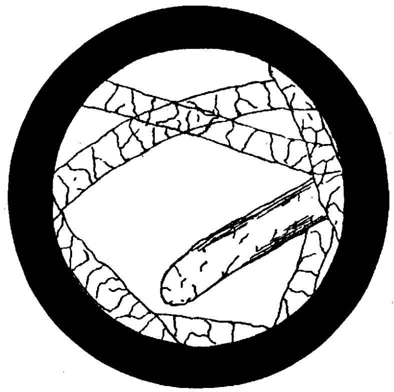


Fig. 33

by felted fabrics results in that short fibres, about $\frac{1}{8}$th to $\frac{4}{8}$th of an inch in length, are obtained. Short staple, broken fibres, worn-off scales as well as difference in shade of color, are the only points which can guide you to distinguish mungo from new wool. Fig. 34 shows mungo fibres magnified, showing broken wool fibres, also a jute fibre intermixed.

EXTRACT is artificial wool, produced from mixed rags from which vegetable fibres were extracted by means of carbonizing. An examination of a sample of extract, by means of the miscroscope, will show traces of the process of carbonizing by means of carbonized vegetable refuse found.

To Test Shoddy From Wool.

In testing the presence of shoddy in a lot of woolen yarn or fabric, treat the sample with warm hydrochloric acid, which will remove from the shoddy the color due to its second dyeing and leave its original dye clearly exposed. As the wool present was at the same time stripped of its color, it was left more or less white, thus distinguishing shoddy from wool.

FLOCKS are woolen rags ground in the flock cutter into minute portions of fibres, which then, during fulling the cloth, are made to adhere to, *i. e.,* are felted onto the back

(to and into the pores) of the fabric, working their way more or less into the body of the latter.

A good plan to test a fabric as to the amount of flocks it contains is thus: Weigh sample carefully and note its weight. Next take a large white sheet of paper and rub the sample by holding it between thumb and forefinger of both hands changing the position of your fingers on the sample frequently so that each portion of the latter receives a thorough rubbing, and when a considerable portion of the flocks (provided the fabric thus tested was flocked) will be liberated and drop onto the paper. Dissecting sample, *i. e.,* separating warp and filling, will liberate an additional amount of these flocks, more particularly such as had worked their way into the interstices of the structure. Take each thread, whether warp or filling, as picked out by you, and liberate all flocks possible from the thread by pulling it between the thumb and forefinger of one or the other hand, using one or the other of the finger nails for scraping off flocks as

Fig. 34

may adhere to the particular thread. Weigh the refuse thus rubbed from the fabric and its weight compared to the original weight of the sample previously referred to will give you (figuring by proportion) the per cent of flocks the fabric contains.

True Silk as well as *Wild Silk* is met with either as

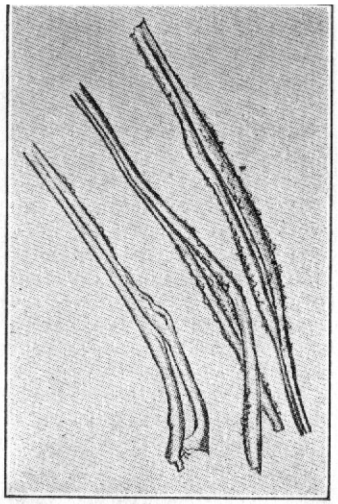


Fig. 35

thrown or spun silk. The latter is readily distinguished

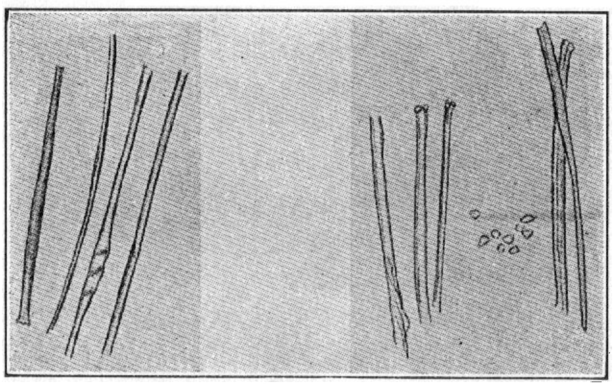


Fig. 36

from the former by its broken-up lengths of fibres composing the thread, caused by its manufacture into yarn.

True Silk, when in its natural or gum condition, consists of a double fibre, and viewed under the microscope has the appearance of two fibres cemented together at intervals as it emerges from the silkworm. Fig. 35 shows (magnified) cocoon fibres of Canton silk with the gum still attached.

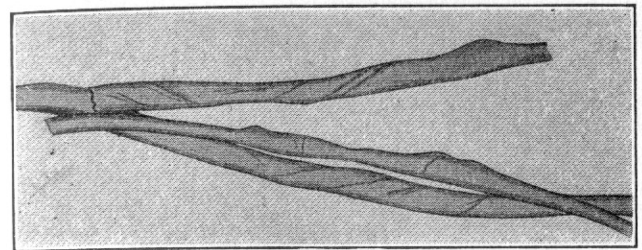


Fig. 37

When degummed, or boiled-off, the two individual fibres are separated as shown in Fig. 36, which in its right hand photograph also shows cross sections of fibres. From illustrations it is seen that the surface of the fibres is smooth,

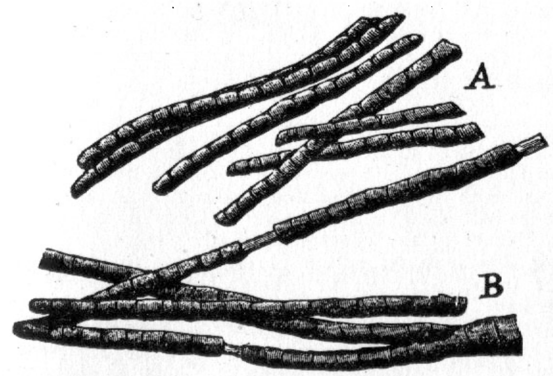


Fig. 38

transparent and structureless, with occasional little nodules in the side of the fibre. It resembles a cylindrical glass rod, in some portions uniform in thickness, while at others of somewhat irregular diameter.

Wild Silk (or as more often called *Tussah* silk and which is the most prominent variety of wild silk) differs from true silk in being much coarser in diameter. Under the microscope the fibres show numerous longitudinal striations. Occasionally, characteristic broad diagonal markings across the surface are seen and which are due to the impression left by another thread upon the fibre. Fig. 37 shows Tussah silk, boiled-off, clearly revealing those diagonal markings previously mentioned. Wild silk has a dark color, which cannot be removed except by means of a powerful bleaching agent; its lustre, softness and elasticity is inferior to those of true silk.

WEIGHTED SILK. In order to make up the loss caused by the boiling-off process as well as in some instances for the purpose of defrauding the buyer, silk is weighted. Fig. 38 shows (magnified) silk that has been weighted, *A* showing a weighting of from one and one-half to twice the weight of the silk; *B* showing a weighting increased to from three and one-half to four times the weight of the silk.

Very interesting is the examination of these silks by Roentgen rays. The Roentgen photography is employed in the examination of silk that has been charged to differently high degrees, and these pictures take the place of the chemical analysis which is often difficult with such charges as consist of salts of iron. The stronger the charge is, the greater is its resistance to perlucidation. Consequently upon the negative plate the uncharged silk gives the darkest, and the most heavily charged the lightest likeness, since the strongest charge is the least penetrable for light.

Cotton.

When viewed under the microscope, fully matured or ripe cotton fibres have the appearance of spirally twisted bands or ribbons, with finely-granulated markings. A grooved appearance will be also noticed on account of the cell walls being thicker at the edges than in the centre.

Fig. 39 illustrates cotton fibres, of which *A* shows two unripe or dead fibres, by which is understood that such fibres have not attained full maturity. Their detection is very important, since their presence is very detrimental to yarn and fabric. They are recognizable by the very thin transparent filaments, which, though ribbon shaped, are not twisted, and do not exhibit the slightest trace of lumen in the cell. *B* shows a specimen of a half ripe fibre, and which is a medium between ripe and dead fibres, and in conjunction with the latter, according to amount present in a lot of cotton, depreciate its value to the manufacturer, such fibres being the result of the cotton being removed from the pod before fully matured. *C* shows two specimens of matured or fully ripe fibres. These are hollow

nearly throughout their entire length, with the exception of the end which had not been attached to the seed. This hollowness of the ripe fibre allows the dyestuffs to penetrate, and produce evenly dyed yarns or fabrics, whereas unripe or dead cotton, which practically has no central cavity, is very

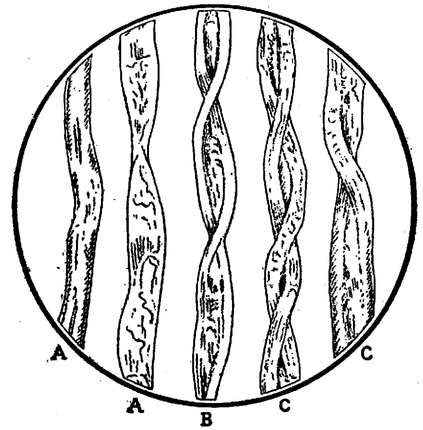


Fig. 39

difficult to dye, and frequently appears as white specks on dyed pieces, particularly in such as are dyed indigo blue or turkey red.

Mercerized Cotton.

Although mercerization of cotton has been carried out on a large technical scale for many years, it is well known that to ascertain whether a particular sample of cotton has been mercerized or not, is no easy question to ask, more so if required to ascertain the degree of mercerization to which a particular sample of cotton has been subjected. Fibres which have been thoroughly mercerized exhibit very distinct microscopic characteristics. It is, however, found to be very difficult in many instances to say with certainty whether fibres have been mercerized if such fibres are taken from fabrics which have been mercerized on an industrial scale. Those who have practical experience in mercerizing will readily understand why this must be the case. In many instances the individual fibres have been only incompletely penetrated by the caustic soda solution, and frequently some of the fibres have not been mercerized at all. The strength of the caustic soda solution used has also a very considerable influence upon the microscopic appearance of the fibres. Among other causes which tend to make the method of microscopic examination difficult in practice should further be mentioned the application of certain finishing operations, such as the Schreiner finish, after mercerization. Mercerized cotton exhibits increased affinity for the substantive cotton colors.

Mercerized Cotton Compared to Cotton as well as Silk.

Two typical classes of mercerized cotton must be considered, *viz:* such as mercerized without and with tension. The silky lustre in mercerized cotton depends on the stretching, mercerization without tension producing shrinkage and no lustre to the cotton thus treated.

If comparing cotton fibres not mercerized with cotton fibres mercerized but without tension, the latter, if viewed under the microscope, in their outer appearance somewhat resemble silk. The fibres look smoother and more uniform, and the lumen is contracted either entirely or in places. Cotton treated with strong caustic soda, without tension, is capable of absorbing about 40 per cent more of the substantive cotton colors and of the sulphur colors than is ordinary non-mercerized cotton.

If we examine under the microscope cotton fibres which have been mercerized under tension (the process which in practical work is known as mercerizing) we find that such fibres resemble silk more closely than such cotton as has been mercerized without tension. The lumen often becomes obliterated altogether, the spirals, *i. e.*, the characteristic twist of the raw cotton fibre disappear, showing us smooth, uniform, silk like, straight rods.

Treating the fibres with cuprate of ammonia, the lumen reappears if dealing with mercerized cotton, but not if dealing with silk.

The uncurling of the natural twist in a cotton fibre when mercerizing under tension is essential for the production of its silky lustre, since when cotton is mercerized under tension and thus cannot shrink, the first effect of the lye is to straighten the fibre, and after that to re-curl it the other way. By this time the fibres have swollen, so that when they curl up again (this time in the reverse direction) they then present a rounded and not a flattened section. This second twist causes the surface of the fibre, smoothed by the swelling it has undergone, to catch the light at different angles, and thus to produce the lustre. When examined by the microscope, the use of elliptically polarized light is necessary to bring out the new twistings. There is, however, a possibility that the lustre is due to the joint action of chemical and physical agencies.

Some chemists claim that the mercerizing lye acts on one or more of the inner layers of the fibre, causing them on rinsing to exert a stretching effect on the outer cuticle of the fibre, with the result of smoothing it, and making it lustrous by increasing light reflection.

To Ascertain the Degree of Mercerization.

For the purpose of examining a pattern of either cloth or yarn with a view to ascertaining the strength of caustic soda with which it has been mercerized, a range of patterns mercerized with different strengths of soda should be prepared for the purpose of comparison. If colored samples are to be examined, it is necessary either to discharge the color by means of any of the well-known agents or the standard patterns must be dyed to approximately the same shade with dyestuffs similar to those which have been used in producing the pattern under examination. The patterns are then immersed in the iodine solution for a few seconds and washed. With careful observation the degree of mercerization can be ascertained with fair accuracy.

It is however not always an easy matter to tell by means of the microscope whether cotton threads found in a sample have been mercerized or not, since, as mentioned before, during the process of mercerizing the inner fibres of the hank are relatively protected against the action of the caustic soda, in turn of which many of the fibres will retain their characteristic twisted form of untreated cotton. It is therefore essential to supplement a microscopical examination by a chemical test.

Other Vegetable Fibres.

Flax, when viewed under the microscope, as shown in Fig. 40, has the appearance of long grasses or reeds, with bamboo-like joints or nodes, arranged at regular intervals. The cell wall is regular in thickness and leaves a narrow internal channel, which, if visible, appears as a fine dark line. When bleached, flax (*i. e.*, linen fibre) becomes snowy white and lustrous.

Tow yarn, made from the waste in flax spinning, may be distinguished from linen yarn by its uneven, rough and knotty appearance, due to containing particles of shives, from which linen yarn is free.

Jute, if viewed under the microscope, is shown to consist of stiff lustrous and cylindrical fibrils, the walls being irregular in thickness, with a comparatively large central opening. Fig. 41 shows specimens of jute fibres magnified.

RAMIE. These fibres are about twice the breadth of that of cotton, and appear under the microscope as a broad flat ribbon. Ramie fibres in the raw state have a soft, silky feel,

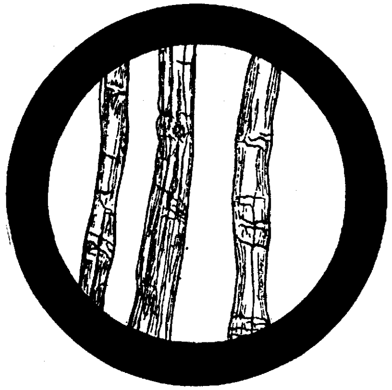


Fig. 40

but by pulling the staple, this quality becomes reduced and gives way to more or less harshness in the feel. Fig. 42 shows specimens of the fibre magnified.

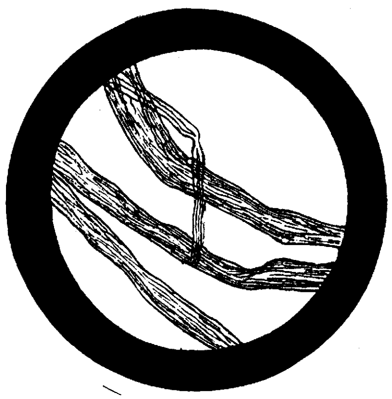


Fig. 41

HEMP. A view of the fibre as seen under the microscope, is given in Fig. 43. It somewhat resembles that of flax, being however coarser and consequently stronger.

Comparing linen threads, principally such as used in heavy stuffs, under the microscope with cotton threads, the former are more or less irregular in their diameter, and in their length

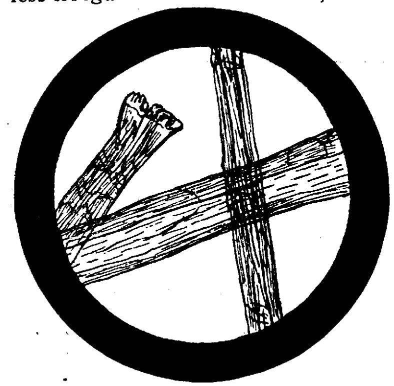


Fig. 42

there are some parts stronger than others, whereas cotton threads are of a more regular character. The difference will be more readily seen in goods that are ironed and where in

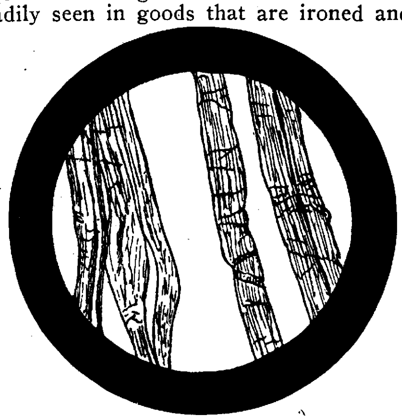


Fig. 43

the fabric, linen threads show larger, *i.e.*, more prominently in some places than in others. A good procedure is to examine the fabrics by holding them up to daylight and when the regularity of cotton threads will be then noticed at once.

Artificial Silks.

These silks during the last ten (or more) years have come in strong competition with the true as well as wild silk fibre, although for a fact are more expensive than the

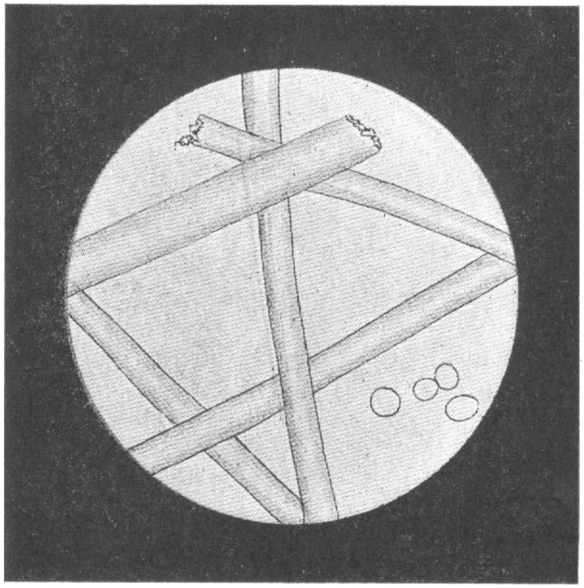


Fig. 44

latter. They are more lustrous than true and wild silk, also stiffer. They do not possess the same smooth feel, being also inferior in strength and elasticity as compared to true silk, neither do they possess the scroop, characteristic to the latter. They can in most cases be detected from true silk, the microscope readily showing their difference in structure. Artificial silks appear under the microscope like a glossy, thin stick, without any structure at all. The most often met with kinds of artificial silk are Chardonnet, Viscose, and Cuprammonium.

CHARDONNET SILK.

Fig. 44 shows specimens of this silk (magnified) giving also cross sections. They are nitro-cellulose prepared from

cotton or wood pulp, which is dissolved under pressure in a mixture of ether and alcohol and the viscous solution forced through small openings. The filaments are spun dry, the solvent evaporating and leaving the nitrated cellulose. Three, four or more filaments are spun together and the

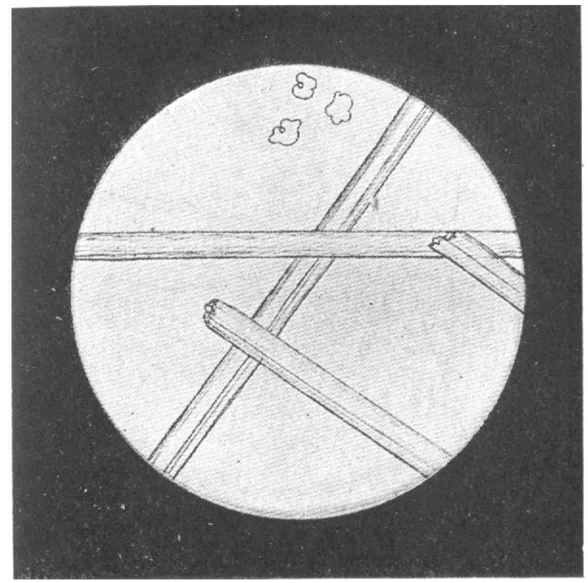


Fig. 45

threads denitrated by immersion in a 5 to 20 per cent solution of ammonium hydro-sulphide, and finally washed, dried, and dyed to any color.

VISCOSE SILK.

In the manufacture of the same, cellulose is treated with strong alkali and carbon bisulphide; the resulting viscose dissolved in water and the solution filtered and forced through jets into a solution of ammonium chloride, which reprecipitates the viscose. Fig. 45 shows specimens of filaments of this silk, magnified, also cross sections of it.

Cuprammonium Silk.

The same is made either by the *Linkmeyer* or the *Thiele* process.

In the first process, the cuprammonium solution of cellulose is coagulated by the addition of a solution of caustic alkali, the threads remaining blue and transparent. The compound is dissociated by water, copper hydroxide being

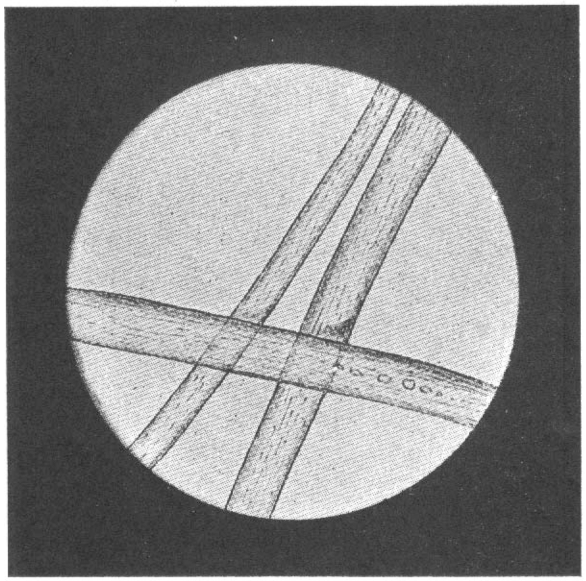


Fig. 46

deposited in the thread. When the copper is removed by treatment with dilute acids, the decolorized threads remain perfectly transparent.

In connection with Thiele's process, a highly concentrated solution of cellulose in cuprammonium solution is passed through wide openings into a vessel containing a substance (*i. e.,* ether) which slowly precipitates the cellulose. The threads are then drawn out to extreme fineness by means of glass rollers revolving in acid.

Fig. 46 shows (magnified) three filaments of cuprammonium silk.

Tests by Burning.

A very simple method of discriminating between fibres of vegetable and animal origin is by the manner in which they burn. Vegetable fibres are composed of carbon, hydrogen and oxygen; silk, in addition, contains nitrogen; and wool, nitrogen and sulphur.

Wool is rather difficult to ignite, the flame is more or less lifeless and the fibre when burnt curls up and forms a bead of burnt matter, and owing to the presence of sulphur gives off a disagreeable odor of burnt horn.

Vegetable fibres burn with a flash, and give off little smell. Cotton burns readily in a free supply of air and leaves little residue; linen does not burn as readily as cotton.

Distinguishing Wool and Cotton.

We can learn a lot regarding the constituents of wool and cotton by viewing the burning, or newly-extinguished, fibres through a microscope. The wool fibre, as it gets hotter through the presence of flame, divides up into a series of bubbles, which become expanded, as shown in the left in Fig. 47, by the contained gas generated by the decomposition. These globes swell considerably, and fuse together, because their exteriors become converted into a kind of melted glue. The fibres curl and bend under the influence of heat, and finally, become masses of tiny, hollow, hard balls much greater in diameter than the original fibres. In reality they are collections of thin-shelled spheres merged together irregularly. Heat drives the sulphurous gas hither and thither in the fibres as bubbles which get enclosed by the melting horny keratin. As the gas expands, the shells do likewise, and eventually become so thin that they break and liberate the offensive gas. The mass is melted and re-melted until all the gas has been driven out, when the spheres fall together as a mere conglomerated mass of charred substance or carbon.

It is noticeable that soon after the flame has been withdrawn from wool fibres, the latter become extinguished, as there is not a sufficient balance of combustible material remaining to allow continued burning on its own account.

A most interesting and effective experiment can easily be made to demonstrate the basic composition of a fabric, say for example a flannel, to ascertain whether it is wool or cotton, thus: Cut off for this purpose a square inch, or less, and lay it between two strips of glass that are tightly bound together with fine wire. It is then placed in front of a clear fire (almost between the bars, say) and within a few minutes, if its constituents are wool fibres, it will change to a deep reddish brown hue—a kind of glue. If it is then magnified, the fibres will be found actually melted and run together to form a bright reddish substance that splits up into flakes or odd pieces. The result is different from that previously described, owing to the absence of flame-generated bubbles. Imagine that you had woven strings of white glue, and that you melted these until they became a cake of substance of the ordinary color—the result will resemble that obtained by heating a piece of all wool fabric in the way described.

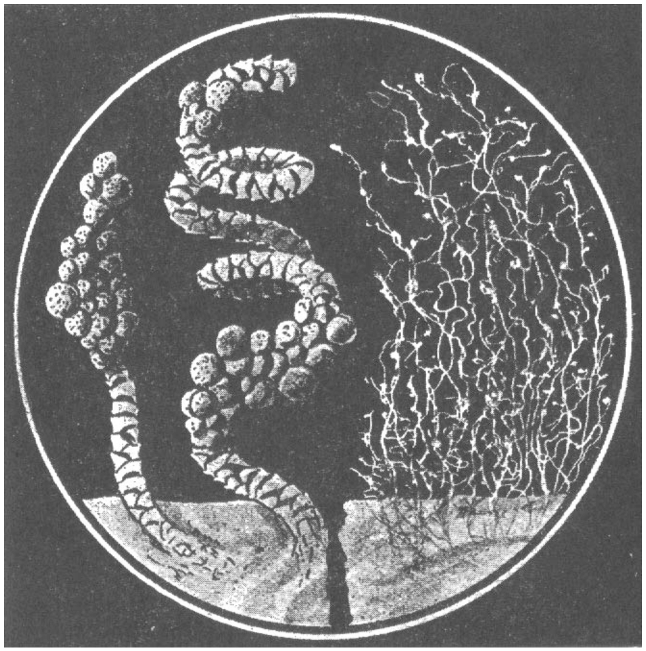


Fig. 47

Upon lighting a piece of cotton flannel, the fibres burn completely away except for a white residue of mineral ash. There is no bubbling or fizzling of material meantime, but simply a steady, or at times a rapid, sustained flame.

When a piece of cotton flannel is then laid between glass and heated by fire in the same way, as described with all wool

flannel, the fibres then will simply shrive to half or quarter their original diameter, and blacken. A kind of juice, which breaks into cakes as it dries, appears around it, but the material does not melt as does the all wool flannel.

If one is very careful while burning a piece of cotton flannel with a flame, a sort of skeleton of the fabric consisting of white ash in the minutest of specks or atoms in strings will remain for a time as shown at the right in Fig. 47. It will, however, fall apart at a mere breath. All vegetable fibres burn similarly.

Distinguishing Cotton and Linen.

To distinguish cotton and linen, used in combination with each other in the construction of a fabric, by the burning process, unravel for this purpose the fabric so as to form a fringe half-an-inch long of both warp and filling. The fringe is then set on fire, and the flame acts differently according to the nature of the material. In a pure linen fabric where both warp and filling fringe has been burned, it will be seen that the flame has also burned the cloth both at the top and the sides. In a fabric similarly treated, but consisting of cotton warp and linen filling, the flame from the linen fringe attacked the cloth, while the cotton fringe burned down to the filling without attacking the fabric.

This difference in the action of the flame is easy to understand. The cotton consists usually of 95 per cent of cellulose, which burns very quickly without giving out sufficient heat to ignite the woven fabric. The linen yarn, on the other hand, is composed of only 75 per cent of cellulose, the remainder being gummy and resinous matter which, when ignited, gives out a much greater quantity of heat, and causes the combustion of the cloth.

Linen and *cotton* threads in one fabric can be also distinguished by tearing. Linen threads are much stronger than cotton and if it is as difficult to tear a fabric warp-way as it is filling-way, it is fairly certain the cloth is pure linen; or at any rate made from only one kind of fibre. After a little practice in tearing cloths, one can distinguish the difference between linen and cotton by the sound of the tear. Linen gives a dull sound, while that caused by tearing cotton is sharper. It will be also noticed that the broken ends of the linen threads have a pearly appearance, the fibres being irregular and lustrous, while the ends of the threads are untwisted, owing to the fibres being so rigid. The ends of the cotton threads, on the other hand, show a cleaner break, and the threads are dull in appearance with the fibres being curled instead of straight.

Silk.

Silk burns in the same manner as wool, but as there is no sulphur present in the fibres, no pronounced smell of horn is evolved. Silk fibres may be distinguished from cotton, linen and other vegetable fibres, by curling up when exposed to a flame, similar to wool.

Weighting of silk is also ascertained by burning the thread. If it is pure silk and properly dyed, it will take fire with some difficulty, and the flame will go out as soon as the fire is withdrawn, in turn leaving a nearly jet black mass, the same as wool. Weighted silk takes fire readily, and once burning, will smoulder, leaving a refuse, retaining the shape of the yarn or fabric tested.

Burning threads of weighted silk will show the following results:

The threads do not burn but only heat up red, *i.e.*, smoulder, leaving a refuse somewhat retaining the shape of the thread.

The threads by burning turn into a spongeous cinder, somewhat like baked coal, showing a heavy curl.

The resulting ashes turn into a curly mass resembling burnt animal matter like hair, horn, etc., and afterwards become very light, crumpling to a powder when touched.

Fig. 48 shows a fabric, metal weighted, showing that it does not burn readily but heats red hot and retains its straight form. The portion of the fabric exposed to the fire has retained considerable of its original texture.

Fig. 49 shows a heavily weighted sample of silk, clearly indicated by the cinder-charred end, *i.e.*, by the blisters appearing in long form from top to bottom, or left to right. If blisters boil we have a sure sign of sugar weighting, which, however now is only little used. Sugar weighting may be detected by chewing and when the taste will indicate whether this is the case or not.

Fig. 50 shows a heavily sugar weighted silk fabric, from which sugar bubbles were oozing during the fire test.

If, while burning, the silk fabric reaches a red heat and blisters appear simultaneously, the same as a rule indicates that the sample was weighted with metal and tannic acid.

If the ash left after burning a weighted sample on a porcelain plate forms more than one per cent of the original weight, the silk has been loaded. If the ash is brown in color, it indicates iron; if white, and is turned brown by the application of sulphide of ammonia, tin is indicated; while brownish-black indicates lead.

Iron weighting is always used for black silk; tin, tannin, and albuminoids for white and light colors; and lead, in conjunction with iron, for black, or separately for light colors.

It is evident, however, that the burning test can only be employed for material in bulk, and is of less value in determining the fibre constituents of a mix in yarns or fabrics.

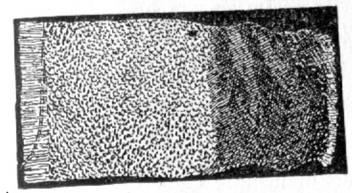


Fig. 48

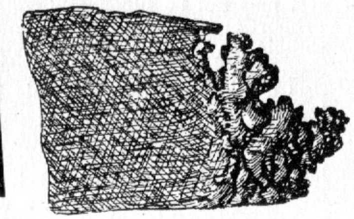


Fig. 50

Artificial silk may be distinguished from true silk by its inferior strength and elasticity, also by its greater inflammability.

Distinguishing Artificial from True Silk.

Artificial silk has become a most important textile fibre and is extensively used, and, for a fact, the demand for it is greater than the supply. It is readily distinguished from

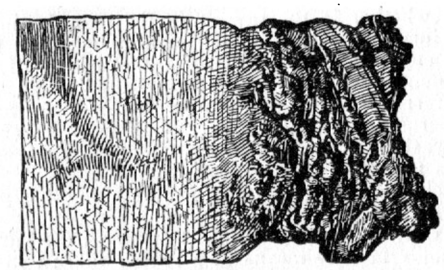


Fig. 49

true silk by its shining bright lustre, as well as that it possesses less elasticity than true silk. It cannot stand as much tensile strain as does true silk, the former breaking more readily.

Combustion, *i.e.*, burning is another good test; true silk, being an animal product burns much slower than the artificial product.

Wetting artificial silk threads makes them very tender, whereas true silk retains its strength.

Chemical Tests.

By microscopic examination the nature of materials used, or to be used, in the manufacture of yarns or fabrics, can be in most cases ascertained; however in some instances this test may not be sufficiently conclusive, again the quantity and proportions in which two or more materials are present in a sample may have to be ascertained, and when then the microscope is of no value.

Chemical reaction not only indicates the type of material, but may also be employed to ascertain the proportion in which different materials are present.

Since all vegetable fibres are of practically the same chemical composition (cellulose) it is very difficult to obtain, by means of a chemical agent, a distinguishing color or feature in one fibre which the same agent does not impart in some degree to the other. Therefore, before any reliable results can be obtained the application of some knowledge and experience of chemistry is essential.

Practically, all fibres employed in the manufacture of yarns or fabrics are either of vegetable or animal origin, hence the chemical reagents used as solvents for fibres can be divided into two distinct classes:

(*a*) Those employed as solvents for animal fibres.

(*b*) Those employed as solvents for vegetable fibres.

Fibres, whether in the raw or in the manufactured state, are often incrusted with some extraneous material (oil, size, glue, dye, etc.) which prevents the direct action of chemical reagents upon them, necessitating (the same as was previously referred to when preparing yarns or fibres for testing by the microscope) a preliminary soaking in ether or benzine, or washing in soap and water, so as to remove this extraneous matter.

These chemical tests can be done at a small expense, requiring a Bunsen gas burner, supplied with a heavy cast-iron foot, into which is screwed a tube to connect the burner with the gas supply pipe by means of a rubber tube; two or three porcelain crucibles, large enough to contain about one gill of solution; a tripod stand with iron wire gauze to support the crucible; a few watch glasses and test tubes, and a graduated vessel for measuring liquids. The chemicals can be obtained at any required strength, and should be kept in glass-stoppered bottles.

A Few Chemical Tests for Cotton, Wool and Silk.

A comparison of animal and vegetable fibres shows that, chemically, they are composed of entirely different substances.

Animal fibres are of a gelatinous nature, while the base of all vegetable fibres is cellulose.

Caustic Soda or Caustic Potash.

On account of this difference in the chemical composition of the fibres, the chemical reagents, employed in testing these two classes of fibre, also differ. Thus, vegetable fibres are insoluble when boiled with caustic soda or caustic potash, whereas animal fibres are soluble, wool dissolving in a cold solution, whereas silk is unaffected when the solution is cold but is dissolved when hot.

Sulphuric Acid.

Sulphuric acid, even when dilute, readily dissolves vegetable fibres, while a concentrated solution has little effect on animal fibres (wool as well as silk) unless at a very high temperature.

Hot concentrated sulphuric acid gradually dissolves animal fibres (wool and silk) with brown coloration.

Hydrochloric acid, if concentrated, dissolves both silk and wool, but, if applied diluted, silk dissolves, while wool is insoluble.

Alcoholic Solution of Naphthol and Sulphuric Acid.

Cellulose, the chief constituent of vegetable fibres, when treated with acids, is partly changed into sugar, giving it the property of producing fine colorings with an alcoholic solution of naphthol and sulphuric acid. This characteristic can be made use of to detect animal from vegetable fibres, thus: Prepare the sample to be tested by boiling it several times in water so as to remove any size, etc., adhering to it, also remove any vegetable impurities, such as burrs, etc. Add several drops of an alcoholic solution of naphthol to 1 c.c. of water, and increase this liquid by its own volume of concentrated sulphuric acid.

Immerse the sample in this solution, then, if any vegetable fibres are present, they are dissolved, and the liquid, after shaking, is colored deep violet; if the sample consists only of animal fibres the liquid is colored a more or less intense yellow, leaning in some instances towards a brown. Since the same result is obtained whether the fibres are dyed or undyed, the presence of vegetable fibres, either in yarn or cloth, can be readily detected by this test.

The degree of solubility of the fibres also determines, to some extent, their character; thus, if the color of the liquid indicates that only animal fibres are present, silk dissolves rapidly, wool is not dissolved at all; if vegetable fibres are shown to be present, an incomplete solution indicates that wool is present, while a complete solution may be obtained though silk is present.

Zinc Chloride with Zinc Oxide.

A boiling solution of basic zinc chloride (at 130 deg. Tw., or 1.65 sp. gr., obtained by dissolving 100 grams of dry zinc chloride in 85 c.c. of distilled water, and adding 4 grams of zinc oxide) dissolves silk, while wool and vegetable fibres are insoluble.

This solution can also be used to detect *true* silk from *tussah* or wild silk, by noting the length of time required to dissolve the respective fibres. True silk dissolves rapidly, whereas tussah silk dissolves only after a longer immersion.

Chromic Acid.

A saturated solution of chromic acid, diluted with an equal bulk of water, dissolves wool and true silk if boiled for one minute, while tussah silk and adulterated silk are barely attacked, even when boiled for from two to three minutes.

Tests thus far given for distinguishing cotton, wool and silk fibres from each other are those most often used, others are:

Ammoniacal Copper Hydrate.

Cotton: Dissolves slowly when cold.
Wool: No effect when cold.
Silk: No effect when cold.

The ammoniacal copper hydrate solution, and which thus distinguishes cotton from wool or silk, or both, is prepared as follows: A solution of copper sulphate is precipitated by caustic soda in the presence of ammonium chloride (sal ammoniac). The precipitate is filtered and well washed. If this precipitate is required to be kept, it must be stored under water. The ammoniacal copper solution is prepared from this precipitate by adding an excess of ammonia until it is completely dissolved, a deep blue solution being thus obtained.

Sodium Plumbite.

Cotton: No effect.
Wool: Turns the latter black, owing to presence of sulphur in the fibre.
Silk: No effect.

The sodium plumbite, which recognizes wool from cotton or silk, or both, is made by heating lead oxide (litharge) with a solution of caustic soda. In doing so, care must be taken to shake the tube vigorously in order to prevent the settling of the heavy lead oxide resulting in the breaking of the tube. After boiling for a minute or two (longer is unnecessary) decant the clear liquor and with it test the fibre. If no blackening occurs cold, then heat, and if still no blackening, wool must be absent.

Copper in Alkaline Solution with Glycerine.

Cotton: No effect.
Wool: No effect.
Silk: Dissolves.

The alkaline solution of copper containing glycerine, and which detects silk from cotton or wool, or both, is prepared by dissolving 10 grams of copper sulphate in 100 grams of water, adding 5 grams of pure glycerine and then enough caustic potash solution to re-dissolve the precipitate first formed.

Madder Tincture.

Cotton: Colors yellow.
Wool: No effect.
Silk: No effect.

Madder tincture is obtained by extracting 1 gram of ground madder with 50 c.c. of alcohol and filtering from undissolved matter.

Fuchsine Solution Magenta.

Cotton: No effect.
Wool: Colors red.
Silk: Colors red.

Fuchsine solution is obtained by dissolving 1 gram of fuchsine (magenta) in 100 c.c. of water, then add caustic soda solution drop by drop until the fuchsine solution is discolorized: filter and preserve in a well-stoppered bottle. In applying the test with this reagent the mixed fibres are treated with the hot solution, then well rinsed, when the animal fibres will be dyed red and the vegetable fibres remain colorless.

Nitric Acid.

Cotton: No effect.
Wool: Colors yellow and dissolves slowly.
Silk: Colors yellow and dissolves rapidly.

Distinguishing Shoddy from New Wool.

Shoddy, Mungo or Extract mixed with new wool is hard to be distinguished in yarns and fabrics. The best test is to boil a sample in dilute hydrochloric acid, which, by removing the dyestuff and dressing from the yarn or fabric, will show if the individual fibres have been previously dyed. Provided the color of the fibres is not uniform, it may be assumed that the material consists of re-manufactured fibres; also under the microscope the latter fibres will appear torn, with the scales partly or entirely removed or very much damaged (more particularly if referring to mungo or extract).

On account of the high cost of silk and the fact that some of the silks, more particularly those from China, are at times found to be adulterated with quantities of fat, the examination of raw silk may in some instances be found very desirable. The commercial value of such an examination will be easily realized when it is stated that we are informed that lately a lot of silk thus examined was found to contain 9 per cent of fat in place of the 1 to 2 per cent usually met with in raw silk.

A typical analysis of a white mulberry silk is thus:

Water	11.00	per cent
Salts	0.30	" "
Wax and Fat	1.36	" "
Sericin	22.01	" "
Fibroin	76.20	" "
Ash of Fibroin	0.09	" "

Moisture is determined in the raw silk by drying a weighted sample at 105 deg. C. to constant weight.

Salts soluble in water, and which the silk contains, are ascertained by steeping a weighted portion of the dried silk sample for half an hour in water, at a temperature of 50 deg. C. It is then rinsed in warm water, dried at 105 deg. C. and reweighted, the difference, *i. e.*, loss in weight giving us the amount of salts present.

For the purpose of obtaining the percentage of *Wax* and *Fat*, the sample left from the previous test, and of which the weight is known, is then extracted for about 5 hours in a Soxhlet apparatus with ethyl-ether, or with C. P. benzene. The solvent in the flask is then evaporated by a current of warm air on a steam bath and the residue in the flask weighted. The difference between this weight and the original weight of the flask with its contents indicates the amount of wax and fat the sample contains.

In order to ascertain the amount of *Sericin* the sample contains, the silk residue, after the salt test has been made and the weight marked down, is now boiled-off in a bath containing 10 grams of perfectly neutral olive oil soap per liter of distilled water. After boiling for one hour the sample is washed in distilled water and dried at 105 deg. C., and weighed. The difference in the two weighings represents the amount (per cent) of silk gum or sericin the silk contains.

The residue left after all the tests quoted have been made, then means almost pure *Fibroin*, the percentage obtained varying from 70 in Canton and 76 in Italian silk to 84 in Japan silk.

Tests for True Silk.

Silk is dissolved by strong alkalies, whereas dilute alkalies, although affecting it, do not dissolve it. Ammonia has no action on silk; the latter also dissolves with difficulty in soda and potash solutions Schweitzer's solution dissolves silk just as it does cotton. Sugar and sulphuric acid dissolves silk with a rose-red coloration (albium reaction) and hydrochloric acid with a violet coloration. When submitted to the action of nitric acid, silk turns yellow.

A concentrated solution of zinc chloride, 138 deg. *Tw.* (sp. gr. 1.69), made neutral, or boiled with excess of zinc oxide will dissolve silk slowly provided the solution is cold, but rapidly if heated, in turn forming a thickened gummy liquid.

Other solvents for true silk are: ammoniacal copper oxide, ammoniacal nickel oxide and caustic potash or soda, it (the silk) being precipitated on adding water.

To Distinguish True from Wild Silk.

Wild silk of commerce, frequently called tussah (although this is only the name of the most prominently known variety of wild silks) is less reactive chemically than true silk.

Alkaline solution of copper hydrate in glycerine: Will scarcely affect wild silk, whereas true silk is readily dissolved by it.

Hot 10 per cent sodium hydroxide solution: Dissolves true silk in 12 minutes, whereas it takes 50 minutes for dissolving wild silk.

Cold HCl (sp. gr. 1.16): Dissolves true silk very rapidly, whereas wild silk is only partly dissolved in 48 hours.

Neutral $ZnCl_2$ solution (sp. gr. 1.725): Dissolves true silk very rapidly whereas wild silk dissolves slowly. This test was previously referred to in connection with testing for wool, cotton and silk.

Strong chromic acid solution: Dissolves true silk very rapidly, whereas wild silk dissolves very slowly.

Distinction Between Artificial Silks.

In outward appearance the different kinds of artificial silks are so nearly alike as to be indistinguishable, even a microscopical examination is liable to error no matter how well acquainted the observer is with the magnified characters of artificial silks.

In all cases of artificial silk, there is no test which gives a quick, definite reaction which is unmistakable, and the reason why it is so difficult to find distinguishing reactions, is that the different artificial silks behave differently within themselves to the same reagent.

Mechanical colorations are unreliable, as in making several tests of different samples of the same class of silk, the colors often differ very widely in intensity. Diphenylamine gives good results for detecting cellulose, but the strength of the fibres frequently varies greatly in different lots, some being capable of standing three times the treatment of others, hence chemical tests must be made with care.

To Distinguish Artificial Silks from each other, and from True Silk.

With reference to distinguishing the various kinds of artificial silk (Cellulose, Collodion, and Gelatin) among each other and against true silk, the following data will explain subject:

Water: No action on true silk; all artificial silks swell.

Diphenylamin in Sulphuric Acid: No action on true silk; collodion silk changes slowly to a blue, the other artificial silks do not change.

Schweitzer's Reagent: Dissolves true silk; cellulose silk swells slowly, collodion silk swells and dissolves, whereas gelatin silk changes to a violet but does not dissolve.

Iodine in Sulphuric Acid: Imparts to true silk a yellow coloration; cellulose and collodion silks are turned to a pure blue, whereas gelatin silk becomes brownish-yellow.

Chlor-iodide of Zinc: Imparts to true silk a yellow coloration; cellulose silk is turned to a grey blue, collodion silk is turned to a blue violet, whereas gelatin silk becomes yellow.

Vetillard's Reagent: Imparts to true silk a yellow coloration; cellulose silk does not become colored; collodion silk changes to a reddish-blue, becoming grey on washing, whereas gelatin silk turns red, which vanishes on washing.

Caustic Potash 40%: Dissolves true silk on boiling; cellulose silk swells but does not dissolve and turns yellow in color; collodion silk swells but does not dissolve, whereas gelatin silk dissolves rapidly.

Chromic Acid: Dissolves true silk very slowly, whereas it dissolves all artificial silks rapidly.

Conc. Sulphuric Acid: Has little action on true silk; cellulose silk becomes transparent and dissolves slowly; collodion silk dissolves rapidly, whereas gelatin silk dissolves slowly when heated.

Acetic Acid: Dissolves true silk; cellulose and collodion silks swell slowly, whereas gelatin silk dissolves completely when heated.

Alcohol: No action on true silk; the fibres of all artificial silks contract.

Conc. Hydrochloric Acid: Has little action on true, cellulose and collodion silks, but dissolves gelatin silk rapidly.

To Distinguish Silk, Cotton and Wool.

To Distinguish Silk from Cotton.

Silk can be distinguished from cotton by alkalinizing a solution of fuchsine, adding drop by drop a liquor of potash or caustic soda. The moment the liquor gets discolored, the threads to be tested are immersed and lifted after half an hour and carefully washed. Under this treatment silk fibres become red, whereas cotton fibres remain colorless.

To Separate Silk, Cotton and Wool.

To separate silk, cotton and wool in a sample containing these three fibres, remove first size and dye, and in turn treat the sample with ammoniacal nickel oxide, which dissolves the silk at once. The cotton in turn is then dissolved from the remaining portion of the sample by means of ammoniacal copper oxide, leaving the wool behind.

In connection with another test the sample is then boiled in an aqueous solution containing 10 per cent of hydrate of soda, and when wool and silk will dissolve, while the vegetable fibres remain unacted upon. The whole is then thrown upon a cotton filter, and the undissolved matter washed with hot water and afterwards acidulated with 5 per cent of hydrochloric acid, to which, if the residue is black or dark colored, a few drops of chlorine water are added.

Meantime, the original alkaline filtrate can be tested for wool with acetate of lead. If a white precipitate is formed, which dissolves on stirring, silk alone is present. A black precipitate indicates wool. The nitro-prusside of sodium gives a violet color if wool is present.

If the tissue is deeply colored it may be cut up and steeped for from fifteen to twenty minutes in a mixture of two measures of concentrated sulphuric and one of fuming nitric acid. Wool, silk and coloring matters are destroyed, while the cellulose is converted into gun-cotton.

White and pale mixed tissues may be tested by their affinity for colors. They must be cleansed and rinsed thoroughly in water to remove starch and similar dressings; soaked for ten minutes at 50 to 60 deg. C. in water containing 2 per cent of sulphuric acid, and washed again. In the meantime the color bath must be prepared by dissolving a few decigrammes of magenta in 28 to 30 cubic centimeters of water, and heated to boiling. During ebullition, caustic soda must be added to it drop by drop, till a pale rose color only remains in the liquid. The liquid must be removed from the fire, and the sample immersed in it for some minutes, after which it must be removed and dried. Silk and wool are dyed by this treatment, while the vegetable fibres remain colorless.

Wool may be detected in silk by the presence of sulphur. If it is immersed for a time in a plumbate of soda prepared by dissolving lead hydroxide in caustic soda, the silk will be colorless and the wool black; or a piece of the tissue 2 centimeters square may be boiled in 10 to 12 cubic centimeters of Schweitzer's solution. In from five to ten minutes the silk will be dissolved. If the silk is black, double the volume of Schweitzer's solution should be added, and the mixture soaked from ten to twelve minutes. The undissolved wool should be then removed and the liquid quickly neutralized with nitric acid. Silk will remain in solution, while cellulose will be precipitated.

Hydrochloric acid is a solvent of silk, while it leaves wool and cotton unacted upon for a lengthened period.

To Ascertain the Percentage of Silk, Cotton and Wool.

Two samples (each weighing 2 grams) are for this test dried, weighed and boiled for a quarter to half an hour, in 200 c.c. of 3 deg. B. Hydrochloric acid, to remove the size and dye, and are then thoroughly washed and pressed.

One sample is then immersed for a short time in a boiling solution of basic zinc chloride, then washed thoroughly, first in acidified, afterwards in clean water, then dried and weighed, the difference in weight giving the amount of silk.

The second sample is then boiled for fifteen minutes in 60 to 80 c.c. of caustic soda (sp. gr. 1.02), and then washed, dried, and weighed, the difference in weight representing the proportion of wool. The residue is cotton, the dry weight of which must be augmented by about 5 per cent to compensate for the corrosion of the fibre during the operation.

To Separate True Silk, Wild Silk, Wool and Cotton.

To separate true silk, wild silk, wool and cotton in a sample, have the latter first acted on by boiling half a minute with concentrated hydrochloric acid, which immediately dissolves the true silk, the wild silk being dissolved at the end of two minutes further boiling. On treating the remainder of the sample with hot caustic potash, the wool will then be dissolved and the cotton left.

To Ascertain Weighting of Silk.

It is often necessary that the amount of loading material in connection with weighted silk has to be estimated, and as there are now so many different methods of adding weight, the task of finding the correct method and percentage is by no means easy.

With colored silks the weighting bodies are tin, phosphoric acid, silica, alumina, lead, antimony, tannin, tungsten, glue, etc.

Blacks may contain tin, phosphoric acid, silica, oxide of iron, cyanide of iron, lead, antimony, etc.

White Silk.

To determine quickly whether white silk is weighted with tin or alumina, a sample is dyed with alizarine with the addition of chalk, and this sample is compared with standards of which the degree of weighting is known. With pure silk the color is a light rose; if weighted with tin it is colored orange; if weighted with alumina it is colored red, and if weighted with a mixture of tin and alumina it is colored a bluish red. Weighting by tannic acid is indicated if by treating with ferrous salt the color turns black.

As weighting bodies are very difficult to strip completely from the silk fibre, the most accurate method is to estimate the amount of nitrogen by decomposing the fibre, one part of nitrogen by weight being equal to 5.455 parts of fibroin or pure silk. Of course, such weighting bodies as contain nitrogen must first be eliminated before the test is made; these bodies are phosphate of ammonia, glue, Prussian blue, etc.

Colored Silks.

The weighting in colored silks can be determined by the following process: A sample from 15 to 30 grams is weighed and boiled for two hours in a solution of soap of 4 ounces to the gallon, which should remove all grit and as far as possible the coloring materials. It is now treated to a boiling solution of carbonate of soda at a strength of 1½ deg. B. to eliminate the ammoniacal salts, after which the sample is washed and dried, and is then ready for the determination of nitrogen. To effect this, the sample is treated for 4 to 6 hours in 1 to 1½ ounces of hot concentrated sulphuric acid, to which has been added a small quantity of anhydrous copper sulphate, the process being stopped when the color of the solution becomes green. The heat is now cut off, and permanganate of potash added until the liquid becomes an intense green, when it is then diluted with water and left to cool. The liquor is now transferred to either a flask or a retort and made alkaline with caustic soda, when on being heated, the nitrogen distills over in the shape of ammonia, which is received in a vessel containing a known quantity of normal sulphuric acid. It now only remains to determine the amount of unneutralized acid, which shows the amount which combined with the ammonia, and this in its turn shows how much ammonia was given off and therefore nitrogen in proportion.

Black Silk.

For determining the weighting of black, a sample of dry silk weighing 15 grains is taken for the test. It is treated in a one per cent solution of hydrochloric acid, heated to 60 deg. C. The solution turns a more or less intense red. The sample is removed and the treatment repeated until the solution turns only a faint rose color. The sample is then washed and left to steep in a solution of Prussian blue and iron salts. The sample is now treated for one hour and a half in 50 ounces of a boiling solution of soap, containing 4 ounces of soap per gallon; then thoroughly washed and dried. The nitrogen is then determined as in the previous test.

Mineral matter, if such is used in the weighting of silk, may also be looked for in the ash, *i. e.,* ascertain if the latter contains either silica, tin, alumina, phosphoric acid, etc.

For this purpose mix the powdered ash with fluorspar and conc. sulphuric acid. Warm gently and detect the escaping silicon fluoride by means of a drop of water held in platinum loop. Now treat the ash several times with hot conc. hydrochloric acid and dilute the whole with water, passing in turn hydrogen sulphide through a portion of it, and when tin is then thrown down as a yellow stannic sulphide.

Add ammonium molybdate to another portion of it, and when a *yellow* precipitate indicates phosphoric acid.

Add ammonium hydrate to another portion of it, and when a *white* gelatinous precipitate indicates alumina.

Calculations as to Percentages of Weighting Silk.

The weighting on a black silk may vary from zero to 250 per cent. Thus if 100 pounds of raw silk yield 75 pounds of boiled-off silk, the dyer must add 25 pounds of weighting in order that he can return 100 pounds to the mill. If now the mill requests that the silk be weighted 50 per cent, the dyer applies an additional 50 pounds of weighting, making a total of 150 pounds. From this we see that a weighting of 50 per cent may actually represent a silk containing $(25 + 50 =)$ 75 pounds of foreign matter in each 150 pounds of dyed silk.

Example: Ascertain weight of dyed (and weighted) silk the dyer has to deliver to the mill which has sent him 100 pounds of raw silk and wants 50 per cent weighting; the silk to lose 25 per cent in the boil-off. (Permissible moisture 11 per cent not taken into consideration.)

To find the weight of the finished goods:

$$100 + (100 \times 0.50) = 150 \text{ (pounds)}$$

To find the weight of the fibroin in the raw silk:

$$100 - (100 \times 0.25) = 75 \text{ (pounds)}$$

To find the percentage of fibroin in the finished goods:

$$100 \times \frac{100 - (100 \times 0.25)}{100 + (100 \times 0.50)} = 50 \text{ per cent.}$$

To find the percentage of weighting in the finished goods:

$$100 - 50 = 50 \text{ per cent.}$$

The weighting of silk is indicated by stating the ounces of weighting which have been added to each pound of raw silk. The charge or quantity of weighting material which silk takes up can be easily regulated by the dyer; it has become a trade custom to allow a variation of two ounces.

For example, if we speak of 24/26 weighting it is understood that 16 ounces of raw silk have been loaded until the weight has reached approximately 25 ounces. Such a weighting is known as 50 per cent above par, *i. e.,* 24 ounces represent an increase $(16 + 8)$ of one-half more, or 50 per cent above 16 ounces.

The results of the chemical analysis will show the amount of actual silk fibre present.

From this the amount of weighting is calculated by difference and reported in ounces per pound. This can be done with the aid of the following table:

Per cent Weighting.	Ounces.	Per cent Weighting.	Ounces.
0-13	12/14	125-142	28/30
13-29	14/16	142-158	30/32
29-45	16/18	158-174	32/34
45-61	18/20	174-190	34/36
61-77	20/22	190-206	36/38
77-93	22/24	206-222	38/40
93-109	24/26	222-238	40/42
109-125	26/28	238-254	42/44

To illustrate the use of the table let us consider we have submitted to us a sample of weighted silk, that dried at 105 deg. C. weighed 0.50 grams. After the weighting was removed and the remaining fibroin dried at 105 deg. C. it weighed 0.30 grams.

Question: Ascertain percentage of weighting.

Weighted silk = 0.50 grams
Fibroin = 0.30 grams

Weighting = 0.20 grams

$$\frac{0.20 \times 100}{0.30} = 66.66 + \textit{ i. e., } 67 \text{ per cent weighting was done.}$$

Consulting table we see that this corresponds to 20/22 ounces, *i. e.,* an average of 21 ounces. These 21 ounces of weighted silk represent 16 ounces of raw (unweighted) silk, or 12 ounces of pure (fibroin, or boiled-off) silk, and by subtraction we find that 21 ounces of the commercial silk contain (21 — 12 =) 9 ounces of foreign matter.

Scroop of Silk.

Scroop is the peculiar crackling sound which silk emits when rubbed or compressed. As a matter of fact, however, scroop is not a natural property of silk, but is the result of passing the silk, after having been deprived of its natural gum, through a bath containing a small percentage of some acid, preferably tartaric acid, although many silk dyers and finishers prefer to use commercial lime juice, claiming that the results obtained from the use of the latter substance are more lasting.

No satisfactory explanation has as yet been given as to the cause of this peculiar rustling sound emitted from silk so treated, but the assumption is that the surface of the silk fibres are somewhat roughened by the acid and that the noise is due to the increased friction upon the application of pressure. It is certain, however, that the acid present is responsible for the peculiar sound. One ounce of tartaric acid dissolved in one gallon of water is found to be a good strength to work with. The silk is simply immersed in the bath for a short time in the cold, then lift, drain, wrap in cotton cloths and whizz or squeeze on the peg. The silk is not subjected to any further treatment.

The scrooping of weighted silks is always the last operation.

Processes have been devised for the purpose of imparting a scroop to mercerized cotton, and this with some measure of success.

Wool acquires a similar property when treated with a solution of a caustic alkali, apparently through its surface being hardened in the same way as that of silk, by acids.

Distinguishing Vegetable Fibres.

Vegetable fibres are soluble in sulphuric acid; this fact is taken advantage of in the operation of carbonizing wool for the removal of vegetable matter.

The action of iodine and sulphuric acid serves to some extent to distinguish the fibres. Cotton, linen, and China grass are stained blue; hemp a bluish green or dirty yellow, and jute a dark yellow.

To Distinguish Cotton and Linen Threads.

(1) An alcoholic solution of fuchsine (1 gram fuchsine in 100 c.c. of alcohol) stains linen and cotton red, but if the fibres are then steeped for three minutes in ammonia the cotton is decolorized, while linen has a permanent rose red color.

(2) By immersing a sample in a boiling mixture of equal parts of hydrate of potassium and water, and allowing to dry, flax turns a deep yellow, cotton becomes white or pale yellow.

(3) Macerate a small piece of the material in a tepid alcoholic solution of the dyestuff cyanine; wash free from excess of the dyestuff with water, then immerse in dilute sulphuric acid. Cotton is completely decolorized by this treatment, but the linen fibres retain the blue tint. If the material is then washed with water, and immersed in a solution of ammonia the color of the flax fibres is intensified.

(4) Treat the sample submitted with a solution of caustic potash (1 : 6). The flax will become more curly than the cotton, and the latter finally turns grayish white, whereas the flax is dyed orange.

(5) Treat the sample with a stronger solution of caustic potash (1 : 2) and boil for two minutes, then wash and dry between blotting paper; flax becomes of a deep yellow color, compared to the cotton which assumes a whitish or straw color.

(6) Boil the sample in water and then steep it in concentrated sulphuric acid for two minutes, when the cotton is dissolved while the flax remains white and unaltered, and can be separated by washing with a weak solution of caustic potash.

(7) Steep the sample in a solution of magenta in spirit, and after rinsing, dip in a bath of ammonium chloride. Flax will retain a pink color, while the cotton becomes colorless.

To Distinguish Jute from Hemp.

Aniline sulphate stains jute a dark yellow, while concentrated nitric acid gives a red-brown stain, distinguishing it from hemp, which is turned yellow.

To Distinguish Jute from Flax.

When treated with dilute chromic acid, to which a little hydrochloric acid has been added, jute turns blue, while iodine and sulphuric acid produce a dark yellow stain, which may be used to distinguish jute from flax.

In connection with another test, moisten the fibres, yarn or fabric, as the case may be, with an acidulated alcoholic solution of phloroglucine. Jute will stain an intense reddish-brown whereas flax will remain practically unchanged; a slight yellowing may be noticed. The stain is not permanent—therefore a lighter color will result in the course of time.

To Distinguish Jute from Flax or Hemp.

The threads are placed in a solution of nitric acid and a little potassium chromate and warmed, then washed, and introduced into warm alkaline water, and washed again; when the water is evaporated from the slide, a drop of glycerine is added, and after a short time the characteristic structure of the jute will be seen, under the microscope, if jute is present.

Jute can be distinguished from flax or hemp also by the following test: Soak the threads in a solution of bleaching powder, then add hydrochloric acid, which bleaches the threads, and an effervescence takes place. Wash the threads in water, then dry, and afterwards immerse them in ammonia. Jute is dyed a deep and pure blood-red color, linen and hemp take a pinkish yellow color. Both colors soon fade, leaving a dirty green.

Another test to distinguish whether a fabric is linen, hemp or jute is thus: Spill upon the cloth muriatic acid and wash several times in clear water to purify, and then spill ammonia over; if linen it will become a gray-brown, if hemp it will turn pink, and if jute blood-red.

Ramie is stained a purple by sulphuric acid and iodine, but aniline sulphate gives no coloration.

Hemp: Iodine and sulphuric acid stain hemp a greenish yellow with a mottled appearance, while Schweitzer's reagent, beyond causing the fibres to swell, has no further action.

Hydrochloric acid and caustic soda give a brown color to hemp, and sulphuric acid gradually dissolves it.

To Distinguish Mercerized from Untreated Cotton.

According to *Lange,* prepare a reagent by dissolving one part by weight of iodine in a solution of 30 parts of pure zinc chloride and 5 parts of pure potassium iodide in 14 parts of water. Pour off (for use) the clear brown liquid which collects above a sediment of undissolved iodine, and which will turn blue both the mercerized and the untreated cotton, with the difference that with mercerized cotton such color is fast to water, but which is not the case with untreated cotton.

According to *Hubner,* steep the cotton for a few seconds in a solution of 20 grammes of iodine in 100 c.c. of a saturated solution of potassium iodide, and then wash it with water, and when untreated cotton becomes nearly white again, whereas mercerized cotton retains the blue-black color which fades very slowly on long washing.

Another test is to dye the cotton with 100 c.c. of a solution of 280 grammes of zinc chloride in 300 c.c. of water, adding to it just before use 10 c.c. of a solution of one gramme of iodine and 20 of potassium iodide in 100 c.c. of water. The cotton to be tested is wetted out, pressed between two filter papers and then dyed; with the result that mercerized cotton will take a dark blue color, untreated cotton remaining white.

Knecht finds that untreated cotton dyed with benzopurpurine becomes blue on the addition of hydrochloric acid, while mercerized cotton is changed to reddish-violet. By adding titanous chloride solution to the liquids from a burette, untreated cotton appears indigo blue and mercerized cotton red at the stage immediately before decolorization, provided caustic soda stronger than 30 deg. Tw. has been used without tension, or 35 deg. Tw. with tension. Cotton that has been treated with nitric acid of 83 deg. Tw. also gives this reaction.

Knaggs advises the following test: Dilute 5 c.c. of a solution of benzopurpurine 4 B in 10,000 times its weight of water to 100 c.c., and dye the cotton with the solution at the boil. On then adding 2 c.c. of strong hydrochloric acid, mercerized cotton becomes red, whereas untreated cotton takes a blue-black.

David, depending upon the fact that a second mercerization does not further increase the affinity of the cotton for dye, stretches the yarn or fabric to be tested, wetting one portion of it with caustic soda lye of 40 deg. B.; another portion of the material with the same lye previously diluted with its own weight of water, and a third portion of the material to be tested with the same lye diluted with twice its own weight of water. The goods are then rinsed, soured, again rinsed and dyed with a substantive dye, under tension the whole time. If both mercerized and untreated cotton are present, the three portions of the material will show differences in tint, whereas if the whole of the cotton has been mercerized, no change in shade will be seen.

To Distinguish Mercerized Cotton from Silk.

Treat fibres to be tested with a solution of iodine in zinc chloride, and when mercerized cotton takes a blue tint, which changes to a blacker tint, according to the degree of mercerization, while under the same condition silk is dyed a yellow or yellowish-brown.

Polished Cotton.

Cotton thread with a glazed surface is prepared by sizing the material and polishing it in a brushing machine. The fibres of cotton treated in this way appear like those of ordinary cotton under the microscope, but the foreign matter may be observed. A commercial sample of polished cotton examined gave the following results: Moisture, 7.63; ash, 0.21; and "sizing," 1.86 per cent.

Chemical Examination of Vegetable Fibres.

The following scheme of examination devised by *Cross, Bevan* and *King,* forms the basis of most modern chemical methods of judging of the value of vegetable fibres.

Moisture: The loss in weight at 110 deg. C. gives the amount of hygroscopic moisture. About 1 per cent of this moisture may be retained at 100 deg. C.

Ash: The residue left on ignition of a weighed quantity. The proportion is relatively low in lignocelluloses; higher in pectocelluloses.

Hydrolysis (a): Loss in weight (calculated upon the dry substance) when 5 grms. of the fibre are boiled for five minutes with a 1 per cent solution of sodium hydroxide. It indicates the "solvent action" of the alkali.

Hydrolysis (β) : Represents the loss in weight after boiling the fibre for 1 hour with the alkali solution, and indicates the degree of the "degrading action" of the alkali. The results will give an idea of the degree of resistance that would be offered by the fibre to bleaching processes, and to the action of alkalis such as are used in the laundry.

Cellulose: This is determined by separation of the non-cellulose constituents by treatment with chlorine and subsequently with sodium sulphite solution.

Mercerization: Loss of weight on treating the fibre with a cold 33 per cent solution of potassium hydroxide is determined.

Nitration: The fibre is treated with a mixture in equal parts by volume of strong nitric and sulphuric acids and the weight of the product determined.

Acid Purification: A weighed quantity of the substance is boiled for one minute with a 20 per cent solution of acetic acid, to dissolve impurities, and the residue washed with water and alcohol, dried and weighed.

Elementary Composition: The percentage of carbon in ordinary cellulose (cotton) is 44.4 per cent. In compound celluloses it may be low (40 to 43 per cent) in the group containing the pectocelluloses, or high (45 to 50 per cent) in the group containing jute cellulose and other lignocelluloses.

Ascertaining Quantities of Materials in Union Yarns and Fabrics.

Results are based upon the fact (previously fully explained) that different fibres, under different reagents, are either dissolved or not. This principle forms the basis for separating one fibre from the other in union yarns or fabrics. For instance, caustic soda dissolves wool but not cotton; again, boiling in dilute or steeping in concentrated sulphuric acid dissolves (carbonizes) the latter, but not the wool.

In most cases, results near enough for ordinary purposes can be obtained by treating the yarns or fabrics in their ordinary state, *i. e.,* containing the same moisture as the surrounding air, but by far the most accurate determinations are obtained by first of all *conditioning* the material, *i. e.,* heating the sample in a conditioning oven to 105 deg. C., until a constant weight is obtained, then basing all calculations on this conditioned weight. (See chapter on Testing for Moisture.)

Analysis of a Wool - Cotton Fabric.

The analysis of this class of fabrics may be made, either depending on the solubility of wool in caustic alkalies, the destruction of the cotton by mineral acids, or the mechanical separation of the warp and filling threads.

Whether to test for wool or for cotton present depends upon the sample, as a rule destroying the fibre we consider to form the smaller percentage present.

Testing for Wool Present.

(*a*) Cut three samples of equal weight say 50 grains; one of these samples keep for reference.

(*b*) Test samples 2 and 3 for sizing and dyestuffs by boiling them for about 15 minutes in either a 3 per cent solution of hydrochloric acid or a one tenth per cent solution of caustic soda. If liquid becomes strongly colored repeat procedure with a fresh acid bath. Next wash both samples thoroughly in several changes of water.

It now depends on the estimated proportion of wool or cotton present which reagent to use; it being advisable to use the one which leaves the larger amount of refuse (in our test, for example cotton, hence caustic soda the reagent to use).

(*c*) Test sample 3 for percentage of wool and cotton present, by boiling it in a 5 per cent solution of caustic soda and which dissolves the wool in the sample. Wash the latter thoroughly.

(*d*) Take samples 2 and 3, and dry them thoroughly and then keep all three samples for about a day uniformly exposed to normal atmospheric conditions.

Example:
All three samples originally weigh 50 grains each.
Sample 2 weighs 49 grains.
Sample 3 weighs 40 grains.

Question: Ascertain percentage of size and dyestuffs, as well as wool and cotton present in sample.

Size and Dyestuffs:
50 grains weight of sample 1
49 " " " " 2
—
1 grain weight of size and dyestuff in every 50 grains of fabric (or yarn) tested, or 2 grains in 100 grains of material = 2 per cent.

Material:
49 grains weight of sample 2
40 " " " " 3 (cotton)
—
9 grains weight of dissolved substance.

The latter is chiefly wool, but it must be remembered that in the procedure the caustic soda produces a loss of about 5 per cent to the cotton, hence:

100 : 95 : : x : 40 = 42.1 grains of cotton in sample, or 84.2 per cent of cotton are present.

9 grains weight of dissolved substance less
2.1 " " " cotton the latter contains.
—
6.9 grains weight of wool in sample, or 13.8 per cent wool are present.

Answer: The sample in question contains:
2. per cent size and dyestuff
84.2 " " cotton
13.8 " " wool.

Testing for Cotton Present.

In this instance, proceed as in previously given example, using however dilute or concentrated sulphuric acid as the reagent for the third sample. The process will destroy about 2 per cent of the wool fibre, and which must be taken care of in the calculations, the same as done in previous example with the cotton.

Analysis of Silk - Cotton Fabrics.

Since caustic soda and sulphuric acid have the same effect on silk as on wool, the test may be conducted the same as for wool and cotton.

Another analysis for silk-cotton fabrics is the treatment with ammoniacal nickel oxide. The previously weighed sample is for this purpose entered into a cold ammoniacal solution of nickel oxide, which then is gently heated. The

silk dissolves in about three minutes. After washing the refuse with dilute hydrochloric acid and drying it in an air-oven, the weight of the cotton present in the sample is then ascertained, to which 1.2 per cent has to be added, representing the average loss to cotton by the process and which must be taken into consideration when calculating percentage of each fibre present in the sample.

Another procedure for obtaining the result is to immerse the previously weighed sample in *Loewe's* alkaline-copper-glycerol solution at a temperature of 50 deg. C. for 15 minutes. The residue of cotton is then rinsed, dried and weighed.

To Ascertain Amount of Silk - Cotton in Mixed Fabrics.

(1) Weigh a suitable size of the sample, in grains.
(2) Ether wash.
(3) Extract all impurities such as dirt, grease, and free dyestuffs by boiling.
(4) Dissolve the silk and ascertain the absolute dry weight of the residue by:
- (*a*) Boiling the sample in a solution containg 10 per cent of caustic soda until the silk dissolves.
- (*b*) Rinse thoroughly in several changes of cold water.
- (*c*) Neutralize the caustic soda and wash thoroughly in hot water.
- (*d*) Dry in oven and cool in desiccator.
- (*e*) Weigh in grains.

(5) In calculating the percentage, add 2 per cent to the weight of cotton on account of loss which occurs in the soda bath.

Example: A sample of cloth is composed of a warp, part of which is cotton and silk twist, the remainder of the cloth being cotton.

Weight before extracting impurities & drying = 10.6 gr.
Weight after extracting impurities & drying = 9.2 "
—
Amount of moisture and impurities = 1.4 gr.

10:6 : 1.4 : : 100 : 13.2 per cent of moisture and impurities.

Weight of residue (cotton) after treating with caustic soda and drying = 8 gr.

9.2 : 8 : : 100 : 87 per cent of residue (cotton).
+ 2 per cent loss incurred in soda bath.
—
89 per cent of cotton, leaving
11 per cent of silk.
—
100

(1) Treat sample first with dilute hydrochloric acid and then with sodium carbonate, to remove finishing materials, etc., after which dry and weigh sample.

A concentrated solution of chemically pure hydrochloric acid (40 per cent) is now heated to 50 deg. C. and into this the sample is dipped for 2 or 3 minutes. By this treatment the wool is hardly affected, while the silk is dissolved. Dilute with water, and filter.

The weight of the dried residue represents the amount of wool present, which has lost about ½ per cent of its weight in the test and for which make proper allowances when calculating.

(2) By another procedure the silk is dissolved by immersion in an ammoniacal nickel hydroxide solution for 5 minutes at 20 deg. C. If it is found that the nickel hydroxide cannot be completely dissolved by the proper proportion of ammonia, then the mixture of hydroxide and ammonia should be thoroughly shaken before using.

After boiling the sample in this turbid liquor for 5 minutes it is removed, rinsed and then thoroughly washed with 1 per cent hydrochloric acid, in order to remove the adhering nickel hydroxide from the fibre and so prevent causing an increase in the weight. The residue of wool is then rinsed again, dried and weighed.

(3) The silk can also be dissolved in a boiling solution of basic zinc chloride. If dipped in this solution for not longer than one minute, the wool will remain unaffected. The residue, and which means wool, is then well washed with 1 per cent hydrochloric acid, washed again with water and in turn dried and weighed.

(4) To identify the presence of silk in a mixture of fine wool and silk, the following confirmatory test will solve the question. A short length of yarn is placed under the microscope on an ordinary glass slide, and is loosely covered with a small glass circle. While under inspection, a drop of concentrated sulphuric acid is taken up on the end of a glass rod, and gently dropped on the slide, so that it just touches the outer rim of the glass cover. By capillary attraction the acid will pass between the glass cover and slide until it comes into contact with the fibre, when it will creep along this for a certain distance.

Under these conditions, and within two minutes from contact with the acid, the silk will completely dissolve, leaving any wool present intact, and with a little practice a rough and preliminary estimate as to the relative proportion of wool and silk may be obtained.

(*a*) Cut out four samples of air-dry fabric, of equal weight, and keep one for reference.

(*b*) Boil three of the samples in a 3 per cent solution of hydrochloric acid, decant and repeat with a fresh solution until all size and coloring matter is removed. Wash thoroughly in order to remove all the acid. Keep one of the samples for reference.

(*c*) Two of these samples are then placed for from one to two minutes in a boiling solution of basic zinc chloride, or the samples are treated with ammoniacal nickel hydroxide solution in order to dissolve the silk. Wash well with 1 per cent hydrochloric acid and distilled water, and keep one of the samples for reference.

(*d*) The sample left has now to be treated for removing either the wool or cotton, using respectively either caustic soda or concentrated sulphuric acid. To remove wool the sample is boiled for 15 minutes with 5 per cent caustic soda, after which wash thoroughly with water.

Take all four samples, dry them thoroughly and keep them for some time uniformily exposed to normal atmospheric conditions.

By then carefully weighing the four samples, each constituent is readily determined: the first loss represents sizing and dyestuffs; the second loss that of silk; the third that of wool; the last is cotton.

The final residue of cotton will be found to be somewhat below the actual percentage present in sample so that 5 per cent should be added to the weight of the residue and subtracted in proportion from the weight of the wool.

Another test is thus:

Two grammes of lead acetate are dissolved in 50 c.c. of distilled water, and to this is added 2 grms. of caustic soda dissolved in 30 c.c. of water. The solution is boiled until clear, and 0·3 grms. of magenta dissolved in 5 c.c. of alcohol is added after the solution is cooled down to about 60 deg. C., when the liquor should be colorless. The magenta may be replaced by 2 grms. of picric acid, and in either case the solution is made up to 100 c.c., and filtered if necessary.

A portion of the fabric or yarn is heated for two minutes in this solution, to somewhere near the boiling point. In the case of magenta it is then washed and placed in a dilute solution of acetic or formic acid, and it is sufficient in this case to heat the solution to 70 deg. C.

After drying, a microscopical examination of the mixture will show silk colored red where magenta has been used, or yellow with picric acid, while wool will be black or dark brown, and artificial silk, cotton, or other vegetable fibres white.

A solution of litharge in caustic soda may take the place of the lead acetate. In that case 2 grms. of NaOH are boiled with 5 grms. of litharge in 50 c.c. of water for fifteen minutes; 0·3 grms. magenta dissolved in 5 c.c. of alcohol is added after cooling, and the whole filtered and made up to 100 c.c. with water.

Artificial silk may be readily detected, and these or any vegetable fibres present are noticeable by their absence of color, when they can be isolated from the yarn for further examination.

Analysis of Cotton-Linen Fabrics.

The sample after having been freed from any size or dye, by a suitable boiling in dilute hydrochloric acid or distilled water, followed by a thorough rinsing, is then dipped for one and a half or two minutes in concentrated 66 deg. *B.* sulphuric acid, then rinsed out well, rubbed between the fingers and neutralized by steeping in dilute ammonia or sodium carbonate solution. After washing over again in water, the sample is pressed between blotting paper and dried and when flax fibres or threads will, as a rule, be found to have retained their structure while the cotton fibres or threads have dissolved after passing through a gelatinous stage in which they will tear like tinder, *i. e.*, have been destroyed.

THE INK TEST.

In order to ascertain quickly whether a fabric is either all linen, or a cotton and flax combination, what is known as the ink test may be used. This procedure consists in dropping a small quantity of black ink on the sample. If the ink spot spreads in all directions from the original spot, forming an aureola, *i. e.*, the ink acting somewhat like a drop of oil on a sheet of paper, then the fabric is pure linen. When, however, the ink is dropped on a sample containing cotton warp and linen filling, or vice versa, the ink will follow the linen threads quicker than the cotton threads, for the fact that the former are more porous, resulting in a more oval spot. The composition of the ink, *i. e.*, whether ordinary ink or copying ink, has something to do with the shape of the spot, ordinary ink running quicker, *i. e.*, producing a more pronounced oval effect spot.

TEST BY OIL.

By this process the cloth is first freed from finishing material by boiling in a weak solution of carbonate of soda, then, after rinsing and drying, is saturated with oil and spread out flat on a glass plate. After giving time for the air-bubbles to get away, the cloth is covered by another sheet of glass and both are squeezed tightly together until the surplus oil is re-

moved, when the fabric is examined by holding it between the observer and the light.

Under this treatment the linen fibres become transparent because of the thickness of the cell walls, which give a refraction equal to that of the oil. By examining it between the light and the observer it appears clear, but when examined in the ordinary way it is opaque. On the other hand, cotton, by reason of its structure and the fact that air is imprisoned in its cells, shows opaque when viewed before the light, and appears clear in other positions.

SULPHATE OF COPPER TEST.

The same consists in removing the finishing materials, and then immersing the sample for ten minutes in a 10 per cent solution of copper sulphate. After rinsing in water, the sample is immersed in a 10 per cent solution of potassium ferrocyanide, when the linen acquires a copper-colored shade produced by the decomposition of the ferrocyanide, while the cotton remains nearly white. The contrast is made very plain after rinsing, by steeping the sample in Canada balsam, or in a very fatty oil.

TEST BY METHYLENE BLUE.

This is a simple test, but not suited for bleached goods, where the fibres may have been partly converted into oxycellulose. It consists in immersing the sample in a hot solution of methylene blue, and then rinsing in water. The washing removes the color from the cotton, while the linen remains blue. Safranine, or Bismarck Brown can also be used for this test.

TEST BY SULPHURIC ACID.

For this purpose the cloth is freed from any finishing materials adhering to it, and immersed for one or two minutes in concentrated sulphuric acid. After then rinsing in water, the sample is dried. The cotton is destroyed by this process, while linen remains unaffected.

TESTS WITH NATURAL DYESTUFFS.

The fabric is for this purpose immersed for 15 minutes in an alcoholic solution of natural dyeing materials, then dried between two sheets of blotting paper.

When madder is used the linen acquires an orange shade, while the cotton becomes yellow.

With cochineal the linen is colored a violet and the cotton a clear red.

Fuchsine, colors the linen, the color being removed from the cotton by rinsing.

Cyanine colors the linen blue, the cotton remaining unstained.

These tests by the aid of dyestuffs require many different products, also considerable time, and, besides are far from conclusive. The most practical tests for distinguishing cotton from linen are those with ink and by burning the fringes, as previously explained.

Mechanical Analysis.

The mechanical analysis of a fabric sample is in many cases quite as satisfactory as the separation of the fibres by chemical means. For this procedure it is however, essential that the yarns be made wholly of one fibre; the warp for instance to be all cotton and the filling all wool. The sample is for this purpose cut exactly parallel to the warp-threads and picks (or as near as possible) next carefully weighed and in turn picked apart, warp and filling threads being weighed separately.

Example: Cut sample of a 16-ounce cotton worsted trousering 4 by 3 inches = 12 square inches.

3 inches, length of cotton warp; 4 inches, length of woolen filling; the sample to weigh 41.71 grains.

Separating warp and filling gives us:

18.25 grains weight of cotton warp.
23.05 " " " wool filling.

41.30 grains weight of warp and filling.
.41 " loss caused by refuse of fibres liberated by picking filling from warp-threads.

41.71 grains original weight of sample.

Grading of Yarns as to Size or Counts.

The diameter of yarns, technically known as their *count* or *number,* are based (with the exception of raw and artificial silks) upon the number of yards necessary to balance 1 lb. avoirdupois. The number of yards thus required vary for each raw material. The higher the count, the finer the yarn with reference to its diameter.

Cotton Yarns.

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

Grading of 2, 3 or More-Ply Yarns.

In connection with 2-ply yarn, the number of yards required for 1 lb. is one-half the amount of that called for by the single thread.

Example: 20's cotton yarn (single) equals 16,800 yards per pound, while a 2-ply thread of 20's cotton, technically indicated as 2/20's cotton, requires only 8400 yards per pound, or is equal to the amount of yards called for in (single) 10's cotton.

If the yarn is more than 2-ply, divide the number of the single yarn by the number of ply, the result being the equivalent counts in a single thread. Thus 3/60's equals single 20's; 4/60's equals single 15's, etc.

Ascertaining Weight in Ounces of a Given Number of Yarns of a Known Count.

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

Example: Find weight of 12,600 yards of 30's cotton yarn.

$12{,}600 \times 16 = 201{,}600$
1 lb. 30's cotton yarn $= 25{,}200$ yards.
$201{,}600 \div 25{,}200 = 8$ oz. *Ans.*

Another rule is: Divide the given yards by the number of yards of the known count required to balance 1 oz. (being yards per lb. $\div$ 16).

Example: Find the weight of 12,600 yards of 30's cotton yarn.

$25{,}200 \div 16 = 1{,}575$ yards 30's cotton yarn $= 1$ oz.
$12{,}600 \div 1{,}575 = 8$ oz. *Ans.*

Ascertaining Weight in Pounds of a Given Number of Yards of a Known Count.

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

Example: Find the weight of 1,260,000 yards of 30's cotton yarn.

30's cotton yarn $= 25{,}200$ yards to 1 lb.
$1{,}260{,}000 \div 25{,}200 = 50$ lbs. *Ans.*

To Find the Equivalent Size in Single Yarn for 2 or More-Ply Yarn of Minor Threads of Unequal Counts.

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

If the compound thread is composed of ***three*** minor threads of unequal counts, compound any two of the minor threads into one, and apply the previously given rule to this compound thread and the third minor thread not used before. In a similar way continue proceedings with 4 or more-ply yarns.

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

$20 \times 30 = 600 \div 50 \ (20 + 30) = 12$

$12 \times 50 = 600 \div 62 \ (12 + 50) = 9\frac{21}{31}$ *Ans.*

A second rule for finding the equivalent counts for a yarn when three or more minor threads are twisted together is as follows: Divide one of the counts by itself, and by the others in succession, and afterwards by the sum of the quotients.

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

$50 \div 50 = 1$

$50 \div 30 = 1\frac{4}{6}$

$50 \div 20 = 2\frac{3}{6}$

$5\frac{1}{6}$ and $50 \div 5\frac{1}{6} = 9\frac{21}{31}$ *Ans.* The same as before.

Woolen Yarns.

Run System.

Woolen yarns, with the exception of the mills in Philadelphia and vicinity are graded by *runs,* which have for their standard 1600 yards. Consequently 1 run yarn requires 1600 yards to 1 lb., 2 run yarn 3200 yards to 1 lb., etc., always adding 1600 yards for each successive run or number. In addition to using whole numbers only as in the case of cotton and worsted yarn, the run is divided into halves, quarters, and occasionally into eighths, hence, 200 yards equal $\frac{1}{8}$*th* run, 400 yards equal $\frac{1}{4}$*th* run, etc.

Ascertaining Weight in Ounces of a Given Number of Yards of a Known Count.

The run basis is convenient for textile calculations by reason of the standard number (1600) equaling 100 times the number of ounces that 1 lb. contains; thus by simply multiplying the size of the yarn given in run counts by 100, and dividing the result into the number of yards given (for which we have to find the weight) gives us as the result the weight expressed in ounces.

Example: Find the weight of 7200 yards of 4 run yarn.

$4 \times 100 = 400$, and

$7200 \div 400 = 18$ oz. *Ans.*

Ascertaining Weight in Pounds of a Given Number of Yards of a Known Count.

Transfer result obtained in ounces into pounds or fractions thereof.

Example: Find the weight of 100,000 yards of $6\frac{1}{4}$ run yarn.

$100{,}000 \div 625 = 160$ oz. $\div 16 = 10$ lbs. *Ans.*

Cut System.

Woolen yarn is also graded by the *cut* system, of which 300 yards is the standard. Calculations are the same as those for cotton yarns, using 300 as standard in place of 840.

Worsted Yarns.

Worsted yarns have for their standard 560 yards to the hank, the number of hanks that balance 1 lb. indicating the number or the count by which it is graded. Calculations are the same as given for cotton yarns, with the difference of using 560 in place of 840 for the standard.

Silk Yarns.

True Silk.

Silk yarns are graded as to their count either by the *denier* or the *dram* system, the first being generally used as applying to raw silk, the other to indicate the size of thrown silk.

Denier System: The length of skein adopted for basis is 450 meters and the unit of weight $\frac{1}{2}$ decigram; thus the count is expressed by the number of $\frac{1}{2}$ decigrams that 450 meters silk weigh.

450 meters = 492.12 yards.
1 lb. = 453.6 grams.
1 gram = 20 deniers.
1 lb. = 9072 deniers.
1 denier = 492.12 yards.
9072 deniers = 4,464,513 yards.

Dram System: The length of the skein adopted for basis is 1000 yards and the unit of weight 1 dram, which equals 256,000 yards per lb. The count is expressed by the number of drams (and fractions of drams) that 1000 yards weigh.

Denier : Drams.

4,464,513 yards to 1 lb. in denier system
256,000 " " 1 " " dram "

Dividing the first number by the last number gives us 17.44 deniers equal to 1 dram.

Spun Silks.

Spun silks are calculated on the same basis as cotton (840 yards to one hank) the number of hanks 1 lb. requires indicating the count. In the calculation of cotton, woolen or worsted 2 or more-ply yarn, the custom is to consider the ply yarn correspondingly 2 or more times as heavy as the single yarn; thus doubled and twisted 40's (technically

2/40's cotton, equals single 20's cotton for calculations, etc. In the calculation of spun silk the single yarn equals the 2 or more-ply; thus single 40's, or 2 or more-ply 40's require the same number of hanks (40 hanks = 33,600 yards) to balance 1 lb. The technical indication of 2 or more-ply spun silk yarn is for this reason correspondingly reversed if compared to cotton, wool and worsted yarn, and where the numeral indicating the ply is put in front of the counts indicating the size of the minor threads (for example 2/40's) while in indicating spun silk this is reversed (for example 40/2's) *i.e.,* in the present example single 80's is doubled to 40's.

Universal Textile Calculations.

There are two different systems of calculations used in the manufacture of textiles, *viz:* (1) Such as have a constant weight with a varying length, the fineness of the thread increasing as the count rises, and (2) Such as are diametrically opposite to this in principle, the length being constant while the weight varies, the fineness of the thread increasing as the count decreases.

TABLE A.

MATERIAL.	SYSTEM.	WEIGHT IN GRAINS OF 1YD. OF 1'S YARN.
All yarns	Metric	14.11
Worsted	Continental	14.11
"	English, American	12.5
"	French (Roubaix)	9.93
"	French (Fournies)	4.97
Spun silk	French, Swiss	14.11
"	English, German, American	8.33
Cotton	English, German, Swiss, American	8.33
"	French	7.05
Linen, hemp	Almost universal	23.33
Ramie	English	23.33
"	Continental	14.11
Woolen	Yorkshire skeins	27.34
"	West of England	21.87
"	American Run	4.375
"	German	4.81
"	Belgian, French (Sedan)	4.72
"	French (Elbeuf)	1.96
Raw silk	Ounce system	437.5

With reference to the first system, Table *A* gives different gradings of yarns used in the various countries of Europe as well as here, quoting in every instance the respective *standard* to use to ascertain its count as well as its corresponding equal counts in any other yarn. By *standard* we mean the number of grains which one yard of 1's yarn weighs.

The Rule by which these examples are figured is:
Multiply standard weight given in Table *A* with number of yards tested, and divide product by weight in grains.

If for example 30 yards of cotton yarn spun by the English system weigh 8.33 grains, what is the count?

$$\frac{8.33 \times 30}{8.33} = 30\text{'s count.} \quad \textit{Ans.}$$

ANOTHER EXAMPLE: If 30 yards of woolen yarn weigh 34.15 grains, what are the counts in (*a*) American Run system; (*b*) German counts; (*c*) Yorkshire skein; (*d*) French (Sedan), and (*e*) Elbeuf (France) counts?

(*a*) *American Run:*

$$\frac{4.375 \times 30}{34.15} = 3.843 \text{ — practically } 3\tfrac{7}{8} \text{ Run.} \quad \textit{Ans.}$$

(*b*) *German Count:*

$$\frac{4.81 \times 30}{34.15} = 4.22 \text{ German count.} \quad \textit{Ans.}$$

(*c*) *Yorkshire Count:*

$$\frac{27.34 \times 30}{34.15} = 24 \text{ Skeins, Yorkshire count.} \quad \textit{Ans.}$$

(*d*) *French* (Sedan) *Count:*

$$\frac{4.72 \times 30}{34.15} = 4.14 \text{ French (Sedan) count; also the Belgian count.} \quad \textit{Ans.}$$

(*e*) *Elbeuf* (France) *Count:*

$$\frac{1.96 \times 30}{34.15} = 1.42 \text{ Elbeuf count.} \quad \textit{Ans.}$$

ANOTHER EXAMPLE: If 30 yards of worsted yarn weigh 24.5 grains, what are the counts in (*a*) American and English; (*b*) Continental; and (*c*) Roubaix (France) systems?

(*a*) $\frac{12.5 \times 30}{24.5} = 15.3$ Count. *Ans.* Practically 15's single or 2/30's worsted (on the light side) American or English count.

(*b*) $\frac{14.11 \times 30}{24.5} = 17.27$ Count. *Ans.* Practically 17's single or 2/34's worsted (on the the light side) Continental count.

(*c*) $\frac{9.93 \times 30}{24.5} = 12.11$ Count. *Ans.* Practically 12's single or 2/24's worsted (on the light side) French (Roubaix) count.

Another Example: If 30 yards of spun silk weigh 18 grains, what are the counts in (*a*) American, English and German systems, and (*b*) in the French and Swiss counts?

(*a*) $\frac{8.33 \times 30}{18} = 13.88$ Count. *Ans.* Practically single 14's or 28/2's, American, English and German count.

(*b*) $\frac{14.11 \times 30}{18} = 23.5$ Count. *Ans.* Practically single 23's to 24's, or 47/2 ply French and Swiss count.

Table B.

Material.	System.	No. of Yards of 1's Yarn which weigh 1 Grain.
Raw silk	Dram system	36.5
"	Denier system	637.26
Woolen	American grain	20

With reference to the second method of calculating previously referred to, the length in this instance remains constant while the weight varies, *i. e.,* the fineness of the thread increases as the count decreases; the figures in Table *B* indicate the number of yards of 1's yarn, which weigh one grain; therefore the number of grains which the given number of yards in any system weighs indicates the counts in that system. Thus, if 36½ yards of raw silk weigh 4 grains the yarn is 4-dram silk.

The Rule by which these examples are figured is:

Multiply standard length given in Table *B* by weight obtained in grains, and divide the product by the number of yards tested.

Example: If 70 yards of yarn weigh 10 grains, what are (*a*) the counts in American grain, (*b*) Raw silk figured by the dram system, and (*c*) that by the denier systems?

(*a*) *American Grain:*

$$\frac{20 \times 10}{70} = 2\tfrac{6}{7} \text{ American grain count. } \textit{Ans.}$$

(*b*) *Raw Silk, Dram System:*

$$\frac{36.5 \times 10}{70} = 5.22 \text{ Dram silk count. } \textit{Ans.}$$

(*c*) *Raw Silk, Denier System:*

$$\frac{637.25 \times 10}{70} = 91.03 \text{ Denier silk count. } \textit{Ans.}$$

Proof: 5.22 (dram silk in example *b*) $\times$ 17.44 (deniers equal to 1 dram) $= 91.0368$ deniers silk count, being the same answer as obtained in example *c*.

Another Example: Consider a union fabric composed of organzine warp and worsted filling, and for both of which you have to find the count.

Four yards of each system of threads (warp and filling) are obtained by cutting the cloth with the aid of a templet (one-tenth yard square) drawing out 40 threads of each system. The four yards of warp weigh .44 grains, and the four yards of filling weigh 1.67 grains. Ascertain the counts of the organzine expressed in the dram and denier system, the worsted filling in the regular (yard) system, as well as the metric system.

In connection with the warp, you have to consult Table *A*, and in connection with the filling consult Table *B*, proceeding in the same way as previously done, using the standard, the number of yards used as well as their weight in grains, in their proper position.

Warp: Multiply standard of dram with weight expressed in grains, and divide the product by the number of yards tested. Calculations in our example will be thus:

$$\frac{36.5 \times .44}{4} = 4 \text{ Dram silk. } \textit{Ans.}$$

Calculating the same yarn but using the denier scale, we simply substitute the denier standard 637.26 for the dram standard 36.5, and proceed as before, thus:

$$\frac{637.26 \times .44}{4} = 70.09 \text{ Denier silk. } \textit{Ans.}$$

Now, coming to the filling, to be expressed in our regular worsted grading as well as the metric system, we find the following two calculations necessary:

Worsted standard multiplied by yards of yarn tested, the product divided by its weight, thus:

$$\frac{12.5 \times 4}{1.67} = 30\text{'s Worsted count. } \textit{Ans.}$$

Now, calculate the same yarn, but use the metric system, substituting the metric standard 14.11 for the regular worsted standard 12.5 used in the previous calculation and which will give us:

$$\frac{14.11 \times 4}{1.67} = 34\text{'s metric.}$$

It must be remembered that the counts obtained in this way from a sample of cloth are only approximate as there is a certain amount of loss during the scouring, bleaching, dyeing and finishing processes, which may or may not be compensated for by the curvature of the yarn (take-up) due to the shrinkage of the threads in crossing each other (weave) which causes the length of each thread to be greater in its yarn state than that of the finished cloth from which our sample for testing was taken. The increase in the length of the thread, noticeable when it is put under slight tension, enables a good estimate to be formed of the amount that the cloth has shrunk in weaving and finishing, and it is only by estimating and allowing for the loss due to finishing, etc., on the one hand, and the gain due to shrinkage in weaving and finishing on the other, that the actual counts can be obtained. No general rule can be laid down here, experience is the only guide. Preserving records of calculations of samples of cloth and yarn thus tested, will greatly simplify your labor by using them for comparison with new tests.

Changing Cotton "Yard System" to "Metric System" and Vice Versa.

The French system of numbering cotton yarns is based upon the metric system. The relation between fineness and weight or length for weight is exactly the same as in the English yard system (as used in this country, Great Britain, Germany and Switzerland) using a fixed weight and a variable length.

The fixed weight employed (in the metric system) is 500 grammes, and the number or count of the yarn is indicated by the number of hanks (each 1,000 metres long) required to weigh 500 grammes.

EXAMPLE: If 27,000 metres weigh 500 grammes, the resultant counts are 27's or 27 times the unit of length.

The French reel being made 1.428 metre in circumference, then:

1 round	=	1.43 metres = 56¼ inches.
70 rounds = 1 lea (échevette)	=	100 metres
700 rounds = 1 hank (échevaux)	=	1000 metres

700 rounds × 1.43 metres gives only 999.60 metres length of yarn theoretically; in practice the superposition of the threads gives approximately the 1,000 metres.

The proportion existing between the "Yard" and the "Metric" system is:

Yard System:

768.08 m (840 yds.) weighing 453 grms. (1 lb.) = 1's cotton yarn by the yard system.

Metric System:

1000 m weighing 500 grms. = 1's cotton yarn calculated by the metric system.

$$\frac{\text{1's Yard counts} \times 768.08 \times 500}{1000 \times 453 \times \text{Metric counts } (.0847)} = \frac{\text{Yard counts}}{\text{Metric counts}} = \frac{1}{0.847}$$

RULE: (Using *constant* number 0.847)

Yard counts × 0.847 = Metric counts.
Metric counts ÷ 0.847 = Yard counts.

Another *constant* number sometimes used is 1.18, used inversely, thus:

Yard counts ÷ 1.18 = Metric counts.
Metric counts × 1.18 = Yard counts.

The former is the correct proportion and more accurate, on account of "closed" fraction resulting, as will be seen by using both *constant* numbers, with one example.

Using *constant* number 0.847

20 (Y. c.) × 0.847 = 16.94 (M. c.)
16.94 (M. c.) ÷ 0.847 = 20 (Y. c.)

Using *constant* number 1.18

20 (Y. c.) ÷ 1.18 = 16.94 + (M. c.)
16.94 (M. c.) × 1.18 = 19.98 + (Y. c.)

Artificial Silk Counts, Vice Versa, Mercerized Cotton and Spun Silk Counts.

The discovery of artificial silks was made on the Continent in Europe, and consequently the numbering of these artificially produced yarns was originally calculated on the same basis as true silk *i. e.* on the Italian denier scale.

This system of numbering artificial silk yarns still holds good; with the result that in making comparisons with mercerized cotton and spun silk yarns, a great deal of confusion arises.

The standard hank used in the calculation of artificial silk yarn counts, according to the London Silk Conditioning House, is equal to 476 metres, approximately 520 yards, and the system of numbering is such that the weight in *deniers* of this length of yarn constitutes the count or number.

It will be understood from this that the coarser the yarn the higher its count will be an exact antithesis of cotton, woolen and worsted yarn numbering. Another debatable point is the equivalent weight of the Italian denier, since the latter varies in different districts. The London Silk Conditioning House gives the weight of a single denier as .001875 ounces or an equivalent of 533⅓ deniers in one ounce or 8533⅓ deniers to the pound avoirdupois.

From this data it will be easy to solve any problems involving the conversion of a denier count into a spun silk or cotton count or *vice versa.*

EXAMPLE. What is the equal in cotton as well as spun silk of 150's denier artificial silk?

Remembering that according to the London Silk Conditioning House, 150's denier indicates that a length of 520 yards of artificial silk weighs 150 deniers we can easily ascertain by proportion the yards per lb. and divide them by the cotton or spun silk standard 840.

EXAMPLE: Ascertain Yards of 150's deniers artificial silk, technically known as *fibre silk.*

520 : 150 : : x : 8533.33 = 29582.2 yards in one pound 150's denier artificial silk.

29582.2 ÷ 840 = 35.21. *Ans.* Practically 150's artificial silk equals single 35's cotton or spun silk or 2/70's cotton or 35/2's spun silk.

Calculations thus given result in the following

RULE: To convert a denier count into a single cotton or spun silk count, "Divide 5282.5 by the *denier* count given."

PROOF (of above example):

5282.5 ÷ 150 = 35.21. *Ans.*

This explains at the same time the ready conversion of cotton and spun silk yarn counts into fibre silk, *i. e.,* artificial silk counts using

RULE: Divide 5282.5 by the cotton or spun silk yarn count.

EXAMPLE: Convert 35.21's cotton or spun silk (as a proof of previous example given) into fibre silk count.

5282.5 ÷ 35.21 = 150's denier fibre silk count. *Ans.*

EXAMPLE: Convert 35's single cotton or fibre silk or 2/70's cotton or 70/2 fibre silk into the denier fibre silk count.

5282.5 ÷ 35 = 151 deniers, fibre silk count. *Ans.*

American System.

The same calls for 450 meters or 492.12 yards; weighing ½ decigram, equal 1 denier.

To Ascertain the Counts of Minor Threads of Union or Twist Yarns, or Fabrics.

This refers to test and calculations often required in the manufacture of fancy worsted fabric. Very often the combination of the two kinds of yarns is used in the warp, like for instance in some styles of Covert Cloth and where the warp is composed of a rather fine count of cotton yarn twisted over a heavier worsted thread. In the finishing process the fabric is then wool dyed, which will leave the cotton white, imparting to the fabric the characteristic mix, *i.e.,* salt and pepper effect, as we technically call it. In some other fancy effect fabrics the union of two threads, composed of different materials, may be done so as to produce a certain effect not possible to be duplicated otherwise. For instance, a fine count of a cotton thread may be twisted over a mohair yarn, the function of the cotton thread being to impart strength to the yarn during the weaving of the cloth. The mohair thread if used alone as a single thread would result in poor weaving, or possibly prevent weaving at all,

on account of the long fibres protruding from the core of the thread clinging together in the formation of the shed and prevent the latter from opening properly for the passage of the shuttle. During the finishing process of the fabric these cotton threads are then carbonized (*i.e.,* chemically destroyed) leaving the lustrous mohair warp yarn intact, in turn imparting to the fabric the desired pleasing appearance.

To Ascertain the Count of Worsted and Cotton Components in Union Yarns.

Two ways for doing this are at our command, *viz:* (*a*) calculations only, and (*b*) chemical procedures in connection with calculations.

Calculations.

Unravel or untwist a definite length of the union thread and weigh the worsted and cotton minor threads separately.

Example: Suppose 10 yards of worsted and cotton yarn weigh 4.2 grains, what will the compound thread equal, expressed in worsted yarn counts.

12.5 × 10 = 125 ÷ 4.2 = 2/59.5's worsted.

Provided the worsted thread when untwisted weighs 2.8 grains and the cotton thread 1.4 grains, the count of either minor thread used is ascertained thus:

12.5 × 10 = 125 ÷ 2.8 = 44.6 count of worsted thread.
8.33 × 10 = 83.3 ÷ 1.4 = 59.5 count of cotton thread.

These counts are approximately (in practical work) equal to single 45's worsted and 60's cotton.

Considered as a 2-ply worsted thread, the same would equal

12.5 × 10 = 125 ÷ 4.2 = 29.76 or practically speaking a (29.76 × 2 = 59.52) 2/60's worsted thread. *Ans.*

Proof: Change cotton count to its equal in worsted, to make calculations possible.

60's cotton = 90's worsted.

Combining 90's and 45's worsted then gives us, by using rule "Multiply both counts and divide product by their sum," the following calculations:

90 × 45 = 4050
90 + 45 = 135 and
4050 ÷ 135 = 30's single or 2/60's worsted, *Ans.,* or the same as before.

Chemical Tests and Calculations.

Dissolve the wool in a boiling solution of caustic soda or caustic potash. The count of the cotton thread may afterwards be calculated from the weight of the residue which is left on the completion of the process. The test is carried out in the following way:

Reel on a wrap reel a suitable length of the yarn to be tested and weigh it in grains.

If 60 yards weigh 25 grains, the count then will be equal to

$12.5 \times 60 = 750 \div 25 = 30$'s single or 2/60's worsted count.

To carry out this experiment accurately, it is necessary to obtain the absolute dry weight of the material, owing to the fact that cotton and worsted have varying properties for absorbing moisture. In consequence the standard regains for the amount of moisture permissible in these two materials are considerably different, being 8½ per cent for cotton, and 18¼ per cent for worsted. This means that 100 lbs. of absolutely dry material, when submitted to the atmosphere, will regain 8½ lbs. and 18¼ lbs. in weight respectively.

The absolutely dry weight is obtained by placing the sample in a conditioning oven and drying it until the weight remains constant for at least five minutes. The weight of the sample in its absolutely dry condition is now (for example) 21.75 grains.

A solution of 2½ per cent caustic soda, or 10 per cent caustic potash is then prepared, and the sample boiled therein until all the wool has been dissolved. The residue is next filtered and washed very thoroughly to remove any alkali from it, and is again placed in the conditioning oven until absolute dryness is obtained, after which the sample is again weighed; this (for example) equalling 7.5 grains. During the boiling of the material in the alkaline solution, there is a loss sustained by the cotton amounting to 2 per cent, which must be added to the residue, in turn giving us

7.5 grains + 2 per cent $(7.5 \times 102 \div 100) = 7.65$ grains.

This weight (7.65 grains) represents the absolute dry weight of the cotton residue, so there must be added to it the standard regain of 8½ per cent, to bring the cotton into correct condition, and to enable the correct count to be obtained. Hence:

7.65 grains + 8.5 per cent $(7.65 \times 108.5 \div 100) = 8.3$ grains, correct conditioned weight of the cotton residue.

The original length taken for the experiment was 60 yards, and therefore the length of the cotton thread forming the residue will also be 60 yards; then the count may be obtained by the following calculation:

8.33 (*c.m.*) $\times 60 = 499.8$ and

$499.8 \div 8.3 = 60.2$ = single 60's cotton. *Ans.*

The count of the worsted yarn may be found by (*a*) deducting the weight of the residue from the original dry weight *i.e.*, 21.75 less $7.65 = 14.1$ grains. To this weight must be added the standard regain of 18¼ per cent for worsted yarn, to bring the worsted into correct condition.

14.1 grains + 18.25 per cent $(14.1 \times 18.25 \div 100) =$ 16.67 grains.

This represents the correct conditioned weight of the worsted yarn. The length will be taken as 60 yards, and the count may be obtained as follows:

12.5 (*c.m.*) $\times 60 = 7500 \div 16.67 = 44.99$ = single 45's worsted, *Ans.*

Proof: Determine the worsted count required to produce twisted with single 60's cotton a 2-ply thread equal in count to 2/60's worsted count. Proceed as before explained:

60's cotton = 90's worsted and 2/60's worsted = single 30's worsted.

$90 \times 30 = 2700 \div (90 - 30 =)\ 60 = 45$'s worsted.

The final result may then be checked by the following:

Question: What is the compound count expressed in worsted standard provided a single 60's cotton and 90's worsted are twisted together?

60's cotton = 90's worsted and following rule previously quoted we find:

$90 \times 45 = 4050$ and

$4050 \div (90 + 45 =)\ 135 = 30$'s single or 2/60's worsted, *Ans.*

Proceeding by explanations thus given, the compound value as to counts for any union or twist yarn can be readily ascertained.

To Ascertain Texture Required in Loom.

To Ascertain Width of Fabric in Reed.

Of all the points required to be ascertained in the analysis of a fabric, the present one is the most difficult to master, and can only be satisfactorily accomplished by practical experience.

To simplify your work, make a collection of a variety of samples of finished fabrics in your line of goods, and of which you know the exact shrinkage from width in reed to finished width. Such a collection of samples will guide you in laying-out similar new fabric structures for the loom.

The *setting* of a fabric in the loom, *i. e.,* the width in the reed the warp must occupy in the loom, compared to its finished width, is regulated by the raw material used, the manner in which the yarn has been spun, turns of twist per inch, as well as the different processes the fabric has to be subjected to during finishing.

The setting of cotton and silk fabrics in the loom make little trouble, since then the width of the fabric from the loom is about equal to the width of the fabric when finished, *i. e.,* very little difference, if any. This however differs when dealing with woolens and worsteds, more particularly the first, and when the proper setting of the fabric in the reed becomes an art and can only be mastered by experience.

Some kinds of woolen fabrics require a considerable amount of fulling, hence must be set wider in the loom than others that may require only little, or possibly no fulling.

For example, the best grades of billiard-cloth are *set* nearly twice as wide in the loom as their finished width, while beavers, kerseys, and similar heavy-weight woolen fabrics need to be *set* but about one-half their finished width wider in the reed, while fancy cassimeres are set only from one-quarter to one-third wider in the reed than in their finished state. Worsteds require a less wide setting compared to woolens, about one sixth wider in the reed than their finished width.

The kind of yarns used in the construction of a fabric as well as the weave used also exert their influence in regulating the setting of certain fabrics in the loom.

A study of the following rules will greatly simplify the work of the designer when planning the construction of a new fabric, or duplicating given examples:

(1) The finer the quality of the stock used and the less twist inserted into the filling, the more in its width the cloth will shrink at the fulling process. If the filling is hard twisted, and of a coarse quality of stock, such cloth will have but little tendency to shrink.

(2) If the weave used presents a far apart interlacing in the fabric structure, this will have a tendency to produce a narrower fabric than when warp and filling are more closely interlaced.

(3) The less tension we put on the warp-threads during weaving the narrower the fabric will become.

(4) In comparing woolen and worsted yarn, the former produces fabrics which shrink more in width than fabrics made with worsted yarn. This result, when produced from the same raw material, is based upon the two different processes (carding or combing) the wool fibres are respectively subjected to in their manufacture into yarn.

By carding the wool, every fibre, through mixing up in every shape and direction, is twisted in itself, and such fibres always endeavor to resume their original position.

By worsted combing, the wool fibres are separately united in the formation of the yarn, *i. e.*, each fibre, as placed in position for forming the thread, remains more or less its own, for which reason such a thread remains undisturbed in the fabric, and when fabrics made out of such threads will keep wider than if using a wool-spun yarn of the same quality and count, under similar conditions.

Again, woolen yarns refer more particularly to fabrics that are felted (shrunk) in the wet finishing (fulling, scouring or both) processes, hence must be laid-out wider in the reed as compared to worsted cloth which, as we might say, has to be made on the loom, whereas the woolen fabric in many instances is made in its finishing process.

Take-up of Warp During Weaving, Shrinkage of Fabric in Length During Finishing.

We must also carefully consider the amount of take-up the warp is subjected to during weaving, and the amount of shrinkage in its length the cloth undergoes during the finishing process. The latter point will not come into consideration in the case of fabrics which are ready for the market or require only a slight finishing after leaving the loom, some of which, by means of pressing or calendering under tension, may actually become longer by this process.

The take-up of the warp during weaving varies from fabrics requiring two, three, four or more times the length in dressing than the length of the fabric woven, compared to fabrics in which the length of the warp dressed equals the length of the fabric finished, or if any difference found, the same to be very little; again in some special cases the warp may stretch sufficiently in weaving and finishing to produce more yards woven than was dressed.

Points previously given on the shrinkage in width of a fabric also apply to its shrinkage in length.

The weave and the number of picks per inch used, are the chief features regulating the take-up of the warp during weaving; for example, a fabric interlaced with a far stitching satin (say 8 to 12-harness) will take up very little, if any, unless we use an extra high texture for warp and filling. Thus, the oftener a warp-thread intersects with its filling in a given distance, the greater the amount of take-up required for the warp. For this reason, fabrics which have two differently interlacing weaves combined, for example ½-inch plain weave to alternate with 1-inch 8-harness satin = 1½ inches in repeat of pattern, require two beams; one to carry the warp for the plain weave and the other beam for carrying the warp for the satin weaving part of the fabric.

This feature also applies to worsted fabrics made with a woolen back-warp, as well as such where the face-warp interlaces different from that of the back-warp, like for example a 4-harness twill for the face and an 8-harness satin for the back, a combination which in most instances will call for two-beam work on account of the difference in the take-up of the two systems of warp-threads. Double cloth, wool or worsted face warp used in connection with a cotton back warp will also call for two-beam work.

The amount of shrinkage in warp pile fabrics, for its pile-warp is considerable. It is regulated by the height of pile required, the amount of wires or loops per inch, etc. Such fabrics may often require their pile-warp dressed four to eight times longer than the piece measures woven.

To ascertain the exact percentage of take-up for a fabric needs experience, and can only be mastered by a thorough study of the theory of constructing the different weaves, the nature of the various raw materials, their various methods of preparing the yarn for the loom and the different processes of finishing fabrics in question are subjected to.

If dealing with a cotton or silk fabric, or a loosely interlacing worsted fabric, using in either structure two, or more different interlacings for the warp-threads, for example, a certain number of warp-threads interlacing with a closely intersecting granite or crêpe weave to alternate with a certain number of warp-threads interlacing with a loosely interlacing (floating) 7 or 8-harness satin. The difference in the take-up of these two systems of weaves is readily seen by liberating one or two threads of each system and holding the same against a contrasting background. Their original length before woven may then be ascertained by stretching one thread after the other on a finely graded scale or ruler, holding each end of the thread, while stretching and measuring the same, by means of a delicate pair of pinchers so as to obtain a short but solid grip on the two ends of the thread during the stretching operation.

Arrangement of Colors, Counts and Twist.

In the reproduction of fancies, of any kind of textile fabrics, the proper arrangement of colors in warp and filling in combination with the weave used is of the greatest of importance; any mistake made is liable to make the fabric unsaleable. The same also holds good if dealing with two or more different counts or twists of yarn used in warp or filling, or in both systems of threads.

It must be remembered that different colors, counts or twists of yarn may have to interlace with certain warp-threads or picks of the weave and that any derivation of the proper arrangement of either warp or filling threads will spoil the pattern or effect in the fabric.

The proper placing of fancy ends in a pattern must be taken care of when preparing the sample for picking out the weave, and in order to simplify matters arrange wherever convenient to do so your warp fringe of the sample prepared for picking out, to start with a fancy thread. This will simplify the picking out as well as keep the repeat of the weave and that of the arrangement or dressing of the warp under your control.

The repeat of the color arrangement may equal that of the weave, again one or the other may be a multiple of the other, etc.

How to Proceed with the Analysis.

In preparing the sample according to details given before when explaining the picking-out process, during the latter work indicate at the right hand side on your point paper next to the weave, for each pick as liberated from the sample, its color, or any other remarks as to count, twist, etc., as the case may require.

After you have ascertained the interlacing of the first pick, indicate on the top of the portion of the point paper that you

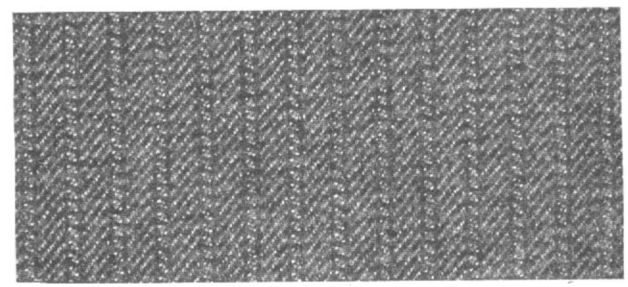


Fig. 51

have reserved for indicating the weave, in its proper position the color arrangement of the warp for one or two repeats of the pattern. Do the same if dealing with different counts of yarn.

In most fabric structures the weave and the color arrangement for warp and filling repeat on a corresponding number of threads; in some instances, as mentioned before, one may be a multiple of the other. If the fancy arrangement of the warp is the smaller number, indicate it once, or repeat it over the entire repeat of the weave. If the weave is the smaller number, carry on the indicating of the color effect up to its repeat on the point paper, or if dealing with a large repeat of a dressing, write out the respective color, count or twist arrangement of warp and filling on note paper, beginning each list (warp or filling or both) with its start as you are marking it on the point paper.

We will now explain subject with two samples, both referring to a fancy color arrangement of the warp-threads; the first has one kind of filling (stripe) the other deals with three different kinds of yarn used for warp and filling.

Worsted Trousering.

Fig. 51 is a photographic reproduction of the fabric to be analyzed, a worsted trousering previously referred to in connection with the chapter on "Obtaining Texture by Calculations."

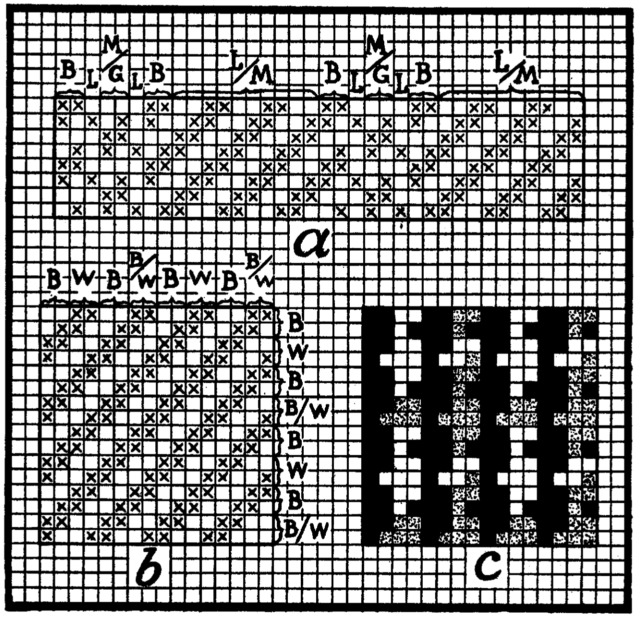


Fig. 52

Fig. 52[a] shows the weave for this fabric on point paper, also showing the color arrangement of the warp indicated on top of the weave; the filling is all black, hence no notice was taken of it on the weave plan when picking-out the sample.

The arrangement of the warp, technically known as the *dressing*, as indicated on top of the weave, reads thus:

2 ends (*B*) 2/42's worsted, Black
1 end (*L*) 2/48's worsted, Light gray
2 ends (*M/G*) 2/48's worsted, Medium Gray
1 end (*L*) 2/48's worsted, Light gray
2 ends (*B*) 2/48's worsted, Black
10 ends (*L/M*) 2/48's worsted, Light and Medium Gray twist

18 ends, repeat of pattern; two repeats are given.

This analysis of the color arrangement of the warp, placed on the point paper in its proper position to the weave, will readily explain the wisdom of the procedure when we take into consideration that any misunderstanding in the weave

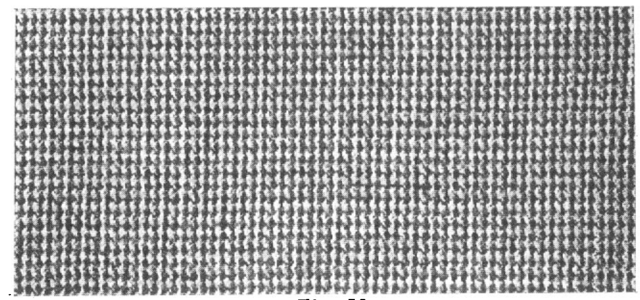


Fig. 53

room might be the cause of a mistake in the woven cloth on the loom, until discovered, and when possibly too late to correct.

L means one end Light gray interlacing 1 *up* 3 *down*, for its repeat.

M/G means two ends Medium gray interlacing 2 *up* 2 *down*, for its repeat.

B and *L/M* are fourteen warp-threads interlacing with the 2 *up* 2 *down* 4-harness twill, and of which the first and last two ends (*B*) are Black, the others (*L* and *M*) referring to Light and Medium gray twist threads.

Letters of reference for colors have been and are used to simplify matters to the reader, indications (fancy crayons) can be substituted.

Worsted Suiting.

Fig. 53 is a photographic reproduction of a worsted suiting, being given to illustrate a fancy arrangement of warp and filling.

Fig. 52[b] shows the weave (or pickout as we technically call it) also the color arrangement in warp and filling, both being the same, *viz:*

2 ends	(*B*)	2/60's	worsted	Black
2 "	(*W*)	"	"	White
2 "	(*B*)	"	"	Black
2 "	(*B/W*)	"	"	Black and White twist.

8 ends in repeat of pattern for warp and filling.

Fig. 52c shows the color effect for fabric sample Fig. 53, executed on point paper thus:

Black worsted is indicated by ***full*** type,
White worsted by *empty* type, and
Black and *White* twist by *shaded* type.

From color scheme Fig. 52c it will be readily understood that the proper placing of the different colors in warp and filling is a most important item in planning the design and that any mistake (even if only one thread out the way) would spoil the effect aimed at by the designer, and in turn make the fabric second, hence the importance of indicating, if dealing with a fancy fabric, the proper warp-threads and picks in connection with the weave on the point paper while you are picking out the weave.

Ascertaining Weight per Yard and Counts of Yarn.

This subject is best explained by means of practical examples.

Worsted Plaid Dress Goods. (*54 inches wide.*)

Ascertain from information thus far given, *Texture* and *Color Arrangement* for warp and filling; the same to be:

Texture: 63 warp-threads and 77 picks per inch.

Warp Dressed: 16 ends White
16 " Brown
——
32 ends, repeat.

Filling Arrangement: 20 picks White
20 " Brown
——
40 picks, repeat.

After having thus ascertained texture and color arrangement for warp and filling, trim your sample to the largest regular dimensions.

In our example the same to be $3\frac{13}{16}$ inches wide (cut to length of filling) and 2 inches long (cut to length of warp) or $7\frac{5}{8}$ square inches of fabric.

We now weigh this sample and find its weight to be 9.1 grains.

Always trim sample given accurately to its largest possible dimensions; the larger the sample, the more accurate your calculations will be. Be sure to use a reliable pair of scales for your work.

Ascertain Weight of Fabric for one Yard.

This, like all textile calculations is solved by means of proportion, based upon facts previously obtained, as well as that there are ($36 \times 54 =$) 1944 square inches of cloth in one yard of goods under consideration.

$$7\tfrac{5}{8} \quad : \quad 9.1 \quad :: \quad 1944 \quad : \quad x$$

$$\frac{1944 \times 9.1}{7\frac{5}{8}} = 2320 \text{ grains, weight of sample for one yard.}$$

This, divided by 437.5 (number of grains in one oz.) gives us the weight of the fabric as 5.302 oz.

Answer: The fabric in question weighs 5.3 oz., or practically $5\frac{1}{2}$ oz. per yard, including selvage, and which before was not taken into consideration.

Ascertain Counts of Yarn Used.

For this purpose liberate carefully warp and filling in the sample, keeping each separate; also keep the different kinds of yarns in each system of threads separate from each other. Weigh each kind of yarn most carefully, also keep track of any refuse fibres liberated from the sample while separating warp from filling. For this reason do the separating on a large sheet of paper so you can clearly see this refuse and if necessary allow for it in your calculations.

Proceeding in this manner we find:

White Warp: 114 ends, 2″ long = 228″; to weigh 2.5 grains.
Brown Warp: 125 ends, 2″ long = 250″; to weigh 2.74 grains.
White Filling: 74 picks, $3\frac{13}{16}$″ long = $282\frac{1}{8}$″; to weigh 1.91 grains.
Brown Filling: 77 picks, $3\frac{13}{16}$″ long = $293\frac{9}{16}$″; to weigh 1.95 grains.

Having obtained a given length of each yarn used in the construction of the fabric, also its respective weight, the count of each yarn is readily obtained by proportion, remembering that there are 7000 grains in one yard, and that the standard of the yarn we deal with in our example is 560 yards to the hank of worsted yarn.

White Warp: 228 inches weigh 2.5 grains; ascertain count of yarn.

$$228 \quad : \quad 2.5 \quad :: \quad x \quad : \quad 7000$$

$228 \times 7000 \div 2.5 = 638{,}400$ inches of yarn will balance 1 lb., or what is the same, ascertain weight per yard = 2 Last.

$638{,}400 \div 36 = 17{,}733.33$ yards.

$17{,}733.33 \div 560$ (worsted standard) $= 31.66$.

Answer: 31.66, or practically 32's single or 2/64's (two ply) worsted is the count of the yarn in the finished sample.

After thus ascertaining the count of the yarn in the finished sample, experience has to guide us as to its count in the spun state, taking into consideration any take-up in weaving, loss in weight of cloth in scouring, loss of weight by shearing, singeing, brushing, etc. In our example these items are next to nil, since the sample submitted deals with a very clean yarn from the start and a loosely interlacing weave and texture, balancing any possible take-up in weaving by the life in the yarn; in other words, yards dressed to equal yards woven and finished, 2/64's worsted, on the heavy side, being the count of the white warp yarn.

Brown Warp: 250 inches weigh 2.74 grains, ascertain count of yarn.

$250 : 2.74 :: x : 7000$

$250 \times 7000 \div 2.74 = 638686.13$

$638686.13 \div 36 \div 560 = 31.68$

Answer: 31.68, or practically 32's single or 2/64's (two ply) worsted (being the same count as its mate, the white warp) is the count of the brown warp yarn to use, to be spun on the heavy side.

White Filling: 282½ inches weigh 1.91 grains, ascertain count of yarn.

$282\frac{1}{8} : 1.91 :: x : 7000$, and

$282\frac{1}{8} \times 7000 \div 1.91 = 1033965.97$

$1033965.97 \div 36 \div 560 = 51.28$

Answer: 51.28, or practically 52's single, or 2/100's (two ply) worsted is the count of the yarn to use.

Brown Filling: $293\frac{9}{16}$ inches weigh 1.95 grains, ascertain count of yarn.

$293\frac{9}{16} : 1.95 :: x : 7000$, and

$293\frac{9}{16} \times 7000 \div 1.95 = 1053813.89$

$1053813.89 \div 36 \div 560 = 52.27$

Answer: 52.27, or practically 52's single, or 2/100's (two ply) worsted, is the count of the yarn to use.

Woolen Cheviot Suiting. (*56 inches wide.*)

Ascertain *Texture and Color Arrangement* for warp and filling; the same to be:

Texture: 20 warp-threads and 15 picks per inch.

Warp Dressed: 1 end Mix
1 " Black

2 ends, repeat.

Filling: All Mix.

Sample trimmed to 3½ inches square, *i. e.,* 12.25 square inches weighs 61.72 grains.

Ascertain Weight of Fabric for One Yard.

$36 \times 56 = 2016$ square inches in one yard of fabric.

$12.25 : 61.72 :: 2016 : x$

$x = 10157.34$ grains and

$10157.34 \div 437.5 = 23.21$

Answer: Sample in question weighs 23.2, or practically 23¼ ounces per yard, exclusive of any selvage.

Ascertaining Counts of Yarn Used.

Wool Standard, *Run* System, is 1600 yards to 1 run.

Mix Warp: 34 ends, 3½" long = 119"; weigh 14.36 grains.

Black Warp: 35 ends, 3½" long = 122.5"; weigh 17.4 grains.

Filling: 55 picks, 3½" long = 192.5"; weigh 30.37 grains.

Mix Warp: $119 : 14.36 :: x \; 7000$

$x = 58{,}008$ inches $\div 36 = 1611$ yards, and

$1611 \div 1600 = 1.+$

Answer: 1 run woolen yarn is the count of the yarn in the finished sample, to which add loss in finishing (scouring), also consider a take-up of 10 per cent in weaving. The first item will call for a heavier spun yarn, the latter will somewhat counteract this, with the result that a 1 run yarn, spun on the heavy side, *i. e.,* leaning towards a ⅞ run will be the count desired.

Black Warp: $122.5 : 17.4 :: x : 7000$

$x \div 36 = 1368$ yards, and

$1368 \div 1600 =$ practically ⅞ run is the count. *Ans.*

Filling: $192.5 : 30.37 :: x : 7000$

$x \div 36 = 1{,}232$ yards, and

$1{,}232 \div 1600 =$ practically a ¾ run yarn in the finished fabric. Laying the fabric 74 inches in the loom will in this instance more than counteract loss in scouring, hence the count of yarn to spin is

$54 : \frac{7}{8} :: 74 : x = 1.2$

less loss in scouring (20%) $= 0.2$

1.0 run. *Ans.*

To find Number of Yards of Cloth to the pound, Avoirdupois.

Cut from the cloth a piece two inches square. The weight of this multiplied by the width of the cloth gives a product which divided into 778 gives the number of yards to the pound.

Example: Suppose we have a piece of cloth 27 inches wide, from which a piece two inches square is cut, weighing 20 grains, then

$778 \div (27 \times 20) = 1.44$ yards to the pound.

Another Example: Suppose the cloth is 30 inches wide and weighs 10 grains, then

$778 \div (30 \times 10) = 2.59$ yards to the pound.

Testing Yarn.

Yarn may have to be tested for its count, strength, elongation to breaking point, elasticity, twist, regularity,

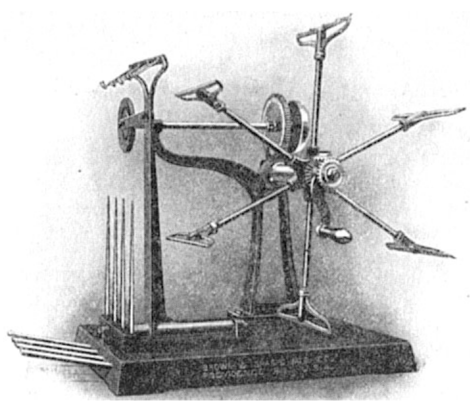


Fig. 54

cleanliness, and moisture. It may have to be tested from the cop or bobbin, the hank, the ball or the beam warp, or from threads taken from the woven texture.

Testing for Count.

Considering the yarn to be tested to be in the condition most frequently furnished for this purpose, *i. e.,* in the condition in which it has left the spinning machinery, it may be well to consider: *first,* the most suitable length of material to use for a test to arrive at an accurate result; *second,* what are the differences to be found in the count of a yarn when various lengths are tested; *third,* the effects of testing the material from various parts of a cop or bobbin and to note what differences, if any, exist; *fourth,* the most suitable method of measuring the yarn, the tension to be put on during reeling and the effect on the length of yarn reeled, due to tension and possibly the speed of reeling.

Yarn is tested for its count by measuring off a certain length (the latter depending upon the kind, character and value of the yarn to be tested) from the weight of which the count then can be readily calculated.

For example, let us consider the testing of cotton yarns. The standard length for testing cotton yarn is the *Lea* of 120 yards, which equals $(840 \div 120 = 7)$ $\frac{1}{7}$*th* of a hank, and which is measured by an apparatus known as the *Wrap Reel,* the circumference of which is 54 inches, or 1½ yards. Therefore 80 revolutions of this reel produce the lea, the completion of which is indicated by the ringing of a bell. There are also smaller reels built, measuring only 36 inches in their circumference.

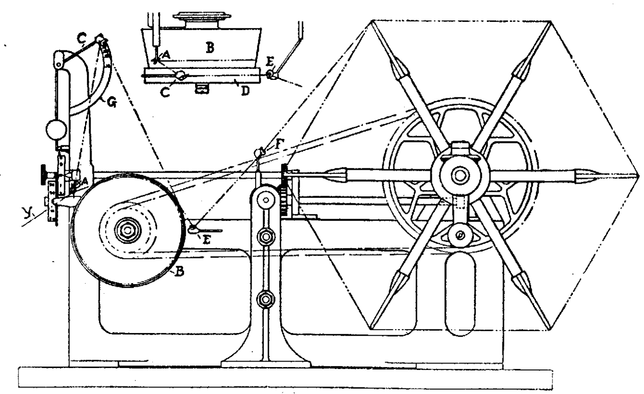


Fig. 55

Wrap reels are built to handle from four to seven cops, bobbins, or skeins. Be careful to have a uniform tension and traverse of the threads during winding, the same having an important effect upon the result of the test.

Fig. 54 shows such a wrap reel in its perspective view, the same being built by the Brown & Sharpe Mfg. Co., of Providence, R. I. These reels are made entirely of metal so that dampness will not affect them. The dial of the machine is graduated into 120 parts, indicating the number of yards reeled from each spindle. A desirable feature when reeling fine yarns is found in the correct alignment of the yarn guides and spindles. The extra length of yarn guides is of use in increasing the friction upon the yarn by taking a half turn or more of yarn around them. The automatic feed motion lays the yarn flat upon the reel, thus securing accurate and uniform measurement.

When the count of one bobbin only (or one skein) has to be ascertained, the reel is then stopped at the completion of each lea and the thread passed through the next guide eye in the traverse rail, and so on, until the required number of leas for testing have been wound on the reel. This operation, which involves additional attention, is in some wrap reels done automatically, it being actuated by the measuring motion. When in action, the latter causes a rod to rotate, which is provided with a series of stops arranged spirally round its circumference, and of a number corresponding with that of the number of leas to be wound. For every part of a revolution made by this rod, the guide through which the thread passes moves one step forward, the operation being repeated until the full wrap has been made.

At the testing house of the Manchester (England) Chamber of Commerce, there is used a specially constructed wrap reel with a measuring, tensioning, and stopping device, a description of which will be of interest, although for average

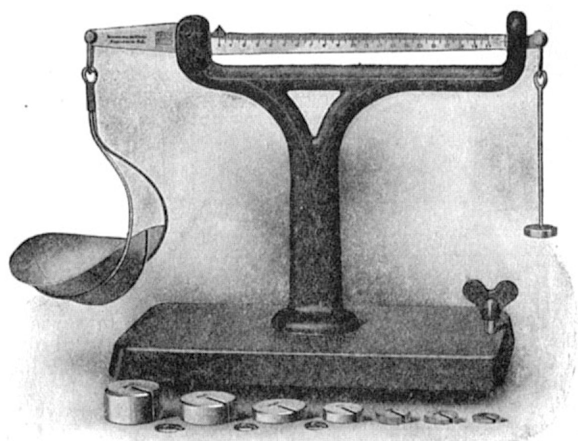


Fig. 56

mill use this reel would be not only too complicated, but at the same time too expensive, features which probably prevent its general adoption.

Fig. 55 shows a front view of this reel, with the device attached. The mechanism is constructed to put a definite amount of tension upon the yarn during reeling, the standard of tension being the weight of 1,000 yards of yarn of the various counts; the speed of reeling does not effect the degree of tension.

The yarn to be reeled is passed through a guide eye *A*, and round a conical drum *B* covered with emery (see detail in upper portion of Fig. 55) then again through the eye *A*, and upwards to an eye mounted on a lever *C* which registers the amount of tension, then the thread is led downward and passed round the measuring drum, *D* and in turn through two eyes *E* and *F* and on to the reel. The degree of tension is governed by the position occupied by the yarn during its passage round the emery covered cone *B* and the amount of tension is recorded by a pointer secured to lever *C*, working on quadrant *G*. This is a very ingenious and well-constructed machine, and suited to the requirements of accurate measuring; it is, however, rather costly, which probably prevents its general adoption.

After the yarn has been measured it must be weighed and the count calculated. Fig. 56 shows a perspective view of a handy yarn balance designed for weighing leas of yarn, built by Henry Troemner, Phila. The beam is graded to 20 grains with sub-divisions in $\frac{1}{10}$ grain. This scale will weigh one pound by tenths of grains, or one seventy-thousandth part of one pound avoirdupois, rendering it espe-

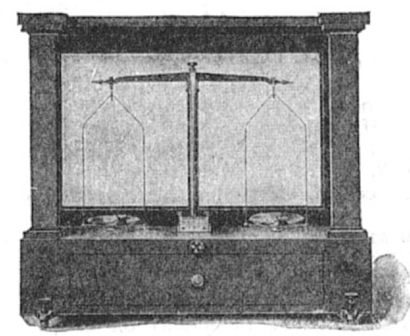


Fig. 57

cially well adapted for use in connection with Yarn Reels, for the numbering of yarn from the weight of hank, giving the weight in tenths of grains to compare with tables which you can readily prepare, or the builders of the scale will furnish.

For accurate weighing nothing is better than a chemical balance, a specimen of which is shown in Fig. 57, representing the balance as built by Henry Troemner, Phila., equipped with weights graded to $\frac{1}{100}$ grain. This plan, however, does not lend itself to the every day practice of a mill warehouse or office, hence special balances have been designed to expedite this work, *i. e.,* ascertaining counts of yarns without having to calculate, using a standard length of skein, or a certain number of yards of yarn for the test.

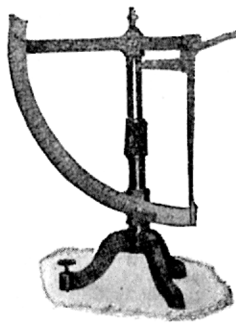


Fig. 58

An apparatus of this kind, a *Sizing Balance* or *Quadrant,* is shown in Fig. 58. The same is handled by Alfred Suter of New York and is equipped with a direct reading denier and dram scale if needed for the testing of true silk, or with numbers if used for cotton, spun silk, wool, worsted, linen or artificial silk. A combined cotton and worsted, as well as a combined cotton, worsted and wool scale can be also furnished.

The clearness of the numbering of the scales of such an apparatus depends upon the size of the lever, the length of yarn to be weighed, as well as the amount of numbers desired on the scale. It will be found advisable not to plan too many divisions (*i. e.,* numerals) on one scale, nor to use very low counts, except the latter is absolutely necessary, since indicating these low counts is influencing the clearness of indicating the high counts of yarns on the scale. Provided low and high counts are necessary to be tested on one apparatus, it will be found advisable to divide the numbers on two scales, using for the coarse counts less length of yarn for weighing, compared to when testing high counts of yarn. As will be readily understood, the lever suspension of this apparatus must be very sensitive. If the yarns are sized they should be washed and dried previous to weighing, to obtain the true counts.

Fig. 59 shows another kind of scale for conveniently obtaining the count of yarns to be tested minus calculations, built by the Torsion Balance Co., 92 Reade Street, New York.

They build two types of these *Yarn Calculating Balances;* one for testing the counts of Cotton Yarns, and the other for Woolen and Worsted Yarns. The one illustrated is their automatic "Cotton Yarn Calculating Balance."

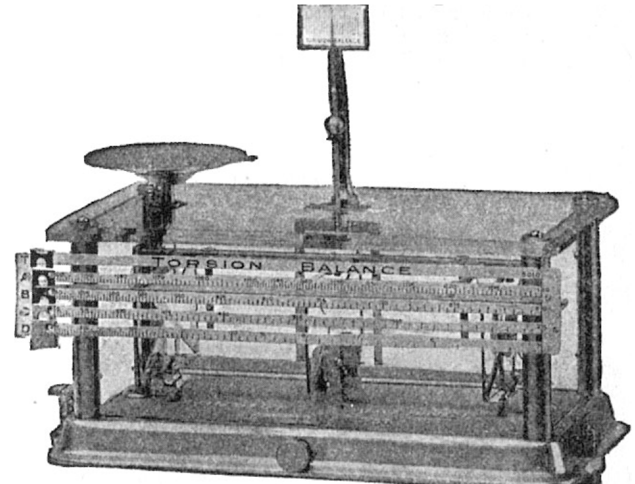


Fig. 59

The only difference between these two scales is the different reading on the slide beams, one for reading "Cotton Counts" the other for reading "Runs" and "Cuts" for Woolen Yarns as well as "Counts" for Worsted Yarns, these three readings being marked on each slide beam. Different length of yarns to be tested are used in both balances.

The Cotton Yarn Calculating Balance, shown in Fig. 59, is equipped with five (5) slide beams *viz:*

T a blank beam for all numbers above 200
A Nos. 200 to 110
Yarn number 200 to 150 by 1
Yarn number 150 to 110 by ½
B Yarn number 110 to 60 by ½
C Yarn number 60 to 25 by ½
D Yarn number 25 to 5
Yarn number 20 to 20 by ½
Yarn number 20 to 5 by ¼

120 yards (or one lea) of cotton yarn is the unit used in every instance for testing; said 120 yards of yarn being placed in the aluminum pan shown on the left-hand side of illustration. The sensitiveness of this scale is $\frac{1}{32}$ grain; the pan for holding the yarn to be tested is of aluminum, 3 inches in diameter; the indicator of the balance is shown in the centre of the illustration.

With reference to the "Woolen and Worsted Yarn Calculating Balance" the same is provided with only four slide beams in place of the five used with the Cotton Yarn Balance:

The arrangement of the four slide beams used is:

	Woolen Yarns		Worsted Yarns
	Run System	*Cut System*	
T (blank)	0 to 35	$1\frac{3}{4}$ to 186	1 to 100
A	35 to 14	186 to 75	100 to 40
	by $\frac{1}{2}$	by 1	100 to 70 by 1
			70 to 40 by $\frac{1}{2}$
B	14 to $3\frac{1}{2}$	75 to $18\frac{2}{3}$	40 to 10 by $\frac{1}{2}$
	by $\frac{1}{2}$	by 1	
C	$3\frac{1}{2}$ to 0	$18\frac{2}{3}$ to $1\frac{3}{4}$	10 to 1 by $\frac{1}{2}$
	by $\frac{1}{2}$	by $\frac{1}{2}$	

Each slide beam carries all three readings, Worsted Numbers on top, Run and Cut numbers marked respectively above and below on one line on bottom.

20 yard samples are in this instance used for the test. Sensitiveness of the scale, as well as size of the pan used is the same as that of the cotton yarn balance previously referred to. No illustration of this balance is given, the cotton yarn balance shown in connection with explanations given fully explaining subject.

In another system of ascertaining the counts, scales are used with a pan at each end of the beam, one pan receiving a given length of yarn (according to the system of numbering) which is balanced by placing a standard weight in the other pan. The weights used are numbered to represent the actual counts of the yarn, a given length of which is balanced.

Thus, if 80 yards for worsted and 120 yards for cotton (representing in each case one-seventh of a hank) be taken as the unit length,

40's counts would be balanced by a weight of $(7000 \div (7 \times 40 =) \ 280 =)$ 25 grains;

20's counts by a weight of $(7000 \div (7 \times 20 =) \ 140 =)$ 50 grains, etc.

This system is useful for getting the approximate counts when a considerable length of yarn is available, but cannot be used for short lengths.

Fig. 60 shows the "Yarn Scale Balance" built by Henry Troemner, Philadelphia, for ascertaining without calculations the counts of Cotton, Woolen ("cut" and "run" basis) or Worsted Yarns, using a different graduation of the scale-beam for each kind of yarn quoted, so as to comply with their standards of grading as to count or number.

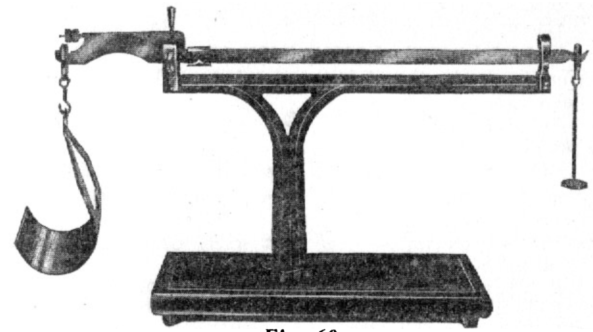


Fig. 60

We will explain the construction and working of this scale balance with one example, based on "Testing of Woolen Yarns spun by the 'Cut' System", and which example will at the same time explain the handling of other kinds of yarns, using then with each kind of yarn a special graduated scale-beam, to conform with the standard number of yards used in grading the counts of the kind of yarn to be tested.

The scale-beam of this balance is graduated to indicate woolen yarns by the "cut" numbers (from 5 cut to 40 cut) representing the bulk of woolen yarn used by the textile industry in Philadelphia, New York State, etc. The graduations of the heavier counts (from 5 up) are sub-divided into quarters.

The length of yarn used for testing these woolen yarns is 50 yards, and which after a careful reeling are placed on the pan of the scale. Heavy counts of yarn require the sliding poise operated more toward the end of the scale-beam and where the graduations for these heavy counts (5, 6, 7 etc.) are located. The graduation (for the lighter *i. e.*, higher counts of yarns) are on the other end of the scale-beam, and where they read from 40's down. By using this scale the spinner can at once detect any variation in counts and correct them in his work.

Although this balance has its scale-beam graded by the cut (wool) system, provided the case should come up to test by this balance the counts or numbers of other yarns, this can be done by means of calculations, *i. e.,* taking the standard of the cut system (300) and the standard of the other yarn to be tested into consideration. New England does not use the "cut" system but uses the "run" basis.

CUT SYSTEM—RUN SYSTEM (or 300 to 1600).

For Example, the sliding poise balanced on 40 cut mark. Then $40 \times 300 = 12{,}000 \div 1600 = 7\frac{1}{2}$ run. *Ans.*

CUT SYSTEM—COTTON YARN (or 300 to 840).

For Example, the sliding poise balanced (as before) on 40 cut mark.

Then $40 \times 300 = 12{,}000 \div 840 = 14.28$ or practically $14\frac{1}{4}$'s cotton yarn. *Ans.*

CUT SYSTEM—WORSTED YARN (or 300 to 560).

For Example. Transfer previous test of 40 cut into worsted number.

$40 \times 300 = 12{,}000 \div 560 = 21.42$ or practically $21\frac{1}{2}$'s worsted yarn. *Ans.*

Fig. 61 shows another "Yarn Scale Balance" built by Henry Troemner, Phila., designed more particularly for the testing of Cotton, Worsted and Spun Silk yarns.

TO ASCERTAIN COTTON AND SPUN SILK COUNTS.

This Yarn Balance is built upon the basis of 840 yards, the standard for both, Cotton and Spun Silk yarns.

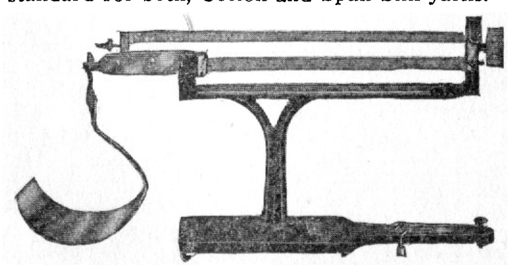


Fig. 61

For quicker work, only 60 yards ($\frac{1}{14}$th part of the standard) in place of 840—the standard, are used, the builders in turn reducing the weights accordingly, *viz:*

7000 grains in one lb. $\div 14 = 500$ grains, weight of 60 yards yarn of number 1 count. This number 1 is then stamped on the upper part of the lower beam. Number 2 yarn is just $\frac{1}{2}$ the weight of number 1 yarn, or 250 grains,

this is stamped with a 2 on the beam. Number 5 yarn is $\frac{1}{5}$th the weight of number 1 or 100 grains. Number 10 yarn weighing 50 grains is then indicated on the beam, and the procedure kept on down to number 100 yarn, which weighs ($500 \div 100 =$) 5 grains. The upper rows of graduations on both beams indicate the number of the yarn.

Spun Silk Yarn is only in a few instances used as single yarn—if so it equals single, cotton yarn.

The difference between both yarns is found when dealing with 2 or more-ply yarn, and in which instance:

Considering Cotton Yarn Twist, the minor threads of 2-ply yarn are twice the count of that expressed in writing; those of 3-ply yarn, three times the count expressed in writing, etc., thus:

2 ply 60's cotton = single 30's cotton

3 ply 60's cotton = single 20's cotton, etc.

Considering Spun Silk Yarn Twist, the minor threads are of the count expressed in writing, thus 2-ply, 3-ply, etc., equal the double, triple etc., compound thread of the minor thread. For this reason:

2-ply 60's spun silk = 2 ends of single 120's twisted, and for this reason is written 60/2.

3-ply 60's spun silk = 3 ends of 120's twisted, and for this reason is written 60/3, in order to show the difference between spun silk and cotton yarns with reference to ply yarns, a feature which must be taken into consideration when testing for the counts of ply yarns with these scale balances.

Worsted Yarn in 2 or more-ply, works on the same principle as cotton yarn, *i. e.,* 2 ply 60 (written 2/60's) = single 30's in count; 3/60's = single 20's etc.

No difference in the count is taken into consideration when dealing with twist yarns, although a difference exists and which is taken into consideration by the more careful analyst, who then can rely on his experience; again the minor threads may be spun on the light side to bring the compound thread up to standard count.

TO ASCERTAIN COUNTS OF WORSTED YARN.

"Yarn Scale Balance" shown in Fig. 61, and provided with graduations based on Cotton Yarns, can also be used for testing Worsted Yarns as to their count, by using in the latter instance only 40 yards of yarn for testing purposes in place of the 60 yards of yarn used with cotton yarn, for the reason that the worsted standard 560 is $\frac{2}{3}$ of the cotton standard 840, or as 560 : 840 : : 40 : 60.

Proof: $560 \times 60 = 33{,}600$ and $840 \times 40 =$ also $33{,}600$.

The lower row of graduations on the beams on Balance shown in Fig. 61 are used independent from the one above. These are actual weights in grains from $\frac{1}{10}$th of a grain to