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".

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**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.

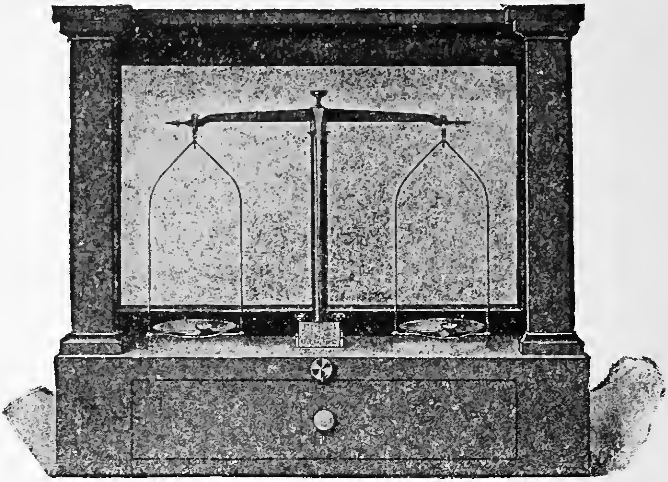
A thorough knowledge of weave-formation and fabric-structure will greatly simplify the work of the analyst. Not only will he become convinced that his pick-out is correct, but for instance, the harder a weave takes-up the filling, *i. e.,* the closer the interlacing, the stronger the warp-yarn must be,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

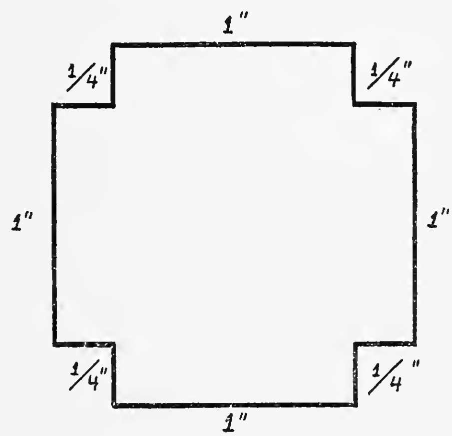
In place of the latter, a steel die or *cutter,* of a known size may be used, or two or more sizes of such cutters may be kept on hand.

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.

$54 \times 36$ (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:* $12\frac{1}{3}$ 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:* $15\frac{1}{2}$ 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:* $5\frac{1}{5}$ 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.

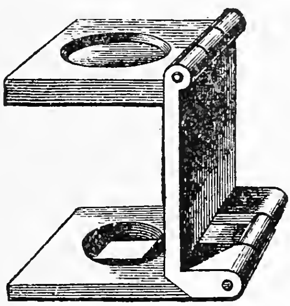
*Example:* Ribbon, sample furnished 3½ inches long; to weigh 15.126 grains.

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

*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.

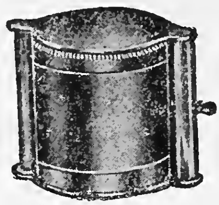
There are two methods practised for determining the weave used in a given cloth, *viz:* by *synthesis* and by *analysis.*

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

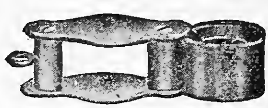


DOUBLET MAGNIFIER.
*Spencer Lens Company.*

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 , $\frac{1}{2}$ x $\frac{1}{2}$ , $\frac{1}{4}$ x $\frac{1}{2}$ , $\frac{1}{4}$ x $\frac{1}{4}$ or $\frac{1}{4}$ *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 $\times$ lense being (considered in an average) the most useful.

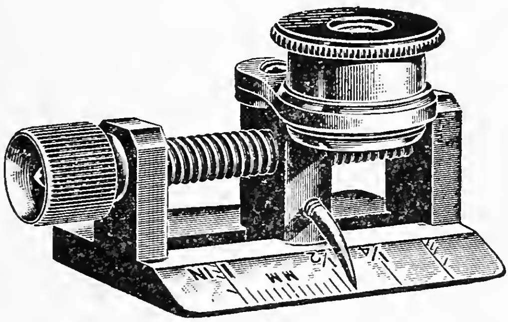


TRIPLE APLANATIC MAGNIFIER.
Equipped with Folding Case.
*Spencer Lens Company.*

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.

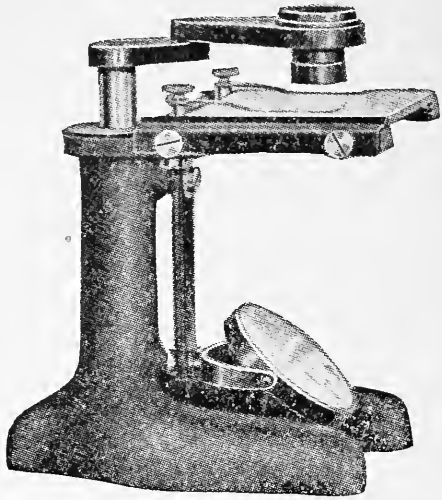
The Dissecting Microscope has its stand all brass, or of a rich black lacquered mounting, with broad circular Base and large firm Stage; Jointed Arm to carry the Lenses, with Rack-and-pinion adjustment of Focus; Concave Mirror with complete adjustments; Single or Double Lenses, of Doublet, Coddington 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 eye-piece 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.

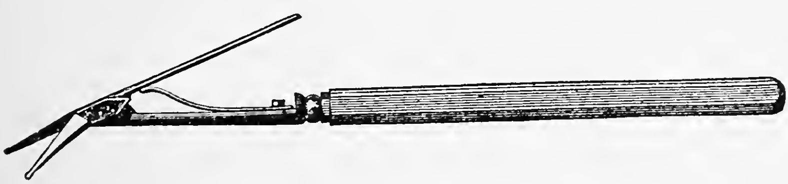
Over-ruling of the point paper, besides simplifying matters to the designer, at the same time prevents mistakes in counting-off the repeat of a weave, a feature possible to occur otherwise, more particularly if dealing with a weave of a large repeat. It, at the same time, will guide the designer when 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.

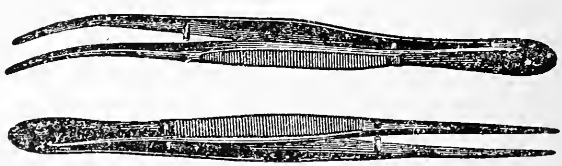
The best picking-out needle to use is a common heavy crocheting needle, of which file the hook away—adding in place of it a fairly fine point, but not too fine since the latter might catch in the core of your threads in the sample you handle.

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.

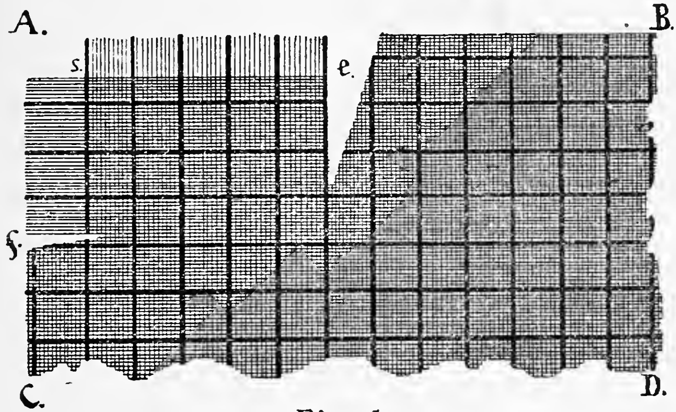



*Fig. 1*

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

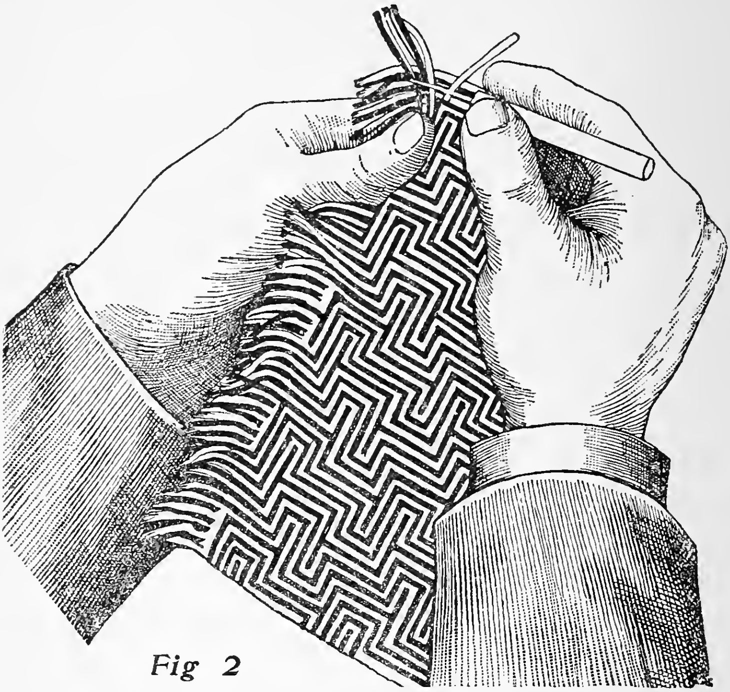


*Fig 2*

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 corkscrew. 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.

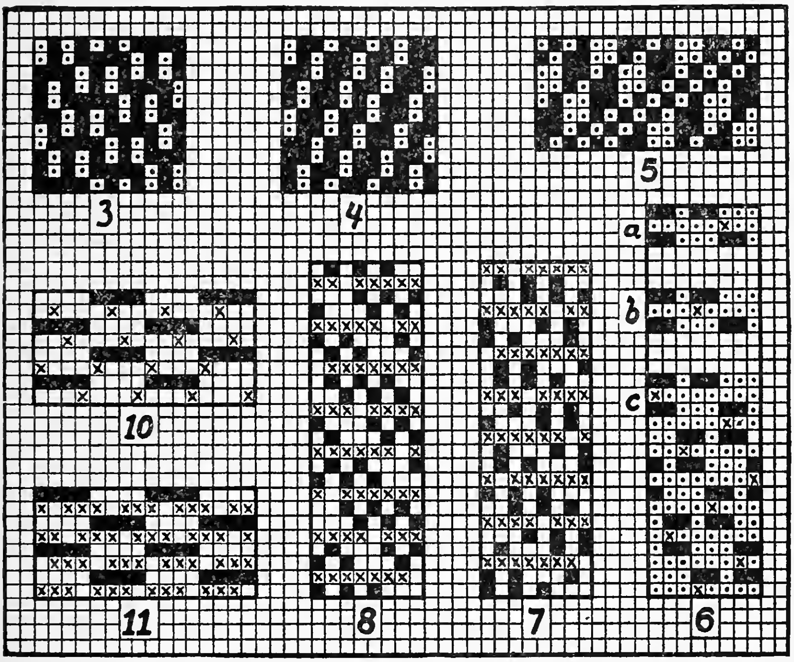
Pick-out and record interlacing of the first face thread you can get hold of.

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 $\frac{1}{2}\,\frac{3}{2}$ and $\frac{1}{7}$ is easier, compared to picking-out $\frac{3}{\phantom{3}}\frac{1}{3}\frac{1}{1}\frac{\phantom{1}}{7}$, 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 facilitate 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.

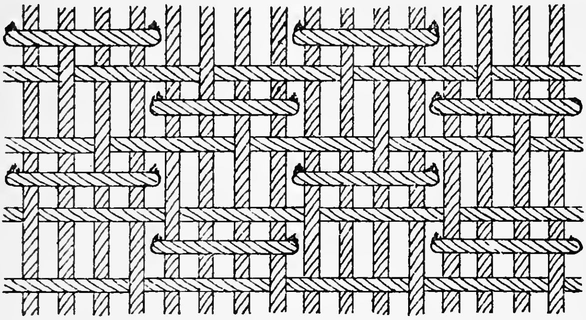


*Fig. 9*

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.**

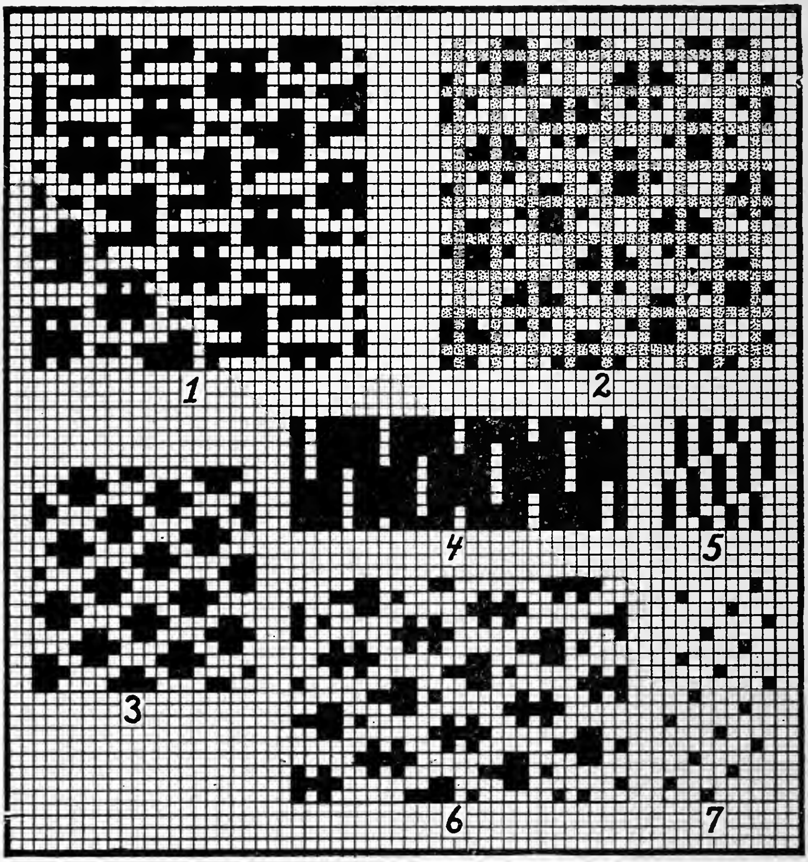



*Fig. 12*

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 $42 \times 36$ 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.

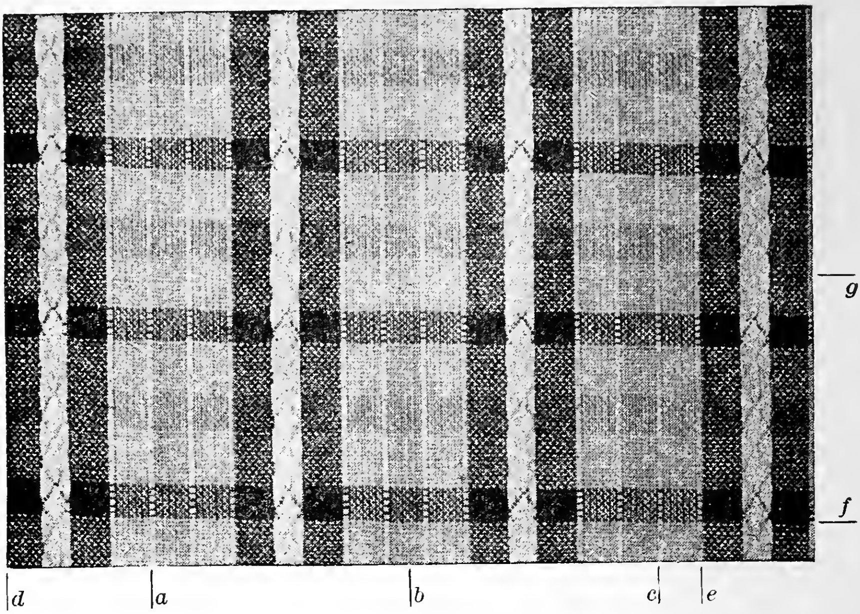



*Fig. 13*

*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.

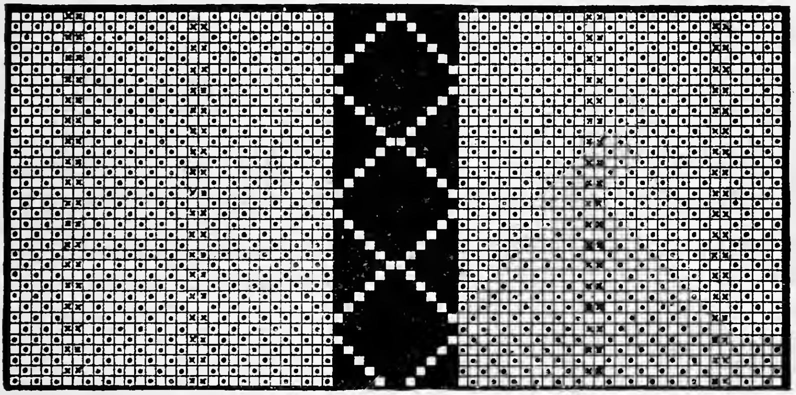


*Fig. 14*

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.

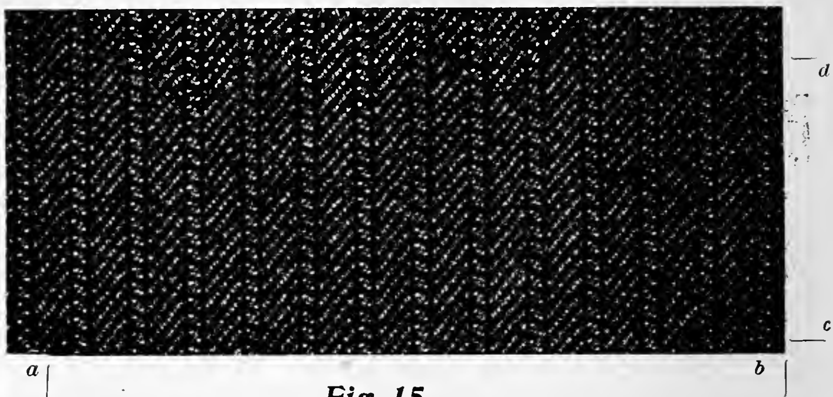



*Fig. 15*

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.

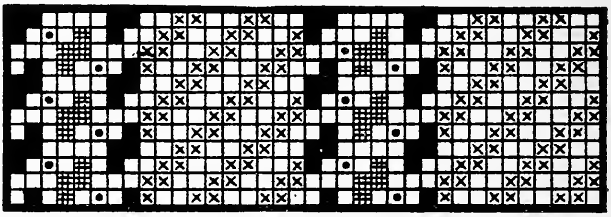


*Fig. 16*

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

234 ÷ 3 inches = 78 ends per inch *Ans.*

Dealing with a fabric 56 inches wide, this will mean (78 × 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.

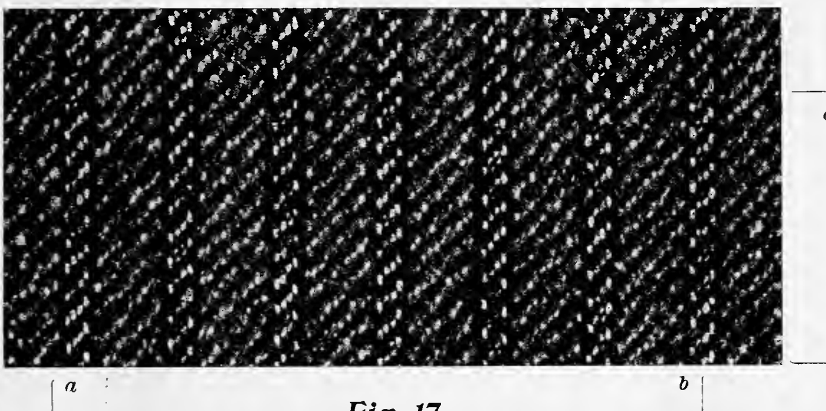



*Fig. 17*

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.

Distance of *c* to *d*, on side of fabric sample, is one inch, showing 9 interlacings of the 4-harness twill, hence (9 $\times$ 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

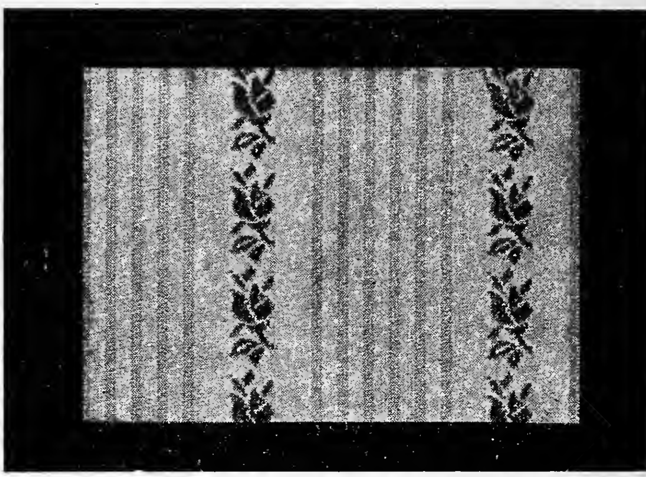


*Fig. 18*

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; showing 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.

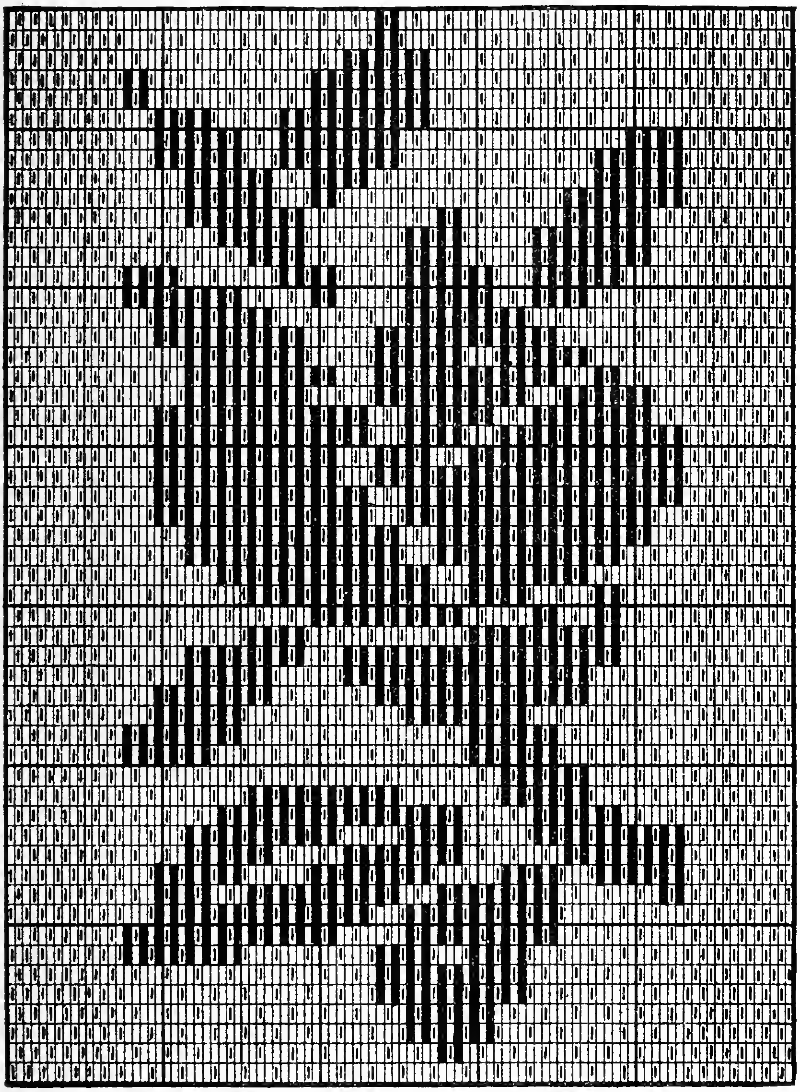


*Fig. 19*

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.

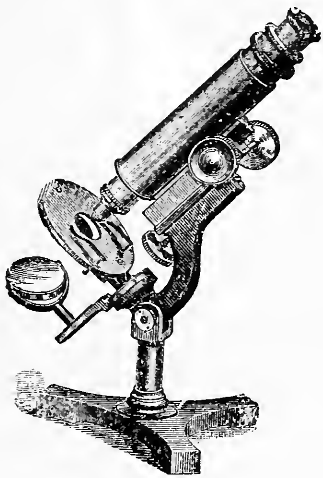
Textile fibres of commerce belong to two distinct varieties: (*a*) animal fibres, (*b*) vegetable fibres.

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.

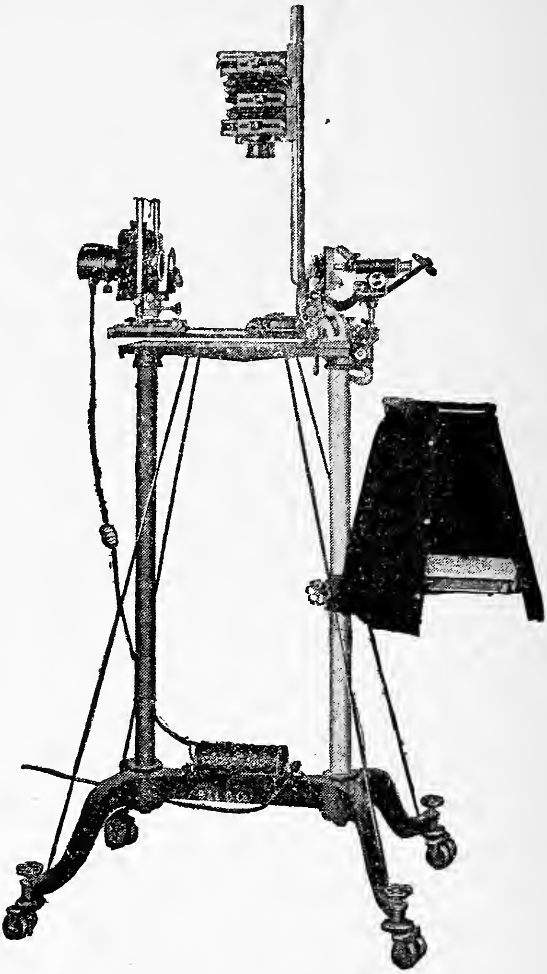
Cross-sections may easily be cut from this by means of a microtone, or with a sharp razor with a little practice.

**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

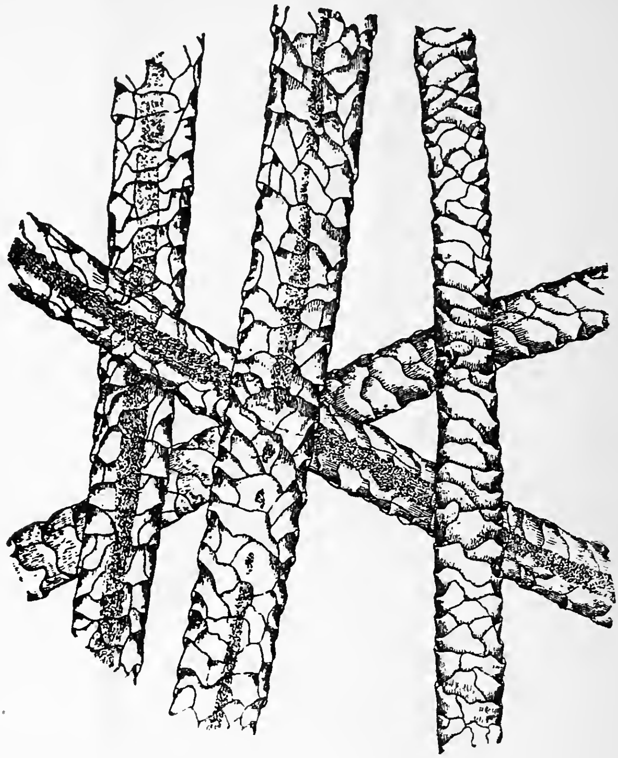


*Fig. 20*

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

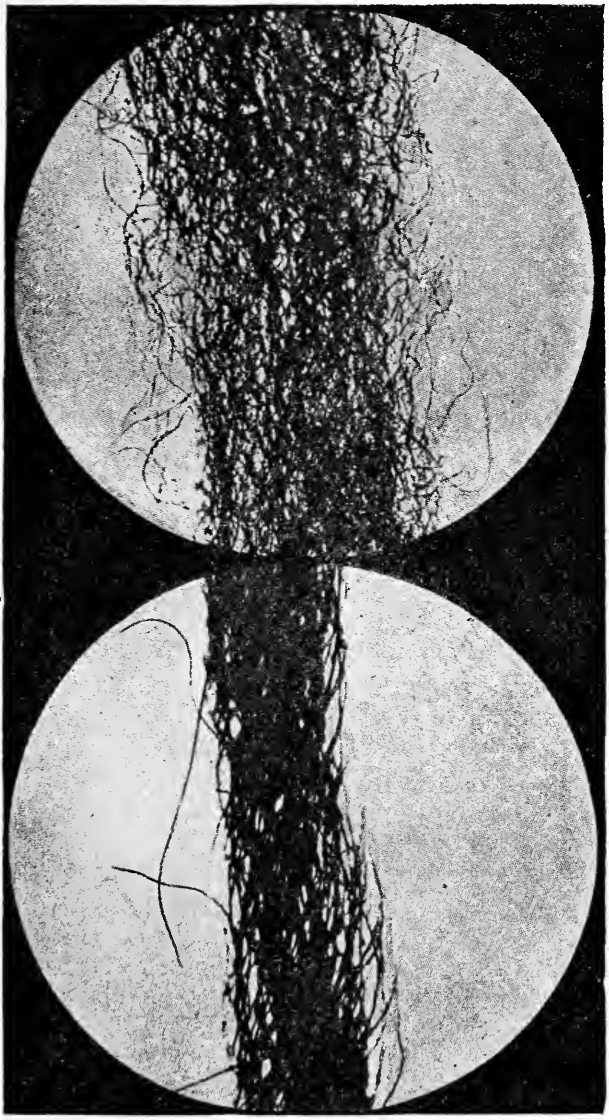


*Fig. 21*

*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.

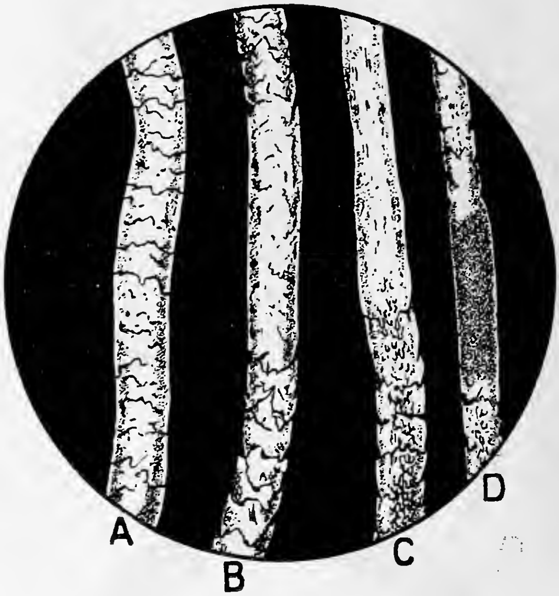



*Fig. 24*

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

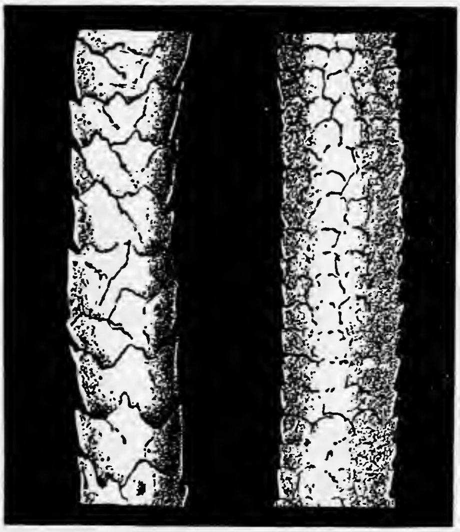


*Fig. 25* *Fig. 26*

from 1¼ to 3½ inches and possesses no medullary substance. The outer hairs are of a length of from 3½ to 4½ inches,

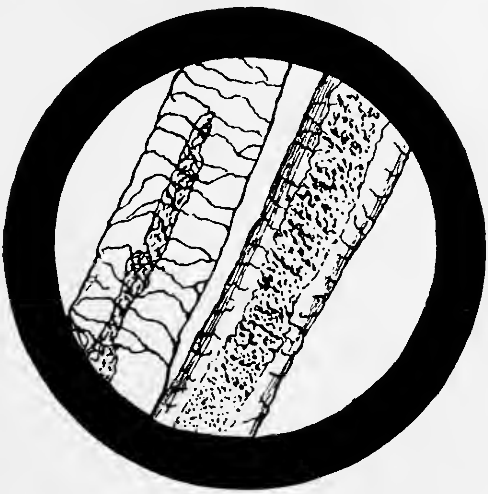


*Fig. 27*

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.

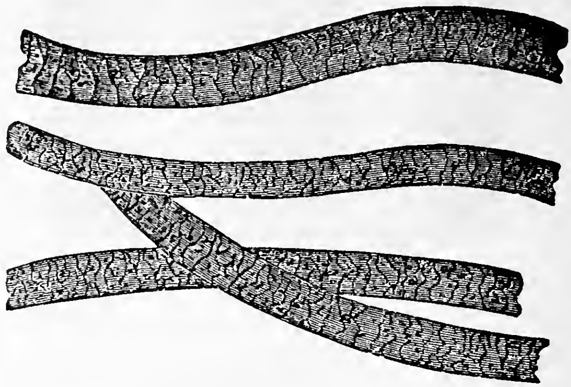


*Fig. 28*

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.

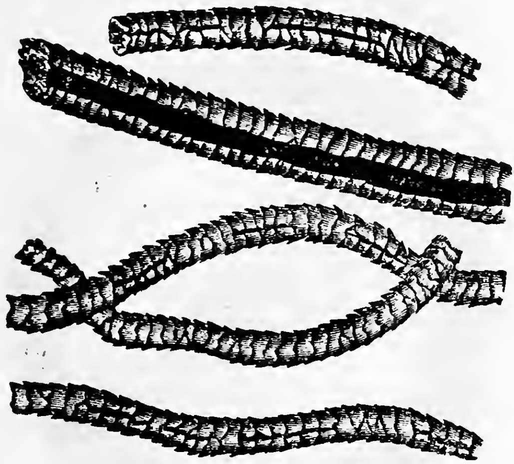


*Fig. 29*

*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

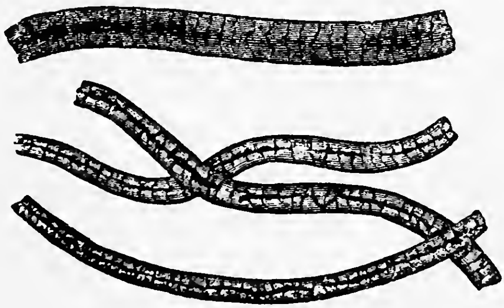


*Fig. 30*

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.

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

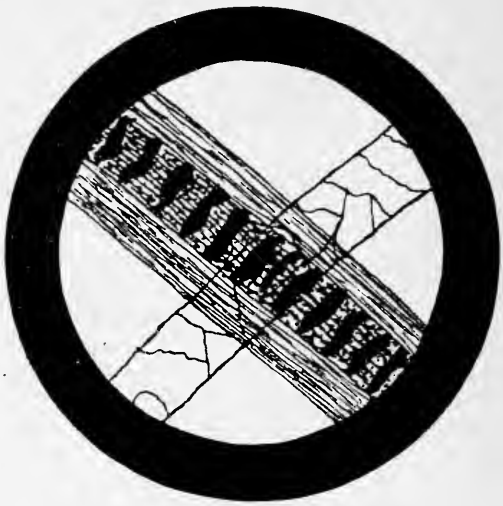


*Fig. 31*

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 $\frac{3}{8}$th to $1\frac{1}{8}$th 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

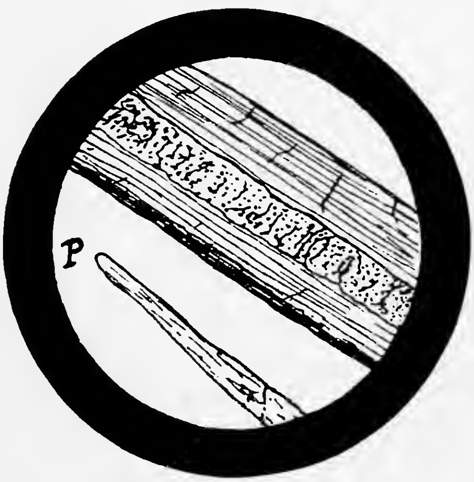



*Fig. 32*

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.

**Silk.**

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

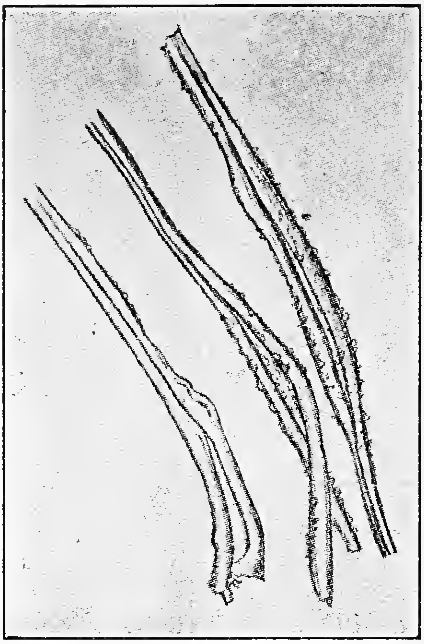


*Fig. 35*

thrown or spun silk. The latter is readily distinguished

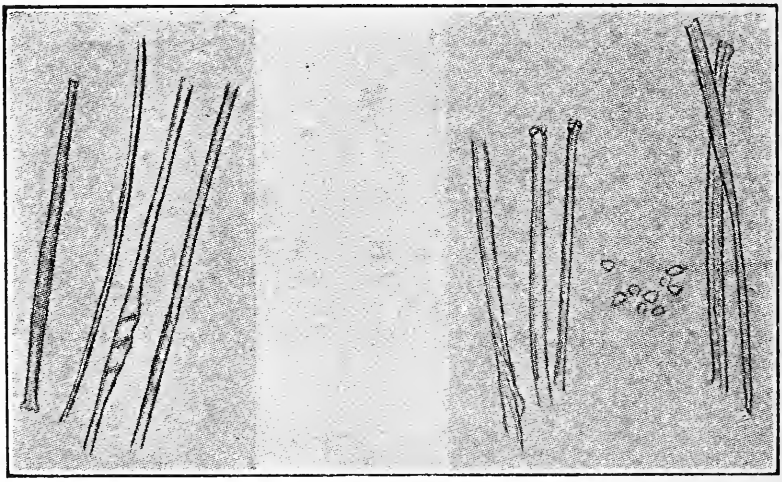


*Fig. 36*

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,

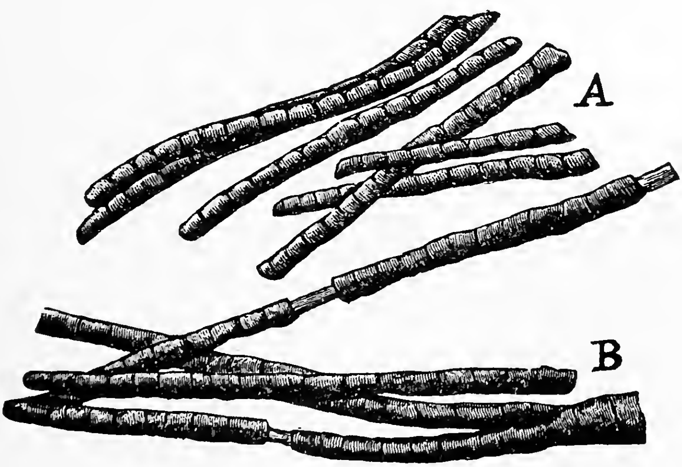



*Fig. 38*

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

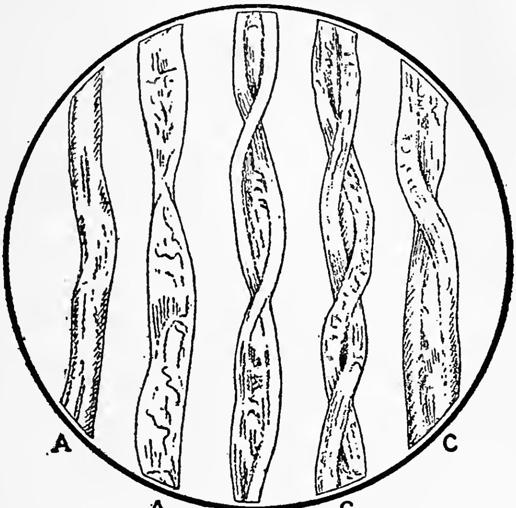



*Fig. 39*

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,

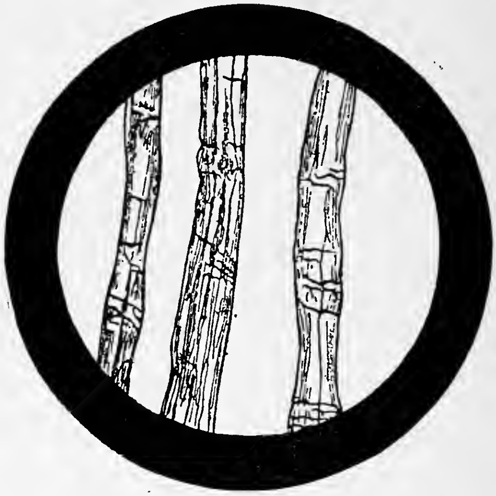


*Fig. 40*

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

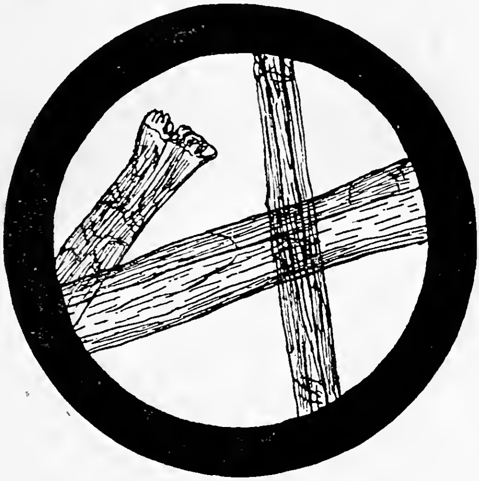


*Fig. 42*

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

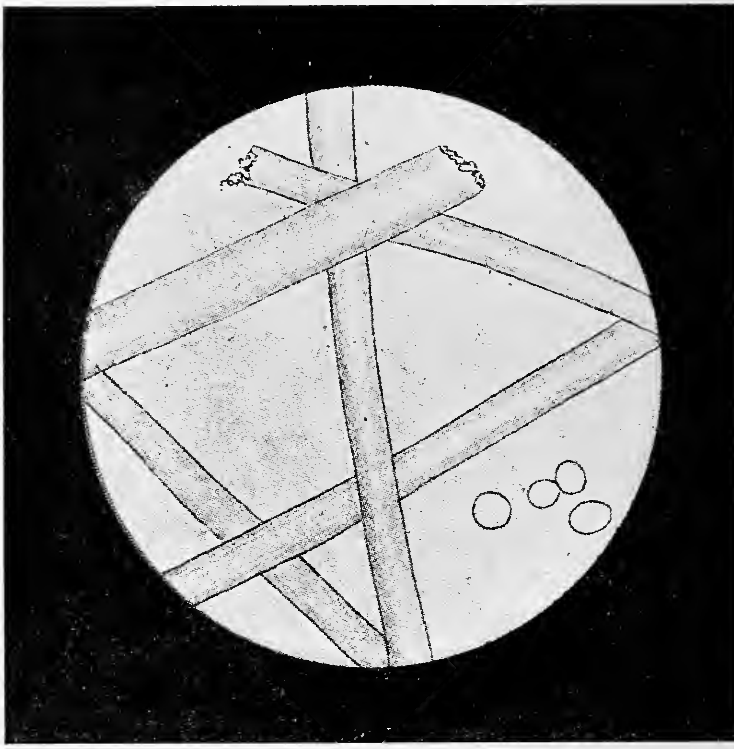


*Fig. 44*

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

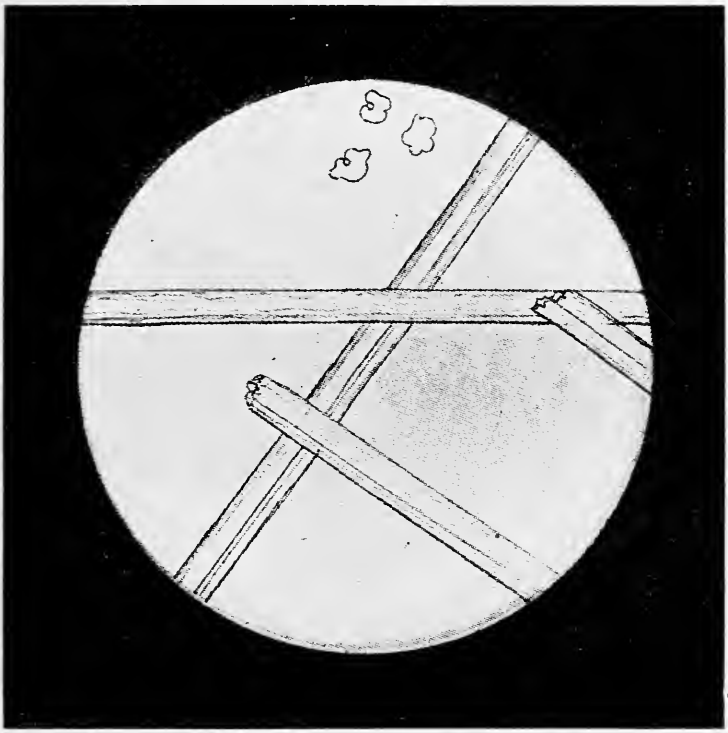


*Fig. 45*

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

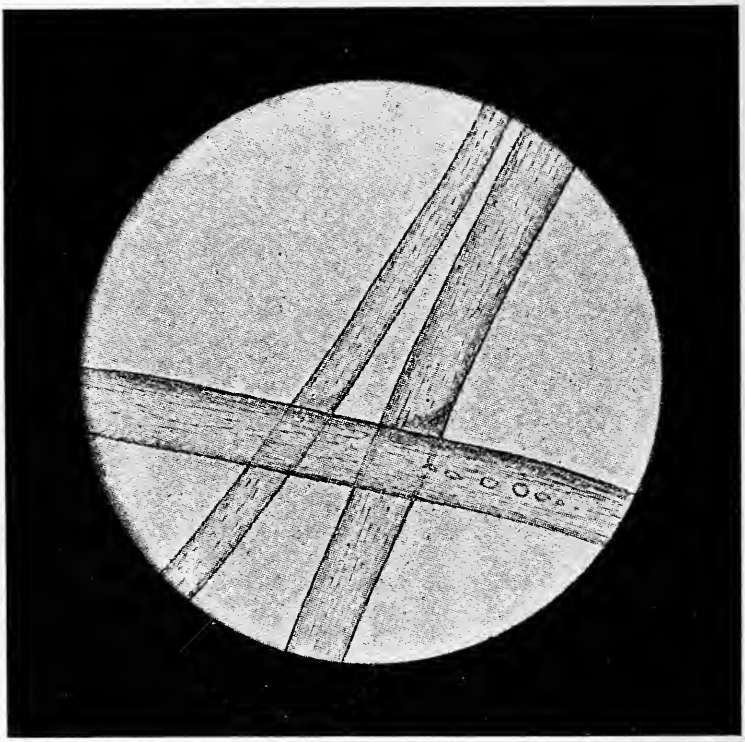


*Fig. 46*

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.

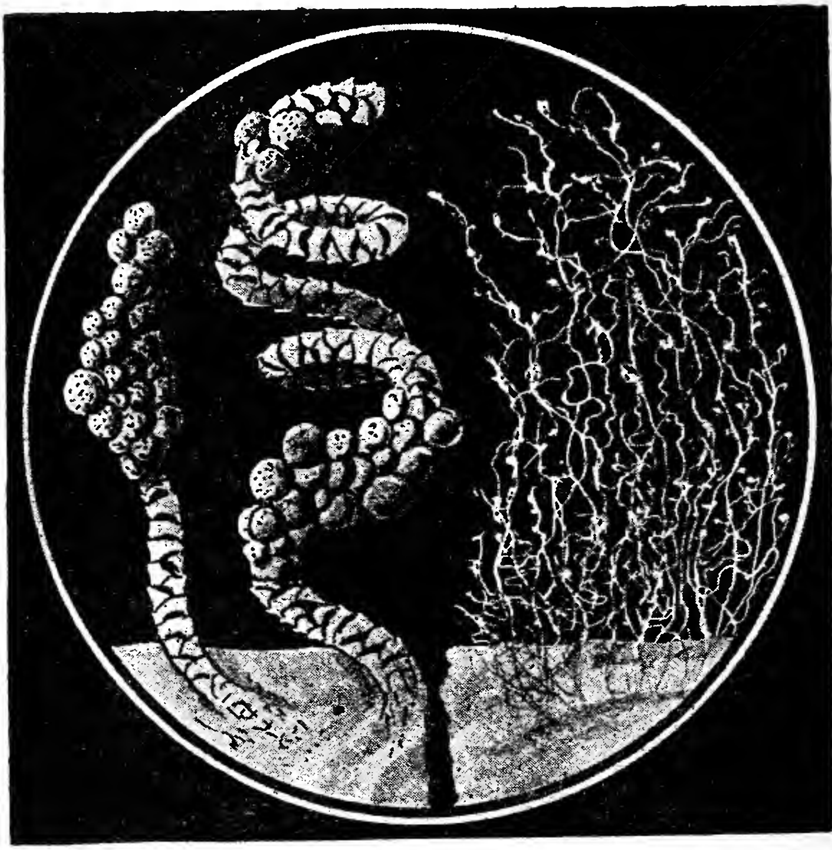


*Fig. 47*

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.

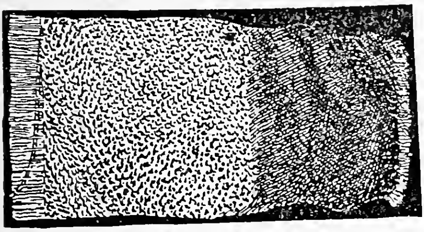


*Fig. 48*

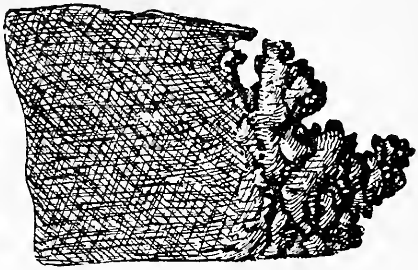


*Fig. 50*

*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

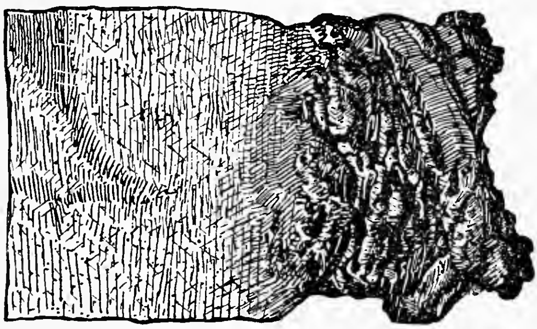


*Fig. 49*

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).

## Analysis of Raw Silk.

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, Wild and Artificial 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 1¼ 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* ($\beta$) *:* 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 containing 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

**Analysis of Silk - Wool Fabrics.**

(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.

## Analysis of Wool - Silk - Cotton Fabrics.

(*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 removed, 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 $2 \times 840$ 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. ÷ 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 6¼ 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 ½ decigram; thus the count is expressed by the number of ½ 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:*

$$\frac{4.72 \times 30}{34.15} = 4.14$$ French (Sedan) count; also the Belgian count. *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:*

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

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

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

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

$$\frac{637.25 \times 10}{70} = 91.03$$ Denier silk count. *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 $\times$ 0.847 = Metric counts.

Metric counts $\div$ 0.847 = Yard counts.

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

Yard counts $\div$ 1.18 = Metric counts.

Metric counts $\times$ 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.) $\times$ 0.847 = 16.94 (M. c.)

16.94 (M. c.) $\div$ 0.847 = 20 (Y. c.)

Using *constant* number 1.18

20 (Y. c.) $\div$ 1.18 = 16.94 + (M. c.)

16.94 (M. c.) $\times$ 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.

$12.5 \times 10 = 125 \div 4.2 = 2/59.5$'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:

$12.5 \times 10 = 125 \div 2.8 = 44.6$ count of worsted thread.

$8.33 \times 10 = 83.3 \div 1.4 = 59.5$ 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

$12.5 \times 10 = 125 \div 4.2 = 29.76$ or practically speaking a ($29.76 \times 2 = 59.52$) 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:

$90 \times 45 = 4050$

$90 + 45 = 135$ and

$4050 \div 135 = 30$'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

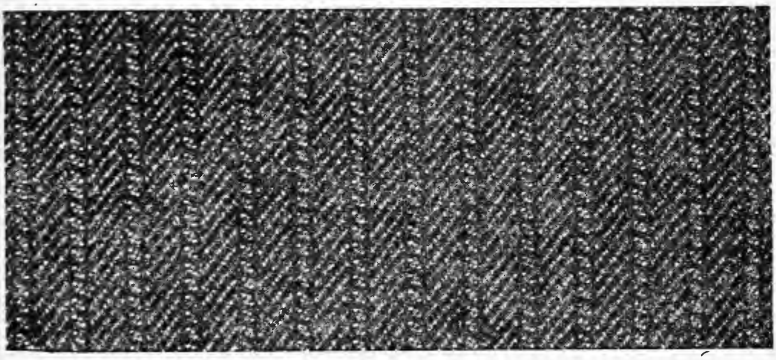


*Fig. 51*

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."

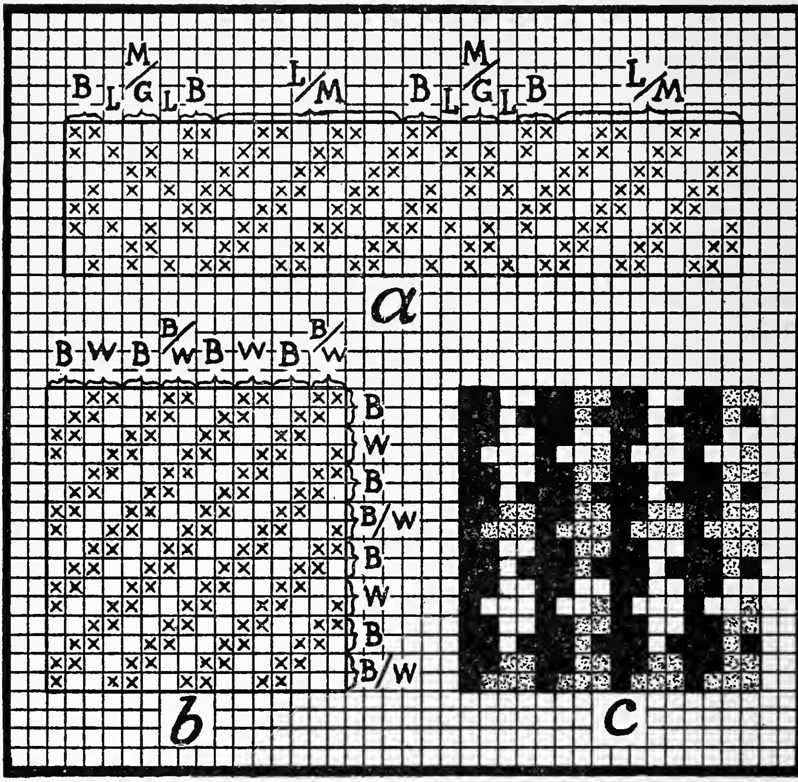



*Fig. 52*

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

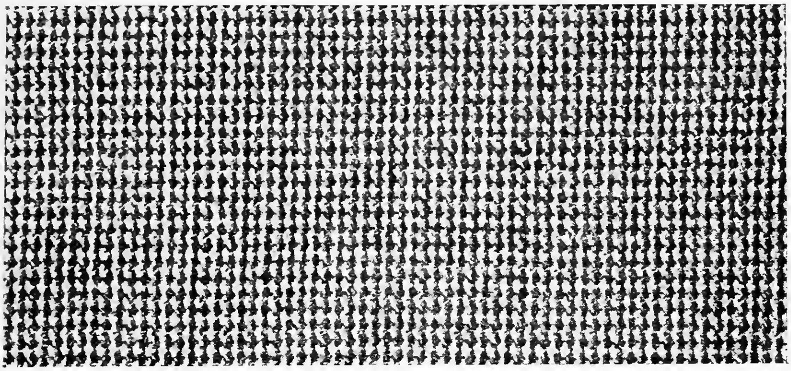


*Fig. 53*

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.

$$7\frac{5}{8} \quad : \quad 9.1 \quad :: \quad 1944 \quad : \quad x$$

$$\frac{1944 \times 9.1}{7\frac{5}{8}} = 2320 \text{ grains, weight of sample for one yard.}$$

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 $23\frac{1}{4}$ 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, $3\frac{1}{2}''$ long = 119″; weigh 14.36 grains.

*Black Warp:* 35 ends, $3\frac{1}{2}''$ long = 122.5″; weigh 17.4 grains.

*Filling:* 55 picks, $3\frac{1}{2}''$ long = 192.5″; weigh 30.37 grains.

*Mix Warp:* $119 : 14.36 :: x \quad 7000$

$x = 58{,}008$ 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 $\frac{7}{8}$ run will be the count desired.

*Black Warp:* $122.5 : 17.4 :: x : 7000$

$x \div 36 = 1368$ yards, and

$1368 \div 1600 =$ practically $\frac{7}{8}$ 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 $\frac{3}{4}$ 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,

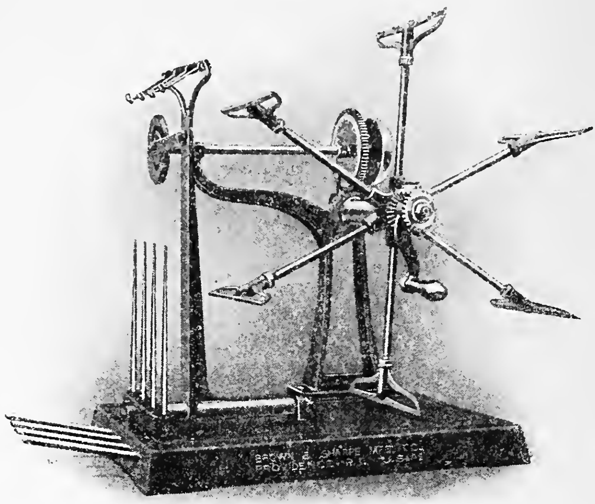


*Fig. 54*

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

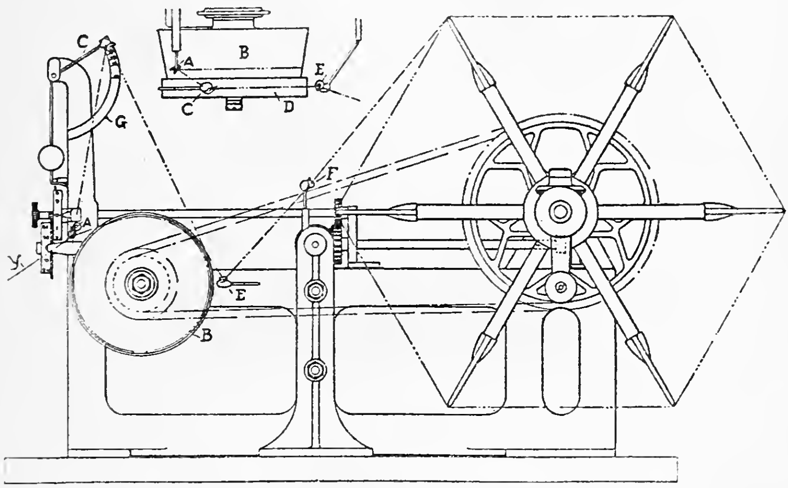



*Fig. 55*

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

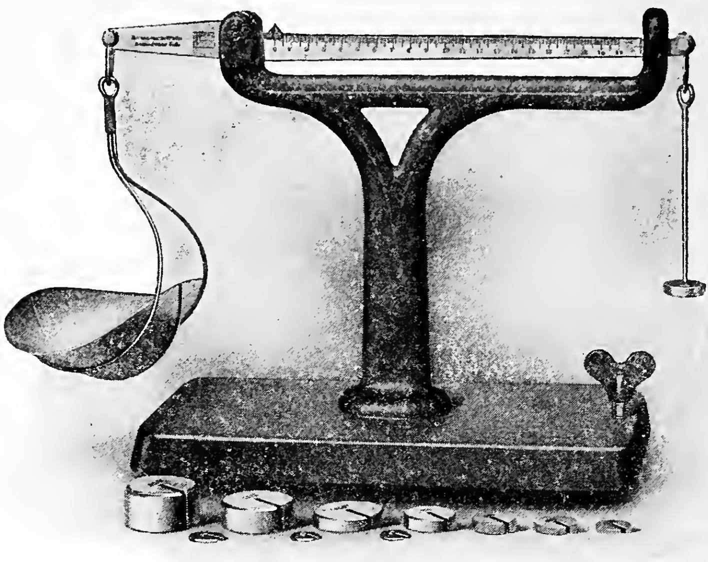


*Fig. 56*

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-

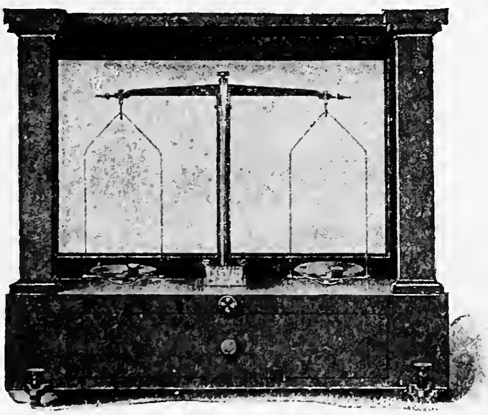


*Fig. 57*

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."

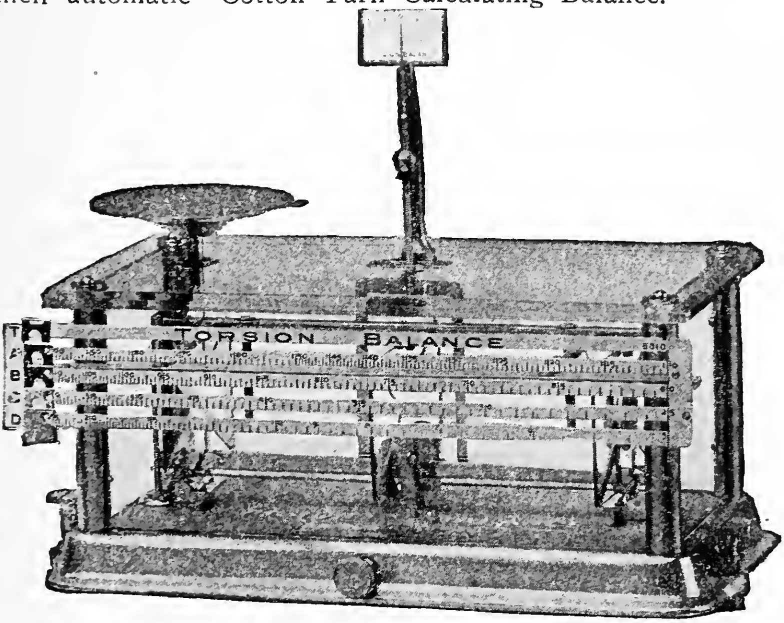



***Fig. 59***

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 by $\frac{1}{2}$ | 186 to 75 by 1 | 100 to 40<br>100 to 70 by 1<br>70 to 40 by $\frac{1}{2}$ |
| *B* | 14 to $3\frac{1}{2}$ by $\frac{1}{2}$ | 75 to $18\frac{2}{3}$ by 1 | 40 to 10 by $\frac{1}{2}$ |
| *C* | $3\frac{1}{2}$ to 0 by $\frac{1}{2}$ | $18\frac{2}{3}$ to $1\frac{3}{4}$ by $\frac{1}{2}$ | 10 to 1 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.

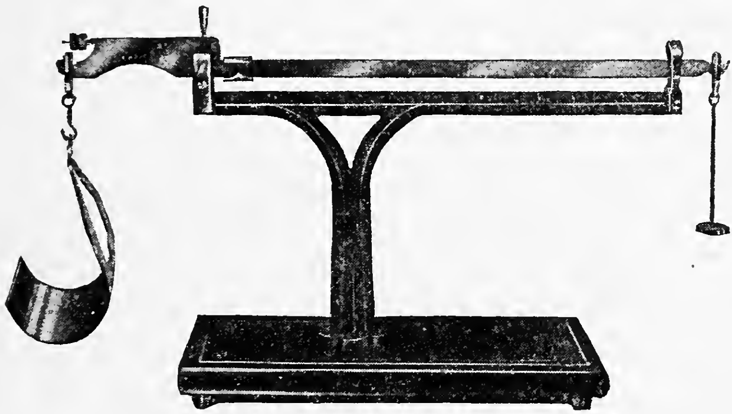


***Fig. 60***

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.

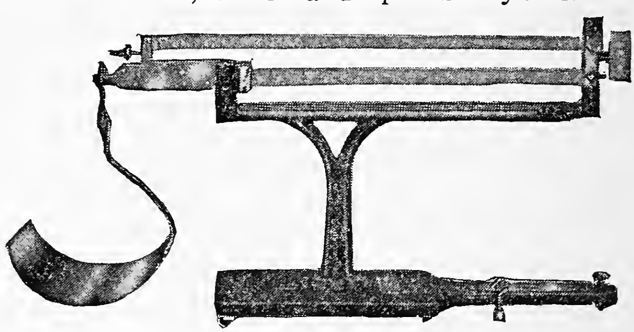


*Fig. 61*

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

500 grains, plus an extra hanging weight of 500 grains. These beams are used in connection with a Chart giving all the different weights of the numbers of yarn you are to use. By this method of weighing reel-off as many yards as your chart specifies, and then weigh them on your scale, using the lower row of graduations only. This will give you the actual weight of your sample of yarn expressed in grains. Now consult your chart and then the number next to the weight in grains is your count.

*Example:* Consider dealing with worsted yarn. Suppose your chart is made for handling 120 yards. Then reel off 120 yards and weigh it. Say it weighs 68 grains. Now consult chart and (for example) find that next to 68 grains is number 22; then 22 worsted is the number or count of the yarn.

*Proof:* 22's worsted ($\times$ 560) = 12,320 yards and

| Yds. in 22's Worsted. | | Grains in One Lb. | | Yards Tested. | | Number of Scale. |
|---|---|---|---|---|---|---|
| 12,320 | : | 7000 | : : | 120 | : | $x$ |

7,000 $\div$ 120 = 840,000 and

840,000 $\div$ 12,320 = 68.18, *i. e.* 22's worsted is the count of the yarn, since 68 and 68.18 grains are practically the same figures.

Balances described as well as others built upon similar principles are somewhat limited in their application, since it is necessary to employ a fixed unit length of yarn; and, in addition, it is impossible for any one balance to be applicable to all the different systems of numbering yarns. However, by the use of a chemical balancer, used in connection with grain weights as was shown in Fig. 57, any length of yarn can be employed, and the counts obtained in any system of numbering, by the aid of a simple calculation. These scales are best enclosed in a glass case to keep them free from dust and draughts, have appliances for the arrest of pans and beam, and are supplied with adjustable screw feet for levelling the apparatus. In the more sensitive scales of this kind, the beam is graduated, and a pair of hooked rods are provided for the purpose of moving a rider or sliding weight of platinum wire on the beam, by the aid of which it is possible to work to a greater degree of accuracy than the usual weights permit. The weights are arranged in grains as follows: 300, 200, 100, 50, 20, 20, 10; 5, 2, 2, 1; ·5, ·2, ·2, ·1; tweezers being supplied for handling them. The hundredths parts of one grain are read off by means of an indicator needle working on a scale graded for *plus* and *minus*.

### To Ascertain Counts by Tables.

This introduces the question as to the most suitable kind of weights to be used with an ordinary scale or balance. Some people still use the 1 oz., ½ oz., ¼ oz. and dwt. and grain weights and this practice has been fostered by the use of one of the oldest and best known tables which gives the heavier weights in ozs. and dwts. This is a very cumbersome method, and one to be deprecated and discouraged.

Where an ordinary balance is used, it is much better to use grain weights throughout and these can be purchased along with 0.1 and 0.01 grains. In such cases other tables are used, the best ones published in connection with the cotton industry being those of the Draper Corporation.

### To Find Counts by Calculations.

To Ascertain the Number of Cotton Yarn.

For this purpose divide 1,000 by the weight of a lea in grains. Thus, if one lea weighs 50 grains, the count is $1{,}000 \div 50 = 20$'s.

If two leas be wrapped (as is sometimes the case) with very fine yarns, 2,000 must be taken as a dividend.

From the formula $1{,}000 \div \text{grains} = \text{counts}$, we can obtain $1{,}000 \div \text{counts} = \text{weight of a lea in grains}$. By the aid of this, a wrapping table can be constructed to save the necessity for calculation.

When complete leas are not available, shorter lengths can be measured by the *wrap reel* (see Fig. 54) which is provided with a dial indicating up to 120 yards, and the counts are calculated therefrom by proportion. In the latter case, the following formula will be found convenient:

Multiply yards by 100, multiply grains by 12, and divide the latter product into the first product, the quotient being the count of the yarn.

Thus if 60 yards weigh 11 grains, the count of the yarn is

$60 \times 100 = 6{,}000 \div (11 \times 12 = )\ \ 132 = 45.45$ (practically 46's) is the count.

Another rule is thus:

Reel or measure off and weigh 9, 18, 30 or any number of yards of the yarn, observing that the greater the number the more correct the result will be. Multiply the number of yards by 8⅓ and divide the product by the weight of the sample expressed in grains; the quotient will be the number of the yarn, *i.e.*, the number of hanks in a pound avoirdupois.

*Example:* Prove previously given example, 60 yards weighing 11 grains. $60 \times 8\tfrac{1}{3} = 500 \div 11 = 45.45$. *Ans.*

*Example:* Suppose 9 yards are only at our disposal, the same to weigh 5 grains, then $9 \times 8\frac{1}{3} = 75 \div 5 = 15$, the number of the yarn, *i.e.*, the number of hanks to a pound avoirdupois.

### To Ascertain the Number of Worsted Yarn.

Reel or measure off and weigh 9, 18, 30, 90, or any number of yards. Multiply the number of yards by $12\frac{1}{2}$ and divide the product by the weight of the sample in grains; the quotient will be the number of the yarn, *i.e.*, the number of hanks to the pound avoirdupois.

*Example:* Suppose 90 yards weigh 15 grains; then $90 \times 12\frac{1}{2} = 1125$, and $1125 \div 15 = 75$, the number of hanks per pound.

*Another Example:* Suppose 9 yards weigh 5 grains, then $9 \times 12\frac{1}{2} = 112.5$ and $112.5 \div 5 = 22\frac{1}{2}$, the number of the yarn.

### To Ascertain the Number of Woolen Yarn.

Reel or measure off and weigh any number of yards of the yarn. Multiply the number of yards by $4\frac{3}{8}$ and divide the product by the weight of the sample in grains; the quotient will be the number of runs per pound.

*Example:* Suppose 90 yards weigh 45 grains; then $90 \times 4\frac{3}{8} = 393.75$, and $393.75 \div 45 = 8\frac{3}{4}$, the number of run of the yarn.

*Another Example:* Suppose 9 yards weigh 5 grains, then $9 \times 4\frac{3}{8} = 39.375$, and $39.375 \div 5 = 7\frac{7}{8}$, the number of the yarn.

### To Ascertain the Number of Linen Yarn.

Reel or measure off and weigh 9, 18, 30, 90 or any number of yards. Multiply the number of yards by $23\frac{1}{3}$ and divide the product by the weight of the sample in grains; the quotient will be the number of the yarn, *i.e.*, the number of leas to the pound avoirdupois.

*Example:* Suppose 12 yards weigh $17\frac{1}{2}$ grains; then $12 \times 23\frac{1}{3} = 280$, and $280 \div 17\frac{1}{2} = 16$, the number of leas per pound.

*Another Example:* Suppose 9 yards weigh 5 grains; then $9 \times 23\frac{1}{3} = 210$, and $210 \div 5 = 42$, the number of the yarn.

## Testing by Comparative Weighing.

As a rule, progressive manufacturers and commission merchants have in stock samples of cloths of their own make, and of which they thus have full particulars and which in most instances will closely resemble the goods they may be asked to make, both in construction and finish. With the aid of these samples, and by the use of balances, a quick and reliable analysis is readily made.

*Example:* Suppose we have among our collection of known fabric textures a sample made of 32's cotton warp and 4-dram silk *(tram)* filling, and which sample we have registered as *"S"* and which about equals in construction and appearance a sample submitted to us for reproduction or estimating price and which we will call *"A"* in our explanation.

First cut both samples exactly the same size, then draw out from *"S"* a number of threads of warp, the most convenient number in this case (for example) being 32, as the counts are 32's. Place these in one of the pans of the scales; then the number of warp-threads from *"A"* which balances the 32 threads from *"S"* indicates the counts of the warp in *"A"*. Thus, if it is found that 24 threads from *"A"* balance the 32 threads from *"S"*,

32 : 24 :: 32's : 24's

*Answer:* The count of the warp-threads to be used in sample *"A"* is 24's cotton.

The filling is dealt with in a similar manner to the warp-threads, but as in this case the system of counting is based on the constant length principle, the counts will vary inversely to the number of threads which balance each other. Thus, if 32 picks of *"S"* are balanced by 24 picks of *"A"*

$$24 : 32 :: 4 : x$$
$$32 \times 4 = 128 \div 24 = 5\tfrac{8}{24}$$

*Answer:* $5\frac{1}{3}$ dram is the count of the tram used in sample *"A"*.

### Testing Yarns for Strength and Elasticity.

The old-fashioned methods of testing yarns for strength and stretch by breaking between the hands is rapidly superseded by mechanical appliances which enable mathematical exactitude to be obtained in place of mere guesswork.

Mechanical tests, systematically carried out, are very important, since by their aid any difference between yarns can be immediately detected, and the mere fact that a buyer is in a position to adequately test all his material is the greatest preventative against fraud.

By carefully recording the results obtained by systematic testing, reliable data can be obtained showing how the conditions of manufacture and variations in the quality of the raw material affect the yarn; the effect of any variations in the blending of the raw stock; the correct amount of twist necessary to yield a maximum of strength at the same time that the thread yields the other qualities suitable for the purpose to which the yarn is to be put; the result of any process of treatment, such as bleaching, dyeing, sizing, mercerizing, etc.

### Lea Testing.

The machine in general use for this purpose is known as the *Lea Tester*. A lea of yarn (120 yards $= \frac{1}{7}$ th of a hank) from the wrap reel is placed upon the two hooks of the apparatus; the lower hook is then caused to descend by turning the handle, by hand or operating a power drive provided the testing machine is thus equipped. Thereupon the upper hook pulls round a small drum, into which a weighted lever is bolted, thus causing the weight to travel outwards and pull against the yarn until the latter breaks, at which point the weight is supported by a curved rack. A sector on the drum moves a finger in front of the dial, on which is engraved a scale of lbs., representing the dead-weight pull.

Elasticity, or stretch is measured by means of two small scales of inches engraved upon the pillar opposite to the upper and lower hooks. Thus the distances traveled by the two hooks, during the making of a strength test, can be observed.

Suppose the upper hook to travel $1\frac{1}{4}$ inches, while the lower one moves $2\frac{3}{4}$ inches, then the difference is $1\frac{1}{2}$ inches, or a total of 3 inches upon the length of the lea, the latter being doubled when on the hooks. The lea being 54 inches, the stretch is equal to $3 \times 100 = 300 \div 54 = 5.56$ per cent.

The defect of this system of testing lies in the difficulty experienced in getting all the threads at a uniform tension before the test commences. Owing to the threads being bunched together when placed on the hooks there is a liability of the strain being applied to some threads before others, this defect being increased if the reeling of the yarns is at all uneven. Unless there is some mechanical method of ensuring that the same tension is put on each thread at the commencement of the test, as in the single-thread testing machine, there is no security that the test is fair and accurate; also, when such a large number of threads are tested at one operation, no idea can be formed of the variations in the strength and stretch of the same thread at different parts. For these reasons it is probable that lea (or skein) testing, which has been so largely practiced, will be gradually superseded by single or double thread testing.

Fig. 62 shows the Power driven Lea, or Skein Tester as handled by Alfred Suter, New York. The illustration clearly shows the skein in position on the apparatus, ready for testing; the dial for indicating the breaking point of the skein tested; weight caused to swing outward, away from its vertical position, and the little click or pawl on the steel rack below the weight in position for starting testing.

Fig. 63 shows another make of a Lea or Skein Tester, either Hand or Power driven; equipped with self-aligning ball bearings. This makes the recording head practically frictionless, in turn permitting the use of an extremely light pendulum, which (with an average weight of 100 kg. (= 220

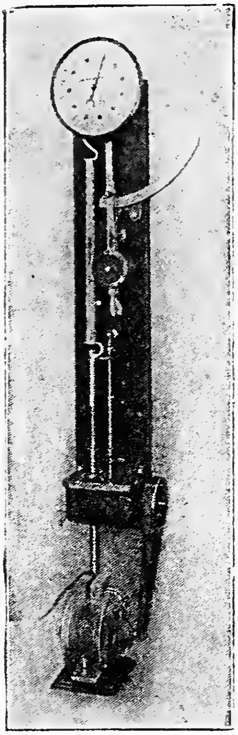


*Fig. 62*

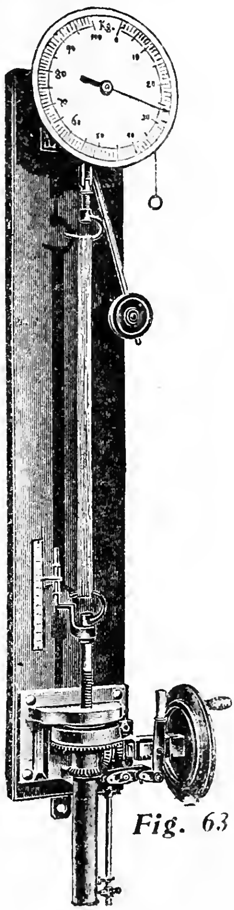


*Fig. 63*

lbs.) of the apparatus) only weighs 2 kg. (= 4.4 lbs.). By means of this improvement in the construction of this apparatus, the steel rack for arresting a heavy weight, as used in other apparatuses, is omitted. The pointer working on the dial is taken along by the head motion of the apparatus and automatically retains its position at the moment when the skein breaks, thus indicating the breaking point, *i. e.,* the breaking strength of the yarn tested. Pulling on the string, shown at the right hand side of the illustration (below the dial) sets the pointer on the latter again to zero. Connections are made to stop the rotation of the screw spindle at the moment the same arrives on its highest or lowest position. At the lower left in the illustration is shown a scale for the pointer (connected to the lower hook that holds the skein) to indicate the percentage of stretch, *i. e.*, elongation the yarn possesses at the breaking point of the skein. The diameter of the dials measures 320 mm (= 12.6 inches). The apparatus is designed to be fastened to the wall with three or four screws.

### Single and Double Thread Strength Testers.

Some of these machines are elaborate in their construction and are capable of giving very accurate results, but they are costly, and consequently not readily available for ordinary warehouse use. Others again are handy, and made to bear the ordinary wear and tear of warehouse work, besides having the merit of moderate cost.

#### Testing Strength and Stretch of Single Threads.

The apparatus for accurately testing the strength and stretch of single threads consists essentially of:

Two jaws, between which a given length of thread can be suspended in such a manner that when testing a number of threads the initial tension on each thread is the same;

A mechanism for moving one of the jaws in a line with the thread always at a uniform rate;

Means of measuring the stretch of the thread up to the breaking point, as well as the load or weight under which the thread breaks.

Fig. 64 shows a single thread strength tester in its perspective view, a simple machine, but doing excellent work. Quoting letters of reference accompanying the illustration will readily explain the construction and method of operation of the little apparatus: *A* is a base board of hard wood (generally leaded) upon which is fixed a pillar *B*. The top end is forked into a jaw, carrying on each side a screwed centre piece, into which is fixed the fulcrum of the lever *C-D*. These two centre pieces can be screwed closer together, or further apart, as required, and the pivot which forms the fulcrum *E* of the lever is pointed at each end, fitting into a hollow in the two ends of the centre pieces, enabling it to work perfectly free, and yet can have no lateral motion as would be the case if knife edges were used.

The lever from *E* to *D* is divided into five equal parts, each of which is equal to the distance of the centre of the jaws *C*, from the centre of the fulcrum at *E*. A balance weight *G* counterpoises the longer arm *E-D* of the lever.

Each of the five divisions of the lever *E-D* are divided into ten parts.

The range of the instrument depends upon the weight of the sliding weight *F*, and which can be varied when desirable.

Three different weights, *viz.*, 50 grains, 100 grains, and 1,000 grains are most frequently used, and the range of the instrument with these different weights is as follows:

| WEIGHT. *Grains.* | DIV. 1. *Grains.* | DIV. 2. *Grains.* | DIV. 3. *Grains.* | DIV. 4. *Grains.* | DIV. 5. *Grains.* |
|---|---|---|---|---|---|
| 50 | 50 | 100 | 150 | 200 | 250 |
| 100 | 100 | 200 | 300 | 400 | 500 |
| 1,000 | 1,000 | 2,000 | 3,000 | 4,000 | 5,000 |

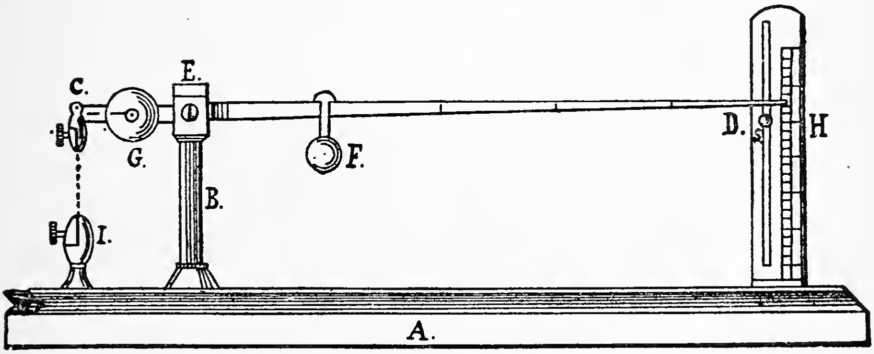


*Fig. 64*

By using the intermediate decimal divisions of spaces on the levers we obtain in the case of the 50 grains weight, an increase of 5 grains for each division; with the 100 grains weight, 10 grains for each division, and with the 1,000 grains weight, 100 grains for each division; so that the range is from 50 grains up to 5,000 grains, with difference of not less than 2.5 grains when the 50 grain weight is used, 5 grains when the 100 grain weight is used, and 50 grains when the 1,000 grain weight is used.

At the end of the lever *D* a graduated scale *H* is placed, divided into spaces which enable the elasticity of the fibre to be measured in terms of the distance of the two jaws *C* and *I* from each other. The generally used arrangement is that if the jaws *C* and *I* are separated one tenth of an inch, it will indicate half an inch on the scale *H*, thus enabling very small ranges of elasticity to be readily seen.

A small stop *S*, adjusted by a thumb screw at the back of the plate, is inserted in a long slot in the divided plate so as to prevent the lever from falling when the point of fracture is reached.

For moving the weight along the lever, a fine silk thread (attached to the ring which slides along the lever) is used, so as to avoid any pressure which otherwise, if using the fingers, would be exercised. Generally two or more experimental tests are made previously to the final ones as required for reference.

Another make of a Strength Tester is shown in Fig. 65, the same referring to a sextant *a* on which the proper scale

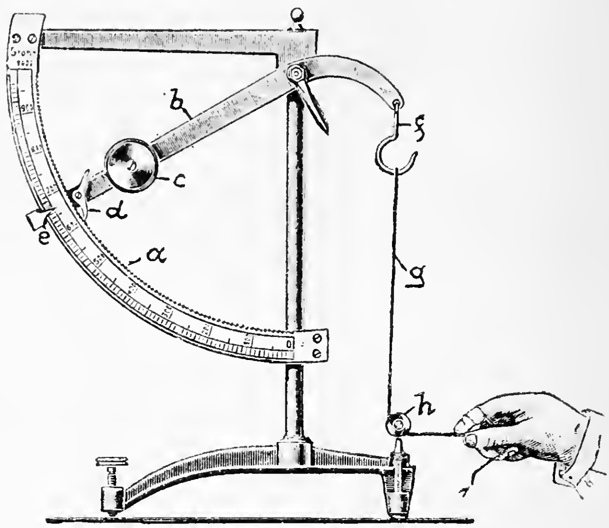



***Fig. 65***

(representing weight required to break the thread to be tested) is engraved, showing a breaking strain of from zero (0) to 1000 grams, sub-divided again in tens. *b* is the lever, fulcrumed (easily moving) to the pillar of the apparatus. To the long end of the latter, weight *c*, catch *d* and pointer *e* are attached, whereas to its short end a movable hook *f* is secured and to which the thread *g* is attached (looped) as clearly shown in the illustration, passing around pulley *h*, where it is then gripped by the hand of the operator. Pulling on the thread *g*, will (by means of the long arm of lever *b* and its weight *c*) gradually increase the weight exerted upon the thread, which finally will have to break, bringing at the some moment catch *d* into action (in the proper grove on sextant *a*) in turn showing by pointer *e* the amount of weight required (expressed in grams) to break the thread. In place of the metric scale *a* in illustration, a scale may be used showing inches and fractions ($\frac{1}{16}$ or smaller) of it.

Fig. 66 shows the same tester, having in this instance added a sextant *i* to lever *b*, which by means of clamp *j* holds the thread *d* to be tested, containing a scale to show the length of stretch the thread was subjected to when breaking, *i. e.*, showing its elasticity.

Fig. 67 shows the Strength and Elasticity Testing Apparatus as built by Chas. H. Knapp of Paterson, N. J. This instrument gives the tensile strength of the thread expressed

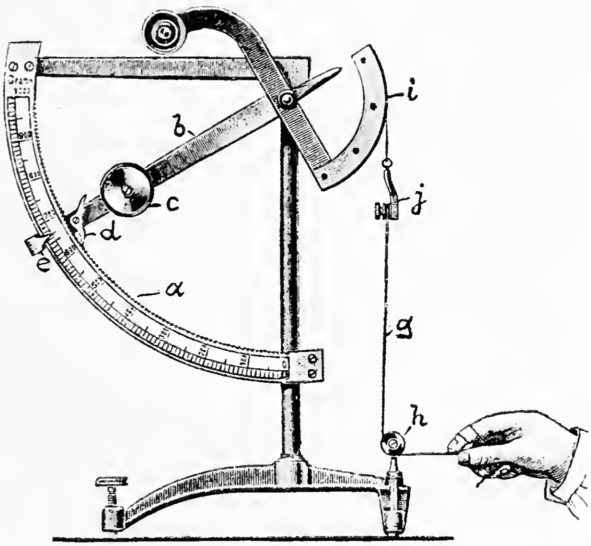



*Fig. 66*

in quarter ounces and the elasticity in tenths of inches. Its capacity is one pound tensile strength, and sixth inches elongation, permitting the testing of a thread from six to eighteen inches long. The working of the apparatus is thus: After setting clamp *a*, by means of screw knob *b*, in the proper distance on (scale) rod *c* to suit the length of thread to be tested, place the two ends of your thread securely between clamps *a* and *d* respectively. By turning handle *e*, rod *f* is simultaneously turned and which by means of its screw portion *g* raises catch *d* and thus puts tension on the thread tested, until the same breaks. *h* is a handle catch, engaging in a notch rock that holds the notched sliding rod *i* in place when the thread breaks. Each notch equals one quarter (¼) oz., hence handle catch *h* shows tensile strength of thread in quarter ounces. Pointer *j* shows on rod *c* the elasticity of the thread tested.

A Single Strand Strength and Elasticity Tester, with oil tank controlled pull is shown in its perspective view in Fig. 68; the same is built by Henry Baer & Co., Zurich, Switzerland, and sold in this country by Alfred Suter, New York.

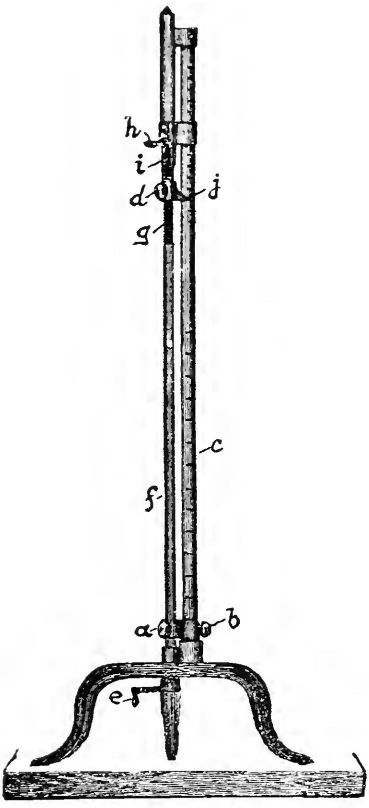



*Fig. 67*

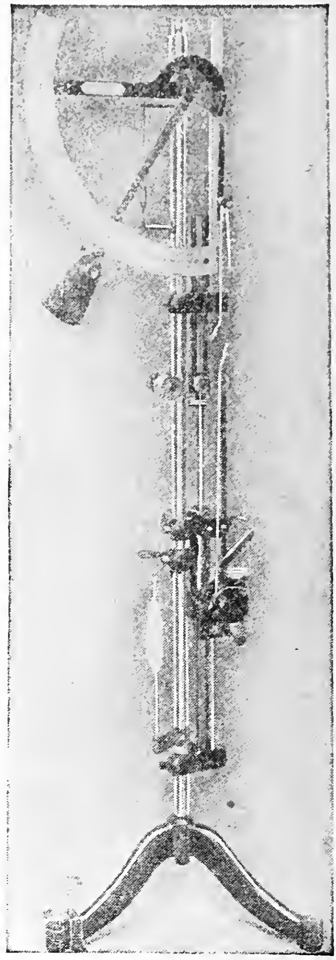


*Fig. 68*

Fig. 69 is a diagram of this tester, being given to better explain the working of the apparatus, giving also a detail drawing showing how the speed of the plunger is regulated, and all vibration during the test eliminated.

The action of the machine is somewhat as follows: A thread is looped over a small pulley at *B*, and the two ends are held by a screw clip at *S*. This is attached to a frame which, when the apparatus is at rest is held up by a catch *K*. This frame carries a perforated plunger *F* working in an

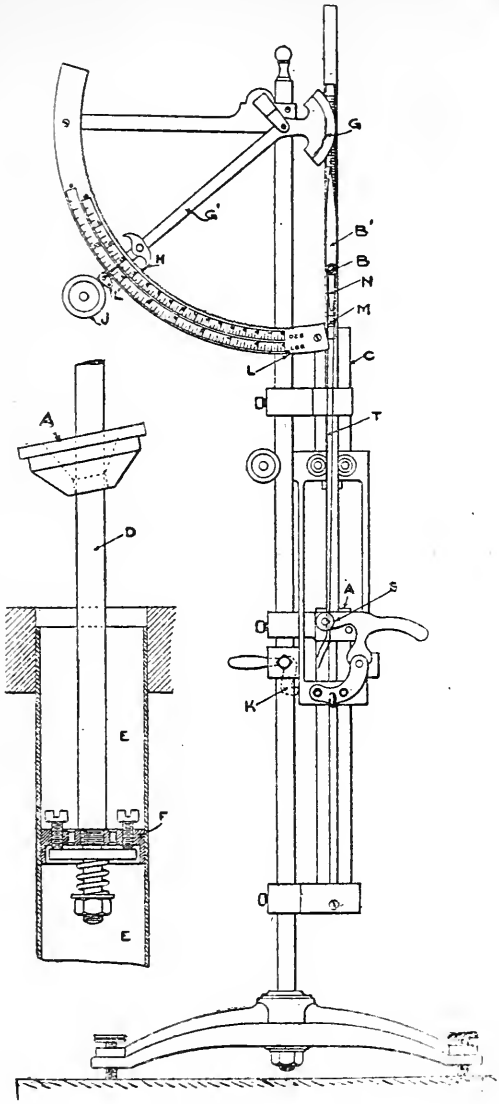



*Fig. 69*

oil cylinder *E;* the upper part *D* of the plunger terminates in a lead weight covered with brass. The quadrant and arm *G, G'*, carry a pair of catches and a weight *J*, which latter supplies the necessary strain required to break the yarn.

When a test has to be made, the arm $G'$ is brought down, and a square catch $L'$ takes into the detent $L$ until the thread is placed in position as mentioned. $L'$ is now lowered, and catch $K$ lifted, which allows the frame to descend and put strain on the yarn; the weight $J$ is slowly raised until the thread breaks and when the load is shown on the quadrant. While the frame descends, and the thread is still unbroken, the graduated scale $M$ descends at the same speed, but as soon as the thread breaks the scale is released and stops, and the elongation is shown on the scale by the pointer $N$, which is connected with $B$ and consequently comes down at the same rate.

The machines are provided with two scales on the quadrant, one having a range of sixteen ounces, and the other a range of four pounds; for the finer yarns, the front portion of the weight is removed and when then the break is read on the upper or sixteen ounce scale. The speed of the plunger is set to one inch in five seconds by regulating the aperture through which the oil flows.

In practice a double thread test will be found convenient, and a large number of tests can be made in a short time. The length of yarn tested is 18 inches for single and 36 inches for double thread tests.

Another Strength and Elasticity Tester is shown in its perspective view in Fig. 70, the same (similarly to the apparatus previously described) operating also with oil controlled pull.

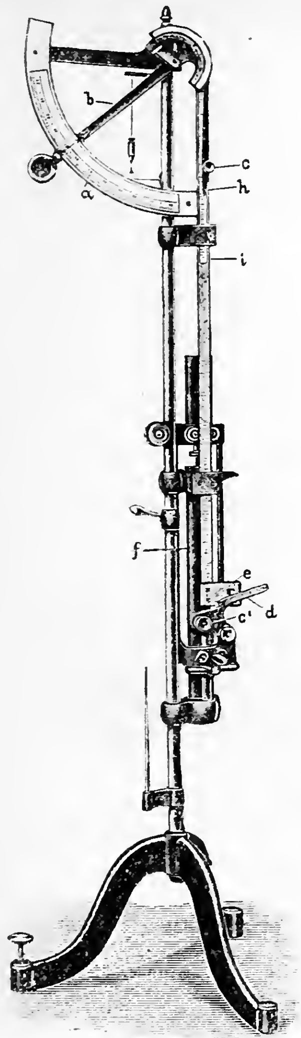
The procedure of testing by this apparatus is thus: Insert your thread between clamps $c$ and $c'$ being careful that the catch lever with its thumb $d$ rests upon pivot $e$ so that when the piston $f$ is lowered, scale $i$ is simultaneously lowered.

When the thread tested breaks, said catch lever simultaneously tips over and scale $i$ then remains at rest. Arm $b$ then has locked itself to the sextant $a$, showing the breaking strength of the thread, on its scale, whereas pointer $h$ shows the elasticity of the thread on scale $i$.

### Special Testing Apparatus for Raw, Thrown, Spun, and Artificial Silk, etc.

Fig. 71 shows in its perspective view such an apparatus as used extensively in the silk industry of the European Continent and which from data given previously will explain itself.

The apparatus comprises two adjustable reels each holding one silk skein to be tested. Each end of the latter then passes through a guide-eye, a series of four glass rods placed one above the other so as to impart the required tension to the thread, which then passes through another guide-eye and onto the reel to which motion is imparted by hand. The



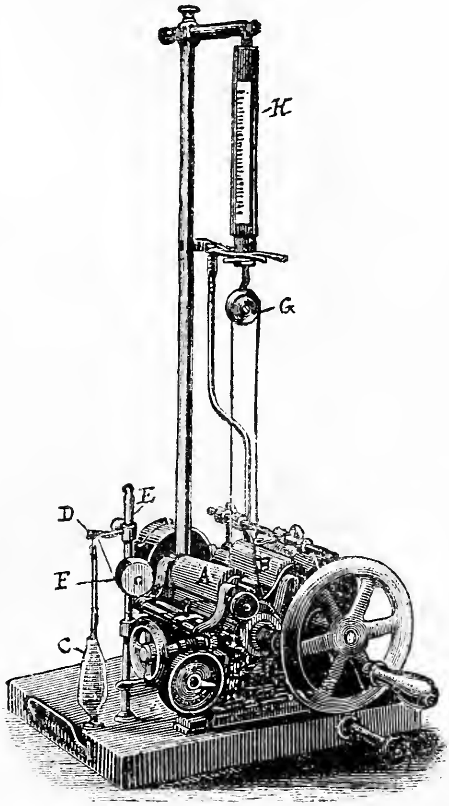




*Fig. 72*

*Fig. 70*

latter is secured to the lower section of the stand carrying the Sizing Balance or Quadrant for weighing the skein. The complete apparatus is secured to a hardwood case.

A Continuous-acting Strength Tester.

Fig. 72 shows this apparatus in its perspective view, the work of which consists in testing a cop, bobbin or skein of yarn throughout its entire length, *i. e.*, to ascertain a fair average of the maximum stretch the yarn can be subjected to without causing unnecessary breakage. The procedure of testing by this apparatus is thus: The yarn as coming from the bobbin *C* then passes through guide-eye *D*, secured to stand *E*, then partly around guide roller *F* to and between the bite of a pair of conical rollers *A*, from which the thread

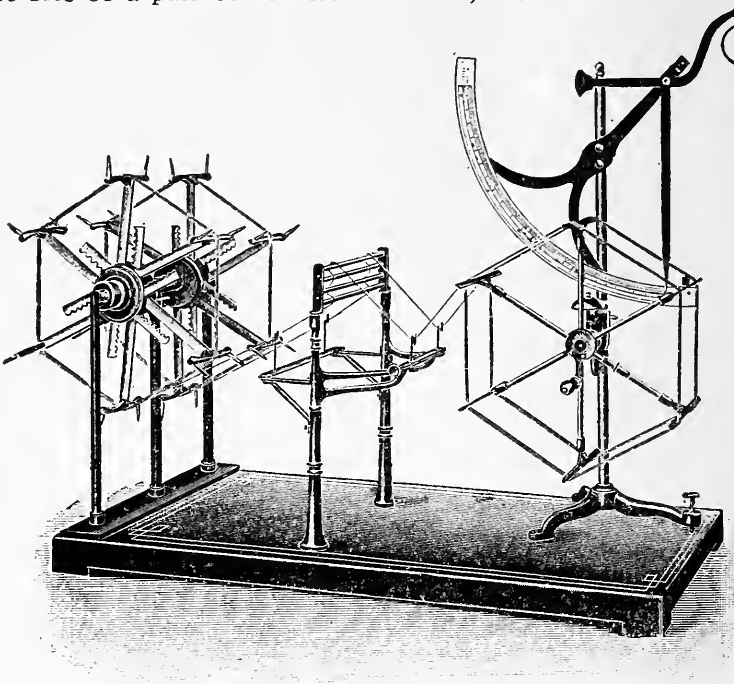


*Fig. 71*

then passes over a pulley *G*, secured to the spring dynamometer (spring scale) *H*, then to and through the bite of two rollers *B*, and in turn laid onto a roller, covered with plush (not shown). By means of using movable thread guides the tension on the thread can be regulated, being read off from the scale of the spring dynamometer *H* and from which information tension can be regulated to suit requirements of the yarn. The apparatus may be driven either by hand or power, its surface speed being 15m. (about 16⅓ yards) per minute.

In some testing apparatuses water is adopted as the means of obtaining the load required for breaking the thread; a graduated vessel, into which the water is poured, gives the weight in grammes or ounces. The stretch of the thread is recorded by means of a pointer, which is attached to the sliding jaw, on a scale divided into fiftieths of an inch.

When making tests, no matter what apparatus is used, note should be taken as to whether the breakage of the thread causes a clear fracture of the fibres, as in an uneven thread the fibres may be liable to slip from each other in the thick parts. Ten or twenty tests should be made from as many bobbins or hanks taken at random from the lot, and the average found; at the same time a note should be made of the amount of variation. Other things being equal, the quality and holding power of the fibres of which a thread is composed, as well as the evenness of the thread, will be indicated by the results of tests for strength and stretch.

Although this method of testing a single or double thread is the one most commonly practised by spinners, it is thought by some not to give the best average results, inasmuch as the strength of the stronger threads is not taken into account, and possibly only a percentage of the weaker ones. What the test gives, they claim, is merely the approximate strength of an unknown quantity of weaker threads. This gave rise to the introduction in the United States of the *Moscrop Tester* by the Draper Corporation, Hopedale, Mass.

The action of the machine may be gathered from the following description: The cops or bobbins are placed on skewers mounted upon a frame having a traversing motion, each thread being passed through the tensioning hooks and eyes, and between a clip.

When the machine is started the frame moves forward, and a plate lying underneath the threads rises and lays each thread into the jaws of another series of clips which immediately close. When the frame or carriage has receded about 12 inches, the clips in the carriage close on the threads, and as the carriage continues its outward movement for about another 4 inches strain is put on the threads, and which strain distends a series of springs mounted at the rear end of the second set of clips. This distension draws a series of pointers along until the several threads are broken, then the pointers are pressed down into the diagram slip, at the positions to which the pointers have been pulled, and thus a record of the breaking load is made.

The broken ends are then cleared away from the clips, the pointers pushed back to zero and the whole cycle of movements is repeated about eighty times, when the machine is stopped automatically. The record of the breaking strength of the several threads is shown on a punctured slip, and the variations are readily observed.

Different strengths of springs are used for various qualities and counts of yarn. The only apparently weak part of the machine is the springs, and to eliminate error, the greatest possible care must be exercised in the selection of these springs.

## Twist.

### Object of Twist.

The turns of twist required in twisted yarns varies according to their ultimate use, from hard-twisted sewing yarns to the soft-twisted threads for knit goods purposes; so does also vary the twist in single yarns.

Before considering the twists that custom recommends, in order to obtain these different results, it is necessary to consider the effect the variously twisted singles impart to produce the desired solidity and resistance to tensile strain, while conserving its elasticity. If the twist is not sufficient in the single, there will be a slippage of the fibres over one another; if the twist is too much, the yarn will be dry and harsh to the feel. It is necessary, therefore, in order to obtain a strong and sufficiently elastic yarn, to take a medium course in twist.

The twists of different numbers, spun from the same material, are proportional to the square root of the numbers. But it is evident that the length of the fibres will exercise considerable influence on the strength and elasticity, and must, therefore, have an influence on the twist.

If, for example, a spinner gives a twist of 25 turns per inch to a single yarn made from a cotton of one inch staple, the twist should be different for a staple of $1\frac{1}{4}$ inches. A twist of 25 turns per inch in the case of a one inch staple indicates a twist of 25 turns per length of the fibre. This yarn being found suitable in strength and elasticity with turns of 25 (that is, 25 points of contact of the fibres with each other) the question may arise to ascertain the turns necessary to get the same strength and elasticity from fibres of $1\frac{1}{4}$ inches in staple. Then the same number of points of contact should suffice; that is, 25 turns per staple (or $1\frac{1}{4}$ inches). By proportion we then find that:

$$1\tfrac{1}{4} : 1 :: 25 : \times, \text{ or } \frac{25}{1\frac{1}{4}} = 20 \text{ turns per inch, } \textit{Ans.}$$

It may therefore be stated that, all other conditions being equal, the twist should be in inverse proportion to the length of the fibres, and the *constants* or *standards* for twist are based on this idea.

To the mill manager a knowledge of the influence wielded by twist, not only in the finished thread, but also in the single yarn used, is of considerable importance, especially when dealing with the higher qualities of yarns and fabrics.

The twist of the doubled and twisted thread is almost invariably in the direction reverse to the single; it is evident therefore that some portion of the twist in the single yarn is removed during the subsequent doubling and twisting operation.

Taking for an example a 2/70's cotton yarn into consideration. The twist in the single thread (according to rules) will be about $\sqrt{70} \times 3.39 = 8.36 \times 3.39 = 28$ turns per inch; the twist put into the folded yarn for usual twist is 30 turns per inch.

At an intermediate stage (between one turn and 30 turns per inch) so much twist will have been taken out of the single that a state of equilibrium will have been established between the twist in the single and that of the folded yarn. Actually this balance will occur when the folded yarn has received 11 to 12 turns per inch. In this condition the thread contains only the turns requisite for a very soft thread, and in this condition will be oozy, lustrous, soft, and pliant; but it will not be of the strength, elasticity and compactness necessary for most purposes.

The question then arises: Is it advantageous to increase the single twist until the balance of twist approximates to the finished twist (necessary to obtain the required strength, appearance, etc.) or to increase the finished twist independently of the single twist?

A harder twisted single will make the stronger thread at all doubling twists from 11 to 12 turns to 30 turns; it will be more compact, wiry and elastic.

The softer twisted single will be weaker in the soft and medium doubling twists, but will rapidly gain in strength, until in extra-hard twists (32 to 34 turns per inch) it would be as strong as the previous single.

Knowing the use to which the single yarn will be put to, it remains a question to be solved whether it is of advantage for the spinner to put more twist in the single (which will naturally cost more) or to use the ordinary doubling filling and lose on the extra turns required in the folded yarn to obtain the same strength. The spinner will vary the twist in the single for various reasons; but as a rule he is only governed so far as twist is concerned by the least amount he can put in to ensure good spinning and to produce a yarn somewhere near the strength required.

If the overseer of the twisting department would ask the boss spinner what twist there is in the single, he may be told that it is ordinary doubling filling, or that the twist standard used was 3.5, or 3.3 × square root of counts. He may consider himself favored, however, should he get the latter reply.

The ascertaining of the actual twist of the single is, however, as simple a matter as that of testing folded yarns for twist. In the case of single yarn, not more than one inch in length should be tested at one operation, while with folded yarns ten inches should be the least taken for length.

If the staple of the material used in the single thread is less than one inch, it will be better to reduce the setting of the twist tester to approximately the length of the staple, since the loose ends of the fibre have an objectionable way of re-twisting on one another.

The twists employed, as mentioned before, must be in accordance with the result it is desired to obtain in the finished thread, or fabric. There is a fairly standard list, although the twister will rarely use a constant multiplier with the square root of the counts. Occasionally the buyer will stipulate the twist or range of twists he will require. In any case the testing of twists in folded yarn is so simple and so universally adopted by buyers of yarns, that the utmost care should be taken that the twists are up to standard and uniform.

In general practice (for example) the twists for 2-fold cotton yarns (from 2/20's to 2/200's) expressed in turns of twist per inch are:

| | 2/20 | 2/30 | 2/40 | 2/50 | 2/60 | 2/80 |
|---|---|---|---|---|---|---|
| Extra hard .... | — | — | — | — | 32 | 34 |
| Usual ......... | 20 | 22 | 24 | 26 | 28 | 30 |
| Medium ....... | 16 | 18 | 20 | 21 | 23 | 26 |
| Mercerizing ... | 11 | 12 | 13 | 14 | 16 | 19 |
| Soft .......... | — | — | 13/14 | 16 | 18 | 22 |
| Extra soft .... | — | — | 10 | 11 | 12 | 13 |

| | 2/100 | 2/120 | 2/140 | 2/160 | 2/180 | 2/200 |
|---|---|---|---|---|---|---|
| Extra hard .... | 38 | 40 | 42 | 44 | 46 | 50 to 52 |
| Usual ......... | 34 | 36 | 38 | 42 | 46 | 50 |
| Medium ....... | 30 | 33 | 36 | 40 | 44 | — |
| Mercerizing ... | 23 | 25 | 27 | — | — | — |
| Soft .......... | 25 | 28 | 32 | 36 | 39 | — |
| Extra soft .... | 15 | 17 | 19 | 21 | — | — |

### Influence of Twist Upon the Fabric.

The twist which is put into yarn in order to bind the fibres together not only affects the handle, strength and wearing property of a fabric, but also has a considerable influence upon its appearance, more particularly in connection with such fabrics in which any form of twill line is developed. Generally, just sufficient twist is inserted to enable the threads to withstand the strain of weaving. More turns per inch are required in fine than in thick threads, and for short than for long-fibred materials, while warp yarns are mostly harder twisted than filling yarns. The twist, while strengthening the yarn, makes it harder, and reduces its lustre; to many fabrics the necessary firmness of structure is imparted by the warp, and softness and brightness by the filling. For special purposes, yarns are twisted more or less than the normal, according to the effect required in the fabric, thus *voile, crepon* and *grenadine* yarns are very hard twisted, whereas yarns for raised (napped) fabrics are soft twisted, in order to be able to produce the required nap to the cloth in the finishing process.

To explain the importance of ascertaining the direction of the twist, the six diagrams in Fig. 73 are given.

Provided the direction of the twist imparted to the yarn is to the right, as shown at *A* it is termed *open-band,* and if to the left, as represented at *B, cross-band.*

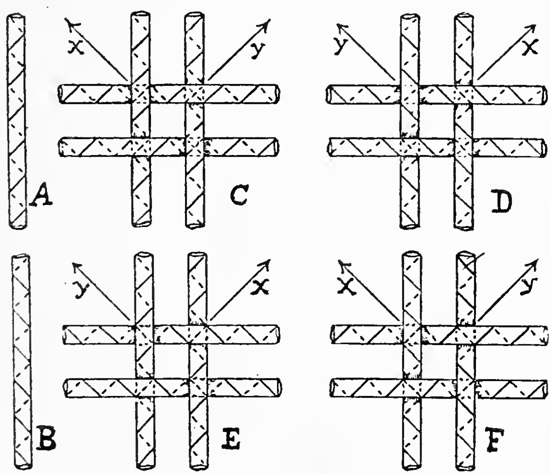



*Fig. 73*

In *cotton* yarns, *A* represents warp twist (twist way) and *B* filling twist (filling way), whereas in *worsted* yarns, warp twist is as shown at *B,* and filling twist as shown at *A.* Single *woolen* yarn (warp and filling) is almost invariably twisted as indicated at *B.* In twisting (throwing) silk, tram and first—spinning of organzine is to the right, as shown at *A,* the second twist of organzine is to the left, as shown at *B.* In *folded* yarns, the twist is most always inserted in the opposite direction to that of the single threads, since this causes some of the twist to be taken out of the singles, and a softer folded yarn results than if the direction of the twist is the same in both twisting operations; the latter method increases the twist in the singles and tends to make the folded yarn hard.

Diagrams *C, D, E,* and *F* in the illustration shows the different ways in which the warp and filling threads may be placed in relation to each other, as regards the direction of the twist.

In *C*, the warp twist is as shown at *A*, and the filling twist as at *B*, the surface direction of the twist being to the right in both threads when the filling is laid at right angles to the warp.

*D* shows the exact opposite of *C*, the surface direction of the twist being to the left.

*E* shows both series of threads twisted as shown at *A*, and *F* same as at *B*.

In *C* and *D*, the direction of the twist on the under side of the top thread, is opposite to that on the upper side of the lower thread, thence the threads do not readily bed into, but tend to stand off from each other, which assists in showing up the weave and structure of the cloth distinctly.

In *E* and *F*, on the other hand, the twist of the under side of the top thread is in the same direction as that on the upper side of the lower thread, hence in this case the conditions are favorable for the threads to bed into each other and form a compact cloth in which the weave and thread structure are not distinct.

In twill fabrics, the clearness and prominence of the twill lines are accentuated if their direction is opposite to the surface direction of the twist of the yarn. If, however, the lines of a twill are required to show indistinctly, the twill should run the same as the surface direction of the twist of the yarn.

If one yarn predominates on the surface, the twill should oppose, or run with the twist of the surface threads, according to whether the effect is required to show prominently or otherwise. Thus in *C* and *D*, the arrows *X* indicate the direction in which the twill should run if the lines are required to show boldly and clearly, and the arrows *Y* if an indistinct twill effect is desired. In *E* and *F* the arrows *X* show the proper direction for producing a bold twill, and the arrows *Y* for producing an indistinct twill if the filling predominates on the surface. If, however, the warp forms the face of the fabric in *E* and *F*, the arrows *Y* indicate the proper direction for a bold twill effect, and the arrows *X* for an indistinct twill.

If a twill runs both to right and left in a fabric (a herring-bone twill) it shows more clearly in one direction than the other. Also, the difference in the appearance of right and left twist is sufficient to show clearly in a twill fabric in which the weave is continuous, and *shadow effects* are produced in warp-face weaves by employing both kinds of twist in the dressing of the warp.

**Testing for Twist.**

As mentioned before, threads which are perfectly alike in quality and counts, but vary in their twist, may produce a fabric quite different when finished. Therefore, when desiring to produce a yarn similar in character to another yarn, the average number of turns per inch must be found.

Testing for twist consists in untwisting a double and twist thread, or a 3 or more ply twisted thread, and noting the number of turns per inch that was required before a complete parallelism of fibres of this thread had been obtained. Single threads are not so often tested for twist as 2 or more ply yarns, since a turn or two (more or less) does not materially affect the strength or appearance of the ordinary run of single yarns, and for a fact, most manufacturers do not concern themselves about the exact number of turns in singles, so long as there is sufficient strength for working purposes, and sufficient fullness to give a well covered face to the fabric. Double and twist yarns are tested on account of the influence of the twist upon their appearance and suitability for the fabric they are to be used for.

In testing thread for twist, it should be placed on the twist testing machine with the same tension as that of the doubling and twisting frame. When the twist has been extracted from ten inches (or more) of twisted yarn, it will be noticed that the strands of yarn will be slack, indicating that in the twisting process there has been a certain amount of contraction in the length of yarn doubled. Under whatever conditions the yarn has been twisted, this contraction will take place. In threads twisted in doubling in the direction reverse to the single twists, and in soft and extra soft threads, this contraction will be at its minimum. The contraction will be at its maximum in threads twisted in the same direction as the single yarn, and in hard-twisted threads. The extent of it will depend upon: (1) the elasticity, (2) the degree of twist in both single and doubled yarn, (3) in the drag exerted in twisting, and (4) in the relative counts used. This contraction has an important effect on the counts produced; the more contraction there is, the heavier will be the finished counts of the resulting yarn. It is a good system to record the contraction of different threads as you test them, and keep them with a portion of the sample for reference. If in testing a 10 inch thread, the increased length of the minor threads is $10\frac{1}{2}$ inches, then the contraction is $\frac{1}{2}$ inch in $10\frac{1}{2}$ inches of single, or the take-up is $4\frac{1}{2}$ per cent.

$100 : x :: 10.5 : 10 = 95\frac{1}{2}$ and $100 - 95\frac{1}{2} = 4\frac{1}{2}$ *Ans.* Such samples will guide you in your future work.

Fig. 74 shows the Twist Counter as built by Chas. H. Knapp, Paterson, N. J. Quoting letters of references in connection with explanations given will readily explain the working of the apparatus: *a* is the handle for turning the worm *b*, and in turn the dial *c* on which pointer *d* registers. *e* and *f* are the two clamps for holding the two ends of the thread to be tested. *e'* and *f'* are the two screw knobs for tightening the bite of the clamps to securely hold the ends of the threads. Clamp *e* is revolving in a stationary position for all tests, whereas clamp *f* is adjustable to suit any length of thread within compass of the apparatus to be tested by being moved (to suit the length of the thread to be tested) on screw rod *g*, turning the latter by handle *h*.

*i* is the bar for sustaining the carrier of clamp *f* in proper position in its to and fro adjustment for testing different lengths of threads, it being also graduated either in tenth parts of an inch, or in centimeters, or both, to register any length of thread to be tested.

When the movable clamp *f* has been fixed at the desired distance from the standard clamp *e* and the thread to be tested secured by screws *f'* and *e'* into the jaws of clamps *f* and *e*, the latter is then revolved by turning the hand-wheel *a*

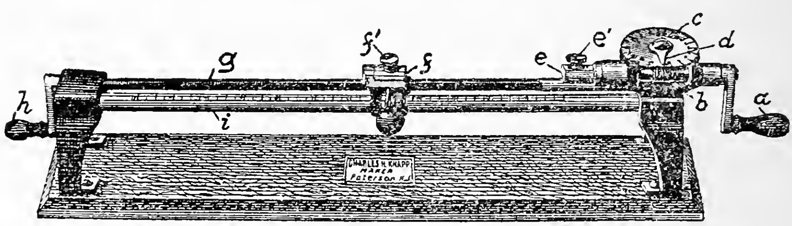



*Fig. 74*

until the whole of the twist has been removed. The number of revolutions are then read from the dial *c* and divided by the number of inches of yarn tested, giving the number of turns per inch in the yarn.

*Example:* Suppose pointer *d* on dial *c* indicates 60, and length of thread between the ends of the two clamps *f* and *e* (for example) is 6 inches (it may be more or less) the turns of twist per inch in the yarn are then (60 ÷ 6 =) 10 turns.

To test single threads, an apparatus is used in which both stands carry movable spindles, so that twist can be taken out from either ends of the thread. If using the twist tester previously described for testing single threads, it may happen that one end, having been untwisted, begins to retwist in the opposite direction before the other end has been untwisted.

Fig. 75 shows the Twist Counter built by Henry L. Scott & Co., Providence, R. I., having a capacity of testing threads from one to ten or twenty inches. The standard machine is equipped with a dial graduated from 0 to 50 for both right and left hand twists. Movable or quick return dials that can be reset after each test, are furnished when so ordered. The drive is made with cut gears and the jaws are self-opening. The graduations of the bar are ½ inch. The apparatus is mounted upon an iron base and finished in hard-baked black enamel and nickel plate.

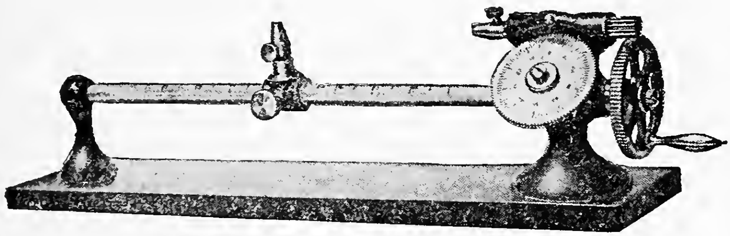


*Fig. 75*

When a folded yarn is being tested, it will be found of help to insert a needle between the threads (close up to the fixed jaw) and slide the same along, as the threads are untwisted; the operator then can easily determine when the thread is free from twist. When the thread is single, however, this process cannot be adopted, but by examining the thread through a microscope with which the apparatus is then fitted out, the point at which the thread is free from twist can be accurately determined.

### Testing for Take-up in Folded Yarns.

When threads are twisted together in the production of folded yarns, a certain amount of take-up or contraction takes place, which has a material influence in determining the resulting length or counts of the yarn, and also its cost. The amount of take-up of each thread varies according to the number of turns per inch and also according to the bending power of the individual threads. Thus, if the diameters of the threads are unequal, or one thread is softer than the other, the bending power of the threads will be unequal, and different lengths of each yarn will be required.

Special twist testers are built whereby the amount of take-up of each thread can be readily found. The jaws, between which the threads are suspended, are so arranged that a separate tension weight can be placed on each minor thread, and any required number of turns per inch, either taken out or inserted, by revolving the hand wheel in the proper direction. The amount of contraction is determined by measuring the distance moved by the tension weights.

Fig. 76 shows a Twist Counter used for ascertaining the turns of twist per inch in double and twist yarn, showing also the amount of take-up caused by this twisting, *i. e.,* the original length of the minor threads. The apparatus also can be used for ascertaining the amount of twist in single yarn.

As seen from the illustration, the apparatus consists of two clamping devices *a* and *b,* each supplied with a screw knob for holding the thread to be tested on both of its ends. *c* is a dial, numbered so as to show at a glance the number of turns imparted to clamp *a* and thus the number of turns of twist taken out (or inserted, if so required) of the thread

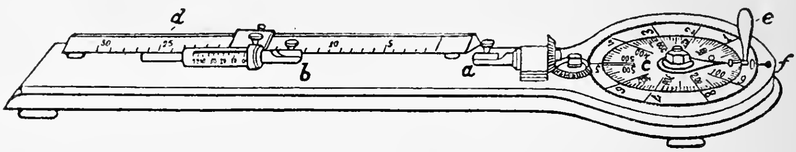



*Fig. 76*

tested. To permit the testing of different lengths of yarn, clamp *b* is arranged movable, *i. e.,* can be moved up or down on the three sided guide rack *d,* secured to the latter by a set screw on its back (only the knob of the latter is seen slightly to protrude back of the large screw) by means of which the take-up measurer is secured to the required position on guide rack *d,* so as to adjust clamps *b* from that of *a* to the length of thread to be tested. The counting attachment of the device consists in counting-dial *c* (which is turned by means of handle *e*) and two pointers, one of which, the pointer *f,* as is situated on the outside of the counting-dial, registers the individual turns of twist, whereas the other pointer, as placed on the counting-dial, indicates tenths and hundredths of turns of twist in the yarn. The counting-dial *c* is numbered to permit the reading of either left or right hand twist in the yarn.

To operate this twist tester, open the large screw shown on top of the take-up measurer and pull the latter out, as far as it will go; adjust the exact distance required between clamps *a* and *b* to suit the length of thread to be tested, allowing besides sufficient length of thread on each end to give both clamps a good grip on the thread to be tested.

Now place your measuring arrangement so that zero (0) on the dial is opposite pointer *f*, and in turn place thread to be tested (under fair tension) into clamps *a* and *b*, and release the knob of the take-up measuring device, giving in turn to the spring as is inside of the casing (and which spring was depressed before) a chance to expand and thus take up any slackness of the minor threads when untwisting the compound thread. Now turn the counting disk *c* by means of handle *e*. The turning of the latter (by means of gearing shown) is in turn transferred to the thread to be tested in the ratio of 1 : 10. For the pointer located in the centre of the dial the ratio is 0 to 1000, the pointer being moved by hand, if so required.

When the compound thread has been untwisted, insert a needle between the minor ends (singles) the twisted thread is composed of, and see that the twist originally imparted to the compound thread is removed, moving the needle for this purpose gradually to and fro until the same can pass unrestricted from clamp *a* to clamp *b;* all the twist having been removed, its number of turns are read from dial *c*.

Next ascertain the amount of extension of the minor threads (singles) during the test, the latter being expressed in millimeters.

Both results obtained are based on the metric measure and in turn can be changed over to the yard measure, if so desired.

*Example:* Suppose that by testing 20 *cm.* length of thread, you find 90 turns of clamp *a* (*i. e.,* 90 turns of twist was in the 20 *cm* of thread) and that your take-up scale shows 11 *mm* stretch for the minor (single) threads; then proceed with your calculation thus:

One meter $(100 \times 90 \div 20) = 450$ number of turns of twist yarn tested, and

0.011 (= 11 *mm*) : 0.2 (2 *dm* or 20 *cm*) : : *x* : 1 (*m*)

$0.011 \div 0.2 = 0.055 = 5.5\,\%$ extension of the minor (single) threads in testing, *i. e.,* their loss in length when originally twisting them.

100 (twist) : 105.5 (single) :: *x* : 100 and

$100{,}000 \div 1{,}055 = 94.8$, or 1 meter of yarn single will produce 948 *mm* twist.

One meter = 39.37 inches, will then give us

$450 \div 39.37 = 11.43$, or practically $11\frac{1}{2}$ turns of twist was inserted *per inch* in the thread thus tested.

To ascertain the twist in a single thread, set clamps *a* and *b* about 2 to 4 *cm* apart from each other (guide rack *d* is divided by metric system) and insert the thread to be tested, fastening the clamps and turning the counting-disk *c* by means of handle *e*. The turning of the latter, as previously explained, is in turn transferred to the thread to be tested, in the ratio of 1:10. The filaments composing the thread in turn are untwisted until they rest side by side, and then the amount of twist that was in the (2, 3 or 4 *cm*) thread tested is read-off on the counting-disk, there is no take-up in twisting to be taken into consideration in connection with single yarn.

Another make of a Combined Twist Counter and Take-up Measurer is shown in its perspective view in Fig. 77, showing on its right hand side the twist counting portion of the apparatus consisting of a geared hand wheel meshing with a smaller gear fast to the end of the shaft that carries on its other end one of the clamps for holding one of the ends of the thread to be tested. In its centre this shaft carries a worm wheel that operates the measuring dial. On the left of the illustration is shown a weight, placed there to exercise the necessary tension on the thread when untwisting the latter, indicating at the same time the amount of its elongation (*i. e.* the percentage in loss of length to the minor threads in the process of twisting) on the scale shown on top of the rod holding the other clamp.

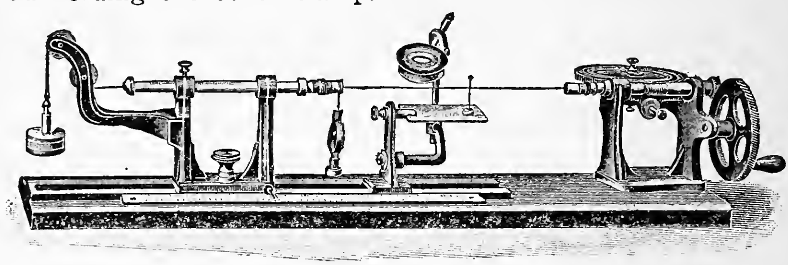


*Fig. 77*

The scale for setting the distance of the two jaws, holding the thread for untwisting, is shown on the base of the apparatus, the extension portion of the apparatus being movable in a slide way, and held in proper position (after knowing the length of thread to be tested) by means of the large screw shown between the two posts. In the same slide way is mounted (movable) a plate presenting either a black or white surface as a background for examining the thread handled, using the white side of the plate up when dealing with a black or dark yarn, and the black side up when dealing with a white or light colored yarn, in this way simplifying work. Connected to the same upright as carrying the background plate, is a magnifying glass, to make examination of twist (present or not present) easier work.

### Effect of Twist on Length and Counts of Cotton Yarn.

Single as well as ply yarn can be twisted in either one of two directions — namely, right or left. The ply yarn may be twisted in the same or in the opposite direction from that of the single yarn of which it is composed, but in most cases the ply yarn is twisted in the opposite direction from that of the single yarn.

If two single threads are twisted in the same direction as the single strands are twisted, the ply yarn becomes brittle and shrinks in length. From two hanks (840 yds.) of 32's doubled with 18 turns per inch, only about 720 yds. of 2-ply yarn are obtained.

If, however, these two hanks are twisted in the opposite direction from that in which the single yarn was twisted when spun, 855 yds. of 2-ply yarn are obtained.

The shrinkage of yarn under the first-named conditions is well known; the increase in length, however, is seldom taken into account, although both are very important factors in manufacturing. In the above example there is an increase of 15 yards in the length of the hank when two hanks of 32's are twisted with 18 turns per inch. The cause for this increase is that a slack twist of 18 turns per inch not only does not reduce, but in fact increases the length of the yarn when the single yarn and ply yarn are twisted in different directions. This increase in the length of the single thread takes place in all cases where the twist is reversed when twisting the ply yarn, but is overcome by the twisting of the two threads around each other when the number of turns is increased sufficiently.

The normal twist (that is to say, the twist by which the 2-ply thread is just one-half the length of the two single threads) is twenty-four turns per inch for 2/32's. It is evident that the exact length cannot be determined exactly for each kind of yarn, on account of the many conditions that affect the increase or decrease in length by twisting. This change in length depends upon the kind of material and twist in the single yarn, whether the yarn has been twisted from cops or has been previously spooled, whether the yarn has been steamed, etc. The weight of the traveller and the speed of the spindles, as well as the temperature of the spinning room, also have their effect.

Expriments with yarn of different counts made from the same material and twisted under the same conditions to determine the change in length by twisting have been carried out and the results are shown in the following table:

| Counts. | Turns per Inch. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | |
| 12 | 840 | 832 | 825 | 817 | 810 | 800 | 790 | | | | | | Yards. |
| 14 | 843 | 838 | 833 | 824 | 815 | 806 | 790 | 773 | | | | | " |
| 16 | 848 | 843 | 838 | 831 | 823 | 816 | 809 | 787 | 772 | | | | " |
| 18 | 856 | 850 | 843 | 836 | 830 | 822 | 814 | 805 | 796 | 763 | | | " |
| 20 | 862 | 855 | 848 | 841 | 835 | 833 | 828 | 822 | 816 | 786 | 761 | | " |
| 22 | 863 | 858 | 852 | 846 | 840 | 837 | 835 | 829 | 823 | 800 | 775 | 752 | " |
| 24 | 862 | 860 | 856 | 852 | 846 | 840 | 837 | 832 | 829 | 809 | 790 | 769 | " |
| 26 | 863 | 862 | 859 | 856 | 850 | 846 | 840 | 836 | 831 | 816 | 802 | 788 | " |
| 28 | 864 | 863 | 861 | 858 | 856 | 849 | 843 | 840 | 836 | 824 | 812 | 801 | " |
| 30 | 865 | 864 | 862 | 860 | 857 | 852 | 847 | 843 | 839 | 831 | 822 | 813 | " |
| 32 | 866 | 865 | 863 | 861 | 859 | 855 | 850 | 845 | 841 | 835 | 830 | 826 | " |
| 34 | | 866 | 864 | 862 | 860 | 857 | 853 | 848 | 844 | 840 | 836 | 832 | " |
| 36 | | | 865 | 863 | 861 | 859 | 855 | 849 | 846 | 843 | 840 | 837 | " |
| 38 | | | | 864 | 862 | 860 | 857 | 853 | 849 | 845 | 842 | 839 | " |
| 40 | | | | | 863 | 861 | 858 | 854 | 850 | 846 | 843 | 840 | " |

The numbers at the left of the table indicate the counts of the single yarn; those at the top of the columns the number of turns per inch in the 2-ply yarn. The yarn was made from first quality $1\frac{1}{4}$ in. staple and spun on a ring frame. The number of turns of twist in the single yarn was equal to four times the square root of the count.

*For example,* in 20's yarn there were $4 \times 4.47 = 17.8$ turns per inch. The yarn was spooled for twisting and twisted dry.

According to this table, two hanks of 24's doubled with 10 turns per inch will measure 860 yds. when twisted. This represents an increase of 2.4 per cent. The consequence is that 840 yds. of the twisted yarn is 2.4 per cent lighter than 1680 yds. of the single yarn. It will be necessary to spin the single yarn to 29's in order to have the 2-ply equal to 15's (2/30) yarn with 10 turns per inch.

On the other hand, if 2/30's yarn is doubled with a hard twist of 30 turns per inch, 1680 yds. of the single yarn measures but 813 yds. when doubled, a loss of 813 yds. per hank, or 3.21 per cent.

If a 2400 end warp 900 yds. long is made from this yarn, the calculated weight will be as follows:

$(900 \times 2400) \div (840 \times 15) = 171.4$ lb. The actual weight, however, will be 176.9 lb., a difference of $5\frac{1}{2}$ lb. on 900 yds. of warp.

If the single yarn is spun finer, in this case to 31's, in order to obtain a 2-ply yarn of the required size, several other difficulties arise. First, the higher count involves a higher cost of production, because no spinner can spin 31's at the same price as 30's. Again, the 31's when twisted will not be as strong as the 30's yarn.

Turning to the table we find that its use is very simple. Take, for example, a 2/30's to be twisted with 12 turns per inch. The table shows that two hanks of 30's will measure 862 yds. when doubled with 12 turns per inch. The increase in length is 22 yds., and the yarn will be 2.6 per cent too light.

### Testing for Regularity.

To examine and compare the evenness of the yarn and its freedom from defects is best done by using what is known as a Yarn Examining Machine. The same consists of a board, (known as a mirror) black on both sides, or black on one side and white on the other, or of any color to contrast with the color of the yarn to be examined, so

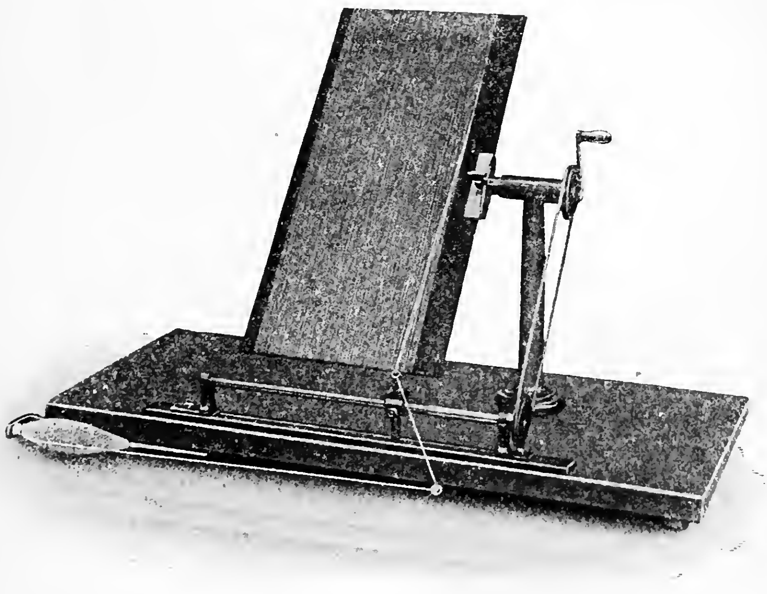


*Fig. 78*

as to clearly show up its defects. This board is secured to a clamp, the shaft of which is suitably rotated by gearing through a hand-wheel situated on the outside of the pillar carrying the shaft of the clamp. The threads to be tested are wound either from one or two cops or bobbins, as may be desired. The thread guides, which travel on a screw turned by a band from the hand-wheel, lay the yarn regularly on the surface of the board previously referred to, with a small space between the threads. The perfectly even distribution of the yarn enables any irregularities, such as knots or weak places, to be readily observed; also as the yarn from two cops or bobbins may be wound simultaneously, the external appearance of one yarn can then be compared with that of the other. The board, which may be of wood, cardboard or aluminum, is held in position on one side by the clamp and its thumb-screw, as previously referred to, and when filled, is taken out and another board put in its place, while the bracket carrying the thread guides is raised up and moved back to the starting point for another test. Defects of any kind in the yarn are thus readily exposed and the sample wound on the board may be held on file for future reference and comparison, spare boards being provided for this purpose.

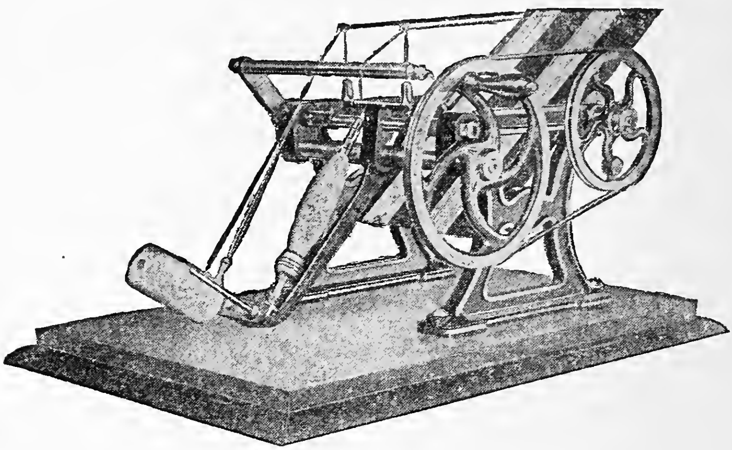


*Fig. 79*

Fig. 78 shows the Yarn Examining Machine, as handled by A. Suter, New York, in its perspective view, equipped with one bobbin for winding, and black or white velvet covered aluminium boards and the usual cardboard clamp. Machines equipped with winding from two bobbins are also furnished.

Fig. 79 shows the Yarn Inspector as built by Henry L. Scott & Co., with board in position. The yarn is shown wound from two cops or spools, and is laid evenly in parallel lines upon boards $17\frac{7}{8}$ inches long by 8 inches wide.

These boards are held in either machine by a spring clamp and are instantly interchangeable. The machine is mounted upon a well-finished weathered oak base and designed with two solid iron side frames which support the mechanism. All metal parts are finished in black enamel and nickel plate, making these machines attractive as well as serviceable.

A simple method of performing this test when an apparatus is not available, consists of winding the threads round a board (which is notched at opposite extremities) at uniform intervals of about one-sixteenth of an inch, care being taken to always put equal tension on the yarn.

It should be remembered that although called a Yarn Examining Machine, it is not an examining machine, but a machine by the use of which the yarn may be placed in a position favorable for future examination.

There are two objections which may be raised to a too general use of the machine:

(1st) If the boards or cards are not limited, they may, when filled with yarn for observation, be placed aside for future examination, which may never occur.

(2nd) The quantity or length of yarn thereon available for inspection is not sufficient, and may be misleading. If the yarn on the boards be examined regularly and rigorously, the second objection holds not good.

For preference, therefore, the leas (portions of skeins or hanks, as the case may be) as wrapped for testing should be carefully examined before removal from the wrap reel; and perhaps after removal from the reel, by expanding the threads or rounds on an iron bar before weighing, and again examining for unevenness, slubs, snarls, snicks, neps, etc., etc. This expansion of the rounds will not affect the condition of the skeins so far as strength tests are concerned, and the same can be used for examination, counts and strength tests.

An apparatus for doing this work is shown in its perspective view in Fig. 80, the same being built by Chas. H. Knapp, Paterson, N. J. This apparatus is adjustable for handling different size skeins by pressing lever *a* towards handle *b*, of slide *c*, loosening in turn the grip of the latter on guide rod *d*, thus permitting the positioning of slide *c* either up or down on rod *d*, to suit the diameter of the skein (not shown) to be examined, and which is placed over rollers *e* and *f*. Slide *g*, operating on rod *d*, can be also adjusted (if needed) by means of tightening knob *h*. To make examination more quickly and at the same time more thorough, backboard (mirror) *i* is provided, being secured in its centre to rod *d*. The latter, and with it the apparatus, can be tipped in any position as required by the examiner and secured in that position by tightening knob *k;* the raising and lowering of the apparatus on the standard *l* is done by loosening and then tightening knob *m*.

If the yarn on examination is found to be passable, or up to the usual standard, no remark is made; if, however, the yarn should show any distinctive faults, the latter should be entered in the remarks column of a reference book. It is then at the option of the management of the mill to trace that fault in the yarn in its progress through its manufacture,

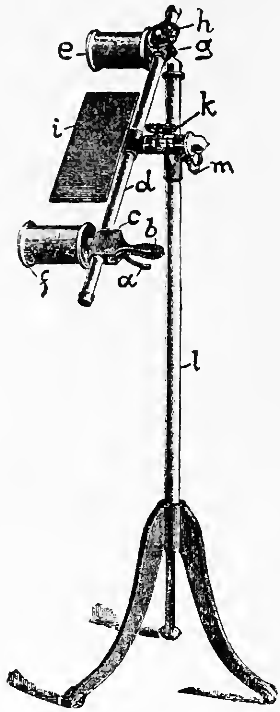



*Fig. 80*

and when the faults can be located. It is of advantage to thoroughly and carefully examine single yarns at this initial stage.

**To Find Counts of Yarns by Comparison.**

A common method of finding the counts by comparison consists of looping together a variable number of threads picked out from the sample and a given number of threads taken from a similar cloth of which the particulars are known. The ends of each series of threads is held between a finger and thumb, and twist is inserted by hand until both appear like solid threads, when it is possible for their thickness to be compared. Threads are added to or taken from the series of threads of which the counts are not known until the two sets appear to be equal in thickness. The counts are then in direct proportion to the respective number of threads used for the test. This method, though largely employed for low and medium counts, is not always satisfactory, and for fine counts is not reliable.

By means of the apparatus shown in Fig. 81 the threads can be twisted and their relative diameters afterwards compared with greater accuracy than is possible with the unaided eye. The apparatus has been specially designed for the

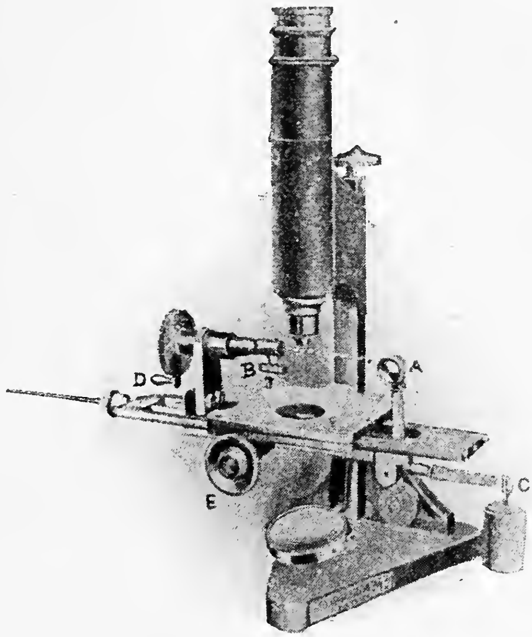



***Fig. 81***

purpose of enabling threads drawn from small pieces of cloth to be minutely examined.

The lower portion of the apparatus consists of a movable stage, carrying two jaws *A* and *B,* which may be placed at any required distance apart (from ¾ to 3 inches) according to the length of thread to be tested. The two series of threads are looped over each other in the ordinary way, and the ends of one series are placed in the jaw *A,* and the ends of the other series in the jaw *B.* Tension is then put on the threads by placing a weight in one of the notched positions on the arm *C,* which is movably connected to rod carrying jaw *A.* By means of the hand wheel *D,* the jaw *B* is made to rotate until sufficient twist has been inserted to make each series of threads appear like a solid thread.

The upper part of the apparatus carries a miscroscope which is fitted with a micrometer scale, by means of which the diameter of a single thread (or of a group of threads) can be measured to the nearest millimetre (or to the nearest one-thousandth part of an inch) as required. By turning the hand wheel *E*, the stage carrying the jaws *A* and *B* is made to slide to the right or the left, so that any part of the thread between the two jaws can be brought under the field of vision of the microscope. The diameter of the known series of threads is first measured on the scale, then the hand wheel *E* is turned and the diameter of the other series is measured and compared with it.

The microscope has a magnifying power of from 60 to 100 diameters, so that small differences are easily detected.

As the threads (before twisting) are screwed up tightly in the jaws of the apparatus, it is more convenient to vary the number by breaking out threads in place of adding threads. For this reason, when first put into the jaw, the number of the threads of the unknown count should preferably be in excess of what is required.

### Testing Diameters of Threads.

The same may vary, depending upon (*a*) more or less specific gravity of the raw material; (*b*) air contained; (*c*) the axial arrangement of the fibres and (*d*) the compression due to twist in spinning.

Measurements of the diameter of a thread are useful for indicating the evenness of the thread, which frequently varies up to 30 per cent; at the same time it indicates bulkiness of the thread.

The diameter of a thread is obtained by measuring, using a microscope and micrometer in connection with the procedure, by means of which the following standard rule has been accepted by the textile industry:

Square root taken of yards per lb. of yarn to be tested, minus 10 per cent for worsted, 7 per cent for silk and cotton, and 16 per cent for woolen.

*Example:* 2/50's cotton $= 50 \div 2 = 25 \times 840 = 21{,}000$ yards per lb.

$\sqrt{21{,}000} = 144.9 - 10.1\ (7\%) = 134.8$

***Answer:*** $\frac{1}{135}$ inch is the diameter of 2/50's cotton.

*Example:* 6 run woolen $= 6 \times 1600 = 9{,}600$ yards per lb.

$\sqrt{9{,}600} = 97.97 - 15.67\ (16\%) = 82.30$

***Answer:*** $\frac{1}{82}$ inch is the diameter of 6 run woolen.

*Example:* 22 cut woolen $= 22 \times 300 = 6{,}600$ yards per lb.

$\sqrt{6{,}600} = 81.24 - 12.99\ (16\%) = 68.25$

***Answer:*** $\frac{1}{68}$ inch is the diameter of 22 cut woolen.

*Example:* 2/32's worsted $= 32 \div 2 = 16 \times 560 = 8{,}960$ yards per lb.

$\sqrt{8{,}960} = 94.6 - 9.4\ (10\%) = 85.2$

*Answer:* $\frac{1}{85}$ inch is the diameter of 2/32's worsted.

*Example:* 40/3 spun silk $= 40 \times 840 = 33{,}600$ yards per lb.

$\sqrt{33{,}600} = 183.3 - 12.8\ (7\%) = 170.5$

*Answer:* $\frac{1}{170}$ inch is the diameter of 40/3 spun silk.

*Example:* 4 dram silk $= 64{,}000$ yards per lb.

$\sqrt{64{,}000} = 252.9 - 10.1\ (4\%) = 242.8$

*Answer:* $\frac{1}{243}$ inch is the diameter of 4 dram silk.

The microscope, with which the machine for testing the diameter of threads is equipped, is mounted on a stand, which can be made to slide along the bed of the machine in a line with the thread, which passes between pegs on the table of the microscope.

By focussing, the thread can be made to come up sharp and clear on the black surface of the table (a slip of white paper being placed on the table for a dark-colored yarn) enabling the thread, magnified about 20 times, to be seen across a micrometer scale, by means of which it is possible to measure it to the one-thousandth part of an inch.

By sliding the microscope in a line with the thread, the effect of any of the previous tests, on any part of the thread, can be minutely observed.

### Identification and Separation of Fibres.

For the purpose of testing textile fibres as to their identity, the micro-photograph is of great value, but if the question comes up to ascertain the proportion of cotton mixed with wool, cotton with silk, or some other mixtures, chemical analysis gives results of greater value and accuracy.

There is, however, one precaution to be taken which is frequently overlooked, and this is the necessity for checking the analysis by ascertaining the amount of the dissolving reagent or chemical which remains in the weighed fibre, and we must also take into account any loss that may have resulted from partial solution.

If a mixture of cotton and wool is under consideration, we should treat some weighed pure cotton with a caustic solution in exactly the same manner that the mixture is to be dealt with, noting the loss or gain in weight, estimating the ash, and making proper corrections for moisture.

## Testing Strength and Stretch of Fabrics.

Fabrics purchased by the Government Clothing Departments, Railway Companies, Police, Fire, etc., Departments of our large cities, are tested to ascertain if they reach a minimum standard of strength and stretch. Cloths intended for special purposes, such as sail cloths, sheetings, linings, foundation cloths for card clothing, etc., are subjected to tests for strength and stretch. These tests are of value to the manufacturer, as they enable him to accurately compare the quality

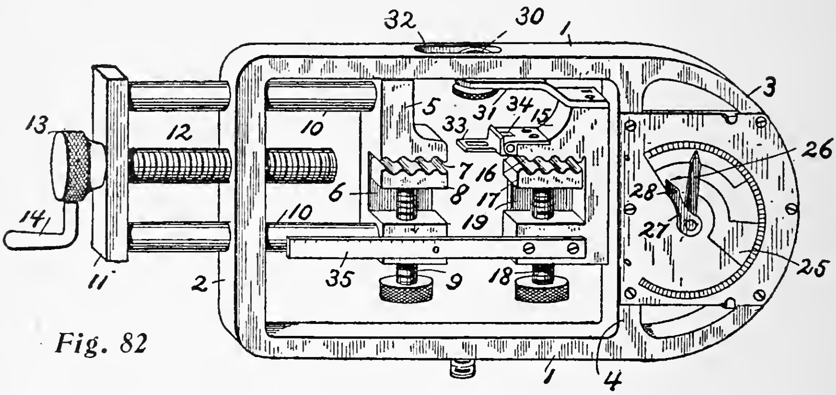



*Fig. 82*

of his own productions with those of his competitors. They also afford the most positive means of indicating the effect of bleaching, dyeing, finishing, etc., on the cloth.

It is frequently found that the strength and stretch of a cloth on leaving the loom are much greater than when the cloth is finished, ready for the market, and for this reason very elaborate experiments are now being made in some of the dyeing and finishing works in this country for the purpose of discovering in which processes the cloth is affected. It is only by such experimental work that the source of the defects which arise from the present methods of manufacture can be ascertained and the remedy attempted.

The object of this process is to ascertain the strength of cloth, *i. e.* to ascertain the amount of tension required to tear it apart, thus ascertaining the quality of the material (as to strength) used in its construction.

A cloth tester used for this work is shown in Figs. 82 and 83, the object of which is to provide not only means for indicating the strength of the fabric tested, but at the same time also means by which the texture or structure of the fabric may be examined while testing its strength. Fig. 82 is a perspective view of this tester, and Fig. 83 a bottom or back view of it.

The frame of this tester comprises parallel side members 1, an end member 2 at right angles to the side members, and a curved or semi-circular member 3 at the opposite end. At the junction of the member 3 and the side members 1, a cross bar 4 is formed.

Movable in the frame thus referred to is a block 5, which has a recess 6, one wall 7 of which is provided with teeth, which, co-acting with a corrugated block 8, form jaws for clamping the fabric to be tested. The part 8 is movable in the recess 6, and it is moved toward and from the jaw section 7 by means of a screw 9, engaging in a tapped opening in the block 5. Guide rods 10 extend outward from the block 5 through openings in the end portion 2 of the frame, and at the outer end these guide bars are connected by a cross head 11, and mounted to turn in this cross head is a screw 12, which engages in a tapped hole in the portion 2 of the frame. The screw 12 has a milled head 13, and also a handle 14, so that it can be easily turned while stretching the material. Another block 15 is also movable in the frame and has a recess, one wall 16 of which is corrugated to provide a jaw section co-acting with the corrugations or teeth on the other jaw section or block 17 in the recess in the block, the latter being adjusted by means of a screw 18. A plate 19 is attached to the rear side of the block 15, and the rear side of the recess 6 is also closed by a cross piece or bridge. These closures provide a stop against which the straight edge of the fabric to be tested is placed when between the jaws, to insure the placing of the threads lengthwise of the pulling strain. From the block 15, guide rods 20, 21, extend through openings in the cross bar 4, guide rod 21 being provided with a rack 22, engaging with a pinion 23, one end of the shaft of said pinion having a bearing in a plate 24, extended from the cross bar 4, and the other end of said pinion shaft extends through an opening in a dial plate 25, secured to the frame of the machine.

Loosely mounted on the shaft of the pinion is the indicating pointer 26, and rigidly connected to said shaft is a shifting arm 27, having a pin 28, adapted to engage with the pointer 26. A coiled spring 29 is attached at one end to the frame section 3 and at the other end to the block 15, said spring serving as a counterbalance for strain on fabric.

As a means for observing the texture and structure of the fabric while being stretched, a magnifying glass arranged in a tube 30, attached to an arm 31, extended from the block 15 is employed. The upper member 1 of the frame is provided with a slot 32, into which the upper portion of the tube passes and wherein said tube moves as the block moves. Also attached to the block 15 is a plate 33, having a rectangular sight-opening in line with the magnifying glass. In order that the plate 33 may be swung upward to permit the blocks 5 and 15, to move close together, the said plate has a hinge connection 34 with the block 15.

In operation, after clamping a strip of the fabric to be tested in the clamping device and the outer edge is trimmed

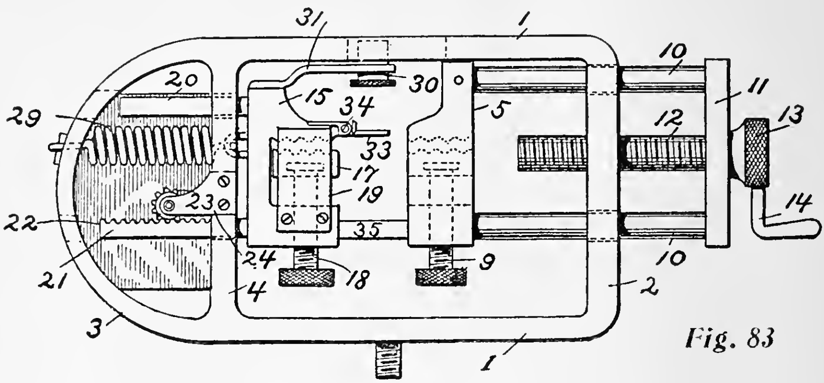



*Fig. 83*

off close to the outer surface of the clamping device, the screw 12 is operated to draw the block 5 outward. The block 15 is also drawn against the resistance of the spring 29. The rack 22 in its movement with the block 15 rotates the pinion 23, and consequently also the arm 27, and the pin 28 on said arm 27 will engage with the pointer 26, moving it over the dial.

When the fabric breaks, the block 15 is immediately drawn back to its normal position by means of the spring returning the arm 27 to its normal position, but leaving the pointer 26, having frictional contact with the dial at its adjusted place on the dial, from which the strength of the fabric may be observed.

The texture of the fabric may be observed through the magnifying glass during the whole operation of testing it for strength — that is, by its use the parting of the interlacing (weave) of warp and filling can be observed.

This device if desired may be made quite small and comparatively light, so that it can be carried in the pocket.

To observe the stretching quality of the fabric being tested, a gauge 35 attached to the block 15 is employed, its scale co-acting with a pointer or indicator mark on the block 5.

Fig. 84 shows the power tester as built by Henry L. Scott & Co., Providence, R. I., in its perspective view, adapted for handling the toughest fabric structures, like tire cloth, etc.

It is designed with two heavy cast iron ends holding four solid steel bars $1\frac{1}{2}$ inches in diameter so fastened as to give greater rigidity than a cast frame. This construction has the advantage of leaving all parts in full view and easily accesible. All parts are protected, making it impossible for the samples to catch, or the operator to be injured.

Resistance to the pull on the sample is obtained by dead weight and there are no springs to influence the test. The recording head is a one piece casting rigidly fastened to the frame. The main shaft rotates in two hardened steel self-aligning frictionless ball bearings protected by dust caps,

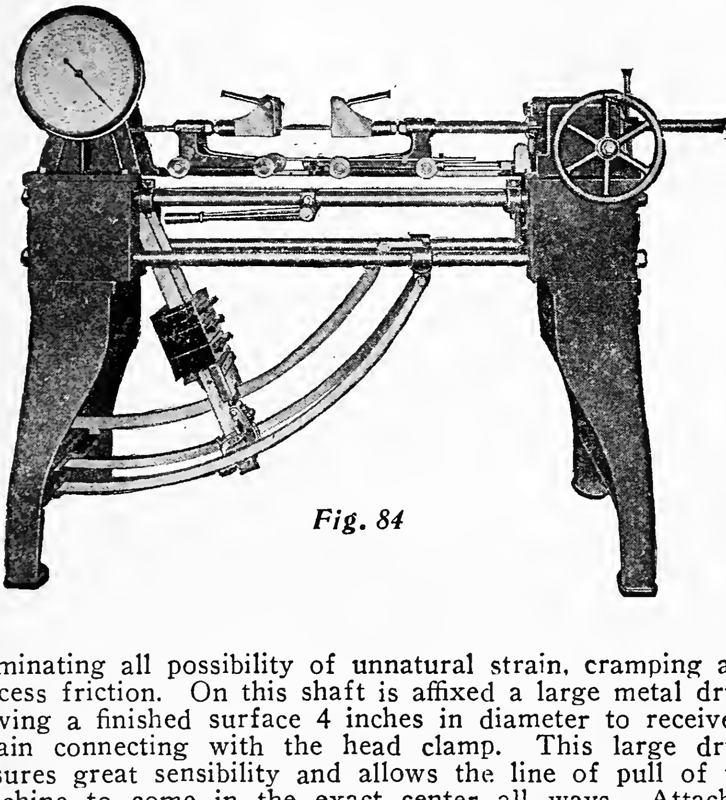


*Fig. 84*

eliminating all possibility of unnatural strain, cramping and excess friction. On this shaft is affixed a large metal drum having a finished surface 4 inches in diameter to receive a chain connecting with the head clamp. This large drum insures great sensibility and allows the line of pull of the machine to come in the exact center all ways. Attached rigidly to each side of this drum are two finished steel bars, heavily riveted at their lower end to form one solid unit. These double bars carry the resistance weights which are iron and made in sections for convenience in handling. The two levers fastened rigidly in this manner, support the weight evenly upon the shaft bearings, avoiding any tendency to cramp or distort the working parts. The capacity of the machine is determined by the number of weights placed upon the levers. Two rows of graduations can be placed upon the dial, the outer row reading from 0 to any capacity desired up to 2,000 pounds. The inner row may be made to read from 0 to any capacity desired so that by removing certain weights (shown shaded) a more delicate machine is obtained for lighter materials Thus a machine for tire fabrics may be constructed with a total capacity of 800 pounds and by removing part of the weights a machine of 400 pounds capacity may be had for tapes, braids, etc. The dial hand or indicator is positively operated by a single gear whose shaft rotates in "jewel" ball bearings.

Attached rigidly to the frame of the machine are two one inch curved steel quadrants the upper side of which are provided with machine cut teeth. On the outer sides of the weight levers are six steel pawls of varying length which engage the rack teeth and hold the weight levers and dial pointer at the exact position of the break. A third quadrant without teeth is suspended from the frame and passes between the weight levers connecting with a long hand lever on the head end of the machine. To re-set the weight lever and dial hand, it is only necessary for the operator to pull this lever. This action moves the upper quadrant downward, operating a lever which in turn trips the pawls and applies two brakes to the under side of the toothed quadrants allowing the weight lever to swing slowly to its normal position. A safety cam on the upper quadrants prevents any possibility of the weight lever swinging too rapidly and injuring the machine.

When it is desirable to drive by motor, a small gear attachment is used to replace the tight and loose pulleys increasing the speed in a ratio of 3 to 1, thus enabling the drive to be made by a single belt direct from a one quarter H. P. motor placed on the floor under the machine.

In making a test, the operator stands directly before the dial, and with the right hand on the horizontal lever can start, stop or reverse the machine at will. With the left hand, the machine is re-set, as described before.

The clamps are supported on carriages mounted on wheels which roll on two tracks or flat steel bars placed on edge. They are constructed with swinging flat anvils or gripping surfaces and automatically tighten on the sample as the stretch is applied.

A compensating elasticity scale, consisting of a steel tape which automatically winds and unwinds, is attached to the machine. On the moving carriage is an adjustable rod to which the end of the tape is attached in such manner as to bring the zero mark opposite a pointer on the head clamp when the sample is in place. The net stretch is read at the time of the break.

## Testing Yarns and Fabrics for Moisture.

A most important factor with which the textile industry has to deal with, is the hygroscopic nature of all textile fibres, *i. e.,* the power (which all fibres used, possess) of absorbing moisture from the air without altering in external appearance, but undergoing changes in weight, volume and strength, corresponding to the amount of moisture absorbed, whereas if exposed in a dry atmosphere they will lose moisture and decrease in weight. This tendency of taking up moisture varies with the different materials in the same atmospheric conditions and largely depends upon the humidity of the atmosphere as well as upon temperature and barometric pressure. The time which lapses before an exposed raw material, yarn or fabric, responds to changed condition of the atmosphere is termed *time-lag,* and is governed by several factors, such as the bulk of sample, the extent of surface exposed, and the movement of the surrounding air.

The determination of moisture in raw materials, yarns or finished fabrics is technically called *conditioning.* It is one of the most important tests connected with either the raw material or the finished yarn, as it is possible to load them with a considerable amount of unnatural moisture, which in the subsequent processes of manufacture speedily evaporates, and, by leaving them much lighter, increases the price.

### Over-condition.

The fault of over-condition is a most insidious cause of loss to any mill that buys its yarn. One of our most noted mill architects and company promoters remarked a few years ago (in an after-dinner speech) that he liked to erect a cotton spinning mill on a good clay foundation, as it was very advantageous to the conditioning cellar, and he considered a good conditioning cellar an important asset and perhaps the best dividend-earning department of the spinning mill. This frank admission is very interesting from any point of view; but from a manufacturer's consideration of the question, it must call for the greatest energy in its repression. No yarns can be spun or doubled without moisture, in reason; but to pay for excess moisture at the price of yarn is a suicidal policy, and its continuation leads inevitably to bankruptcy.

The moisture of the atmosphere in certain mill districts is said to be one of the reasons for the success of cotton-spinning, but even in that instance, for years many systems of further humidifying the atmosphere have been adopted in these spinning mills. This humidity in the air is essential to the working of any textile fibre, and a yarn spun under these favorable conditions is more suitable in every way for the doubling and twisting processes than a dry-spun yarn. This, it may be readily admitted, is perfectly legitimate; but it is doubtful whether that term could fairly be applied to the uses to which the watering can is devoted in certain mills. Nor perhaps is it advisable or necessary to accept as in good condition single yarn that has been half-drowned in the mill reservoir or other receptacle, previous to sending it on a precarious journey in a heavy rainstorm to the purchasing and innocent weaving or knitting mill.

It is safe to say that all firms add moisture to the yarn artificially after spinning by some process or another. During processes in the spinning mill, notwithstanding natural or artificial humidification, some moisture will be lost, and it is necessary that this natural loss should be made good. Moisture in any textile fibre is a natural constituent at any temperature below that resulting in actual incineration, and is necessary for the perfect working. Excess moisture in the single yarn will not be injurious to the doubling and twisting of yarns, except in so far as the excess may damage the parts of the machinery with which it comes in contact.

The Handbook of Conditioning and Testing (Manchester Chamber of Commerce) is responsible for the following:

"Of cotton, it may be said that to a limited extent a standard applies, since some spinners and manufacturers have agreed between themselves upon the 8½ per cent *'regain'* standard as applied to yarn. Raw cotton is not subject to any definite standard of moisture."

It is erroneous to say that for instance cotton in a perfect condition contains 8½ per cent of moisture. What the term is intended to convey is that if 100 parts of absolutely dry cotton is exposed to a normal condition of the atmosphere, it will gain 8½ parts of moisture. The normal condition of the cotton will be 108½ parts; if therefore 108½ parts contains 8½ parts of moisture, 100 parts of normal conditioned cotton contain 7.834 parts of moisture. The 8½ parts is termed the *"regain per cent,"* and is the standard for cotton in any process offered for sale.

### How to Test for Moisture.

For the purpose of making this test for moisture, two lots of not less than 1 lb. each are removed from the skip of the yarn as received at the mill. The apparatus used for this test consists of a circular oven; surmounting the top of the oven, is fixed a pair of scales. On one extremity of the beam is a pan to contain the weights; at the other end of the beam is suspended, either a wire cage, if cops are being tested, or a reel, if the yarn is in hank, so that the material to be tested hangs within the oven; and the balance of the scale is in equilibrium. A thermometer is placed through the lid, with the bulb in the oven, and the scale portion projects outwards to facilitate the reading of the degrees.

The sample is placed in the oven and very accurately weighed, and the heat is generated either by a Bunsen burner or electricity. The temperature adopted by the Testing House for cotton is 212 deg. *F.* The temperature is a most vital part of the drying process, and care must be taken not to exceed this heat. At 212 deg. *F.* cotton is said to be quite dry, although moisture will still be contained therein, but for all practical purposes it may be regarded as being dry. Frequent readings of the thermometer are therefore very necessary.

The following points are set out in the Handbook brought out by the Manchester Chamber of Commerce Testing House:

### Time of Drying.

The length of time necessary to dry samples is frequently stated; for such rough methods of testing as those under consideration, three hours is sometimes recommended. With any properly constructed oven, a far shorter time than this should be ample, so long as the sample does not exceed one or two pounds. There are serious objections to extending the time of drying; for instance, the *increase* of weight known to follow the protracted heating of fibres. The weighing should be conducted within the hot atmosphere of the oven; weighing of the sample after leaving the oven is anything but reliable, making exact results a matter of chance. If the sample be weighed immediately after removal from the oven, it causes an upward current of air at that side of the balance, thus giving an accurate weight; and if left to cool before weighing, it will absorb moisture from the air and become too heavy.

### Error Due to Weighing Hot.

It is true that a very small error results from weighing the sample in the hot state as compared with weighing when cold, quite apart from absorption of moisture or the setting up of air currents. This error is, however, easily calculable, and is: (weight of air displaced by the sample at normal temperature) minus (weight of air displaced by the sample at its temperature when weighed). It will be found that the error is too small to be worth consideration except for the purposes of precise scientific investigation.

### Effects at Different Temperatures.

A series of tests have been carried out at the Manchester Chamber of Commerce Testing House with a view to ascertaining the effect of drying at different temperatures. Two lots of yarn were dried for three hours at a temperature of about 160 deg. *F.* The loss due to moisture driven off at, and below, this temperature was ascertained by frequent weighings; the samples were then submitted to higher temperatures for further periods, and the subsequent loss recorded.

As the heat rises the material being treated will commence to lose weight, and this loss of weight will continue until the yarn has been brought to a perfectly dry state. Above the reel or cage is a small pan attached to the suspending arm, and into this pan weights are placed to compensate for the evaporating moisture. These indicate at a glance the total weight the yarn has lost.

**To Ascertain Amount of Moisture.**

To find the amount of moisture which the yarn contains, proceed as follows:

ORIGINAL WEIGHT. WEIGHT LOST.

16 oz. : 100 : : 2 oz. : x

$2 \times 100 = 200 \div 16 = 12\frac{1}{2}$ per cent.

$12\frac{1}{2}$ per cent in loss leaves $100 - 12\frac{1}{2} = 87.5$ of cotton in absolutely dry condition, a regain of $8\frac{1}{2}$ per cent from the absolutely dry cotton to a normal condition.

$87.5 \times 8.5 \div 100 = 7.44$ per cent.

87.5 absolutely dry cotton + 7.44 per cent ($8\frac{1}{2}$ per cent) = 94.94 correct condition weight per cent and, 100 — 94.94 = 5.06 per cent excess moisture.

Water at prices varying from 25 cents to $7.– a pound is too expensive a luxury for most weaving or knitting mills. The condition of the yarn received is a most important consideration for the mill, and claims for excess moisture are the most difficult to settle with the spinner, as a rule. It is therefore imperative that tests of spinnings should be regularly made, and in case of default most drastic measures should be adopted to prevent their recurring.

**Wool—Silk—Cotton—Flax.**

WOOL in a normal condition (scoured) contains about 16 per cent of its weight of moisture, and can absorb up to 30 per cent without showing any material change, while in a high temperature, with the atmosphere at the point of saturation, it has been known to absorb as much as 50 per cent. Woolen Yarns in a normal condition contain about $18\frac{1}{4}$ per cent of its weight of moisture.

SILK contains normally about 11 per cent of moisture, but is capable of absorbing up to 30 per cent.

COTTON contains normally about $8\frac{1}{2}$ per cent of moisture, *i. e.* water, as a natural constituent; if any or all of this moisture is extracted the cotton will, upon exposure to a suitable atmosphere, again absorb moisture up to the before mentioned normal percentage. Cotton may, however, easily contain twice the latter percentage without either altering in appearance or feeling unduly damp.

FLAX is more hygroscopic than cotton, absorbing 12 per cent normally, with about 27 per cent as maximum.

### Union Yarns and Fabrics.

For union yarns and mixed fabrics the amount of regain is based on the relative proportions of the materials contained in the mixture. Thus for a mixture, which, when absolutely dry, contains 75 per cent wool and 25 per cent cotton, the regain is found thus:

$100 : 75 :: 18\frac{1}{4} : 13.69\ \%$ for the wool.
$100 : 25 :: 8\frac{1}{2} : 2.125\ \%$ for the cotton.

Giving a total of 15.815 % regain.

Dealing in the textile industry with raw materials liable to such wide fluctuations, and which may be due either to the natural condition of the atmosphere, to the temperature of the work rooms, or to fraudulent practices, shows how important it is that means should be adopted by the mill, for determining and taking into account the percentage of moisture contained in the material when bought and sold, *i. e.*, the necessity for a *standard* regarding permissible moisture, raw materials, yarns, or fabrics may contain.

It will thus be readily seen, that for example the absolute dry weight of the contents of a bale of cotton, silk, etc., is a constant and unchanged quantity (as long as no portion has been removed) whereas its actual weight varies, depending on atmospheric or other influences.

The artificial, like the natural moistening of textile material is confined to no particular country or branch of the industry. It is firmly established as a natural and artificial factor in the textile trade and this is what makes it necessary for every person who buys or sells textile materials to protect himself against loss by adopting a reliable method of testing or conditioning all the material bought or sold.

Established standards for moisture in textile materials are as important for both buyer and seller as are established standards for money or for weights and measures. A variation in the quantity of water in a lot of raw material or yarn has the same effect on the buyer's and seller's bank accounts as an alteration in the size of the pound or in the number of cents in a dollar would have.

### Conditioning.

In testing for moisture, or as technically called *conditioning,* whether referring to the raw material, yarn or finished product, the absolute dry weight of the material is first found, then, to get the true invoice weight, the standard regain of moisture must be added to the dry weight.

This standard regain has been fixed as the result of experiments extending over many years, and is supposed to represent the amount of moisture absorbed by the various fibres under average conditions of humidity and temperature.

### Standard Regains.

To ascertain the standard condition of a raw material, yarn or fabric, a definite quantity of either is heated until *absolute* dryness is attained, the same being determined by frequent weighings and continuance of the heat until no further loss takes place. The addition of the percentage of the *standard regain* permissible to the final weight then gives the weight in the *correct* condition. It is essential that the weighing be performed without removal of the material from the influence of the heat, otherwise re-absorption would immediately commence, and would interfere with the correctness of the result.

A certain amount of moisture is a natural constituent of all fibres, as without it they would be harsh and wiry. With a view to determining the percentage of natural moisture, *i. e.*, "standard regains" together with the "equivalent losses" which the various fibres contain, a conference of experts met at Turin, in 1875, to deal with this matter, and as a result of many tests and much observation, the percentages given in the appended table were agreed upon.

| Material. | Regain. | | Loss from normal condition. | |
|---|---|---|---|---|
| Wool Scoured | 16 | per cent | 13.79 | per cent |
| " Tops in oil | 19 | " | 15.96 | " |
| " Tops dry | 18¼ | " | 15.43 | " |
| " Noils | 14 | " | 12.28 | " |
| " Yarns | 18¼ | " | 15.43 | " |
| Silk | 11 | " | 9.91 | " |
| Cotton | 8½ | " | 7.83 | " |
| Flax | 12 | " | 10.71 | " |
| Jute | 13¾ | " | 12.09 | " |
| Hemp | 12 | " | 10.71 | " |

The above percentages must be added to the chemically dry weight, obtained by drying at 212 deg. *F.*, for several hours.

For example: Suppose a quantity of cotton yarn weighs 1,000 grains, and after thoroughly drying is found to weigh only 880 grains, the amount of excess moisture is found by adding 8½ per cent of 880, and deducting the sum from 1,000, the percentage being then obtained in the usual way.

$$880 + 8\tfrac{1}{2}\% = 954{\cdot}8 \text{ grains.}$$
$$1{,}000 - 954{\cdot}8 = 45{\cdot}2 \text{ grains excess.}$$
$$1{,}000 : 45{\cdot}2 :: 100 : 4{\cdot}52\%.$$

Accurate weighing is a great *desideratum* in all moisture tests, and to obtain this a chemical balance is almost essential. Next there is the condition of the yarn after being dried. If it is allowed to cool in the ordinary atmosphere it will quickly absorb a certain quantity of moisture, the amount depending upon the state of the atmosphere, and this would reduce the value of the test. To guard against this, the material should be placed in some receptacle from which the atmosphere is excluded, and all weighed together, and having deducted the weight of the bottle, proceed to ascertain the moisture in the manner indicated above.

#### Conditioning Oven.

To carry out such a test as this, the material may be dried in a copper drying oven, having a cavity all round, containing the water to be kept at boiling point for from 2 to 5 hours, by means of a Bunsen burner.

In addition to this plan there are many others, some being a combination of a drying chamber and a balance; such a one is shown at Fig. 85. *A* is the outer casing of the apparatus; *B* shows the cavity in which the water is contained

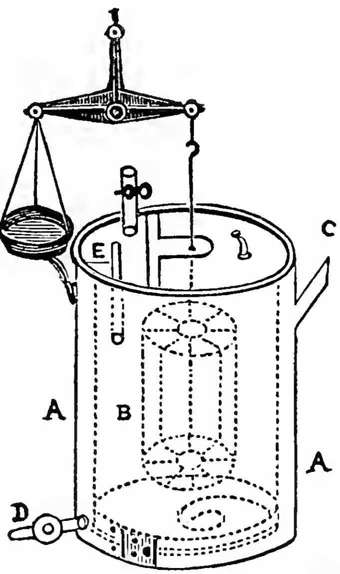



*Fig. 85*

and kept heated by gas admitted through the pipe *D; E* is a thermometer, and near it is shown a pipe which acts as an outlet for evaporated moisture; *C* is the outlet for steam and the inlet for water. The cage shown in dotted lines contains the material to be tested, and is suitably suspended from one end of the balance *F*, the other end or pan containing the weights. The reduction in weight is carefully watched until there is no further loss, when the percentage is obtained in the manner stated. One of the faults of this and similar machines is that some portion of the condensed steam settles upon the wire, which must extend into the drying chamber, and to this extent the weighing is incorrect.

For testing silk much more elaborate machines are employed; but for cotton, wool, and linen the one shown is sufficiently accurate for all practical purposes.

The apparatus used by testing houses, as well as large silk, etc., mills, who make conditioning an object of their routine work for obtaining absolute dryness, consists of an oven of cylindrical shape constructed with an inner and outer case, about 40 inches high and 30 inches in diameter (outside measurement). A space of 1½ inches is allowed between the two cases to permit the heated air to circulate freely around the inner hot-air chamber. A pair of scales, sensitive to 0.1 gram, is firmly fixed to the oven in such a position that a reel or cage suspended from one arm is directly in the centre of the oven. Both reel and cage are of equal weight, the former being employed for tops or yarns and the latter for loose materials or in the form of cops, and each one corresponds in weight with the pan and chains at the other end of the beam. The heat is obtained from a Bunsen gas burner, the lighted jets being arranged in a circle underneath the inner oven. A thermometer ranging from 40 to 120 deg. *C.* or higher, is placed so that the bulb reaches half way down the oven, to register the temperature within.

Conditioning Ovens are also built to be heated by electricity instead of by gas. In this instance two (sometimes three) electric heaters are employed. Each heater is controlled from a separate switch, so as to facilitate the regulation of the temperature. This system is less liable to fire, and as there are no fumes discharged it is less injurious to the person in charge.

Fig. 86 shows the Baer "Standard Conditioning Oven" heated by electricity, equipped with a Fore-heater attachment by which the waste of hot air is made to partly dry out another sample while one test is made, *i. e.*, to build an apparatus in which the material to be dried out could be thoroughly dried in as short a time as possible, at the right temperature and without chances of overheating or scorching the material.

In the old type oven it was relied upon that the warm air being lighter than the cold, would travel of its own accord up through the material and in this way it took a long time before the warm air really penetrated through the material.

In the new Conditioning Oven, the heating-coils are therefore built somewhat stronger and very compact, providing at the same time a fan, driven by an electric motor, which, drawing the air from the outside through a fine wire screen, forces it through the heating unit and from there through the material to be dried. In its passing through the heating

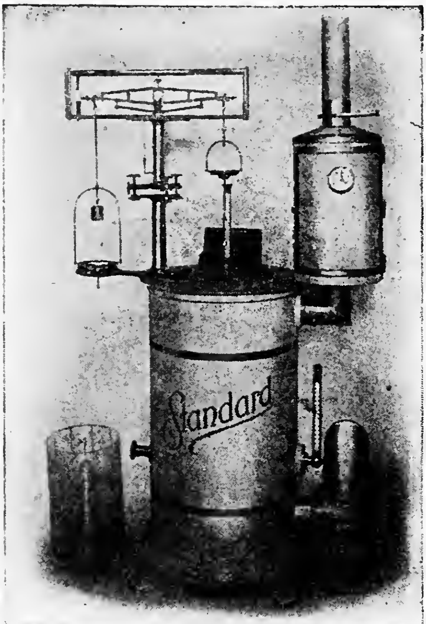



***Fig. 86***

coil the air is heated up to 235 to 284 degrees *F.*, according to the material to be dried; for silk 284 degrees *F.*, is the average temperature used.

In order to insure an even drying of the material, the baskets are provided with a conical mesh wire funnel into which the air passes on its reaching the drying chamber. Not being able to scatter all around the baskets, it is forced to go through the material to be dried.

From the drying chamber the air enters into the pre-drying chamber, in which the waste air is used to partially dry a second sample; in this way making the Oven more economical and effective.

It has been found that the first sample which is placed into the drying chamber (cold) takes about 45 minutes to completely dry out, while a second sample which was subjected to the waste warm air while the first sample was being dried out, requires only 25 minutes additional time to completely dry out when placed in the drying chamber.

By means of a Thermostat and Reostat the temperature of the air, as it leaves the heating unit, is automatically controlled, and registered by an angle thermometer. A second thermometer indicates the heat in the drying chamber, which is always 10 to 15 degrees lower than the temperature indicated by the angle thermometer, on account of the expansion of the warm air in the drying chamber.

This "Standard Conditioning Oven" is handled in the U. S. by Alfred Suter, Textile Engineer, 200 Fifth Ave. New York.

In the silk trade there are recognized Conditioning Houses to which all purchases are sent to be tested, and upon the results of these tests the material is bought. This, of course is a very necessary precaution with such a valuable fibre as silk, but in cotton and some other fibres it is considered sufficient to test samples from any doubtful delivery of raw material or yarn, and it is this class of testing which will be dealt with here.

**Conditioning Process.**

The material to be conditioned is first weighed in the bulk; then, in order to secure a fair average sample, three equal portions are taken — one from the top, one from the centre, and the third from the bottom of the bale; or one portion may be taken from the centre and two from the sides.

The sample is immediately weighed, great care being taken that it is evenly balanced, and is then suspended from the apparatus by means of the cage or reel, a weight corresponding with the weight of the material being placed in the pan at the other end of the beam. The oven is heated up to 230 deg. *F.* for wool, 220 deg. *F.* for cotton, and up to 248 deg. *F.* for silk, any higher degree being liable to scorch and discolor the sample, while anything lower than 212 deg. *F.* will not abstract all the moisture.

As the moisture is driven off, the change in the weight of the sample is compensated for by the addition of small weights, which are placed in a cup above the rod of the reel or cage, the original weight of the sample being left at the opposite end of the scale. The sample is subjected to heat until it ceases to lose weight, a further period of five or six minutes being allowed, during which the needle of the scale remains stationary, the material being then considered absolutely dry.

The percentage of moisture present is obtained by comparing the weight in the cup with the original weight in the pan, and for clean material the true invoice weight = (gross weight — percentage of moisture) + standard regain per cent.

**Testing Scoured Wool.**

For example, assume that a bale of scoured, *i. e.,* clean loose wool weighs 200 lbs.

The original weight of the sample = 16 oz., or 100%
The weight in the cup = 3 oz., or $18\frac{3}{4}$% direct loss.

There is left....................13 oz., or $81\frac{1}{4}$% dry wool.

The temperature used with wool is 230 deg. *F.*

The dry weight of the 200 lb. bale is:

16 oz. : 13 oz. :: 200 lbs. : $162\frac{1}{2}$ lbs. of dry wool;
or, 100% : $81\frac{1}{4}$% :: 200 lbs. : $162\frac{1}{2}$ lbs. of dry wool.

To this must be added the percentage of regain, which for loose scoured wool is 16 per cent, giving an invoice weight of:

100 : 116 :: $162\frac{1}{2}$ : $188\frac{1}{2}$ lbs.

To find the excess of moisture expressed in % present:

100 : 116 :: $81\frac{1}{4}$% of dry wool : $94\frac{1}{4}$%.
$100 - 94\frac{1}{4} = 5\frac{3}{4}$% excess, *Ans.*

**Testing Raw Cotton.**

To make a test, samples are collected from different parts of the bulk, and placed as loosely as possible within the oven and then weighed. Next the heat is turned on; and 10 to 15 minutes after a temperature of 220 deg. *F.* has been attained, weights are placed in the small pan attached to the cage wire, to restore equilibrium. The material is then shaken and turned top to bottom, and again submitted to the heat, and weighed at intervals of 5 to 8 minutes until a constant weight, indicating absolute dryness, is obtained. The weights in the cage pan represent loss or moisture, and the same subtracted from the original weight (which has remained undisturbed throughout the operation) gives the dry weight. The addition of the percentage regain to the latter then gives the correct weight, or weight in the correct condition.

*Example:* Suppose 2 lbs. of cotton are taken from a 500 lb. bale of cotton, and they are to lose 4 oz. in drying.

The dry weight of these 2 lbs. of cotton is thus 1 lb. 12 oz., or 28 oz.

Adding $8\frac{1}{2}$ per cent of permissible moisture to the latter (*i. e.,* 2.38 oz.) we obtain (28 + 2.38 = ) 30.38 oz. as the correct weight.

From this we obtain the invoice weight of the bale of cotton thus:

$$\frac{30.38 \times 500}{32} = 474.68 \text{ lbs.}$$

Excess moisture in the bale of cotton under consideration thus is:

$$500 - 474.68 = 25.32 \text{ lbs.}$$

*Another Example:* From a lot of cotton yarn weighing 260 lbs. net, 1½ lbs. of cops are taken for testing.

When absolutely dry, they weigh 1 lb. 5¼ oz.

*Question:* Can any claim be made for excess moisture, and if so to what amount, assuming the yarn to cost 22 cents per lb.

| | |
|---|---|
| Dry weight (1 lb. 5¼ oz. =)............ | 21.25000 oz. |
| Add 8½ per cent........................ | 1.80625 oz. |
| Correct weight...................... | 23.05625 oz. |
| Original weight (1½ lbs. =)............ | 24.00000 oz. |
| Correct weight.......................... | 23.05625 oz. |
| Excess moisture..................... | 0.94375 oz. |

$$\text{Total excess moisture} = \frac{0.94375 \times 260}{1\frac{1}{2} \times 16} = 10.22 \text{ lbs.}$$

*Answer:* Claim to be made is 10.22 lbs. @ 22c = $2.25.

### Testing Yarns for Moisture.

For testing yarn in the hank a number of hanks are selected and placed upon the reel. Provided the yarn to be tested is upon spools, tubes or bobbins it must be wound into hanks, whereas if warp yarn is ball shape, a convenient number of ends are split off.

When dealing with the testing of loose material, for convenience of simplifying calculations, as a rule a fixed quantity is used, whereas this is not the case when dealing with yarns and when the sample is weighed intact, and the calculation worked out as previously explained, the difference being that we may have to use additional fractions in the calculation.

### Testing Fabrics for Moisture.

The percentage of moisture present in fabrics can be largely increased above the normal amount by storing the goods in damp cellars, or by loading the material with certain hygroscopic substances which have a natural affinity for moisture. In former days, and when conditioning was unknown, loading of woolen goods by moisture was then the means of producing by Government contracts some of the old time millionaire textile manufacturers in this country, and when storing goods rejected on account of "below weight" were stored for some time in damp cellars, to be in turn found "up to weight" later on by the government. The basements of mills on the Schuylkill of the "Falls" furnishing excellent specimens for this work.

To determine the percentage of moisture at present, a given quantity of fabric is weighed and dried in a conditioning oven as previously explained.

Whether dealing with fabric, yarn or raw materials, provided only small samples are tested, a most delicate balance must be used, one weighing up to the ten-thousandths part of a grain or even finer; the *"Troemner Balance"* being the Standard Balance used by the Government.

### Conditioning Unscoured Material.

In some cases unscoured or dirty material has to be conditioned, and when besides ascertaining the percentage of moisture in the sample, we must also ascertain the percentage of yolk, dirt, gum and other foreign matter. The percentage of oil in tops, yarns, or fabrics is also often required to be known.

For this purpose a sample is carefully weighed, then thoroughly scoured with a neutral soap and water to which a little ammonia is added, dried, cleansed, and shaken to rid it of sand, lime, etc. It is then made absolutely dry in the conditioning oven, as previously explained, its weight again recorded, and subtracted from the first weight taken, the difference giving the amount of foreign matter, plus the moisture the sample contained.

### Silk Conditioning.

In conditioning of silk, besides ascertaining the percentage of moisture present it may be necessary to also obtain the percentage of gum or sericin before the true weight of the fibroin the silk contains can be given. This gum, which is the natural product of the silkworm, is poured by the latter on to the fibre during the spinning of its cocoon, and usually amounts to about 18 to 25 per cent, depending upon the kind of raw silk, China silk containing the most.

Thrown silk yarns are supplied either boiled-off (that is with all the gum removed) or as *gum-yarns,* in which case only a portion of the gum will have been removed, the proportion varying according to the purpose to which the yarn is to be put. Thus *souple* silk has only from 6 to 12 per cent of the gum removed, whereas silk known as *ecru* has only as little as possible removed, consistent with the success of the bleaching of the material, say from 3 to 5 per cent.

Spun Silk, which is made from the waste of raw silk, is supplied as *ordinary spun silk* in which the gum is all boiled out, or as *schappe* or *floss* silk in which the gum is retained.

The usual process of testing a silk sample as to moisture and boil-off consists of first weighing a sample on a pair of most delicate scales, then finding the absolute dry weight by placing it in the dessicating apparatus, which has been previously explained, but smaller. The dry sample is then immersed twice in a bath of boiling soap suds, ¼ lb. of silk soap being used to each pound of silk, for a half hour, after which the heat should be permitted to run down, the sample afterwards being washed in a current of cold water to remove the soap.

The sample is then conditioned a second time, and when then the difference between the absolute dry weights before and after boiling gives the amount of moisture and gum that was present, and from which the percentage of loss can be readily calculated.

**Count in Correct Condition.**

The moisture in the air of the room at the time of this testing for the count of the yarn (or weight of fabric) "in correct condition", *i. e., conditioning* as you technically call it, has no influence on the result of the test; that is to say, several tests might be carried out on the yarn under widely varying conditions with regard to moisture, and assuming there to be no natural variation in the count of the yarn, the "count in correct condition" would always be the same.

**Count in Condition Received.**

On the other hand, in the case of a test for *"count in condition received,"* that is, count of yarn without correction for moisture, the result of the test will vary according to

(1), the moisture in the sample, and

(2), the atmospheric conditions prevailing at the time the test is made.

When a sample is tested in a damp state, the result will show the varn to be coarser than is actually the case, whereas a test of yarn in a dry condition will give a result finer than the true count.

For the purpose of investigating the effect of variation in the amount of atmospheric moisture on the count of a yarn, a sample of a normal gray cotton yarn, after being accurately weighed, was placed in a cage specially designed so as to expose the sample as freely as possible to the atmosphere of the testing room, but at the same time to afford the maximum amount of protection from dust and dirt. The sample was weighed at frequent intervals during a period of about three months, and the weights recorded. Hygrometric readings were also taken during the same period, and the variation in the weight of the test portion of yarn was found to be generally coincident with the variation in the amount of atmospheric moisture. As was to be expected, however, there was a certain amount of *time lag* due to the condition of the test portion not coming immediately into equilibrium with the condition of the air.

At the end of the period during which the yarn was exposed, and after the final weighing, the sample was dried and the *absolute dry weight* ascertained. From this, the percentage of moisture in the yarn at the time of each preceding weighing was calculated, and the results showed the moisture to have varied approximately from 6 to 10 per cent.

Assuming the yarn to have been 40's, tests for count at different times during the period in question would have shown an approximate variation of from 39's to 41's. That is to say, if tested on the most humid day during the three months, the yarn would have been found to be 39's, whereas if the test had been made on the driest day, it would have shown the yarn to be 41's.

Although the true count of a yarn may be ascertained from a test of the material *"in correct condition,"* tests of strength of yarn and cloth are commonly carried out on the material in its ordinary air-dry state. It is generally recognized by manufacturers that the strength of yarn and cloth varies to some extent according to the amount of moisture in the material, and in some works, strength tests are never made unless the samples have been previously exposed to the air in order that they may gain or lose moisture, and come to a supposed *natural* condition. No method of testing, however, has been generally adopted which obviates the discrepancies in the results of tests arising from variation in the amount of atmospheric moisture in materials at the time of testing. It has been stated that, in the case of flax canvas purchased by some foreign governments, it is stipulated that before testing for strength, the material shall be subjected to a certain temperature for a stated time. Objections may be raised to this procedure, however, since it is possible that physical changes may be brought about by the heat used in drying, and, on cooling, the material may not be in its natural condition.

With a view to determining the effect of atmospheric moisture on the strength of cloth, a series of tests have been carried out some time ago by the Manchester Testing House on wool, cotton, and linen cloths, and the results obtained show that the degree of strength possessed by these materials depends to a considerable extent upon the conditions of the atmosphere to which the cloth is exposed prior to testing.

Having regard to the variation in strength usually found from place to place in a piece, it was necessary for the purpose of this investigation that special precautions should be taken so as to reduce to a minimum any natural variation in strength existing from one test portion to another. The cloth was tested in the direction of the warp only, in order that the strength of the test pieces would not be influenced by the accidental presence of mixed filling yarn, or by variation in the number of picks per inch due to irregular beating-up in weaving, a piece of cloth, measuring several yards in length was cut into six strips in the direction of the warp. Each strip was of such length as to provide about thirty test pieces, which could be cut off as required. The strips were numbered before being divided, so that the exact position in the cloth of any particular test portion could (if desired) be ascertained after the tests had been made.

The strips were so prepared that each had the same number of threads in its width, and they were then exposed in the testing room, the necessary sized test piece being cut from each of the six strips, and the remaining portions left exposed to the air for subsequent tests whenever the moisture conditions of the air showed a change from those prevailing at the time of the previous test. The tests were not made at strictly regular intervals, but only after the hygrometer readings showed a change to have taken place in the relative humidity of the air.

A serge of the type used for military uniforms was selected to represent the wool cloth, while an ordinary gray cotton drill and a flax canvas were chosen as typical of the cotton and linen cloths which are frequently brought to a specification strength.

Comparison of the highest and lowest results obtained in each of the series of tests show that, when tested in their assumed *normal* air-dry condition, the average strength of the materials varied to the extent of 14 per cent in the wool cloth, 12 per cent in the cotton cloth, and 18 per cent in the flax canvas.

SUMMARY OF TESTS.

*Average of six tests in each case.*

| Relative Humidity of the Air. Per cent. | Wool (Serge). Average Strength. lb. | Cotton (Drill). Average Strength. lb. | Flax (Canvas). Average Strength. lb. |
|---|---|---|---|
| 44 | 186 | 521 | 599 |
| 47 | 181 | 538 | 637 |
| 56 | 180 | 527 | 652 |
| 57 | 173 | 545 | 650 |
| 59 | 174 | 541 | 650 |
| 60 | 175 | 531 | 639 |
| 62 | 175 | 550 | 669 |
| 65 | 169 | 552 | 681 |
| 66 | 173 | 563 | 687 |
| 68 | 173 | 551 | 661 |
| 70 | 159 | 571 | 702 |
| 71 | 173 | 568 | 712 |
| 72 | 168 | 569 | 688 |
| 75 | 168 | 582 | 710 |
| 77 | 165 | 581 | 710 |
| 82 | 160 | 592 | 729 |

It cannot be claimed, however, that the foregoing results should be accepted as showing the precise and definite degree of variation in count and strength, consequent upon the percentage of moisture in the air, or in the sample, at the time the test is made, as no universally recognized standards of variation in count, twist, and strength exist.

If the amount of moisture present in the air can influence the count of yarn to such an extent as to show an actual 40's yarn as 39's on a humid day, and 41's on a dry day, and to influence the strength of cloth from 12 to 18 per cent, and possibly more, it would seem unreasonable that exception should be taken to goods which fall short of a contract or specification by these amounts, unless reliable tests have been carried out under stated and agreed conditions of humidity.

### Hygrometer.

The *dew* point is the foundation for the estimation of humidity or moisture in the air and for which reason we must know this before the percentage of humidity in a room can be ascertained. There is *Absolute, Maximum* and *Relative* Humidity. The first means the actual amount of vapor present in a given volume of air; the second means the amount of vapor that could be present in the same volume of air under precisely the same conditions of pressure and temperarture, whereas relative humidity means the ratio of the absolute to the maximum humidity and is the one we are mostly concerned with in connection with textile problems.

The instrument for measuring the degree of relative humidity, *i.e.*, drying power of the atmosphere, as we may say, is called psychrometer, or wet bulb hygrometer or hygrometer for short and of which a perspective view is given in Fig. 87. From the same it will be seen that the apparatus consists of two delicate thermometers placed near each other, the bulb of one of which is kept wet by being covered with a piece of muslin, the end of which (a kind of wick) dips into a small vessel filled with water.

It is one of nature's laws that when anything evaporates, it absorbs heat, therefore, the water evaporating from the wick which surrounds one of the bulbs of the Hygrometer, absorbs or draws out the heat from the thermometer, thus lowering the temperature. The dryer the air, the faster the water evaporates from the bulb and the greater the difference would be between the two thermometers. If the air would be perfectly saturated with moisture, there would be no evaporation taking place from the wick, and consequently the two thermometers would read exactly alike.

After ascertaining the difference between the two thermometers, by consulting table given herewith, the relative humidity may be read off direct.

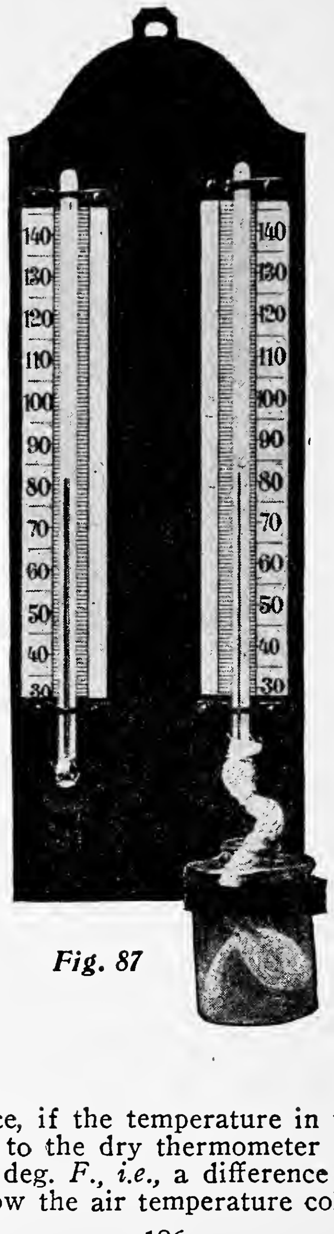



*Fig. 87*

As, for instance, if the temperature in the room was 100 deg. *F.* according to the dry thermometer and the wet thermometer read 85 deg. *F.*, *i.e.*, a difference of $(100-85=)$ 15 deg., then follow the air temperature column down to the

100 mark, and then follow that line out to the right until the 15th = 54 per cent humidity.

In the use of hygrometers, attention must be given to:

(*a*) The muslin, covering the wet bulb, must be kept in good condition; the evaporation of the water always leaves a small residuum in the meshes, wihch inevitably causes stiffening of the material, preventing the proper taking up of the water. Hence, use as pure a water as possible, and renew the muslin covering from time to time.

| Air Temperature. | Difference Between the Dry and Wet Thermometers. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 60 | 100 | 94 | 89 | 84 | 78 | 73 | 68 | 63 | 58 | 53 | 48 | 44 | 39 | 34 | 30 | 26 | 22 | 18 | 14 | 10 | 6 | 2 | | | | | | | | | |
| 65 | 100 | 95 | 90 | 85 | 80 | 75 | 70 | 65 | 61 | 56 | 52 | 48 | 44 | 39 | 35 | 81 | 28 | 24 | 20 | 17 | 13 | 10 | 6 | 3 | | | | | | | |
| 70 | 100 | 95 | 90 | 86 | 81 | 77 | 72 | 68 | 64 | 60 | 55 | 52 | 48 | 44 | 40 | 36 | 33 | 29 | 26 | 23 | 19 | 16 | 13 | 10 | 7 | 4 | 1 | | | | |
| 75 | 100 | 95 | 91 | 87 | 82 | 78 | 74 | 70 | 66 | 62 | 58 | 55 | 51 | 47 | 44 | 40 | 37 | 34 | 31 | 27 | 24 | 21 | 19 | 16 | 13 | 10 | 7 | 6 | 2 | | |
| 80 | 100 | 96 | 92 | 87 | 83 | 79 | 75 | 72 | 68 | 64 | 61 | 57 | 54 | 51 | 47 | 44 | 41 | 38 | 35 | 32 | 29 | 26 | 23 | 20 | 18 | 15 | 13 | 10 | 8 | 6 | 3 |
| 85 | 100 | 96 | 92 | 88 | 84 | 80 | 77 | 73 | 70 | 66 | 63 | 60 | 56 | 53 | 50 | 47 | 44 | 41 | 38 | 36 | 33 | 30 | 28 | 25 | 22 | 20 | 17 | 15 | 13 | 11 | 9 |
| 90 | 100 | 96 | 92 | 88 | 85 | 81 | 78 | 75 | 71 | 68 | 65 | 62 | 59 | 56 | 53 | 50 | 47 | 44 | 41 | 39 | 36 | 34 | 32 | 29 | 26 | 24 | 22 | 20 | 17 | 15 | 13 |
| 95 | 100 | 96 | 93 | 89 | 88 | 82 | 79 | 76 | 72 | 69 | 66 | 63 | 60 | 58 | 55 | 52 | 49 | 47 | 44 | 42 | 39 | 37 | 35 | 82 | 30 | 28 | 25 | 23 | 21 | 19 | 17 |
| 100 | 100 | 97 | 93 | 90 | 66 | 83 | 80 | 77 | 74 | 71 | 68 | 65 | 62 | 59 | 57 | 54 | 51 | 49 | 47 | 44 | 42 | 39 | 37 | 85 | 33 | 31 | 29 | 27 | 25 | 23 | 21 |

(*b*) Have the wet bulb 4 inches or more apart from the dry bulb, and the well of water at least 5 inches, in order to prevent the dry bulb being affected by evaporation.

(*c*) Have the gradations cut on the stems of the thermometers, and have them properly tested before being put to use in the mill. A defect in many makes of hygrometers is to have the spherical bulbs of the thermometers too long to adapt themselves quickly to the changes of temperature.

There are also direct reading hygrometers in the market, in which by merely setting the pointers to the wet and dry bulb temperatures, the humidity of the air is obtained on the scale. The apparatus operates as follows: On setting the pointers, the difference between the wet and dry bulb thermometers is obtained. A slotted bar at the back of the instrument multiplies this reading by a factor which obtains the dew point. The scales are so chosen that the vapor tensions corresponding to the dry bulb temperature and dew point are found. These are divided and the result multiplied by 100, thus finding the humidity. It will, of course, be understood that the instrument, by means of the pointers, slots, and special scale, performs all these operations at one setting.

## Standard Condition for Testing.

Ever since the necessity for a definite knowledge of the strength of fabrics began to be felt, various means have been employed for testing them. For a long time proper allowances were not made for the factors entering into the conditions. Lately, however, owing to great divergencies of tests of the same materials, secured from various parties, a need of standardization has been felt, and, in fact, is considered now of the utmost importance.

We are presenting here a method for obtaining a standard condition which will be in line with the results achieved by the Bureau of Standards, and which is easy of application, costs little to install, can be operated at minimum expense, and gives entirely satisfactory results.

### Defects of Bone-Dry Tests.

The method advocated by certain parties known as the "bone-dry" method has numerous defects and disadvantages, the chief of which are:

First: The fabric in this condition is entirely outside the usual working conditions for any, except tire purposes.

Second: The essential oils of the fabric are dried out and the structure changed to the extent that a test will not be a true measure of the behavior of this sample under conditions of use.

Third: The difficulty of securing a "bone-dry" condition with a multiplicity of samples increases in direct ratio to the number of samples to be tested, and in a large establishment makes a prohibitive condition.

A method of testing which secures satisfactory results without the disadvantages of the foregoing plan consists in maintaining a standard condition of regain in the testing room. It is a well-known fact, which has been demonstrated conclusively, that the laws of regain follow a definite line.

We herewith submit details of a test which covers an extended period of time and quite varied hygrometrical conditions of outside air, and embraces several thousand breaking tests.

This shows conclusively the fact that the strength of the fabric remains practically constant where the same percentage of regain had been maintained, irrespective of temperature, between reasonable limits.

## Average Strength—Regain $8\frac{1}{4}\%$

| | Temperature: 60-64° | 65-69° | 70-74° | 75-79° |
|---|---|---|---|---|
| 1 R X | 81-58 | 82-00 | 80-96 | 79-60 |
| 2 D X | 80-42 | 80-92 | 80-38 | 80-20 |
| 3 B R W | 66-66 | 66-41 | 67-00 | 66-60 |
| 5 H S N | 105-50 | 106-15 | 106-41 | 108-20 |
| 5 W | 73-42 | 74-30 | 75-09 | 75-20 |
| 14 S W | 112-25 | 116-55 | 116-81 | 114-00 |
| 17 N X | 63-42 | 64-36 | 63-93 | 63-60 |
| 8 Y | 177-83 | 172-33 | 177-68 | 185-60 |
| Average | 95-14 | 95-38 | 96-03 | 96-63 |
| Average without 8 Y | 83-32 | 84-38 | 84-37 | 83-91 |

**Preparations for Testing.**

The same are as follows: Use a regain scale constructed from a regular yarn balance, but in place of the pan for the samples use a wire rack on which samples similar to those to be tested are exposed. This scale is enclosed in a case made of fine woven brass wire cloth with a glass front, and can be set to indicate a regain of $8\frac{1}{4}\%$, or any other desired. The samples exposed on the rack are trimmed to an exact weight of 200 grains, in absolutely bone-dry condition. This bone-dry state is obtained by exposing them in a drying oven at a temperature of 220 deg. *F.*, for a period of five hours. The scale beam is then made to balance *zero* with this bone-dry test sample on position on the rack.

The testing room is about 10*ft.* × 20*ft.* × 16*ft.*, and is equipped with a means of supplying humidity by artificial methods, and circulating the air. There is a rack on which to expose samples to be tested, and a shelf on which the regain scales are placed. In this room are the various yarn and cloth testing machines required in our investigations.

The regain scale is exposed in the testing room at the same time as the samples to be tested. Readings are taken periodically, and when the regain shows $8\frac{1}{4}\%$, testing is begun. The humidifying apparatus is stopped or started during the continuance of the test, as may be necessary, to maintain this standard condition.

By referring to the results given in the table it will be observed that the strengths maintain a fairly constant value. The testing room is always in a livable condition, and operations can be conducted by a person without a great amount of scientific knowledge.

## To Keep Yarn Numbers Uniform.

Investigations along this line have led us to a number of features which will be of interest to our manufacturing friends, the principal one of which is a satisfactory means of keeping numbers of yarns regular throughout the mills, irrespective of changes of hygrometrical conditions. The means employed are:

First, the installation of a regain scale, on which the amount of moisture in the air, and therefore (for example) in the cotton, is determined at any time. The weight of the picker laps is regulated according to this regain scale. Should the scale indicate a large amount of moisture, the weight of the laps is increased to a point to guarantee the same amount of cotton fibre that is desired in the normal condition of the room, and *vice versâ*.

The second feature is to have a central testing room, equipped as before, located convenient to the carding and spinning departments. Roving and yarn are sized in here, after being allowed to remain a sufficient time to come to the standard condition—seldom more than one hour. Card-room numbers are kept by these sizings. It will be found that few changes of gearing, either in carding or spinning departments, are necessary where this system is employed.

It will be found by employing this procedure that in many tests thus carried on the apparent change in weight of yarns will be surprising to those who have never investigated along this line themselves.

For instance, a test one day showed a number of samples of No. 20 yarn to size 19.72, and the next day, being very bright and windy, the same samples averaged 21.02 in size, a change of nearly 7%. This is quite a large apparent change in weight, while in reality the change consisted merely in the amount of contained moisture in the yarn.

### Wear Resisting Qualities of Cloth.

It is considered by many people that there is a demand for an efficient machine for testing the wearing qualities of cloth, and a number of attempts have been made to produce one for this purpose.

A short statement of the ways in which cloth is subjected to wear may help to suggest some method of dealing with the matter.

Take first, outside clothing; this appears to be most subject to the rubbing of the cloth on another, and therefore if this could be imitated mechanically, perhaps that would meet the case.

Second, shirts and other under-clothing; washing affects the life of these kinds of cloths as much as the actual wearing, and as this entails a good deal of rubbing back and forth, a *to* and *fro* rubbing action might be employed; in addition to this there is the effect of the elbows, and the knees, and the shoulders, and to test this, one might suggest a machine with a boring action.

One of the earliest attempts to solve this problem was made by *Alcan & Tresca,* in 1858, and was intended to test the wearing qualities of felted and woolen fabrics. The cloth was placed in a frame with a rectangular opening and was subjected to the action of a flat brush, which always brushed in one direction, the brush being raised out of action for the return movement. The cloth was weighed before rubbing and was subsequently weighed after every 1,000 passages of the brush; in some cases the cloth was completely used up after 3,000 passages. The brush and the carriage weighed 26,750 *kilograms,* and the brush measured 0.185 by 0.240 *metres.*

Different types of machinery are used for ascertaining the wear resisting qualities of a cloth, namely,

(*a*) to and fro rubbing,

(*b*) boring, and

(*c*) cylinder rubbing.

### To and Fro Rubbing.

The machine used for this test is shown in Fig. 88 in its elevation; Fig. 89 showing a side view, partly in section.

The surface which acts upon the fabric is knorled steel and to this surface a parallel motion is given, the stroke being one inch and the number of complete movements 200 per minute.

In order to make the machine as efficient as possible, a large number of experiments have been made and many disappointments have been encountered. The original stroke was 2½ inches, but that was reduced, as it was found that with the longer stroke the cloth was not worn equally.

Originally the sample to be tested was stretched in the square metal frame and secured by a skeleton lid, which was pressed upwards by a weighted lever in rather a different manner than that shown in the illustration. This plan of presenting the cloth to the rubber was found to be unsatisfactory for several reasons, the principal one being that the cloth became distended and the results of the rubbing were very irregular.

The next experiment consisted of filling the square with a piece of wood so that there was a solid bed for the cloth to rest upon and thus the stretching prevented. It was then found that the cloth was only rubbed at each end and the tests took a very long time.

The result of the protracted test seemed to be because practically only one set of threads was subject to the rubbing action, namely those lying at right angles to the path of the

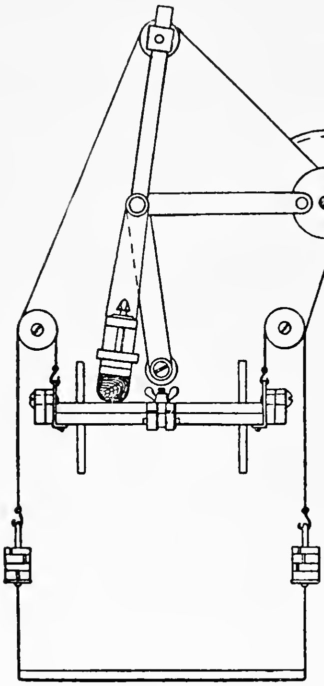


***Fig. 88***

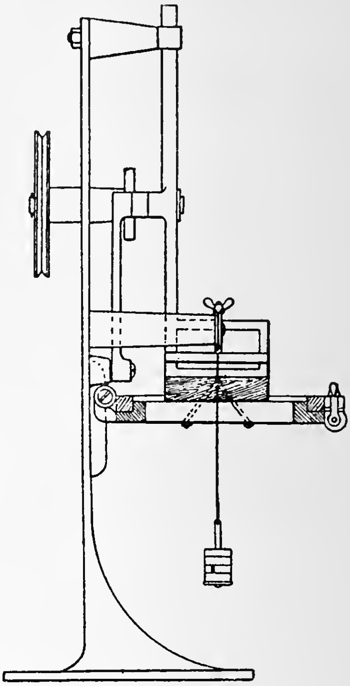


***Fig. 89***

rubber, the other threads seemed to get in between the projections of the rubber and to suffer little or no injury. At this stage of the experiments it was decided to locate distinctly the portion of the fabric which had been rubbed, and after several trials, the present plan used was adopted, consisting of a raised piece in the middle of the square of wood, which effectually causes the cloth to be rubbed and to produce a fracture within a reasonable time.

There was still the difficulty of half the threads being at right angles and the other half parallel to the movement of the rubber, and it was therefore decided to place the sample in the frame on the *cross* and which has proved very successful.

The next point was to determine when the test was complete, and two plans suggested themselves; first to rub each sample for a fixed length of time under identical conditions, and then to compare their appearances at the end of the test;

second to continue the rubbing until a hole appeared in the fabric. The first plan was discarded as it was considered that too much would be left to the judgment of the operator upon the relative conditions of the various samples at the end of the specified time.

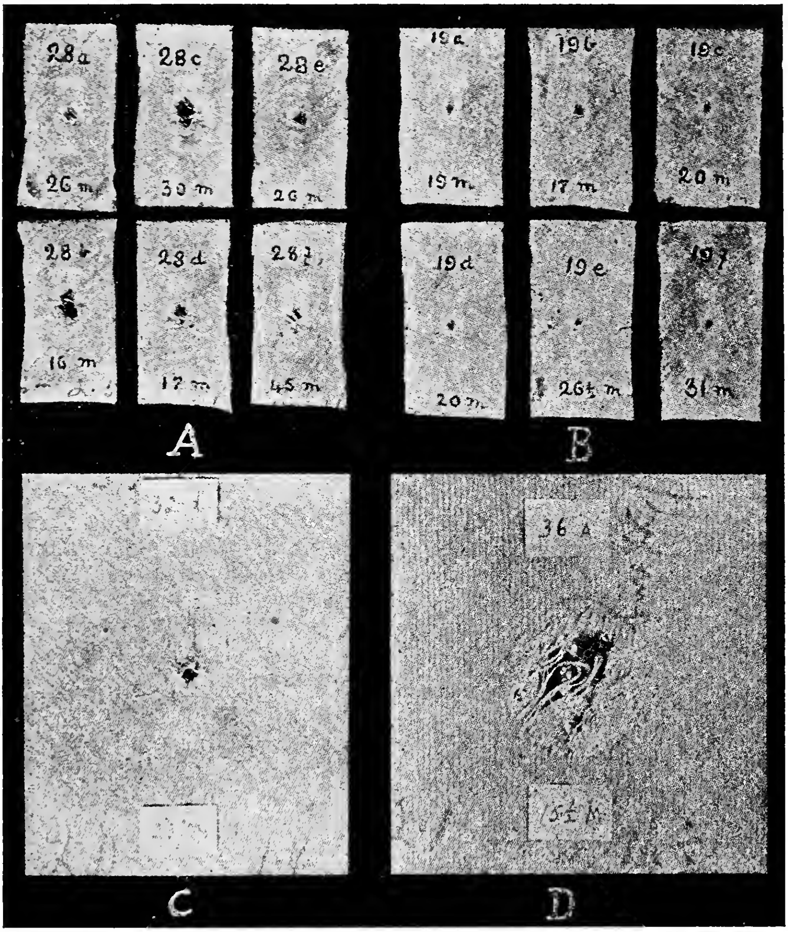



*Fig. 90*

Consequently upon the adoption of the second plan, some means had to be devised to enable the operator to state definitely when the cloth was worn through, and a piece of dark colored paper was put under the cloth before each test and as soon as the paper appeared the test was at an end, and the time occupied was recorded.

A large number of tests have been made on this machine and some of the test samples have been photographed and are shown in diagram *A* and *B* in Figure 90, to illustrate the kinds of fractures which were made in the cloth.

The time results, expressed in (*m*) minutes, of the tests are shown in figures given at the lower end of each sample and show as though this system of wear testing is one which is likely to be of service in testing the wearing qualities of cloth.

From the majority of the tests which have been made it is noticed that there is a consistent increase in the wear resistance coincident with the improvement of the quality of the cloth. The results also compare favorably with those which have been obtained from strength tests, provided the latter have been made.

**Boring Machine.**

The nature of the fractures produced by this method of wearing are shown in diagrams *C* and *D* of Fig. 90.

Fig. 91 shows in its elevation a specimen of such a boring machine tester, the end of the acting tool of which may be fluted, or serrated, or roughened in any other suitable manner, or it may be covered with cloth or any other desired substance.

The cloth to be tested is mounted in a frame, which is borne in an upward direction by means of a weighted lever. If desired, the spindle may revolve all the time in one direction, or its direction of rotation may be reversed after a fixed number of revolutions, and either the number of revolutions or the time taken to wear through the cloth may be recorded. As far as possible, the weight which presses the frame upward should only be sufficient to keep the cloth in close contact with the drill and should not exert a breaking or tearing influence on the texture.

**Cylinder Rubbing Machine.**

Fig. 92 shows a diagram of the working part of the machine. The same consists of a cylinder *A* having a knorled surface of a similar character to the other wearing devices; to this a circular motion is given in the direction of *D*, by means of the driving rope *B;* the cloth is gripped at C, and a weight is suspended below *D*.

*E* is a weighted saddle, introduced with a view to locating the influence of the wearing action. This saddle *E*, having a metallic surface, it is obvious that the knorled surface of the cylinder would be liable to some injury immediately before a cloth was worn through and to considerable damage upon the breaking of the cloth, hence it was found necessary to introduce something between the saddle and the fabric and after trying various substances, two layers of drawing paper have been used in the recorded tests and they have proved quite satisfactory. Here again, great advantage has been experienced by having the cloth cut on the *cross*, as this insures the even wearing of all the threads.

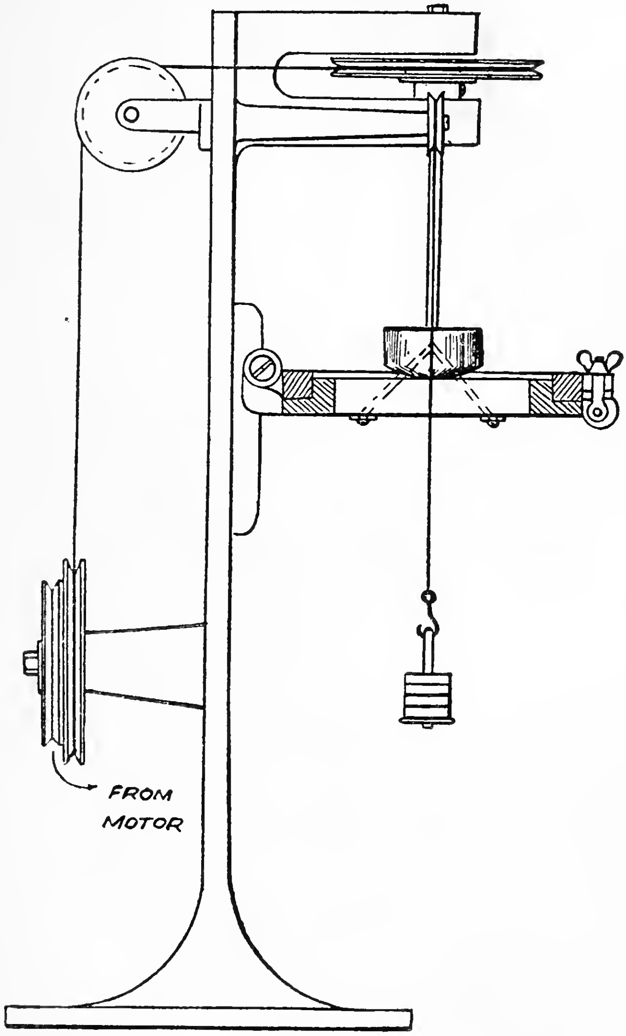



*Fig. 91*

**Moisture Absorbing and Retaining Qualities of Cloth.**

Fabrics composed of different fibres or treated in different ways have greater or less hygroscopic powers, and in making of certain types of cloth it would be well to know to what extent fabrics made in certain ways attract and retain moisture, so that if possible or desirable, alterations could be made to increase or to diminish these features.

In order to determine the hygroscopic properties of cloth, the apparatus shown at Fig. 93 is suggested. The cloth is first weighed, then subjected to steam from boiling water for a given period during which time shot is added in the lower pan to balance the amount of moisture taken up by the cloth. This is poured out and weighed and the cloth is dried until the first weight is balanced.

### Porosity of Fabrics.

It has been thought necessary by some manufacturers to test fabrics in such a manner as to determine their resistance to the passage of air. This, for example, is an important feature in aeroplane cloth, as considerable weights have to be upheld by the cloth planes.

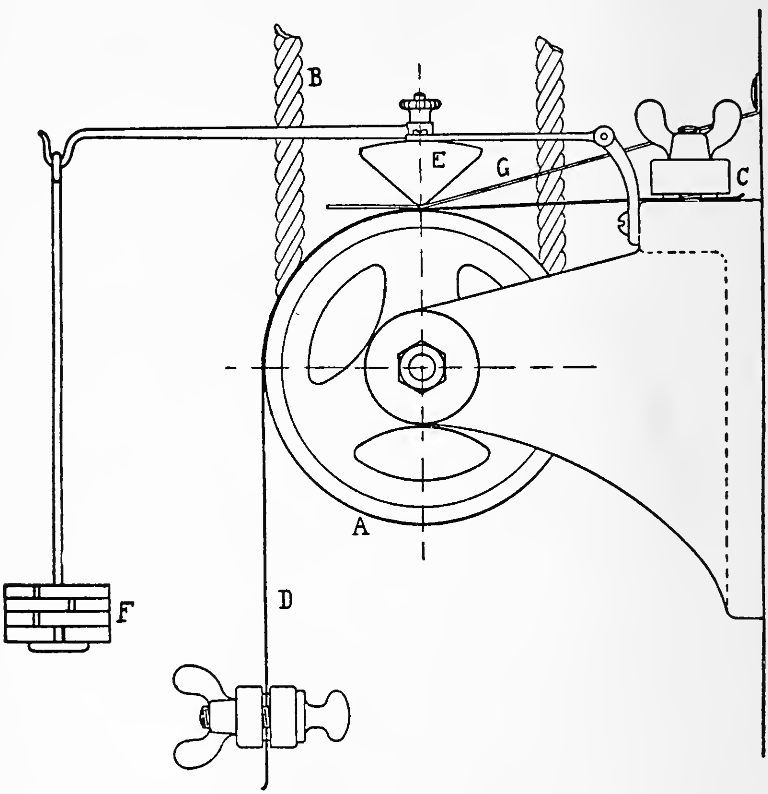



*Fig. 92*

In 1901 J. E. Kennedy patented a machine in England for testing the porosity of cloth by passing gas under pressure through the cloth and then registering the amount passed through.

Recently the Municipal School of Technology, Manchester, Eng., had an apparatus constructed to test the porosity of cer-

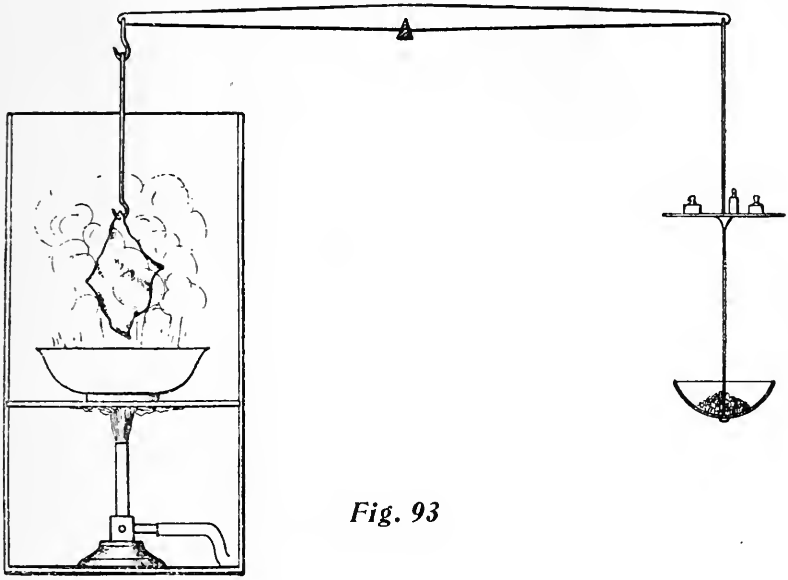


*Fig. 93*

tain fabrics. It consists of a long box, in the middle of which is a metal slide containing the fabric to be tested; the air is admitted behind the slide and as the end of the box is closed the air must pass through the cloth, and the speed at which it does so is registered by an anemometer. If the cloth is fairly close, a kind of back pressure is set up, and this is recorded along with the speed of the air passing through the fabric.

**A New Method for Testing the Durability of Cloths.**

It has been the practice to test cloths by means of the dynamometer, but the inaccuracy of this method for obtaining a measure of the qualities in actual wear has been repeatedly demonstrated. For example, after treating cloth with dilute sulphuric acid, dynamometer tests show an increased tensile strength, but on storing, such cloth becomes brittle, and the German military authorities refuse to accept cloth in an acid or alkaline condition.

The Dutch War Office tried testing cloths with a rotary scraping machine, and the Swiss War Office later adopted for a time the Hasler apparatus with scraping knives. This machine has obtained also some vogue in other quarters, but results obtained with it are very misleading.

It seemed necessary in devising an efficient method to first of all equalize the physical surface of cloths to be tested, and mechanical means were tried, *i. e.,* raising, soaking, pressing, etc., but failed.

Some time ago a machine was constructed in the Municipal School of Technology, Manchester, Eng., for the purpose of testing the wearing qualities of a number of fabrics.

The first machine consisted of a roller in which were set a number of steel blades parallel with its axis; one end of the cloth was held in clips, while the other end had a weight suspended from it. The cloth was laid over the roller, and as the latter revolved a rubbing action was set up which was continued until the cloth was worn away; the blades were quite smooth along their working edges so that the action of the blades was purely rubbing and not scratching. It was found, however, that the treatment was too rough for some of the cloths.

A new roller was put in and this was covered with several layers of the same kind of cloth which was being tested, the idea being to see the effect of cloth rubbing against cloth; the fault of this was that it took too long, unless a heavy weight was hung on the cloth, and this was considered objectionable. It may be mentioned that some of the samples were treated for 70 or 80 hours, and even then it looked as though the weight eventually broke the cloth in some cases. Several other experiments were tried but they were not satisfactory, and another method had to be tried. Two machines have been designed, one on the to and fro rubbing principle, and the other on the boring or drilling plan.

Chemical means, however, have given the desired result in a preliminary treatment with hydrochloric acid and alcohol, which remove salts and grease, giving a new even surface formation. Cloths tested in this prepared state on the scraping machine give good comparative results.

Preliminary treatment is carried out as follows:

Cuttings of cloth 23 *cm.* long (warp direction) and 32 *cm.* broad (filling direction) are treated three-quarters of an hour at 94° *C.* with 10 per cent hydrochloric acid 34° *Tw.* in a liquor 40 times the weight of the cloth. The cutting must not be folded during treatment. It is rinsed with distilled water till almost neutral, squeezed off, and extracted in a Soxhlet apparatus with 400 *cc.* alcohol 96 per cent for 1½ hours, the material being turned inside out after three-quarters of an hour. The samples are squeezed, rinsed, and squeezed again, followed by drying two hours at 65° to 70° *C.* After drying, they are kept for at least half an hour in an oven at 25° *C.* before scraping tests are made. The cuttings are divided into six strips, each 5 *cm.* broad, and these strips are stretched singly in the jaws of the machine, three being scraped on the face and three on the back. The testing is done comparatively with some standard cloth, the relative figures being given by the number of revolutions required before the cloth tears. Scraping rolers provided with engraved flutes proved best suited for the purpose, while special carborundum rollers were also used.

So far only fulled cloths come into consideration for this method of testing, and for this purpose it has proved satisfactory.

## The Importance of Testing Strength of Yarns and Fabrics.

The subject of testing the strength of materials in the textile industry is not quite a new one, as tests have been made and are applied by the Government to army and navy cloths; by city Governments for their police and fire departments' cloth, etc.

The results of tests have not always been satisfactory to those concerned on account of the errors which are liable to creep in, owing to the present methods of testing.

Under the present condition of working, the blend maker requires a large number of years of experience as well as considerable ability to be able to mentally gauge the strength of the yarn he intends to make from the mixture of material he is considering. He may have been making blends out of which some workmen would produce a thread ten per cent stronger than he himself may have produced. His own workmen may at times produce threads of exceptional strength from blends which at other times only yield threads of medium strength. There may be many reasons for such a variation in strength of the spun material which are not due to the variation in quality of the raw stock, but entirely to the skill exercised and the working condition of the machinery.

The amount a thread will stretch before it breaks is generally taken to indicate the high quality and holding power between the fibres composing the thread, while the load it will bear is considered to indicate the quality of the material of which it is composed as well as the evenness of the thread.

The diameter of a thread may seem unimportant, but it is really necessary, and it is valuable information when considered in conjunction with the counts of the yarn, for at the same time that it indicates bulkiness of the thread it to some extent indicates quality due to the manufacturing operations.

Without such measurements it would not be easy to make an absolute record of any important alteration of one of the elements of a blend, or increased or decreased foodiness of the thread due to superior skill in the manufacturing processes.

At the same time that the thread is measured it is magnified about twenty times as its lies across the glass scale by which its diameter is measured. Now the diameter of a thread depends upon five factors, *viz.;* thickness of the fibre of which it is made, the number of fibres, their axial arrangement, their natural elasticity with which they resist compression by the tension in the thread and the tension on it, the load stretching of the thread and the twist which forces the fibres together. The effect of each of these factors can be observed through the microscope.

A person with a memory for form, *i. e.*, who can remember the appearance of things, would quickly detect a change in the diameter of the thread due to the alteration of the thickness of the fibres, their number or axial arrangement, consequently he could find the cause of bulkiness of the thread, because in the first instance he would observe all the threads under the same tension, and as near as he chose under the same amount of tension. This power of analyzing threads should prove useful not only with the every-day processes of manufacture, but as providing means for tracing some of the obscure causes of faulty cloths.

The tension in a thread is a very important factor in connection with its diameter. Threads which are bulky when not under tension and draw into small threads when loaded are made of elastic material, consequently if the diameter of the thread is measured when loaded with the initial tension weight only, and again when loaded to such an extent that the thread has stretched 50 per cent of what it will stretch just before breaking, this weight when taken in conjunction with the reduction in diameter is a measure of its *natural elasticity.*

The weight efficiency is a term to indicate how much per cent of the original blend of raw material has been converted into spun thread. This form can only be found when each blend is finished. It is a very important term, because it shows to some extent the skill and attention exercised in the manufacturing operations.

This efficiency would be found by dividing the weight in pounds of the spun thread in the grease by the weight in pounds of the blend unworked in the grease. If this answer be multiplied by 100 the efficiency of the process of manufacture will be expressed as a per cent of the original weight.

The advantage accruing from testing the strength of materials has hitherto been considered only with reference to the blend maker. He is not the only man who should test to obtain information. The foremen who have the responsibility of making good threads should test to discover what effect each alteration produces, and out of such a store of information obtained find what are the best conditions for producing excellent work. No doubt many clever and skilful workmen will scout the idea of supplementing their excellent judgment by what may be termed a mechanical aid. However, to those less biased this method of obtaining information and confirming their judgment is worth the trouble required to obtain it.

What warp spinner can say, so far as his unaided judgment will permit, that he has the correct amount of twist to yield a maximum of strength at the same time that the thread yields the other qualities desired? It is not an uncommon thing for dealers in warps to order the turns per inch that are to be put into a particular class of warps, and why should they not require the warp to reach a given standard of strength?

A thoughtful and clever spinner would make it his duty to test a thread or two on starting the frame, and while the thread is in the testing machine increase or decrease the twist to ascertain what effect it has on the strength and appearance of the thread. A stock of such private notes, with the experience gained in obtaining them, should enrich the judgment, and thus enable a man to do better work. The cotton spinner is much akin to the woollen and the worsted spinner, and out of the remarks on these branches of spinning he will find what applies to himself.

The woollen mule is a beautiful piece of machinery, not entirely on account of the evolutions it will perform, but partly on account of the fine adjustment and the number of alterations that can be made in it to produce different effects. At present it is not known to what extent each alteration affects the strength and the quality of the thread, nor does the spinner know how much smaller he can draw his thread than what it is carded to in order that the best thread possible may be obtained from the carded thread. For each class of material there must be a limit to which the material can be reduced in thickness by drawing in the mule to yield the best possible thread. As to what the limit is, the spinner can find only by experiment, which would be done by testing the spun thread before and after each alteration.

It frequently happens that a blend spins badly when, if not drawn quite so much, it might spin well. The question naturally arises, how does this hard drawing affect the strength, does the increase in the strength or appearance of the thread compensate for the waste and loss in output caused by hard drawing? This question cannot be answered in a general way, because the character of the blends varies so much as well as the nature of the carded thread. However, by frequent testing before and after each alteration each spinner can find for himself what is the best course for him to adopt.

It frequently happens that in the manufacture of cloth for ready-made suits two threads are twisted together to produce one strong enough to bear the stress put upon it during the wearing of the cloth. Often it is the case that one of these threads is cotton. In the higher class of cloths, such as the West of England cloths or Scotch tweeds, this cotton thread is replaced by a silk thread, but in these cloths it is chiefly for effect in the woven fabric as well as for strength. Now rules are given in the class text-books for finding the resulting counts of two or more threads when twisted together. These rules are very good for academical work, but they are not as complete as desirable, as will be seen from a little consideration of the following rule, which is used to solve such a question as:

"To find the resulting counts of a thread produced by twisting together two threads of known counts."

*Rule:* "Multiply the counts of one thread by the counts of the other thread, and divide this product by the sum of the counts."

It will be observed that no notice whatever is taken of the amount of twist put into the threads to bind them together, nor is their relative rigidity or diameter considered. Now it must be clear to all that the greater the number of turns per inch in the thread the lower will be the counts, because there will be a greater length of yarn per inch. Again, if one thread is hard and stiff, while the other is soft, the soft thread will bend easily round the stiff one, and a greater length of the soft thread will be required than of the hard one. If the diameters are unequal and their counts the same, different lengths of each yarn will be required to produce the twist thread. The relative length of yarns in a twisted thread is an important factor when the cost of the yarn is considered, and so is the twist when the strength is considered.

There are no doubt general laws which might be applied to each of the above cases, but at present nobody knows them, because hitherto no satisfactory apparatus has existed by which they could be discovered. These general laws do not interest, and are not of such practical value to the twister of yarns as special rules are which apply to his own particular class of work. By repeated testing under different conditions and with different classes of material the twister would quickly learn the practical rules underlying his work, and thus be able to find by experiment or by a mental calculation what counts such and such material would produce or be required to yield a twist thread of given counts.

Very little has been done in the shape of research work in the spinning branch of the textile industry, although in each of the many branches of this great industry the field seems almost boundless. What progress has been made seems to come almost entirely from inventors and makers of textile machinery. This is a lamentable state of things, considering to what extent other industries have been benefited by scientific research. What little research work has been done on fibres and threads has been done by *Dr. Bowman,* and recorded in his book on the Wool Fibre.

In order that this good work may be continued under the most favorable conditions for observing effects, the machine which is shown in part in Fig. 94 has been designed. This form of machine is suitable for wool fibres and short threads. The extensions on the fibre or thread under test are magnified one hundred times and the extension on the same can be read to the thousandth part of an inch. This is done by forcing water from under the piston *A* into the pipe *B,* which is marked in inches and tenths of an inch. The weight or load is applied to the thread in the manner described above, but the vessel *C* at the end of the beam is small in diameter and long to obtain fine readings of the quantity of water it contains.

To make a test with this machine first balance the beam *D* by means of the weight *E* while the water tap *F* is closed.

Now fix the fibre in the jaws *G* and *H,* providing *H* is high enough. If it is not high enough throw the clock motor *I* out of gear and raise it by means of the hand wheel *K.* By means of the thumb screw *L* put sufficient tension on the fibre to just make the beam float. Now observe the height of the water in *B,* and begin the test by starting the clock motor *I* and opening the tap *F.* The motor depresses the piston by turning the bevel wheel, which is screwed on the inside. This depression of the piston and the head *H* causes the fibre to stretch, because the beam remains stationary, which is due to the load at one end being equal to the pull at the other or short end of the lever.

If the material stretches much, the water in *B* will quickly rise to the top of the tube; when it has done so stop the motor and draw down the water level in the tube *B* to the point *O* by means of the tap *M.* Then let the test go forward until the water level reaches the top of the tube again. Draw the water level down once more, and again proceed with the test.

When the fibre has broken, add the number of inches together that the surface of the water in *B* has fallen through, and this represents the number of one-hundredths of an inch the fibre has stretched. The amount of water required to break the thread is shown in the vessel *C* in ounces, but this amount should be multiplied by 10 to give the actual breaking load.

The microscope attachment is not shown, but it merely consists of an arrangement for making this instrument slide vertically over the length of the thread or fibre under test.

Fig. 95 shows a special attachment, and consists of a tube surrounding the thread so that the thread may be immersed in air or liquids at any temperature. *A* is a nut working on the screw *B*. This nut is surrounded by an elastic band which enables a good fit to be made between the tube *D* and the nut *A*. *E* is a tube by which air or liquid can be admitted to envelop the fibre or thread, while *F* is an exit for the liquid when one is used. To use this attachment, cause the nut and tube to slide down the screw thread so that the fibre can be fixed in the jaw standing out of the tube. Fix the other end of the fibre in the top jaw, and rotate the tube until it slides up and covers both jaws. The test may then be carried out as described before.

It is well known that the cloth purchased by the Government for the army and navy, by City Governments for their police, fire, etc., departments, railroads for their employees, etc., must reach a minimum standard of strength. This is one of the best means that can be adopted for keeping up its quality and at the same time allowing individual manufacturers liberty to obtain this strength either by a high quality of material and inferior skill, or by using superior skill and a rather low quality of material.

It is a known fact that superior skill alone in the carding and spinning department will frequently increase the value of a thread by ten per cent of its original value, and this increase in value of the thread does not represent the total gain to the manufacturer.

The buying and selling of cloth partly on the strength test, as carried out at present by the Government, or other parties previously referred to, is not always satisfactory to the parties concerned, because of the unreliability of the present methods of testing.

As an example of the want of confidence in the present method of testing the strength of cloths, the following remarks may be of interest, as they were told me by a most trustworthy manufacturer. He said: "I sent three pieces of cloth to three different public places to be tested; I expected them yielding about the same result, but found them to differ so much that none of them could be relied upon." I have myself watched an experienced experimenter obtain results by testing as inexperienced people might test cloth, which varied fifteen per cent. Such a possible variation in any testing machine renders it valueless.

The machine described is designed to prevent experimenters

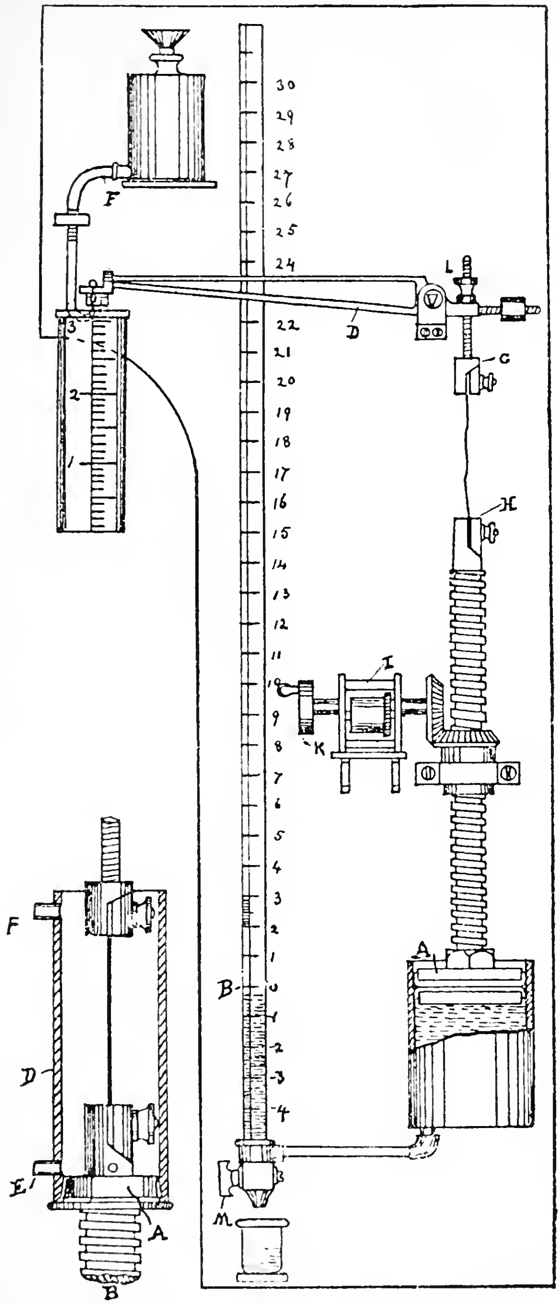

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*Fig. 95* *Fig. 94*

from obtaining other than correct results when testing the same cloth, either at the same or widely different times. As will be seen, it is a gravity and not a spring machine, consequently it is independent of a variation in temperature, and is not liable to deteriorate at the same rate as a spring machine, while friction is reduced to such a small amount that it may be said to be frictionless in the weighing mechanism. In respect to capacity it is very unlike the spring form of testing machine, as it will test with superior accuracy any textile material, whether it requires a pull of five pounds or nine hundred pounds weight to break the material under test.

By means of the Single Thread Testing Machine the following results may be obtained: The breaking strength of the thread; the stretch of the material up to breaking point; the load it will bear before it begins to draw down; the stretch it undergoes before this point is reached; the reduction in diameter due to the load applied; the twist in the thread; the general appearance and character of the thread, both before and during the test; test of quality of size on threads; the effects of various mixtures of raw material on strength of yarn produced; a comparison of yarns of the same or different counts; how the strength of yarn is affected by the twist; how the strength varies as the counts; the best amount of twist for any yarn; the effects of the moisture contained on strength, etc.; how the amount of twist affects the strength of the twisted thread; the actual counts which two threads will yield when twisted together, and the diameter and strength of the resulting thread; the actual relative amounts of yarn necessary to form any kind of twist thread.

In experiments on dyeing, bleaching, and mercerizing, the thread can be immersed in liquids at any temperature, and observations made as to the effect of the strength and temperature of solutions; the effect of twist and tension in the thread during treatment; the effects of drying at various temperatures.

### Dissection of Woolens and Worsteds.

There is probably no branch of textile work which is more dependent upon practical experience for its accurate accomplishment than that of estimating from a finished sample of woolen or worsted cloth the original counts of the yarns employed, the ends and picks per inch, as well as the width in the reed the fabric should be set in the loom. In this they differ from cotton, linen and silk fabrics, which in finishing are not subjected to such severe processes.

The difficulty which arises in connection with woolens and worsteds, more particularly the first, is due to the extreme variations which occur in different makes of cloth, *viz:*

(1) in the loss in weight when subjected to the processes of scouring and finishing;

(2) in the amount of shrinkage in width and length from the loom to the finished state.

So far as regards the counts of yarns, the above influences more or less tend to neutralize each other, for while the shrinkage of the fabric makes each thread shorter, and therefore proportionately thicker and heavier in the finished cloth than it was originally, the loss in weight makes each thread proportionately thinner and lighter. The shrinkage of the cloth affects the setting, and the number of threads per inch in the loom must necessarily vary from the number in the finished cloth, according to the degree of contraction which takes place.

It is an easy matter to count the ends and picks per inch in a sample, and to estimate the counts of a given pattern, but beyond that no rule can be employed which is applicable to all cases. It is purely a matter of observation, coupled with the preservation of records of cloths which have already been made, and then of using the experience gained in this way in estimating the weaving particulars from a finished sample by working retrogressively.

### Loss in Weight.

As a rule, the greatest loss is sustained during the scouring of the cloth, as it is in this process that the various impurities which are present in the piece are removed. These impurities consist of the oil which is added to the wool before spinning, and the sizing matter which is put on the warp; also a certain amount of dirt which has been contracted during the weaving of the cloth is removed, though this, of course, has no effect on the counts of the yarns.

The amount of each of these depends upon the character of the fabric. Thus, low woolen cloths, which are largely composed of shoddy, are usually heavy in oil, and may lose from 15 to 20 per cent and upwards during the scouring. On the other hand, yarn-dyed fabrics are free from oil, though there may be sizing matter on the warp, and, as a rule, they only lose from 2 to 5 per cent in weight. Woolen cloths of the tweed and cheviot type, made from mixture yarns, contain more oil than worsted fabrics, and frequently lose from 10 to 15 per cent in weight, while the latter lose from 5 to 10 per cent. Flannels should lose less in weight than the ordinary run of woolen cloths, as the yarns employed in their manufacture require to be fairly free from grease and dirt in order that a mild scouring agent may be employed.

A further loss in weight takes place during the processes of fulling, gigging and shearing; in each of these operations a small quantity of flock is produced, which varies in amount according to the condition of the fabric and the severity of the process. The loss is usually only a very small percentage of the weight of the piece, being greatest in faced fabrics of the doeskin and beaver type, which are heavily felted, wet gigged and slightly cut to even the pile. Clear-faced worsted fabrics, which are neither fulled nor gigged, suffer very little loss in weight after the scouring, since the flocks produced during the shearing process make no appreciable difference to the weight per yard of the piece; while the same remarks apply to fabrics of the cheviot type, which are only slightly fulled.

The difficulty of estimating the effect of the loss in weight on the counts of the yarn is made greater, owing to one series of threads being liable to suffer in the scouring and finishing to a greater degree than another. For example, in a botany worsted fabric backed with low woolen filling, the face yarns may contain no more than from 5 to 7 per cent of oil, while the low woolen backing yarn may contain double the amount. Again, (though this is of minor importance) when such weaves as satins and broken twills are employed, the raising and shearing processes will affect only that series of threads which forms the face, except when the same finish is applied to both sides of the piece.

### Shrinkage from the Loom to Grey Cloth.

In addition to estimating the length of warp and the width in the reed required to produce any given length and width of finished cloth, it is important that an accurate idea be formed of the dimensions of the cloth in the grey—(1) because the contraction of the material from the loom to the counter is variable, and (2) in order that a suitable degree of shrinkage, according to the desired result, may be allowed for in the scouring and finishing processes.

The variation in the shrinkage of the material from the loom to the grey cloth may be due to several causes. Yarns made from fine wools of the merino type are more flexible and bend more readily than those made from coarser wools. When a thick warp, coarse in the sett, is interwoven with fine filling, there is more shrinkage in width and less in length than when the warp and filling are equal in thickness, while the opposite is the case when a fine warp rankly set, is crossed with thick filling, though in neither case does this apply when the thick yarn is used solely for backing purposes. When a filling corkscrew or any weave of the filling-rib character is employed, the material contracts more in width and less in length than when a plain or ordinary twill weave is employed, while the conditions are reversed when a warp corkscrew or warp-rib weave is employed. A change in the weave frequently causes a change in the dimensions of the cloth in the grey.

For example: A piece of cloth woven with $\frac{3}{3}\frac{1}{1}$ 8-harness twill will (other things being equal) shrink less in width and more in length than if woven with a $\frac{4}{4}$ 8-harness twill, owing to the difference in the relative number of intersections in the two weaves, though, as will be shown later, this does not necessarily indicate that there will be a difference in the dimensions when finished.

As a rule, worsted fabrics shrink on an average about 7 per cent, and woolens up to 10 per cent, from the reed width to the grey width, and 5 per cent is the usual allowance for the take-up of the warp in weaving.

In warp-backed fabrics, if the backing weave be similar to the face weave, the contraction of the face and back warps during weaving is about equal; but if a loose sateen backing weave be employed, the back warp will shrink about one inch to the yard less than the face warp.

On the other hand, in a double fabric composed of a fine face yarn in a twill weave, and a thick backing yarn in plain weave, it is frequently found that the back warp contracts about one inch to the yard more than the face warp.

## Scouring and Finishing Effect on Length and Width.

The scouring process, though primarily intended for the thorough cleansing of the piece without shrinking it, always causes a certain amount of contraction to take place in woolen and worsted fabrics, the degree of shrinkage varying from about 5 to 10 per cent, according to the class of material used. Also, the method of scouring which is adopted has some influence on the shrinkage, as it is found that when goods are scoured in the rope form, they shrink rather more in width than when the operation is performed in the open width scouring machine, in which the pieces are retained at full width during the process.

The fulling or felting process is applied to woolen fabrics and to some classes of worsted goods for the purpose of shrinking the cloth in length and width, and in order to bring up the felt or fibre to the face of the cloth. The extent to which the process is carried varies according to the felting capabilities of the wool of which the cloth is composed and the desired finish, but it is always practised to give permanent solidity and strength to a fabric, while no process gives greater wearing power.

The better classes of heavily-felted woolen fabrics made from fine merino wools, such as plain broads, doeskins, beavers, meltons, the heavier kinds of army goods, etc., are almost entirely dependent upon the success of the fulling process in laying the foundation of the required finish. The shrinkage from the dimensions of the cloth in the grey varies from 10 to 25 per cent, according to requirements, and during the process a bare, thready, flimsy and unserviceable texture is transformed into a firm, compact, full fabric.

The importance of having heavily-felted textures correctly set in the loom cannot be over-estimated. If the number of threads per inch are not sufficient, the goods are liable to full too quickly, and the required width is obtained before a sufficient quantity of fibre has been brought on to the face, so that the cloth is lacking in firmness and has a soft, spongy handle. On the other hand, if there are too many threads per inch, the goods will only full with great difficulty, and will cause the cloth to have a stiff, unkind handle; while if the defect be very great, the cloth may cease to full before the required width is obtained, with the result that the threads begin to chafe and become tender. In tweeds, costume fabrics, low woolens and worsted goods, the fulling is intended to give softness rather than firmness, the shrinkage varying from 5 to 10 per cent in the fulling process. Another important point to note is that if the felting be done in the fulling machine, it is possible, within limits, to so regulate the shrinkage in length in accordance with the necessary shrinkage in width that the exact weight per yard of cloth can be obtained.

The tentering process is employed to regulate the width of the piece, in addition to removing any creases which may have been formed during scouring or fulling. Fabrics are frequently shrunk during the preceding finishing processes rather more in width than is required, in order that the tension used for restoring the piece to its proper width will remove the creases. In the same way, in the tentering process it is possible, to some degree, to remedy defects arising from setting the piece too wide or too narrow in the loom.

For example: A non-felted fabric, set 67 inches wide in the reed, can be finished to the same width as a similar fabric set 64 inches wide in the reed; but if they are both of the same length in the grey cloth, the former will be longer when finished, owing to the difference in the tension applied to the two pieces. This is the reason why some fabrics are slightly longer when finished than they are in the grey; the tension which it is necessary to apply lengthwise of the piece in order to obtain the required width restoring in part the length which the warp contracted during the weaving of the cloth. If, however, it is necessary to tension the cloth very much in width during tentering, the length of the piece will be reduced.

The raising (or brushing) process has some influence on the length and width of the piece, because the tension, being usually lengthwise on the cloth, draws the latter out in length and causes a corresponding shrinkage in width. In the process of shearing, and in winding-on for blowing with steam or for boiling, or decatizing, the tension on the piece has the same effect, though it may be only to a small extent. It can be taken as a general rule, therefore, that with the exception of the tentering, the processes between fulling and pressing tend to increase the fabric in length and to reduce it in width.

## Variations in Shrinkage of Typical Fabrics.

Worsted fabrics vary in setting from 62 to 72 inches wide in the reed, for 56 inches finished, according to the class of material employed, the structure of the cloth, and the required finish. A typical botany worsted fabric, finished with a clear face and without fulling, may be set about 65 or 66 inches in the reed; but if a slight fulling be practised (which is sometimes done in order to get increased softness of handle, and to improve the firmness and wearing quality of the cloth) it is necessary to set the same number of warp-threads 1 or 2 inches wider in the reed.

Fine Worsted Serge Fabrics are set from 63 to 65 inches in the reed for a bright, clear finish, but when the half-rough or vicuna finish (which is popular for serge fabrics, since it prevents the tendency of the cloth to glaze or shine under hard wear) is desired, the cloth should be set from 68 to 72 inches, according to the degree of fulling, *i. e.,* felting required.

In Woolen Fabrics there is far greater scope for variety of finish than in worsted fabrics, hence there is more variation in the shrinkage. Taking 56 inches as the finished width, the reed width varies from 64 to 90 inches and even wider, according to the class of material employed and the amount of felting required.

The cheviot finish (which is the simplest finish applied to woolen goods) should only slightly affect the density of the cloth, or the crispness of handle and brightness of color, which are the distinguishing features of a cheviot, are destroyed. The piece is usually set about 66 inches wide in the reed, and fulled about 7 per cent in width and length.

Woolen Cloths Finished with a Clear Face, such as buckskins, Bedford cords, warp ribs, etc., are made from hard-twisted warp to give clearness of weave effect, using a soft-spun filling of a good felting quality, to impart softness of handle to the fabric when finished. In order to admit of clear cutting, the goods are more firmly woven and more closely felted than a cheviot, being set about 68 inches wide in the reed, and felted about 10 per cent.

VENETIANS AND LIGHT COVERT COATINGS, when finished with a clear face, may be set from 64 to 66 inches wide; but if finished soft, with a draw of fibre on the face, more fulling is required, and the fabrics should be set about 2 inches wider in the reed than for a clear finish. The same widths in the reed may be employed for clear and soft Saxony finishes respectively.

MELTON CLOTH, a stout, strong overcoating fabric, is always excessively felted, and is set from 72 to 80 inches in the loom, according to quality. The same widths are applicable to doeskins, plain broads, Saxony cloakings and fancy woolen vestings, which are heavily felted and finished with a dress face. The beaver and box cloth are hard-felted fabrics, and require to be set from 80 to 82 inches in the reed; while in some of the heavier kinds of army goods, the felting is so excessive that the cloth in some instances is set 96 inches wide for 56 inches finished.

UNION FABRICS, composed of worsted warp and woolen filling, when produced in warp-faced weaves of a whip-cord character, usually require that the warp twill should appear on the face of the cloth as clear and as distinct as in a worsted; while the woolen filling, which floats on the back of the piece, should give the qualities of softness and firmness of a woolen. The felting is done entirely by means of the filling, the piece being tensioned lengthways so that the shrinkage in finishing is only in the width. The piece may be set from 68 to 72 inches wide, according to quality, for 56 inches finished.

DOUBLE-CLOTH VICUNA COATINGS composed of worsted warp and woolen filling are usually made with even sided 4-harness twill for the face weave, which, by bringing up the woolen filling, makes it possible to finish the fabric with a fibrous face. Here the shrinkage during filling is almost entirely in the width, and the fabric should be set about 70 inches wide in the reed.

FINE WORSTED-FACE FABRICS, which are backed with thick woolen filling to give softness and fulness of handle, also shrink more in width than in length, may be set from 66 to 68 inches wide in the reed, with about 5 per cent allowance for contraction of the warp.

FINE PIECE-DYED COATINGS, composed of worsted warp and cotton filling for the face, and backed with thick woolen filling, should be set about 66 inches wide in the reed, since the woolen filling permits of the piece being felted in width; but if the fabric be backed with warp, the piece should be set no more than 60 inches wide, as the cotton filling permits of very little shrinking.

Heavily-felted fabrics made with woolen filling and cotton warp should be set from 72 to 80 inches wide in the reed, according to the quality of wool which is used; but as the cotton warp does not shrink during finishing, the finished piece is usually as long or slightly longer than the grey piece. An allowance of 10 per cent or more is, however, frequently required for the contraction of the warp during weaving, owing to the thickness of the filling, which is usually employed.

**Total Size, or Sizing Matters.**

The amount of size, weighting, stiffening, or finish of cloth is determined by repeatedly boiling the sample with water, with or without the addition of substances to facilitate the solution of the starch, until a complete separation is effected. An error of some importance is sometimes made by considering *all* the matters removed by boiling water to have been added in course of manufacture. It has, however, been found that cotton loses about 2 per cent of its weight on repeated boiling with water. It follows that if this method of size abstraction be adopted, and no correction be made, that an absolutely pure cloth or yarn would be shown to contain 2 per cent of added size.

When the amount of size contained in a sample is relatively small, it is necessary to evaporate the washings to dryness and to weigh the residue, the purified cloth being only weighed (in the absolutely dry state) when the added size exceeds, say, 50 per cent. This procedure reduces the error due to the difficulty of obtaining exact results when weighing such a hygroscopic substance as absolutely dry cotton. In support of the statement that such a difficulty does exist, it may be noted that when a small quantity of absolutely dry cotton is exposed to the air, it may readily take up as much as 3 per cent of moisture in as many minutes.

The amount of fibre mechanically removed from cotton cloth during the scouring is usually very small, even raised flannelettes seldom losing more than $\frac{1}{10}$ th per cent in the process. If any doubt exists as to the complete removal of mineral matter by washing, it is well to ascertain the ash of the washed cloth, and, if necessary, to correct the result accordingly. In calculating the amounts of mineral substances present in cloth, it is necessary to subtract 1 per cent from the result found, to make due allowance for the natural ash of the cotton, the 1 per cent being calculated upon the weight of fibre present.

It is doubtful whether there are any substances extensively used in warp sizing that are not removed by boiling with water alone, but it is well to remember when soap is used in removing zinc or magnesium salts that an insoluble mass is obtained, which may, however, be easily treated by adding small quantities of hydrochloric acid. Large quantities of paraffin wax, cellulose deposits, albumen, and perhaps some other materials will require special treatment. Some methods of dyeing introduce considerable quantities of mineral matter into the cloth, rendering extraction a difficult matter, or necessitating a comparative blank test on pure cotton. This shows what allowance must be made for the action of the reagent or chemical selected to effect removal.

### Analysis of Size, Sizing Compositions, Finishes, etc.

The usual analysis of the composition of size comprises determinations of starch (flour), grease (tallow or paraffin), China clay or other minerals, zinc chloride, magnesium chloride, and moisture. Grey cloth may occasionally contain in addition one or more of the following substances: Glucose, dextrin, irish moss, glycerine, calcium sulphate, glauber's salts, epsom salts, oleine oil, common salt, soap, chloride of calcium.

The peculiar finish which distinguishes the production of some firms is not always capable of imitation when based on purely analytical grounds, owing to some peculiarity in the mechanical treatment (hot calendering, open steaming, beetling, raising, etc.) so that it is impossible in many cases for the analyst to imitate a finish from the results of his analysis alone.

As an instance may be given the well-known appearance of an "Epsom finish," the characteristic hardness of which may be almost entirely removed by what is sometimes known as "breaking down"; in this case the crystals entangled amongst the fibres are merely crushed, but this entirely alters the handle or feel of the cloth—analysis would not show any difference.

### Stained, Tendered, or Otherwise Damaged Goods.

We have no hesitation in admitting that it is sometimes impossible to state the exact cause of damage to textiles, particularly when information has to be based upon the results of analysis of a single sample. All traces of the cause of the damage are sometimes absent, while, again, the indications may be so obscure that the cost of examination would be beyond all reason.

### Mildew.

Chloride of zinc has been extensively used for the prevention of mildew, chiefly perhaps for goods that are to be shipped to warm climates. It has often been said that all sized goods sent to warm climates should contain this substance, and it is undoubtedly true so long as the additional use of chloride of magnesium, or packing in a moist state, is a necessity. Chloride of zinc has, in fact, gained so important a place as an antiseptic that there seems to be a danger of forgetting that so long as goods are packed in a sufficiently, dry state, mildew is an impossibility. Several cases have been known where unsized or bleached cloth or pure yarn has been returned from abroad in a mildewed condition, and wherever it has been possible to ascertain the amount of moisture when packed, it has been abundantly evident that the mildew has been due to an excess of such moisture; further, it has been shown that isolated packages from the same consignments have remained sound, owing to normal or deficient moisture. This is, perhaps, one of the best reasons for resisting any increase of the existing standard of moisture.

When goods are packed in bale form, it frequently happens that the mildew is more distinct towards the sides or edges than at the centre, and this has often been taken as evidence of "external damage" from water. If we consider the greater amount of pressure present at the outer parts of the bale, along with the well-known preference which mildew has for growing in enclosed air spaces, we shall see that it is easy to attach too much importance to the distribution of mildew throughout the bale. The enclosed air spaces are found at the ends or edges of pieces, at the headings of knots in bundles of yarn, alongside string used in making-up separate parcels, and these places provide the best conditions for mildew growth. Such spaces, moreover, are the very places where the mildew grows most luxuriantly when this defect has attacked the whole package to some extent.

It is almost impossible, from an examination of a damaged sample, to distinguish between rain water that has penetrated through the packing to the goods in transit, and water already contained when packed; but sea water can generally be identified with certainty. If the goods contain antiseptics, however, it may in some cases be impossible to say whether sea water is present.

The amount of chloride of zinc required to prevent mildew is stated to be 8 per cent of dry chloride, calculated upon the weight of organic matter added in sizing. This amount is accepted as a standard, and cloths are only assumed to be mildew-resisting when they contain this or a greater amount of chloride. The above does not apply when magnesium chloride is present.

In deciding upon the cause of damage, it is not enough to attribute stains to mildew merely because they have the appearance common to this growth, but it is necessary to identify the mildew by observation of the fructification and filaments seen under the microscope. Stains caused by iron or grease frequently simulate mildew to a remarkable degree. The common acidity of mildew stains has frequently been overlooked, and we have known cause and effect to be transposed through failure to grasp this.

When goods are returned mildewed from abroad, it is always advisable to have an unopened bale or case returned, so that some idea can be gathered of the amount of moisture present in the goods at the time of packing.

The use of excessive quantities of paste for fastening tickets may also be mentioned as an occasional source of the excessive moisture and consequently a cause of the mildew growth.

### Tendered Cloth or Yarn.

Difficulty frequently arises in deciding whether a sample of cloth or yarn is tender, the buyer and the seller holding entirely different views upon the particular case in point. They can seldom agree upon the definition of the word, and it is not surprising, since it admits of a comparative meaning, that both may have some grounds for their position. A broad trade meaning to the term is "below the strength common to the goods in question," but others will maintain that the meaning is "of such weakness that the buyer is entitled to reject the goods or to claim an allowance." Whatever meaning may be attached to tenderness, the only reliable ground upon which an opinion can be based or a conclusion arrived at as regards any particular instance, must be the strength test; this may be arrived at by ascertaining the breaking strain of the woven cloth, or where a comparison of tearing strain is more to the point, the separate threads of the cloth should be tested. This latter means of testing is frequently more valuable than the cloth test, because the results are directly comparable with the hand tests or rule-of-thumb tests practised by buyers.

In testing cloth or yarn supposed to have been tendered by chemical action on the fibres, it is advisable to note the elasticity or extension of the sample, these figures frequently showing large differences between sound and tender yarn or cloth. It is of course necessary to compare the strength of the suspected sample with that of a sample admittedly sound, since it would be impossible in the present state of the industry to have standards for all kinds of cloth and yarn, sized, bleached and dyed goods. This is a branch of testing requiring much further investigation, particularly so in view of the greatly-increased importance attached in recent years to the value of the test.

Cloth is frequently tendered in the singeing process previous to bleaching or dyeing. A determination of the amount of chloride of magnesium present in the grey cloth will at once show whether this substance has contributed to or caused the damage. We have known at least one case where the manufacturer was quite unaware that chloride of magnesium was present in his size-mixing until it was pointed out that one of his sizing compositions contained this substance without his knowledge. It must be mentioned that the ash of pure cotton naturally contains calcium and magnesium chlorides to a small extent. The quantities natural to cotton have been carefully ascertained, and the quantities found by analysis have, of course, to be reduced by the amounts natural to the cotton in order to find the amounts of added salts.

The tendering of bleached goods is frequently attributable to the imperfect removal of acid liquors, and it is taken for granted, so long as any mineral acid can be found in the cloth, that this is the cause of damage. It is frequently impossible to state the amount of acid found, since it is too small to be estimated by any means with which we are acquainted. By the special methods, however, it is not difficult to ascertain with certainty the presence of mere traces of acid. It frequently happens that goods have been tendered during some particular process, and that owing to a subsequent alkaline treatment or thorough washing, no acid remains; examination of the tender sample can then, of course, furnish no clue to the cause of damage. If the amount of acid left in bleached goods is small, no tenderness may be apparent for some time, but on protracted exposure to conditions of warmth and dryness the tendering may become very pronounced. Cloth has very frequently been found to be tendered when exported to warm climates, while the reference sample kept in this country has remained apparently or actually sound.

### Testing Cotton Bleached for Gun-cotton.

Cotton waste and linters are bleached thoroughly previously to nitration for the production of gun-cotton; it is of great importance that the thoroughness of the bleaching must be of a high order, making it necessary to submit the bleached cotton to careful examination before it can be allowed to pass on to be nitrated.

The amount of moisture present in the cotton is one feature requiring determination. This is ascertained by placing a sample of about 20 grms. of the bleached cotton in a large weighing bottle and drying it at 105 deg. C., for three hours, or until no further loss in weight is sustained. The loss in weight is calculated to percentage of moisture.

For the determination of the ash 2 or 3 grms. of the sample are treated in a silica dish until well charred. The flame is then removed and the dish allowed to cool, when three or four drops of pure nitric acid are added and the contents cautiously heated for a few minutes, and then strongly, until all carbon has been consumed. The dish is then cooled in a desiccator, weighed and the ash calculated.

Fats are estimated by placing about 5 grms. of the dry sample rolled in the form of a cartridge, using fat-free filter-paper, in a Knorr extractor and treating with ether for about two hours. The increase in the weight of the flask equals the amount of oil and grease. The flask containing the extracted matter should be dried at 105 deg. C., to remove the last traces of ether. Care should be observed that no cotton fibres are carried over mechanically, otherwise the results obtained would be erroneous.

The presence of acid is determined at the bleaching stage by testing the wash-water after the operation of souring. Two test-tubes are used, one containing a portion of the wash-water and the other distilled water. One drop of methyl orange is added to each test-tube and comparison made. When the wash-liquor matches the standard it is concluded that all acid has been removed, and that washing is complete.

At the bleaching stage tests must also be made for the detection of free chlorine. For this test a portion of the wash-water is placed in a test-tube, a few drops of acetic acid added, followed by a small amount of a solution of potassium iodide and starch. The production of a blue color indicates the presence of chlorine.

As cellulose is insoluble in alkalies, whereas hydro-cellulose and oxycellulose are soluble, these characteristics afford a means of determining the presence or absence of the two forms of modified cellulose. A solution of caustic potash, 10 per cent, accurately checked against standard acid, is employed for the purpose. About 2 grms. of the cotton previously dried are placed in a beaker of about 250 c.c. capacity, and covered with 100 c.c. of the 10 per cent solution of caustic potash; the beaker is covered over with a watch-glass, and the contents heated at 100 deg. C. for three hours, during which time the cotton must be kept completely submerged in the solution. Any loss of liquor by evaporation during the period of heating must be compensated for by the addition of distilled water. After heating the required length of time, the contents of the beaker are poured into a litre of water in a larger vessel, any residue being washed from the small beaker to the larger. The alkali is then neutralized by an excess of acetic acid; any undissolved cotton is then filtered into a weighed Gooch crucible and washed successively with hot water, alcohol and ether, and dried at 105 deg. C. to a constant weight.

## Water Tests.

One of the strong points in textile manufacturing as well as "Testing Yarns and Fabrics," etc., is the use of a soft water and which must be "Zero," in order to make reliable tests.

The following data comprises simple methods of testing water for the presence of iron, lime, magnesia, sulphates, ammonia, nitrates and organic matter. For the process, take a porcelain dish and not a glass one, because glass is attacked by boiling water—more so than porcelain.

Boil 2,000 grms. of carefully-collected water in the porcelain dish down to one-half. This generally produces a precipitate containing those constituents of water which are only kept in solution through the agency of free carbonic acid, as carbonate of lime, carbonate of magnesia and sesquioxide of iron; pass the fluid through a filter perfectly clean and free from any trace of iron or lime, wash the precipitate well after removing the filtrate, then examine both thus:

Dissolve the precipitate on the filter in the least quantity of dilute hydrochloric acid (effervescence shows carbonic acid); treat separate portions as follows:

(*a*) Add sulphocyanide or ferrocyanide of potassium to test for iron; if iron is present, a red or blue color respectively is formed.

(*b*) Take another portion, boil with ammonia, filter if there is any cloudiness or precipitate, mix the filtrate with oxalate of ammonia in excess and keep it for some time in a warm place; a white precipitate indicates lime as carbonate, sulphate, chloride or some other combination. Filter off any precipitate and mix the filtrate again with ammonia, and add some phosphate of soda, stir well and allow to stand for half-a-day; a white crystalline precipitate, which may often be visible only on the side of the glass when the fluid is poured out, indicates magnesia.

(*c*) Add some chloride of barium to another portion of water and allow to stand for some time, say 10 to 17 hours; a white precipitate indicates that sulphates are present.

Examine the filtrate:

(*a*) Mix a portion with a little hydrochloric acid and chloride of barium; a white precipitate indicates sulphates.

(*b*) Mix a portion with nitric acid and add nitrate of silver; a white precipitate or turbidity indicates chlorine.

(*c*) Evaporate a fairly large quantity of the filtrate to concentration point, and add a little brucia dissolved in concentrated sulphuric acid; then the solution immediately acquires a magnificent red color, indicating nitrates. This is a very delicate test.

(*d*) Acidify a large portion of the water after filtering (to remove suspended matter) with hydrochloric acid and evaporate nearly to dryness; add hydrate of lime thoroughly mixed in a mortar; then if ammonia is present it betrays its presence by its characteristic odor, and if a glass rod dipped in hydrochloric acid is brought in contact with the solution, white fumes appear.

(*e*) Organic matter is detected by the blackening which occurs when a portion of the water is evaporated to dryness and gently ignited. The precipitate which is formed is at first white, then darkens, and, when the organic matter is driven off, returns to a light color again.

### Quick Tests.

The following are some rapid tests for pure water.

Water should show no change on the addition of sulphide of ammonia; if it does, it shows the presence of heavy metals, such as copper, iron or lead.

If carbonic acid is present, baryta water turns it turbid; add oxalate of ammonia, and if lime is present the water becomes cloudy.

If chloride of barium and hydrochloric acid are added to the water, the latter becomes turbid if sulphates are present. Nitrate of silver and nitric acid show chlorides present if the water shows white cloudiness, and chloride of mercury and carbonate of soda indicate ammonia.

## Testing Soaps for Textile Purposes.

Several points have to be considered in testing soaps intended for use in fulling woolen goods. The soap should first be subjected to an ordinary chemical analysis. In this it is necessary to determine the amount of water in the soap, the amount of free alkali and unsaponified fat, if any, and also the quantity of any adulteration or filling, such as rosin, water-glass, etc., that may be present.

After this, if the first investigation has turned out satisfactory, the spinning test should be applied. This will show whether the soap is capable of forming a paste having the necessary toughness for fulling, *i. e.,* felting purposes.

Ten grammes of the soap are cut into very thin shavings and dissolved over the water bath in 100 c. c. of water in a beaker. The beaker is then stood in cold water and the solution, which must be quite free from solid particles, is stirred with a thermometer until it will draw out into threads. The temperature probably depends upon the fusion points of the fatty acids of the soap, but it is independent of the amount of water in it. Nevertheless, the spinning temperature decreases much faster than the melting points of the fatty acids. A tallow grain soap, the fatty acids of which melted at 43.5° C., spun at 43°; while a Marseilles soap, with fatty acids melting at 26°, would not spin till the temperature was as low as 4°, so that it was useless for fulling purposes.

As regards the use of soaps in textile industries, the branch which requires the best soap is silk dyeing. Here free alkali, whether caustic or carbonated, and also saponified fat, are all inadmissible.

The wool trade also requires soap perfectly free from alkali or alkaline salts, except in the production of inferior qualities of goods. A good fulling soap must be free from excess either of fat or alkali, must have a great detergent power, and must assist the felting during the fulling process.

One of the worst impurities of a fulling soap is water-glass. It has a mechanically-abrading action on the wool, as well as a corrosive effect on it. If there is much of it, it often coats the fibre and gives the fulled cloth a very bad feel.

Both hard and soft soaps are used for fulling. The best fats to use in their manufacture are tallow, and palm oil. Rosin is a very harmful filling in a fulling soap, and, in short, the standard to be aimed at is a soap consisting solely of pure fatty acid salts of soda or potash. It need hardly be said that a washing powder, or even a powder professing to be pure soap in a ground state, should never be used for fulling purposes.

## Dye Testing.

The fastness of dyestuffs is always comparative. Unfortunately no standards for comparisons have been devised, and published statements of dye stuff manufactures varying greatly. Personal opinion also differs to a great extent in this matter of fastness, and tests are made often necessarily under widely different conditions.

In most cases when *fastness* of a product is in question, it is best for those interested to make tests in a small way themselves before arriving at any definite conclusions regarding the properties of fastness, and such tests are satisfactory only when they are carefully made to approximate closely the conditions of actual practice.

Most important are the fastness to light, washing and fulling. Goods are often washed with soap and soda, and the fastness to alkali must be known. Fastness to acids is also frequently required for cotton warps intended for cross dyeing and for woolen goods to be carbonized after dyeing. Materials to be worn next the skin should be dyed with color not affected by the organic acids contained in the perspiration. Fastness to stoving (that is, the action of sulphurous acid) and fastness to chlorine are sometimes required where piece goods are bleached after dyeing. Wool blankets and cotton towelling with colored stripes or borders are often bleached in this manner. When goods have to be steamed, as in calico printing, or hot-pressed in finishing, care must be taken to obtain colors that are not stripped or do not change their shade in these operations.

The method of estimating the fastness of a product is obvious, and consists in putting a properly dyed sample through the operations it must withstand. It is not necessary to make a large dyeing in order to obtain samples to experiment upon. A 10 *grm.* skein can be dyed by any prescribed method, and except in the case of fastness to perspiration can be given the necessary test. It is often required that in washing a color shall not bleed on to white cotton or wool.

Whenever several tests are to be made comparatively, it is necessary that they be made under the same conditions. For example, suppose several colors were to be tested for their fastness to washing and bleeding into white cotton, the same amount of the dyed sample would be taken in each case; a convenient amount would be, say, fifty strands 18 inches long. These would be braided with twenty strands white cotton and twenty strands wool. For each test the same amount of soap solution would be used, and the washing carried out at the same temperature. The washing operation would thus have been carried out under the same conditions for all the samples, and the results would be comparative.

Generally, the "light" test is made under glass exposed to the direct rays of the sun, so as to get the greatest possible proportion of the direct rays, and thus the maximum effect in the shortest time. Sometimes it is best to let the dyeing stand not only the light, but also the weather; this latter test is better when the finished product must stand similar conditions, as for awnings, etc. When a light test is made, one part of the dyeing should be protected, so that any change taking place can be easily seen and compared with the original dyeing.

A good way for testing dyeing on yarn for exposure to light is to wind the yarn on heavy cardboard about 4 inches wide, covering about 1 inch. Several dyeings can thus be wrapped side by side. One-half of the dyeing is then covered with a piece of black paper, and over this a strip of heavy oiled paper is placed, large enough to turn under, and be firmly fastened with small brass fasteners. The length of the exposure depends of course on the requirements, and varies from a few days to several months.

To get a general idea of the fastness of a dyestuff, the following tests should be made:

Fastness to Light: Samples prepared (as before explained) should be exposed one to six weeks in summer and nearly twice as long in winter (under glass) to the direct rays of the sun, or (if required) to the combined action of light and weather.

Fastness to Washing: The dyed yarn should be braided with undyed cotton and wool and washed with a solution of soap, using for 5 grms. goods, 200 *cc.* of a 5 per cent soap solution.

Fastness to Alkali: 5 grms. of the dyed yarn, together with 1 *grm.* skeins of undyed wool and cotton, should be treated for one hour at 70° *C.,* with 200 *cc.* 5 per cent soda solution, or with 200 *cc.* of a 5 per cent solution of equal parts soap and soda.

Fastness to Acids: 5 *grms.* of the dyed yarn, together with 1 *grm.* skeins of undyed wool and cotton, should be boiled for one hour with 4 per cent sulphuric acid and 10 per cent Glauber's salt, calculated on the weight of the goods; that is for 5 *grms.* goods, 2½ *cc.* sulphuric acid 1 : 10 and 5 *cc.* Glauber's salt 1 : 10, and water up to 200 *cc.*

Fastness to Chlorine: Samples should be immersed in a solution of chloride of lime 2° *Tw.* for from one-half to twenty-four hours. The number of colors that can stand twenty-four hours is limited.

Fastness to Stoving: The dyed sample is moistened and subjected to the action of the fumes from burning sulphur for from one to twenty-four hours. The number of colors that will stand stoving is very much greater than for chloring.

Fastness to Fulling: There are few colors that will stand a severe fulling, while a great many products will withstand a light fulling, and are sufficiently fast for many purposes. As a rule colors that will withstand an ordinary flannel fulling are considered to be fast to fulling.

Fastness to Perspiration: The fastness to perspiration must be determined by a practical test — that is, by actually wearing the dyed material in question.

Level Dyeing Properties: It is often desirable to test the levelling power of a dyestuff, and this may be determined by practical tests to determine the amount of turning or agitating necessary to produce level results. The selection of the proper amounts of assistants and the temperature at which the dyeing is conducted are also important factors.

It is frequently necessary to duplicate the results given by one color with mixtures of other colors of the same class. Matching one dyestuff with mixtures of others is an art only acquired after a large amount of experience. Often an exact match is an impossibility, but generally a very close approximation is possible. Colors are best matched in a small way, making series of comparative dyeings, a number of appropriate mixtures being dyed under identical conditions with two strengths of the standard.

It is always good practice to dye two strengths of a standard, as it makes possible a greater number of comparisons with fewer dyeings. In attempting to prepare a match it is often well to make a large series of combinations. The number of possible combinations and possibilities are infinite. The art of matching colors can be learned by experience only, and requires a broad knowledge of dyestuffs and their application.

Cotton and wool, both mordanted and unmordanted, should be dyed under various conditions. Systematic trials should be made as follows: In each of five dye-pots 50 *cc.* of a solution of the color 1:500 and 200 *cc.* water are placed. If a solution of the product is difficult to obtain, a small amount of the dye is heated in a test tube with hydrochloric acid and the escaping fumes tested with filter paper moistened with lead acetate. If a dark coloration is formed, the product is a sulphur dye.

In the five dye-pots the following tests are applied: In No. 1 unmordanted cotton is dyed with 30 per cent Glauber's salt; No. 2, unmordanted wool with the solution neutral; No. 3, unmordanted wool with 4 per cent $H_2SO_4$ and 10 per cent Glauber's salt; No. 4, mordanted cotton (tannin and tartar emetic), having the solution neutral; No. 5, wool mordanted with bichromate of potash and tartar. After slowly heating to boiling and allowing to cool, the dyeings are taken out and thoroughly washed. The result will probably indicate at once to what class the color belongs.

As has been already stated, most dyestuffs are diluted with salt, Glauber's salt, or dextrine. If dextrine has been used, it is easily detected by the characteristic odor on dissolving in hot water. It is best detected when mixed in the dry state, as is usually the case, by means of the microscope.

Glauber's salt or sulphates may usually be detected by adding hydrochloric acid and barium chloride to a dilute solution of the dye. When the color of the solution obscures the reaction, the dye may be precipitated or salted out by saturating the solution with pure salt and the sulphate detected in the filtrate by adding hydrochloric acid and barium chloride.

Chlorides can usually be detected by simply adding nitric acid and silver nitrate to a dilute solution of the dye. The coloring matter can also be extracted with alcohol, leaving the salt undissolved in the residue, which is then tested for chloride in the usual manner with nitric acid and silver nitrate.

By far the larger proportion of dyes found in commerce, sold under various names, consist of mixtures of straight colors. A manufacturer may make but twenty straight colors, yet place hundreds of different mixtures on the market. When, as is most frequently the case, dyes have been mixed in the powdered state, they can be recognized by blowing gently a little of the powdered dye upon a large piece of filter paper that has been moistened with water, or if the dye be insoluble, with alcohol or some suitable solvent. Each particle as it dissolves forms a little streak of color, and if more than one coloring matter is present, each can be readily detected.

Another good method is to blow the powder over the surface of concentrated sulphuric acid contained in a white porcelain dish. The particles of dye are dissolved and give their color reaction with the sulphuric acid, and in this manner mixtures of dyes of the same shades in their water solution can be recognized.

Sometimes mixtures are made by dissolving two or more dyes together and reprecipitating them; in this case the before mentioned methods are not reliable. As most colors do not exhaust exactly the same, such mixtures can usually be detected by dyeing three or four successive samples from the same bath of the color in question, either by the difference in shade of the first and last trial, or the differences in the color reactions of the dye on the fibre will reveal the fact of its being a mixture.

Dyestuffs are recognized both on the fibre and in the coloring matters themselves by means of characteristic reactions or colorations that are given when they are treated with various reagents. In practice, however, shades are more frequently obtained by combinations of two or more coloring matters which often render detection extremely difficult, if not impossible. Many tables of reactions have been published, but the difficulties encountered in describing such reactions are great, and the number of products is getting to be so numerous that the practical dyer does not inquire further than the practical results to be obtained from a dyestuff or the properties possessed by a given dyeing. A man who is constantly testing dyestuffs, can in time recognize products with comparative facility, and when one coloring matter only has been applied to a fabric, can often tell what that coloring matter is.

## Microscopic Examination of Textile Fibres.

Testing materials by microscopic examination is a most valuable and reliable method, especially when the mechanical structure of the fibre has not been altered, during the processes of manufacture, as is usually the case in woven fabrics.

When fibres are placed under the microscope and examined, especially with transmitted light, and with powers varying from 20 up to 200 diameters, their appearance and distinctions will be clearly visible and may be compared with the well-known structures of:

**Wool.**—This fibre is easily distinguished, being practically always of a more or less cylindrical form. It is covered with rings or scales, with fine, smooth, or imbricated edges, which point from root to tip of the fibre. These scales differ much in form, regularity, and in size. There are also indications of a curl or curvature in the fibre. These peculiarities are always distinctive and enable wool to be at once differentiated from silk and other fibres.

**Hair** differs in appearance from wool inasmuch as though it is usually covered with similar scales on the surface of the fibre, these scales are always more closely adherent to the shaft of the fibre and the edges are not turned outwards. Mohair, Alpaca, Vicuna, Llama, Cashmere and other hairs all closely resemble each other in this respect.

**Mohair:**—Is obtained in Turkey from the Angora goat. It is very stiff, long, silky, lustrous, and almost pure white in color.

DIAMETER: 0.025 *mm.* (0.0010 inch).

LENGTHS 10 to 25 *cm.* (5 to 10 inches).

MICROSCOPE: The scales can be observed only with high magnifying powers, if at all. They are regular and encircle the whole hair. In most cases the pith is absent, although it is sometimes seen in the form of a canal occupying more than half of the diameter.

Less important goat hairs are obtained from the Alpaca, Vicuna and Llama of South America, and from the Cashmere and the Thibet Goats of China and India.

The term **Alpaca** is frequently applied in a general sense to all South American goat hairs. The common varieties are brown and black.

**Cashmere** is used in the manufacture of the famous *Cashmere Shawls.* The commercial varieties are gray and white.

**Camel hair** is obtained from Russia, Syria, and China. It is fine, crimpy, and soft (wool hair); or coarse, straight and stiff (beard hair). It is used, among other things, in the manufacture of the *Jaeger Normal Fabrics.*

DIAMETER: 0.015 to 0.075 *mm.*

LENGTH: 5 to 10 *cm.*

**Cow Hair:** It is short and irregular in diameter; black, white, or red in color. Under the microscope the hair-root can frequently be observed, as the fibre is obtained from the tanneries as PULLED HAIR. Coarse beard hairs, fine beard hairs and wool hairs may be distinguished. This fibre is used to a large extent in the carpet industry.

DIAMETER: 0.080 to 0.180 *mm.*

LENGTH: 1.5 to 5 *cm.*

**Horse hair** is used in the manufacture of *haircloth* linings and *upholstery* fabrics. That obtained from the tail is about 65 *cm.* and that from the mane about 45 *cm.* in length. PULLED HORSE HAIR is approximately 3 *cm.* in length.

DIAMETER: 0.090 to 0.250 *mm.*

The hairs from the dog, cat, rabbit and squirrel are also used to a limited extent in the textile and related industries (in the manufacture of hats, etc.).

In true hair the scales are firmly attached to the cortical fibrous substance throughout the greater part of their length, and only reveal themselves under the microscope as fine irregular transverse lines on the surface, and by notches at the edge of the hair. The internal arrangement of the cells of the fibrous substance shows a fairly distinct medullary axis. The shaft, or medulla, is usually firm and straight, and the scales are horny and dense. In wood fibre the scales are attached much less firmly, and their free margin is more prominent, being frequently notched in a more or less irregular manner. The serrations are distinct and the scales translucent.

**Cotton:** Under the microscope, cotton as a seed hair appears as a single long cell, covered with a thin membrane — the cuticle, which is not altered by concentrated sulphuric acid. The lumen or inner canal contains air, or as is sometimes the case the fibre appears as a band pressed firmly together, so that the lumen disappears from view. The fibre in all cases appears as a broad band which has been twisted around its axis many times.

**Mercerized Cotton.** Mercerized cotton appears like silk to the naked eye, yet microscopic examination of the fibres determines the matter in case of doubt. When the yarn or cloth has been fully mercerized, the cotton fibre is fuller and almost void of the surface markings or twists which characterize ordinary cotton.

TEST FOR MERCERIZED COTTON.

A solution of iodine in saturated potassium iodide solution, colors both ordinary and mercerized cotton a deep brown.

On washing with water mercerized cotton changes to a blue black, which fades very slowly on long washing, whereas ordinary cotton rapidly becomes white on washing.

**Silk.** The cultivated silk fibre derived from mulberry silkworm has the appearance of a double strand of a clear, semi-transparent, lustrous, continuous fibre. Wild silks always exhibit a fibre which is much flatter and irregular, and is usually more striated on the surface in the direction of length. It is also larger in diameter than cultivated silks.

**Cultivated Silk:** Raw silk is rather dull in appearance, due to the covering of sericin which is always to be found surrounding the fibre. It might be added that this encrusting matter increases the strength of the fibre considerably. Most of the silk obtained from Japan, China, Italy and France is of a *silvery white* appearance, but there is also a large amount of the *yellow* silk produced in Italy and China. The golden yellow coloring matter is contained in the gum and may be removed by boiling-off. Under the microscope the silk fibre appears white, or yellowish white and lustrous. The thread is seen to consist of two distinct fibrils, between which is the sericin. The average diameter is 0.018 *mm.*

**Wild Silk:** The raw silk varies in color from light buff to dark brown. This coloring matter is distributed through the fibre, while in the case of cultivated silk the color is contained in the gum and may therefore be removed by boiling-off. In the case of tussah silk the fibre must be thoroughly boiled off and then bleached with sodium peroxide. Owing to its large diameter (0.050 *mm.*) wild silk is much stronger than the cultivated variety. Under the microscope the fibre is seen to be very broad, while the cross-section appears wedge shaped. (Distinction from cultivated silk.) Longitudinal striations running obliquely across the fibre are plainly visible. Irregularly occurring coarser striations due to bundles of circular threads may also be noticed. The sericin cannot readily be distinguished from the fibroin. The narrow side of the fibre appears dark gray with pink or light green spots, while the broad side is irregular in thickness, the thinner parts appearing bluish white or light brown.

**Silk Tests:** Silk may be distinguished from vegetable fibres by burning the fibres, when it emits a smell of burnt horn. Wool gives a similar odor. When submitted to the action of nitric acid, the fibre is turned yellow. Silk is dissolved by strong alkalies. Dilute alkalies affect it, but without solution; ammonia has no action on the silk fibre. Schweitzer's solution dissolves the silk fibre just as it does cotton. Silk, like wool, has an affinity for tinctorial dyes. A solution of zinc chloride of 1.7 specific gravity dissolves silk, but has no action on wool. The silk is reprecipitated on adding water.

When flax, hemp, cotton and jute are mixed with wool and silk, the sample may then be boiled in an aqueous solution containing 10 per cent of hydrate of soda; the wool and silk dissolve, while the vegetable fibres remain unacted upon. The whole is thrown upon a cotton filter, and the undissolved matter is then 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 centimetres 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 centimetres square may be boiled in 10 to 12 cubic centimetres 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.

**Artificial Silks.** Viscose, imitation horse hair, etc. The artificial silk fibre under the microscope is very similar to silk. Chemically, silk and artificial silk are very different, which is better disclosed by a burning or chemical test than by microscopic means.

**Flax, Hemp and Jute.** These fibres have a general similar appearance, consisting of a series of cells united together longitudinally and in the case of flax and hemp usually thickened at the point of juncture with a node or ring, which adds strength and rigidity to the fibre. In the case of jute, the nodes are generally absent, although the point of juncture of the multiple cells is very apparent.

**Flax** (Linum usitatissimum): Of the numerous tests which have been repeatedly recommended for distinguishing between flax and cotton only a few are worthy of mention.

FRANKENHEIM'S TEST (applicable only to bleached fibres containing no sizing). If the dry fibres be immersed in olive oil and then pressed between blotting paper, cotton remains opaque while linen becomes transparent.

KINDT'S TEST. First remove the size from the sample by boiling and rubbing in distilled water. Then dry and place for about one-half minute in concentrated sulphuric acid.

Wash well, place in dilute ammonia water and then dry. By this treatment the cotton is turned into a gelatinous mass and may be removed by washing and rubbing. The success of this test is dependent on the complete removal of the size and upon the time of immersion in the acid.

SCHWEITZER'S SOLUTION causes flax to swell up strongly; the fibre does not, however, dissolve completely.

MICROSCOPE: Under the microscope the fibre appears regular with a lumen which is in some cases not wider than a line. The end is pointed. The characteristics of the fibre are the dislocations or nodes which occur at rather regular intervals. These sometimes take the form of pronounced lines extending across the fibre at an angle of from 60 to 90 degrees. There is *no* cuticle.

DIAMETER: 0.05 *mm.* to 0.20 *mm.*

LENGTH: 20 to 100 *cm.* This of itself often serves to distinguish the fibre from cotton, the maximum length of which is 5 *cm.*

COLOR: Yellowish white to gray, but it may be bleached a pure white with potassium permanganate, chloride of lime, or by the *grass bleach.* The bleached fibre is lustrous and can often be mistaken for silk at a rough glance.

**Hemp** (*Cannabis sativa*): SCHWEITZER'S REAGENT swells the fibre irregularly and finally dissolves it, leaving only the parenchymous tissue.

MICROSCOPE: The forked ends of this fibre serve to distinguish it from flax. The cells are irregular in shape, at times flat, and then again cylindrical. The inner canal is generally broad, diminishing in width toward the end of the fibre. The cell walls are much less regular than in the case of flax. The forked ends of the fibre terminate abruptly (dist. from flax), the walls are thick and no nodes are visible. The cross-sections have round edges which are colored yellow by iodine and sulphuric acid; they are devoid of contents.

LENGTH: 15 to 25 *mm.* COLOR: light buff.

DIAMETER: 0.016 to 0.025 *mm.* LUSTRE: not pronounced.

**Jute** under the microscope, the cells possess a peculiar appearance due to irregular thickening of the cell walls. The interior (lumen) appears at some places quite large and at others not wider than single line. Not all commercial samples show this variation, however. The cell wall appears sharply defined by the lumen, the latter at times exceeding the cell wall in width. The varying thickness of the walls is probably the main reason for the small tensile strength of the fibre.

LENGTH: Maximum = 3.5 *m.* COLOR: pale yellow to brown.
DIAMETER: 0.010 to 0.030 *mm.* LUSTRE: silky.

**Ramie** (*Boehmeria Tenacissima*): Microscope: The interior canal occupies about two-thirds of the whole diameter. Very often lines may be noticed extending through the individual cells and a granular protoplasm is seen. The cell walls are regularly thickened so that the lumen is usually uniform. The extremes have thick-walled, round ends and striated lumen. Length: 5 to 100 *cm.* Diameter: 0.25 to 0.110 *mm.* (characteristic). The purified fibre is quite white, lustrous, generally tubular in form, with bast cells about 8 centimetres in length. The fibre is less elastic than wool, less flexible than cotton and more lustrous than flax.

### 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 deg. *C.* 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 centimetres 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.

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## Specimen Page of "Technology of Textile Design."
(Reduced in Size)



The cuts in the fabric are shown at the places indicated by *e* and *f*. Letter *S* indicates the place where the first warp-thread and the first pick meet—the point for commencing to "pick-out."

After the sample is prepared according to the illustration just given, raise the first pick about $\frac{1}{16}$ of an inch with the "picking-out needle." See Fig. 1010.

Place the sample in the left hand as shown in diagram 1011, next ascertain the arrangement of interlacing pick number 1, warp-ways, until repeat is obtained.

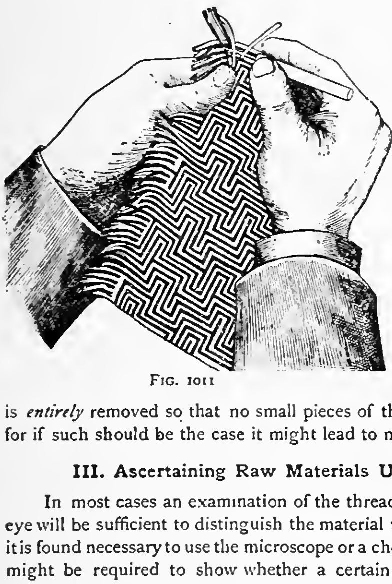

Fig. 1011

Every time a warp-thread is found situated above the filling, put a corresponding indication on the respective square of the designing paper (with pencil marks or prick holes with the needle), whenever you find the filling covering (floating over) one, two or more successive warp-threads, leave correspondingly one, two or more successive squares empty in the lateral line of small squares upon the designing paper.

After the intersecting of number 1 pick has been clearly ascertained liberate this pick out of the fringed warp edge and duplicate the procedure with pick number 2, to be followed by picks 3, 4, 5, etc., until the repeat is obtained. If dealing with a soft-spun filling yarn be careful in raising it, to avoid breaking the thread; also be careful that after the interlacing of the pick has been ascertained, it is *entirely* removed so that no small pieces of the thread remain in the fringed part of the warp; for if such should be the case it might lead to mistakes in examining the next adjoining pick.

### III. Ascertaining Raw Materials Used in the Construction of a Fabric.

In most cases an examination of the threads liberated during "picking-out" with the naked eye will be sufficient to distinguish the material used in the construction of the fabric yet sometimes it is found necessary to use the microscope or a chemical test for their detection. For example: Tests might be required to show whether a certain thread is all wool or whether a certain thread is all silk, etc. For solving such questions, the following methods are given:

A common and ready method for ascertaining the difference between animal and vegetable fibres is to burn some of the threads of yarn in a flame. The vegetable fibre is composed of carbon, hydrogen and oxygen, while the animal fibre, in addition to these, contains nitrogen. By burning, the threads used in testing the first mentioned fibre will result in carbonic acid and water, while those of the latter, or of animal fibre, result in combinations containing nitrogen which element readily makes itself known by its peculiar smell or disagreeable odor similar to burnt feathers. Another point which it is well to note is the rapidity with which the thread composed of vegetable origin burns as compared with the burning of the thread having an animal substance for its basis. In the latter case, only a little bunch of porous carbon forms itself at the end submitted to the flame, and it does not form a flame as in the case of the former. As in some instances these two tests will be found unreliable, a more exact analysis may be required. If so, proceed after one or the other of the following formulas:

*To Detect Cotton or other Vegetable Fibre in Woolen or Silk Fabrics.*

Boil the sample to be tested in a concentrated solution of caustic soda or potash, and the wool or silk fibre will rapidly dissolve, producing a soapy liquid. The cotton or other vegetable

Specimen Page of "Textile Calculations."
(Reduced in Size)

# ANALYSIS.

## How to Ascertain the Raw Materials Used in the Construction of Textile Fabrics.

In many instances an examination of the threads (liberated during picking-out) with the naked eye, will be sufficient to distinguish the material used in the construction of the fabric, yet sometimes it is found necessary to use either the microscope, or a chemical test for their detection.

As a means for merely distinguishing between the fibres the simplest and most generally applicable test is to make a microscopical examination of the fabric; and for this reason it is necessary for the analyst to be acquainted with the appearance of the individual fibres. By means of the microscope the fibre used in the construction of a fabric is at once ascertained on account of the different surface structures of the various fibres used in the manufacture of textiles. This characteristic surface structure cannot be distinguished with the naked eye; a common magnifying glass will not do either, but an enlargement of about 200 times will in most instances suffice. In order to prepare a fabric for examination with the microscope liberate (pick out), the threads forming the fabric; next untwist a few threads so as to liberate the individual fibres composing the same. Place these fibres upon a slide of the microscope, carefully wet them with a drop of distilled or rain water, and cover them with a cover glass; or smear the surface of a slide with glycerine or gum water, upon which the fibres, adhering slightly, may readily be arranged for examination.

### MICROSCOPICAL APPEARANCE OF FIBRES.

#### Cotton.

Examining cotton fibres under the microscope shows them to be spirally twisted bands, containing thickened borders and irregular markings on the surface. The fibre is as a rule thicker at the edges than in the centre, and has, therefore, a grooved or channeled appearance. The spiral character is much more highly developed in some varieties than in others.

Care must be taken not to mistake *wild silk* for cotton, since wild silk frequently has a similar spiral band like appearance. If any time in doubt remember that these two kinds of fibres can readily be distinguished by other tests.

A. B. C.

FIG. 50.

The accompanying illustration, Fig. 49, shows cotton fibres magnified.

In fully ripe cotton the twisted form is regular and uniform, compared to unripe, half ripe or structureless cotton, which are now and then found amongst a lot of cotton, yarns or fabrics.

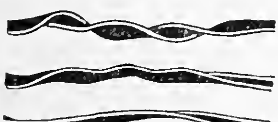

FIG. 49.

For illustrating this subject the accompanying illustration, Fig. 50, is given. *A* represents an unripe cotton fibre; *B*, a half ripe fibre, having a thin cell wall; and *C* represents the ripe fibre having a full twist and a properly defined cell-wall. Fig. 51 shows a structureless fibre as found occasionally. Half ripe, unripe, and structureless fibres, if found in a lot of cotton, yarn, or

Specimen Page of "Textile Machinery Relating to Weaving."
(Reduced in Size)

# SHEDDING MECHANISMS.

### THE KNOWLES SHEDDING MECHANISM.

This mechanism is shown in the accompanying three illustrations, of which Fig 1 shows the complete shedding mechanism. Fig. 2 shows the top and bottom cylinders, also the vibrator and jack attachment, Fig. 3 shows the box mechanism for raising and lowering the shuttle boxes.

*a*, indicates arch of loom frame, *b*, the loom frame *c*, the bolts for fastening the arch *a*, on to loom frame *b*; *d*, indicates the top cylinder for operating shedding mechanism. *e*, the bottom cylinder for operating shedding mechanism, *d'* the part of top cylinder for operating shuttle boxes. *e'*, the part of bottom cylinder for operating shuttle-boxes; *f*, the vibrator levers; *g*, the vibrator gears, *h*, the vibrator connectors; *i*, the harness jacks, *i'*, the comb for keeping them in proper position.

Vibrator lever, gear and connector are the same for shedding and box mechanism, with the exception of the long connector *h'*, used for raising single box.

*j*, arbor of harness jacks, fulcrumed to rod *k*, fastened to the lower extension of arch *a*, of the loom frame

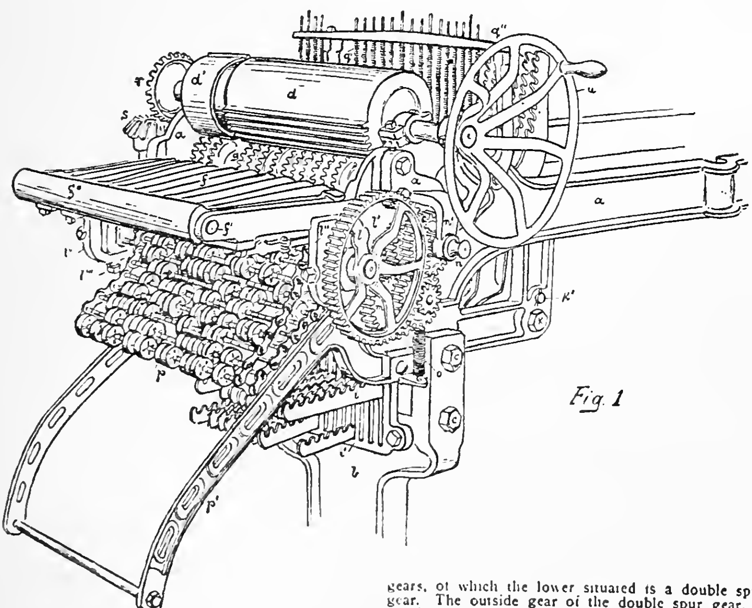

*Fig. 1*

*k'* is a small rod running across the top of jacks for holding them down on the rod *k*.

*l* chain cylinder gear, fastened to the chain cylinder *l'*, by means of a soft set screw (not shown), so that provided any catch occurs no other breakage but the breaking of said soft set screw will result; *l''*, the boxes for holding chain cylinder and which can be raised or lowered by set screws *l'''*.

*m*, two elliptical gears for transferring the characteristic fast and slow motion to chain cylinder *l'*. To the right of these two elliptical gears *m*, are seen two spur gears, of which the lower situated is a double spur gear. The outside gear of the double spur gear, is smaller and meshes into the teeth of the chain cylinder gear *l*.

*n*, the reverse key, held in position by casting *n'*, bolted on to loom frame *a*. This reverse key acts as a shaft for all the upper sections of previously referred to three sets of gears. It has a double key set in its shaft. When the loom is in motion and the chain cylinder running forward, one of the lips fastens the top elliptical gear and also the previously referred to outside situated upper gear, which meshes with the chain cylinder gear *l*. If required to reverse the chain cylinder the reverse key *m*, is drawn out, in turn liberating the top elliptical gear and fastening the middle spur

Specimen Page of "Cotton Manufacturing, Part 2."
(Reduced in Size)



serves the purpose to keep the slivers better down on the spoons *G*, thus obtaining a prompt action of the stop motion. From the spoons *G*, the slivers pass down a specially shaped guide plate *H*, each sliver being kept separated from the others by means of grooves or channels *I*, through which they pass. The slivers are in this manner brought

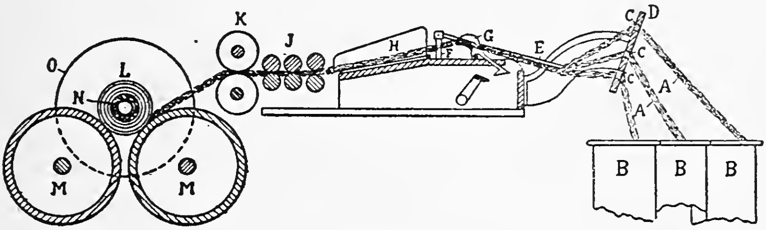


Fig. 106.

together and made into a comparatively level sheet without overlapping each other as they enter the series of drawing rolls *J*, side by side. The object of the machine is not to draw the slivers out, but to lay them side by side in the form of an even lap, for which reason the draft in the rollers *J* is just enough to prevent bulkiness of the lap and should not exceed about $1\frac{3}{4}$ to 2. Emerging from the drawing rolls *J*, the cotton

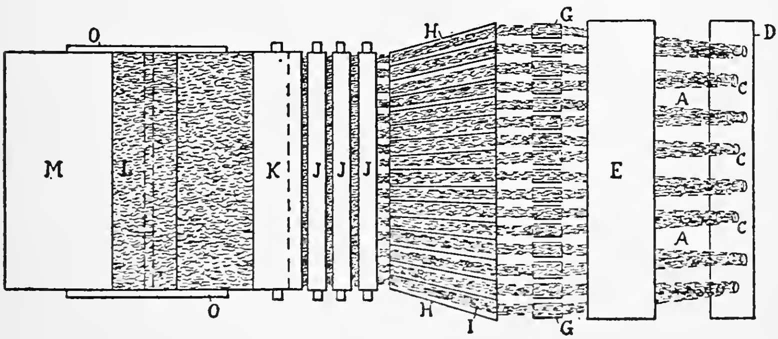


Fig 107

is conducted between a pair of heavy calender rolls *K*, which compress it into a sheet or lap which enables it to be rolled up. The top calender roller *K* is weighted either by a spring or lever arrangement at each end, with from 80 to 140 lbs. pressure. After the cotton leaves the calender rollers *K*, it is wound in the form of a lap *L*, upon the wooden spool *N*

## Specimen Page of "Wool, Cotton, Silk from Fibre to Finished Fabric."

(Reduced inSize)



caustic potash, then wash it well and re-dry it. During boiling add from time to time a few drops of water so as to prevent the alkali from becoming too concentrated. After drying at 212° F. the residue is weighed, the result giving the weight of cotton, and the loss, that of wool. Instead of potash, 7° B. caustic soda may be used, boiling being in this case restricted to a quarter of an hour

**To Separate Wool from Cotton,** remove any size or dye by boiling the sample in dilute hydrochloric acid, dilute lye, or by extraction with alcohol, ether, etc., and dried at 212° F., and placed in four parts of sulphuric acid and one part of water for twelve hours, then mixed with three volumes of absolute alcohol and water and filtered. The residue is washed in absolute alcohol until the washings are colorless, and afterwards with water, being finally dried and weighed to ascertain the weight of wool present.

Another method is thus: After freeing the sample from dye and sizing as before, and washing, the same is dried and weighed, and then immersed in ammoniacal copper oxide for twenty minutes, after which water is added. The residue left after filtration is thoroughly washed, dried and weighed, the result giving the amount of wool in the mixture.

**To Separate Silk, Cotton and Wool** in a sample containing these three fibres, remove the size and dye, as previously explained, 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.

To ascertain the percentage of each in a sample composed of Silk, Cotton and Wool, two samples of yarn, each weighing 2 grams, are dried, weighed and boiled for a quarter to half an hour, in 200 c.c. of 3° 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 Silk, Tussah Silk, Wool and Cotton** in a sample, have the sample first acted on by boiling half a minute with concentrated hydrochloric acid, which immediately dissolves the silk, the tussah 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 Determine the Presence of Cotton and Flax** in a sample, the same is dyed by immersion in alcoholic fuchsine solution (1 gram fuchsine in 100 c.c. alcohol), then washed with clean water until the color ceases to run, and steeped in ammonia for about three minutes. The flax fibres or threads will then have been dyed rose color, whereas the cotton fibres or threads will be decolorized.

For the purpose of quantitative separation, 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° 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 whilst the cotton fibres or threads have dissolved after passing through a gelatinous stage in which they will tear like tinder.

## SILK.

Silk is the simplest, and in its properties the highest and most perfect of all spinning materials. It differs from other textile fibres, both as to its nature as well as the machinery used in preparing it for the loom, the machinery used being much simpler and less cumbersome than the processes employed in preparing other fibres.

THE SILK WORM.
Larva,—Cocoon,—Chrysalis,—Moth.

The countries that produce silk are in the temperate zone. Starting from Japan to China and the belt of Central Asia, including a part of India, the silk-producing belt runs westward through Persia, the Caucasus, Syria, Asia Minor, Turkey, and the countries of South and Western Europe. Silk is divided into three main groups: (1) Cultivated silk, (2) Wild silk, (3) Artificial silk; the most important by far to the textile industry being

### CULTIVATED SILK.

The same is imported in the form of "raw silk" *i. e.* in skeins, which are carefully packed in linen, with an outer covering of rush matting. The bales are square shaped, and as a rule contain 9 or 10 compound bundles of 9 or 10 skeins each. These bales, thus received by the manufacturer, on account of the high price of silk (it takes from 2250 to 3000 cocoons to make one pound of reeled silk), are carefully weighed and their contents subjected to a critical examination.

New York City, the only raw silk market in America, now holds the first place among all the raw silk markets of the world, Shanghai alone excepted; more raw silk being annually sold here than is consumed in France, which is still the largest raw silk consuming country in Europe.

The standard sizes of swifts in American mills are twenty-two and twenty-four inches, that is, the skein to measure fifty-six to fifty-eight inches in circumference. The reelers of Japan silks conform more nearly to this standard than do the reelers of Canton and Italian silks. The reelers of China steam filatures are quite uniform in the diameter of their skeins, but are apt to put too little silk in their skeins, which

filling, entering from the left, interlaces in taffeta until coming to the point where the entering threads have to be drawn into the fabric, passing after this below the right hand situated entering thread, sur-

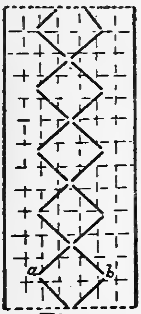


Fig. 120

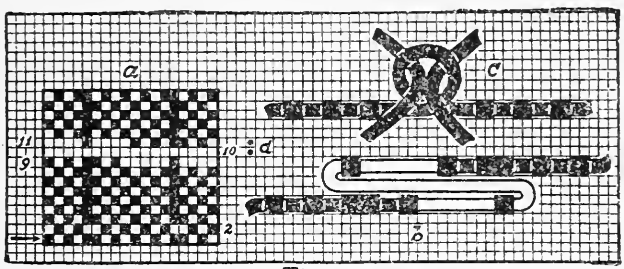


Fig. 121

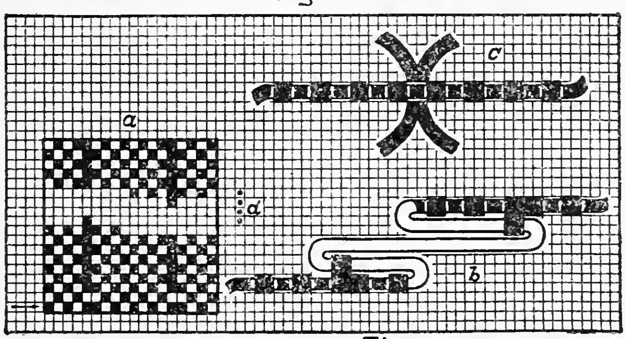


Fig. 122

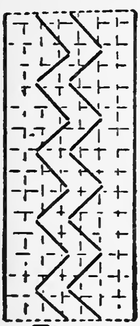

Fig. 123

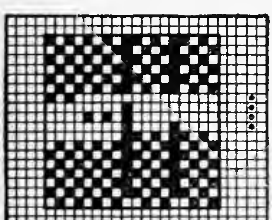

Fig. 124

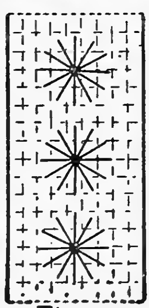

Fig. 125

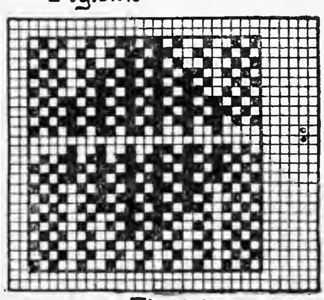

Fig. 126

rounding then, in union with pick 10, this entering thread as situated on the right hand side of the design.

Pick 10, in unison with pick 11, loops around the left hand situated entering thread; pick 11 forming in the body of the fabric the continuation to pick 9.

## Thrown Silk.

THROWN SILK may be defined as yarn made from raw silk, that is, from silk reeled from the cocoon.

RAW SILK consists of several parallel cocoon filaments held together by the natural gum, emitted by the worm. It can not be boiled off, dyed and weighted, and remain in workable condition.

If the silk is to be skein dyed it must therefore first be *thrown* into yarn.

Silk *"throwing"* (from the Saxon *"thrawan,"* i. e., to twist) is the technical term used for the processes involved in making yarn from raw silk. As raw silk is already in the form of a continuous strand, there is no occasion for the preparatory machinery that is needed for the manufacture of yarns for all other textiles, and where a mass of short tangled fibres of varied lengths has to be transformed into a continuous length of roving.

In silk throwing the main object is the insertion of twist into the raw silk, with such doubling as may be desired.

*Thrown silks* are known as *organzine, tram,* or *singles,* according to the method of manufacture.

ORGANZINE (mainly used as warp) is made by doubling two or more threads which have first been well twisted in the single, and then giving them a firm twisting in the opposite direction.

TRAM (mainly used as filling) is made by combining two or more raw-silk threads, and then twisting them together with a slack twist. Strength is not as essential as it is in the warp, the slack twisted filling permitting a more brilliant finish.

SINGLES are single raw-silk threads, twisted or not. Such yarns, when very hard twisted, are used for the warp and filling of chiffon and kindred fabrics. Some singles are woven in the gum, without twist, and produce cloths which after being boiled out and bleached have a softness and brilliancy unattainable in

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