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. $60 \times 8\frac{1}{3} = 500 \div 11 = 45.45$. *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"*,

$$32 : 24 :: 32\text{'s} : 24\text{'s}$$

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

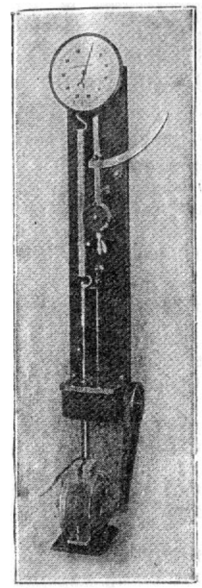

Fig. 62

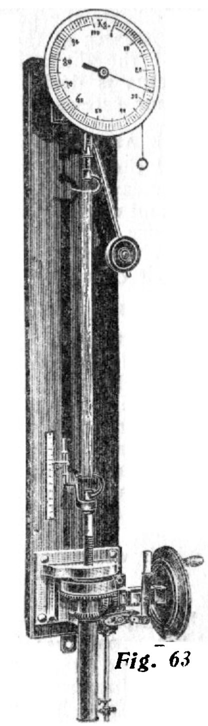

Fig. 63

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

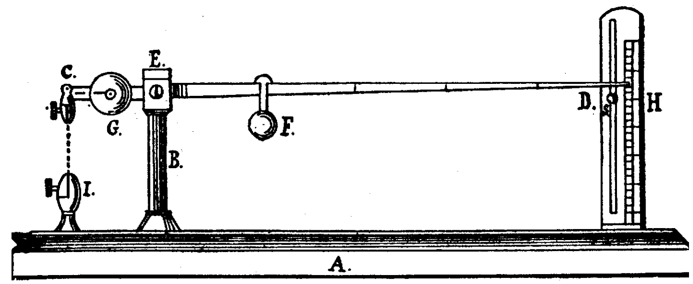

Fig. 64

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

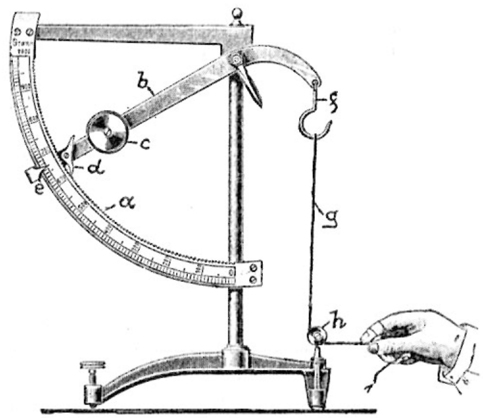

Fig. 65

(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

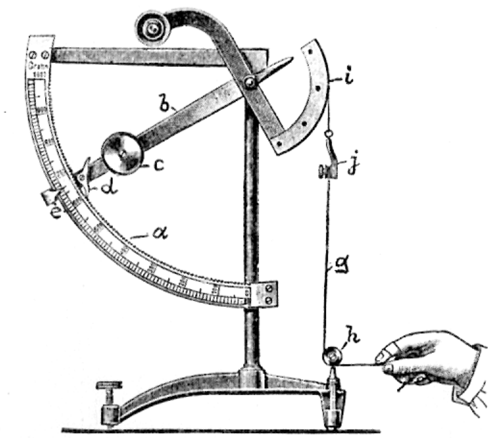

Fig. 66

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 ($\frac{1}{4}$) 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.

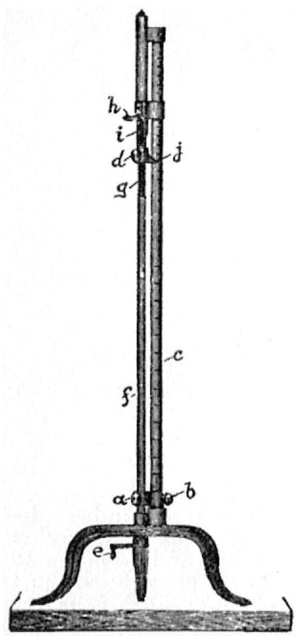

Fig. 67

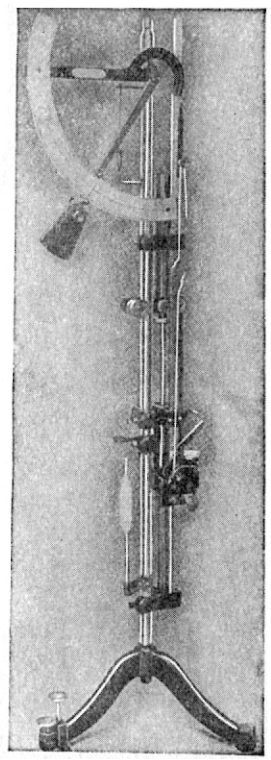

Fig. 68

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

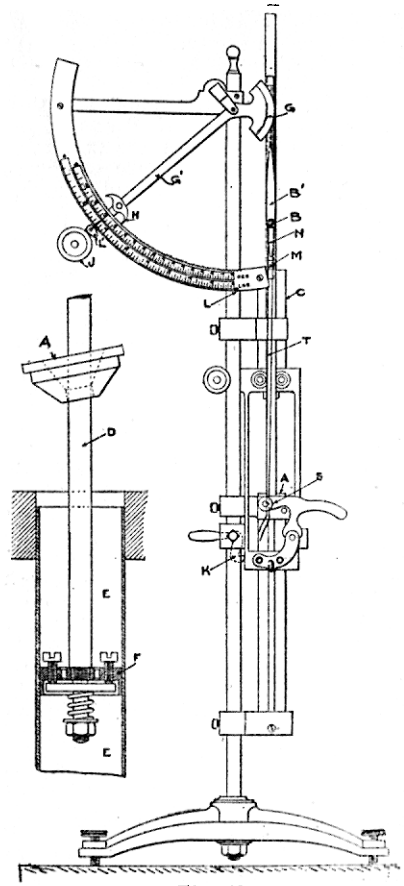

Fig. 69

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

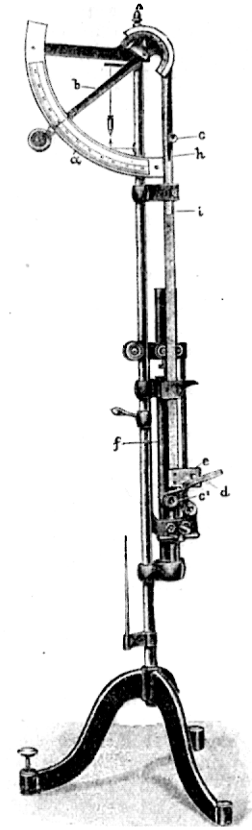

Fig. 70

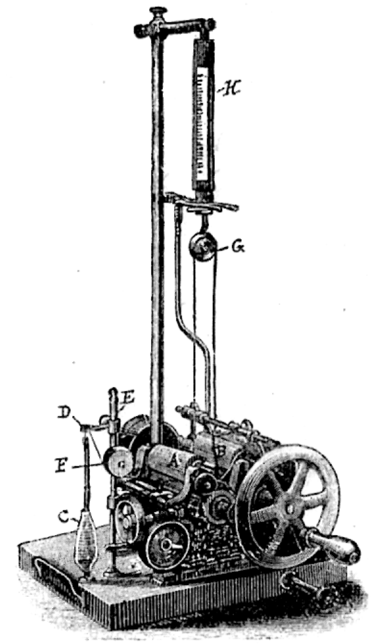

Fig. 72

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

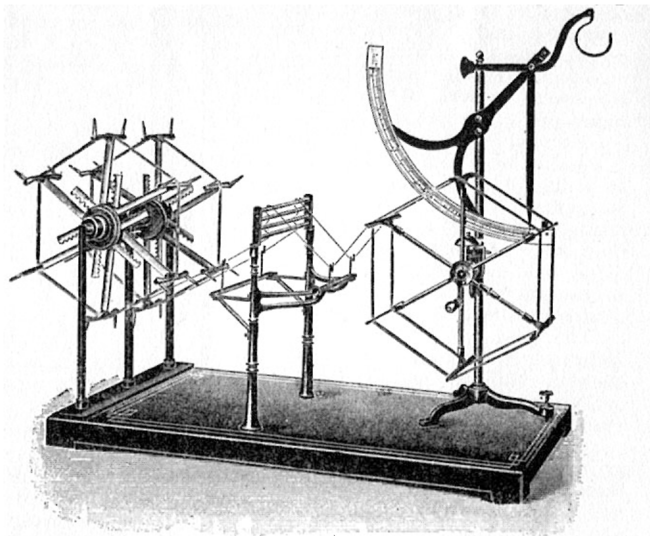

Fig. 71

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.*

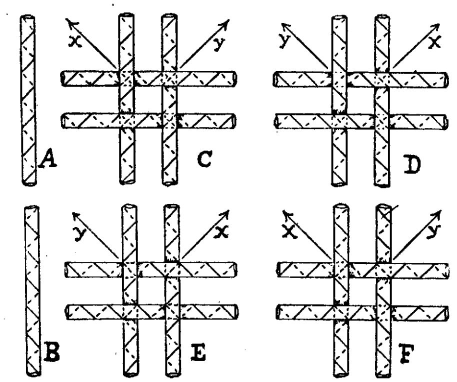

Fig. 73

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*

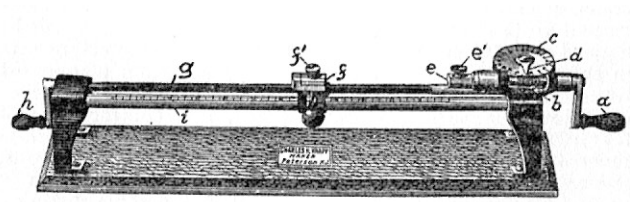

Fig. 74

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 ($60 \div 6 =$) 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.

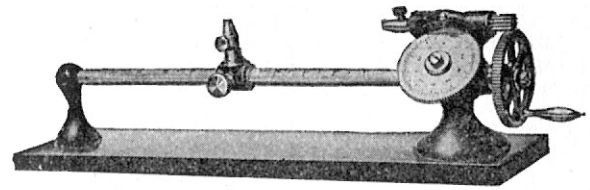

Fig. 75

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

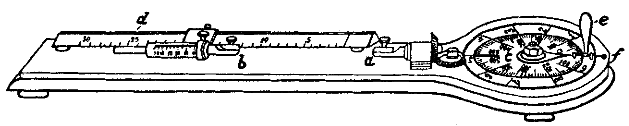

Fig. 76

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.

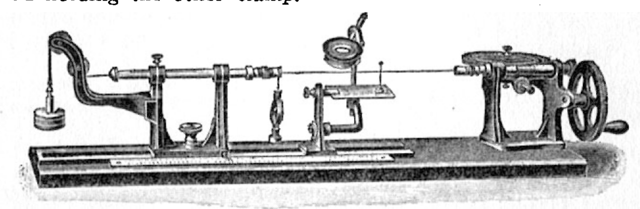

Fig. 77

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

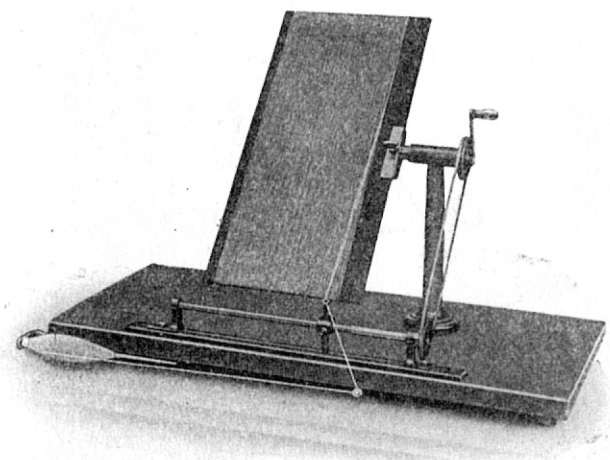

Fig. 78

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.

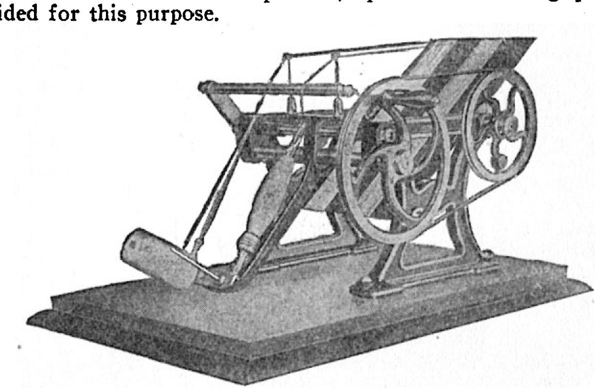

Fig. 79

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 17⅞ 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,

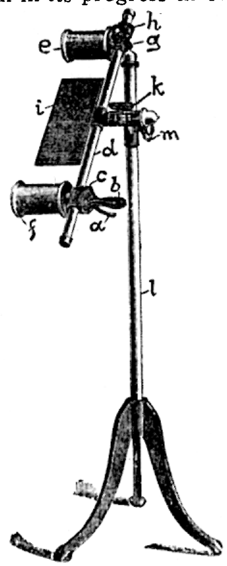

Fig. 80

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

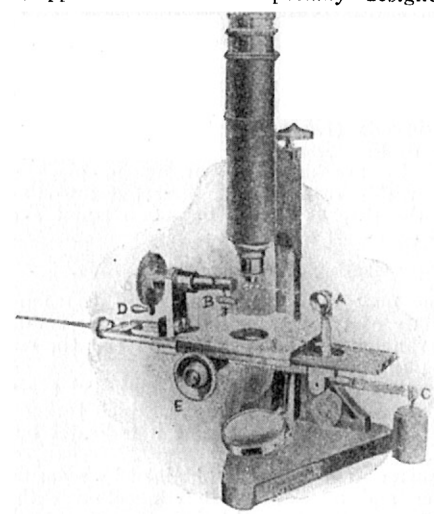

Fig. 81

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 $\frac{3}{4}$ 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

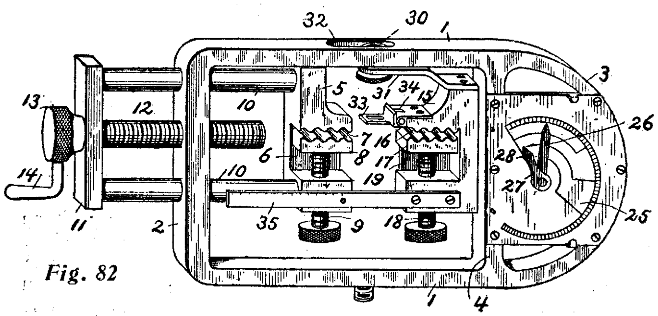

Fig. 82

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

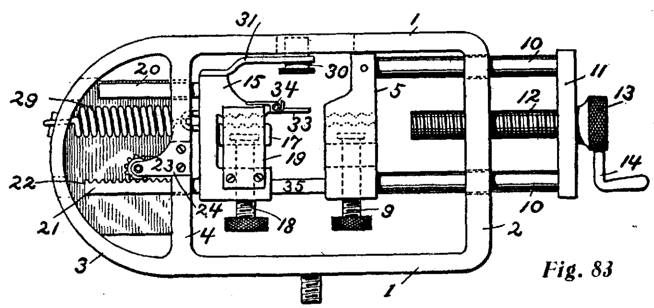

Fig. 83

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 1½ 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,

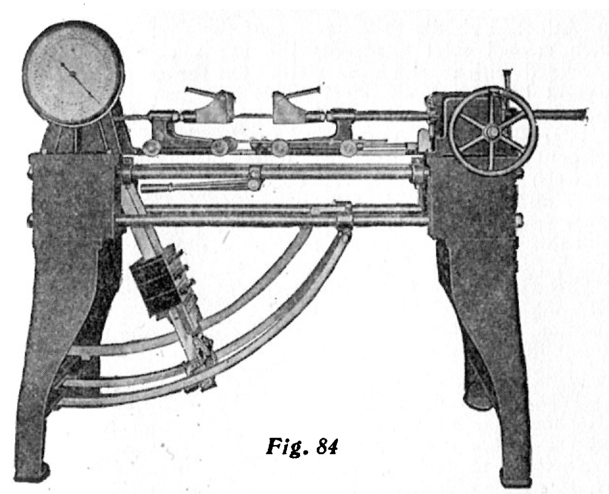

Fig. 84

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

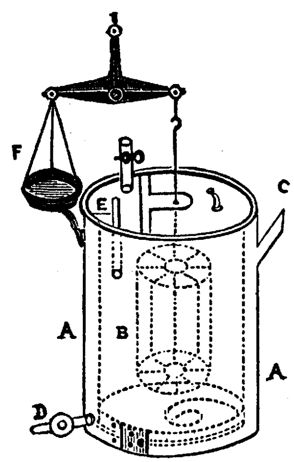

Fig. 85

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 there-

fore 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

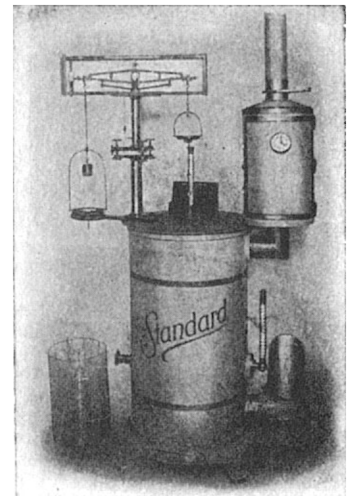

Fig. 86

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.

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

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 yarn 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.

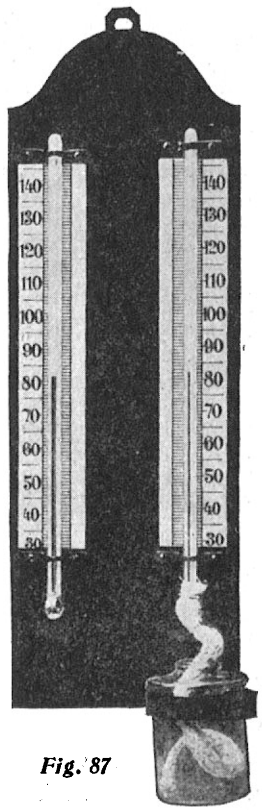

Fig. 87

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	31	28	24	20	17	13	10	6	3							
70	100	95	90	86	81	77	72	68	64	60	56	52	48	44	40	36	33	29	26	23	19	16	13	10	7	4	1				
75	100	96	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	5	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	23	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	86	82	79	76	72	69	66	63	60	58	56	52	49	47	44	42	39	37	35	32	30	28	25	23	21	19	17
100	100	97	93	90	86	83	80	77	74	71	68	65	62	59	57	54	51	49	47	44	42	39	37	35	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 8¼%

	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 8¼%, 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 8¼%, 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

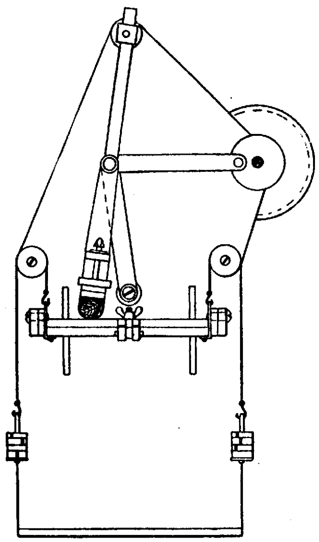

Fig. 88

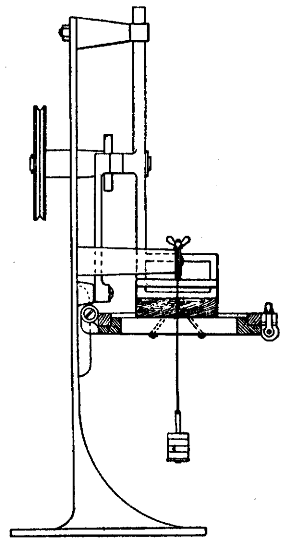

Fig. 89

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.

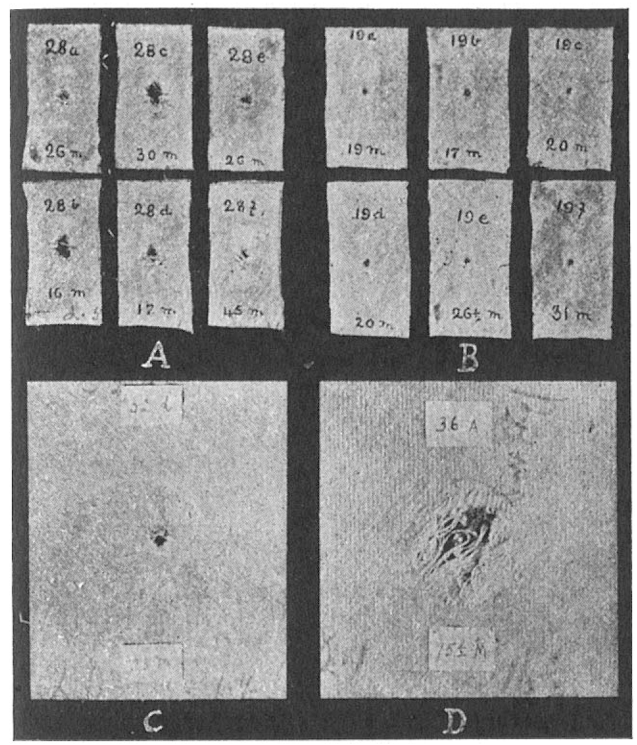

Fig. 90

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.

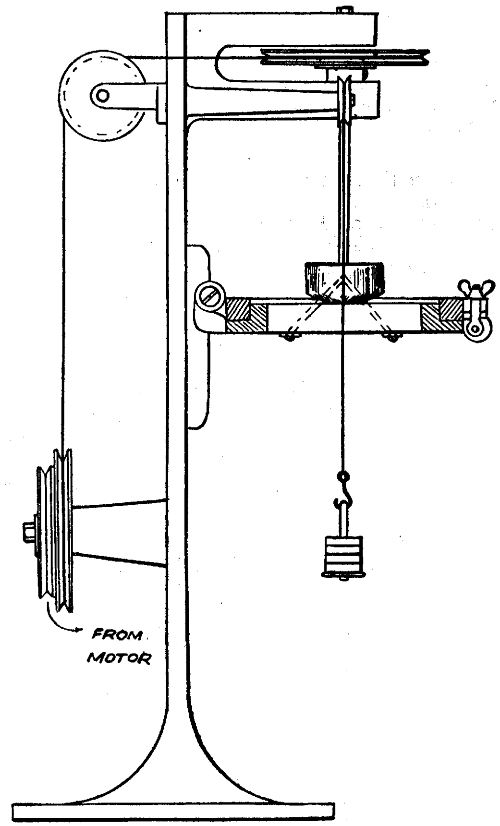

Fig. 91

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.

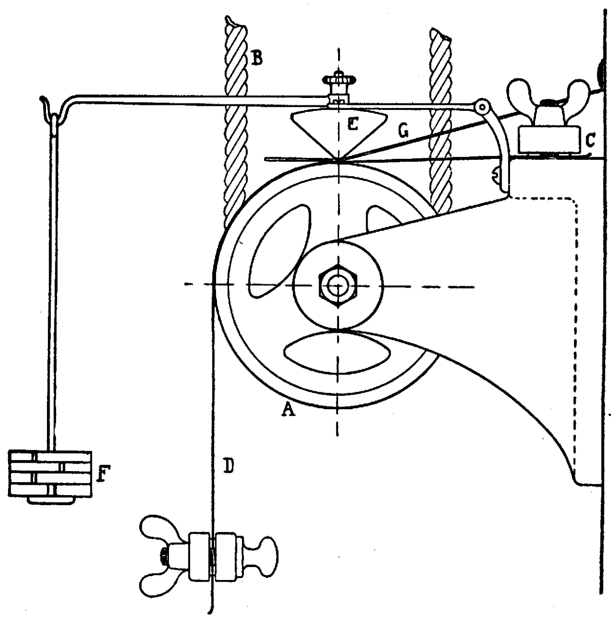

Fig. 92

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-

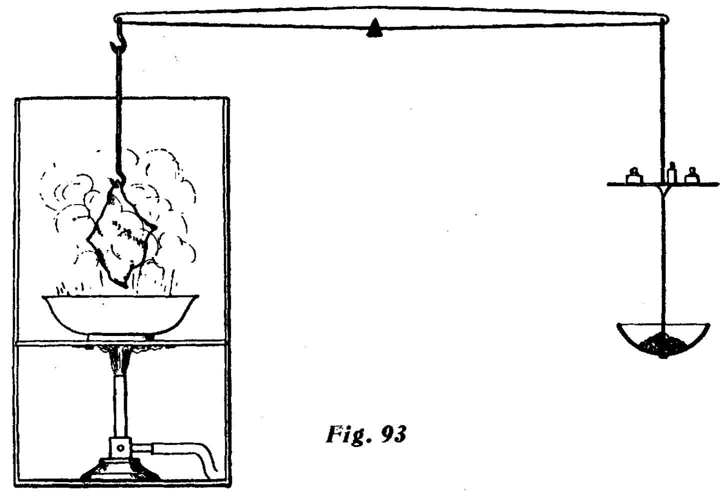

Fig. 93

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

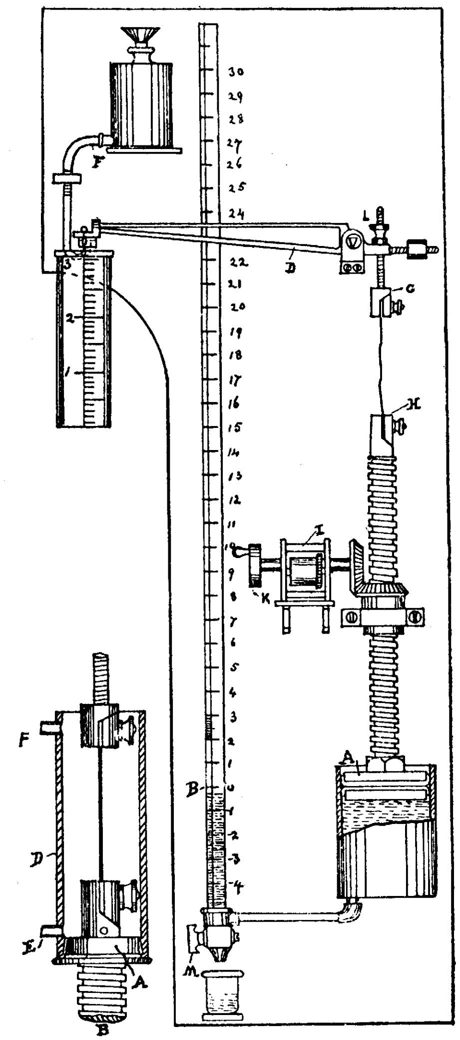

Fig. 95 *Fig. 94*

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 sub-

stance, 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.

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.

Technology of Textile Design

A Practical Treatise on the Construction and Application of Weaves for all Kinds of Textile Fabrics, Giving Also Full Particulars as to the Analysis of Cloth

By E. A. POSSELT

Editor of Posselt's Textile Journal

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ABSTRACT OF CONTENTS:

DIVISION OF TEXTILE FABRICS ACCORDING TO THEIR CONSTRUCTION. SQUARED DESIGNING PAPER.

FOUNDATION WEAVES: PLAIN. TWILLS. SATINS.

DRAWING-IN DRAFTS.

DERIVATIVE WEAVES: RIB WEAVES. BASKET WEAVES. BROKEN TWILLS. STEEP TWILLS. RECLINING TWILLS. CURVED TWILLS. COMBINATION TWILLS. CORKSCREWS. ENTWINING TWILLS. DOUBLE TWILLS. CHECKERBOARD TWILLS. FANCY TWILLS. POINTED TWILLS. DOUBLE SATINS. GRANITES. COMBINATION WEAVES. COLOR EFFECTS.

SPECIAL SINGLE CLOTH WEAVES: HONEYCOMB WEAVES. IMITATION GAUZE WEAVES. ONE SYSTEM WARP AND TWO SYSTEMS FILLING. SWIVEL WEAVING. TWO SYSTEMS WARP AND ONE SYSTEM FILLING. LAPPET WEAVING. TRICOTS.

DOUBLE AND MORE PLY CLOTH: REGULAR DOUBLE CLOTH. WORSTED COATINGS. MATELASSES. QUILTS. RIB FABRICS. THREE, FOUR, ETC., PLY FABRICS.

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TWO PLY INGRAIN CARPETS. GAUZE FABRICS. THE JACQUARD MACHINE. GOBELIN TAPESTRY. ANALYSIS OF TEXTILE FABRICS.

NOVELTIES IN DESIGNING: DESIGNING WEAVES BY FOUR CHANGES. SHADED FABRICS. SOLEIL WEAVES. CHECK PATTERNS. CRAPE WEAVES. HUCK PATTERNS. WOVEN TUCKS. CRIMP STRIPES. BEDFORD CORDS. CROCODILE CLOTH. LARGE DIAGONALS. TO INCREASE THE THICKNESS OF A FABRIC WITHOUT SPECIAL BACKING THREADS. BRACKET WEAVES. FRINGES. PEARL EDGES.

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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.

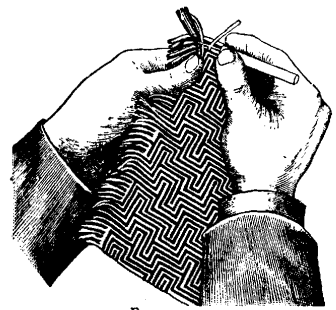

FIG. 1011

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

Textile Calculations

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ABSTRACT OF THE CONTENTS

YARN AND CLOTH CALCULATIONS

Grading of the Various Yarns Used in the Manufacture of Textile Fabrics According to Size or Counts. To Find the Equivalent Counts of a Given Thread in Another System. To Ascertain the Counts of Twisted Threads Composed of Different Materials. To Ascertain the Counts for a Minor Thread to Produce, with Other Given Minor Threads, Two, Three or More Ply Yarn of a Given Count. To Ascertain the Amount of Material Required for Each Minor Thread in Laying out Lots for Two, Three or More Ply Yarn. To Ascertain the Cost of Two, Three or More Ply Yarn. To Find the Mean or Average Value of Yarns of Mixed Stocks. Reed Calculations. Warp Calculations. Filling Calculations. To Ascertain the Amount and Cost of the Materials Used in the Construction of All Kinds of Plain and Fancy Cotton and Woolen Fabrics.

STRUCTURE OF TEXTILE FABRICS

The Purpose of Wear that the Fabric will be Subject to. The Nature of Raw Materials. Counts of Yarn Required to Produce a Perfect Structure of Cloth. To Find the Diameter of a Thread by Means of a Given Diameter of Another Count of Yarn. To Find the Counts of Yarn Required for a Given Warp Texture by Means of a Known Warp Texture with the Respective Counts of the Yarn Given. Influence of the Twist of Yarns upon the Texture of a Cloth. To Find the Amount of Twist Required for a Yarn if the Counts and Twists of a Yarn of the Same System, but of Different Counts, are Known. Influence of the Weave upon the Texture of a Fabric. To find the Texture of a Cloth. To Change the Texture for Given Counts of Yarn from one Weave to Another. To Change the Weight of a Fabric without Influencing its General Appearance. To Find Number of Ends Per Inch in Required Cloth. Weaves Which will Work with the Same Texture as the two and two Twill. Weaves which will Work with the Same Texture as the three and three, four and four, etc., Twill. Selections of the Proper Texture for Fabrics Interlaced with Satin Weaves. Rib Weaves. Corkscrew Weaves. Two Systems Filling and One System Warp. Two Systems Warp and One System Filling. Two Systems Warp and Two Systems Filling.

ANALYSIS

How to Ascertain the Raw Materials Used in the Construction of Textile Fabrics. Microscopical Appearance of Fibres. Tests for Ascertaining the Raw Materials Used in the Construction of Yarns or Fabrics. How to Ascertain the Percentage of Each Material Constituting the Fabric. How to Test the Soundness of Fibres or Yarns. How to Test Given Counts of Yarn. How to Ascertain the Weight of Cloth. How to Calculate the Weight. How to test and Analyze the Various Finishes. Cotton Spinning.

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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.

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.

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

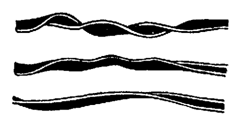
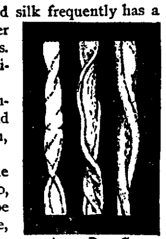


Fig. 49.



A. B. C.

Fig. 50.

Cotton Manufacturing

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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

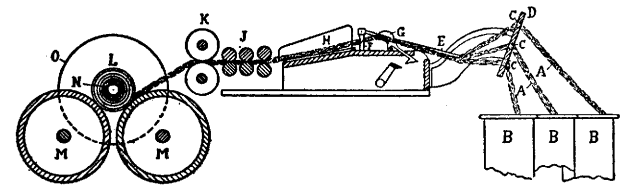

Fig. 106.

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

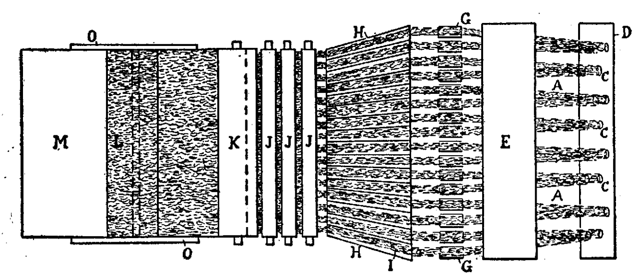

Fig 107

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*

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

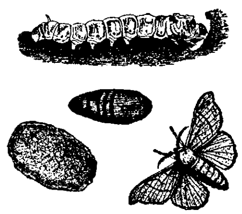
To Separate Silk, Tussah Silk, Wool and Cotton in a sample, have the sample first acted on by boiling half a minute with concentrated hydrochloric acid, which immediately dissolves the silk, the tussah silk being dissolved at the end of two minutes' further boiling. On treating the remainder of the sample 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

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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-

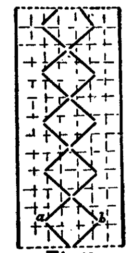

Fig. 120

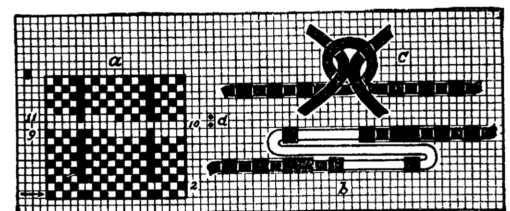

Fig. 121

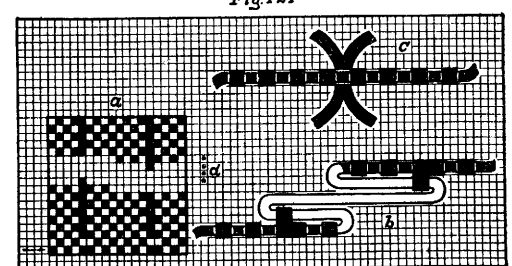

Fig. 122

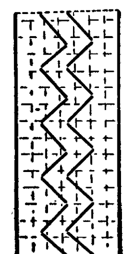

Fig. 123

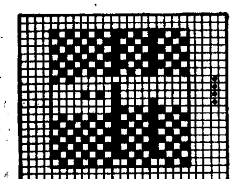

Fig. 124

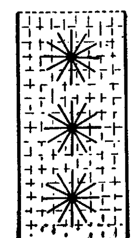

Fig. 125

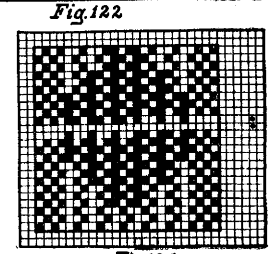

Fig. 126

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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