WOOL COTTON SILK FROM FIBRE TO FABRIC

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VOL. IX

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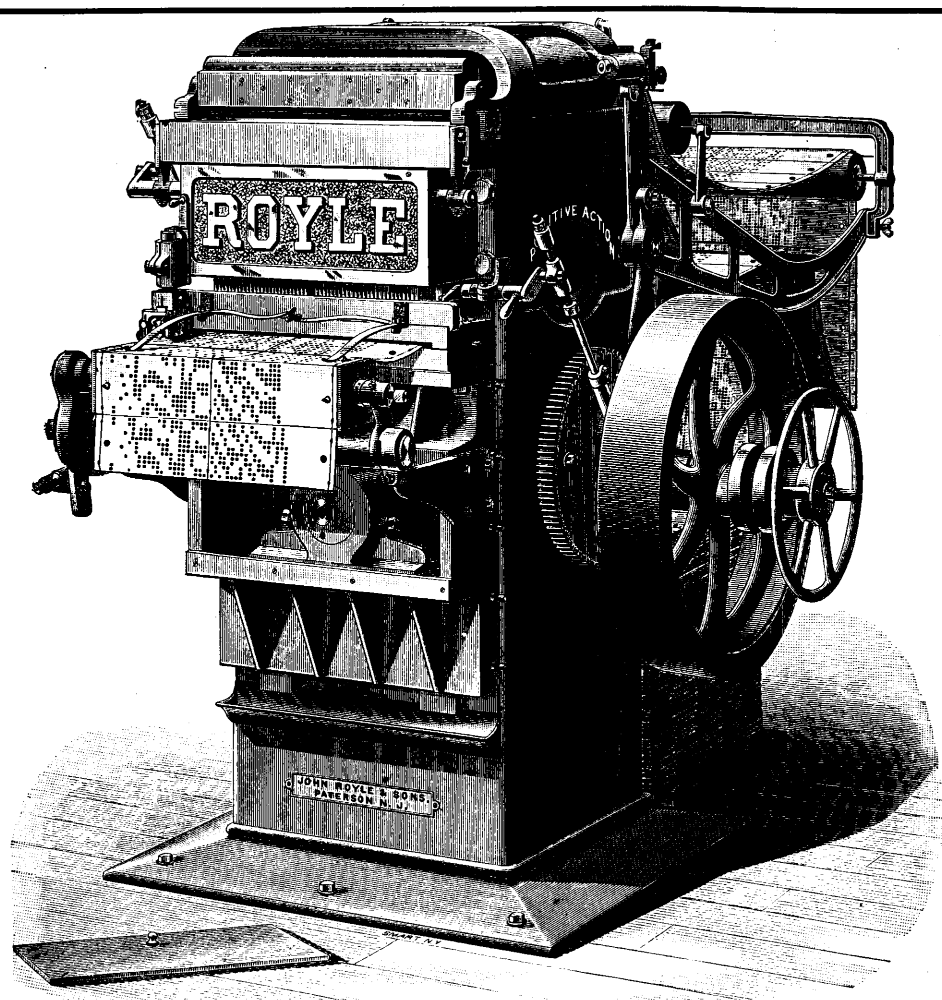

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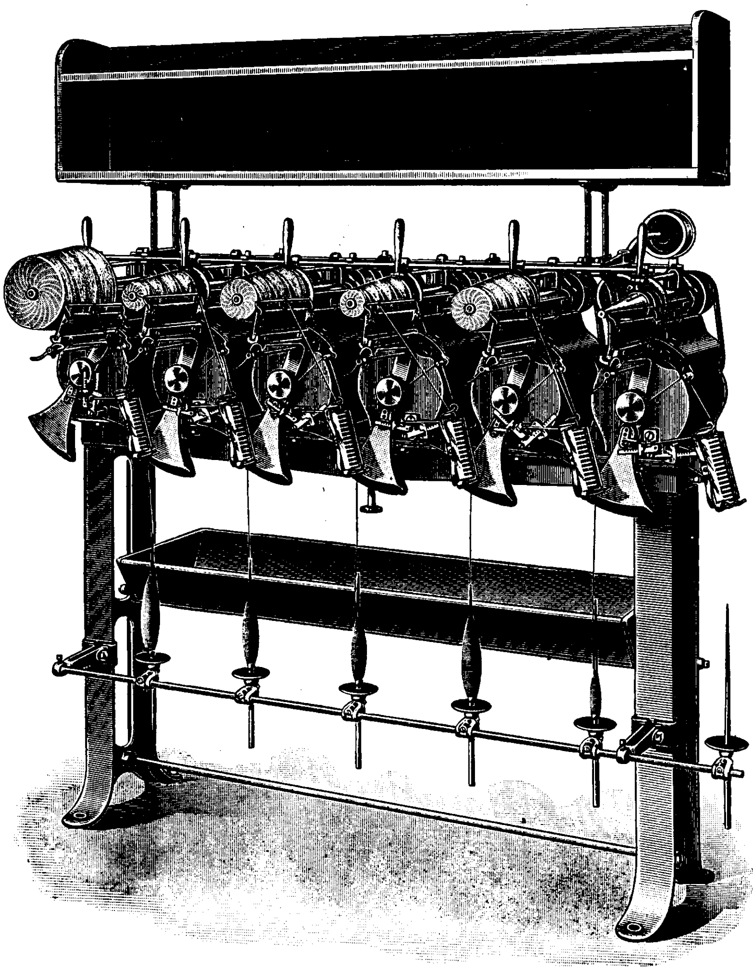

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Heat, Power, Transmission, Etc.

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Manufacturers, Mill Managers, Overseers, Students and Inventors

By E. A. POSSELT

CONSULTING EXPERT ON TEXTILE DESIGNING AND MANUFACTURING,
Author and Publisher of "Technology of Textile Design," "Structure of Fibres, Yarns and Fabrics," "The Jacquard Machine Analyzed and Explained," "Textile Calculations," "Cotton Manufacturing," "Recent Improvements in Textile Machinery—Parts 1 and 2," Principal of "Posselt's School of Textile Design," formerly Director of the Philadelphia Textile School.

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PREFACE.

The object of this volume is to present to Textile Manufacturers, Mill Managers, Overseers, Commission Merchants and Students, the first illustrated treatise on "Modern Textile Machinery and Processes in use for converting the Fibres into Fabrics, covering Cotton, Wool, Silk, etc."

The book will be of special value, since there are no books in print with reference to some of the various branches of textile manufacturing, like Knitting and Modern Knitting Machinery; Modern Dyeing, Bleaching, Mercerizing, etc., Machinery; Finishing Woolen, Worsted, Cotton and Silk Fabrics.

Due regard, however, has also been paid to Preparatory, Carding, Spinning, Winding and Weaving Machinery; Dyestuffs, Chemicals, etc., as well as the various Auxiliary Machinery, Devices and Supplies for each department of the mill.

Another interesting chapter is the one on Heat, Power, Transmission and Accessories to Mills, with a description of some of the most important items to Modern Textile Plants.

SUMMARY OF CONTENTS.

RAW MATERIALS.

WOOL: Its Characteristics, Classes of Sheep and Wool, Grading and Sorting, Theory of Felting, Chemical Composition, Other Animal Fibres, Wool Scouring, Drying, Artificial Wools, Carbonizing, etc.

COTTON: Its Characteristics, Spinning Properties, Varieties, Grading, Mercerized Cotton, Tests, etc.

SILK: Cultivated Silk, its Properties, Silk Throwing, Varieties of True Silk; Spun Silk, Weighted Silk, Artificial Silk, Tests, etc.

FLAX, HEMP, JUTE AND RAMIE.

PREPARATORY PROCESSES.

WOOL: A thorough description of the construction and operation of Modern Wool Washers, Stock Dryers, Dusters, Burr-Pickers, Feeds, Oiling and Picking Machinery, etc.

COTTON: Statistics of Interest; The Gin, Modern Bale Breakers, Hopper Feeds, Improvements to Pickers and Scutchers, etc.

SILK: Silk Reeling Machinery for Cultivated Silk, and Preparatory Machinery for Waste Silk.

CARDING, DRAWING, SPINNING AND TWISTING.

WOOL: Feeding Machinery for Cards, Improvements to Cards, Twisters, Fancy Yarns, Grinding Machinery, etc.

COTTON: The Revolving Flat Card, Various Improvements to it, Stripping and Grinding; The Drawing Frame, Metallic Drawing Rolls; Flyer Frames, Differential Motion; Improvements to Speeders, Spinning and Twisting Frames; The Mule; Loop Banding Machine; Humidity, Humidifiers, etc.

SILK: Silk Throwing: Spinning, Doubling, Twisting and Testing Machinery.

WINDING, WARPING, Etc., MACHINERY.

Description of the most important Winding Machinery with reference to Knit and Woven Goods; Stop Motions, Quillers, Spoolers, Warpers, Beamers, Cop Winders, etc.

WEAVING MACHINERY AND SUPPLIES.

The various motions of the different Looms; Jacquards, Card Stamping and Lacing Machinery; Shuttles, Heddles, Reeds, Temples, etc.

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(THE FIRST TREATISE ON THIS SUBJECT EVER PUBLISHED)

Explanation of the Principle of Knitting with Latch and Spring Beard Needles; Different Stitches; Description of Construction and Operation of Modern Knitting Machinery; Trimming and Finishing of Knit Goods, etc.

DYEING, BLEACHING, MERCERIZING, Etc., MACHINERY, DYESTUFFS, CHEMICALS.

Description of Modern Machinery Used for the Various Processes for Dyeing, Bleaching, Mercerizing, etc.; Description of Dyestuffs and Chemicals with Directions for Using.

FINISHING PROCESSES AND MACHINERY.

The First Treatise on the Finishing of Woolen, Worsted, Cotton and Silk Fabrics ever Published, with a Complete Description of the Machinery used.

HEAT, POWER, TRANSMISSION, Etc.

Principles and Calculations on Heat, Power, and Transmission of Power; Explanation of Latest Improved Accessories Relating to Construction and Equipment of Modern Textile Manufacturing Plants.

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RAW MATERIALS.

WOOL.

Wool is the hairy covering of the sheep; it is softer than the actual hair, also more flexible and elastic, and, besides having a wavy character, it also differs in certain details of surface structure. Although wool and hair are found in the fleece of the sheep, yet wool predominates in all cases, hair in the properly bred sheep being practically absent. The covering of certain other animals, such as the Cashmere goat, the Angora goat, the Llama, etc., are also classed as Wool.

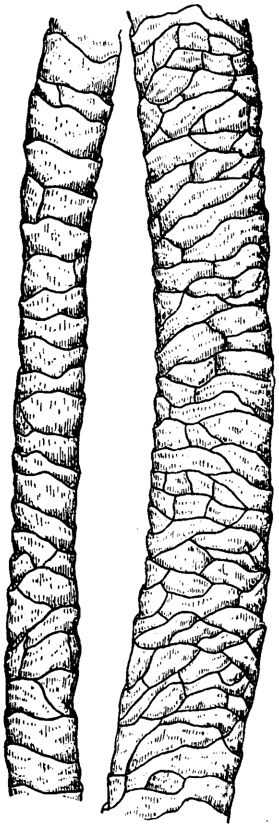


Fig. 1.

No doubt in its original wild state there has been less wool in proportion to hair in the covering of the sheep, but under the influence of domestication the hair has largely disappeared and wool has taken its place.

Wool fibres serve as the protective covering to the hide of the sheep, and are made into woolen fabrics, chiefly for outside garments as well as for underwear. In the latter instance they differ from cotton or linen fabrics in that a cotton or linen fabric, worn next to the skin, conducts heat, becomes moist, and keeps the skin damp and cool, whereas wool does not conduct the heat from the skin, and consequently has the reverse effect.

Under the microscope, wool appears as a solid rod-shaped substance, the surface of which is covered with scales, as shown in Fig. 1, which is a view of two typical wool fibres highly magnified. A transverse section of a good quality wool fibre will show at least two parts, whereas in the poorer qualities a third part will be frequently found.

The first or outer part consists of a circular layer of scales, partially overlapping each other somewhat in the same manner as the scales of a fish, being arranged with more or less regularity, according to the fineness of the wool. The size of the individual scales varies, some surrounding the circumference of the fibre to a greater or less extent than others. The upper edges of the scales are more or less free, the lower being apparently imbedded in the interior of the fibre. Although these scales are also found in hair, yet in that fibre they are more deeply imbedded, lie flatter and present very little free edges, a feature readily seen from Figs. 2 and 3, of which Fig. 2 shows, magnified, a wool fibre treated with caustic soda, and Fig. 3 a human hair, similarly treated, so as to show the serrations distinctly.

These scales are more strongly and regularly developed in proportion to the fineness of the wool, whilst in coarse wools they are small and irregularly placed. Underneath these scales rests the true fibrous material, generally colorless, but sometimes also colored, constituting nearly, and sometimes entirely, the whole internal portion of the fibre, being composed of narrow spindle-shaped cells, which have assumed a more or less horny character.

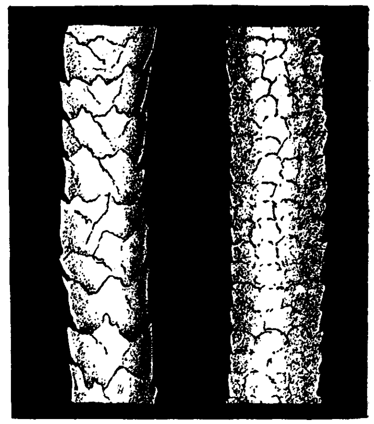


Fig. 2. Fig. 3.

The third or central portion of the fibre, when present, is known as the medullary portion, being formed of several layers of rhombic or cubical cells, which appear as the marrow of the fibre and traverse its whole length or appear only in parts. Under the microscope this substance is dark, but may be rendered transparent by boiling the fibre in glycerine and oil of turpentine. As previously mentioned, in the better classes of wool this medullary portion is entirely absent, its presence or absence depending upon the breed, health and care of the sheep, and also the part of the body upon which the wool is grown. Wool fibres which contain this medullary portion are less suitable for manufacturing purposes than such where this portion is absent. True wool fibres are of equal diameter throughout their entire length, lamb's wool alone tapering off gradually to a point.

Wool fibres, with reference to their general appearance, are characterized by their wavy structure, being another item depending upon the breed of the sheep. Fig. 4 shows such a series of curves characteristic to wool fibres as compared to hair, where it is absent, said curves being technically known as the *wave of the crimp*. While wool fibres grow separately on the body of the sheep, yet, owing to their wavy or crimpy nature, referred to, they form themselves into locks, which are simply a great many fibres more or less adhering to each other, Fig. 5 being a specimen of such a lock.

Fig. 4.

The wool fibres, thus more or less in locks on the sheep's back, would have a tendency to felt or mat and thus spoil their properties for manufacturing into yarn, if it were not for their natural yolk, which is a natural secretion from the skin and protects the fibres, said yolk being most prevalent on the back and shoulders of the sheep, *i. e.*, the places yielding the best fibres.

Wool that is shorn from the sheep while living is termed fleece wool. It has better felting properties than that obtained from the sheep skin after life becomes extinct, the latter wool being known as pulled wool.

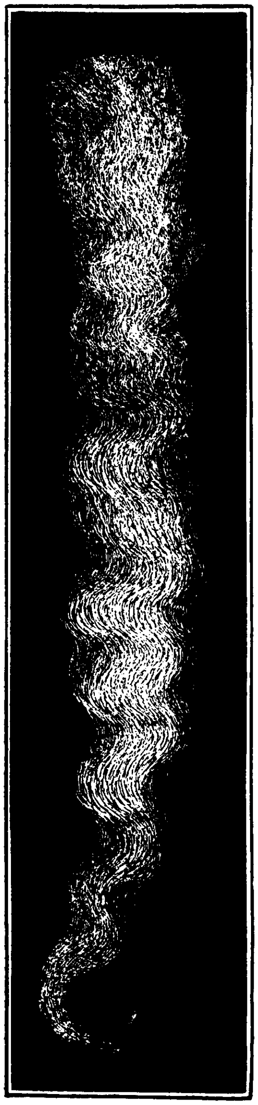


Fig. 5.

With reference to the introduction of the sheep into this country, the first of these importations consisted of the common native sheep of Spain, which were introduced by the Spaniards into that part of the American Continent which became subjected to its discoveries, including the West Indies. About the beginning of the seventeenth century the first English sheep were introduced into Virginia (Jamestown). Repeated importations were made during the next two centuries, and thus was founded a very good specimen known as the Virginian sheep, being a long-wool sheep. Leicester, Cotswold and Southdown sheep, etc., have since been imported and crossed with the same. The first merinos were imported by a Mr. Foster, of Boston, who presented the same (two ewes and one ram) to a friend who was in the sheep-raising business; but somehow this friend transferred these costly sheep into mutton. This same friend of Mr. Foster's paid a short time afterward $1,000 for one merino ram. Several importations of merinos were made later on by different parties, but the main effort to firmly establish the merino belongs to the late Hon. W. Jarvis, who was our Consul in Lisbon in 1809 and 1810. In 1809 he bought and shipped to this country 3,850 head of the choicest kind of Spanish merinos, duplicating this shipment with 2,500 head in 1810. In 1851 Silesian merinos, then the choicest sheep of Europe, were imported, and readily became acclimated. The ewes from this kind shear from 8 to 11 pounds and the rams from 12 to 16 pounds of unwashed wool. The length of staple is from 2½ to 3 inches, and the color of the wool dark on the outside, its yolk containing plenty of oil of a white and free, but not a sticky character. The best grade of our merinos at present produce what is acknowledged as the finest wool in the world, the diameter of these fibres being 0.003 inch, with about 6,000 scales per inch.

The fibres of fine wool grow very closely together upon the skin. The pure merino has from 40,000 to 48,000 fibres to a single square inch, while coarse wool breeds contain only from 5,000 to 6,000 to the square inch.

In judging wool, the buyer must take the following points into consideration, all of which directly increase or decrease its value to him: (1) Quality, (2) Strength, (3) Elasticity, (4) Length of Staple, (5) Trueness of fibre (or blood), (6) Cleanliness, (7) Absence of kemp, (8) Lustre, (9) Color, (10) Moisture.

Quality indicates a certain character in fineness of fibre the manufacturer requires for certain fabrics to be made by him.

The two general classes of wool are Clothing and Combing wools. There is no absolute standard, because improvements to machinery are constantly made, enabling by means of them a shorter staple to be combed, however at present it may be considered that any fleece that falls considerably below three inches in length of staple is not used for combing purposes. The grades under the clothing class also refer to the fineness of the fibre without reference to the particular breed of sheep, since a wool grader is, as a rule, not versed about breeds of sheep. A skillful breeder will learn to discern the character of a fleece by its external surface, whereas the wool grader examines a fleece almost entirely from the clipped ends of the fibres. He learns that certain characteristics are almost always associated, so that a skillful grader knows at a glance into what pile a fleece should go, provided it has not a weak fibre.

The merino wools, or clothing wools, are commonly classified as Picklock, XXX, XX, X, one-half blood, three-eighths blood and one-fourth blood.

Picklock is an extremely fine fibre, of which a very little is found in the remaining Saxony flocks of breeders in Western Pennsylvania. Most of these breeders have modified their flocks to obtain heavier fleeces of longer fibre, bringing much more money. There is also very little of the XXX grade, which is only exceeded in fineness by the purest breeding of Saxony merinos.

The mass of high-grade clothing wool is of the XX and X grades. XX is the finest of the standard merino flocks of the country, and includes nearly all merino fleeces not long enough to comb. X is the coarse, uneven merino fleece, such as contain coarse hair that extends beyond the external surface of the fleece. Many of the very heavily wrinkled merinos produce this grade. These include all of the merino wools except the Delaine; that belongs under the head of combing.

The lower grades are made by dealers according to fineness and quality, without a knowledge (which would be impossible to attain) of the precise fraction of merino blood of the sheep producing them. The one-half blood grade largely receives the fleeces from Merino-Southdown and Merino-Shropshire crosses, also some of the fine Southdown fleeces. The three-eighth blood grade takes much of the pure Down fleeces of the families that were originally a cross of the Southdown with some of the long-wool breeds, which is in fact most of them. It also takes them from the more recent crosses of Merino and some of the long wools. The one-fourth blood, or coarse, is a small grade of inferior short wool, too coarse for either of the above grades, a product of mongrel breeding and poor care. All the above grades comprise only the shorter fibred fleeces. The majority of half-blood wool from well-kept sheep and that from highly-kept Down flocks go into combing grades.

The combing wools are of two classes. Formerly they were exclusively of the English mutton breeds, or at least were not of merino origin. The exigencies of wool manufacture, the insufficiency of supply of true combing wool, made it however necessary to adapt machinery for combing the merino carding or felting wools. This rendered necessary a fibre longer than 2½ inches, which is about the length of the finer qualities. A considerable difference always existed in length of fibre of different families under different climatic and nutritive conditions; it was easy, by selection and breeding, to increase the length, a process of modification which has been in progress for many years. This merino division of combing wools known as "Delaine" is classified in three grades—fine, the finest of long staple; medium, not quite so fine, and low, of combing length and a little finer than the combing wool of mutton breeds. Besides length and strength of staple, a fleece to be Delaine must have that character of fibre that spins well. This is indicated by a closely clinging fleece. The opposite character is indicated by a fleece in which the locks are somewhat detached and have a sort of tapering, corkscrew end.

The combing wool of mutton breeds are classed as three-eighths blood, one-fourth blood, common and braid, the last being the long and lustrous wools of the Lincolns, and also of Leicesters and Cotswolds.

The wools intended for worsted spinning are better with latent than strong felting properties, whereas with reference to wools for carding, *i. e.*, clothing wools, felting is a potent factor, especially if required for fabrics where fulling during the process of finishing is essential. In worsteds, wools that have few felting qualities, but otherwise are of good, long and fine staple, are often preferred on account of their lustre.

Besides Clothing and Combing wools we find what are known as *Carpet wools*, they being coarse wools obtained from the Mexican sheep as bred extensively in our Western States, Canadian breeds of sheep, or wools imported from Asia (the fat-tailed sheep), etc., etc., and are considerably intermixed with hair.

The Strength of Staple is the next important consideration. This is determined by pulling a few fibres out of a lock of wool, grasping them at their ends with the thumb and finger of both hands, and when a steady, hard pull will soon show weakness in them, provided any exists. Weakness of the staple may or may not prove a barrier to the use of a wool under consideration, it all depending upon the extent of this defect and whether the material is destined for warp, combing or filling yarn, in the first two instances strength being absolutely necessary.

Elasticity of Staple is also a very essential characteristic and may be described as the facility with which all good wools assume their former proportions after being compressed or stretched. This quality is one of considerable moment, as it practically determines the working quality of the wool, since an elastic fibre will work up with less loss than a non-elastic, as the wool will stretch under strain during its manufacture into yarn and fabric, and thus accommodate itself in the passage through the different processes without breaking the fibre, in turn reducing waste to a minimum.

Length of Staple is a point regulated by the class of yarn for which the wool is required, and as mentioned previously, short staple wools are more adapted for carding purposes, while longer staples will result in less "noil" in combing. For example if required to produce the filling for a lot of face-finished fabrics, as Doeskin, Broadcloth, Beavers, Kerseys, etc., long staple stock would be unsuitable, since in this instance we must produce a yarn with a velvet or nap, as we would technically call it, *i. e.*, a yarn resembling a chenille thread, *i. e.*, a great number of ends of the individual fibres as composing the thread, protruding from the body of the thread so as to assist us during the process of finishing the cloth (gigging or napping) in getting a full nap or pile on its face, produced by the ends of the fibres extending out of the body of the threads, or in other words out the face of the cloth. For warp yarns for these fabrics we may want a longer staple wool, so as to produce a yarn which will weave well, yet on account of the nap required for the finished cloth, we must be careful not to use a longer staple than absolutely necessary. In purchasing it is therefore essential for a manufacturer to keep in view the kind of cloth he is intending to produce. Clothing wools are usually softer, finer and shorter than combing wools; but, on the contrary, short, fine wool is often combed, so that no hard and fast rules can be laid down in these respects. Softness is generally a desirable quality, but if we have to make a cheviot or serge character of fabric it is not very essential, as the property for which these cloths are noted is a certain crispness of handle and touch, which can only be obtained from a wool possessing these properties in its natural state.

Trueness of the Fibre relates more or less to strength of staple, previously referred to. Under true or even fibres, we classify those having a nearly uniform diameter throughout their entire length, whereas, fibres wanting this character are termed untrue or uneven, the latter being characterized by variations in diameter on the same fibre, a feature which will seriously interfere with the working quality of the wool. A specimen of an untrue fibre, highly magnified, is shown in Fig. 6, which will readily show that where these abnormal forms occur, there are changes in the form and size of the outer scales as well as in the diameter of the fibre, consequently the internal structure of the fibre must be equally affected, thus reducing the strength and elasticity of such fibres. It is well known that a chain is no stronger than its weakest link, and, in a similar manner, we may say that the strength of a wool fibre is proportionate to its smallest cross section; so that the buyer, in judging of such a wool would measure its value to him by this very defect.

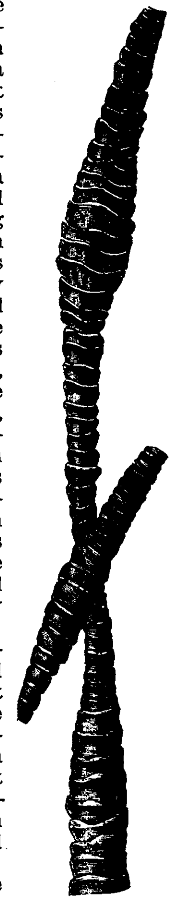


Fig. 6.

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

Cleanliness of Wool means absence of superfluous grease and all dirt, the first being composed of neutral fats and the latter of earthy matter, burrs, etc. The presence of these impurities in some classes of wools—for example, in South American wools—may reach 75% of the weight of the fleece, whereas in connection with other wools it often falls as low as 50% of the weight. Consequently good judgment as to the probable amount of actual wool fibre in a given lot of wool must be exercised by the buyer, requiring an experienced person for this position.

Absence of Kemp. Kemps are another kind of imperfect fibres met with in wool. The characteristics of an ordinary kemp fibre is a hair of dead silvery white, thicker and shorter than the good wool. Kemp fibres do not seem to differ considerably in their chemical composition from the good or true wool fibres, but possess no absorbent power, thus resisting either entirely, or partly, the entrance of dye-stuffs, in the latter case producing a different shade from that imparted to the good fibres of the same lot, hence kemp fibres will be readily detected in dyed lots of wool, yarns or fabrics. The presence of kemp fibres in a lot of wool will also result in poor spinning and poor yarn, since they will not thoroughly combine with the good wool, and will show prominently on the face of the yarn or fabric. Neither will they felt. The accompanying illustrations Figs. 7 and 8, are given to illustrate various degrees of these kempy fibres. Fig. 7, A, is a fibre in which the kempy structure continues throughout the entire fibre, and which looks more or less like a glass rod, yet has short and faint transverse lines which indicate the margins of the scales. When the change is a complete one, even the application of caustic alkali fails to bring out the lamination of the scales with any degree of distinctness. In Fig. 7, B, a fibre is shown in which the change from true wool to kemp is only partial. The lower portion of the fibre shows wool structure (the scales being distinctly visible), whereas the central portion of the fibre shows kemp structure (having the scales closely attached to the body of the fibre, giving the latter the usual ivory-like appearance). The upper portion of the fibre leans again towards wool structure. Both illustrations, Figs. 7, A and B, are representations of fibres seen by reflected light. In Figs. 8, A and B, illustrations are given of kemp fibres seen by transmitted light. In Fig. 8, A, a kempy fibre is seen with transmitted light and where we see again a gradual passage of wool structure into kemp. In this case, with transmitted light, the kempy part retains almost the same transparency as the wool, but exhibits none of the interior arrangement of cells. The fibre shown in Fig. 8, B, is practically kempt structure. In the wild breeds of sheep kemp is plentiful and appears to be part of their nature; and in domestic sheep it may be looked upon as an inherent tendency to reversion to the original and native type of the animal. It is sometimes found in the finest grades of wool as well as in the coarsest. In the fine wool sheep, kemp occurs most frequently in the neck of the fleece and on the legs, whereas in the coarse wooled sheep, it may be found on any part, especially if there is a lack of trueness in the blood. The presence of kemp in a fleece greatly depreciates the value of the lot of wool, and a buyer is always cautious to ascertain if wools contain them.

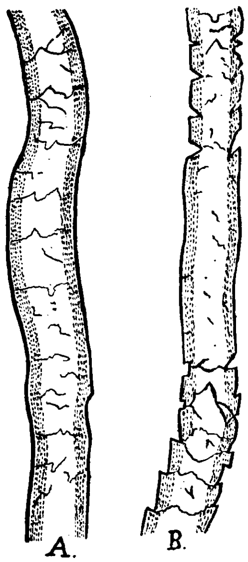


Fig. 7.

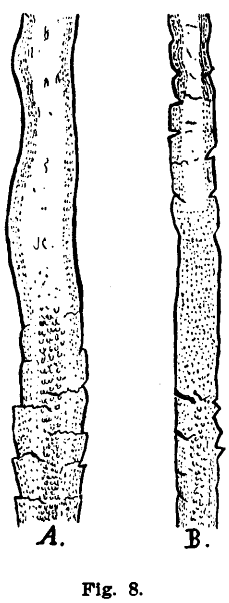


Fig. 8.

The Lustre of Wool varies considerably in the different breeds of sheep, straight, smooth, stiff wool having more lustre than curly merino wool. The amount of lustre of the wool depends partly upon the internal structure of the fibre, but chiefly upon the varying arrangement and transparency of the scales on the surface of the fibre. Some classes of wool are characterized by the lustre of their fibres and in connection with such wool, its presence is a sure indication of a healthy fleece and a good guarantee of its working qualities.

The Natural Color of Wool, and the one in which the same is most generally found is white, in less quantities and in lower qualities, we find brown, black, gray, red, or a faint yellow. White, though not always essential, is a very desirable quality.

The color varies to a considerable extent with the kind of soil on which the sheep pasture, rich grass lands favoring a pure white, whilst a sandy soil usually tinges the wool a faint yellow. This coloration of the fibre is caused by the presence of an organic pigment in the cortical portion of the fibre. For dark shades this natural color of wool is not of great objection, but for light delicate shades of colors it is essential to have a good pure white fleece.

Moisture in Wool as it comes from the sheep's back varies from 6 to 24%, and for which reason attention should be paid that no excess of it is present, since wool loaded with excess of moisture means loss to the buyer.

To ascertain the exact amount of moisture present in a lot of wool, take a sample of it, weigh it, and then subject it for half an hour to a temperature of 212° F. The wool is then weighed and the procedure repeated until the latter weight is constant. This weight subtracted from the original weight gives the moisture in the sample and from which the percentage can be readily ascertained.

No standard of moisture for wool in grease exists, since the amount of moisture in unwashed wool varies with the amount of fatty matter it contains; the more fatty matter, the less moisture; but with reference to scoured wools, the permissible limit of moisture in wool is:

17% measured with perfectly dry wool as a basis for clothing wool; and

18¼% measured with perfectly dry wool as a basis for combing wools.

VARIOUS CLASSES OF SHEEP.

Amongst the breeds of sheep of consequence in this country are:

The Lincoln Sheep, being a breed originating in Lincolnshire, England from crossing the native breed of that part of the country with the Leicester breed.

The Leicester, or what is now called the New Leicester sheep, was originated by crossing the old Leicester with several different species of sheep. The fleece is fine, glossy, white and of moderate length, the external structure of the fibres being shown highly magnified in Fig. 9.

The Cotswold Sheep originated in Gloucestershire, England, and received their name from the hills on which they were raised. These sheep produce a large, white, coarse, long wool, and the breed has become practically native to this country. The structure of the fibres is shown in Fig. 10. In the Cotswold, we find the lines indicating the edges of the scales more irregular and broken than in the Leicester and Lincoln; and more so in the Lincoln than in the Leicester. In all of them the scales are more or less oblong, but in width they are much larger than in the Downs and Merinos.

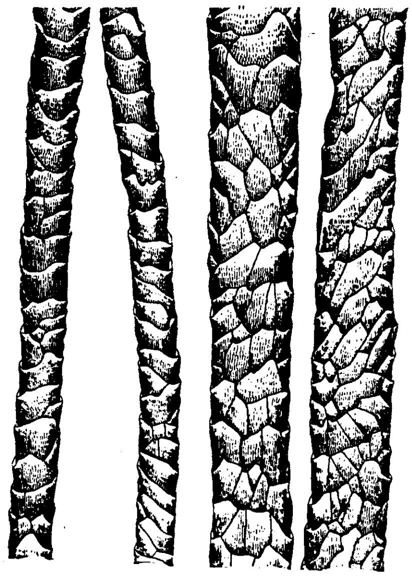


Fig. 9.

If we compare locks of Cotswold and Lincoln wool we find that a larger proportion of the fibres in the former are more white and opaque than the others, and that the whole bunch has very much less of lustre than the Lincoln wool. When these Cotswold fibres are examined in the natural state with the microscope, we find extending through the centre a band of matter more or less broad, which is very much more opaque than the matter surrounding it. The forms of this band are given in the illustration of Cotswold wools. It appears to be of irregular thickness and to allow more light to pass through at certain places than at others.

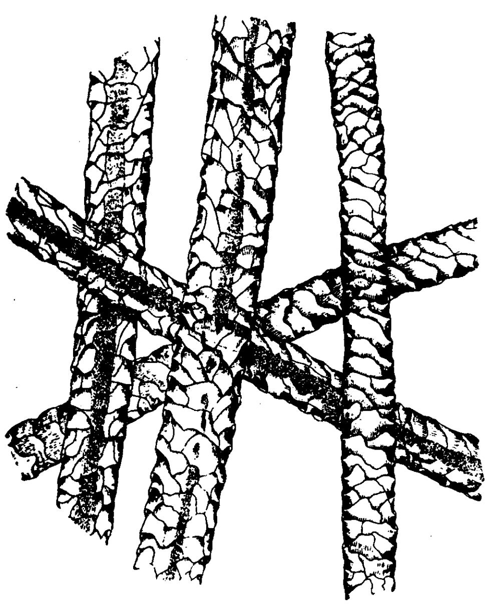


Fig. 10.

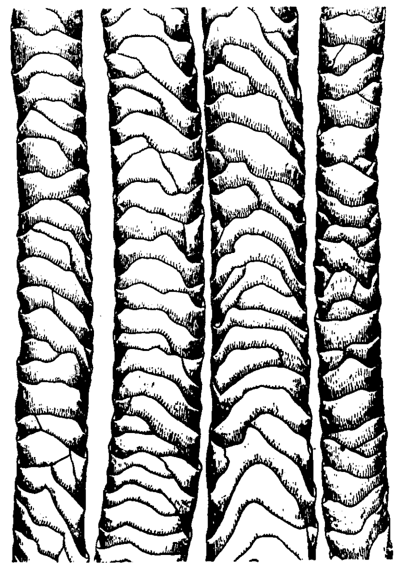


Fig. 11.

The Oxford Down Sheep is also of English origin, being a cross between the Cotswold ram and the Hampshire Down ewe. The wool produced by the Oxford Down is finer and firmer than that of the Cotswold and has a staple of from 5 to 7 inches in length, the average weight of the fleece being 9 pounds. Fig. 11 shows typical specimens of these fibres highly magnified. The wool of this sheep, as well as that from the Cotswold, the Leicester and the Lincoln are the most important classes of what we term long staple wools, vice versa the Merino and the Southdown sheep, which are the most important breeds of sheep, producing what we term short staple, carding or clothing wools.

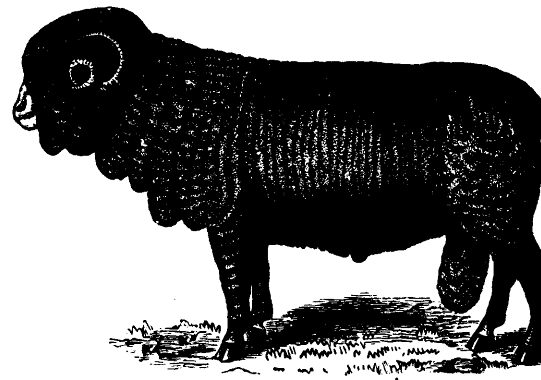


Fig. 12.

The Merino Sheep. The original home of this animal is Spain, from there they have been spread during the last two centuries through every quarter of the globe. The great value of the merino wool consists in the fineness and felting property of their fibres, as well as the weight of the fleece, the average weight of which is 8 pounds from the ram and 5 pounds from the ewe.

In Fig. 12 a specimen of the Saxon merino is shown, being an animal superior in quality of wool produced to the Spanish merino, and is a grade of merino previously referred to as found to a very small extent in the western part of Pennsylvania (and Eastern Ohio), producing what is considered the finest grade of wool (picklock) in the market.

Fig. 13 shows the average American merino, which is a fine white wool sheep of medium size, equally built, the body rather short, round and thick. It has good quarters, stout legs which are short and woolly,

Fig. 13.

short ears; its cheeks and forehead to the eyes being thickly covered with wool, its skin being wrinkled or in folds, and of a rosy color. This sheep produces the XXX, XX and X grades of our wool supply. Typical specimens of merino fibres have been previously given in Fig. 1.

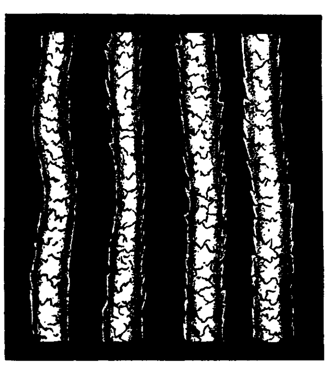


Fig. 14.

The Southdown Sheep, while originating in England, has become also a very important factor in sheep raising in this country. This breed is characterized by the dark faces and compact fleeces of the sheep, the average weight of the fleece being 6 pounds and the wool is well adapted for spinning good grades of woolen yarns.

Imported Wools. Amongst the most important imported wools we find the Australian Merino. Different grades of them are raised according to climate and soil as well as different breeds of sheep crossed with merino, one of the best and most important being the Leicester Botany, typical fibres of which from different portions of the fleece are given in Fig. 14. In these fibres we have the curl and softness of the merino, united with the length and lustre of the best deep-grown English wool. South America, chiefly the Argentine Republic and to a less extent Uruguay, also exports merino wool, which is characterized by its immense amount of screw burrs adhering to the fleece.

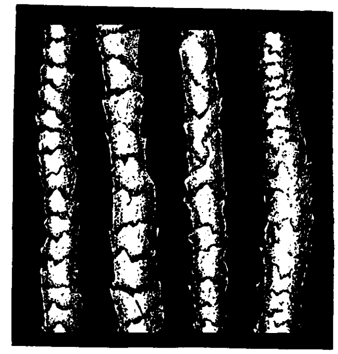


Fig. 15.

With reference to coarse imported wools (carpet wools) a most important class is that obtained from the fat-tailed sheep of Asia. These sheep are characterized by their enormous tails, which is one mass of fat. The wool is coarse and freely intermixed with dark colored hair, Fig. 15 being a magnified view of several fibres, showing the structure of fine, coarse and mixed fibres of a fleece from this sheep.

Hog's Wool, is a term applied to wool fibres that are clipped from the lamb during its first shearing. These fibres are characterized by a curly appearance and pliable staple, and are well suited for spinning fine woolen yarns.

Burry Wools. We should always try and obtain our wool as free from burrs as possible. With reference to domestic wools, burrs will not be met with extensively, and when found, are readily removed by means of burr picking. Although now and then, burry lots of wool or individual fleeces may be met with in domestic wool, the name "burry wools" more particularly referring to wools as imported from South America, and which wool is literally speaking a home for burrs, the fleeces being covered with them. These burrs or burr weeds are quite different from ours, and are known as screw burrs, having spiral or conical seed-pods covered with densely-set horny spines, which readily hook into the woolly covering on the sheep's back and are hard to remove, requiring for this purpose an extra efficiently built burrpicker, or if the same is not on hand, or in connection with extra bad cases, carbonizing.

Wool from Slaughtered Sheep. Besides wool as taken from the live sheep, we also come in contact with such as taken from the slaughtered sheep and where the wool is removed from the skin in two ways, *i. e.*, either by cutting or by a chemical process. The first process requires more labor than the chemical process, hence is less practiced, but by means of it the wool fibres will not suffer in their quality. The chemical process, and the one most generally practiced, consists in steeping the pelts for a length of time in lime or in a dilute solution of sodium sulphide, by means of which the fibres become sufficiently loosened at their roots, so that they can be readily removed from the skin. Such wool is known as "pulled wool" and on account of the hurtful action of the lime or sodium sulphide, is inferior in quality to shorn wool.

The process of using sodium sulphide so that the wool may readily be removed from the pelt is as follows:

The skins are placed on tables flesh side up. Care should be taken that they are perfectly smooth on the surface. Apply sulphide of sodium to the skins with a vegetable fibre brush or a swab made of burlap. A sufficient quantity of the solution should be used to cover the skins fairly, but not enough to run off skins. Fold the skins up, wool out, and place in a pile. In cold weather 6 to 8 may be put in a pile together, but in warm weather 2 to 4, and if they are to lay 24 hours or longer in warm weather it will be much better to single them; that is, lay them out so that one will lay over the next and so on.

If possible this operation should take place in a cool, moist room and in winter care should be taken that the skins are not frozen. The wool should start well in 5 to 6 hours after painting. It makes much cleaner work to pull next day after painting. Cleaner and better results are obtained to pull the skins double as they come from the painters, for in this way only the wool side is exposed and there is much less chance for any of the sulphide to come in contact with the wool.

Wool from Diseased Sheep, live or dead, it will be readily understood, is inferior in quality to wool taken from a healthy animal of the same breed. Not only will such wool cause poor yarn, but it also will behave differently in dyeing, as compared to the healthy fibres, it will not dye as full a shade.

GRADING AND SORTING.

The wool after being shorn from the sheep at the ranch or farm, as the case may be, is next folded and rolled up, each fleece in a package and tied up with a string, in order to make further handling easier, any number of these fleeces being then placed in a large sack and in this manner reach either the commission merchants in the East (Boston being the wool centre) or the larger mills which send out their own wool buyers direct.

In the putting up of wool for market there has long been a cause of variance and friction between grower and buyer in all parts of the country. The buyer complains of filthy tags and dirt in the fleeces, and of the use of unnecessary quantities of unreasonably large twine of a fibrous quality that injures the fabric in the manufacture, by means of these vegetable, jute, hemp or waste fibres of every description intermingling with the wool fibres, and in turn being directly the cause of an unnecessary amount of specks in the fabrics, the removal of which requires time and labor and consequently means extra expenses to the manufacturer. The same also refers to the quality of bagging used by the sheep raiser in packing the fleeces. On the other hand, growers say that when they exercise the greatest care in all these respects, the buyers will allow no discrimination in price. There is doubtless some truth in these countercharges, yet a lot of fleeces carefully handled, of even quality, would claim some consideration from a practical buyer, or they could be sent to a reliable commission house and command a price that would pay well for the extra care.

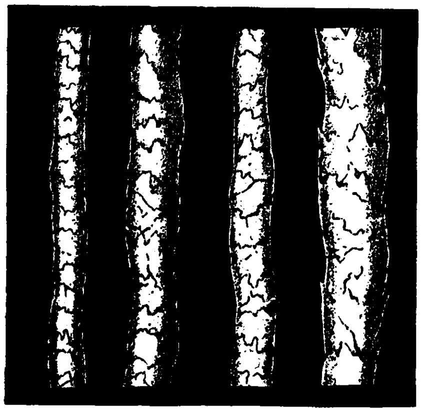
The advisability of washing sheep before shearing has long been a subject for discussion. Its purpose is the better condition and higher price of the wool. The difficulty presented, which appears to be insuperable, is in obtaining a uniform condition of cleanliness. Necessarily some flocks have more foreign matter in their fleeces than others; there is always great difference in the amount of yolk or grease which the ordinary washing does not affect. Facilities for washing are very poor on many farms and ranches, and different methods of washing are very unequal in their results. If a grower is not inclined to be exactly square in his dealings, or if his perceptions of strict honesty are a little confused by the unfairness of buyers in making no discrimination as to degrees of cleanness in buying, he may slight the process or drive the flock through muddy water. Altogether most flock raisers prefer not to wash, and nearly all dealers unite in a preference for unwashed wools. They find so much unevenness, that in buying washed wool, they usually make some deduction from established washed rates, and in some cases pay little more than for unwashed. It is said that much of the country washing is a positive disadvantage in scouring the wool. Therefore the practice of washing is declining; in many districts it has been altogether abandoned. There are many of these scouring mill plants, even as far west as New Mexico. The saving of the freight on the grease and dirt certainly should be a large item in favor of sending only scoured wool (certainly being only partly scoured wool to the manufacturer for his mill) East.

In some instances the fleeces are graded, for one reason or the other, by the commission merchant, but no matter from which source they reach the mill, when arriving there, each and every fleece is graded properly by a competent expert employed by the mill for this purpose, before the fleeces reach the wool sorter. This is done by the mill for the fact that there is no standard or basis or fast rule of grading, and in the nature of wool there never can be. Persons may have what they call a standard grade, but such a standard will be merely an understanding of these people among themselves. For example, what one or more graders might only call a one-half blood, other equally competent graders might term a low three-fourths blood, etc. Certainly with reference to pronounced fleeces, *i. e.*, full grades, no two expert graders would differ, all disputes regarding fleeces chiefly arising when dealing with what are termed "liners," being fleeces which more or less fall between grades, and which one expert might class with the higher and the other with the lower grade. Every mill has its own idea of grades, and it is therefore particular to have its purchases examined by its own grader, in order to be sure that the wool is graded as desired by them.

Sorting and grading are in smaller mills frequently done by one person, but in large mills, especially those large and prominent woolen and worsted mills where wool sorting is not only required but at the same time its value understood, and where division of labor can be profitably made, one person (or two if the mill is very large) grades the fleeces which several others in turn sort. Grading the wool consists in separating a lot of fleeces into various grades, according to the fineness or coarseness of the fibre, and sometimes according to the length of the staple, and this refers to possibly thousands and thousands of fleeces in a certain lot of wool bought by the mill; whereas sorting consists in taking the fleece and separating the finer and coarser parts. It will be readily understood that fleeces graded by an expert in a mill will certainly simplify the work of the sorters considerably, besides resulting in more wool sorted in a given time by each sorter.

The sorter's work is one requiring constant care, a quick eye, and good judgment, which can only come from long experience. To the uninitiated he appears to work without thought, but there is no work requiring more care, especially in mills whose product is yarn which it is desirable to have of a constant uniform grade. Before explaining the procedure of sorting, it will be in its place to refer to the object of sorting which finds its necessity in the fact that wool not only varies in quality with different animals, but also on one and the same sheep.

The character of the breed and the pasturage that is afforded to the animals have an important bearing on the wool fibres of commerce and the structural characteristics of wool produced on the different parts of the body. The uniformity of length and of diameter, and the number of scales per inch, vary in different individuals, even among the same breed of sheep. The best is that from the shoulders, the lower part of the neck, the back and the upper part of the sides, while that which covers the head, breech, tail, belly and legs is of an inferior quality.



A B C D

Fig. 16.

To illustrate the influence of taking care or not of sheep, as well as the variation in fibres on the same sheep, the accompanying illustration Fig. 16 is given, representing:—

A. Specimen of a fibre taken from the shoulder of a sheep which had proper care;

B. Specimen of a fibre taken from the breech of the same fleece as fibre A was taken from;

C. Specimen of a fibre taken from the shoulder of a sheep of the same class from which fibres A and B had been taken but where the animal was poorly-bred, *i. e.*, neglected;

D. Specimen of a fibre taken from the breech of the same fleece as fibre C was taken from.

In some mills, making an average class of fabrics, grading or sorting or both is omitted, the mill in this case running on one or possibly two standard qualities of yarn only and where they rely on the judgment of the commission merchant, with reference to a lot of wool, for their wants, from which it will be seen that by such mills the services of a grader or sorter are not required.

The first task for the sorter when the fleeces reach him, from the grader, is to open the first fleece, *i. e.*, undo the strings placed by the wool grower about the fleece in order to keep the latter compact by itself in the wool bag. The grader was not compelled to cut this string for the reason that he has been able to determine the grade of the fleece in question by pulling out bits of staple here and there from the fleece, thus averaging the whole fleece. After the strings are removed, the fleece is shaken out by the sorter on his sorting table, thus separating from the whole fleece any loose pieces of wool, called "locks," as well as bits of short, coarse, and dirty wool as are occasionally rolled up inside the fleece and which are called "stuffings." These droppings from the fleece must in turn be separately sorted, since coarse and fine fibres are apt to be mixed up together.

The fleece is now spread out by the sorter on his table, so that he can readily separate the coarser and finer parts from the fleece.

Before explaining and illustrating Sorting proper, it is not out of place to refer to what is known as "Clips" or rejections, and which are portions of wool which must be treated entirely different in the mill than the other wool of the fleece. By clips we refer to portions of wool heavily contaminated with burrs, or hardened paint, tar or hard lumps of manure; or possibly to be badly, perhaps irremediably stained. The sorter then clips off the wool containing such hard bits of paint, tar, and hard lumps of manure, and tears out any irremediably stained portions as well as such filled with burrs not easily removable, and puts these various clippings in a sort by themselves, since such wool has to be treated differently during scouring and picking than the wool from the rest of the fleece. It must be mentioned here that the amount of these clippings varies considerably with certain lots of wool, fine, high priced and consequently carefully raised wool having little if any, whereas in connection with cheap grades of wool, carelessly raised, these clippings are of considerable proportions, and consequently increase the cost of such a lot of wool to the mill.

The fleece is now in a condition to be sorted into its different grades. As previously mentioned, two main divisions are fixed for the classification of wools, viz.:

Clothing wools and which are wools to be carded and spun into woolen yarns; and

Combing wools which are wools combed during their manufacture into worsted yarns.

For either kind, a different sorting of the fleece is used, the two diagrams Figs. 17 and 18, showing the procedure as practiced in either case.

Fig. 17 refers to grading clothing wools. In this diagram, 1 indicates the portion of the fleece where the best wool grows, and the other numerals indicate successively lower or coarser portions of the fleece. The different grades on the fleece have regular terms

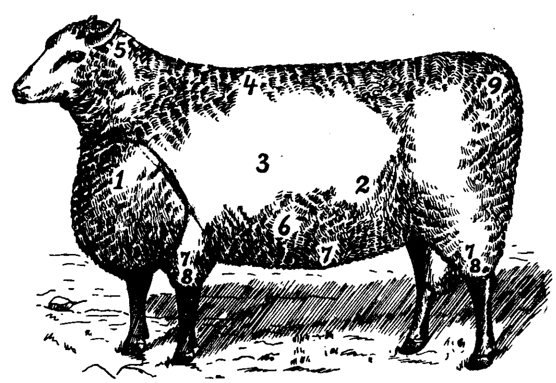


Fig. 17.

and are as follows: 1—Picklock; 2—Prime; 3—Choice; 4—Super; 5—Head; 6—Downrights; 7—Seconds; 8—Abb; 9—Breech.

The grading of the fleece of combing wools, with reference to diagram Fig. 18 is as follows: 1—Fine; 2—Blue; 3—Neat; 4—Brown; 5—Breech; 6—Downrights; 7—Seconds; 8—Abb. The grades 6, 7 and 8 are rarely used for spinning worsted yarns on account of their unsuitability for combing, and hence find their way into low grades of carded yarns.

We will thus see that the finest and most even grown staples are found on the shoulders and sides of the fleece, the lower part of the back yielding a staple of fairly good quality, resembling that from the shoulders. On the loin and the back of the sheep the staple is shorter and of a more tender nature. The upper parts of the legs yield a long and strong wool, which hangs in large, open locks. It is this part of the fleece which comes in contact with the burr plant if such is found on the pasture land,

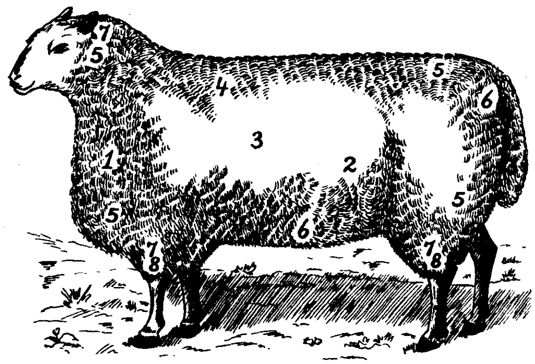


Fig. 18.

and causes the burrs to become entangled in the wool. This item also refers to that portion of the fleece as grown on the lower portions of the sides of the animal. The upper part of the neck gives an irregular staple that is often infested by the spinose leaves of wild prairie plants and seeds. If there is any gray wool in the fleece, it is generally found here. The wool grown on the belly is short and fine, but as a rule, dirty, said wool having been cramped in its growth when the sheep has been lying down, for which reason it is always more or less matted, and besides this, it is apt to be stained by material on which the sheep has lain. That portion of the fleece which is taken from the vicinity of the ears is invariably coarse and of an inferior grade. On the chest and throat, the wool is usually short and apt to be worn from rubbing. The coarsest part of the fleece grows about the hind quarters or breech, and on the tail.

Sometimes, however, the fleece has a dingy brown color, called a "Winter stain," which is a sure indication that the wool is not in a thoroughly sound state. Such fleeces are thrown out by the wool sorter, being suitable only for goods that are to be dyed black or dark colors.

Wool Sorter's Disease (Anthrax) is caused by Bacillus Anthracis, which may enter the system either by the skin or by the internal organs. In the former case it gives rise to pustules, which become painful and cause perspiration, fever, delirium, and other disorders. In the latter case it produces the most serious ailments, such as blood-poisoning and inflammation of the lungs, which often prove speedily fatal.

THEORY OF FELTING IN THE WOOL FIBRE.

When woolen cloth is felted or fulled, it always shrinks in length and width and increases in thickness, the individual fibres becoming more intimately associated with each other, and form as a result a fabric which is very compact in structure. In some instances the process is carried to such an extent, that the yarns in the fabric practically lose their individuality and appear as a solid mass. Naturally what is true of the fabric must be true of the parts of which it is built up, and consequently if the cloth, or yarns shrink or contract, then the fibres composing them must have contracted. This fact may be proved by taking a lock of wool having felting properties and carefully measuring the length and diameter of its staple; then put it in a thin cotton bag and sew the latter to a piece of cloth which is to be fulled. After thus fulling the lock of wool for some time, take it out of the bag and carefully measure its staple again. A comparison of the two measurements will show that after fulling, the fibres have increased in thickness and decreased in length.

Let us first consider what are the conditions necessary for felting, then we may be in a better position to comprehend the causes of felting. The primary and essential requirements for felting are the presence of heat and moisture. The primary qualities of a good felting wool are, a large number of spindle shaped cells with extremely thin and elastic walls, which respond very readily to the influence of water and heat, and permit of its free absorption into every portion of the fibre. The cells must be small, so as to impart the necessary flexibility and elastic nature, in order to enable the fibres to readily intermingle and mat together. Its constitution must be more of the nature of gelatine than horn, so that when submitted to the action of hot water, assisted by acids and alkalies, the cell walls are readily softened. The central or medullary portion of the fibre is absent in wools having the best felting qualities.

A microscopical examination of a cross section of a fibre before and after felting, will show that the form of the cells, composing the inner structure, and the scales composing the outer structure have materially changed. The scales of the fibre in their normal condition are flat and very dense, and the internal cells only exhibit a small cell cavity, while after felting, it will be found that the outer cells have lost their flattened form and become swollen, and in some cases, a distinct cell cavity may be present. The inner cells have also increased in width, and the diameter of the fibre as a whole is greater.

If we take a single wool fibre, measure it, and then moisten it, and then attach a small weight to it, so as to stretch it, its length will be increased; but when released and allowed to dry, perfectly free, it will shrink. This experiment will show that the presence of moisture endows the wool fibre with peculiar properties, and felting, in the true sense of the term, cannot be produced in its absence, no matter how much we agitate wool, or how entangled it may be. The combined action of hot water and acids causes the cell walls to soften, change in form, and adhere more closely together, this becoming more pronounced where pressure is applied as well. Under these circumstances the cells and fibres lose their individuality, and become practically matted together into a more or less homogeneous mass.

The various wools exhibit a diversity in their power of felting, and some scarcely have that property at all, even when apparently suitable conditions are present, and the conclusion which we thus arrive at is that some inherent difference exists in the structure of the different fibres. This brings us to the point where it is necessary to know the properties of different structures of fibres, that is, of their scales and inner cells. It has been found that those cells, which possess the thinnest and most elastic walls, will yield most readily and receive the greatest modification. This is a characteristic feature of the best felting wools. The extent of the modification is very largely dependent upon the rigidity of the walls of the cells, and it is even found that one portion of the same fibre will felt better than another portion, due to the cells in the first portion of the fibre being thinner and more easily influenced by external agents than other portions in which the cells have undergone a kind of secondary thickening.

We know from experience and observation that the felting may be accelerated by certain conditions, such as heat, pressure and the presence of alkalies and acids, and this is best accounted for on the assumption that these agents produce some change in the cell's fibre itself, rather than only the interlocking of the superficial scales of adjacent fibres.

We have seen that an ordinary felting wool, when treated properly, will shrink, but the process must be carried on under suitable conditions and the wool must be in a certain state in order to get results. It is well known that, although a worsted thread will felt to a certain extent, the property is not present to the same extent as with a woolen thread. The most logical reason, with our knowledge of what produces felting, is in the construction of the thread, which is such in worsted yarn, that it prevents the requisite shrinkage taking place to enable the fibres to felt, since the ends of each fibre are more or less fixed, and practically no decrease in their length can take place, this being also further prevented by their being tightly wrapped around each other. On the other hand, in a woolen thread, the fibres are disposed in a different manner to those of a worsted thread. By means of carding they cross and recross each other in every direction, no attempt being made to impart any regular arrangement to them. All kinds of fibres are utilized, both long and short, curly and straight, entering into the construction of the yarn. Further, since they are not tightly bound down throughout their length by twist in the yarn, the ends are to a great extent free, and hence are more easily acted upon. Thus when much felting is required in a woolen thread, it is made loose and open, so as to admit of all the fibres readily responding to the action of the moisture and mechanical operations.

CHEMICAL COMPOSITION OF WOOL.

Wool fibre that has been freed from foreign matters consists principally of keratin, which is similar in chemical composition to horn and feathers, and which varies somewhat in composition in different wools. The presence of sulphur in wool is readily detected when the latter is burned, and the odor given off is characteristic of all burnt horny substances. This is one of the simplest methods of ascertaining whether a yarn is wool or cotton, since the latter is composed chiefly of cellulose, which is very different in composition from wool, and does not give off that odor. Besides this, the cotton fibre is highly inflammable, while, on the other hand, wool does not burn readily, but frizzles when in contact with a flame, leaving a charred mass.

A quantitative analysis of a good average wool shows it to have approximately the following composition:

Carbon	50%
Hydrogen	7 "
Oxygen	24 "
Nitrogen	15 "
Sulphur	4 "
	100

The presence of sulphur in wool is, in some cases, liable to cause dark stains on the wool, when the fibre comes in contact with either metallic salts in the dye bath or metallic surfaces during processes of dyeing, due to the formation of metallic sulphides. On the other hand, when dyeing with certain basic coal tar dyestuffs, its presence seems to aid in the dyeing, for when wool, mordanted with sulphur, is dyed with these dyestuffs, a darker shade is produced than on unmordanted wool.

The behavior of wool towards certain chemical reagents differs considerably from that of the vegetable fibres. A solution of boiling caustic potash or soda dissolves wool very readily, and if acetic acid be added to this solution, sulphuretted hydrogen is evolved and a precipitate formed. Cold concentrated sulphuric acid does not decompose the fibres but merely loosens the scales, while on boiling the solution it dissolves the wool fairly quickly, and produces a reddish-brown solution. Hydrochloric and nitric acids also dissolve wool.

OTHER ANIMAL FIBRES

used in the textile industry are obtained from the Cashmere goat, the Angora goat, the Alpaca, the Camel, the common Goat, the Cow and the Horse.

The Cashmere Goat is a native of the district of that name in India. The fur of the Cashmere goat is of two sorts, viz.: a soft, woolly, white or grayish

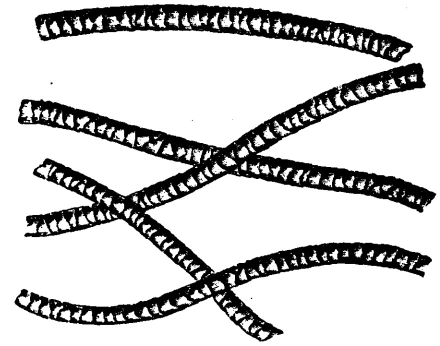


Fig. 19.

undercoat, and a coarse covering of long hairs, that seems to defend the previously mentioned undercoat from the effects of winter. The woolly undercoat, as will be readily understood, is the more valuable fibre and is wool fibre in its structure, as will be readily seen from illustration Fig. 19, which shows, greatly magnified, such fibres, and where the outer scales of the fibres are clearly visible. These fibres vary in length from 1¼ to 3½ inches, and possess no medullary substance. They are plucked from the animal, exported, and used in the manufacture of some of the finest textiles, both on account of the fineness of the fibres as well as its high price.

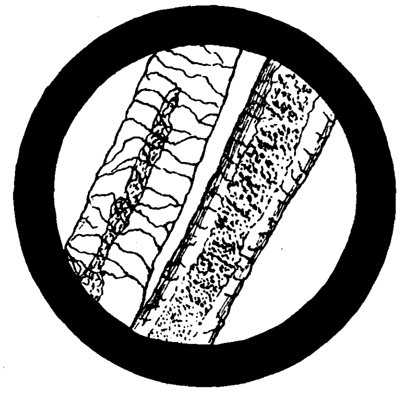


Fig. 20.

However, as a rule, the supply of this fibre is considerably intermixed with those long hairs of the outer fur of the animal, and which according to amount present reduce its value, since they must be separated from it. These outer hairs are of a length of from 3½ to 4½ inches, and possess the central or medullary substance, as seen by examining Fig. 20, which shows two such fibres highly magnified. These fibres are used in the manufacture of cheaper grades of yarns.

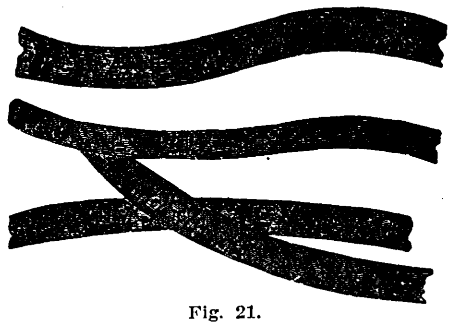


Fig. 21.

Mohair is the name given to the hairy covering of the Angora goat, a native of the interior of Asia Minor, but now extensively raised in Cape Colony and also to some extent here. Besides our domestic supply, mohair is also imported. It is of a pure white color (more rarely gray), rather fine, more or less curly, of high lustre, and on an average of from 5 to 6 inches long, although in some cases as long as 12 inches. Fig. 21 shows mohair fibres highly magnified, showing that their outer scales are extremely delicate, giving the fibres a spotted appearance all over their surface.

Besides the mohair, there grows upon the Angora goat a short, stiff hair, which is technically known as "kemp," a relic of the common goat. Its presence depends entirely upon the kind of breed of Angora, being nearly nil in the pure animal. This kemp fibre in mohair always reduces its value, in proportion to the amount that is present, for the same reason as explained in connection with kemp in the fleece of the sheep. Thus it will be seen that care must be taken by the buyer regarding the kempy condition of a lot of mohair under consideration.

The wide range of prices of mohair in the market is due to various causes, but to none so much as the unevenness in quality of fibres, since mohair in a general sense is an expansive term, covering the fleeces of goats of various Angora crosses.

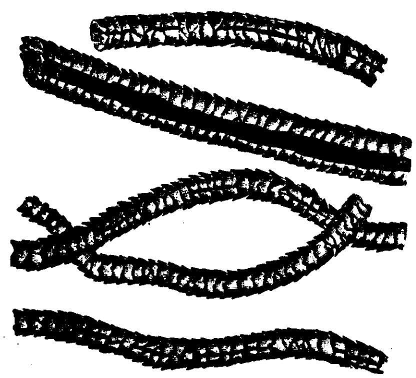


Fig. 22.

After sorting, scouring and drying, mohair is combed, the long fibres being used in spinning the yarns for plushes, fine dress goods, braids, etc., while the noils (which carry all the kemp fibres) go into the manufacture of carpets, blankets, hats, etc.

Alpaca and similar wools are obtained from a group of animals indigenous to the highlands of the South American Cordilleras, where they are met with in a domestic as well as wild state. The group of animals in question comprises the Alpaca, the Llama, the Vicugna and the Guanaco, and of which the one mentioned first is the most important.

The Alpaca is a domesticated animal, furnishing a fine fibre, about 6 to 8 inches long, except when the animal is only sheared once in two years, and when the fibre is then considerably longer. Its color is white, gray, brown or black. It is a lustrous fibre, although this lustre is inferior to that of mohair. The outer scales of the fibre are extremely fine, and the central or medullary substance is present either throughout its entire length or in small elongated masses. Fig. 22 shows Alpaca fibres, highly magnified. The fibre is used in the manufacture of dress-goods, suitings, over coatings, etc.

The Llama, in its native country, is employed as a beast of burden and furnishes a coarse, long unelastic, white and brown wool, mingled with true hair, and which is used in the manufacture of coarse yarns.

Vicugna Wool is seldom met with in commerce, for the fact that the animal is only hunted, and not bred for any domestic purposes. In its fur we also find two pronounced different kinds of fibres, viz.: a fine woolly under hair, covered with scales and free from medulla, and a coarse upper or beard hair, having the medullary substance strongly developed.

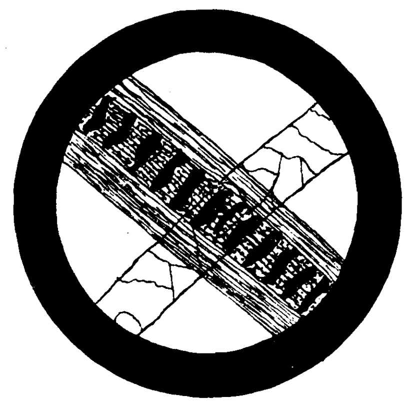


Fig. 23.

The Guanaco is another wild animal of this class, yielding fibres of varying quality, however it is of even less importance than the Vicugna.

Camel Hair is obtained from the Camel and the Dromedary, both animals being natives of Asia and Africa. Their hair is of two kinds, viz.: very fine, curly, reddish or yellow brown hairs, about 4 inches in length and known in commerce as camel wool, and coarse straight, dark brown to blackish body hairs, about 2 to 2½ inches long. Both kinds of hair show, under the microscope, faint scales. The medullary substance always appears in the coarse hair, whereas in the fine hair it is either wanting or appears in insulated masses. Camel wool is used either alone or in connection with wool, in the manufacture of ladies' dressgoods, overcoatings, driving belts, etc., whereas the coarse fibre is used in the manufacture of carpet and cheap backing yarns. It will be advisable to mention, that the fibres from the Alpaca, Llama and Vicugna are frequently referred to, in the market, as Camels hair. Fig. 23 shows Camel hair fibres highly magnified.

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

Cow and Calf Hair is also used for textile purposes, and is the hair removed from the hides of these animals in the tannery, by means of subjecting the pelts to the action of lime, the same as practiced with the pelt of the sheep. They are coarse, stiff fibres, of a white, reddish brown or black color, possessing a slight lustre, and in turn are spun, mixed with low grades of sheep wool, into coarse yarns, used for rugs, horse blankets, and similar coarse fabrics, as well as for backing yarns in cheap grades of overcoating, cloakings, etc. Fig. 24 shows a specimen of the fibre, highly magnified, clearly showing the central or medullary portion of the fibre. The fibre indicated by P in the illustration shows a pointed end of one of these hairs.

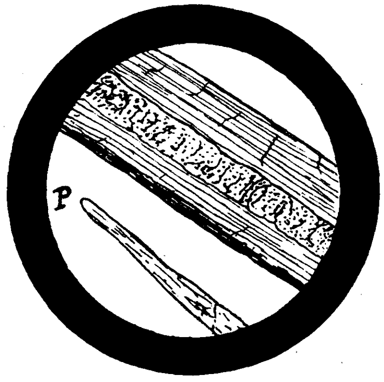


Fig. 24.

Horse Hair. Of this, two kinds are met with in commerce, viz.: tail hair, or the long hair, measuring at least 23 inches, though it occasionally attains a length of 32 to 34 inches, and mane hair, or the short hair, and which rarely exceeds 19 inches in length. White and black are the colors most esteemed, whilst red, gray, etc., hair is less valuable. Both, entire tails and pulled hair are sold. The hair is readily cleansed by simply washing it with soap and water, and is employed as filling in connection with a cotton warp in the manufacture of hair cloth, as used for upholstering furniture, as well as stiff linings for women's wear, etc., etc.

WOOL SCOURING.

Wool, as it comes from the sheep, contains many substances besides the wool fibre itself, and before the latter can be carded or dyed, these substances must be removed from the fibre. It is necessary not only that the processes used for this purpose shall clean the fibre from all adhering matter, but that they also leave the wool in the best possible condition for the further dyeing, carding, combing and spinning processes.

It must be remembered that if we destroy the natural softness of the fibre during scouring, by any kind of harsh treatment, we at the same time destroy its soundness, and may so hurt the fibre that it will be impossible to produce as fine a quality of yarn as should be afforded by that grade of wool under operation.

The impurities adhering to wool in its natural state consist of

First: Matter mechanically adhering to it, and which may consist simply of dirt, pieces of leaves, etc., and which are readily taken out during the process of scouring. But in some cases there are on the wool, burrs which adhere with tenacity, and cannot be entirely removed either by scouring or in the mixing picker, and for which reason the scoured wool has to be subjected to the action of a burr picker, or extracted, *i. e.*, carbonized; the latter being a process liable to leave the wool harsh, and thus is to be avoided whenever possible.

Secondly: A great variety of substances secreted from the sheep and which are mostly potassium salts derived from the soil and assimilated by the sheep through its food. These secreted substances can be divided into two classes, the first of which is the "yolk" or "suint," and which is probably the exudations of animal matter from the pores of the skin, which seems to be a natural provision for the proper lubrication of the fleece, and which substance is soluble in water, while the other substance known as "wool fat," is insoluble in water and can only be removed by alkaline liquids.

Suint or yolk consists mostly of soluble salts of potash, such as the carbonate, stearate, oleate, and probably also salts of palmitic and valeric acids. There are also present varying amounts of other salts of potash, such as the chlorides, sulphates, etc.

If we take a wool rich in these soluble potash salts, and wash it in warm water, and so continue with fresh lots, we soon get a very turbid, soapy liquor which acts as a mild scouring agent, and not only removes the yolk or suint from the fibre, but also some of the wool fat, by forming an emulsion with it. This action of these soluble potash salts would admit of the wool being almost thoroughly and completely washed in a stream of running water were it not for the presence in the fleece of wool fat, uncombined, chemically, with the yolk, which remains attached to the wool fibres, and refuses to pass off by the use of water only.

When applying alkalies to wool we must go carefully to work, for the fact that wool, subjected to the action of strong alkalies, dissolves, *i. e.*, we are taking away so much of the life element of the wool and thus spoil it for future perfect carding and spinning. Heat carried to excess acts upon wool in a similar manner, and if the heat employed exceeds 120° F., the soda acts upon the wool very adversely, as wool is very sensitive to the action of alkalies, especially at high temperatures. By the action of hot water the outer scales of the wool fibre are raised slightly and also the interior cells are penetrated and softened. The action is slightly increased if the water is a little acid, and this accounts for the well known fact that in dyeing wool, it can be boiled much longer in the sweet way than in a sour kettle, without matting. The action is still greater if the water is made alkaline, and in all such cases great care must be used in order not to injure the fibre.

To illustrate the influence of scouring liquor if either too hot or too strong, or both, upon the fibre, the accompanying three illustrations Figs. 25, 26 and 27 are given, and of which Fig. 25 represents a

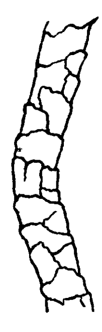


Fig. 25.

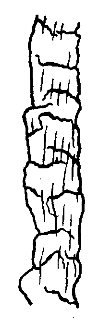


Fig. 26.

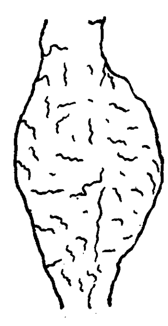


Fig. 27.

healthy wool fibre, magnified; Fig. 26 shows a similar fibre, when magnified, after being previously treated in a bath containing five per cent carbonate of soda to its weight and heated to about 100° F.; whereas Fig. 27 shows a similar fibre as visible by being treated in a bath containing only one per cent carbonate of soda to its weight, but being heated to 212° F. These results will clearly show that alkaline carbonates no doubt will hurt the fibre, but that boiling the scouring liquid will be more hurtful. These facts will readily demonstrate that the greatest of care must be exercised in scouring wool, since the latter may be injuriously acted upon by being subjected to too hot a scouring solution, or from being brought in contact with powerful alkalies. No rigid rule as to temperature can be furnished, this being a feature which varies according to the nature of the wool under operation, the best rule being never to have the scouring liquor a higher temperature than is absolutely necessary to cleanse the material properly, a pretty safe temperature being, not to exceed 110° F. for fine, nor 125° for coarse wools.

The substances used to remove the various impurities from wool are but few in number and, as a rule, consist of solutions of various alkaline salts in water. With the exception of a few cases in which volatile liquids are used, water is always the medium employed. It serves the double purpose of dissolving the chemicals to be used, thus enabling us to present them to the fibre in a solution of just the strength desired, and also as a carrier for the wool and the impurities removed from it. For this reason it is of the greatest importance to have good, soft water, for if it is hard, the scouring operation is made much more difficult and also more expensive. The iron, calcium and magnesium salts in such a hard water precipitate the soap used as sticky, insoluble soaps of these elements, and when these are once formed on the fibre they are very difficult to remove. Provided hard water is the only one at our disposal, it must be first softened by the addition of a strong solution of "Granulated Carbonate of Soda" or "Wyandotte Textile Soda," and then make up your soap as usual. The amount of either material required to be added depends on the hardness of the water.

A chemist determines the degree of hardness of water by the amount of soap the water will destroy. An alcoholic solution of soap is dropped carefully into a measured amount of distilled water containing a known amount of a lime salt. The value of a cubic centimeter being determined, the soap solution is dropped from the graduated tube into a measured amount of the water to be tested, and when a permanent lather is produced by shaking, the amount of soap-solution is noted and the hardness of the water calculated.

One grain of Gran. Carb. Soda will precipitate about one and a half grains of sulphate of lime (soluble in water) as carbonate of lime (insoluble in water). Nearly all water contains some lime, and may have as much as fifty grains to the gallon. It is therefore necessary to experiment with the water to be used, and discover the amount of Gran. Carb. Soda required to precipitate the dissolved salts of lime and magnesia.

To test for the presence of lime and magnesia, fill a clean tumbler with hot water and add a few drops of a strong solution of Gran. Carb. Soda. A milky appearance followed by a white precipitate shows their presence.

If water contains five grains of lime and magnesia to the gallon, every 1000 gallons will destroy over ten pounds of neutral soap: and if 10,000 gallons are used in a day, 100 pounds of soap will have been used to kill the mineral salts, when five and a quarter pounds of Gran. Carb. Soda would have done the same work and with no dangerous scum. Once the scum is formed, no amount of soap, Gran. Carb. Soda, Wyandotte Textile Soda, or lye will get rid of it again. The precipitate of the carbonates of lime and magnesia will settle to the bottom of the vat. Have a large tank of known capacity provided with a steampipe to bring the water to a boil, add the proper amount of Gran. Carb. Soda, or Wyandotte Textile Soda, necessary to precipitate the lime and magnesia, and allow to settle. Draw from the tank several inches above the bottom, for the supply to make up the soap-liquor, and for washing and rinsing.

The substances used in connection with water for scouring wool are principally the carbonates of sodium, potassium, and ammonium; Wyandotte Textile Soda; ammonia; sal ammoniac; salt, and finally soap. These substances differ in their effect on the fibre, but so long as the solutions are not too hot or strong there is no appreciable injury to it.

Caustic soda and potash will dissolve wool if strong enough solutions are used, and as even small quantities are deleterious to the fibre, its presence should be carefully avoided.

Sodium Carbonate is a chemical used for wool scouring and is sold in several different forms. Soda ash is an impure carbonate containing about 70 to 95 per cent Na_2CO_3. Among the impurities in this substance caustic soda is of frequent occurrence, and the injurious effect upon wool of even very small amounts of caustic alkali has already been insisted upon. It is therefore very necessary to have a simple means of detecting the presence of caustic soda in carbonate, and what is readily done by dissolving a sample of the soda ash in water, adding excess of barium chloride, filtering, and adding phenol phthalein; when a pink color is immediately developed caustic soda is present, but the solution remains quite colorless in its absence.

There are now, however, several forms of carbonate of soda in the market, which while guaranteed to be absolutely free from caustic alkali, are only slightly more costly than the much more impure soda ash. Such are the so-called "pure alkali" which is a practically pure and anhydrous carbonate, containing 98 to 99 per cent Na_2CO_3, "crystal carbonate," which is a beautiful preparation of the composition $Na_2CO_3H_2O$, and "sesqui-carbonate," which is presented by the formula $Na_2CO_3NaHCO_3$. Any of these products can be highly recommended. The ordinary preparation, known as "soda crystals," or "washing soda," has the composition $Na_2CO_3,10H_2O$, and thus contain no less than 63 per cent of its weight of water.

Potassium Carbonate has a milder effect on the fibre than the soda salt. It is considerably more expensive than the soda salt, and has the disadvantage of absorbing moisture from the air, forming in turn a pasty mass. As the salts occurring naturally in wool are salts of potassium, it is claimed by many manufacturers that only potash salts should be used in wool scouring, since the wool is thereby left softer and in better condition than is the case if soda salts are used.

Ammonium Carbonate has a very mild action on wool; in fact its action is so mild that a higher temperature of the liquor can be employed than if using either of the previously mentioned chemicals. If it were not for its high cost it would be more frequently used, since wool scoured by it is left in an excellent condition. Ammonium carbonate is also used in the form of stale urine or "lant," which contains not only ammonia but a large amount of potash. The potash (as mentioned in connection with potassium carbonate) causes the whiteness, and the ammonia will saponify the animal grease, and when put into the scouring liquor in a warm state, the grease will easily wash off.

Wyandotte Textile Soda is a mild scouring agent, being perfectly free from all caustic alkali, and does not act on the wool fibre injuriously. It is best used in connection with sodium carbonate, or soap.

Ammonia is also sometimes employed, but only in very small quantities, when dealing with wools hard to get clean, since its cost is very high.

Sal Ammoniac is another substance often employed and usually in connection with carbonate of soda. So is also salt often used instead of sal ammoniac, and this at a great saving in expense and with nearly as good result. However, neither salt nor sal ammoniac are alkaline salts, and consequently their action and utility in scouring wool has been questioned.

It is, however, very difficult to remove all the grease with any of the chemicals named, unless there is sufficient soluble yolk in the wool to assist them. For this reason it is necessary that with wool deficient in soluble yolk, more or less soap must be used in order to get rid of all the grease in the wool under operation.

Soap is the scouring agent, above all others, for wool, and in cases where it is used it gives most excellent results. Both hard and soft soaps are used. Chemically speaking, soaps are salts containing fatty acids (oleic, stearic, etc.); "hard" soaps resulting when sodium is the base, while potassium gives rise to "soft" soaps, thus:

$$\underset{\text{Caustic Soda.}}{NaOH} + \underset{\text{Fatty Acid.}}{\text{Oleic Acid}} = \underset{\text{Hard Soap.}}{\text{NaOleate}} + H_2O$$

$$\text{and } \underset{\text{Caustic Potash.}}{KOH} + \underset{\text{Fatty Acid.}}{\text{Oleic Acid}} = \underset{\text{Soft Soap.}}{\text{K Oleate}} + H_2O$$

Any soap, when unskillfully made, is liable to contain caustic alkali, but potash soaps are, on account of the method adopted in their manufacture, particularly liable to this defect. It is therefore a great mistake to suppose that soft soap is a less sévere scouring agent than hard soap, the exact opposite being usually the case.

The value of any soap largely depends upon the amount and correct proportions of fatty acid and alkali. The fatty acid is determined by weighing 50 grains of the soap, and boiling it in a beaker, in distilled water, till dissolved, then adding 10 grains of solid paraffine, and then 0.6103 cubic inch of sulphuric acid, diluted in a little water. The whole is gently boiled until the liquid clears, and the oily matter completely rises. It is then set aside till quite cold, so that the fatty acid can be removed in a cake, then dried upon blotting paper, and weighed. The weight, from which the paraffine added must be deducted, gives the fatty acid, the double of which, if 50 grains of soap had been taken, is the percentage.

A very simple test sufficing to show whether uncombined alkali is present is thus: Pour on to the soap a small quantity of an alcoholic solution of phenol phthalein, when the production of a red color indicates that free alkali exists.

Soap has a much milder action on the fibre than either the carbonate of soda or potash, but it possesses the disadvantage of being decomposed by hard water, forming a sticky, insoluble lime soap. In this way one pound of lime in hard water will destroy ten or fifteen pounds of ordinary soap. For this reason in cases where the water is hard, or the wool contains considerable quantities of lime, magnesia or iron salts, like some of our western wools do, or pulled wool which has been removed from the pelts by soaking them in lime, it is necessary to use other substances before the soap in order to get proper results, *i. e.*, soften the water before the scouring process, or when the water is soft but the wool contains lime or iron salts, by soaking such wool in water previous to scouring and when the larger portion of these troublesome salts are removed, and the wool then can be scoured as usual with soap.

For fine quality wools a well-made soap, quite free from caustic alkali, with or without the addition of ammonia, may be considered the most suitable scouring agent.

The Different Treatment required for scouring different wools will be best explained by means of comparing two different breeds of sheep. Closely examining an unwashed fleece from a fine grade of our domestic sheep will show it to be so full of grease that by handling it the hands become sticky and greasy, and that by twisting a lock between the fingers some grease can be squeezed out. We also find the wool divided into locks, each being composed of a small bundle of fibres held together by a very sticky, fatty substance which contains more or less dirt adhering to it. Examining in turn another fleece from a poorer breed, raised, for example, in a region where vegetation is scant, but where the soil contains much lime, iron and magnesia salts, said wool may scarcely feel greasy, its impurities possibly consisting largely of the salts previously referred to, and which are so detrimental to a soap solution that the attempt to scour such a wool with soap would prove a failure, so that if a wool scourer who had always been used to the first kind of wool was to receive a lot of the second quality mentioned, and should not change his methods of scouring, he would find that what was good for one was not good for all, and that judgment must be exercised for each different class of wool as coming under his care.

Again in the case of very greasy wools there will be found a great difference in the relative proportions of the soluble fatty substances "yolk or suint" and the insoluble substances, "wool fat," so that different classes of wool, although they may contain the same total amount of fatty matter, may require a considerable difference in treatment in scouring, owing to the different proportions of soluble and insoluble fatty matter present.

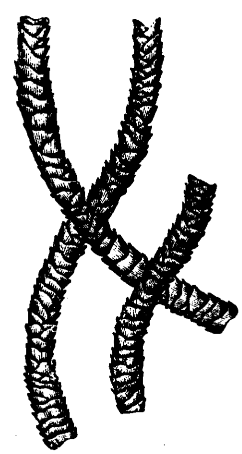


Fig. 28.

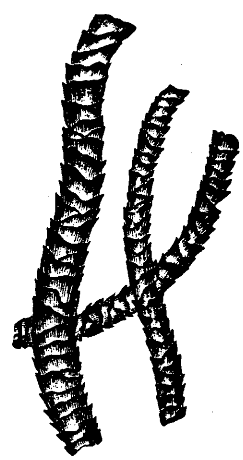


Fig. 29.

The strength of the scouring solutions to be used depends on several things, and the same is true of the temperature to be employed. The longer the wool remains in the bath, the weaker the solution that can be used, and for a machine that required but four minutes for a passage through the bowl, a stronger solution would have to be used than if eight minutes were required. Also for very dirty wool, stronger solutions have to be used than for fairly clean wool. The temperature for the scouring liquor depends on the quality of the wool under operation and also on the scouring agents used. Many do not take this latter into account, but in fact, with soft water and a neutral soap, the fibre is less injured at 120° F. than is the case when pure alkali and a lower temperature are employed.

Greasy wools, *i. e.*, such in which there is a large amount of "wool fat" and a small amount of soluble fatty matter, *i. e.*, yolk, if washed in water alone, there will be but a very small amount of matter removed. The wool fat retains even the mechanical impurities, and prevents their removal. Pure alkali, salt nor even soap itself will hardly remove all the fat, unless very large quantities are used, and which of course makes it very expensive. In case such wool is encountered, it is necessary to use some oil that is easily saponified, and especially an oil like "red oil." By the use of this oil and pure alkali even the greasiest wool can be cleaned.

To illustrate the external change the fibres undergo during scouring, Figs. 28 and 29 are given, and of which Fig. 28 shows wool fibres, highly magnified, before being scoured, Fig. 29 showing fibres from this wool, magnified similarly, as they appear after having been scoured.

Having decided upon the chemicals and the strength of the solution to be used, the next question is: How can we best apply them?

There are different distinct methods of scouring wool by machinery in use, the machines being constructed to produce the result either by agitation in the scour liquor and then squeezing, or by steeping with the least possible agitation and then squeezing. A thorough description of the construction and operation of modern wool scouring machines is given in the chapter "Preparatory Processes."

There are always more or less patents brought out. having for their object to scour wool by means of volatile liquids, which process theoretically is certainly much simpler and more economical than the ordinary process, and will probably come into general use in the future. At present, however, the mechanical difficulties of applying the large volumes of volatile and usually explosive liquids necessary have not been adequately surmounted.

DRYING.

The wool on leaving the last bowl in the set of scouring machines, *i. e.*, the rinse bowl, is taken to the dryer. The ideal drying machine should be perfectly calculated to pass the wool forward to the next operation unimpaired in vitality and working qualities. Any form of machine that will accomplish this, and at the same time reduce the moisture to the desired point, may be used. The degree of moisture to be extracted varies according to quality of wool under operation, and whether for carded or combed yarns. A thorough description of the construction and operation of modern Automatic Wool Dryers is given in the chapter "Preparatory Processes."

ARTIFICIAL WOOLS.

The same are re-manufactured products from old or new wool wastes, or recovered from rags, and according to their source are divided into three classes, viz.: Shoddy, Mungo and Extract. Of these

Shoddy is the best, being the wool fibre recovered from worn, but all wool, long staple materials, and which had never been fulled, or if so, only slightly. Amongst these materials, we find, knit goods, shawls, flannels and similar fabrics, also the yarn and fabric waste made in the process of manufacturing them. The fact that these materials, known in the market as "softs," are readily disintegrated, causes the resulting fibres to be comparatively long and sound, they varying in length on an average of from ⅖ to 1⅕ inches, according to the original length of the staple in the fabric from which the shoddy is made.

Shoddy is occasionally worked up alone into heavy counts of yarn, but more generally is mixed with new wool and thus used in the manufacture of a great quantity of good average grades of yarns for all classes of all-wool fabrics.

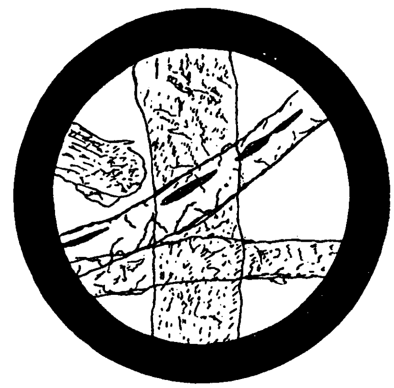


Fig. 30.

Shoddy fibres are sometimes found to be spoiled by scales being worn off, or the ends of the fibres broken, and which may be caused during the process of rag picking or garnetting (coarse carding). Dyed shoddy can be detected from similarly dyed new wool, for the reason that the color of the former will betray the inferior article compared to wool, since the rags or waste, previous to the re-dyeing, had been dyed different colors, and which will consequently influence the final shade of color obtained from re-dyeing accordingly. Of the accompanying illustrations, Fig. 30 shows specimens of coarse wool shoddy, magnified, and Fig. 31 specimens of a fine wool shoddy, magnified.

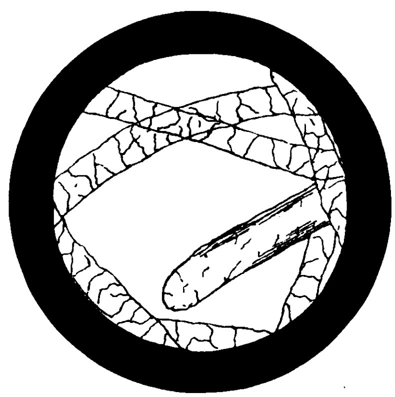


Fig. 31.

Mungo is obtained by reducing to fibre pure woolen rags, from cloth originally heavily fulled, and when the natural consequence of the strong resistance to disintegration offered by felted fabrics, results in that short fibres, about ⅕ to ⅘ of an inch in length, are obtained. Mungo, for this reason, is never worked up again alone into yarn, but is generally mixed with new wool or cotton and generally made up into low counts of filling yarn. On account of mungo referring to a fibre once before having been heavily

Fig. 32.

felted, the same has lost its capacity for further felting. Fig. 32 is a typical illustration of Mungo fibres, magnified, showing also the presence of a foreign fibre.

Extract Wool is the product obtained by disintegrating fabrics composed of animal and vegetable fibres, chiefly wool and cotton, instead of pure wool only. The vegetable fibres in this instance are removed by carbonizing when the material has to be used in connection with wool, in the spinning of all wool yarn.

Testing Artificial Wool for Cotton Present. When buying a lot of shoddy, mungo or extract, and we are not positive that it is "all wool," a test should be made to ascertain if any and what percentage of cotton is present, for which reason a sample is taken out of one of the bales, and after weighing, is boiled for ¼ of an hour in an 8° B. caustic soda solution, in which the wool will be dissolved, leaving cotton fibres, if any present, unchanged. These cotton fibres are then collected on a linen filter, and after washing with hot water, until all traces of caustic soda are gone, the fibres are dried and weighed, and the percentage calculated from the original weight. If the artificial wool contains many impurities, the sample must be first washed with slightly acidified water, and afterwards with pure water, in order to remove these impurities, which, otherwise, would have been undissolved and consequently weighed as cotton. This estimation, however, gives only approximate results.

Testing the Presence of Shoddy in Wool. The chief characteristic test for artificial wool, in the presence of new wool, is its color, which is seldom uniform when seen under the microscope, the same always containing fibres of different shades and colors, especially in the cheaper grades, whereas in the better grades, this difference is not so pronounced.

In testing for the presence of shoddy, it is advisable to treat the sample beforehand with warm hydrochloric acid, which will remove from the artificial wool, the color due to the second dyeing and leave the original dye clearly exposed, and as the new wool present was stripped of its color at the same time, leaving it more or less white, the two classes of wool are easily distinguished.

Another microscopical test for shoddy is afforded by the appearance of the ends of the fibres, these being usually unbroken in the case of natural wool, whereas in the artificial varieties they are always torn or ragged.

CARBONIZING,

is used for wool as well as rags.

With reference to wool its purpose is the chemical removal of vegetable impurities, like burrs, with which the wool in question is heavily contaminated, and which cannot be removed successfully or economically in a mechanical way.

The process of carbonizing is based on the different behavior of animal and vegetable fibres in the presence of certain chemicals, such as dilute sulphuric acid, gaseous hydrochloric acid, and certain metallic salts, such as the chlorides of aluminium and magnesium.

The Sulphuric acid process consists in steeping the burry wool in a bath of the acid with the strength of 2° to 4° Tw. until saturated, then squeezing and drying. During the drying, the acid on the fibres becomes more concentrated, and the vegetable matter present is disintegrated or practically burned up, and is afterwards removed in the form of dust by shaking or beating. This process is known as liquid or wet carbonizing.

Dry or Gas Carbonizing consists in treating the burry wool with hydrochloric acid gas in a heated chamber, the action of the acid being the same on the vegetable matter as with sulphuric acid.

Another method of carbonizing is by the use of certain metallic salts, such as magnesium or aluminium chlorides, etc., instead of acid. When using

Chloride of Aluminium, the wool to be carbonized is entered in a chloride of aluminium bath from 6° to 7° B., and carefully handled, and the carbonizing fluid permitted to operate for a few hours. The wool is then taken out, hydro-extracted, and dried at a medium temperature, and entered into the carbonizing chamber, which is heated to 194° F., and in which the wool is left for one hour, during which time the vegetable matter is disintegrated. The remains of the vegetable fibres, *i. e.* dust, is then removed from the wool by beating, after which the wool is washed in soft water with fuller's earth, and when the soluble chloride of aluminium is readily removed. This process is not as liable to be injurious to the fibre as the acid process.

Carbonizing Waste or Rags has for its object the separation, *i. e.* destruction of all vegetable fibres, as found in a lot of woolen material, and thus eliminate them from the wool fibres. The sulphuric acid process is used almost exclusively on account of its comparative cheapness.

The mass of rags or waste is steeped in a solution of sulphuric acid, and then heated in an enclosed chamber (see articles on stock dryers in the chapter "Preparatory Processes"). This drying process evaporates the water, and leaves the sulphuric acid in a very concentrated form, the effect of which is to destroy the vegetable fibre, and leave only cinders or dust, which disappears when the material is afterwards subjected to a thorough washing, any acid on the stock being removed by this process at the same time.

LATE INVENTIONS IN THE CONSTRUCTION OF SHEEP-SHEARS.

Sheep are sheared either by hand or machine shears.

An attachment to regulate the size of "cut" in hand shears. The object aimed at in the construction of the shears shown in diagram Fig. 33 (shown open) is to provide means so that the opening out of the blades of the shears can be set to the required distance to suit the demands of the operator and thus reduce the strain on his hand.

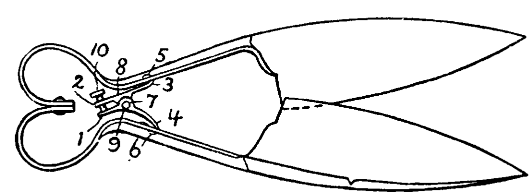


Fig. 33.

Examining this illustration, we find that the new device consists of a pair of spring links 1 and 2, bent at their respective ends 3 and 4 to form the hooks 5 and 6, which fit in the handles of the blades of the shears. The links 1 and 2 are also formed with lugs 7 and 8, through which is passed the fulcrum pin 9. A thumb screw 10 is threaded through the end of the link 2 and regulates the expansion of the blades of the shears by means of the end of said thumb screw 10 bearing on the end of the link 1, preventing the blades of the shears from opening any farther than thus set.

Thus it will be seen that by turning the thumb screw 10 the blades can be drawn more or less together, according to the length of cut required by the operator. At the same time overlapping of the blades is prevented, as well as any jar to the hand of the operator when operating the shears.

A Detachable Hand Shear. The object consists in making the blades of the shears detachable from the bow and in providing drivers which allow of a very secure grip, whereby the open shears may be easily driven into the wool.

Of the accompanying illustration Fig. 34, diagram A is a perspective view of such a pair of shears and diagram B a view showing the method of securing a green-hide pad to the knocker.

The blades B B′ are made separately from the handles A and each blade is secured thereto by two bolts C and D and C′ and D′, respectively. In order to allow of the blade being secured to the handle, there is a short extension of the rear of the blade formed of such shape as to fit neatly within the hollow of the handle proper and perforated with two holes corresponding to two in the handle.

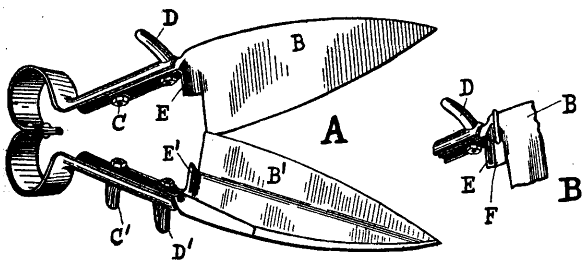


Fig. 34.

The connections of the blades to the handles are made as follows: The top (as the shear is used) blade is secured to its handle by two bolts. The rear one C has a head finished to correspond exactly with the form of the handle, but the forward one D has an elongated and curved head, forming a driver which serves as a stop and fits neatly between the thumb and first finger of the operator. The bottom blade is secured to its handle by two bolts, each of which has an elongated and curved head, forming drivers. The front driver D′ fits between the first and second fingers and the rear driver C′ between the third and fourth fingers. The holes in the blades to take the rear bolts are elongated, thereby permitting of the insertion of packing between the handle and the rear of the extension to widen the blow, or cut, if desired, without increasing the width in the grip. The knockers E E′ of the blades are made sufficiently short in order to allow a green-hide pad F (shown in diagram B) to be securely tied to each blade to lessen the noise and prevent the jar upon the wrist as the blades are closed. With shears made in this manner a shearer will be able to get a bow of exactly the size and strength to suit him that will last for years and can be fitted with successive sets of blades, while in the event of one blade being harder than the other (as is often the case) the best can be kept until perfectly matched with a new blade.

Method of Driving the Cutters in Machine Sheep Shears. The motive power generally used for driving machine sheep shears is from a revolving shaft driven by steam or other power, whereas the motor or driving arrangement for the new shears is contained in the handle or an extension of the handle of the shears, and is operated automatically while shearing by the tension upon a flexible cord which

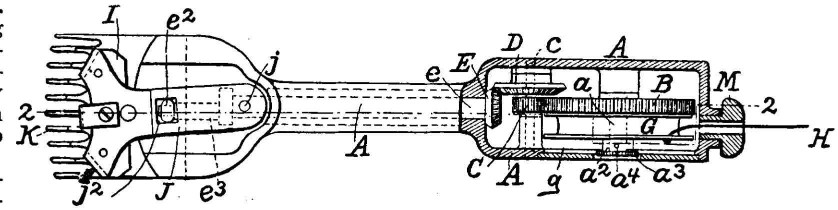


Fig. 35.

is alternately uncoiled from and coiled upon a drum.

Of the accompanying illustrations, Fig. 35 is a plan showing in section the driving arrangement for the shears, and Fig. 36 a longitudinal vertical section taken on the line 2-2 of Fig. 35.

Fixed to the casing A of the shears is an axle a, on which is rotatably mounted a spur wheel B, which engages with a pinion C, secured to a spindle c, mounted in bearings in the casing A. Secured upon the spindle c or to the pinion C is a bevel wheel D, which imparts rotation to another bevel wheel E, secured upon a longitudinal shaft e, by means of which motion of the driving mechanism is conveyed to the reciprocating cutter I.

The spur wheel B is provided with a ratchet wheel F, secured to the wheel B by screws b, and mounted so as to revolve upon the axle a. Adjacent to the wheel B is a drum G, within which is a spiral spring g, which has one end secured to the drum G and the other to a sleeve a^2, which enables the spring to be readily wound up. The sleeve is provided with a milled head a^3, by means of which it can be partly wound up and the said milled head be afterward secured to the axle a by a pin a^4, so as to maintain a permanent tension on the spring. Motion is conveyed from the drum G to the spur wheel B by a pawl g^2, which is secured to the said drum and is kept in contact with the ratchet wheel F by a spring g^3.

How the shears are worked: A cord H is wound upon the drum G and has its inner end secured to the flange of the said drum; its outer end, passing through a tubular guide M, is secured to a fixed point outside the machine when in use, so that on moving the shears away from the said fixed point,

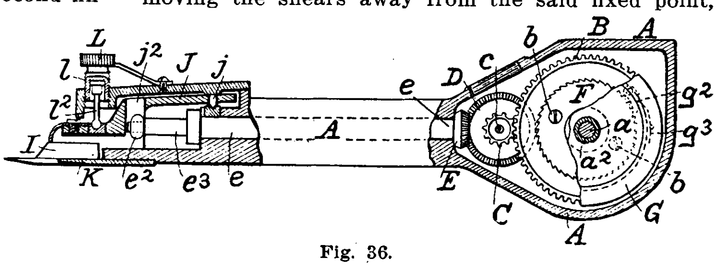


Fig. 36.

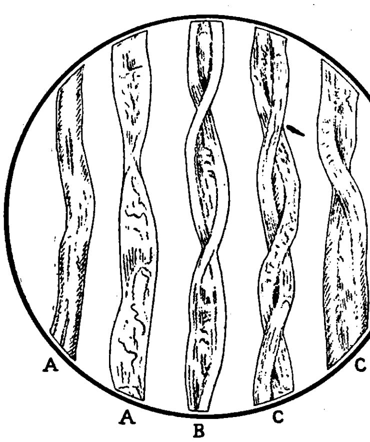
the drum G is rotated by the cord being unwound therefrom, and the reciprocating cutter operated, the spring g being at the same time wound up. On the backward movement of the apparatus the spring unwinds and rewinds the cord H upon the drum. The reciprocating cutter I is attached to a lever J, which is centred at one end on the pin j, the lever J being also provided with a slot or recess f^2, in which fits an antifriction roller e^2, the said roller being mounted upon an eccentric stud or crank pin e^3, carried by the shaft e, so that as the said shaft is rotated the reciprocating cutter I is oscillated to and fro over the stationary cutter K.

L represents a tension device by which the pressure of the reciprocating cutter I on the stationary cutter K can be regulated, the said tension device consisting of a screw l with a milled head, which bears on a thrust piece l^2 with a ball end bearing in a recess in the reciprocating cutter.

COTTON.

The cotton fibre is the filament which grows around the seeds of the various species of the cotton plant.

The fruits of the cotton plant known as "bolls" (of about 1 inch diameter) are divided by membranous walls into three or five cells containing three or four seeds each, and from which the thin transparent cylindrical filaments known as cotton, grow, said filaments being pressed against each other in a more or less matted condition. Towards maturity of the boll, these filaments are changed from their cylindrical form to a compressed or ribbon shape, by means of the collapse of their walls; each fibre simultaneously twisting more or less on its axis, causing in turn a sufficient pressure on the inside of the boll, to burst the latter at the junctions of the compartments in the casing, which by this time has become dried up. After being left on the plant for a few days, so as to properly ripen the fibres, the cotton is picked. During the time the cotton thus remains on the plant, exposed to the direct influence of the air (if the weather is unfavorable) great damage to the fibre



COTTON FIBRES MAGNIFIED.

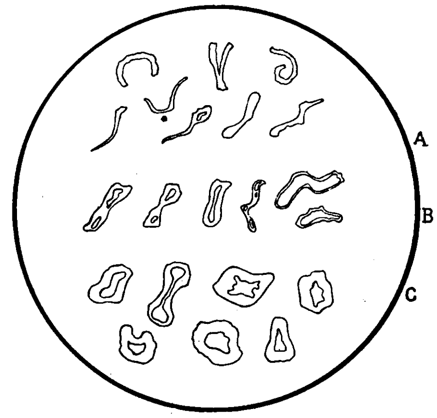
A—Unripe or Dead Fibres,
B—Half Ripe Fibres,
C—Matured or Ripe Fibres.

may be done either by rain which stains the cotton, excessive heat which renders the fibres harsh and brittle, or by storms which fill the exposed cotton with leaves, dust and sand.

The Length of the cotton fibre varies from about ¾ inch to 2½ inches, and upon this length, commercially known as "staple," the value of a respective lot of cotton depends.

The Color of the cotton fibre is not always what we practically term white, but is sometimes creamy, as in Sea Island, or of a light and varying golden tint, as in brown Egyptian.

A Microscopical Examination of cross sections of the various cotton fibres will reveal considerable individuality amongst them, some exhibiting thick cell walls with a very small central cavity, while in others the hollow tubular space is greatly enlarged. Some fibres also retain much of their original cylindrical form, while others are completely flattened, exhibiting only a mere line instead of a central cavity, the latter change in structure indicating what is known as unripe or dead fibres, by which is understood that such fibres have not attained full maturity.



SECTIONS OF COTTON FIBRES MAGNIFIED.

A—Unripe or Dead Fibres,
B—Half Ripe Fibres,
C—Fully Matured or Ripe Fibres.

Their detection is very important, since their presence is very detrimental to yarn and fabric. They are recognizable by the very thin transparent filaments, which, though ribbon shaped, are not twisted, and do not exhibit the slightest trace of lumen in the cell.

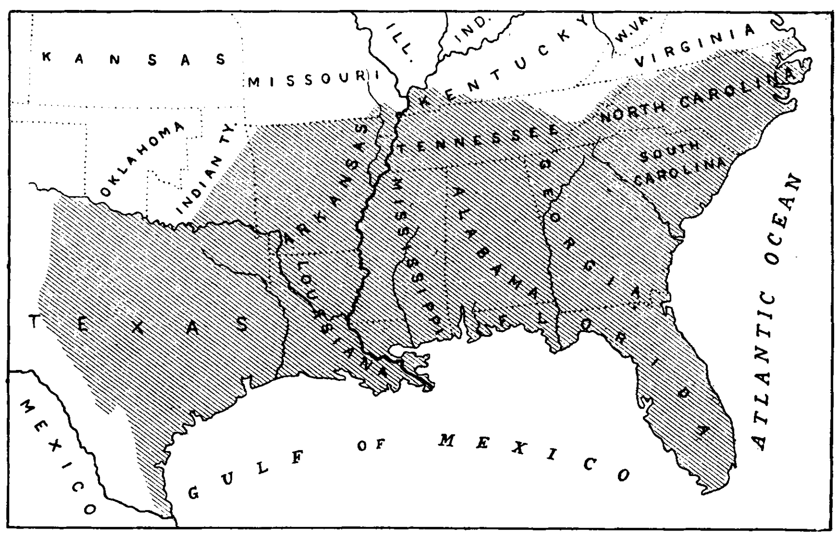
Half ripe fibres are a medium between ripe and dead fibres, and in conjunction with the latter, according to amount present in a lot of cotton, depreciate its value to the manufacturer, such fibres being the result of the cotton being removed from the pod before fully matured, a feature readily explained by the fact that the stages of maturity vary considerably even on different parts of the same seed, since the germination of cells does not begin simultaneously at every point on the surface of the seed, and the absorption of the parts of the cell walls in contact throughout each linear deposit is not effected at the same moment, and that the secretive and suctorial powers of each individual tube are not all of the same force and energy.

The proportion of half ripe and unripe fibre is also more or less dependent on the character of the season and the health of the plant. Again, fibres produced on the crown of the seed are always more advanced compared to those on the base; and it is by the removal of this undergrowth, in the process of ginning, that so much immature fibre exists in the general cotton supply.

Ripe Cotton Fibres are hollow nearly throughout their entire length, with the exception of the end which had not been attached to the seed. This hollowness of the ripe fibre allows the dyestuffs to penetrate, and produce evenly dyed yarns or fabrics, whereas unripe or dead cotton which practically has no central cavity, is very difficult to dye, and frequently appears as white specks on dyed pieces, particularly in such as are dyed indigo blue or turkey red.

The Diameter of the Cotton Fibre, which varies from 0.0004 inch in the best of Sea Island to 0.001 inch in the lowest of Indian, is, in the average, somewhat less than that of wool, the latter ranging from 0.0005 to 0.002 inch; but a comparison of the thickness is of absolutely no value in distinguishing between the fibres. In this respect silk also is similar, having a diameter of about 0.0007 inch. Comparing silk, wool and cotton fibres of equal diameter, silk is much the strongest fibre, wool the weakest, while cotton holds an intermediate place. In respect to elasticity, however—apart from that due to the spiral character of the fibre—both wool and silk are much superior to cotton.

The Spinning Property of cotton fibres largely depends upon their spiral character, which feature greatly facilitates the interlocking of the fibres and largely increases their grip upon one another. This spiral character of the fibre—its natural twist—is due to unequal or irregular drying of the cell walls. The direction and the amount of twist varies, increasing as the plant is cultivated. No turning of the axis takes place in the formation of this twist, the same being the result of the action of natural laws acting externally, and is not an inherent feature or essential part of the life of the plant. Owing to this presence of natural twist, cotton can be distinguished from other fibres, and can be readily detected by means of the microscope in yarn or cloth, whether in a rough, dressed, dyed or undyed condition. Wild silks however have frequently a very similar flattened and twisted fibre, and may frequently be mistaken for cotton, if the microscopic appearance alone is relied upon, but the two fibres can be readily distinguished by chemical tests. Mercerized cotton presents an entirely different appearance to ordinary cotton, due to the chemicals used in this process.



COTTON BELT OF THE UNITED STATES.

Impurities and Moisture. There are always several kinds of foreign impurities met with in raw cottons, and which include sand, broken seed, leaf, motes, etc. Sand, when present in the cotton, is termed "Dead Loss," whereas an excessive amount of moisture present in a lot of cotton is termed "Invisible Loss."

The amount of moisture contained in cotton varies from 6¾ to 12½ per cent over absolute dryness, anything over 10½ being considered excessive, and for which claims can be made. Raw cotton, after being exposed for several days during its process of manufacture to the working temperature of a mill, which ranges on an average from 70° to 90° F., will, if placed for twenty-four hours on the ground floor of the mill, open to the outer air, absorb from 1.6 to 3.6 per cent of moisture, the amount varying with the state of the weather and climatical conditions, a feature which will indicate that cotton will lose about 5% of moisture in the course of its manufacture, and afterwards regain from 2 to 4 per cent of said moisture by proper conditioning of the yarn.

Acids have a very destructive effect on cotton fibres, so that their use in the cotton industry is generally dispensed with, since alkalies, such as soap, borax, ammonia, and phosphate of soda, can be employed for scouring and cleaning cotton fibres without materially injuring them. In boiling cotton with caustic alkalies the air ought to be excluded and the goods kept well under the surface of the liquid, otherwise defects will be caused in the subsequent bleaching of the goods.

Mercerized Cotton. Cotton in the form of yarn or fabric, when immersed in a solution of caustic soda of a density of 28 to 30° Beaumè, undergoes an important change. The cell wall of the fibres will swell out, and acquire a glossiness that causes the yarn or fabric to have a silky appearance, the process being known as mercerization. The swelling of the fibres during this process causes a shrinkage in their length, the fibres become more transparent, and gain something in strength and in weight, their capability for taking up certain dyes being greatly increased.

VARIETIES OF COTTON OF IMPORTANCE TO US.

Sea Island Cotton is the best grade of cotton in the world; such as raised on the islands off the coast of South Carolina and Georgia or directly on the coast, having a staple of from 1¾ to 2½ inches. The fibre closely resembles silk, being extremely fine, strong and clean, permitting it to be spun readily into 150's, and, if required, can be spun up to 400's for ply yarn. Such of this cotton as grown further away from the coast of Georgia and South Carolina averages from 1½ to 2 inches in length of staple and closely resembles the actual Sea Island cotton, from which it is grown, permitting, if required, its spinning into 150's and up to 200's for ply yarn. Florida Sea Island Cotton is grown on the mainland of Florida from Sea Island Seed. It has a white, glossy, strong fibre, a little coarser than strict Sea Island, varying from 1¼ to 1¾ inches in length, and is not as carefully handled during cultivation. It is suited for lower grades of Sea Island yarns spun up to 100's, and 150's for ply.

American or Mainland Cotton is the typical cotton of the world, grown in what is considered the "mainland cotton belt" which extends from southeast Virginia to Texas, its distribution being mainly between the tide water district and the foothills of the Appalachian Mountain System. The deep alluvial soils of the Mississippi Valley favor extension of cotton growing much farther northward, from the sugar district of southern Louisiana to the southern border of Missouri, including most of Arkansas and western Tennessee, while the higher elevation of central and eastern Tennessee limits culture and diverts sharply the line of limitation around the foothills of northwestern Georgia.

This cotton is suited for all numbers of yarn up to 50's warp and 80's filling, being clean, regular in length of staple and well graded. On account of these features, as well as the fact that the quantity raised is greater than that in all other parts of the world together, the price of American cotton regulates the price of cotton throughout the world.

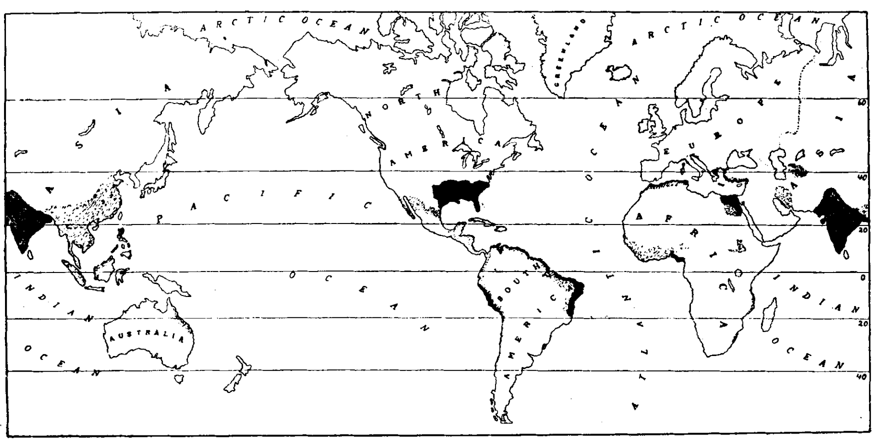
Of this American cotton, the Gulf (or New Orleans), Benders or Bottom Land Varieties are the most important, varying as to length of staple from 1 to 1⅜ inches (1⅝ in special instances), permitting spinning up to 50's warp and 80's filling. Cotton brought in the market as Mobile, Peelers and Allan Seed, belong to the same variety and are next in importance, while Mississippi, Louisiana, Selma, Arkansas and Memphis cottons, also belonging to this variety, are slightly inferior. Texas cotton varies from ⅞ to 1 inch in length of staple, and is well suited for warp yarns up to 32's. Next in importance are the Uplands cotton, having a length of staple from ¾ to 1 inch, permitting ready spinning into 30's filling. Cottons as brought in the market under the name of Georgia, Boweds, Norfolk, or Savannah cottons also belong to the variety of Uplands.

Egyptian Cotton stands high in the estimation of the commercial world, the success of growing being largely due to the equability of the climate in the delta of the Nile. Of the different varieties grown there, the one known as brown Egyptian is the best, although requiring combing on account of its irregularities of staple. The color itself varies from dark cream to a brown tint, according to soil in which it is grown. The length of its fibre varies from 1⅛ to 1½ inches, and is spun in 50's to 80's warp, up to 100's for filling and up to 120's for ply yarn. It is not as fine as Sea Island cotton, and of course does not bring so high a price, but is better than our mainland cotton, especially for goods requiring smooth finish and high lustre, at the same time giving to fabrics a soft silk like finish, a feature which makes this cotton very desirable for use in cotton mixed silk goods.

Cotton Crops of the United States. The following table, compiled and copyrighted by Alfred B. Shepperson of New York, and covering a record of the yearly cotton crops from 1827 to 1904, will be found of interest by the reader.

Season.	Bales.	Season.	Bales.
1827-28	720,593	1866-67	2,233,000
1828-29	857,744	1867-68	2,599,000
1829-30	976,845	1868-69	2,434,000
1830-31	1,038,848	1869-70	3,114,592
1831-32	987,477	1870-71	4,347,006
1832-33	1,070,438	1871-72	2,974,351
1833-34	1,205,324	1872-73	3,874,000
1834-35	1,254,328	1873-74	4,130,000
1835-36	1,360,725	1874-75	3,831,000
1836-37	1,425,575	1875-76	4,632,313
1837-38	1,804,797	1876-77	4,474,069
1838-39	1,363,403	1877-78	4,773,865
1839-40	2,181,749	1878-79	5,074,155
1840-41	1,639,353	1879-80	5,761,252
1841-42	1,683,574	1880-81	6,605,750
1842-43	2,378,875	1881-82	5,456,048
1843-44	2,030,409	1882-83	6,949,756
1844-45	2,394,503	1883-84	5,713,200
1845-46	2,100,537	1884-85	5,706,165
1846-47	1,778,651	1885-86	6,575,691
1847-48	2,423,000	1886-87	6,499,585
1848-49	2,840,000	1887-88	7,046,833
1849-50	2,204,000	1888-89	6,939,000
1850-51	2,415,000	1889-90	7,297,000
1851-52	3,126,000	1890-91	8,674,000
1852-53	3,416,000	1891-92	9,018,000
1853-54	3,075,000	1892-93	6,664,000
1854-55	2,983,000	1893-94	7,532,000
1855-56	3,665,000	1894-95	9,837,000
1856-57	3,094,000	1895-96	7,147,000
1857-58	3,257,000	1896-97	8,706,000
1858-59	4,019,000	1897-98	11,216,000
1859-60	4,861,000	1898-99	11,256,000
1860-61	3,849,000	1899-1900	9,422,000
1861-62	CIVIL WAR; NO RECORD.	1900-01	10,339,000
1862-63		1901-02	10,768,000
1863-64		1902-03	10,674,000
1864-65		1903-04	10,002,000
1865-66	2,278,000	1904-05*	12,162,000

*Government estimate Dec. 3, 1904.



MAP OF THE COTTON GROWING COUNTRIES OF THE WORLD
(Shaded According to Importance).

Peruvian Cotton. Peru produces a considerable amount of cotton, three varieties being brought into the market, called respectively, Sea Island, Rough and Smooth. The "Rough Peruvian" is the only important variety, having a strong, rough, woolly, crinkly staple, about 1¼ to 1½ inches long and is usually very clean and well handled. Its chief use is for mixing with wool in the manufacture of Merino yarns, for which reason it is called "vegetable wool," and when carded, its resemblance is so close and its characteristics so strikingly similar to wool that it would readily be sold as wool, even to a dealer. When woven into goods along with wool, the cotton fibres cannot be determined with any certainty except by using chemical tests. When mixed with wool, it reduces the tendency of the goods, in which it is used, to shrink, makes them more durable, lessens their cost of production, besides giving them a better lustre and finish; hence it is frequently used in the manufacture of underwear and hosiery. For dyed goods it is equally suitable.

GRADING OF COTTON.

There are several principal factors in a good cotton, length of staple, uniformity, strength, color, cleanliness, and flexibility. The first can be found by the gradual reduction of a tuft by the hand until individual fibres are drawn from the tuft, so as to enable their length to be ascertained. To do this well requires practice. In grading cotton from samples not only should its length be ascertained, but at the same time its uniformity of staple. If the staple is uneven, the cotton is of less value than if it were a little shorter, but of greater evenness. The color of the cotton also must be carefully considered, because of the necessity of keeping an even shade of yarn. The cleanliness of a lot of cotton under consideration affects the amount of waste made later on in the mill, being an item of great importance. The amount in a sample is best ascertained by shaking the sample of cotton over a paper, and when it will be seen if said cotton contains much dirt or sand. The flexibility of the cotton is best ascertained by the feel, which will show if it is soft or harsh. Flexibility does not necessarily imply a lack of strength, which some might regard as a more essential factor, but rather includes it. A weak fibre would not be a flexible but a brittle one, and without considerable strength, flexibility in the true sense cannot exist. On the other hand, a fibre might be strong and harsh and yet not flexible, being, therefore, not so suitable for spinning.

Warp yarn has to stand considerable strain during weaving, a feature not required by the filling, hence the strongest cottons have to be used for warp yarns. Filling, although required to be made from fibres of proper length and strength, in order not to influence the strength of the fabric, yet requires a soft and flexible fibre. Any attempt to determine the average strength of single fibres in a lot of cotton necessitates the testing of an enormous number of fibres, since a pound of cotton contains at least one hundred million fibres, and the strength of the fibres varies widely.

The classification of our Mainland Cottons is generally done by means of 7 full grades, which if required are divided in half or quarter grades, thus giving a chance to grade either by 7 full, 13 half, or 25 quarter grades as the case may warrant.

The full grades are Fair, Middling Fair, Good Middling, Middling, Low Middling, Good Ordinary and Ordinary. "Fair" is considered the best quality, the other varying downwards in proportion, so that "Ordinary" becomes the lowest, or perhaps has the shortest staple, and will chiefly lend itself for the spinning of inferior counts of yarns.

The half grades are designated by the prefix "Strict."

The quarter grades are designated by the prefixes of "Barely," meaning the mean point between the half grade and the next full grade above, and "Fully," meaning the mean point between the half grade and the next full grade below.

Sea Island cottons are graded as follows: Extra Fine, Fine, Medium Fine, Good Medium, Medium, Common and Ordinary which is the lowest priced staple.

Egyptian cottons are as a rule quoted under four or five grades, viz.: Good, Fully Good Fair, Good Fair and Fair, which is the lowest quality. Between the grades Good and Fully Good Fair there is often an intermediate grade adopted, called Extra Fully Good Fair.

Highest and Lowest Prices of Middling Upland Cotton. The following table, compiled and copyrighted by Alfred B. Shepperson of New York, covers the highest and lowest prices in New York, of the bulk of our cotton supply, quoted in calendar years, since 1831.

Year.	Highest.	Lowest.	Year.	Highest.	Lowest.
1831	11	7	1868	33	16
1832	12	7	1869	35	25
1833	17	9	1870	25 3/4	15
1834	16	10	1871	21 1/4	14 3/4
1835	20	15	1872	27 3/8	18 5/8
1836	20	12	1873	21 3/8	13 5/8
1837	17	7	1874	18 7/8	14 3/4
1838	12	9	1875	17 1/8	13 1/16
1839	16	11	1876	13 3/8	10 7/8
1840	10	8	1877	13 5/16	10 13/16
1841	11	9	1878	12 3/16	8 13/16
1842	9	7	1879	13 3/4	9 1/4
1843	8	5	1880	13 1/4	10 15/16
1844	9	5	1881	13	10 7/16
1845	8 3/8	5	1882	13 1/16	10 1/4
1846	10	6	1883	11 1/8	10
1847	12	7	1884	11 15/16	9 3/4
1848	8	5	1885	11 1/2	9 3/16
1849	11	6	1886	9 9/16	8 13/16
1850	14	11	1887	11 7/16	9 7/16
1851	14	8	1888	11 3/8	9 5/8
1852	10	8	1889	11 1/2	9 3/4
1853	11	10	1890	12 1/4	9 3/16
1854	10	8	1891	9 1/2	7 3/4
1855	12	8	1892	10	6 11/16
1856	13	9	1893	9 15/16	7 1/4
1857	15 7/8	9	1894	8 5/16	5 9/16
1858	13 1/2	8 7/8	1895	9 3/8	5 9/16
1859	12 1/4	10 5/8	1896	8 7/8	7 1/16
1860	11 5/8	10	1897	8 1/4	5 13/16
1861	38	11 1/2	1898*	7 13/16	5 3/4
1862	69 1/2	20	1899*	6 5/8	5 5/16
1863	93	51	1900*	10 1/4	6 1/4
1864	1.90	72	1901*	12	8
1865	1.20	35	1902*	9 7/8	7 13/16
1866	52	32	1903*	13 1/2	8 30
1867	36	15 1/2	1904*†	17 1/4	9 1/2

*For year ending August 31. †Supplied by The S. Blaisdell Jr. Co.

In many instances Cotton can be distinguished from Wool, Silk, Flax or Hemp by means of the naked eye, again in other cases the microscope will readily reveal its presence, and it will only be necessary to rely on Chemistry in extreme particular cases, or when the exact percentage of cotton in a mixture of it with other fibres is required to be known.

TESTS FOR DISTINGUISHING COTTON FROM OTHER FIBRES.

To Determine the Presence of Cotton in Connection with Wool or Silk, by means of a chemical analysis, the sample must be thoroughly boiled with water in order to extract the sizing and color. When this is done, about 0.1 gram is put in a test glass with 1 c.c. of water and two drops of an alcoholic solution (15—20 per cent) of a-naphthol, and as much concentrated sulphuric acid as there is liquid already. Cotton (as well as other vegetable fibres), if present, is readily dissolved, and the liquid assumes a deep violet color when agitated; wool or silk gives a more or less yellow to reddish-brown coloration.

To Ascertain the Percentage of Cotton in a Sample Composed of Wool and Cotton, boil the cleaned, dried and weighed sample gently for two hours in 8° B.

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.

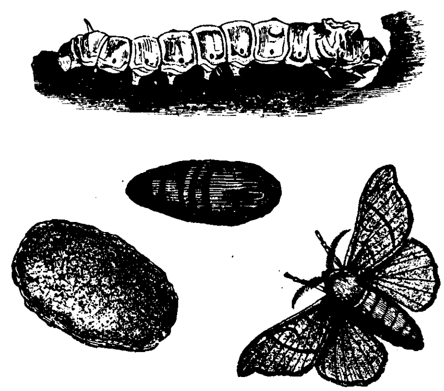
To Separate Silk, Tussah Silk, Wool and Cotton in a sample, have the sample first acted on by boiling half a minute with concentrated hydrochloric acid, which immediately dissolves the silk, the tussah silk being dissolved at the end of two minutes' further boiling. On treating the remainder of the sample 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 makes them, in throwsters' parlance, too "skinny;" by this is meant too little yardage, or weight of skein. There is absolutely no uniformity in the length and size of Canton skeins. Many Italian reelers are approaching uniformity in size or diameter of skein.

The annual supply of raw silk throughout the world is approximately thus:

China	40 per cent.
Japan	20 per cent.
Italy	20 per cent.
Levant	10 per cent.
France, Austria, Spain, and Portugal	10 per cent.

Of the total silk supply of the world, this country consumes about one third, and of which about 46% is furnished by Japan, 30% by China and 24% by Europe.

The sizes of silk most in demand in this market are 13-15 deniers. Low grades and fine sizes, as 10-12 or even 11-13 deniers, are not much used by our broad silk and silk ribbon manufacturers, although the tendency is undoubtedly toward the use of finer counts.

Cultivated silk, also termed "true silk" is the lustrous, fine, but comparatively strong thread spun by the silkworm (the larva of the silk moth Bombyx mori) at its entry into the chrysalis stage. Its cultivation dates back to about 2640 B.C. in China, and from where its culture has spread to Japan, India, Central Asia and Europe, until in 1838 a Mr. Samuel Whitmarsh made the first attempt to introduce silk culture here (Penna.) which affair however turned out a failure. Several attempts made since then, which, although not as complete failures as the first, have met and are meeting with little success, although considerable stimulants from states, societies as well as individual parties are constantly given the matter here.

The silkworm exists in four stages—egg, larva, chrysalis, and adult.

The silkworm feeds on the fleshy parts of leaves (leaving the veins almost untouched) of plants, more particularly on those of the mulberry tree, and requires a dry climate, pure air and continued moderate warmth. The mulberry tree presents several varieties, the most important of which are the white, the black and the variegated, and of which the first mentioned variety is the best, since it develops without much care and can be easily cultivated. It reaches maturity more quickly than the other species, and the silkworms take to it more kindly, producing in this instance also the best quality of silk. The practice is to strip the leaves, as are used for feeding the silkworms, once in every two years, as it has been noticed that the tree lives much longer than when deprived of its leaves annually. When the leaves are gathered they are placed for eight or ten hours in a cool and well ventilated room in order that a good portion of the moisture may evaporate before giving them to the worms.

The eggs are hatched artificially by means of incubators, because if allowed to proceed naturally, the caterpillars would be produced at unequal and at long intervals. The temperature of the incubator is allowed to rise gradually to from 70 degrees to 75 degrees F., thus imitating the process of nature. Incubation lasts from 20 to 30 days.

When the eggs are hatched, the caterpillars are covered with small branches of the mulberry tree, and in a very short time, stimulated by hunger, they climb on the leaves, and are then removed to the rearing house, a closed room, where the worms are sheltered from the wind and cold. This room is filled with shelves about a foot apart, made of wickerwork. The object of these shelves is to furnish a large surface to the insects, where they can move about freely, eat, breathe and moult. About 1,600 pounds of leaves are necessary for 35,000 silkworms produced from one ounce of eggs. When first hatched the worm is blackish and hairy, barely more than a quarter of an inch in length; then brownish-yellow, and finally milk-white. It lives about 30 days, during which period it sloughs its skin four times, increasing in length to 3 or 3½ inches, and in weight from 4,000 to 6,000 times its weight at birth. An increased temperature of between 75° and 80° F. must be maintained, and the greatest of care bestowed to the worms, on account of their impressionability to change in weather or improperly given food. A storm, a sudden lowering of the temperature, or feeding with damp leaves or some other apparently trifling accident would be sufficient to destroy the best breed of silkworms. In order to prevent overcrowding by the worms, they are covered with clean sheets of paper, perforated with a series of holes corresponding to the size of the insects, the food being placed on the top of the paper. The worms then pass through these holes, and climb upon the leaves. When a sufficient number is thus collected, the paper is removed to one of the vacant shelves and the same operation repeated, until all the worms have been removed from the place they first occupied, when the shelves are cleaned. This latter operation is also repeated after each moulting period. About the sixth day of the last period, the spaces between the shelves are lined with twigs of briar, broom or oak, placed in an upright position at a distance of about a foot apart, and disposed in the form of an arch or vine trellis. On the ninth day the silkworms climb up these branches in large numbers and choose a place for spinning their cocoons.

Meanwhile the two internal spinning glands, known as the sericteria in the worm's body, had become filled with a clear, transparent sap about as thick as honey, and which then is ejected from the glands through openings underneath the mouth in the shape of two delicate threads, see Fig. 1, which unite on issuing and form a single thread that quickly hardens in the air; hence it follows that silk exhibits no definite structure, but consists of two cylindrical, sometimes flattened, or, more rarely, helical (twisted round the axis) compact fibres or brins, consisting of homogeneous lustrous matter (fibroin) surrounded and cemented together by a substance resembling gelatine (sericin or silk-gelatine) technically called "gum," which enables the worm to fasten the silk where it wants it, and which substance contains the coloring matter in the case of colored silk, and is the cause of the rough, hard and stiff character of raw silk, a condition, however, suitable for the manufacture of certain fabrics in which this quality is of importance, such as lace and gauze. It loses this property, though, and becomes soft, supple, lustrous and a brilliant white when the coating of sericin is removed by the aid of an alkaline solution, such as hot soap and water, the silk then becoming changed into scoured silk.

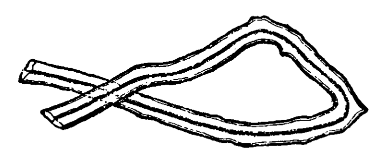


Fig. 1.

In the course of three days the larva envelops itself in a loose, coarse, transparent external covering of this doubled thread, termed the husk or knub, a kind of fluffy silk (florette or floss silk), followed by a second or internal casing of "cocoon," which being a strong and compact mass, composed of a firm and continuous thread, which is not wound in concentric circles as might be expected, but in a short figure **8**, resembling loops (Fig. 2), first in one place and then in another, hence in reeling, several yards of silk may be taken off without the cocoon turning around. The cocoon when completed, is of an oval, or a more cylindrical shape from 1¼ to 1½ inches long and ⅝ to 1 inch wide, the first-named shape of cocoon yielding female moths, the other males. Fig. 3 is a cross section of a cocoon, clearly showing its two divisions. The weight of the individual cocoons varies from 16 to 50 grains. The cocoons which have a hard and firm covering are regarded as the most valuable, as they contain the greatest quantity of silk, while those which are soft and thin are regarded as inferior in quality. The total length of thread composing a cocoon is about 4,000 yards, but only from 300 to 1,000 yards can be recovered by reeling, neither the external floss silk nor the innermost parchment-like layer being obtainable by this means, and which, as will be explained later on, are used in the manufacture of waste silk. In the cocoon the larva then changes into a chrysalis (pupa) about 1 inch long and ⅓ inch thick, by casting its skin; and from the pupa, if undisturbed, develops the dirty-white silk moth, which, in a short time (two or three weeks) after the change, bores its way out through the apex of the cocoon—the threads having been previously softened by an excreted juice—and immediately begins to pair in order to maintain its species. This exit of the moth from its cocoon interferes with the commercial qualities of the silk, and to avoid it, such of the cocoons as selected for fibre are subjected to a temperature of about 145° F. for 12 hours, which has the effect of killing (stifling) the chrysalis or pupa. Although other processes are also practical to obtain this result, the one quoted is the quickest procedure.

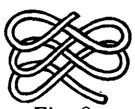


Fig. 2.

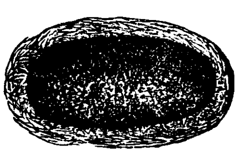


Fig. 3.

In connection with cocoons selected for reproducing purposes, and which must be only the best, the moth is permitted to leave the cocoon, as explained before, in turn spoiling the latter for reeling, *i. e.* true silk, being worked up in what is known as spun or waste silk.

The maximum amount of cocoons which one ounce of eggs (comprising 35,000 worms) furnishes, is 130 pounds, but a return of 80 pounds is considered very satisfactory. From 625 to 1,100 cocoons are required to make one pound of silk, and the price of a pound of cocoons is about 84 cents. The moth is yellowish-white in color, with dim cross markings, and a pale brown lunar spot on the upper wings, which are cut away below the tip, and measure about 1½ to 2 inches from tip to tip. There are three kinds: white, yellow and green moths. The moths are allowed to couple for from six to eight hours, and then the females are removed and enclosed in little sacks made of gauze, called cellules, where they lay their eggs and die. Later on, the dead insects are examined under the microscope to discover if any traces of any disease detrimental to the worm are present, and if so the eggs from the moths that are affected are destroyed. The average production of each female is about 400 eggs.

The eggs are very small and exceedingly light, generally from 30,000 to 40,000 to the ounce, and in size and shape of turnip seeds. The best breeds of silkworms go through their changes but once a year, yielding in return large cocoons, and being of little trouble to the silk grower, whereas other breeds (apparently not of the same species, but of the same genus) go through these changes two, three, four or more times a year, yielding in turn an equal number of crops of cocoons. These silkworms are classified as polyvoltines, such as yielding two crops are known as bivoltines; three crops as trivoltines, etc., etc. The silkworm yielding the greatest number of crops (8) is known as dacey and is found in Bengal.

Chemical Composition. As previously mentioned, the silk fibre is composed of fibroin ($C_{15}H_{23}N_5O_6$) and sericin ($C_{15}H_{25}N_5O_8$). Besides these two bodies proper others occur in smaller proportions. Two samples of silk submitted to the successive action of hot water, alcohol, ether, and acetic acid gave the following results:

	Yellow Italian Silk.	White Levant Silk.
Silk fibre	53.35	54.05
Matters soluble in water	28.86	28.10
" " " acetic acid	16:30	16.50
" " " alcohol	1.48	1.30
" " ether	0.01	0.05
	100.00	100.00

Examining in detail the substances which each solvent had extracted, gave the following results:

	Yellow Italian Silk.	White Levant Silk.
Silk fibre	53.37	54.04
Gelatin	20.66	19.08
Albumen	24.43	25.47
Wax	1.39	1.11
Coloring matter	0.05	0.00
Resinous and fatty matter	0.10	0.30
	100.00	100.00

The proportion of fibroin here given is probably too low, and the albumen too high, owing to acetic acid having a solvent action on fibroin, and thus the percentage given for albumen, must be too high, owing to the altered fibroin it contains.

In practice during the "boiling off" process there is about 30 per cent. of loss. When boiled for some considerable time with water, raw silk loses its gum but not the fatty or other matter it contains, and the tenacity of the fibre is somewhat reduced. All hot liquids exert a similar solvent action on the gum, and for this reason it is necessary to carry on any mordanting or dyeing operations at as low a temperature as possible. Dilute mineral acids have no appreciable action on silk, but they have the property of imparting to it a peculiar "scroop" or crackle, the cause of which has not been ascertained. Strong mineral acids act readily upon silk.

Concentrated sulphuric acid reduces it to a brown solution, from which, when diluted with water, the fibroin can be precipitated by tannic acid.

Concentrated nitric acid also destroys silk, but moderately dilute nitric acid gives it a yellow color, due to the production of xanthopreteic acid, the silk being considerably weakened by the operation. This reaction with nitric acid can be used to distinguish silk from cotton.

Concentrated hydrochloric acid dissolves silk even when used cold.

Sulphurous acid, either in a solution or as gas, destroys the color of raw silk, and is therefore made use of in bleaching silk.

Organic acids when used in the form of hot dilute solutions, simply remove the sericin, and have very little action on the fibroin; weak solutions of such acids as acetic, tartaric, and oxalic are largely used for restoring the lustre of silk after it has been boiled in soap, or dyed, this being the basis of the brightening operation.

Strong solutions of the caustic alkalies, potash or soda, completely and rapidly dissolve silk, especially if applied warm, while very weak solutions simply remove the sericin from raw silk, and although they have no appreciable solvent action on the silk fibre, yet they destroy its brilliancy or lustre, and more or less affect its color, hence the use of the caustic alkalies in the treatment of raw silk is very undesirable.

The carbonates of potash or soda act in a similar manner, completely dissolving the silk when used in a concentrated form, but when weak, their action is not so energetic, and is therefore more under control, though their use is not advisable on account of the risk of damaging the silk fibre.

Soap is almost the only alkaline substance that can be safely used for boiling off or degumming silk. Hot soap solutions readily and completely remove the gum and leave the fibroin elastic and strong. Being cheap and easily obtainable, soap is the boiling off agent usually applied in all silk mills.

Borax is a weak alkaline salt that has no action on silk, but while very useful as a mordant for some colors that require an alkaline bath, it is not useful as a boiling off agent.

Lime water first causes the silk to swell, if the latter be steeped in it, and has an apparently softening action on the silk gum; if, however, the action of the lime water be too prolonged, the silk fibre has a tendency to become brittle.

If silk be allowed to steep in a solution of potassium bichromate, it is slowly oxidized, the silk acquiring an olive green tint due to the formation and deposition of chromium oxide in the fibre. This is useful in mordanting silk which is to be dyed with the alizarine dyes. However, the action of the salt is not very great, silk differing from wool in this respect; on this account, bichromate is rarely used as a mordant for silk dyeing.

Silk, when immersed in neutral or basic solutions of many metallic salts, such as alum, sulphate of alumina, nitrate of iron, chloride of tin, acetates of iron, alumina, lead and chromium, etc., has the peculiar property of attracting to itself the oxides of the metals. This property is a very valuable one and much used in mordanting silk for blacks and those colors which require a mordant. In some cases, as in those of nitrate of iron and perchloride of iron, the quantity of oxide absorbed from the solutions greatly increases the weight of the silk, a property which is taken into consideration by silk dyers.

Silk is soluble in strong solutions of chloride of zinc, from which it is thrown down as a precipitate on diluting the solution with water. It is also soluble in strong solutions of stannic chloride, 70° Tw.; in an ammoniacal solution of copper; in an alkaline solution of copper sulphate and glycerine. This property serves as a means to distinguish silk from wool, and cotton, since the solution has no action on these latter fibres. The solution is made as follows:—Dissolve 16 grams of copper sulphate in 150 c.c. water, add 10 grams of pure glycerine, then add a solution of caustic soda until the precipitate which first forms is just dissolved; much excess of caustic soda is to be avoided.

Hygroscopicity. Silk can absorb moisture from the air without becoming noticeably damp, the quantity of moisture thus absorbed may attain as much as 30%. The normal or standard weight of silk in silk conditioning establishments is calculated by allowing 11% of moisture to the dry weight of the sample. In yarns composed of silk and wool the permissible limit of moisture is 16%.

Important properties characteristic to silk. Amongst these we find:

Color. Cultivated or true silk is generally white, although some are of a yellow color, varying in shade from pale canary to a deep gold yellow, whilst reddish, bluish or green silks are rare.

Fineness. The smaller diameter of silk fibres varies from 0.00052 inches, to 0.00104 inches.

Strength. The breaking strain of raw silk is considerable, a feature contributing largely to its usefulness as a textile fibre.

Lustre. This property is superior in silk to other textile fibres.

Elasticity is also one of the chief characteristic properties in true silk.

Scroop. Silk (especially after immersion in weak acid), when compressed and rubbed, gives out a peculiar rustling sound, which is known as scroop.

Reeling. This process is always done in the countries where the silk is raised. Before starting the reeling, the cocoons are first sorted, in order to obtain silk of uniform character and value. White and yellow cocoons are put aside in separate lots; whilst spotted (or rusty) cocoons, dead cocoons, (containing putrefying dead pupa) mouldy cocoons and cocoons that have been gnawed by insects, etc., or are in holes or otherwise defective, as well as double cocoons (which are very troublesome to wind), are thrown aside and worked up as waste (floss) silk.

The outside or loose silk of the cocoon is then removed as this cannot be reeled, after which the cocoons are immersed in hot soapy water to soften the gum which sticks the threads together. The operator brushes the cocoon with a small broom, to the straws of which their fibres become attached, and then carefully unwinds the loose silk until each cocoon shows but one thread. The silk filament as formed by the worm is so fine that if the strand from each cocoon were reeled separately, it would be totally unfit for the purpose of the manufacturer, besides being difficult to handle; and consequently in reeling, the ends from several cocoons are united and reeled off together, so as to form one thread, which in turn can be handled. From 3 to 20 ends from a corresponding number of cocoons are reeled together and the thread thus formed is twisted a few times with a similar thread in their passage to the reel, and afterwards separated before reaching it, the object being to thus wring the water from the threads, consolidate the cocoon threads more solidly and make the resulting thread smooth and round. When one of the cocoon filaments breaks or the limit of good fibre is reached, the operator takes a fresh end of a cocoon filament, and with his thumb and forefinger, twists it onto the running compound thread, of which from that moment it becomes a constituent part. Different methods of reeling prevail in different countries, but the most careful are practiced in France and Italy. The fibre of the cocoon is somewhat finer in the floss or outside part on the cocoon, and thickens at the point of forming the more compact part, and gradually diminishes in diameter until it becomes so fine as to be incapable of standing the strain of reeling. The decrease in the diameter results from one of the worm glands becoming exhausted, leaving only one-half of the original fibre.

The standard American skein calls for the following specifications:

Length: Skein to measure 56 to 58 inches in circumference.

Width: Width on reel to be three inches.

Traverse: Threads to make 33 complete crossings across the skein and back in 50 revolutions of the skein.