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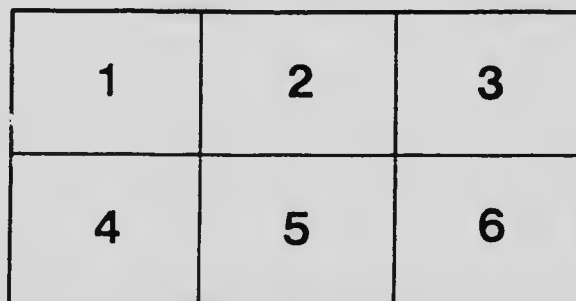
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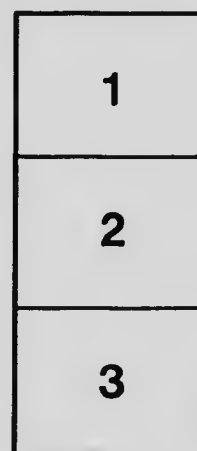
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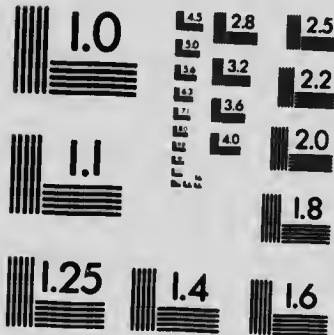
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# WOOL AND ITS MANUFACTURE

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A Description of the Different Processes  
of Manufacture and the Classes of Wool  
Used for the Various Fabrics . . . . .

BY

T. REG. ARKELL, B.S.A., B.Sc.



Top of Different Lengths.

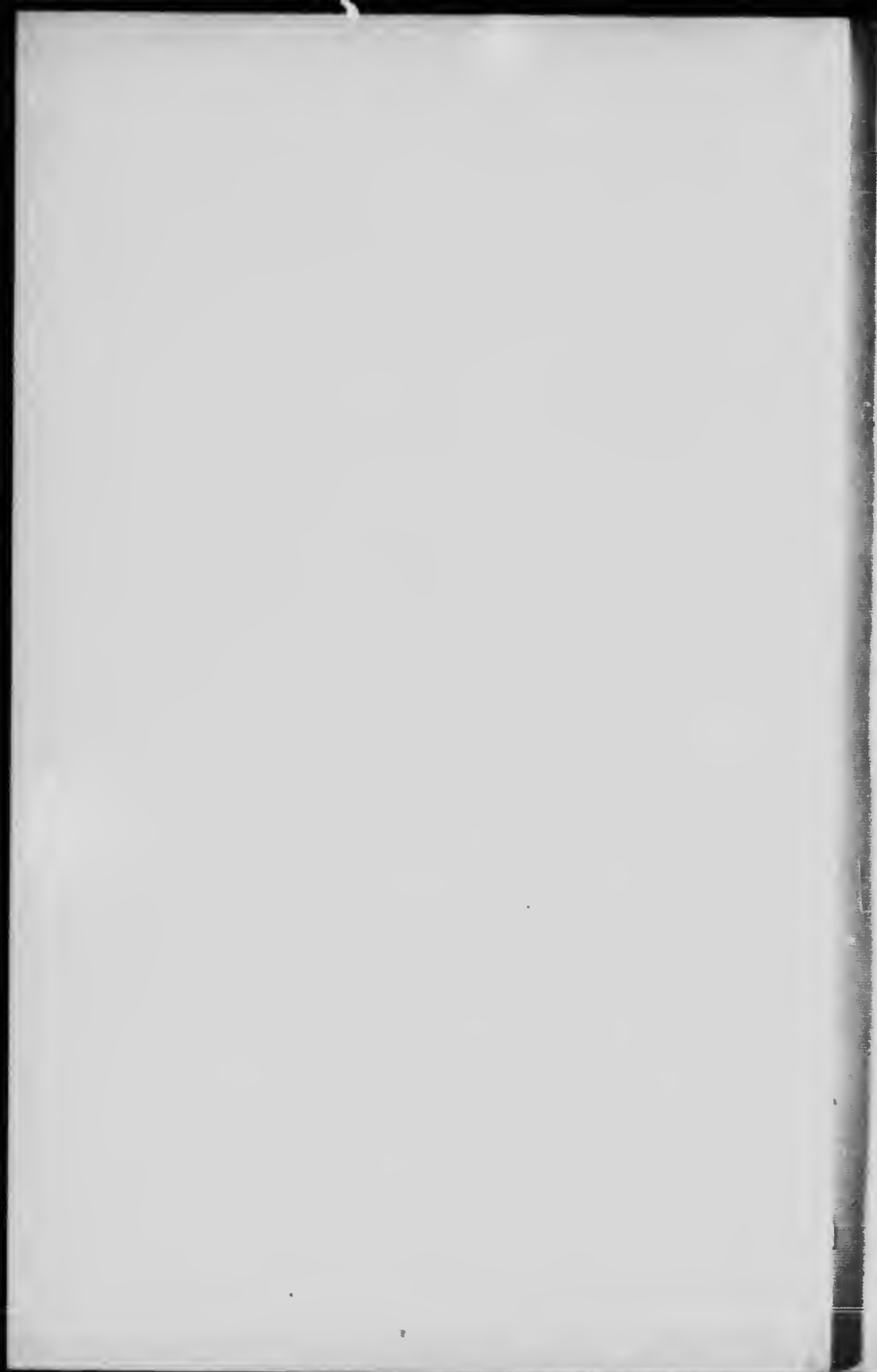
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PAMPHLET No. 3—SHEEP AND GOAT DIVISION

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DOMINION DEPARTMENT OF AGRICULTURE.

LIVE STOCK BRANCH.

JOHN BRIGHT,  
Commissioner.

H. S. ARKELL,  
Asst. Commissioner.

SHEEP AND GOAT DIVISION.

PAMPHLET No. 3.

April, 1914.

# WOOL AND ITS MANUFACTURE

BY

T. REG. ARKELL, B.S.A., B.Sc.

Although for twelve months in the year every resident of Canada, man and woman, depends for the maintenance of bodily warmth and comfort upon clothing made wholly or partially from wool, it is surprising how little the great majority of people really know respecting the various qualities and classes of cloth composing their wearing apparel, the source of the raw material and the process of manufacture. Everyone is more or less certain that wool comes from sheep, but not infrequently that comprises the limit of their knowledge. It is still more surprising, however, how poorly informed in too many instances is the wool grower himself as to the grades and purposes in manufacture of the wool he produces. Lack of information in this regard is especially to be regretted since it precludes the grower from disposing of his product to the best advantage. To assist farmers and city dwellers alike to gain a more complete and definite knowledge of the character of wools grown in this and other countries, and of the products manufactured therefrom, the wool exhibit of the Live Stock Branch, Dominion Department of Agriculture, is presented to the public.

The technical terms used in describing the various specimens in the exhibit may, perhaps, prove puzzling at times. Therefore, a full and concise explanation of these, and a popular description of the worsted and woollen processes of manufacture, outlining the essential stages in the transformation of wool to cloth, have been prepared in this pamphlet.

## THE WOOL FIBRE.

The wool fibre possesses many peculiar physical properties, which especially adapt it for textile purposes. It is covered with minute scales, apparent only under the microscope, and resembling to some extent those upon fish, which not only impart strength to the fibre but give to it its distinctive lustre. When a scale is injured or destroyed through disease, mechanical or other agency, a weak section will exist in the fibre at that point, thus decreasing its tensile strength and rendering it unfit to withstand the strain of the combing process in worsted manufacture. The interlocking or fitting of the scales of one fibre into those of another creates felting or close matting

together of the fibres, which is a necessary proceeding in cloth production. The number of scales upon a fibre is very variable, depending upon the class or grade of wool. For instance, Merino wool, which is the finest, or has the least diameter, is



Wool exhibit of the Live Stock Branch, Dominion Department of Agriculture. The letters in the sign are made from Top.

frequently found with only a single scale surrounding the entire circumference of the fibre; a medium wool, as grown upon the Shropshire or Hampshire Down, two, three or even more scales; and a coarse grade, represented by the wool of the Cotswold, Leicester or Lincoln, several scales.



## WAVINESS OR CRIMP.

Examined casually, it will be observed that the wool fibre possesses a wavy or curled appearance, which is technically known as crimp. A heavy crimp produces compactness of fleece, and the closer the wool the more effectively will it retain the yolk or grease which exudes naturally from the skin of sheep and tends to prevent rain or snow from penetrating to the body. The degree of crimp bears a distinct relation to the diameter of the fibre. Fine wools have greater crimp than coarse. It has been estimated that Merino wool will bear as many as twenty-four to thirty waves per inch; Southdown, thirteen to eighteen, and Lincoln, only three to five. The average diameters of the fibres upon which were based the foregoing data were: For Merino, .00064 of an inch; Southdown, .001; and Lincoln, .0018. These figures will also serve to illustrate the extreme minuteness of the wool fibre. Compared with human hair, even Lincoln wool is finer.

## VARIATIONS IN LENGTH.

Considerable variation occurs in the length of the wool fibre in the same fleece, as well as in different sheep. The shortest wool is upon the belly; the longest, on the thighs. Generally speaking, the coarser the wool, the longer it is in the natural state, but this cannot be taken as a definite criterion, for many of the medium-wooled breeds have coarser, yet shorter, wool than the Merino. The length cannot be estimated accurately by merely opening the wool upon the sheep without a thorough examination of the extent of crimp. A fine Merino fibre may be stretched by hand easily thirty per cent beyond its crimped length, and by gradual pressure upon a machine fully that much more. The average range of wools in length is between two and eight inches, and the number of fibres growing per square inch, between 4,000 and 6,000.

## ABSORPTION OF DYE.

In dyeing, the central portion of the wool fibre underneath the scales alone absorbs the colouring matter. The scales themselves become but slightly, if at all, changed. Where the scales are thick and cling firmly, the same rich effect cannot be obtained as where they are small and open. Therefore, this explains why one class of wool will not dye as readily as another and also why such care must be taken in the mill, in the manufacture of many styles of fabrics, to separate the fleece into lots containing similar specimens.

Difficulty is, at times, experienced in colouring effectively paled or skin wools, which are removed from the pelts of sheep after death, frequently by means of a lime solution, since the lime permeates the cells of the fibre and prevents the uniform distribution of the dye, following a disease such as scab, or through insufficient nourishment, the fibre may be imperfectly developed and will not take the colouring solution in the ordinary factory fashion.

Kemps, which are like fibres, found mostly on the thighs or britch of coarse-wooled sheep, will absorb little dye, if any at all, and, consequently, all wool of this nature must be entirely removed from the fleece before the process of manufacture commences, constituting a waste product. Black, brown or grey wool must be included in this class also, since it can be used only in dark-coloured fabrics. Moreover, even with a black colour it is difficult to stain it exactly the same shade as white wool. For this reason, dark wool enters mostly into the manufacture of natural underwear. Therefore, it may be readily understood from this cursory description how careful, if he hopes to obtain the highest quality of his product, the wool producer should be to eliminate from his breeding flock anything coming to any degree a defective quality of wool.

## TESTS FOR WOOL IN CLOTH.

It may be said at the outset that there are no reliable tests for ascertaining the percentage of pure wool in cloth. By pure wool is meant that which enters cloth for the first time or was converted from the raw state. The amount of cotton can be discovered by a chemical test, but the shoddy content, if originally from goods composed of wool, cannot be distinguished. A guess may be hazarded from the presence of many short or differently coloured fibres that cloth contains shoddy, yet a conjecture from such evidence is crude. Shoddy is frequently derived from a source producing fairly long fibres; or noil may be used, which is raw wool of a very short nature, a by-product of the combing process.

Examination for cotton may be performed by two methods, namely, by boiling cloth in a five per cent solution of caustic soda which destroys the wool and leaves the cotton intact, or by using similarly a five per cent solution of sulphuric acid



Fibres of cottonwool. Magnified 225 times.



Fibres of Oxford wool. Magnified 300 times.

which has the opposite effect. In each instance the cloth sample and the resultant product should be carefully weighed and the difference in weight estimated, which will show the degree of each substance used. Of course, there are simpler tests, but by no means so accurate. For instance, cotton or other vegetable material will burn readily; while wool will only char. However, so long as a goods answers the purpose for which it was bought, and wears consistently well for the price paid, little need one worry about its composition.

## CLASSIFICATION OF WOOLS IN THE FLEECE (GRADING).

Classification of wools in the fleece comprehends what is technically called grading, and should be performed by the grower or dealer before the wool reaches the mill. Grading is done without untying the fleece, and three distinct divisions are made according to the *Condition, Quality, Staple or Length* of the wool.

Every wool-growing country has its own special methods of classification and its own nomenclature for the different grades, which, however, are more or less similar and allied. Canadians, owing to contingencies of market, should be more especially

interested in understanding those of Great Britain and the United States, and in correlating them with our own. For this purpose some attention will be given to a description of these.

Little difference exists in the form of grading according to condition. Therefore, a baldness on it as practised in this country should be sufficient.



Fibres of merino wool. Magnified 300 times.



Fibres of Lincoln wool. Magnified 75 times. A and B fibres taken from shoulder. C and D from britch.

#### CONDITION.

*Unwashed or Greasy.*—(Wool shorn from the sheep in its natural condition.)

*Washed.*—(Wool washed with soap and water upon the sheep's back.)

*Unwashable.*—(Wool poorly washed or not shorn for some time after washing.)

*Tubwashed.*—(Wool scoured by hand with soap and water frequently containing a weak solution of caustic alkali, after it has been removed from the sheep.)

*Scoured.*—(Wool cleansed in the mill by efficient machinery.)

*Rejection or Reject.*—(Wool containing an excessive quantity of seeds, burrs, straw, hay or kemp.)

*Cotted Reject or Cots.*—(Wool matted together. Cotting is created by ill-health and is due to lack of sufficient yolk or grease in the wool, which ordinarily keeps the fibres from sticking together.)

*Black or Grey Reject.*—(Wool containing numerous black, brown or grey fibres.)

*Tags, Lung Locks or Stained Pieces.*—(Short locks generally besprinkled with manure.)

*Pulled or Skin.*—(Wool removed from the pelts of dead sheep.)

#### SHRINKAGE FROM WASHING.

Washing removes only the foreign material or dirt and creates a shrinkage in weight from fifteen per cent to twenty-two per cent on the average. Not only the dirt but the yolk or grease as well are taken from the wool by scouring and it is left in a thoroughly clean condition ready for being spun into yarn. Tubwashing is an attempt

to fulfill the same purpose as scouring, but the process is not so effective. Before the wool can be used for manufacture it must be rescoured. The loss in weight through tubwashing ranges from thirty per cent to fifty per cent.

In washing wool the sheep-raiser should carefully estimate the decrease in weight and the cost of labour against the higher price received for the washed product before undertaking the operation.

#### QUALITY.

Quality refers in this respect to fineness of the fibre or the diameter. The finest wools are arranged in the classifications at the top, each quality following being slightly coarser.

#### CORRELATION OF AMERICAN, BRITISH AND CANADIAN QUALITIES (GRADES), AND THEIR DISTINCTIVE TERMS.

American.	*British.	Canadian.	
		Domestic.	Range.
Fine .....	64's to 66's		
One-half Blood .....	66's	Fine .....	Fine.
Three-eighths Blood .....	58's	Fine medium ..	
One-quarter Blood .....	50's	Medium .....	Medium.
Low one-quarter Blood .....	44's to 46's	Low medium ..	
Common .....	40's	Coarse .....	Low.
Braid .....	36's	Luster .....	

#### AMERICAN CLASSIFICATION.

The American classification and nomenclature are based upon the quality of Merino wool which, being the finest, was taken originally as the standard. Different crosses between the Merino and the mutton breeds were supposed to produce the inter-



Cross section of wool fibre. Magnified 450 times.

mediate grades. The first cross resulted in so-called one-half blood wool, that is, one-half Merino, and presumably twice as coarse as the Merino parent. The other grades followed similarly to show the relative and corresponding lack of fine wool blood.

Fine is frequently subdivided into three separate classes, known as XXX, XX and X. This comprises an exceptionally fine distinction for Merino wools. XXX represents the highest class obtained from the Spanish Merino, and is surpassed only

by Picklock. derived from the Saxony Merino, which is generally conceded the finest type produced in the world. This breed is confined almost entirely to Germany, and is not raised at all extensively.

American wools are also divided into Territory and Domestic classes. The former refers to Western range wools; the latter, to Eastern and Middle Western, such as is produced on the small farm. Range wool is of a finer character than the other, being either Merino or a Merino cross. It therefore possesses, usually, a higher shrinkage owing to the excessive greasiness of the Merino, but contains little or no straw or chaff which unfortunately are found all too frequently in Eastern wool. These conditions apply in similar fashion to Canadian wools.

#### BRITISH CLASSIFICATION.

Differences in the spinning qualities of wool on the worsted principle are taken as the basis of the British system of grading. The factor used is called a count. A single count, which represents the standard or unit, will produce, from one pound of seoured wool, a fixed number of yards of spun yarn. Wool twice as fine as the estab-



Grading and packing wool, Alberta Wool Grower's Association.

lished standard will spin as far again, since the weight being the same there must be double the number of fibres, and would thus represent two counts or, as commonly abbreviated, 2s. Therefore, the finer the wool, the higher will be the counts. A comparison of the range of fineness in the various classes can readily be obtained from the foregoing table.

#### CANADIAN CLASSIFICATION.

No organized method of grading Canadian wools has been pursued on a national scale. This is being overcome, however, now that the sheep industry is in a state of rapid development and is fast becoming a permanent asset in the agricultural system of the country.

The following comprehends a complete classification, in respect to quality and staple, of Canadian wools in the grease, with the exception of tubwashed, which, as previously stated, cannot be satisfactorily arranged:—

Western	}	Domestic fine medium combing.
Eastern		
Western	}	Domestic medium combing.
Eastern		
Western	}	Domestic low medium combing.
Eastern		
Western	}	Domestic coarse combing.
Eastern		
Western	}	Domestic lustre combing.
Eastern		
Western	}	Domestic fine medium clothing.
Eastern		
Western	}	Domestic medium clothing.
Eastern		
Western	}	Domestic low medium clothing.
Eastern		
		Western range fine staple.
		Western range medium staple.
		Western range low staple.
		Western range fine clothing.
		Western range medium clothing.
		Western range low clothing.
		Rejections.
		Grey and black.
		Locks and pieces.
		Tags.

Fort William acts as the dividing line for Eastern and Western wool. Domestic refers to wool produced in small lots upon the farm; while range applies to wool raised under ranching conditions. Domestic grades are also offered upon the market in the washed state.

It is difficult to correlate the types of wool produced by the different breeds with the foregoing grades, for the reason that within each breed there is always a wide range and great variety of qualities. Grading is performed entirely irrespective of breed type, and Shropshire or Hampshire wool may be included in the same grade with Oxford or Suffolk. Fleeces of several hundred sheep of one of the Down breeds, which are the most variable, may fill every category except fine and braid. The wool of the Cotswold, Lincoln and Leicester is the most constant in quality, and seldom is classed as other than braid.

#### STAPLE OR LENGTH.

Fleeces are separated very generally, according to staple, into two lengths, combing and clothing. Three inches is ordinarily the dividing point. Combing is the long wool, intended for worsted purposes. Clothing is too short for the combs and must be carded, entering mostly into woollen goods. Delaine, a word frequently used in connection with Western wools, signifies a combing fine or Merino fleece.

In Great Britain further divisions are made into what are technically termed Hogg and Wether classes. Hogg represents the first fleece shorn from a sheep; and Wether, all subsequent ones. For Down breeds, as Oxford, Suffolk, Hampshire, Shropshire and Southdown, the titles, Teg and Ewe, are sometimes substituted for Hogg and Wether, respectively. This classification may well be adopted in this country with some types of wools, since lamb's wool, in most instances, is not only longer than other fleeces, but, owing to its finer texture and tapered end, possesses better spinning qualities.

## SKIRTING THE FLEECE.

Skirting comprehends the removal from the body of the fleece of the inferior portions. This custom is followed mostly with fine wools and very high grade cross-breeds. In Australia and New Zealand the grower performs this operation before packing and shipping to market. It is, perhaps unfortunately, but little practised in this country.

The degree and fashion of skirting wools are not fixed factors, depending upon the demands of special markets. The tags, dung locks and britch only may be taken



Wool Scouring Machinery.

off, but skirting in the true sense means the removal of the neck and belly pieces as well. These are packed and sold separately.

Wools, thus skirted, will claim a higher price, since they will meet a more favourable reception from manufacturers who prepare a specialized line of goods and do not use every part of the fleece. Wool disposed of upon the London, England, market must needs be in this condition if a satisfactory sale is to be obtained.

## SORTING THE FLEECE.

Sorting must not be confused with grading. They are two entirely different operations. Grading consists of the separation of the entire fleeces into lots of similar character anent condition, quality and staple; while sorting comprises the breaking up of the fleece itself into unit parts. Sorting is performed in the mill before scouring. The sorter places the fleece upon a table which is covered with wire netting, through which a portion of the dust and small locks of wool fall. The fleece is torn apart by hand and the different lots thrown into huge portable baskets.

The number and nature of the sorts will vary with the grade of wool and the style of goods to be manufactured. To serve as a practical illustration, a medium of fleece may be roughly differentiated into five classes or sorts: First, back, sides and brisket; second, neck; third belly; fourth, thighs; and fifth, brokes or short locks and tags.



## SCOURING.

Scouring is the next step after sorting. The wool passes through three or four vats containing warm, soapy water, and is kept in constant motion by means of automatic rakes, which tends to free it from the dirt and grease. It is then pressed through rollers to remove the water, and taken to the drying room.

Shrinkage from this operation is considerable. An average medium grade fleece, not containing an excessive quantity of foreign matter, will lose in weight about fifty per cent, that is, from 100 pounds of wool, the manufacturer will obtain 50 pounds



Sorting Wool.

that he can use. Wool is purchased upon the basis of the clean scoured pound, and, since shrinkage is most variable and in instances may be as great as eighty per cent, it can readily be understood how careful the dealer must be to examine all the wool offered to him for sale before he can afford to quote a justifiable price.

## CARBONIZATION.

Not all the vegetable matter is taken from the wool in the scouring. A considerable portion, firmly incorporated, will continue to adhere. In the worsted principle of manufacture, it is removed with the noil (short fibres of clothing staple) in the combing process. It can be eliminated from the noil or from wools intended for carding or woollen purposes only by carbonization, which consists of immersing the wool in a dilute solution of sulphuric acid, and subsequently drying it at a very high degree of heat. This process entirely destroys the vegetable material, but creates little or no change upon the animal fibres of the wool.

If wool has been tied with sisal or binder twine, the fibres may become unravelled and in worsted manufacture embodied in the top and subsequently in the cloth. Sisal will not absorb dye. Consequently, a blemish shows in the cloth. The defective fibre may be plucked out, but sometimes carbonization of the finished fabric is necessary.



All this should help to show how troublesome dirty wool is to manufacturers and, if sheep-raisers expect keen competition in the purchase of their wool, or a high price, the preparation of a clean article is absolutely necessary.

### DISTINCTION BETWEEN WORSTED AND WOOLLEN FABRICS.

Most people speak of yarn or cloth containing wool as a woollen, which technically is incorrect. Woollen, as opposed to worsted, represents a specific type of fabric and a special process of manufacture.

Woollens and worsteds principally differ in the character of the wool which is employed in their manufacture. The fibres entering worsted yarns are straightened out by what is called a comb, so that they not only lie parallel but are of uniform length. The short wools or noil are removed, and cannot be used under this principle. On the other hand, woollens are made from yarns in which short wool can be utilized to advantage, and the fibres cross, are matted together and line in every direction.



Packing wool in bales

Therefore, it can be readily recognized why the term combing length is used in grading, the reference being to a wool that is long enough to comb or draw out to form a worsted thread. A clothing wool cannot be combed satisfactorily but must be worked on the cards in the making of woollens. There are, however, two classes of combs, known as English and French. The French, which has but recently been adopted in wool manufacture, permits the use of shorter fibres.

### WORSTED PROCESS OF MANUFACTURE.

The resultant product of the combs is called top. This is drawn and redrawn several times by machinery until reduced sufficiently in size for spinning. At this point it is given the title of roving. Drawing still proceeds in spinning until the proper size of thread is attained, when, either singly or two or more strands twisted together, it will be transferred to the weaving looms. Weaving consists of passing

the filling or woof threads, running across the cloth, under and above the warp threads, which lie lengthwise. The cloth then passes through several operations to give to it the required finish, before it ultimately reaches the tailor's shop. Dyeing may be done either in the top, the thread after spinning or in the web or cloth.

#### IDENTIFICATION OF CLOTHS.

Worsted fabrics can be identified from woollens by their more clearly defined pattern and more firmly woven appearance. Woollen cloths are softer, and the distinction of colours not so pronounced. Woollens frequently present a fuzzy, downy surface; while worsteds are always smooth, except for the slight serrations or marks of the thread. The principal worsted cloth is *Serge*. Several prominent styles are included in the woollen category, as *Beaver*, *Melton* and *Kersey* overcoatings, *Tweeds*, *Cheviots* and *Broadcloths*. The manufacture of underwear is also essentially a woollen process.

#### SHODDY.

Shoddy is the general term used to indicate the material obtained by converting worn-out clothing, rags and waste for loose fibres for subsequent remanufacture. Technically, it should be applied only to that derived from all-wool cloths and knit

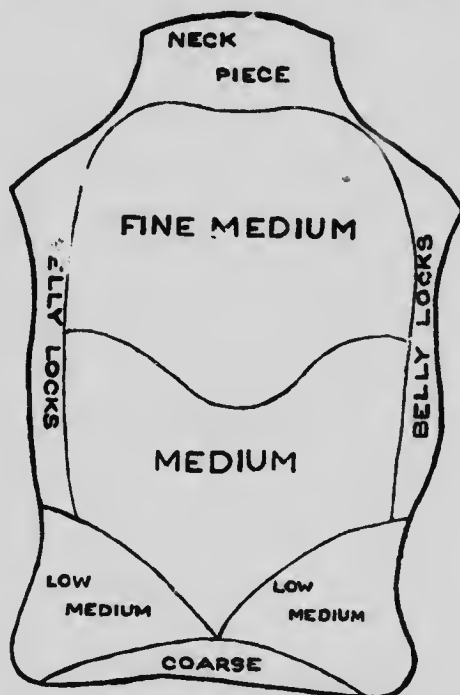


Diagram showing the different qualities of wool in a domestic medium fleece.

goods, which produce a long fibre. Short-stapled material of this nature is referred to as *Mungo*, and that obtained from a mixture of wool and cotton, called a *Union* fabric; as *Extract*. Owing to the lack of uniformity and general shortness of the fibres, shoddy is best adapted for use in the woollen process of manufacture.

threads, re to it may be  
 Farmers frequently complain that the shoddy mill is a direct cause in reducing the price of wool. There are also people who would prevent its use entirely. Should it ever be prohibited, the price of pure wool clothing would more than double, and

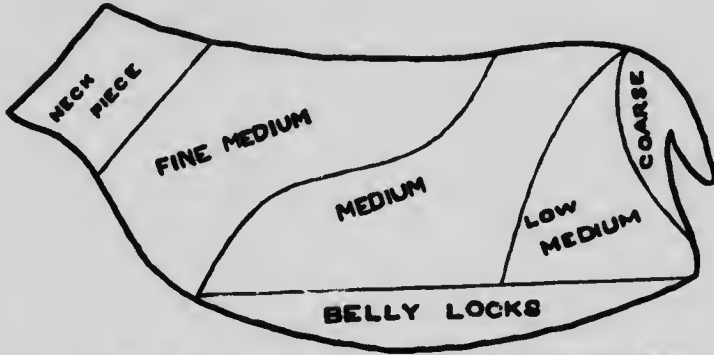


Diagram showing the different qualities of wool in a domestic medium fleece. (Side view).

most of us would wear cotton or emigrate to the tropics. Manufacturers do not wantonly adulterate their goods. If they could obtain an ample supply of good wool they would much prefer it, since it can be worked up for any purpose more effectively. They use shoddy because there is a constant demand for a cheap grade of wearing apparel and, secondly, the world's annual production of wool is many millions of



Correct method of examining wool on the sheep.

pounds less than the demand. Shoddy does not enter worsteds to any degree, and, if derived from all-wool sources, is more commendable than the mixture of cotton in cloths.

### MOHAIR.

Mohair is the product of the Angora goat. The fibre is coarse, very long, exceedingly lustrous, and with very little crimp.

It is chiefly used for the manufacture of braids, felts, linings and plushes. Mohair is also being employed quite extensively now as a substitute for human hair in switches and wigs.

### MINOR GOAT FIBRES.

Alpaca, Vicuna and Llama, native of South America, are distinctive types of goats, which produce fibres used to some degree in commerce. These animals are not domesticated, and, consequently, the annual yield is an uncertain quantity. Their hair is very similar and varies in colour from white and reddish-brown to black.

Cashmere is another goat fibre, noted for its exceptional softness, from which the famous Indian shawls are made.

### CAMEL HAIR.

Camel hair is quite important as a textile fibre, and is divided, according to quality, into three grades. The first grade is very fine and is employed for making such articles as toques, neckerchiefs and blankets. The coarser grades go principally into carpets. The hair is of a peculiar yellowish colour, which is not destroyed by bleaching, and, therefore, can be dyed only in dark shades.

### WOOD WOOL.

Pulpwood is bleached and shredded into long fibres, resembling at first glance braid wool. Its lustrous sheen, however, acts as an instant betrayal of its character. It is mixed with wool in the manufacture of heavy mats and stable blankets. It is also used to some extent in the imitation of silk, as in neckties or stockings, but for this purpose, Ramie, a vegetable fibre grown in China and India, is the chief natural substitute.



