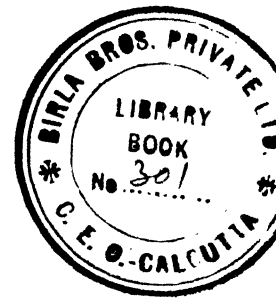
WOOLLEN AND WORSTED RAW MATERIALS



WOOLLEN & WORSTED RAW MATERIALS

Covering the Syllabus of the City and Guilds of London Examinations in these subjects

BY

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PREFACE

THE best craftsmen of the Woollen and Worsted Industries are those who understand the raw materials. This applies to every branch of the industry, whether it be carding, combing, spinning, weaving, cloth finishing, or dyeing.

So I hope that this book will be serviceable to all who sell, buy or manufacture the raw materials of the wool textile industry. For this reason great care has been taken to present the information so that sheep farmers and wool merchants may be able to obtain a better understanding of the requirements of the wool trade.

The chapters are arranged to cover the syllabus for the raw materials and scouring of woollen yarn manufacture and worsted yarn manufacture, issued by the City and Guilds of London Institute, which will commend the book to students who are studying for either examination.

Chapter XIV on Tops and Qualities is not included in the syllabus for woollen yarn manufacture, but woollen students will find some useful information therein on the wool quality numbers.

In a similar way Chapter XV on Textile Wastes is not covered by the worsted syllabus, yet worsted students are advised to study this subject as it will enable them to realize how the woollen spinner utilizes materials which a worsted spinner considers as " waste."

Huddersfield 1934.

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Chapter I

WOOL PRODUCTION

Coverings of sheep and goats have been used by man for clothing purposes for thousands of years, which accounts for the fact that in all civilized countries sheep and goats are reared for their meat, milk, and wool. The northern wool-producing area extends across Europe and Asia from Great Britain to China and thence to the United States of America and Canada; while the southern hemisphere contains the four largest wool-growing areas in the world, Australia, New Zealand, South Africa, and South America. Wools from these areas are known by trade names such as " Botany " for Australian wool, " N.Z." for New Zealand, " Cape " for South African and " B.A." for South American.

The world's sheep population is about 800 million animals, which produce about 3,800 million lb. of wool annually. The average growth of wool per sheep is about $4\frac{1}{2}$ lb. but in the colder areas this may reach 20 lb. per sheep, while in the warmer districts fleeces weighing only 1 to $1\frac{1}{2}$ lb. are obtained. One-third of the world's sheep, which produce half of the world's wool, are reared in the British Empire.

Table I

World's Production of Textile Fibres

Type of Material	*Percentage Production.*
Cotton	51
Jute	17
Wool	15
Hemp	9
Flax	5
Silk and Rayon	2
Other fibres	1

TABLE II

WOOL PRODUCTION BY CONTINENTS

WORLD'S ANNUAL AVERAGE WOOL PRODUCTION
(3,477,000,000 lb.)
(taken over 7 years, 1924-30)

Name of Continent.	*Percentage Production.*
Australasia	33
America	26·5
Europe	23·8
Africa	10·2
Asia	6·5

TABLE III

AUSTRALASIAN WOOL PRODUCTION

(1,149,000,000 lb. annually)
(average of 1924-30)

Name of Country.	*Percentage Production.*
Australia	77·5
New Zealand	22·5

TABLE IV

AMERICAN WOOL PRODUCTION

(920,000,000 lb. annually)
(average of 1924-30)

Name of Country.	*Percentage Production.*
United States of America	39·6
Argentina	35·4
Uruguay	14·0
Brazil	3·1
Chile	2·9
Canada	2·0
Peru	1·5
Mexico	·6
Falkland Islands	·4
Other Countries	·5

WOOL PRODUCTION

Table V

European Wool Production

(827,000,000 lb. annually)
(average of 1924-30)

Name of Country.	*Percentage Production.*
Russia (and in Asia)	38·1
Great Britain and Ireland	16·3
Spain and Portugal	10·2
Roumania	6·9
Central Europe	5·7
France	5·5
Germany	4·6
Italy	3·9
Baltic States	3·0
Bulgaria	2·6
Netherlands and Scandinavia	1·7
Greece	1·5

Table VI

African Wool Production

(355,000,000 lb. annually)
(average of 1924-30)

Name of Country.	*Percentage Production.*
South Africa	80·4
Algeria and Tunisia	11·0
Morocco	6·8
Egypt	1·5
Central Africa	·3

Table VII

Asiatic Wool Production

(226,000,000 lb. annually)
(average of 1924-30)

Name of Country.	*Percentage Production.*
China	30
India	25

Name of Country.	*Percentage Production.*
Persia	21
Turkey	12
Syria	9
Other countries (not including Russia) ..	3

Growth of Wool

The conditions which affect the growth of wool are (1) breed, (2) climate, (3) soil, and (4) food. The breed is the most important factor in the growth of wool, because every type of sheep grows wool with distinct features. A warm temperate climate is favourable for producing the finest wools. Hot and dry climates produce sheep which have thin, harsh, and wiry wools, while cold and damp areas influence the sheep in growing thick, long, and lustrous wools. The sheep grows a coat for its comfort and protection, which varies according to the climatic conditions under which it is reared. When sheep are taken from one country to another, the effect of climate on wool is very noticeable.

The nature of the soil on which sheep are reared has a direct effect on the growth of wool. Sheep which live on rich pastures give soft and clean wools, while the sheep reared on the chalky soil of the Cotswold Hills are noted for their thrift, which is due to the calcium nature of the soil. The sheep reared on the clay of the Romney Marshes are noted for their power of resisting foot-rot, and also yield a soft spongy type of wool.

For nourishment, the sheep depends upon its food, and scarcity of food or sudden change of diet will have a marked effect on the wool.

Sheep Pests

The fleece of the sheep affords cover and nourishment to parasites which live on the skin of the sheep. Four types of these are (1) mites, (2) keds, (3) lice, and (4) blowfly maggots. The mite is the cause of sheep scab, because it bores into the skin and produces sores and scabs all over the animal's body. The best remedy for this trouble is to treat the sheep with a lime and sulphur dip, and after seven days repeat the treatment.

Keds are troublesome to the sheep and stain the wool by their excretion.

Lice annoy the sheep by causing it to itch and rub its fleece against the posts and walls, which matts and felts the wool into cotty lumps.

The Blowfly Pest

One of the worst pests to both British and Colonial sheep is the blowfly, which attacks the animals at lambing time, and in some cases has been known to be the cause of the loss of about five per cent of a flock. The blowfly attacks the britch and organs, impregnating them with maggots, which have been known to kill a sheep in forty-eight hours. Salves and lotions should be applied to sheep which have received cuts or sores, in order to prevent the blowfly from striking them.

Investigations carried out in the Colonies, have shown that the blowfly will attack the sheep skin in preference to carrion, and that treating the sheep's skin with oil is the best preventive. Olive oil proved to be most suitable, but is expensive. Fish oils such as herring and whale oil also are suitable, while cotton seed oil and neats-foot oil do not penetrate the fleece so easily as olive or fish oils.

Sheep Diseases

Four of the main diseases which affect the sheep are (1) anthrax, (2) worms, (3) foot-rot, and (4) liver fluke. Anthrax is a deadly blood disease which causes the death of many sheep and may be conveyed to man by the animal's skin or wool. A general method of treating sheep infected with this disease is to inject an antitoxin into the blood. Special precautions for handling anthrax-infected wools are given on page 146 in Chapter XIII on Wool Sorting.

Intestinal and stomach worms, such as tape and wire worm troubles of sheep usually are treated by changes of diet, such as the addition of iron and salt licks, which are given to the sheep with their food. Such treatment is beneficial to the sheep, but in some cases the change over of diet causes a weak place in the wool and makes the wool defect which is known as tender staple.

Foot-rot generally attacks fine woolled sheep such as Merino and Down breeds, because these animals have not the powers of resistance, nor the thickness of hoof that is possessed by the Lustre and Demi-Lustre sheep. In some cases farmers have tried to eradicate this disease by crossbreeding with Romney Marsh and other foot-rot resisting breeds. This has resulted in some very low and coarse fibres being introduced into fine crossbred fleeces.

Sheep infected with foot-rot may be treated in two ways, (1) by foot baths, and (2) by medicated foot socks. When foot baths are given to the sheep the lotion is washed off again as the sheep run on the damp ground. Medicated socks, which protect the hoof from the damp soil, are made of waterproof canvas, and fasted with strings above the fetlock. These are considered to be better than the foot baths, because lotion can be poured into the sock to treat the sore and is not washed off when the sheep returns to the damp soil.

Liver fluke is prevalent in sheep which live in damp areas, and usually is treated by drenches. In using these, farmers should take great care to see that the wool is not stained, and that the drench does not contain impurities which are likely to damage the wool.

Feeding Sheep

The methods of feeding sheep depend on the climate and the nature of the soil. The best wool is grown on sheep which have been given a light dry diet, and reared on good grass lands, with plenty of clover, sheep's fescue grass, or sweet vernal grass. On the Downland hills, sheep live all the year round on grass, but in the colder climates, certain sheep are brought to the lowland pastures and fed on turnips, hay, rye, or barley straw.

In many cases the sheep are turned into the turnip fields to eat up the plants, and at the same time manure the soil. Many farmers do this to prepare the land for the next wheat crop, which has given rise to the saying, " No sheep means no corn."

Sheep which are being fattened for the meat market are given richer foods, such as corn, oats, and in some cases oil cake, to enable them to put on weight and so produce heavy carcases to meet the butcher's requirements.

Sheep Washing

Wool sometimes is washed on the sheep's back to remove loose pieces of dirt from the fleece. This may be done in three ways, (1) immersion, (2) hand washing, (3) swilling and pumping. On large farms the immersion method is used, the sheep are made to jump into a river or brook and swim for a few yards, which washes away any loose earthy matter from the fleece.

When sheep are to be hand-washed, each animal is placed into a pit or stream and given a thorough wash by hand. This method is too laborious and costly for general use. Swilling or pumping is done at those farms where the river or dam is not handy, and consists of holding each animal under a jet of water from either a hose pipe or a hand pump. The fleeces from washed sheep are classed as " washed fleeces " to distinguish them from " scoured " wool.

Sheep Shearing

On the small farms in Britain, shearing is just an incidental job, which comes in a day's work, while on the large Colonial and American sheep stations, shearing means a month's work and is the most important business of the year. The manager of a large sheep farm should have qualifications of good generalship, and be able to plan the movement of the flocks of sheep so that the whole of the sheep on the farm can be shorn without waiting. It usually is arranged to have several flocks of about a thousand sheep, within a day's call, to keep the shearers well employed. The movement of the flocks of sheep forty miles or so away, is planned so that the sheep can be brought up to the shearing station as required by the shearers.

The average Australian sheep farm covers an area of about a hundred square miles, and some of the larger ones have areas of over a thousand square miles. In some sheep runs there are fences which go for over thirty miles without a break, so it is an easy matter for a flock to be late at the shearing station.

Shearing Routine

It is essential that the sheep are dry before being shorn, because wet sheep are liable to give the shearers stomach

cramp. Three days prior to shearing, the sheep are placed in a covered pen to keep their wool dry. They are crowded together to make them sweat, because the wool shears easier under these conditions.

The shearer picks a sheep from the catching pen which runs alongside the sweating pen, and takes it to the shearing stand. The animal is thrown over on to its side, and the wool is cut from the legs and allowed to drop on to the floor. This material is swept up as " locks." Next the wool on the belly of the sheep is cut, which is thrown on to the pile of wool called " bellies." Then by six or seven strokes from the britch to the neck, the shearer brings away one side of the fleece. The sheep then is turned over, without disturbing the cut fleece and the rest of the wool removed.

A " picker " stands in readiness to take the fleece to the classer, while the sheep is pushed down a chute by the shearer. Each shearer has a special chute with a trap door, which keeps a tally of the sheep shorn. In hot weather, the newly-shorn sheep are kept under cover for a few days, to protect them against sun-burn or scald, because their newly-shorn skins are tender.

The length of time taken in shearing depends upon the type of sheep, and the kind of wool. Young wether sheep forcibly object to being shorn, but the old ewes, who are used to the process, are very docile. An average sheep will take about five minutes to shear. Rams are always stubborn and object to the treatment more as the years go on, so arrangements have to be made to shear them by hand clippers. Rams often take half an hour to shear and count double for payment.

Restless sheep sometimes receive nasty cuts when they try to wriggle away. A dab of tar is the usual treatment for small cuts, but seriously wounded sheep are killed. Blood-stianed wool, double cuts, and flesh bits greatly depreciate the value of a fleece, and straight shearing is better for the sheep, and brings more money for the wool.

Dipping Sheep

Sheep are dipped twice or three times a year, to rid their bodies of parasites which live in the wool near to the sheep's skin. The usual times for sheep dipping are in the early summer

immediately after shearing and in the autumn. The animals are plunged into baths containing suitable sheep dips which are made up of arsenic, sulphur, carbolic acid, or tobacco juice. Poisonous dips should not be used, because they may prove fatal to the sheep, while chemicals which stain the wool are not to be recommended. The Australian farmers use a dip made up of sulphur and lime, and have succeeded in eradicating the sheep mites which are the cause of sheep scab. The swim bath is preferred rather than the plunge bath by farmers, because the sheep get a thorough soaking which is more likely to kill the parasites.

Sheep Branding

Farmers brand their sheep with tar, paint, and other stains, in order to distinguish the various sheep of their flocks, and prevent confusion with the sheep owned by other farmers. Tar stains on wool are very difficult to remove, and many suggestions have been made for sheep staining fluids which are free from tar and red lead. A suitable fluid should be able to resist water, stand exposure to sun and rough weather, but yet be easy to remove when the wool is scoured. Tar on wool cannot be removed in the ordinary way, and wool sorters have to cut pitch stained wool from the fleece to effect a complete removal.

Chapter II

MANIPULATION OF WOOLS FOR SALE

A certain amount of " get up " is necessary to make the fleeces saleable before they can be presented at the wool sales. Wool should reach the market in self-contained fleeces which are unbroken and properly rolled up. Accurate classification also is essential if the wools are to be sold at their full value, so a great deal of attention is given to this matter on the wool stations.

The value of the wool depends on its condition, handle, and soundness. The condition of wool is due to the type of breed, soil, pasture, and whether the wool is dirty, clean, or burry. Handle denotes the softness, length, and fineness of the wool and is considered by certain wool men to be the main feature in wool value. A dirty lot of wool with good handling properties often will fetch a better price than cleaner wools with a poor handle. Soundness of staple is essential to the spinner, because wools which snap in processing are good for nothing but waste.

Table VIII

Sheep and Wool Terms

Term.	*Abbreviation.*	*General meaning.*
Ram ..	R ..	A male sheep
Tup ..	Tp ..	A Yorkshire and Scottish term for ram.
Ewe ..	E ..	A female sheep.
Stud ..	Sd ..	Special ram or ewe for breeding.
Lamb ..	L ..	A young sheep under 5 months.
Weaner	Wnr ..	A young sheep over 5 months but under 12 months old.
Hog ..	H ..	The first clip after 15 months growth.
Wether wool	Whr ..	All subsequent 12 months clips after hog or lamb.

Term.	*Abbreviation.*	*General meaning.*
Teg ..	Tg	.. Downland term for hog.
Shearling	Shl	.. A sheep shorn as hog and not over two years old.
Warp ..	Wp	.. A good combing wool over 3″ long.
Half-warp	½wp	.. A warp wool deficient in length.
Weft ..	Wft	.. Softer and shorter wool than half-warp.

Marketing of Greasy, Washed, and Scoured Wools

Wool reaches the market in four different conditions, (1) fleece wool, (2) scoured wool, (3) washed wool, and (4) skin wool. The majority of the wool from the Colonial markets is transported in the raw state to the factories, where it is scoured and made into yarn. In spite of the fact that the bale may contain 50 per cent of grease and dirt this method of transporting wool is preferred by manufacturers. Wool transported in the grease has the natural protection of the wool fat until it reaches the manufacturing process, which enables the material to maintain its handle, softness, and colour. Another important point in favour of transporting greasy wool is that the wool can be sorted to the buyers' requirements.

The wools which have been sorted and scoured on the upland stations of the Colonies enable a great saving in carriage and transport expenses. However, this wool may not be sorted to the exacting requirements of the manufacturer, and should it be soiled in transport a second washing would be necessary.

Fleece washed material is cleansed on the sheep's back, as described on page 7 ; the heavier impurities are removed, while the grease remains to protect the fibres. The fleece is transported intact, which enables sorting to take place as required.

Skin wools are sold to fellmongers who separate the wool from the skins as described in Chapter III on page 16.

Grading of Fleeces

The fleeces obtained from a flock of sheep are " classed " or grouped according to their qualities. This is necessary because great variations are to be found in the fleeces grown in

each flock. Also defective fleeces must be weeded out and packed in specific bales. The person who does this work on the wool shearing station is the classer or wool expert, who is one of the main men on a wool station. It depends upon the classer's judgment for the allotment of the various types of wool. A consistent wool classer has his judgments verified six months or a year later, when the wool reaches the British factories and meets with the manufacturers' requirements.

Classification of Wool

The work in a shearing shed is done by two distinct teams of men, (1) the shearers who remove the wool from the backs of the sheep, and (2) the packers who take charge of the fleece as soon as the shearers have removed it from the sheep. A station with twelve shearers will have a maintenance staff consisting of an overseer, a classer, a mechanic, six pickers-up, four rollers, and two pressers.

The first division of the fleece takes place when the shearer is cutting the wool. The coverings from the lower parts of the legs are called " locks " ; these are clipped first and allowed to fall on the floor. They are swept up by one of the pickers, who is specially detailed for this work. The wool from the belly of the sheep is taken off next and thrown into a special pile, but the fleece proper is handled with great care. A picker waits in readiness to take it to the rollers, and so prevents the shearer from throwing it on to the floor.

Fleeces then are divided by the classer according to the requirements of the two sections of the wool textile industry, which are (1) worsted wools, and (2) woollen wools. The long woolled fleeces for the worsted trade are put into the " combing " bin, and the shorter types of wool used for woollens are classed as " clothing." Accurate classing produces large amounts of fleeces uniform in quality, and prevents many small lots being made.

Every fleece cut on a station is presented to one classer, so that the judgment throughout a set of bales is uniform. Fleeces which have been poorly classed are turned down by the wool buyers, because they are expensive to sort. When fleeces are mixed together and not scientifically classed they are sold at a

flat rate, which is based on the lowest quality wool and not on the best fleeces in the bales.

Three grades of each quality of wool are made, (1) super, (2) firsts, and (3) seconds. The finest wool of the clip is classed as super, and contains fleeces with good length which are regular in fineness and features. Firsts form a medium quality, but have fair features, while seconds have the strongest and coarsest wools of the group. These wools are indicated by marks as shown in Table IX.

TABLE IX

CLASSERS' BALE MARKINGS

Type of Wool.	*Australian mark.*	*South African mark.*
Choicest fleeces ..	AAAA	ESC
70-80's quality ..	AAA	SC
70's quality	AA	C
64-70's quality ..	A	CC
60's warp	CBG	CCC
60's weft	CTHG	S
Tender	Tender	TDR
Bellies	Bellies	B
Pieces	Pieces	P
Locks	Locks	LOX
Burry	Burry	BUR
Rams' wool	Rams	RAM
Dead or Fallen ..	Fallen	DEAD

SKIRTING

After the fleece is taken from the shearer it is thrown over a table and skirted; this operation consists of tearing off the ragged and dirty pieces of wool. Large pieces of wool torn off in this way are called " pieces " and small ones " bellies." Bits of wool which fall to the floor during shearing or classing are swept up and sold as " locks." Great care should be taken in skirting, because it is the division of the high and low grade wool. When this is not done well, rough and coarse fibres find their way into the better class wool which depreciates the value, while a too rigorous skirting places good wool into the bellies

and pieces, which only sell at about one third of the value of good wool. Locks and bellies are classified and lettered in a way similar to the fleece wools as shown in Table IX.

Defective and Faulty Wool

Sheep which die through illness have the wool shorn from them ; this is washed, disinfected and packed as " fallen fleeces." Black and grey wools are placed into separate lots known as " black " and " grey." Cotty and burry fleeces have their respective bales, while any fleeces of odd growth such as exceptional fleeces of low grades, and fleeces from sheep which have escaped shearing during a previous year—called double growth—are placed in a special bale known as " cast " fleeces.

Fleece Rolling

Rolling a fleece is skilful work, and a fleece roller needs considerable practice before he becomes proficient. The fleece is spread out by the picker on the roller's table with the flesh side down, and is given a vigorous shaking to remove any fribs, loose earth, or burrs. The two sides of the fleece are folded over and then over again until the fleece becomes a narrow strip, which is then rolled up having the britch in the middle and the shoulders—where the best wool grows—on the outside. The neck part of the fleece is twisted into a rope which is used to fasten the ball of wool securely.

Baling and Marking

The fleeces are press-packed into bales by a press. On some stations hydraulic presses may be used, but hand presses are employed generally. Wool packing is an art and great care is taken to prevent false packs. Certain wool stations place the finest fleeces round the outside and lower quality fleeces in the middle. Bales made up in this way may not be discovered at the time of sale, but they are found by the wool sorters. Firms who have been deceived in this way note the bale markings and avoid lots from this source in the future. At one time it was not uncommon to find stones, soil, and even pieces of iron inserted in the middle of the bale to give weight.

After packing, the bales are marked with stencils to indicate

the type of wool in the bale, and the station at which it was packed. A bale may be marked in the following way :—

$$6 \quad \begin{matrix} \text{C.B.} \\ \text{Darling} \end{matrix} \quad \text{AAA} \quad \text{CBG} \quad \text{W}$$

which indicates that this is the sixth bale of 80's quality combing wether wool packed at Charles Brown's station at Darling.

Types of Bags for Packing

Wool is packed in a jute bag which is known as a " wool pack." In recent years it has been suggested that certain vegetable impurities found in the wool have their origin in the bags which contain the fleeces during transport from the farms to the mills. Jute being a vegetable fibre does not dye like wool and the cloths which contain jute fibres come up speckled in dyeing. Suggestions have been made from time to time, to use (1) " all wool " wool packs, (2) paper wool packs made with wire supports and water and fireproof paper, and (3) ramie wool packs. The " all wool " wool pack would be the ideal bag for transporting wool but, unfortunately, has proved to be very costly and not strong enough for this work.

Table X

Average Weight of Bales

(in lb.)

Name of Country.	*Greasy.*	*Scoured.*
English pack	240	
English square	700	
Scottish bag	225	
Australasia	330	250
South Africa	370	210
Mohair	500	
Argentina	1000	800
Peru	230	180
Chile	580	
Punta Arenas	450	
China	500	
Asiatic	330	
East Indian	330	
Turkey	200	

CHAPTER III

SKIN WOOLS

THE development of the frozen mutton trade has brought a large amount of skin wools into the market. The sheep are reared, and killed for their mutton ; the skins, with the pelt and wool intact are sold to the fellmongers. The work of the fellmonger is twofold, he must remove the wool in the natural condition, and also leave the skin uninjured. The wool removed in this way is called "pulled wool," while the skin after the wool removal is known as the "pelt."

There are three classes of skin wools : (1) British skins which come from the Long-woolled and Downland sheep, (2) Merino skins from Australian and South African sheep, and (3) Crossbred skins from New Zealand and South American sheep. British skins come from the local slaughter houses of the sheep-rearing districts, where about 12,000,000 sheep are killed annually and their skins sold to the fellmongers.

Merino skins come from Australia, South Africa, and South America. The Merino sheep is not a meat-producing animal as its body is too small and cannot produce large juicy joints, and the flesh has a dark appearance which lacks the freshness of the meat from the lustre sheep. The bulk of the Merino skins which reach the skin wool market are obtained from the old sheep of the flock, which have been shorn three or four times, and killed in their fifth year.

Crossbred skins arrive from the mutton-producing areas of New Zealand and the Argentine. These skins are larger and firmer than the Merino type, but the wool is coarser and longer, and consequently does not reach the prices of Merino wools. The skins are very solid, and are greatly prized by the leather dealers.

The Frozen Mutton Trade.

A good mutton sheep for the frozen meat trade has been obtained by crossbreeding, which has brought a considerable amount of skin wool into the wool textile trade. The main districts for the production of these types of skin wools are New Zealand and Argentina. In 1880 about 400 carcases of mutton were imported into Britain, while over 15,000,000 carcases per annum are now received. In the crossbred areas, an early maturing lamb, which is fattened for about four months and then killed is favoured. About three-quarters of New Zealand's supplies are skins from lambs, while the rest are from older sheep.

In the southern hemisphere spring begins early in September, and the lambing season starts. As soon as the farmers have dealt with the lambs, they start the shearing operations, which extend from late September until November, while on some farms shearing has to be done as late as Christmas.

By November, the lambs born in September have grown to a good size. The farmers then divide the rams from the ewes and select the finest rams for stud breeding, while the rest of the male lambs are sold to the meat freezing companies and are slaughtered for their mutton. These carcases arrive in Britain just before Easter as " Prime New Season's Lamb." During the winter months—July to September—the freezing stations close down and open out again for the new season early in October.

The older sheep are collected from the sheep stations by the meat freezing companies and slaughtered in the same way as the lambs. The carcases are frozen and the skins classed and packed into bales.

Classification of Skin Wools.

The classification of skin wools is not as skilfully done as that of fleece wools owing to (1) the various lengths of growth, (2) sheep from different stations and of many types are slaughtered together, and (3) the freezing stations do not specialize in wool production. Conditions have improved greatly in recent years and many killing houses now employ competent wool classers to group the skins.

Killing is not consistent with the time of shearing ; some sheep are slaughtered one month after shearing, while others will have an eleven months' growth of wool when they are killed. All skins with less than six months' growth of wool are called " clothing " and those with from six to eleven months' growth are known as " combing." A further division is given sometimes by separating the half year's growth and the three-quarters' growth into two groups.

Skin wool is never as long as fleece wool for identical qualities, and the classification of this wool into groups is often a matter of guess-work. Lamb skins with only three months' growth of wool are sold as " lambs pelts." The wool is very short, and is purchased by blanket makers.

The supple skins removed from the sheeps' bodies are known as " green skins." Before these can be baled, they are dried to stiffen the soft limp skin. This may be done in two ways ; (1) in the sunshine, or (2) by salting. Each skin is given a coating of arsenic to protect it from attacks by grubs and mice during transport.

Sheepskins are packed at the freezing stations into bales ; each bale containing sixty large skins or 120 lamb skins. The pelts are packed skin to skin to protect the hides, and the bale is then press-packed and surrounded with iron hoops. The usual weight of a bale is from 6 to 7 cwt. The ends of the bale are covered with strips of canvas and marked on the outside to indicate the type of wool, and the freezing station of origin.

Methods of Dewoolling Skins

The fellmongers who purchase the woolled sheepskins have the choice of three methods for removing the wool from the skins: (1) the lime method, (2) the sweating method, and (3) the chemical or reagent method. The oldest of these systems is the lime process which is being displaced by the sweating method for Merino skins, while the stouter crossbred and lustre skins usually are treated by the chemical process.

Lime Method

Skins treated by the lime method are soaked in a mixture of lime and water for a short time, after which the wool can be

pulled away without damaging the skin. In some cases the lime is made into a paste and rubbed into the flesh side of the woolled sheepskin, and in a few hours time the wool can be removed without difficulty. The removal of the wool is done by plucking or flipping the wool from the skins, which has given these wools the name of " flipe " or " slipe." In the American wool trade, skin wool is known as " pulled wool."

The lime-method is falling into disuse owing to the very harsh handle it gives to the wool. Lime also is very difficult to remove ; in scouring it combines with the soap and reduces the washing power of the liquor by forming lime-soap. One lb. of lime will destroy 16 lb. of soap in the liquor. Lime removal should be regarded as a very expensive item in the scouring costs.

Sweating or Stoving Method

Wools treated by the sweating method are called " stoved " wools, owing to the fact that the woolled sheepskins are stoved in a penthouse during this process. The first operation is soaking ; the skins are laid flesh side down in vats containing water, for twenty-four hours to make them soft and supple. The vats are about 10 feet square, 3 yards deep, and will hold about 500 skins. At the scheduled time, the water is let off, and the skins are left to drain for about three hours before being removed from the vat.

On removal from the vats, the skins are hung in the sweat house, which has several rows of hanging racks and hooks arranged in a similar way to a huge cloakroom. The skins are hung in pairs with the flesh sides together, and suspended from the back part of the neck because this is the strongest portion of the skin. Continental fellmongers do not hang skins in this way, but place them over wooden bars which support the wet and heavy skins at both ends.

As soon as all the skins are assembled, the sweat house is closed and the temperature raised until a moist heat rises and produces the strong steamy atmosphere which softens the pelt and loosens the wool fibres.

The sweating should be watched carefully, so that the skins can be taken out at the right time. When skins have been left

in the penthouse too long, they are reduced to a soft sticky mass which will run like glue. Different types of skins vary in the amount of stoving needed to soften the pelt, and rapid changes of weather and temperature may cause the stoving to be too quick or too slow, which results in serious losses of both wool and skin.

Reagent Method

The chemical method of dewoolling sheepskins consists of painting the flesh side of the skin with a sodium sulphide solution, which loosens the wool by destroying the hair bulbs in which it grows. The skins are then hung for about six hours when the wool can be removed from the skin without difficulty. This method of treatment is only used on very stout, strong skins such as those from lustre and crossbred sheep.

Great care has to be taken, because sodium sulphide is a very powerful reagent. A ten per cent solution of sodium sulphide would destroy wool in fifteen minutes. Should any of the paint touch the woolled side of the skin, the fibres would be damaged and probably rendered useless.

Wool Pulling

The wool puller removes the wool from the skin and sorts it into qualities in a way similar to which a wool sorter divides up the fleece into its various divisions as described in Chapter XIII on page 143

Each skin is thrown over a curved board, which rests at an angle of about 60° and slopes towards the puller. The puller in plucking the wool from the skin sorts the wool into qualities and throws the various lots into different bins. As many as six qualities may be made from a group of skins, but as a general rule the wool is made up into three qualities : shoulders, haunches, and skirtings. After pulling and sorting, the wool is dried and then passed to the scouring operation in the same way as fleece wool. An average woolled sheepskin will yield 4 lb. of wool and 1½ lb. of skin.

Mazamet Wools

A considerable amount of woolled sheepskins are bought by Continental buyers, who ship their purchases to Mazamet in

Southern France, where an extensive dewoolling industry exists. It is claimed that the soft waters of the Tarn are ideal for sweating Merino skins. The wool then is resold to wool merchants in Northern France, Great Britain and Germany, while the pelts are purchased by leather dealers.

Uses of Sheep's Skins

Pelts or sheep's skins after the wool has been removed are made into several types of leather. The skin of the sheep does not make up into the strong and stout leather like that which is obtained from the hides of cattle, but is made into a softer and finer type of leather which is used in book-binding, and for the uppers of ladies' shoes. A very serviceable imitation Morocco leather called " roan " can be made from these skins, while certain leather manufacturers split the skins and treat the outer layer with oil to make an imitation chamois leather, the inner layer is made into parchment. The value of the skins which are sold by the fellmongers to the leather merchants depends on their condition, colour, and handle. Badly treated and improperly cleansed skins do not command the prices which can be obtained for neat, clean and regular skins.

Comparison of Fleece and Skin Wool

The death of the sheep does not affect the quality of the wool. Should the carcases be shorn after killing, the wool would be just the same as fleece wool. But this would necessitate a dehairing process at the tannery where the pelts are treated. Fellmongers save this process by removing the wool completely. Defects in skin wool therefore are due to the processes used in removing the wool from the skin.

Lime wools are harsh in handle owing to the presence of the lime, which also makes them grey and dingy in colour. Wools treated by this method cannot be spun to high counts, dyed to delicate shades, or used for heavily felted or milled cloths. These wools suffer from a lack of elasticity and need more oil to make them sufficiently supple for satisfactory processing.

Stoved wools suffer when the sweating process has melted the yolk and left the fibres unprotected, which causes the wool to be tender and work up wasty in carding and spinning.

Wools treated with sodium sulphide, where the fibres have been in contact with the reagent may produce broken fibres in carding, and a consequent low tearage in combing. When this process is done with care, these wools should compare favourably with fleece wools.

Irregularity of qualities is always found in skin wools, because the classification of the fibres is not done with the skill which is used in the case of fleece wools. The skin wools cannot be skirted prior to sorting. These wools do not possess the length and regularity of the fleece wools owing to the time of killing varying.

Chapter IV

WOOL SALES

Wool from the farms and sheep stations may be sold to the manufacturers in two ways, (1) by private treaty, and (2) by public auction. For wools grown in the manufacturing areas, such as Yorkshire and Devon, the private treaty method of sale generally is used, but a large percentage of imported wool and a considerable amount of home-grown wool is sold by public auction. Wool auctions may be divided into four groups and classified as (1) Colonial Wool Sales, (2) Sales of Woolled Sheepskins, (3) Sales of Low Wools and Hairs, and (4) Local Wool Sales.

Places of Sales

The most important wool sales in the world are those of Colonial wool, which are held in the Wool Exchange, Coleman Street, London. At these sales, large amounts of Australian, South American, and South African fine wools are sold. The name of Colonial Wool Sales is still retained in spite of the fact that South American and British wools are offered for sale. Colonial Wool Sales are held also in Roubaix in France, Antwerp in Belgium, and Hamburg in Germany. In Australia wool is sold at sales held in Sydney, Brisbane, Melbourne, Adelaide, Geelong, Hobart, Perth, Launceston, Albury, Newcastle, and Ballarat.

New Zealand has eleven wool-selling centres, which are : Wellington and Napier which have five sales a year ; Wanganui, Christchurch, Dunedin, and Auckland have four sales a year ; while the smaller wool selling centres of Timaru, Invercargill, Gisborne, Blenheim and Nelson have one or two sales in the middle of the wool season.

South African wool is sold at Port Elizabeth, East London, Durban, and Cape Town. The wools from South America are

sold at Buenos Aires and Bahia Blanca for the Argentine clip, while the wools grown in Uruguay are sold at Montevideo. There is not a wool-selling centre in the southern part of South America, so the wools from the Falkland Islands, Tierra del Fuego and Punta Arenas are sold at the London and European wool sales. The wool markets of the United States of America are Boston, New York, and Philadelphia. The Marseilles wool market in the south of France also deals with certain types of low wool from Algiers, French Sudan, Baghdad, Cyprus, Portugal, Tunis, and Tripoli.

Local British wool sales, which dispose of the home-grown wools are held in the various towns of Great Britain, see Table XI. The dates and places of these wool auctions are arranged by the British Wool Federation, which meets in Bradford soon after Easter each year, and, in consultation with the wool buyers and auctioneers, issues a schedule of dates for the wool fairs.

TABLE XI

LIST OF BRITISH WOOL FAIRS

Andover	Fishguard
Ashby-de-la-Zouch	Glasgow
Aylesbury	Guildford
Basingstoke	Haverfordwest
Bicester	Hawick
Blandford	Henley
Brackley	Huntingdon
Bury St. Edmunds	Ipswich
Campden	Inverness
Carmarthen	Kettering
Chester	Lampeter
Cirencester	Leicester
Crewe	Leith
Crymmych Arms	Lewes
Devizes	Lichfield
Diss	Llandilo
Dorchester	Llandovery
Dublin	Llandyssul
Edinburgh	Llangollen

List of British Wool Fairs

Llanidloes	Perth
Llanrhaiadr	Peterborough
Llanybyther	Reading
Loughborough	Rugby
Marlborough	Salisbury
Melton Mowbray	St. Clears
Monmouth	Shrewsbury
Narberth	Stratford-on-Avon
Newark	Swansea
Newbury	Swindon
Newcastle Emlyn	Thrapston
Newport, I.O.W.	Wallingford
Newtown	Wantage
Northampton	Wellingborough
Nottingham	Wellington
Oswestry	Whitland
Pembroke	Winchester
Pencader	Wrexham

Types of Wool offered

The types of wool offered at the London Colonial sales are the fine Merino and crossbred wools, which have been grown in Australia, New Zealand, South Africa, South America, Canada, Kenya, together with certain types of British wools. About 75 per cent of the wool sold at these sales is used in the Yorkshire and Continental worsted industries, and 25 per cent in the woollen industry. At the Colonial wool sales held in the countries where the wool is grown, only wools from the immediate neighbourhood are offered, so a buyer who wishes to inspect a large assortment of wools grown in different parts of the world, will visit the London Colonial wool sales. Another advantage in using London as the wool selling centre is tha a merchant can purchase wool on the spot and have it delivered to his mill within a few days of the sale.

Woolled sheepskins come from the backs of slaughtered animals, and consist of all types of wools, which are grouped and classed according to length and quality. The bulk of

these come from the frozen mutton areas of New Zealand and Argentina, although some sheepskins from all sheep-rearing areas usually are offered for sale.

The annual business done at these sales represents over £1,250,000, and the weight of woolled sheepskins sold is well over 14,000 tons. Buyers from the United Kingdom, France, Germany and the United States are present in large numbers, because sheepskins are a very valuable commodity of the leather trade. Business at these sales usually is very brisk, because both the wool and skin industries are interested in their raw materials.

Low-grade wools are sold at Liverpool as well as London, and consist of all types of wool not sold as Colonial or skin wools. Low crossbred wools are purchased by the low woollen manufacturers, because they form a very desirable addition to their reworked wool blends. One hundred million pounds of this type of wool is sent every year from New Zealand, which is worth about £6,000,000. A similar amount of South American crossbreds—known as " River Plate " or " La Plata " wools—also are received.

The wools from India average about 50,000,000 lb. each year and are sold for about £1,250,000. A special market is held for these wools at Liverpool, where they are sold by auction six times a year. All types of hair such as Cashmere, camel hair, mohair, alpaca and horse hair are sold at the Liverpool Wool Sales. There are also the " Liverpool Miscellaneous Wool Sales " which correspond to the " London Low-grade Wool Sales " where lots of wools and hairs from Egypt, Sudan, Spain, Portugal, Iceland, and Morocco are offered for sale.

British wools, offered for sale at Coleman Street and at the local wool fairs, consist of Lustre, Demi-Lustre, Down, Half-bred and Mountain wools. The skins from slaughtered British sheep usually are sold by private treaty to the fellmongers, but at certain periods of the year local auctions of woolled sheepskins may be held. The number of sheep slaughtered in Great Britain is about 11,000,000 a year, which yield about 30,000,000 lb. of skin wool. The amount of fleece wool produced each year is about 80,000,000 lb. About half of the total production of British grown wool is taken by

the Continent and America, while the remainder is used in the local industries.

Sales by Auction

The first public auction of Colonial wool took place in Garraway's Coffee House, Cornhill, London, in 1821, when 167 lb. of wool was sold. The wool-selling centre of the world sprung up in this area, and in 1875 the present Wool Exchange was built.

Since 1808 when the Rev. Samuel Marsden, of Farsley, brought the first consignment of Australian wool to England an elaborate system of wool importation has been organized. Large trading houses known as Pastoral Companies form a liaison between the Colonial farmers and the wool users. These companies arrange to collect the wool from the farmers, insure, and ship it to London where it is delivered to the brokers for sale. The company make a payment of 50 per cent of the value of the wool and send the remainder after the auction. In some cases international banks act as Pastoral Companies and negotiate the shipments of wool.

Special boats ply between London and the Colonies to bring the wool to the lower reaches of the Thames. The bales of wool are then brought up the river to the wool warehouses of the Port of London Authority in the London and St. Katharine's Dock. At one time whole boat-loads of wool were carried by lighters—the flat-bottomed boats of the Thames—from the wool boats to the warehouses, but motor transport is used now to bring the bales of wool from Tilbury to London by road.

Wool Warehouses

The wool warehouses of the Port of London have a floor space of 1,250,000 square feet, with a holding capacity of 1,000,000 bales of wool. The wool is placed in the lower storeys, while the top floors are used for showrooms where bales are placed for inspection by the buyers. A north light is given by a shed roof, which gives a good even light—well diffused, but without glare. Some of the Australian wool showrooms have been painted a light cobalt blue to give a better light for wool judging.

Forty thousand bales of wool can be displayed in the London wool warehouses. These buildings have been built for the wool trade and cannot be used for any other purpose, such as the storage of grain or meat, because of the peculiar odour given off by the wool. The custom in London is to weigh the bales as they go out of the wool warehouses to the purchasers, but at the wool sales held in Australia and South Africa, the bales are weighed as they are received into the warehouses.

The wool in the warehouse is viewed first by the brokers who are entrusted with its sale. A 1 lb. sample of wool is taken from each bale and valued. The owners, or their representatives in consultation with the brokers, place a reserve price on the wool, which represents the minimum that will be accepted as a bid, when the auction begins. In many cases this matter of the minimum price is left entirely in the brokers' hands.

Examination of Colonial Wools.

After a consignment of wool has been examined, the brokers issue catalogues to the prospective buyers. A wool sales catalogue is full of information; it gives the port of embarkation, the name of the ship which brought the wool, the warehouse where the wool is stored, where the sample bale may be examined, the type of wool, the number of bales in each lot, the bale markings, the classers' markings and the tare.

The origin of the bales of wool is indicated by bale markings; these form a useful method of establishing confidence between growers and buyers. A wool buyer will often bid on repeats which have given him former satisfaction. In cases where "false packs" have been discovered or the quality of the fleeces has not been consistent, revealing the poor judgment of the classer, buyers note the bale markings and avoid these lots at a future sale.

Tuesday is the opening day for a series of sales, and buyers often arrive on the Monday to make an early start with their wool inspections. A buyer carefully examines the various lots of wool for fineness of diameter, estimates yields, tests for strength and soundness of staple and tries to determine what results the lots he desires will give in "tearage." He then decides how

far he intends to go when the bidding begins, usually noting his initial and final bids in the catalogue.

Types of Wool Buyers

Three types of wool buyers attend the sales, (1) professional buyers, (2) wool merchants, and (3) private buyers. Professional buyers purchase the wool and charge about 2 per cent. commission to their clients. Wool merchants buy wool, which is sorted into qualities and sold as " matchings." Private wool buyers are experts from individual firms, who buy lots of wool to suit their requirements. Several worsted spinning firms buy wool at the sales, have it combed on commission and delivered to their mills as tops.

Wool Auction

At 3 p.m. on the first Tuesday of a sale, there is a great deal of excitement as all are anxious to see how the prices will move. The opening figures are taken as an indication of the tendency to be expected throughout the sale ; these are promptly cabled to wool growers in Australia, South Africa, and South America and to the manufacturers of the West Riding, France, Germany, and the United States.

Each lot is offered in catalogue order and the bidding starts at the brokers' reserve price in pence per lb. In the early stages farthing bids are taken, but on reaching a certain figure halfpenny bids are demanded. The lot is sold to the highest bidder who may be required to make a 25 per cent. deposit of cash at the time of sale. The usual terms are cash within seven days, and the wool must be removed by the fourteenth day after the auction.

No time is lost at a wool sale ; both auctioneer and buyers are very anxious to keep the business moving, and in many cases 400 lots an hour have been sold. The hammer has been known to drop at the rate of ten seconds a lot. It is not an unusual occurrence for an auctioneer to sell £250,000 worth of wool per hour, or approximately £4,000 per minute.

Star Lots

The odds and ends of the wool trade are marked with an asterisk in the sales catalogue, these are called " star lots," and

are sold in the " star " or " small " room. They consist of broken and odd fleeces which only fetch about a third of the price of the first-class lines. These lots are difficult to estimate and have no uniformity of quality. The wool purchased in the small room is sorted and used for making blends. In some of the Australian sale rooms, a special star lot catalogue is issued and a separate sale conducted, but at the London Colonial sales, the numbers in the catalogue run consecutively for both top and star lots. The star sale room opens a quarter of an hour later than the " straight sale " and quickly disposes of all lots which consist of less than four bales.

Prompt Day

The fourteenth day after the sale is known as prompt day, which is the last day for receiving complaints concerning false packing, improper marking or mixed lots. In some of the Australian wool markets a buyer who receives a false pack, can within three days of the sale demand the name of the vendor, with a view to obtaining legal redress. Where any false packing of bales is suspected in the London wool warehouses, the buyer is allowed to unpack the whole bale and thoroughly examine all the fleeces, which are then sold at their true value. It is customary for the buyer to remove the wool from the warehouse before the prompt day. Should he fail to do so he is allowed three days grace, and then is charged rent per cubic foot for the space taken up in storing the wool. Unclaimed bales are sold by the brokers, either at the next public auction or by private treaty.

Sales of Woolled Sheepskins

Public auctions of woolled sheepskins are held in the Wool Exchange, Coleman Street, London, about six times a year. As a rule these sales are held in January, March, May, July, September, and November. The procedure at the sale is very similar to that of the Colonial wool sale, but with modifications owing to the difference between the wool and the woolled sheepskin. In the case of fleece wool, the farmer deals directly with the Colonial Pastoral Companies, while woolled sheepskins are purchased by the Pastoral Companies from the Meat Freezing

Companies, who in turn have bought old sheep or young lambs from the farmers.

The lots are made up by the brokers ; a usual amount being about a dozen bales to a lot. The extensive system of wool valuing cannot be done with the woolled sheepskins, nor can 1 lb samples be taken from each bale, in the same way as in the case of fleece wools. In order to enable the buyers to examine the type of material offered for sale, a typical bale of each lot is opened out in the bale showroom. A deal of business is done by private treaty in the skin wool trade. A buyer on receiving the brokers' catalogue will sometimes negotiate for an immediate purchase of certain bales whose markings are known to him and have given satisfaction in the past.

Sales of Low-grade Wools

The wools from the East are collected from the native farmers by merchant firms. There is not a specialized system of wool exportation like that of the Colonial wools. The merchant firms purchase maize, barks of trees, coffee, copra, hides, hemp, skins, and wool. When a merchant ship from the East arrives in London, its wares are examined and sent to the specialist brokers. Instead of coming in ships full of wool, the low wools arrive in port as a few bales amongst various types of produce in the ship.

Merchant firms either purchase the wool outright from the native farmers, or when large consignments are dealt with, advance on despatch about 50 per cent of its estimated value and send the balance after sale. Certain brokers specialize in low wools, and separate rooms are reserved in the wool warehouses of the Port of London, for the storage and exhibition of these wools.

Examination of Low Wools

In order to make a successful examination of the fleeces in the low wool market, an expert buyer is needed, because there is a wide divergence of quality in the wools offered. The buyer should understand the different ways in which the wool is presented to the market.

From eighty to one hundred fleeces are packed into a bale and

will weigh about 400 lb. Lots are made up on a colour basis rather than quality, and consist of fleeces, skins, and pieces. At these sales there are no 1 lb. samples taken as in the case of Colonial wool, but the bales are broken open for inspection. A few typical fleeces are taken out of each lot, which are valued by the brokers and a catalogue issued.

Dates of Sales

There are no fixed dates for the sales, as many of the purchasers of low wools visit the brokers' offices and warehouses and buy the required wools by private treaty. The frequency of sales depends on the wool available, and when three or four brokers have enough wool to justify a sale, the date is arranged for the auction. It is not an unusual occurrence for a sale to be cancelled after the issue of the catalogues, owing to all the wools being sold privately.

The sales are held in the Wool Exchange, Coleman Street, London, usually commencing at 10 a.m. The procedure is very similar to that of the Colonial sales with modifications suitable for the different types of material. The value of these wools is much lower than the star room prices for the Colonial wools. Many lots do not fetch 3d. per lb. so a special rate of bidding is used. For the better types of low wools, the usual advance in bids of a $\frac{1}{4}$d. per lb. is taken, but below 3d. per lb. bids advance by one-eighth of a penny known as "half-farthing" bids.

Local Wool Sales or Fairs

Wool auctions are held from June to August each year to sell the home-grown wool. The places of sales are given in Table XI on page 24. The wools at these sales are offered in small groups of fleeces and not in bale lots. There is a marked absence of local wool auctions in the manufacturing districts, because the wool grown in Yorkshire, Cornwall, and Devon is sold direct to the local manufacturers. Many local wool fairs, being held for generations, have become part of the established customs of the district. These are maintained often in spite of some overlapping.

Arrangements for Sale

The arrangements for a local sale are taken in hand by the auctioneers who are to conduct the sale. A month before the scheduled date—while the farmers are busy shearing—the auctioneers announce the date and place of the sale, usually by posting notices to the farmers and placarding bills round the country-side. The farmers who intend to offer fleeces for sale apply to the auctioneer for a supply of bags in which to pack their wool. The bags used at these sales are called " sheets " and consist of two sheets of jute sewn together. After the bags have been filled with the fleeces the top is fastened by wood skewers. A full sheet of wool is called a " pack " and weighs 240 lb. which forms a useful figure in valuing a lot of wool as the pence per lb. equals pounds per pack. A sheet of wool costing 7½d. per lb. is worth £7 10s. 0d. per pack. The farmer is responsible for transporting the wool to the sale, and also for displaying the wool prior to the start of the auction.

Wool Inspection

Wool auctions often are held in the market places of the towns, and the wool is exposed in the open to the dust on hot days and the rain in wet weather. The general lack of suitable storage warehouses cause the local sales to be little sought after by many wool buyers. Generally the farmer and the auctioneer know very little about the features, properties, and market value of the wool. Consequently, after a sale many of the buyers claim rebates on their purchases owing to faulty packing, mixed fleeces, or black and grey wool.

The procedure of the local wool sales follows that of the London sales with this difference that the initial bids are received from the buyers, and are not taken at the farmers' reserve price. Bidding is taken in pence per lb. and rises in farthings. After a sale, the buyers give written instructions to the auctioneer regarding the transport of the wool. When this regulation is not complied with, the auctioneer will charge the buyer with the cost for storage of the wool until instructions are received.

Auctioneers make a charge of ninepence for the loan of each

sheet in which the wool is carried from the sale to the mill. The sheets should be returned as soon as emptied, and in any case within four months of the sale. At the end of this period, the auctioneer charges the buyers £1 for each sheet not returned.

Direct Purchase of Wool

Wools from the manufacturing areas of the north of England, Devon, and Cornwall are bought from the farmers by direct purchase. Large merchanting companies of the West Riding send out buyers, who inspect and purchase the wool required. The buyers supply the sheets to the farmers at shearing time. The wools are packed into distinct lots such as ewe, lamb, washed, hog, and wether. A price is agreed upon, and the purchasers make their own arrangements for the wool to be transported to the mills. Few farmers have facilities for storing wool, and are glad to give immediate delivery for prompt payment. Terms are arranged, whereby the farmer will accept certain reductions if on subsequent examination the wool is found to contain cotts or grey hairs.

Wool Agencies

Many large firms of wool merchants have agents throughout the agricultural areas, who visit farms and inspect the wools which the farmer offers for sale. This is a usual practice in Cumberland, Westmorland, Northumberland, and Durham. In some cases the farmers have very small flocks of two or three different breeds of sheep which become mixed together. A wool agent will have to classify a clip of about a hundred fleeces into twelve or fourteen groups.

Farms vary in size and the number of sheep kept by a farmer varies accordingly. The larger farms with flocks of a thousand sheep of one breed soon become well known to the wool agent, who will make good offers for this wool, but when an agent is confronted with fourteen lots of odds and ends he has a difficult problem to settle. The agent desires to satisfy the farmer, but not compromise the merchants he represents. When he has collected several lots of wool from many farms, he then classifies

and makes them up into lots according to their breed and grade.

General Dealers

Another way in which local wools are sold is through a general dealer. Many farmers deal with the local provision merchant for their supplies of groceries, etc. These dealers will also purchase goods, and in many instances buy wool from the farmers. The money paid by the dealer for the wool is not based on its value, and is taken at a flat rate. Some years the dealer may be fortunate enough to make a profit when he sells the wool to an agent, he is, however, prepared to lose money on the wool deals in order to maintain friendly business relations with his farmer customers.

Co-operative Wool Marketing

Since 1920 a much better system of marketing the home-grown clip has been arranged in certain areas which is known as Co-operative Wool Marketing. Groups of farmers have established themselves as Limited Companies, and each company employs (1) a secretary, (2) a wool broker, and (3) a wool classer or grader.

Before shearing time commences each year, the members of the wool company inform the secretary of the number and type of fleeces they intend to offer for sale. Dates and places are given, where and when the wool sheets have to be sent and the transport of the wool to the co-operative warehouse is arranged. On arrival at the warehouse, the wool is weighed-in, and checked against the individual farmer.

When all the fleeces have arrived from the various farms, the classer grades them into lots, and then arranges for the baling to be done in readiness for dispatching to the London wool sales. By this method a better price is obtained than would be the case at the local wool fairs. On completion of the grading, the secretary sends a cheque to the farmer to cover 70 per cent of the estimated value of his wool. The money for these advance payments to the farmers is obtained from banks on the security of the wool.

The wools are offered for auction at the Wool Exchange,

Coleman Street, London, along with the Colonial wools. At the year end, the accounts of the Co-operative Wool Company are made up and each farmer receives a cheque for the balance due to him, less a proportionate share of the expenses of the company.

Chapter V

FEATURES AND PROPERTIES OF WOOLS AND HAIRS

Wool grows in small locks which are known as staples. Each staple consists of hundreds of wool fibres, which are tightly bound together. On one square inch of a sheep's back there are as many as 5,000 fibres. The wool fibre is curly and wavy, with a rough scaly surface. Hairs usually come from goats, and are straighter and smoother than the wool fibre, they do not grow in locks. The scales of the wool fibres are open and have serrated edges, which are known as serrations or serratures ; hairs have closed scales without serrations.

Growth of Wool

In the skin of the sheep are little pear-shaped sacs called follicles, shown in Fig. 1, which are the bulb-like roots of the wool fibres. The narrow openings of these follicles come out on to the surface of the skin. As the wool fibre grows in the follicle it consists of a mass of small soft slightly elongated cells. The act of forcing these cells through the narrow mouth of the follicle shapes them into the round cells of the wool fibre, while the outside cells are flattened to form the scales on the fibre surface. As soon as these cells come in contact with the air, they harden and form the wool fibres.

Wool grows by the continual formation of new cells at the bottom of the follicle, which push the existing cells further out. The fibre grows from the base, and not the tip, so the new wool is nearest to the skin. During growth, the wool fibre is assisted by a little oil from the sebaceous glands to lubricate the cells, and assist their passage through the nervous linings of the dermis.

Other glands which exist in the skin of the sheep are the

sudoriforous or sweat glands. These take the sweat of the sheep direct to the outer surface of the skin, where it is deposited on the wool fibre as suint. As the growing wool cells force their way through the skin they collapse, and shrink into a continuous chain. Each cell forms a scale with a series of

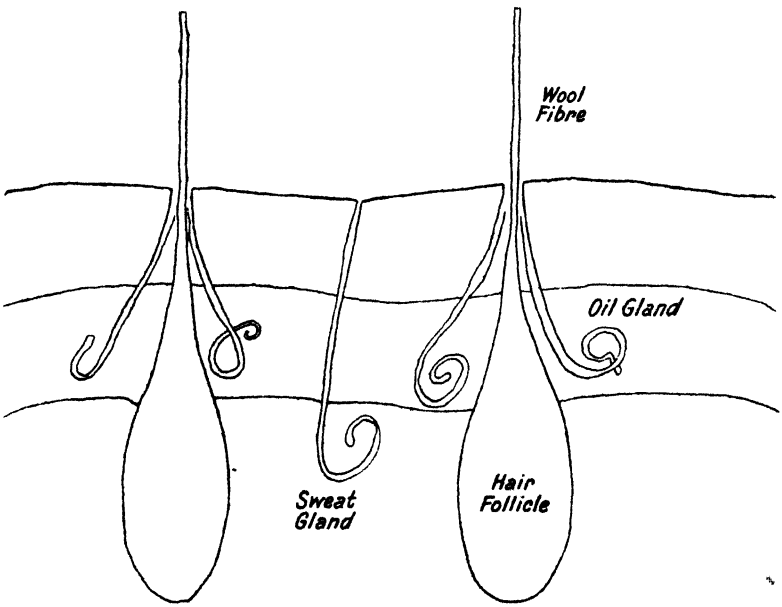


FIG. 1. GROWTH OF THE WOOL FIBRE. The wool fibre grows in the skin of the sheep, and is lubricated by the oil glands.

broken edges known as serrations. The scales are formed into a continuous fibre, as shown in Fig. 2.

CELLULAR FORMATION

Wool fibres are cylindrical in shape, and consist of three types of cells, (1) outer flat scales called the cuticle cells, (2) inner spindle shaped cells known as the cortical cells, and (3) the central round cells of the fibre, which are called the medulla. The outer scales of the fibre are flattened as the cells force their way out of the neck of the follicle and form the outer hard scale of the fibre.

Cortical cells are the main cells of the wool fibre and vary in size and distribution according to the type of wool. Coarse wools have a relatively smaller area of cortical cells, and an increased area of medulla. The spindle shaped cells of the cortical are composed of molecules, which are in themselves chains of fibres lying parallel to the main cell and build up the spindle shaped structure like the individual fibres in a yarn. These internal cells are known as micelles and are bunched together in a circular chain. When the fibre is stretched they open out into straight formations and give the cortical cells their elasticity.

Medulla cells are not very plain in fine wools, but are clearly defined in the coarser types of wool and hair. The groups of cells in the medullary channels govern the colour of the wool. Brown and black wools are so coloured because of the pigment in these cells.

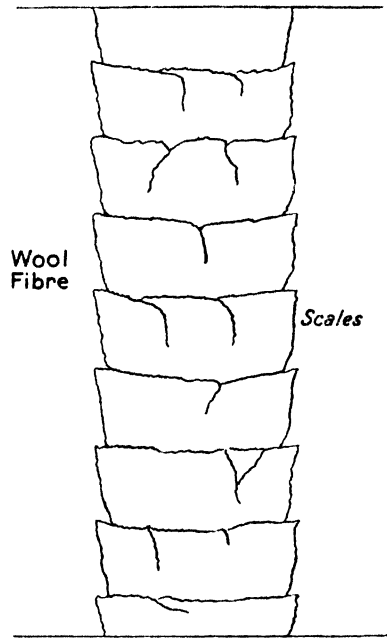


FIG. 2. THE WOOL FIBRE. Wool fibres are made up of cells which have collapsed and shrunk into a continuous chain. The broken edges of the scales are called serrations.

WOOL QUALITY

The four main properties possessed by the wool fibre are (1) fineness, (2) softness, (3) length, and (4) scaliness. It is the combination of these properties in a wool which denotes its quality, while the deficiency or irregularity of any of these features indicates lack of quality.

FINENESS

Fineness is essential, because fine fibres are needed to make fine yarns. It would be impossible to make fine yarns from

coarse wools because the number of fibres in the cross section of a yarn would be reduced. In the wool trade, a series of quality numbers is used to indicate the fineness of the fibres. These quality numbers are empirical estimations based on the fineness of diameter of the wool fibres. Wool has a very small diameter which varies from $\frac{1}{400}$-in. to $\frac{1}{2000}$-in. The fineness of wool varies in direct ratio to its length ; long wools are thick, while short wools are smaller in diameter.

Softness

Softness is a very desirable property in wool, but it cannot be indicated by anything except the expert touch of the wool dealer and operative. The wool trade term for softness is " handle." A " good handling " wool is a soft wool, while a " poor handling " wool feels harsh and rough when rubbed between the fingers.

Length

Fibre length is used in classifying wools. Fibres below 3-in. are used in the woollen trade and are known as " clothing wools," while those over 3-in. and under 7-in. are called " combing wools." The wools which are over 7-in. long are known as " long wools " or " preparing " wools.

Scaliness of Wool

The size and frequency of the wool scales give indications of wool quality. As a general rule, long wools have big scales and fine wools smaller scales. The lustre of a wool depends upon the size, position and smoothness of its scales. Wools with large scales which are maintained close to the fibre excel in lustre, while wools which have small scales projecting out from the fibre have not much lustre.

Crimpiness in wool is due to the open formation of the scales at the time of hardening. A certain amount of uneven shrinkage takes place with the fine open cells and gives the wool fibre its crimp. Hairs have very little crimp owing to their tight fitting scales which keep the cells straight and in line with the body of the fibre as they shrink.

TABLE XII

DENSITY OF WOOL CRIMPS

Type of Wool.	*Crimps per inch.*
Fine Merino	24
Merino	20
Comeback	16
Fine Crossbred	12
Medium Crossbred	8
Coarse Crossbred	6
Lustre wool	4
Mohair	2

In addition to fineness, softness, length and scaliness, there are several other properties possessed by the wool fibre, which consist of strength, elasticity, colour, felting power, hygroscopicity and plasticity.

STRENGTH

Strength is an important feature, essential in cloth production. Wool fibres are fairly strong ; being stronger than cotton, but not so strong as silk or linen. A single wool fibre should support 1 oz. Wool fibres which have been grown without sufficient nutrition are stunted and produce unsound and tender staples. Sheep which have been fed on poor soils grow wools with taper tips, while sheep which have been exposed to rough weather grow wool with thick fibre ends, known in the wool trade as " blocky " tips.

ELASTICITY

Wool is more elastic than any other textile fibre. It readily resumes its original shape after compression. This property makes it very suitable for clothing purposes. The elasticity of wool enables garments which have been stretched to recover their original shape by hanging or folding for a short time. This feature also is known as the resilience of wool, and enables it to hold and retain its shape when made up into garments. When wool loses its power of elasticity it becomes lifeless and

stretches without returning to its original shape. Garments made from wool with reduced elastic properties wrinkle and stretch.

Colour

Generally wool is creamy white in colour, but black, brown, and grey wool also is obtained. White wool is needed for dyeing to bright shades, because dingy-looking wool will not produce the delicate shades needed. The whitest Merino wool comes from South Africa, while the East Indian wools are yellow owing to being exposed to the heavy rains.

Felting Power of Wool

The power of interlocking of fibres is a feature of wool not possessed to the same degree by any other textile fibre. Felting or interlocking of the fibres is brought about by heat, moisture, and pressure. When placed in hot water the fibres become gelatinous and swell. On being pressed together in this condition, the individual cells interlock and form a solid mass of material. During drying the cells do not resume their original position, but shrink further into each other. Cloth which has been felted is bulkier and shorter. Stated briefly, felting is due to three factors, (1) interlocking of the scales of the fibres, (2) fibre creep under compression, and (3) fibre shrinkage in a gelatinous state.

Hygroscopic Property

The hygroscopic property of wool is its power of retaining moisture. Wool can hold 40 per cent. of water, which is known as the water of condition. About 20 per cent. of moisture can be carried by wool without it feeling damp, for this reason wet wool clothes are more comfortable than cotton or linen. Wool fibres are insoluble in cold water, but can be damaged by hot water over 160°F. and permanently injured or set by continued boiling. Wool tenaciously holds about 10 per cent of residual water and has to be subjected to very high temperatures before this can be removed and a " bone dry wool " obtained.

Plasticity of Wool

Wool treated with boiling water or steam becomes soft and gelatinous, and while in this condition it can be stretched, compressed or moulded into any specific shape. When the wool which has been treated in this way is dried and returns to a normal temperature, it retains its moulded shape. This property is known as plasticity and is used to its fullest advantage in cloth finishing, where fabrics can be shaped and moulded as required for special lines of business. Wool fabrics treated in this way contract in length and width and expand in thickness.

Chemical Properties

The wool fibre is composed of animal tissue, and is classed as a protein known as keratin. The chemical formula varies for different types of wool, but a general classification can be made as follows :—

	Per cent.
Carbon	50
Oxygen	20
Nitrogen	15
Hydrogen	10
Sulphur	5

It will be seen that half the wool fibre is carbon, one-fifth oxygen, one-seventh nitrogen, one-tenth hydrogen, and one-twentieth sulphur.

Treatment with Heat

Water at low temperatures does not affect the wool fibre, but on reaching 80°F. water will dissolve the suint residue on the fibre. At 130°F. the yolk is melted and can be removed in scouring. Hot air at over 170°F. dries the outer surface of the wool fibre, which gives a harsh feeling when the drying is prolonged, the outer surface of the wool fibre will crack, which reduces its felting and spinning properties. When wool is heated to 220°F. the residual moisture is removed and the bone dry wool becomes harsh and brittle. If the temperature is

allowed to exceed 220°F. the wool becomes discoloured, and at 260°F. the protein dissolves into ammonia.

Action of Acids and Alkalis on Wool

Wool has an acid nature which gives the fibres a great affinity for weak solutions of acid. This property makes acid dyeing a possibility, and various types of dyes can be used. The absorption of acids by wools is increased by raising the temperature ; wool immersed in a warm acid bath will absorb more acid than would be the case if a cold acid bath were used.

When wool is treated by dilute sulphuric acid it absorbs a certain amount which can only be removed with considerable difficulty. Dilute hydrochloric acid can be absorbed by the wool fibre, but not to the same extent as sulphuric acid, and readily discharges after treatment with boiling water. Being an animal tissue, wool is turned yellow by weak applications of nitric acid. Concentrated solutions of acid will destroy wool by slowly disintegrating the cells of the fibres.

Alkalis are much more stringent in their action, and a 5 per cent solution of caustic soda will completely dissolve its weight in wool in five minutes. Alkaline carbonates, such as sodium carbonate and ammonium carbonate if used in weak solutions and at low temperatures will not damage wool.

Dyeing Properties of Wool

Wool has a great affinity for dyes, and owing to its absorbent nature it can be dyed with almost any type of dyestuff. Wool fibres will allow the rays of colour to pass through them to a certain point, because the outer part of the fibre is not transparent but translucent, and is capable of absorbing and reflecting rays of colour.

In order to understand the relationship of the wool fibre to colour rays it can be compared with a glass tube. When a glass tube is filled with clear water, both the water and the glass are transparent, but when some dyestuff is added to the water, the water ceases to be transparent. The clear water reflected all the rays of light as they passed through the tube and glass, but after the dyestuff was added only those rays which could pene-

trate the dyestuff were reflected. Some rays were absorbed and some reflected.

A purple dye would quench the yellow rays of light passing through the water and reflect only the combination of the red and blue rays which form the purple. The suppression of the yellow rays and the permutation of the red and blue produce a purple colour within the glass tube which is reflected by the transparence of the glass. Wool fibres are not transparent like the glass but are translucent, so that the rays of light are allowed to permeate to a certain degree.

There are two differences between the reflection of colour by a glass tube and that of a wool fibre, (1) the wool fibre is not transparent and (2) the serrations of the wool fibre break the colour reflection. A dyestuff in a cut glass tube would not be reflected in the same way, but the beam of light would be broken or refracted on the edges of the various markings of the cut glass. This effect is brought about by dyed wool fibres, because there is the surface reflection of white light to account for as well as the reflection of colour.

A dyed wool fibre deals with the rays of light in a similar way to the tube which contains the dyestuff. It absorbs some rays and reflects others, but in every case there is a certain amount of white light reflected by the serrations of the fibre, which prevents a pure reflection of colour. Bleached wool has exceptional whiteness and reflects all the rays of light, while black wool absorbs all the rays and reflects none. The reflective power of white, and the absorbent power of black is used in the choice of white garments for coolness in hot climates.

The absorbent and reflective power of colours vary with their luminosity, the light which is not absorbed is reflected to the eye. White wools examined in white rays give a pure reflection, while white wools examined in coloured rays reflect the colour of the ray. A white wool examined under a red ray will show up as a red, while a red wool examined under a red ray will show up as a softer red. A yellow wool examined under a red ray will only reflect its own red rays and show as a pale red, while a blue—having nothing in common with red—will show up as a black. A blue wool only shows as a blue when it is examined under rays which contain blue. Red light

has no blue rays so that the blue wool cannot reflect rays which it has not received.

Suitability for Clothing Purposes

An ideal fabric for clothing should possess five properties, which are (1) elasticity, (2) durability, (3) plasticity, (4) heat resistance, and (5) good washing properties. Wool was the earliest fabric used for clothing, and is considered still to be the best type of fibre to be used for both underwear and outerwear.

In elasticity, wool exceeds cotton and linen, and enables fabrics to be made which readily return to their normal shape after being extended or stretched. Careless washing reduces the elasticity of wool and makes the garments hard and boardy. Wool is very durable. The plasticity of wool enables it to be shaped and moulded into hats, imitation skins and heavily felted cloths.

Heat resistance is essential in a good clothing fabric, and in this respect wool is ideal. In hot weather it protects the body from the sun, and in cold weather it prevents the heat of the body from escaping too easily. While resisting the heat waves from the sun, wool will allow the ultra-violet rays of light to pass through it and benefit the wearer.

The protecting nature of wool from the sun and cold is measured in terms of heat flow. Dryness of wool increases the heat flow, while dampness reduces it, so a wet wool has much greater resistance to heat than dry wool. Enmeshed air between the fibres of a wool fabric increases its resistance to the passage of heat. The density of the wool fibre is from 1·33 to 1·35 according to the quality of the wool, which makes it comparatively light and therefore easy to wear. Being of an animal nature, wool absorbs and retains odours to a much greater extent than the vegetable fibres, and is more liable to carry germs.

Comparison of Animal and Vegetable Fibres

Animal fibres have a rough curly nature owing to their scale formation, they are very elastic and will conduct electricity. They burn with difficulty and give off a smell of sulphur, like burning feathers, and leave a globular residue. Strong alkalis

will dissolve wool, but weak solutions of alkali are not harmful.

Vegetable fibres are smooth and pliable, they are not elastic, but are plastic. They burn with ease, give off no smell and leave a white ash. Vegetable fibres are non-conductors of electricity and dissolve in acids. Tests for determination of textile fibres are shown in Table XIII.

TABLE XIII

DETERMINATION TESTS FOR TEXTILE FIBRES

Material.	*Burning test.*	*Chemical test.*	*Microscopic test.*
Wool	Emits sulphur leaving globular residue.	Turns black with lead oxide.	Fibres look like cylinder with scales.
Silk ..	No sulphur, but leaves globular residue.	Dissolves in ammoniacal nickel oxide.	Double cylindrical glass tube.
Cotton ..	Bright flame, leaving a white ash	Dissolves in boiling hydrochloric acid.	Flattened twisted tubes.
Flax	Like cotton.	Turns red with magenta.	Bamboo cane with notches
Hemp ..	Like cotton.	Turns red with nitric acid.	Stiff tubular formation.
Jute	Like cotton ..	Turns yellow with nitric acid	Stiff tubular formation.
Ramie ..	Highlyinflammable and leaves fine ash	Dissolves in boiling hydrochloric acid.	Spindle shaped fibres.
Viscose Rayon	Bright flame leaving a white ash	Dissolves into brown solution by sulphuric acid.	Cylindrical glass tube.
Acetate Rayon	Burns with difficulty and fuses	Dissolves in acetone.	Cylindrical glass tube.

DEFECTS IN WOOL

The main defects in wool are : (1) kemps, (2) cotts, and (3) burrs. Kemps are irregular growths of wool which have no cortical cells and are formed by poor breeding, exposure to rough weather and grazing on unsuitable pastures. Cotts are made by the sheep rubbing their fleeces against posts, etc., and producing matted pieces of wool which are known as cotts.

Burrs are the seed vessels of the burr tree, which adhere to the fleece and cause irregularities in processing.

These defects have serious effects on the value of the wool, because these wools can only be manufactured into fabrics at increased cost. Burry wools often necessitate a carbonizing process, which adds considerably to the expenses of manufacture. Kempy wools will not dye, and show as speckled spots on dyed goods, while cotty wools have to be broken to disintegrate the fibres, and can only be used for low-class goods.

Mildew

Damp wool is liable to be attacked by mildew, which is a bacterial growth of an acid nature. In processing care has to be taken to prevent clean wool from remaining damp. Mildew is a low species of fungi which gives the fibres a stained appearance. In some cases these stains are brown like rust stains, light green like copper stains or black like lead stains.

Chapter VI

BRITISH WOOLS

Great Britain produces more types of wool than any other country of its size, and justly deserves the title of the " World's stock market." There are about forty-five distinct breeds of sheep in these islands which may be divided into five groups according to the qualities of the wools produced. These classes are : (1) Lustres or long wools, (2) Demi-lustres, (3) Downs, (4) Half-bred wools, and (5) Mountain wools.

Various types of sheep existed prior to 1755 when Robert Bakewell, of Dishley, improved the flocks by scientific breeding.

King George III—the farmer king—in 1792 obtained a flock of Negretti Merino sheep from Spain, and used them to improve certain types of British sheep. The Negretti Merino is noted for its purity of breed and fineness of wool and has left a marked influence on certain British flocks, notably Southdowns, Dorsets, Wiltshires, and Cheviots.

A small flock of Merino sheep still exist in England, and with much care and supervision yield wool which comes up to the Spanish and Australian standards.

The general type of British sheep has one pair of horns, but there still exist specimens of the four-horned St. Kilda breed and the four-horned Irish sheep. Special breeds such as Tailless and Fat-tailed sheep are not reared in Britain, although the heavy bony tail of the South Yorkshire " Penistone " sheep may have had their origin in some ancient Fat-tailed breed.

British sheep are essentially mutton sheep, although certain breeds may be classed as dual-purpose sheep which are reared for : (1) mutton, and (2) wool. In spite of the fact that British sheep are not reared primarily for wool, some of the heaviest fleeces in the world, which weigh from 20 to 35 lb. are grown on these sheep.

WOOLLEN AND WORSTED RAW MATERIALS

About half of the British grown wool is exported to Europe and America, as shown in Table XIV. The total amount of wool grown in Great Britain is about 100 million lb. 50 million lb. is used in Great Britain and the rest exported.

TABLE XIV

EXPORTS OF BRITISH WOOL

	Per Cent.
United States of America	40
Germany	18
Belgium	11
Poland	5·4
Canada	3·6
Finland	3·1
France	2·7
Spain	2·6
Sweden	2·4
Holland	2·3
Italy	2·2
Norway	1·3
Denmark	1·0
Other Countries	4·4

LUSTRE OR LONG WOOLS

The chief wools of the Lustre class are those obtained from Lincoln, Nottingham, Leicester, Devon, and Wensleydale sheep. The wool is noted for its strength and lustre, and is made up into dress fabrics, linings, boot laces, bunting and in some cases serges and broadcloths for heavy wear.

Modern long wool production owes much to the care and work of Robert Bakewell, of Dishley, who strove to improve the British sheep by systematic selection. The specialized grass feeds, and also the hiring of rams were introduced by Bakewell. Lustre woolled sheep require fairly rich soil and arable lands. These sheep can be distinguished by their white faces and legs. As a rule they grow quickly, and are fattened easily, but their mutton is coarse and contains more fat than that from the Down type of sheep.

TABLE XV

BRITISH LONG WOOLS

Name of breed	*Quality on shoulders*	*Fibre length in inches*	*Weight of fleece in lb.*	*Average diameter in inches*
Lincoln ..	36's	15	16	$\frac{1}{550}$
Nottingham	40's	12	14	$\frac{1}{575}$
Leicester ..	44's	10	10	$\frac{1}{600}$
Devon ..	36's	9	10	$\frac{1}{575}$
Wensleydale	40's	10	$6\frac{1}{2}$	$\frac{1}{650}$

LINCOLN WOOL

The Lincoln sheep is one of the largest animals of its class in the world. It thrives well in Lincolnshire and on the east coast of Yorkshire. Good wholesome pastures, which have plenty of grass that is rich in nutriment and well watered are essential. If these sheep are taken to poorer parts they deteriorate rapidly. Length of staple and beautiful lustre are features of Lincoln wool, for which this breed has a world-wide reputation.

In the Colonies some notable flocks of Lincoln sheep are to be found, chiefly in Australia, New Zealand, and Argentina. The long straight wool of the Lincoln sheep has an advantage over the curly types of wool in those parts where bushes and shrubs grow extensively, because the sheep are not liable to become entangled in the bushes, and any foreign matter gathered easily drops out. When Lincoln sheep are reared on the lighter soil of Nottinghamshire, a finer fleece is produced, which is known in the wool trade as " Nottingham Wool."

LEICESTER WOOL

One of the finest types of British long wool comes from the Leicester sheep. Robert Bakewell, of Dishley, chose the Leicester sheep for his breeding experiments in systematic selection, and in 1760 produced the modern Leicester breed. These sheep have been used for improving almost every other British breed of sheep, and in the Colonies at the present time some of the best crossbreds are obtained with Leicester sires. The wool has not the lustre of the Lincoln, but it is finer in quality.

Leicesters are more adaptable to dryer soil than the Lincolns, and some of the finest Leicester sheep live in the North and East Ridings of Yorkshire, Durham, Cumberland, and Westmorland.

Wensleydale, or Ripon Wool

Wensleydale sheep are to be found in the Yorkshire dales, South Durham, and in some of the Scottish dales. An old Teesdale breed called the Mugg sheep was crossed by the Leicester and the new breed of Wensleydales, noted for their excellent carriage, was evolved. The wool has a very bright lustre and is fairly strong. The fleece is rather sparse, and the ringlet staple almost resembles mohair in curliness. Being a Dale sheep, the Wensleydale does not thrive on the hills. The deep blue skin of this animal is one of its special features, and is regarded with pride by the sheep rearers. Present-day wool dealers know this wool by its area and not by the breed of sheep, so that in the wool markets Wensleydale wool is sold as " Ripon."

Devon Long Wool

The long woolled sheep of Devon was evolved from the old Devon Nott sheep by Leicester influence. The animal is high standing, a good climber and lives on the hills and moorlands of Devon. In the meat trade, these sheep are prized greatly for their heavy solid carcases. The lambs are very thrifty and soon fatten under the care of the Devon ewe which is a very good mother. The wool grows densely, and hangs in curly locks to a good length. The lustre of this wool compares favourably with the Leicester, but does not come up to the Lincoln standard. In handle it is firm, and of a good colour. Devon long wool is noted for its durability and hard wearing properties ; this feature commends its use for serges and broadcloths. A considerable amount of Devon wool is exported to the Continent for the manufacture of these goods.

Demi-Lustre Wools

Various crosses between Lustre and Down sheep, and Lustre and Mountain sheep have resulted in producing several breeds,

which grow wool of a lustrous nature but yet cannot be classified as Lustres, so the classification of Demi-lustre is used. This material is manufactured into plain cloths, tweeds, and coatings. Large amounts of this type of material are used in the tweed centres of Britain where it excels the Colonial crossbred wools in handle, although they are similar in quality and length.

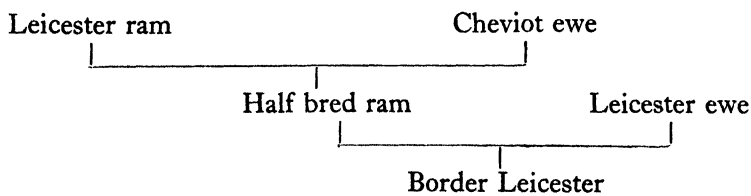
TABLE XVI

DEMI-LUSTRE WOOLS

Name of breed	*Quality on shoulders*	*Fibre length in inches*	*Weight of fleece in lb.*	*Average diameter in inches*
Border Leicester	44's	10	10	$\frac{1}{700}$
North	46's	8	$6\frac{1}{2}$	$\frac{1}{700}$
Romney Marsh	46's	7	$8\frac{1}{2}$	$\frac{1}{720}$
Cotswold ..	44's	8	8	$\frac{1}{650}$
Roscommon ..	40's	$6\frac{1}{2}$	4	$\frac{1}{650}$

BORDER LEICESTER

Over 100 years ago certain breeding experiments were taken in hand by Mr. J. Culley and his brother. The Leicester and Cheviot sheep were used, which resulted in the modern Border Leicester breed. A Leicester ram was mated with a Cheviot ewe and the half bred rams then were crossed with Leicester ewes in the order given below.



The wool is finer than the Leicester, but not quite as long ; and has a fair amount of lustre. The lambs fatten quickly, but the mutton is not as good as that from the Leicester sheep. Border Leicester rams are noted for excellent crossing results with Cheviots and Scottish Blackface. In New Zealand,

Border Leicester rams are greatly in demand for mating with Merino ewes, which produce the famous Corriedale sheep. As a cross with the Merino the Border Leicester is noted for the high quality of its mutton. The Cheviot feature of a clear white face without a tuft of wool on the poll is one of the distinguishing points of this breed.

North Wool

The North is a moorland sheep, which is found on the Pennine Hills, the moors of Lancashire, Yorkshire and south Scotland. This breed is obtained by crossing Border Leicester rams on to Cheviot ewes and produces a sheep with a type of wool which is noted for its fullness, uniformity, and whiteness. North wool is used extensively in blanket manufacture owing to its softness of handle.

Romney Marsh

Kent or Romney Marsh sheep are found in the marshy inlets of south and east Kent, where the rich pastures enable the sheep to be reared on grass all the year round. Romney Marsh sheep endure cold and wet better than any other sheep in the world, and their big hard hoofs will resist foot-rot under the most adverse conditions. For this reason they have been used to improve other breeds with a view to strengthening their powers of resistance against foot-rot in wet pastures. The Romney Marsh is a favourite in the South Island, New Zealand, because of its wet resisting properties, and also for the early maturity of the lambs from the Romney Marsh-Merino cross. The deeply grown wool is very bright, and considered to be a typical Demi-lustre wool.

Cotswold

On the hills of Gloucestershire there lives a hardy breed of sheep known as the Cotswold. This breed was obtained by crossing the Leicester with an old Gloucester breed, which produced one of the most symmetrical sheep in Great Britain. These animals reared on the chalky soil of the Cotswolds are very thrifty and hardy, and their rams have been used to introduce stamina into backward breeds in many parts of the world.

The wool is dense, fairly lustrous and slightly curly. In handle, it lacks the softness of the Romney Marsh wool, but is rather sharp and crisp.

Roscommon

In the wet grassy dales of the western Irish Hills, there exists a breed of demi-lustre sheep known as the Roscommon ; this breed originated through an old Irish breed being improved by the Leicester. The wool is fairly long and has a good handle ; a special feature of the Roscommon wool is its freedom from dirt and vegetable impurities.

British Down Wools

The sheep which live on the Downland Hills of the south of England produce a distinct type of wool which is known in the wool trade as " Down." This material is much shorter and finer than the Lustres and Demi-Lustres, but has poor milling properties and not much lustre. The loftyness of handle of this type of wool is called " Blobbiness " which makes it suitable for hosiery and knit goods, whether machine or hand knitted.

Down sheep live on the low lying hills and thrive on dry pastures, they cannot live in damp marshy districts like the Lustre and Demi-lustre sheep. As a general rule Down sheep are hornless, but in some cases horned types exist. Well bred Down sheep form a neat picture, because their black faces and legs contrast against their white fleeces.

These breeds are noted for their excellent carcases which consist of meat with not too much fat and bone. The mutton is firm, finely grained and has a rich colour. Down sheep can be fattened for the meat market better than any other sheep in the world, because they put on weight in solid flesh and not fat. For this reason certain types of Down sheep are used for improving the mutton value of the Lincoln-Merino crosses in the Colonies and in other parts of the world. South Down and Shropshire Down rams are sold to Australia, New Zealand, Argentina, Chile, West Indies, United States, Canada, Kenya, Scandinavia, Japan, and China.

TABLE XVII

BRITISH DOWN WOOLS

Name of breed	*Quality on shoulders*	*Length in inches*	*Weight of fleece in lb.*	*Average diameter in inches*
South Down ..	56's	3½	4½	$\frac{1}{900}$
Shropshire ..	50's	6½	6	$\frac{1}{800}$
Hampshire ..	50's	6	6½	$\frac{1}{750}$
Oxford ..	50's	5½	5	$\frac{1}{700}$
Wiltshire ..	48/50's	6	6	$\frac{1}{700}$
Suffolk ..	50's	5	6½	$\frac{1}{725}$
Dorset ..	48/50's	4½	4½	$\frac{1}{650}$
Ryeland ..	56's	5	5½	$\frac{1}{750}$
Kerry Hill ..	50's	5½	5	$\frac{1}{700}$
Clun Forest ..	50's	5	5½	$\frac{1}{700}$

THE SOUTH DOWN

The South Down sheep lives on the chalky hills of Sussex, where the herbage is not very abundant and the rainfall is low. The wool from these sheep is the shortest and finest produced in Great Britain, and is made up into woollen goods, because it is too short for the English worsted system. The sheep is noted for its excellent form, and considered by certain sheep rearers to have the most symmetrical body of any of the British breeds. South Down sheep are used for park life and have been called the " gentlemen's sheep." This breed was improved by John Ellman, of Glynde, who began his experiments in 1775, and worked on the principle of selection rather than intercrossing with other breeds. The carcase has small joints, and for this reason South Down rams are crossed with Merino ewes to produce fat lambs in the Colonies.

SHROPSHIRE

The Shropshire is a larger sheep than the South Down, due to Leicester and Cotswold influence. It is supposed that the modern Shropshire sheep have been evolved from the now extinct Morfe Common and blackfaced Mendip breeds. The wool has a crisp handle with a good length, and is regular in quality. This breed can be distinguished by its " wool cap,"

the face and head of the sheep being enveloped by a growth of short fine wool. Owing to the lambs gaining weight quickly ; the sheep being very economical in choice of feed and the regular supply of good wool at the shearing time, the Shropshire is known as the " farmer's sheep."

Hampshire Down

The Hampshire Down sheep is the largest of the Down class, and was obtained by crossing the old Wiltshire horned rams with Berkshire Knot ewes. This breed is noted for quick maturity. Several of the lambs born in April and May will weigh 10 to 12 stones in November and December. The wool is not quite as regular as the Shropshire Down, although it is fine and fairly dense. The Hampshire has a wool cap over its head and face like the Shropshire sheep.

Hampshire sheep thrive on the high chalky uplands of Hampshire, Berkshire, Wiltshire, and Dorset. These animals are kept in larger flocks than the general class of Down sheep, and in some cases flocks of over 1,000 sheep are to be found. These sheep are favoured greatly in the United States, and flourish on the wide open ranches of Alberta in Canada.

Wiltshire Horned or Western

In general features the Wiltshire sheep resembles the Hampshire Down. There are not many flocks of this class of sheep left, but a number are kept on the stud farms of Anglesey where rams are bred for crossing with the Welsh Mountain ewes. This sheep grows a small amount of wool. Shearing usually is done early because the wool tends to fall from the sheep's back as the weather becomes warmer.

Oxford Down

The Oxford Down breed was started about 1820 when Cotswold rams were crossed with Hampshire ewes. These animals have a neat comely body, but are not so large as the Hampshires. Oxfords can be distinguished from Shropshires and Hampshires by the absence of the wool cap, and by the fact that their brows have a crest of shaggy wool. The wool is open and curly with a good fullness which is soft in handle.

Suffolk Down

The Suffolk is sometimes known as an Eastern Counties Down sheep, and was obtained by crossing South Down rams with the old Norfolk horn sheep. Until 1859 they were known as Blackfaces when their name was changed to Suffolk. These animals resemble the sheep which live on the European banks of the Mediterranean Sea. Pure Suffolk lambs are born with a dark fleece which gradually becomes white as the lamb advances in age. The wool is not so fine as the South Down, and has a lot of dark hair. Owing to its crisp soft handle and curliness of staple this wool is used in the hosiery and tweed trades. These sheep are very hardy. They can live on scanty pastures, and have been known to travel long distances in search of food. For this reason Suffolk Down rams have been found a very useful animal for crossing with the native sheep of Central Africa.

Dorset Horn

Two classes of sheep are given the name of Dorset, and consist of: (1) Dorset Horn Down and (2) Dorset Down. The Dorset Horn is one of the few horned sheep of the Down class, and was developed from an old Wiltshire breed by South Down influence. These animals retain the Wiltshire features of a white face, pink nose and graceful curly horns which are to be found on both rams and ewes.

The wool is of a medium quality Down type, and noted for its crisp handle, whiteness and freedom from black hairs. Dorset Horn rams are used in the Colonies for crossbreeding and are favoured because the crossbred wool also is free from black hairs. In New South Wales breeding experiments have been carried out with Dorset Horn-Merino crosses, and some very desirable wool has been obtained, which is noted for its exceptional softness of handle.

Over a century ago, this breed was assisted with Merino blood, which accounts for the better felting property of this wool over the ordinary Down types. A considerable amount of Dorset Horn wool is used in the Welsh flannel trade.

The Dorset Down is a hornless sheep, which was obtained

by a Hampshire-South Down cross and is noted for short fine wool.

Ryeland

The sheep which lives on the hills round Hereford is known as the Ryeland or Wyeland. This breed is not a Down type, and if the wool were lustrous it would be classed as a Demi-lustre, but for convenience of the wool trade it is placed in the Down class. The wool is strong, dense and curly with a soft silk-like handle. The fineness of the Ryeland wool is due to the fact that from 1792 onwards, Merino rams have been used to improve the breed, which increased the annual weight of a Ryeland fleece from 2 lb. to 5 lb. In later years Leicester and Shropshire blood has been introduced to improve the quality of the mutton. Ryeland sheep are noted for their hardy constitution and solid hoofs ; they can live on damp ground and resist foot-rot as well as the Romney Marsh sheep.

Kerry Hill (Wales)

The Kerry Hill sheep are found in Montgomeryshire, Radnor and Shropshire. They are placed in the Down group for wool classing purposes. Since 1840 this breed has made considerable advances in both the mutton and wool trades. The sheep are hornless and have white faces. They are good climbers and will travel miles across the hills seeking suitable pasture. Kerry Hill wool is noted for its whiteness and freedom from black hairs, it is fairly dense and has an even growth. In handle it is very firm and springy, which makes it a good wet resister, which is necessary for the Welsh mountain climate with its 80-inch rainfall per year.

Clun Forest

The district of Shropshire, Radnor, and Montgomeryshire which surrounds the ancient town of Clun is noted for the Clun Forest breed of sheep. This is an old British breed which has been improved by culling of ewes and selection of rams, until it now is regarded as a very promising British dual purpose sheep. Since 1925 considerable progress has been made in the sales of rams and ewes to establish flocks of Clun

Forest in other parts of Britain. These animals are prolific breeders and the lambs thrive and fatten well.

Half-bred Wools

The crossing of Lustre and Demi-lustre sheep with the Mountain types have produced a new type of wool which is classified as Half-bred. The chief wool in this class is the Cheviot, which has now become a distinct breed. The wool from these sheep is not a Lustre neither is it a Down, while being a 50's quality material it cannot be classified as a Mountain wool so it has been grouped as a "Half-bred." The material obtained from these sheep is used in the tweed trade and produces fabrics which cannot be obtained from any other material. Attempts have been made to produce these cloths from mixtures of Down and Colonial Crossbred wools, but they have not the same handle as those made from British Half-bred wools.

Table XVIII

British Half-Bred Wools

Name of breed	*Quality on shoulders*	*Length of fibre in ins.*	*Weight of fleece in lb.*	*Average diameter in inches*
Cheviot	50's	$5\frac{1}{2}$	$4\frac{1}{2}$	$\frac{1}{700}$
Masham	46's	6	5	$\frac{1}{650}$
Swaledale ..	40's	$7\frac{1}{2}$	5	$\frac{1}{600}$
Devon close wool	40's	7	6	$\frac{1}{600}$

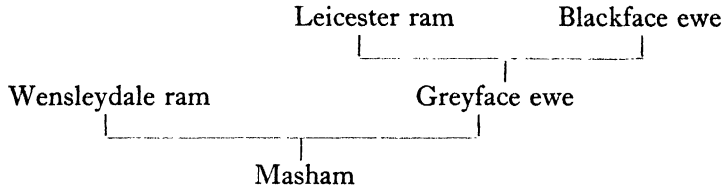
Cheviot

The sheep which are reared on the Cheviot Hills are noted both for their mutton and wool. These animals live on grass and produce finer wools than the Blackface, which feeds on coarse pastures and heather. Taken from their native hills they do not thrive well, although several flocks of Cheviots are to be found on the Wicklow Hills in Ireland and also on the Falkland Islands of South America. This breed is classed by wool users as a half-bred, and has been produced from an older type of Scottish sheep by the use of Merino and South Down rams, under the direction of Sir John Sinclair in 1791.

The wool is white and densely grown. It is fairly fine in quality, and noted for its crisp handle. A considerable amount of this wool is used in the tweed trade which centres round Galashiels in South Scotland.

MASHAM

A breed of sheep which live around Masham in North Yorkshire is obtained by crossing Wensleydale rams on to Greyface ewes in the following way.



These are ideal mutton sheep. An open wool of medium length without many kemps, which has good handling properties is grown by these sheep. In Scotland the Wensleydale is known as a "Yorkshire" and the Masham is called a "Yorkshire cross."

SWALEDALE

In North Yorkshire, Westmorland, and Durham there exists a breed of sheep which have been obtained by crossing Wensleydale rams with Scottish Blackface ewes. This cross is prized greatly by the moorland farmers. The wool is finer than the Blackface and is not so thickly grown as the Greyface, owing no doubt to the more open nature of the wool on the Wensleydale ram as compared with the Leicester. The Swaledale breed is noted for its regular growth of wool, which has a hard handle, but is free from black hair and kemp.

DEVON CLOSE WOOL

One of the latest types of British dual purpose sheep is the Devon close wool breed, which was evolved about 1890 by crossing Devon long wool rams with Exmoor Horned ewes. The wool produced has a fair length, medium lustre and good handling properties. These fleeces are very regular and

consistent in wool quality. The Devon close wool sheep is a shapely animal with a white face, and the crown of the head and the legs are well covered with wool. The animals are able to resist cold and wet better than the long wool type of sheep ; and thrive in the dales of Devon and Somerset. Devon close wool sheep breeders aim at maintaining the breed by selection rather than by introducing sires of other breeds. The rams and ewes for breeding are culled according to their adherence to the close wool type of animal, as the breeders desire to obtain a type distinct from either the Devon long wool sheep or the Exmoor Horn.

British Mountain Sheep

The hardy active animals found on the Pennine, Cheviot, Scottish, Welsh, and Devon hills are known as Mountain sheep. The wool grown on these sheep is coarse and the fleeces are small in size owing to the small body of the animal. The mutton is high in quality and noted for its excellent taste. Weakly sheep do not exist in Mountain breeds, because the cold season weeds them out.

British Mountain sheep produce a wool peculiar to these islands. Several attempts have been made to acclimatize these breeds in other mountainous regions, but they have not met with much success. Mountain wool is used for making into blankets, carpets and certain types of homespun cloths, and far exceeds the East Indian and Asiatic wools which are sometimes used for this purpose.

Table XIX

British Mountain Wools

Name of breed	*Quality on shoulders*	*Length of fibre in ins.*	*Weight of fleece in lbs.*	*Average diameter in inches*
Scottish Black-face	28/32's	12	5	$\frac{1}{450}$
Welsh Mountain	32's	6	$3\frac{1}{2}$	$\frac{1}{650}$
Radnor ..	40's	$6\frac{1}{2}$	5	$\frac{1}{800}$
Herdwick ..	28/32's	7	$3\frac{1}{2}$	$\frac{1}{800}$

Name of breed	*Quality on shoulders*	*Length of fibre in ins.*	*Weight of fleece in lbs.*	*Average diameter in inches*
Lonk ..	.. 40's	$6\frac{1}{2}$	5	$\frac{1}{600}$
Greyface	.. 32's	$6\frac{1}{2}$	4	$\frac{1}{800}$
Gritstone	.. 36's	6	4	$\frac{1}{800}$
Penistone	.. 36's	$6\frac{1}{2}$	$4\frac{1}{2}$	$\frac{1}{820}$
Exmoor	.. 40's	5	4	$\frac{1}{700}$
Dartmoor	.. 40's	12	6	$\frac{1}{250}$
Wicklow	.. 36's	7	4	$\frac{1}{600}$
Kerry	.. 36's	6	$3\frac{1}{2}$	$\frac{1}{850}$

Scottish Blackface

The Scottish Blackface sheep, which are found in the highlands of Scotland, the Pennines, and hills of Northern Ireland, are hardy and accustomed to rough weather. The wool is hard in handle, rough and shaggy, with plentiful supplies of kemps. Medium Blackface wool is used for the homespun fabrics of Lewis and Harris, while the coarser wool is used in carpet manufacture. A considerable amount of this type of wool is exported to the United States of America to be made into carpets. Seeing that the Scottish Blackface cannot be acclimatized outside Britain this kind of wool cannot be grown in North America, so imports of Scottish Blackface wool are exempt from duty.

Welsh Mountain

The Welsh Mountain sheep is a small active animal, which has a fleece of rather poor wool seldom exceeding 2 lb. in weight. The small carcase of this animal is very solid and forms a notable type of mutton. These sheep have tan faces which are taken as an indication of their hardy constitution. They are good climbers and cannot be restricted by walls and fences. The rams have horns, but the ewes are hornless. Several attempts have been made to improve the breed by South Down influence, but they have not proved very successful, although Wiltshire rams make a suitable cross. The sheep tend to shed their fleeces in the warmer weather, so the farmers have to take precautions to shear these sheep early in the

summer. Certain flocks of Black Welsh Mountain sheep are maintained, and the wool from these animals is used in the Welsh flannel trade.

Radnor

The Radnor breed of sheep has been obtained by crossing Kerry Hill and Shropshire rams with Welsh Mountain ewes and has produced a type of wool which has not the coarseness or the kemp of the Welsh Mountain type. Radnor sheep are small in build and have short legs, but they are very hardy. In some cases Radnor wool can be used in making hosiery, and some very useful hand knitting yarns are produced. The chief difficulties are (1) kemps and (2) grey hairs. Large patches of grey and black fibres exist in the fleeces which need careful sorting as this wool cannot be dyed to the bright shades often in demand in this trade.

Herdwick

A breed of sheep is found on the fells of Cumberland and Westmorland known as the Herdwick. There have been many speculations made as to the origin of the breed and one story tells how that in 1588 an Armada galleon was wrecked near Drigg, and the Merino sheep—carried for food—swam ashore and were claimed by the Lord of the Manor. The sheep are noted for their hardiness and resource, they live on the hills through the severest weather and select good shelter to protect them from the storms. Under a heavy fall of snow they will dig to find food. In spite of these adverse conditions they do not wander and seldom leave the hills on which they are reared. The wool is coarse and open with plenty of kemps and long hairs. Several attempts have been made to improve the breed by inter-crossing, but these have not been successful.

Lonk

The Lonk is the largest type of mountain sheep, and is the native sheep of the hills of the West Riding of Yorkshire, East Lancashire, and North Derbyshire. This breed is similar to the Scottish Blackface, but is not quite so hardy, and may have been improved by Cheviot blood. These animals are

able to stand exposure to the severest weather and in winter often are buried with snow, but find some food underneath until the shepherds come to dig them out. The wool is fairly long and noted for its whiteness, which almost compares with the Down type. It has not much kemp, is soft in handle and fairly elastic.

Greyface

A popular cross in the Highlands of Scotland and on the hills of Northumberland and Cumberland is the Greyface, which is obtained by crossing Leicester rams with Blackface ewes and produces a breed of sheep with speckled or grey faces. The wool from these sheep sometimes is known as the " Scottish cross." The fibres are not so coarse as those of the Blackface, but not as good as those of the Lonk ; the colour is fairly white. Greyface sheep are good foragers and produce fatter lambs than the Blackface type of mountain sheep.

Gritstone

Around the Derbyshire Peak district and on the Yorkshire Pennines there lives a very old breed of sheep known as the " Gritstone." It has been suggested that this breed originated by crossing Down rams with Lonk ewes. Gritstones are hornless and have black faces which suggest Down influence. The wool is finer than Lonk and grows fairly closely, but there is a considerable amount of black and grey hairs in the fleece. Its springy handle makes it a valuable wool for hosiery, and at one time considerable amounts were used in the footwear trade. Gritstone sheep have mottled faces, ears, and legs. They have great powers of resistance against disease, damp, and cold, and owing to their active nature, produce a lean mutton which is prized greatly by butchers.

Penistone

The Penistone is another Pennine breed which is akin to the Lonk and Blackface. This breed lives in South West Yorkshire and on the borders of Lancashire and Cheshire. These animals are very rough-looking, and are the only British breed

which retain the muscular tail of the European Heath sheep. The wool is rough, harsh in handle, and of a fair length.

Exmoor Horn or Porlock

On the hills and moorlands of west Somerset and north Devonshire the Exmoor Horn sheep are to be found. These animals have horns and white faces and were evolved by crossing Down rams with the ewes of an old forest breed. These sheep are noted for wandering and periodical collections are necessary, accompanied with an examination of the ear and horn marks to ensure that the flocks have been discovered by their rightful owners. The wool is strong, full and fairly open, with a good colour and soft handle.

Dartmoor

Dartmoor sheep, which live on the moorlands of Devon and Cornwall, consist of native sheep which have been improved by Leicester influence. The wool has a good length and is free from kemp, some of it could be classed as a Demi-lustre type. Dartmoor sheep are good foragers and can live on various types of food. Dartmoor rams are used to strengthen weaker types of sheep against attacks of liver fluke, because they have wonderful powers for combating this disease.

Wicklow

The sheep which are to be found on the Wicklow Hills around Dublin resemble the Welsh Mountain breed, but give better wool. This breed has been assisted by Cheviot influence until in some cases the wool is known as a Wicklow-Cheviot.

Kerry

The Irish Mountain sheep is known as a Kerry. It is a larger animal than the Wicklow, but the mutton and wool are not so good, and it somewhat resembles the Herdwick in type of fleece.

Northern Island Breeds

A primitive breed of sheep called the " Soay " exist in the northern islands of St. Kilda and Soay. These sheep are a

Mouflon type. The wool is shorter and finer than that of any other British breed, and is brown in colour. Crosses made with Soay-South Down have yielded an excellent white wool, 58's quality, while a Soay-Shropshire cross is white, but resembles New Zealand crossbreds.

SHETLAND

In the Shetland Islands a primitive breed of sheep probably of Loaghtan origin which has been modified by Cheviot and Blackface influence is to be found. These animals have a hardy constitution to weather the storms of these northern islands. The wool of these sheep has a resemblance to camel hair and retains the thick outer coat with the fine inner one. These sheep are not shorn, but plucked by hand, which operation is known as " rooing."

Chapter VII

EUROPEAN WOOLS

Domestic sheep have been reared for over 4,000 years, and the earliest records suggest that the Chaldees domesticated the sheep in order to obtain supplies of meat, milk, skins, and wool. The type of sheep kept by these early pastoralists are now known as Mouflon sheep. Modern examples of this type have been found on the island of Corsica in the Mediterranean Sea and on the island of Soay in the Hebrides. Comte de Buffon, the French naturalist, named these animals as Mouflon, and it is suggested that sheep of this type were the ancestors of the modern European breeds. These animals are more like antelopes than the sheep of to-day, they have large curved horns and grow two coats of wool. The winter coat is darker, longer and more coarse than the summer one.

Spanish Wools

Next to Great Britain, Spain is the greatest wool producing country of Western Europe, as shown in Table V. Three types of wool are reared in Spain : (1) fine wools from Merino sheep ; (2) a medium type of wool from the Manchega sheep which is similar to British Down wool, and (3) a long wool from the Churra sheep.

The Merino sheep, which has made great progress in wool production in almost every part of the world is a native of Spain. It has been suggested that the Moors brought this type of animal from North Africa. In the Middle Ages, Spanish woollen cloths were noted for their fineness of quality, all over Europe. Very strict laws were enforced to prevent Merino sheep being exported. There are four types of Spanish Merino sheep : (1) Segovia, (2) Escurial, (3) Negretti, and (4) Infantado.

Segovia Merino sheep live in the mountainous region of the Sierra de Guadarrama, and are not moved from pasture to pasture, they are known as " stationary " Merinos. These sheep produce some of the best wools of the country.

Escurial Merino sheep are migratory, and move from pasture to pasture according to weather and climate. Most of the Merinos which were distributed across Europe during the eighteenth century were of this type.

Negretti Merino sheep were kept by Count Negretti at Alicante, and grew one of the best types of Spanish Merino wool. These sheep are strong and very hardy, and were the type sent to King George III for his stud farm at Kew in 1787.

The native name for the migratory sheep is " Ovejas marinas " which has given rise to the modern name of " Merino " and means " sheep moved from pasture to pasture."

Merino Sheep Distribution

A flock of Spanish Escurial Merino sheep were sent to Sweden in 1723, and stud flocks were established. In 1764, 92 rams and 128 ewes were sent by King Charles III of Spain to the Elector Frederick Augustus of Saxony. The flock arrived at Dresden on July 31, 1764, and were kept on the Elector's stud farm.

In 1785 the Merino sheep were introduced to France, and King Louis XVI kept them at his farm in Rambouillet, where the famous French Merino stud flock has been maintained through many changes of administration.

Spanish Merino sheep were introduced to Austria in 1773, when Queen Marie Theresa obtained a flock of 325 sheep. These were the main type of fine woolled sheep in Austria for over a century, but since 1876 the Austrian Merino flocks have declined rapidly.

A flock of Merino sheep was presented by the King of Spain to King George III of England in 1787. These were kept at Kew, and used to improve British breeds of sheep. The climate of England was too wet and cold for these sheep, and their lambs were very late in maturing, and backward in thrift. King George III sent some of his Kew flock to

Australia in 1794, and after his death in 1820, the Kew Merinos were sent to South Africa.

The introduction of Merino sheep to the United States of America took place when the American ambassador at Madrid, sent a flock of sheep to Mr. Foster of Boston in 1793.

Modern Spanish Sheep

The Sierras of Spain are ideal sheep raising lands where the modern Spanish Merino sheep are reared. Spain is the only European country which has increased her flocks of sheep since 1914, while France, Germany, and Central Europe have suffered severe decreases in wool production. The rainfall in Spain is on the low side, and the hills are rather too cold for the sheep in winter, so the old system of migratory sheep rearing still maintains.

In the spring, the sheep are taken to the mountain pastures of Old Castile and Leon for the summer, and are brought back in the autumn to the valleys of Estremadura for the winter. Merino sheep are hill sheep and thrive best where they are allowed freedom to wander in search of food. Too rich food is almost as detrimental to their thriftiness as too poor. Sweet, dry grass is an ideal herbage, although the sheep can live and thrive on the leaves and tender twigs of shrub plants.

Modern Spanish Merino sheep are small compared with the sheep of the southern hemisphere, and are known in Spain as " Humante sheep." These animals have flat sides and are not very robust. The wools obtained are about a 64's quality, but much of this is very kempy owing to the constant changes of climate and pasture when the sheep are taken from the summer to the winter pastures. The wool is fairly thick and close, but is difficult to estimate for yields owing to the presence of a deal of sand. Large amounts of yolk give the greasy wool a stiff feel and yields of over 40 per cent. are seldom exceeded. Wool grows all over the sheep's head and, in some cases, covers the face. On the neck are two or three small skin folds which are not so prominent as those of the Australian type.

Spanish medium wool is grown on the Manchega sheep, which live in the Toledo district. It is a Down type of wool

which is crisp and soft in handle. The openness of this type of wool commends its use in the Spanish knitting trade.

The long wool obtained from the Churra sheep is known as " basta " and resembles the type of wool grown on the British Demi-lustre sheep. In some cases kemps are found in the fleeces and the wool has rather a harsh handle. Churra sheep are found on the lowlands near the coast and resemble the Romney Marsh or Old Leicester sheep. Some authorities suggest that these animals were the primitive breeds of Spain before the Merino was introduced by the Moors about the year 1000 A.D.

Exports of Spanish wool are sent to America, France, Belgium, and Germany, while the rest is used in the local industries of Catalonia. The Spanish Wool Association collects wool from the farmers, scour, card, comb, and sell it to the mills as " tops " and " noils." Skin wools are exported, usually to Mazamet, while the natural black and brown wools are used for making the famous black serges which are so popular in Spain.

Commercial Types of Merino

The evolution of modern Merino sheep is the result of a considerable number of experiments which were carried out in the nineteenth century. Three distinct types of Merino sheep exist to-day ; (1) the Rambouillet, (2) the Riverina, and (3) the Vermont. The Rambouillet or French type has a straight skin without wrinkles, and gives a level crop of wool. This type of sheep is favoured greatly in North and South America. The wool producers of Ohio have evolved a North American type of Rambouillet, which is known as the " Delaine " Merino.

Riverina Merino sheep, which are to be found in the large wool producing area of New South Wales, are one of the main Australian types of Merino. The body is free from wrinkles, but there are huge folds of wool on the neck. This type of Merino is favoured by the wool producers of Australia and South Africa.

Vermont Merino sheep were produced in the United States of America, and consist of a type where the whole fleece hangs in great folds and ridges across the body. The heaviest

fleece of any type of Merino is produced on these sheep, but the wool is irregular between the wrinkles, and cannot be sorted easily.

Saxony Merinos

The gift of a flock of Merino sheep from Charles III of Spain to the Elector of Saxony, started the Saxony Merino stud farm in 1764. By careful breeding and selection a distinct type of Merino sheep have been evolved, which are known as " Saxony" or " Electoral." These animals have longer legs than the other Merino types, and have very little wool on the neck and head. The sheep are rather delicate and need a great amount of care. In summer they are housed at night and not allowed out in the morning until the dew has been dried up by the sun. During the winter they are not taken out to the pastures, but are fed on hay and corn, and exercised under cover in warm, well ventilated sheds.

Saxony wool was greatly prized in the woollen trade, and its name has become a trade term which means the finest woollen blends. The wool is very short and fine and often does not yield more than 40 to 45 per cent. An average Saxony fleece weighs about 3 lb.

Central European Wool

In Hungary, Austria, and Czechoslovakia the sheep industry consists of rearing animals which could be called triple purpose sheep, seeing that their products are (1) milk, (2) meat, and (3) wool. The sheep milk and cheese trades of Central Europe are regarded of much more importance than wool production.

Two breeds of sheep exist in most of these countries which are (1) Cigalya sheep and (2) Racka sheep. The Cigalya sheep are of a Friesian type, which yield excellent milk for cheese making. Racka sheep, are a mountain type, which produce good mutton, and a coarse wool used for shawls, rugs, and carpets. A few flocks of Merino sheep exist from the old Austrian Merino stud farms, but these are a type which are declining rapidly. In 1870 the number of sheep in this area was about 15 million, but at the present time there are only about 1 million. The Central European clip is used in the

local mills, and a one day wool sale in Budapest, disposes of the remainder to German merchants.

French Wool

Three classes of sheep exist in France : (1) Merino, (2) Medium, and (3) Long wool sheep. The French Merino sheep were obtained from Spain in October 1785, when Louis XVI imported 318 ewes and 41 rams. These animals were kept at the King's farm at Rambouillet, which gave the name to the world-famous French Rambouillet Merino sheep. During the revolutionary and Napoleonic periods this farm was maintained for experiments in sheep breeding, and careful records have been compiled and kept since the day that the initial Spanish sheep arrived.

The aim of the directors of the Rambouillet farm was to produce a dual purpose sheep which would grow fine wool and yet produce a suitable carcase. The Rambouillet Merino is the largest type of fine woolled sheep, and has good mutton features of thickness of body, upstanding carriage, strong boned and full fleshy thighs. A full grown Rambouillet Merino carcase will weigh from 150 to 220 lb.

Wools from these sheep are well grown and fine, the rams will produce from 15 to 20 lb. of wool and the ewes from 10 to 18 lb. Rambouillet Merino sheep are noted for the absence of body folds or wrinkles, but the growth of wool over the face tends to make the animals wool blind. The wools yield about 50 per cent., and have rather a heavy sticky yolk.

Strength of muscle and powers of endurance are two features of this breed, which commend its introduction into areas where food is scarce and the sheep have to traverse wide areas in search of nutriment. They are active animals and can travel twenty miles a day without fatigue. When grazing they move in groups and are seldom found individually. The ewes are good mothers, prolific in breeding, and tend their lambs with great care.

French medium wool is obtained from the Bayonne and Poitou breeds of sheep, which are reared on the hills of Southern France. These wools are of a fine Down type which are light and lofty with a crisp handle. Bayonne fine crossbred wools

are grown by half-bred sheep which have been obtained by crossing the medium ewes with Merino rams.

Lustre wools are grown on the sheep of the Ardennes regions, which are similar to the British Cotswold sheep and grow a long lustrous wool.

Italian Wool

The sheep rearing districts of Italy are (1) Lombardia, (2) Rome, (3) Puglia, and (4) Sardinia. The sheep of Lombardia are of the Friesian type, and are similar animals to the Cigalya sheep of Hungary. These sheep are noted for the excellent cheese which is made from their milk. The wool from these sheep is used in the Italian mattress industry.

Around Rome there live the central Italian sheep which are a type of half-bred, probably obtained by crossing the Merino with the Cigalya. The wool is white and fairly strong, and makes good hosiery, while large amounts are used in making blankets. Sales of Italian wools are held in Rome, while the main industrial area is round Piedmont. Italy only supplies one-sixth of her requirements and imports five-sixths of her wool from South America and the Balkans.

The Italian Merino sheep is reared in the south around Puglia. These are small animals of the Spanish type, and produce a short fine wool which is used in the woollen industry round Piedmont. The wool from the Puglia Merino sheep is lightly grown. Fleeces which exceed 5 lb. in weight are very rare ; the average fleece will weigh about 3½ to 4 lb.

There are two islands in the Mediterranean Sea noted for their sheep. Sardinia for its improved Merino, and Corsica for the primitive Mouflon sheep which still exist. Sardinian sheep are good milk producers, while their wool is regular and even. In quality it is a good 46's and is used in the woollen trade of Northern Italy.

Balkan Wools

The wool from the Bulgarian Zigaya sheep is considered one of the best types of wool from the Balkan States. This material is fairly fine and well grown, but rather dirty owing to the sheep being moved from pasture to pasture. It is packed and sold

from Adrianople and sometimes is called " Adrianople Merino." The Macedonian sheep live in the dales and valleys of this country, and produce a fleece of long straight lustre wool, which usually reaches the market in a dirty yellow state. The wool of Macedonia is sold in Constantinople and used in the Smyrna mills for the manufacture of Turkish carpets.

Wallachian sheep produce a large mixed fleece, which consists of wool and hair, and has not much value as a textile fibre. Crosses have been made between the Wallachian and Macedonian sheep. The wool from this crossbred can be used in the low carpet business.

Volo wools from Greece get their name from the port of dispatch, and are obtained from the mountain sheep of the district. The best of these wools are sold to the Italian mattress makers, while the poorer types reach the Smyrna carpet mills.

Zackel wools are taken up by the Czechoslovakian mills. These wools are rather kempy, but can be made into useful yarns by the Continental system of porcupine drawing. The wool is obtained from the Zackel sheep of the Balkans, which have long tapering horns, not curved, but standing out straight from the sheep's head and look like corkscrews. In the finest types of Zackel sheep their horns are over 24 inches in length.

German and Scandinavian Wools

The countries on the Baltic Sea are not wool producing countries. Before 1914 Germany had a declining wool growing industry, which has waned except for special stud flocks of Saxony and Silesian Merinos. Certain types of medium and long-woolled sheep exist, but these are reared primarily for their meat. A type of wool similar to the British Down is obtained from the sheep of East Prussia, which is known as " Skudde wool." Lustre wools are obtained from the Württemberg sheep, which yield a long wool similar in quality to the " Devon long wool."

Denmark and Norway are well developed in dairy farming, but find sheep rearing an unprofitable business. On the higher lands of Norway there is much rock and forest country which is not suitable for sheep rearing.

Sweden was one of the first countries to introduce Merino sheep, but they were not a success, and a breed similar to the Scottish Blackface has been evolved. Leicester and Cheviot rams have been introduced to improve this breed and have resulted in increasing the weight of the fleece.

Iceland and Faroe Islands Wool

In these North Atlantic Islands, there exists some half wild breeds of Loaghtan sheep, such as live in the Isle of Man and the Outer Hebrides. These sheep develop extra horns and some of the rams have as many as six horns. During the winter when the pasture becomes scarce these animals come down to the sea shore and feed on seaweed. The wool is similar to that of the Shetland sheep and consists of two growths : (1) an undergrowth of soft fine wool, and (2) a coarse overgrowth of longer hairs. These animals are not shorn, but plucked by hand in the early summer when the wool tends to fall away from the sheep owing to the approach of the warmer weather. This operation is called rooing. The climate of Iceland is very favourable for sheep rearing, because the Gulf Stream prevents extremes of temperature.

Russian Wool

The wools grown in South Russia include (1) Donskoi, (2) Savolga, (3) Kazan, (4) Ukraine, and (5) Georgian wools. Donskoi wools are obtained from the sheep which live on the banks of the River Don, and are shipped from Rostov, the port of Azov adjoining the Black Sea. Prior to 1918, Great Britain bought large amounts of Russian wool, but this trade has now ceased, and the wools are used in the Russian and Polish mills. These wools are white, strong, and uniform, but have an open fibre arrangement, without much regard to staple.

Savolga wools are obtained from the sheep reared on the lands adjoining the southern part of the Volga River, which flows into the Caspian Sea. The wools are shipped from Astrakhan, taken down the Caspian Sea to Baku ; and from thence by rail to Poti on the Black Sea. These wools are of a Lustre type, and consist of fleeces which weigh about 8 lb. and

have 8 to 10 inch staples. They are fairly curly, but are poorly classed and contain considerable amounts of coloured and grey fibres. Astrakhan lamb skins are used as a fur for coats, etc., with the wool and skin intact. Black Astrakhan lamb skins are regarded as valuable commodities of trade.

Kazan wools are obtained from the sheep which inhabit the huge plain of European Russia. These sheep are of the Heath type which are to be found on the plains of Europe. The wool is soft and has a fair lustre, but is not resilient enough for carpets.

Ukraine Wools

Wools from the Ukraine Republic are grown on the sheep which live in the fertile area north of the Black Sea and are shipped from Odessa. These wools are obtained from the Negretti Merino sheep introduced into this area by Georges Rouvier in 1802. The wool of these sheep has not the quality of the Spanish and Italian Merinos, but is a fine even wool which forms a suitable raw material for the medium woollen trade.

Georgian Wools

Georgian wools are obtained from the small Republic which exists between the Black and Caspian Seas. These wools are packed and despatched from Tiflis, and sent by rail to Poti on the Black Sea. There are two types of Georgian wools : (1) Toucha and (2) Nouka. Toucha wool is a Down-land type, which is rather coarse, but not kempy. The fibres are springy and strong, and owing to their resilience form an excellent type of wool for carpets. Nouka wool is a mountain type which is full, but rather irregular and dirty, and is used for making plush.

Chapter VIII

AUSTRALASIAN WOOLS

In the worsted trade, Australian wools have been known as " Botany " wools for over a century. The first consignment of Australian wool was shipped from Botany Bay about 1800. The name " Botany " was given to this bay by Sir Joseph Banks, who visited Australia in 1770 with Captain Cook, and was greatly interested in the plants and flowers he found there. The term " Botany " now is used to denote an Australian wool of about 60/64's quality.

The two persons associated with the introduction of sheep to Australia are Captain John McArthur and the Reverend Samuel Marsden. When Captain McArthur suggested that Australia could be used as a sheep rearing country, it was argued that the vegetation of Australia was unsuitable for sheep, and the introduction and cultivation of British grasses would be a long and expensive business, It was found, however, that sheep could not only be reared, but thrived on the Australian vegetation.

McArthur's Farm at Parramatta

Captain McArthur started sheep breeding experiments in 1793 at Parramatta. His object was to procure a breed of sheep which would produce good mutton. He obtained some East Indian ewes, and proceeded to cross them with Leicester, South Down, and Irish rams. These experiments were not very successful, so in 1797 he procured some Escurial Merino sheep from Cape Colony through the medium of Captain Waterhouse of the Royal Navy. About this time Colonel Gordon, a sheep breeder in South Africa, died, and Mrs. Gordon sent some of his flock of Escurial Merino sheep to Governor King of Australia. The Governor sent these sheep to Captain McArthur for his sheep farm at Parramatta.

In 1804 Captain McArthur imported some Negretti Merino sheep sent to him by King George III from the Royal Stud Farm at Kew Gardens. These were crossed with the Escurial Merino sheep and formed the famous stud sheep of Parramatta. Captain McArthur in 1827 moved his stud farm to Camden Park, because he found that the finest wools could not be reared in a coastal region. After a century of selection and inbreeding the Camden Park Merino sheep still maintain their original features.

Marsden's Experiments at Botany Bay

The Reverend Samuel Marsden, who was born at Farsley in Yorkshire, went as a missionary to Australia and New Zealand in 1794. Marsden had a farm at Botany Bay where he took an active interest in sheep breeding. The wools from this farm were the original " Botanies."

McArthur kept his Merino strains pure, while Marsden experimented with many types of crosses and combinations. Samuel Marsden was regarded in his day as the great authority on crossbreeding. The insight and judgment which he showed in his selections have left a marked effect on the Merino and crossbred wools produced in New South Wales.

The first record of Australian wool being received in England is found in a letter written in 1808 by William Thompson, of Horsforth, who states that he had spun and made into cloth the wool which the Reverend Samuel Marsden had sent to him from Botany Bay. It is interesting to note from Thompson's letter, that the method of packing the early consignments of Colonial wool was in wood barrels.

Progress in Sheep Breeding

Since 1830 Australian farmers have specialized in wool growing, giving much attention to climate and environment. Certain experiments were tried to improve the wool by crossing Merino ewes with British long wool rams with a view to obtaining greater length of staple. The project was abandoned, but certain types of Merino sheep grow some coarse fibres on the haunches due to the influence of the long wool rams.

Sheep scab infections about 1870-80 wiped off flocks of

sheep, but control of transport together with the compulsory use of sulphur and lime dips eventually enabled the scourge to be overcome.

Some of the finest Merino wools in the world were reared in Australia from 1880 to 1900, but the recent developments of rearing the sheep primarily for the frozen mutton trade have decreased the production of high quality wools.

The Australian Merino

The Australian Merino sheep is a distinct type which has taken a hundred years to evolve and is the result of careful selection and crossing. About 1840 American rams of the Vermont type were introduced to give larger frame and produce more wool, but the type obtained after the Vermont cross had too many large folds of wool across the body to be a useful wool producer. To counteract this George Peppin of Wanganella introduced Rambouillet rams, and aimed at producing sheep with neck folds only.

Stud flocks are reared and maintained with a view to obtaining uniformity of build and breed. Careful records are kept with details of the parents and progeny. Modern Australian Merino sheep are larger than the Spanish and Saxony types, with well sprung ribs, strong shoulders and firm backs which have a slight curve. The face, legs, ears, and belly should be covered with soft fine wool. The fleece should be fairly bulky, and densely grown, with thick staples and a good flow of yolk.

Uniformity of growth is taken as an indication of good quality and the fleece should not have any coarse fibres, even in the britch. The modern tendency is to discourage the growth of body wrinkles owing to the uneven growth produced and the plain bodied sheep are favoured. Wool blindness, caused by a heavy growth of wool on the face and poll, is disappearing owing to breeders selecting animals without too much wool on the face and poll.

Australian Merino sheep thrive well in large flocks when on dry vegetation, and can stand drought better than any other breed in the world. They are rather nervous animals and do not thrive well in small flocks. Both rams and ewes are active

animals and good searchers after food. The progress made in wool growing can be indicated by the weight of wool produced per sheep. In 1890 the average growth per sheep was 4·6 lb. while in 1930 an average of 8·4 lb. per sheep was obtained.

TABLE XX

AUSTRALIAN WOOL CLIP

(889,000,000 lb.)

Country	*Percentage*
New South Wales	50·3
Victoria	18·6
Queensland	15·5
South Australia	7·7
Western Australia	6·5
Tasmania	1·4

PASTURES

The pastures of Australia have received attention since the days of Captain McArthur, who sent to England for grass seeds. The natural grass lands of Australia and New Zealand grow a coarse grassy herb called Mitchell grass which, when kept in hand, can be used for sheep rearing. English grasses, such as cocksfoot and rye-grass, thrive in Australia, and form a very nutritious type of feed for the sheep.

When grass is scarce, the sheep live on a weed called " pigs-foot," but this pasture produces poorly-nourished sheep and has a tendency to make the wool very greasy with yolk. Stud flocks need more nutriment than the ordinary wool-rearing sheep, while the dual purpose sheep which rears both good mutton and wool needs luxurious pastures. These can only be grown near the coast where the rainfall is good.

In times of drought, the sheep have to rely on bushes for their sustenance, the main types are (1) the salt bush, (2) the burr bush, and (3) the Mulga bush. The salt bush is a slowly developing bushland shrub with nutritious leaves and seeds.

Three types of burr bushes may be used in feeding sheep : (1) the trefoil or clover burr, (2) the Bathurst or solid burr,

and (3) the bidi-bidi. The burr bush has long deep roots which can obtain moisture when most of the other vegetation has dried up. In very dry seasons, when the burr bush dries up, its leaves and seeds are nutritious and can sustain the animals for several days.

The soil of Australia has been found to be deficient in phosphorus and much of the pasture is treated with a phosphate manure. In some cases when the sheep are backward in development, bone meal with their food, or licks with their water, is given to make up for this deficiency.

Drought

One of the greatest difficulties which the sheep rearers in Australia have to face, when the rainfall ceases, is the drying up of the land and vegetation under the hot summer sun. The flocks of sheep are left without means of sustenance, which, if continued for a few days, causes the sheep to starve to death. In years of drought such as 1895 and 1902 whole flocks of sheep were wiped out, while other sheep stations lost from 70 to 90 per cent of their animals.

Drought alleviation now is being attempted by (1) boring wells for water supplies, (2) systems of irrigation, (3) supplementary supplies of fodder, and (4) planting drought-resisting bushes, such as the salt bush. Artesian wells with suitable pumps are being used where practicable, and the land irrigated for producing grasses. When a drought occurs, the flocks of sheep are taken from the open pastures and fed on the artificially produced ones. The growth and storage of such plants as lucerne, oats, and hay provide a stock of nutritious food which can be taken out to the sheep when a drought sets in.

Australian Pests

Elimination of pests in the wool rearing areas takes up a considerable amount of time and money. The main pests of Australia are (1) animal parasites, (2) rabbits, wild pigs, and deer which devour the pasture in times of scarcity, (3) dingoes which devour the sheep, (4) cactus vegetation which prevents the growth of grass.

One of the main parasites is the blowfly, which can be caught

in traps or killed by poisoned bait. In Victoria, the sheep are dipped immediately after shearing with a view to rendering their bodies immune from attack. Queensland sheep rearers protect their sheep from blowflies by jetting their hind quarters with concentrated dip. Elimination of rabbits can be done by setting poison traps and keeping the sheep runs well fenced.

Dingoes are native dogs which live in the mountains and swoop down on the sheep runs to devour the animals. They are noted for their cunning and are difficult to ensnare, but "dingo hunts" are arranged when these dogs are shot in packs. Kangaroos do not usually harm the sheep, but often break down the fences and admit the dingoes.

The prickly pear bush, which often grows on sheep pastures and prevents the sheep from feeding, is becoming a menace in certain parts of Queensland. Measures have to be taken to poison the roots and burn the dead plants.

TABLE XXI

AUSTRALIAN WOOLS

Name of Wool	*Quality on shoulders*	*Fibre length in inches*	*Weight of fleece in lb.*
Victorian	70/90's	4½	8
Sydney	64/70's	5½	9
Adelaide	60/64's	5½	10
Queensland.. ..	60/64's	6	7
Westralian	60/70's	6	8
Tasmanian	70/80's	3½	6
Corriedale	58/60's	6½	10
Polwarth	56/58's	7	11

VICTORIAN WOOLS

Victorian Merino wool is the longest and finest wool in the world. The two main wool centres of Victoria are Melbourne and Geelong. The Melbourne Merino wool is shipped from Port Philip and is known in the wool trade as "P.P. Merino."

Port Philip was named after Captain Arthur Philip, the first Governor of Australia, who landed there on January 18, 1788, with the first convoy of prisoners to start penal settlements.

Victorian wools are very fine in quality, the staple is strong

and sound, while the colour is white and clean. The spinning and felting properties of these wools are all that a worsted spinner and cloth finisher can desire. Victoria is an ideal place for wool growing because its nutritious pastures are sheltered and the climate is mild. Compared with other Australian flocks, the Victorian sheep farms are small, but this facilitates careful selection.

Lambs wools from Victoria are favoured by the manufacturers of high class flannels such as those used in the West of England trade, while for hosiery, this fine short wool with its good handling properties is unrivalled.

New South Wales Wools

The wools grown in New South Wales are known as " Sydney " wools and are good all round Australian wools. New South Wales has more sheep per square mile than any other Australian province. The dry climate causes the wool to be rather sandy. The wool growing areas in New South Wales can be divided into three groups : (1) Riverina, (2) New England, and (3) Western Slopes.

Riverina Wools

Riverina wools come from the sheep which live on the open grass plains between the Rivers Darling and Murray. This area constitutes a triangle with Bourke at the north, Wentworth at the east, and Albury at the south-west corner.

Very robust sheep are reared in this area, because a hardy constitution is needed to withstand the winter's frost and the summer's heat. The herbage is short and nutritious while it lasts, but in summer it is dried up, and the sheep have to live on the leaves of the salt and burr bushes.

As soon as the autumn rains descend the grass and clover spring up, and in a very short time the whole area is covered with rich vegetation. In the good seasons, when the rainfall is regular, the Riverina is one of the finest areas which could be desired for rearing sheep, but precautions are taken to prevent overstocking, which would be disastrous should a dry season set in. Sheep which have been starved during a drought often show a weak place in the staple.

Several famous stud farms are to be found in this area, such as Boonoke, Bundemar, Coonong, Egelabra, Haddon Rig, Havilah, Wanganella, and Willandra, where stud rams are reared which are sold to farmers at prices from £1,000 to £5,500.

The Riverina Merino sheep is a large plain-bodied animal with folds of wool on the neck only. These sheep are strong, robust, and good foragers. Their wool is long, bright, deeply grown, and compact in staple. This type has been evolved through the diligence of such pioneers as Fred and George Peppin, of Wanganella, who in 1859 introduced Rambouillet rams to strengthen the Riverina breed, and by careful culling and breeding produced a type that could thrive and produce fine wool.

An irrigation scheme now has been evolved to maintain a water supply in the dry season by damming the river Murrumbidgee at Burrinjuck, and supplying the low lying areas with water from the reservoir.

New England Wools

The finest wool in New South Wales comes from the mountainous tablelands of New England. The herbage is short, good and lasting. The climate is very bracing and some very fine animals are reared. The dangers of drought are not so great as those of the Riverina plain. The wool produced by these sheep is bright, but has not the crimp and elasticity of the Victorian Merino.

New England Merino sheep are noted for their fine heads and horns. They have pink noses and carry their heads erect to display their beautifully shaped horns, which are to be found on all the rams and on some of the ewes. Many of the ewes of the flock are noted for their long life, ewes ten and twelve years old grow as fine a wool as many of the shearlings.

Some of the best New England wools come from Barraba on the Nandewar range of hills. These wools are produced from sheep which are reared from the Riverina studs, and grow exceptionally fine material which can be classed as a good shafty warp wool. In many cases where the pasture is well watered, these wools are free from burr and are called " Free wools."

Wools grown on the sheep which live on the Warrumbungle Hills are very fine with a fair length, these are dispatched from Mudgee. Much of this wool is so near in features to the Saxony, that it is greatly in demand by German buyers. Low yields often are obtained because New England wools tend to be heavy in grease.

Western Slopes Wools

The Western Slopes are much nearer the coast than the Riverina, and a considerable amount of crossbred wool is reared. The chief wool towns of this area are Yass, and Monaro for fine Merino wools, and Orange and Molong for crossbred wools. Good nutritious grasses grow in these areas, but a considerable amount of khaki weed overruns the grass lands, and when used for feeding the sheep make the wool very yolky.

Some of the finest combing wools in the world are produced by the sheep which live on the Western Slopes of New South Wales and on the banks of the Murrumbidgee River. The quality is 70's, the colour is bright and white, and yields 56 to 58 per cent. In a good season, sound level wools of a very choice type are produced.

South Australian Wools

The " Adelaide " Merinos of South Australia are a " woolman's wool " because a good weight of a sound quality can be obtained from each sheep. The wool is full and sound, but does not come up to the " Sydney " wool for quality. In handle, the wool is fairly soft and the staples are dense, but its felting properties and colour do not reach the Victorian standard. South Australian wools sometimes are known as " red " wools owing to the red sandy soil which becomes embedded in the fleece.

Merino sheep are reared on the inland stations, while crossbred sheep live near the coast. The two agricultural areas of South Australia are divided by a line which is known as " Goyders line " and indicates the area of safe wheat production. On the south side of Goyders line, crossbred sheep can be reared on pastures which need top dressing with phosphate

manures. North of Goyders line Merino sheep live on the hill sides, and feed on the salt bush and Mulga shrubs after the other vegetation has dried up. Merino sheep can be reared in those areas where the rainfall reaches 20 inches per annum, but on the drier lands the animals die from hunger when the drought sets in. Some of the best wools from South Australia come from Millbrae and Munduney.

Queensland Wools

The wools of Queensland are known as Brisbane Merinos and are shipped from Brisbane. The dry and open nature of the pastures of this province produces sheep which grow a much lighter fleece than the Victorian, and of a coarser quality than the Sydney Merinos. Some of the best wools are grown on the Darling Downs, but farther north the herbage is too poor for successful sheep rearing.

The central basin of Queensland is covered with coarse Mitchell grass and is irrigated by floods. Several dry periods exist in the summer, but when the rain comes, the whole of the low-lying ground is flooded. Some of the sheep farmers have made dams and reservoirs and irrigate the land so that a good growth of vegetation exists throughout the year.

Darling Downs on the north side of the Darling River are noted for being the best wool-producing areas of Queensland, where the famous wools from Weribone and Maneroo are grown. Warrego wools are rather burry, and in dry seasons are lean and tender. Some of the Queensland wools are used in the Rochdale flannel trade, where their openness and fullness produces an ideal type of flannel.

Western Australian Wools

"Westralian" wools are a new type of Australian wool which has not as yet become so firmly established in quality as the wools from the eastern provinces. A considerable amount of clearing out of the woodland to give access to the good pastures which are to be found in these areas is taking place. Owing to the sheep moving in and out of the burnt bushes, their fleeces become tinged with a dark blue shade, which has caused these wools to be known as "blue wools."

The Western Australian sheep breeders specialize in purchasing sheep from South Australia and New South Wales, with a view to building up a sound pastoral industry in that province. In recent years wools from the sheep which live on the banks of the Murchison River have made remarkable progress, and in quality some almost exceed the Sydney standards. The quality is a good 64's warp, and the length 4 to 4½ inches with a yield of 54 per cent.

Well-known wool stations such as Gabyon, Belele, Kirkalocka, Webbs Patch, Noondie, and Wogarno are noted for wools with good spinning properties. Wools from Wandagee have been watched with interest at the wool sales, while the wools from Kalgoorlie, Cranmore Park and Kimberley are well known to the buyers for good felting and soft handling properties suitable for hosiery.

Tasmanian Wools

The possibilities of Tasmania as a wool growing country were recognized in the early days of the colonization of Australasia. In 1820 Governor Macquarie of Australia sent Lieut.-Governor Sorrell of Tasmania 300 Camden Park Merino sheep from Capt. McArthur's farm. These were distributed to the various sheep breeders in the Island. Two enterprising breeders, Messrs. Gillis and Horne, then sent to Saxony and imported several pure Saxony Merino rams in 1823.

By 1825, the Van Diemen's Land Company, spent £30,000 on Saxony Merino rams and ewes, and by 1830 had huge flocks of stud rams for sale. In some wool districts, Tasmanian wools still are known as " Van Diemen's wools."

The climate and pasture of Tasmania favour wool growing, and wools are produced with distinct features, because drought and lack of nourishment are unknown. In recent years, dual-purpose sheep have been reared, and large amounts of Tasmanian crossbred wools have reached the markets. In fineness the Tasmanian Merino wools are equal to the Victorian, but they have not the length of the wools from the other Australian States. The wool quality is high and the material has excellent milling properties, which make it an ideal raw material for the woollen spinner.

Tasmania still is noted for its stud rams, which command high prices ranging from £1,000 to £5,000, and are sold to South Africa, South America, and most of the other Australian States.

North Australian Wools

Sheep rearing now is being developed around the shores of the Gulf of Carpentaria. The chief districts are Burketown in Queensland, and Port McArthur and Booroloola in North Australia. Merino sheep were introduced into this area in 1918 by the Brothers Wolfgang, who used the Peppin rams and ewes from Wanganella to establish the flocks.

The grass in this area is chiefly Mitchell grass, although several large patches of Flinders grass are to be found. Water supplies are good, because artesian wells can be sunk which soon strike good water. The rainfall in the Gulf Territory is about 40 inches annually, which should be ideal for sheep rearing. The wool grown in this area is shipped from Burketown to Brisbane. Transporting the wool by ship has been found to be cheaper than the road or rail transport from many of the South Queensland stations to Brisbane.

Crossbred Wools

Increase in the frozen mutton trade has had a marked effect on sheep rearing. A sheep which produces fine wool does not supply a good type of mutton. The sheep farmer therefore has two markets to supply : (1) meat and (2) wool. He is prepared to sacrifice the quality of the wool to get a good carcase when better prices are to be obtained for the meat rather than the wool.

A dual-purpose sheep has been bred, which gives a fairly fine wool and plenty of meat. This has been achieved by crossbreeding, using Lustre and Down rams on Merino sheep. Lustre and Down sheep are big animals with plenty of flesh, while Merino sheep are small, but grow very fine wool. The type of wool and mutton varies with each cross, and sheep farmers cross specific animals to produce breeds suitable for their stations and districts. Table XXII gives the type of wool and mutton from several popular crosses.

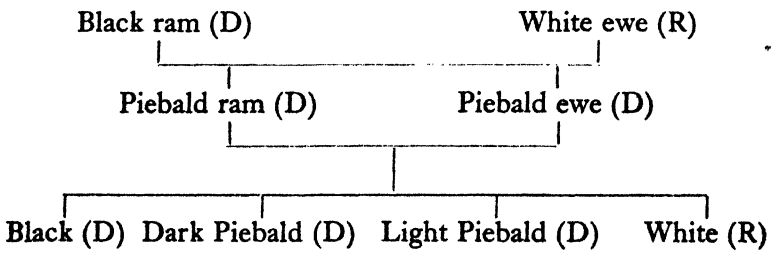
TABLE XXII

TYPICAL AUSTRALIAN CROSSES

Sire	*Dam*	*Type of Mutton*	*Type of Wool*
Lincoln	Merino	Fatty and open	Long and coarse
Leicester	Merino	Open grained	Long and curly
Border Leicester	Merino	Good grain	Irregular
South Down	Merino	Even grain and good joints	Medium wool grey in patches
Shropshire	Merino	Early maturing lamb	Coarse on haunches
Romney Marsh	Merino	Good mutton, sheep which can stand damp areas	Irregular, with coarse fibres

MENDELISM

The scientific sheep breeding and crossing, carried out in Australasia, follows very closely on the lines suggested by Abbot Mendel, who conducted experiments in breeding about 1850. Mendel's discoveries were worked out in a system of dominants (D), and recessives (R), where every possible type from a given cross appears in the second generation.

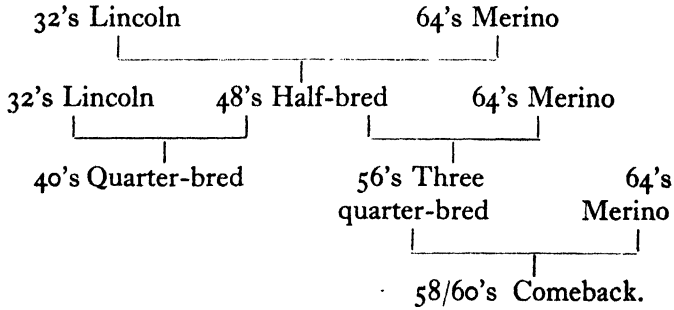


CORRIEDALE WOOLS

A new type of sheep has been produced in New Zealand, which is called the " Corriedale," after the name of the farm in Otago, where experiments were made in 1867 by Mr. James Little. This breed has been obtained by crossing Lustre

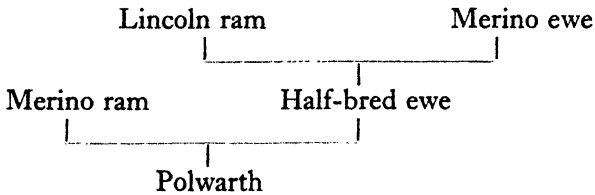
rams with Merino ewes, until a standard comeback has been obtained. Both the wool and mutton are satisfactory, the wool being soft, fine, and regular with a standard 58/60's quality.

True Corriedale wools can only be obtained from sheep which have been sired with Lincoln, Leicester, or Border Leicester rams as shown below.



POLWARTH SHEEP

A pure Lincoln-Merino cross has been produced in South Australia, New South Wales, Victoria, and Tasmania. This is known as the Polwarth, and is produced from two pure strains : (1) the Lincoln and (2) the Merino, which usually are crossed in the following way.



Corriedales are wider in selection than Polwarths, because the rams used are Lustres such as Lincolns, Leicesters, and Border Leicesters, while Polwarths are bred with one infusion of Lincoln blood. In order to obtain distinct Merino features in the Polwarth, the second cross is done with a Merino ram on the half-bred ewe. Before the Polwarth rams can be entered in the flock books as pure breds, five generations of inbreeding are required.

Crossbred wools are obtained from sheep reared on the coastal areas, where the rainfall is much greater than on the inland

stations. For this reason New Zealand is an ideal country for producing dual-purpose sheep. Queensland is too arid to rear mutton sheep, and has only a very small amount of crossbred wool to offer for sale. Table XXIII shows the number of British breeds reared in Australia, which are chiefly maintained to produce rams for crossbreeding.

TABLE XXIII

BRITISH BREEDS IN AUSTRALIA

Type	*Percentage*
Border Leicester	41
Lustre	19
Dorset Horn	13
Shropshire	12
Romney Marsh and Ryeland	9
South Down and Suffolk	6

NEW ZEALAND WOOLS

New Zealand is the largest mutton producing country in the world, and therefore is the greatest supplier of crossbred wools. This industry is due to the fertile soil, good rainfall, and mild winters. Table XXIV shows that 75 per cent. of New Zealand's wool is crossbred, while only 3·25 is Merino. Lustre woolled sheep, which were greatly in favour for crossbreeding during the second half of the last century, have been displaced by the Demi-lustres and Downs. One-tenth of the sheep of New Zealand are Romney Marsh, while the Down are excellent mutton sheep and are gaining favour as suitable sires for crossing.

TABLE XXIV

BREEDS OF SHEEP IN NEW ZEALAND

Type	*Percentage*
Crossbred	75
Romney Marsh	10·5
South Down	6·25
Corriedale	4·0
Merino	3·25
Lustre	·75
Shropshire and Ryeland	·25

AUSTRALASIAN WOOLS

The sheep in New Zealand live in areas which are inaccessible to cattle, and also in districts which are not suitable for agricultural development. Merinos live on the high slopes of the mountains, but in the valleys the sheep are mostly British breeds or crossbred. Being islands, New Zealand is cool and not troubled with drought like Australia, which makes it an ideal country for producing the dual-purpose sheep.

Table XXV shows the distribution of the New Zealand wool clip according to the districts in which it is reared.

TABLE XXV

NEW ZEALAND WOOL CLIP

(260,000,000 lb.)

District	*Percentage*
Wellington	22·3
Canterbury	16·6
Hawke Bay	12·6
Otago	12·2
Gisborne	11·3
Southland	7·5
Auckland	5·3
Marlborough	3·9
North Auckland	3·5
Taranaki	3·4
Nelson	1·2
Westland	·2

The Merino sheep was introduced to New Zealand about 1840, but needed a warmer climate to produce the finest wools. Up to 1890 large amounts of Merino wool were produced, but with the introduction of the frozen mutton trade, these have been reduced to less than 4 per cent of the wool clip.

Sheep diseases are not very common in New Zealand, other than foot-rot and liver fluke, which are found in the sheep which live in the damp areas of the North Island. To combat these diseases, crosses with Romney Marsh rams have been very successful. In those cases where the animals have not been well selected some very coarse fibres are grown in the haunches and britch.

The Romney Marsh cross also produces a better grained mutton than the Lustre crosses, and has a better colour and less fat. In the high wet regions around Canterbury, the sheep have improved greatly under the influence of Romney Marsh strains.

Best quality crossbred wools come from Wellington ; these are long and fairly fine, without many strong and coarse fibres in the haunches. Wools from Napier are reputed to be the finest in fibre diameter and regularity, but in dry seasons tend to be too thin and tender. Taranaki wools are similar to the wools from Napier, but are much heavier in grease. Auckland wools are mixed types and need to be classified into many groups and lots, they also have a tendency to be seedy and burry.

Chapter IX

AFRICAN WOOLS

Native sheep have been reared by the Hottentots of South Africa for hundreds of years. The Dutch East India Co., in 1652, introduced European sheep to the Cape of Good Hope. These sheep were kept on Robben Island, out of reach of the native tribes who raided the sheep stations on the mainland. Further supplies of rams and ewes from Holland were imported to the Cape in 1724.

Colonel Gordon, of the Dutch Army, introduced the Merino to South Africa in 1785, when he obtained some Escurial Merino sheep from Spain. Colonel Gordon's farm was one of the most important breeding stations in the southern hemisphere about 1800. Spanish rams of both the Escurial and Negretti type were introduced and assisted in 1812 by Saxonies, with a view to forming a Merino type suitable for the climate and pasture of South Africa.

The British settlers who came to the Cape of Good Hope about 1810 to 1820 started sheep farms which exist to-day. The Algoa Bay settlements started about this time, and by 1827 many of the British settlers had sheep farms in the Albany district.

When King George III of England died, in 1820, the famous flock of Merino sheep which he had kept at Kew were sold to Lord Charles Somerset. Eventually some of these animals were sent to South Africa, and kept on the Government farm at Groote Post.

About 1858, South African farmers experimented with Vermont rams, in the same way as the Australian farmers had done, but too many body folds were produced and Rambouillet rams were introduced to bring the flocks back to the plain bodied sheep. South African wools were very fine, but lacked length, and in 1904 Australian stud rams of the Riverina and

Tasmanian types were introduced to bring the Cape wools up to the Australian standards.

South African Sheep Farms

The coastal areas are too dry for sheep rearing, so the sheep stations are found on the plateaux which range from 3,000 to 6,000 feet in height. In the winter these are fairly dry, but receive plenty of rain in the summer. The average rainfall on the lower plateaux is about 12 inches per year, while on the higher ranges a 36 to 40 inches rainfall is obtained annually.

Crossbreeding with British Long wool and Down sires is not practised in South Africa to the same extent as it is in Australia and America, because the African pastures do not supply sufficient nutriment for British sheep and their crosses to thrive. Experiments have been tried with many types of British rams and the most successful results have been obtained from a Suffolk-Native sheep cross in Natal and Transvaal. Corriedale sheep from New Zealand have been introduced in areas where the climate is suitable and are making satisfactory progress.

Pastures in South Africa

The pastures of South Africa consist of (1) grasslands, (2) Karroo bushes, and (3) mixed veldt. Sheep fed on the grasslands produce wools which are free from dust and sand, but are rather yolky. The Karroo bush is a splendid drought resister and forms a nutritious food for the sheep. Wool produced on the sheep fed on the Karroo bush is rather stronger and coarser than that from the sheep fed on the grasslands, and contains much red sand and dust.

Grasses grown on the mixed veldt may be too coarse and sour for the sheep. The Rooi-grass of the Transvaal is now being displaced by cocksfoot grass. Some of the finest wool in South Africa is grown at high altitudes, and where the rainfall and suitable geological formation produce rich pastures. A moderate rainfall at 7,000 feet will produce a soft sweet herbage.

South African Sheep

Breeds of the original Hottentot sheep still exist. They have fat tails and drooping ears like the Asiatic sheep.

Their bodies are thin and lean, and do not produce much mutton, while the wool is very rough and coarse. These animals are hardy and can survive in dry, parched regions. Attacks of body parasites do not affect these sheep so they can live in areas where other breeds of sheep contract disease and die. The native types of African sheep are grouped as one class and called " Fat-tailed Afrikander " sheep.

English settlers crossed the native sheep with Merino rams, and produced a South African crossbred sheep. These crossbred sheep produce a better class of mutton than the native animals, and grow a coarse shaggy fleece, which is rather kempy. They are good drought-resisters, and can live on arid lands where Merino and British types of sheep cannot exist.

Fat-Rumped Sheep

Mutton is a favourite dish in South Africa, and the sheep reared are consumed in the Union, so that there is not an export trade in frozen mutton and lamb. The South African farmers introduced the Persian fat-rumped sheep about 1880 because—after many experiments—it was discovered that this animal could live in the South African climate and produce a satisfactory mutton.

These sheep have white bodies with a jet black head, and they are not wool-producing animals. Many farmers have crossed them with British breeds such as the Suffolks, and obtained a satisfactory mutton, and a certain amount of wool which is rather kempy and grey. A cross between the Angora goat and the fat-rumped sheep produces mutton which is regarded by many farmers as being an ideal joint for evenness of grain and quality of flavour. These animals have pouches of fat on their rump which produces an edible grease used by many farmers instead of butter.

Wool Improvement

Prior to 1904, Cape Merino wools were too short for the British worsted trade, and could only be used for the manufacture of woollen goods. Since that time enormous progress has been made in fine wool production in South Africa by (1)

improved breeding, (2) better pastures, (3) annual shearing, and (4) careful classing and get-up for sale.

The improvement in breeding of South African Merino sheep started about 1904, when Australian rams were introduced. Wool improvement in South Africa is regarded as a matter of national importance, and the sheep and wool division of the Ministry of Agriculture is doing some very useful work.

Stud Farms

Since the Government took a greater interest in sheep rearing, South African stud farms have been introduced. The original stocks were obtained from studs from (1) the Riverina in Australia, (2) Tasmania, and (3) Rambouillet in France, but by careful selection, distinct South African types have been evolved. The chief stud rams used in South Africa are obtained from the following stud farms, Belle Vue, Grassdale, Highland Home, Hillmoor, Koloniesplaats, Rolfontein, Winton, and Zuurplaats.

Pasture Improvement

The improvement in the South African sheep pastures consists of (1) irrigation of dry areas, (2) introduction of new grasses, (3) planting edible shrubs, (4) suitable fencing, and (5) trekking sheep to and from summer and winter pastures. Systems of land irrigation consist of boring artesian wells and making water dams. The water is run on to the land and maintains a sufficient supply to nourish suitable grass.

New grasses and plants such as cocksfoot, woolly-finger grass, and lucerne, are being planted in cleared veldt areas and have proved to be suitable sheep-rearing pastures. Edible shrubs such as the Acacia shrub, Australian salt bush, spineless cactus and American aloe have been introduced in the areas which are too dry and steep for irrigation. The plants are excellent nourishment for the sheep when the periods of drought set in, and also provide suitable shelter from the heat of the sun.

Fencing the pastures has received considerable attention in recent years, because the sheep can feed over a specific area on carefully cultivated food, and at the same time be protected against night attacks from jackals. In many districts where

wild animals abound, the sheep are gathered and kraaled at night. There is a certain deficiency of phosphate in the South African soil, which can be overcome by either top dressing the soil or giving the sheep phosphate licks and bone meal.

Annual Shearing

Prior to 1904 Cape sheep were shorn after about six or nine months growth and the wools were known in the wool trade as "thumb nail wools." The shearing now is done annually which allows the wool to grow longer. As a rule, native boys on the stations do the shearing, but a certain amount of wool is cut on the Australian system of itinerant shearers. Fribs and double cuts which were once so prevalent in Cape wools owing to careless native labour have now become things of the past.

Improved Get up

Standards of wool classification have been issued as shown in Table IX, on page 13, and farmers aim at producing a well grouped saleable article. South African fleeces are not usually scoured, but in some cases bellies and locks are improved by scouring and present a better marketable appearance.

Table XXVI

South African Wool Clip

(285,000,000 lb.)

	Percentage
Cape Province	48·3
Orange Free State	34·1
Transvaal	12·4
Natal	5·2

Cape Province Wools

The wools grown in the Cape Province on the upper Karroo plateaux are obtained from sheep which live at an altitude of 6,000 feet. The rainfall is about 25 inches annually which maintains a regular feed. The main wool towns of this area are Carnarvon, Prieska, Graaff-Reinet, Victoria West, and

Swellendam. Cape wools vary in yields from 40 to 50 per cent, only very exceptional wools yield over 50 per cent. The area around Port Elizabeth is noted for its " snow white capes." These wools are used for black and white check cloths, and other fabrics where snow-white effects are desired.

Orange Free State Wools

The great Karroo plain extends into the Orange Free State, and the wools of this area are similar to those of Cape Province. The sheep are herded at night and placed in kraals to protect them from cold and jackals. In most of the districts of the Orange Free State there is a rainfall of 30 inches, but in certain areas bore-hole water has to be obtained and is run into dams to provide water during the drought periods. Sheep from dry areas have fleeces with a slight red cast owing to the dust and sand which they contain. The main wool towns of the Orange Free State are Bethlehem and Harrismith.

Transvaal Wools

Wools grown in the Transvaal are produced under more difficult conditions than those obtained in Cape Province or the Orange Free State. As the summer advances the pastures dry up and the sheep are trekked to Natal. There is a certain deficiency of phosphates in the soil of the Transvaal, and the sheep have periodically to be given licks and meal feeds to assist their growth. Parasites are more common, and sheep dipping has to be done regularly. The average yield obtained from Transvaal wools varies from 47 to 52 per cent.

Natal Wools

Certain high-class South African wool is grown in Natal, chiefly in the Richmond area. The flocks are not large, and the wool is well cared for. Natal has some excellent sheep rearing areas in the river valleys, which provide a sufficient growth of pasture all the year round, provided that they are not overstocked. Yields of more than 60 per cent can be obtained from these wools which are considered one of the best yielding wools of South Africa.

Rhodesian Wools

Wool producing stations are being opened out in Southern Rhodesia and the South African Government have a stud farm to supply the needs of the farmers of this area. Several large sheep stations which produce a good 60's quality wool are situated in Matabeleland at Melsetter and Rusapi. The owner of a large Matabeleland sheep station is the Hon. H. U. Moffat, who became Premier of Southern Rhodesia in 1929, and has done much to encourage sheep rearing and fine wool production in Rhodesia.

The pioneer of Rhodesian sheep rearing was the great Cecil Rhodes, who saw possibilities of wool production and selected a place on the high veldt of Inyanga, where he established a pioneer flock of the Merino sheep of Rhodesia.

North African Wools

Wools from North Africa are short, coarse and wiry, because the sheep in these areas do not require as much covering as those living in cooler climates. The sheep population of North Africa is estimated at about 22 millions, which are distributed with about 10½ millions in Algeria, 10 millions in Morocco, 1 million in Tunisia and ½ million in Sudan. Most of these wools are grown on sheep which have been reared in coastal areas. The rainfall of the inland districts is very low and irregular, which causes the flocks to be nomadic, moving from the dry pastures to the nutritious ones.

Several breeds of sheep exist in this area and include (1) the long-legged sheep called the Fezzan, (2) the fat-tailed sheep of the Tunisian type, (3) lop-eared sheep known as Adimain sheep, and (4) the maned sheep of the Barbary type.

Sheep have been reared in Egypt from prehistoric times. The animals carved on the tombs of the Hamitic settlements appear to represent the ancestors of the present-day Fezzan sheep, which live on the banks of the Nile. The fat-tailed sheep was introduced from Asia along with Arabian horses by the Shepherd Kings. These sheep were the main wool and meat producing animals in the days of the Pharaohs. A special type of sheep is found on the banks of the White Nile

which are known as " Dinka " sheep and resemble the Oudad or African-maned sheep.

The flocks of North Africa are scattered over the wilderness and do not receive much care or control. In many cases a small flock of sheep is kept by the natives for milk and meat. The climatic conditions are not conducive to sheep-rearing, because the days are hot and the nights cold, while a general lack of water prevents the sheep from thriving.

The sheep of Tripoli are the fat-tailed Barbary type, which are noted for their powers of resisting drought, they can exist for several days without food and water. The fat tail of the animal reserves nourishment which the sheep can draw upon when impoverishment of pasture takes place. The wools from North Africa are sold as " French Colonial wools " in the Marseilles market, while a little comes into the London and Liverpool low-grade wool sales. These wools are used mainly for carpets, felts, and bedding.

Central African Wool

The native sheep of Central Africa are a type of African maned sheep known as " Baluba " sheep. Fat-rumped sheep have been introduced from North Africa and thrive well, while recent experiments have been made with Russian Karakul sheep to find an animal suitable for the hot dry climate of Kenya and Northern Rhodesia. At present the wool industry of this district is only at the experimental stage, but when a suitable sheep has been discovered, and the industry developed some satisfactory wool may be expected from Central Africa.

Western African Wool

West African sheep are called Zuny sheep. They do not yield much wool owing to the hot climate. These animals have four horns like the four-horned Irish sheep and provide a novel type of sheep, which are sometimes kept in the parks of the country estates of Britain. These animals grow piebald wool and have a white streak down the centre of their faces. A very remarkable fact about these African native sheep is that their belly wool is black, whereas most of the European and Asiatic breeds from the Mouflon and the Argali have white under parts.

Chapter X

AMERICAN WOOLS

The amount of wool grown in the countries of South America is almost equal to that produced in the United States, Canada, and Mexico. The chief wool producing areas of South America are Argentina, which produces two-thirds of the South American wools, Uruguay grows about a fifth, while Chile, Brazil, Peru, and the Falkland Islands yield the remaining seventh of the South American wools.

Buenos Aires, Montevideo, and Punta Arenas are stations for the collection and dispatch of the wool to the manufacturing countries. Most of the Argentine clip is collected at Buenos Aires, and the wools grown in Uruguay and Southern Brazil are gathered at Montevideo, while wools from Patagonia and Tierra del Fuego are shipped from Punta Arenas the Chilean port on the Straits of Magellan. South American wools often are known by the initials of the ports of shipment, the Buenos Aires wools are classed as " B.A." Montevideo wools as " M.V.," and the Punta Arenas wools are known as " Punta wools " or " P.A."

Progress in Wool Growing

Merino sheep were introduced into Argentina in 1794, and in 1824 Southdown ewes were used for breeding with the Merino rams. In 1844 Southdown rams were used to give more robustness of body to the Merino sheep. About 1883 the start of the frozen mutton industry made a radical change in policy, and from that time large numbers of crossbred sheep have been produced. Until about 1904 the Lincoln-Merino cross was favoured which produced a crossbred fleece of long, strong, and lustrous wool.

Since those days experiments have been made with Leicesters, Border Leicesters, Shropshire, Hampshire, Oxford, Romney Marsh and Dorset Horn rams, while a modern tendency

is to employ the New Zealand Corriedale crossbred sheep.

The type of Merino sheep favoured in South America is the Rambouillet, which readily acclimatizes in this district and produces a very satisfactory type of wool.

Uncertainty of weather in South America is always a trouble to the sheep farmer. Rain may come at any time of the year, or in some years may miss completely. In 1830 there was no rain in Central Argentina and practically all the cattle, horses, and sheep perished.

The sheep farms—which are known as estancias—are fenced round to save labour in herding the sheep, and also to extend the life of the pasture. The sheep farmers of South America are not troubled with wild animals, like the South African farmer experiences with the jackal, and the Australian farmer with the dingo.

Marketing South American Wool

In many cases the wool is bought by merchants who inspect the clips on the estancias. Early in the season the wool may be inspected on the sheep's back before the shearing commences. Shearing, which begins in December and ends in February, is done by the shepherds of the farms, who in many cases are Italian immigrants. The fleeces are skirted and classed, but this work does not reach the standards achieved in Australia and South Africa. Merchants who purchase the wools usually pay a flat rate for the consignment and have it sent to their warehouses, to be inspected, classed, and grouped. The large wool classing and storage warehouses of Buenos Aires, Montevideo, Bahia Blanca and Punta Arenas are known as " barracas."

Table XXVII

Classes of South American Wools

South American Name	*English Equivalent*	*Type of Wool*
Supras ..	Super	Well skirted attractive wool of a good quality.
Primeras ..	First Quality	Sound, clean, well grown wool.
Segundas ..	Inferior	Less attractive wool, burry and faulty.

ARGENTINA

The conditions for rearing wool in Argentina are ideal, because the soil is one of the richest in the world, being well watered by rivers such as the La Plata, Colorad, and Rio Negro. Excellent grasses are grown, and winter feeding of the sheep is not necessary. On the higher ground there is an ample growth of shrub, which provides an excellent food for the sheep in the dry weather. Sheep diseases are not common, the worst being occasional attacks of scab. In recent years the sheep are being driven to the higher ground and the valleys are now being used for growing wheat, maize, and corn, while where the pastures allow cattle ranching is becoming a very profitable business.

Argentina may be divided into three parts. (1) The Andes area of the north, (2) the Pampas area, and the River Parana basin, and (3) Patagonia in the south. Crossbred wools are reared on sheep kept in the valleys where good pastures allow dual purpose sheep to be reared, but on the high grounds of the Andes and Patagonia regions Merino sheep are kept. In the Andean region there is not much wool grown, but a few sheep exist on some of the farms. The wool production of the Andean Provinces does not amount to over 7 per cent of the country's output.

TABLE XXVIII

ARGENTINE WOOL CLIP

(330,000,000 lb.)

	Percentage
Buenos Aires	50·6
Santa Cruz	9·1
Entre Rios	8·3
Rio Negro	6·3
Corrientes	4·7
Chubut	4·4
La Pampas	4·2
Santa Fé and Cordoba	4·1
Andean Provinces	2·4
San Luis and Santiago del Estero	2·1
Neuquen	1·9
Tierra del Fuego	1·6
Chaco, Formosa, Los Andes and Misiones	·3

Buenos Aires

One of the main wool growing areas of the Argentine Republic is the Province of Buenos Aires, which extends from the River Plate to Bahia Blanca. This area produces half of the wools grown in Argentina which consist of low and heavy crossbreds obtained from Lincoln-Merino crosses. In some cases wools from the province of Buenos Aires are deficient in length, and wool combers find that although the wools are too long to card they are not long enough for the preparing processes. A considerable amount of burrs exists in some of the wools, but, as a rule, the wools have a soft texture and a good handle. The qualities obtained range from 32's to 46's.

La Pampas

South-west of Buenos Aires is the province of La Pampas, which consists of plain lands where a considerable amount of sheep rearing takes place. The wools from the sheep of this province are regular and even. On the slopes of the Andes, where the pasture becomes scarce, the sheep produce fine crossbred wools which often are tender and wasty.

Entre Rios

North of Buenos Aires is the province of Entre Rios, which is the third largest wool producing area of Argentina. The sheep rearing areas between the River Parana and the River Uruguay are much warmer than any of the other wool rearing districts.

The soil is rich and provides good pasture for dual-purpose sheep of the Lincoln-Rambouillet type. The coarse hard grass is eaten by the cattle which sometimes are farmed on the same areas as the sheep. Under the coarse vegetation is a fine grass and a deal of clover which forms suitable nourishment for the sheep. Winter comes in July, and on many estancias the lambs are born in May, because they thrive better in the cooler periods.

Entre Rios wools are rather hard, but have good fullness and blobbiness, which makes them suitable for hosiery and

felted fabrics. In the lower qualities some coarse fibres are to be found on the haunches.

Corrientes

The hot climate and marshy ground in the north around Caa Cati make this district like a subtropical region where palm trees and heavy vegetation thrive, but it is not suitable for sheep rearing. On the drier lands a certain amount of crossbred sheep can be reared, which produce a good type of medium crossbred wool. The Lincoln-Rambouillet does not produce a type suitable for these regions, and the Shropshire-Rambouillet cross is favoured.

Table XXIX

Distribution of Argentine Wool

Type of Wool	*60's and over*	*56's*	*50's*	*46's*	*40's*	*36's and below*
Chubut, Rio Negro	70	17	10	3		
La Pampas ..	20	20	30	25	5	
Corrientes and Entre Rios	10	40	40	10		
Santa Cruz ..	10	20	35	30	5	
Punta Arenas ..	5	15	30	40	10	
Buenos Aires ..	2	3	5	10	30	50

Patagonian Wools

The large tract of country between the Rivers Negro and Chubut was regarded by the early settlers in South America as a " wind-swept desert waste." Charles Darwin who visited South America in 1830, considered the Patagonian plateau as " hopeless." By diligent labour this desert has been turned into one of the finest sheep rearing areas of the world.

Merino sheep are reared in the hilly districts, while crossbred are favoured on the richer pastures. The initial crosses about 1890 were by Lincoln rams, while about 1905 Romney Marsh rams were tried, and since 1920 New Zealand Corriedale rams and ewes have been in demand. The finest Merino wools of

South America come from Patagonia and are known by the names of the states, Chubut, Rio Negro, and Santa Cruz.

Chubut

The central area of Patagonia between the River Chubut and the River Deseado is known as the Chubut Territory and produces the finest Merino wools of South America. The low land round the Gulf of St. George (San Jorge) is desert waste, but higher up towards the Andes, there is a considerable amount of good pasture suitable for Merino sheep. The loose soil of the district sticks to the wools and gives them a black appearance. The quality is about a 64-70's, but the wools are rather dry and somewhat resemble the Brisbane Merino type. Excellent yarns can be made from these wools by porcupine drawing and mule spinning.

Rio Negro

North of the Chubut area is the territory of Rio Negro, which is bounded by the Rivers Chubut and Negro. The Rambouillet Merino sheep of this area produce a fine even fleece, which is used for hosiery yarns, and compares favourably with the Chubut wools. Two faults are found in the wools from Rio Negro : (1) grey hairs in the haunches, which prevents them from being used for light colours, and (2) they lack length, which does not allow them to be made into yarns by the English worsted system, although some very full and soft yarns can be made by porcupine drawing.

Santa Cruz

The most southerly portion of the South American mainland is Santa Cruz, which extends from the River Deseado in the north to the Straits of Magellan in the south. The territory receives its name from the River Santa Cruz which flows from the Lake Argentino in the Lower Andes to the Atlantic Ocean. Summer winds blow the loose soil into these wools and make them look very dirty, but the soil can be scoured out and some very white clean wool obtained. In the lowlands of Santa Cruz, crossbred wools are produced from Lincoln-Merino crosses, and in recent years a considerable amount of

crossbred wool has been produced around the mouth of the River Santa Cruz.

Tierra del Fuego

Tierra del Fuego, the island at the south of South America, is half Chilean and half Argentine. The rich black peaty soil is one of the finest in the world for producing good grasses and clover, where excellent wools can be reared. The rainfall is about 40 inches per year, the summers are cool and in the hardest winter there is not much snow.

The first sheep introduced were the Rambouillet type of Merino, which still exist on the high ground in the south of the Island, while crossbred sheep are reared on the better pastures. Lincoln and Romney Marsh rams have been used in producing the Tierra del Fuego crossbred sheep. The soft fine wools from this Island are well known in the Leicester hosiery trade for their good colour, springiness, and crimp which is accompanied with a full and lofty handle. Owing to the high winds of the summer months, dust is blown into the fleece which makes these wools heavy in earthy impurities and gives a dirty appearance.

Wools from Uruguay

Uruguay is the smallest republic in South America and consists of good forest country with rocky ridges of well wooded pasture. The estancias of this region are usually clearings where the sheep are fenced in by hedges. There is not much agriculture such as wheat and corn growing, although cattle ranching is proving a very profitable business.

Merino sheep exist on the hills, while in the valleys crossbred sheep are favoured. Several British sires have been used, such as Lincoln, Leicester, Sussex, Shropshire, and Hampshire breeds.

The sheep are very healthy on this side of La Plata River, the only trouble being occasional attacks of sheep scab which can be controlled by using lime and sulphur dips. Locust plagues sometimes settle on the land, eat up all the green vegetation and leave the sheep to starve.

Wools from Uruguay are collected and shipped from Monte-

video, which is a collecting station for most of the wools grown on the north of La Plata River, so that a considerable amount of Brazilean wool is dispatched from Montevideo. These wools are more deeply grown than the Argentine types and are much cleaner, owing to the firmer nature of the soil and lack of winds. The Montevidean wools lack the density of the New Zealand types of crossbred, but form a very useful material for the hosiery trade.

Brazil

South Brazil has a large sheep and wool industry, which supplies a great amount of fine crossbred wool. The land is very fertile and firm which enables good grasses and clover to be grown. Brazilean wools are the cleanest type produced in South America and somewhat resemble the wools from Uruguay. The main port for the collection and shipment of the wool from South Brazil is Montevideo.

Chile

The long strip of narrow country at the west side of the Andes is called Chile, and produces some of the finest crossbred wools in the world. The pastures of Magellanes are mostly arable lands or forest clearings. On the slopes of the Andes Merino sheep are reared, while on the better pastures of the river valleys dual-purpose sheep live.

Chilean wools are collected at Punta Arenas, and are well known in all manufacturing areas for their fullness and soft handling properties. These wools are ideal for hosiery and felting fabrics, which need fullness with softness of handle. The black soil of this area gives the wools a dirty appearance, but this can be removed by careful scouring.

The sheep of Chile are known as " criollos " sheep, and consist of Spanish Merino animals, which were introduced about 1600 A.D. These sheep were not farmed or tended for three hundred years, which has resulted in considerable deterioration of the wool.

Punta Arenas, the port on the Straits of Magellan, serves three tracts of land : (1) the Magellanes district of South Chile, (2) Patagonia, South Argentina, and the Island of

Tierra del Fuego which is half Chilean and half Argentine. The bales of wool from Tierra del Fuego are brought by boat from the Island across the straits to the port of Punta Arenas.

TABLE XXX

WOOLS COLLECTED AT PUNTA ARENAS

Name of Area	*Percentage*
Magallanes (Chile)	39
Chilean Tierra del Fuego	26
Argentine Tierra del Fuego	18
South Patagonia	17

FALKLAND ISLANDS

The two islands of the South Atlantic Ocean near to the mainland of South America are known as the East and West Falkland Islands. A century ago these islands were populated by Scottish immigrants, who started sheep farming with Cheviot rams and ewes. There is a great contrast between the soil of the Falklands and that of the mainland, because these islands consist of rocks covered with loose soil and bog.

In more recent years the sheep of the Falklands have been improved by Leicester and Romney Marsh influence. Great care has to be taken to prevent overstocking. The people of this colony are dependent on sheep-rearing and wool-growing for their livelihood.

PERUVIAN SHEEP

Pure Merino sheep were introduced by the Spaniards into Peru at the time of the Spanish conquest in 1530. In the course of 400 years they have degenerated into small lean animals which only weigh from 40 to 50 lb. each. The annual fleece from these sheep does not exceed 1½ lb. in weight, and consists of wool from the back of the animal as there is no growth on the belly. This wool is used locally on the low-woollen system for the production of rugs and blankets. Chilean wools from Lima are of a miscellaneous nature, very kempy, with mixtures of coloured hairs.

Since 1920 the Peruvian Government has taken an interest

in wool growing and started an experimental farm at Chuquibambilla in South Peru. This sheep station is about 13,000 feet above sea level and is very near to the snow-capped peaks of the Cordilleras.

Under the advice of Professor Barker, of Leeds University, some European rams were obtained to cross with the native sheep. The types selected were Southdown, Hampshire, Suffolk, Shropshire, Rambouillet, and Soay rams. After many experiments it was discovered that the best progeny was obtained by using Southdown rams, while useful animals were produced by the Hampshire, Soay, and Rambouillet crosses.

The Shropshire rams did not thrive in the high altitude, but when they were brought down to the lower plains to acclimatize some useful crossing was achieved. The unsuccessful cross was the Suffolk, which needs a more nutritious pasture for the rams and progeny than the mountains of Peru afford.

Some very serviceable flocks of sheep now are being reared in the high altitudes of the Andes of Peru, where the rainfall and the geological formation are suitable. An annual 30-inch rainfall with well drained land is essential, and where the rocky soil produces a soft sweet herbage. The enclosure of pastures to ensure a continuous feed, and the introduction of modern methods of breeding, dipping, shearing, and wool get-up will bring Peruvian wools into the world's markets.

North American Wools

The three main wool producing areas of North America are the United States, which produce about 90 per cent of the North American clip, Canada which grows 6 per cent, while the rest is reared in Mexico.

The United States of America is one of the few countries of the world which do not export wool and has to buy about 40 per cent over the production of their home-grown wools. When the wool clip of the United States is spoken of as a separate entity, the term "Domestic wools" is used in a similar way to which the Australian clip is called "Botany."

An import duty is placed on all types of wool which could be grown in the United States, but wools which cannot be

produced there are allowed to be imported duty free. Chinese, East Indian and Scottish Blackface wools form typical examples of this class.

Early Days

English Colonists who settled in Virginia and Maryland about 1600 started the sheep and wool industry of the United States. British sheep such as the Dorset, Wiltshire, and Romney Marsh breeds were introduced about 1624. The Dutch immigrants settled around New York about 1625 and brought with them Dutch Texel sheep. After 1664, when the English settlers took over the Colony, the sheep rearing industry flourished.

George Washington, the first President of the United States, took a great interest in sheep breeding, and in 1788 had a flock of 800 sheep at Mount Vernon.

Merino sheep were introduced into North America by Mr. Foster, of Boston, Massachusetts, who imported some Negretti Merino rams in 1793. In 1802 the American Ambassador of Madrid sent a flock of 21 rams and 70 ewes to Mr. Foster's farm in Vermont. Further importations of sheep from Spain took place in 1809 and 1810.

Negretti Merino rams were crossed with the native American sheep, which produced an animal with coarse ruffles of wool across the body, which now is known as the " Vermont Merino " type.

" Fleece " and " Territory " Wools

The natural division of the United States into east and west is made by the River Mississippi. In the early days, the wool growing areas of the States were found east of this river. Since 1860 the western states have been opened out and the main wool growing areas are now to be found in the west.

Beyond the River Mississippi were the Indian reserves which were called the " Indian Territory " and gave rise to the wool term " Territory wools," which describes those wools grown in the land immediately west of the River Mississippi. Wools grown east of this river are known in the American wool trade as " Fleece " wools.

Western American Sheep Farms

" Fleece " wools of the eastern states are obtained from small flocks, while the " Territory " wools of the west come from sheep reared in larger flocks. On the prairie land the sheep are not enclosed, but allowed freedom to wander and feed on the hills and in the dales of the vast ranches. The American farmers of the northern states are not troubled with drought, because the snow-capped peaks ensure a constant water supply, as the increasing heat of the summer melts more and more snow.

When the winter comes, the sheep are forced down to the valleys, while in the summer they are taken back to the higher pastures. As a general rule winter penning and feeding are not necessary, because the sheep can find food and shelter in the valleys.

Shearing in the United States of America starts about April in the southern states and lasts until July and August in the northern states. The Australian system of itinerant teams is used, who start in the south and work northwards.

North American wools are grouped into three classes which are : (1) clothing, (2) French or " baby combing," and (3) strictly combing. Clothing wools are those under 1½ inches long, while French or " baby combing " wools are under 2½ inches in length and " strictly combing " over 3 inches.

Table XXXI

North American Classing Terms

British Qualities	*United States Terms*	*Canadian Terms*
64's to 80's	Fine	Fine
58's to 60's	½ Blood	Fine medium
56's	⅜ Blood	Medium
48's to 50's	¼ Blood	Low medium
46's	Low ¼ Blood	Low combing
44's	Common	Low combing
36's to 40's	Braid	Coarse

North American Sheep and Wool Pests

One of the main troubles on the North American sheep farms is the attacks from the coyotes—the prairie wolves—

which devour the sheep and lambs. Fencing is done in Texas, but as a general rule the majority of American farmers prefer to keep this menace in hand by " coyote hunts."

The northern states are not troubled with drought, but in the southern states wells have been sunk, so that the land can be irrigated during the summer months. When the pasture is scarce, some of the sheep eat certain poisonous shrubs with fatal results. In those areas where this has taken place attempts have been made to destroy the poisonous plants and replace them with Australian salt bushes and American aloe plants.

The Vermont Merino

The Vermont Merino sheep produce the heaviest fleece of any type of Merino, owing to their wrinkled skins. The quality and length of the wool varies on the ridges and furrows of the fleece. The wool is deeply grown with dense staples and is heavy in grease. Poor yields usually are obtained, owing to the excessive amount of yolk which gathers in the folds of the fleece. Sorting Vermont Merino fleeces is a difficult job, owing to the variation of lengths and qualities in those parts of the fleece which should be regular and even.

Modern Merino sheep in the United States are chiefly Rambouillet and Rambouillet-Vermont crosses, which are mainly found in Wyoming, Colorado, Texas, New Mexico, Arizona, Nevada, and Southern California.

North American Crossbred Wools

Crossbreeding for dual-purpose sheep was started in America about 1895. Where the pastures yield sufficient nourishment, suitable crossbred sheep are reared. There are, however, about 25 per cent of Merino sheep on the higher ranges, where there is sufficient warmth and pasture.

The original crosses were made by Lincoln rams with Rambouillet ewes, but in more recent times Down and Romney Marsh rams have been favoured, owing to the fat lambs which readily mature from their crosses. The North American crossbreds produced by Lincoln rams and Rambouillet Merino ewes have standardized a crossbred—similar to the " Polwarth " of Australia—which is called the " Columbia." The

fleece is deeply grown and produces about 10 lb. of 56/58's wool.

Another North American type of crossbred sheep is the "Panamas," which has been developed by the Idaho farmers by crossing Rambouillet sires with Lincoln ewes and have produced a type of crossbred sheep distinct from the Columbia.

"Romeldale" American crossbred sheep are bred in California from a cross of Romney Marsh rams with Rambouillet Merino ewes. These animals can thrive in damp areas without foot-rot troubles. The wool is regular and even.

Kentucky, Tennessee, and Oklahoma specialize in rearing mutton sheep, which are mainly of the British Down types and Down-Merino crosses. Fat lambs are of more importance than good wool.

Ohio

Some of the finest Merino wools produced in the United States are the Ohio Merinos. These usually are called "Delaine" wools, and are used in the production of fine worsted fabrics such as delaines, taffetas, and tricotines. Ohio lambs wool forms a splendid type of material for the knitting trade as it is fine, soft, and full. The Delaine Merino type was introduced by the wool growers of Ohio about 1870 and has Rambouillet blood as a foundation stock which has been assisted in crossing by Saxony Merino rams.

Sheep farming in Ohio is being displaced by new towns springing up and consequently the farmers find that pigs and cattle—which yield bacon and dairy produce—are more profitable than sheep. Stray dogs are a great trouble to the sheep farmers of this area and measures have to be taken to have them destroyed. The Ohio sheep and fine wool industry overlaps into the surrounding states of Pennsylvania, Virginia, Indiana, and Kentucky.

New England States

The wools grown in the New England states of Vermont, New York, Maryland, and Virginia now are mainly crossbred, the original Vermonts have been moved west and are found on the hills of Wyoming and Colorado. Winters are longer in

these eastern states than in the west, and the cost of winter shelter and food is much more expensive.

Grasslands in these parts are known as the blue grass areas, because the limestone soil grows a healthy type of nutritious grass. Dual-purpose sheep which yield a fine grained mutton are reared on the blue grass. The crosses favoured are Dorset-Merinos which yield a medium fleece of about 10 lb. with a yield of about 68 per cent.

Semi-Brights

The " fleece " wools from the eastern states are bright and clean, while the " Territory " wools from the west are dusty and heavy in earthy impurities. Medium types of wool known as semi-brights are obtained from the States of Kansas, Nebraska, Dakota, Missouri, Iowa, Minnesota, Wisconsin, and Illinois. The average number of sheep kept on these farms does not exceed fifty, and they are usually of the British Down types, with a certain amount of Down-Merino crosses. These wools scour well and give good yields, which vary from 55 to 70 per cent.

Wyoming and Colorado Wools

One of the best types of Merino wools grown west of the River Mississippi is the Wyoming Merino. On the open ranches there is a sufficiency of pasture to produce suitable Merino wools, while in the valleys dual-purpose crossbred sheep are reared. A good water supply exists, owing to the mountains, but it is rather alkaline, which prevents the production of a full handling wool. The shearing season is late in Wyoming, so that the summer is well advanced, and these wools are rather dry and dusty, although they are not heavy in grease. In some cases yields of 68 per cent can be obtained.

The Colorado sheep lack care in breeding, and the wools are classed as the poorest type of " range " wools.

Idaho and Montana Wools

Dual-purpose sheep which are noted for their early maturing fat lambs are reared in the two northern states of Idaho and Montana. The wools are medium crossbreds obtained from Down and Romney Marsh-Merino crosses. These wools

have good felting properties and length, but a somewhat harsh handle and the yields are rather low, due to the alkaline nature of the soil. A distinguishing feature of Idaho wools is that after scouring they are not white, but have a cream tint.

Lincoln rams are being displaced by Downs and " Columbias " because the Lincoln blood tends to make the wool " brashy " on the haunches.

Pacific States Wools

Wools from Washington, Oregon, Nevada, and North California are known as " Valley " or " Western " wools. Some Merino sheep are to be found on the hills, but on the plains and in the valleys the sheep are mostly crossbred. Down crosses are favoured, but a lot of Lincoln-Rambouillet-Merino sheep give good mutton and long lustre wools. In Nevada a white short Merino combing wool is obtained. The crossbred sheep are produced from Cotswold rams and Rambouillet ewes.

The rainfall in the Humboldt district of California is about 70 inches per year, and Romney Marsh sheep are favoured in this district. On the Sierra Nevada, Merino, and Lincoln-Merino crossbred sheep are reared, while in the Sacramento, Sonoma, and San Joaquin valleys, Lincoln, Romney Marsh, and British Down sheep of the Shropshire and Hampshire types thrive.

Border Wools

On the Mexican border in the States of South California, Arizona, New Mexico, and Texas, the wools produced are rather dirty and the " get-up " is poor compared with that of the more northern districts. Tender staples sometimes are found owing to droughts in the summer, while, when the rain comes, the sheep get their fleeces badly soaked. In order to prevent the deterioration of the wool in this way, the sheep are shorn just before the rain starts, which produces two clips per year. These are known as : (1) spring clip and (2) fall clip. Owing to their shortness these wools are used in the felt hat industry. Arizona wools are noted for their whiteness, and often yield about 68 to 70 per cent.

Canadian Wools

Sheep were introduced into Canada by the early French settlers about 1650, and many farms in Quebec retain the old system of combing, dyeing, spinning, and knitting the wool which they obtain from their sheep. In the majority of cases the sheep on these farms are Lustre animals mainly of the Leicester type, and each farmer keeps from about 30 to 50 to eat up the remnants of the wheat crops, and keep down the weeds on the inaccessible parts of the farm.

The women folk of the French Canadian farmers of Quebec are dexterous with their domestic plants and can produce socks, mitts, sweaters, and underwear from the wools. In some of the larger towns, village mills exist where they card and spin the wool, while some of the farmers have hand looms and make their own cloths.

Farther west, the sheep are kept on the wheat producing farms, not for mutton or wool, but as scavengers to eat up the weeds and stubble and manure the land. The Canadian Government encourages the use of sheep on farms, and will give a number of ewes to any farmer who will return the same number of ewe lambs in five years' time.

Wools obtained from wheat farms tend to contain chaff, which is very difficult to remove and necessitates carbonization. This wool is classed as " burry and seedy " and often depreciates its value by 33 per cent. A wool association now controls the sales of wool, which has made a marked improvement in the get-up and classing of the fleeces.

Table XXXII

Canadian Wool Clip

(18,000,000 lb.)	*Percentage*
Ontario	30.0
Quebec	23·8
Alberta	14·7
Nova Scotia	7·8
Manitoba	6.0
Saskatchewan	5·7
British Columbia	5·4
New Brunswick	4·2
Prince Edward Island	2·4

Ontario

The largest number of sheep of the Canadian provinces is reared in Ontario, as the pastures are rich and very suitable for sheep rearing. Long woolled sheep are used mainly, chiefly of the Leicester type, because they provide good mutton and produce a fairly long staple of wool, which is prized by the domestic spinners and knitters; while Merinos are not favoured by the home knitters owing to the shortness of the staple.

Winter feeding of the sheep on oats and hay is necessary. The Ontario sheep usually are not troubled with disease, but in some damp areas foot-rot may break out, while regular dipping prevents attacks from parasites.

Quebec

The next province of importance is Quebec, where most of the sheep are reared in small flocks, and a deal of the wool is used in domestic spinning and knitting. Long woolled Leicester and Lincoln sheep are preferred to Merino or Down types. The wools of Nova Scotia and New Brunswick are similar in quality and uses to those of Quebec.

Prairie Wools

Wools from Manitoba, Saskatchewan, and Alberta are obtained from sheep which live on the open prairie. The main produce of the low plain lands is wheat, but on the hilly country large flocks of 20,000 to 30,000 sheep are kept. Canada is not a sheep-rearing and wool-producing country. The methods of pasturage are carried out on the same lines as those in the United States, as described on page 114.

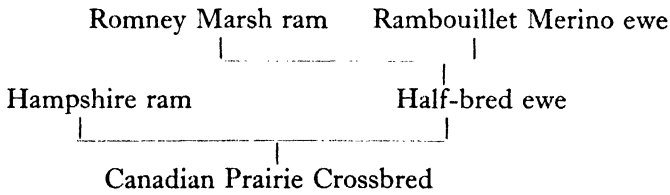
Canadian Merino wool is of the Rambouillet type, it is short and heavy in grease and forms an ideal raw material for the Canadian woollen industry. The chief trouble with the prairie wools is the presence of chaff, which the sheep acquire in foraging in the wheat fields.

In certain areas there is much loose soil, which is blown into the fleece by the winds and makes the wool heavy in earthy impurities. The soil can be scoured out without discolouring the wool, but gives a poor appearance for sale. For this reason

Canadian wools are grouped as " Bright," " Semi-bright," and " Dark."

Canadian Crossbred Wools

The crossbred sheep of Canada are obtained from Rambouillet Merinos, Romney Marsh, and Hampshire Downs, which are crossed in the following way :



Shropshire rams have been tried and produce excellent early lambs, but the wool cap tends to make the crossbred sheep wool blind. Tender staple is a fault which often is found in Canadian crossbred wools and is caused mainly by the change over from the summer to the winter pastures. As the snow descends on to the mountains the sheep are brought down to the lower grounds, and in some cases the nutriment is insufficient, which causes a weak place in the wool. Many farmers supplement the winter feed by corn for a week or so after they have changed pastures to acclimatize the sheep to the impoverished feed.

The wools are shorn, " got-up " and classed in a similar way to the United States clip as described on page 114. A certain amount of this wool is used in the Canadian worsted trade, while the rest is sent to Boston and London.

British Columbia

Owing to being on the shores of the Pacific Ocean and protected by the Rocky Mountains, British Columbia is much warmer than Alberta and consequently the sheep grow finer wool. The Merinos from this district are similar to the Wyoming type of the United States, while the crossbreds are not so coarse as the Colorado types. The pasture is good, and the snow-clad mountains provide a regular supply of water.

Prince Edward Island

The sheep of this well-sheltered island near the mouth of the River St. Lawrence produce some of the best crossbred wools in Canada. Great care is taken not to overstock the island, as its carrying capacity is not very great. The wool is regular and even, and, as a rule, well prepared for market and can be relied upon for being free from chaff and loose dirt.

Mexico

Mexico is not an important wool-growing country, and most of the wool grown is similar to that of the southern states of South California, Arizona, and Texas. The wools obtained from Mexican sheep are irregular and tender. During the summer, when the pastures dry up, the sheep suffer from starvation. When the rain starts there is little shelter, so the wool becomes very wet and mushy. The drought of the summer combined with the wet of the autumn produce a very irregular fibre of poor quality.

Chapter XI

ASIATIC WOOLS

Migration of Asiatic sheep commenced when the Gobi Sea of China dried up. The animals which lived on the banks of this sea, scattered in search of food, so that some of them reached Africa and America, while certain types are to be found in all parts of Asia.

The original Asiatic sheep was the Argali, which still is found in the wilds of Siberia. The Argali sheep are well-built animals, and often stand from 3 to 4 feet high. They have two large beautiful horns, and grow two coats of wool like the Mouflon. The wool is a red-brown in colour and does not grow on the head or on the under parts of the body.

As the Argali sheep migrated across arid deserts in the summers and through barren wastes in the winters, certain features were developed which are : (1) fat tails, (2) fat rumps, (3) long legs, and (4) big horns. Fat-tailed Argali sheep are found in desert regions, where they have to live without food and survive on the store of fat carried in their tail. Fat-rumped sheep grow two pouches of fat, one on each buttock, and have a very small tail which in some cases does not exceed three inches in length. These animals often weigh 200 lb. each and have from 30 to 40 lb. of fat.

Long-legged sheep live on the lowlands. They frequently grow beards. The Oudad of North Africa often is called the Bearded Argali. Their length of leg enables them to traverse marshy ground with speed and ease. The Big-horned Argali are found on the Rocky Mountains of North America, they are very similar to the Siberian Argali, but have huge horns which gives these sheep the name of " American Big-horn."

Asiatic sheep can be divided into four groups : (1) East Indian, (2) Persian, (3) Chinese, and (4) Russian.

East Indian Sheep

The estimated number of sheep in India is about 25 millions, which yield about 50 million lb. of wool annually. Sheep bred in India include the Barwal, Ladak, Cago, Dumba, and Urial. On the hillsides of the north-west of the Himalayas round Nepal and the United Provinces, the Barwal sheep are reared by the natives, and are very useful little animals as they supply milk, wool, mutton, and leather.

Barwal sheep grow a rather long, shaggy and coarse wool, but there is not much kemp in it and the quality is regular. A large amount of this wool is used by Buddhist monks in making clothing. Barwal rams are noted for fighting, and with this in view, the natives aim at producing a unicorn ram by searing the sprouting horns with hot irons, so that they grow together as one horn in the middle of the sheep's head.

Ladak sheep are a hardy breed, which are employed to carry salt and other goods across the mountain passes. Two bags of salt are strapped on to each animal. In the lower parts of the Himalayan district, the Cago sheep exist, they are fairly tall animals, having horns on both rams and ewes and are noted for their drooping ears.

The main wool supplies of India come from the sheep which live on the plain of the Indus and in the " Thar " or Indian Desert. The important wool centre of this district is Bikanir, and a wool suitable for clothing is obtained from the sheep of this district. Amritsar wool is coarse, but can be used for woollen wefts. Joria wools are fairly white, but Vicanere wools have a distinct yellow cast, and are purchased by blanket makers.

On the Salt Ranges of the Punjab, a type of Urial sheep exist which supply large amounts of typical East Indian wool. The sheep are allowed to retain their fleeces during the wet season, which gives the wool a yellow cast. The largest flocks in India are kept in this area, although they do not exceed 500 sheep per flock. Rams and ewes are not separated, and in many cases 100 rams will be maintained in each flock. The main wool town of this district is Hissar, while a certain amount of the wools are collected and packed at Garhwal.

ASIATIC WOOLS

Indian sheep are found in small flocks on the western coast and in the Deccan area. These animals yield a white fleece which is collected and packed at Khandesh. The sheep reared on the banks of the Ganges in Bihar and Bengal usually are the Indian Dumba sheep, which grow small fleeces weighing from 1½ lb. to 2½ lb. The natives call these animals " puchia " sheep owing to their large fat tails. The coarsest Indian wools come from the sheep which live on the Malwa Plateau, and are shipped from Bombay. These wools are not strong enough for carpet manufacture and usually are made into felts.

The sheep in Madras are reared primarily for their mutton, and not for wool. As a rule the flocks do not exceed 20, and are kept by the poor people for their milk and meat. These animals have long legs and resemble goats rather than sheep.

Kandahar wools are shipped from Karachi. These wools are gathered from the surrounding districts and from several centres in Afghanistan. Black and white wools are mixed indiscriminately, which makes an extra sorting operation necessary. Owing to their elastic properties, these wools make up into good hard-wearing carpets. The wool from Kalat in Baluchistan is shorter and of a poorer quality than that from Kandahar.

North-West Frontier sheep are the result of sheep-breeding experiments which have been carried out in the North-West Frontier Province, by crossing the native ewes with Australian Merino rams and some very striking results have been obtained. The carcase is not greatly improved, but the 2 lb. growth of wool has been increased to 7 and 8 lb. The wool is well grown, fairly fine, and has a marked absence of kemp.

Indian sheep are shorn by sickles, and the wool is cut without any regard to the structure of the fleece. In shearing, some men cut the different colours of wool separately, but a usual practice is to cut all the wool from the sheep and have the colours sorted by the native girls. The wool is packed into bales, which weigh 3 cwt. Madras wools are packed into 500 lb. bales. East Indian wools are sold at Liverpool and the London low-grade wool sales.

PERSIAN SHEEP

Several breeds of sheep exist in Persia, Arabia, Iraq, and Palestine, which consist of (1) fat-rumped black-head sheep, (2) red goat-like sheep, and (3) long-tailed Bedouin sheep.

Persian sheep originated from the Argali, and have developed the fat rumps and black heads. The fat of the rump supplies the sheep with nourishment when the pasture fails. Two distinct types exist which are known as (1) the Hedjaz and (2) the Mecca. Persian fat-rumped sheep thrive in the arid regions of the South African veldt.

A large amount of Persian wool is used in the rug industries of Khorasan. The whole of the Kerman clip is used in the production of the finest rugs made in that area, while wools from the district around Kermanshah are used in the Sultanbad and Hamadan rug factories. The rest of the Persian wool is classed as Baghdad, Firsts and Seconds in black, brown, red, and grey, and sold at Marseilles.

Red goat-like sheep live in Persia and produce a wool which is not unlike camel hair in colour. This material is sold under the trade name of "Peliton" and comes from the Ispahan and Laristan breeds of sheep. A very similar breed of red goat-like sheep are reared in the Island of Cyprus and produces the Cyprian red wool.

Considerable amounts of Persian coloured wools are woven into shawls in the native factories around Yezd.

Bedouin sheep, reared by the nomadic Arabs, consist of a long-tailed breed of sheep which sometimes is known as the Arabian sheep. These animals are covered with a fairly soft wool from the shoulders to the end of the tail which in some cases touches the ground. The lamb skins from Bedouin sheep are sold as Persian lamb and used for coat trimmings. Several flocks exist in Palestine, where they are allowed to roam on the hills in summer, but in winter are brought to warmer pastures.

The sheep reared by these tribes are kept for their milk and meat, while the supplies of wool and leather from the skins are regarded as being of a secondary importance. In some cases Merino rams have been crossed with Bedouin ewes

and have produced better wool on the crossbreds without any loss of quality from a meat or milk point of view.

Syrian Wools

Syrian wools are gathered from the districts of Syria and Palestine. These wools are packed at Damascus and shipped from Beirut and Jaffa. Syrian wools are fairly strong and elastic, and are sorted into colours prior to packing.

The Awassi wools from Iraq are obtained from the sheep reared on the fertile soil between the two mighty rivers of Asia—the Tigris and the Euphrates—and are shipped from Aleppo. These wools may appear to be faked, because the fleeces are clean on the outside, but very dirty in the middle ; the reason being that these fleeces are dipped into the river, given a good squeeze and left to dry in the sun.

Wools from the sandy deserts around Baghdad contain a lot of earthy impurities. If the sheep are river washed before shearing, the wools fetch a much better price at the sale. Baghdad wools are known as : (1) Karadi, (2) Bussora, and (3) Bushire. Karadi wools are coarse, long stapled wools, which are packed into " grey " and " coloured " lots, like the Awassi type. These wools are packed at Baghdad and sent down the River Euphrates to Basra.

Bussora wools are very weak and tender, and therefore not suitable for carpets, but are made into felts, because their tender staples are not able to stand frictional wear. These wools are mainly coloured and contain very small portions of white. Wools from Bushire are not so dirty as the Bussora wools, they are sorted into browns, blacks, and greys, and are sold at Liverpool and Marseilles. Iraq wools are made into travelling and house rugs, coverlets, shawls, and wraps. A considerable amount is used in the tapestry and carpet trade. In many cases self-coloured wools are used for blacks, browns, and fawns, but the bright colours are obtained by dyeing the white and grey wools.

Chinese Wools

Three distinct breeds of sheep exist in China, which are :— (1) Mongolian maned sheep, (2) Chinese fat-rumped sheep,

and (3) Tibetan fat-tailed sheep. These are definite types, but all have features which denote that their probable ancestor was the Argali of Central Asia.

The Chinese wool centres are Tientsin for the Manchurian and Mongolian wools; and Shanghai for the Kansu and Sze-chwan wools, while the Tibetan wools usually are transported over the mountain passes of the Himalayas and shipped from Calcutta.

America is the great purchaser of China wools; owing to the fact that these wools cannot be grown in America, they are imported into the United States free of tax. Three classes of wools are made, known as (1) strictly combing, (2) semi-combing, and (3) filling wools. (Filling is an American term for full handling weft yarns.) China wools are used mainly for carpets and felts, although certain types make good woollen yarns. As a rule the wools lack elasticity and springiness, and contain large amounts of kemp and sand.

Natives make up bales of wool which weigh about two piculs. A Chinese picul weighs 133·3 lb. The wool is usually conveyed by river barges, while it can be transported on bullock wagons and on the backs of coolies and camels.

Tsing-ning wools, which come from Kansu, are considered the best type of Chinese wools, and are purchased by American buyers. There is very little sand in this type of wool, and it can be carded and combed into good yarns on the worsted system.

Wools from Sze-chwan, south of Kansu, are not so good as the Tsing-ning wools, and contain a lot of short fibres and sand. These wools are grouped as semi-combing, while a lower type of Sze-chwan wool is known as Woosie, it contains lambs wool and is classed as a " filling wool."

The wools from Tsing-ning and Sze-chwan are conveyed across China, usually on the Yangtze River to Shanghai. A classification of China wools takes place in Tientsin and Shanghai, where the fleeces are grouped into classes and denoted by various chop marks. To save expense in freights, cleaning stations at these ports dust the wool and press-pack the bales ready for shipment.

Mongolian wool from Urga on the River Tola, is the cleanest

type of China wool and known as "Washed Mongolian." The fleeces are river washed and dried in the sun, by being hung out on ropes, like domestic washing. The bleaching given by the sun produces a white fleece, which sells well, but owing to the short fibres it cannot be combed, so it is classed as semi-combing and used for woollens.

Fat-tailed Mongolian sheep have been crossed with Merino rams which has greatly improved the fleeces in the crossbred. The crossbred sheep do not have very fat tails, and there is a considerable reduction of kemp in the fleeces.

Manchurian wool comes from the sheep which roam in the Gobi Desert. Food is scarce and the sheep have to live on the fat supplies in their tails, which causes the growth of wool to be very irregular and kempy. "Washed Manchurian" wool comes from Hailar, and is washed in the Sungari River; it is not so long as washed Mongolian and is more coarse and kempy.

Chin-chow wools sometimes are known as Hatta wools, and come from South Manchuria, where the sheep are reared on the banks of the Liao-ting Gulf. A second clip of wool often is produced in this area. The summer growth of wool is shorn from the sheep in the autumn, and is shorter and crisper than the spring clip.

Ball wool is a feature of the Chinese wool trade, and consists of balls of wool which have been rolled up with the grease from the rump and the sand of the desert. Many of these wools only yield 40 per cent. Wools from Shunte-fu are of this nature, but when the grease and sand have been removed the wool is fairly good.

Tibetan Sheep

The four main breeds of sheep which exist in Tibet are: (1) the Hunia, (2) Haluk, (3) Peluk, and (4) Bharal. In Western Tibet, the Hunia sheep is used as a beast of burden to carry bags of salt and borax from Lhasa and other Tibetan areas to the Ganges basin of India. Two leather bags which contain 20 lb. of salt are strapped to each sheep. These sheep are able to carry a load of 40 lb. at the rate of 12 miles per day.

Hunia sheep need good pastures, and thrive at high altitudes, such as 7,000 to 8,000 feet above the sea level. The Haluk of Eastern Tibet is a similar type of sheep, while the Indian type of Hunia is known as the Ladak sheep. The wool is a long stapled coarse material, which is used in making native blankets and rugs.

The short-tailed Tibetan sheep called the Peluk, which lives on the plains, grows a medium type of wool. This material is used by the natives to make their blankets and other woollen garments. In some districts this wool is known as " Silinga " and is sold to the wool merchants of the United States of America. Silinga wool is shipped from Calcutta.

Blue sheep of Tibet are called Bharal sheep, and live in the mountains in a wild state. Very little fleece wool is produced by these animals, but the skins are obtained when the Bharal sheep are killed for their mutton.

Asiatic Russian Wool

Large flocks of sheep are reared around Bukhara, which yield good mutton, and a fair amount of coarse curly wool. The skins on the young lambs are washed daily and the locks pressed into curls. At about 4 months old, the lambs are killed and their skins are sold as Karakul lambskins. These were greatly prized in Athens and Rome over 2,000 years ago.

The famous breeds of sheep kept at Tarent in Italy and known in Roman times as the Tarentinian sheep are supposed to have been crossbred sheep obtained from Bukhara rams crossed with native Italian ewes.

Baraba sheep are reared on the Kirghiz Steppe between the Rivers Volga, Ob, and Irtish and are noted for their mutton, wool, and fat. A considerable amount of trade is done in Russian tallow, which is obtained from the fatty cushions which grow on the rumps of the Baraba sheep.

Chapter XII

TEXTILE HAIRS

In the textile trade several types of hairs are used, which consist of Mohair, Alpaca, Llama hair, Cashmere, Camel hair, Rabbit fur, Horsehair, and Cow hair.

Mohair

Mohair is obtained from the Angora goat, which has flourished in Asia Minor for over 1500 years. The general utility of this fibre has caused new centres of production to spring up, and Angora goats now are reared in South Africa, United States, and Queensland. The Angora goat is a graceful animal, with a neat shapely head, a broad forehead and widely set ears. The greater part of the face and legs are covered with short lustrous hair. These goats readily acclimatize when placed in suitable environment.

In producing fancy fabrics and decorative effects mohair is used. The important features of this fibre are fineness, length, lustre, strength, and durability. Examined microscopically the mohair fibre is covered with thin, flat, smooth epidermal scales projecting over each other and have only a few serrations on their edges, which accounts for the smoothness of the fibre. In diameter the fine fibres are about $\frac{1}{1000}$-in., while the coarse ones measure $\frac{1}{500}$-in. in diameter.

The length of the mohair fibre varies according to the number of shearings given each year. Turkish goats are shorn in spring and yield a fibre about 10-in. in length for the year's growth, while the South African and American types are shorn twice a year and have a fibre length of 6 to 8 in. Fibre stability is a feature peculiar to mohair, the fibres can be fixed in upright positions and will return after compression, which commends mohair for making pile goods such as plushes and furnishing fabrics.

Mohair fibres have a natural curl and the material hangs from the goat in close locks which form curly ringlets, but it does not possess any natural crimp, which accounts for its slipperiness and lack of felting property.

Properties of Mohair

The lustre of mohair is due to the closed scale formation of the fibre, and is not impaired by careful processing and dyeing. It is this property which commends its use for furnishing fabrics and hangings, because dust does not come to rest on the slippery fibres. When any dust remains between the intersecting threads of the fabric it can easily be removed by brushing or shaking. Kempy fibres do not take the dye evenly and lack the sheen of the true mohair. It is a smooth material and can be made into fabrics which are noted for coolness, such as lightweight summer fabrics and Palm Beach cloths. For linings it is admirable because it combines coolness with durability.

In Asia Minor the growth and manufacture of mohair has been carried on for over 1,500 years. It was imported into Britain about the year 1600 A.D., and soon afterwards the British Levant Company did a large business in mohair, which was supplied to make the Lutherine, Rufferine, and Prunella fabrics worn in the Caroline and Hanoverian days.

Turkey Mohair

About 1830 there was an increased demand for mohair, which caused the Turkish farmers—who had the world's monopoly at that time—to cross the pure Angora goats with the common Kurd goats. An increased output was obtained, but at the cost of quality because the Kurd goat has a thick, kempy fleece of black and dark coloured hair.

Mohair goats produce varying lengths of hair according to its position on their bodies, the finest hair comes from the shoulders, the longest from the haunches, and the coarsest from the britch. The fleeces are packed into bags which hold about 200 lb. and are sold from the Constantinople market. Fine hairs come from the Angora and Yozgat districts, while medium types are grown in the Afium-Kara-Hissar, Eskishehr

and Kutaya areas. A considerable amount of this material is used in the making of blankets and cloth for the uniforms of the Turkish Army.

Low and coarse types of mohair are grown in the Konieh districts, but much of this does not come into the textile markets, because it is used in the carpet factories of Smyrna. Mohair goat skins are dealt with by local fellmongers, and the hair removed from the pelts is used by the low blanket weavers of Syria.

Material obtained from the goats of the Lake Van area is inferior in quality and often infected with anthrax. Details of the treatment of Van mohair are given in Chapter XIII on Wool Sorting, on page 146.

South African Mohair

The mohair goat was introduced into South Africa in 1838, when a convoy of twelve rams and one ewe were taken from Angora to the Caledon district of Cape Colony to be crossed with the native goats. It was found, however, that the twelve rams had been rendered impotent, so the movement would have been futile, but for the ewe which gave birth to a kid ram on the voyage. White South African ewes were graded and a strain of Angora blood was started, which was appreciated by the South African farmers, because the Angora strain made the native goats able to resist the scab which had been a source of trouble. Another importation of rams took place in 1857, and from that time a pure-bred Angora strain has been maintained in South Africa.

Routine arrangements on the Cape farms differ from those in Asia Minor because the heavy rainfall in Asia is in the winter, and the shearing takes place in spring, so that the goats have the benefit of their fleeces during the cold weather. The wet season in South Africa comes in summer and the goats are shorn twice a year—in the early spring and the late autumn. The first shearing from the Cape kids produces some of the finest mohair in the world.

South African mohair is denser in fibre distribution than the mohair from Asia Minor, because the Angora goat of the Cape grows a heavier fleece owing to a slightly cooler climate. The

great mohair growing district is Cape Province, which produces about 91 per cent of the mohair grown in the Union of South Africa; Orange Free State comes next with about 6 per cent; Transvaal produces 2 per cent, and Natal 1 per cent.

American Mohair

Mohair production is a growing industry of the United States, and many goat farms are to be found in California, Oregon, and Washington. Angora goats thrive well in this country, and great care has been taken to employ the best rams from both Asia Minor and South Africa in order to obtain very good strains so that good quality material can be obtained. The mohair goats thrive well in the hot climate of the Western States, and are shorn twice a year.

American mohair goats are used to eat the undergrowth from the woodlands of these districts. The goats relish the leaves of the small shrubs and brushwood. Many farmers find that a small flock of Angora goats is the cheapest way of clearing overgrown areas. The loose open nature of the fleece prevents entanglements in the shrubs, which would happen if sheep were used, owing to their thick and close fleeces. The weight of a clip from a mohair goat is only about 3 lb., because the hair grows in a very open formation, and in wet weather it does not give adequate protection to the goat against the rain, so small shelters have to be provided to give the necessary cover.

Uses of Mohair

Mohair is made into plushes, tapestries, linings, boot laces, and other fabrics which are noted for strength and good wearing properties. Owing to its lightness, summer fabrics such as beach suits and golf jackets are made from mohair. In the furnishing trade mohair is used in making upholstery fabrics such as Utrecht velvet, while, for covering railway, motor and theatre seats, mohair is unrivalled.

Alpaca

In the heights of the Andes of South America there exists a species of goats which can be divided into four types:

(1) Alpaca, (2) Llama, (3) Vicuna, and (4) Huanaco or Guanaco. These animals are peculiar to South America and attempts which have been made to acclimatize them in India, South Africa, and Australia have not been successful.

The Llama goat is a larger animal than the Alpaca, and, being very sure-footed, is used as a beast of burden to transport materials across the Andes. The Alpaca yields a finer type of hair than the Llama. Alpaca ewes are kept on the farms of the Andes as they yield a rich milk. While the Alpaca and Llama goats can be domesticated the Vicuna and Huanaco are wild. Attempts which have been made to domesticate these goats have not met with much success. Vicunas may be held in captivity, but the males refuse to do any work, while the females will not yield milk, and both stoutly refuse to be shorn. Huanacos are much more independent creatures, and when captured they refuse to eat and languish away.

Fifty years ago, Vicuna hunts were arranged and the animals were shot in order to obtain their valuable skins, but the Peruvian Government have taken the matter in hand, and stopped the extermination of this type of goat. Consequently, the expensive " Vicuna cloth," which was a valuable commodity in the Victorian days, has disappeared from the woollen market. Although a very good imitation " Vicuna " cloth is made, the merchants say that it has not got the soft handle of the original Vicuna cloth.

After shearing the Llama and Alpaca goats, the hair is packed into bales and sent down to Lima and Arequipa, and shipped to Liverpool, where sales of Alpaca take place six times a year, as described on page 26. The covering of the Llama is slightly coarser than the Alpaca and is sold under the trade name of " coarse Alpaca."

In formation the Alpaca fibre is not very different to wool. It is long and fine with a soft downy handle, but has not the strength or elasticity of wool. A microscopic examination shows that these fibres have numerous scales, which are smooth and not so pronounced as those on the wool fibre. The uses of Alpaca are similar to those of mohair.

Cashmere Goat Hair

Cashmere goats are found in the valleys which lie between the perilous slopes of the Himalayas on the Indo-Chinese border. They are small agile animals, and are used by the natives of India for food, milk and hair. The covering of the animal is a soft, fine hair, which is noted for its warmth and has been made into Cashmere shawls for a thousand years past. It was during the British occupation of India about 1800 that Cashmere came into prominence, and since those days there has been a steady and regular trade from the covering of this goat.

In colour, Cashmere goat hair is a greyish white, and usually is made into garments of a self-coloured nature, owing to the difficulties which are experienced in dyeing. Real Cashmere hair costs about 5s. per lb., and is too expensive for the general hair market, but a soft handling wool can be treated in such a way as to produce garments with a " Cashmere finish."

The goat is not shorn like the other animals of this class, but as the summer advances, it gradually sheds its coat over a period which usually covers a fortnight. During this time, the native Cashmere goat farmers comb the animals and assist the loose hairs to fall away. A considerable amount of Cashmere hair is gathered by native girls from the bushes where the goats rub their bodies to remove the loose hair. About one third of the Cashmere hair crop is obtained in this way.

Under captivity, the natural habits of these goats change, and they need to be acclimatized with great care. A fine specimen was reared for several years in the New York Zoological Park, but unfortunately it died suddenly from pneumonia, which it contracted after having been combed.

The average weight of hair obtained from a Cashmere goat is about $\frac{3}{4}$ lb., and the annual output is about 60,000 lb. North-west of Peking, certain Chinese farmers specialize in rearing goats which produce the finest Cashmere hair in the world. Cashmere hair is very soft and fine and is noted for its warmth-giving properties. It is straight and silky, but has not much lustre because the scales are more pronounced than on the wool fibre.

Camel Hair

Camel hair is used as a textile raw material, and is obtained from China, Egypt, Persia, and India. The best hair comes from the Bactrian camels which inhabit the desert wastes from China to Afghanistan. In summer their heavy coats of hair are " rooed " or plucked by hand. These camels often live until they are sixty years old, and from their second year yield about 15 lb of hair.

Bactrian camels are superior in strength to the Indian camels and Arabian dromedaries, and live much longer. Like the llamas of Peru, they are used for transporting goods, and are able to carry loads which weigh from 700 to 800 lb. for a week on journeys covering 35 to 40 miles a day without requiring a drink of water.

Camel hair consists of two growths, a short fine downy body hair, and a strong, coarse, tough beard hair. The long strong beard hair is used for making camel hair belts for driving machines in damp places where leather belts would rot, and also for making bagging for cotton bales, tent ropes and other articles which require fibres of great strength. Mongols have used camel hair ropes for over 2,000 years.

The short, downy, body hair is noted for its warmth-giving properties, and is used in making dressing gowns, slipper linings, motor rugs and other garments where warmth is desirable. Like the hair from the Cashmere goat, it cannot be dyed easily, and frequently is made into self-coloured garments. Unlike wool, where whiteness is one of the main qualities desired by the buyer, white camel hair is always at a discount, and the merchants in Tientsin and Shanghai insist on a due proportion of white being taken with each purchase.

Separating the fine body hair from the thick beard hair was a big problem in the textile trade until the late Lord Masham invented the Lister comb, which divides the long hairs from the short ones. In the case of camels hair, the " noils," or ejected waste, are more valuable than the long hairs. The short hair then is taken and treated between spiked rollers, to throw out any fragments of the coarse hairs which may remain. After being cleansed, the noils are made into the finest camel hair cloths, which form some of the most expensive

fabrics produced in the textile trade. The noils from the double combed camel hair are used for making felt hats.

Rabbit Fur

The fur of the ordinary rabbit is used in the felt hat industry, while the white hairy covering of the Angora rabbit can be made into yarns. An annual yield of 8 oz. per rabbit can be obtained, which is made into worsted yarns on the porcupine drawing system. Rabbit hairs have not the same felting property as wool and the fibres tend to stand out from the main body of the yarn. This feature is employed in the decoration of knitted goods.

In certain wool blends, Angora rabbit wool is used to produce the softness of handle originally obtained from vicuna hair. One of the main centres for rearing Angora rabbits is Grenoble, in France.

Horse Hair

Two kinds of horse hair are used in the textile trade : (1) tail hair and (2) mane hair. The tail hair is about two feet in length, while the mane hair usually is about 15 to 18 inches. This material is the thickest type of textile raw material, and in some cases, fibres from $\frac{1}{100}$ to $\frac{1}{200}$-inch in thickness are found. Horse hair is sorted into colours and grades, then washed in the same way as wool. The better qualities are made into braids, haircloth, and stiffening fabrics, while the lower qualities are used for press cloths and covers.

Cow Hair

Cow hair is obtained at the tanneries from the hides of slaughtered animals. It is sorted and cleansed for introducing into low woollen blends for making horse blankets, insulating cords for steam pipes and rough felts.

Chapter XIII

WOOL SORTING

Wool sorting is the operation where each part of the fleece is examined, for fineness, length, crimp, strength, and colour. The fleece is divided up into distinct groups of fibres known as " matchings," which are necessary because the quality, fineness and length of wool varies in the different parts of the fleece. An individual classification of the raw material is peculiar to the wools and hairs used in textile manufacturing ; the vegetable raw materials such as cotton and flax have a fairly even growth and therefore do not need an individual sorting.

This process is the first operation which is given to the wool on reaching the mill, because the selection of fibres for specific uses concerns the whole industry. Faulty sorting not only causes trouble in the operations which follow immediately, but affects all the processes from initial scouring onwards, and finally shows defects in the finished fabric.

Difference Between Sorting and Classing

In sorting a fleece, the material is divided into distinct groups of wool fibres, determined by their fineness and length. Classing on the other hand, consists of placing whole fleeces into lots according to the wool found on the shoulders of the fleeces. Wool sorting does not make finer qualities, but a careful subdivision of the fibres enables the fine wools to be used for fine counts. Wool sorting depends upon human skill and is done by manual labour, as there is not a machine which can sort wool into qualities.

British wools are not classed with the judgment and care that is given to the Colonial wools, but usually are grouped according to breeds and baled. On reaching the wool warehouse, the bale is opened and the fleeces are " cased " ; each

fleece is classed according to its quality and put into a case or bin. Sometimes it is necessary to make a further division of the cased fleeces into hogs and wethers.

Relative Positions of Wool in the Fleece

Length, fineness, and the condition of the wool in the fleece vary according to the conditions under which the sheep live. The wool on the shoulders gets the most sun and has the least movement, while the wool on the haunches which receives the same amount of sun is given plenty of movement. Fine short fibres grow on the shoulders, while long, strong locks of wool grow on the haunches to protect the animal's back legs. Bellies are always short and contain vegetable matters, while wool from the breast is fine, but badly felted.

Before leaving the shearing station, the fleeces are classed into batches according to the quality of the wool on their shoulders, which assists the wool sorter in allocating the qualities as all his divisions range downwards from the classer's quality number. A bale which is classed as 56's quality will contain only a very small amount of 58's or 60's. Accurate classing is responsible mainly for uniform matchings.

Number of Qualities

The number of qualities which may be made from a lot of wool varies according to the purposes for which the wool is required. In the low-class wool trade, where clearly defined qualities are not necessary because the wool is made into carpets, felts, and rough cloths, women are employed as sorters, but this work does not reach anything like the perfection of the sorting given to fine wools. Merino fleeces are often divided into three qualities, which are: (1) shoulders, (2) haunches, and (3) skirtings, while medium crossbreds and British wools are divided into six or seven lots.

The three main classes of wool used by the trade are classed as long, medium and short. Long wools are divided into qualities which range from 28's to 40's. Medium wools from 44's to 56's, and fine wools from 58's to 90's. Each type of wool has certain features which cause variation in the procedure of sorting.

Names and Marks for Qualities

Each firm has its own code for indicating wool qualities. In some cases, trade names such as fine, blue, neat, and picklock are used, while other firms, use numbers, such as 8's, 10's, 21 B, 7's W, and some firms indicate their qualities by letters, L.W., M., P.X., and O.Z. These methods of marking ensure privacy between rival top making firms, but tend to cause confusion between qualities, and the formation of quality standards.

Table XXXIII

Wool Sorting Terms

Part of Sheep	*Type of Wool*	*Woollen Sorting Terms*	*Worsted Sorting Terms*
Shoulders	Best wool	Picklock	Fine
Loin	Strong and fine	Prime	Neat
Neck	Fine, but short	Downrights	Blue
Upper Neck	Faulty and short	Downrights	Downrights
Upper Back	Fine and close	Super	Super
Back	Fairly long	Choice	Choice
Haunches	Long and strong	Abb	Abb
Britch	Coarse and dirty	Breech	Britch
Back Legs	Strong and coarse	Brown	Cowtail
Belly	Short and dirty	Seconds	Seconds
Fore Legs	Short and faulty	Brokes	Brokes

Qualifications for Wool Sorters

A wool sorter is a craftsman who has been trained by years of experience, and possesses three important faculties : (1) good eyesight, (2) a keen sense of touch, and (3) prompt and reliable judgment. A competent wool sorter is able to estimate wool qualities to $\frac{1}{1000}$ part of an inch, and should be able to group and classify wools, which look almost identical to the average textile man. Good wool sorters make a special study of the types of fleeces which they usually handle, and after careful observations are able to make intelligent comparisons between fleece and fleece. To the sorter no two fleeces are alike, they cannot therefore be split up to a set rule. Should unskilled

men tear up fleece after fleece as though they were machine-made and cast to one pattern, a lot of fine wool will be thrown into the lower qualities, and the final matchings will not be uniform.

Specialization in wool sorting is a great feature of the trade, because there is so much variation between the types of materials which have to be sorted. A sorter who served his apprenticeship to sorting fine wools, would find considerable difficulty in allocating the qualities of a Leicester or a Lincoln fleece. Sorters who deal with mohair, alpaca, camel hair, and other types of animal textile materials, are included under the general term of wool sorters.

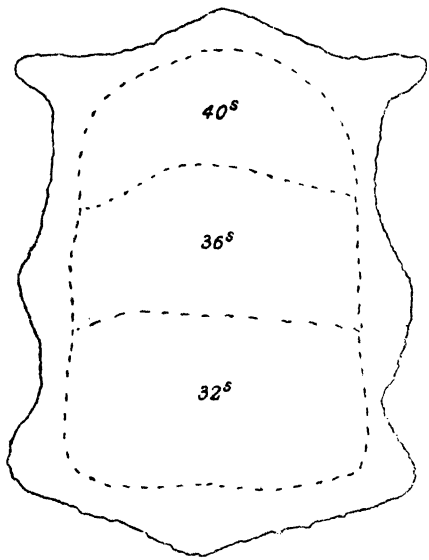


FIG. 3. SORTING A LUSTRE FLEECE. The outer edges of wool are removed as skirtings, then the coarse wool from the haunches is taken away ; finally the finest wool from the shoulders is classified.

SORTING ROOMS

Sorting rooms are arranged on the top floor of the building to obtain the best light, and allow the sorters to work in quietness, away from the distractions and noises of the machines. This arrangement also facilitates wool blending, because when the wool has been sorted it is passed through the trap doors in the floor to the bins of the blending room below. Large factories usually have two storeys of blending rooms, and connect the lower floor to the sorting room by chutes. A shed roof with north lights is used over a wool sorting room, in order to get a regular and steady light without having any of the direct rays of the sun which cast shadows and make sorting very difficult.

WOOL SORTING

A wool sorter's " stand " occupies about 8 by 12 feet, and consists of a " board " or table, and a series of bins and baskets. The sorter's board is placed under the windows, and usually extends along the north side of the room. A partition about a foot high on the board divides one stand from the next. The window bottom usually is partitioned into boxes for the minor sorts of wool which are only found occasionally, while under the board is a box for the extraneous matters which the sorter cuts from the fleece. Five or six skeps are used, which the sorter generally places at his right hand to facilitate the work. The only mechanical equipment employed in wool sorting is a pair of shears, which enables the sorter to cut away tar and paint-stained wool, earth, dung, and any pieces of flesh which a careless shearer may have left in the fleece.

Sorting Long Wools

English long-wool fleeces are too large to be sorted whole on the sorter's board, so a preliminary operation of opening precedes the actual sorting. The fleeces are taken out of the sheets with care, because the open growth of lustre wool does not tend to make a compact bundle like a Merino or a fine Cross-bred fleece, and the natural fibre arrangement may be disturbed in unpacking.

After being removed from the sheets, the fleeces are unrolled and split into halves. This is called " rigging " and is done by tearing the fleece from the tail to the head, following the natural parting of the wool. A good shaking is given to each half to remove twigs, straw, fribs, and loose pieces of wool. The half fleeces are then placed in a convenient position for the sorter to reach them—usually at the sorter's left hand. Locks of wool, which fall to the floor during the shaking, are picked up, screened, and sorted into qualities.

Each half fleece is placed on the board with the skirt side towards the sorter, and the britch at the right hand, to enable him to tear the fleece into parts with ease. All paint and tar-stained wool is cut off, together with any lumps of earth, and thrown into the box under the table. Next, the wool from the britch, belly, breast, and neck which is very short and

low in quality is removed. This operation is known as "skirting" and the wool removed is called "brokes" or "shorts."

Black or grey hairs are taken from the fleece and made up into a special lot, which is used for goods dyed to dark shades. The sorter then divides the fleece into qualities according to the fineness, length, and position of the fibres in the fleece. The human skill displayed at this juncture is the chief factor in wool sorting, and is one which relies solely on trained judgment, because no machine could decide between the different qualities of wool found on a fleece. Sorting starts at the britch and works towards the finest wool on the shoulders. This method of wool sorting is a system of elimination of the coarse pieces of the fleece, until the finest wool is reached.

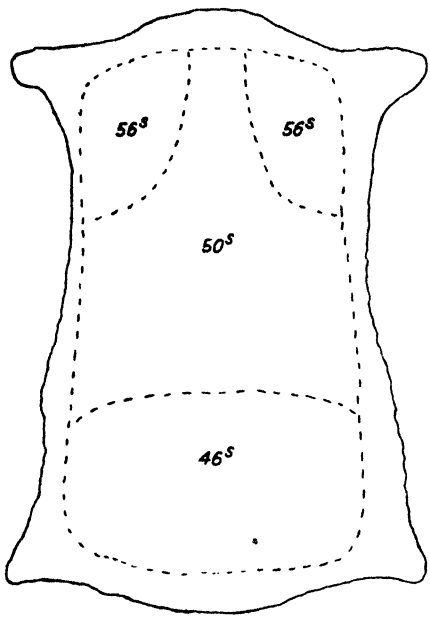


FIG. 4. SORTING A DOWN FLEECE.

A fleece contains many different qualities of wool, and even when fleeces have been taken from sheep identical in breed and pasturage, each fleece has been found to vary in quality, and quality distribution. The quality positions found on one fleece cannot be used as a standard for the breed, because each fleece must be sorted on its own merits. A typical sheet of long wool fleeces, sorted recently ,gave the following result. The material was classed as a 40's Lincoln, and the sorting result was 80 per cent. of 40's quality, 10 per cent. of 36's quality, 5 per cent. of 28's quality, 3 per cent. of 44's quality, and 2 per cent. skirtings.

Sorting Crossbred Fleeces

Crossbred fleeces are sorted in a similar way to the home-grown wool, but in the finer qualities it is not necessary to tear the fleeces into halves, because they are small enough to be sorted whole. Dirty crossbred wools are sorted on a wire mesh frame, which is placed on the sorting table to allow the dirt to fall through and not soil the cleaner parts of the fleece.

The bales are cut open, and the sorter takes out a fleece when he requires one. Many firms insist on the bags being opened by cutting the sewing bands and not the canvas, because the canvas tends to fray, and fragments of jute may become intermixed with the wool. When certain bulk lots of a low quality are required, the fleeces are "trapped" and not sorted. A general look over for low ends, grey and stained pieces is given, and then the fleeces are thrown down the trap doors into the mixing bins.

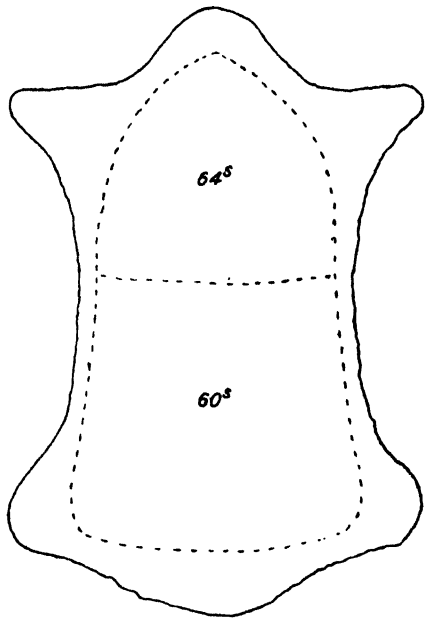


Fig. 5. Sorting a Merino Fleece.

An average bale of a good 50's quality crossbred wool, should give about 60 per cent of 50's quality, 30 per cent of 46's quality, 6 per cent of 40/36's qualities, and 4 per cent of skirtings, etc.

Sorting Merino Wools

Merino sheep produce the finest fibres in the world, and these fleeces require careful sorting in order to produce the high qualities of tops needed in the worsted trade. Wool quality is denominated by its fineness, and it is on this point

that the sorter makes his decisions and groups the fibres into specific lots.

In cold weather, Merino fleeces are as hard as a board, owing to the solidification of the natural grease, which makes them difficult to open out. The hard fleeces usually are placed in a sorter's oven to warm to about 80°F. when they will be found to unroll with ease. The sorter puts a fleece into the oven to warm while he sorts one warmed previously. Ovens may be used also for the fleeces from the South American market, these fleeces are press-packed, and are therefore difficult to roll out. This factor is noted in the piece rates on which the sorters are paid, and a special allowance for the extra time taken in opening out these press-packed fleeces is paid to the sorters.

An average bale of Merino fleeces will give about 40 per cent of 64's quality, 50 per cent of 60's quality, and 10 per cent of skirtings. In some cases, sorters are expected to divide the qualities on a length basis, and class the fibres as ordinary, weft, warp, and super.

Taking-Off

A general practice in many sorting rooms, is to give the finer qualities of material a double check. As each sorter fills a skep it is delivered to a well experienced man called a " taker-off," who examines each piece of wool for consistency of quality, and then passes it down into the mixing bins. By this method, although each sorter is responsible for his own work, the " taker-off " ensures a uniformity of fibre judgment throughout the sorting room.

Anthrax

Anthrax is a fatal disease carried by certain animals, which may be conveyed to man by handling the wool or hair taken from animals which have died from anthrax. British and Australian wools usually are free from this disease, because being greasy wools they are not so susceptible to infection as the drier types of wool. The scheduled list of dangerous wools include, Van mohair, Persian wools and hairs, East Indian wools, Cashmere, Russian wools and camel hair. These

wools should be sorted on a board with a downward draught to prevent the dust from rising. Certain types of material have to be steeped before the bale is opened.

Blood stained material always should be sorted with great care as anthrax is a blood disease. Anthrax germs in wool can be destroyed by steeping the wool in a 2 per cent solution of formalin at 102° F. for ten minutes, without damage being done to the wool fibres.

The disease may be contracted by breathing or swallowing the dust from infected materials. Broken skin, chapped hands and rough necks are sources of danger, while the disease may be carried by the sorter's finger nails.

Symptoms of Anthrax

The first indication of anthrax infection is the appearance of an inflamed swelling like a boil, which is often quite painless. This is accompanied with a feeling like that of a cold in the head, the person is tired and discharges from the eyes and nose. In a few hours, the boil becomes black in the centre, this is the dangerous time, because, should the boil burst, there would be a danger of the poison reaching the blood stream with fatal results. A surgical operation is necessary when the disease has reached this stage in order to cut away any infected parts. In recent years, injections have been given to infected persons, and the results have been very successful.

Blending

Prior to the scouring operation, various types and lots of wool are blended together. This may be done for three reasons : (1) to obtain features from several qualities of wool, (2) to bring in a given lot at a stated price, and (3) to maintain a standard of quality. For instance, a specific wool which has good spinning and handling properties may be improved in the blend by the addition of another wool which has good colour.

Wool Warehouses

Sorted wool is stored in warehouses in either bins or sheets. When bins are used they are connected by wool chutes from

the sorting room, while large stocks of wool are packed into sheets ready for use when required. Blends of wool are made in the bins of the wool warehouse. The bins used are about four yards square and the various types of wool are laid down in thin consecutive layers until a large pile is made. When this material is passed on to the scouring bowl, the wool is removed from the pile in a vertical direction so that every armful contains an exact proportion of each type of wool.

Chapter XIV

TOPS AND QUALITIES

Long wools usually are gilled into tops by a set of preparer boxes, while short wools are carded. The material is divided at about seven inches, wools over seven inches are prepared, and those under seven inches are carded.

A backwashing operation is given to all types of wool, to cleanse them of impurities which were concealed in the initial scouring and those which have been acquired in preparing or carding. Certain hairs are unable to stand this process as they would lose their silver formation, and so they come into the market as " unbackwashed tops."

The combing operation which follows backwashing, divides the material into tops and noils. The division of these fibres is done on a length basis—usually one inch—all fibres below one inch in length are rejected as noils, while all those over an inch go into the top. The ratio of the top to the noil is called the " tear " or the " tearage." For example, when 10 lb. of wool has been combed and 9 lb. of top been made the tearage is 9 : 1. Noils are sold to waste dealers and a worsted comber regards them as a valuable by-product which, in many cases, will pay for the cost of combing.

Balled and Bumped Tops

After the combing operation, the wool is made up into balls or tops, which are the drawers' and spinners' raw material. Two kinds of tops are made : (1) balled tops, and (2) bumped tops. Balled tops are self-wrapped balls of wool which are very convenient for storage, transport, and subsequent processing. These are composed of Merino and Down wools, while bumped tops are made of long wools and the loose and open textile hairs. Eight types of worsted tops are made as shown in Table XXXIV.

TABLE XXXIV

TYPES OF TOPS

No.	*Name of Tops*	*Materials used*	*Counts obtained*	*Fabrics constructed*
1	Fine wool	Victorian and Delaine Merino	2/70's to 2/100's	Delaines, Taffetas, Italians, Venetians and Tricotines
2	Botany	Merino wools	2/48's to 2/64's	Coatings, Coverts, Gabardines, Serges, & dress goods
3	Fine Crossbred	Comeback, Corriedale and Polwarth	2/36's to 2/44's	Serges, Whipcords and men's wear
4	Coarse Crossbreds	Half and Quarter-breds	2/14's to 2/32's	Plain cloths and Overcoatings
5	Downs	British Down wools	4/12's to 3/42's	Machine and hand-knitted goods and Broad cloths
6	English or Lustre	Lustre and Demi-Lustre wools	2/12's to 1/36's	Linings, Braids Boot laces, Bunting and Roller wrapping
7	Hair tops	Mohair, Alpaca Camel hair, Cashmere, etc.	2/18's to 2/44's	Palm Beach cloths, linings, Hair and Upholstery fabrics
8	Carpet tops	British Mountain, East Indian, Persian and China wools	6/6's to 2/15's	Carpets, Mats and felts

STANDARD QUALITIES OF TOPS

Standard numbers are used for denoting the fineness or quality of worsted tops. These originated about 1850, and were intended to indicate the counts to which the specific qualities would spin. Modern tops are unable to reach these counts in the lower top numbers, while the quality numbers

can be exceeded by the spinning limit in the qualities above 60's. Prior to the introduction of quality numbers worsted tops were grouped as Hog, Super, Wether, Fine, Medium, and Low. Table XXXV gives a list of the standard qualities of tops used to-day in making worsted yarns.

TABLE XXXV

STANDARD QUALITIES OF TOPS

No.	*Quality No.*	*Type*	*Length in inches*	*Fineness*	*Price in pence 1932*
1	90's	Fine wool	4	$\frac{1}{2000}$	36
2	80's	Fine wool	$4\frac{1}{4}$	$\frac{1}{1600}$	32
3	70's	Fine wool	$4\frac{3}{4}$	$\frac{1}{1400}$	27
4	64's	Botany	$5\frac{1}{4}$	$\frac{1}{1200}$	24
5	60's	Botany	$5\frac{1}{2}$	$\frac{1}{1100}$	22
6	58's	Fine Crossbred	$6\frac{1}{2}$	$\frac{1}{1000}$	20
7	56's	Fine Crossbred	$7\frac{1}{2}$	$\frac{1}{900}$	18
8	50's	Down	8	$\frac{1}{800}$	16
9	46's	Down	$9\frac{1}{2}$	$\frac{1}{700}$	11
10	44's P.	Coarse Crossbred	10	$\frac{1}{650}$	10
11	40's C.	Coarse Crossbred	11	$\frac{1}{600}$	9
12	40's P.	Coarse Crossbred	12	$\frac{1}{600}$	9
13	36's	English	13	$\frac{1}{480}$	8
14	32's	English	14	$\frac{1}{400}$	$7\frac{1}{2}$
15	28's	Carpet	15	$\frac{1}{300}$	6

DEFECTS IN TOPS

The choice of suitable raw material is the chief factor in producing level yarns. Quality in tops is determined by the fineness of the fibres, and in selecting tops, a careful comparison of fibre diameters—as shown in Table XXXV—should be made. Tops which contain coarse or thick fibres should be rejected as unsuitable for fine yarns. Length and regularity of fibres also are desirable features in a top, and, as a rule, tops with plenty of long fibres make good spins, while tops where the short fibres predominate are likely to cause trouble in the spinning, weaving, and finishing operations. Tops which contain neps and slubs indicate that the combing has not been

satisfactory and should be rejected as they are unsuitable for fine yarn production. Irregularity of fibre distribution in the sliver causes uneven yarns. A good test for evenness in tops is to draw four or five yards from the centre of the ball and insert a few turns of twist. The twist runs to the small places and indicates irregularities in the sliver.

Blending the various lots of tops should be done carefully, because wools grown in different areas may have similar qualities as measured by length and fineness, but may not make suitable combinations for yarn production. The felting property of wool grown in different parts varies, and this has a direct effect on the spinning and finishing properties. The amount and type of the serrations of a fibre govern their adherence in a yarn, and their matting in the cloth. Seeing that every group or class of wool varies in this respect, great care is necessary in the selection and combination of blends of wool.

Defects in tops cannot be corrected in the drawing and spinning, because a faulty top is made in the combing, and no amount of gilling will remove slubs, nor extra drafting make uneven slivers, level. A faulty top is always a source of trouble, and does not improve as the sliver becomes finer, because each drawing operation accentuates the imperfections. Cheap and faulty tops are costly experiments, because technical skill cannot overcome badly selected wools nor defective combing.

Top Examination

Tops are examined by taking a draw of fibres from the sliver, and analysing them on a velvet board. Arranging the longest fibres at one end, and placing the shorter ones in order, towards the other end, a comprehensive survey of the features of a top can be made. The factors to be observed are : (1) fineness, (2) the length of the fibres, (3) regularity of fineness and length, (4) the proportion of short fibres to the long, and (5) the amount of short fibres, neps, etc., left in at the combing process.

Cellaring of Tops

After the combing processes the tops are " cellared " by being placed in a cool dark room for about a fortnight, which is

necessary to allow the fibres to settle down after the harsh treatment they have received in the carding and combing operations. In cellaring, the cortical cells of the fibres—elongated during the cleansing and combing operations—regain their natural structure. When tops are used in drawing and spinning without sufficient cellaring, the fibres have a tendency to fly, and the slivers become wild and distorted, instead of being smooth and level.

Top Calculations

The cost of a top is reckoned on the price of the raw wool with allowances for loss in scouring and the noil removal in combing. An example may be taken of the 70's quality top given in Table XXXVI

100 lb. of greasy wool at 13d.	=	1300d.
58 lb. of clean wool is worth		1300d.

$$\frac{1300}{58} = 22.41\text{d.}$$

The value of the clean wool is 22½d., as compared with its cost at 13d. In reports of wool sales, the " clean cost " of a wool often is expressed in brackets after the greasy selling price, e.g., Victorian, good 70's warp, 13d. (22½d.) The 7 : 1 tearage or combing result given in Table XXXVI indicates that in combing seven parts of wool were passed into the top, while one part went into the noil. Out of the 58 per cent of clean wool from the original lot, $\frac{7}{8}$ of 58 is top and $\frac{1}{8}$ of 58 is noil. The figures of the top and noil are 50·75 per cent of top and 7·25 per cent of noil.

The noil is worth 12d. per lb., and its value, therefore, is

$$7{\cdot}25 \times 12 = 87\text{d.}$$

The noil value is deducted from the value of the clean wool

$$1300 - 87 = 1213$$

then the value of the top is

$$\frac{1213}{50{\cdot}75} = 24\text{d. value of top.}$$

To this is added the cost of combing :

$$24 + 3\tfrac{1}{2} = 27\tfrac{1}{2}\text{d., cost of top.}$$

TABLE XXXVI

COMBING RESULTS AND TOP COSTS

Quality of Top	*Value of Raw Wool in pence per lb.*	*Yield in Scouring*	*Tearage in combing*	*Value of noil in pence per lb.*	*Cost of combing pence per lb.*	*Cost of Top in pence per lb.*
70's	13	58	7 : 1	12	$3\frac{1}{2}$	$27\frac{1}{2}$
64's	12	60	8 : 1	10	$3\frac{1}{4}$	$24\frac{1}{2}$
60's	11	62	9 : 1	$9\frac{1}{2}$	3	$21\frac{3}{4}$
58's	$10\frac{1}{2}$	66	10 : 1	$8\frac{1}{2}$	3	$19\frac{3}{4}$
56's	10	70	12 : 1	9	3	$17\frac{3}{4}$
50's	$9\frac{1}{2}$	73	14 : 1	7	$2\frac{5}{8}$	16
46's	6	75	14 : 1	$6\frac{1}{2}$	$2\frac{1}{2}$	$10\frac{1}{2}$
44's	$5\frac{1}{2}$	77	15 : 1	$6\frac{1}{2}$	$2\frac{1}{2}$	$9\frac{3}{4}$
40's	$5\frac{1}{4}$	80	16 : 1	$6\frac{1}{4}$	$2\frac{1}{2}$	9
36's	$5\frac{1}{4}$	82	16 : 1	6	$2\frac{1}{4}$	$8\frac{3}{4}$
32's	4	80	15 : 1	5	$2\frac{1}{4}$	$7\frac{1}{4}$

Chapter XV

TEXTILE WASTES

In the woollen trade three classes of waste fibres are used as raw materials, which are (1) noils, (2) spinners' wastes, and (3) fibres from fabric wastes. Noils are semi-manufactured short fibres which have been cleansed and separated from the long fibres at the combing operation. They are as good as virgin wool on all points except length. The treatment which they have received is not detrimental to their use.

Wastes are made in the processes of manufacturing, and can be classified into several groups such as : laps, soft, condenser, brush, hard, and thread wastes, and also sweepings. Fibres obtained from disintegrated fabrics include shoddy, mungo, extract, and flocks.

The strength of the wool fibre will outlast many of the other materials with which it is combined, and therefore after disintegration it can be used again. Reworked wool is much cheaper than virgin wool and can be made to produce effects which cannot be obtained by new material. Cheaper yarns and fabrics can be produced which give an economic importance to these materials.

Noils

Noils have the same features as the wools from which they are removed, and usually are classified under the wool quality numbers. For example, a 64's wool will produce a 64's top and a 64's noil. Five classes of noils are made : (1) carded noils, (2) prepared noils, (3) hair noils, (4) coloured noils, and (5) carbonized noils.

Carded noils are obtained from the Noble, Holden, and rectilinear combs, and consist of noils which have been removed from crossbred and Merino wools. In the finer qualities, neps are plentiful owing to the matty nature of the wool, but

below 58's quality, a noil fairly free from neps can be obtained. Carded noils range from 50's to 80's.

Prepared noils consist of coarse crossbred and lustre fibres whose qualities are from 32's to 50's. Neps are not present owing to the fact that a carding operation has not taken place, but the short fibres gather in batches or slubs.

Hair noils are obtained from Mohair, Alpaca, Camels hair and Cashmere. In many cases the noils are more valuable than the top, because they contain the finest fibres.

Coloured Noils

Worsted slivers usually are carded and combed in the white state and dyed in top form. After this operation a second combing is given and coloured noils are obtained. These are much shorter than white noils, but do not contain large amounts of neps.

Carbonized Noils

The worsted comber breaks the burrs on the worsted card by the burr crushing rollers and ejects the broken burr with the noil. This material is sold as " burry noil " and is carbonized by the sulphuric acid process as described for virgin wool on page 207. When the carbonizing process has been carried out to perfection, these noils are as good as virgin wool, but where they have been rolled or matted the felting properties of the fibres are impaired, which makes them spin poorly.

Laps

Laps are the soft waste from the worsted drawing and spinning operations. The material is clean and in a fibrous condition, which forms an ideal raw material for the woollen trade. A single conversion process is necessary in preparing laps for blending, and consists of breaking up the material by the Garnett opening machine.

Coloured Laps

Fibre blends made in the worsted drawing and top dyeing cause a certain amount of coloured lap waste to be made. This is sorted into qualities and colours, and sold as " coloured

lap." Dirty and soiled laps do not fetch a good price, and in many cases, the introduction of dirty and greasy laps into a bale will depreciate its value by 80 per cent.

Brush Waste

Very short fibres leave the sliver in the drawing and spinning operations, and gather on the top boards, behind the rollers and on the framework of the machine. This material sometimes is called " fud " and is gathered and used for low-woollen blends.

Hard Waste

The waste made after the spinning operation contains twist and is known as hard waste. This waste is made in spinning, twisting, winding, warping, and weaving, and has to be opened out in a knot breaker before it can be blended with the other materials. While soft waste retains most of the features of virgin wool, hard waste is an inferior material with reduced length and strength.

Sweepings

Sweepings from woollen and worsted spinning and weaving factories are screened and sorted, because much valuable waste may be lost if they were burnt. Dirty laps and soft waste are scoured and opened, while the hard waste is opened out in the thread breaker.

Table XXXVII

Value of Noils, Laps, and Waste
(in pence per lb., 1932)

Quality	*Noils*	*Carbonized noils*	*White laps*	*Coloured laps*	*Thread waste*
70's ..	12	16	21	19	11
64's ..	10	14	18	17	10
60's ..	9½	13	17	16	9
56's ..	9	12	12	12	8
50's ..	7	11½	11	10	8
46's ..	6½	11	9	8	7½
40's ..	6¼	9	8	7	7

Reworked Waste

Fabrics now are torn up after use and the fibres are used over again. Four types of fibres can be obtained : (1) shoddy, (2) mungo, (3) extract, and (4) flocks. Prior to 1800 rags were burnt, left in heaps to rot, and, in some cases, buried as a method of disposal. The disintegration of fabrics was started about 1820, and much credit is due to two men who lived at Batley, in Yorkshire, Benjamin Law and Benjamin Parr. The rags were torn up into fibres and re-incorporated into yarns and subsequently into fabrics. In the early days there was a considerable amount of opposition to rag grinding as people objected to suits being made from " Devil's dust " as they called the disintegrated fibres. In 1820, a suit of clothes was handed down from generation to generation until it finished on the rag heap to decay. To-day it is not the suit, but the fibres which are handed on from wearer to wearer.

Shoddy

Shoddy is the best type of reworked fibres, and consists of wool fibres which vary from ½ inch to 1½ inches in length. The serrations of the fibres are damaged, and compared with virgin wool, the shoddy fibre is badly broken, crushed and torn. This material is obtained by opening up knitted fabrics such as wool hosiery, knit goods, and underwear. These fabrics are made of soft spun yarns and in their construction the fibres have not been interlocked with the tenacity of that of a woven cloth. Knitted goods are more easily dissected than woven goods, which enables the shoddy fibres to have more length and strength than the mungo taken from woven fabrics. For certain fabrics, shoddy fibres are preferred to new wool, because they produce a full, heavy and solid yarn. Shoddies are known by certain trade names obtained from the types of their component materials such as " pulled Berlins," which indicate a type of shoddy obtained from knitted goods.

Extract

The recovered wool fibres from cloths which have contained cotton are known as extract, because the cotton is burnt out by

dry carbonization and leaves the wool. Details of this method of carbonization are given in Chapter XX, on page 209.

Mungo

Fibres recovered from heavily milled and closely felted cloths are known as " Mungo " and consist of the short fibres which are less than ½-inch in length. In reducing closely-woven cloths to fibres a considerable amount of force is used in the " Devil " or rag grinding machine, which breaks them into small pieces. The scales of the fibres are torn away which reduces their felting and spinning properties. Mungo is an all-wool product, and is useful in woollen blends.

The name " Mungo " is said to have originated in the early days of the rag trade. A Dewsbury cloth manufacturer purchased some very low shoddy and his carder complained that the woollen card refused to " go " with the low blend. " My words, lad," said the manufacturer, " It mun (must) go." The various types of mungo used in the woollen trade are known by trade names such as " Pulled worsteds " which indicates a mungo obtained from disintegrated worsted cloths.

Flocks

Surface hairs cut from the woollen and worsted cloths in the cropping and shearing operations are known as flocks. The best flocks are added to woollen yarn blends, medium lengths of flocks are used for packings of beddings and chairs, etc., while very short and low flocks are employed in the making of wallpaper.

Wool Dust

In cleansing the recovered fibres, large amounts of wool dust are made which consist of very small particles of wool, these are gathered by waste merchants, and after classification are sold to be used as manure on the hop fields of Kent and the apple orchards of Devon.

Waste and Rag Sorting

Wastes and rags are sorted for material, quality and colour before being subjected to any preparatory processes. The

proportion of cotton and artificial silk in woollen rags has to be determined prior to the carbonizing operation, because the amount of vegetable matters determines the length of the treatment. Special care has to be taken to divide rags from garments because they contain cotton sewing threads, which are difficult to remove. In cases where the garments are all wool, a special carbonizing operation is given to destroy the cotton sewing thread, which is known as " seaming."

The quality of the material has to be taken into consideration, and wastes and rags are sorted into four quality groups : (1) fine wools ; (2) coarse wools ; (3) low woollens, and (4) knitted fabrics and wastes. Sorting for colour is essential because whites and greys are more valuable than dark blues, browns and blacks. Light colours and whites can be dyed into bright shades, while the dull colours are used for the darker blends.

Blending

Woollen raw materials are blended before being made into yarns, and great skill has to be used in producing a blend which is suitable in (1) quality of material, (2) colour, and (3) price. In some cases the price of the blend is more important than the colour, but careful matching of shades is carried out to obtain level blends. A knowledge of the properties of the materials being used, and their combinations with each other is very important, because the handle of the yarn and the finished cloth depend on these factors.

Blends should be thought out carefully to obtain the right kind of raw materials and suitable combinations. Two important rules to be remembered in blending are that the materials should be similar in (1) fineness and (2) length.

Blending for Price

Woollen blends often are made to meet a specific price for the blended fibres. An example could be taken where a blend is desired to come in at 7d. per lb. The materials used may be, noils at 9d. per lb., waste at 6d., and cotton at 4d. The price and proportions of the materials would be obtained in this way:

7d.	9d.	1	3	1+3	= 4
	6d.	2			2
	4d.		2		2
					8

4 parts of noils at 9d. = 36d.
2 parts of waste at 6d. = 12d.
2 parts of cotton at 4d. = 8d.

56

The total cost of these proportions is 56d., which is divided by 8 parts, so that the blend comes in at the required price :

$$\frac{56}{8} = 7\text{d. per lb.}$$

Taking these proportions for a 200 lb. lot they could be arranged in this way :

100 lb. of noils at 9d. = 900d.
50 lb. of waste at 6d. = 300d.
50 lb. of cotton at 4d. = 200d.

1,400d.

The blend of 200 lb. would cost 1,400d. or 7d. per lb. :

$$\frac{1400}{200} = 7\text{d. per lb.}$$

Lay out of Blends

Level woollen yarns depend on regular fibre distribution, so a method of arranging the component fibres in the blend has been evolved. The materials are laid out in thin layers until a pile is made, as shown in Fig. 6. In taking the material from the pile, the operative takes it downwards and not from the top, so that in every basketful removed, there is the given proportion. The distribution of the materials in the pile should be made to allot all component materials equally. In the case of the above mixture, a layer of noil would be placed between each layer of waste and cotton.

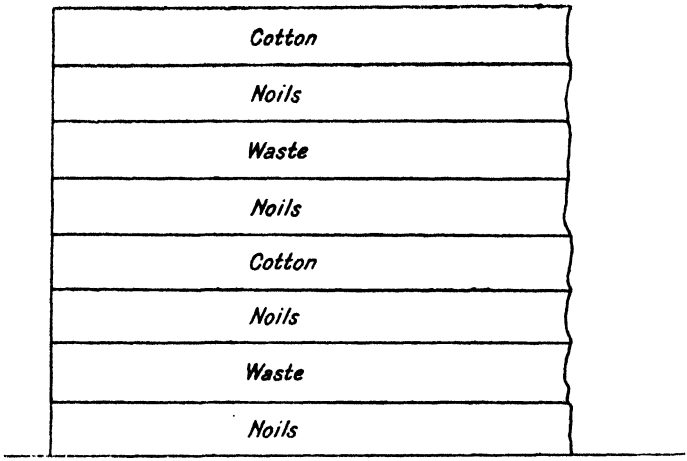


FIG. 6. LAYOUT OF A WOOLLEN BLEND. The various components of the blend are spread out in layers. Material taken from the Pile is removed from the end, giving an even distribution of all types of the material.

OILING WOOLLEN BLENDS

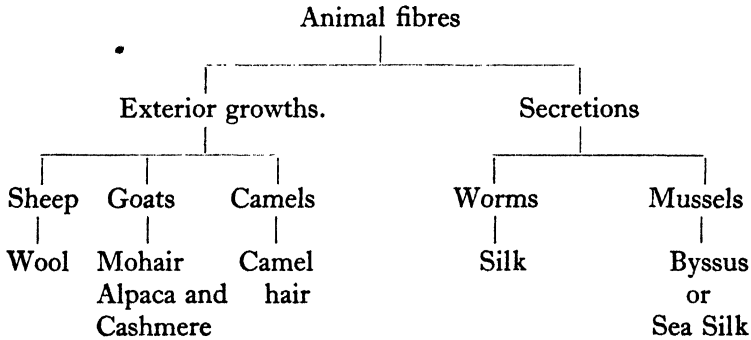
The scouring operation leaves the virgin wool fibres unprotected, and the re-worked wastes have their added lubricants removed in the finishing, so it is necessary to supply a new covering of oil. The object of the oil is twofold : (1) to protect the fibres, and (2) to assist in yarn making.

Suitable oils consist of non-drying vegetable oils such as olive oil, but it is expensive for woollen yarns, so oleines chiefly are used. In some cases the oils are applied as emulsions. The application of oil in woollen blending rooms is done by hand and known as " batching." Oil is applied over the blend as it is laid out in the pile by means of an oil can with a T-shaped spout. As each layer of the blend is laid down it is oiled before the next type of material is placed in position.

Chapter XVI

OTHER TEXTILE MATERIALS

Wool textile goods often are assisted in their manufacture by other types of materials, which are added to produce special effects, or to give additional strength to the fabrics. Textile materials may be placed in three classes : (1) animal fibres, (2) vegetable fibres, and (3) mineral fibres.



Silk

Silk is the second important animal fibre, and is grown in warm, sunny climates, where cheap labour is plentiful. The chief silk producing countries are China, Japan, Italy and France. Japan produces 65 per cent of the world's output of raw silk, China 20 per cent, Italy 10 per cent, and other countries, which include India, Turkey, Asia Minor, France, Central Europe, Spain and Uganda, supply 5 per cent.

Growth of Silk

The eggs laid by the silk moth are placed in the sun for about thirty days until they hatch, when a tiny caterpillar emerges from the egg. It then takes a month for the caterpillar to grow to maturity, but owing to its rapid growth it is necessary

for it to cast its skin every five or six days. On reaching maturity, the silkworm builds a cocoon to contain the chrysalis while the metamorphosis takes place. The cocoon is made of a silk secretion which is a gumlike substance called fibrine, and is built up by the worm with a figure of eight motion. The layers of silk are fastened together by a silk glue known as sericin, and this has to be melted by hot water or steam before the silk can be unwound.

There are about 4,000 yards of silk in a cocoon, but much of it is entangled and only about 1,000 yards can be wound into hanks, the rest is sold as silk waste. The finest silk is found in the middle layers of a cocoon. The outside of a cocoon is rough, coarse and tangled, while the inside is too weak for reeling, these parts are known as " Frisons " or reeling waste.

Feeding the silkworm is one of the most important factors in rearing silk, and special care is taken to ensure that the worms are given suitable leaves. As a general rule mulberry leaves are used, but in certain areas the leaves of oaks and other trees can be used. The amount and type of food has a marked effect upon the silk produced.

Certain silkworms are allowed to form moths for breeding, but egg production usually is specialized. When the moths are about to come out of the cocoons, they soften the end of the cocoon by an alkaline substance and eat their way through the silk. Cocoons which are opened in this way have their strands of silk broken and are useless for reeling, these are known as " pierced cocoons." The Actias silk moths cut their way out of the cocoon by a small, sharp instrument placed at the base of their front wings. All silk moths possess a similar attachment, but the Actias breed are the only ones known to use it.

Silk Reeling

Cocoons are sorted into grades and qualities, and also into male and female. The best cocoons are made by the male worms and are kidney shaped, while the female ones are smaller and oval in shape. Cocoons are collected before the moths have had time to mature and are placed in boiling water to kill the pupa which is inside. This is done in large silk reeling

establishments called " Filatures." Six or seven cocoons are placed in a bowl of hot water and the six or seven threads are wound into a hank. This yarn is called grege and usually measures 13-15 deniers.

After winding, each hank is dried and wrapped in soft paper. Thirty hanks are packed into a bundle which is called a " book " and weighs from 5 to 10 lb. Thirty books make a bale and weigh about 200 lb. The bales have an inner surround of cotton cloth and an outer covering of tea matting to protect the silk during transport.

Silk Yarns

For weaving, the grege silk threads obtained are too fine, so they are doubled or " thrown " together. The best silk is made into warp threads and called " Organzine " silk, while the inferior types are known as " Tram " and are made into weft yarns. Organzine yarns usually have 16 ends thrown together, while tram yarns have about 12. Silk hosiery yarns usually are of a tram type, owing to the reduction in twist.

Chinese Silks

The silk industry of China has been carried on for thousands of years, and dates back to about 2700 B.C. The silks produced in China are the finest in the world, but tend to be rather irregular and weak.

Shanghai Silk

Shanghai is the centre for the best China silk trade and collects raw silk from the filatures of the central provinces. The silkworm of this area is the Bombyx mori. In recent years silk factories of this district have reeled silk to set standards, and the material has improved in quality. Formerly the Chinese silk was produced on the primitive Tsatlee reel. The hanks were inconsistent, in size, yarn diameter, weight, and length. Certain silk factories bought primitively reeled hanks and re-reeled them to set standards, these were known as " China re-reels." Shanghai silk is favoured by the British merchants, and although it is expensive, it is the main type of silk used in Great Britain for better class work.

Canton Silk

Canton raw silk is not as good as the silk from Shanghai, and is obtained from the Bombyx textor, which produces a silk, coarser in handle and darker in colour than that of the Bombyx mori. In diameter it is finer than the mori, but it is lacking in stability and firmness, the silk tends to be fluffy and soft. Considerable amounts of Canton silk are used for weft yarns and crêpes.

Tussah Silk

Chinese Tussah is the thickest type of silk produced in the country, and is obtained from the cocoons of the beautiful Antherea mylitta moth, which is a wild moth, and is not cultivated in a domestic state like those of the Bombyx types. The cocoons are gathered from the trees and bushes where the silkworm has formed them. The Tussah moth does not feed on the mulberry tree, but on the Baer seemul plant which gives the silk its brown yellow shade. The colour of this silk greatly depreciates its value, because the seemul conveys a permanent dark shade to the silk, which can only be removed by a chemical treatment such as hydrogen-peroxide. Chinese Tussah silk is shipped from Shanghai and Canton.

Shantung Silk

Shantung silk is a second type of Chinese Tussah silk, which is obtained from the Antherea pernyi silkworm. In genus this moth is the same as the Antherea mylitta, but the difference in species varies according to the type of tree to which the silkworms have become attached. The Antherea mylitta favours the seemul plant, while the Antherea pernyi feeds on oak leaves. The great producing area for the Chinese oak silkworm is Manchuria, where the oak trees are cultivated to grow only five or six feet high, so that the cocoons may be gathered easily.

Japanese Silk

The silk industry is comparatively new to Japan, and is not hindered like China, by centuries of conservative procedure. Japanese silks are regular in quality, and the diameters of the thrown yarns are receiving considerable attention in order to

obtain uniformity. The modern Japanese silkworm is the Antherea yama-mai, which has been obtained from an older type of Japanese oak worm moth, which originally produced the famous wild silks of Japan. Since about 1870, the wild silkworm has been domesticated, building up a huge silk industry. The Japanese silk moth is an Antherea type like those in North China. Care and attention bestowed by the Japanese on the domestication and cultivation of the Antherea yama-mai has resulted in obtaining a silk fibre which is $\frac{1}{11\frac{1}{00}}$-inch in diameter, while the wild Chinese types of this moth produce silks which have diameters of about $\frac{1}{70}$-inch.

Indian Silks

The Indian silk industry is not specialized like those of China and Japan, and does not produce a specific type of silk. There are about a dozen types of Indian silks which are obtained from four different breeds of silkworms, these are : (1) Bombyx, (2) Antherea, (3) Attacus, and (4) Actias. Bombyx silkworms are natives of China, but were taken to India hundreds of years ago. The Bombyx mori, which spins the fine silk of China has not been cultivated in India, but the Bombyx textor spins the fine silks of Bengal. These silkworms feed on mulberry leaves and produce a silk of a light green shade. This silk is one of the finest in the world, with a fibre diameter of $\frac{1}{25\frac{1}{00}}$-inch. In handle it is very soft and has a fluffy nature.

European Silks

Silk fabrics were used by the Romans in very early times, according to references made by Tacitus, but it was not until about the year 550 A.D. that sericulture was introduced to Europe. Two Persian monks who had lived in China and learned the art of rearing silkworms on mulberry trees brought over some silkworm eggs, which they carried in their bamboo rods to elude the vigilance of the Chinese authorities. From that time silk rearing spread to Italy, Spain and France. The chief modern silk-producing areas of Europe centre round Lyons and Milan, and are known as the French and Italian silk-rearing areas. The silk produced is of a good quality, but it is expensive owing to the high labour costs.

Physical Structure of Silk

The structure of silk is like a double stranded glass rod. The fibres are straight and not curled in the same way as wool. Natural silk varies in colour from yellow to golden brown, and has a great amount of lustre. It is soft and slippery owing to the fact that it has fewer surface features than any other fibre.

Chemical Composition

Silk is made up of the same elements as wool, except that it does not contain sulphur. A general classification of the component parts of a silk fibre may be given as :

	Percentage
Carbon	50
Oxygen	25
Nitrogen	20
Hydrogen	5

Properties of Silk

Silk has greater strength than any other textile fibre, and is very elastic, but is a poor conductor of electricity, so it soon becomes electrified. After being steeped in a weak solution of acid, silk has a scroop or rustle.

Schappe or Spun Silk

The reeling wastes from silk filatures are sold as silk waste and made into yarns on the spun silk system. In quality these silks resemble the thrown types, but consist of the tangled and unreelable parts of the cocoons. Waste silk is cut into lengths about 6 to 8 inches long, to process it on a system which is not unlike the worsted system. During the combing process, silk noils are made which are used in woollen blends to give strength and lustre to the fabrics. Spun silk yarns are used for weft with silk, cotton or worsted warps. Embroidery, knitting and ribbon silks are made from spun silk.

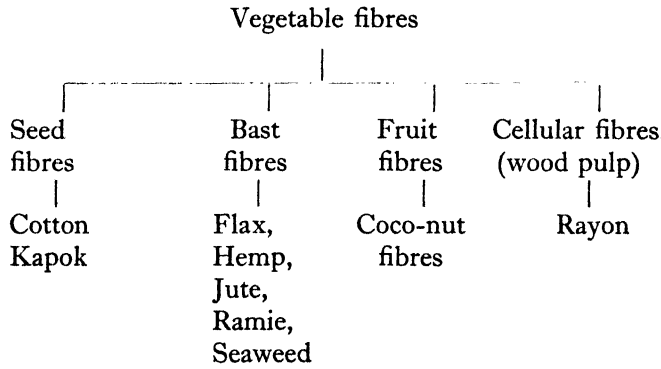
Silk Wastes and Noils

Waste from the spun silk operations and the noils from the silk combing process are used in woollen blends. In some

cases thick yarns are made from pure silk noils and are known as Stumba yarns. The smallest wastes which could only be made into yarns with difficulty are used for packing and wadding, and also as heat insulators.

Byssus Silk

Byssus silk is obtained from a mussel which is found on the shores of the Mediterranean Sea and on the Normandy coast. This material is opened out and combed into a yarn, which is used by the natives of Italy and Normandy for making vests, gloves and outer wear. Byssus silk is strong with good wearing properties and has a natural shade which varies from golden brown to olive green.



Cotton

The seed vessel of the cotton plant has a downy covering which is used in making yarns and fabrics. At seeding time the bolls of cotton burst and the fluffy seed is gathered. Before leaving the cotton plantations, the seeds are removed by ginning which leaves batches of fluffy fibres ready for making into yarns.

Features and Properties of Cotton

Cotton fibres resemble a flattened tube with a depressed centre, but rounded walls on the sides. These tubes are twisted, and in many cases, 200 twists per inch can be found on certain cottons. It is a fairly straight fibre, not curly like

wool, and is very short and fine. The natural colour of cotton varies from a golden brown to a chalky white. Cotton fibres do not need a preliminary washing operation like silk and wool.

Fineness is the main feature of cotton fibres, the finest type is Sea Island cotton which is about $\frac{1}{5000}$-inch thick, while the thickest cotton fibre is the East Indian with a $\frac{1}{1000}$-inch fibre diameter. The length of the longest cotton fibre is 2 inches, and is obtained from the Sea Islands. American cottons are about 1 inch in length, while Egyptian cottons are about $1\frac{1}{4}$ inches long and the shortest cotton fibres are grown in India, and measure from $\frac{1}{2}$ to $\frac{5}{8}$-inch.

East Indian cotton has the strongest fibres which need a 10-dram weight to break them, while the weakest are Sea Island cottons which have a breaking strain of two drams. Cotton is not elastic, but breaks with a snap when tension is applied.

The fineness of cotton gives it good spinning properties which cause it to be used to supplement low woollen blends, as the fine cotton fibres bind the thicker wool fibres together.

Chemical Composition of Cotton

Cotton consists of three elements, oxygen, hydrogen and carbon, which are found in different proportions in various types of cotton, a general classification may be given as

	Percentage
Oxygen	50
Carbon	43
Hydrogen	7

Action of Reagents on Cotton

Weak acids will dissolve cotton, so acid dyes cannot be used. Alkalis cause the fibres to swell when the cotton is held under tension which produces the effect known as mercerized cotton.

Flax

Flax is the oldest textile fibre, and is grown in Ireland, Belgium, France, Holland, Germany, and Egypt. The stems of the flax plant are retted to remove the wooden core and

soften the bast. When these processes are completed the material is hackled to divide the stems into fibres.

Hackled flax is known as line, and is treated on a spreader which forms the material into a continuous sliver. The material is spun wet and is passed through a trough of hot water immediately before drafting, which softens the natural gum so that attenuation may take place. While the material is still pliable the required twist is inserted and the flax wound on to the bobbin, where the yarn becomes hard and firm.

The tow, rejected at the hackling process, is made into yarns by carding, combing, drawing and spinning. Three classes of linen yarns are made: (1) fine counts, (2) line yarns, and (3) tow yarns. Fine linen yarns are used in the manufacture of cambrics, linen clothings, coatings, batiste, linings, handkerchiefs, shirtings, stiffened linen (collars, etc.), and tulle. Line yarns make up into linen atlas, damask, drills, table linen, towel linen and bed ticks. Tow yarns are used for towel manufacture, and produce a soft handling material which is pleasant for the skin, and readily absorbs moisture. Low tow yarns are used for a coarse towel fabric called crash.

Hemp

Hemp is a bast fibre like flax and is obtained from a plant which grows in Italy, Spain and North Africa. A lower quality of this material can be obtained from Russia, Germany, and Austria. The first operation given to hemp is batching, which consists of blending the fibres for strength, colour and uniformity. During this operation the material is softened with oil and water, and impurities such as bark and sticks are removed. Hemp slivers are formed by carding, and are attenuated into fine threads by drawing and spinning. Owing to the strength of the material special drag mechanisms have to be used on the machines. Hemp yarns are used for sail cloths, canvas, webb equipment, fire hose, sacking, packing cloths, hawsers and carpet base yarns.

Jute

Jute is obtained from the stems of a plant of Bengal, which grows from 6 to 15 feet high. The processing given is similar

to that of hemp, and the yarns made can be employed in similar ways. The main use of jute is for bag and string making, while for sacking and tarpauling jute is unrivalled. Jute cannot be made into garments because it is unable to resist frictional wear, but for curtains and furnishings where resistance to mechanical wear is not essential some useful fabrics can be made.

Ramie

Ramie is obtained from the stems of a Chinese nettle and is very similar in physical properties to the Rhea fibre obtained in Mexico and Malay. These stems are rich in cellulose and are retted in a similar way to the flax plants. This material is tough and strong, and has good wearing properties. Ramie fibres are bleached and made into yarns on the spun silk system of yarn production. Great care is essential in processing ramie because of its highly inflammable nature. Ramie yarns are knitted into incandescent mantles for gas illuminations, and also are used as warp yarns for woollen and linen goods.

Marine Fibre

A sea plant obtained in the South Seas, can be made into bast fibres by a process similar to that used for jute, and is made into yarns and fabrics suitable for the cord and packing industries.

Coco-nut Fibre

Coco-nut fibre is known as coir, and is obtained from the Malabar Coast and exported from Cochin. The material is hand spun by the natives and made up into hanks for shipment. Coir fibres are made into mats and bags. The special feature of the coco-nut fibre is its resistance to frictional wear, which enables it to be used in the making of brake linings and other goods where resistance to frictional heat is an advantage.

Rayon

The rayon or artificial silk industry has made rapid progress during recent years and produces a vegetable yarn of which there are four types : (1) Chardonnet, (2) Cuprammonium,

(3) Viscose, and (4) Acetate rayon. The artificially produced fibres are exact in diameter, each filament is spun under controlled conditions which makes the uniformity of size and texture possible. True silk is not even in diameter, because the cocoons and threads vary.

Suitability of Vegetable Fibres for Clothing

The suitability of vegetable materials for clothing depend on the same factors as those for animal fibres, as given on page 46. These are (1) elasticity, (2) durability, (3) plasticity, (4) heat resistance, and (5) good washing properties. Cotton and linen fabrics have these features, and make suitable garments, jute is unable to stand frictional wear and cannot be considered as durable from a clothing point of view.

Rayon has properties which are not possessed by the animal fibres such as silk and wool. One of its commendable features is its power of absorption. Underwear made from rayon absorbs perspiration and allows the skin to become dry and comfortable. Perspiration which in time destroys wool and silk has no effect upon rayon. Another advantage of the use of rayon is its cleanness. The chemically produced yarn is a tube without edges, so that there are no serrations or twists to gather and hold the dirt as in the case of the wool and cotton fibres.

Mineral Fibres

Yarns can be made from precious metals such as gold and silver, as well as from brass, copper, aluminium, and lead. The metal is produced as a strip and is wrapped round a central core which may be silk for the precious metals or strong cotton for the baser types. The base thread is encased in the metal so that it is not visible in the finished yarn. These yarns are known as tinsel yarns, and are used for decorations on uniforms and costumes. Considerable amounts of metal yarns are used in the millinery trade for hat trimmings.

Asbestos

Asbestos is a mineral which is obtained in Canada, Italy, and Russia, and is known as mountain flax. This material

is noted for its fire and heat resisting properties, and is made into goods which have to resist fire, steam or frictional heat. Raw asbestos has a rock formation which can be broken into stratas about four inches in length, these are then divided into fibres. The Canadian material has the best spinning properties, and is mixed with cotton to assist in the yarn production. In the later stages the cotton is burnt away, leaving a pure asbestos yarn.

Chapter XVII

WOOL SCOURING

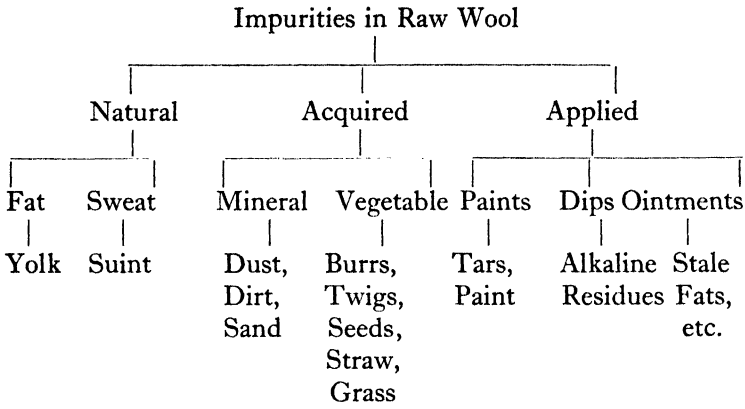
Cleansing the impurities from raw wool is a process which is essential in the manufacture of both woollen and worsted yarns. Faults in the material, discovered in the later operations, often originate in wool scouring, so this process needs special care because it is so vital to perfect yarns and cloths.

Impurities in Wool

Three types of impurities are found in raw wool: (1) natural, (2) acquired, and (3) applied. Natural impurities consist of oils and fats which come out of the oil glands of the sheep's skin and are deposited on the wool fibre. This oil known as yolk assists the growth of the wool fibre and protects it after growth so long as it remains on the sheep's back. A second class of natural impurity is the condensed potash formed by the residue of the perspiration of the sheep, which settles on the fibres and is known as suint.

Acquired impurities are those which adhere to the wool during its growth, these may be subdivided into two groups: (1) mineral impurities such as dust, dirt and earthy matters, and (2) vegetable substances like straw, burrs, twigs, and grasses.

Applied impurities found in raw wool consist of matters which have been applied deliberately to the wool, such as tar, paint, sheep dips, and ointments. The removal of the impurities from wool is difficult, because they are acquired gradually and are intermixed with the wool fibres.



Removal of Impurities

Suint will dissolve in water at 80°F., while yolk needs water with a temperature of 130°F., before it melts, or it can be removed with an alkaline liquor at about 100°F. Yolk is nature's protection for the sheep, and it would be good for nothing if it could be washed away by a simple application of water.

Removing Loose Impurities

Some of the dust and dirt may be removed from the wool by dusting prior to scouring, but a large amount of the dirt is stuck to the fibre by the grease and falls away from the wool when the grease is removed. Certain types of wool benefit greatly by being given a vigorous shaking in a willow prior to scouring. The loose impurities are removed, which prevents the scouring liquors from becoming heavily charged with dirt.

Wools which have been dusted before scouring wash brighter and save soap by keeping excessive dirt out of the scouring bowl. Long wools should be dusted with great care, or the fibres may be broken. Slipe wools often are dried and dusted in a willow to remove the lime. Burrs and vegetable matters can be removed by mechanical means, or by destroying the burrs by carbonization.

TABLE XXXVIII

IMPURITIES IN WOOL

		Percentage of		
Type of wool	*Example*	*Yolk and Suint*	*Dirt*	*Clean wool*
Short wool	Merino	40	15	45
Medium wool	Crossbred	35	10	55
Long wool	Lustre	20	8	72

SCOURING COSTS

Impurities removed in wool scouring are grouped as (1) sinkage, and (2) yield. The percentage of clean wool is called the " yield," while the matters which have been removed are called " sinkage." The value of the clean wool can be calculated from the following formula :—

$$\frac{\text{Price per lb. of Raw Wool} \times 100}{\text{Percentage of yield}} = \text{Value of clean wool.}$$

A raw wool which costs 20d., and yields 54 per cent will be worth 37d. as clean wool :

$$\frac{20 \times 100}{54} = 37\text{d.}$$

The cost of scouring which includes, water, soap, alkali, and standing charges, is worked out per lb. of wool scoured. If the charges for scouring the above wool were 1¼d. then the cost of the clean wool would be 37d. + 1¼d. = 38¼d.

DESUINTING WOOLS

Certain wools are steeped in warm water prior to the scouring operation to remove the suint and obtain the valuable potash salts. The material is given a series of flushings with water at 90°F., and when the liquor reaches a given thickness it is run to an evaporating plant. The potash ladened liquor is boiled in a large shallow pan, and as the water evaporates, the potassium salts crystallize. These form suint ash which then is refined and divided into carbonates, sulphates and chlorides of potassium.

Two methods of desuinting wool are in use : (1) steeping tubs and (2) desuinting machines. When the steeping tub method is used, the raw wool is placed into steel tubs which run on wheels. Each tub is run under a liquor jet for 3 or 4 minutes. The liquor flushes the wool and runs away through the perforated bottom of the tub into a drain where it is pumped back again for further flushings. The potash salts are removed from the wool and after several flushings the liquor becomes thick, and is taken to the retort for evaporation.

Desuinting machines consist of series of lattices, which convey wool from jet to jet when it is flushed with liquor at various stages of density. Dirty wool is flushed with dirty liquor, while the clean wool is flushed with clean water. Two kinds of machines are in general use : (1) straight lattice machines and (2) tier lattice machines. In both types, the liquor from each spraying is collected in a draining tank and pumped to flush a dirtier wool until finally, the liquor heavy in potash is passed to the evaporating plant.

TABLE XXXIX

ANALYSIS OF SUINT ASH

	Percentage
Carbonate of Potash	86
Sulphate of Potash	6
Chloride of Potash	3
Iron, Lime and Phosphorus	5

EMULSION AND SOLVENT SYSTEMS OF WOOL CLEANSING

In the *emulsion* system of cleansing wool, the grease is removed by the action of a lather or emulsion, which is formed by detergents added to the scouring liquors. These detergents have a twofold purpose : (1) saponification and (2) emulsification. Saponification is a chemical process and consists of forming a soap by the combination of the fats or oils with the alkaline reagents. Emulsification is a mechanical action which divides the fats into fine particles in order to remove them.

The *solvent* system of wool cleansing dissolves the grease on the wool fibre by a physical action by means of a solvent such as petrol or naphtha.

Wool Cleansing Agents

The agents employed in cleansing wool by the alkaline system are : (1) water, (2) alkali, (3) soap, and (4) heat. Each has its own part to play. The water dissolves the suint and acts as a vehicle which brings the other agents into combination, and washes away the saponified grease and dirt. Alkali softens the water and makes it more expansive, so that its powers of penetration are increased and can more effectively cleanse the wool. The function of soap in scouring wool is to form the wool fats into emulsions and effect their removal from the fibres. When the yolk is removed, the dirt falls to the bottom of the bowl and leaves the fibres free from grease and dirt.

Heat is essential in wool cleansing, because the suint needs liquor with a temperature of 80°F., before it will dissolve and come away from the wool. Yolk on the other hand, requires a liquor at a temperature of 130°F. before it melts, while it may be removed in an emulsion form by liquors at about 115°F. —120°F. Liquors with very high temperatures should not be used, because there would be a danger of the alkalis burning the wool, and even when the liquors exceed 140°F. there is a danger of serious and irreparable damage being done to the delicate scales of the wool fibre.

Water for Wool Scouring

An ample supply of suitable water is needed for wool cleansing. The water should be soft and clean, and arrangements made so that supplies of several thousands gallons are available at short notice. For cleansing purposes water is ideal, it has a solvent nature, which commends its use to wool scourers. Owing to its readiness to dissolve matter, pure water is seldom found. Rain water absorbs gases from the air and spring waters as they flow take up particles of rock and sand. Impurities in water correspond to the nature of the ground from where the water is obtained or over which it flows.

Water Supplies

There are four sources of water supplies : (1) rain water, (2) springs, wells and bore holes, (3) river and lake water, and

(4) towns water. Some mills collect the rain water from the roofs, and obtain a large supply of fairly soft water in this way. Industrial areas often have soot, dirt and sulphur in the atmosphere, so that this water is not very clean.

The water from the earth is obtained from wells, springs, and bore holes ; and, although it usually is free from mud, and cleaner than collected rain water, it frequently contains suspended impurities. Water from chalk or lime areas contains calcium, either as a carbonate or a sulphate, and is a great destroyer of soap. A water softening process generally is necessary when spring water is used, whether the water is supplied from a natural spring or an artesian well.

River water is not so clear as spring water, and may be contaminated by impurities such as sewage and industrial refuse. Spent dyestuffs, exhausted steam and overcharged scouring liquors form a serious type of impurity, and special precautions should be taken to ensure their removal when these waters have to be used.

Public supplies of water have from five to six degrees of hardness, because a hard water is better for drinking and cooking purposes than a soft one, and is less liable to convey infection.

Treatment of Hard Water

Hardness in water is due to metallic salts which have been acquired by the water, causing it to lack lathering properties. Water quickly assumes a certain amount of the physical features of the areas from whence it springs or flows, and the nature of the soil and the composition of the rocks soon make their mark on the type of water. A typical example of the acquirement of hardness will be found in water which flows over limestone areas. Limestone is not soluble in water, but will dissolve in carbonic acid. Rain water takes carbon dioxide from the air and therefore contains a trace of carbonic acid. When this water falls on a limestone strata, it forms carbonates of lime. Temporary hard water contains bi-carbonates of lime, iron, or magnesium, which are held in the water by carbon dioxide gas.

Temporary hard water can be softened by removing the

carbon dioxide ; which may be done in two ways : (1) to boil the water and liberate the gas, which precipitates the carbonates and deposits them on the bottom and sides of the tank ; (2) to decompose the carbonates by the addition of a specific amount of suitable acid.

Sulphates and chlorides present in water cannot be removed by boiling, because the solubility of water increases with heat and when the impurities are of this nature the hardness is increased. Sulphates of lime, iron, or magnesium are general causes of permanently hard water.

Hardness is expressed in degrees. Each degree indicates the presence of one grain of carbonate of lime in a gallon of water. Seeing that there are ten pounds to a gallon, the degrees of hardness are expressed against a base of 70,000 gallons. Twenty degrees of hardness indicate that there are 20 grains of carbonate of lime in one gallon of water. Hardness recorded on a basis of 70,000 is called Clarke's degrees. The Continental method is to use a base of 100,000, which is known as Frankland's degrees.

Water Softening

Water can be purified by settlement, filtration, or by chemical means. Polluted water from rivers, containing suspended impurities, may be cleansed by settlement, because mud, sand, and drainage have a greater specific gravity than water and fall to the bottom when allowed to settle in a dam or tank. When mineral oils or trade effluents are present in water, filtration is necessary because these are suspended impurities and may be deposited on the wool. The various types of water filters used, consist of screens, sedimentation tanks, sludge beds, intermittent sand, and pressure filters.

The chemical methods of water purification consist of (1) lime-soda methods and (2) base exchange methods. When the lime-soda system of water-softening is used, the degrees of hardness should be known, and applications of specific amounts of soda or lime, or both, will cause the carbonates of calcium and magnesium to precipitate and form a sludge at the bottom of the tank.

When lime is added to hard water it combines with the

carbonates of lime in the water and forms bi-carbonates, which are insoluble at ordinary temperatures and form a sludge at the bottom of the tank. The lime-soda method will reduce the hardness to 2 or 3 degrees, but control tests are essential at regular intervals to ensure that the standard is being maintained.

Base Exchange Water Softening

Water can be softened by means of a zeolite, such as sodium aluminium silicate, which can reduce the hardness to zero, but it costs more than the lime-soda process and should not be used for dirty water. Calcium salts are converted into sodium salts as the hard water percolates through the column of base exchanging silicates, and causes this method to be known as the " base exchange " system. The zeolite loses its softening powers after treating a considerable amount of water, but the efficiency of the softener may be restored by treatment with a solution of common salt (sodium chloride). All traces of the salt solution should be cleared away before the softener is restored to use.

Table XL

Tests for Impurities in Water

Suspected Impurity	*Testing Agent*	*Result*
Chlorides	Silver nitrate	Dense white precipitate.
Lime	Ammonium oxalate	Forms white precipitate
Organic matters	Permanganate of potash	Change of colour
Sulphates	Barium chloride	Milky
Hardness	Standard soap solution in $\frac{1}{10}$ parts	Number of parts added, minus one, equals degrees of hardness.

Alkalis used in Wool Scouring

In wool scouring, the functions of the alkalis are (1) to convert the fatty oils into emulsions, (2) to lower the surface

tension of the water, and (3) to soften the water. The addition of alkali to a scouring liquor converts the wool fats into emulsions and together with the soap, effects their removal. When alkalis lower the surface tension of liquors they make them thinner, so that the liquor is able to pass between the scales of the wool fibres and dislodge the grease.

Alkalis used in wool scouring are (1) ammonia, (2) sodium carbonate, and (3) potassium carbonate. Caustic soda and caustic potash are not suitable for scouring wool owing to the drastic action they would have on the wool fibre. The trade terms applied to the alkalis chiefly used in wool cleansing are " Soda ash " for the sodium carbonate and " Pearl ash " for the potassium carbonate.

Ammonia is the mildest type of detergent, and will keep the soap solution in a fluid condition for a longer time than the other types of alkalis, but owing to its volatile nature ammonia soon loses its washing power. Pearl ash has a milder action than soda ash and produces cleaner wool with a softer handle than that which is obtained after soda scouring.

Testing Alkalis

Alkalis should be tested for purity, strength, and caustic alkali. The presence of caustic alkali will turn red litmus paper blue, but if a more detailed test is needed, the alkali could be treated with barium chloride and tested for caustic by phenol-phthalein.

Soaps

Soaps used in wool cleansing should have easy solubility at low temperatures. The function of the soap is to emulsify the wool fats so that they may be taken away. Good lathering soaps are essential so that the grease can be carried away in the emulsion. Excesses of alkali in good wool soaps should be carbonate and not caustic. The foreign matters on the wool fibres, such as grease and dirt are loosened by the soap, broken up into small particles and surrounded by soap bubbles which take them away. A coating of soap surrounds each particle of grease and prevents it from joining the others again, or returning to the wool fibre. The action of the soap which splits the fat into small particles is called emulsification.

The soap should be able to maintain this emulsifying property from two to six hours, and must have good washing-out properties to facilitate the rinsing operations. Wools which contain traces of soap after the scouring operation are liable to mildew at future stages of processing. Soaps which have disagreeable smells should not be used, as they transfer the smell to the wool.

Composition of Soap

Soap is formed by mixing a caustic alkali with a fatty oil. The oils used may be tallow, cotton seed oil, palm oil, olive oil, or coco-nut oil. Hard soaps are made with soda as a base, while soft soaps have a potash base. Soft soaps contain less water than the hard ones and melt with greater ease.

Hard soaps made with soda are more liable to be adulterated than the soft ones made with a potash base. Some of the impurities which are used to adulterate soaps are :—flour, resin, potato starch, China clay, salt, Fullers earth, and French chalk. Foreign matters of this nature cause a loss of washing power by forming a scum on the top of the liquor which interferes with the cleansing of the wool. In some cases these impurities cling to the wool and are difficult to remove. Soap tests should be made to find the amount of water, combined alkali, free alkali, fatty acids, and adulterants present in the soap. Details of soap tests are given in Table XLI.

Table XLI

Tests for Impurities in Soap

Suspected Impurity	*Testing Agent*	*Result*
Free Alkali	Phenol-phthalein	Pink colour formed
Excessive moisture	Heat to bone dry	Compare loss in weight
Resin	Boil with acetic anhydride	Sulphuric acid drops turn the resin violet
Alum	Ammonia	White jelly is precipitated.
Salt	Silver nitrate	White precipitate

WOOL SCOURING

Development of Wool Scouring Machinery

From primitive times, wool has been washed in vats and tanks, which were filled with liquors made from various kinds of detergents such as soap, alkali, lant, and other agents. Lant was favoured owing to the ammonium carbonate which it contained, and was a very good detergent with suitable scouring power.

The dirty wool was put into the bowl by hand, and agitated by poles or rakes for a specific time, then it was taken out and allowed to drain on a scray. After several treatments of this nature the wool was given a final rinse in clean water and dried in the sun. Since 1850, various mechanical devices have been invented for scouring wool, and several of the early machines had appliances for agitating and squeezing the wool both in and out of the liquor. Modern scouring machines give very little agitation to the wool and aim at removing the impurities without much mechanical disturbance.

Machinery for Wool Scouring

Wool scouring machines are arranged in sets. Four bowl sets are needed in scouring Merino wools, while, for crossbred and long wools, three bowl sets may be used. The liquor capacity of the bowls of a set is reduced as the wool becomes cleaner. A usual arrangement is to have 1,000 gallons in the first bowl, 900 in the second, 750 in the third, and 600 gallons in the last bowl. The mechanical parts of a scouring bowl consist of three mechanisms : (1) feeding motion, (2) propelling mechanism, and (3) delivery mechanism. These are arranged to feed the wool into the bowl, get it through the liquor and finally take it out of the bowl.

Two methods of feeding may be used : (1) hopper feeds and (2) lattice feeds. Hopper feeds give a regular and even supply of wool which is opened out by the spiked lattice and beaters, and allows the mineral impurities to be removed. Scoured wool which has been delivered to the bowl by hopper feeds is brighter owing to the greater penetration afforded by the well-opened wool, and the removal of the mineral impurities enables a great saving in soap. The hopper feed should distribute the wool evenly across the width of the bowl, and prevent the rollers

and forks from locking and jamming. Lattice feeds take the wool straight into the bowl without a preliminary opening.

Propelling Mechanisms

There are two kinds of propelling mechanisms which may be used: (1) harrow forks, and (2) swing rakes. Harrow forks are used for fine wools and swing rakes for long and coarse materials. Should long wools be scoured on a harrow

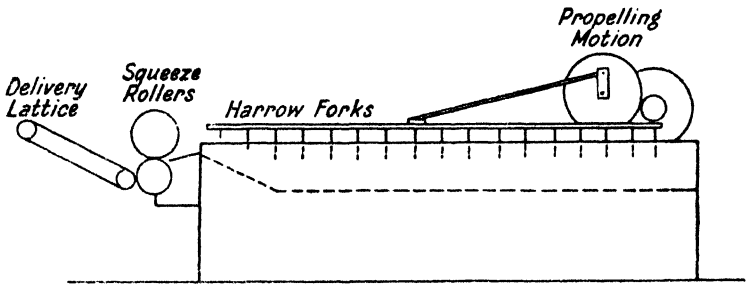


Fig. 7. Harrow Scouring Bowl. The wool fed into the bowl by the lattice is propelled through the liquor by the harrow forks, until it is squeezed by the squeeze rollers.

fork type of bowl there would be a danger of the wool becoming entangled and choking up the forks.

The forks are propelled by a cam as shown in Fig. 7, and move the wool forward in the liquor. The speed of the propelling motion is governed by the type of wool being cleansed, greasy and short materials need longer periods of immersion than the longer and cleaner wools. Wool should be disturbed as little as possible during this operation and propelling mechanisms which agitate the wool often produce felted materials.

A plunger or perforated immersion box is fitted to the first rows of forks on the harrow type of bowls. The object of this arrangement is to plunge the wool into the liquor as soon as it enters the bowl and prevent it from floating. The perforations allow the liquor to pass through the box and the wool underneath becomes saturated. The scouring operation,

therefore, starts with a possing action, which forces the liquor between the individual fibres.

Swing rake propelling motions are used for long wools. The rakes can be arranged to work in unison or sweep individually. Details of the movement of the swing rakes are shown in Fig. 8.

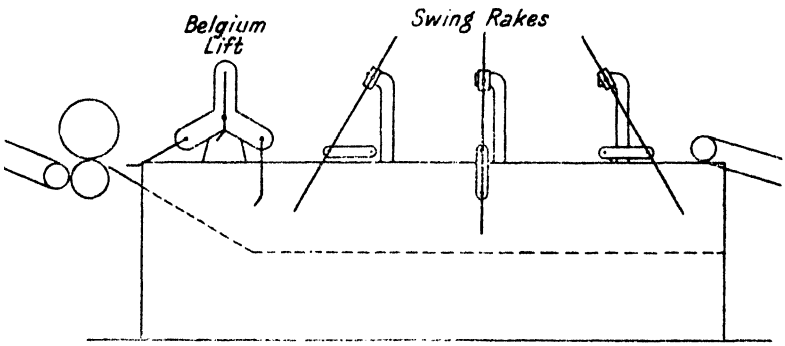


FIG. 8. SWING RAKE SCOURING BOWL. The wool is propelled by the rakes, which push it forward until it is seized by the Belgium lift and thrown into the nip of the squeeze rollers.

DELIVERY MECHANISMS

The wool is carried by the forks to the end of the bowl, but not near enough for the squeeze rollers to take it, so various devices are employed to place the wool in the nip of the squeeze rollers, such as (1) the swill-over, (2) the slide lift, and (3) the Belgium lift.

The swill-over is done by maintaining a constant flow of liquor, which swills the wool over the end of the bowl and washes it down into the nip of the squeeze rollers. Slide lift methods of wool delivery to the squeeze rollers consist of series of slides, which have spiked pins, and carry the wool to the end of the bowl. The Belgium lift works like a " grab " with a series of forks, which dip into the bowl, lift out lumps of wool and drop them into the squeeze rollers.

SQUEEZE ROLLERS

Wool is removed from each bowl by a pair of squeeze rollers, which assist in wool cleansing by squeezing out the dirty

liquor from the wool. The top squeeze roller is an iron one, which is covered with strong lustre wool known as roller wrapping, while the bottom roller is a brass one. Suitable surfaces are essential as these two rollers often exert a compression of several tons on the wool. If two metal surfaces were

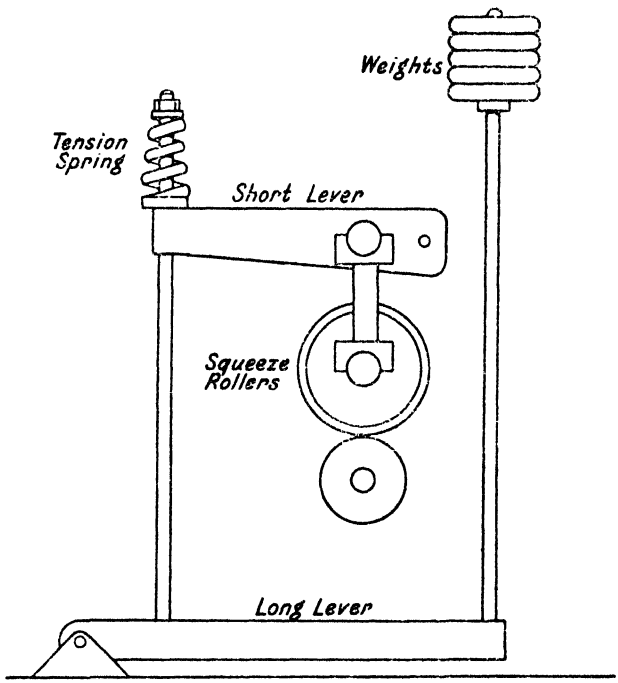


FIG. 9. SQUEEZE ROLLERS. These rollers have a system of leverage and pressure weights to enable a thorough squeeze to be given to the wool.

used, the wool would be cut in the attempt to wring out the water, so a wool covered top roller is used, which has a very resilient surface.

PRESSURE ON SQUEEZE ROLLERS

Pressure on the squeeze rollers of the scouring machine can be obtained in three ways : (1) by levers, (2) by springs, and (3) by levers and springs. When the lever method of applying pressure is used, two levers are employed at each

side of the machine. A long bottom lever and a short top one as shown in Fig. 9. Round iron weights which weigh about 40 lb. each can be placed on the top of the lever rod. When five weights are used in the early bowls, an initial pressure of 200 lb. is applied, but on the later bowls an initial pressure of 120 lb. is obtained by using three weights.

When the pressure is applied by the weights on the lever rod to the bottom lever, the force is conveyed to the top one, and by applying about 200 lb. in weight, a pressure of about $2\frac{1}{4}$ tons can be obtained. A top lever, 24 inches long, is fulcrumed at 4 inches from the end, and a bottom lever, 36 inches long, has a 9-inch fulcrum. Five weights are used, which weigh 40 lb. each, giving a total weight of 200 lb. The effect of the weights and leverage is

$$\frac{200 \times 36 \times 24}{9 \times 4} = 4800 \text{ lb. pressure on one side of the top roller,}$$

or about $4\frac{1}{2}$ tons pressure across the whole roller.

Escapement Motion

The wool-covered roller is maintained in contact with the brass roller, and driven by friction. Yet at times, large pieces of wool are wedged between the two rollers and temporarily take the top roller out of contact. This emergency is provided against by having a system of gearing in readiness, known as the escapement motion. When the top roller stops, a clutch wheel is put into gear, and instead of the roller being driven by frictional contact, it is moved by a positive drive.

Preparation of Scouring Solutions

Soap and alkali are made up into solutions in the mixing tanks, before being added to the scouring bowls. Mixing tanks usually measure 4 ft. × 2 ft. × 2 ft., and have a cubic capacity of 16 cubic feet to hold 100 gallons of liquid. Water weighs 10 lb. to the gallon, so a full tank holds 1,000 lb. of water. One hundred pound of soap is put into the tank, which makes a 10 per cent solution, or 1 lb. of soap to the gallon. When the scouring agents are made up in this way, it facilitates the measuring, because, say 50 lb. of soap is needed in the

liquor, 50 gallons of the solution can be measured out with accuracy.

Some firms arrange their mixing tanks above the scouring bowls, so that the liquors may be run to the bowls by pipes, which prevents the labour of carrying buckets of soap and alkali.

Changing the Solution

A set of bowls for scouring Merino wools made up as shown in Table XLII, should retain their scouring efficiency for about 8 hours, according to the amount of grease on the wool fibres. In scouring some classes of wool, the solutions may need changing about every four hours. When the solutions are thick and heavy with impurities, the liquor from the first bowl is run to the grease recovery plant, and the empty bowl should be given a thorough cleansing, by being swilled by a hose pipe until all the deposited grease and dirt is removed.

The liquor from the second bowl would then be injected into the first bowl. After the second bowl had been cleansed, the liquor from the third bowl would be injected to the second and so on, while the last bowl would be filled with clean water. The liquors would then be made up to scouring strength and the operation would continue.

Settlement of Liquor

Dirty liquor removed from the wool at the squeeze rollers, is purified in the settling tank. The liquor settles and, according to the law of gravity, the heavier impurities fall to the bottom of the tank, while the lighter ones float to the top. Purified liquor is pumped back into the feed end of the scouring bowl, and the flow of liquor is distributed across the width of the bowl by a cushion box.

Table XLII

Set of Harrow Scouring Bowls Suitable for Merino Wools

No. of Bowl	*Capacity in gallons*	*Soap in lb.*	*Soap in per cent*	*Alkali in lb.*	*Alkali in per cent*	*Temperature*
1	1,000	50	·5	50	·5	130°F.
2	900	24	·26	12	·13	125°F.
3	750	12	·16	6	·08	115°F.
4	600	6	·1	None		110°F.

TABLE XLIII

SET OF SWING RAKE SCOURING BOWLS SUITABLE FOR LUSTRE AND CROSSBRED WOOLS

No. of Bowl	*Capacity in gallons*	*Soap in lb.*	*Soap in per cent*	*Alkali in lb.*	*Alkali in per cent*	*Temperature*
1	1,000	30	·3	20	·2	120°F.
2	900	20	·22	10	·1	110°F.
3	750	5	·06		None	105°F.

SELF-CLEANSING BOWLS

Certain types of scouring bowls prolong the life of the liquor by removing the dirt from the bottom of the bowl at regular intervals. A spiral shaft runs down the middle of the bowl and carries right and left-hand screws, which bring the dirt to a central sump. This is flushed at regular intervals when about 10 gallons of dirty liquor is removed. A new supply of liquor is drawn from the second bowl, which is replenished from the third and so on, until at the last bowl the deficit is made up by an automatic water supply. The scour is maintained by new supplies of soap and alkali as required.

SUINT SCOURING

In some cases wools can be scoured without soap when the liquor is heated to 140°F., so that the wool fat is melted and runs like an oil. The liquor soon becomes heavy with the potash salts removed from the wool, and these assist in the removal of the dirt and grease. When this method of scouring is used, a centrifuge is employed in place of the settling tank.

MAINTAINING THE SCOUR

Constant attention is needed in maintaining the cleansing efficiency of a set of scouring bowls. Liquors soon start to deteriorate and need replenishments of soap and alkali to keep them up to the standards required. A newly-made liquor is not as good as one which has received the additions of the suint from the wool. A scouring liquor reaches its finest condition about an hour after the scouring starts, but from this point it starts to deteriorate. As more wool is cleansed, the liquor becomes further impaired and a good and effective liquor can

only be maintained by ameliorating the lowered scouring power by constant and regular additions of soap and alkali.

Various types of wool require replenished liquors at different intervals. Wools heavy in dirt and foreign matters tend to become stained when poor liquors are used, while wools heavy in grease are improperly cleansed with impoverished liquors.

When a liquor is heavy in dissolved impurities, such as sand and earth, the soap and alkalis of the liquor start to cleanse these instead of the wool. If the wool does not come out of the first bowl clean and well scoured, and additions of soap and alkali do not improve the dingy wool, the liquor should be run off and a new solution made. Large amounts of sand and dirt in a scouring liquor are broken up into small particles by the soap and distributed through the liquor instead of dropping to the bottom of the bowl. These tend to stain the liquor and tint the wool. No amount of soap or alkali can alter this liquor, the only thing to do is to let the liquor off and make up a new solution.

A second type of degenerated liquor is found in those wools which are heavy in grease. The test for the cleansing power of a soap is found in its capacity to reduce fats into suspension in the form of emulsions, and thereby break up the colloidal dirt from its assembled state and cause it to be distributed throughout the liquor. Gradually the heavier solid substances fall to the bottom of the scouring bowl in the form of a thick mud.

If the liquor contains emulsified grease and fat when the wool is washed down to the squeeze rollers at the swill over, the grease will be transferred to the squeeze rollers causing the wool to wrap round the greasy slivers of the top pressing roller. When this takes place the wool covered roller should be rinsed with alkali and then washed with soap until it is clean and free from grease.

SCOURING BOWL DETAILS

Speed of shaft	106 rev. per min.
Forks drum diameter	8 in.
Forks pulley	24 in.

SCOURING BOWL DETAILS

Forks driving wheel	18 teeth
Forks driven wheel	72 teeth
Sweep of forks	9½ in.
Squeeze roller drum diameter ..	20 in.
Squeeze roller pulley diameter	30 in.
Squeeze roller driving wheel	12 teeth
Squeeze roller driven wheel	90 teeth
Squeeze roller diameter	12 in.

Speed of Forks :

$$\frac{\text{(Speed of shaft)}\ 106 \times \text{(Drum)}\ 8 \times \text{(Driving wheel)}\ 18}{\text{(Pulley)}\ 24 \times \text{(Driven wheel)}\ 72} = 8{\cdot}8 \text{ rev. per min.}$$

$$\text{(Rev. of forks)}\ 8{\cdot}8 \times \text{(Sweep of forks)}\ 9\tfrac{1}{2} = 83{\cdot}6 \text{ in. per min.}$$

In a 24 feet scouring bowl, the wool will be propelled through the bowl in about 3½ minutes.

$$\frac{\text{(Length of bowl)}\ 24 \times \text{(Inches per foot)}\ 12}{\text{(Inches per min. of forks)}\ 83.6} = 3{\cdot}44 \text{ min. of immersion}$$

Speed of Squeeze Rollers :

$$\frac{\text{(Speed of shaft)}\ 106 \times \text{(Drum)}\ 20 \times \text{(Driving wheel)}\ 12}{\text{(Pulley)}\ 30 \times \text{(Driven wheel)}\ 90} = 9{\cdot}42 \text{ rev. per min.}$$

Surface speed of Squeeze Roller:

$$9{\cdot}42 \times 12 \times \pi = 355 \text{ in. per min.}$$

GREASE RECOVERY

In the interests of public health, scouring effluents must be kept out of the rivers and streams, and, in many cases, by-laws enforce a grease recovery before the liquors are permitted to be run into the public sewers. The amount of grease, dirt

and potash removed from wool in Great Britain is about 300 million pound per year.

Three methods of grease recovery may be used : (1) cracking scouring suds with acid or the magma process, (2) grease extraction by solvents, and (3) grease separation by a centrifuge.

Magma Process

The liquor from the scouring bowls is run into a large tank which will hold about 8,000 gallons. Then it is treated with sulphuric acid, which neutralizes the liquor and by turning the alkalis into salts, liberates the grease which gathers on the top of the tank. The distribution of the acid is assisted by stirring the liquor with long poles every few hours. Tests are taken, and when the alkalinity of the liquor has been turned to acidity, the acid water is let off, leaving the grease and dirt.

Magma grease or " seak " is run into a settlement tank with a tile drainage system. Layers of cinders and sawdust allow the water to drain away and also retain the grease. Draining in the settlement tanks takes from 12 to 15 days.

Pressing the grease to obtain the oil may be done in two ways : (1) by a " pudding press," or (2) by a filter press. When the pudding press system is used, the grease is cut up by manual labour into " puddings," which consist of pieces of grease 1 foot square and 6 inches in thickness. Each piece of grease is wrapped in a press cloth, and four are placed on each tray ready for pressing. The press used is like a huge oven and is steam heated to about 140°F. to melt the grease. When all the trays of grease have been placed like shelves in an oven, the press is sealed, and a powerful hydraulic ram compresses the puddings to squeeze the oil from them. A certain amount of water is removed with the oil under this treatment, but both the oil and water are caught in a pit under the press. The oil floats on the water and is retained, while the water is let off into the drains.

After the withdrawal of the ram, on opening the press doors, cakes of hard earthy residue are found wrapped in the press cloths. These are taken out of the press and emptied. The magma cake is sold to farmers who find it very useful as a manure. A recent analysis of the constitution of the magma

grease prior to entering the press, indicated that it contained 40 per cent of grease and oil, 37 per cent solid matter and 23 per cent water.

Filter Press

Many firms prefer the filter press, because of the great saving in manual labour. The press consists of a series of steel frames which have sheets of canvas stretched across them to hold the grease during pressing. Grease from the settlement tanks is heated to 150°F., which makes it thin enough to run like a sludge. The sludge is forced into the press by steam and a small tap at the bottom of each frame lets out the grease and water into a trough. When all the grease is removed, the pressure is taken from the frames and the magma cake is knocked out into a hole in the floor where it is gathered and removed.

Centrifugal Grease Recovery

Centrifugal grease recovery is used in many modern mills. The suds from the wash bowls are boiled to concentrate them, and a condensed water is recovered, which is ideal for re-use in scouring. After boiling, the concentrated fats are run into storage tanks and treated by the centrifuge.

The difference in the densities of the fats, potash and dirt assists the centrifugal action, the earthy matter is the heaviest and gathers in one layer. A second layer consists of water and potash, while the third layer contains the pure grease. Fatty matter recovered in this way is free from acid, and consequently has a better market value. The potash liquor is evaporated and placed in a calcining furnace to remove the organic impurities. The potash is collected and purified by crystallization.

Uses of Wool Fat

Wool fat or yolk, which is recovered from the scouring liquor, consists of fatty acid esters of cholesterol, but contains no glycerine so technically it is a wax. After a process of clarification by caustic soda and alcohol, a pure wax can be obtained, which is difficult to saponify, but can be emulsified easily.

This property commends its use in the medical trade, where it is used as a base for salves.

A crude form of wool fat is used as a dressing for leather goods ; for which it is very serviceable because it is the natural grease of the sheep's skin. Large amounts of this fat are used for shoe polishes, and a considerable quantity is used for lubricating machines, where a fluid oil would not give the results desired.

In the heavy woollen trade, crude wool oils known as " black oil " and " brown oil " are used as lubricants both in rag grinding and in re-working the shoddy and mungo yarns. Rope makers also use crude wool oil in the construction of ropes and bands. The waterproof nature of this fat can be utilized —after a chemical treatment—in the manufacture of waterproof goods.

Chapter XVIII

CLEANSING WOOL BY VOLATILE SOLVENTS

Impurities may be removed from raw wool by dissolving the grease by a solvent. The use and suitability of this method of wool cleansing depends upon the type of wool under treatment, and the requirements of the subsequent processes.

Solvents Available

Carbon-bi-sulphide was one of the first types of solvents used for removing grease from raw wool, but difficulties were encountered in removing the suint after cleansing. On being treated with alkali in the after washing operation the wool was turned a yellow colour.

Naphtha is a very effective solvent for the wool fat, but its highly inflammable nature is a disadvantage. An inert gas is used after the wool has been treated with the naphtha to prevent explosions. The gas serves a double purpose : (1) it propels the naphtha through the tanks, and (2) it ensures the removal of the naphtha from the wool before the air is admitted into the tank.

System of Operation

The grease removal takes place in underground tanks or kiers, which are 10 feet deep and 6 feet in diameter, with a holding capacity of 300 cubic feet, and can take 12 packs of wool at a time. The wool is placed in a galvanized cage which just fits into the tank, and lowered into position by a small crane. Three flushings of the solvent are given to the wool, the first flush is done by naphtha which has been used twice before ; the second flush by slightly soiled naphtha and the final flushing is done by a clean solvent. About 1,500 gallons of solvent are needed for each flush.

Compressed inert gas is passed through the tank to remove

the naphtha. This is done for three reasons : (1) owing to the highly inflammable nature of the solvent which may cause an explosion if atmospheric air was admitted into the naphtha-ladened tank ; (2) to allow the workmen to remove the wool ; which would not be possible if the naphtha remained ; (3) all traces of the solvent should be removed from the wool, because if this was allowed to remain until the next operation it would cause the wool to be discoloured.

Gas Control

The discovery of an inert non-flammable gas made solvent wool cleansing a commercial possibility. The naphtha is controlled and propelled by the gas. It would be a very dangerous practice to pump and compress a highly-explosive agent of this nature, so this difficulty is overcome by compressing the gas and controlling the naphtha by its movement.

Several reserve or " trap " tanks which contain the partly used solution are employed. When the wool is placed in the flushing kier, the compressed gas is forced into the first trap tank, and the valves opened to pass the naphtha through the wool. On completion, a second flushing is given from the second reserve tank in the same way, while the third flush is done by clean naphtha from the distillery, propelled by a charge of gas. After all the flushings are completed a supply of gas is passed up the kier to ensure that all the solvent has been removed.

Recovery of Solvents and By-Products

The grease-ladened solvent is taken to the distillery where the naphtha is recovered, and a crude lanolin is obtained from the wool fat. The grease recovered from alkaline scouring is always in a dirty state, because it is removed from the wool along with the dirt, but the grease removed by a solvent is clear, and commands a better price. There is a certain amount of solvent lost each time the grease is recovered, but this does not exceed two or three per cent. The initial cost of the solvent is expensive, but the costs of replenishments are very small.

On being removed from the flushing kier, the wool is passed through three scouring bowls, which contain tepid water at

about 80°F., to remove the potash and dirt. A gentle agitation in this liquor allows the sand and dirt to fall to the bottom of the bowls, while the alkaline nature of the potash effects its own removal and washes out the dirt. When these bowls are started up about 25 lb. of potash is placed in the first bowl to remove the suint. A further addition of alkali is unnecessary, because a sufficiency of potash is removed from the wool. The liquor is passed through a settling tank to allow the dirt to fall to the bottom. It then is run into a retort, and allowed to evaporate in large shallow pans. A greater amount of potash is obtained in this way, than by desuintage.

Advantages of the Solvent System

The lofty open nature of degreased wool is due to the solvent passing through the wool, and not the wool passing through the liquor. By this method matted fibres and ropey wools are prevented. High counts can be reached with wools treated by solvent scouring because the fibres are cleansed without being impaired. A great advantage in solvent cleansing is that the wool is not dried. Solvent cleansed wools should be oiled before carding, because the volatile agents remove all the oil from the wool, and the fibres have a harsh handle which would cause roughness.

Large insurance premiums have to be paid where solvent scouring plants are in use, owing to the great amount of highly explosive and inflammable solvent used.

Comparison With Alkaline System

The solvent system cleanses wool by destroying the grease, while the alkaline system removes the grease by emulsification. In the solvent system the grease is removed alone, while in the alkaline it is taken away together with the suint and dirt. By the volatile method both the grease and the potash can be recovered, but many firms using the alkaline system have found that it is cheaper to lose the potash salts in an alkaline scour rather than attempt to recover them prior to scouring. When large bulk lots are to be cleansed, the solvent system is very economical, but for smaller amounts of wool the alkaline system can be used with advantage.

Chapter XIX

WOOL DRYING

A Drying process is necessary after scouring to remove the excessive moisture retained by the wool. The property of retention of moisture by wool is known as its hygroscopic nature.

Principles of Wool Drying

The principles of wool drying involve a consideration of the physical actions of water. The removal of water from wool can only be accomplished by pressure, which may be applied in two ways: (1) mechanical pressure, (2) atmospheric pressure. Mechanical pressure obtained by squeeze rollers and hydro-extractors does not take all the moisture from the wool, but removes from 70 to 80 per cent.

Atmospheric pressure will dry more moisture out of wool than mechanical pressure. Should some wet wool be allowed to remain in the open air for a specific time, a drying action would take place, and the moisture held by the wool would be removed by the normal pressure of the atmosphere. The application of heat accentuates the atmospheric pressure and causes a greater amount of moisture to be removed.

Moisture Content

Wool in a normal atmosphere retains a certain percentage of moisture which varies according to the condition of the material and the state of the atmosphere. Raw and scoured wools have a standard regain of 16 per cent, tops and worsted yarns, 18¼ per cent, and noils have a 14 per cent regain. Four stages exist between wet and dry wool (1) wet, (2) damp, (3) normal, and (4) dry. A wet wool is one which retains an excessive amount of moisture without any tendency for the water to run. Damp wool holds moisture far in excess of

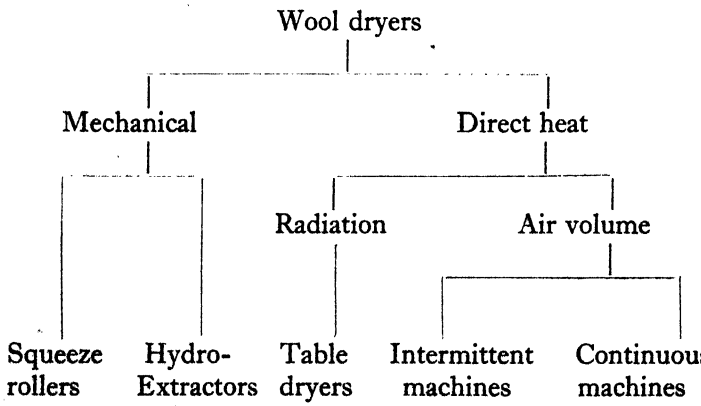
normal, but is neither wet nor dry. As a rule, wool in a damp state will hold 36 per cent of its weight of water. Mechanical methods of wool drying are unable to dry wool beyond this stage. Worsted cards are fed with damp wool because wool fibres open out better and straighter when they are fed into the worsted cards in a damp condition.

Absolutely dry wool is called " bone dry." To reach the bone dry condition, wool has to be subjected to both heat and atmospheric pressure to remove every trace of moisture. Bone dry wool is taken as the basis for moisture regain, and all moisture content tests are worked from this basis.

A sample of wool is dried until all the moisture is removed and the wool is absolutely dry. Should this wool be brought back to a normal atmosphere it would regain 16 per cent of its weight in moisture in about three hours. The percentage of moisture recovered by wools in this way is known as the " regain percentage " and forms an important factor in the sale of wools, tops, and yarns, as the basic selling weights are obtained from the absolute dry weights plus an agreed amount of regain.

Wool Drying Machinery

Two kinds of dryers are used : (1) mechanical and (2) direct heat, these may be grouped in the following way :



The use of squeeze rollers for drying wool is described in Chapter XVII on Wool Scouring, which will be found on

page 188. The second type of mechanical dryer is the hydro-extractor.

The Hydro-Extractor

Wool is placed in the basket of the extractor and revolved at a high speed, which causes a centrifugal action to take place. The excessive moisture drains through the perforations of the basket. This type of machine entails a large amount of manual labour.

Drying by Direct Heat

When dry wool is needed, forced vaporization has to be produced in a drying machine. A temperature of 180°F. is injurious to wool, so that if the heat goes beyond this point irreparable damage will be done to the wool fibre, because the internal moisture of the fibre would be converted into steam, and crack the outer surface of the fibre.

Direct heat dryers can be divided into two classes: (1) radiation dryers, and (2) air volume dryers. Table dryers are the radiation type of drying machines. The wool is placed on a wire mesh table over some steam pipes, and is dried by radiation. This method of drying is slow, costly, and irregular, because the wool is not dried evenly.

Hot Air Dryers

Hot air dryers usually are continuous machines, which take the wool into the machine on a lattice, dry it and bring it out again. A current of hot air is passed into the dryer and on coming into contact with the wool, causes evaporation to take place, because the water in the wool has a greater avidity to the higher temperature of the hot air. Table XLIV shows details of the moisture carried by the air in varying temperatures. As the temperature rises the power of carrying moisture is extended until it reaches the steam limit. At 212°F hot air will carry 326 grains of moisture to the cubic foot, while at 75°F. air will only hold 9·4 grains of moisture per cubic foot. The volume of the hot air also is an essential part of the wool drying operation, because the pressure of the hot air should be sufficient to penetrate the wool and not dry the outer parts only.

TABLE XLIV

MOISTURE CARRIED BY AIR IN VARYING TEMPERATURES

Temperatures in Degrees Fahrenheit	*Weight of moisture in grains per cubic foot of air*
25	1·5
30	1·9
40	2·9
50	4·1
55	4·9
60	5·8
65	6·6
70	8·1
75	9·4
80	11·1
85	13·3
90	15·0
95	17·3
100	20·0
125	39·9
150	82·0
175	153·0
200	260·0
212	326·0

LATTICE DRYERS

The lattice dryer is one of the best types of dryers, and is shown in Fig. 10. Wool is fed on to a lattice and taken to the top tier, and carried by lattices three times across the drying area. The lattices which carry the wool are supported in the middle and driven from each end. Hot air is obtained from the heater below the dryer and conveyed to the lattices. Three methods of air currents are used : (1) a straight current which goes the same way as the wool, (2) a reverse air current which passes through the machine in the opposite way to the wool, and (3) separate air currents for each tier.

When a straight current dryer is used, the driest air comes into contact with the wettest wool and causes an evaporation to take place at the beginning of the operation. In this way

moist air is carried through the dryer and in the later tiers the temperature of the air is reduced by carrying the moisture, so that its drying properties are considerably reduced.

Reverse air currents cause the driest air to act on the driest wool, so that the hot air comes into contact with the wool as it leaves the machine. In these cases, the most useful air is not employed until the drying operation is practically finished.

When separate air currents are used for each tier, the wet

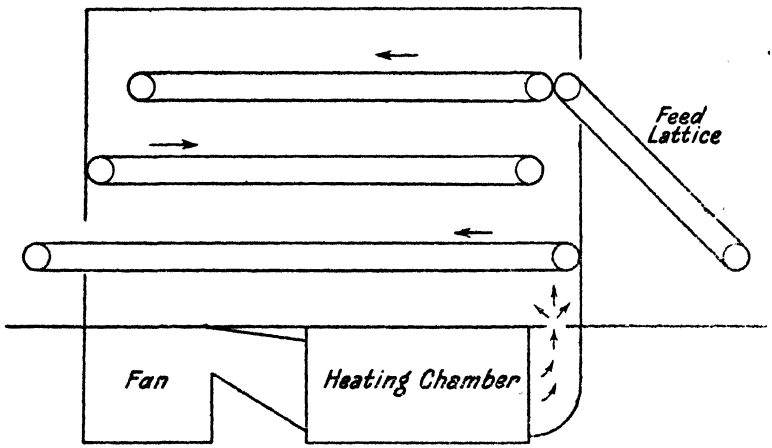


FIG. 10. LATTICE DRYER. The wool is fed on to the top lattice and is carried forward, while the second lattice brings it backwards and the third lattice carries it out of the machine.

wool is fed on to the top tier and the moisture removed is allowed to escape into the atmosphere. The hot air from the bottom and middle tiers is returned to the heater and used again. In this way the most economical use of hot air is effected, and the wool receives different supplies according to the requirements at each stage of drying.

PNEUMATIC CONVEYOR

A type of wool dryer which is very popular in worsted factories is the pneumatic conveyor. The wool is delivered from the squeeze rollers of the scouring bowl and carried to the cards by a large iron tube. In many cases these tubes are

24 inches in diameter. The material is propelled through the tube by a current of hot air, which serves a dual purpose: (1) it propels the wool from the scouring bowls to the cards, (2) it dries the wool as it passes along. Wools dried in this way are delivered to the card in a natural, open condition, and are the least damaged of any type of dried wool.

Details of Dryer

Shaft	120 rev. per min.
Drum diameter	20 inches
Pulley diameter	24 ,,
Gear wheel	24 teeth
Large stud wheel	120 ,,
Small stud wheel	30 ,,
Lattice end wheel	120 ,,
Diameter of lattice	9 inches.

Speed of Lattices.

$$\frac{\text{(Shaft) } 120 \times \text{(Drum) } 20 \times \text{(Gear wheel) } 24 \times \text{(Small stud wheel) } 30}{\text{(Pulley) } 24 \times \text{(Large stud wheel) } 120 \times \text{(Lattice end wheel) } 120} = 5 \text{ rev. per min.}$$

Surface speed of Lattice

$$\underset{\text{(Speed of lattice)}}{5} \times \underset{\text{(Diameter)}}{9} \times \pi = 141{\cdot}43 \text{ in. per min.}$$

The dryer is 5 yards long with 3 tiers, so that its drying space is 15 yards. The wool passes through the dryer in 3·81 min.

$$\frac{15 \times 36}{141{\cdot}43} = 3{\cdot}81 \text{ min.}$$

Chapter XX

BURRING AND CARBONIZING

Certain types of wool contain large amounts of burrs, seeds, and other vegetable matters, which are acquired by the wool during its growth on the sheep's back. British wools often have straw, twigs and thorns in them, while wools from Australasia and South America contain large numbers of the prickly seed vessel of the burr bush. These are commonly known as " burrs " and the fleeces which contain them are called " burry."

Nature of Vegetable Matters in Wool

The burr bush has a deep root and continues to thrive when all other vegetation has been scorched. In many cases flocks of sheep have to rely on the burr bush for food in the dry season.

Many faults in yarn manufacture are caused by the presence of burrs. They may cause the pins of the cards and combs to be damaged, while burrs entangled in the sliver during the drawing and spinning operations cause uneven drafting which makes twitty yarns. In dyeing, these vegetable matters do not absorb dyestuffs in the same proportion as wool and show up as defects.

Methods of Removal

Burrs and vegetable matters can be removed from wool by two methods : (1) mechanical and (2) chemical. The mechanical method of burr removal is called " burring " and is done by using machines which remove the burrs from the wool. Burring machines cause a certain amount of fibre breakage and waste, because some of the wool clings to the burrs.

A second method is to remove the burrs by chemical reagents, and is known as the carbonizing process. When this method

is used, no waste is made, and the process takes place without breaking the fibres. Improper carbonization may diminish the felting and spinning properties of the wool.

Choice of System

The type and size of the burrs determine the method of treatment. Small burrs which are few in number could be removed by the burring attachments on carding machines. Small amounts of large burrs may be removed by a burring machine, while the carbonization process can be used for removing large amounts of either large or small burrs.

Principles of Carbonization

Carbonization is a chemical process which reduces the vegetable matters in wool to carbon compounds and removes them. This method of burr removal is more effective than the mechanical methods, because every trace of vegetable matter is removed.

Methods of Carbonization

Two methods of carbonization are in use : (1) the wet or steeping system, and (2) dry carbonization or the vaporizing method. Burry wools are treated on the wet system, while dry carbonization is used for extracting wool fibres from rags.

Wet Carbonization

In carbonizing wool or noils six operations are used : (1) steeping, (2) excess acid removal, (3) drying, (4) crushing, (5) shaking, and (6) neutralizing.

The first operation consists of steeping the wool in an acid bath for a short time. The wool should be clean, because wool which contains grease does not yield the best results as the suint tends to neutralize the acid. In construction the steeping bowls are similar to those used in scouring as described in Chapter XVII. Owing to the steeping solution being an acid, special precautions have to be taken, as it will readily attack the iron parts of the machine and cause corrosion. The bowls are made of wood, lined with lead and the forks also are immune from acid attacks being made of a lead alloy.

The time required for steeping the material in the solution varies according to the amount of vegetable matter present in the wool. Fifteen to twenty minutes is a safe period which gives the vegetable matters time to absorb a sufficient amount of acid without damaging the wool. Vegetable matters have a greater avidity for acids than animal fibres, so that in the acidifying tank the acid permeates the vegetable matters to a larger degree.

Excess Acid Removal

Wools and burrs which have absorbed the acid then are passed through the squeeze rollers. It is essential to remove as much acid as possible from the wool before passing it into the dryer and yet give the burrs a full concentration which will ensure their removal. The excess acid can be removed in two ways. One method is to use a second set of squeeze rollers and give the wool an extra wringing. A second method is to place the wool into a lead-lined hydro-extractor and remove the excess acid in this way. There is more acid removed by the hydro-extractor, but this method involves extra manual labour, while the double squeeze is a continuous method and prevents the wool from becoming " ropey " by much handling.

Drying or Carbonization

The actual reduction of the burrs to carbon compounds takes place in the drying machine. Great heat is used which concentrates on the acid, carried by the burrs. The hydrogen and oxygen are evaporated quickly so that the burrs become frail carbon compounds. A good practice is to divide this stage of the process into two parts : (1) a drying at about 180°F. which dries the wool to fix the acid on the burrs, and (2) a final charring in a second dryer for a very short time with a temperature of 212°F.

Burr Crushing

Heavy crushing rollers easily break the brittle carbon compounds. The crushing rollers have usually 3 or 4 pairs of weighted rollers, each pair moves at a greater surface speed

than the previous pair, and drafts the wool after each crushing. The rollers are set apart so that the carbon pieces may fall between them into the dust pan.

A vigorous shaking is given to the wool after crushing to remove all trace of the carbon. A willow is used which beats the wool against a grid by a revolving cylinder, and ensures a complete carbon removal.

Neutralizing

Acid taken up by the wool must be removed, because it would be detrimental in the later processes, and would cause serious defects. Therefore, a neutralization process is given by passing the carbonized wool through a set of three bowls, which are built on a continuous principle like a set of scouring bowls. The first machine contains a supply of warm water at about 85°F. and is intended to cleanse the wool from the carbon dust which it has gathered in the willow. The second bowl is the neutralizing bowl proper; the solution used is about a 2 per cent solution of carbonate of soda, which forms the remaining acid into a salt. A third bowl is necessary to wash away all traces of acid or alkali and render the wool free from every type of impurity. This bowl contains a weak soap solution which cleanses the wool.

Dry Carbonization or Extracting

Rags which contain wool and cotton are carbonized to destroy the cotton and recover the wool. The system used in this case is the dry or vapour method of carbonization and consists of destroying the vegetable fibres by hydrochloric acid vapour. The wool fibres which remain after this operation are known as extract.

Various amounts of vegetable fibres exist in the rags which are to be treated, so a preliminary sorting is necessary. The material is grouped according to the length of treatment needed. Rags with 50 per cent of cotton are given a longer treatment than the rags which have only 10 per cent. of vegetable fibre to destroy.

The principle underlying extracting is the same as that of carbonizing burrs in raw wool, but in the case of rags the acid

and heat are combined, whereas by the wet method they are applied at different stages.

It is necessary to remove all the vapour from the rags prior to carbonizing, because vapour interferes with the action of the acid vapour and prevents effective treatment.

The carbonizing box is a large air-tight box or cylinder which holds the rags. When these have been put in, the opening is screwed down and the box revolves. Acid vapour heated to 180°F. is admitted through a hollow trunnion. After the rags have been shaken and turned over at the rate of four revolutions a minute for two or three hours they can be removed. A test usually is taken prior to the rag removal to ensure that the vegetable compounds have been reduced to carbon. In cases where carbonization has not been complete, it may be necessary to prolong the treatment for another hour or so.

Before the box can be opened to remove the rags, the vapour supply must be stopped and the acid vapour removed from the chamber. The clearance of gas is done by suction fans, which draw out the acid vapour. On being taken out of the box, the rags are cooled and shaken by a cage duster. After a considerable cooling the rags are beaten vigorously in a rag shaker, which causes the brittle carbon compounds to fall away as dust. The carbonized material then is taken to the rag-grinding machine to be torn up.

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