yellowish cast and the milling capacity poor. Vegetable matter is often present in the form of burrs in Australian, New Zealand, and South American wool noils, which must be removed by carbonising, a process which leaves the fibre harsher still in handle. The best qualities of noils are used in the hatting trade, for blankets, and for fine woollens. The lower qualities are blended with mungo, shoddy, etc., for low woollens, and are also used in carpets, their brightness here being a valuable characteristic.

Mohair noils, owing to double and treble combing (with the idea of producing an absolutely uniform top), are frequently so long as to warrant a short top being made from them. These noils are bright and lustrous, soft, and silky, but have neither milling capacity nor marked spinning capacity. They are used in their softer and finer form with other re-manufactured materials in cheap woollens, and they are also made into carpet yarns. Others are used as stuffing for mattresses.

Mungo.—Mungo results from the grinding into a fibrous condition of hard worsted and woollen cloth rags and clippings. The quality varies from medium to fine, but owing to the cloths from which it is made being firmly built it naturally follows that there is considerable breakage of fibre in the grinding process, and, as a result, the mungo produced is not suitable for the finest woollen spinning. The colour naturally varies in accordance with the materials from which the mungo is produced, advantage being taken of this in producing both solid and mixture "natural" shades. The milling capacity is frequently quite satisfactory.

There are two types of mungo—namely, the "new" and the "old," taking their title from the fabrics from which they are produced, the new being naturally the most valuable. Both these materials are made into very cheap fabrics, being blended with wool, cotton, etc., for the production of yarns on the woollen principle.

Shoddy.—This, in a sense, is only another name for mungo; but it is usual to refer to the material produced from soft goods, such as stockings, etc., made in the first instance from the longer wools, as "shoddy." Upon the whole, the shoddy fibre is longer and coarser than the mungo fibre. It is usual to make various qualities and colours, and also to produce shoddy from new and old rags. The milling properties of this material are indifferent, as it partakes, of course, of the qualities of the original material from which the shoddy is derived. Its uses are similar to those of mungo, but the resultant fabrics are naturally of a somewhat coarser character. They are also cheaper.

Processes in the Production of Shoddy and Mungo.—The processes to which rags are submitted which are to be made into shoddy and mungo are, first, dusting; second, sorting; third, seaming; fourth, oiling and grinding.

Dusting is necessary to free the rags from deleterious impurities. If necessary, the rags must be disinfected, but it is curious to note there is no recorded case of any disease having been conveyed by rags.

Sorting of the various colours of rags is undertaken to enable standard mixture colours to be produced without the necessity for stripping and re-dyeing.

Seaming is done with the idea of extracting every bit of hard cotton thread from the material, for if such are left in it they cause breakage of the yarn during the spinning operation.

Oiling and grinding consist, first, in lubricating the rags to prevent, as far as may be, fibre breakage, and secondly in a teazing out of these rags, fibre by fibre, until the whole of the rags are reduced to a fibrous mass.

The following description of a grinding machine will render the process of grinding easy of comprehension.

A large cylinder is employed round which are working a series of small cylinders, both large and small cylinders being clothed with "garnett" wire or blades with saw-like edges. The direction in which the teeth of these various rollers work, and the speed and the closeness of their setting in regard to each other, are such that when the tightly constructed material is fed up to them it is first torn strand from strand and afterwards teased out fibre from fibre with comparatively little breakage, and the various movements of the rollers yielding this are also instrumental in carrying the material through the machine and delivering it in the form of a broad open web of wool. Further particulars of this machine will be found in the section dealing with woollens.

Extract.—Extract is a type of material similar to shoddy or mungo, but it takes its name from the fact that it is made from wool which has been extracted from a cotton and wool cloth by a process of carbonisation, or "extracting," as it is termed. Thus fabrics made of, say, cotton warp and worsted weft are first subjected to a carbonising treatment, by means of which the cotton is pulverised, leaving the worsted weft more or less unaffected. This worsted weft is then ground up into a fibrous mass which receives the name of "extract." This material is, naturally, harsh in handle, owing to its having passed through the carbonising process; in other respects, it largely partakes of the characteristics naturally to be expected in the material from which it is originally produced. It is

COMPARISON OF RE-MANUFACTURED MATERIALS

Material	*Sources*	*Colour and Lustre*	*Fineness*	*Length*	*Handle*	*Appearance*
NOIL .	Combed wool	Vari - coloured; the longer noils lustrous	1·400—1·1500 in.	½—2½ in.	Fairly soft (long noils) and very soft (short noils)	Open and flakey
MUNGO .	"Hard" Woollen and Worsted cloths	Vari - coloured, non-lustrous	1·800—1·1800 in.	¼—¾ in.	Soft and very soft	Partially matted and thready
SHODDY	"Soft" knitted goods	Vari - coloured, lustrous	1·600—1·1200 in.	½—2 in.	Soft	Fairly open and fluffy
EXTRACT	"Hard" "Union" Goods	Vari - coloured, not very lustrous	1·800—1·1500 in.	¼—¾ in.	Harsh	Partially matted and thready
FLOCKS .	Worsted Goods	Vari - coloured, sometimes lustrous	1·400—1·1500 in.	¼—½ in.	Fairly soft	Curly and fluffy

used in the low woollen and tweed trade, being, as a rule, blended with better materials.

Flocks.—There are two kinds of flocks, namely, finishers' flocks, and flocks produced from carbonised burr waste. The finishing flocks are produced in the milling, shearing, and raising processes, and as a consequence are always short in fibre; they vary also in quality according to the fabrics from which they are produced. The burr waste mentioned is also of short length, and only of fair milling and spinning capacity. The best flocks are used for blending materials in the production of the better low-class woollens and tweeds. They are also used as a filling material for certain fabrics, being employed during the process of milling. In the case of the lowest class of all this is used for embossed wall-papers.

A comparative list of the re-manufactured materials will be found on p. 85.

GROWERS' AND USERS' TERMS

Ram : A male sheep.

Ewe : A female sheep. Ewes' wool is finer than that of rams of a corresponding breed.

Lamb : Applied to sheep from time of birth to time of weaning, say until seven months old. Lamb's wool is glossy and slippery, difficult to comb and spin.

Hog (or Hogget) : Given to sheep from time of weaning to that of the first fleece being shorn. "Hogs' wool" is applied to first full fleece. The point of the wool tapers; if the staple be drawn, both this and the neighbouring ones are disarranged. Such wool is finer and brighter than subsequent clips.

Wether: Wool of second and succeeding fleeces. The staple ends are blunt, and the staple can be drawn out cleanly.

Tup: A term originally of Scotch application, given to male sheep. Much used in Yorkshire.

CHAPTER IV

COMMERCE IN WOOLS AND HAIRS

History of the Commerce in English and Irish Wools.—This subject has been treated at great length by writers such as Luccock, Youatt, Bischoff, James, and others, and more recently has claimed the attention of Mr. J. H. Clapham, who at the time he published his work on " The Woollen and Worsted Industries " was Professor of Industrial Economics in the University of Leeds; thus, as he was right in the heart of the wool industry and, further, was able to turn up certain Government Blue Books, he was able to produce a work of the utmost value. The following brief notes are therefore all that are called for here.

Britain was renowned for wool from the earliest times, and it seems probable that the oldest breed was a short wool, which was employed in the first English factory at Winchester. Long wools were no doubt produced as the demand for the quality of length increased, and so well was the demand met that the wool trade of England developed to very great proportions. Thus, prior to 1870, it may be said that prices were good and the industry prosperous, this especially being the case with reference to long wools. Of late, however, the development of the Colonial trade has had a marked influence upon English wool as a raw product. This is well illustrated in Fig. 6 on p. 12, in which the production of English wool from 1800 to 1908 is shown graphically. In fact, it may usefully be considered that now, instead of dealing in English wool, the dealing is in English sheep, which, transported to other congenial climes, naturally result in the production of wool which competes seriously with the English clip.

MOVEMENT OF WOOLS FROM WOOL-GROWING CENTRES TO MANUFACTURING CENTRES

The wool-growing centres are the Home Counties of England, Australasia, the Cape, South America, Continental, and some few other foreign countries. In each case some special procedure is adopted. Thus, for instance, while wool grown on the Australasian coast may be washed, it is obvious that such can rarely be the case with wools grown up country, where there is a shortage of water. A few notes on the procedure in each case will here prove useful.

A. **Home Grown Wools.**—With these buying is usually done direct from the farmer by the wool stapler, or the wool may be bought at the local fairs, of which a list will be found on the next page. Under these conditions the terms are cash, the buyer provides his own sheets, and the wool is weighed by the pound or, more usually, by the tod of 28 pounds. In Ireland there is a good deal of interchange of commodities, the storekeeper often advancing stores in return for wool, and thus acting as a "go-between" for the wool-producer and the wool-user.

If wool is bought direct from the wool-grower it is collected by the railway company's wagons and forwarded by rail to the manufacturing centre. If bought at an auction sale, the wool is also taken charge of by

LIST OF BRITISH WOOL SALES AND FAIRS

June	Leith
	Market Drayton
	Wellington (Salop)
	Colchester
	Shrewsbury
	Oswestry
	Nottingham
	Ipswich
	Lichfield
	Sleaford
	Bury St. Edmunds
	Loughborough
	Leicester
	Glasgow
	Huntingdon
	Rugby
	Wellingboro'
	Northampton
	Melton Mowbray
July	Gloucester
	Cirencester
	Guildford
	Stratford-on-Avon
	Reading
	Blandford
	Andover
	Dorchester
	Leith
	Alton
	Basingstoke
	Chichester
July	Birmingham
	Winchester
	Newport (I. of W.)
	Swindon
	Wantage
	Perth
	Salisbury
	Hungerford
	Newbury
	Wallingford
	Didcot
	London (commences)
	Devizes
	Aylesbury
	Marlborough
	Henley-on-Thames
	Lewes
	Ipswich
	St. Boswell's
	Liverpool (commences)
	Glasgow
	Milnathort
Aug.	Kelso
	Leith
	Perth
Sept.	Glasgow
	Bristol
	Liverpool (commences)
	London ,,
Nov.	Liverpool ,,
	London ,,

the railway company's representative and forwarded to the stapler's order.

B. **Colonial Wool.**—**Australasian.**—Until recent years buying and selling was usually carried on in London, but to-day a considerable business is done at the various centres of production, and the tendency is undoubtedly for this course of procedure to extend. This is largely due to the increased demand for wools on the part of the United States, France, Germany, and Japan. Wool bought for any of these countries is most reasonably shipped direct, although it is really most curious to note how London or even Liverpool may be employed as the centre for distributing wool, in some cases the wool being actually sent to the place whence it originally came. A factor of importance in the development of the direct trade is that wool-growers realise more quickly on their product, although as against this it has been urged that the grower will realise better by waiting for the London sales. This has undoubtedly been true many times of late, but it is questionable whether the better price realised has been accidental or is a stable possibility.

The regular selling season extends over six months of the year—that is, from October to March; and the tendency at present seems to be to lengthen this. Of the Australian clip, 70 per cent. is sold in Australia, and of the New Zealand clip about 40 per cent. is sold in New Zealand. Selling is very largely in the hands of brokers (as, for example, Dalgety and Co., Goldsbrough, Mort and Co., The Australian Land and Finance Co., etc.), who regularly advance money to growers on the security of the clip. The following are the chief selling centres in Australasia:—

Sydney	Brisbane	Christchurch
Melbourne	Wellington	Timaru
Geelong	Napier	Invercargill
Adelaide		

Irrespective of charges of interest when the clip, as is very often the case, is mortgaged to a broker, the selling brokers receive ½ per cent. commission.

From wool stations in reasonable proximity to railways transport by train is universal, while from inland stations horse, bullock, and camel teams convey the wool to the nearest railway connection. Under these latter conditions wool is often weeks on the road, and is consequently relatively dearer. In some few instances steamboats are available. In all cases, however, the destination is, naturally, the selling centre near the port from which shipment to the manufacturing centre takes place. At this selling centre the wool is warehoused and there may be inspected by the selling brokers and buyers.

Shipment—by sailing-boat or steamship—to the manufacturing centre is under the owner's or purchaser's direction. Sailer freightage charges vary from $\frac{1}{16}$d. to $\frac{1}{8}$d. per lb., this being less than the steamboat charges, no doubt to compensate for the longer time required for delivery. The extent to which sailer freight is employed thus naturally depends upon the state of the market, and also on the rates ruling for steamboat. Steamboat charges are about $\frac{1}{2}$d. per lb. for greasy, and $\frac{5}{8}$d. per lb. for scoured wool, but these again vary according to demand. Insurance is effected on what are termed " lots," the rate being $\frac{3}{8}$ per cent. (7s. 6d. per £100) on declared value per broker's invoice, plus 10 per cent. for profit which it is assumed will be realised.

Prior to shipment wool is " dumped "—that is, the bales are compressed, as space on the boat is, of course, important. The removal of the wool for this purpose from the broker's warehouse is possible the day after payment is made.

Direct Trade with London.—Considerable quantities of wool (some of which may have been sold in Colonial centres) are sent to brokers in London to be brought under the hammer at the Coleman Street Sale Room, E.C. Six series of wool sales are held every year, of which the following are the approximate dates :—

January 19th	May 4th	September 21st
March 9th	July 6th	November 23rd

As the Antwerp wool sales are held a fortnight prior to those of London, buyers from the Continent, America, and from all other centres of the textile industry are to be found in attendance. The wool to be sold is open to inspection at the wharf warehouses the morning of the sale, when the buyers have every opportunity of estimating the quality, sinkage, tear, etc. Selling commences each day in the sale room at Coleman Street at 3 p.m., ordinary bulk lots being sold first and "star" lots—that is, three bales and under—later. At these sales pandemonium reigns supreme, many buyers making the same offer without any individual expressing willingness to advance the necessary halfpenny, which is the only advance accepted on wools over 8d. per lb. The auctioneer's task is proportionately great in distributing lots amongst the aggressive bidders, as he naturally wishes to give satisfaction by an equitable distribution. Bids are only accepted from those buyers who have seats allotted to them, such allotment being for a period of years. Seeing that the lots offered total up to very large weights, small dealers are practically debarred from buying save through buying brokers, to whom a commission of about ¼ per cent. is paid.

The terms on which purchases are accepted are net cash within fourteen days, an arrangement which necessitates an allowance for difference between trade terms being made by buyers on material as sold, say in Bradford, where terms are cash within fourteen days less discount at 5 per cent. for four and a half months, or 4½d. in the £. This is usually met by allowing ½d. for wools under 1s., 1d. for wools under 1s. 6d., and 1½d. for wools costing up to 2s., and so forth.

Carriage from London to Consuming Centres.—Wool may be distributed from London to Bradford or other manufacturing centres either by rail or steamboat. The Bradford rates are :—By rail, 30s. per ton ; by steamboat (Hull and Goole), 22s. 6d. per ton. Railroad transport gives advantage in speed—usually one day or night as against four days. Thus, wool bought, say, on a Wednesday and invoiced by the broker next day, may be collected by the railway company's carriers on the Thursday evening, railed to Bradford by Friday morning, and delivered to the comber by noon of that day, thus allowing in special cases a sample ball of the top to be exhibited on the market by the following Monday.

C. **Cape Wools.**—A fair proportion of Cape wool is usually sold in London. As would be expected, however, local storekeepers in South Africa purchase wool from growers and sell it at Port Elizabeth and other distributing centres to European representatives of manufacturing firms, who ship it direct.

D. **Foreign Wools—South American.**—South American wools are sold in Monte Video (fine wools), Buenos Ayres (cross-bred wools), and Bahia Blanca (cross-bred wools). In Buenos Ayres, for example, wool is exhibited in the Market Hall and purchased in the rough, as it were, and sometimes forwarded to European centres for sorting, even though it may be returned later to the United States. Upon the whole, however, buying is much on the same lines as already described, but the unit weight is 10 kilogrammes and payment is in paper dollars. A good deal of South American wool is sold at the Antwerp sales, of which six are held annually, just a fortnight prior to the London sales. So-called River Plate and Punta wools are sold in London, while some proportion of South

American wool is also sold at Liverpool, of which sales the following are the approximate dates * :—

January 26th	May 25th	September 28th
March 23rd	July 27th	November 30th

Some European buyers buy direct from the growers, so that the South American wool trade is somewhat complex in its working. Transport is naturally by steamboat. If Bradford or the Continental centre is the port of destiny the charge is 7s. to 9s. per 40 cubic feet, this being the size of an average "B.A." bale (450 kilogrammes). Insurance is effected at the same rate as for Colonial wool.

Trade Routes.—Though not of prime importance to all interested in the raw material of the woollen and worsted trade, the question of the time taken during shipment, the charges made, and so forth, are of such general interest as to merit attention to the trade routes followed during the transport of textile products from the producing to the consuming centres. As an aid in this connection the map of the world facing page 10 should be referred to, in which the trade routes may be readily traced.

Condition or State in which Wool is Shipped.—Probably three-fourths of the Colonial and foreign clips is shipped "in the grease"; a very small and declining proportion is "fleece washed," and the remainder is "scoured." The fleece washing referred to is effected by either washing the wool on the sheep's back or washing the wool in fleece form after shearing from the sheep, the fleeces being run over rollers and subjected to a warm water spray. The question of shipping in the grease or in the washed or scoured state was very

* It is thus evident that the original idea was for Antwerp, London and Liverpool to follow one another in sequential order.

hotly debated some years ago. The points "for" and "against" in each case are set out below.

When shipped in greasy state:—

ADVANTAGES

Suint or yolk (grease) present, which preserves the nature, colour and form of the fleece. The colour is thus better, and sorting, if necessary, can be more conveniently and cheaply carried out.

When scouring is performed by the comber the wool may be treated just according to requirements.

Grease, as in wool, is useful; it aids the scouring of less greasy types often used in blends, thus saving cost in soap. It also yields potash salt (obtainable from the liquors—which are valuable scouring agents), and fat.

DISADVANTAGES

Increased cost of carriage and freightage.

In the case of some wools that contain much sand and earth, discoloration of the wool results through contact in packing. Again, the longer impurity of this character remains in the wool the greater the risk there is of harshness and brittleness.

Difficulty in estimating the "yield." This difficulty increases with the amount of impurity.

Wool to scour. This means additional cost of, say, $\frac{1}{2}$d. to $\frac{3}{4}$d. per lb.

When shipped in a fleece-washed state:—

ADVANTAGES

Some saving in carriage or freightage, varying according to amount of impurity removed.

Form of fleece preserved.

Sufficient grease present to keep the fibre staples soft and elastic.

Easy to estimate for "yield."

DISADVANTAGES

Cost of fleece-washing operation—not very expensive.

Wool to scour—cost, say, $\frac{1}{8}$d. per lb.

Not sufficient impurity removed by this operation in many cases to bring wool within a reduced freightage rate, nor so as to bring relatively higher price when marketed which compensates for loss in payment on reduced bulk.

When shipped in scoured state :—

ADVANTAGES	DISADVANTAGES
Maximum saving in carriage and freightage charges.	No preserving grease in fibres.
Easy to estimate for "yield."	Often badly scoured, and consequently discoloured, harsh and matted. Agents may have been used which interfere with subsequent processes of scouring and dyeing.
Minimum scouring cost.	Some little dirt is gathered in handling and transit which makes a short scouring operation necessary. Cost, say, $\frac{1}{8}$d. per lb.
	Fleece and staple formation interfered with ; bad to sort ; slightly more wasty in combing.
	No greasy residue (from impurity) of value.

From the foregoing it will be very evident that much depends on the position of the station where the wool is grown, upon the condition of the wool—that is, whether very greasy or fairly clean—and upon the charges ruling for transport. So far as the manufacturing centres are concerned, wool is preferred in the grease, no doubt largely on account of scoured wool so frequently being discoloured and felted. In the future it is probable that a desirable increase in fleece-washing will come about, for this system is economical so far as transport is concerned, and at the same time sufficient grease is left in the fibre to preserve its nature.

Cape wool, however dirty, should always be shipped in the grease, owing to the fact that the fibre is so fine, soft, and curly that after press-packing in the scoured state it cannot be opened and re-washed without considerable injury. Thus efficient scouring would not mitigate this difficulty.

With reference to South American wools much improvement may be effected in the scoured wools shipped. These are often very dirty, the fleeces appearing to have been left unopened and simply to have been dragged through crude wash-bowls and very much matted together.

HAIRS: BUYING AND SHIPMENT

Turkey Mohair. — Turkey mohair is collected from the small farmers and afterwards sold at such distributing centres as Constantinople. It is usually packed in small bags; but, upon the whole, the method of preparation and packing is somewhat primitive. Bradford houses are represented by buyers in Turkey who buy direct from the growers.

Cape Mohair.—The representatives of Bradford firms buy up the clip privately, or it is collected in shipments by storekeepers and consigned for sale in London by brokers.

American Mohair.—As this, comparatively speaking, is a new industry, it is not quite stable as yet, but the tendency is for the mohair manufacturing concerns of the States to purchase direct all they can lay hands on of a good quality.

Alpaca.—Alpaca is shipped from Peru and Chili (Arequipa), and, along with camel's-hair, cashmere, goat's-hair, and Chinese, Russian, Egyptian, Persian, and other low sorts of wool, is sold at the Liverpool wool sales.

Commerce in Skin Wools.—The skin wool trade has markedly developed of late. Skin wool sales are held in the Colonies, South America, and in London, at which sales buyers representing fellmongering firms attend. Brokers collect the skins from the mutton-freezing centres and classify them. These are then pulled (*see* Chapter III., p. 71) at Colonial, Continental, and Home pulling centres. Home skins are often treated locally, many being bought directly from the butchers by the puller.

The pulled wool is offered at London and the Colonial centres. Mazamet, in France, perhaps the greatest wool-pulling centre, samples its wools through agents to all parts of the world, who offer to prospective buyers "if unsold." If the bargain is struck the passing of a sample bale—say, fourteen days later—decides the transaction. Large quantities of skin wool are used in Bradford as blending material, exceptionally good yield and tear resulting with the tops made.

WOOL AND HAIR WASHING

British Wools.—With British wools, wool-washing on the sheep's back is usually a distinct advantage; thus in Bradford, while it is stated that Merino wools can be better judged in the grease, it is also admitted that lustre wools can be better judged in the washed state. By washing, the wool is made more attractive, and owing to the long, smooth, and non-felting characteristics, little or no injury is done during the process, or subsequently. About 72 per cent. of British wools are washed, but in some few cases the climate, character of water, and condition of wool do not lend themselves to this operation. Upon the whole, wool-washing pays. In an investigation carried out by Mr. Bernard M. Wale, B.Sc., of the South-Eastern Agricultural College, Wye, it was found that for a wide range of fleeces sold over a period of many years the washed types averaged 4.17d. per fleece more than unwashed. Unfortunately, the tendency is for washing to decrease, owing to cost, injury to sheep (particularly if weak), and the danger of transmitting scab.

Washing most largely obtains in the Midlands and northern portion of England, with the exception of Northumberland.

A fair proportion of English "Down" wools are washed.

Very little Devon, Cornwall, and Surrey wool is washed.

Scotland washes comparatively little, and Ireland washes a great deal of the wool produced.

Description of Washing.—In this country washing is effected as follows. A suitable stream is dammed up, and fencing is then so arranged as to drive the sheep up to the water, or to a walled yard close to the water, with an opening into the dam (or equipped with a circular trough). The sheep are dropped into the stream, immersed once or twice by the washer standing in mid-stream, or by men standing on the banks with crooks, and are afterwards driven into a clear grass field, where they may dry without any fear of contamination with straw or other unsatisfactory vegetable matter. By this means much dung and dirt which would cause expense and inconvenience in the subsequent processes is removed. The cost may reach ½d. per head. It is not advisable in this process to employ anything other than cold water.

Dipping.—Two or three times during the growth of the fleece (twelve to fourteen months) dipping is almost of necessity employed to overcome the harmful influence of ticks, lice, etc., which would tend to produce scab. A good dip may be useful as regards the wool. It may lubricate the fibre, giving softness and elasticity, and may even improve the colour by slightly bleaching it. Dipping with unsatisfactory agents, however, is most harmful. The wool is made weak and brittle, its growth is stunted, its colour will probably be unsatisfactory, and in the processes through which it must subsequently pass it is most difficult and costly to manipulate. The harmful dips are generally supposed to be :—

Lime and sulphur combinations,
Tobacco compositions,
Pitch oil preparations.

Among the satisfactory dips are :—

Arsenical dips (like Quibell's),
Carbolic acid and oil (MacDougal's).

It is but fair to add, however, that claims are made on fairly satisfactory grounds that lime and sulphur do not seriously affect the wool. Again, farmers frequently employ special dips to "get-up" wool on the sheep's back for show purposes. The point at issue is as to whether the harmful dips have a lasting influence upon the wool, or whether the wool, as it were, in the few months' subsequent growth throws them off and attains to its natural condition. Upon the whole, there is here ample room for further experiment.

Branding.—After shearing, branding is necessary in order that the sheep on a special farm or station may be recognisable. Marking of the ear and hoof obtain, but these marks are not sufficiently distinctive for general and easy recognition ; some larger mark on the wool is necessary. Tar was formerly employed, but has been found very injurious to the work, and consequently wasteful ; wool thus treated must be separated and used for low-class goods on account of discoloration. Branding agents are now available, composed of vegetable oils and non-injurious colouring matters. These will withstand the influence of the growth of the staple, rain, and light, and will wash out fairly well in an alkaline bath. In all cases brands should be applied by means of a proper stencil.

SHEARING

British Methods.—Very crude systems of shearing wool still prevail in this country. Hand-shears are frequently employed, producing much "fribby"—that is, double-cut—wool, and often leaving the staple shorter than it need be. On the other hand, if automatic shears are employed, it usually means one man turning a handle while the other man shears, so that the shearer must shear at least double the number of sheep to compete with hand-shearing. Deficiencies of this kind must be attributed to the comparatively small number of sheep to be dealt with per farm.

No system of trimming or classing the fleeces obtains. They are simply wound inside out, bound with a tassel made from the shoulder, and packed by the buyer just as taken from the sheep's back. If intended for the export trade, "casing"—that is, classing according to quality—is carried out by the stapler. At no stage is press-packing employed, but the fleeces are packed in large sheets, very different in form from the Colonial rectangular bale.

Colonial Methods.—In the Colonies, as a rule, most up-to-date arrangements prevail. The operation of shearing a large flock of sheep is effected as follows. In the separating yards of the sheep station "hog" sheep are separated from "wethers," and a rough classification thus effected prior to shearing. Each class is now directed to some special part of the shearing shed, thus expediting both the handling and classing of the wool. The sheep pens from which the shearer draws his sheep are convenient of access from the shearer's board, while equally conveniently placed are the pens for the shorn sheep. Machine shearing is almost universally in vogue, it being more thorough, cheaper, easier for the shearer, and less painful for the sheep.

The mechanical shearer consists of working combs with inner faces sharpened, centred so as to work as ordinary scissors. They are driven mechanically from the main shaft of the room through many-jointed or flexible shafting.

The shearer begins at the neck of the animal, works down the front, and then round to the back, allowing the fleece to fall back as a shroud until severing is completely effected at the haunches, where the leg portion of the wool is pulled off and the fleece left for removal by the "rouse-about" (a shed hand). The sheep is now turned into the shorn sheep pen, while the fleece goes to the skirting table, where the dirty and lower portions are removed and it is then rolled inside out, with the sides wrapped over and rolled from the tail. It is finally "classed"—that is, put in a quality agreeing with the bulk sort—and "stacked" until packing. A special section of the shed is reserved for the skirting, classing, and packing of the fleece.

Baling is the packing of the wool in hemp packing, giving, say, a 3 ft. 6 in. by 2 ft. by 6 in. bale, weighing about $2\frac{1}{2}$ cwt., for Botany wool, and a 4 ft. by 2 ft. 6 in. bale, weighing $3\frac{1}{2}$ cwt., for cross-breds. The hemp packing must necessarily be made from good hemp spun into threads of a closely-twisted character, which in turn must be woven into a smooth face, tight cloth, inside which corrugated paper lining is advisably placed, this, so far as may be, excluding contamination with vegetable fibre. It is interesting to note that the most important firms of wool users are willing specially to consider wools forwarded in packing of the above-defined type.

Actually to make the bale, fleeces are piled in orderly fashion in a strong wooden, bottomless box, inside which the bagging is placed as a lining. The sides of this box are hinged to admit of the finally completed bale being removed. Over this box another similar box is brought and wool is filled into both boxes from bottom to top. A ram, underneath the plate of which the top flap of the pack is fixed, is now lowered into the boxes and the whole bulk by this means compressed into one box and finally sewn up into one bag or pack. The top box being removed, the sewing of the top cover is effected, and afterwards the bottom box is removed, leaving the bale ready for the next process.*

Branding of bales.—In this process the particulars descriptive of the wool baled are stencilled on the bale cover. These are generally the district where the wool is grown, the name or mark of station where grown, the sort or type of wool—that is, whether fleece or pieces, hogs or wethers, first combing or second combing, etc.—and number and weight of bale.

* Owing to Australian wools being shipped by weight and South American wools by bulk, the latter are compressed into solid looking bales, which are necessarily bound by iron hoops. Punta wools are sometimes simply bound by wire bands. It is further interesting to note that South American fleeces are usually tied up with string instead of with the wool itself, a very harmful procedure.

Cape and South American Methods.—Considerable improvement is possible in regard to both shearing, classing, and the packing of these wools. In the case of the Cape, negligence and ignorance may be urged; in the case of South America, the cost of labour is a difficulty. The sprinkling in of sand and the introduction of rags, etc., are naturally to be deprecated. These practices, however, must be considered the exception.

TRADE TERMS APPLIED TO SHEEP AND WOOL

As some confusion exists with regard to these, an attempt at classification may be here attempted. Without undue egotism we would here urge that the following terms should, if possible, be adhered to:—

Teg.—Given mostly to male sheep of Down type from time of weaning to shearing.

Ewe-teg.—Applied to female sheep of Down type from time of weaning to shearing.

Gimmer.—Scotch term applied to female sheep. Generally used also in Yorkshire.

Half-bred.—A cross from two pure breeds.

Three-quarter-bred.—A cross produced by a half-bred crossed again on to a breed already represented.

Come-back.—The result of continued crossing towards one of the breeds originally employed. Merino Come-back is most commonly produced on account of mutton requirements, and also to gain fineness and softness in wool grown.

Cross-bred.—The progeny of two breeds not necessarily pure. A term largely applied to all cross-breds in the Colonies. Equivalent in Britain to the term "half-bred."

Mixed Breed.—The product of many crosses of varied types. Wool in which well-known characteristics are indistinct.

WOOL CLASSERS' TERMS

Matching.—Applied to various sorts of qualities as made from fleeces.

Combing Wool.—Of a length sufficiently long for combing purposes, say two inches and over.

Clothing Wool.—Wool too short for combing—that is, two inches and under—and most suitable for use in the woollen trade.

Super Combing.—The finest quality wool of the clip.

First Combing.—The bulk sort of the clip.

Second Combing.—Longer and coarser wool—a quality lower than the first combing.

Broken Fleece.—Sorts made from skirtings of fleeces and from low and dirty pieces.

First Pieces.—The bigger pieces of the dirty skirtings left after sorting broken pieces.

Second Pieces.—The smallest, dirtiest, and lowest portions from the skirting.

Locks.—Odd staples from skirtings, usually swept from under the screen of the picking table; very dirty and of varying quality.

CHAPTER V

WOOL CLASSING AND SORTING

The Classing of English Wools.—In the case of English wools there is no attempt prior to shearing to classify the sheep, and little is done in the way of classifying the fleeces after shearing until the wool stapler comes on the scene. Thus the wool stapler generally buys the whole clip—usually a comparatively small one—and receives it exactly as taken from the sheep's back. During the process of classing, the fleeces are examined in a good light and separated in the first place into "hogs" and "wethers"; this classification is dependent upon the appearance of the wool staples, the hogs being pointed at the tips, while wethers are more or less square, showing the cut of the previous year. The hogs, as a rule, are also finer and longer in staple than the wethers, often representing fourteen months' growth. After this classification the quality of each fleece is determined, each being classed as "super," "selected" or "picked," "ordinary" or "cast," and placed in its distinctive bin. Kempy and damaged fleeces are placed on one side and made into special lots.

The Classing of Colonial Wools.—This is carried out in the Colonies, and, so far as Australasia is concerned, is exceedingly well done, largely owing to the fact that classing pays the grower, the buyer being ready to pay a better price for bulk lots of which he is certain of the quality, and in connection with which he knows that little additional labour will be necessary to prepare for the manufacturer. After "skirting," the fleeces are classed as "first," "second" or "third combing" or "clothing," according to length, fineness, soundness, colour and condition, etc.

Merino wools come from the highest class flocks and are very uniform in quality, and consequently, are chiefly classed from the point of view of condition, two or three grades being made. Other Merinoes are classed into "super-combing" (the very best of the clip, and consequently a small lot), "first combing" (the bulk type), "second combing," and "clothing" (this being produced from short fleeces).

Cross-bred wools are not usually very thoroughly skirted, and are classed as "super-cross-breds" (which are derived from fine cross-breds and Merino "come-back" sheep, ranging from 56's to 58's qualities), "first cross-bred combings" (46's to 50's qualities), "second cross-bred combings" (40's to 44's qualities), and "third cross-bred combings" (32's to 40's qualities).

In pure-bred Colonial sheep the long wools are classed as "hogs" and "wethers," the best hogs being branded as "extra lustre hogs" and the wethers as "lustre wethers." The better of the latter class are termed "fine lustre wethers." In the shorter types of wool, fleeces are classed as "tegs" (corresponding closely to "hogs"), if specially satisfactory, and the remainder are termed "wethers." Combing or clothing quality is not defined in this case.

In the case of lamb's-wool, fatty, stained and dirty portions of the fleece are removed, in the process of which the fleece is unavoidably disorganised, and consequently, lamb's-wool comes to us packed as "firsts" or "seconds," according to the variation in length prevailing.

What are termed "pieces" come from the skirtings and edges, these being sorted into "broken fleece" (the largest proportion), "firsts" and "seconds" pieces and "locks," this being in the case of Merinoes. Cross-bred pieces are made into "pieces," "locks" and "discoloured"; a "bellies' sort" is also made.

In the case of Cape fleeces, there is much room for improvement of the classing, which now is happily claiming more attention. Fortunately most Cape wools are fine throughout the fleece; thus the neglect of this operation has not been so seriously felt as might have been the case had the fleeces been less uniform. Australian methods, by which uniform lots of "combings" and "clothing," and "first greasy" and "second greasy" are made, are now being adopted at the Cape.

South American wool classing has also been somewhat neglected, it only being attempted on the biggest stations. Even on these skirting and trimming have been imperfectly carried out, and the method of classing has not been all that could be desired. For example, in a B.A. bale, stated as 40's, cross-bred qualities varying from 32's to 46's, long and short, clear and burry, kempy and discoloured, will often be found in by no means small quantities. Low lots are occasionally found secreted in the middle of the fleeces.

WOOL-SORTING

A definition of wool-sorting would be "the dividing up of the fleece into the various qualities representing the variation in length, fineness, soundness, and colour of the staples." This variation of staple is due to certain portions of the sheep being better nourished than others—for example, the shoulders, as compared with the haunches. It is also the result of certain portions being subjected to harsher treatment during growth, due to the natural habits of the animal. The lists given on p. 117 and the accompanying illustrations show the positions where the various qualities are to be found on representative fleeces, and may be used as a means of comparison.

The ideal condition from a wool user's point of view would be to breed a sheep which yielded an absolutely uniform staple throughout. As this is impossible, wool-sorting is a necessary operation. It may also be premised that without it fine yarn spinning would be impossible, as only the very finest wool of the fine fleeces can be used for this purpose. In practice, to sort wool is usually economical, because if a lower quality is worked along with a better quality, the former injures the latter to a greater degree than the low quality is improved through the influence of the better quality. By sorting, therefore, the best result is obtained from each fleece, as each variety of staple may be placed in its lot, which lot will subsequently receive the treatment best suited to develop its most favourable characteristics.

The extent to which sorting is carried on varies in part according to the trade centre, but more particularly according to the classes of wool dealt with. Thus America probably classes, rather than sorts, being mostly concerned with bulk lots, while Merino wools, as a rule, require less sorting than the low quality wools, being more uniform. As an example of this, English Lincolns, or more especially black-faced sheep, producing wool under severe climatic and difficult conditions,

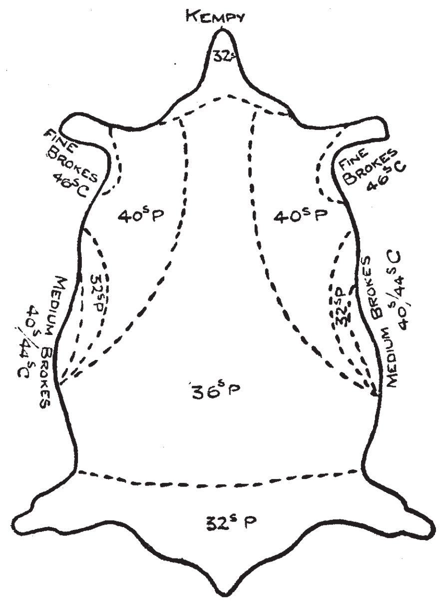

Fig. 34.—Lincoln Hog

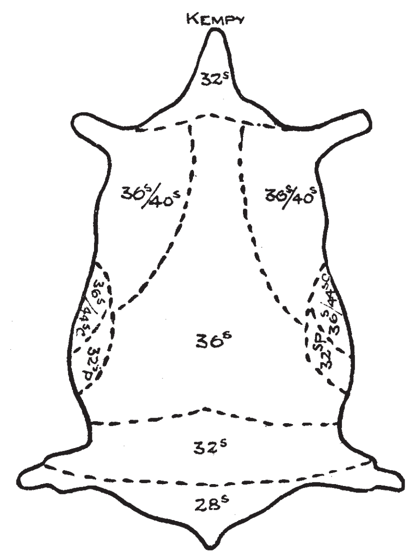

Fig. 35.—Lincoln Wether

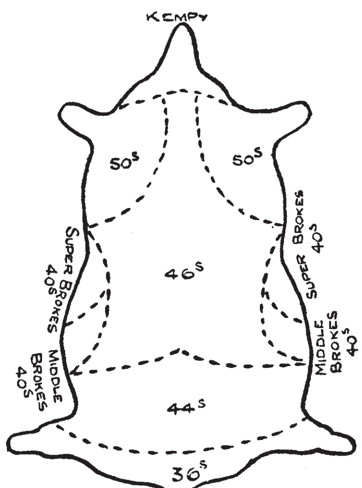

Fig. 36.—Cheviot

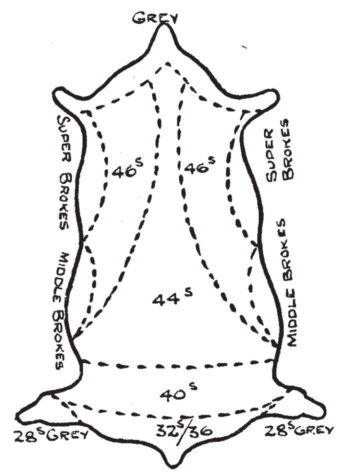

Fig. 37.—Kent

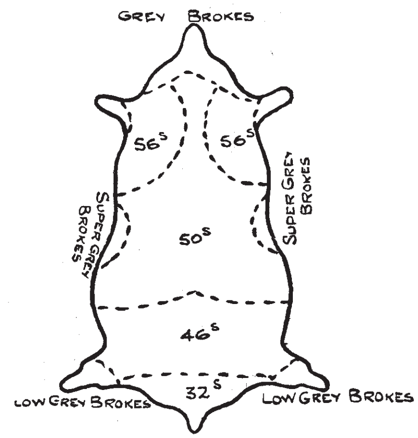

Fig. 38.—Southdown

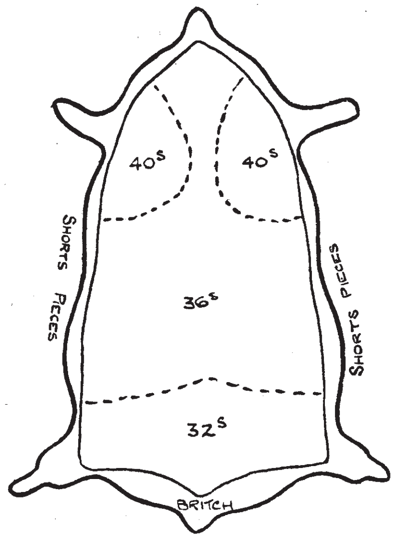

Fig. 39.—Low Cross-bred

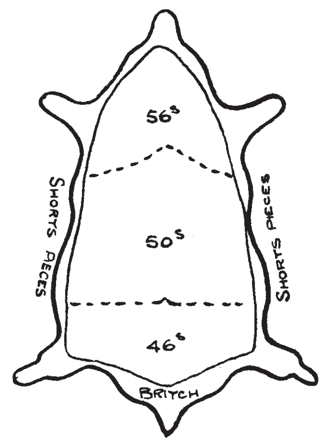

Fig. 40.—Fine Cross-bred

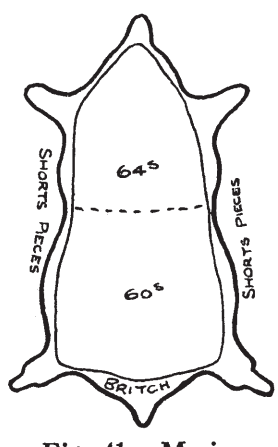

Fig. 41.—Merino

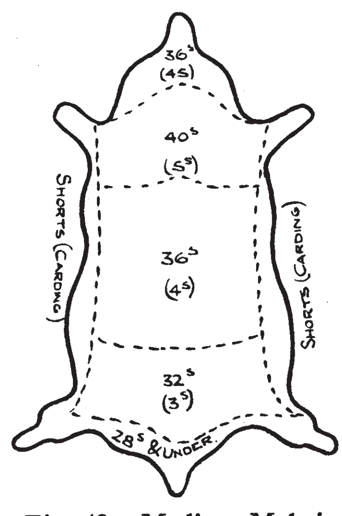

Fig. 42.—Medium Mohair

are liable to yield variations in fleece along with such characteristics as kemps, grey wool, hairy and lustreless fibres, which the most careful breeding will not entirely eliminate.

Again, fleeces vary in the conditions in which they are received by the users. Colonial fleeces, for instance, are usually skirted and britched, while English are received just as they have been shorn. Naturally, more sorting is necessary with the latter types.

Although sorting is, as a rule, an advantage, it is not always carried out to the extent that the fleece naturally admits of. With Lincoln fleeces, for example, ten or twelve sorts could be obtained, but the little variations in the resultant yarns or cloths from these, and the expense incurred in treating such lots separately, would not justify the great cost of such careful sorting. Truly distinctive qualities only are therefore made, and in the case of firms whose tops are not so much super-excellent, as cheap and useful for general purposes, the minimum number of qualities are made.

The Wool-sorters' Equipment.—A usefully varied experience is the first essential in wool-sorting. By this means a sorter develops a keenness of perception and a fine sense of touch—factors which are of most importance in this trade. Again, quickness of decision is required, and also the facility of handling fleeces smartly. Having obtained a good general experience, it seems, then, as though it were better for sorters to confine their attention to one particular type of wool. In fact, it is possible to confuse classes and to alter the quality standards by changing sorters.

In dealing with Colonial fleeces, wood tabling is arranged about eight feet per man and sufficiently deep for the fleece to be fully exposed. For handling

English wool, screens or hurdles (wood frames with wire meshes) take the place of the table, and through these the dust, dirt, etc., fall. The sorting-room should be so arranged that a good north light is available. Thus, as a rule, the operation is carried out either in a shed or in a room at the top of a building. The latter is preferable, as in this, by "trapping," much labour in the conveyance of material is avoided. Skeps are given to each sorter for his regular "sorts," while under his table and in the window bottoms are thrown the tar bits and stained pieces, etc., which slowly accumulate. Shears are also supplied for cutting dung bits away. As some fleeces from the Colonies are very heavy in the grease, they become consolidated by the press packing, and heat is required to open them out. Ovens are therefore provided; these are about 9 feet long, 3 feet broad, and 2 feet deep; cheap coal is employed to heat them.

The actual operation of sorting is conducted as follows:—

Fleeces are weighed off to the sorter by the pack of 240 lb.

English fleeces are unwound and opened by loosening the tassel made from the shoulder. They are laid on the screen flesh side downwards, thus showing up clearly the whole exterior of the fleece, which so far has been wound up in such a way that all the low portions are inside, while the best wool is on the outside. They are now "rigged," that is, divided by way of the natural division from the top of the sheep's back, up the centre of the fleece, so that the fleece is of a size to be handled conveniently. Each half-fleece is then vigorously shaken to remove dirt and vegetable impurity, and placed in pile form until the whole pack has been dealt with. True sorting then begins, first at the britch end, then up towards the neck, until the shoulder portions, usually the best in quality, are removed.

Cross-bred and Merino fleeces are much more quickly dealt with. They are not so large, so dirty, nor so varied in the qualities of wool they yield. Indeed, some of these are hardly sorted at all. The process is rather one of looking over, in which dirty and extra coarse locks and vegetable impurities are removed. No rigging of the fleece is carried out, and comparatively few qualities are made.

Hairs are extremely difficult and tedious to sort, on account of the smoothness and slipperiness of the staples, which causes disorganisation of the fleece as soon as it is shorn. Practically, individual staples must be dealt with; sorting by position is almost impossible.

Wool-sorters' Terms Applied to Qualities.—Considerable variation is to be noted in the use of sorting terms. Thus terms in the woollen trade differ from those in general use in the worsted trade. Again, numbers and letters are frequently employed to maintain secrecy with regard to the composition of blends into which such qualities ultimately go. The terms and quality numbers tabulated on p. 117 represent the various methods employed, and in Fig. 43 actual photographs of typical staples as taken from a range of qualities found in a lustre fleece are illustrated, from which an idea of the variations obtaining in practice may be gained.

In longer qualities "prepared" and carded" sorts are usually made, and in finer qualities "super," "warp" and "weft" qualities are frequently to be met with.

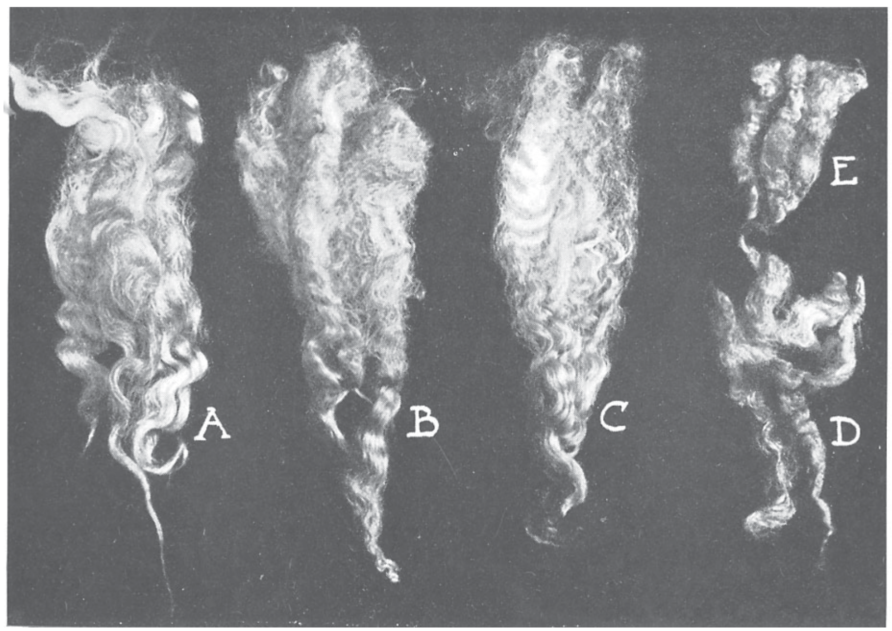

Fig. 43.—Wool-Sorter's Qualities

A, From Haunches   B, From Middle of Side   C, Shoulders   D, Discoloured   E, Shorts

English Worsted		Colonial Worsted	
Term	*Quality Represented*	*Term*	*Quality Represented*
"Fine"	44's	11's	60's
"Blue"	40's	10's	56's
"Neat"	36's	9's	50's
"Brown"	32's	8's	46's
"Britch"	24's	7's C.	40's & 44's
"Cowtail"	18's	7's P.	40's
"Downrights"	40's short	6's	36's
"Seconds"	32's short	5's	32's
"Abb"	24's short	4's	28's

Mohair		Woollen Terms*
Term	*Quality Represented*	
9's	Super	"Picklock"
8's	60's	"Prime"
7's	56's	"Choice"
6's	50's	"Super"
5's	46's	"Seconds"
4's	40's	"Downrights"
3's	36's	"Abb"
2's	32's	"Britch"
1's	28's	

* Quality numbers are not usually attached to sorts in the woollen trade. The terms given above signify a variation in spinning capacity somewhat similar to that given in respect of the Colonial worsted list.

ANTHRAX AND ANTHRAX REGULATIONS

The following description of anthrax, taken from Government publications, is possibly the best statement that can be made on the matter.

"Anthrax is a fatal disease affecting certain animals, which may be conveyed from them to man by the handling of wools or hairs from animals which have died of the disease. The germs of the disease (Anthrax spores) are found in the dust attaching to the wool, or in the excrement, and in the substance of the pieces of skin, and may remain active for years. In Great Britain and Australia anthrax is rare, consequently there is little danger in handling wools from the sheep of these two countries; but in China, Persia, Turkey, Russia, the East Indies, and in many other parts of the world, the disease is common, and infected fleeces or locks (which may not differ from others in appearance) are often shipped to Great Britain. Hence, in handling foreign dry wools and hair, the Regulations should be carefully observed. Greasy wools are comparatively free from dust, and therefore little risk is incurred in handling them.

"The disease is communicated to man sometimes by breathing or swallowing the dust from these wools or hair, and sometimes by the poison lodging in some point where the skin is broken, such as a fresh scratch or cut, or a scratched pimple, or even chapped hands. This happens more readily on the uncovered parts of the body, the hand, arm, face and, most frequently of all, on the neck, owing either to infected wool rubbing against the bare skin, or to dust from such wool alighting on the raw surface. But a raw surface covered by clothing is not free from risk, for dust lodging upon the clothes may sooner or later work its way to the skin beneath. Infection may also be brought about by rubbing or scratching a pimple with hand or nail carrying the anthrax poison. Use of the nail brush, and frequent washing and bathing of the whole body, especially of the arms, neck and head, will lessen the chance of contracting anthrax.

"The first symptom of anthrax is usually a small, inflamed swelling like a pimple or boil—often quite painless—which extends, and in a few days becomes black at the centre, and surrounded by other 'pimples.' The poison is now liable to be absorbed into the system, and will cause risk of life, which can be avoided only by prompt and effective medical treatment in the early stage, while the poison is still confined to the pimple. Hence, it is of the utmost importance that a doctor should be *at once* consulted if there is any suspicion of infection."

The Factory Act of 1901 enforces certain regulations regarding the treatment of these dangerous wools. Van mohair and Persian wool, prior to being willowed and sorted, must be thoroughly steeped before the bale is opened. Alpaca, Peliton, East Indian, Cashmere, Russian camel's-hair, Persian, or so-called Persian, including Karadi and Bagdad, if it be willowed and sorted, must be steeped and opened over a regulation screen or board. All other than Van mohair, if to be sorted, must be dealt with on a special screen provided with downward draught. The most recent discovery with reference to wool-sorters' disease is that blood is the main carrier of the germs. Thus workpeople should be specially careful in dealing with blood bits, fallen bits, and skin bits, which should all be steamed.

The details of the open screens are as follows: These must be 12 ft. square and supplied with an exhaust draught working at a velocity of 150 feet per minute and measuring 18 inches from the centre of the screen.

The sorting boards are made as follows:—

The screen is of wire work, underneath which is a clear space of not less than 3 inches. Then comes the tin tray, leading down to the funnel of 10 inches or more, which in turn leads to the extraction shaft. The air draught in this case should be 75 ft. per minute, measured 12 inches from centre. The dust must be discharged into a suitable receptacle and burnt. An air space of 1,000 cubic feet must be allowed for each operative.

CHAPTER VI

THE PHYSICAL AND CHEMICAL PROPERTIES OF WOOLS, HAIRS, ETC.

1. **Length and Diameter of Fibre.**—The most important characteristics of the wool fibre are its length and diameter. As will be gathered from the statements made in Chapter III., p. 52, and Chapter V., p. 114, length and fineness and a certain undefined relationship of the two decide what is spoken of in the wool trade as the "quality." There is, however, a more subtle definition of "quality," which would take into account all the physical characteristics and also the causes of such differences as result in Welsh wools, shrinking less on being washed, Shetland wools handling softer and so forth. The more practical definition, however, is the one which chiefly concerns us here.

As the length and diameter of fibre have been clearly indicated in Chapter III., pp. 52, 59 and 65, there is no need to deal further with the question at this point.

2. **The Cell and Scale Structure of Typical Wool Fibres.**—The structure of the wool fibre is peculiar and complex, being of a nature comparable with no other known fibre. Its peculiarities need to be thoroughly understood, otherwise the fibre will not be given that treatment which will render it best fitted for conversion into the most useful and best wearing fabrics.

If the natural wool grease present on and in the raw fibre be removed by boiling in a weak alkaline solution, the fibre, under the microscope, will then be found to be fairly cylindrical in shape and on the exterior to show certain peculiar surface markings formed by round, plate-like cells or scales which overlap each other and more or less stand off from the body of the fibre (Figs. 44, 45, 46, and 47). These exterior scales vary very considerably in shape in the different types of wools. Some appear to form rings round the fibre; others are cylindrical; and others almost pointed. In Merino wool fibres as many as 5,000 scales per inch are counted, taken in a straight line along the fibre. English Down wools give about 2,500, and English Lustre wools about 1,800. As will naturally be expected, the variation in surface structure, i.e. in scaliness, largely accounts for the lustrous or non-lustrous characteristics of the several wools, the presence or absence of this quality being due to the way in which the light is reflected from the surface of the fibre.

To investigate the internal structure of the wool fibre, transverse or cross sections must be cut, this being effected by embedding the fibres in wax or some other similar enveloping and controlling substance and then shaving off the sections by means of the microtone, or, in the absence of such an instrument, by a finely sharpened razor. Under the microscope such sections usually reveal the presence of three types of cells, viz. rounded or oval-shaped cells in the central or medullary portion of the fibre; more elongated or spindle-shaped cells in the middle or cuticle portion; and flattened cells or horny scales, these latter being sections of the exterior wool scales already referred to. The colouring matter of wools which are not white is found to reside in the

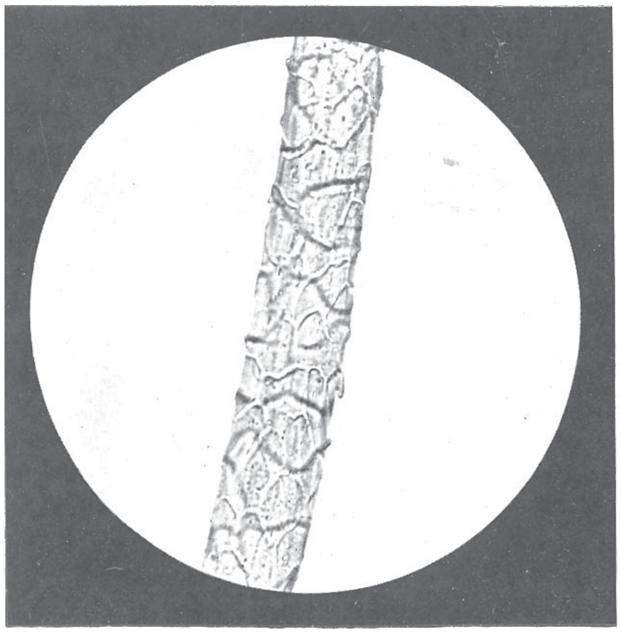

Fig. 44.—Fibre of Yorkshire Wool

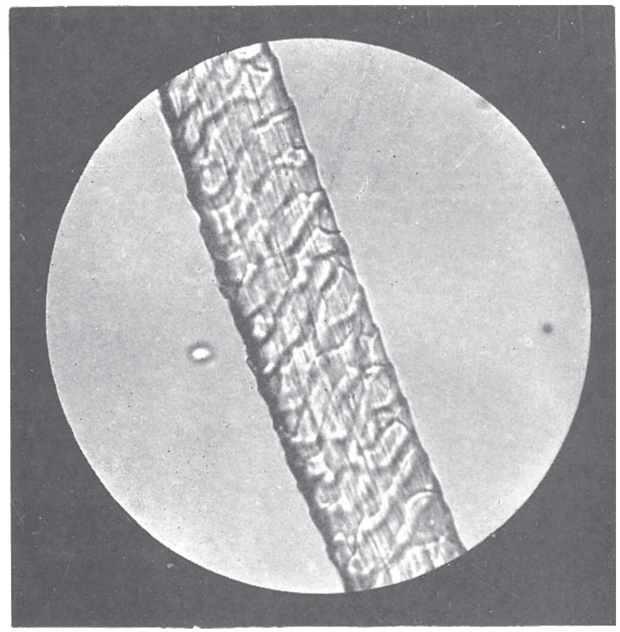

Fig. 45.—Fibre of Scotch Blackface Wool

(Magnified 330 times)

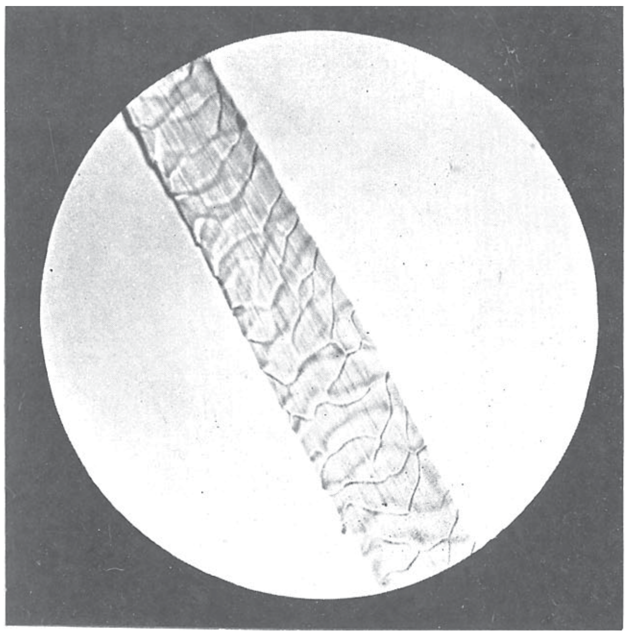

Fig. 46.—Fibre of Down Wool

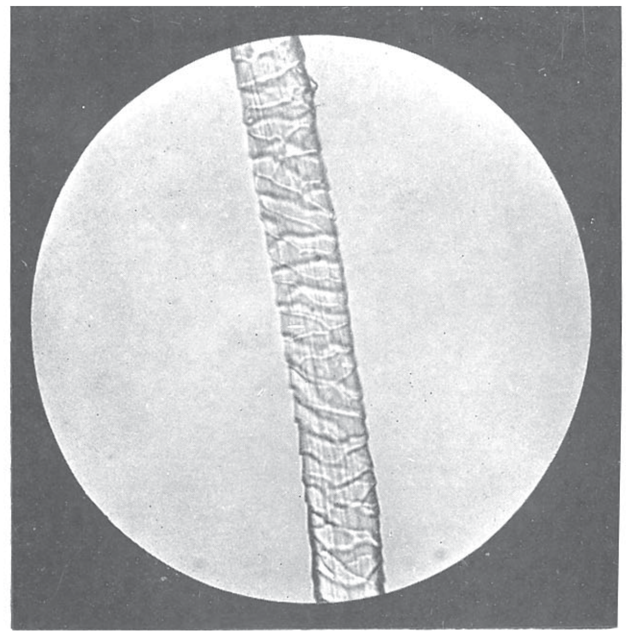

Fig. 47.—Fibre of Australian Merino

(Magnified 330 times)

central or in the cuticle portion. Fat globules and air are also to be noted in the central portion, these no doubt playing some part in deciding the real nature of the fibre.

Ordinary and microscopical examinations reveal many valuable features respecting the fineness, length, colour, lustre and straightness of the various wool fibres. It may be argued that no result of practical value is possible when working with the microscope, owing to the limited field covered; but even in this case it is found possible to average up and often obtain results of a practical character. While working with the unaided faculties or with the microscope, extremes must obviously be avoided and deductions made from the bulk proportion.

The following list gives a good idea of the physical characteristics of typical wools :—

Type	*Scaliness*	*Length*	*Fineness*
	(*Per lineal inch*)		
English Lustre	1,800	10 in.–12 in.	1-600 in.
English Down	2,500	3 in.–4 in.	1-900 in.
Colonial Medium Cross-bred	3,000	5 in.–7 in.	1-750 in.
Colonial Merino . . .	5,000	$2\frac{1}{2}$ in.–$3\frac{1}{2}$ in.	1-1200 in.

Type	*Lustre*	*Colour*	*Softness*	*Straightness*
English Lustre .	Very lustrous	Yellowish	Fairly firm	Very straight
English Down .	Non-lustrous	White	Soft	Crimpy
Colonial Medium Cross-bred .	Fairly lustrous	Fairly white	Fairly soft	Fairly straight
Colonial Merino	Non-lustrous	Very white	Very soft	Very crimpy

Much of the value of wool as a textile fabric must be attributed to the previously-mentioned characteristics. Thus in the mixing which takes place in the various preliminary processes, fibres upon the average will be placed root to tip and tip to root, and it is conceivable that the scale structures will thus come into action, resulting in an interlocking of adjacent fibres. Again, on the principle that "in union is strength," the interlocking or felting of the wool explains, at least in part, the durability of the wool fabric. The tendency of the wool fibre always to revert to its original form may also be made use of, the extension of the fibre in the various spinning processes resulting in the final production of a fabric which has only to be subjected to the processes of "finishing" to contract and resolve itself into the typical woollen or worsted fabric. The softness and elasticity of wool, due to its nature and physical structure, may also be taken advantage of and made a special feature of the fabric into which the wool is finally woven.

It will further be gathered that usually the thickest, least scaly, and longest fibres are the most lustrous. On the other hand, fibres of the finer class are scaly, crimpy and usually relatively strong, spinning into strong and durable yarns, owing to their ability to resist "slip." For it should be noted that the strength of a thread depends upon two factors, viz. absolute strength of the fibres in the cross-section, and the "binding" effect of fibre on fibre.

The tendency to "felt" or "mill" which the different wool fibres possess in varying degree is one of the most valuable characteristics, and is found in no other fibre. This quality, however, must not be taken to reside entirely in the external scale structure. It seems to be partly dependent upon the actual shapes of the scales and the refined nature of the fibre itself, as well as upon the crimpiness of the fibre. This probably explains why Cape wools, which in number of scales and crimpiness are equal to Australian wools, are less satisfactory felting wools. In the former case the crimp is less pronounced and the scales are not so clearly defined. The affinity of the wool fibre as regards moisture and the various dye-stuffs, and its action when treated with certain re-agents, are exceptional and must be attributed to its porosity as well as to its more refined nature.

The Growth of the Fibre.—The growth of the wool fibre may usefully be studied, as by this means its characteristic features may be the better accounted for and understood. The fibre is produced in what is known as the hair-follicle—a pear-shaped depression of the skin—and it has its origin in a group of cells (*see* Fig. 48). Examination of the skin itself, Fig. 49, reveals a complicated structure, which naturally favours both the origination and development of the fibre. The skin is mainly composed of two parts, the epidermis D and the dermis E, but each of these is found capable of further sub-division, as will be found on reference to Fig. 50. In the epidermis there is first to be noted the cuticle or scarf-skin, S S, which is composed of dead cells, flattened, dried, and horny; under this the *rete mucosum*, or true skin, S G, is found, which is formed of smaller flattened cells more densely organised. Both these layers are produced from the dermal layers beneath during the process of growth, and their more important function is to preserve and protect the more delicate texture which underlies them.

The dermis, or inner skin, is composed of two layers (*see* Fig. 49 and portion marked D), the *papillary* or vascular, and the *corium* or deep-seated skin. The papillary P is in the upper position, and its surface is cone-like, consisting of a dense tissue of blood-vessels and nerves. In the corium C the bases of the hair sacs are formed, together with sweat glands, sebaceous or oil glands, clusters of fat globules, or adipose cells, and their various connecting ducts, and also blood-vessels and nerves. The sweat or sudoriferous glands, as they are termed, collect the grease and moisture from the adipose cells and discharge it through specially formed channels to the surface of the skin as "perspiration." Sebaceous glands fulfil a different purpose. They are of a distinctly different structure and arrangement, and produce an oily excretion which is conducted to the fibre follicle and acts as a lubricant, being useful in preventing irritation during growth, and of further value in giving to the fibre a high degree of softness and suppleness. The hair follicle is formed by an involution of the skin, and is the result of a process of cell division and re-division. Three stages may be noticed in Fig. 51, A, B, and C. During formation, a portion of the inner skin—the dermis—becomes enclosed and creates a papilla (*see* H P, Fig. 48), on which the fibre is subsequently built. This papilla contains the necessary tissues by which plastic lymph is supplied for the formation of cells and to assist in their re-division. As the cells round the papilla multiply, they are forced up the fibre follicle, ultimately forming the fibre shaft, as seen in Fig. 52. On reaching and forcing their way through the surface of the skin, at the point where the follicle is smallest, lateral pressure is applied to the fibre; thus the outer cells are forced into closer proximity and made to assume the flattened and scale-like form which

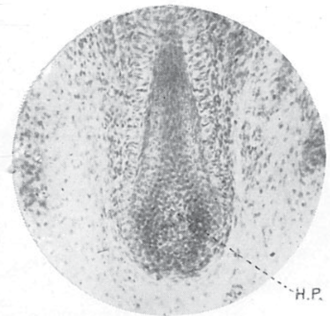

Fig. 48.—Hair Follicle

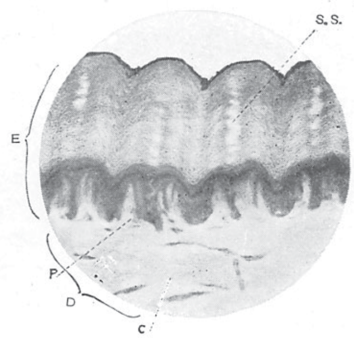

Fig. 49.—Section of Skin

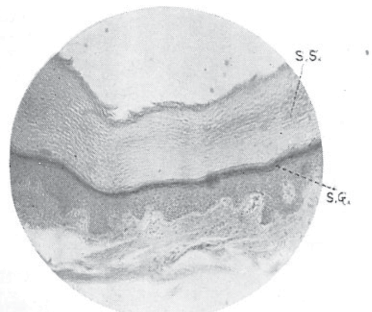

Fig. 50.—Section of Epidermis

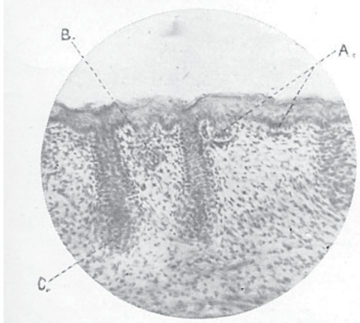

Fig. 51.—Three Stages of Formation of Hair Follicle

Fig. 52.—Showing Formation of the Fibre-shaft

For the micrographs here shown we are indebted to Dr. Woodhead of the Huddersfield Technical College give the wool fibre its characteristic scale-like structure.*

Physical Characteristics of the Various Hairs Compared with Wool.—The differences between wool and hair are somewhat difficult to define. In chemical composition they are alike, and the difference in their physical structure is not readily noticed save in the most extreme types. This difference, however, is noticeable in Figs. 53 and 54, which illustrate typical mohair and wool (Merino). Lustre wool (closely related to hair) is shown in Fig. 55. Curiously enough, although what may be termed chemical and physical methods fail in determining the difference, still in actual practice in handling the respective materials little difficulty is experienced in discriminating between them. The following comments respecting differences between particular hairs and wools may prove useful.

(*a*) **Mohair.**—Mohair is very lustrous and of a more solid construction than wool. It is stiffer and straighter. Thus it is impossible to tie a knot on a mohair staple, while this may readily be done in wool. Under the microscope the scales of the mohair fibre are found to be bound to the fibre shaft for almost all their length and are not readily observable, while in the typical wool fibre the extremities of the scales stand away from the fibre shaft for a considerable portion of their length. This accounts for much of the lustre of the mohair and in part for the stiffness. Further, mohair, by reason of its diminished scale structure, is not readily felted; it does not readily absorb moisture, nor is it susceptible to influences which cause the fibre to mil-

* For further information on this subject see "The Structure of the Wool Fibre," by Dr. F. H. Bowman, and also "The Microscope, and Its Uses for Textile Purposes," by Dr. T. W. Woodhead in the *Journal of the Huddersfield Textile Society* for 1908-9.

dew. It is exceptionally strong, and weak fibres are seldom to be found. Fabrics made from this material are of excellent draping qualities and wear very cleanly.

(*b*) **Alpaca.**—In alpaca the lustre of mohair is to be noted, but with a closer approximation to wool. Under the microscope it appears equally as scaly as wool, but the scales are held more firmly to the fibre shaft, and they are considerably smoother. This explains its lustre and brightness, and, in conjunction with the fineness of the fibre, its softness also. The fibre is of very solid construction, which causes difficulties in the thorough dyeing. In the natural state alpaca is black, brown, fawn, and white, though the white type is not so white as mohair. The length of the fibre is somewhat remarkable, but it is liable to be deficient in strength.

(*c*) **Camel-hair.**—Camel-hair of the true type is not unlike wool, so far as its scale structure is concerned. It is fairly bright and lustrous, this being, no doubt, due to the large scale structure. Such scales, however, are not well bound down to the fibre shaft. It is not uniform in thickness, thick bristly hair being frequently found. It is somewhat downy in handle, and is not entirely satisfactory so far as strength is concerned.* The fibre length is about 5 inches. In colour it varies considerably, but is usually of a bright fawn. Camel-hair is somewhat short in staple.

(*d*) **Cashmere.**—The cashmere fibre is remarkable for its fineness. The scales are numerous and, as they are fairly firmly fixed to the fibre shaft, favour lustre; but on the other hand their small size and the fineness of the fibre partially minimise this. The slight tendency

* This remark does not apply to the camel-hair used for belting, the bristly material being more particularly employed for this purpose.

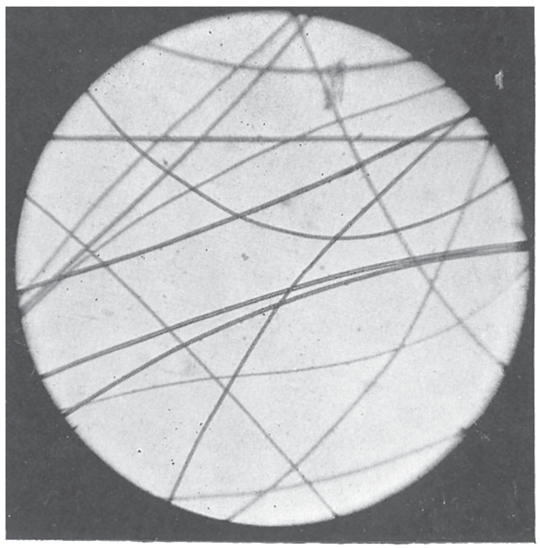

Fig. 53.—Mohair

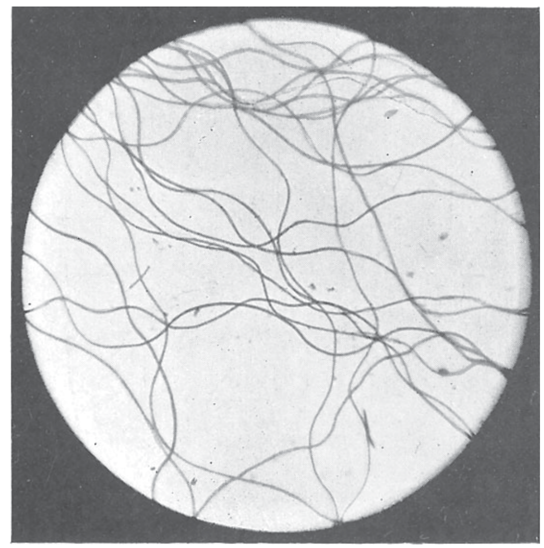

Fig. 54.—Merino Wool

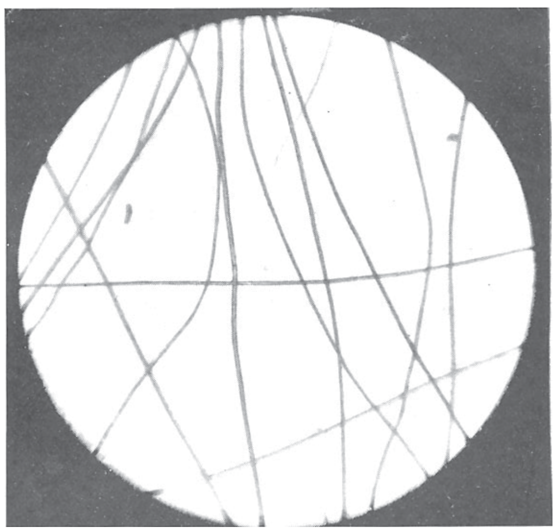

Fig. 55.—Lustre Wool

to curl on the part of the fibre further tends to develop a soft handle.

Natural and Unnatural Impurities in Wool.—Two classes of impurities are present in wool, the natural and the unnatural. The natural impurities are essential to the growth and development of the fibre, and are also necessary to its preservation prior to being subjected to the manufacturing processes. The unnatural impurities found in the fleece are due to the method of feeding the sheep and to its natural habits. They vary both in form and quantity, according to the locality in which the wool has been grown. Of the first class, wool yolk and wool fat may be cited; and in the latter class, sand, dust, dirt, dung, burrs, straw, hard-heads, and twigs.

The natural impurities are usually removed by the process of scouring with heated solution of soap, alkali and water. During the operation of scouring the greater proportion of dust, sand, dung, etc., is also removed, along with the natural grease, by which they are often held in the wool staple.

The other impurities—burrs, straws, twigs, etc.—are usually taken from the wool by being broken up in the various preparing, carding and combing processes. Burrs, however, usually cling tenaciously to the staples, and can only be effectually removed by either special mechanical or chemical treatment.

The Chemical Composition of Wool Impurities.—Much sebaceous matter is essential to ensure the satisfactory growth and development of the wool fibre. This matter may conveniently be considered as coming under two heads: there is first the yolk or suint, which is really the product of "sweat," and there is the wool fat, which may reasonably be considered as fibre oil. Earthy matters and moisture naturally become added to both of these. Commercially, however, all impurities are referred to as "wool yolk," and such impurities are carefully taken into account in buying wool "in the grease."

The following analysis of a Merino fleece by Chevreul, and quoted by Hummel, Bowman, and others, gives some idea of the relative proportions of the component parts :—

Yolk soluble in cold distilled water	32.74	per cent.
Earthy matter deposited from above	26.06	,, ,,
Fatty matter dissolved by alcohol	8.57	,, ,,
Earthy matter cohering to fat	1.40	,, ,,
Wool fibre	31.23	,, ,,
	100.00	

The commercial allowance or "loss," or "shrinkage," as it is termed, in the various raw wools is approximately as follows :—

English Long Lustre Wools	16 to 24	per cent.
English Medium	18 ,, 25	,, ,,
English Down	20 ,, 30	,, ,,
Low Cross-bred	18 ,, 26	,, ,,
Medium Cross-bred	25 ,, 35	,, ,,
Fine Cross-bred	25 ,, 45	,, ,,
Merino Wools	40 ,, 70	,, ,,

These proportions include all impurities, but do not take into account any variation in the moisture the wools may hold, the standard allowance for which is 16 per cent.

The wool yolk present is soluble in water, and partly so in alcohol. It consists mainly of potassium carbonate, but potassium sulphate and potassium chloride are also formed in small quantities, along with traces of silica, phosphorus, lime, iron, alumina, etc. The potash salts are of great commercial value, and on this account much attention is now being paid in manufacturing centres to their recovery from the wash water and scouring liquors. The means of effecting this recovery will be dealt with later.

The remaining portion of the wool yolk—the wool fat—is naturally insoluble in water. If this be treated with boiling alcohol it is found to consist of two parts, a fat and an oil. These were classified by Chevreul as "Stearerin" (wool suet) and "Elairerin" (wool oil). These substances can only be partially removed by alkaline reagents, but solvents such as carbon bisulphide are much more thorough in their action on them. Thus it is evident that the fleece of the sheep is not subject to every shower of rain which falls, but is to a certain extent resistant. It is further evident that a certain proportion of these wool fats is essential to the well-being of the fibre, for on their entire removal, either by treatment with alkalies on the emulsion principle, or by solvents, the wool is left somewhat weak, inelastic, and harsh to the hand.

Chemically, the pure wool fibre is composed of a very complex compound known as Keratin, and this, although the composition of various types of wools varies somewhat, is fairly well represented by the following analysis by Mulder :—

Carbon	50.5	per cent.
Hydrogen	6.8	,, ,,
Nitrogen	16.8	,, ,,
Oxygen	20.5	,, ,,
Sulphur	5.4	,, ,,
	100.0	

THE ACTION OF VARIOUS REAGENTS ON WOOL

Water.—Water in its cold or in its tepid state has no injurious influence on the wool fibre. In the case of unmanufactured wool, its effect is to separate the fibres and to cause them to relieve themselves of their impurity. Hot water, however, say beyond 55° C. (130° F.), robs the fibre of its lustre, discolours and weakens it, and causes it to shrink both laterally and transversely. At 130° C. wool may be altogether decomposed in water. In the cleansing of wool, according to the Bradford system, water is the vehicle by which the material and the detergents for scouring are brought into contact, and as such it is extremely handy. To heat the water is essential, the water particles being thereby more finely divided, and its efficiency thereby increased. Heat to excess, however, counteracts this action by causing the wool fats to be dissolved upon the fibre, thereby bringing about its discoloration through the impossibility of removing these in their dissolved state.

For treating wool, pure water is essential, and as all water available for commercial purposes contains impurities—in suspension or in solution—varying in type and quantity according to the source and course from whence it comes, it is necessary, if the best and cheapest results are to be obtained, to subject the water to some form of purification. Excessively "hard" water causes great waste of soap (e.g. 1 degree of hardness will destroy about 1½ lbs. of soap per gallon), and, what is more troublesome still, it gives rise to the production of an insoluble pasty substance, which greatly militates against the action of the scouring agent. The most important reason why Bradford is a wool-treating centre is because of the purity and convenience of its water supply, the "hardness" not exceeding 4 degrees. Still, it is found extremely advantageous to "soften" even this down to between 1 and 2 degrees of hardness.

Soap.—The action of soap in connection with the scouring of wool is twofold. It first renders the liquid elastic and free, making it more capable of enveloping the fibre; and, secondly, it removes by emulsification—that is, by mechanical combination with small particles—the fatty matter present.*

If the soap be of a satisfactory composition it should not only clean the wool, but it should give to it a certain softness and supplenes of handle, much appreciated by those who can rightly estimate the value of "handle." Many soaps are liable to contain free caustic alkalies which, on contact with the fibre, will harshen and discolour it. Fillings may also be present in the soap in the form of silicate of soda, resin, potato starch, china clay, fuller's earth, French chalk, and so forth, and these are not only useless, but they may do considerable harm. In all cases good standard proprietary soaps of a neutral character (that is, with minimum free alkali—not more than 2 per cent.) are advisable. By this means the alkalinity of the bath may be fairly accurately estimated, and the wool given just the treatment necessary.

Two classes of soap are available, viz. hard soaps made from caustic soda, and soft soaps made from caustic potash, the alkali, in each case, being combined with oils and fats. Soft soap is more often employed in wool washing, as it is more soluble in water and com-

* For further information as to character of impurities, tests, and methods of purification, *see* "The Wool Year-book" (Barker), "Dyeing of Textile Fabrics" (Hummel), and "Wool Dyeing" (Gardner).

posed of much the same substance as the fibre grease, which it is intended to remove. There is also present a small proportion of the glycerine which is considered by some to act as a preservative to the fibre. Soft soaps naturally contain more moisture and there is liable to be more free alkali present than in hard soaps. Upon the whole, there is always the necessity for careful testing and of exercising a wise discretion in selecting a scouring soap.

Alkalies.—The action of alkalies on wool is somewhat severe. A 5 per cent. solution of caustic soda applied with heat will completely dissolve wool in five minutes. Alkalies, however, are necessary in wool scouring to increase the efficiency of the soda or potash as a grease remover; but it should be observed that, even when used in small quantities, their action is slightly injurious to the fibre. Their function in the wash-bowl is to prevent that coalescence of the soap and the grease which would render the bath ineffective. Three alkalies are commonly employed: sodium, potassium and ammonium carbonate. Of these the ammonium carbonate is the best, it being the mildest in action. It is also a volatile alkali, and may on this account be removed in the drying process if any should be left in the wool after washing. Other types are liable to be concentrated on the fibre. Potassium carbonate, sold as "pearl ash," is preferable to sodium carbonate ("soda ash," "pure alkali," and "crystal carbonate" are well-known trade types), it being of the same character as the wool yolk salts, and also more readily soluble in water. It is, however, more costly. Attention should be directed towards soda and potash in their caustic state, for although they are very powerful detergents they should not be used for washing wool owing to the injury they give rise to as regards appearance, handle, and strength.

That the results of carelessness or ignorance in regard to the operation of wool-scouring are serious is shown unmistakably by data as given below, which has been obtained from actual experiment. And when it is remembered that this process is the first *real* manufacturing process employed on wool, and that any defect produced here tends, in the nature of things, to become aggravated during subsequent treatment, the value of following, instead of some haphazard means, a system such as is suggested on pp. 156 and 157 will be readily appreciated.

EXCESSIVE USE OF SCOURING AGENTS

EFFECT ON WOOL (64's QUALITY AUSTRALIAN MERINO)

Type	*Length*	*Strength*	*Handle*
	Ins.		
Fair average sample	2½	Strong .	Very soft
Excessive heat . .	2¼	Fairly strong	Greasy
Excessive alkali . .	2⅛	Fairly weak	Harsh
Excessive soap . .	2½	Strong . .	Very soft and slippery
Excessive agitation .	1½	Fairly strong	Fairly harsh
Excessive immersion	2¼	Fairly weak	Fairly soft

Type	*Condition of Staple*	*Colour*	*Loss or Sinkage*
Fair average sample	Free and open	Very white .	58 %
Excessive heat . .	"Stringy" .	Yellow and dirty	57 %
Excessive alkali . .	"Stringy" . .	Discoloured .	59 %
Excessive soap . .	Free and open	Very white .	59 %
Excessive agitation .	Very "stringy"	Fairly white .	59 %
Excessive immersion	Fairly "stringy"	Fairly yellow .	57 %

The action of other reagents is dealt with in list form on pp. 136 and 137, and their application in carbonising, etc., is also described.

DETECTION OF TEXTILE MATERIALS

CHARACTERISTICS OF FIBRES AS SUBJECTED TO ORDINARY MICROSCOPICAL AND CHEMICAL EXAMINATION

Material	*General Appearance*	*Handle*	*Result when Breaking Fibre*	*Microscopic Appearance*	*Chemical Test*	*Burning Test*
WOOL . .	Curly, non-lustrous, short and fine; or Straight, lustrous, long, and fairly coarse Natural colour: white	Soft (fine wool) to fairly soft (long wool)	Shows good strength and elasticity and tendency to drag before severance	Cylindrical; marked scale structure	Wool, hairs, and silk dissolve readily in cold, concentrated caustic soda, while vegetable fibres remain unchanged	
MOHAIR .	Straight, very lustrous, long, and fairly fine Natural colour: white	Soft and slippery	Shows considerable strength and elasticity, with breakage like wool	Cylindrical; scale structure not pronounced		
ALPACA .	Straight, lustrous, very long and fairly fine Natural colour: brown, white, fawn, and black	Soft and downy	Not very elastic and strong; considerable drag when breaking	Scales numerous and smooth; not pronounced	Nitric acid turns wool, hairs, and silk yellow; vegetable fibres are not coloured	Animal fibres burn with considerable difficulty when free from extraneous grease; flame dies out frequently. Disagreeable odour is emitted, and when burnt residue is in beadlike form
CAMEL-HAIR	Somewhat curly, fairly lustrous, long, and fine Natural colour: brown and fawn	Very soft and downy	Ditto	Scales numerous; fairly smooth; not pronounced		
CASHMERE	Very curly, slight lustre, very fine and short Natural colour: brown and white	Very very soft and downy	Ditto	Scales fairly numerous, but smooth; fairly pronounced		
SILK . .	Dull yellowish or brownish in undegummed state; brilliantly lustrous, yellowish (tussah) or white as degummed	Very soft and slippery	Shows considerable strength and elasticity; breaks with a slight snap	Generally cylindrical; double stranded; very smooth and glossy	Cuprate of ammonium dissolves vegetable fibres; on animal fibres there is no action	
COTTON .	Short, but fairly straight and non-lustrous Natural colour: white and light brown	Somewhat "dead"; downy	Very strong; not elastic; breaks with a clean snap	Like flattened tube or twisted ribbons	Steeped in dilute sulphuric acid and then dried, cotton may be crushed to powder,	

FLAX	Straight, long, and fairly fine; yellowish and lustrous, or (as bleached) white and lustrous	Fairly soft	Ditto	Hollow tube, with markings transverse and lateral, similar to bamboo cane	while animal fibres will not be affected.	Vegetable fibres ignite readily and burn brightly and quickly, leaving no ash
HEMP	Fairly lustrous, straight, and long Natural colour: yellowish to brown	Firm and solid	Ditto	Tubular; composed of stiff, cylindrical fibrils		
JUTE	Ditto	Firm and harsh handling	Ditto	Ditto	Wool is dyed, silk is stained, while vegetable fibres are unaffected when boiled in a solution of indigo extract in the presence of a little sulphuric acid	
RAMIE (Rhea or China-grass)	Straight, very long, and lustrous Natural colour: yellow; as decorticated: white	Soft and slippery	Exceptionally strong; similar to above	Composed of small spindle-shaped fibrils		
NOILS	Lustre and hair: straight and stiff; fairly fine and lustrous—1 inch to 3 inches	Fairly soft; hair slippery	As wool	As wool		As animal fibres
	Fine quality: curly and non-lustrous—¼ inch to 1 inch Natural colour: yellowish to white Recombed noils: white and vari-coloured	Very soft and downy			After treatment with boiling solution of caustic potash and water, flax turns dark yellow on removal of excess of liquid; cotton remains white or light yellow	
MUNGO	Short (upwards of ¾ inch) and usually fine; not generally lustrous. Contains "thready" pieces	Soft	As wool	As wool, but containing numerous broken fibres and fibres damaged in scale structure		
SHODDY	One inch or more in length; not usually very fine. Contains part "thready" pieces	Very soft	As wool	Ditto	Cotton and flax turn yellow under influence of sulphuric acid and iodine; hemp is green in colour, and jute yellowish brown	
EXTRACT	Very short and "thready"; not generally lustrous	Harsh	Weak in strength and elasticity	As above, but showing very pronounced scale structure		

CARBONISING, BLUEING, AND BLEACHING

Carbonising.—In the woollen trade, and also in one section of the worsted trade, considerable advantage is taken of the disintegrating action which acids have upon vegetable fibres. If thoroughly steeped in a dilute solution of sulphuric acid or "oil of vitriol," as it is spoken of in the works, and then dried at a high temperature, the acid is concentrated on the material, and this acts upon the oxygen and hydrogen present in the vegetable fibre (probably in the form of water), thoroughly disintegrating the body of the fibre, leaving it in the form of a blackened carbon mass, which is easily reducible to dust. Such treatment has little or no action upon wool, although under the influence of very strong sulphuric acid the fibre may be disintegrated. Applied reasonably, however, the fibre may be actually strengthened.

This process, which is termed "carbonising" or "extracting," is used in removing the objectionable burr and other vegetable impurity from wool waste and noils in the woollen trade, and also in freeing the wool from the cotton in the case of cotton and wool rags. In the worsted trade, a system of "dry" carbonising, by means of hydrochloric acid gas, is employed. This is in connection with the removal of the cotton thread spun with a wool or mohair thread for strengthening purposes in manufacturing certain "all-wool" goods. A similar process is also used in the woollen rag trade, its value residing in the reduced injury caused to any colouring which may be present in the materials treated.

In the first-mentioned—the "wet" carbonising process—the material is thoroughly cleaned prior to treatment. Steeping is undertaken in a vat containing sulphuric acid of 8° Twaddell (1.04 sp. gr.) for forty minutes or more, according to the character and extent of impurity present. After this the acid is allowed to drain away, the material lying on suitable scrays. It is then passed through the hydro-extractor for the removal of all superfluous acid. Drying follows at a temperature varying from 190° F. to 212° F., to effect the concentration of the acid on the vegetable matter, this requiring about twenty minutes or more. Next comes crushing of the charred remains by means of heavily weighted and finely fluted rollers, together with a process of willeying to remove the dust produced. Neutralisation of the residuent acid is then effected in a bath containing soda carbonate; this is followed by ordinary soap-and-water washing, rinsing in water only, then drying.

"Gas" carbonising consists of exposing the material —rags or cloth—to the fumes of hydrochloric acid gas for a few hours in an enclosed chamber. This may be a machine or an ordinary room; in either case a gas-producing apparatus and heating arrangements are necessary adjuncts to the process. Steaming or damping of the fabric is essential prior to this treatment, as by this means is created that affinity between the gas and the vegetable fibre which ultimately results in carbonisation. When thoroughly permeated by the gas, hot air is driven into contact with the material, and this causes concentration of acid according to the principle previously explained. Crushing, neutralisation, washing and drying are later required for the removal of impurities.

In addition to the foregoing, aluminium, magnesium and calcium chloride have been employed with more or less success. The first of these gives certain decided advantages.

Blueing.—The demand by the trade for perfection in colour of textile materials, consequent on the production of goods to be sold either "in the white" or as dyed into pale colours, has resulted in the demand that materials during manufacture shall be perfectly cleaned, and that in cases where naturally "yellowish" wool is employed an attempt should be made artificially to improve its colour. The use of the "backwashing" operation in worsted preparation and "blueing" or "tinting" also, both in woollen and worsted preparatory processes, are the outcome of this. In the case of "blueing," however, it is generally conceded that both the spinning capacity of the fibre and its ultimate fitness for dyeing are lessened, and that when blueing is adopted it is with the idea of effecting a ready sale of the product, and not with any particular regard to the subsequent behaviour and appearance of the material. To "blue" wool is to bring it into contact with a dilute solution of acid colouring matter of a blue, purple or violet tint, the tint thus absorbed being "complementary" to the yellow tint naturally present, and thereby causing a neutral tint to be produced which creates the impression of whiteness. Such tinting, however, is usually proved "fugitive" on contact with light, and it may also be more or less removed by washing. Further, its presence is liable to cause certain harshness of the fibre, though, if well done, this drawback is perhaps negligible. If its removal be attempted, as is sometimes necessary prior to dyeing, much difficulty is often experienced in effecting a regular "stripping," and any irregularity interferes with the production of a uniform shade in the dyed result.

Of the "blues" available—"ultra," "indigo" and "methyl"—the first mentioned is most often employed. Its value lies in the reduced risk of over blueing and irregular blueing, and in the ease with which the blue may be removed. The two others are very economical, but " spottiness " and a distinct " cast " in the ultimate material may easily result from their use.

Bleaching.—Bleaching gives a more permanent whiteness in colour to wool than " blueing," and on this account it is used in many instances, as, for example, in noils for the hatting trade, where colour is a prime consideration. It has, however, a harshening and weakening action on the fibre; consequently it can only be used on those materials which in character of fibre, and which in respect also of their ultimate form —yarn or cloth—will admit of it. Bleaching is not successfully employed in the worsted trade, save in connection with yarn and cloth. The bleaches used vary in the way in which they act on the fibre. Some reduce its colour pigment, while others destroy this pigment and decolorise the fibre. In the latter case the whiteness obtained is quite permanent. The simplest form of the first-mentioned system of bleaching is that known as " stoving " ; it is suitable chiefly for yarn or cloth. It consists of bringing the fumes from a burning bar of sulphur into contact with the material for a period of ten to twelve hours. For effective work, the material must be conveniently placed in an air-tight chamber and moistened. For cloth, a chamber, with mechanically working rollers, is employed, so that the material may be bleached on the continuous principle by a slow passage through the machine.

The action of the sulphur gas (SO_2) and water (H_2O) may be represented as follows :

$SO_2 + H_2O = H_2SO_3$ (sulphurous acid). This tends to become sulphuric acid (H_2SO_4), and in so doing deoxidises the colouring matter present.

After "stoving," most thorough washing is necessary to remove the acid, otherwise weakening of the fibre may result, along with certain injury to any other material with which it may be subsequently placed.

There are many systems of liquid bleaching, the commonest being that in which sulphurous acid is employed. Most satisfactory results, however, are obtained by the hydrogen peroxide treatment, and this is used on a very considerable scale for wools and noils. The process consists of steeping the material in a hydrogen peroxide bath to which has been added a small quantity of strong ammonia. A period of several hours is required for complete decolorisation, after which washing, first in water and sulphuric acid, and later water only, is necessary. If the harshness of the bleached material is pronounced, the wool may be finally "fed" in a soapy water bath. The bleaching action in this case is an oxidising action as against a deoxidising action in the previous case.

Resists: Chlorinated Wool.—Of late there has been a tendency to employ reagents of an interesting character and action for such purposes as "resists," i.e. making the fibre resistant to dyes (usually certain dyes only). This as a rule is effected by treatment with tannic acid. The American coating manufacturers have employed this system to great advantage, but the superior organisation of the Yorkshire colour spinning trade has probably militated against its adoption in this country.

Chlorination of wool, with the object of influencing both the colour-taking and shrinking properties, has also been employed to some extent. Again, in the many and varied combinations of different materials, now so prevalent in the dress goods trade, variation in shrinkage may be either desirable or undesirable. Under these circumstances the fibre shrinkage may be at least partially controlled, not only by boiling under tension, i.e. "setting," but also by subjecting the material to acid vapours, formaldehyde, etc., There is still quite a field for original research here, which the technical chemistry student will certainly find interesting and probably profitable.

CHAPTER VII

WOOL STEEPING, SCOURING, AND DRYING

THE object of wool-scouring is, so far as possible, to remove from the wool both the natural and unnatural impurities, thereby rendering it free and open in staple, and fitted for the subsequent processes through which it has to pass. Scouring should also develop the colour and lustre, and further favour the attainment of a soft handle, which ought to be maintained right through the various processes up to the piece itself. Scouring is certainly one of the most important processes to which wool is submitted, for if it be not performed satisfactorily none of the subsequent operations can be applied to advantage. Even in the wash-bowl itself the disadvantages of a bad scour will be felt, for if the wool be left dirty and greasy there will be difficulties in passing it through the rollers, and difficulties will also be experienced in passing it through the subsequent machines. On the other hand, should the wool be over-scoured, it will prove weak in fibre and will lose a good deal in the subsequent processes. Moreover, the ultimate fabric into which it passes will probably show irregularities in appearance and will be of defective handle and strength.

General Consideration of Wool Scouring.—Before passing on to the details of wool steeping and

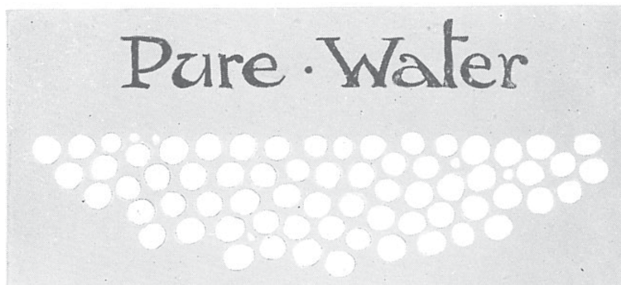

Fig. 56

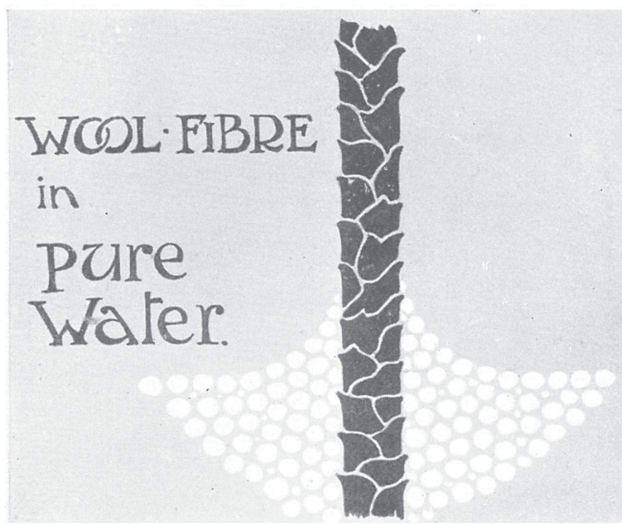

Fig. 57

scouring, a general review of these processes is desirable. The first point to be realised is that the wool yolk itself forms a natural scour, which may either be removed without giving it a chance to act to the fullest extent possible, or may be left to play its part along with the artificial scouring agent added. Upon the whole, its early removal by steeping is to be advocated, as thereby the fibre is undoubtedly cleansed to a very considerable extent. Further, as the wool yolk is in a pure form, it may readily be treated chemically for the extraction of the wash-water by-products, now quite a valuable asset against the cost of scouring.

In the second place, it should be realised that the scouring action is a chemico-physical action; thus it is not true to say that there is no chemical action during scouring, but it is certainly true that the action is largely physical, and that this action is of a most interesting character, including the study of such matters as capillarity, surface tension, pedesis, etc. Thus, as shown in Fig. 56, pure water may be considered to consist of molecules or globules of a spherical form, each globule tending to keep this form. If a tube or wool fibre be placed perpendicularly in water the capillary-attraction causes the surface to take the form shown in Fig. 57.

In Fig. 58 the effect of adding soap to the water is graphically indicated, the surface tension or attraction of globule for globule being modified by the soap.

In Fig. 59 the result of reduced surface tension due to the addition of the soap is indicated; the capillary attraction being much more marked.

In Fig. 60 the possibility of the water and soap globules surrounding the fat and dirt globules on the exterior of the wool fibre is graphically indicated, the reduced surface tension and consequently increased penetrating power of the liquid in conjunction with heat resulting in the formation of a water, soap, fat and dirt emulsion which is readily got away from the cleansed fibre.

The third point to take into consideration is the handling of the wool during scouring. Not only is the material to be suitably got into the bowl, but it must be passed through the bowl with the least possible felting, and, this accomplished, must be satisfactorily taken out of the bowl. These are operations which require very careful study.

In the fourth place, it must be realised that to insure perfect contact between the scouring agent and the fibre, not only is agitation necessary, but heat also is required. Realising that heat may have a very deleterious action on the wool fibre, it is obvious that there must here be a nice balance between the strength of the scouring agent and the intensity of the heat employed, both being as it were balanced by the natural protective influence of the wool grease itself.

In the fifth place, the economies to be effected without detriment to the wool require careful consideration. There is a difference between true and false economy ; thus, while it may be false economy to employ a cheap scouring agent which jeopardises the wool, it is nevertheless possible, by a careful consideration of all the factors involved, markedly to cheapen the cost of this and subsequent processes.

The Steeping of Wool.—As indicated in the previous chapter, a large proportion of the suint or yolk present in greasy wool is soluble in water. On the other hand, the wool fats are only soluble in such agents as carbon bisulphide, ether, etc., spoken of as the volatile agents, or removable by emulsification by treat-

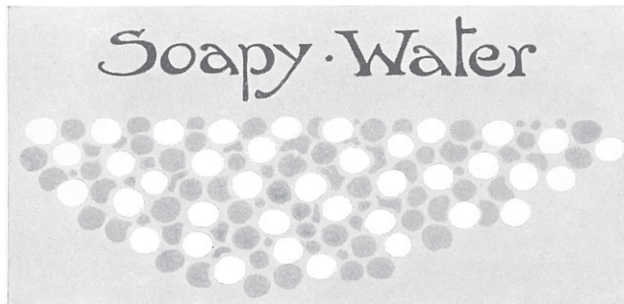

Fig. 58

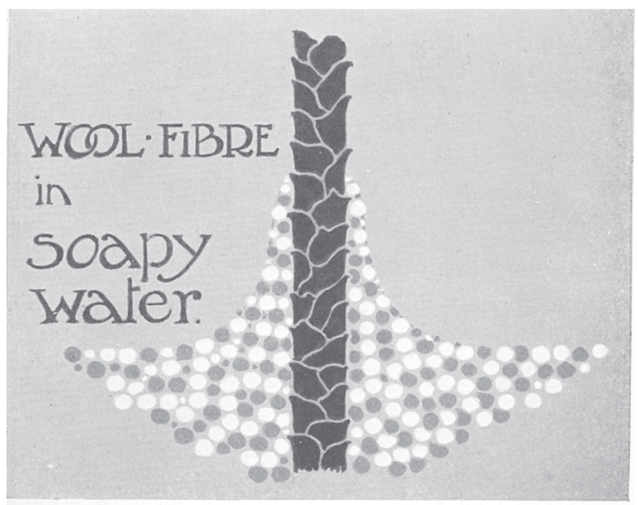

Fig. 59

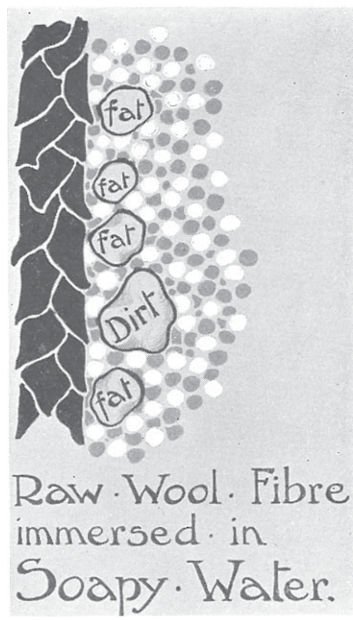

Fig. 60

ment with alkaline detergents. Consequently it is possible, by a system of cold or tepid water steeping, to remove from the greasy wool a great proportion of that impurity which otherwise might necessitate a somewhat severe scouring operation. Again, the suint removable by steeping consists mainly of potash salts from which the potassium carbonate—the most suitable alkali for wool washing—may be extracted, this being worth about £25 per ton. It is therefore evident that, in the case of very dirty, greasy wools, steeping is very advantageous, as thereby all dirt not held in the fleece by grease will be removed prior to the scouring operation proper, thus markedly cheapening this latter process.

Although steeping is by no means unknown in this country, it has never been widely adopted, apparently for the reason that it has not been tried under the circumstances in which its advantages could be fully demonstrated. Possibly the usual method of removing sand, dirt, etc., from the wool by willowing, previous to scouring, also accounts for the little use made of steeping. Willowing, however, is by no means satisfactory from the length of fibre point of view. When steeping has been practised it has too often been carried out with inefficient apparatus, necessitating too much handling of the wool, or treating the wool too freely. On the Continent, however, careful attention has been given to steeping, special machines having been designed as auxiliary to the wool-scouring sets, and this has brought about superior results, both from the points of view of the quality of the material treated and the saving in cost.

From the following description of a representative machine known as "the Maloard," which is made in France, an idea of a satisfactory steeping process will

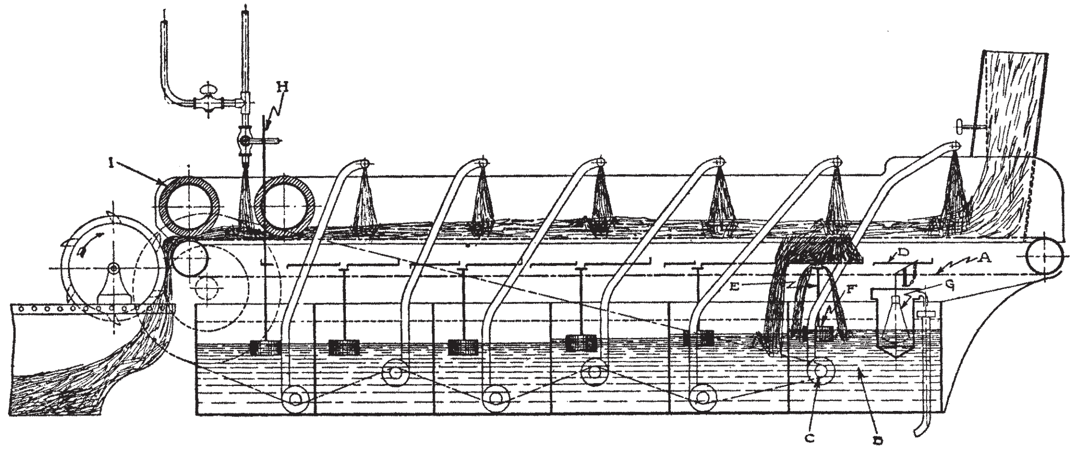

Fig. 61.—The "Maloard" Steeping Bowl

be gained. This arrangement, which is shown in Fig. 61, is largely employed both on the Continent and in America.

The wool is delivered, usually by way of a shoot, on to a slowly moving lattice (A), being arranged in layer form, of a thickness of six inches or more, varying according to its yolky condition. Below the lattice is a series of six compartments (B) containing tepid water, and with each of these is connected a centrifugal pump (C) to effect circulation of the water through a spraying tube on to the wool which is slowly passing. The wool is thoroughly saturated by this means without being agitated or in the least felted. Moreover, as it is repeatedly treated with liquor of increasing cleanness, and finally with pure water, the operation is thorough. After percolating through the wool and removing the potash impurity, the liquor from each sprayer falls on to a special tray (D), which contains two openings—a larger and a smaller—though in the case of the last compartment only one tray opening—a large one—is fitted. In each case the large outlet conveys the liquor from the wool to the tank from which it was pumped; but the smaller—which is fitted with a hinged valve worked by a float (F) in the liquor—conducts a small portion—say one-seventh—into the preceding tank. By this means connection is established between the various bowls, and the pure water supplied at the delivery end of the machine, after being successively passed in to each compartment, is ultimately run off for recovery of the potash. The changing of the liquor is dependent on a hydrometer (G) placed in the compartment at the feed end of the machine, which closes the outlet so long as the liquor is below a desired density. During this time addition of liquor from the preceding compartments is being made to the last compartment through the small tray openings until a certain level is reached, at which point the tray valve is closed and the water diverted into preceding tanks until each in turn is filled. In the last case the supply from the main (H) is cut off. Continued circulation of liquor and extraction of potash brings about the required density of the liquor in the last compartment. This raises the hydrometer, which in turn releases the outlet by which the contents are led away from the machine. Then with the lowered level of this liquor comes the opening of the tray valve previously referred to; and this creates a passage for liquor from the preceding into the succeeding compartment. In turn the level in the other compartments is similarly influenced, causing ultimately the opening of the pure water supply valve at the end of the machine.

From this description it will be realised that this machine is entirely automatic in action, and that consequently no extra labour is required when it is used in conjunction with a scouring set. It is exceedingly efficient as a steeper, firstly, because of the numerous penetrations of the wool by the water employed, and secondly, owing to the wool being steeped at each stage of its forward movement in water of increased purity. At the delivery point in the machine two nips are given to the wool, one to remove the wash-water liquor prior to the final strain, and the other immediately after to dry the fibre. After this the wool is mechanically conveyed by a feed sheet or beater roller to the first scouring bowl. In the Maloard machine the quantity of water employed in proportion to the wool must be small if the idea is to recover the potash salts, for under these conditions a saturated solution will be obtained. If, however, the removal and not the recovery of the potash salts is the end sought, a much greater quantity of water may be employed, as this enables the material to be passed more quickly through the machine. Even with the yolkiest wools, however, one of these machines will supply a full scouring set. The recovery of the potash salts, however, is of such prime importance that every attention should be paid to it, for from 1 lb. of liquor charged with impurity to 15° Beaume, or 1.11 sp. gr., as much as $1\frac{3}{4}$ oz. of potassium carbonate may be obtained after the evaporation of water followed by calcination to remove impurities.

Recovery of Waste Products in Wool Scouring.—Although wool steeping and the recovery of the potash salts from the wash-water products is not largely in vogue in Bradford, still the tendency is towards securing all that may usefully be recovered from the suds or refuse from the actual scouring operation. That this is done is in the first place mainly due to the fact that the treatment of the effluent is legally enforced, and, in the second place, only because such treatment may yield a small profit. Generally speaking, however, the methods employed are unsatisfactory, so that much grease and practically the whole of the valuable potash salts are lost. In the Magma process, which is most commonly in use, the liquors are drained into large tanks, and sulphuric acid added. "Cracking" is by this means effected, the grease thus separated rising to the top, while the heavier impurities fall to the bottom, leaving fairly clean liquor between. From the top of the tanks the greasy liquid is then conducted to filter beds for the removal of superfluous water, after which the remainder, as a pasty mass, is placed in bags and pressed with heat, the oil being thus extracted. The residue from this pressing is a dark coloured cake consisting of a small quantity of grease, dirt and sand, along with all the potash salts. It is sold very cheaply for manurial purposes. It is somewhat unfortunate that there is no simple, handy and inexpensive process available whereby the whole of the sud constituents may be reclaimed in their separate form.

A very efficient method—the Smith-Leach process—for complete treatment was patented about 1898, and worked for a time on a very large scale. The first cost and running expenses, however, placed it out of court save for those firms dealing with tremendous quantities of very greasy wool. By this treatment pure wool fat, potassium carbonate, and distilled water were obtained, the only residue being a small proportion of sand.

WOOL SCOURING SYSTEMS AND THE PRINCIPLES INVOLVED

The system of wool scouring most commonly in use is that known as the alkaline or emulsion system. Its action depends upon the power possessed by certain alkalies—soda, potash, and ammonia—of emulsifying, in the presence of soap and water, the fatty impurity present in the wool fibre, thereby effecting the removal of this impurity. This removal is accelerated if the liquor be heated, and is further facilitated by a certain amount of agitation of the material during treatment. Much has been done to perfect the necessary mechanical arrangements for working upon this system, and it is now possible to give the fibre, whatever its character or condition may be, just that degree of movement it requires freely to relieve itself of its impurities. Modern scouring sets are also most thoughtfully designed to deal with large quantities of wools quickly. In the hands of careful and experienced men very satisfactory results are obtained, but the system is not without its element of danger when judged from the standpoint of the quality of the delivered wool. As will be gathered from the preceding chapter, the action of strong alkalies and high temperatures may readily injure the delicate scales of the fibre, or, through concentration in the interior of the fibre, may cause it to become weak and discoloured. Again, too much agitation will have the effect of matting the fibres, this implying considerable breakage and a poor yield of top should the wool subsequently be combed.

The other recognised system is known as the "solvent system," in which such agents as ether, carbon bisulphide, petroleum-benzine, naphtha, alcohol, etc., are employed to dissolve out the oily part of the yolky impurity, thereby liberating the potash salts and any adhering dirt, these being subsequently removed by a simple process of water steeping. This method is at present finding considerable employment in the United States and on the Continent. It is possible that as yet this process has not received the attention from the mechanical standpoint which it merits, for it is certain that, as regards simplicity of action and effect on the material treated, the system upon the whole is superior to the one more generally employed. The chief cause of the diffidence in adopting this process is no doubt the difficulty of handling the highly inflammable solvents. This and other troubles, however, are only such as may be expected in developing a comparatively new method, and must not be considered as insurmountable. The advantages of the system are manifest when it is realised that on the fibre itself the solvents have practically no influence, there being no harshening or discolouring; and, further, that on account of it being quite feasible to hold the wool and pass the solvent through it, instead of working the wool in the solvent, no matting of the fibre results. In principle, no process could be simpler or more complete, or more economical, as the solvent has simply to be passed through the wool, and when distilled is ready for use again, while the valuable by-products are left as a residue.

Practical Wool Scouring: the Alkaline System.—To effect the complete removal of the impurities found in wool in the shortest possible time and with the least possible injurious action on the wool, it is found desirable to employ three, four or five bowls of large, but varying capacity—the last bowl, for instance, as a rinser being short, while the first bowl, as a steeper, may advisedly be long. Fine wools require larger sets of machinery, the five-bowl sets being successfully adopted for the greasiest and dirtiest merinoes. The following is a description of a three-bowl set, from which the principles of arrangement either for three, four- or five-bowl sets may readily be deduced,

As three bowls only are to be employed, the first bowl cannot be employed as a pure steeper. It must rather be employed as a strong scourer in which a strongly acting artificial scouring agent is employed to "shift" the greasy impurity, while the wool fibre is still protected by the yolk and natural wool fat. Further, to facilitate this, the greatest heat is here employed, say 125° F. The second bowl must be regarded as a scourer of unprotected wool; its scouring strength must then be very materially reduced, say to about one-sixth of that of the first bowl; but soap, as an aid to the action of the scouring agent and as a feeder, may still be present to a marked extent, say about half as much as in the first bowl. This bowl need not be so long as the first bowl, and the temperature is advisedly kept lower, say 115° F. The third bowl must be considered as a rinser, and as such must contain no alkali at all, but soap of neutralising character, so that any free alkali left in the wool may be rinsed off and neutralised. The soap in this bowl should feed the wool, supplying the place of any natural grease which may have been unavoidably removed in scouring the wool in the first and second bowls. Possibly the best results would accrue by using a large bowl—say 24 feet—but the custom is to employ an 18-ft. bowl. Whatever length is adopted the liquor must be of such a character that the wool leaves it free from pure alkali—for if this be left on the fibre it will ultimately tend to disintegrate it—and with all harshness which may have arisen in the previous severe processes, subdued by the "feeding" of the wool. As there is here no question of loosening the natural wool fats by heat, a lower temperature may be employed, say 110° F. Careful consideration of the list on pp. 156 and 157 will show how these principles are carried out in practice.

Having decided upon the length of bowls to employ, the constitution of the scouring liquors and the temperatures, the next point to consider is the method of presenting the wool to the action of the scouring agent. Here it is evident that two points claim special attention: firstly, the necessity for a thorough penetration of the wool staples by the scouring agent; secondly, the equal necessity for carrying the wool through the bowls with little or no felting action, and the delivery of the wool in a nice open condition. At first sight it would appear that these two necessities are so opposed to one another that to ensure one means an ignoring of the other; but in practice this is not so.

PARTICULARS FOR WOOL SCOURING

APPROXIMATE QUANTITIES USED PER DAY (10 HOURS)

MERINO WOOL.—CAPACITY OF SET: 20 PACKS (4,800 lb.)

Bowl	*Type*	*Length*	*Capacity* *	*Temperature*	*Type of Soap, and Quantity*	*Type of Alkali, and Quantity*	*Immersion*
1	Swing Harrow	30 feet	1,800 galls.	120° F.	125 lb. Soft (Potash) †	35 lb. Potassium Carbonate	3 mins.
2		24 ,,	1,500 ,,	115° F.	65 ,, ,,	5 ,, ,, ,,	2½ ,,
3		18 ,,	1,000 ,,	110° F.	40 ,, ,,	None	2 ,,
4		12 ,,	750 ,,	105° F.	10 ,, ,,	None	1½ ,,

MEDIUM CROSS-BRED WOOL.—CAPACITY OF SET: 24 PACKS (5,760 lb.)

Bowl	*Type*	*Length*	*Capacity*	*Temperature*	*Type of Soap, and Quantity*	*Type of Alkali, and Quantity*	*Immersion*
1	Swing Harrow, sometimes Swing Rake, and Three Swing Harrow Bls.	24 feet	1,500 galls.	125° F.	130 lb. Soft (Potash)	35 lb. Potassium Carbonate	2½ mins.
2		18 ,,	1,000 ,,	120° F.	65 ,, ,,	7 ,, ,, ,,	2 ,,
3		18 ,,	1,000 ,,	115° F.	35 ,, ,,	None	2 ,,
4		12 ,,	750 ,,	110° F.	10 ,, ,,	None	1½ ,,

ENGLISH LUSTRE, OR LUSTRE CROSS-BRED WOOL.—CAPACITY OF SET: 28 PACKS (6,720 lb.)

Bowl	*Type*	*Length*	*Capacity*	*Temperature*	*Type of Soap, and Quantity*	*Type of Alkali, and Quantity*	*Immersion*
1	Swing Rake	24 feet	1,500 galls.	125° F.	150 lb. Potash or Soda (Hard)	35 lb. Soda Carbonate	2½ mins.
2	"	18 "	1,000 "	120° F.	85 " "	7 " " "	2 "
3‡	"	18 "	1,000 "	115° F.	10 " "	None	2 "

* Capacity of bowl generally equals 60 galls. per lineal foot.

† Agents are commonly put in bucketsful when the liquor shows lack of strength, or when the colour of the wool appears less satisfactory. The best arrangement, however. is to bring the liquor up to the required standard at the commencement and afterwards drip the agents continuously into the bowl to keep the suds up to the required degree of efficiency. This may be conveniently done by pipe arrangements from the soap and alkali tanks. Or pumping of the agents into the bowl may be done at intervals.

‡ A fourth bowl—a 12-ft. machine—is sometimes used here.

It is not at this stage desirable to go into the various types of early scouring machines in which any and every kind of action has been tried, but rather to emphasise the principle upon which the best wool scouring is based. This principle is that wool naturally opens out when placed in water, this being due to the elimination of surface tension. If, then, the wool is naturally opened out in the scouring liquor, is partially carried forward by the flow of the liquor, and this movement is gently aided by the action of suitably worked forks, then it will be evident that a satisfactory progression of the wool will be ensured. The only further difficulty at this stage is taking the wool out of one bowl and feeding it into the next. This is best effected by presenting the wool to the squeezing rollers placed at the end of the bowl, so far as possible, just as it has been floated through the bowl. To ensure this, it is necessary practically to float the wool as close to the nip as possible, and then further to aid its passage forward by some special feed action, such as McNaught's "auxiliary rake feed," whereby a level continuous feed to the rollers is ensured. This seems very simple, but so closely are the chemical, physical, and mechanical problems here at issue interwoven that failure of the one may mean the failure of the other. If the chemico-physical action of the scouring bath has failed to remove a sufficient amount of the wool fat, the squeezing rollers will refuse to take the wool presented to them. Thus, although it may be wise to lay down the rule, "as little agitation in the bath as possible," it may, nevertheless, be absolutely necessary, in dealing with certain types of wool, to provide for agitation of the wool in its passage through the scouring liquor. Several styles of rake action are placed on the market with this idea in view.

Having floated the wool out of the first machine, it is now fed, without disturbance, by means of a travelling lattice, into the second machine. The feed to all these machines consists of a travelling lattice, upon which the wool is evenly spread, a pair of taking-in rollers, and an immersing apparatus, whereby the wool on emerging from the taking-in rollers is immediately sprayed and well immersed in the liquor.

It is somewhat remarkable to note that, even after the wool has passed through five bowls, there is still a considerable quantity of dirt left in the staples, which the carding or preparing operations show up. This is usually removed in the back-washing operation, which follows carding or preparing. The presence of this dirt renders it very undesirable to give the wool a "wet nip" on its passage from even the last scouring bowl, as a "wet nip" is usually considered to nip the remaining dirt into the fibre, and thus to spoil the colour of the wool.

It will at once be realised that the method of dealing with the scouring liquors for a set of bowls will be very different from the method adopted in the early days of the industry, when one bowl only was employed, and the wool simply forked about until it was considered clean. Roughly, there are three main points here to be taken into consideration: firstly, the getting of the liquor into the bowl, and into a fit state for scouring; secondly, suitable arrangements whereby the liquor in the bowl shall be used to the greatest advantage; thirdly, the clearing of the bowls of the sud and of the settling products.

Suitably to prepare the liquor, water and steam must be carried to the bowl so that water of the required heat may readily be obtained. In close proximity to the bowls two tanks should be arranged, one for soap liquor and the other for alkali. If these can be fixed above the level of the scouring bowl, then pipes may be laid to connect them up, and a gravity feed, allowing a gradual introduction of the scouring agent during the actual operation, may be arranged.

The control of the liquors during the actual operation of scouring has claimed the attention of the makers of scouring machines for the last fifty years. The main points to be observed are, firstly, to make suitable arrangements for the dirt and grit from the wool to fall, as it were, out of the scouring liquor; secondly, to remove any spent or dirty scum; and, thirdly, to keep up a flow of the active scouring liquor. The first object is attained by means of the false bottom of the wool trough placed inside the bowl, in conjunction with the shape of the bowl. This is further ensured by the settling tank, into which the carrying liquor, which passes with the wool up to the nip of the rollers, falls, there to be allowed to stand until impurities rise or settle out of it, when it is pumped back as a feeding spray, fresh scouring liquor being added to it as previously described. The third object is attained by this pumping of the liquor from the settling tank into the main bowl, and possibly by the forking of the wool forward.

The design of the scouring bowl, to facilitate the running out of the scouring liquor and the removal of solid impurities, is worthy of most careful consideration. Instances are on record in which the production of a scouring set has been seriously limited by the size of the drain for carrying off the waste liquors. It is equally important to be able thoroughly to clean the machines as expeditiously as possible. In Figs. 62 and 63 the best style of machine is illustrated, in which reasonable consideration is given to these points, and a representative system of drainage is also shown in Fig. 64.

Having dealt with a set of wool-scouring machines,

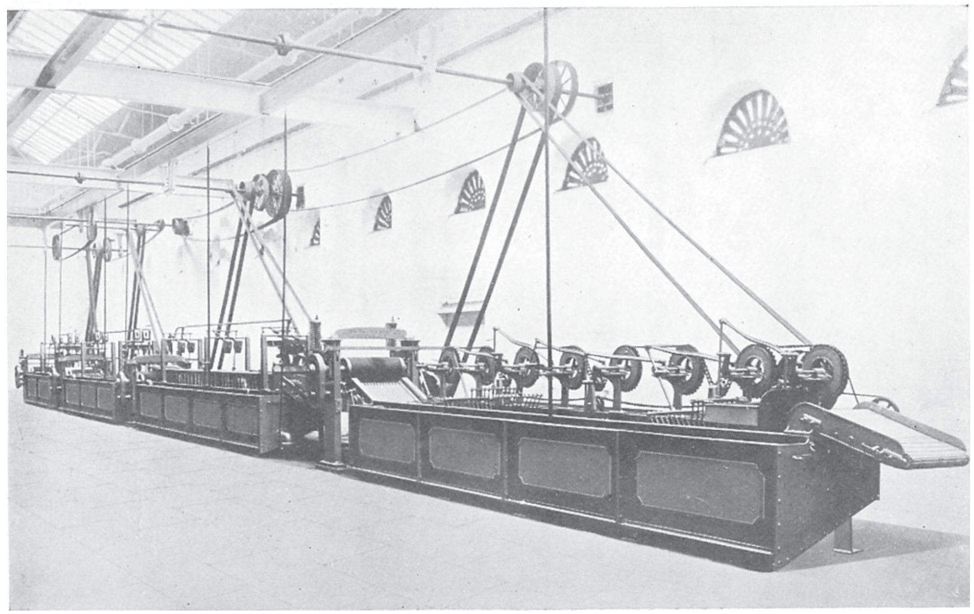

Fig. 62.—Four-bowl Scouring Set for Merino Wool

1st Bowl, Swing Rake, 24 feet ; 2nd, 3rd and 4th, Swing Harrow, 24 feet, 18 feet, and 12 feet respectively attention may now be turned to the detailed construction and arrangements of the bowl.

The bottom of the bowl proper generally slopes, as in the case of Messrs. McNaught's and Messrs. Petrie's (both of Rochdale) machines; or it may be circular, as in Messrs. Dawson's (of Milnrow) bowl. In such case, dirty impurity, once removed, settles to a point farthest away from the wool, from which it may be cleared by steam, or, as in the case of Dawson's circular-shaped bowl, thorough removal may be facilitated by means of a plate mounted on a shaft running the length of the bowl and oscillated by hand from the feed end. The first two (or three) bowls are, as a rule, fitted with a special settling tank, by which the dirty liquor, delivered by way of the nip, may, on standing for a while, free itself from its impurities (the dirt falling to the bottom and the grease rising to the top of the sud) and admit of the clearer liquor being carried back to the bowl, where scouring is to be done by means of a centrifugal pump fixed in a suitable position at the feed end. In the McNaught bowl connection to this tank is by way of a channel from the trough under the nip; in the Petrie, the centrifugal pump may be employed as an alternative if desired. For the longer qualities and cleaner wools, in the machine as made specially for this work by Messrs. Petrie, washing takes place in the big bowl. It contains, however, a perforated bottom to control dirty impurity, and, if desired, there may also be fitted with it a side settling tank. This form of bowl enables big quantities of material to be handled, and it also admits of a dry nip being given, the wool being brought up to the rollers by a special slide of toothed bars, which are traversed in sets by cranks. This arrangement is used instead of the system of floating the wool to the nip through the agency of forks, and a special chute arrangement, which is part of the end of the bowl, and is necessary in the case of wools, which, if not fed to the nip in open condition, will readily mat.

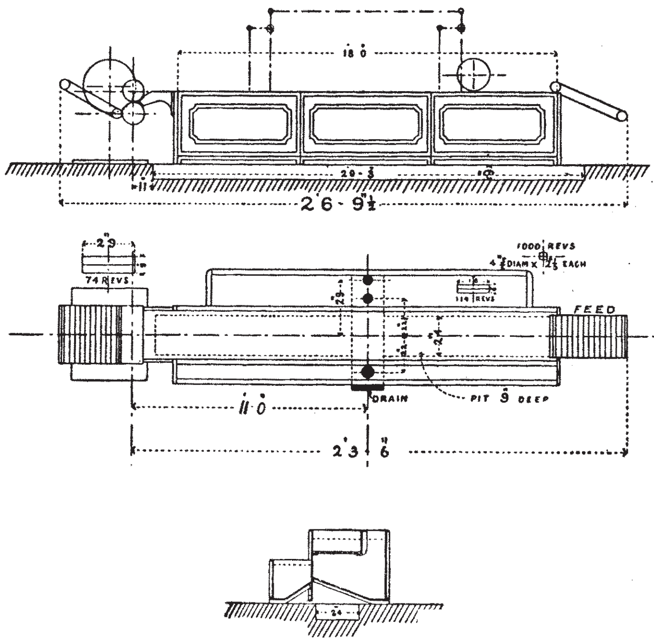

Fig. 63.—Plan, Elevation and Section of McNaught's Washing Machine

To the second and succeeding bowls pump transmitters and pipe connections are fitted so as to provide for the changing of the liquors. As the wool, on passing through the later bowls (the third and fourth), is in a fair state of cleanliness, the liquor used is by no means unsuitable for treatment of the dirtiest wool; therefore, as such procedure means considerable economy, it is usual to drain away the contents of the first bowl only, filling this with the suds from the preceding machines, these being afterwards raised to the required standard of scouring by the addition of agents. Clean water is, of course, added to the last bowl.

Rake Motions.—Propulsion of the wool through the machines, or agitation, is effected by either the "swing-rake" or "swing-harrow" mechanism, or by a combination of both. The first-mentioned (first bowl, Fig. 62) is for the lower qualities, which do not readily mat. The movement given to the wool by this method is great, but it has the advantage of increasing the turn-off. Forks or rakes of brass (hollowed) are mounted on an upright lever, this being connected to a shorter and more horizontally working link, fixed in turn to a standard. For each rake a short crank arm is driven by bevel gear; this is linked up to the rake stem, and thus, on the revolution of the crank, the rake is made to follow an elliptical path sufficient to propel wool. By simple adjustment the forks may be worked in unison, or they may be alternately worked, one up while the next is in the liquor, in this way giving useful modification of treatment according to the condition of the material.

In the "swing-harrow" (second and subsequent bowls, Fig. 62) the rakes are fixed transversely with the machine to two long arms of tubing running parallel with it. The connection is then established between the frame of forks and two T-levers fixed on vertical standards, the levers being also fixed together. The T-levers are weighted at their extremities to preserve a balance; one of these is linked to a

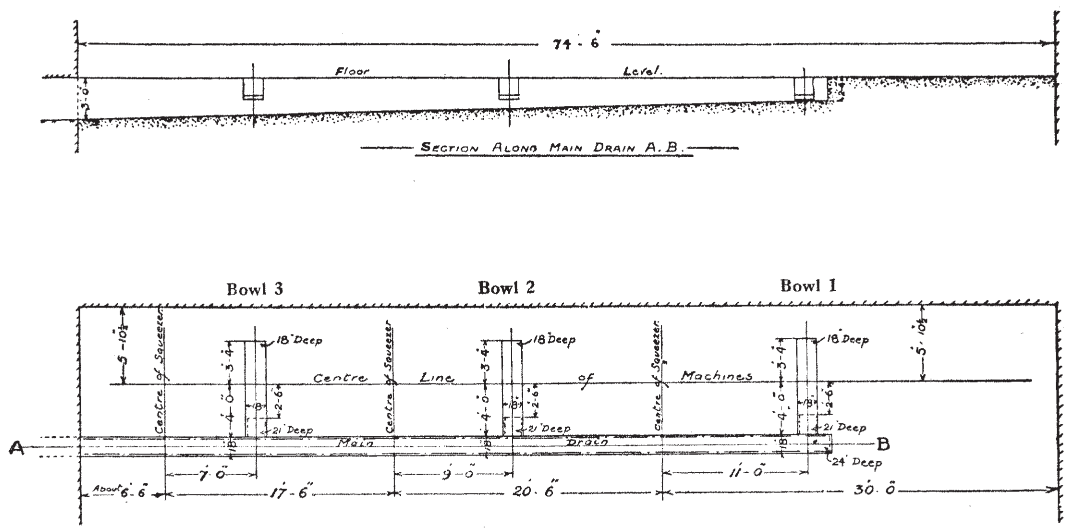

Fig. 64.—Plan of Drainage Connections for a McNaught Washer

horizontal lever centred at one end, which is given a rising and lowering movement through the action of a cam on the main shaft. By this means the harrow is made to follow one part of its course.

To the harrow also a horizontal rod is fixed by which it receives backward and forward action. This rod is connected to a slotted lever, centred at its upper extremity, in which works a crank pin driven from the cam shaft before referred to. The combined movement thus given is circular, and for the forward movement (when in the sud) it is slow, but on being lifted clear of the sud for returning, it moves the harrow quickly. As all the rakes in this system strike the liquor together and have slow action, the minimum disturbance to both wool and sud is caused, a condition absolutely vital to its freeness and openness if fine material be treated. The same movement is also used on a perforated box fixed to the harrow, by which the wool is submerged immediately on entering the bowl.

In Fig. 65, which shows a machine of this type, the wool is fed by hand on to the feed lattice A. Immediately the wool is pressed down into the sud by means of a "ducker" B, thus preventing the wool from riding on the water. To reach this point it is assisted by the flush of water entering the tank at C, which also gives it the necessary impetus to reach the forks D. The forks here are arranged on the harrow system, which implies that the forks are in rows and fastened on to laths E (at equal distances), which laths run the whole length of the machine. These are moved in a regular path as follows:

First Movement.—Down into the sud.

Second Movement.—Forward towards the delivery rollers a distance of about one foot, carrying the wool in the bowl with them.

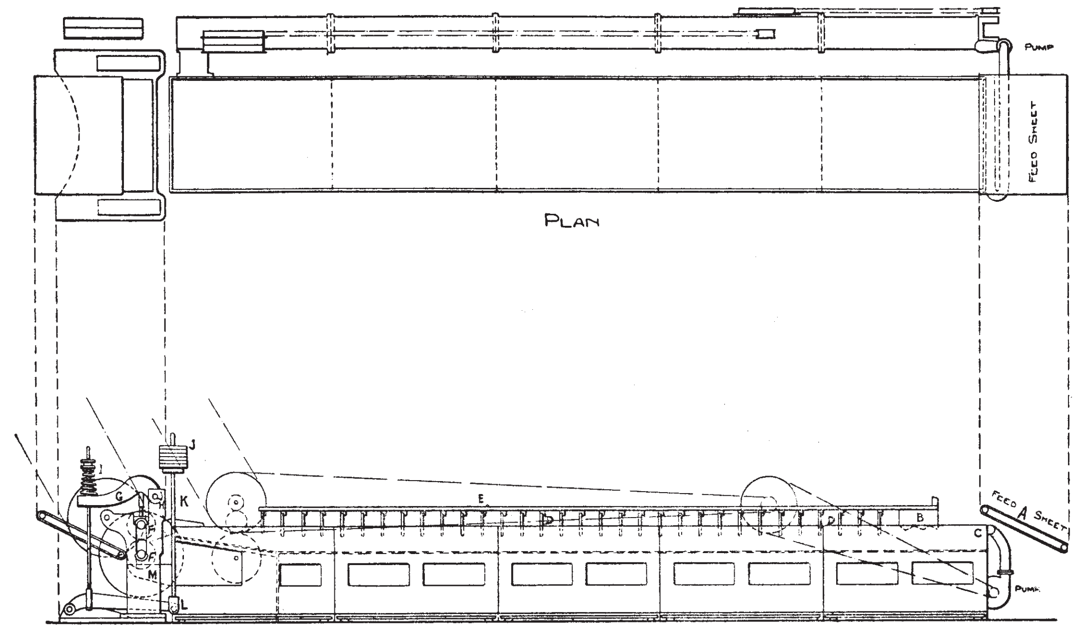

Fig. 65.—Harrow Washing Machine

Third Movement.—Upward and out of the sud.

Fourth Movement.—Backward until they are in their original position.

Thus they propel forward the wool until the delivery rollers are reached. To lift the wool from the bottom of the tank the tank bottom is inclined and consequently the forks are shortened at this point. The wool enters the squeeze rollers F in a very wet condition, water from the tank flowing with it. This is designed to give the wool a wet nip. The squeeze rollers are weighted by a strong pressure lever G having its fulcrum at H. Power is applied at I by means of a strong spring. Weights J are placed on the rod K which cause a depression to act at L, and these, though small, cause considerable pressure on the squeeze rollers. The waste water which is always very dirty, is allowed to fall into a settling tank M instead of being returned to the washbowl again. The sand and dirt are allowed to settle in this tank and the water, now clear, is pumped back again into the bowl at the feed end of the machine. After settling, however, the water is heated to the required temperature, making the addition of steam to the bowl unnecessary.

Arrangement of Sets.—For medium and medium-to-fine wools an auxiliary rake is sometimes fitted to the machine to ensure a regular feed to the squeezing rollers. This motion—put on McNaught's machine—is also of great value, for its movement most markedly aids that of the main harrow. The combined rake and harrow arrangement is used frequently, as is found in Messrs. Dawson's sets of machines. The action in this case will be realised from the description already given. In other cases, one or two of the "swing-rake" bowls precede those of the "swing-harrow" type, this arrangement being adopted to favour increased output at that period of the operation when the wool, being greasy, is less liable to be injured by the severer action of the rakes.

The "Nip."—The squeeze-head or "nip" of the scouring bowl is a part of no small importance. It is required not only thoroughly to remove superfluous moisture from the wool, and by this means reduce the time necessary for drying, but it must also leave the wool free and unbroken. For the purpose of efficiency, the bottom roller is of steel or cast iron, and sometimes is brass-covered; the top one is of iron and generally wrapped with hog-wool slubbing, or, as in Petrie's special squeeze-head, covered with compressed cloth to prevent the fibres being cut. For ordinary wool the bottom roller is plain-faced, but for exceptionally greasy wools, which, particularly in the first bowl, tend to stick at the nip through slipping on the roller, a slight marking or dimpling is applied to it. The application of weight, as the illustration well shows, is by means of compound leverage; with this as much as eight tons pressure may be applied if desired. An indicator for this is supplied on the Petrie machine. A danger is found in that through this weight "flats" may be produced on the upper roller through neglect when the machine is standing; but as a means of avoiding this by supplying a handy method of removing the weight, McNaught's worm and pinion arrangement, actuated by a handle, is extremely serviceable.

A somewhat novel departure in wool-scouring machinery has been placed upon the market by Messrs. W. A. Layland and Co. The bowl employed has a false bottom, while underneath is a division carried lengthwise and also slantingwise to allow for the settling liquors. Two partitions, forming three compartments in the bowl, are also placed crosswise to aid in the settling process. The dirty liquors coming from the squeezing head run into the first compartment, the sand and dirt falling to the bottom. Constant addition causes an overflow of the upper part of the liquor, which more or less consists of greasy matter, and this in the second compartment is removed from the surface by a special overflow valve. The connection with the third compartment is effected through an opening in the bottom of the partition, the freer liquid by this means being drained off. This, after further settling, is carried back to the wool by a rotary pump. The agitating mechanism is on the parallel rake system, but in this case motion is conveyed from below, an arrangement which at least admits all the light possible and in some respects perhaps results in freer access to the bowl. The rakes are borne by transversely and laterally arranged arms, and are worked by a series of cranks, cams, and the connecting links, the movement obtained being similar to that ordinarily employed. For increased output, the width of the bowl may reach 4 feet, but such a width is not altogether satisfactory, owing to the difficulty of giving an effective nip with the long rollers necessary.

The Solvent System.—An apparatus, to be successful on this system, must provide for the following: (*a*) The thorough removal of the greasy impurities, with little or no agitation of the wool and no discoloration of fibre; (*b*) simple action and, if possible, continuity of action; (*c*) absolute safety as regards both control of the volatile liquid and of the vapour from such liquid. It is with reference to the two last-mentioned conditions that the arrangements so far designed have proved somewhat ineffective. At the same time, it must be realised that the use of carbon bisulphide in the

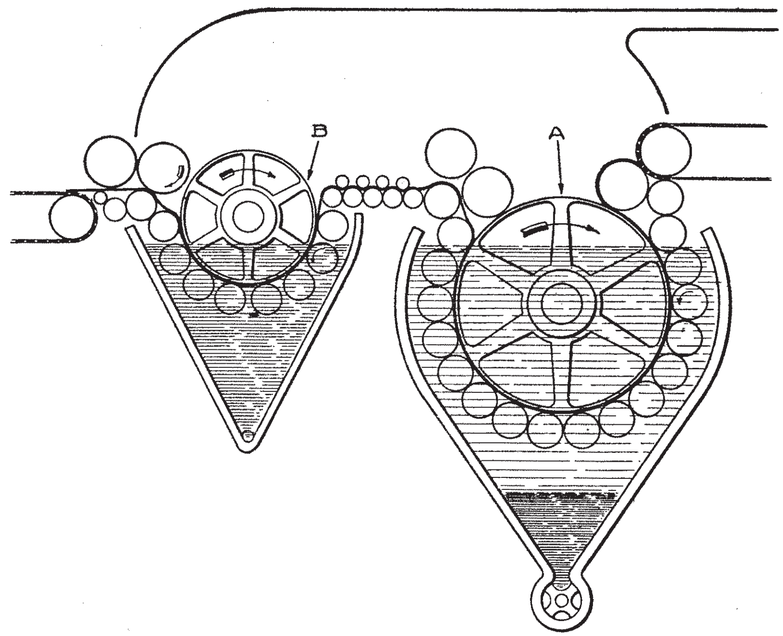

Fig. 66.—The "Burnell" Wool Scouring Machine

presence of heat is liable to discolour the fibre. Prior to 1888 many attempts were made to design satisfactory machines, but it was not until 1909, when a useful machine was placed on the market by Messrs. G. and A. Burnell, that the practical possibilities of this system were realised. This machine (Fig. 66) consisted of two V-shaped tanks, a larger and a smaller. The larger was charged with the solvent, petroleum benzine, while the latter was charged with hot water to release the potash salts and to evaporate any remaining solvent. Revolving in each tank was a large cylinder (A and B), while forming a series of nips with this cylinder were a number of smaller cylinders. The wool was fed from an ordinary apron through feed rollers and then successively squeezed and released in the first tank—a process which quickened the separation of impurities. The heavier of these dropped to the bottom of the V, and from thence were readily removed. To prevent loss of solvent while this was being done, water (heavier than benzine) was run into the bottom of the vessel, being maintained at a fixed level. A thorough action of the benzine on the wool was ensured by conducting the benzine into the first bowl at its delivery end. Having passed through the first bowl, the wool was conducted to the second bowl, in which it was cleared of all the sand, grease, etc., while any remaining benzine was vaporised. Purification of the solvent agents was effected by distillation in separate tanks, by which means the agent was used over and over again. The potash liquor was subjected to a process of evaporation and calcination for the recovery of the potash salts. To prevent explosion or discomfiture of the attendants through the escape of vapours, an iron hood was fitted over the upper part of the machine; the top portion of this was drawn into a tube, through which suction induced the gases (which otherwise might find exit from the sides of the machine) to pass into the condenser.

As regards output, the machine equalled that of the emulsion system as generally employed. Possibly some slight matting of the fibres resulted from the nipping, while the high temperature (170° F. and over) of the water in the second bath possibly hardened the fibre. This machine, however, is interesting from its being the representative machine for continuity of action.

Maertens' Machine.—The modern application of the system of solvent scouring is represented by an apparatus patented by Mr. E. Maertens, of Rhode Island, U.S.A., which, it is stated, is now in use on 250,000 lb. of greasy wool per day at Arlington Mills, Lawrence, Mass., and also at Verviers in Belgium. It is interesting to note that in 1909 an installation was made in a Bradford mill. The fact that the quantities of wool mentioned are handled, speaks well for the efficiency and economy of the process; on the other hand, it is difficult to see how, with the costly and complex equipment necessary, it can ever attain wide adoption, especially among the smaller firms.

The following description and sketch plans (Fig. 67), extracted from an article by Mr. William Naylor, F.C.S., in the *Textile Recorder*, will give a general idea of its action.

" Referring to sketch plan of the plant, drawn to show the principle rather than the actual location of the parts in entirety, the wool is introduced first into vertical kiers, or digesters, of which there are four, worked in pairs—A with B and C with D. The tops or mouths only of these digesters protrude through the floor of the room above them. The digesters are charged by hand, each taking 3,000 lb. per charge.

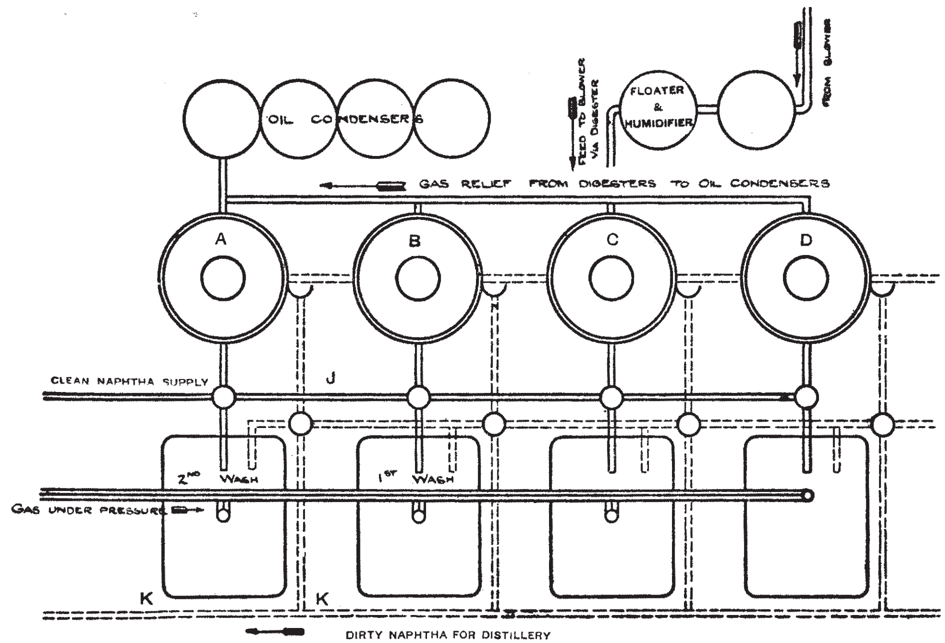

Fig. 67.—The Maertens Wool Degreasing Plant

When full, the digesters, provided with gas-tight joints, are screwed down, a flush of naphtha is injected through a side pipe at the top of the digester, but in the room below, so as to spray over the wool and pass through it, bearing away the grease.

" It will be seen, therefore, that the naphtha feed resembles in some measure the traverse of high pressure kier liquor, being propelled as it is by a pressure of gas behind, except that, instead of traversing the same kier continually, it passes on to the next kier, subject to further remark. For complete cleansing of each batch of wool three of the flushings are required, but the operations are so arranged that the solvent always goes away fully charged with grease, and that the last flush is always made with clean solvent. Assuming the digesters A and B to be newly charged with greasy wool, a flush of naphtha is injected from the reservoir—naphtha which has already been used twice over. The injection is of the well-known dip-pipe and compressed-gas type, like a Shone's ejector or laboratory wash bottle, but the gas used is inert and non-inflammable. A connected delivery from the reservoir to kiers is shown by the single line J, the kier A being flushed first with naphtha already fouled, and the dirty naphtha being returned by K and K to the distillery for the separation of the grease and naphtha. Kier A is next flushed by solvent, having been used only once; but this, instead of being returned to the distillery, is used to flush kier B, the same continuous gas pressure propelling it, following which it is returned to the distillery. The next flush for A is clean naphtha, either from distillery direct or from a clean reservoir, and this, after being passed through B, is returned to reservoir, or to one reserved for solvents of its special degree of grease content. Kier B is finally flushed with clean naphtha, completing batches in A and B kiers, and so on *ad infinitum.* The various valves and by-passes to effect these movements are considerable in number.

" Nevertheless, they are easily controlled in practice, each series of pipes being painted a distinctive colour and the valves marked unmistakably. In addition, the particular flush passing through a digester can be recognised at once in the gauge glass. They are right after each other, and the line of demarcation is plainly visible all down the glass. Four-way valves or passes are shown by small circles in the sketch plan, three-way by the semicircles.

" Any digester can be connected with any reservoir, or with the clean naphtha supply, or with the distillery dirty discharge. The digesters are on the ground floor, accessible from every point, but the reservoirs are in subterranean vaults, buried in sand, except for the protruding valves, gauge glasses, and fittings.

" After the third flushing the digesters are left (their contents saturated with adherent solvent) under a gas pressure sufficient to overcome the lift, and gas itself saturated with solvent vapour. Such a condition of affairs is met in a very creditable manner. The gas pressure is released through oil condensers, or scrubbers, passing from thence to the gas holder, from which the compressor draws its supply, the oil condensers sending their saturated charges periodically to the distillery for the liberation of absorbed solvent. The covers are not removed from the digesters until they have been swept out by a current of warm, moist air for a considerable period of time. Humidity and temperature of this air are nicely regulated to ensure the abstraction of solvent vapour only, without affecting the natural hygroscopic condition of the wool. The moist, warm air is propelled, by means of a Root's blower, through an adjustable humidifier, and after passing through the digester, forms the feed to the blower. But between the blower and the humidifier is a condenser for the abstraction of solvent vapour, and, unavoidably, some water vapour. By this arrangement the same current of air is used constantly over and over again, alternately absorbing and depositing naphtha vapour in its circuit, its load as it passes any point between the digester and the condenser growing less each time. Every trace of vapour is recovered from the wool by this method, following which the digesters are opened and degreased wool discharged, still containing all the potash and much of the dirt.

" Live steam is used in the distillery for driving off the solvent, and is recovered without torrefying the resultant grease. A mixture of naphtha and water naturally forms the distillate, and for purpose of drawing off at frequent intervals, the distillate receivers are provided with numerous dip pipes of different lengths, which permit the withdrawal of either solvent or water at almost any point.

" A very easy matter is the washing of the wool after degreasing; in fact, the wool requires no washing—simply a rinsing. This operation is startling to one who has been accustomed to see the laborious process of a scouring machine. A simple rinse through cold water changes the colour from brown to white, the water just racing through as through old hay. The rinsing water contains all the potash, too, from which it can be recovered by evaporation."

WOOL DRYING

General Considerations.—Although wool is very thoroughly squeezed on leaving the scouring bowl,

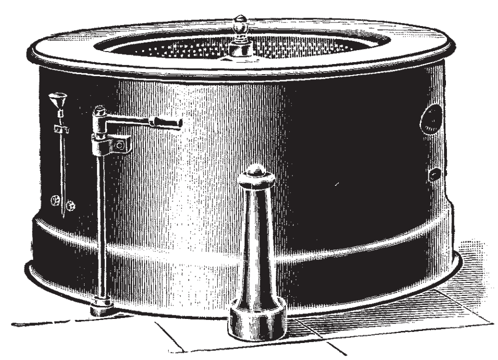

Fig. 68.—Hydro-Extractor or "Whuzzer"